POWER UP!
Running your ham radio long-term on portable power

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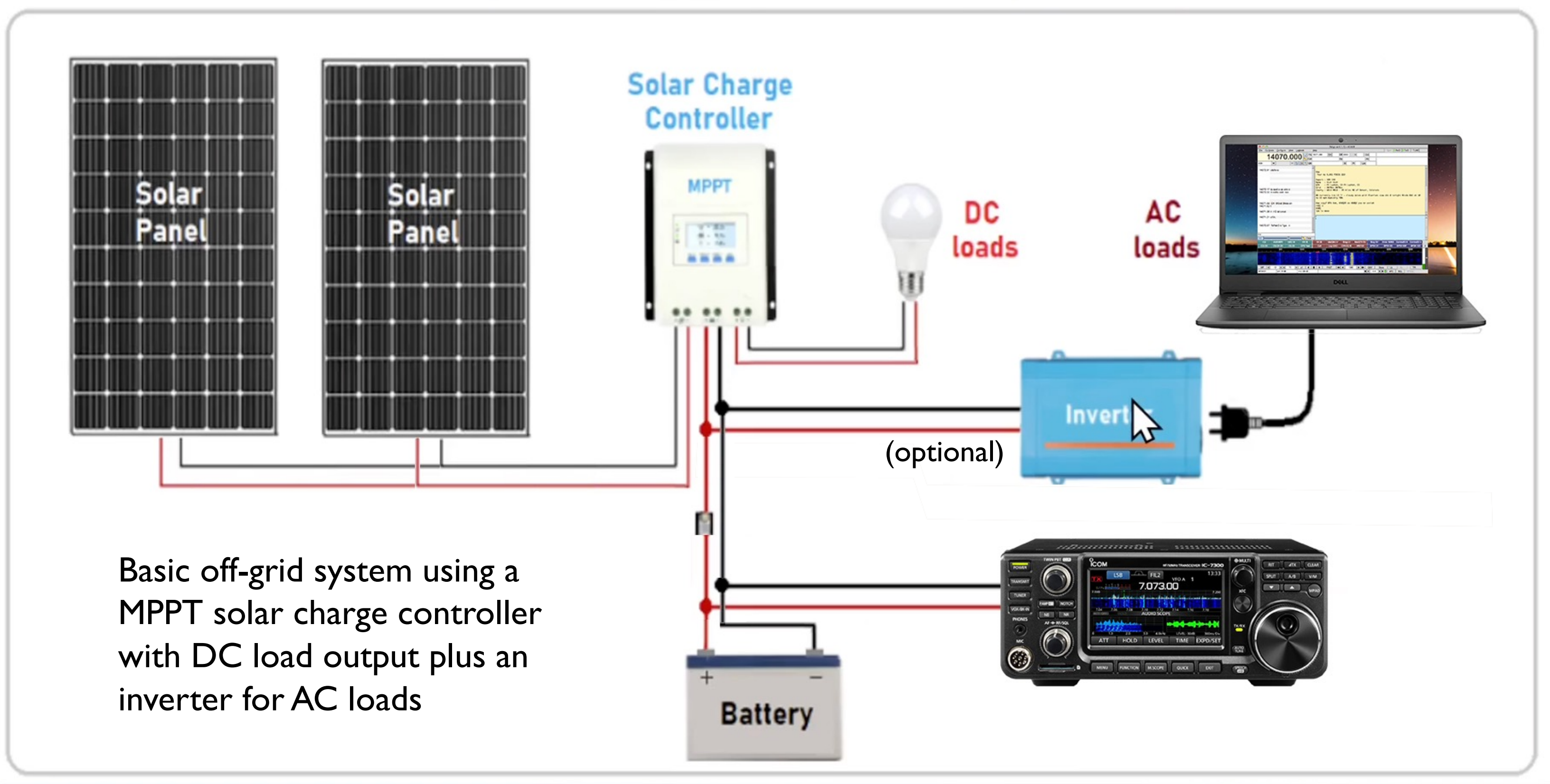
Let’s answer these questions, in order:

1. **How much power might you consume?**
   (rate of use, for how long, by operating style)
2. **What size energy source will you need?**
   (capacity & type of battery)
3. **How will you replenish your battery?**
   (battery recharging considerations)
4. **How much will this cost?**
   (equipment examples)

System Overview

How the parts relate… gear must be compatible to interact well and safely



hypothetical system

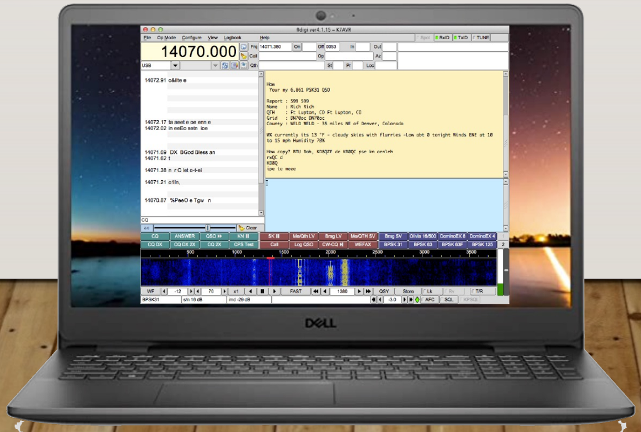
1. How much power might you consume?

important factors

- Choice of Radio Transceiver
- Power draw, Transmit vs. Receive
- Transmit high power or QRP?
- Duty Cycle and Mode (SSB vs. FT8)
- Ancillary gear (computer, etc.)

" I have a 100-watt radio, so it uses 100 watts of power, right? "

Er… no.



Example Power Consumption

	Icom IC-7300	Yaesu FT-857D	Xiegu G90
	(100W SSB/FM)	(100W SSB/FM)	(20W SSB/FM)
Receive Standby	0.9 A	0.55 A	0.22 A
Receive Active	1.25 A	1.0 A	0.7 A
Transmit 10W	~ 2.1 A	~ 2.2 A	~ 3.0 A*
Transmit 20W	~ 4.2 A	~ 4.4 A	~ 4.0 A*
Transmit 50W	~ 10.5 A	~ 11.0 A	n/a
Transmit 100W	21.0 A	22.0 A	n/a

Watts = V x A

Amps = W / V

Rough rule of thumb: each 5 watts of RF output uses 1A on a 12VDC system.
Said another way: radios are <50% efficient (~100W RF out consumes >200W).
Tip: use an in-line power meter to show actual cumulative draw (~$20).

