200 amp vs. 100 amp Inverter pass through

By Robin Gudgel, MidNite Solar

For 30+ years customers have requested whole house backup. This goes all the way back to my Trace Engineering days in the early 1990's. We barely had a 60 amp bypass relay in our inverters back then. I suppose we could have used an expensive external 200 amp contactor, but we couldn't justify trying to run the entire house from a 4000 watt inverter, so we talked the customers out of that idea. OK, jump decades into the future and has the story changed? Yes and no. Some very popular All In One inverters now have internal 200 amp relays and breakers. So, can you just put these inverters between your utility meter and the main distribution panel? Physically you sometimes can, but it isn't quite that simple. This type of connection is not legal in North America.

Not Legal??? It is being done every day! Well probably not as simple as stated above. You see those 200 amp circuit breakers built into the inverter have only a 5000 amp interrupt rating. They are not designed for or approved for direct connection to the utility. They are not rated as a service disconnect. So how you ask are they doing it?

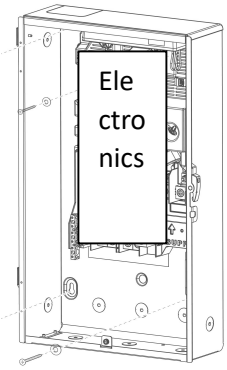
Look at the picture below.

This is a utility rated 200 amp 120/240 breaker like you would find inside your main distribution panel. It is rated for a minimum of 20,000 amps of interrupt current. That means when there is a short circuit downstream from this breaker somewhere in the home, you are assured that this breaker will trip. You can imagine when something big like an oven, dryer, EV car charger etc. shorts out, there is an enormous amount of current coming from the utility to that short and back out to the utility in the return wiring. The oven circuit will have 6AWG wire and possibly a 50 amp stab in breaker feeding it from the main distribution panel. The wiring in this circuit is large enough (low enough resistance) to allow many thousands of amps during a short circuit event. Well, that is why the 50 amp, 10,000 AIC stab in breaker is there to shut off current. But, sometimes with large wire that 10,000 AIC breaker doesn't have sufficient interrupt rating to actually open. What happens in this scenario is the breaker welds its contacts closed. Now you must relay on the upstream main 200 amp distribution panel breaker to trip. That is why these breakers have a much higher interrupt rating. Without that protection, there would be a fire. Main distribution panels have to undergo special evaluations by UL, CSA and other agencies to ensure their interrupt rating is sufficient.

Now back to how these AIO inverters are allowed to back up a whole house. Look at the picture to the right. This is an example of an external 200 amp

disconnect/overcurrent device rated for direct utility connection (service rated disconnect). This or another device with similar specs must be connected in front of that 200 amp rated inverter.

These separate devices aren't cheap and neither is the labor to connect them. It will require a licensed electrician to schedule and connect equipment directly to the utility. Approvals for this type of connection are somewhat more complicated than merely adding circuits to an already existing distribution panel. Another thing to consider on a whole house backed up system is what do you do if the inverter breaks. Every system I have designed in the past 35 years has a built in AC bypass switch. So if the inverter develops a problem, you can at least manually flip a bypass switch and take the inverter out of the system. Then at least you will have utility power again and time to call your electrician. This bypass switch may be required in your jurisdiction and they are expensive, but it is a very good idea anyways. You will also be required to change your grounding as it is no longer to come from the main distribution panel. The grounds now have to be moved to the service disconnect. None the less some customers believe it is much simpler to have the whole house run off the inverter during an outage. The simple answer is it can be done just fine. If you have an inverter capable of powering a fair amount of your larger loads and a battery bank capable of supporting them for the intended time, it can be a great way to go. Plan on multiple inverters and literally tons of batteries. Unfortunately, in most cases a single inverter isn't going to do the job. Today's inverters are now rated for as much as 10,000 to 12,000 watts of continuous output. Here is a simple math exercise for you to ponder. Electric range (12,000 watts), Hot water heater (5,500 watts), Electric clothes dryer (5,000 watts), Air conditioners (3500 watts each), fridge (800 watts), EV charger (7,200 watts). Lights, up to 1000 watts, hot tub (don't even go there). Now you wouldn't normally have most of these on at the same time, but even just a couple along with lights and TV can and usually will put you over your inverters power capability. When that happens the inverter will shut off to protect itself. These loads listed amount to 35,000 watts. It is quite conceivable that one or more of these large loads could be on during an outage. We haven't really even included normal loads such as toasters, microwaves, lights, TV, and such. If you are like my wife, there might be a wine cooler, freezer, espresso machine hair curler etc. You just can't tell when there will be a utility outage and you certainly aren't going to plan your electrical usage based on what ifs! No worries, the industry has a solution for this. Look at the picture to the right.



