Solar/Battery Backup System

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Updated: 4/23/2020

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Introduction

I'm creating this document with two purposes. The most important one is to document how my backup system works and how I can monitor how well it's working. The second goal is to help others who might be considering putting in a battery backup system.

I started thinking about backup power systems when CalFire and the electric companies started making plans to turn off electrical power during high fire weather. I also had been reading the news about how we need to lower CO_2 emissions drastically, very soon, or the planet may become very difficult to live on. Extreme temperatures, fires, rising seas, extreme weather, etc. are coming unless we act strongly and soon. I started planning a backup system that would allow me to have electricity through power shutdowns, in addition to reducing my power consumption and CO_2 emissions.

I initially considered a generator, but quickly discarded that idea, even though it would have been much less expensive. But, its noise, CO_2 emissions, and regular maintenance needs made it a poor choice.

I started by first getting an approximate idea of my home power needs. Fortunately, I had already gathered solar data from my existing, 12 year old, solar panel system to model a battery backup system, so I had a pretty good idea of how much solar power and battery capacity I would need. On the cost side, an important incentive was the 30% federal income tax credit (26% in 2020) and “Solar Generation Incentive Program” (SGIP) from California. The federal program is a direct credit of a percentage of the total cost of the installation, off the federal tax bill. The SGIP program is a State program and money is distributed by the utilities. It promised to provide funds for a sizeable portion of the cost of the backup batteries, but in the end the amount was about 25% of what I expected.

I contacted 3 different companies for proposals and bids. I chose local installers because I had experienced poor service from one of the larger solar companies. I also checked Yelp. I chose local company: “Sun Pacific Solar Electric” and am very happy with the result.

What I found out during this process is that the technology is complex and there are many choices that affect the final product. Ideally these would have been addressed before accepting a bid, rather during and after installation. Some capabilities are different than I expected, but overall, it performs very well and meets my basic requirements.

Overview

The purpose of the installation is to provide power during SCE power outages, for as many days as required. The power needs of our home are modest: lighting is mostly LED's, 2 computers, modern energy efficient refrigerator, dishwasher, and television. During a recent "off grid" test this system powered all of our appliances including a small spa for 5 days. We have a gas stove, water heater, and dryer (but mostly dry with the sun). Gas appliances will need to be phased out in the future, so it is wise to design to accommodate electric ones. Here is a link to a summary of typical power requirements for appliances: https://www.mea.coop/wp-content/uploads/2014/06/High-Bill-Packet.pdf

During normal operation the solar panels provide energy to run the home and keep the batteries charged. Excess power is sent back to the grid (SCE). Currently we are on a "Net Metering" plan, which charges for net power used during a year. This plan will be discontinued by SCE, so we expect to be on "Time of Use" (TOU) plans in the next year or so. TOU plans are supported by running the home on battery power during high cost times (general 3PM to 8PM) and charging batteries during low cost time, or earlier in the day from solar power. In our case, with average sunshine, the batteries should charge before the 3PM TOU shutdown occurs. The purpose of TOU plans is to lower the power needs during high use times, reducing the need for "peaking" power plants that mostly use CO2 emitting natural gas or coal.

Equipment

Installation was done by Sun Pacific Solar, of Santa Barbara. They provided excellent service, prompt attention to concerns, and were responsive to questions. The biggest challenge in this kind of installation is that the system is complex, there are numerous design choices, and it is difficult to make sure the final result will satisfy one's assumptions about the end product. The questions that need to be asked and considered, are not always obvious and may only occur after installation begins. I hope this document will help others, who are implementing similar systems, identify crucial design decisions that should be addressed during the bid process.

Key design choices: One of the very important initial design decisions that will be made is whether the system will be an AC or a DC coupled system. This decision may affect the choice of various components, including batteries. For example: before and during the installation, I had watched YouTube demo videos for an Outback system that was DC coupled, but my system was configured as an AC coupled system, which significantly changed the way the system was monitored when the grid was down. The equipment manufacturers and installers may emphasize AC vs DC coupled systems, so it can be confusing for the homeowner. With a DC coupled system, solar power comes from the panels and is converted to AC to power the home, but a direct DC feed is retained to charge batteries. With an AC coupled system, all of the solar energy is converted to AC and separate inverters convert the AC back to DC to use in battery charging. The inverters are very efficient, so losses from the conversions are small. An AC system allows a wider range of equipment to be used, because the voltages from the solar panels don't need to be matched as closely to the battery charging requirements. DC coupled systems have the advantage of simpler electronics and slightly better efficiency. Our home configuration favored the AC coupled approach.

Choice of batteries: Although Lithium Ion batteries have caught fire, or exploded if charged or discharged too quickly, I haven't heard of fires in home backup systems. In spite of this, I prefer a fire-safe solution. Lithium Iron Phosphate batteries are less susceptible to fires and I feel better about having them in my home. They are sold by several manufacturers and are a bit more expensive than Lithium Ion.

Subpanel or Main Panel connection: Many systems connect the backup power to the home through a sub-panel that only powers specific circuits. This automatically disables high power drain appliances when the grid is down. One of the large power consuming appliances is the air conditioner. Mine draws about 3Kw. If the AC was on 24 hrs, the drain would be 3Kw*24hrs, or about 72Kwh. My solar system produces about 25Kwh on a sunny day in the winter. To be able run the AC normally during an outage would require unacceptable added expense for the system. We did add a small Fujitsu split duct AC for our bedroom, which we could run for 8 hrs and use about 0.8Kw*8hrs = 6.4Kwh, which is manageable. This will keep us cooler if nights are hot. Although battery prices keep coming down, they are still quite expensive at around $800-$1,000 per Kwh for home systems. I decided that we would not use a sub-panel (which would not have supplied all of our circuits), so we could have maximum flexibility in what we power during an outage.

Surge and continuous current: Some electric stoves require 40-50amp breakers. If you want to power an electric stove, you should factor this in. Or, to save cost and allow cooking during outages, you might use an electric frying pan or cooking appliance that draws less. Be sure your backup system will power your critical appliances. Don't worry about the refrigerator. Most are very energy efficient.

List of Hardware Installed

1. **Batteries** : 2, RB48V200 ReLiOn Lithium Iron Phosphate Batteries (20 kWh capacity).
2. **Solar Panels**: 18, 5.886 kW roof mounted solar PV system: 18 Sunpower E20-327
3. **Inverter**: SolarEdge SE7600H inverters with DC optimizers and monitoring
4. **Inverter**: Outback Radian 8048A-AC with Mate3 monitoring.
5. **Monitor**: Neurio monitoring system
6. Transfer relays and various junction boxes

Figure 1 shows the equipment installed on the wall of our home workshop. Living quarters are above this area.

Mechanical Components, labeled as shown in figure 1

A. Disconnect for the solar panels
B. 50amp fused AC Disconnect. Disconnects Outback inverter from grid.
C. Main transfer switch 200 amp.
D. Mate3S "Outback" control box

---"Junction Box for breakers and connections", and contains the ReLiOn battery status meter.

Figure 1. Components of the backup system, installed by Sun Pacific Solar Electric.

