

Residential solar with battery storage

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The Sun Always Wins!

Agenda

- Company & background
- Project Background
- Project design, install, testing and inspections
- Operational modes
- Pros / Cons
- Costs
- Updates since install
- Adding an electric vehicle
- Phase 5 – Ideas for next projects
- Future

Company

- Formed Rock Paper Sun Ltd in 2007
 - Worked on solar thermal installs initially
 - Solar electric (PV) installs started in 2009
 - Worked on a number of high efficiency buildings
 - Passive House
 - Super insulated
 - Designed and installed many boiler systems
 - Worked on a number of heat pump installs
 - Worked on projects for builders, City of Saskatoon, universities, commercial projects, farms and acreages, residential and with the SES solar coop
 - In house design, install and service offered



Battery project history

- Lead acid systems
 - Multiple manufacturers of inverters and charge controllers
 - SMA battery and solar inverters
 - Magnum battery inverter and Enphase solar microinverters
 - Off grid whole home system Magnum battery inverter and solar microinverters
 - Various small off grid systems
 - Mainly supplying parts and expertise
- Training
 - Design and service through manufacturers and NABCEP conferences
- Since completion of my project
 - Installed same system for an existing solar customer in Regina



Project background

- We have been installing Enphase microinverters since we started installing solar electric systems
- Enphase announced their release of integrated battery storage
- Receive training and learn what is involved to install
- Use my home as a test project to learn and pipe clean the process before offering to other customers
- Desire always to have some backup for when the grid is down
- Desire to get to net zero for electricity consumption

Project background – Home specifics

- Bungalow built in 2000 located in Nutana – Saskatoon
 - Occupied by myself my wife, mother in law and our two teenage boys
 - Approximately 1350 sq ft house
 - Detached garage existing and new workshop building added in 2012
 - Heated by an integrated mechanical system (IMS) I installed in 2009
 - IMS is a natural gas boiler, with forced air and hydronic, DHW and HRV
 - 2 panel solar thermal domestic hot water system added in 2007
 - Utility - Saskatoon Light & Power customer



Project Background – Solar install phases

- Phase 1 – 2010
 - 12 – 185W panels, system size 2.22kW
 - Cost around \$8 per kW
- Phase 2 – 2011
 - Added 3 – 185W panels, new system size 2.78kW
- Phase 3 – 2012
 - Added 10 – 255W panels, new system size 5.33kW
- Phase 4 – 2020 (also added batteries)
 - Added 18 – 325W panels, 10 – 335W panels & 2 – 300W panels
 - New system size 15.13kW and 55 panels
 - Cost around \$2.50 per kW

