Adding Batteries to a PV System

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15 November 2025

THE STARTING POINT:

6.5kW PV modules, Longi

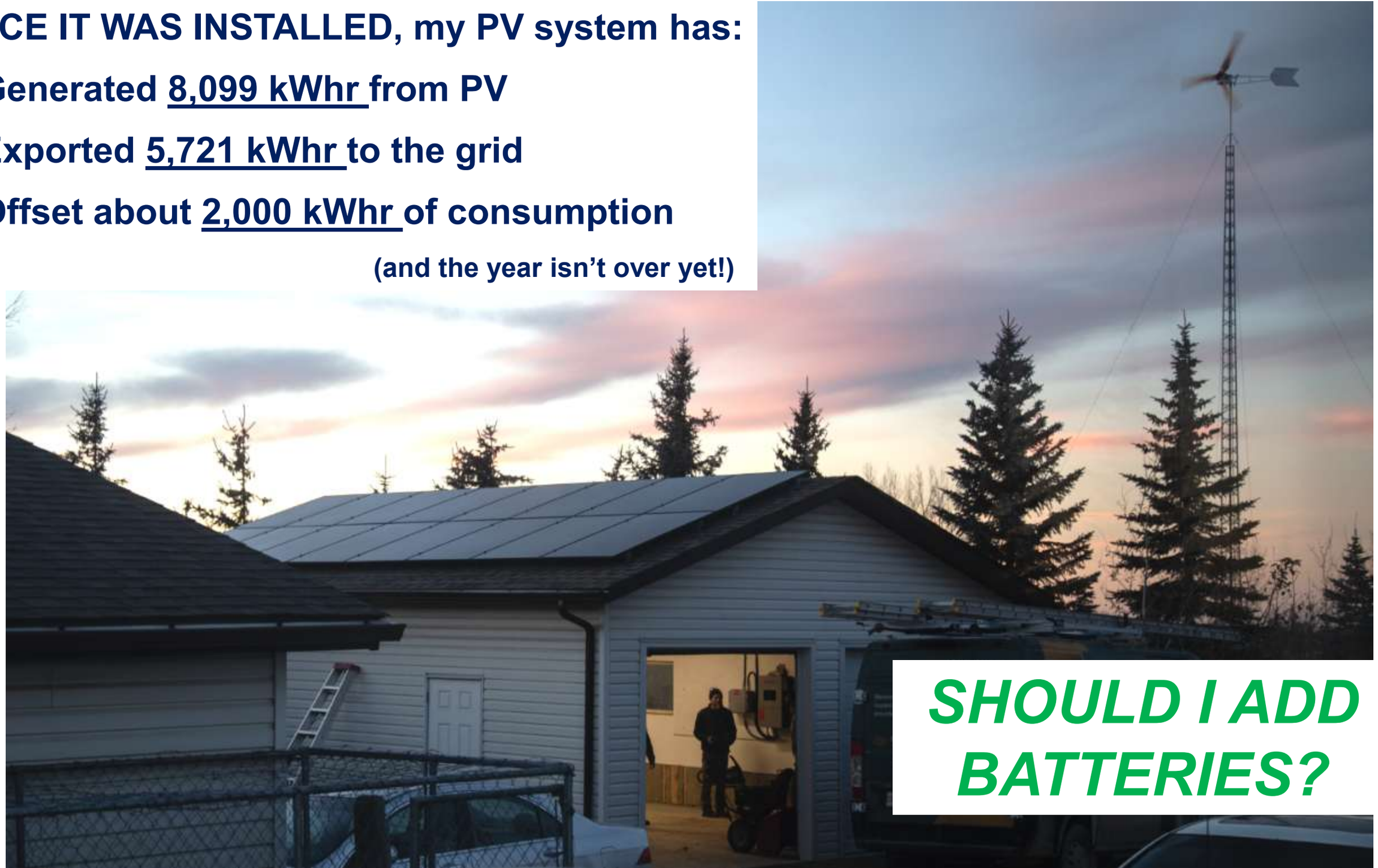
8kW Hybrid Inverter, Sol-Ark

Grid-Tied – Installed December 2024

SINCE IT WAS INSTALLED, my PV system has:

- **Generated 8,099 kWhr from PV**
- **Exported 5,721 kWhr to the grid**
- **Offset about 2,000 kWhr of consumption**

(and the year isn't over yet!)



