BY TED CUSHMAN

Grid-Optimized Solar-and-Battery Systems

In the past few years, the solar panel industry in the United States has been in a running battle with the nation's electric utility lobby over solar's proper place in the power resource mix (see "Solar at the Crossroads," Feb/16).

The controversy centers around the policy called "net metering." When a power company bills its customers based on net metering, utility customers with solar panels on their roofs get paid their retail electric rate for every extra kilowatt-hour (kWh) their panels push out into the grid. Then, any time the house needs more power than the panels can make (at night, for example, or on a cloudy day, or when the hot tub is operating), the customer pays to draw power from the pole on the street. Over a month or a year, the dollars balance out, and over time, many solar-equipped homeowners pay almost no electric bill—even though every day, whenever they need it, they are free to pull a lot of juice out of the grid.

With a "grid-tied" setup like this, the house doesn't need batteries. As solar-panel providers like to say, "The grid is your battery." That's great for homeowners: They have ready power whenever they need it, and they can sell extra power back if they don't need it. It's also great for the solar-panel industry, which can offer its customers reliable power and a quick payback for their investment.

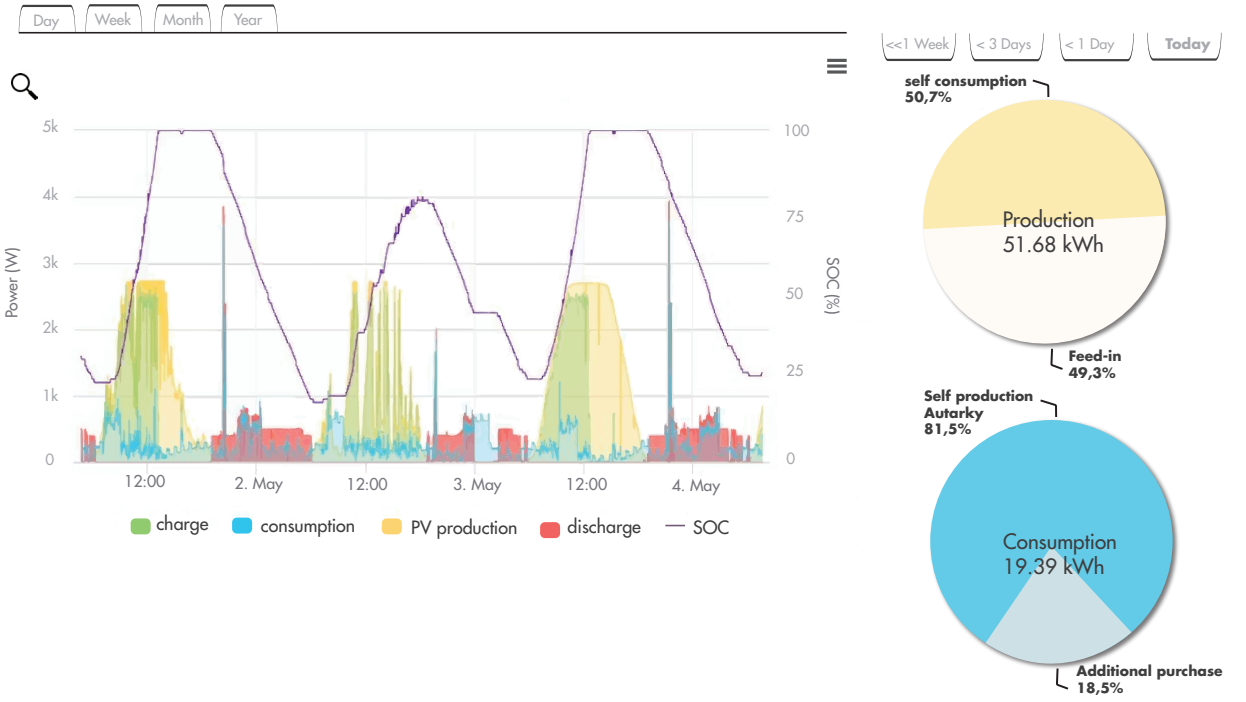
But net metering is not so great for the power company, and here's why. In reality, the grid is not a battery; that phrase is just a metaphor. In fact, the grid is a real-time network conducting power from generators to loads. The grid has almost no electrical storage capacity at all. So in order to keep their customers happy, grid operators are constantly finagling to match their various power sources to the changing power draws of homes and industry. That happens moment by moment, 24 hours a day. When you push extra power from your solar panels out to the street, the power company immediately sends it to another user; if no other user needs it, the power company needs to get rid of it, even if that means dumping it into the earth. But then when you need power at seven o'clock that night, the power company has to find you some. It's a tricky problem—and solar panels make it trickier.