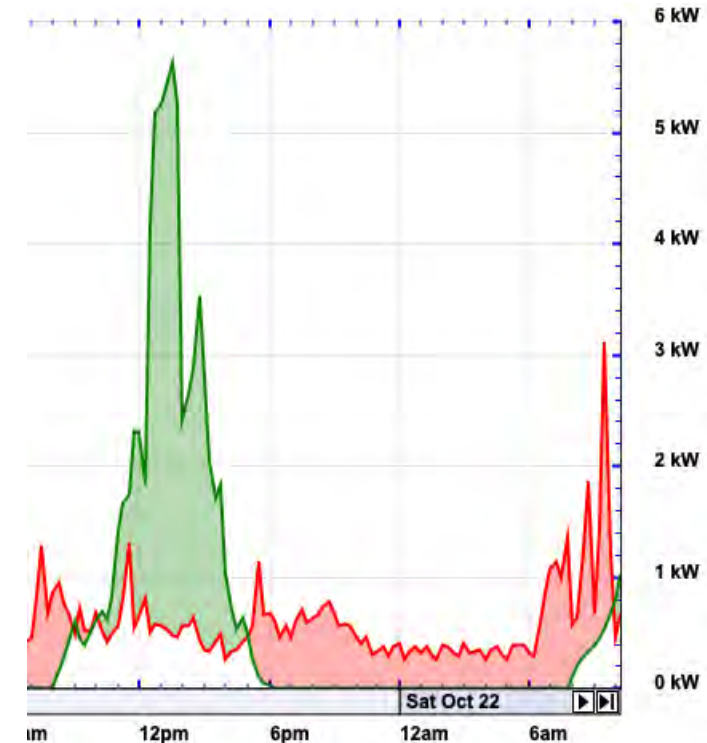


Project background - Electrical

- Electrical loads at start of project - 2020
 - Oven, microwave (Note: we have a natural gas cooktop)
 - Washer & dryer (European style)
 - Personal computers and entertainment
 - LED lighting
 - HVAC loads small including low energy ECM pumps etc
- Annual average electrical consumption – 7 MWh
- Annual average PV generation – 4.6 MWh
- Solar offset was approximately 66% of load

Project Design – Sizing of equipment

- Design sizing
 - Worked through manufacturer training to right size battery equipment
 - Load analysis
 - Has to cover the largest single load at a minimum
 - Batteries need to be able to supply inductive and reactive loads (motors, pumps etc)
 - Multiple batteries required to meet loads
 - Backup of whole home
 - Load shedding custom plan – relay to remove loads (Air conditioner)
 - Design review of plan with manufacturer
 - Electrical plan sent to SaskPower plans review for approval



Project Design – Batteries chosen

- 1 x Encharge 10 (contains 3 Encharge 3's)
- 1 x Encharge 3
 - Total capacity – 14kWh
 - Usable capacity – 13.44 kWh
 - Continuous output power 5.12kW or 21.2 Amps
 - Peak output power (10 seconds) 7.68kW or 32.8 Amps
 - Other specifications
 - Lithium iron phosphate technology
 - Each battery weighs around 100lbs
 - Temp range –15 to 55C, Optimum 0 to 30C
 - AC round trip efficiency 89%

