Standby Generators

Whether designed for regular use or emergency power, the system your clients choose should match their particular needs

by Larry Schmitt

Our company does electrical and general contracting in Northern California. In 1999, customers started asking us to install standby generators because they were concerned that the upcoming Y2K event would lead to widespread power outages. We installed several units that year, found we liked doing it, and have since come to specialize in installing and maintaining standby power systems in homes and businesses.

A standby generator is permanently wired to the building's electrical system. If the utility power goes down, an electronic control mechanism starts the generator and, after about 25 seconds, signals a transfer switch to disconnect the building from the grid and connect it to generator power. When the utility power comes back on, the transfer switch reconnects the house to the grid; after a short cool-down period, the generator turns off.

Choosing the Right System

Before we can install an electrical generator, we need to find out what the client expects the system to do.

Standby or prime? The first question we ask is whether the client plans to use the system for emergency use only (standby power) or on a regular basis (prime power). Most of our customers are looking for the former — a way to produce their own electricity on those rare occasions when the utility power is down. For these systems, we recommend generators that run on propane or natural gas.

But we've also installed power systems for people who live off the grid, by choice or because the house is so far back from the road the utility wants a lot of money to run power lines in. These customers usually want generators for prime-power uses, such as charging the backup batteries for solar- or wind-powered systems. In these cases, when the system is likely to run frequently or for long periods of time, we suggest diesel-powered units; they're more durable and the manufacturers will warranty them for prime-power applications (see sidebar, page 5).

Whole or partial? We also need to find out the size of the house and whether the

Figure 1. Most residential generators are air-cooled and burn propane or natural gas. A small standby system might have a 7-kw generator (above), while a large one might have a 13-kw unit (the minimum size for a whole-house system). This whole-house system has a 16-kw generator (right).

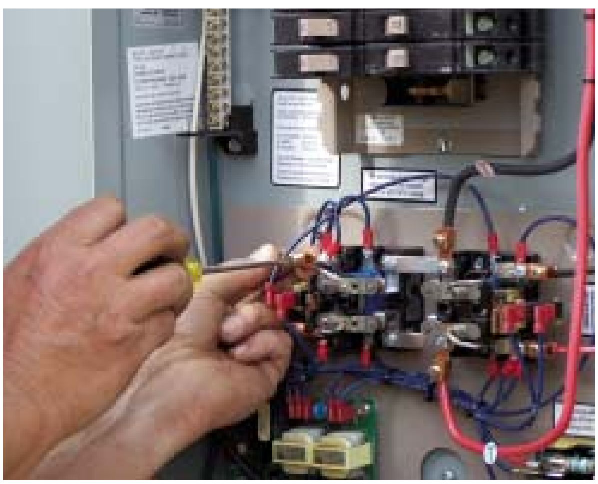


Figure 2. An electrician connects a wire from the main load center to the transfer switch in a panel that contains the load center for the emergency circuits. The thick wires tagged "T" run to the load center above, and the smaller red and black wires on the right go to the generator. The blues are control wires.

client expects the generator to power all or just some of the circuits (**see illustration, page 3**). A whole-house system — one that powers all the circuits — costs more because it requires a larger generator and transfer switch than a partial system. Most people opt for a partial system that powers vital circuits, like the ones for the furnace, refrigerator, sump pump, well pump, freezer, and some of the lights.

Sizing the Generator

To determine the size of the generator for an emergency backup system, we look at the circuits the client wants to run and then add up the loads they are likely to carry. For a whole-house backup system, sizing is a little more complicated: We have to add up the existing loads and anticipate future ones. If the client is thinking about installing a sauna or spa, for instance, that's something we'd need to know about.

A household's loads vary with the time of day and from day to day, so if we want to know for sure how much power clients use, we connect a recording ammeter to the power service and measure power usage over some period of time.