Sometimes, of course, there's another user who needs your extra power right now. When your panels are powering the house next door, your production doesn't go to waste. But it does cost the power company money to manage that power. And if you get paid a full retail price for that power at your own personal meter, then the power company has no financial margin to work with.

Monthly service fees could make up the difference. And the infrastructure to bring power from your house to the house next door might be cheaper than the high-tension lines and transformers needed to bring current to your whole town from a power plant many miles away. So in theory, over the long run, utilities could either make money or lose money out of net metering, depending on the details. But even the

Photos courtesy Mandalay Homes

Power in reserve. Above left, Mandalay Homes' prototype for its grid-optimized houses actually has more panels than the production models will require to run the house independently between 3 and 8 p.m. every day. The secret is in the home's Sonnen battery compartment (above right); here, power stored up on sunny mornings will supply the houses all afternoon.



Knowledge is power. The user interface for Sonnen's battery bank and grid-tie control system supplies an up-to-the-minute display of the home's energy use, energy production, battery charge, and battery discharge. This example, taken from a grid-tied house with grandfathered net metering, shows how the home's battery charges up in the day and discharges at night.

solar-power industry, which absolutely benefits from the arrangement, doesn't claim that net metering is perfect. And in some states, net metering in its present form is a losing proposition for the power company. That's one reason that power companies have been fighting the practice all over the U.S., and it's the reason Arizona, for example, has given up on net metering.

Arizona has perhaps the worst case in the nation of the famous "duck curve"—the situation where there's too much solar power flowing into the grid all day long, but then just as the sun starts to go down, people come home from work, turn on their air conditioning, and start to cook or watch television. In Arizona, peak power needs ramp up just as the solar power fades out in the evening, leaving the utility company in the lurch. Solar power is not just variable in Arizona; it's variable in a predictable way that is the opposite of what the grid requires. So starting in 2016, new rooftop solar installations in Arizona won't qualify for net metering. New solar homeowners might or might not get paid for their surplus power; but if they do get paid, it won't be at the full retail rate.

MANAGING DEMAND WITH POWER STORAGE

One production builder in Arizona has come up with a workaround that looks like a win for all sides, including builders, homeowners, power companies—and the environment. Prescott, Ariz., builder Mandalay Homes, in partnership with German battery supplier Sonnen, has broken ground on Mountain View, a 323-home development where each house will have a solar array on the roof and a power-storage battery bank in the garage. And rather than be either a threat or a burden to the local utilities, the community's "solar plus storage" setup will help the power company solve its own difficulties with managing Arizona's sharp daily swings in energy supply and demand.

The homes in Mountain View will generate about 80% of the power they need, on an annual basis, says Mandalay chief technology officer Geoff Ferrell, and they will qualify for a federal tax credit to offset part of the cost of the solar and battery investment. But unlike solar-equipped homes that don't have batteries, these battery-equipped homes won't pump excess power production into the grid during sunny periods when the roof is making electricity, but nobody is home to use it—times when the utility already has more electricity than it can easily handle. Instead, each home's panels will charge up its own batteries every day, using the home's own extra solar power. Later in the day, when the utility is struggling to meet its daily peak service demand, the house will stop pulling power from the grid and instead supply its needs from the battery bank. Rather than being part of the problem, these solar-powered houses will be part of the solution.

In return, Arizona Public Service (APS) has agreed to give homeowners a reduced electric rate—as long as the house keeps its side of the bargain by "going dark" (from the utility's point of view) from 3 to 8 p.m., the crucial peak-demand period. That reduced rate more than pays for the cost to finance the solar-plus-battery system that makes the whole strategy work.

"A money-making machine." Geoff Ferrell explained the solution to *JLC* in a series of interviews this year. Mandalay owner Dave Everson toyed with the idea of building net-zero homes, or even an off-grid house, Ferrell said; but given the company's position as a mid-market production homebuilder, neither strategy seemed practical.

"As you get closer to zero energy," said Ferrell, "your cost for each additional HERS [Home Energy Rating System] point goes up. So you are asking your potential buyer to invest in a higher cost with a much longer return on investment." And as for off-grid, said Ferrell, "As a production builder, it's a terrible idea for us, because nobody would buy into it. Nobody buys a production home and says, 'I want to be off grid.' Those are million-dollar homes, or people who want to convert an old missile silo—things like that. It's a very specific niche. And solar alone wouldn't accomplish it anyway—you'd still need a $15,000 generator to get you through weeks of cloudy days, even though that equipment would rarely run."

