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CASE STUDY

Living Off-Grid

Melinda and Ezra Auerbach began living off grid on Lasqueti Island in the 1970's. Since then, their lifestyle has literally evolved from kerosene and candles to dishwashers and Wi-Fi. Their journey is similar to thousands of other early PV adopters with the exception that they are also PV industry pioneers. They started their first solar business in 1986 and have been active in the industry since then. A result of this ongoing activity is an electrical system that is ever evolving and up to date.

There are a number of buildings on the homestead, so Ezra and Melinda decided to adopt an AC coupled micro-grid approach for their current iteration of the electrical system. The "grid" is serviced by SMA Sunny Island and Sunny Boy inverters. There are additional DC coupled PV inputs, that are managed by Morningstar Charge Controllers and a backup generator covers the PV deficit in the winter months where the system supports a 6 to 10 kWh daily load. Ezra explained, "Our loads are larger than average. We use a lot of power keeping the internet up all the time, have large draw appliances and in addition to supporting our own refrigeration needs we also provide power for two neighbors freezers. The load varies so much because we try to use electricity to cook and heat water as much as possible during the summer months when sunshine is abundant."

In May 2017 the Auerbachs installed a 390 A/h (18 kWh usable to 90% DOD) Discover AES (Advanced Energy Systems) Battery Bank. It replaced a 750 A/h flooded lead acid battery (18 kWh usable to 50% DOD). Ezra stated, "We have always used lead acid batteries, and they have proven to be reliable, although their charging and discharging efficiency is low which really adds to system losses. The 60 to 65% two-way efficiency we typically see with these batteries is really noticeable when PV resources are scarce or when we are running the generator."

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PROJECT HIGHLIGHTS

Battery
42-48-6650 Advanced Energy System (AES)
48V Lithium Ion Battery providing 19.95kWh of total energy

Application
Off-grid home

Charge Controllers
- MS MPPT 60/600TR (60 amp 600 Vdc input)
- MS MPPT 60/150 (60 amp 150 Vdc input)

Battery Inverter
- SMA Sunny Island 6048 (6 kW)
- Solar Inverter(s) Sunny Boy 2000

PV
- 2 kW Phonos modules (shop)
- 2kW Sharp modules (house)
- 1.2 kW Mitsubishi modules (pole mount on house)

Generator
- 8kW Kubota (1800 rpm)

Customer
Melinda and Ezra Auerbach

Location
Lasqueti Island, BC, Canada

The Auerbachs installed a 390 A/h (18 kWh usable to 90% DOD) Discover AES Battery Bank, replacing a 750 A/h flooded lead acid battery (18 kWh usable to 50% DOD).

A battery replacement was due before the winter of 2017/18, the existing bank had been through thirteen winters and while still working well, their capacity had visibly diminished.

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>
> Melinda Auerbach

Melinda quoted, “I was cautious and a bit dubious about making the switch to AES batteries. I knew we were going to need new batteries and I assumed we’d replace them with the same ones which had provided such good service to us”. It took a bit of convincing on Ezra’s part, and the deal they agreed upon was that the new batteries could be installed but the old ones had to stay behind.

“I can’t count the number of different inverters, charge controllers, and meters he’s tried out over the years, but the batteries are mine, I look after them and they keep everything running. I wasn’t anxious to risk any loss of power to ‘new technology’. As usual it was the human connection that gave me the confidence to let him install them” Melinda explained.

Melinda learned that Discover, that makes the AES, was based close by and had senior employees that have extensive experience with the unique demands of off grid residential application. “Knowing that people that I’ve known for decades were supporting these batteries helped a lot. They know perfectly well, how critical keeping the lights on are for us.”

The AES batteries installed at the Auerbach residence have a two-way efficiency that is over 95%. The increase in charging efficiency was most notable to Ezra and Melinda.

“The increase in charging efficiency was so evident that it was like discovering MPPT all over again.” Ezra claimed. They also noticed another significant change in system behavior, which is the stability of operating voltage range of the AES batteries. Melinda added, “I was used to seeing as much as a 10-Volt swing with the old batteries, the voltage barely changes on the new ones, even when I turn on the toaster and coffee maker at the same time.”