A partial system typically provides about 25 percent of the electricity normally used. The generator for such a system would likely be between 7 kw (7,000 watts) and 13 kw in size. For a whole-house system, a 13-kw unit is the absolute bottom end. In most cases a whole-house system requires a unit able to produce between 15 kw and 25 kw (**see Figure 1**). Even that might not be enough if the house is very large and has central air conditioning, electric heat, an elevator, or anything else that consumes a lot of electricity.

If the generator is too small to produce the necessary amount of power, a circuit breaker at the generator will trip and cut off power to the house. The owner then has to reduce the load (by turning off lights or appliances) and reset the breaker. One way to avoid this problem is to oversize the system — but larger equipment is more expensive to buy and fuel. A better solution is to buy a generator designed to temporarily shed excess loads, or to install an optional load control module (LCM) or air conditioner control module (ACCM). These devices prioritize loads and automatically shut down (then later reconnect) selected circuits when the generator can't meet demand.

Altitude. Another issue to consider is altitude. We work in the foothills of the Sierra Nevada mountains, and many of our clients live at altitudes between 3,000 and 7,000 feet. The motors in generators lose about 3 percent efficiency for every 1,000 feet above sea level. At 7,000 feet, they lose 21 percent. If we didn't take this factor into account, we could undersize the system.

Locating the Generator

Generators can be installed outdoors or in. We nearly always do outdoor installations; they're simpler and don't waste indoor space. However, we have installed units indoors in areas subject to deep snowpack, which can block the air intakes to the motor.

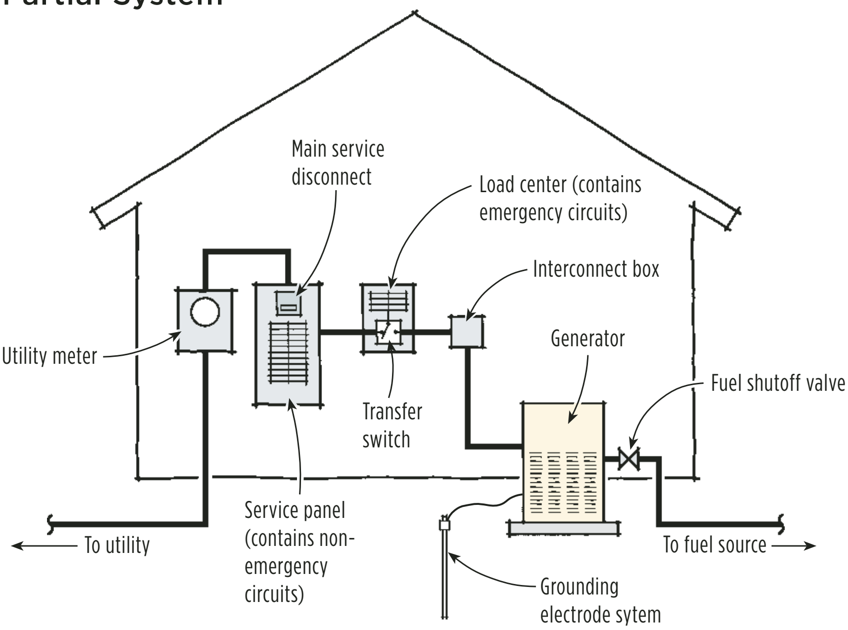
Most standby generators are designed to be installed outdoors only. Those that can be installed indoors — usually in an outbuilding or detached garage — must be connected to an exhaust pipe run to the exterior and provided with a specified amount of combustion air and cooling air (both intake and exhaust).