This is a concept of what a Load shed box or system might look like.

Here is how the story might go after your first utility outage. The day after your utility outage occurs and your nice new shiny inverter system just shut off rather that supplying your whole house, you call your installer. You and your family are confused why the new expensive back up system failed to back anything up. Just so you know, installers hate getting these calls. And you hate going around in the dark trying to figure out how to get the power back on. Nothing is obvious. You were probably warned this could happen during the quoting phase, but you declined the additional $4,000 to $8,000 to add a load shedding box/system. Afterall, the utility disconnect/bypass already cost you thousands more and wasn't anticipated. There are a couple of ways this would work though. Some load shedding boxes are nothing more than relays that will shut off circuits once there is a utility outage. Those boxes have between 3 and 8 relays. Wiring is run from the main distribution panel to the relay box and then back again. This system would immediately shut off your large loads. Kind of messy. Another method would be more elegant and programmable. (more expensive, but still just as messy) This would look at battery voltage or state of charge and will shut off certain circuits based on how they were

programmed to act. This now requires communications between the battery bank, inverter and relays. It is also possible to use shunt trip circuit breakers with an associated power supply and control system, but they will not turn themselves back on once the utility comes back on. Plus, they will not fit inside the main distribution panel.

So you can see these 200 amp inverters can back up your whole house as long as you don't mind spending thousands more for multiple inverters and very large battery banks. You can likewise design a system to shut off part of your house during an outage. Hmmmm, something just doesn't sit right with either scenario? You pay for a whole house back up system, but have to shut off certain parts of it due to inadequacies of the products plus you have additional expenses and complexity. There is a big difference between running a few loads during an outage and attempting to run a utility connected home off-grid during an outage. All off-grid homes run "whole house" 24/7. This is something we know about. In 35 years of designing manufacturing these inverters and systems, we have heard every horror story imaginable.

How do you avoid these problems? Glad you asked. We at MidNite Solar have been involved in most of the truly great off-grid inverter companies for over 30 years and we actually know how to deal with limited inverter and battery capacity. Now if money is no object or if you think your inverter would never shut down during an outage, you can stop reading.

The new MidNite Solar 12/10,000 watt All in One inverter MN15-12KW-AIO was developed with you, the home owner and utility connected homes in mind. The self imposed design criteria we faced was this:

1. We do not want an expensive 200 amp disconnect/overcurrent and AC bypass switch device to be required in front of the inverter on the utility side.
2. We need to deal with these large house loads without requiring an external load shedding box that costs thousands of dollars.

The first thing we did is what we have always done. Design for a 100 amp sub panel for all critical loads. We know from history that utility outages are mainly about **lights, TV and cold beer**! That may be a bit over simplified, but you get the idea. Select the circuits that you absolutely can't live without during an outage. We provide four 120V circuit breakers to aid in this, but a separate 125 amp sub panel may make more sense. You can also use the four 15 and 20 amp breakers built into our inverter for backing up circuits of choice. Lights, AC outlets, fridge, microwave, TV or two, water and sewer pumps, freezers, etc.