* These Xiegu specifications were taken from field reports, not the manual.

Duty Cycle and Modes

- Duty Cycle = percentage of time spent transmitting
- Mode examples:
  - SSB (typically LOW duty cycle; only during voice TX, varies with input volume*)
  - FT8 (averages about 50% due to regularly alternating TX/RX cycles)
  - Other Digital Modes (can extend to 100% duty cycle, so operate wisely!)
- Know your radio's Duty Cycle limitations * *

* Tip: use audio compression to improve audio quality without consuming more power
* * FT-857D as example radio; it has a100% duty cycle of no more than 25 watts

Power Consumption Example Calcs

Let's calculate energy needed for **one hour** of:

- SSB on 25% duty cycle at 50 watts, and
- FT8 (50% duty cycle) at 25 watts.

Our example radio* uses 1A on RX and 22A on 100W TX:

- SSB: (25% TX * 11A) + (75% * 1A RX) = **3.5Ah**
- FT8: (50% TX * 5.5A) + (50% * 1A RX) = **3.25Ah**

So, running 4 hrs will require **~14Ah** for the radio alone.

* FT-857D as example radio; Yaesu recommends 100% duty cycle of no more than 25 watts

Power Consumption Calculator

	A	B	C	D	E	F	G	H	I	J	K
1											
2		**RADIO TRANSCEIVER BATTERY SIZING CALCULATION - By Fleep KA4KOE**									
3		Revision 1 - 16 January 24									
4											
5						Block 1					
6		1. Enter radio ampere draw in receive:				1.00	Amps	***Enter actual measured current.***			
7											
8						Block 2					
9		2. Enter radio ampere draw in transmit:				22.00	Amps	***Enter actual max measured current.***			
10											
11		3. Enter transmit average power (equal or less than 1.0):				0.5		*Suggested Averages:*			
12								*0.1 - 0.2 SSB, 1.0 FT8/FM, 0.5 CW.*			
13		4. Calculated Average Ampere Load (Line 2 x Line 3):				11.0					
14											
15						RX	TX				
16		3. Enter anticipated receive / transmit ratio (9:1 typical):				0.75	0.25				
17		**Both numbers must add up to 1.0.**									
18											
19											
20		We calculate for a full-hour time period.									
21		Receive	1.00	Amperes	X	0.75	Hours	=	0.75	Amp-hrs per 1 hour	
22		Transmit	11.00	Amperes	X	0.25	Hours	=	2.75	Amp-hrs per 1 hour	
23		Total Amp-hours drawn per hour							3.50	Amp-hrs per 1 hour	
24						Block 3					
25		Enter Total Hours of Operation				4.00	Hours				
26		Ampere Draw Per Hour				14.00	Amp-hrs				
27											
28		Lead Acid Battery Capacity @ 50% Available				28.0	Min. AH				
29											
30		LiFEPO4 Capacity @ 90% available				15.6	Min. AH	See Note 1			
31											
32		You Enter Data in Yellow Cells									
33		Blue Cells are those automatically calculated.									
34		Green Cells are calculated minimum battery sizes									
35											

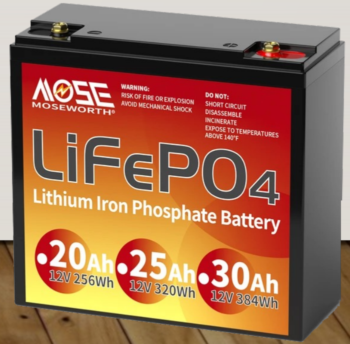
https://qrper.com/wp-content/uploads/2023/05/Battery-Sizing-Calculator-by-KA4KOE-Rev1.xlsx

2. What size energy source will you need?

- Choice of battery chemistry (SLA/AGM, Li-ion, LiFePO4)
- Discharge Curve of your battery
- Battery Capacity, Max Continuous, Max Peak Current
- Max Charge/Discharge Rate (C Rating)
- Depth of Discharge limit
- Ambient operating temperature

Battery Chemistry Options

- SLA / AGM / Gel: sealed lead-acid
- Li-ion: lithium ion
- LiPo: lithium-ion polymer
- LiFePO4: lithium iron phosphate



Battery Chemistry Options (only ONE, really)

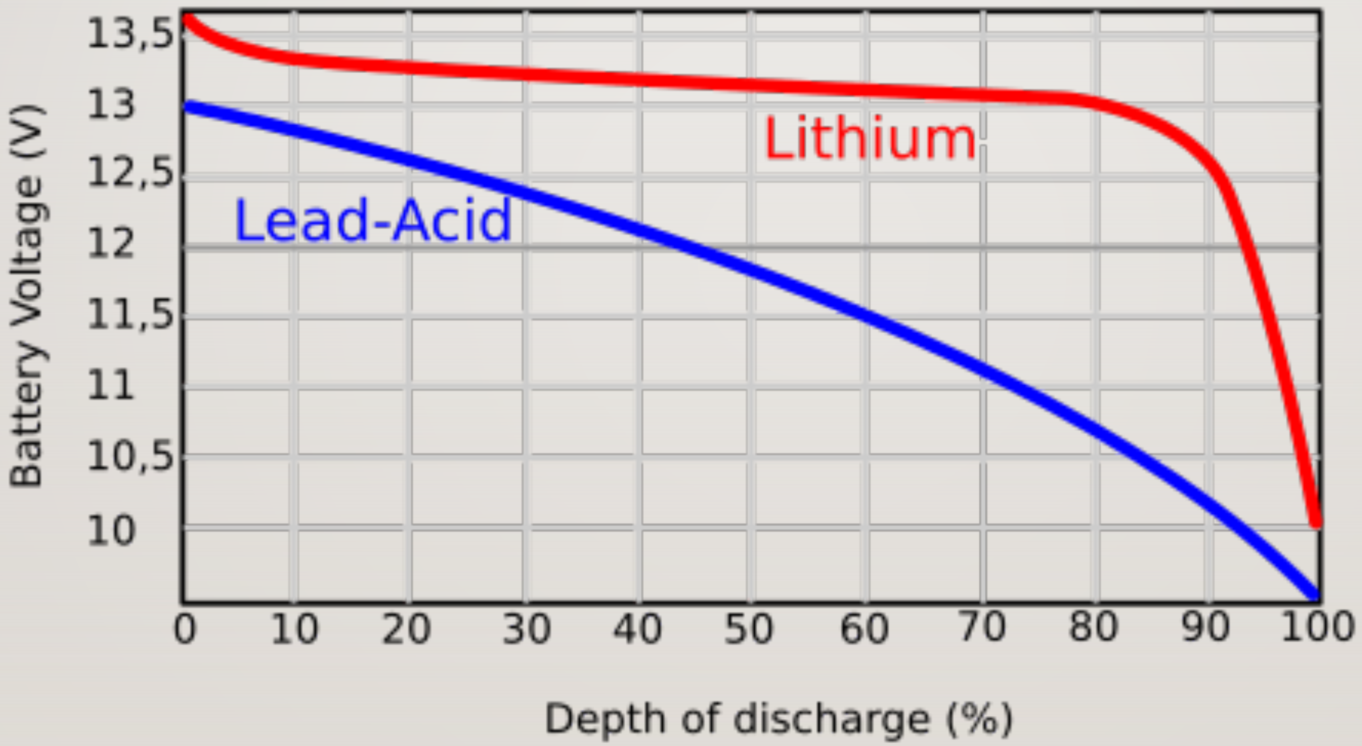
- ~~SLA / AGM / Gel: sealed lead-acid~~ — Not performant (50% DoD)
- ~~Li-ion: lithium ion~~ — Potential FIRE hazard in the field!
- ~~LiPo: lithium-ion polymer~~ — Potential FIRE hazard in the field!
- LiFePO4: lithium iron phosphate
  - Deep DoD (90%) without damage*
  - 10x recharge cycle life than SLA
  - Less than half the weight of SLA
  - Higher discharge voltage than SLA
  - Intelligent cell balancing (via BMS)
  - Better at low temperatures**