Description of operation

Figure 2 shows the major system components and how they interact. The solar panels are connected to the SolarEdge inverters, which convert the DC power from the panels into 240VAC, which powers a 240V and two 120VAC circuit banks. When there is more power than needed by the home, the surplus is sent back to the grid. In this "state", the Outback Radian inverters do nothing except monitor the battery's voltage and charge them when it drops below a preset value. If charging is triggered when there is insufficient solar power, power is drawn also from the grid. When the grid is connected normally, the automatic transfer switch connects node C to node B, as shown in figure 2.

When the grid goes down, the Outback system automatically senses it and creates a local AC grid (called a "microgrid" in the Outback manuals), powered by the batteries, which power the home. It actuates the AC transfer switch, connecting node C to node A (figure 2). This connects the Outback virtual grid to the home circuits. At this point, the purpose of the SolarEdge inverters is to provide AC power to the Outback system, from the solar panels, to charge the batteries and supplement whatever is needed for the home.

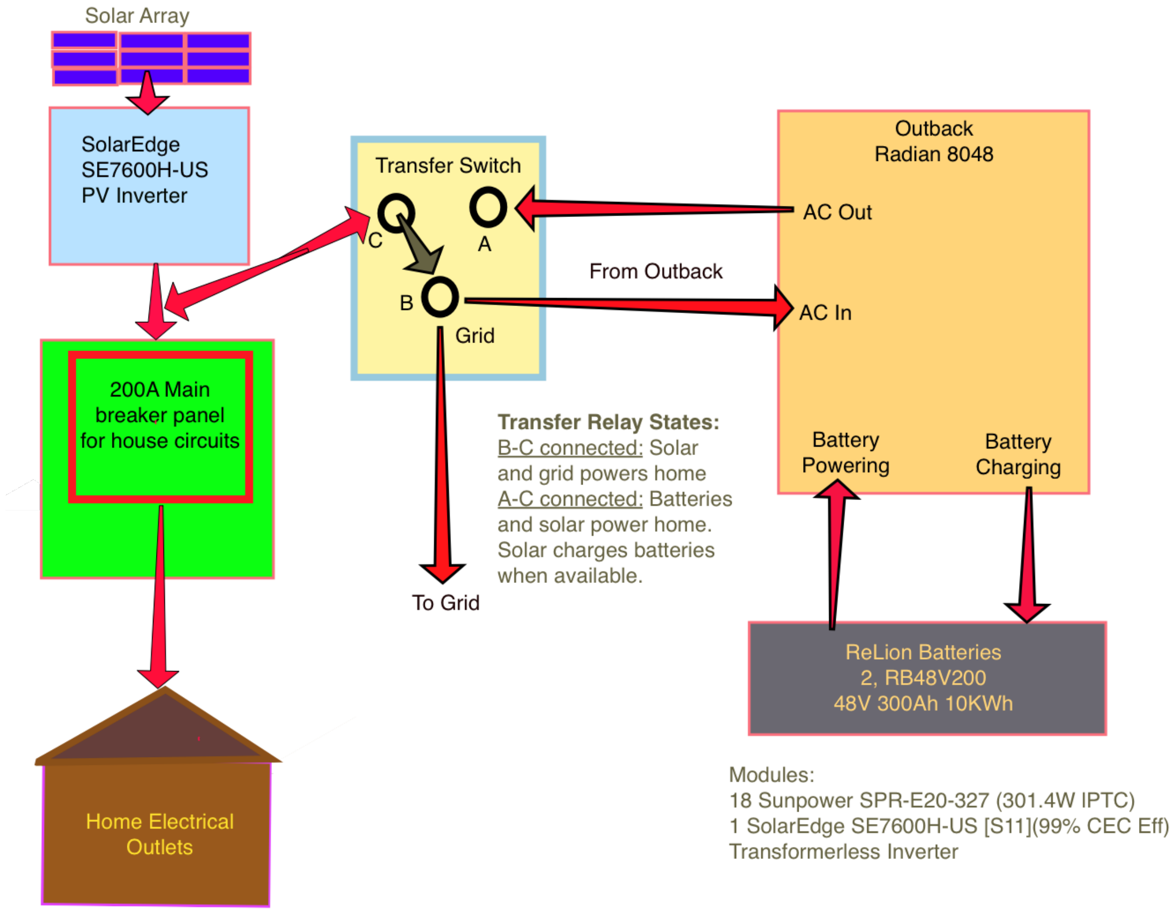

Figure 2. Diagram illustrating the functions and interaction of the system components. Note that I am calling the electric power system (SCE in Santa Barbara) "the grid."

With the power grid down, batteries and solar are powering the home. If there is more solar power available than the home needs, the excess will go to charging the batteries when in the charge state. During the night, when there is no solar power, batteries supply all of the power for the home. During the day, when there is enough solar power and the batteries become fully charged, the Outback senses this and signals the SolarEdge to stop sending power. The batteries then power the home until they are discharged to a specific level, at which time the Outback signals the SolarEdge to begin sending power again, if there is sun.

To summarize, there are several states of the system:

1) Normal: grid connected batteries fully charged
    a) Night-time: grid powers the home
    b) Day-time: solar powers home and excess is sent to grid
    c) When batteries have low enough voltage, charging is initiated whether or not solar is available.
2) Grid is down, batteries and solar power the home.
    a) No solar (night-time): batteries power the home
    b) Solar (day-time): solar power goes to power the home and excess goes to charge

batteries if battery voltage is below the “start charging” threshold.

c) Solar (day-time): battery voltage is above the “start charging” threshold and do not need charging. Solar is disabled and the home is powered by batteries alone. When battery voltage reaches the “start charging” value, the solar electronics is activated and state a) (night-time) or b) (day-time) is activated.

System Monitoring

The ability to conveniently monitor your backup system is important. You may need to ration your power consumption to get through an outage comfortably. When the system is new you will also want to get familiar with the system capabilities and limitations. If the outage lasts a few days you will want to know whether you are consuming your battery power for the most important uses, especially during cloudy stretches where solar production is low. Monitoring is usually implemented on a wi-fi connected interface accessed using an app or internet browser, on a mobile phone, tablet, or desktop computer.

Items that should be monitored are 1) solar power generation, 2) home power consumption, and 3) state of charge of the battery. A well-designed system will be able to power the home overnight and charge the batteries during the daytime, unless it is so cloudy that there is insufficient solar production. You would want to be able to get through a couple of cloudy days. Fortunately, during power shutdowns during high fire weather, the sun is probably also sufficient to charge the batteries each day. The following paragraphs explain the monitoring systems and how and when they provide the most useful information.

An aside for a homeowner getting bids:
Design choices made early on may affect the monitoring resources available at the culmination of the installation. There are beautiful YouTube demo videos illustrating monitoring interfaces for various manufacturers, but they may not be available on all system configurations. It is difficult for the homeowner, who is not familiar with all of the equipment details, to pore through the online specs of each element of the system to discover “gotchas.” So it is very important to specify, as carefully as possible, what you expect for the final result. Fortunately for me, the Sun Pacific personnel were very patient in explaining the system and accommodating my requests. There were still surprises and I didn’t get exactly what I expected, but none seriously impacted the use-ability of my installation and it does a great job of powering my home during an outage.