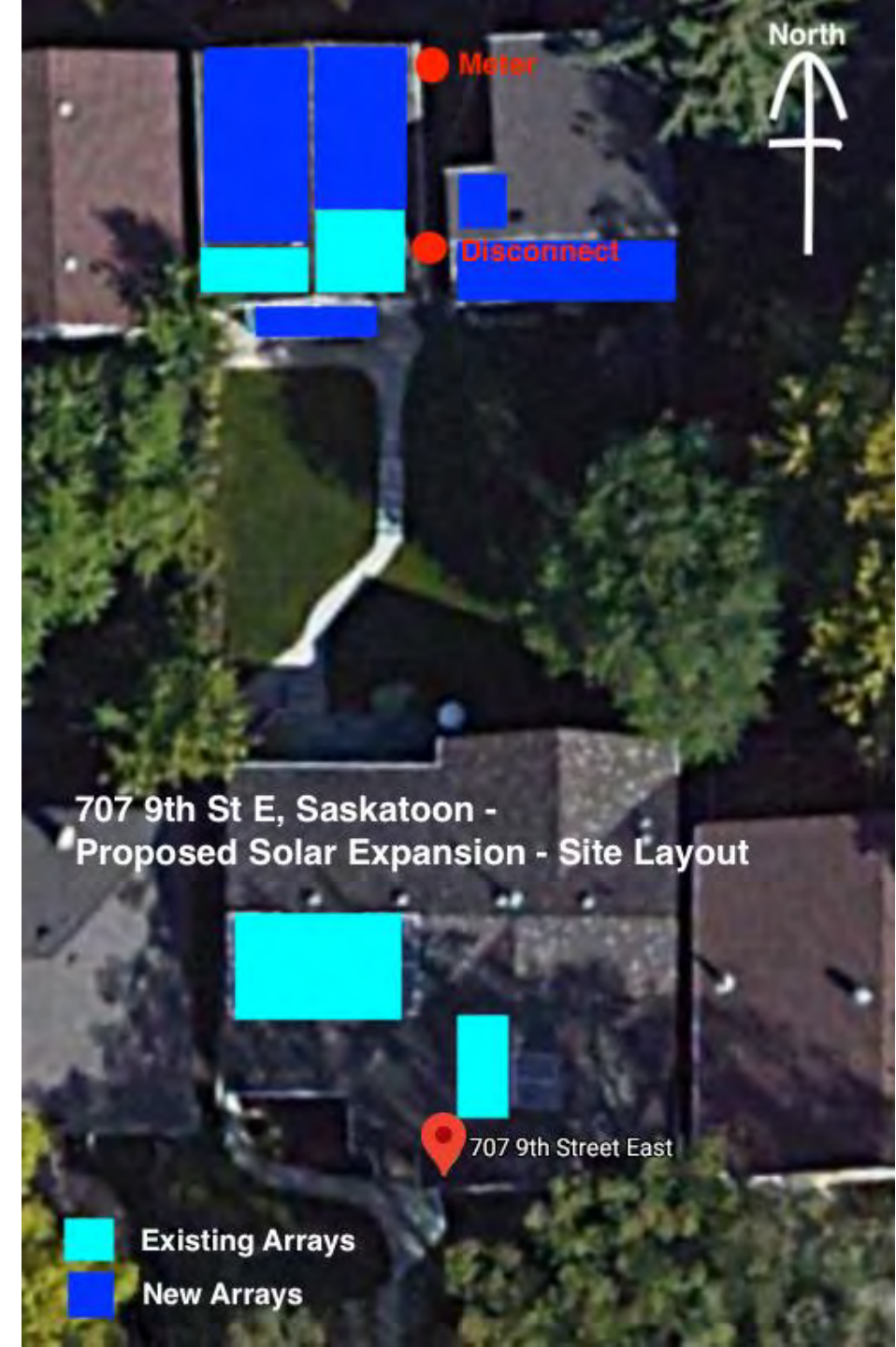


Project Design – Solar paired with batteries

- Battery technology works with later IQ microinverters
- Ratio of size of solar array no larger than 1.5 times that of battery output
 - Decided to maximise this and added 30 panels and IQ microinverters
 - AC output – 7.68kW (9.8kW DC rated output from panels)
- Locate new panels in optimum locations
 - Relocate existing panels and microinverters to accommodate
 - Gain more roof space
 - Move overhead service to underground – mast would shade as well as limit panels
 - Move garage heater vent from roof to sidewall

Site plan

- Original panels on house not changed
- Relocated panels on shop and garage wall
 - East West garage roof
- New panels
 - Shop south roof
 - Shop north roof
 - Garage adjustable wall
 - Garage east and west roofs













Project Design – Other components

- Enpower smart switch (microgrid interconnection device – MID)
 - Allows disconnect & reconnect to grid safely
 - Provides neutral when grid is not present
- Envoy
 - Monitoring and control system, added wireless data module – communicates between batteries and smart switch
- Safety disconnect switches
 - Disconnect on main service optional but allowed for simulating loss of grid
 - External disconnect for batteries and solar – code requirements for some
- Upgrade service
 - 200 Amp panel in garage with house as a sub panel
 - Previously split service 100amp in house and garage