* Can technically be discharged to 100% without immediate damage, but DoD of 80% to 90% is recommended for longevity.

** LiFePO4 discharges well below 0°F — but do not ***charge*** below 32°F (some have built-in cell heating).

Further proof / benefit

SLA vs. LiFePO4 discharge voltage curves



LiFePO4 is above 13V for most of its discharge cycle!

By comparison,
a fully charged SLA is
only 12.6V–12.8V,
and voltage declines sharply.

Size Matters — but so does “Strength”

Reminder: Our example radio uses 22A at 100W TX.
So, to transmit on this radio **at full power**
the battery’s **discharge rate** ability must be at least that much.

Look for terms like “Max Continuous Current” or “Peak Discharge Current”.

Alternatively, “C-Rate”: the rate of charge or discharge relative to maximum capacity
(e.g. a 20Ah battery that can discharge its 20A in 1 hour = 1C; 1/2-hour = 2C)

Size Matters — but so does "Strength"

Reminder: Our example radio **uses 22A** at 100W TX

avoid this potential pitfall

Nominal Voltage: 12V Actual Voltage: 12.8V
Nominal Capacity: 20Ah
Discharge Cut-Off: 10V
Charge Cut-Off: 14.6V
Charge Current: 15A
Peak Discharge: 15A [C-Rate is 0.75C]
Charge Temperature: 32F - 113F
Discharge Temperature: -20F - 140F

FAIL

Voltage: 12V
Capacity: 15 Ah
Case Type: PVC Pack
Charge Connector: DC Plug (5.5/2.1mm)
Discharge Connector: Anderson Powerpole
Maximum Continuous Discharge Current: 30A [C-Rate is 2C]
Maximum Peak Pulse Current: 60A (for 2 sec.)

PASS

LiFePO4 Battery Recommendations

GoldenMate
Capacity: 30 Ah
Peak Discharge: 30A
$85 on Amazon

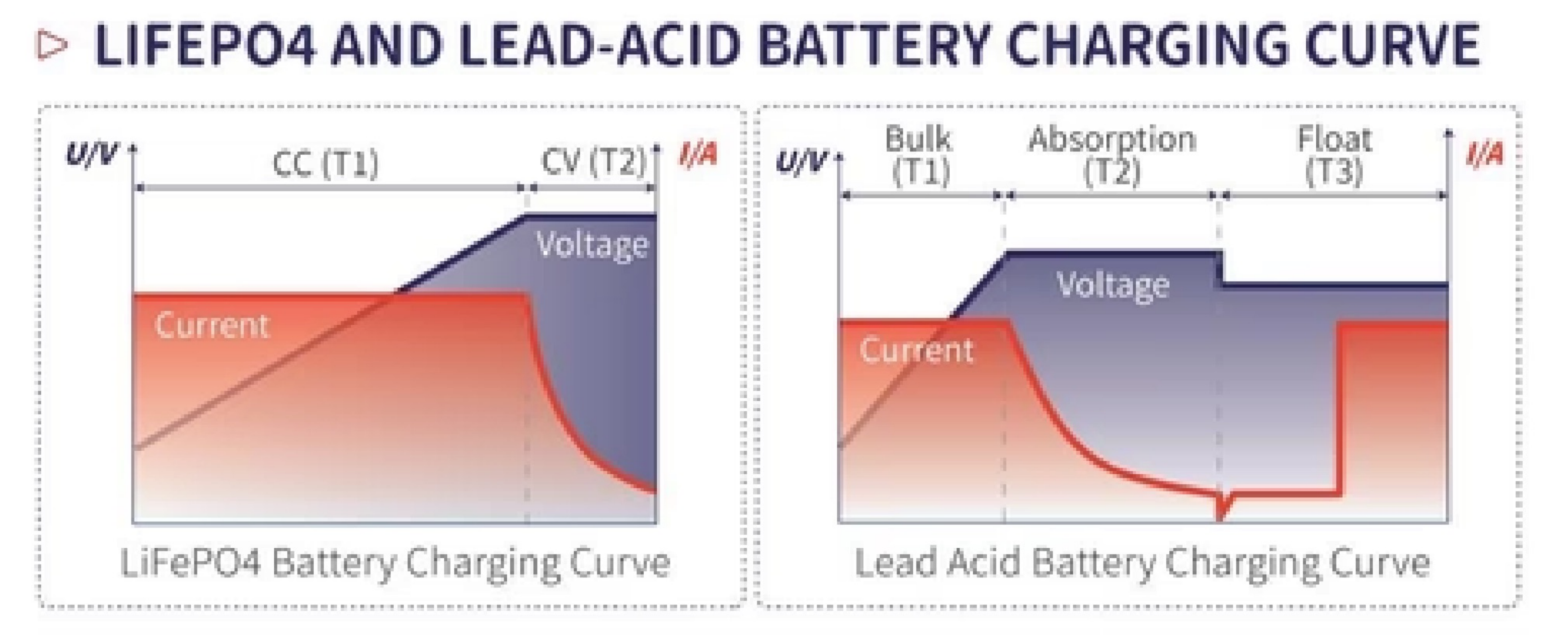
SOK SK12V100H
Capacity: 100 Ah
Peak Discharge: 100A
Built-in heater & Bluetooth
$299