During grid-powered operation, the SolarEdge system, as delivered, was not capable of showing the home power consumption. So, a Neurio (PWRView) power monitor was added to provide that functionality during grid connected states.

Monitoring, when the grid is down, is done using the Outback Mate3 interface and ReLiOn battery meter. The Mate3 is connected to the internet and allows for remote management of system settings through the OpticsRE application. Unfortunately, the Outback online monitoring system was optimized for a DC coupled configuration. It is confusing for an AC coupled system and will be only marginally useful for most homeowners. The battery voltages are available online but it is much easier to get readings directly from the Mate3 interface and the very capable battery monitor meter, which produces the necessary information. Ideally, a more capable monitor interface for the system (found at: https://store.egauge.net) would be installed, but is not included with my system, as I didn't find it necessary. A DC system using the Outback Radian would use the Outback network hardware.

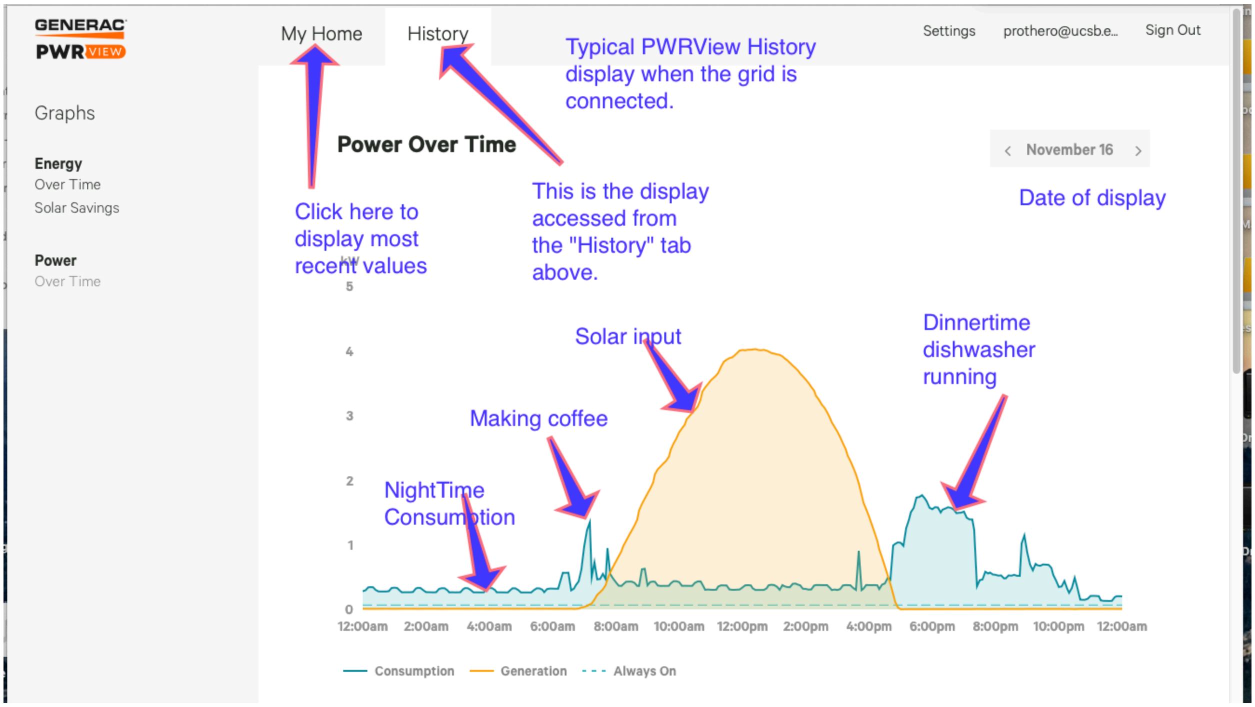

Figure 3. Normal day, where the grid is connected. You can choose various display choices, including total power (kilowatt hours, kwh) consumed and sent to the grid, for each day. When the mouse is moved over the data line, a small box showing the value appears.

Monitoring-Normal grid connected operation: PWRView (Neurio)

The PWRView interface is accessible on web browsers and mobile device apps. It provides excellent information on solar generation and home consumption when the grid is on. When the grid is off, it provides solar generation data only.

Figure 3 shows a screen (with my annotations) from the Neurio monitor, displayed in the Safari internet browser during the normal operating situation where the grid is connected all day (https://mypwrview.generac.com/#trends/power/over-time). The home power consumption plot line is identified by pointers labeled "Nighttime Consumption" and "Dinnertime dishwasher running." On a color plot, or computer screen the line and shading beneath are blue. After 8AM the sun is coming up and the "Solar input" line (shown in orange on a color figure) shows the solar power production from the solar panels increasing, then declining in the afternoon.

Off grid test: Between November 19 and 24, 2019, the grid was disconnected and the home was powered exclusively by this system. Figure 4 is a plot of November, showing the daily generation and home consumption. The "grid off" test was November 19-24, as indicated in the figure. In the "grid off" state, all of the solar generation goes to the Outback system to run the home and charge the batteries, so generation and consumption are shown equal. During the “grid off” state, monitoring is most effectively done with the OpticsRE app and physical ReliOn

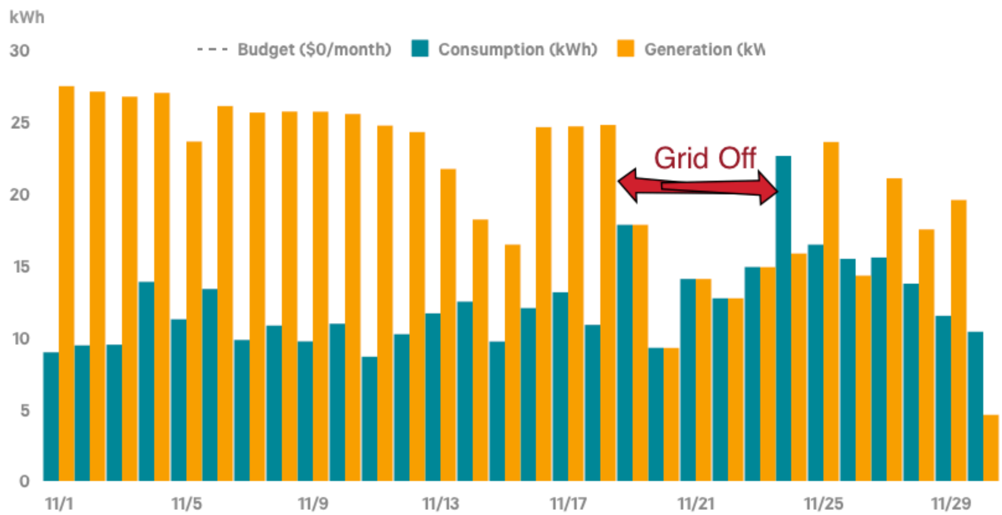

Figure 4. PWRView (Neurio) history for the month of November. The system generated more energy from solar than used by the home. During the 6 day “grid off” test (Nov 19-24), all of the solar looks like load to the Neurio, so the bars are equal height and to the Outback Mate3, this looks like grid input.

