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Using Solar and Batteries to Weather Hurricanes: A Case Study

FSEC-RR-667-25

October 8, 2025

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Using Solar and Batteries to Weather Hurricanes: A Case Study

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Updated: October 2025

Abstract

This case study examines the use of a residential solar photovoltaic (PV) system coupled with battery storage to maintain energy services during and after a major hurricane. Based on real operational data from Hurricane Dorian (2019) in Cocoa Beach, Florida, the study documents system preparation, performance during grid isolation, and post-storm recovery. The 6-kW rooftop PV array and two Tesla Powerwall 2 units (27 kWh storage) supported the entire household for five days without grid power. The system powered critical loads including refrigeration, air conditioning via mini-splits, lighting, and electric vehicle charging. The paper highlights strategies such as thermal pre-cooling, load minimization, and daytime energy use management. Broader implications are discussed for grid resilience in hurricane-prone regions, including the potential of vehicle-to-home integration and the evolving role of residential battery systems in utility operations.

Introduction

Florida faces some of the most severe hurricane threats in the United States. Historical storm tracks show the state as a frequent target for major tropical cyclones, and statistical analyses of satellite-era data reveal a steady increase in both tropical storm and major hurricane frequency since 1967. These trends, coupled with the state's growing population and reliance on centralized power infrastructure, make extended grid outages during storms increasingly likely. Similar vulnerabilities have been observed elsewhere in the U.S., including the 2021 Texas winter storm, California's wildfire-related Public Safety Power Shutoffs (PSPS), and major Atlantic hurricanes affecting Puerto Rico and the Carolinas. Residential PV and battery systems offer a promising pathway to maintain critical household functions during outages, yet most PV systems in Florida remain grid-tied without storage.

Given the paths of past hurricanes, there is reason for vigilance. Florida is right in the zone for tropical storms moving north from the tropics. Examination of tracks for September, as shown in Figure 1 suggests many hits by major storms, and many near misses:

[1] Parts of this exposé appeared in *CleanTechnica.com*, and is used here in a modified and updated fashion. Updated by permission.

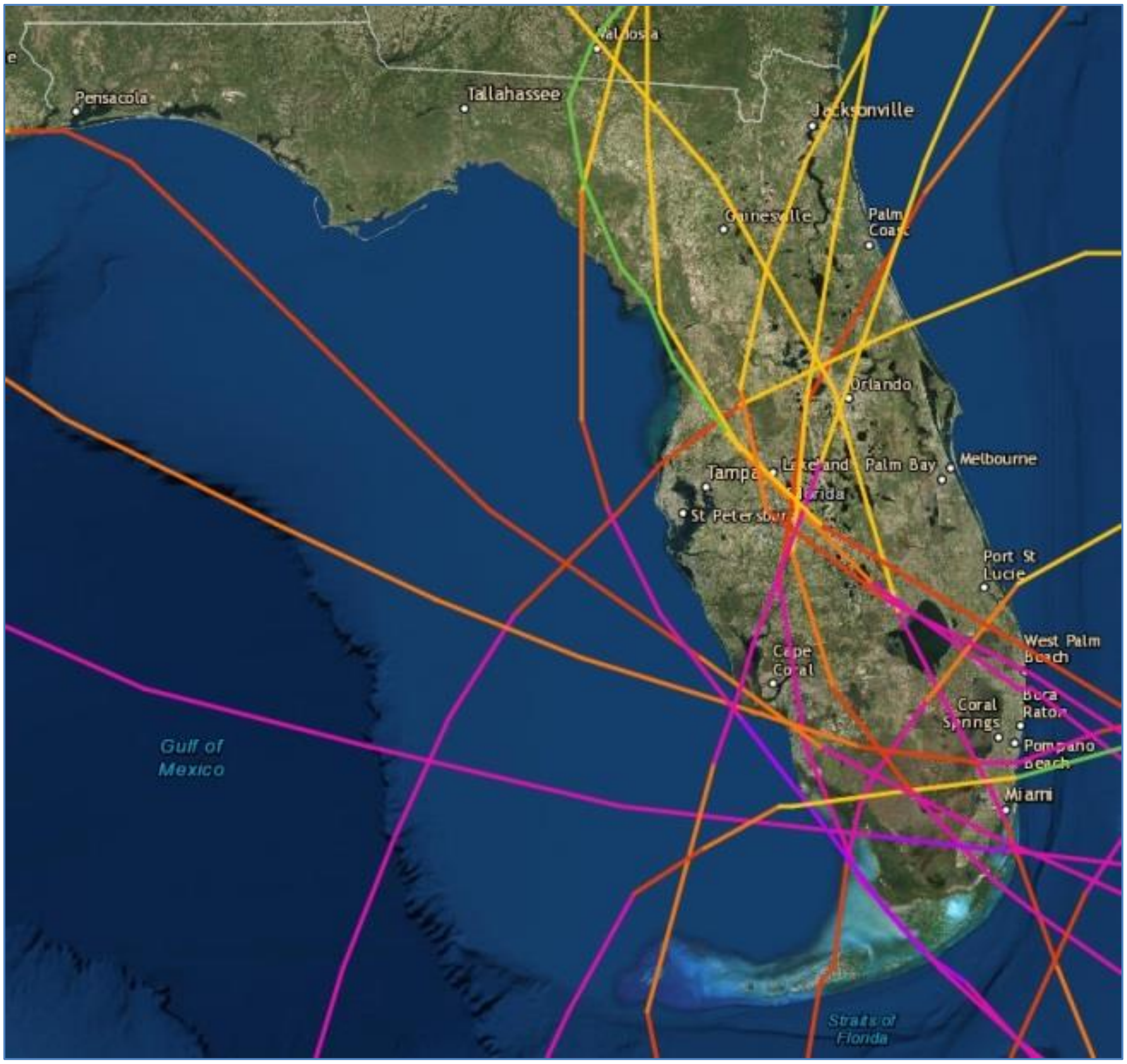

Figure 1: Hurricanes striking Florida last century with many more tropical storms and near misses. (USA Today w/permission)

Also, although the changes are scarcely perceptible to the population, the frequency of tropical storms, hurricane and major hurricanes in the Atlantic are growing. Figure 2 shows the frequency of these storms during the consistent satellite era. A dashed line shows the ten year moving average of major hurricanes over the period.