Battery Box (for above)
For up to 30Ah
$70 on Amazon

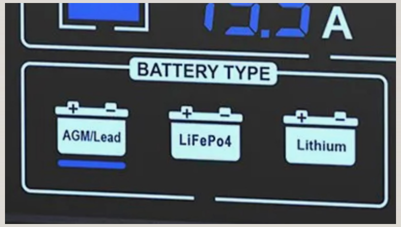
Bioenno BLF-1215A
Capacity: 15 Ah
Peak Discharge: 30A
$149

3. How will you replenish your battery?

Charging by battery type: different algorithms are used…



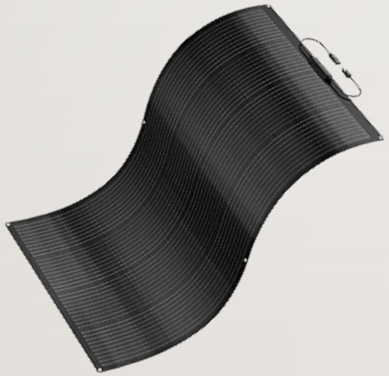
…so your charger must have a setting for your battery's chemistry:



What if solar is your refill source?

Of course you'll need a **solar panel** or two…

Predator 100W $129



BougeRV Arch 200W Flexible $279

Renogy 200W Solar Blanket $229

High-power monocrystalline rigid panels

Be sure to know these specifications:

Module Type:	4a-65-73-75-73
Max Power at STC (P_{max})	100 W
Open-Circuit Voltage (V_{oc})	21.2 V
Short-Circuit Current (I_{sc})	6.10 A
Optimum Operating Voltage (V_{mp})	17.7 V
Optimum Operating Current (I_{mp})	5.70 A
Temp Coefficient of P_{max}	-0.38%/°C
Temp Coefficient of V_{oc}	-0.28%/°C
Temp Coefficient of I_{sc}	0.06%/°C
Max System Voltage	600VDC (UL)
Max Series Fuse Rating	10 A
Fire Rating	Class C
Weight	6.8kg / 15lbs
Dimensions	1038x533x35mm / 40.9x21.0x1.37in
STC	Irradiance 1000 W/m², T = 25°C, AM=1.5

*Voltage changes with temperature: efficiency decreases as panel gets hotter and increases as temp goes down.

What if solar is your refill source?

Solar panel tips:

- Know your optimal insolation Tilt & Azimuth angles
- Voltage changes with temperature: efficiency decreases as panel gets hotter and *increases** as temp goes down.
- Wire multiple panels in *parallel* (most likely for expansion)
- Avoid shade (shadows can drastically reduce panel output)**

*Voltage temperature coefficient effect might make your panel voltage too high for your system

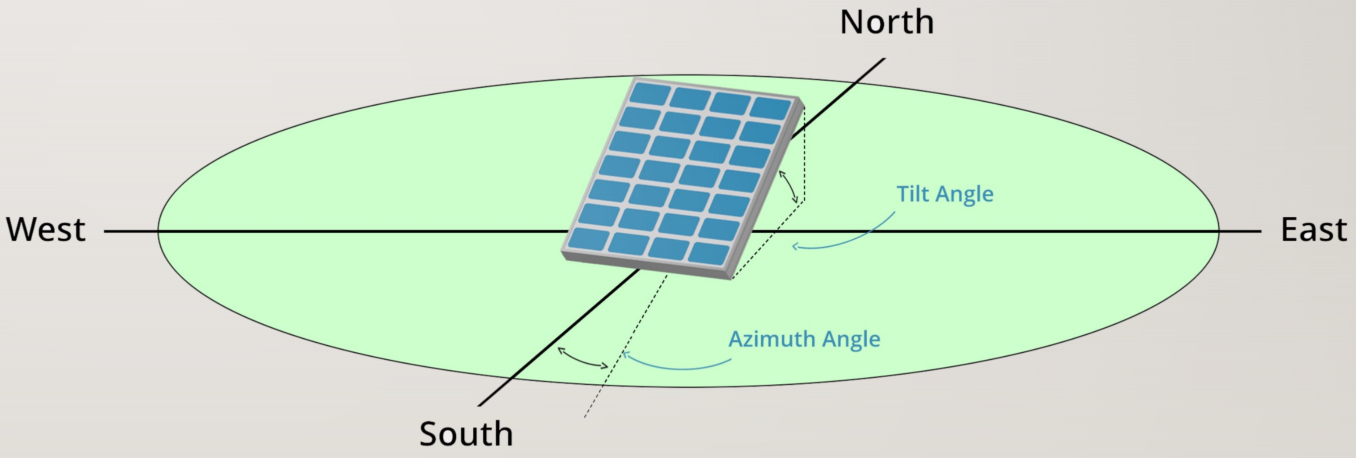
** Some panels are less affected by shade than others; again, wire in parallel.

What if solar is your refill source?