meter, which is described later in this document. The graph shows that for the first half of the month, the power sent back to the grid is about double the home consumption, but later in the month, its cloudier and less solar is generated. Figure 5 shows the PWRView data for the day that the grid was turned back on at about 2:00PM. This figure is shown because it illustrates some of the behavior of the system both on and off grid. Prior to grid activation (still referring to figure 5), all of the solar power went to the Outback inverters, which initially are powering the home and charging the battery. The curve shows generation and consumption equal. The area beneath the curve is colored a light green (grey on the printout) because the solar and load curves overlap exactly. At about 11:30AM, the battery has reached fully charged state (grid is still off) and the solar panel inverters (SolarEdge) shut down and the home is powered from batteries alone. When the battery voltage is discharged to a preset discharge level, the SolarEdge is reactivated and solar energy is distributed between the home and battery recharging. Until 2:00pm the state oscillates between these two states. About 2:00PM, the “off-grid” test was concluded and the grid was connected. The plot shows normal solar power being generated and a relatively large consumption load because a spa was running. The other peaks in consumption are from cooking and miscellaneous appliances, like dishwasher, etc.

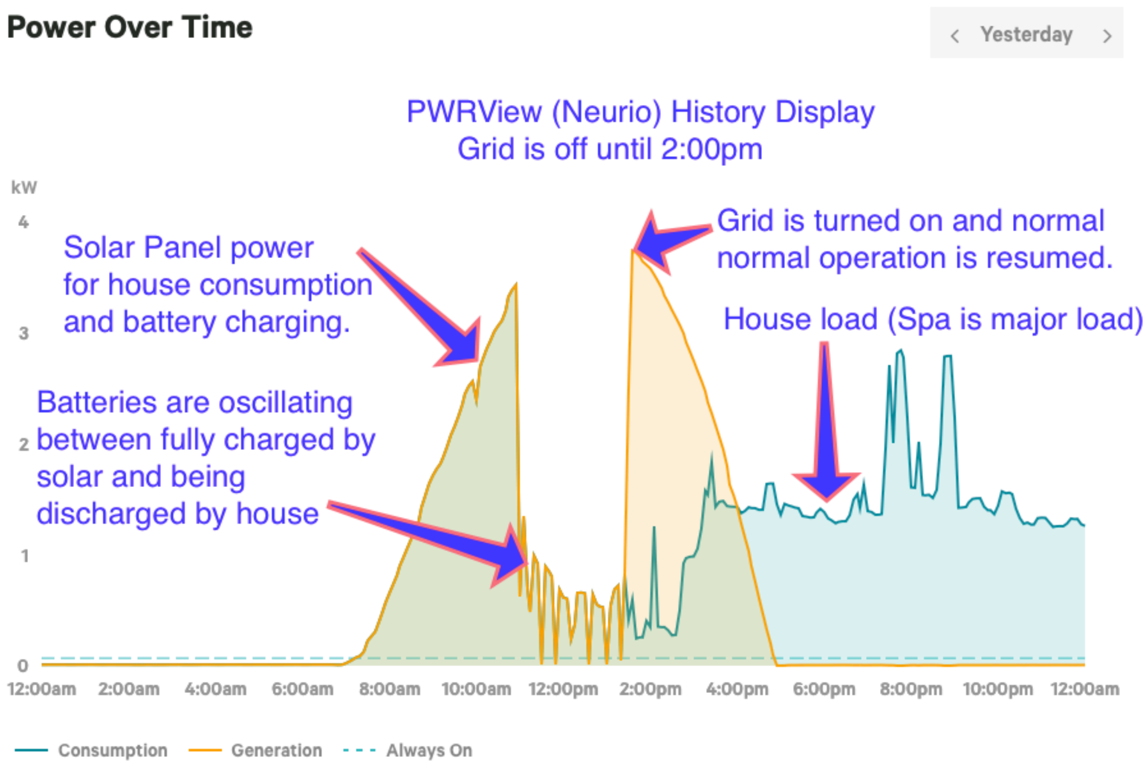

Figure 5. PWRView history display (Nov 24, 2019) for the day the grid was turned back on after a 5 day "off-grid" test. The load and consumption lines overlap because all of the SolarEdge output goes to the Outback controllers, thus looking like load.

Monitoring system components when the grid is down:

When the power is shut off, monitoring vital components, like battery state of charge, house load and solar power generation is performed using the OpticsRE interface, the Mate3 controller display, and the ReliOn battery meter. The PWRView/Neurio display will look like the first part of that shown in figure 5. Solar power will rise in the morning until the battery is fully charged (similar to fig. 5, 12AM to 11:00AM), then enter a charge/discharge state (similar to fig. 5, 11:30AM-2:00PM). When there is no solar as evening approaches, the plot line goes to 0.

Mate3S Display: This display is mounted on the wall (figure 1). The data can also be acquired at the web browser interface. The sign-in link is https://opticsre.com/Home/#/sign-in. The system installer will give you a username and password so you can set up an account. The battery state of charge is accessed at the ReLiOn meter (inside box C shown in figure 1).

The next set of images shows the Mate3 display during various states of the system, with the grid off. This is one place where system information is best accessed during grid outages.

Figure 6. Mate3 display. This shows the controls for accessing the off grid configuration information. This screen indicates normal operation. Press Charger button on left to get this display.

Figure 6 is the Mate3 control box, as shown in figure 1. The Charger button, on the left, is pressed to get this display. The display shows the battery voltage at 53.2 volts. The Absorb and Float values are settings made at system setup. When the battery is in charge mode, its voltage slowly increases until the "Float" value is reached, then charging stops.

Figure 7 shows the Mate3 display when the Back button is pressed after the Charger button. Notice the bottom line of the display shows the battery voltage and a left arrow with the value of 243 V shown. This indicates that the grid is supplying 243 volts.

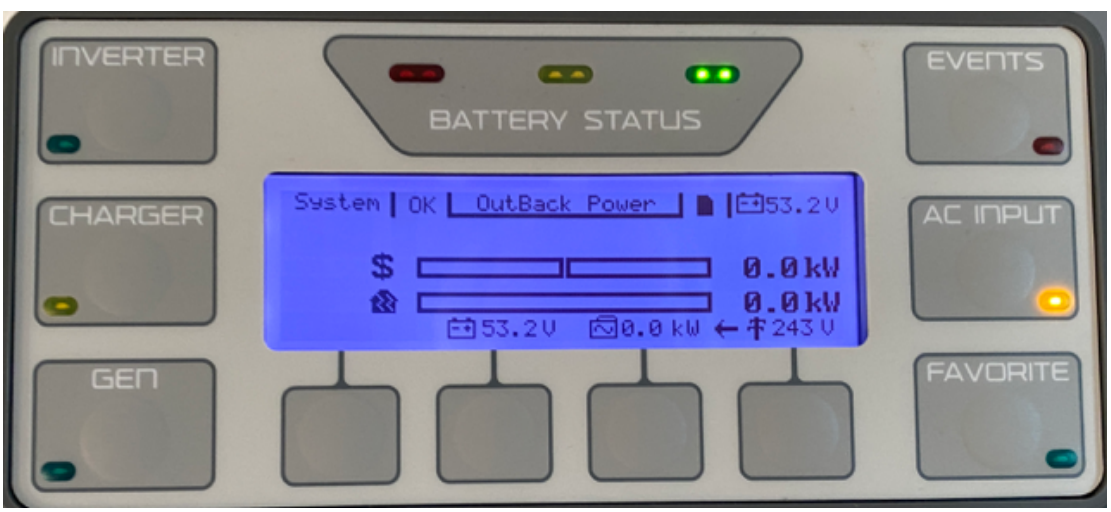

Figure 7. This display is shown when the Back button (see figure 5) is pressed after the Charger button. This is a normal, grid on situation.