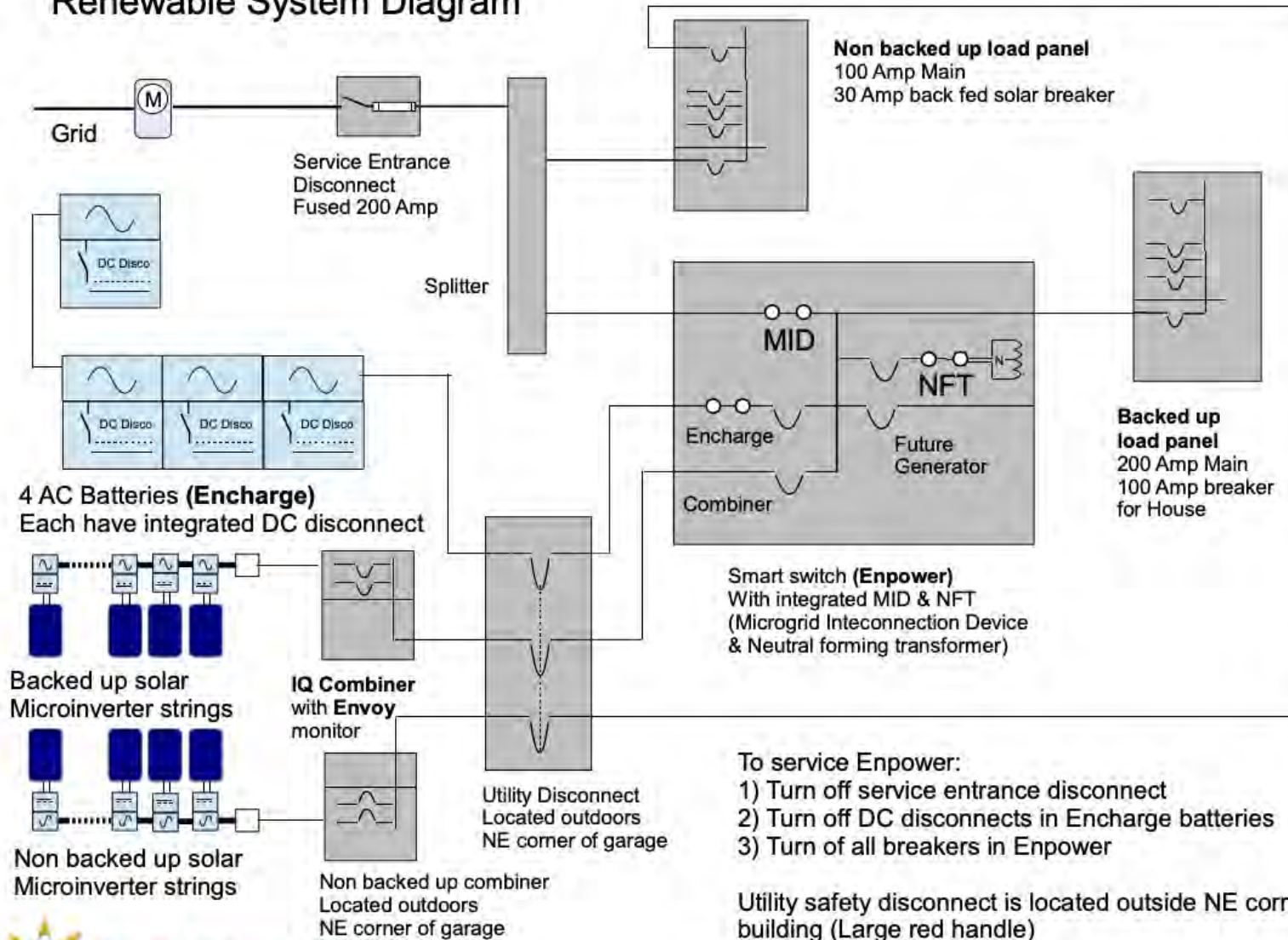




Main service and utility disconnects



Renewable System Diagram



To service Enpower:

- 1) Turn off service entrance disconnect
- 2) Turn off DC disconnects in Encharge batteries
- 3) Turn off all breakers in Enpower

Utility safety disconnect is located outside NE corner of garage building (Large red handle)

In the event of smart switch failure:

MID can be bypassed by removing label on front of Enpower box and following Enphase support instructions to manually override system



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Testing, commissioning and inspections

- Lengthy procedure to commission
 - Hit some roadblocks
 - Found out one of first systems in Canada so lots of time working through issues
 - Supply chain issues missing one battery for a number of months
- Testing
 - Test overloading system and recovery
 - Found some surge loads would not allow brown start
- Electrical inspections
 - New technology for inspectors
 - Multiple visits and people to inspect
 - Passed inspections but wanted changes to diagrams to aid understanding

Operational modes

- Full backup
 - Allows the system to backup loads in event of outage
- Self consumption
 - Allows surplus solar production to be stored locally and used later
 - Good model for SaskPower customers under new netmetering program
- Time of Use
 - Allows stored power to be used when electricity rates are highest
- Some modes you can decide if you want to charge from grid or solar or combination
- You can also set thresholds for reserve capacity

