Misc.survivalism Generator FAQ

This is version 1.1 of the Generator FAQ.

Disclaimer

This document provides an overview of the use of generators for standby power. Use of generators can be dangerous. While an overview of safety issues is given, READERS SHOULD OBTAIN AND FOLLOW SAFETY INFORMATION FROM A SEPARATE, RELIABLE SOURCE PRIOR TO USING ANY GENERATOR. This FAQ is not comprehensive and in particular does not pertain to standby systems used for life support or other situations where power failure could cause bodily injury or property damage. Information on transfer switches and electrical wiring is not intended as a substitute for competent work by a qualified, licensed electrician.

Generator Basics

Generators are shaft-driven machines that produce electric power. Broadly speaking, they range in size and capacity from the tiny devices used as sensors to the extremely large machines used at commercial power plants. The term "alternator" is also used and means essentially the same thing. The term "generator set" or "genset" is sometimes used to describe a generator along with a gasoline or diesel engine or other power source.

This FAQ covers the use of generators to provide standby power in an emergency for a single family or small group.

Generators are rated in terms of the amount of power they can produce. This is measured in Watts (W) or Kilowatts (kW). A Kilowatt is equal to 1,000 Watts. Some household items list their power requirement in Watts, such as light bulbs and small appliances. Others only list Amperes (abbreviated A or Amps). Most household electrical loads (including all cord-connected appliances that plug into a standard outlet) run on 120 Volts, and since Watts = Amps X Volts, you can determine Watts by multiplying the amp requirement by 120. Large heating and cooling appliances, and well pumps, sometimes use 240 Volts. This can be determined from the nameplate. For these loads, wattage is determined by multiplying amps by 240.

Types

Commercially available generators useful for small-scale standby power fall into these categories:

Type	Wattage	Approximate Price Range
Small portable units marketed primarily for camping	Generally less than 2 kW	$400-$600
Midsize portable units	3-5 kW.	$400-$2,000
Large trailer-mount units without engines, driven by a farm tractor PTO	15-60 kW	$2,000-$5,000

Large trailer-mount units designed for construction or industrial use	10 kW or more.	
Large standby units designed for permanent installation.	5-40 kW or more	$4,000-$12,000

Costs vary depending on ruggedness, reliability, and features.

The more expensive units typically include features like:

- Better quality engines, with pressure lubrication, cast iron cylinder blocks (or cast iron sleeves), oil filters, and electronic ignition. The primary benefit of these is longevity, although the better engines may be somewhat more reliable.
- Larger fuel tank for long, unattended runs.
- Low oil shutdown to prevent engine damage
- Electric start
- Built in battery charger for 12V car batteries
- Quieter design, achieved through better mufflers, soundproofing, and lower operating RPM
- Ground fault circuit interruptors (GFCI) for safety
- Wheels. Even the smaller generators are heavy.

There are a wide variety of brands available. All of them work, and most are adequate for occasional standby use.

The generators that are driven by a farm tractor are a good buy if you already own one or more farm tractors. Unlike car and truck mount generators, tractor-driven ones produce ample power. Tractors are better suited to continuous, stationary operation than cars and trucks.

Uses

Generators can be useful in a long-duration power outage by providing power to run essential equipment, such as refrigerators, freezers, lighting, water pumps, sump pumps, and furnaces. They are also useful for providing power where it is inconvenient, costly, or impossible to bring commercially produced power.

Sizing

Determining the exact size generator required for a household involves adding up the wattage required by each load, including the starting power required by the largest motor and any others that will be started at the same time. It is difficult to get accurate results since starting current requirements often vary and because nameplate ratings sometimes overstate the power required.

If a generator is too small for its load, the voltage will drop. This can cause damage to the generator, the load, or both. Circuit breakers and thermal protectors may trip and prevent damage, but cannot be relied upon. Do not connect loads to the generator that are too large for its capacity.