It didn’t take very long for Melinda to gain confidence in the AES batteries, one month after they were installed she agreed to have the old batteries removed from the shed. “We’d been through a bit of cloudy weather and I could see how much better they performed than the old batteries.” She also appreciated that there were three batteries, each of which was 48V. “For me that really lowered the likelihood of catastrophic failure. All three batteries breaking at the same time seems pretty unlikely.”

Previous to the installation of the AES batteries the automatic generator control was managed by the SMA inverter. Ezra explained “Most of my life I’ve managed generator operation manually. This means, look at the meter on the wall, go out start the generator, come in, wait a few hours, look at the meter some more, go back out and turn it off. It works well but has its limitations, particularly on cold stormy nights.” A few years ago, Ezra was helping automate the generator starting for the local health centre. They had the same SMA Sunny Island inverter as he did, so he was determined to learn how the system worked. “The only thing I could do was to use my system as a test bed so I hooked up the auto start from the inverter to my diesel generator.”

It didn’t take long for Ezra and Melinda to begin to truly appreciate the benefits of having the generator start and stop on state of charge parameters. Melinda stated “It actually worked much better than I expected and it makes going away in the winter a bit easier, knowing that the generator will start if the batteries get too low.”

Ezra then went on to say "The Sunny Island is a great inverter charger, but like most products of its kind, the battery state of charge values are approximations, rather than calculated. Therefore its not uncommon to have erratic generator stops and starts.

The AES batteries installed at the Auerbach residence have three communications ports. They provide a variety of ways to access detailed battery information including the actual state of charge. Using his laptop computer, Ezra is able to make direct connection with each battery. This allows him look at each battery individually, for detailed real time and historical performance information. The Auerbach batteries have the Xanbus communications network protocol enabled which allows them to see their performance as a single battery bank.

The availability of the Xanbus network allows them to use the ComBox and other accessories from the Schneider XW platform of products. This means that there is easy web based access to system performance and controls. In addition to the AES batteries, the Xanbus network at the Auerbach residence consists of the following Schneider XW equipment:

- System Control Panel (SCP)
- ComBox for network accessible metering and control
- Automatic Generator Start (AGS) for generator start control

The SOC input for the AGS comes directly from the AES batteries. This is one of the most notably different features for Ezra. "To have a battery that is capable of 'feeding itself' by starting and stopping the generator without any external guess work is a game changer. It's more or less like having an autonomous battery".

At the end of September 2017, the Auerbachs wanted to put the AGS to the test. With winter approaching, they needed to be sure that the system would work as they expected. They have the automatic generator start threshold set to 40% SOC. "I understand that we could take the batteries to a much greater depth of discharge, but I prefer to keep a healthy reserve of power just in case something goes wrong. The generator could not start, the fuel barge could be stuck in bad weather, any number of things like this can and do happen. That's why I don't like to go to empty." Melinda stated.

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> Ezra Auerbach

It took a couple of rainy days in a row and some extra cooking and dishwasher action to bring the batteries low enough to trigger the auto start. "It worked perfectly". Stared Ezra, who went on to explain, "The batteries reached the 40% SOC threshold sometime during the night but because we have quiet time set to end at 8:00 a.m. the generator did not start until then. At exactly 8:00 the generator started, it ran until the batteries had reached 60% SOC, our generator cut off point, and turned off." "I am so thrilled to have the AGS controlled directly by the batteries, finally a system that doesn't depend on guess work to determine SOC values".

Since the batteries have been installed the things that have impressed the Auerbachs the most are; efficiency, voltage stability, and communications. "We are used to having our inverters and controllers on our local network so we can monitor their performance but it's amazing to have the batteries on the network too. I really like getting SOC information that I can really count on" shared Ezra.

One of the characteristics of AES batteries is their charging profile, unlike lead acid batteries they do not require a lengthy absorption cycle. Ezra and Melinda are expecting that the combination of higher efficiency and no absorption cycle will result in considerably reduced generator hours over the coming winter.

"As we move into the dark rainy season we are seeing that our expectations of lower fuel costs are being borne out. We are very happy with all aspects of these batteries so far and saving us some diesel dollars is truly icing on the cake," Ezra mentioned.

