SOLAR AND STORAGE

7.5 kW solar grid tied PV system / Tesla Powerwall 2

Second Edition

CONTENTS

- Who am I ?
- Motivations
- Goals
- Solar
- Tesla Powerwall 2
  - General Info
  - My (custom) Powerwall 2 Installation
- Monitoring and stats
- Dollars and Cents
- Benefits from Powerwall
- Challenges/surprises/unknowns
- Sustainability and potential future of Powerwall 2
- Looking ahead:
  - Global
  - Personal

WHO AM I ?

- Retired IT professional (primarily on Infrastructure/Administration side)
- Not an energy expert; just a homeowner and energy consumer with an interest in renewable technology and sustainability.
- The focus on my presentation is how I approached energy consumption, wanting to be as sustainable as possible. Your focus may be different.
- I consider myself an early adopter.

ORIGINAL MOTIVATIONS FOR SOLAR AND STORAGE

- Interested in renewable/sustainable technology that “pushes the envelope”
- Lifestyle/philosophy
  - Try to focus on sustainability
  - Concern for future generations (have children)
  - Something I can do
  - Fortunate to be in position to make financial choices
- Like semi-independence provided by self-generation/self consumption of electricity
- Future-proof some costs
- home improvement/equity
- Availability of Alberta Government Rebates (circa 2017)
- Availability of second-generation Powerwall
  - 13.5 kWh energy storage vs 6.4 kWh for Gen 1

ORIGINAL GOALS

- Minimize electricity consumption from primarily (at the time) coal/natural gas fired grid
- Have a backup in case of a grid outage
- generate and consume electricity produced in a renewable and sustainable format
  - support small local electricity retailer (BowValley Power)
    - 1.66 cent/kWh premium to use “Green” power (wind farms etc.)
  - maximize size of solar PV system, including installation on east/west facing part of roof and the garage (which has some shading)
  - maximize self-consumption
  - Use a sustainable PV module manufacturer

SOLAR

- 25 x Hanwha q.Peak-G4.1 300 watt monocrystalline modules = 7.5 kW
- 25 x SolarEdge P400 Power Optimizers in 2 “strings” (11 and 14)
- SolarEdge single phase inverter SE6000A-US (6.0 kW max)
- Solar PV systems have been covered numerous times in past Meetups. My focus today, specific to solar, will be on:
  - real-world production relative to solar panel orientation (totals since install in Aug 2017)
  - Newest financial calculations (especially benefit of “Solar Club”)

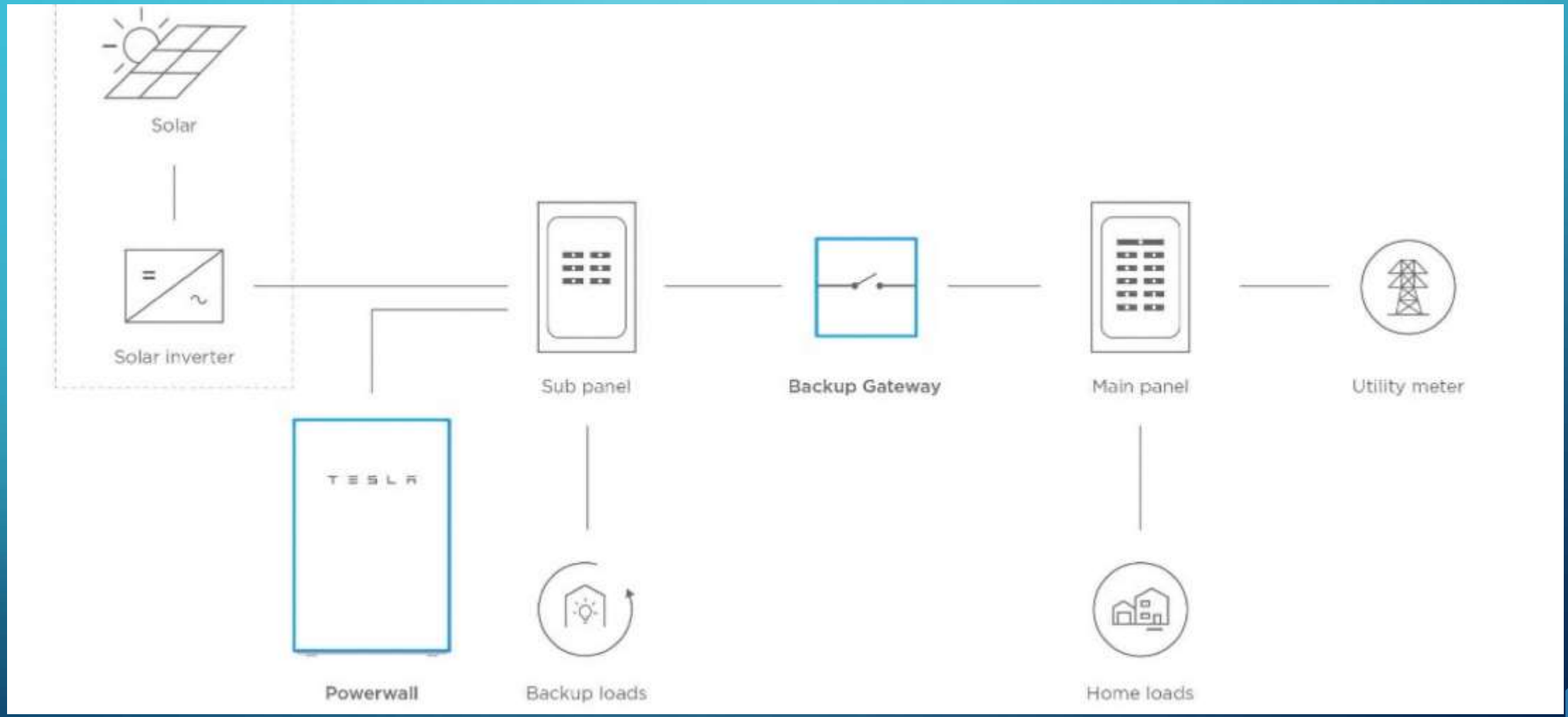
TESLA POWERWALL 2 GENERAL INFO:

- Mitigates the intermittent nature of solar (cloud/snow/night/smoke)
- Benefits from the cost differential between sending electricity to the grid vs receiving it
  - net billing in Calgary vs net metering (details later)
- Increases self-consumption of PV generated electricity, particularly in the evening
- Increase house value? (may still be too early to measure)
- Initial Usable Capacity: 13.5 kWh
  - Can reserve a predetermined amount for backup only (e.g. when no solar or grid)
- Power output (as of 2017 version): 7kW peak / 5kW continuous
- Published efficiency: 90% round-trip
- Warranty: 10 years at 80% capacity (Canada)

MY (CUSTOM) POWERWALL 2 INSTALLATION

- One of the first installs in Alberta
- Total purchase cost (excludes install/labour) = **$ 9,801.35 CAD**
  - Powerwall: $7800 + $573.62 Freight + GST = $ 8,792.30 CAD
  - Tesla Energy Gateway: $961 + GST = $1,009.05 CAD
    - Gateway provides intelligent switch/breaker capability
- Added an electrical subpanel and circuitry (notably the Gateway) to accommodate:
  - Scenario 1: no grid power BUT solar PV production
    - solar PV can still supply critical house loads (lights, Fridge, furnace fan etc.) from this subpanel and/or charge Powerwall
  - Scenario 2: no grid power AND no solar PV production
    - Powerwall can supply critical systems (lights, Fridge, furnace fan etc.) from this subpanel