If you only want to run a few critical items, you can use this chart as a guide:

Generator size	Loads typically supported
1000W or less	Lights, radio, battery chargers, clocks, fax, or computer
1500W	above items, also small manual defrost freezer or refrigerator

3500W 240V	same as 1500W, plus ½ H.P. well pump (if 240V)
3500W 120V	Most refrigerators and freezers, clothes washer, gas clothes dryer, sump pump, ½ H.P. furnace blower, ½ H.P. well pump (if 120V), nearly any plug-connected appliance with a standard 120V plug
5000W 240V	Same as 3500W, plus most well pumps up to 2 H.P.
15,000 W 240V	Will run all the loads in most households including electric water heaters, dryers, well pumps, and ranges; will run many central air conditioning units. Electric heat systems need to be considered case by case as many larger systems use more power than even a big generator like this produces.

Determining the size analytically

To determine the size generator required using pencil and paper, you need to add up the power used by everything that you want to operate at the same time. Use the starting power required for the largest motor and for any other motors that will start simultaneously.

For small installations, the large motor loads that need to be served determine the size generator that is needed. Induction motors, such as those used in water pumps, sump pumps, washers, dryers, refrigerators, freezers, air conditioners, and furnace blowers require a large amount of power to start. These motors will draw 2-3 times or more their rated amperage for about a second when first started. If the generator cannot produce this number of amps while still maintaining roughly 90% or more of the rated voltage, the motor will not start.

Portable hand tools use universal motors still use a lot of power to start, but they are not as sensitive to voltage drop and will usually start anyway even if the voltage drops as much as 50%.

Larger motors will list a "code" on the motor nameplate which indicates the starting current required. This applies primarily to industrial and farm equipment, and well pumps, since small household motors do not include the code. Here’s a list of the codes:

Code	Starting kW per horsepower
A	0-3.15
B	3.15-3.55
C	3.55-4.0
D	4.0-4.5
E	4.5-5.0
F	5.0-5.6
G	5.6-6.3
H	6.3-7.1
J	7.1-8.0

K	8.0-9.0
L	9.0-10.0
M	10.0-11.2
N	11.2-12.5
P	12.5-14.0
R	14.0-16.0
S	16.0-18.0
T	18.0-20.0
U	20.0-22.4
V	22.4 and up

Most capacitor-start motors have codes between G-L, meaning that they will require 6,000 to 10,000 watts per horsepower to start. With less power available, line voltage will drop and the motor may not start. Several generator manufacturers publish sample wattage tables that list the number of watts required to start a motor of a certain size. We have seen some tables that understate the wattage required by a considerable amount compared to the nameplate data on typical motors that we encounter.

If a code is not present, assume that the motor will require at least 5 times its rated amperage to start. Some require much more.

Measuring the Load

Sometimes it helps to measure the amount of power a particular piece of equipment (or an entire household) uses. This may be the only way to determine power requirements accurately if there is no nameplate listing the power required. Clamp-on ammeters are available at most building supply stores for about $50-$100 that will measure the number of amps flowing through a wire. They usually include an attachment that you can use for cord-and-plug connected devices.

More sophisticated ammeters that measure starting current are available but are costly ($400) and require some expertise to use.

Electrical Hookup

There are three ways to hook up generators:

- Plug in loads directly, using extension cords if necessary.
- Transfer switch
- Suicide wiring

Plugging in loads to the generator's outlets directly is the simplest and works OK when only a few small loads are used. This method is used in remote areas and for construction, where no electric wiring is present. It also works in standby situations for running a handful of things, say, a freezer, refrigerator, sump pump, and a couple lights.

Generators must be operated outdoors unless specifically designed for indoor operation. Those designed for indoor use have an exhaust system that vents outside.

Since the generator is usually outside and the load is inside, extension cords are needed. Be sure they're big enough. Most of the orange extension cords sold use 16 gauge wire and are rated for 13 amps. These are fine for a couple of small appliances but create a fire hazard when used for heavier loads.