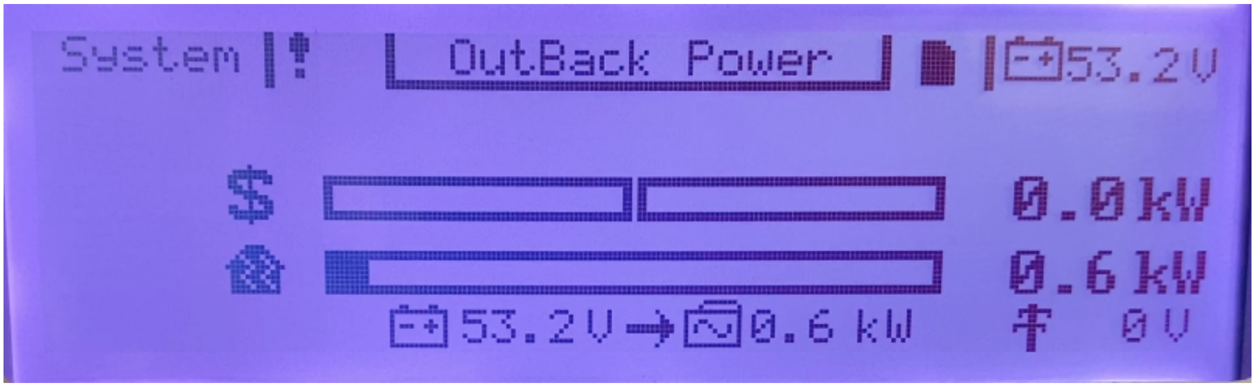

Figure 8. The **grid is disconnected** here. Notice the bottom line, where the arrow points from the battery symbol to the right, indicating that it is supplying 0.6 kW to the home. The battery voltage is shown in the upper right, at 53.6 V. It is colored red to indicate power is being taken from the battery. Note also that the lower right with the grid symbol, shows 0 V, indicating that no power is coming from the grid.

The Mate3 is where battery charge settings are entered and a host of other options are configured. Schedules for charging and grid connections can be set to satisfy Time of Use (TOU) utility requirements. So, it is possible to run on batteries during high use times and charge them when solar is present.

Using the Online OpticsRE Monitor

The OpticsRE display is accessed in a web browser and is shown in figures 9 to 13. It is accessed at: https://opticsre.com/Home/#/sign-in. The system installer (Sun Pacific in my case) will supply you with the sign-in information. The figures are printed in black and white, but the browser display is animated and colored. The dot color is specified in the caption below each figure

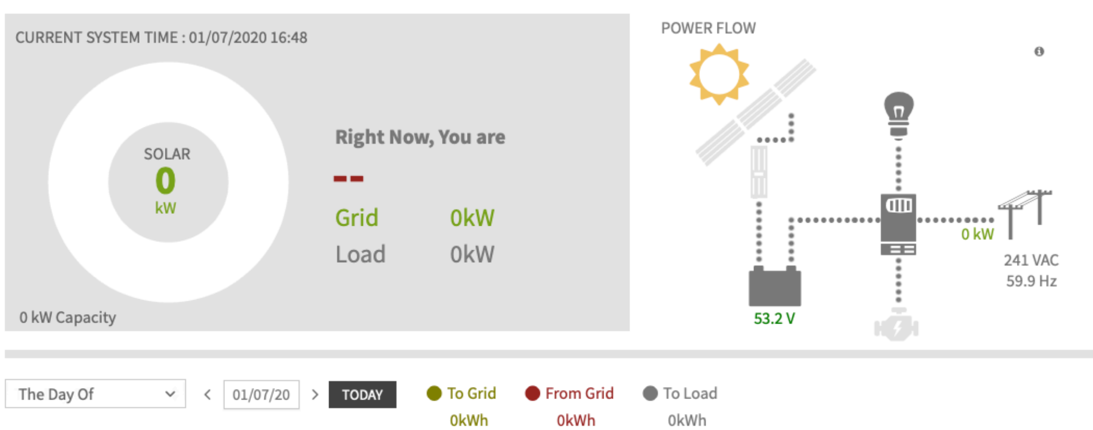

Figure 9. OpticsRE display. This is the top of the web page, where system status is shown. The grid is connected. The relevant information is the battery voltage and that the grid is on. This is indicated by the 241 VAC value beneath the power lines symbol.

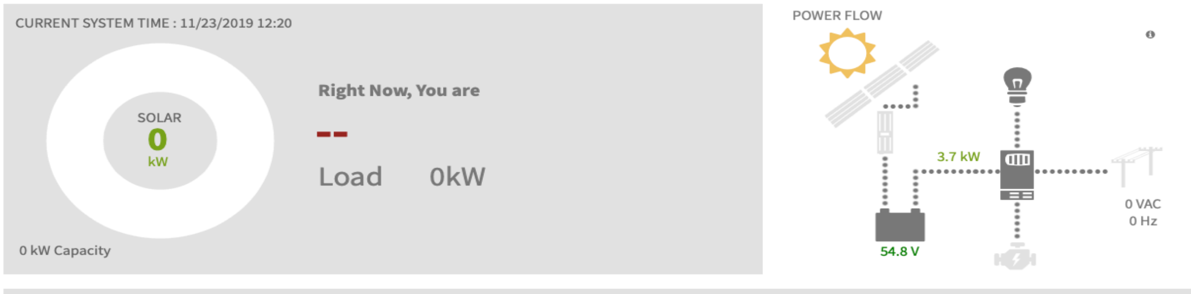

Figure 10. OpticsRE display when the grid is off and batteries are being charged (3.7kW, green). There is enough solar power for the house load and to put some back into the batteries. (Grey dots)

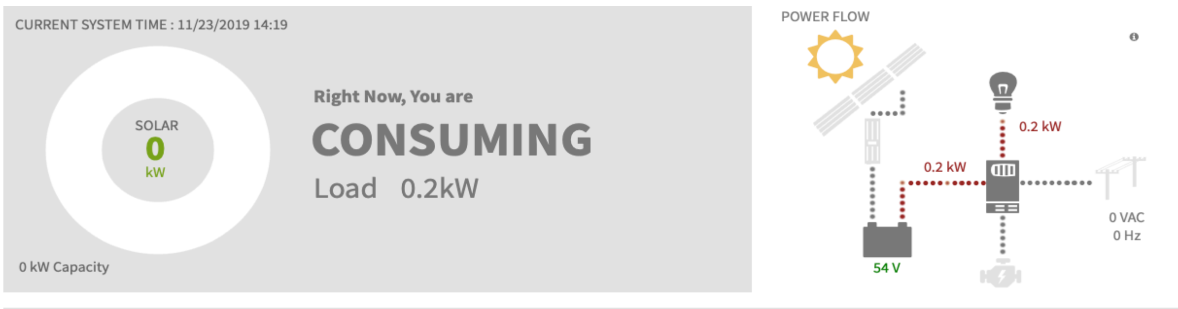

Figure 11. OpticsRE display when current is flowing from the batteries. Power is flowing from the batteries to the house. If the batteries have been charged above 54.2 (or so) volts, the solar power connection is shut down and batteries supply power until their voltages reaches a bit lower level and then it switches to charge state. 0.2 kW (red) to inverter.