Where is the Sun? Know its location (elevation and azimuth)

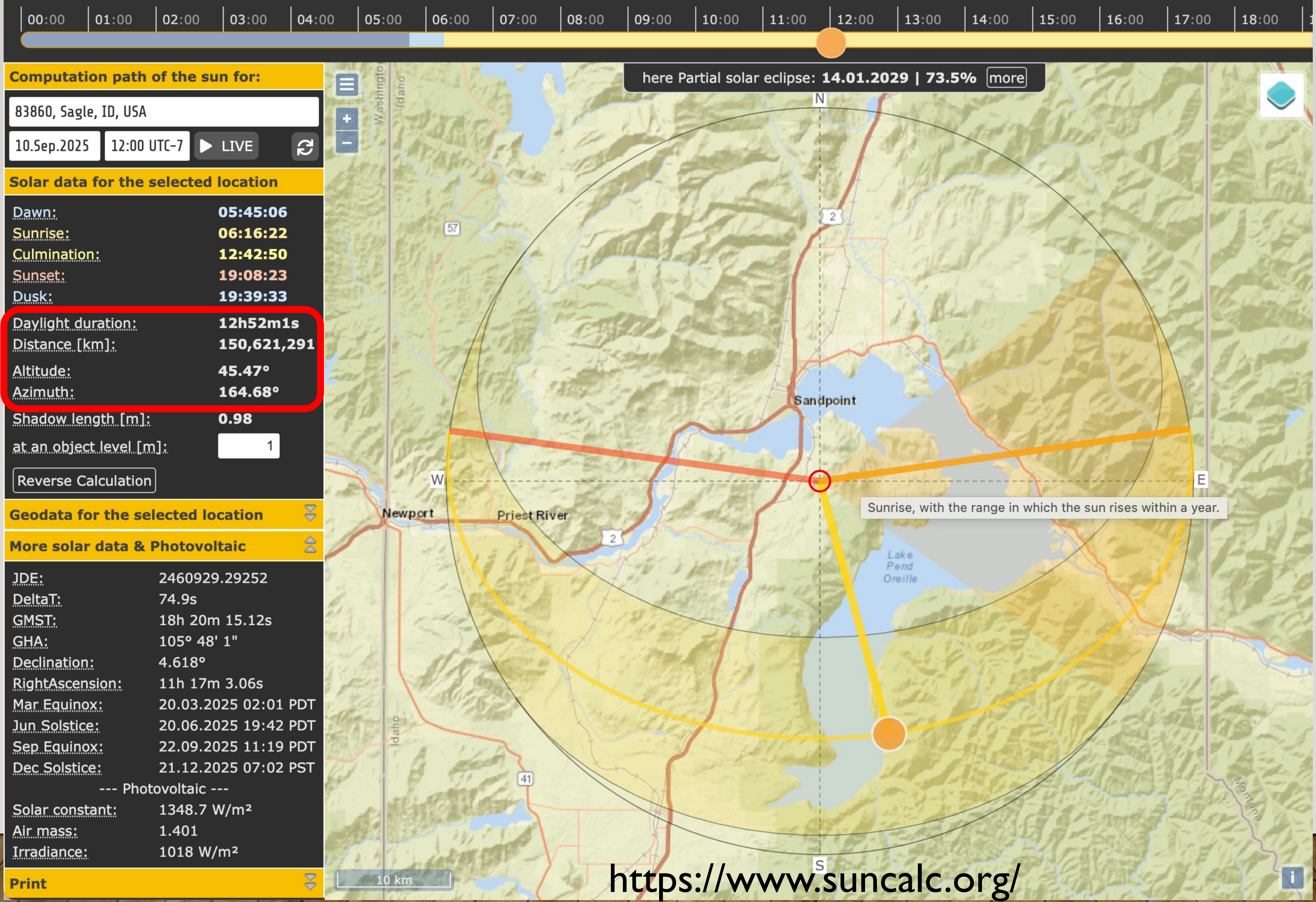
Local optimal TILT angle*	
January	44.9°
February	39.9°
March	34.9°
April	29.9°
May	24.9°
June	19.9°
July	24.9°
August	29.9°
September	34.9°
October	39.9°
November	44.9°
December	49.9°

Local optimal AZIMUTH angle
True South (or adjust for max exposure)



Or, if you want to know ***exactly*** where the sun is located…

* 0° tilt is flat (horizontal) Values above are more applicable to fixed installations.

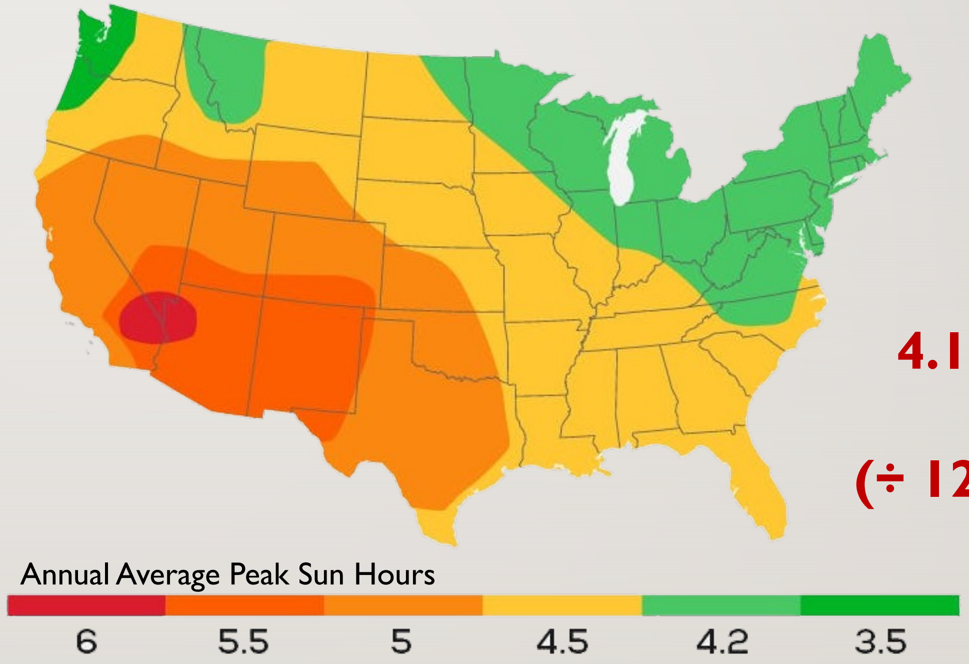


https://www.suncalc.org/

What if solar is your refill source?