Transfer Switch

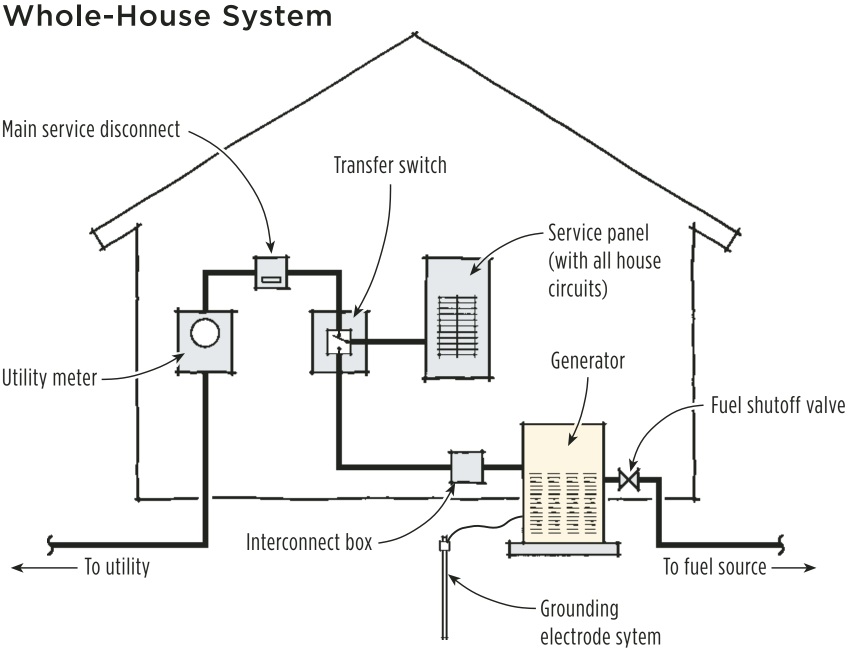
The electricity from the generator enters the building's electrical system through a transfer switch (**Figure 2, page 2**). Required by code, this switch prevents

Standby Generator Systems

Partial System



Whole-House System



In a partial system, the transfer switch is installed between a two-pole breaker in the main load center and a separate emergency load center. In a whole-house system, the transfer switch must be installed between the main service disconnect and all the loads in the building.

Figure 3. At left, the electrician attaches a white control wire to a fuse block connected to the electronic controller above. The controller tells the generator and the whole-house transfer switch — the device with large black wires coming out of it — when to operate. At the generator (below), the control wire is screwed to a terminal on the system control panel.

electricity from backfeeding into the grid and injuring the people who are working to restore power.

We get a lot of calls from homeowners who have already purchased a generator and want us to install it for them. They often buy the wrong-sized unit and nearly always get the wrong transfer switch. The most common mistake is buying a switch with a NEMA 1 (indoor use only) rating. In this part of the country, service panels (and transfer switches) are frequently installed outdoors, and for that application the switch needs a NEMA 3R rating.

How it works. To understand how an automatic transfer switch works, picture a switch that has six contacts: two on top, two on the bottom, and two that swing from pivots on the back. Each pair of contacts equals 240 volts (two 120-volt legs).

Typically, the upper contacts will connect to the utility, the lower contacts to the generator, and the pivoting contacts to the loads. When the pivoting contacts swing up, they land on the upper contacts and complete the circuit to the utility. When they swing down, they land on the lower contacts and complete the circuit to the generator. Since there are only two positions — up and down — the loads can be connected to either the utility or the generator, but not to both at the same time.

In a small standby system, where arcing is not a major concern, the transfer switch may rely on a simple magnetic relay to flip back and forth between utility and generator. In a larger system, the transfer switch is operated by one or more solenoids.

Control mechanism. In most cases, the enclosure that houses the transfer switch also contains an electronic controller (**Figure 3**). The controller monitors the utility, and if it senses a loss of power (or a large drop in voltage) it signals the generator to start. (A time lag of several seconds prevents nuisance starts.) Once the generator is up and running, the controller signals the transfer switch to switch from utility to generator power. When the utility power comes back on, the voltage may be low because of the number of motors and appliances starting up at the same time. So, instead of immediately switching to utility power, the controller waits until the power is stable — usually a 60-second delay — before making the switch and shutting down the generator.

Partial Transfer

Partial and whole-house systems are wired differently. In a partial system, the wires from the emergency circuits — the ones selected to run on generator power

Under the Hood

From the outside, a standby generator looks a lot like a central air-conditioning system's compressor: It has a metal housing with access panels, openings for intake and exhaust, and pipes and wires going in and out. The housing contains an engine with a starting battery, an alternator, and — in some cases — a control system.

