

BY TED CUSHMAN

The Solar Power Island



This 5.6-kilowatt solar array (top), combined with a Pika Energy battery and controller inside the barn (above), kept Hans Albee's house powered up during a recent statewide power failure in Maine.

Photos by Hans Albee

At the end of October last year, a major windstorm knocked out power to more than a million customers in the northeast United States. My own street, near Bangor, Maine, went dark as trees fell on wires at three locations between my house and the main road, just two blocks away.

Utilities in Maine took almost two weeks to get power back to all their customers; the linemen didn't reach the end of my road for 10 days. But the lights stayed on at my house, and my ordinary life continued on as usual. That's because my house is equipped with an 8,500-kilowatt propane-fueled Generac generator. As soon as the power from the street failed, the generator started up, and it ran continuously for 10 days. While tens of thousands of Mainers dined by candlelight, cooked with camp stoves, and took sponge baths from a spackle bucket, my family enjoyed hot showers and regular meals, and I kept right on working in my home office.

The solar option. A half-hour's drive away, in the little town of Brooks, Maine, homeowner Hans Albee had a similar experience. When the power from the street failed, Albee's backup system kicked in without so much as a hiccup. Albee, however, doesn't have a gas generator. Instead, Albee—a professional engineer who works for ReVision Energy, a major supplier of photovoltaic power systems in Maine and New Hampshire—has a 5.6-kilowatt solar panel array.

By themselves, Albee's panels wouldn't keep the house going around the clock—in fact, most solar panel arrays don't work at all when the grid power fails. But Albee's home is a special case, because the house also has backup batteries and a power control system, manufactured by Pika Energy, an energy technology startup based in Westbrook, Maine (pika-energy.com). The Pika Energy Island control system, paired with Pika's Coral battery, took control of the home's power and kept the lights on until the utility company came back on line. While the power was out on his road, Albee's backup batteries soaked up excess solar power during the day and fed it back to the house as needed at night.

Three flavors of solar. Solar electric power has been growing by leaps and bounds in the last few years. But most solar arrays installed on houses don't include batteries; they're the more economical "grid-tied" systems.

In a grid-tied setup, panels feed the electric loads in the house when the sun is shining; if the panels make extra power, it flows out to the grid and supplies other buildings nearby. In return, whenever the panels don't make enough power for the house, the house draws what it needs from the grid.

"Off-grid" solar power systems, which aren't connected to an electric utility, work differently. They require on-site batteries and a control system in order to function effectively as the stand-alone power supply for the house. The batteries have to be beefy enough to power the house through the night, and the solar array has to have enough capacity to charge the batteries during the day, while also meeting the daytime requirements of the house.

Unlike my propane-fueled generator, a solar array by itself can't keep a house running without batteries. A generator can ramp up or down as needed whenever people in the house turn the lights on or plug in a vacuum cleaner, but solar-panel output depends on the sun. As electricity production rises and falls in response to the sunshine, and residents turn lights or equipment on and off, the batteries and controller on the system play middleman, balancing the loads and the supply throughout the 24-hour day.

Setups like Hans Albee's, which have all three elements—solar panels (or "modules"), a grid connection, and storage batteries—are a third flavor of system. When a grid-tied photovoltaic array also has batteries, like Albee's, the possibilities proliferate. You could use surplus solar production to charge up the batteries by day, and draw the batteries down at night. You're also free to charge the batteries up any time, day or night, using grid power. For instance, if your utility offers a lower off-peak rate at night, you could store up power at night when it's cheap and use it later instead of higher-priced daytime power. In addition, if your array and your battery are sized appropriately, you can run as a freestanding power island whenever you choose—or whenever you have to, as Hans Albee did in the days following Maine's October wind storm.

The early adopter. A few weeks after the storm, *JLC* talked with Hans Albee to ask about his system and to learn a little more about the ins and outs of battery-equipped photovoltaic power systems (or, to use the solar industry's catchphrase, "solar+storage").

"We started out with a basic PV system in 2013," said Albee, "an ordinary grid-tied inverter with 13 modules, to meet our annual usage at the time. Over the next couple of years, our usage increased, and we wanted to expand the array. At the same time, Pika was interested in doing some beta testing with some of its equipment. We ended up getting some of the first inverters it produced. Then, when it started to bring its batteries to market, it wanted a place to put that battery in a real live situation as well. We were a willing guinea pig."

"So what we have currently," Albee said, "is a 5.6-kilowatt array (22 modules), and a 7.6-kilowatt inverter, the Pika Energy Island, and the Pika Coral battery. The Coral is a sealed lead-acid absorbent glass mat (AGM) battery. We chose that type of battery because our batteries are in an unconditioned barn, where it's cold, and the lead-acid batteries handle that better than some other kinds of battery. We also

get a little bit higher power out of the lead-acid; the Coral has about 15 kilowatt-hours of total energy storage, and it can produce 8 kilowatts of continuous power and up to 12 kilowatts peak output."