SHOULD I ADD BATTERIES?

Adding Batteries to a Grid-Tied Solar PV System

- Do batteries make a PV system work better?
- Which batteries are better?
- How much do batteries cost?

? Questions ?
that should be answered before making a decision.

PRO

- Provides back-up power in a grid outage.
- Inverter can continue collecting energy from PV, even during a grid outage.
- Simplifies the integration of wind energy.
- Shift consumption to hours with lower billing
  - Time-of-Use billing is in BC, Ontario
  - Coming to Alberta, “when” not “if”?

CON

- Batteries are expensive.
- Batteries require maintenance.
- Batteries have a limited life.
- Not all inverters can support batteries.
- Batteries require energy to maintain their charge.

Do batteries make a PV system work better?

The MAIN reason to add batteries: Being able to ride through grid outages.

It is energy stored at your site that you can use, even when the grid is out.

Inverters…
We need to talk about inverters before we can see how batteries fit into a PV System

How much does anyone need?

The period you can ride through on batteries depends on:

- The energy capacity of the batteries
- The amount of energy you consume
- The configuration of the inverter that transforms battery energy into AC for your house
- The condition of the batteries at the start of a grid outage
  - If the batteries aren't full, they won't be as helpful
  - When batteries are cold, their capacity is reduced
  - As batteries get old, their capacity diminishes

Do batteries make a PV system work better?

During a grid outage, SIMPLE grid-tied inverters cannot use or store PV energy.

Grid-tied Inverters rely on the grid to maintain & stabilize their operation

- control AC frequency (60 Hertz)
- regulate voltage (240 VAC)
- balance energy demands (rather than just generate heat)

If they don't have batteries, or aren't designed to use batteries at all, they must shut down.

- compliance with design standards such as UL 1741 and CSA C22.2-107.1-16 and IEEE 1547
- protect any devices connected to them from over-voltage or over-frequency

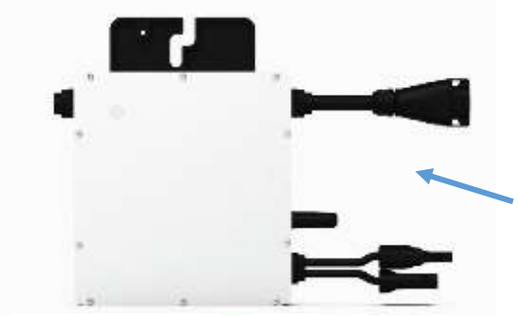
This is why we need to know a little more about inverters…

There are 3 major types of Inverters (that concern our RE Systems)

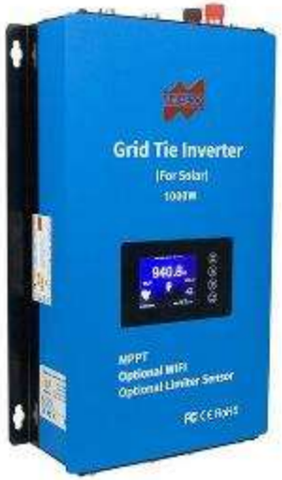
GRID-TIED INVERTER

Relies only on the grid to control frequency and voltage, for simplicity

(Grid only)



UL Listed
High quality



Possibly not Legal…
…anywhere

HYBRID INVERTER

Controls its voltage and frequency independently of its grid connection

(Battery AND/OR Grid)

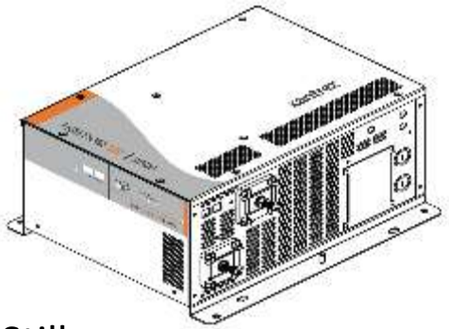
Relied upon by RE enthusiasts for >30 years

New designs
<10 years old

OFF-GRID INVERTER

Controls its own voltage and frequency. Has no grid connections

(Battery only)



Still uses copper Transformers!