Engine. Most residential standby generators take gaseous fuels — propane or natural gas. An engine run on propane will be 6 percent to 8 percent more efficient than one run on natural gas, so a generator rated for 13 kw on propane might produce only 12 kw on gas. Commercial generators and generators used for prime power usually have diesel engines.

Most small gaseous fuel units are air-cooled. Diesel generators and some of the larger gaseous-fuel generators are water-cooled. Water-cooled generators last longer, can be run harder, and have a more consistent power curve than ones run on gaseous fuels.

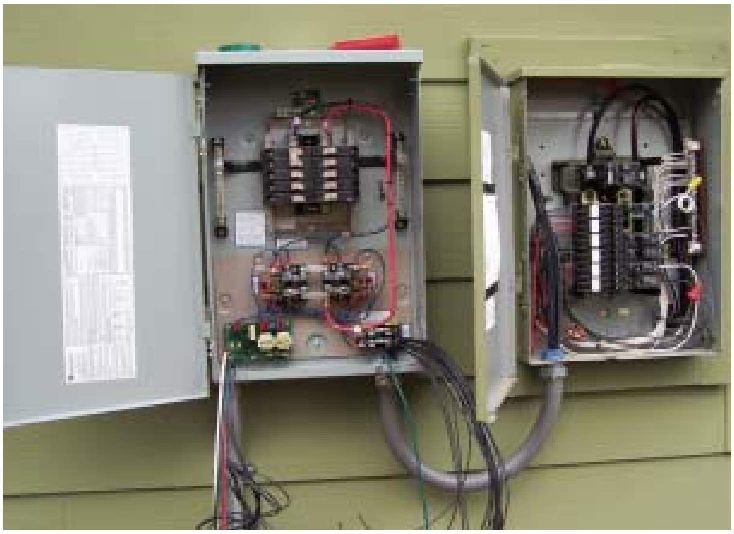
Before buying a generator, be sure to check that the manufacturer will warranty it for the intended application.

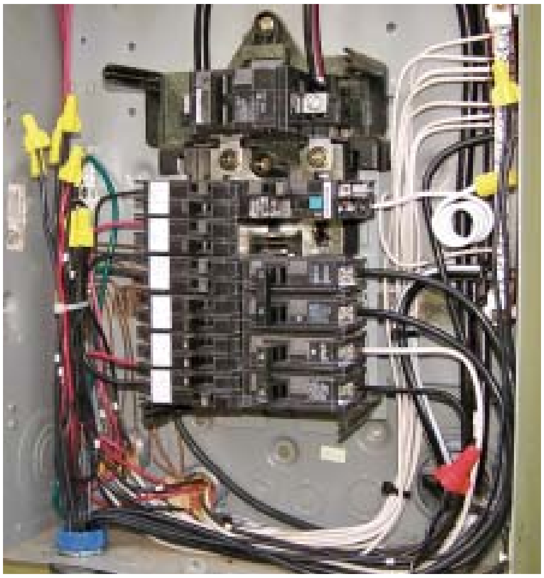
Alternator. The generator's engine drives an alternator, which in turn produces electricity. The alternators in standby systems come in two types: ones with two-pole rotors and ones with four-pole rotors.

Residential systems generally have two-pole rotors, which produce electricity of a lower quality (meaning part of the sine wave is clipped off) than that provided by the utility. Though this is not a problem for most residential customers, it can be one for commercial customers who run large numbers of computer servers. We advise these customers to spend the extra money for a generator with a four-pole rotor.

Generators with two-pole rotors run at 3,600 rpm and those with four-pole rotors at 1,800 rpm. People often ask whether the generator slows down under load; the answer is no. Generators must run very close to the specified rpm or they will not produce power with the correct voltage and hertz. The generator's motor is controlled by a mechanical or electronic governor that maintains a constant speed by varying the amount of fuel fed to it.