Power flow via a simplified schematic

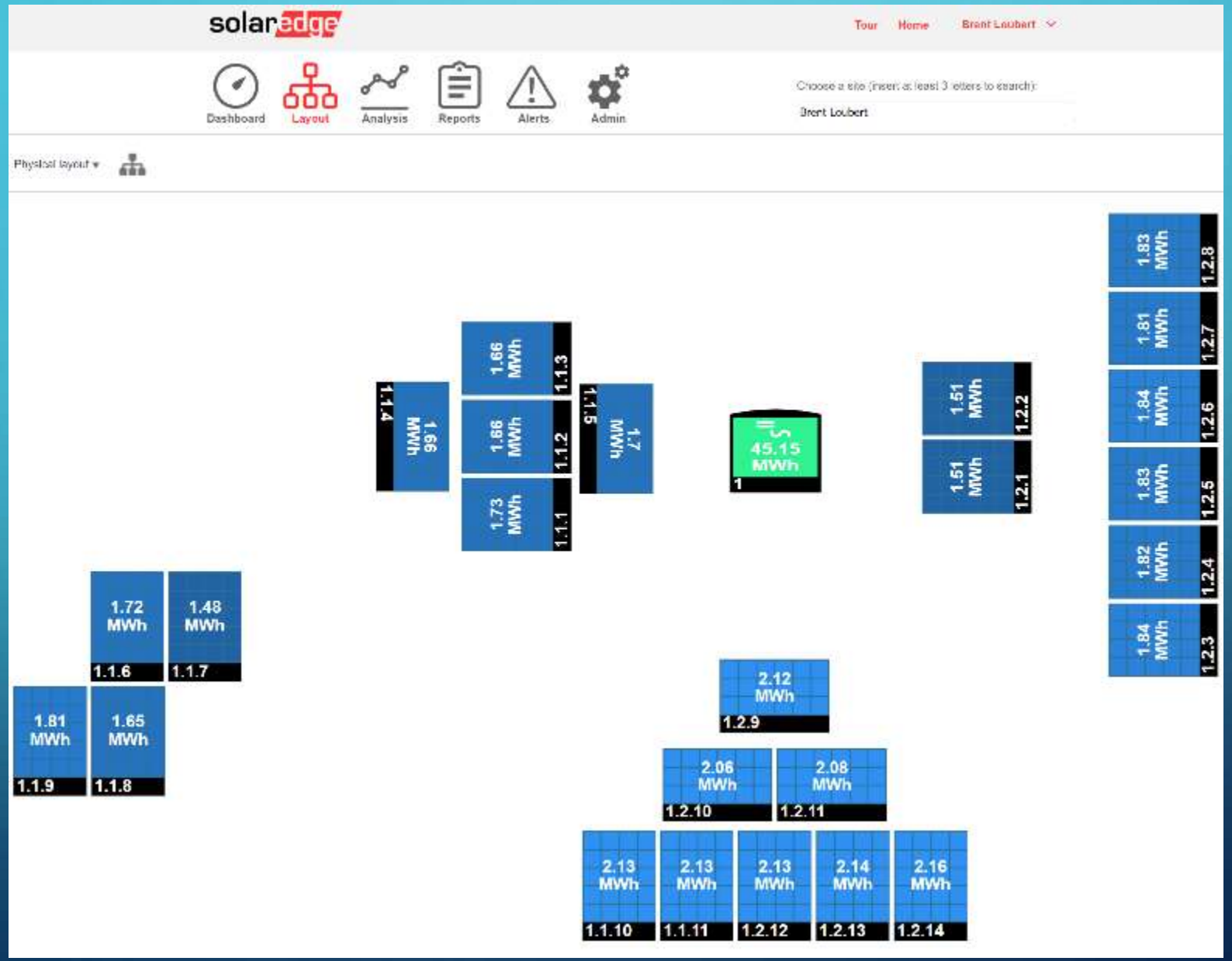



TESLA

Monitoring and stats:

SolarEdge app

Total energy production up to May 1 2023

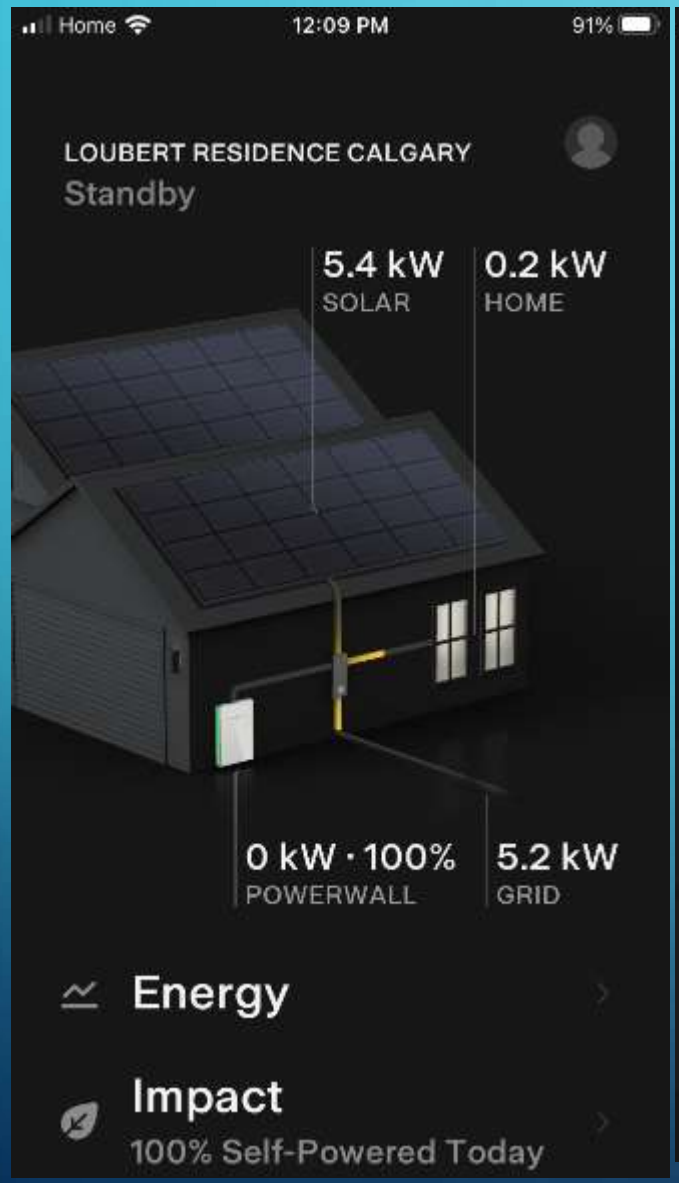


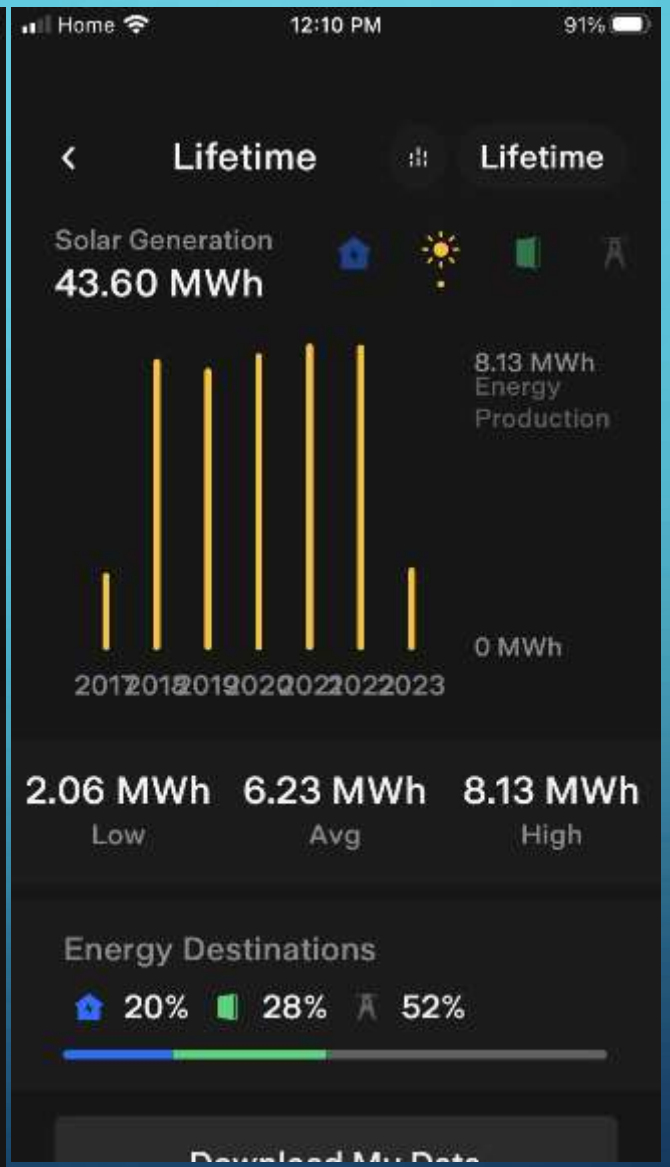
Total energy production relative to orientation