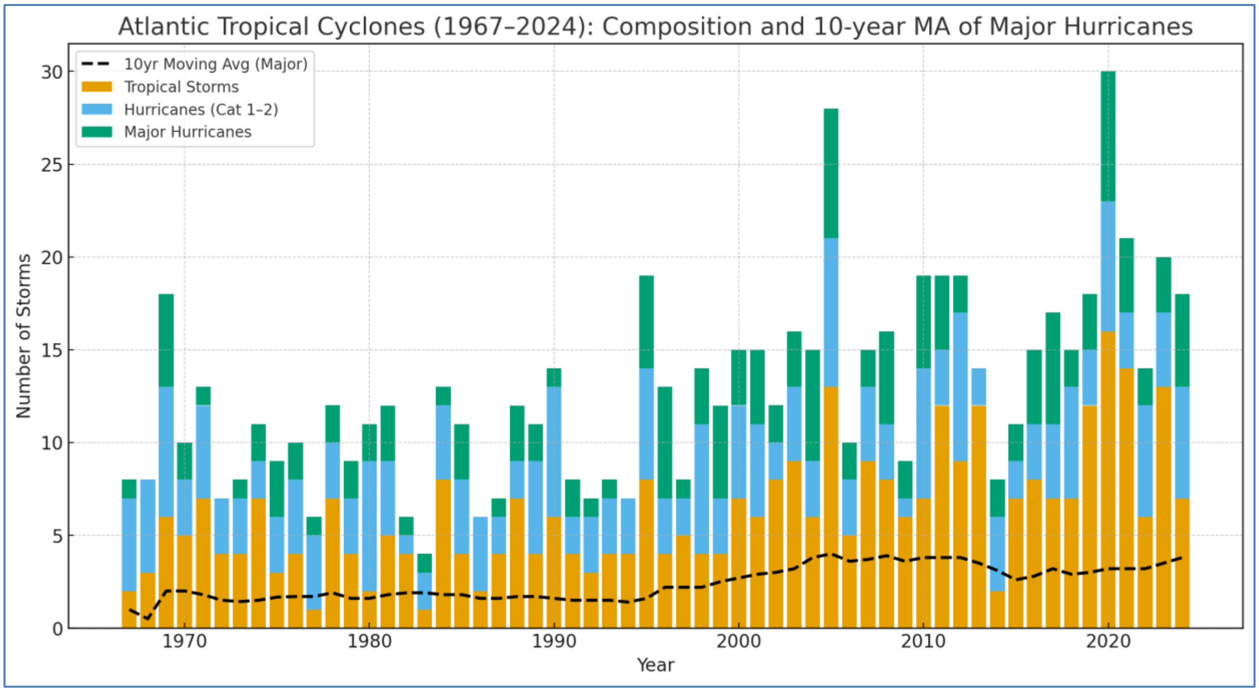

Figure 2: Frequency of Tropical Storms, Hurricanes and Major Hurricanes in the Satellite Era (1967-2024)

The trends are starkly revealed by a simple data examination using classical statistics. On average there is one additional tropical storm seen every six years since 1967 with another annual major hurricane seen every twenty years. This means that 2024 has about nine more annual tropical storms than was seen in the 1960s. Similarly, recent data shows 2-3 major annual hurricanes that were not experienced sixty years ago. The changes are significant in a statistical sense but not obvious to the overall population since the changes are generational.[2]

The year 2019 was not kind from a storm perspective. Hurricane Dorian was a massive killer storm. It is tied with the 1935 Labor Day hurricane as the most powerful Atlantic cyclone to make landfall in history. With sustained winds of 185 mph that gusted to over 220 mph, Dorian was by far the strongest hurricane to strike the Bahamas. Through the grim job of combing through the wreckage in the Abacos is it was learned that hundreds died with many missing and some swept out to sea. The humanitarian disaster there was nearly unfathomable.

Dorian has deeply scared the islands for decades. Each year risks another such disaster. In 2018, it was Hurricane Irma. In September 2017 it was the devastation to Puerto Rico from Hurricane Maria. One year after another, Florida is under threat from hurricanes and not only Florida, but Louisiana and Gulf region as well as the Carolinas in the South.

At FSEC, we have specialized in studying how to greatly reduce space cooling needs and overall residential energy use in Florida's tough hot-humid climate. On our home, we have a white metal roof, solar control windows and good insulation, efficient lighting and appliances and solar hot water too.

[2] There are other episodes of power interruptions: earthquake, storm or wild fire. For instance in February 2021, 4.5 million Texas customers were without power for days due to problems with an ice storm and gas supply constraints. From October to November of 2019, well over a million California customers were without power due to Precautionary Public Safety shutoff during dry conditions of high wildfire risk. In 2017 Hurricane Irma placed over three million Florida residents without power; in 2017 over a million were without power in Texas due to Hurricane Harvey.

There are many actions which homeowners can take if they wish to reduce their consumption. In Florida in summer, there is the constant summer threat of hurricanes.

On my our home we have had a 6 kW solar electric photovoltaic or PV system on my roof for the last 20 years. Each year it reliably pumps out about 23 kWh per day and sends it back into the grid. Generally, we produce about as much power as we use over the year which mostly zeros things out with net metering. The problem has been that when a hurricane comes through and knocks down power lines and the grid we have no electric power, even though the solar electric system is operating fine. In spite of five hurricanes interrupting power over the years, it has functioned reliably. In fact, studies show that unless a roof is lost that most roof-top PV systems operate reliably after hurricanes.[3] However, if the grid is down the inverter properly shuts off when there is a power interruption to protect linemen working to restore power. This creates the fundamental paradox of grid connected PV systems in a power outage—lots of power and no way to use it (Belding et al. 2020).

Figure 3: Home in Cocoa Beach: Solar hot water, PV pumped pool and 6 kW PV system.

A large complaint in the wake of Hurricane Irma was that individuals who had installed solar electric PV systems were unable to use that solar power when the grid was down. As described elsewhere, the PV systems themselves almost universally survived the storm if roofs survived. Generally, homeowners have spent thousands of dollars for a PV system, but even the storm clouds parted and the sun came out over rain soaked streets, they are unable to use the electricity being generated by the PV modules. This problem is seen with all PV systems without

[3] Alex Langon, *Will Your Solar Panels Survive the Next Hurricane?* Energy Sage, 18 Aug 2025. https://www.energysage.com/news/solar-panels-withstand-hurricanes/

battery back-up. Off-grid systems with battery backup can work well when the grid is down after power interruption, but the vast majority of the roughly half a million PV systems in the U.S. are net-metered, but without batteries. However, this problem does not extend to all grid-tied systems.

Some SMA "Sunny Boy" inverters feature its *Secure Power Supply (SPS).* This is an add-on component that allows two 120 Volt plugs from the inverter during a power outage that provides up to 16 amps of loads (2000 Watts). Post Irma, many of those in Florida with these systems were able to plug in refrigerators, phones and fans when the sun was up. *A key recommendation to those installing net-metered PV systems in Florida is that these systems should be preferred unless battery backup systems are installed.* In 2019, the SMA inverters with this feature were the TL-22, TLS-US or the US-40 inverters.[4]

After Hurricane Irma my household was with without power for six miserable days; no refrigeration, cooling or lights. And meanwhile we had PV on the roof capable of generating twenty or kilowatt hours each day, just sitting there mute and non-productive with no one able to use the power

Being without electricity for most of a week, we installed two Tesla Powerwall 2 battery systems in the car port so that in the event of power interruption we can still use the batteries and the PV system to potentially operate the house and main power systems assuming that the roof and PV system survives. In winter 2019, we obtained bids for two power walls to be installed at my home.[5] A professional crew from Tesla- Orlando came in May to install the system. This went without a hitch and it was all installed in a single day on May 22nd 2019. The total cost turnkey was $18,100 which included two Powerwall 2s, the required wiring, the gateway with the inverter and the full installation.[6]

It is possible to install a generator for less than a $1000, *but as seen in Puerto Rico in October 2017, what happens when you no longer have gasoline easily available*? There may be long lines.