Behind the main access panel of this 15-kw unit (top) is a starting battery and a pair of breakers. The demand regulator on the lower right side of the unit opens and regulates the flow of gas to the motor. Gas reaches the generator by passing through a shutoff valve, a low pressure regulator, and a flexible hose (above).





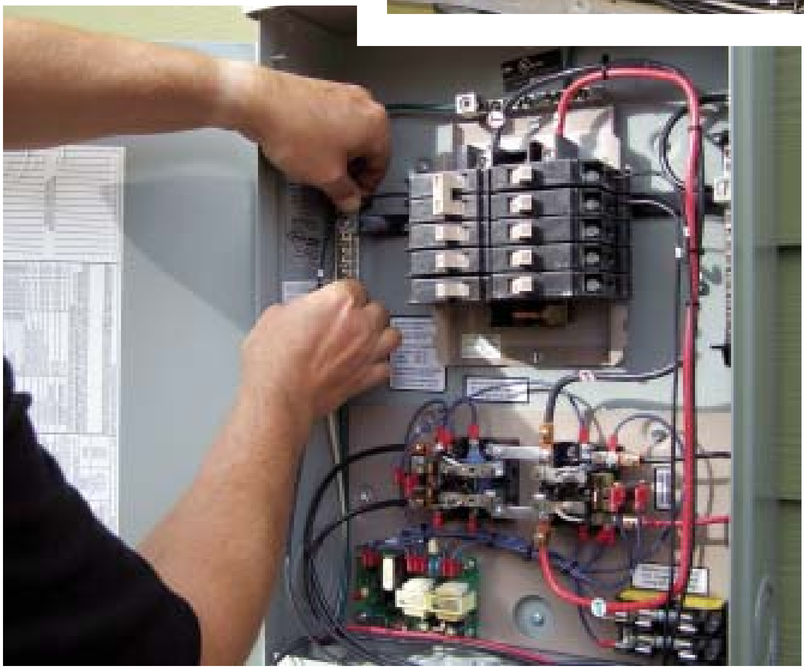


Figure 4. In the photo above, the new panel on the left contains an emergency load center, transfer switch, and controller for a partial system, and the one on the right is an existing load center. To convert some of the existing circuits to emergency circuits, the author removes their wires from the breakers (above right) and connects them to wires that run to breakers in the new load center (right).

— must be disconnected from their breakers in the main panel and spliced to new wires that run to breakers in a separate load center (**Figure 4**). The load center is usually installed in the same enclosure as the transfer switch and connects to the switch, which in turn connects to both the generator and a two-pole breaker in the main panel. Under normal conditions, utility power flows through the breaker and transfer switch on its way to the load center.

When the utility power goes down, the transfer switch disconnects from the main panel and the generator comes on to power only those circuits in the load center. Later, when the utility power comes back on and is stable, the transfer switch reconnects the load center to the main panel, then turns off the generator.

A 7-kw generator is usually paired with a 100-amp transfer switch and a load center with space for eight to 10 circuits. A larger system usually has a 200-amp transfer switch and room for 12 to 16 circuits.