	A	B	C	D	E
1	**Orientation**	**Module**	**Output (MWh)**	**Average for specific orientation (MWh)**	**Percentage relative to south facing**
2	East Roof	1.2.1	1.51		
3	East Roof	1.2.2	1.51		
4	East Roof	1.2.3	1.84		
5	East Roof	1.2.4	1.82		
6	East Roof	1.2.5	1.83		
7	East Roof	1.2.6	1.84		
8	East Roof	1.2.7	1.81		
9	East Roof	1.2.8	1.83		
10				1.74875	82.54
11	South Roof	1.1.10	2.13		
12	South Roof	1.1.11	2.13		
13	South Roof	1.2.9	2.12		
14	South Roof	1.2.10	2.06		
15	South Roof	1.2.11	2.08		
16	South Roof	1.2.12	2.13		
17	South Roof	1.2.13	2.14		
18	South Roof	1.2.14	2.16		
19				2.11875	100.00
20	West Roof	1.1.1	1.73		
21	West Roof	1.1.2	1.66		
22	West Roof	1.1.3	1.66		
23	West Roof	1.1.4	1.66		
24	West Roof	1.1.5	1.7		
25				1.682	79.39
26	South Garage	1.1.6	1.72		
27	South Garage	1.1.7	1.48		
28	South Garage	1.1.8	1.65		
29	South Garage	1.1.9	1.81		
30				1.665	78.58
31					
32		Total output	46.01		
33					
34					
35					

Total up to May 1 2023

Tesla app


Home
12:09 PM
91%
LOUBERT RESIDENCE CALGARY
Standby
5.4 kW
SOLAR
0.2 kW
HOME
0 kW · 100%
POWERWALL
5.2 kW
GRID
Energy
Impact
100% Self-Powered Today


Home
12:10 PM
91%
Lifetime
Lifetime
Solar Generation
43.60 MWh
8.13 MWh
Energy
Production
0 MWh
2017 2018 2019 2020 2021 2022 2023
2.06 MWh
Low
6.23 MWh
Avg
8.13 MWh
High
Energy Destinations
20%
28%
52%


Home
12:11 PM
91%
Lifetime
Lifetime
Solar Generation
43.60 MWh
8.13 MWh
Energy
Production
Timescale
Today
Day
Week
Month
Year
Lifetime

Home 12:18 PM 89%

Powerwall

Backup Reserve

Reserve Energy for Grid Outages

20% Backup | 80% Self-Powered

Recommended

Operational Mode

Self-Powered

Use stored energy to power your home after the sun goes down. Reduces your reliance on the grid.

Time-Based Control

Home 12:19 PM 89%

Storm Watch

Storm Watch

Automatically protect your home against severe weather events which may cause outages. Tesla uses your home address to identify these events. When Storm Watch activates, Powerwall will charge to maximum capacity for additional backup protection.

Home 12:19 PM 89%

Powerwall

Time-Based Control

Use stored energy to maximize savings based on your utility rate plan. Gives you the lowest energy bill.

Utility Rate Plan
Flat (edited)

ADVANCED OPTIONS

Grid Charging

No | Yes

Enable this when you're allowed to grid charge. Powerwall will use the grid to charge to your backup reserve and for daily use in Time-

High level summary from Tesla app

Total solar energy generation since Aug 2017 of **43.61 MWh**

Three potential destinations for this energy (could be a mixture at any given time), sorted by priority:

1)	Directly To house	~20% ~= 8.72 MWh
2)	To Powerwall	~28% ~= 12.21 MWh
3)	To grid*	~52% ~= 22.67 MWh

Total home energy consumption since Aug 2017 of **28.35 MWh**

Three potential sources of this energy (could be a mixture at any given time), sorted by priority:

1)	From solar	~31% ~= 8.79 MWh
2)	from Powerwall	~36% ~= 10.21 MWh
3)	from grid*	~33% ~= 9.36 MWh

* **Net export to grid** = 22.67 MWh - 9.36 MWh ~= **13.31 MWh**

- so ~ 13.31 / 43.61 ~= **30.52 % of total solar generation**

EFFICIENCIES

SOLAREDGE INVERTER

Total output from SolarEdge app (46.1 MWh) versus from Tesla app 43.61 MWh
= **94.6 %** (~ 5 % loss via inverter)

POWERWALL ROUND TRIP EFFICIENCY:

- 2018 2.37 MWh / 2.69 MWh = 88.1 %
- 2019 1.87 MWh / 2.17 MWh = 86.2 %
- 2020 1.60 MWh / 1.81 MWh = 88.4 %
- 2021 1.97 MWh / 2.19 MWh = 89.9 %
- 2022 1.84 MWh / 2.03 MWh = 90.6 %

5 Year Average = 88.6 %

DOLLARS AND CENTS

Notes:

- There are other benefits besides a strictly financial analysis
- My timeframe is decades rather than years
- My consumption is much lower than average household even with charging a PHEV
- I had some extra costs unique to my installation:
  - Complex PV install (25 modules over 4 roof surfaces facing east, west and south)
  - New Main panel (200 Amp bus) and Subpanel (100 Amp bus)
  - Extra circuitry to allow Solar / Powerwall to supply some of house from subpanel if no PV and/or grid

TCO

Install costs:

- Powerwall/Gateway hardware purchase $9,801.35

- Balance of labour and materials $27,913.27

  (no breakout specific to PV modules or Powerwall)

- Cost before rebate $37,714.62
- Alberta Government Rebate ($.75 x 7500 Watts) $5,625.00

- Final cost* **$32,089.62**

Anticipate 20 year life of Powerwall and 30 year life of PV panels and component recycling will be in place by that time. That cost is unknown at this point

* Added Rodent guard in April 2021 (details later) $2,294.25

ROI ESTIMATES UP TO MAY 1 2023

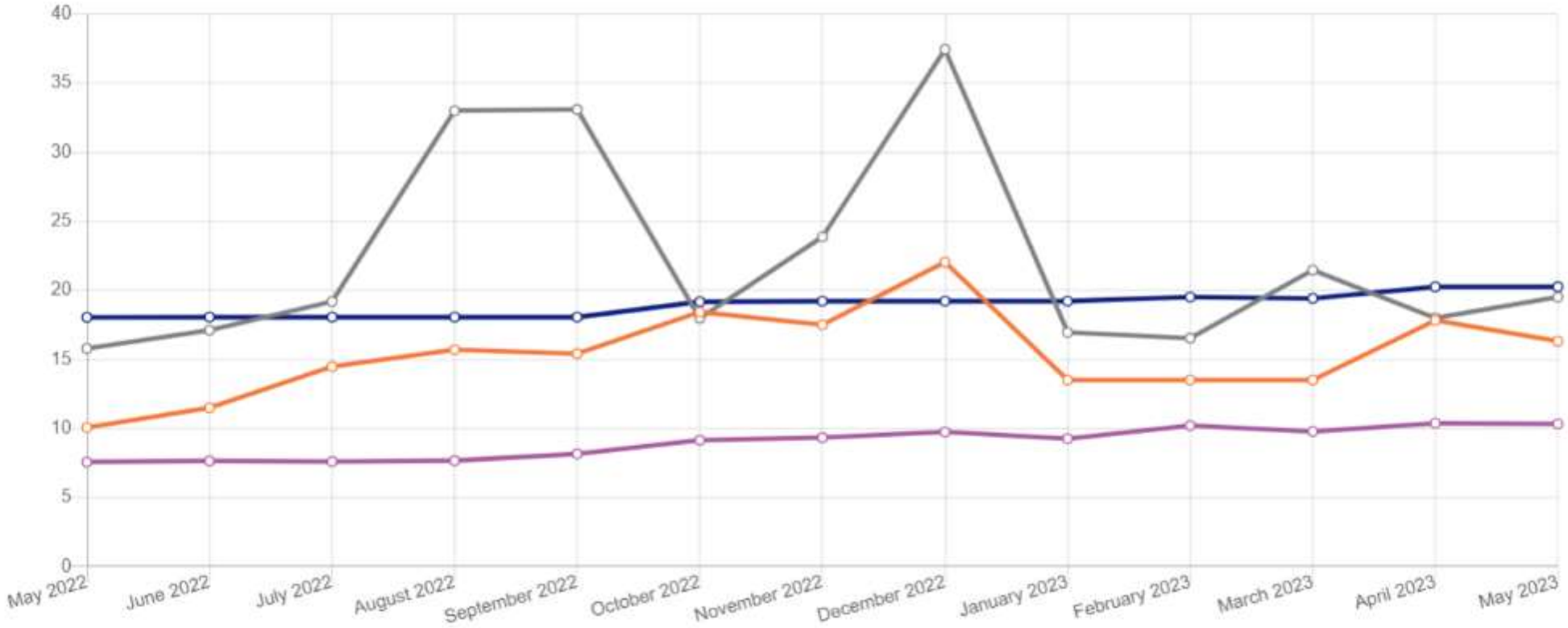
(OR "GETTING INTO THE WEEDS/GOING DOWN THE RABBIT HOLE" ?):