Then since you don't know how long the outage will last, we added three 120/240VAC programmable load circuits. If the outage is brief, why shut down some of your larger important circuits? We added one 30 amp, one 50 amp and one 60 amp circuit complete with breakers and programmable relays. This is actually six 120VAC or three 120/240VAC circuits or a combination of both depending on how they get configured on-site. It is up to you and your installer to decide what circuits to back up, so choose wisely. The goal is that these included programmable load shedding circuits will suffice for all but the most demanding home. These three programmable load shedding circuits will also save the customer many thousands of dollars over an external load shed solution. The good thing is these breakers and relays are already included in the MidNite inverter. You can program them to turn on and off based on battery voltage, battery state of charge, utility outage length of time etc. They operate totally automatic. No intervention is required once set up.

One of the things that can also force an inverter to unexpectedly shut off is the surge that some loads demand when turning on. For instance, if you have a deep well pump or another such large starting load (s), they don't really amount to much in the overall current/wattage budget since a pump is only on for a short period of time. The problem is the surge required to get the pump started. A pump and some air conditioners take three times the running power to get them started. So, just one such load can force your inverter to shut off. Having spent as much time as we have supplying hundreds of thousands of inverters to off-grid homes, we learned a long time ago that surge is really, really important. We estimate that over 80% of the off-grid homes in North America and the Caribbean use inverters and charge controllers designed by the MidNite engineers and manufactured in the US while we were at Trace Engineering, Xantrex, OutBack Power and Magnum Energy. And most of those products are still running! Reliability has always been a "must have" feature. Our new AIO inverter will be able to start that pump (or any other large surge load) where as our competitors haven't figured this out. They just don't have the experience or history we have. Designs that have high surge power have more parts inside and cost more as a general rule. However we have done a good job of still maintaining a competitive edge. Check this out as surge power is extremely important. It is actually more important than continuous power ratings.

As a side note, you will notice MidNite uses CBI breakers throughout this AIO inverter. CBI breakers (made in South Africa) are 100% duty cycle rated. All the other AIO inverters use inexpensive thermal breakers and can only be used to 80% of their rating. So are they really 200 amps? No, they are only good for 160 amps continuous. Our circuits are rated to be used at the full 100 amps continuous. After having supplied millions and millions of these breakers over the past 23 years, it is great to honestly say there have been less than a couple hundred failures. All of those were covered under warranty regardless of when they were purchased.

The MidNite MN15-12KW-AIO

After writing the above thoughts on whole house back up, I ran across this article from Barry Cinnamon. I do not know and have never spoken to Barry, but he is an experienced dealer/installer in California. I agree 100% with what Barry wrote. Barry seems to be saying the same thing I am, but from a different perspective. I am copying it here unedited.

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Limits to whole-home battery backup

But there's a catch to this. We like to believe the myth of whole-home backup or the notion that our 21st century lifestyle will continue unabated despite fire hell or high water. The reality is different: Typical battery backup systems work best when they are designed to ration battery capacity and minimize the use of major appliances.

Myths often have origins in fact: Whole-house battery systems do indeed work for off-grid applications. There are an estimated 180,000 such homes in the U.S.

But these homes were designed for off-grid living: they are typically smaller and well insulated; use combustion heating with propane backup; incorporate active and passive solar thermal systems; and do not have power-hungry air conditioning systems, Level 2 EV chargers or swimming pools.

There are two fundamental engineering limits that make it impractical to run a whole house on battery power alone. First, the energy capacity of typical lithium-ion battery systems is insufficient to power an entire house through a nighttime blackout. Second, battery backup inverters are not powerful enough to start and run many large appliances.

Of course, multiple batteries and inverters can address these energy and power limitations. But the cost of 20+ kilowatts of inverters and 40+ kilowatt-hours of batteries is prohibitive for the typical homeowner.