Calculate your **peak sun hours** for energy production

Avg # Peak Sun Hours*	
January	1.9
February	3.0
March	3.8
April	5.0
May	5.8
June	6.4
July	6.9
August	6.6
September	5.7
October	3.8
November	2.2
December	1.8



4.19 hrs x 200W
= 838 Wh
(÷ 12.8V = 65A/day)

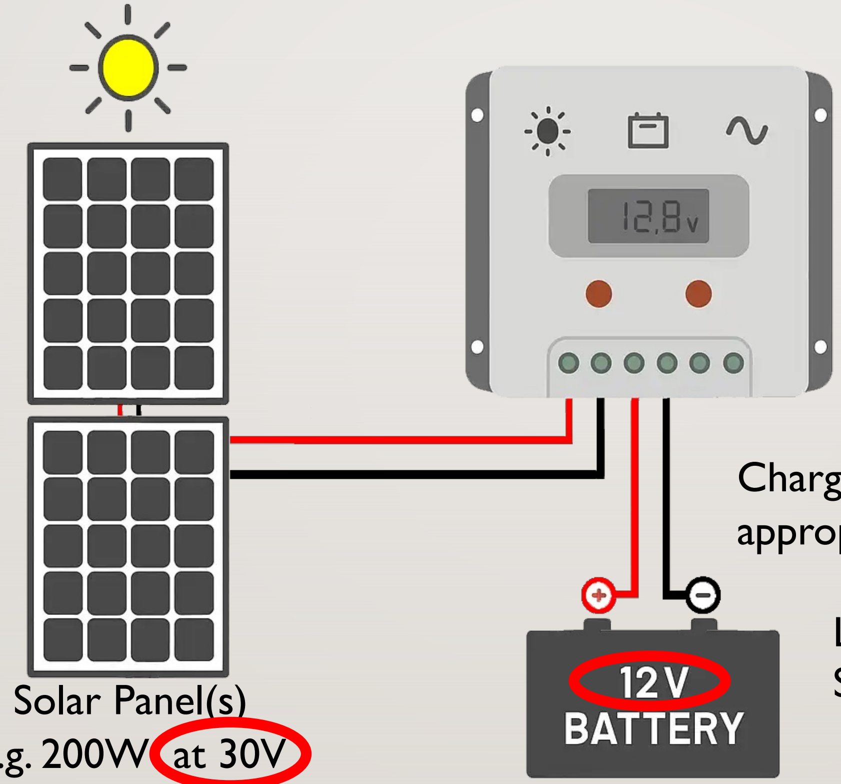
For Sandpoint ID, annual *average* peak sun: 4.19 hours per day.**

* when solar irradiance is greater than 1,000 watts per square meter

** National Renewable Energy Laboratory PVWatts calculator: https://pvwatts.nrel.gov

What if solar is your refill source?

…and you'll need a **solar charge controller**…



Since solar panel electricity production varies with lighting conditions, the controller protects the battery (and the panels) and optimizes charging.

Charges with algorithm appropriate to battery chemistry:

LiFePO4: CCCV ~14.6V
SLA/AGM: CVCC ~13.8V

Solar Panel(s)
e.g. 200W at 30V
varies with conditions
(light and temperature)

Solar Charge Controllers come in two "flavors"

- ➢MPPT (Maximum Power Point Tracking)
- ➢PWM (Pulse Width Modulation)

Feature	MPPT	PWM
Efficiency	As much as 30% higher efficiency than PWM	Lower efficiency compared to MPPT
Winter Performance	Best for colder, cloudier environments	May struggle; works better on warm, sunny days
Flexibility	More versatile, good for larger systems	May be okay for smaller, simpler systems
Cost	Generally more expensive	Typically cheaper
Voltage mode	Converts excess input voltage into amperage	Array voltage is "pulled down" to battery voltage

Bottom line: while *some* PWM controllers can be configured to work adequately with LiFePO4 batteries, **MPPT controllers are the better choice**.

https://www.renogy.com/blogs/buyers-guide/what-is-the-difference-between-mppt-and-pwm-charge-controllers

MPPT Charge Controllers come in all sizes…

Match the controller to your battery(s) and panel(s):

- ➢ Battery voltage (e.g. 12/24/48)
- ➢ Panel array wattage & max open-circuit voltage (Voc)*

Accepts 200W at 30 Voc from panels
and can charge batteries at 10 A
Bateria $38

Accepts 360W at 50 Voc from panels
and can charge batteries at 30 A
Harbor Freight $70

Accepts 520W at 100 Voc from panels
and can charge batteries at 40 A
Renogy Rover Li $199

Many controllers have Bluetooth connectivity for monitoring.

* Must calculate using Temperature Coefficient of Voc for deviation from Standard Conditions (77°F)

MPPT Charge Controllers come in all sizes…

…and are part of your all-in-one power station:

Predator 350 $279
Accepts 120W at 30 Voc from panels,
has 22Ah battery supplying 350W AC

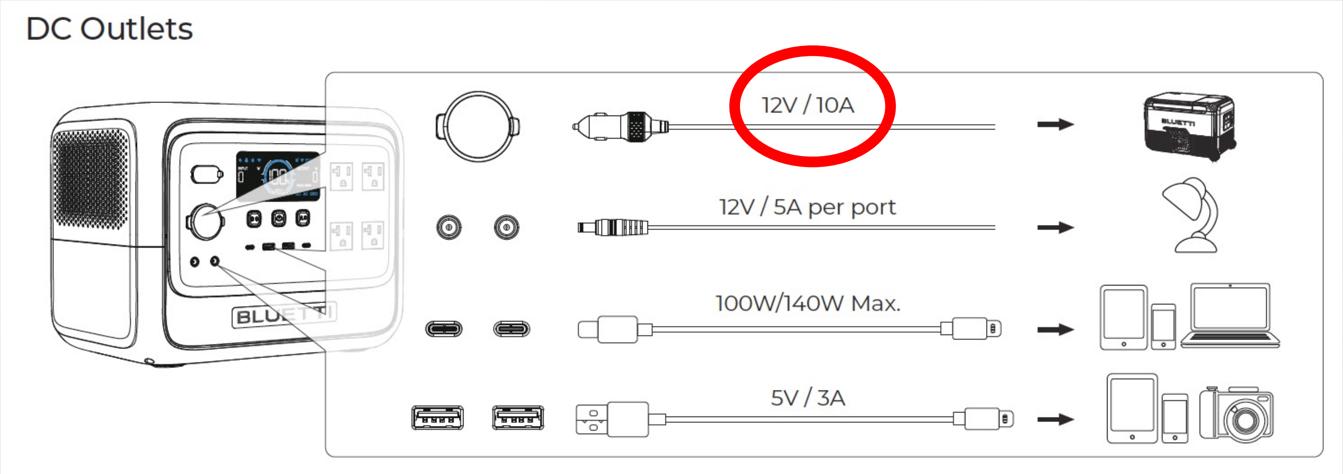
Bluetti Elite 100 V2 $499
Accepts 1000W at 60 Voc from panels,
has 80Ah battery supplying 1800W AC

Jackery Explorer 2000 V2 $899
Accepts 400W at 60 Voc from panels,
has 160Ah battery supplying 2200W AC

Power Stations are best for AC loads

We've been talking DC loads until now — **however** the DC sections of power stations generally have limits below our example radio's 22A max power draw.