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[4] Current (2025) SMA Sunny Boy inverters with a "Secure Power Supply" (SPS) component are the SB7.7-1SP-US40 and SB6.0-1SP-US41, which can be wired to a separate SPS outlet. It can provide up to 2kW of 120V power in SPS mode in case of a grid failure. In such a case, it must be manually activated via the provided SPS switch.

[5] The newer Powerwall 3 also has a 13.5 kWh storage capacity, but with better ability to handle higher continuous power output (11.5 kW) as well as short peak output (30 kW) for appliances with high in-rush current needs.

[6] The cost of installing a single Powerwall 2 with gateway and wiring would have been $11,600 in 2019. Price is higher in 2025. The cost of a single installed Powerwall3 in 2024 was $13,000.

Figure 4: Installation of two Tesla Powerwall 2s on 22 May 2019

The system includes 27 kWh of electrical storage that essentially islands the power within the house when the grid is interrupted. This means that both the PV we have on the roof as well as the full storage can be used in the case of a major power interruption. Because my home is quite efficient (using two low wattage mini-split heat pumps for cooling), we were able to tie in the entire home electrical service to the Powerwall so that theoretically it would be possible to operate the entire home in the event of a power outage.

A guiding concept was that during hurricane season we would use the close approach of a Tropical Depression during August and September (virtually assured) as a way of testing the system by disconnecting from the grid. My plan was to set the Tesla Power Wall to self-consumption (an available mode) at the height of the storm and then see if we could go for five days without grid power.

Needless to say, we had no idea that Hurricane Dorian would alter ideas of a simulated test to an active threat from a monster hurricane. It was not what we would have wanted—or even chosen. Instead, we had to contemplate leaving Cocoa Beach altogether and to use the potential to use the Tesla Power Wall to see if my home could survive the storm but also provide power in the event of an outage and keep house systems operating.

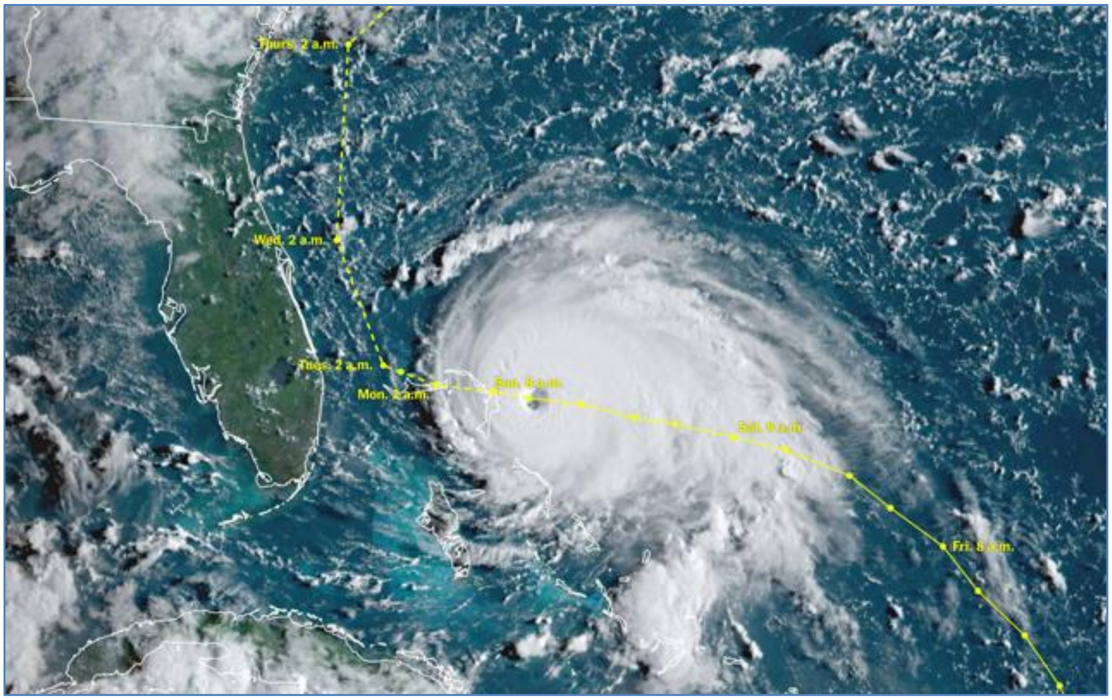

Figure 5: Forecast path of Hurricane Dorian, 31 August 2019 (NOAA, Track by NY Times)

On Thursday, August 27th while the storm was pummeling the Bahamas, we disconnected the 2nd refrigerator in the garage, (which uses about 3 kWh per day in the hot summer). We transferred contents to the main refrigerator. We then left the central mini-split set on to 78 °F inside and we ran the house normally, but with no car charging to see how we might do when powered down for a storm. The Tesla Powerwall app is very helpful to understand exactly how much power one is drawing at any given time, as well as how consumption progresses over a daily period.[7]

[7] Tesla has updated the Powerwall displays, but all functionality seen in 2019 remains, although with a somewhat different look.