Transfer switches

Transfer switches allow you to connect a load to either the generator or the commercial power source simply by flipping a switch. They are the only reasonable and safe alternative for running an entire house from a generator. They are also the only way to run equipment that can't be unplugged, such as furnace blowers, well pumps, and the like. Different configurations are available that allow switching of all or part of a household's electrical circuits. They are expensive and must be installed by an electrician or other qualified person. Some examples:

- Transfer switches that have 4-6 different handles, each of which switches a single circuit, are available for around $200 from many retailers that sell generators. They wire into the house's breaker or fuse panel. You only hook up the circuits that you will need in an emergency, which reduces the cost, and you can switch them one at a time so all the motors don't start at once. Some designs include an ammeter so you can see how much power you're using.
- Some designs, including one from Square D that I have seen, use circuit breakers to perform the switching and have an interlock so you can only turn on one circuit breaker – either the generator breaker or the commercial power breaker. I have seen these for as little as $60 plus the cost of the circuit breakers. Again you only hook up the circuits that you think you will need in an emergency. These panels hook up to your main breaker panel as a sub-panel.
- Large transfer switches switch the power to a house or group of buildings and are wired between the meter socket and breaker (or fuse) panel. These cost $300-$600 depending on capacity. They are costly to install as well.
- Automatic transfer switches will start the generator and switch the load to it without intervention. Some standby systems have these built in. One catalog I have lists a 200A model as costing almost $2,000. Telephone companies, hospitals, radio and TV stations, and the like use larger versions of these.

Transfer switches are wired with a large, flexible cord and plug for use with portable generators. The cord and plug are not normally included with the transfer switch and must be purchased separately. Welding supply companies are a good, inexpensive source for the heavy gauge wire required.

If you plan to connect the generator to building wiring, consider the transfer switch part of the cost of the generator.

Suicide wiring

Any method of connecting a generator to a building's electrical system, other than by using a transfer switch, falls under the category of suicide wiring.

You can be killed. And you can kill an electric lineman if you fail to isolate your generator from the power company's lines, by causing electricity to back-feed into the commercial power system. You can also burn up your generator or your house. It is also against the law in many jurisdictions.

Plan ahead. Buy a transfer switch. Get it installed. Don't use suicide wiring.

There is no safe way to do suicide wiring and the author does not recommend it under any circumstances. If you choose to go ahead and do it anyway, this information may help you:

1. Get somebody qualified to help you unless you really know what you're doing.
2. ISOLATE the breaker panel from the commercial power source by disconnecting and taping the supply connection from the main breaker or busbars. You can leave the neutral connected, just remove the hot connections. Follow the precautions for working on live electrical circuits since the commercial power could come back on without warning while you're working: make sure everything is dry, keep your left hand in your pocket, and use the buddy system.

3. Use wire of adequate capacity for the full rated output of the generator. For generators up to 4800 watts that would be 12 gauge unless you're going more than 50 feet or so. Use wire rated for outdoor use. If possible, connect it to the main breaker or lugs where you removed the supply connection. Sometimes the smaller wire won't connect securely to big breakers or lugs. You can try folding it over a couple times to make it bigger around or undo the wires from a non-critical 240V breaker, say for the air conditioning, and hook the hot up there. Hook up the neutral to the neutral busbar. If your generator has a separate ground, hook that up to the ground bus if there is one, or the neutral bus if it is bonded. Be sure everything is connected securely or it will overheat. Use the right plug to connect to your generator.
4. Check everything to make sure there are no signs of overheating while operating.
5. Get a qualified electrician to clean up the mess and put in a transfer switch when the power comes back on.

Again, the author does not recommend that this type of wiring be used under any circumstances.

Safety

Here's some basic advice on generator safety. Read the instructions for your generator or check with a dealer or licensed electrician for authoritative safety rules.