A more practical approach is to design a battery backup system to power critical loads only: no large appliances such as air conditioning, 240-volt EV chargers or electric stoves. Instead, just four to eight smaller circuits in the house for refrigeration, lighting, entertainment, communications and convenience outlets.

Our current housing stock uses a lot of electricity, and because of a plethora of plugged-in devices, newer homes often use even more.

High-power-use appliances are most challenging for whole-home backup systems. Power consumption for a large central air conditioner is 5,000 watts, an EV charger is 7,000 watts, an electric stove is 10,000 watts and pool pumps are 2,200 watts.

Battery energy limits

So how long does a typical solar and battery system operate at night while operating these larger appliances? Answer: not very long at all.

The math is simple. If the battery is down to an energy capacity of 2.5 kilowatt-hours at night (typical if the battery is used during the evening to maximize self-consumption savings), there is only enough battery energy to run pool pumps for 60 minutes, a central AC for 30 minutes, an EV charger for 20 minutes or an electric stove for 15 minutes.

With any of these appliances running — after only a relatively brief interval of automatic whole-home backup — the battery will be soon dead and unable to power critical loads. In lyrical terms: No lights. No phone. No electric car. Not a single luxury. Like Robinson Crusoe, as primitive as can be.

One possible solution is to manually shut off large appliance loads during a blackout. Unfortunately, many blackouts occur during the day when no one is home or at night when people are asleep. Customers who have tried to manually shed loads usually end up being disappointed with their backup system.

Another solution (if a homeowner's budget and wall space allows) is to add a second storage battery — effectively doubling the energy storage duration.

Over the past few months, we have worked with customers who have had a range of good and bad battery backup experiences. During the first blackout in our area, which happened at about 10:30 p.m., one customer who uses a continuous positive airway pressure (CPAP) machine depleted his storage battery at about 2 a.m. (he started snoring and his wife told him to sleep on the couch). Another customer used the backup system to power one of the subpanels in his home, and he did not realize there was a power failure until the battery was depleted.

The solution for both customers was to remove a few discretionary circuits from their backup subpanels so the battery would last through the night.

Inverter power limits

The battery inverter's maximum power output (in kilowatts) is the second reason for the whole-home backup myth.

Most battery backup inverters were designed for 200-amp home electric services, implying a maximum AC output of 7,600 watts when grid-connected. When powered from the battery (which has a limited peak discharge rate), these inverters can typically provide 5,000 watts of steady-state power or 6,000 watts of peak power (about 25 amps).

However, the momentary startup surge current requirements of an AC or pump motor is often two or three times the normal current draw — meaning that the inverter simply will not switch over to backup mode. Even if the battery is fully charged on a sunny day, the AC and pool pump will not start, and none of the critical loads will get power.

Designing solar-coupled battery backup systems

Regardless of these energy, power and financial limitations, a well-designed solar and backup system can provide power almost indefinitely. Three design elements are critical.

First, the battery's energy capacity (kilowatt-hours) and inverter output (kilowatts) should be matched to the needs of the home at night when the battery is partially discharged. Second, the number of backup circuits should be strictly limited to prevent powering too many small devices or any large appliances. Third, the size of the solar system should be sufficient to partially recharge the battery even on a cloudy winter day.

Upcoming smart home electric system technologies will address these practical limitations by automatically shedding loads during a blackout. At the 2019 Solar Power International show, companies exhibited smart appliance controls and circuit breakers that could automatically disable large appliances. Smart electric panel technology was also on display that could automatically manage all the circuits in a house.

By the end of 2019, there will be over 10,000 homes and businesses in California equipped with combined solar and battery backup systems. As these systems become less expensive (both through equipment cost reductions and incentives), they will become the most expedient and effective way for people to adjust to the new normal of public safety power shutoffs.

Not to mention the cleanest, safest and economical way to rebuild our archaic electric grid.

Barry Cinnamon is CEO of California's Cinnamon Energy Systems.