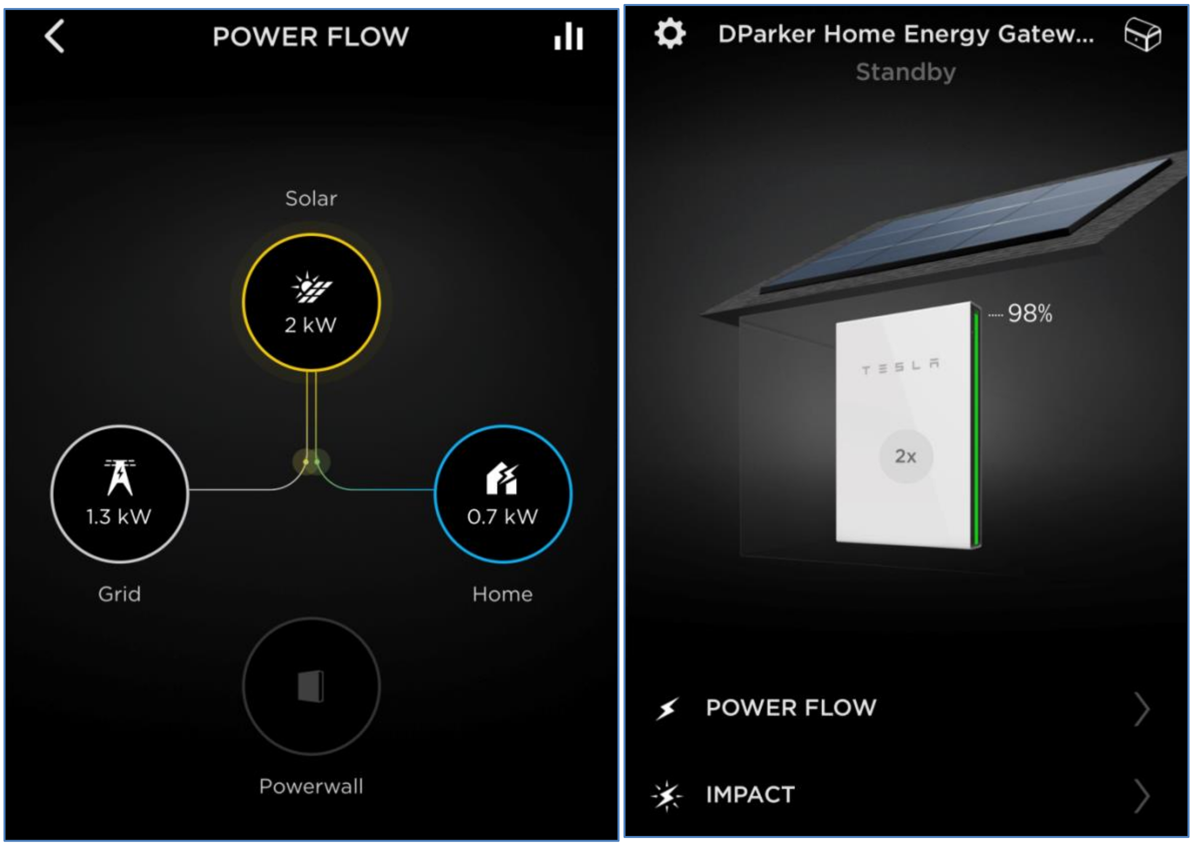

Figure 6: Powerwall app showing 2kW being produced by solar; 1.3 kW going to grid and the house electric load at 0.7 kW.

Essentially this test showed that we were able to get my home power use down to about 11.7 kWh per day—less than half what the two Powerwalls have available and half of what solar produced on that sunny day (23.5 kWh). That gave me faith that with some reasonably sunny days following the storm, the Powerwall and solar would be able to carry the household load. And even with cloudy days following, we should be able to last several days without any loss of household functionality.

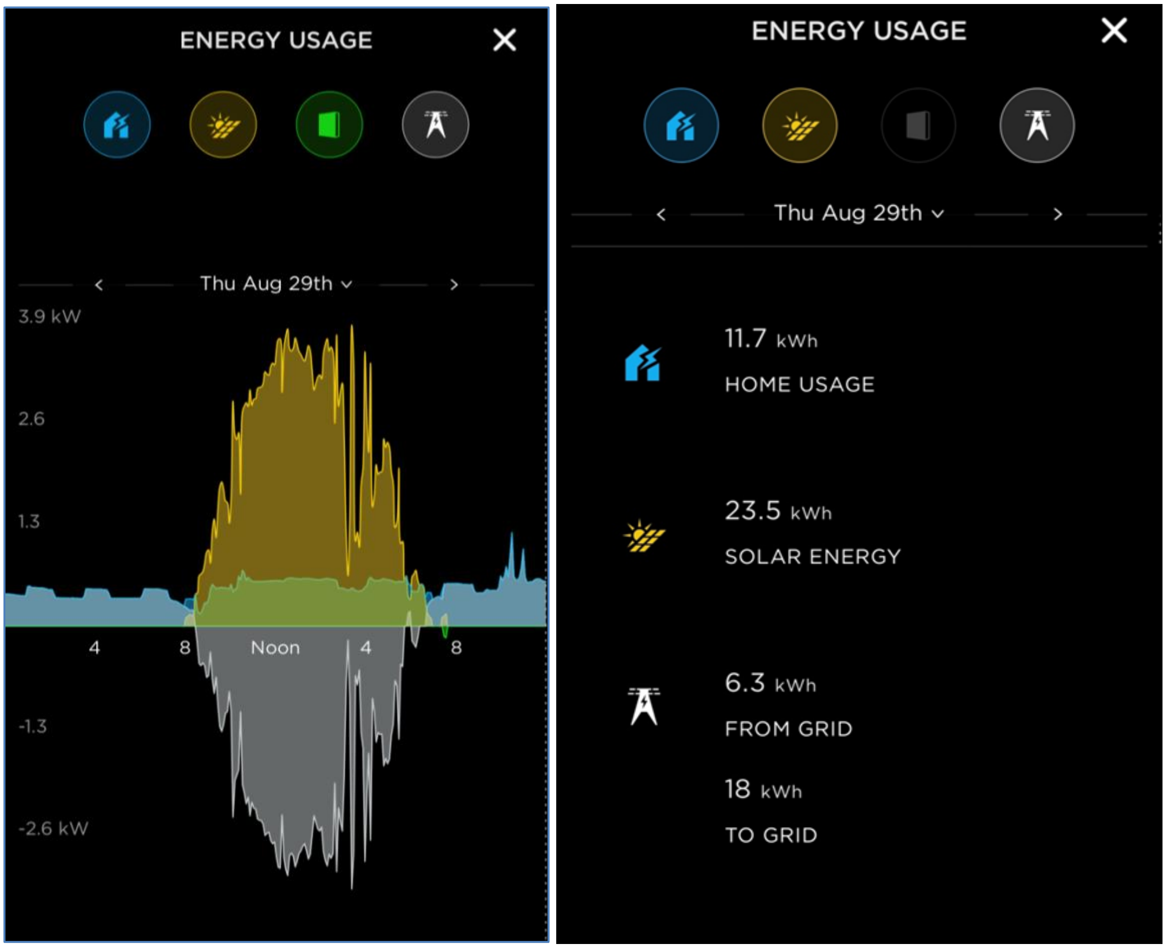

Figure 7: Measured house total loads on Thursday, August 29th. Blue is house loads in kW, white to grid, green to powerwall, yellow is solar output. The recurrent square-waves in house power is the home main refrigerator cycling.

Our household buttoned down: shuttered the windows, tied down everything and elevated possessions above the tile floor. We bunkerized the entire home with aluminum panels closing in the exposed porch. Alas, we are at risk on a barrier island and only about 600m from the beach. Hurricane Dorian was a monster and a killer. At the end of August 2019 the monster Category 5 storm stalled over the Abacos in the Bahamas with 180mph winds—smashing the entire islands with unimaginable destruction.