How long could Albee's house function in a power failure? "The short answer," said Albee, "is forever—as long as the sun keeps shining. We can use more energy in summer than we can in winter, just because there's more sunshine. But we can run as long as the batteries are functionally serviceable. The inverter should last for 20 years, and you can get 30 or 40 years out of the panels. You would never have to connect to the utility again. It's more convenient to hook to them, but I don't have to."

Flexible options. Even when a house is connected to the grid, batteries give the customer more freedom of choice. "Having storage adds quite a lot of flexibility to an ordinary grid-tied system," Albee explained. "It allows the owner to have a lot more control over when they are a producer or a user of energy. With a grid-tied system, you use the energy in real time. If there's excess, it just goes straight to the grid, and if you need more than your solar system is producing, it comes straight from the grid, and you don't have much to say about that choice. With the addition of storage, you get some of that control back.

"There can be real financial value in taking control back into your own hands."

"For example, you can use a mode called 'self supply,' where energy is produced, used in the house, and stored in the batteries, and it's only sent back to the grid if there's more than the batteries and house can use. Then, if the house is using more than the solar array can produce at a given moment, that extra power, instead of coming from the grid, will come from the battery. Only if the battery runs down and the solar array can't keep up will you draw from the grid. So it minimizes the interaction of the home with the grid. That can be beneficial, in some cases, depending on what the net-metering rules are in that jurisdiction."

"In Maine," Albee noted, "there is not a financial reason to do that. But in other parts of the country, there can be real financial value to taking that control back into your hands and deciding for yourself whether you interact with the utility or you don't."

Marginal economics. ReVision Energy has started to offer the Pika setup to customers in New England. ReVision also sells the Tesla Powerwall, which has similar capabilities (see "Tesla Powerwall: Not Just for Solar," May/16). "We're seeing quite a bit of interest," Albee said, "but it's in the early-adopter stage still. For pretty much everyone, it's hard to make a financial case, because the only benefit is the backup power, typically, and that's hard to value."

"You can easily make an economic case for installing grid-tied PV almost anywhere that has decent sun exposure," Albee explained. "But adding batteries—let's say that starts at \$12,000. That

sinks the economics of your grid-tied system quickly. You have a grid-tied system that is making power for you every day, but the battery is just like your propane generator—99% of the time, it's just sitting there, until you need it. When you do need it, you're glad you have it, but most of the time, it's not doing anything."

The big picture. Nationally and globally, however, solar+storage setups are gaining a strong toehold. The reason is that these systems offer benefits not just to the individual power customer, but also to the whole power system—and to the community. In Puerto Rico, where last fall's devastating hurricane strikes left the power grid in a shambles, Tesla has installed solar+storage systems at several critical facilities.

Solar+storage can also be the answer in less dramatic situations. Massachusetts, for instance, recently offered \$20 million of grants to fund solar+storage projects for places like Nantucket and Martha's Vineyard, where batteries can eliminate the need for costly new power cables from the mainland. The U.S. military has ordered large solar+storage installations for islands in the Pacific, where stand-alone self-sufficiency has a strategic value.

On the national scale, Tesla's biggest-ever solar and battery system is already proving its worth in Australia. Last month, Tesla's batteries responded in a fraction of a second to a coal-burning plant's sudden drop in output. Tesla's story in Australia is a large-scale example of the critical role that batteries will assume as time goes on and as batteries continue to drop in cost. That's because

small batteries in houses can play the same stabilizing role as Tesla's massive plant in the outback—if there are enough of them.

"That is a big topic of discussion right now," said Hans Albee. "While the interests of grid owners and homeowners are not perfectly aligned, they can be pretty darned close. If you just have a bunch of systems like mine operating at the whim of their owners, without any interaction with a central planning group, then that doesn't really add to or take away from the grid. But if you allow those small systems to talk to each other and coordinate through some sort of organization that aggregates a bunch of residential systems, then all of a sudden you have what looks a lot like a power plant.

"Instead of the plant being centralized, though, and owned by some organization, it's distributed and it's everywhere. It can be either a source or a sink, depending on what is needed on the grid, so it's much more flexible than a traditional power plant. And it's much more efficient, because that energy production is happening close to where the energy is being used, instead of being produced and then transmitted over long distances. So there are benefits to having distributed energy production and energy storage, but you really can't access it until you get good data to allow the grid operators to know what's going on and what's available, and then dispatch those resources in a way that makes sense for the whole system."

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