Generators

So, you're thinking about getting prepared for a power blackout. Briefly, here are some things you need to know about various options.

A combination system with solar and generation is the best alternative, but it is not inexpensive.

Solar power is a big commitment but in the long run will be a great way to generate power but there are challenges.

1. A standard, grid-connected solar panel array has a required device that is called an inverter. The inverter takes the low-voltage, direct current power from the solar panels and turns it into 120 volt 60 cycle current that is needed for our home appliances. *A basic inverter is required to have a shutoff that turns off all power from the solar grid when the utility power is off.*[1] This is a safety requirement and it means that without utility power you have no solar power either.
2. A hybrid system has a battery bank to store power. This is more expensive and requires more maintenance but allows you to have solar and battery power when utility power is out.
3. A stand-alone system does not connect to the utility grid and is used mainly in rural areas without the option of utility connection.

Battery power is a fairly new option. A Tesla Powerwall 2.0 will power your home for a short period. Tesla recommends 2 Powerwalls per day for a 2200 sq. ft. home. Equipment only cost of $14,100 per day.

Generator power is the most cost efficient option but there are many things you need to determine before moving ahead with a generator or inverter.

1) What is the difference between a generator and an inverter?

a) A traditional generator system has a small engine that drives an electric generator.
   i) The engine runs at a constant speed (usually 3600 rpm).
   ii) Most generators are 'open frame' meaning the parts are visible but there is no soundproofing.
   iii) The unit is usually moderately noisy.
   iv) The generator output is usually either 120 volts or 240 volts at 60 cycles. This is what our home needs. The power is not 'clean' in that it has voltage and frequency spikes that may affect some sensitive electronics.

b) An inverter generator also has a small engine that drives a 12 volt generator.
   i) The engine runs at variable speeds. The speed varies by the power demand and always outputs 12 volts DC.
   ii) An inverter converts the 12 volt DC power into 60 cycle 120 volt AC for your home.
   iii) The inverter generator is normally fully enclosed, helping make it quieter.
   iv) Because the engine speed varies with the load, inverters are normally more fuel efficient.
   v) Inverter generators are normally small capacity and more expensive.

c) **What kind of generator do you need?** What do you want to power?
   i) Do you want to power your whole house, including A/C?
   ii) Do you want to power part your house without A/C?
   iii) Do you want to power just your refrigeration plus recharge some small electronics and fans?

[1] National Electric Code 690.12 (A-D)

2) **How do you want the switch-over to happen?**

Generators must be isolated from the utility power grid to prevent power feed back which can electrocute utility workers.

a) Automatically. Within seconds of loss of power, the generator starts and the power shifts from utility-lines to generator. This requires an automatic **transfer switch** installed by a qualified electrician.
b) Manually. You start the generator. You have a transfer switch installed for some circuits (not AC) and you manually switch-over. This requires a **transfer switch** installed by a qualified electrician.
c) Manually. You start the generator. You run a cord from the outside generator into the house and you run extension cords to the appliances. **DO NOT EVER CONNECT** to house wiring without a transfer switch installed.

3) **What type of fuel will you use?**

a) Whole house generators can run diesel, natural gas or propane.
b) Portable generators normally run on gasoline or propane.
    i) Diesel
        (a) Good for large generators.
        (b) Requires a storage tank.
        (c) Services by a fuel company.
    ii) Natural gas
        (a) Already at most residential properties.
        (b) Normally endless supply.
        (c) Economical.
    iii) Propane
        (a) Needs a tank. Small, portable or large, fixed.
        (b) Lasts in the tank forever. Tanks need to be re-certified after 12 years.
    iv) Gasoline
        (a) Can be purchased at gas station with ethanol blended (bad). Note: gas stations will not be able to pump when the power is out.
        (b) Can be purchased at specialty stores without ethanol (expensive).
        (c) Needs to be stabilized. Gas goes bad within a few months. Once stabilized, it can last many more months.
        (d) When it stands in the fuel system of the generator, it coats surfaces with a varnish like layer that hinders smooth starting and running.
        (e) Needs to be drained from the fuel tank.

4) **How much maintenance do you (will you) want to do?**

a) Only you know yourself. How much maintenance will you do on a regular basis? Do it yourself or hire a service company.
b) Generators require regular starting.
    i) Start once a month and run for a few minutes.
    ii) If electric start, charge the battery periodically.
c) Gasoline requires periodic cleaning of the fuel system.
    i) Drain gas from the fuel tank.
    ii) Run the generator until it stops to get all gas out of the fuel lines.
    iii) Clean (or have a company clean) the carburetor.
d) Propane just requires that you shutoff the tank and run until the generator stops.
e) Check engine oil before every start.
f) Change engine oil and clean air filter every 6 months.
g) Check and clean the spark plug every year.