- Scenario comparison:
  - If I did nothing (no solar/Powerwall)
    - using cost of electricity from ENMAX Calgary Regulated Rate Option (RRO) historical monthly rates since August 2017
  - financial benefit (avoided cost) of Solar/Powerwall compared to RRO
  - Additional financial benefit from Solar Club (started in spring 2019)

Regulated Rate	Fixed Rate	Variable Rate	Microgeneration Rate
13-Month Average	13-Month Average	13-Month Average	13-Month Average
15.37¢ / kWh	8.99¢ / kWh	22.3¢ / kWh	18.96¢ / kWh

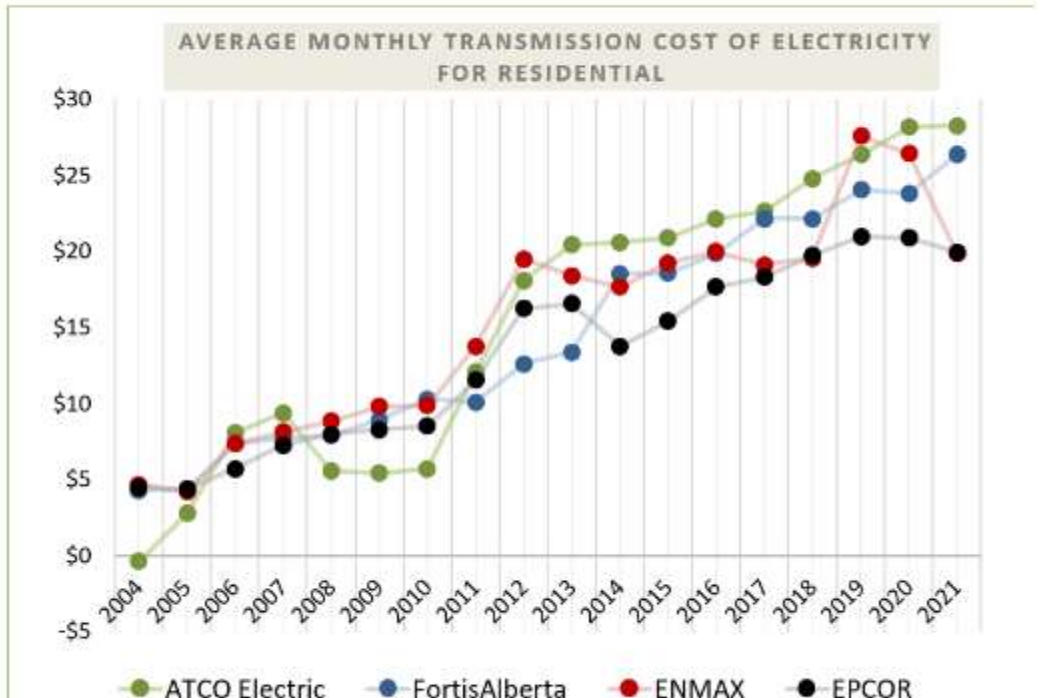
These average rates are intended to show price trends over time. They are not intended to represent specific rates or plans at any given time and don't include delivery charges.

Variable rates in the chart include transaction charges and may not be populated within the first two weeks of the following month.



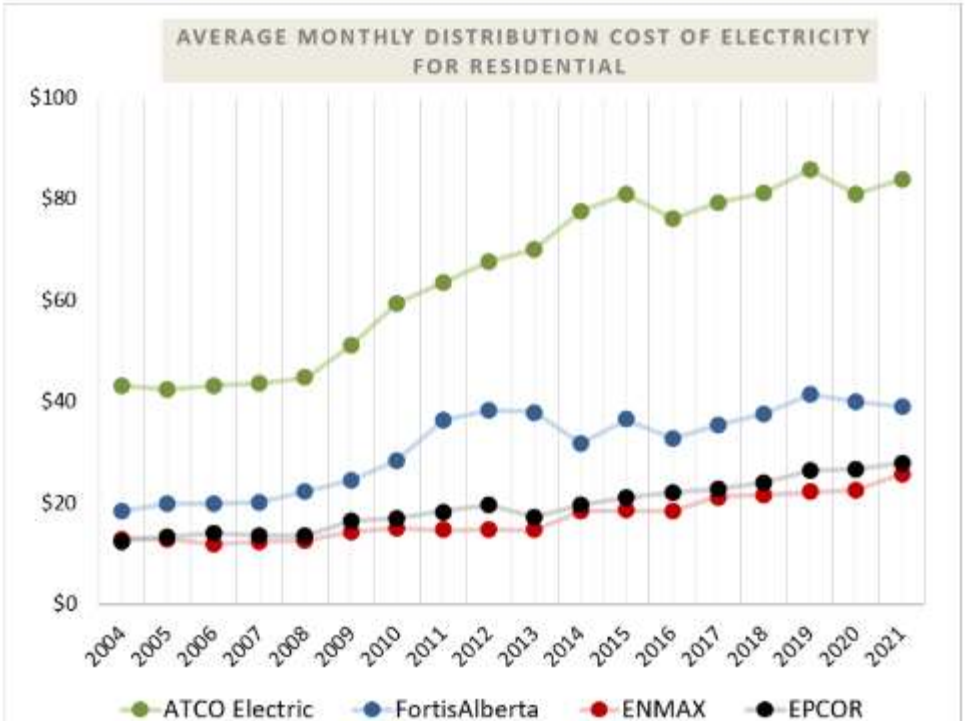
ESTIMATING DISTRIBUTION AND TRANSMISSION COSTS

Figure 1. Average monthly transmission charges for residential RRO customers, by service area, 2004 to 2021



Source: Compiled by the Office of the Utilities Consumer Advocate based on data provided by the Alberta Utilities Commission and Alberta Electric System Operator

Figure 2. Average monthly distribution charges for residential RRO customers, by service area, 2004 to 2021