In the OpticsRE display diagrams shown in figures 10 and 11, the dots are animated and colored grey or red. If the dots are red, power is flowing from the batteries, but if grey, the batteries are being charged.

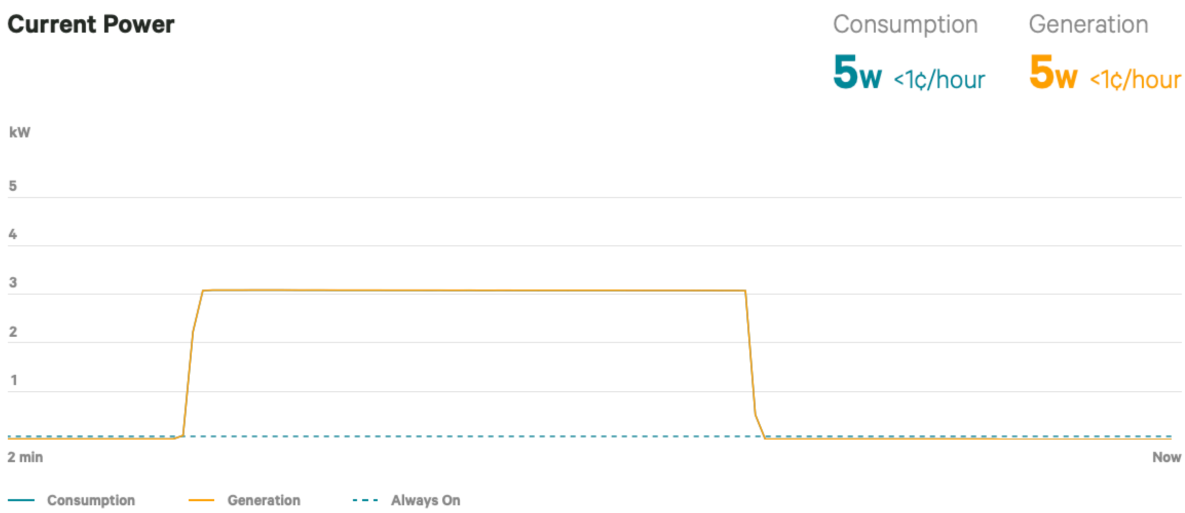

Figure 12. PWRView display, grid off. When the batteries have been fully charged by the solar, the solar is switched off (indicated by the very low kw level in the plot above) and the house load is serviced by the charged batteries, but when the batteries get low enough, the system switches to a charge state and are being charged by the solar. The solar will be charging batteries and the supplying the house, as well. The system goes back and forth between charging the batteries (and supplying part of the load) and running the house only from batteries. During fully charged state, where the battery voltage is between a preset high and low value, the SolarEdge power (from panels) is shut down.

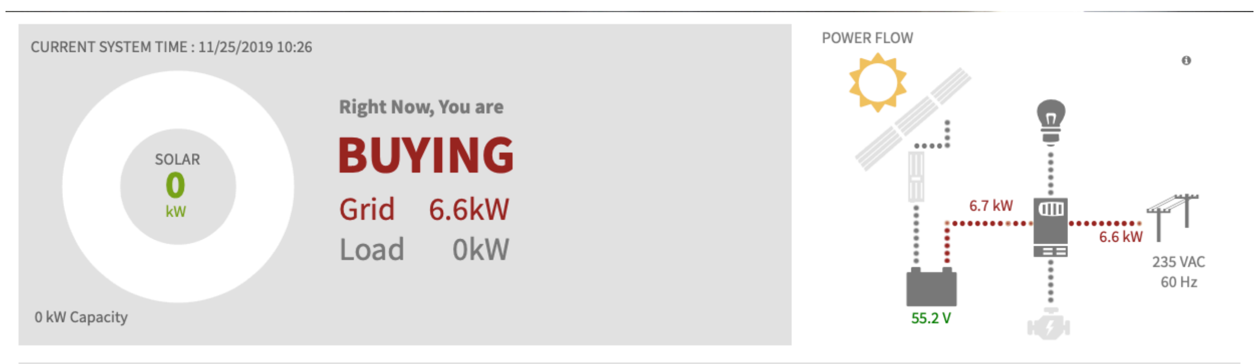

Figure 13. Above, (grid on) we see that 6.6 kW is shown flowing from the grid symbol (235 VAC) and 6.7 kW is flowing into the battery at 55.2v. The dots between grid and inverter, and inverter and battery are colored red (which may not show up on black and white printout).

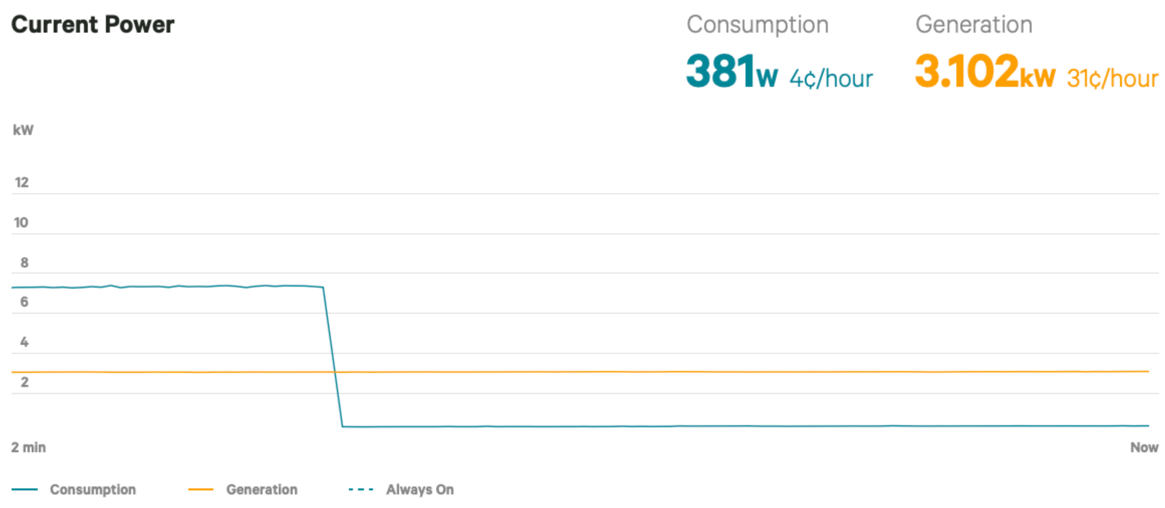

Figure 14. The image above shows the PWRView display where the blue line (consumption for battery charging mostly) is at about 6.6kw, but then switches to 0. The images of figure 13 and 14 were captured at the time when Consumption was at 6.6kw. (Note that 6.7 kW at 55.2v is 121 amps =6,700/55.2).