Example:



Likewise for DC Load of charge controllers

They likely won't support your system's DC requirements.

SOLUTIONS:

- ❑ Wire all DC loads directly to battery*
- ❑ Run AC loads off your power station (if you have one)
- ❑ Connect an inverter to battery and use its AC ports

* Loads pull from whatever source has the least resistance

Use an Inverter to convert DC to AC

Can deliver clean 120VAC with minor efficiency loss*

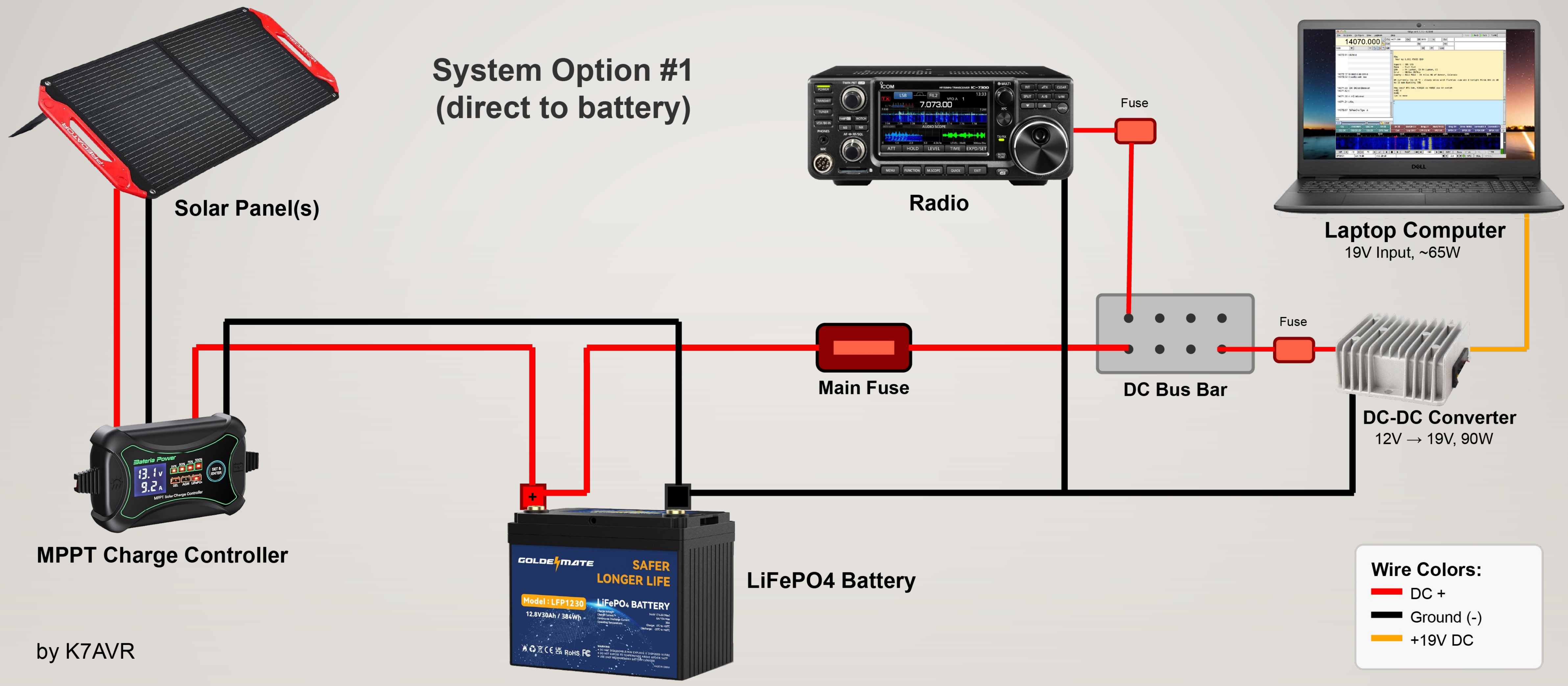
- Power ALL your gear (computer, monitor, radio)
- Use an AC radio power supply to get stable 13.8VDC**