Instead, Ferrell said, Mandalay decided to build a "grid-optimized" house—and that, he explained, has proven to be an easy sell. "As a production builder, you look at the bell curve," he said, "and you want to be at the very top of it. You want to offer the greatest savings for the lowest investment price possible. The added cost for our grid-optimized homes, compared with our competition, is $20 to $25 a month on the homeowner's monthly payment for a 30-year mortgage. But we're saving our homeowners $75 to $80 a month on their electric bills. I can offer our customers close to a 4 to 1 in terms of cash flow: If you give me 20 bucks, I give you back 80 bucks a month in utility savings. You're clearing 60 bucks a month. I'm giving you back 3 bucks for every dollar you put in my hand. People buy that all day. It's a money-making machine."

To hit that sweet spot, Mandalay Homes constructs a high-performance building envelope that can earn a HERS score of about 50 (meaning that the home uses about 50% of the power of a comparable home that meets the energy code, but doesn't exceed it).

That's without any site energy or battery storage. Then Mandalay takes it a step further. "First we look at the energy load," said Ferrell. "How much power is that home going to use on the hottest day in summer, or on the coldest day in winter? And we have some pretty good equations for that." Next, the company installs a solar array to supply 80% of that peak load. "We do still pull some energy from the grid," said Ferrell. "It's about 5 or 6 kWh on any given day. But we pull that energy when the utility wants us to—in the middle of the night, or a little bit in the morning. Then when the sun comes up, the solar panels start collecting, and when we're collecting enough solar power to run the house, any excess solar power begins charging the battery."

Sonnen software controls the system: "The software looks at the battery and says, 'I need to get back to 100% charged by 3 p.m. Am I getting enough power from the solar panels?' And if not, it starts to trickle-charge off the grid as well. Which is good for the grid, because that's when the grid already has a ton of energy and they're looking for places for it to go."

"We have 15 different floor plans in Mountain Gate that go from 1,400 square feet up to about 3,000," said Ferrell. "They offer between three and four bedrooms standard, but some plans have options that allow them to go up to five and six bedrooms." The solar arrays are relatively modest, Ferrell said: six panels on the smallest homes, and eight for the larger models. But the battery packs are larger: All the homes, even the smallest ones, get a 10-kWh battery pack—"which is more than any of them need," Ferrell said. "But I need that much battery power to match the 8-kW inverter that we put in every house. And we need that powerful inverter because between 3 p.m. and 8 p.m., I have to ensure that we do not use grid power, no matter what. So I need that power at my disposal for an oven turning on, or the washing machine starting up, or whatever—so that I can handle those peak loads."

FUTURE PROMISE

So far, the strategy is a hit, said Ferrell. By April, the company had pre-sold 10 homes in Mountain View and was selling homes as fast as it could build them. Mandalay Homes plans to pursue the same grid-optimized strategy in other neighborhoods. Eventually, said Ferrell, the plan is to put thousands of battery packs in thousands of houses in Prescott and vicinity.

Once the company reaches a critical mass of installed battery power, said Ferrell, the scene will be set for another step forward: using the battery cabinets and their Sonnen controllers to create an entire "virtual power plant" that the utility company can charge up whenever it wants to, and discharge whenever it needs the power. That's exactly what battery supplier Sonnen does in Germany, Ferrell said, and there's no reason the same thing couldn't work in Arizona.

"In Germany," said Ferrell, "the majority of their power is a mixture of wind, solar, and biogas. Over there, Sonnen is a grid operator: When you get a Sonnen battery and you are part of the Sonnen Community, your utility becomes Sonnen. It has a team of engineers that manage the whole system, just like a utility would, and they work behind the scenes to make sure there is enough power in the grid to run everybody's lights. Then they actively manage all the batteries within the community to charge and discharge, to supply the grid."

"That's what we call Phase Three," said Ferrell. "The cabinets that we are installing have storage space for up to 20 kWh of energy. Our homes only need between 6 and 8 kWh of storage to weather that 3 p.m. to 8 p.m. dark time, and give my customers the maximum benefit that they are ever going to get out of the battery. But I've got room for 12 kWh more storage in every home I build, that the customer doesn't need. So we could go to the utility and say 'Hey! I've got 12 kWh times 1,000, storage just sitting out there. If you have excess during the day, push it to these meters. We can store it in our battery, and when we go into the evening and you start to hit peak load, when you need a rapid discharge to offset something, call on our batteries to do whatever you need to do. Don't charge my customer for that energy, but use it.' And there is an interesting business plan behind that, which we are starting to talk through."

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