ReLiOn Battery Status Indicator, Use and Setup

This meter is a product of the ReLiOn battery supplier and provides information about the battery voltage, state of charge, and current flow (charge or discharge). It is easy to use and is the only way to directly access the battery's state of charge.

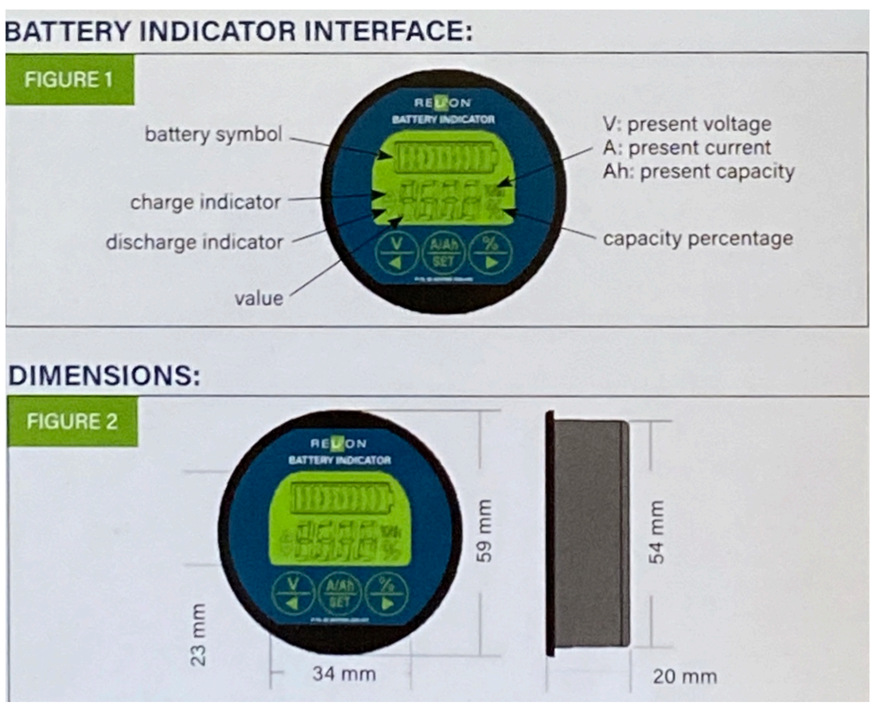

Figure 15. This is a diagram of the meter, contained within the "Junction Box for Breakers and Connections", shown in Figure 1.

There are 3 buttons near the bottom of the meter (round image). The labels are:

1. V – volts
2. A/Ah and SET - Amps and Amp hours
3. % - percentage of charge

Calibrating the meter:

1. Fully charge the batteries and then press the "%" button for 3 seconds to set the meter to 100% state of charge.
2. To enter the capacity directly, press the A/Ah button for 3 seconds. Use the V button and the % button to increase or decrease the capacity. Press the A/Ah button when done.

ReLiOn Battery Charging Specs

The detailed specifications are in the data sheet for the RB48V200 battery. Specs relevant to battery charging and discharging controller are given below.

- Recommended charge voltage 56.0 – 58.4V
- Recommended low voltage disconnect 44V

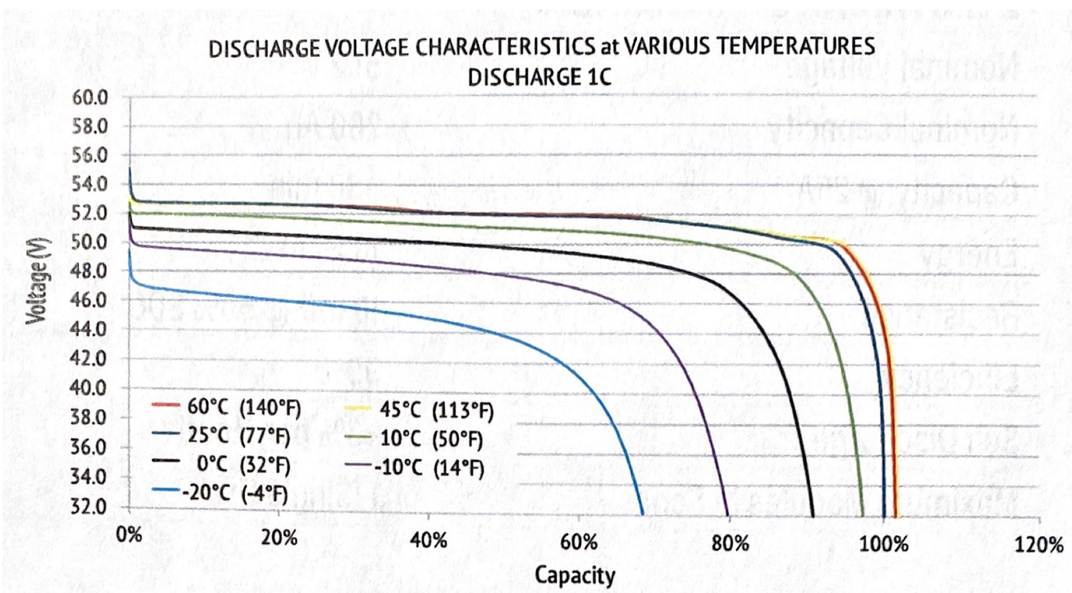

Figure 16. State of charge curves for the RB48V200 battery. These curves show that, at the SOC (State of Charge) is very close to 100% at 56.0V. However, for this system, we have set the fully charged voltage to 55.2v and the voltage at which charging is initiated at 52v.