To determine how large a generator you need, gather your appliance power information. This is sample information from a portable generator installation:

Appliance	Starting Watts	Running Watts	Duty Cycle %	Average Running
Refrigerator	720	720	40	288
Wine Cooler	1200	800	40	320
Laptops (2) comb.	165	165	33	55
Cable modem	20	20	100	20
Phone base station	15	15	100	15
Total	2,120	1.720		698

Appliance is the name of the unit.

Watts is the power required. Some appliances with motors will list Starting and Running. If your appliance does not list both, just use the same number in both columns. Many appliances will not list Watts on their nameplate but rather will list voltage and amps. A typical refrigerator may be 120 volts, 6 amps. Multiplying these together gives watts. 120 * 6 = 720 watts.

Duty Cycle is how much of the time the unit is running during the day. Refrigeration is 24 hours a day, but the compressor only needs to run 15 minutes per hour to stay cool. During hot weather, this will increase to 20-25 minutes per hour. Set your duty cycle to 40%. Modems run 24x7 so they are 100%. Laptops would be usually 8 hours so 33%.

Average Running is Running Watts times Duty Cycle. This gives average wattage for fuel calculations. 698 Watts is 20% of 3500W so use 20-25% for fuel consumption to determine how much fuel you need to store.

Starting (Peak) and Running Watts are the minimum power requirement of your generator. Usually, generators are designed to run efficiently at ¼ to ½ load. Spec sheet fuel consumption is normally listed at 25% and 50% load. The example above would require a 3500W Running / 4500W Peak generator.

Suggestions

The best long term solution would be to have a solar array installed with a battery. Couple this with a whole-house natural gas fired generator with an automatic transfer switch. This would give you the benefits of having solar plus the assurance of never losing power (unless we lose the natural gas supply, which could happen following an earthquake). A very rough range of cost is $25,000 to $50,000.

Without the solar, a natural gas generator, installed with automatic transfer, will run about $5000 to $10,000.

A portable generator to run only your refrigeration and minor electronics (no A/C, no TV) is $400 - $1200.

For a generator, gasoline is easy to get but problematic to store and deteriorates quickly. Consider getting a Dual-Fuel model that you can usually run on propane. If you run out of propane, you can switch it to gas.

A very reliable system would be a Dual-Fuel generator with 3 propane tanks, an automatic crossover regulator which switches from an empty tank to a full one automatically. The third tank is reserve. You will need to drive to an area with power to get the tanks (and your car) refilled.

The 'Cadillac' models of small generators, like Honda, are very expensive but also very reliable. A 2800W running / 3000W peak Inverter Generator from Honda will cost about $2000. A Generac model (also an excellent brand) will be more like $900. Both are Gasoline only and are fairly quiet.

There are several models of Dual-Fuel generators such as the Westinghouse WGen3600DF (about $530). This unit will run the sample load above for 1 hour per pound of propane. That's 20 hours for a standard, BBQ size 20# propane tank. A 5 day shutdown would need 6 tanks (120 pounds of propane). Total investment with generator, tanks, propane, power cables, hose, switchover regulator, etc. is less than $1200.

A battery only system, the Goal Zero Yeti 3000 will power a refrigerator and some small items for about 40 hours and costs over $3000.

Sample System

Budget – $1,000 – everything is manual. You plug your appliances into extension cords.

Generator – Westinghouse WGen3600DF. Amazon or Home Depot. $530

Generator cover – Champion. Amazon $23

Gauge – Tank gauge. DOZYANT or similar. Amazon $18

Regulator – Flame King 2-stage Auto Changeover. Amazon $44

Tanks – Flame King 30#. Amazon $44 each (3)

Hour Meter – tracks running time for maintenance. Runleader Hour Meter. Amazon $11

Hose – from regulator to generator 12'. Amazon $25

Cable – Generator to inside the house. Cable Matters 25' NEMA L5-30P – 3x 5-15R. Amazon $43 - DO NOT CONNECT to house wiring.

Cables – various 3 prong extension cords from house input cable to appliances.

Propane – costs about $4.50 per gallon. A 30# tank hold about 7.1 gallons or about $32. 20# exchange tanks may be more convenient and fit into BBQs and deck heaters, etc. About $50 new, filled.