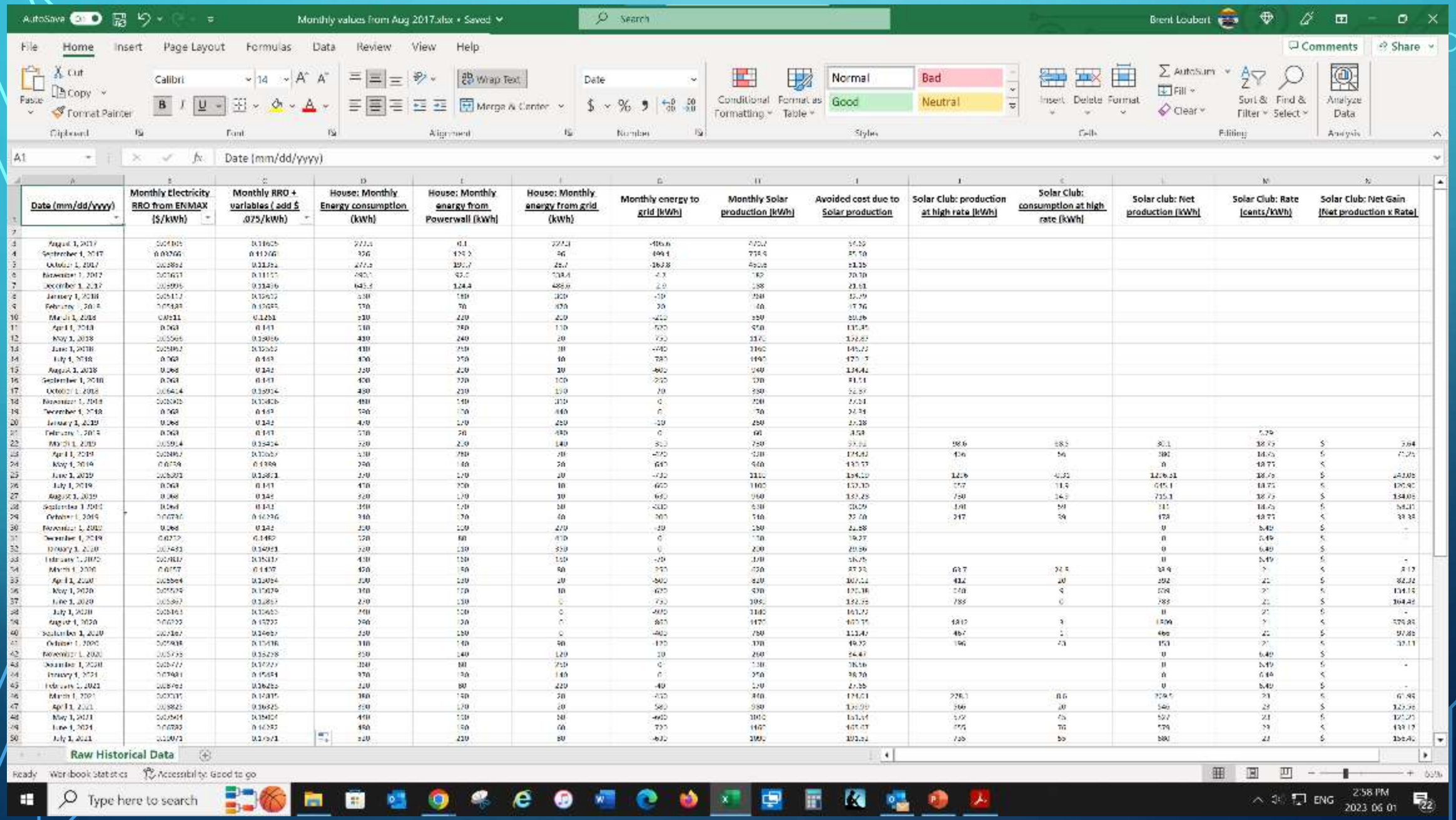


Source: Compiled by the Office of the Utilities Consumer Advocate based on data provided by the Alberta Utilities Commission and Alberta Electric System Operator

Average ENMAX Transmission and Distribution rates over 2017 –2023:

~$24 + $21 ~= $45/month for average house (600 kWh) . So ~ 45/600

~= 7.5 cents/kWh


Monthly values from Aug 2017.xlsx • Saved
Brent Loubert
File Home Insert Page Layout Formulas Data Review View Help
Comments Share
Cut Copy Format Painter Paste
Calibri 14
Wrap Text Merge & Center
Date
Normal Bad Good Neutral
Conditional Formatting Format as Table
Insert Delete Format
AutoSum Fill Clear
Sort & Filter Find & Select
Analyze Data
A1
Date (mm/dd/yyyy)
Date (mm/dd/yyyy)
Monthly Electricity RRO from ENMAX ($/kWh)
Monthly RRO + variables (add $ .075/kWh)
House: Monthly Energy consumption (kWh)
House: Monthly energy from Powerwall (kWh)
House: Monthly energy from grid (kWh)
Monthly energy to grid (kWh)
Monthly Solar production (kWh)
Avoided cost due to Solar production
Solar Club: production at high rate (kWh)
Solar Club: consumption at high rate (kWh)
Solar club: Net production (kWh)
Solar Club: Rate (cents/kWh)
Solar Club: Net Gain (Net production x Rate)
Raw Historical Data
Ready
Workbook Statistics
Accessibility: Good to go
Type here to search
ENG
2:58 PM
2023 06 01

COST SAVINGS FROM SOLAR PRODUCTION*:

Month	Monthly Electricity RRO from ENMAX ($/kWh)	Monthly RRO + variables (add $ .075/kWh)	Monthly Solar production (kWh)	Avoided cost due to Solar production		
November 1, 2021	0.10669	0.18169	330.00	$ 59.96		
December 1, 2021	0.11972	0.19472	80.00	$ 15.58	$ 1,349.37	2021 total
January 1, 2022	0.15876	0.23376	240.00	$ 56.10		
February 1, 2022	0.1652	0.2402	240.00	$ 57.65		
March 1, 2022	0.1058	0.1808	720.00	$ 130.18		
April 1, 2022	0.10316	0.17816	880.00	$ 156.78		
May 1, 2022	0.09971	0.17471	1080.00	$ 188.69		
June 1, 2022	0.1184	0.1934	1020.00	$ 197.27		
July 1, 2022	0.14777	0.22277	1150.00	$ 256.19		
August 1, 2022	0.17341	0.24841	1050.00	$ 260.83		
September 1, 2022	0.15699	0.23199	830.00	$ 192.55		
October 1, 2022	0.18031	0.25531	560.00	$ 142.97		
November 1, 2022	0.18245	0.25745	230.00	$ 59.21		
December 1, 2022	0.22133	0.29633	130.00	$ 38.52	$ 1,736.94	2022 total
January 1, 2023	0.135	0.21	262.80	$ 55.19		
February 1, 2023	0.135	0.21	294.40	$ 61.82		
March 1, 2023	0.135	0.21	642.10	$ 134.84		
April 1, 2023	0.17662	0.25162	984.10	$ 247.62		
May 1, 2023	0.16007	0.23507		$ -		
Totals			43573.60	$ 6,992.75		

Value of solar from Aug 2017 – April 2023 = **$6992.75**

~ $1500 / year average

*Solar production data is from the Gateway view where inverter conversion losses are already factored in

ADDITIONAL VALUE OF SOLAR CLUB

Month	Solar Club: production at high rate (kWh)	Solar Club: consumption at high rate (kWh)	Solar club: Net production (kWh)	Solar Club: Rate (cents/kWh)	Monthly Electricity RRO from ENMAX ($/kWh)	Solar Club rate less RRO rate	Solar Club: Net Gain (Net production x Rate)			
February 1, 2021			0	6.49	0.08763		$ -			
March 1, 2021	278.1	8.6	269.5	23	0.07335	0.15665	$ 42.22			
April 1, 2021	566	20	546	23	0.08825	0.14175	$ 77.40			
May 1, 2021	572	45	527	23	0.07504	0.15496	$ 81.66			
June 1, 2021	655	76	579	23	0.06782	0.16218	$ 93.90			
July 1, 2021	735	55	680	23	0.10071	0.12929	$ 87.92			
August 1, 2021	478	63	415	23	0.12024	0.10976	$ 45.55			
September 1, 2021	564	76	488	23	0.10518	0.12482	$ 60.91			
October 1, 2021	171.4	103.4	68	23	0.10384	0.12616	$ 8.58			
November 1, 2021			0	6.49	0.10669		$ -			
December 1, 2021			0	6.49	0.11972		$ -	$	498.14	2021 total
January 1, 2022			0	6.49	0.15876		$ -			
February 1, 2022			0	6.49	0.1652		$ -			
March 1, 2022	24.3	16.3	8	25.85	0.1058	0.15270	$ 1.22			
April 1, 2022	338.4	35	303.4	25.85	0.10316	0.15534	$ 47.13			
May 1, 2022	513	84	429	25.85	0.09971	0.15879	$ 68.12			
June 1, 2022	575	26	549	25.85	0.1184	0.14010	$ 76.91			
July 1, 2022	936	9	927	25.85	0.14777	0.11073	$ 102.65			
August 1, 2022	733	11	722	25.85	0.17341	0.08509	$ 61.43			
September 1, 2022	556	9	547	25.85	0.15699	0.10151	$ 55.53			
October 1, 2022	438	44	394	25.85	0.18031	0.07819	$ 30.81			
November 1, 2022			0	6.49	0.18245		$ -			
December 1, 2022			0	6.49	0.22133		$ -	$	443.80	2022 total
January 1, 2023			0	6.49	0.135		$ -			
February 1, 2023			0	6.49	0.135		$ -			
March 1, 2023	6	4.5	1.5	28.5	0.135	0.15000	$ 0.23			
April 1, 2023	644	1	643	28.5	0.17662	0.10838	$ 69.69			
May 1, 2023			0		0.16007		$ -			
Totals							$ 2,087.45			