(often used in RV's & camping)

Really cheap
on Amazon

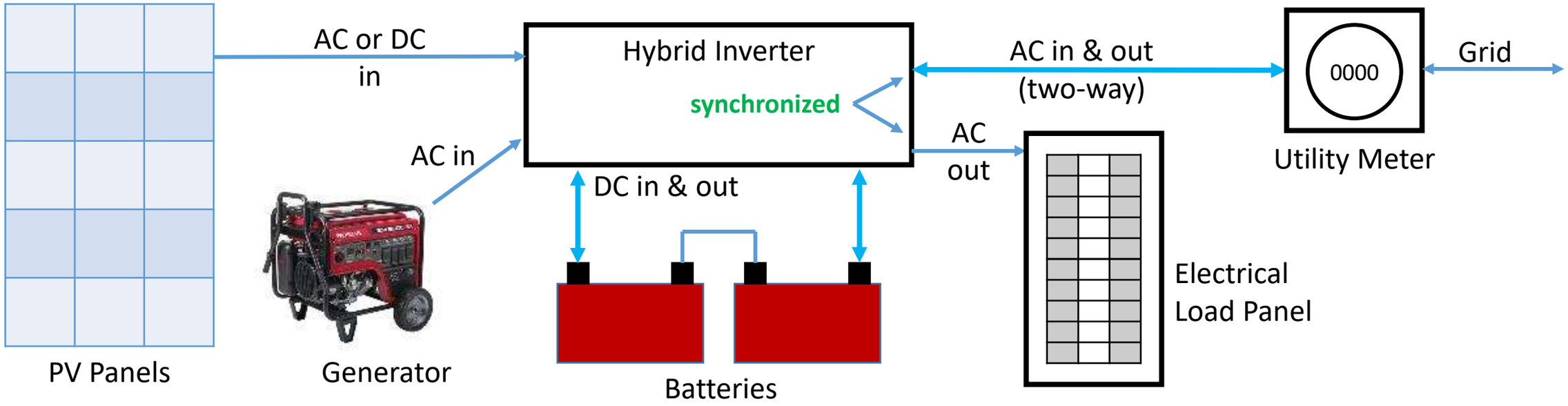
Do batteries make a PV system work better?

Batteries enable substantial system flexibility when paired with a Hybrid Inverter

With batteries, the grid-tied HYBRID inverter can:

- Withdraw energy from the batteries to operate electrical loads (the lights in your house)
- Store energy from PV panels in the battery
- Recharge the battery when there is more PV energy than electrical loads

This allows grid-tied system to have “off-grid” operation. In fact this is how “off-grid” systems work.



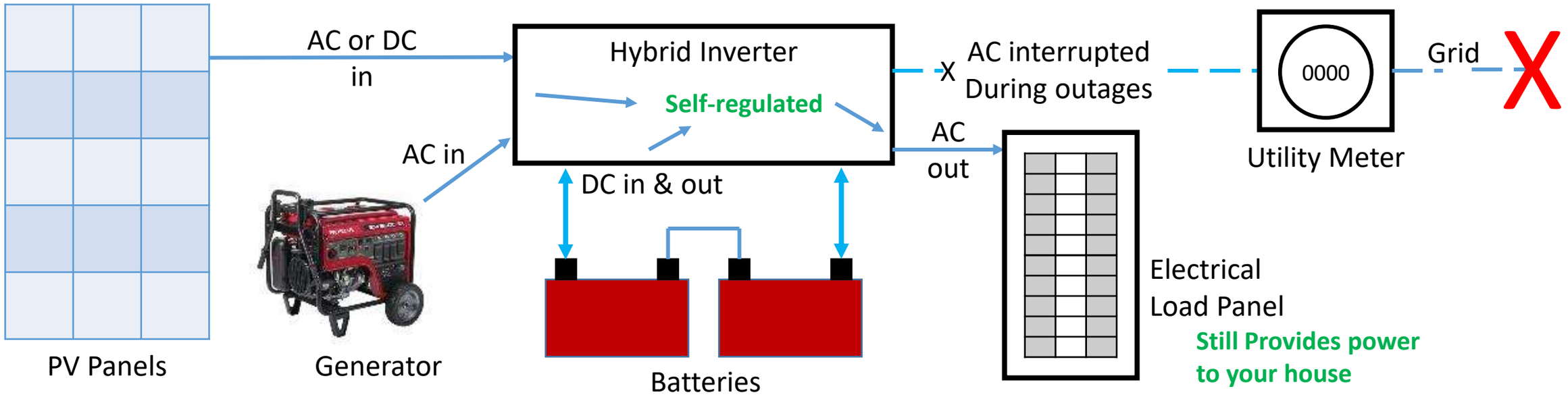
Do batteries make a PV system work better?