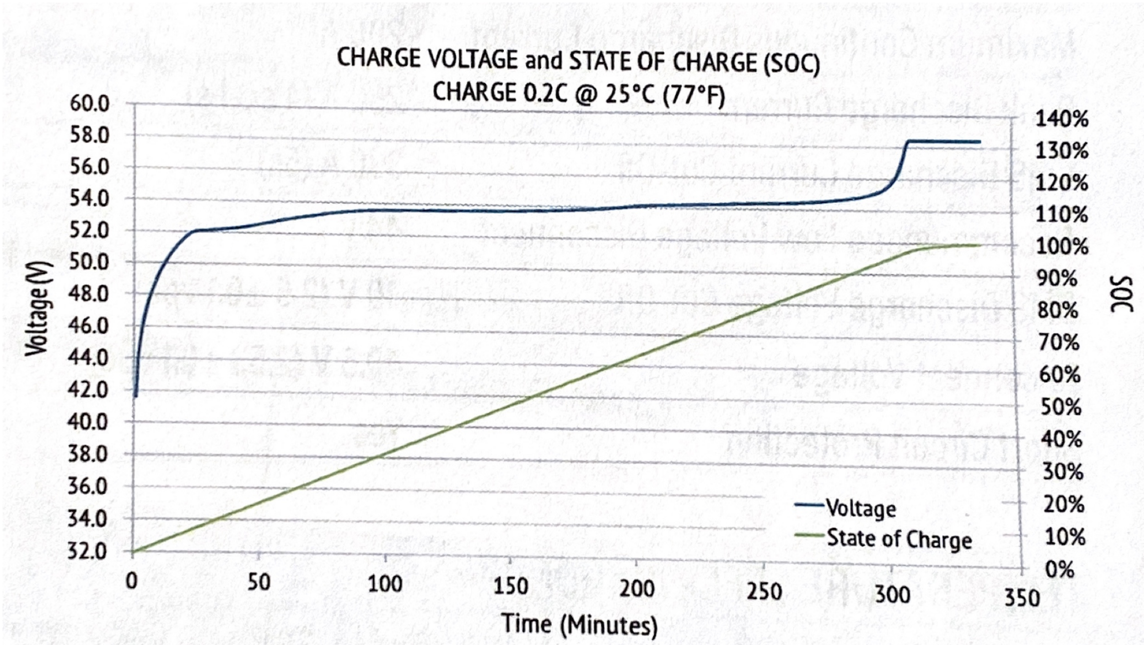

Figure 17. State of charge curves for the RB48V200 battery. These curves show that, at the SOC (State of Charge) is very close to 100% at 56.0V.

The battery charge state can be determined using this meter. The charge curves are included for future reference and in setting the parameters of the Mate3.

Battery Charge Terminology

There is a specific terminology to describe battery charging. These values are set using the Mate3 control system. The desired charge rates, voltages, and charge currents are specific to the battery chemistry. The Outback charger is very flexible and can be set for a wide variety of battery types. The terms used are:

- **Bulk**: During the **Bulk** phase of the charge cycle, the voltage gradually rises to the Bulk level (usually 14.4v volts) while the batteries draw maximum current. When Bulk level voltage is reached the absorption stage begins. During the bulk charging stage the charger works in a constant current mode. That is, the charger supplies a constant current to the battery while monitoring the battery voltage. As the battery charges, the voltage increases even though the current stays constant. When the battery voltage reaches a present value, charging switches to the Absorption phase.
- **Absorption**: During this phase the voltage is maintained at Bulk voltage level for a specified time (usually an hour) while the current gradually tapers off as the batteries charge up.
- **Float**: This is a constant voltage that holds the battery at full charge. The ReliOn batteries have extremely low discharge when not used and applying a float voltage is actually harmful to the battery, so a float voltage is not applied.

Purchasing Solar/Battery Backup Equipment

There are a number of important design consideration that affect the useability of the backup system. This is a discussion of what I found, from a homeowner's viewpoint, to be important.

The first thing you will be thinking of is how long it will power your home in an outage. Ideally, it will run all of the items in your home that are important to you. For me, it was the refrigerator, lights, computer and internet, and television. You should make a power budget, which you can get from your electric utility (SCE for me) online, specific for your home. Greedier power consuming appliances include A/C, electric stoves, spas, anything with motors. During our 5 day off grid test, the weather was cool, so we didn't try to run the A/C, and it was fairly sunny. We used our dishwasher, gas dryer, gas range, lights, TV, computers, as we would when the grid was connected. A/C draws a lot of power and will probably need to be used sparingly when the grid is down. We have a small split duct A/C in our bedroom, which we should be able to power during the night-time. Another limitation is if it is cloudy and solar is insufficient to keep the batteries charged, they could run down in a few days. These considerations illustrate the importance of monitoring the state of the batteries so less important high power consumers can be shut down as needed.

A backup system can be quite expensive and to keep costs affordable, many installers put in a sub-panel, which only powers circuits that are most important to you. In our case, we power the entire home and will rely on monitoring (an manually optimizing our power use) to get through an outage.

During normal operation, with a connection to the grid, the current carrying limit (important for high power consumption devices like motors) is the capacity of the home's main electrical panel. On battery power, electricity doesn't flow from the grid through the main panel and it is limited by the inverters that convert the DC from batteries to the AC required by household appliances.

Status	Capacity	Surge Limit	Home Energy Source	Battery Charging
SCE Grid connected, normal operation	200 amps	200 amps	Solar & Grid	Grid or Outback charge over-ride
Outback Grid Reference, grid connected	33.3 amps	50 amps	Solar & Grid	Grid or Outback charge over-ride
Grid is down, system on batteries	33.3 amps	50 amps	Solar & Batteries	Solar

Table 1. Electrical current limits of my system. These are important when planning support for high current appliances like air conditioning, electric stoves, etc.

A motor draws a high current when it is starting (surge current), then less as it gets up to speed. Another high current consuming item is an induction stovetop, which draw a lot of current for short periods of time. It is prudent to check the electrical specifications of appliances you hope to use during an outage. As an example, an ElectroLux **EW30IC60LB** induction cooktop requires a 40amp (at 240v) breaker, which exceeds the Table 1 limit of our system. However, a single cooking element draws approximately 16amps, so limited cooking is probably possible without blowing a fuse.

So, in summary, if you have high current appliances that you want to operate during a power outage, find the users manual or ask an electrician what it's surge current requirement and continuous power consumption is. An appliance may have a high surge current for starting, then relatively low power consumption while it operates. Or it may have high power consumption but you only operate it for short periods of time.

Getting bids:

The main thing is to try and get an idea of your requirements. You can invite a solar company to design a system for you, but you will need to decide on the appliances you want to power during an outage. A/C is probably the biggest power consumer. An electric stove may consume a great deal of power for a short time, but exceed the current limit for the inverters that convert the DC battery voltage to AC grid voltage it requires.

What kind of monitoring interface do you want? Most systems have an internet connected monitoring system that you access in an app, or browser. The most important parameters you will want to monitor are solar generation, home load, and battery state of charge. If you want these parameters to be accessible in an app or browser, for both grid connected and grid disconnected states, you should specify it in your contract.

Another specification that may be desirable is the degree of expansion the system can support. Since batteries are expensive, you may want to start small and add more batteries later.

Tax incentives:

There currently are 2 incentive programs (as of January 2020). There is a federal income tax rebate for the cost of your entire solar and battery system. It is currently at 26% and will be reduced each year. This may change. There is also a "Solar Generation Incentive Program" (SGIP for SCE: https://www.sce.com/business/generating-your-own-power/incentive-program) funded through California and managed by your utility. You can get calculators at your utility's web site. The amount is dependent on the energy storage (KWh) of your batteries and the maximum current that can be extracted from them by the utility. In my case, the 33.3 amp limit reduced the amount to 25% of the maximum. The utility also has specific requirements on how you set up your system to use your batteries to reduce peak loads. The installer should be responsible for filing the application for the SGIP incentives. Sun Pacific hired a specialty firm to do the submission.