As a closing note, Ezra explained that he wrecked another favorite shirt moving the old lead acid batteries out of the shed. "Hopefully that's the last one ever."

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My confidence in this technology continues to grow: Ezra Auerbach

Update: October 2017 - January 2018

The Auerbachs have gone through the darkest and coldest part of the winter with their Discover AES $LiFePO_4$ batteries. From October 21st to January 21st, Ezra and Melinda Auerbach reduced the generator run time by more than 50%.

"We ran the generator for a total of 90 hours, a shade under one hour per day." In past years, he mentioned, the system would require the generator to run for 4-6 hours every second or third day.

"This year we added more freezer capacity that uses about 1 kWh per day and yet we are still seeing such dramatic reduction in generator run time. If we were comparing last year's load profile with this year we would be running the generator even less. This is really big for us, it costs about $4.00 per hour in fuel cost to operate the generator so cutting the run time in half represents significant savings in annual operating costs," mentioned Ezra.

He explained that there are three primary reasons for massive reduction in generator use: ability to operate for extended periods at partial charge, battery efficiency, and charge acceptance.

The fact that a full charge doesn't need to be achieved according to a schedule means that finish charging never has to take place with a generator running. Discover AES $LiFePO_4$ batteries, with AEON© cycle life technology, can be continuously operated in a partial State of Charge (SOC).

"Knowing that I didn't need to finish charging the battery to maintain its health, meant that we could wait for the odd sunny day when we were sure to run the generator in the morning so the sun could finish the charge during the afternoon," said Ezra.

The Discover AES $LiFePO_4$ batteries can accept a continuous 1C charge rate from 0-100% SOC (by comparison a healthy lead acid battery may only be charged at a C10 rate).

When using a generator, the entire time that it's running the inverters maximum charge rate is being applied to the batteries. If the system is well designed with respect to a match between the generator and the inverter/charger, the generator can be run at optimum load whenever it is being used to charge the batteries, maximizing the efficiency of fuel utilization and provide the additional benefit of extending the generator's service life.

The two graphs show the difference in generator runtime to achieve the Auerbach's electrical demand on a typical winter day. *Graph 1* demonstrates the generator runtime that is wasted in the absorption

MISER©

MISER© saves Ezra and Melinda at least 15% of their stored energy capacity, each and every time they cycle their system when compared to high quality, lead acid battery options.

AEON©

AEON© cycle life technology means the Auerbach's batteries can be continuously operated in a partial state of charge, or discharged to 0% SOC without consequence.

portion of a lead acid battery charge. *Graph 2* shows how effective the Discover AES $LiFePO_4$ battery is at "partnering" with a generator for fast effective energy replenishment.

The BMS and charge control system of the Discover AES battery optimize the charge current and voltage to safely recharge the battery at the highest and most efficient rate regardless of its SOC.

RAPI-CHARGE©

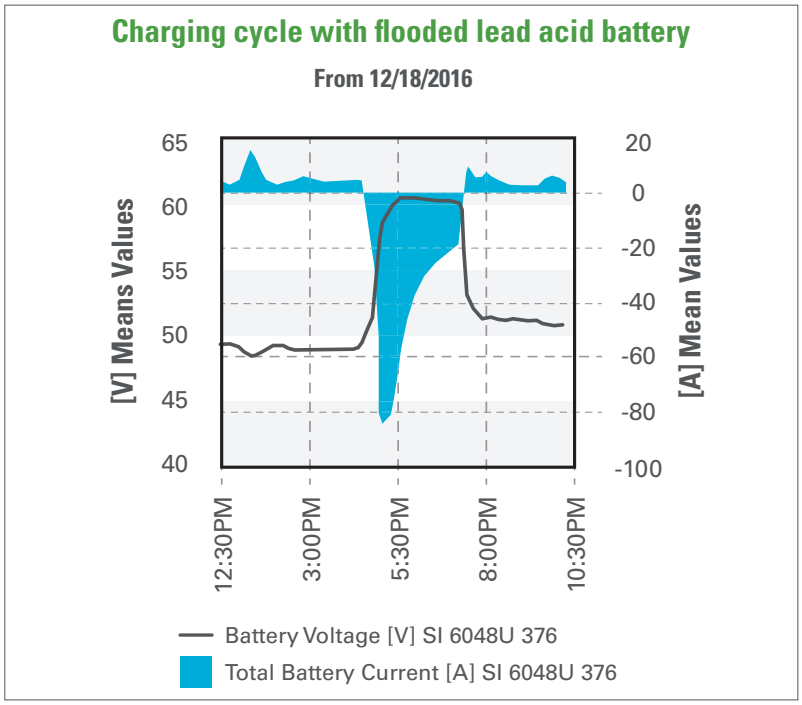
RAPI-CHARGE© charge source optimization allows the Auerbach's Discover AES $LiFePO_4$ batteries to fully recharge between 5 and 10x faster than their lead acid batteries.