Batteries keep your system running when the grid goes out

The battery becomes the “foundation” that the Hybrid inverter can use to regulate its operation.

When the grid goes down, you are essentially in “off-grid” mode:

- Some inverters can automatically transfer – you don’t even notice!
- Some inverters can also run a gasoline/diesel generator and recharge batteries from them
- Most will continue to manage power input from the solar PV panels



Which batteries are better?

There are a wide variety of batteries you can choose.

- Lead-acid
  - Absorbed glass mat
  - Gel
  - Flooded
- Lithium
  - Lithium Ion “Li-on”
  - Lithium Polymer “Li-Po”
- Nickel-Iron, Nickel-Cadmium, Redox Flow, Sodium-Iron, and many more…

There is no single right answer.

- Overnight temperatures in Western Canada can be as low as -35C in the winter:
  - Lead-acid batteries can be used as low as -30C.
  - Most Lithium batteries cannot work below 0C (some work down to -20C with heaters).

- What if the battery is installed in a heated area of your home, kept between 15C and 25C year-round?
  - Lead-acid batteries need to be vented because they release hydrogen gas.
  - Lithium batteries emit no gases.

- Which would you choose? There are **MANY** factors to consider before you make a decision.

How much do batteries cost?

- They are not cheap.
- You get what you pay for.
- Installing them is a significant cost, too.
- So is maintaining them.

Lithium Polymer	Lead-Acid	Powerwall 3	(Priced May 2025, CAD$)
300 – 500 $ / kWhr	300 – 600 $ / kWhr	>1000 $ / kWhr	(before delivery)
10 – 13 kg / kWhr	20 – 30 kg / kWhr	<10 kg / kWhr	(shipping is expensive, too)

Install inside a dwelling:

Code compliance is strict:

- Smoke detectors (all types)
- Fire-rated walls (all types)
- Fire suppression (Lithium)
- Venting (Lead-Acid)
- Many more rules if you have tenants.

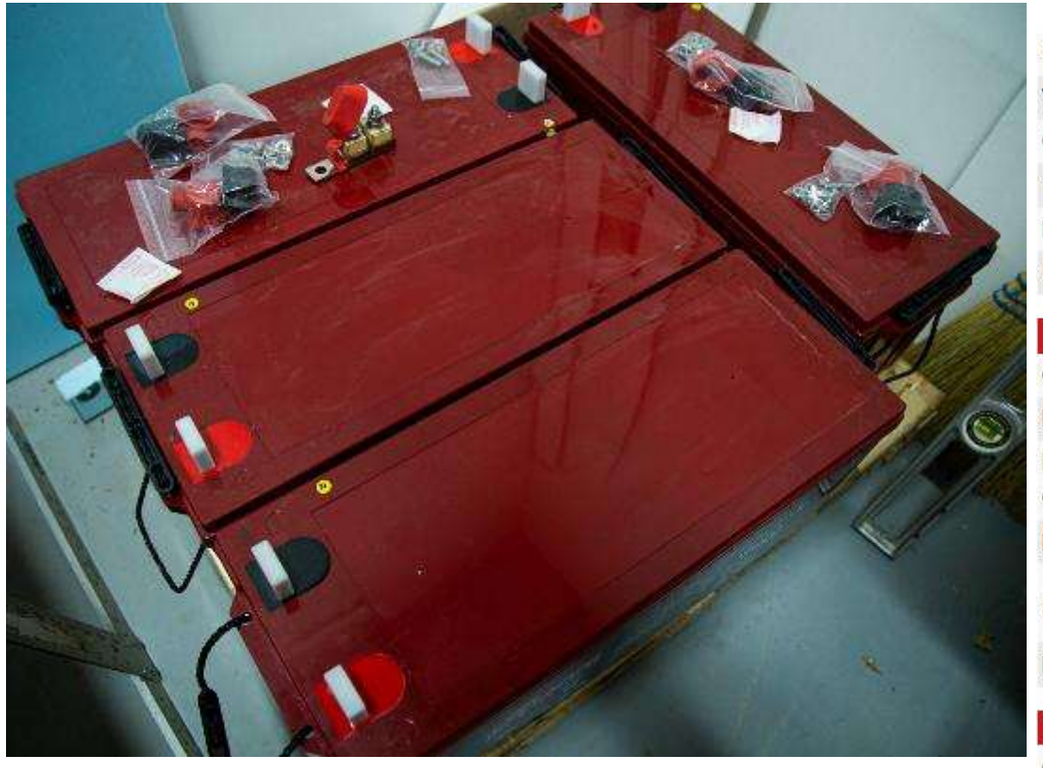
Install outside a dwelling:

Fire code compliance is minimal.

Unheated spaces reduced performance.

Easier to protect against tampering.

Bringing This Together Into My System



Rolls Batteries

Absorbed Glass Mat (long life)

Sealed (no leaks, no refilling)

Made in Canada!

210 Amp-hours @ 12 Volts each

Series	VRLA AGM-S	**Warranty**	See Warranty Terms
Volts	12	**Design**	4D
Cells	6		
Terminal Type	L6		
Included Hardware	M8 stainless bolts, washers & nuts		
Size & Thread	M8		

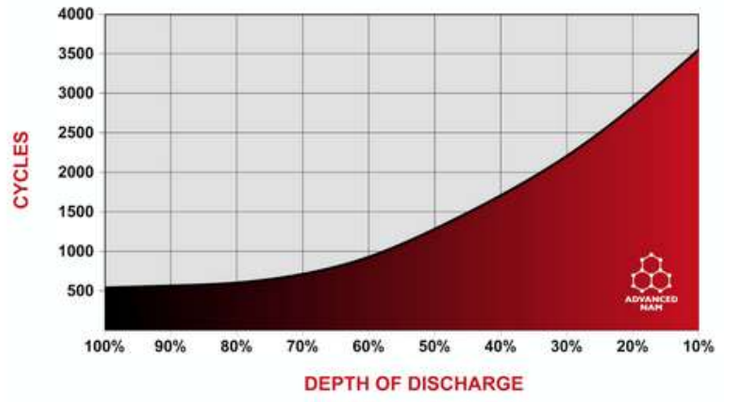
Charge | Discharge	
Charge Voltage Range	14.7V @ 25°C (77°F)
Float Voltage Range	13.8V @ 25°C (77°F)
Recommended Charge Current	40 A
Maximum Charge Current	65 A
Self-Discharge Rate	Less than 2% per month at 25°C (77°F)
Internal Resistance	2.3 mΩ

Capacity	
Cold Crank Amps (CCA) 0°F / -18°C	1200
Marine Crank Amps (MCA) 32°F / 0°C	1425
Reserve Capacity (RC @ 25A)	400 Minutes
Reserve Capacity (RC @ 75A)	105 Minutes

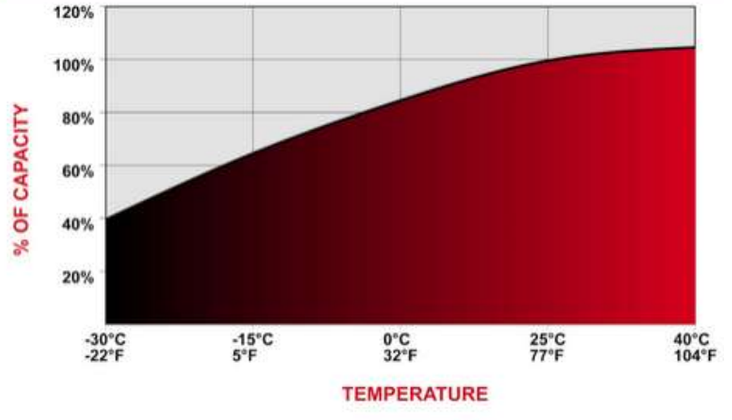
Capacity Affect by Temperature	**40°C (104°F)**	**25°C (77°F)**	**0°C (32°F)**	**-15°C (5°F)**
	102%	100%	85%	65%

Hour Rate	Capacity / AMP Hour	Current / AMPs
@ 100 Hour Rate	230 AH	2.3 A
@ 20 Hour Rate	210 AH	10.5 A
@ 10 Hour Rate	189 AH	18.9 A
@ 5 Hour Rate	172 AH	34.4 A

Cycle Life vs. Depth of Discharge



Capacity vs. Temperature



BATTERY COUNCIL INTERNATIONAL

Designed in compliance with applicable BCI, DIN, BS & IEC standards.
Tested in compliance to BCI & IEC standards.