Net benefit from Solar Club (spring 2019 – April 2023) = $2087.45

~ $500 / year average

GUESTIMATED RETURN ON INVESTMENT AFTER ~ 5 ¾ YEARS*

Value of solar from Aug 2017 – April 2023 =	$6992.75
Net benefit from Solar Club (spring 2019 – April 2023) =	$2087.45

Total:	**$9,080.20**

Value of solar / initial investment + rodent guard

= $9,080.20/ $32,089.62 + $2,294.25

= $9,080.20/ $34,383.87

= 26.4 % *

*Coming into large production months May-Sept 2023 with anticipated additional $2,000 by end of 6th year. Adding anticipated value of summer production of $2,000 will mean ($9080.2 + ~$2000) / cost ~= $11,080.2 / $34,383.87 ~= **32.2 % after 6 years**

ACTUAL ELECTRIC COST SINCE SYSTEM INSTALL

Electric bills from Aug 2017 – April 2023 (screen shows ~ last two years) Note the highlighted amounts are credits

Date (mm/dd/yyyy)	Electric bill from BowValley Power - Amount due	Rebate from BowValley Power		
January 1, 2021	$ 43.34			
February 1, 2021	$ 66.28			
March 1, 2021	$ 70.98			
April 1, 2021	$ -			
May 1, 2021	$ -			
June 1, 2021	$ -			
July 1, 2021	$ -			
August 1, 2021	$ -	$ 344.80		
September 1, 2021	$ -			
October 1, 2021	$ -			
November 1, 2021	$ -			
December 1, 2021	$ -	$ 255.35	-$ 419.55	2021 total
January 1, 2022	$ 84.84			
February 1, 2022	$ 128.98			
March 1, 2022	$ 52.38			
April 1, 2022	$ 35.91			
May 1, 2022	$ -			
June 1, 2022	$ -			
July 1, 2022	$ -			
August 1, 2022	$ -			
September 1, 2022	$ -	$ 546.50		
October 1, 2022	$ -			
November 1, 2022	$ -	$ 386.31		
December 1, 2022	$ -		-$ 630.70	2022 total
January 1, 2023	$ -			
February 1, 2023	$ -			
March 1, 2023	$ -			
April 1, 2023	$ -			
May 1, 2023	$ -	$ 295.44		
	$ 1,477.93	$ 2,915.48	-$ 1,437.55	Total bills - total rebates

Total credit = $1437.55 and ~ $500 / year credit over the last two years

FINANCIAL BENEFIT ESTIMATE OF POWERWALL ONLY:

How much of the cost savings is directly attributable to the Powerwall?

Small benefit from **Net billing** in Calgary (vs **net metering** where there is no benefit):

- **Net billing** tracks energy export separately from import. **Net metering only** tracks the cumulative amount.
- Powerwall benefit is from cost differential between importing energy from the grid (energy rate **plus variable costs,** previously calculated at ~ 7.5 cents/kWh) vs exporting energy to the grid (**only** energy rate).

  eg importing 1 kWh vs exporting it costs an additional 7.5 cents
- Powerwall will avoid this differential by storing some excess solar generation for self-consumption versus exporting this excess only to import it back later when house needs it (ie when no solar production)

NET POWERWALL VALUE

Date (mm/dd/yyyy)	House: Monthly energy received from Powerwall (kWh)	Savings on differential (7.5 cents x monthly kWh from Powerwall)	
January 1, 2021	130	$ 9.75	
February 1, 2021	80	$ 6.00	
March 1, 2021	190	$ 14.25	
April 1, 2021	170	$ 12.75	
May 1, 2021	190	$ 14.25	
June 1, 2021	190	$ 14.25	
July 1, 2021	210	$ 15.75	
August 1, 2021	160	$ 12.00	
September 1, 2021	170	$ 12.75	
October 1, 2021	260	$ 19.50	
November 1, 2021	180	$ 13.50	
December 1, 2021	30	$ 2.25	$ 147.00
January 1, 2022	130	$ 9.75	
February 1, 2022	110	$ 8.25	
March 1, 2022	220	$ 16.50	
April 1, 2022	200	$ 15.00	
May 1, 2022	240	$ 18.00	
June 1, 2022	140	$ 10.50	
July 1, 2022	150	$ 11.25	
August 1, 2022	140	$ 10.50	
September 1, 2022	170	$ 12.75	
October 1, 2022	140	$ 10.50	
November 1, 2022	130	$ 9.75	
December 1, 2022	70	$ 5.25	$ 138.00
January 1, 2023	151.9	$ 11.39	
February 1, 2023	131.2	$ 9.84	
March 1, 2023	138.1	$ 10.36	
April 1, 2023	153.3	$ 11.50	
May 1, 2023		$ -	
		$ -	
Totals	10740.50	$ 805.54	

Net Powerwall value = Savings on differential

= $805.54

Financial only benefit conclusion for Powerwall:

Powerwall 2 battery storage currently has only a small financial benefit from a raw cost analysis. As of May 1, 2023 (after 5 ¾ years), it represents:

$805.54/total financial return = $ 805.54/$9,080.20 ~ = 8.9 % of my total financial return

and

$ 805.53 / Powerwall cost = $ 805.54 / $9,801.35 ~= 8.2 % ROI on Powerwall cost

May not be appealing for anyone who is only looking at ROI:

- Minimum financial return if only viewing Powerwall as a financial investment instrument
- Could be considered a low risk/low return investment

BENEFITS FROM POWERWALL NOT INCLUDED IN PREVIOUS CALCULATIONS:

- Self-consumption in evening from solar generation during day
  - Reduce load on grid in the evening.
- Future-proofing some of the cost of electricity
- Increased equity in house (home improvement)
- Electricity backup capabilities with no intervention or maintenance
  - No outage if grid goes down (automatic cut-over)
  - Storage of solar generation can still occur when grid is down because of anti-islanding feature (Gateway)
  - No need for gas/diesel generator or other (typically manual) backup systems
- More sustainable than Solar alone when adding a PHEV/EV
  - Can charge PHEV/EV in the evening from electricity generated from solar
- As more people add storage, this may:
  - Defer/eliminate need for costly grid upgrades / Peaker plants
  - Potential to participate in future Virtual Power Plants (VPP)

CHALLENGES/SURPRISES/UNKNOWNS

1) Solar:

- Insurance:
  - Structural Engineer report ~ $500 (required by my insurance company). Not included in initial estimate because not required by all insurance companies
  - Some insurance companies may increase rates
- Pigeons
  - They like the protection from predators and may try to nest under the panels
  - Get rodent guard and make sure it is done properly
- Snow

SNOW

- A five-year study led by the Northern Alberta Institute of Technology's (NAIT) Alternative Energy Technology program found that the impact of snowfall on solar energy production is much less than previously estimated. Until now, the industry estimated photovoltaic solar panels lose about 20 per cent of their energy because of snow buildup in winter. However, the NAIT study found the energy loss to be only about three per cent [1][2][3].

- The study also found that the angle of the solar panels has a far greater impact on energy production than snowfall. The ideal angle for maximum energy production with snow accumulation was 45 degrees [2][3].

- Source: Conversation with Bing, 2023-06-12 (1) Edmonton study shows snow only mildly affects solar panel productivity .... https://www.thestar.com/edmonton/2018/07/22/edmonton-study-shows-snow-only-mildly-affects-solar-panel-productivity.html Accessed 2023-06-12.
- (2) Solar panels shine despite winter's blast, NAIT study finds. https://www.nait.ca/nait/about/newsroom/2018/solar-panels-shine-despite-winters-blast-nait-st Accessed 2023-06-12.
- (3) Solar panels shine despite winter's blast, NAIT study finds. https://www.nait.ca/applied-research/about/news-media/solar-panels-shine-despite-winters-blast-nait-st Accessed 2023-06-12.
- (4) Nait Solar Array - Orizon Energy. https://orizonenergy.ca/nait-solar-array/ Accessed 2023-06-12.
- (5) FACT SHEET: Solar Panels in Winter?. https://www.3ne.ca/wp-content/uploads/2020/11/Solar-Panels-in-Winter-Fact-Sheet-3NE-e.pdf Accessed 2023-06-12.