Figure 8: Lisa ties down her boats in the carport with the Tesla Power walls. She drives a Ford Cmax Energi with 20 miles of battery range (Level 2 Charger on the wall)

We prepared to evacuate. We charged up the Model 3 to its full range of 300 miles with home power as many gas stations around Cocoa Beach already had long lines or no gas at all. As with Hurricane Matthew and Irma years before, we prepared to escape to Gainesville, Florida to spend a weekend as storm refugees with Lisa's best friend. Watching the destruction in the Bahamas, we prepared to go.

Figure 9: Our home all shuttered and bunkerized.

However, Monday afternoon, 3 September, before we departed, two rather marvelous things happened: all of the forecast tracks for the storm began showing it passing well off the coast of Florida similar to Hurricane Matthew years before. Also, the storm intensity suddenly fell to a Level 3—still a major storm, but not the killer variety that is the dreaded Level 5 hurricane. Of course, we were still in the forbidden cone. What to do?

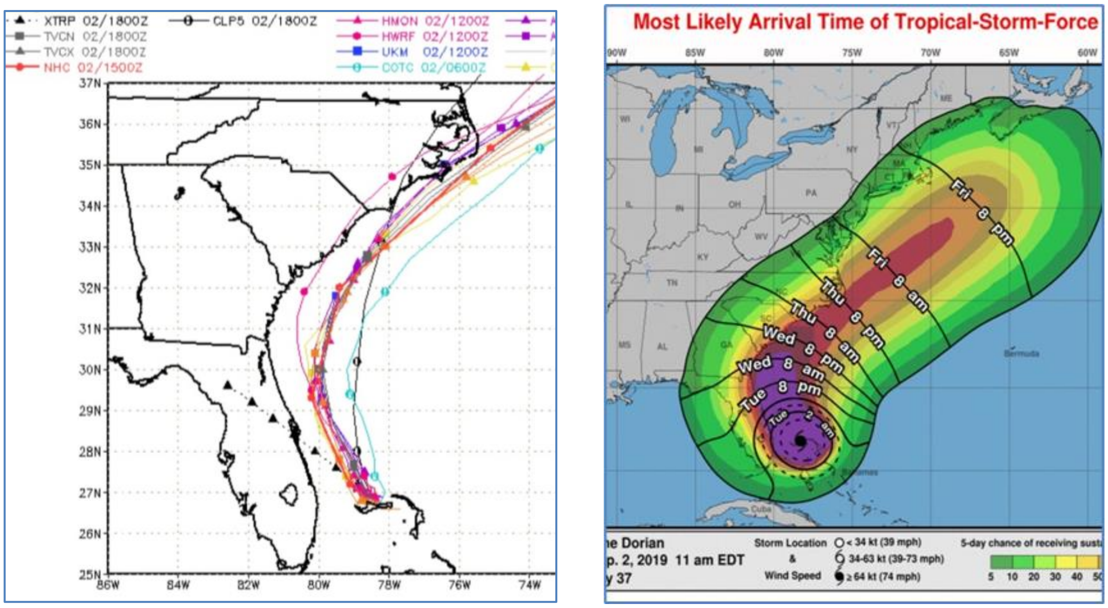

Figure 10: Forecast tracks of Hurricane Dorian and wind field afternoon of 2 September 2019

Although there was very reasonable concern to flooding, we recalled that with Matthew we did not have such trouble for our area. Indeed, when we had left to Gainesville ahead of Matthew, we drove north only to have that storm hit our place of refuge more completely.

So, at the last minute we elected to stay—as many of our neighbors did as well. I'll be honest here and tell readers that I don't recommend the decision we made as real storm surge associated with hurricane relate flooding can be a killer. *We made a calculated bet and don't necessarily recommend the same decision for others in similar circumstances.* <u>In other words, do what the NHC says, and not as we did</u>.

On September 3rd as the storm approached, we pre-cooled the house down by 2 degrees lower than normal by running the second multi-split system using grid power. In this case you are using the pre-cooled slab floor and sheetrock wall mass as a thermal battery for the house. If, and when power is lost, the interior is cool and dry. The weather was very cloudy and windy, but the PV system still pumped out 13.4 kWh against the 21.7 kWh consumed and even sent power back to the grid. Powerwall remained topped off at 100% capacity with 27 kWh in waiting. In the late afternoon, we carefully walked down to the beach and found ourselves nearly blown about by the winds. The surf was actually low, but the waves were frothy and angry. However walking back it was impressive how much lower the wind speeds were just a few hundred years away at our home , given the shielding effects of landscape and other buildings.

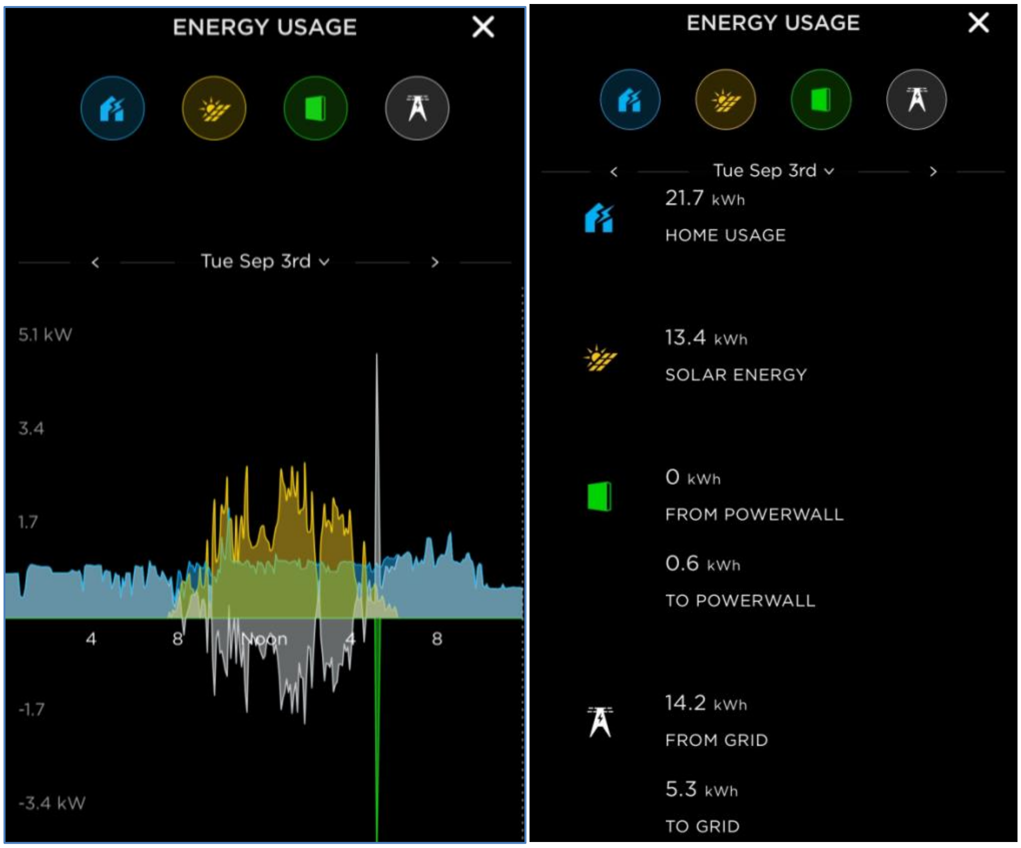

Figure 11: Performance of solar, grid, storage and home energy systems on 3 September as hurricane approached