Inverter Types

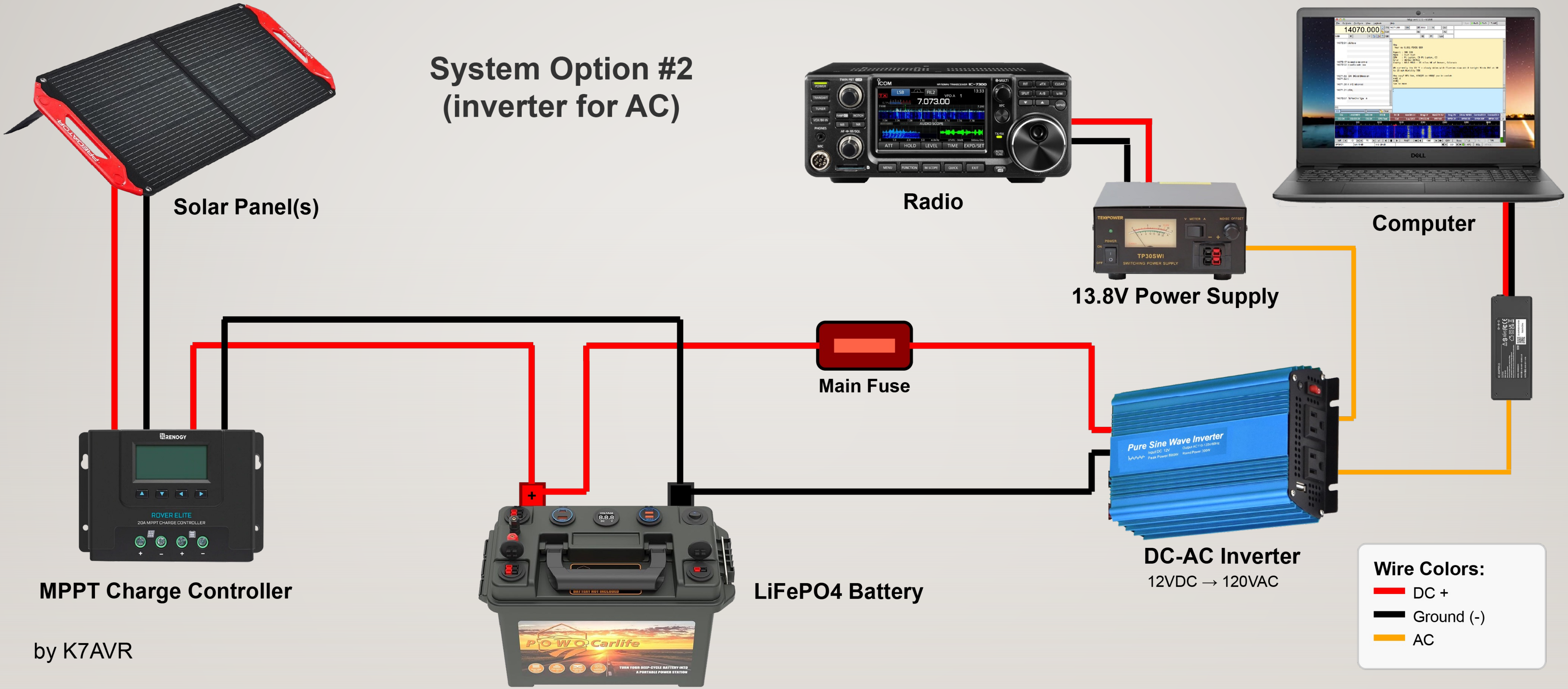
Modified Sine Wave	Pure Sign Wave
Less efficient (70-85%)	More efficient (90-95%)
More affordable	Historically more expensive
Signal can affect electronics	Cleaner signal on power line
May be okay for radio use	Best for sensitive electronics

Pictured: Renogy 1000W Inverter
* Pure Sine Wave 92% efficient
w/Bluetooth & remote on/off
$190

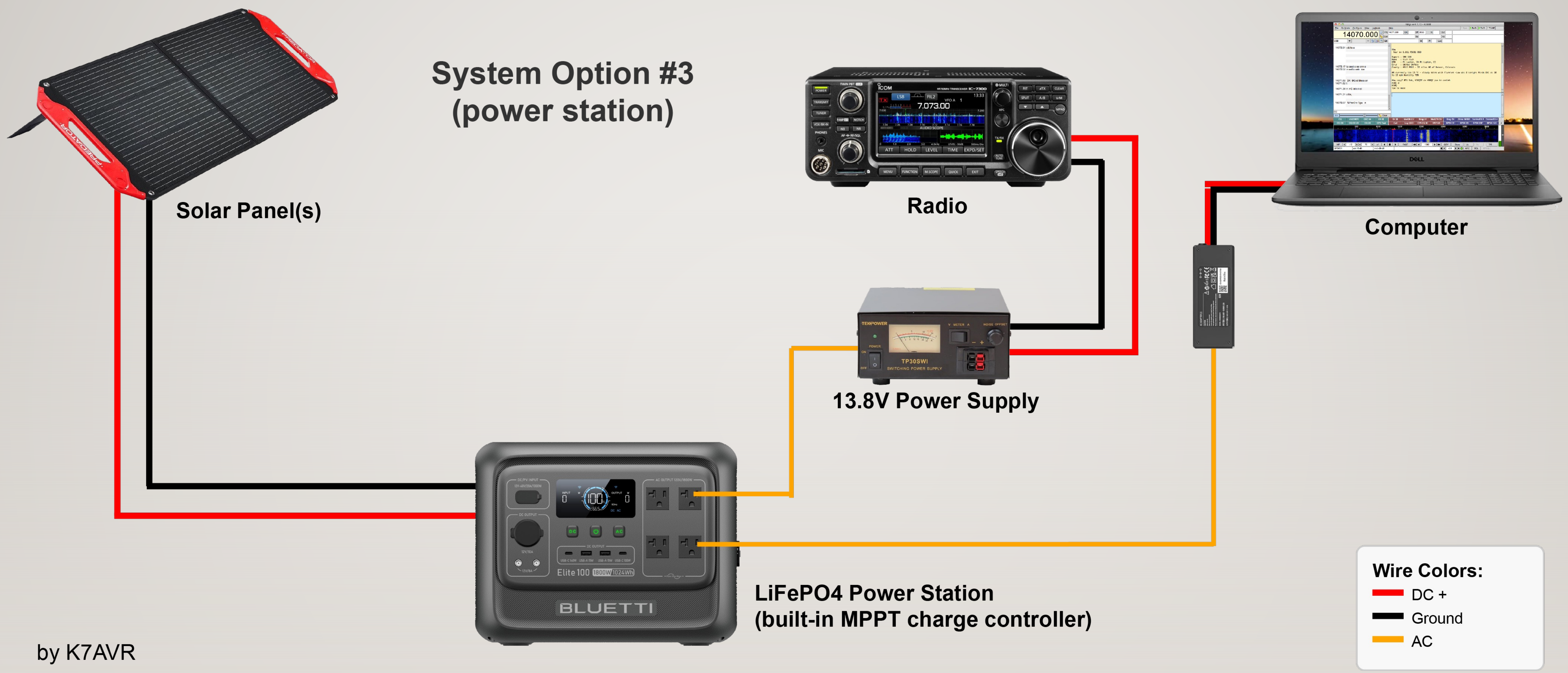
** Using AC power supply for radio means factoring in AC-to-DC efficiency; figure ~85%, so net efficiency 78% in this example.


System Option #1
(direct to battery)
Solar Panel(s)
Radio
Fuse
Laptop Computer
19V Input, ~65W
Main Fuse
DC Bus Bar
Fuse
DC-DC Converter
12V → 19V, 90W
MPPT Charge Controller
LiFePO4 Battery
Wire Colors:
DC +
Ground (-)
+19V DC
by K7AVR

System Option #2
(inverter for AC)



by K7AVR



System Option #3
(power station)
Solar Panel(s)
Radio
Computer
13.8V Power Supply
LiFePO4 Power Station
(built-in MPPT charge controller)
Wire Colors:
DC +
Ground
AC
by K7AVR

Questions?

Contact me!

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