The bane of Solar (and garage sales) in Calgary:

2) Powerwall:

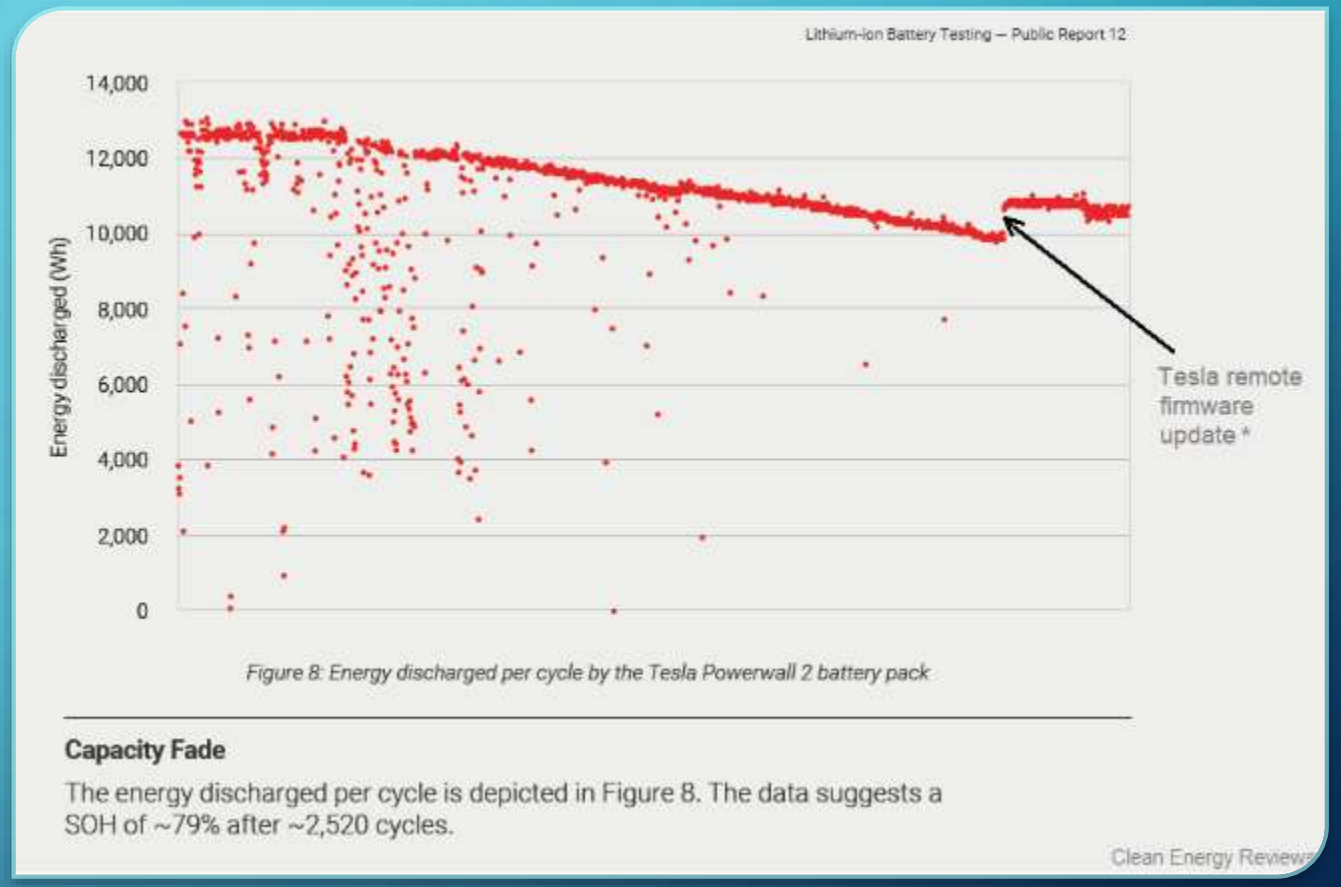
- New Canadian electrical code change Feb 2022:
  - Rule 64-918(1) … prohibits ESSs with a storage capacity greater than 1 kWh or utilizing lithium-ion batteries from being installed in dwelling units.
    - New code has an abundance of caution: Powerwall 2 max power output of 7 kW / storage capacity of 13.5 kWh. Compare to Rear-wheel-drive Model Y max power output of 194 kW / battery storage capacity of ~75 kWh
    - could not find any evidence of a fire caused by a Powerwall 2 (Bing chat)
    - My Powerwall 2 install is grandfathered
- Reduced capacity / degradation of battery (sustainability)

SUSTAINABILITY AND POTENTIAL FUTURE OF POWERWALL 2

- Warranty: 10 years at 80% capacity (Canada) = Minimum of 10.8 kWh after 10 years. Anticipated usability of at least 20 years
- Remote firmware updates so continuous improvements/tweaks
- No maintenance
- EOL recycling: still a new industry but indications are that there is a good business case for recycling battery/components
- Potential participation in VPP's
- TOU coming? If so, charge when rates are low and self-consume when high

DETERMINING CAPACITY DEGRADATION OF TESLA POWERWALL: TWO METHODS

- 1) Inferred: data from Battery test centre Canberra, Australia
  - Under accelerated testing, the Powerwall's degradation rate is **21% after 2,520 cycles** (or 6.9 years at one cycle per day)
  - Note, the test center cycled the battery to a fully discharged state during every cycle, which is not common in a real-world situation



2) Sample data from Tesla app

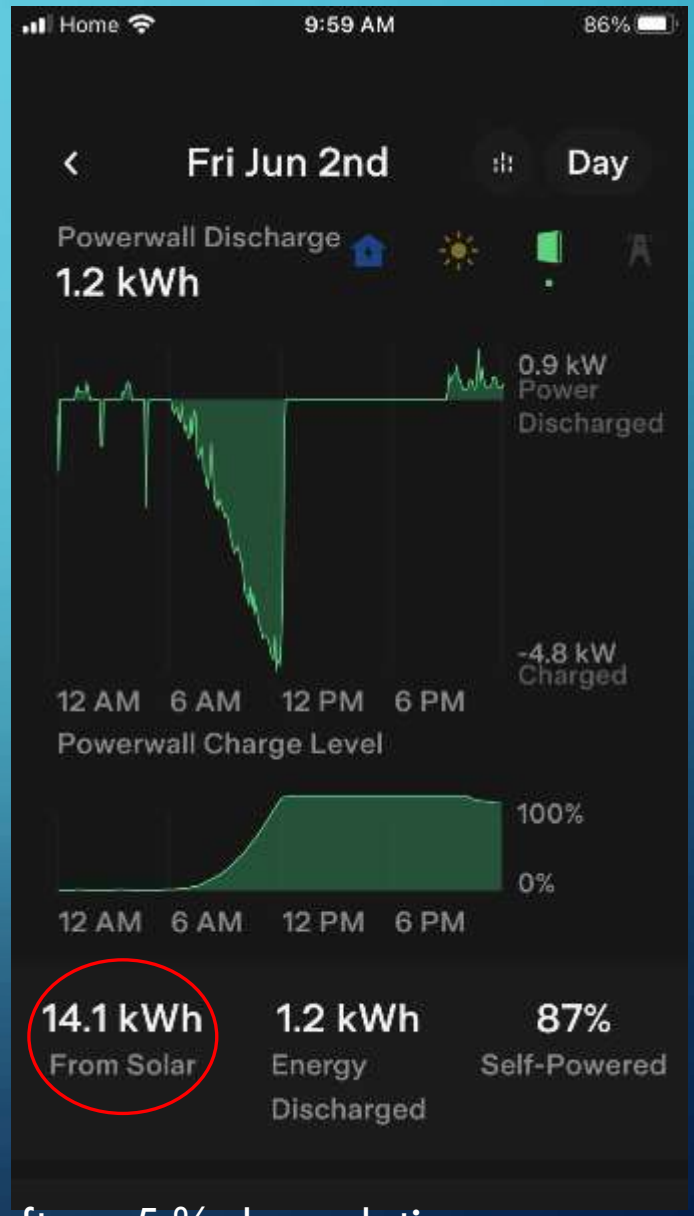
1) INFERRED DEGRADATION CALCULATION

- 1) First need to calculate total energy discharged after 2520 full cycles
  - 21% degradation after 2520 full cycles
  - Average (midpoint) would be 10.5 % degradation (89.5% capacity)
  - take average (midpoint) and multiply by initial available energy capacity of Powerwall
  - ~ 89.5 % * 13.5 kWh ~= 12.1 kWh per full discharge
  - Over 2500 full discharge cycles: 12.1 kWh * 2520 = **30,492 kWh**
- 2) From Tesla app, after ~ 6 years, my Powerwall has discharged **10,210 kWh**