"The increased battery efficiency that I observed stayed true throughout the winter. The speed at which they increased their SOC when the generator was running was amazing," stated Melinda Auerbach. The inverter, she added, has a *'Run generator for 1 hour'* setting which they used for most of the winter. "Keeping the batteries charged and looked after was easier than ever before."

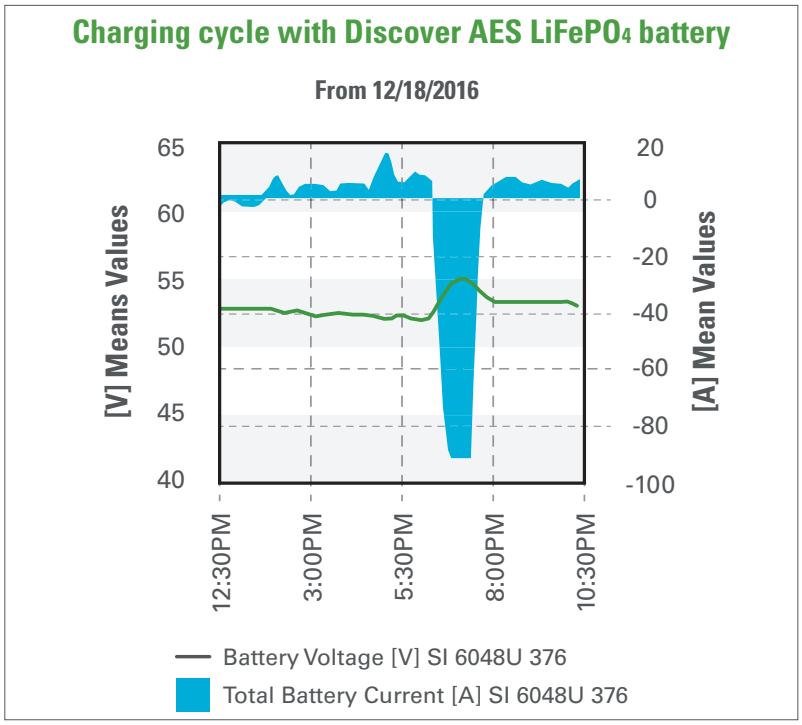
For Ezra was easy to summarize his first winter with Discover AES batteries: more daily kWh and less generator runtime.

"My confidence in this technology continues to grow. We had a cold spell and our batteries didn't *shrink* like the lead acid used to. There was no change in performance during the below zero weather, and nothing in the way the batteries behaved over the past eight months has caused me any concern."

The Auberbachs have put the Discover AES batteries to the test and enjoyed their benefits and performance. If you would like further information, or want to switch from lead acid batteries to Discover AES batteries, email us at info@discoverbattery.com



Graph 1. Charging cycle with flooded lead acid battery. The majority of the time the generator was running was at half load or less. The actual generator runtime is approximately 2.5 hours with only the first 30 minutes being full bulk charge.



Graph 2. Charging cycle with Discover AES $LiFePO_4$ batteries. Almost the entire time that the generator was running at it's maximum current. The runtime is just 1 hour instead of the 2.5 hours charging cycle with lead acid batteries. NOTE: The capacity being replaced (the load) in this 2017 analysis was approximately 20% larger than the load being replaced in 2016.

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