On September 4th as the storm made its closest approach to Florida, winds picked up around our home all day. We have a small weather station one meter above our rooftop and we saw the highest wind speeds at approximately 5 AM. However, at rooftop, the peak gust was only about 30 mph (47 kph). At the beach, or at a 10 m weather tower height the peak wind speed would be much greater. At the nearby Cocoa Beach Pier, a peak gust of 53 mph was measured and with a gust to 81 mph was clocked at Playlinda Beach near Titusville

While the Space Coast dodged a bullet with Hurricane Dorian, we still experienced plenty of tropical force winds and a good soaking rain.

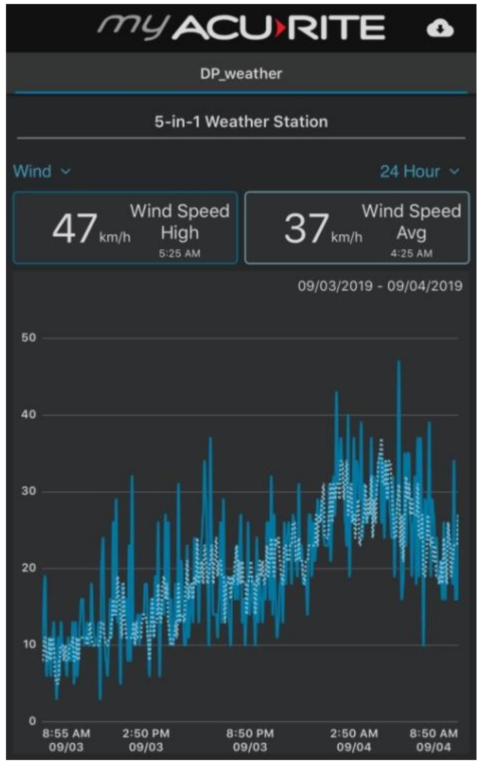

Figure 12: Measured rooftop wind speed on Sept 3-4 as Hurricane Dorian approaches (Author's home weather station)

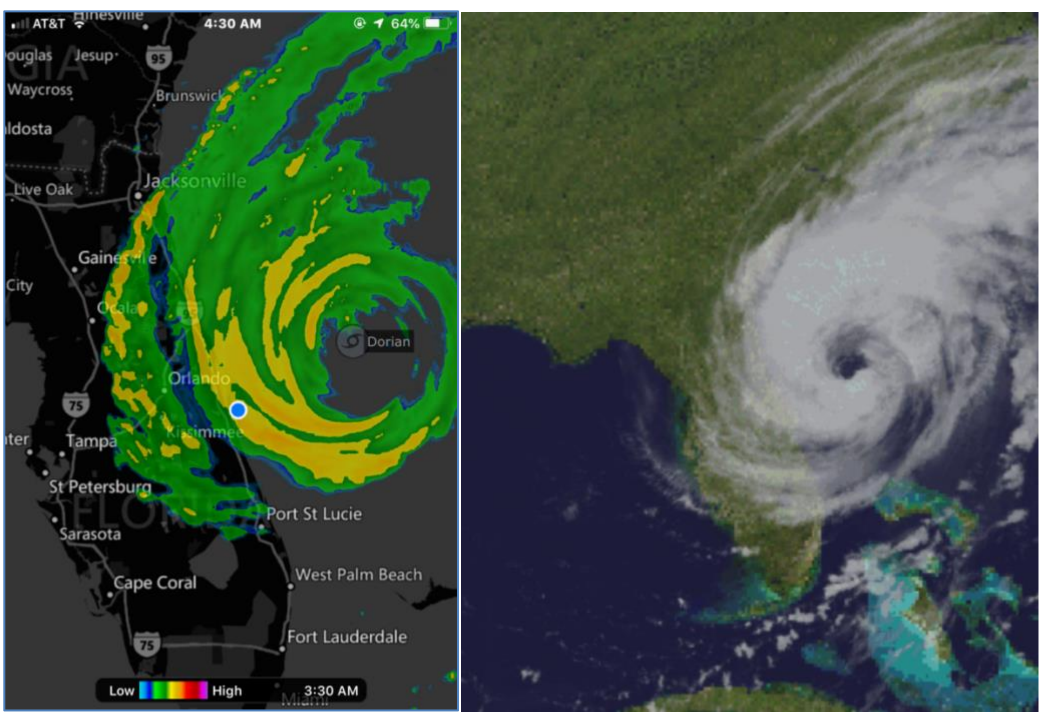

Figure 13: Hurricane Dorian passes by the East Coast of Florida on September 4th, 2019. Blue dot marks our location (NOAA)