- Therefore , this would represent (10,210 / 30,492) of 21 % ~=
- **7% Degradation**

2) DEGRADATION ESTIMATE OF MY POWERWALL USING TESLA APP DATA

- A sample of a full charge cycle from 0 – 100 % (on June 2, 2023) = **14.1 kWh** *
- Factoring in a round-trip efficiency of 88.6 %:
  - 88.6 % * 14.1 kWh ~= **12.5 kWh discharge**
  - 12.5 kWh / 13.5 kWh ~= 92.6 %
  - 92.6 % of initial capacity represents
  - **7.4 % degradation** after ~ 6 years **



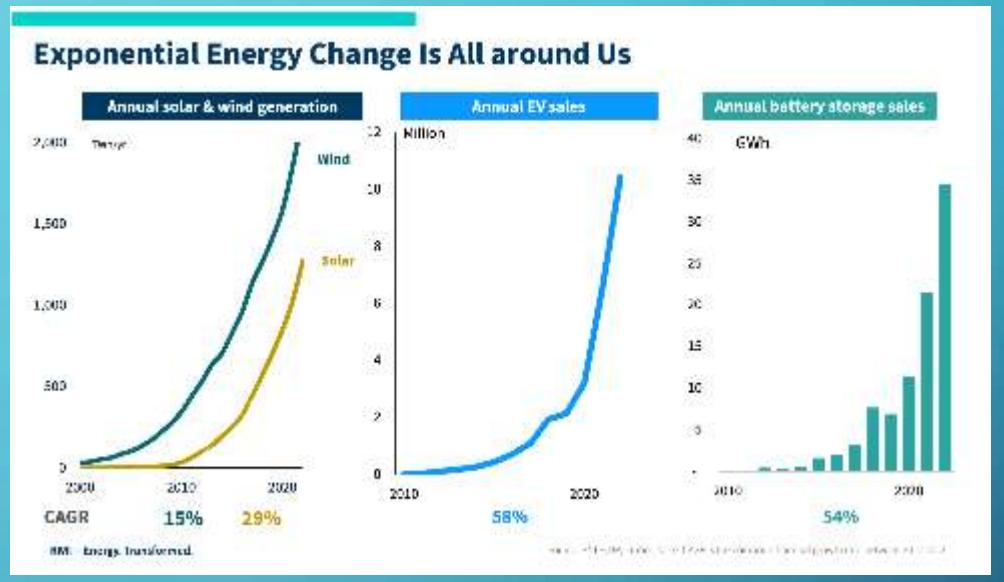
* Possibly some rounding errors from sampling rates

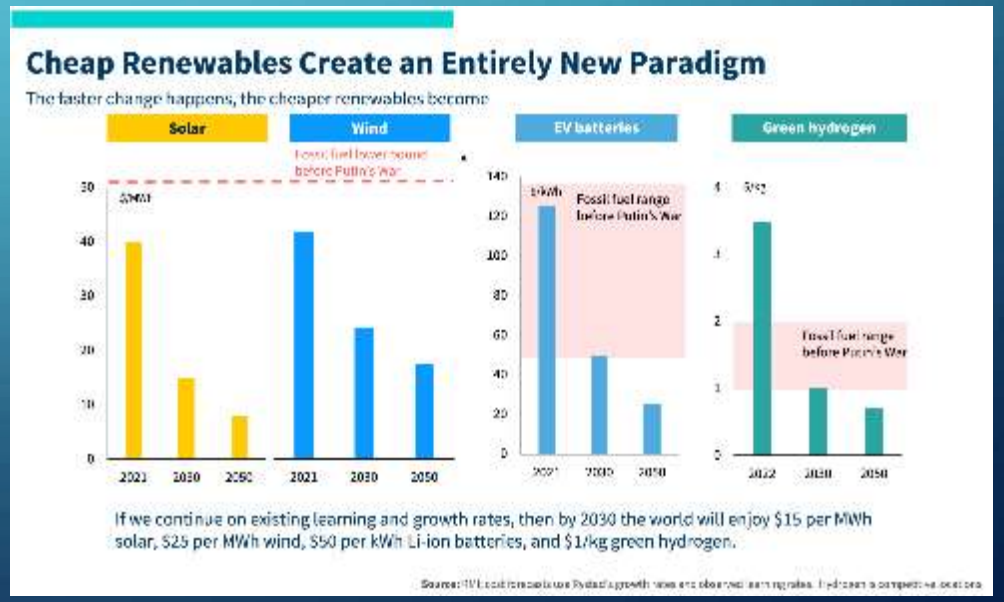
** evidence from other data indicates that degradation tapers off after ~5 % degradation.

LOOKING AHEAD

Global high level:

- "The Energy Transition in Five Charts and Not Too Many Numbers" https://rmi.org/the-energy-transition-in-five-charts-and-not-too-many-numbers
- **1. The energy transition is a technology revolution.**
- **2. The renewables revolution is exponential, not linear.**
- **3. The renewables revolution is led by China.**
- **4. This is the decade of change.**
- **5. By 2030 the debate will be very different.**





Personal actions leveraging renewable energy

- Greener Homes Grant: substantially cheaper than my installation
  - estimated cost of 7.5 kW PV system now if ~$2.50 / watt and rebate
  - ($2.50 x 7500 w) - $5000 = $18,750 - $5000 ~= **$13,500**
- Bullfrog Power
  - help fund community-based green energy projects like solar panels for schools, nonprofits, and Indigenous communities.
- PHEV/EV
- Reduce house energy consumption
  - Insulate
  - Upgrade old windows/doors
  - Reduce air leakage
  - Low power appliances (induction stove/heat pump dryer etc)
- Electrify everything

ELECTRIFY EVERYTHING – IS IT ATTAINABLE?

My stretch goal:

- remove dependence on fossil fuels without major demolition
- stay on 100 AMP grid service while adding
  - Heat pump hot water (share circuit with electric oven?)
  - Cold Climate Air Source Heat Pump (ccASHP)
  - Long range EV
  - energy recovery ventilator (ERV) or heat recovery ventilator (HRV)
  - Heat pump washer / dryer combo. Runs on standard 120 volt / 15 AMP circuit
  - Induction stove

Next Passive House Alberta coffee talk (Frank Crawford) Tuesday, June 27 from 12:00pm - 1:00pm MST. “Electrification without a service upgrade”

https://www.facebook.com/PassiveHouseAB

https://b2electrification.org/home-electrification-service-upgrade-not-required

WHAT'S NEXT

- 1 year assessment after one heating season with a ccASHP
  - Can I use electric heaters as backup on coldest days?
- Reducing consumption vs electrify everything. Not necessarily either/or situation
- Re-assess all-electric goal without major demolition/upgrade to grid connection
- Potential of
  - VPP's ""VPPs are networks of distributed energy resource (DER) portfolios, which can include rooftop solar, smart thermostats, smart water heaters, electric vehicles, and distributed batteries. The VPP network is actively controlled by utilities and energy service providers to benefit consumers, the power system, and the environment." https://pv-magazine-usa.com/2023/05/03/virtual-power-plants-could-save-utilities-up-to-35-billion-by-2033/
  - TOU "ATCO is launching a program to test Time of Use (TOU) rates in select communities in Alberta." https://electric.atco.com/en-ca/energy-future/modernizing-electrical-system/meter-technology/time-use.html

- Quote from Gordon Howell (a solar PV early adopter who installed the first grid-connected solar system in Western Canada on his home in Edmonton in 1995):

”I don’t like calling <solar> an investment; it is a **home improvement option**. People should only buy a solar PV system if they want a reliable ROI, a hedge against high electricity prices, clean zero-emission electricity, knowing that it is fun to generate their own electricity, knowing that it is cheaper than grid electricity over 20 years, and wanting to be a leader to their community, family, kids, and friends. If people don’t want this then that is fine, there are many other things on which to instead spend money on and that have these benefits.”

- https://greenalbertaenergy.blogspot.com/2018/08/blog-post-77.html