Whole-House Transfer

In a whole-house system, the transfer switch is connected to the generator and

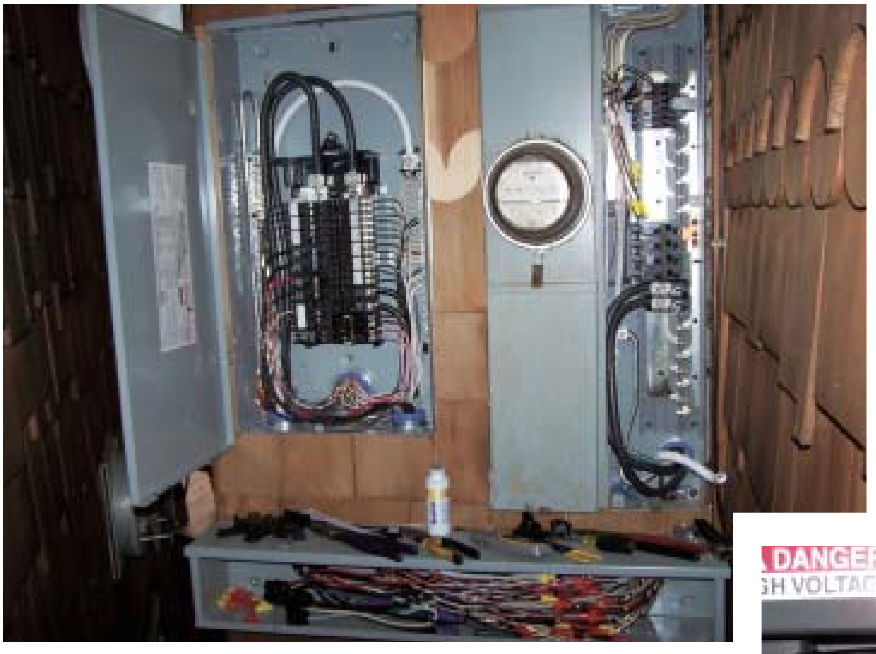


Figure 5. Since the load center in the existing panel was hard-bussed to the meter (left), the author rerouted the existing circuit wires to an electrical gutter (at bottom of photo), where he spliced them to new wires that run to a new load center on the left. A whole-house transfer switch (below left) is inside the building on the other side of the wall. The large wires on top go to the utility via the main service disconnect in the existing panel, the large pair at the bottom go to the new load center, and the wires in the conduit go to the generator, where they connect to the generator's breaker (below).

installed between the meter main disconnect and the circuit breakers in the distribution center of the service panel or a separate load center. Under normal circumstances, utility power passes through the switch on its way to the panel. But when the utility power goes down, the controller turns on the generator, disconnects from the meter, and connects to generator power. When the utility power comes back on, the controller disconnects the transfer switch from the generator and reconnects it to the grid.

This is a simple installation in new construction, but it can be tricky in older homes where the meter is installed in the service panel. If the meter socket is connected to the distribution side of the panel with cables, the transfer switch can be installed between the meter main service disconnect and the distribution center. But if the meter socket is hard-bussed (permanently connected with metal bars) to the distribution side of the panel, it's impossible to put the transfer switch where it belongs without installing a new service panel.

Usually, we remove the hard-bussed panel — but on one recent job we kept it, installed a new panel next to it, and con-

Figure 6. The electrician removes the cover of a 7-kw air-cooled unit and checks the motor's oil level. Air-cooled generators need an oil change after every 50 hours of operation.

nected the two with primary cables that ran through a transfer switch; then we relocated the existing circuits to the new panel. This allowed us to keep the existing meter and service drop.

If the new panel is close to where the old one had been, it may be possible to run the existing circuit wires into it. If not, the wires must be disconnected from their breakers and spliced to new wires, then run to breakers in the new service panel or load center (**Figure 5, page 7**).

Maintenance

Standby generators require regular maintenance. The oil in units with air-cooled engines should be changed after the first 10 or 20 hours of use, then once every 50 hours of operation (**Figure 6**). If that sounds like overkill, compare it with your car: At the same engine speed, your car would be going 100 mph. Fifty hours of driving would cover 5,000 miles.

Water-cooled engines — especially diesels — hold up better and can go much longer between oil changes.

Some generators come with built-in hour meters that measure the hours of operation. If a generator doesn't have such a meter and we sign a maintenance agreement with the owner, we install one so we can keep track.

Exercise. If you let a car sit for six months, it probably won't start the next time you try to drive it. The same is true of generators, which is why standby units typically start up on their own once a week and run for about 15 minutes. The controls on some models allow you to adjust the time and frequency of these exercise periods.

Interconnect box. Although it's not strictly necessary, we like to install an interconnect box between the generator and transfer switch. A terminal strip inside the box connects to the control wires of the generator. For us, this strip is a convenient place to check the output of the generator in hertz and volts during service calls.

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Manufacturers

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