1. Follow the safety instructions that come with the generator.
2. Keep the generator outside so you don't breathe carbon monoxide and die. Protected locations, such as a garage with the garage door open, are helpful if the weather is bad.
3. Follow whatever grounding instructions come with the generator. Generators should be grounded but the recommendations for how this is done vary depending on manufacturer.
4. You can get a bad shock by touching a wet power cord or plug while the generator is running. Shut off the engine before fiddling with the power connections if it is wet out.
5. Don't refuel a hot engine. If you refuel at night, use a source of light that won't ignite the gas. The cyalume sticks work well for this.
6. Don't overload extension cords.
7. Use a transfer switch.
8. Store gasoline outside, in a safe container.

More accidents happen during power outages than occur when power is available, particularly fires. Here are some general tips for safety during power outages:

1. Don't leave candles or oil or gasoline lanterns burning unattended.
2. Realize that smoke and carbon monoxide detectors will not work without power.
3. Have fire extinguishers at hand.
4. Have some water drawn up in buckets or pans to use in case the water supply fails.

Fuels and Fuel Storage

Most portable generators run on gasoline. But gasoline is a poor choice for standby use, because it is unsafe to store in residential areas and is prone to deterioration when stored for any length of time.

Gasoline is extremely flammable and should not be stored in any quantity in a house or garage. There is no safe way to store gasoline in a building. Building and zoning codes, and insurance requirements, vary; some municipalities prohibit permanently installed gasoline tanks and limit the size of portable ones.. In the author's area gasoline suppliers recommend that bulk storage tanks be at least 10' away from garages and other buildings. Some of the author's acquaintances store gasoline in 5 gallon cans in a little building not much larger than a doghouse, that is used for nothing else and is a long way from all the other buildings.

Gasoline can be stored in full, sealed containers for 1-2 years or more without deterioration, provided that high temperatures are avoided. Air, water, and heat all contribute to deterioration.

The author uses a commercial fuel preserving additive in the gas tank for his generator, but there is no consensus on misc.survivalism that such additives materially improve the storage life of gasoline.

Some, mostly larger, generators are available with diesel engines. These engines are, as a rule, noisier than gasoline engines and are more difficult to start in cold weather. For standby use, they may be worth having because of fuel storage considerations.

Diesel fuel and kerosene are much safer to store than gasoline. It is still common to store fuel oil, which has similar properties, indoors in houses in quantities up to 250 gallons. Again, building and zoning codes and insurance rules may limit the amount or method of storage. These products should not be stored in red cans because of the potential for confusion with gasoline. These fuels can be stored 2-3 years before they deteriorate.

Midsize and larger generators designed for permanent installation and standby use are available for use with LP gas or natural gas. The engines are like gasoline engines in most respects but replace the carburetor with a mixing system designed for LP or natural gas. LP gas standby generators are widely used in industrial/commercial settings. The chief benefit is that LP gas can be stored indefinitely without deterioration.

LP gas conversion kits are available for many small generators.

Readiness

There are no statistics available, but anecdotal evidence suggests that generators frequently fail to start when they are needed, even in industrial settings where regular maintenance and testing is performed.

Electric start generators sometimes fail to start because the battery is dead. Batteries that are continuously trickle-charged may start the engine while being charged but fail when the charger is turned off, as in an actual emergency. Battery terminals also have a way of getting corroded.

Stale gasoline can contribute to starting problems, especially in cold weather. Using starting fluid will sometimes make up for this.

Spare parts and supplies should be kept on hand. At a minimum, some extra motor oil, suitable starting aids, air and oil filters (if used), and a spark plug should be available.

You should periodically operate your generator, and hook up whatever loads you plan to use, to make sure that everything is ready if needed. Once a month is probably often enough to catch most problems.

How Practical Is a Generator?

The author has had to resort to using the generator during a couple of long-duration power outages. Severe weather can be extremely disruptive to power systems and the unlucky individuals whose own lines are knocked down in a storm end up at the end of the power company’s list for repairs. Power losses can be costly if you stand to loose the contents of your freezer, or if cold weather and no heat threatens to freeze pipes.