Operational Modes – Control & Monitoring



Total Energy Updated 44 secs ago



PERFORMANCE

Grid Dependence: 2%



Currency Equivalent



Environmental Impact



Net Exported



Total Energy Updated 6 mins ago

3.7 MWh
Imported

7.6 MWh
Produced

2.2 MWh
Discharged



2.9 MWh
Exported

812.7 kWh
Net Imported

2.8 MWh
Charged



PERFORMANCE

Grid Dependence: 47%



Currency Equivalent

7.6 MWh Produced = **\$ 1.3 K** Equivalent

Environmental Impact

Source

7.6 MWh Equivalent < **CO2 REDUCTION 5.5 tonnes**

Net Imported

812.7 kWh Net Imported

Pros and Cons

- Pros

- Had two power outages did not even know they had happened until email
- Self consumption reduces the amount I feed back to the grid
- I'm net zero – solar increase means I have surplus energy about 35% more than demand at time of install

- Cons

- Round trip efficiency I loose approximately 11% of the power I have generated and stored and then retrieve
- Storm guard feature not yet supported in Canada
- Some updates and configurations have been buggy
 - Product has now become more stable

Costs

- Costs of energy storage systems are dropping and capacity is increasing
- Ignoring any solar install costs
 - Materials
 - Batteries approximately \$950 per kWh of capacity
 - Smart switch, controls and other electrical approx \$5000
 - Labour and permits – 20 – 40 man hours to install depending on complexity
- My 13.5 kWh system cost around \$25,000 installed
 - Likely closer to \$20,000 today

Enphase updates since install

- Older M215 and M250 series inverters now supported
- Load shedding equipment added
- Array shedding equipment added
 - Ratio of max solar to batteries changes when on grid
- Generator support implemented
- Batteryless mode implemented
 - Allows loads to be run when grid is out and solar producing enough, needs latest model of solar inverters and smart switch
- New batteries with better specifications released
- New wired control system added to improve reliability

Adding an electric vehicle

- Well I had surplus solar so it made sense!
 - Waited 13 months from order to get a Chevy Bolt EUV
 - Arrived in June of 2023
 - Six months of data show increased power consumption
 - Now have approximately 20% surplus solar generation, down from 35%
 - Service upgrades made it easy to add charging plug



Phase 5 – Ideas for next projects

- Enphase acquired ClipperCreek an eV charger manufacturer in 2022
 - Existing clipper creek charger outside at the Confederation Inn
 - Latest product release integrates with Enphase solar systems
 - Allows control and charging to be aligned with solar production, may install if works with my system
 - IQ EV charger not available with our local suppliers yet, still studying specification
- Heat pump
 - Use excess solar capacity
 - Replace existing 24 year old air conditioner
 - Pair with existing IMS (air handler) for dual fuel system
 - Heat Pump in SK – online and in person Regina Library – Sat 13 Jan 10:30 – 12:00

Future

- Potential 2024 – Canadian electrical codes changes
 - Energy storage systems to be allowed inside dwellings up to 20 kWh
 - Existing only allows 1 kWh so most are in none dwelling locations e.g. garages
- Smart appliances
 - Working at low power rates
 - Working when surplus solar
- Reducing / supplying grid load
 - Smart thermostat can reduce A/C load when requested by utility
 - Batteries systems can help power grid when peak loads occur, utility request

Future – Vehicle to home/grid

- Electric vehicle batteries have large capacity
 - My Bolt has a 65 kWh battery compared to my ESS which is 13.5 kWh
 - Could use car battery to power home or grid in outage, for self consumption or utility services e.g. peak demand
 - Products are still only in early adoption/release phase
 - Standards between vehicle manufacturers are different
 - Plug works with some vehicles to allow up to 12 amp of loads
- Example Ford F150 lightning
 - Adverts showing it powering home
 - Solution is custom to that vehicle with an inverter from sunrun
 - Approximate cost \$15,000 CDN

Future – Vehicle to home/grid

- Enphase is working on bidirectional electric vehicle charger
 - Scheduled for release in 2024
 - expect it will be at least 2025 before available
 - Will allow same modes as Energy storage system
 - Works with existing Enphase solar systems
 - Working with various vehicle manufacturers
 - My hope is a more generic product that will work with many vehicles