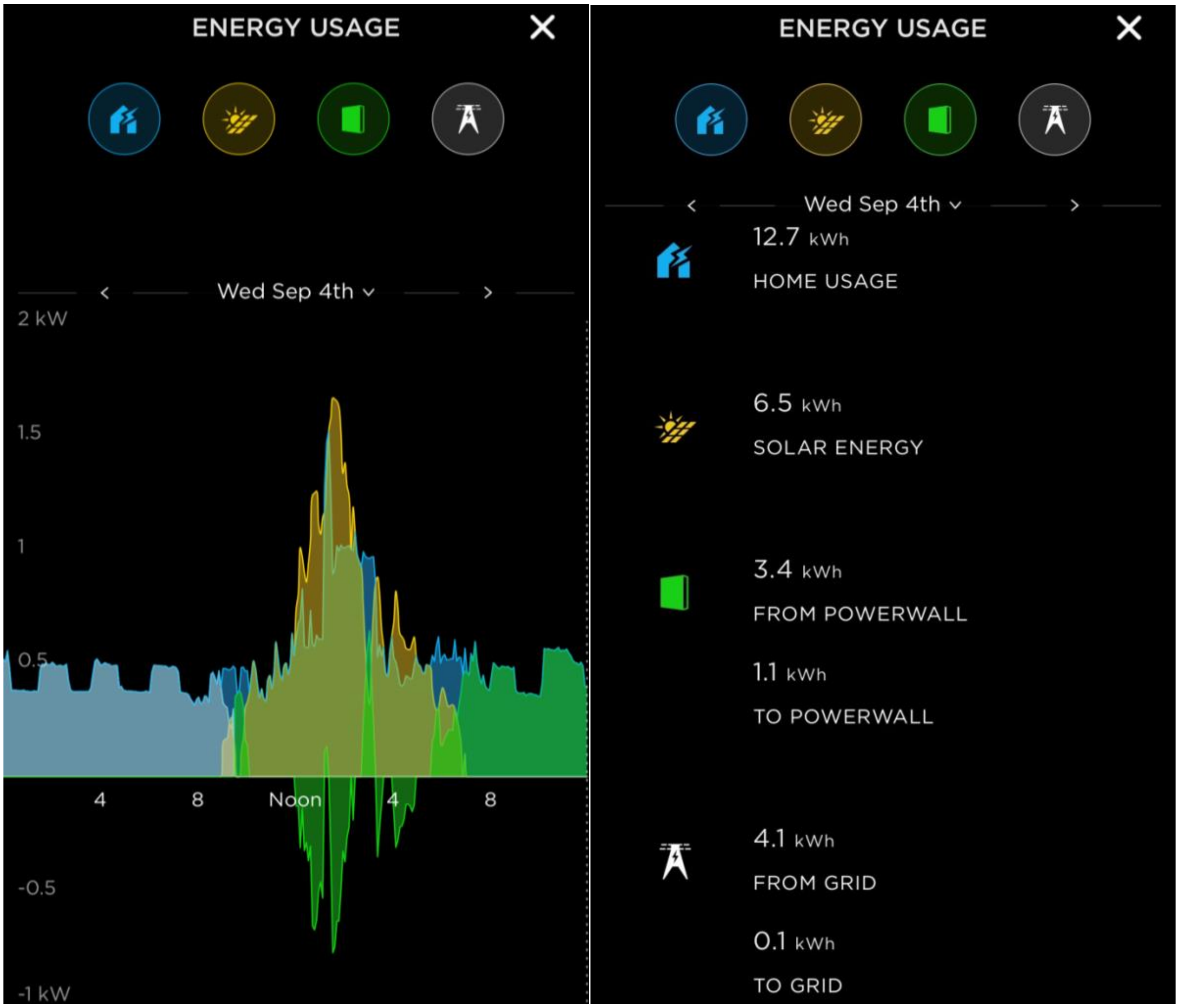

Figure 14: 4 Sept. 2019: Performance of solar & Powerwall system during Hurricane Dorian. Closest approach at 4 AM

As rooftop wind speeds fell from their maximum at 3-5 AM, it became apparent that we were not likely to lose power. We were also safe and there was no flooding at all. In keeping with my original idea for the experiment, we cut off grid power as if we had lost it. We set the Powerwall to "*self-powered*" at 9 AM which minimizes any energy from the grid and uses the storage as you would with power interruption. You can see that change in Figure 15 below. You can also see that for the remainder of the day there was no further energy brought in from the grid. The sun and Powerwall took care of all energy loads for the remainder of the day.

After the storm passed, on September 5th we kept the Powerwall on "self-powered" and found we had plenty of electricity to do all normal activities at home. As is often the case, after a hurricane passes, it draws in much of the regional atmospheric moisture leaving the wind flailed terrain with sunny, but terribly muggy days in its wake. However, we remained completely comfortable inside. We ran the central cooling mini-split 24 hours a day (maintaining 78 °F and ~50% RH inside), ran the refrigerator, had all lights, charging and amenities. And later during the evening powered up the 2nd multi-split system to cool the master bedroom for complete comfort.

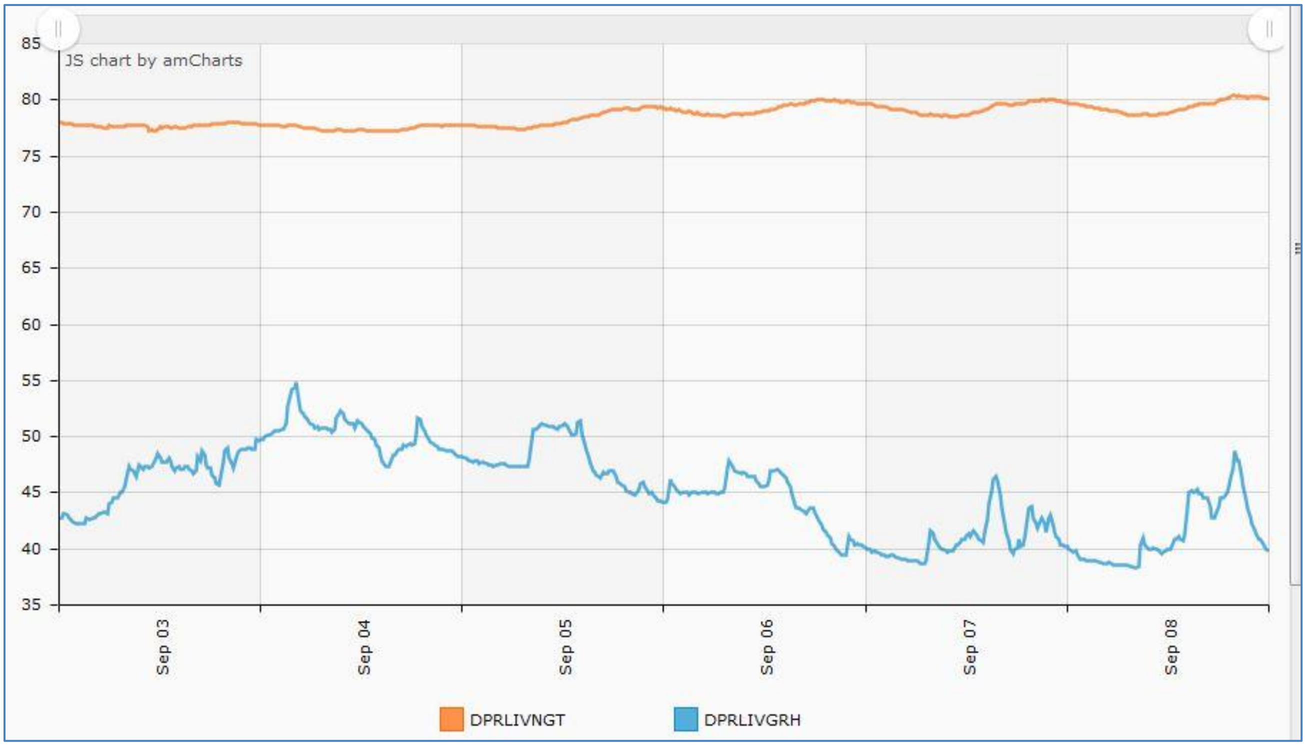

Figure 15: Interior temperature (orange) and relative humidity (blue) inside home from Sept-3rd - 9th, 2019 (Author's data)

It was still partly cloudy after the storm, but there was enough solar to bring the Powerwall back from 62% capacity to 100% by 1 PM on September 5th. For the rest of the afternoon when the PV system output was high—we had power to burn, so we used a Level 1 charger to top off both of the EVs at home in the afternoon, ran the dishwasher and ran the multi-split air conditioner. As the sun went down, we throttled back on the extras, but kept up air conditioning, computers and lighting.