ISO 45001 CERTIFIED · ISO 14001 CERTIFIED · ISO 9001 CERTIFIED

Rev.#5 | August 202

Bringing This Together Into My System

- Sol-Ark 12k is a Hybrid Inverter
- Lead-Acid AGM
  - 48 Volts x 210 Amp-hours
  - 10.1 kWhr nominal capacity at 25 degrees C
    - Allowable depth of discharge is 70%, therefore I should only use 7 kWhr except in emergencies
    - Capacity at -15 degrees C is 65%, therefore they hold 6.5 kWhr in the winter
    - Rated capacity down to -30 degrees C
    - They are installed in the garage

Woulda been cheaper…
…to get micro-inverters, but that does not reach my goal.

No space in the house for batteries

- My average daily consumption in the summer is about 7 kWhr ⟶ 24 hours of charge
- My average daily consumption in the winter is about 20 kWhr ⟶ 8 hours of charge

(If we limit our consumption during a grid outage, the battery will last much longer)

Bringing This Together Into My System

September 25, Batteries arrived

October 30, Battery installation finished

November 1, Batteries commissioned

November 1-7, Batteries charged by Sol-Ark

November 8-today, Wind Power input testing

November 22-23? Off-Grid test (simulated)

Bringing This Together Into My System

- Batteries need at least a trickle of current from the Inverter to maintain themselves at 100% charge.
  - No battery (Not Lithium, Not Lead, Not any kind known to the human species) maintains its charge alone.)

Example: My battery bank's capacity is 210 Amp-hours

210 / 400 = 0.5 Amps trickle charge

0.5 A * 58 V = 29 Watts to maintain battery at 100% charge

Inverter's built-in battery charger is 50% efficient

29 Watts / 50% = 60 Watts ← constant recharge drain (equal to a common light bulb)

60 Watts * 24 hours = 1.5 kWhr per day

1.5 kWhr * 365 days = 526 kWhr per year

526 kWhr * 30 cents = 158 dollars per year!

Were you with me…
…up until the moment you saw that?

About 25% is supplied by PV, thus 119 dollars per year to maintain the battery charge.

Bringing This Together Into My System

- I have approximately 10 grid outages per year. Sometimes several per month.
  - How often does the grid go out at <u>your</u> house?
- Here's an alternative to Solar & Battery:
  - Purchase price 2,600 $CAD

(less than batteries)