On the other hand, unless you can afford a fully automatic, permanently installed system, you had better be able-bodied. It’s work to pull out the generator and start it and hook it up even if you have a good setup.

Big generators are noisy. Everyone in the neighborhood will know that you’re running one.

You may wish to consider running the generator during only part of a 24-hour period. Most refrigerators and freezers will maintain temperature if operated 50% of the time, depending on ambient temperature, condition of the door seal, and how often the door is opened.

Fuel availability is a thorny issue. Gas stations require electricity to be able to pump gas. The author is fortunate enough to live in a setting where it is possible to store ample quantities of fuel to run the generator for a week or more. Even the worst power outages are ordinarily corrected after a week, two at the most.

Those of you concerned about Y2K and other TEOTWAWKI scenarios should consider other alternatives that do not rely on fuel availability.

Other Ways to Produce Electricity

Several companies sell inverters that produce 120V electricity using the power from a car or truck's battery and alternator. These are not suitable for most standby uses because the output power is too low. The largest car and truck alternators produce no more than 2000 watts, and this only at high engine speeds. The really big inverters – 2000W and over, capable of running a refrigerator – are expensive, big, heavy, and require heavy cabling to the battery. The logistics of operating a vehicle while stationary must also be considered: how do you secure the vehicle, potential for damage due to low oil or high temperature while unattended, potential for transmission bearing damage due to extended idling, poor fuel economy.

There are some belt-driven and PTO-driven generators for cars and trucks that have similar problems. In addition, most of these units must be operated at a specific speed. Unless the vehicle is equipped with an engine governor, this is difficult.

Uninterruptable power supplies (UPS) are designed primarily for use with computers and communications equipment. They generally are designed for short-duration outages, 15 minutes or less.

Solar, hydroelectric, and wind generators are a topic in their own right and are beyond the scope of this FAQ. Many products marketed for use with alternative power systems are also useful for standby use. It might make sense in some cases to have low-voltage DC wiring for lights that can be operated from batteries in an emergency.

Non-electric Alternatives

There are a number of low-tech techniques that can reduce your dependence on electricity. Some are effective by themselves, and others will reduce the size generator you need or the hours you need to run it.

1. Use something besides electricity for the primary source of heat. Although any modern central heating system requires some electricity to operate, you can run a natural gas, LP gas, or oil-fired furnace from a generator of modest size. Electric heat systems can't be operated except by very large generators.
2. Replace electric appliances with gas. Houses that are served by a natural gas supplier rarely have gas outages and electric outages at the same time (except possibly in earthquake-prone areas). LP gas is stored in tanks and is independent of electrical and other utilities. A gas stove can be used without electricity if the burners are lit with a match. Most gas water heaters don't require electricity at all (except for horizontal exhaust and other power-vented units).
3. Have a wood stove or fireplace insert that is capable of heating your house. Have enough wood on hand to be able to use it in a power outage.

A wide variety of non-electric lighting is available. Aladdin lamps, which burn kerosene and produce a bright light, are practical and safer to use inside than gasoline lanterns. Lamps that operate on LP gas supplied through pipes are available. They mount permanently to a wall or ceiling, and are bright, safe, and cheap to operate. Inexpensive kerosene wick lamps are widely available and produce more light than candles.

LP gas and kerosene operated refrigerators and freezers are available. Some will also operate on electricity. Full-size units are expensive but no more so than a good generator installation. Smaller refrigerators, such as those used in RVs, are available too – though some require a 12V DC power source to operate the controls and ignition system even when running on LP gas.

The Author

The FAQ is maintained by Steve Dunlop. Steve lives in Minnesota and has several off-the-grid friends. He has two generators of his own, one a 20-year old tractor-driven unit and the other a little 1500 watt Coleman. Comments: dunlop@bitstream.net