Figure 16: Performance of solar system, home and Powerwall after storm

We continued like what you see on September 5th for four more days until the 9th September when we suspended the experiment and returned to grid operation. The morning status of the Powerwall was 41% to 62% of its 27 kWh capacity when the sun came up. We showed that even part sun conditions on cloudy days allowed the Powerwall to recover its capacity for the next night and day. Further, we found that even with a lot of mini-split cooling, we had power to burn during daytime hours and used that power to charge the two EVs at home, do laundry and wash dishes. And yes, with solar charging of the two cars at home, we were literally driving on the sun after the storm.

Table 1 summarizes the day to day performance, showing hour after 3 September that the combination of solar plus the Powerwall was able to meet all loads.

Table 1: Home, Solar and Powerwall Performance from 3 – 8 September 2019

Sept Date	Home kWh	Solar kWh	Powerwall kWh		Grid kWh	
			From	To	From	To
3	21.7	13.4	0	0.6	14.2	5.3
4	12.7	6.5	3.4	13.2	4.1	0.1
5	21.6	21.5	8.9	14.4	0.2	0.1
6	25.1	24.4	9.8	9.1	0.2	0.2
7	21.5	24.9	11	8.5	0.1	0.5
8	23.7	24.5	12.3	1.1	0.1	0.1

Figure 17: Using a Level 1 charger with solar the day after Hurricane Dorian to add range to a Tesla Model 3

Summary

We found that a homeowner with a typical size of solar system and back-up batteries can come through a hurricane that would knock out the grid. The household would be able to get along for five days or more afterwards. Such as system is designed to help guard against the miseries of a week-long post storm power interruption:

- Refrigeration: Without refrigeration, food is lost and the ability to feed a household is compromised.
- Lighting, fans and charging: One needs lighting to see, and modest amounts of power are needed for radios and phones. LED lighting does this for fraction of the energy needed for old incandescent types. Without air conditioning, ceiling or pedestal fans are a must as it is otherwise very difficult to sleep in hot, muggy Florida. Charging is important, both for cell phones and battery-powered tools. These are invariably needed to make the repairs around the house.
- Cooling: This capability to provide house cooling is close to the top over every post-hurricane survivor's list. Central AC systems are power hungry drawing 3000 – 4000 Watts of 240 Volt power which is out of the question for most generators. However, this is not true of mini-split heat pumps which provide cooling for only about 500-600 Watts. Indeed, by utilizing a central

supplemental mini-split heat pump, the household would have air conditioning and be able to operate normally after the hurricane has passed.

Lessons Learned

1) To get the most from your battery post power interruption, minimize electricity loads for the home, particularly during nighttime hours. Turn off unneeded secondary refrigerators and the main central air conditioning system. The Powerwall app is ideal for guidance as it provides second-by-second feedback on household electricity use.
2) Install a small high efficiency mini-split heat pump in a central location in the house. In a one ton size, these often only draw 400-600 Watts and can provide 24-hour cooling in the event of an outage. They can also save a typical homeowner significantly for cooling and provide a redundant cooling system (Fenaughty et al., 2016).
3) Install a high efficiency heat pump water heater with the idea during power interruption to run the system during daytime hours when solar availability is high but otherwise leave it off. You can control it on a breaker.
4) The larger the PV system installed, the more rapid will be the recovery of battery storage during the day. Users may have to use more of it during daytime. Run dishwashers, do laundry and charge cars during the day if you have excess.

Homes that have a modest PV system with battery backup can provide all these essentials with batteries to make it through the evening with daytime charging of electrical storage. Here are a few suggestions for Tesla and the utilities:

Tesla

- As the measurements are obviously at a greater resolution than 0.1 kW, it would be useful for users to select a resolution available regardless of what it is: e.g. 0.11 kW. This makes it easier to judge the power use of many things around the home that are less than 100 Watts.
- While a small 13.5 kWh single Powerwall would seem completely adequate back up for most power interruptions, imagine if Tesla could “unlock” 10-20 kWh of added storage from the vehicles in the case of a localized emergency. Dispatching this over the web would prevent the expensive car batteries from being routinely used but would then allow in emergency them to play an important role in augmenting the Powerwall. Thus, a single Powerwall could provide all the wiring and gateway components at the same time that a larger virtual power bank from the vehicle is available and there is an outage. This would seem to reduce costs for such systems while providing maximum consumer use of the expensive car battery.

Utilities

Florida’s utilities might be incentivized to encourage *PV systems with storage*. Currently, utilities are not enthusiastic towards home PV systems largely because of the loss of revenue from self-generated power. Instead, Florida’s utilities might be encouraging PV systems with electrical storage which the utilities could manipulate to smooth out loads under normal circumstances. This would be distributed solar with distributed storage which could help smooth out demand for utilities and homeowners alike. With possible future time of day pricing, this will allow for maximum flexibility:

https://www.utilitydive.com/news/the-value-of-customer-sited-storage-its-about-more-than-demand-charges-s/562528/

However, post-storm with no grid power, such home battery systems would be very valuable to those who own them. While Florida utilities are rapidly installing utility scale photovoltaics and producing clean renewable power and sell it to you, cannot help the consumer in the event of a power interruption from a storm

When the grid is down, solar electricity and battery storage that can provide assured power. This is true whether you are at risk of losing power from hurricanes, earthquakes, wildfires or other natural disasters. Certainly, it is possible to use generators fueled by gasoline, but are those supplies assured in your situation? And for prospects such as the long-term power interruptions in Puerto Rico? Such questions may bear critical examination for planning.

Sources

Scott Belding, Andy Walker, and Andrea Watson, *Will Solar Panels Help When the Power Goes Out? Planning for PV Resilience*, Golden, CO: National Renewable Energy Laboratory. NREL/TP-7A40-75704, March 2020. https://www.nrel.gov/docs/fy20osti/75704.pdf.

Emma Elgqvist, Gerald Robinson, *Solar Photovoltaic Systems in Hurricanes and Other Severe Weather,* NREL/FS-7A40-72099, 2018.

Karen Fenaughty, Danny Parker and Eric Martin, “Evaluation of Mini-Split Heat Pumps as Supplemental and Full System Retrofits in a Hot Humid Climate,” *ACEEE Summer Study on Energy Efficiency in Buildings*, American Council for an Energy Efficient Economy, , 2016.

Alex Langon, *Will Your Solar Panels Survive the Next Hurricane?* Energy Sage, 18 Aug 2025. https://www.energysage.com/news/solar-panels-withstand-hurricanes/

Selin Oguz and Jennifer West, “Ranked: Largest Power Outages in the U.S. 2013–2023,” Visual Capitalist, 2024. https://www.visualcapitalist.com/sp/ranked-the-largest-power-outages-in-the-us-2013-2023/

Tesla, *Powerwall 3 Datasheet*, 2023.