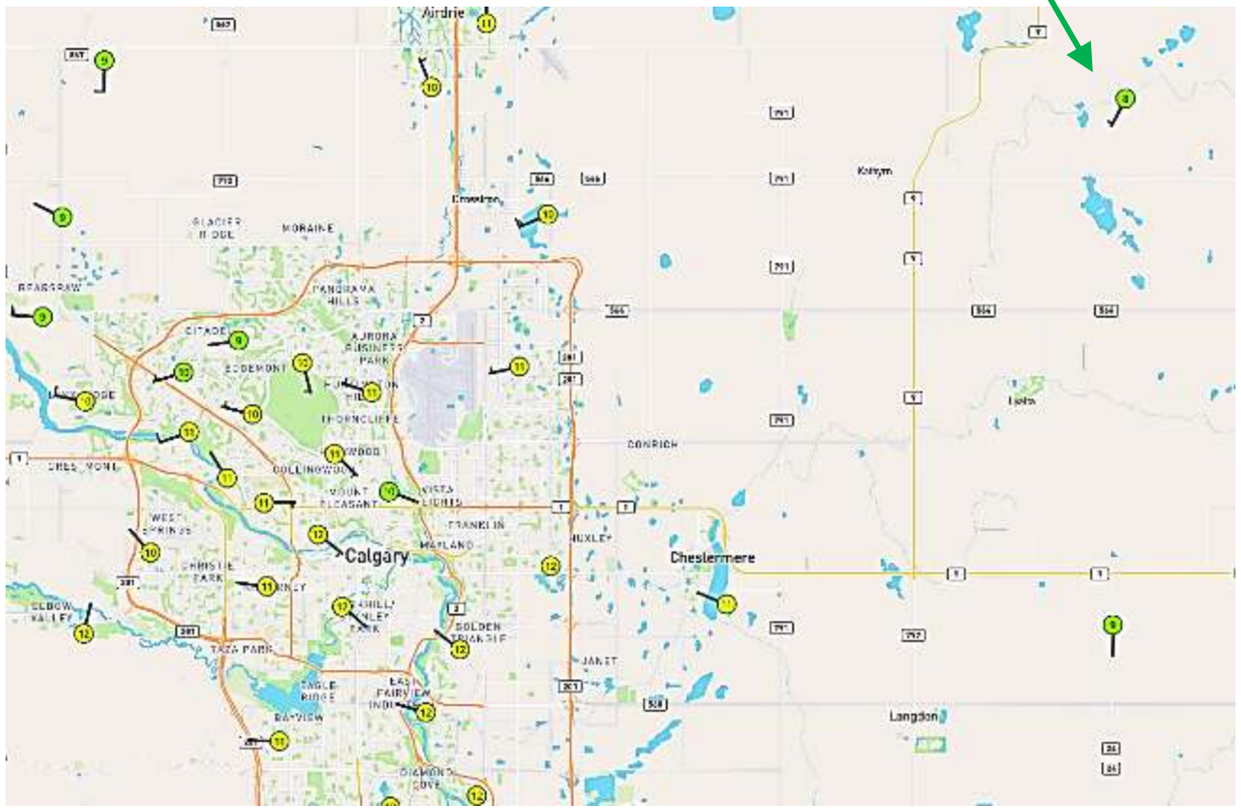
32 hours of run time per year
4 liters per hour
1.6 dollars per liter

→ 32 * 4 * 1.6 = 205 dollars per year

(more than batteries, and don't forget oil)

10 hours run time on a tank (no better than batteries)

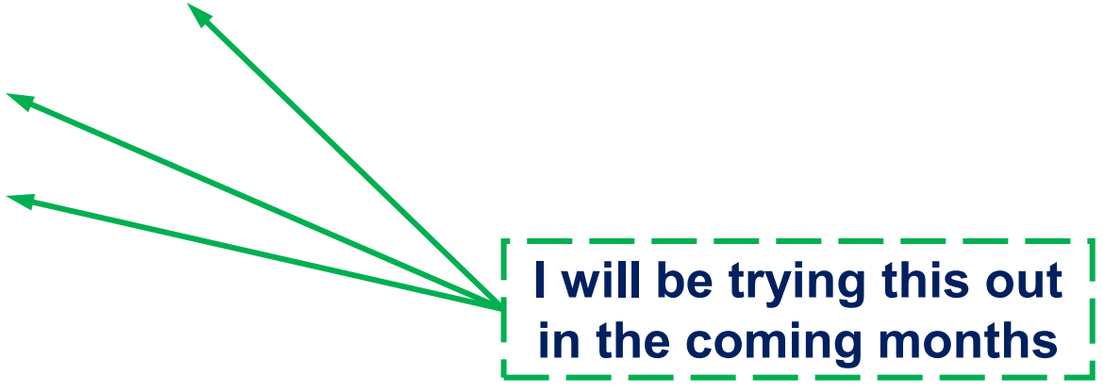
→ 3 refills, each require a trip into town, in my truck.



Compare:	Batteries	Generator
Noise	0 dB	65 dB(A)
CO_2 (per year)	0 kg	310 kg

Bringing This Together Into My System

- **Now that my system has batteries, new options are possible:**
  - Storing energy from wind as my backup supply
  - Riding through extended grid outages
  - Exporting energy from wind to the grid



- **Future possibilities:**
  - Using wind energy to power AC loads
  - Shifting my consumption from grid at peak rate times (if Alberta starts time-of-use billing)
  - I don’t know yet if having batteries will affect the way to add EV charging in the future
    - But I’m going to find out!

QUESTIONS?

I’m never finished…

- Soon integrating wind into the system
  (the battery helps with this too)