Selecting, Assembling and Installing a Backup Power Generator

In the summer of 2003, I decided to install a rather large automatic backup generator at my home. I had begun traveling quite a bit in my job, and I was concerned that my wife would not be able to set up the manual system that I had installed when we built the house. Another concern was the sump pump in the basement. If we were out of town and had a power failure, the sump pump would not run, and could leave us with a major flooding problem.

I began researching on the Internet, and ended up dealing with a company in Maryland, www.nooutage.com. The owner is a retired power generation engineer, with many years of experience in the field, and he was extremely helpful, and very professional. While making endorsements isn't what I am trying to do with this document, I would not hesitate to recommend the company and the owner.

There are a number of factors to consider when planning a project of this nature, not the least being "…can I do a lot of this myself?…" I decided that I could, and moved on to listing the items to consider.

1. How much power is needed
2. What will the fuel source be
3. Where will the genset be located
4. How much noise will it produce
5. How much work will have to be done on the home electrical system to do the interconnect

How much generator do I need?

That is probably the hardest question to answer. You can narrow it down a little by the fact that the smallest remotely started (off the shelf anyway) genset that you can get is around 10,000 watts output. If your home is all electric, you can also eliminate some of the guesswork by admitting from the beginning that you won't be able to power it all. I designed the systems in my house to be somewhat independent of electricity, the furnaces are gas fired, as are the water heaters, and my range is also fueled by gas. More on propane versus natural gas a bit later on.

Start by making a list of those things that are critical in a power failure. Lighting, heating (or cooling), well pumps, septic system pumps, water heaters, etc., should all be considered. Determine how much power will be needed to run them. Keep in mind that you can stagger using each of these items if necessary. Also keep in mind that electric motors draw a substantial amount of current on start up and then level out to a lower load.

Once you have decided what is the minimum you must have, you can begin sizing generators. I ended up putting in a 15 Kw unit, which I expect to able to handle most of the lighting in my home, both gas furnaces, or one air conditioner, the refrigerator, range circuits to light oven and burners, and the entertainment, computer and ham radio equipment with some to spare. Among other considerations for the unit I selected were

the reputation of the manufacturer (Onan), overhead valves, a block heater included, liquid cooling for additional quiet, and not the least, Onan was the only manufacturer that provided a noise specification for each of its units.

What does this thing burn and how much?

Fuel types and consumption rates are usually stated by the manufacturer of the genset. Gasoline, diesel, propane and natural gas are the four that most people must consider. I have natural gas on site, so it was the logical choice for me. It should be available during almost any emergency, and if it isn't, I'll be heading for a shelter! Propane would have been my next choice. Diesel engines are extremely reliable and long lived, however, they are noisy and can be dirty. Plus, storing diesel for any length of time can be a dicey proposal, as you have to turn it over to keep it fresh. If you are currently heating with number 2 oil, diesel may be a good choice, since you change out your fuel supply at least once a heating season. Gasoline would be my last choice, as you have even more storage problems than diesel and still have to turn it over frequently to keep it fresh.

My generator will draw more than 200 cubic feet of natural gas per hour at full load. In order to support this rate plus the other gas appliances in the house I had to replace the gas meter with a much higher capacity one. The gas company will do this for you, and they didn't charge me anything to do it, but I had to stay on them to get it done. A propane system will require a large (probably 300 gallon or more) storage tank to be reliable. It is also possible, during times of extreme cold, that you will have to have the tank at least half full for gas to flow. Check with the distributor before you make the propane decision, but there are many gensets out there powered by propane. If you already have it on site, you may still have to change out or add another tank.

Placement and noise considerations

If you live with a site manager (translated "spouse"), I suggest you coordinate the placement of the genset with him or her. To do otherwise is risky. I was able to persuade my wife that this large box wouldn't look bad at all when the rest of the neighborhood was blacked out, and she was taking a shower. Consequently, I was able to locate my genset within about 10 feet of the natural gas supply, and within 30 feet of my main electrical panel. That makes the installation a little easier. As mentioned earlier, only Onan specified how loud the thing would be and I ended up buying an Onan genset. I am glad that I did, as the quality is excellent – this thing is built like the proverbial tank, and came with great operating and maintenance instructions. The installation instructions left a lot to be desired.

Code requires that you place your genset at least 10 feet away from anything flammable, and you must not locate it close to any openings that can suck in exhaust gas, i.e. windows and doors. Carbon monoxide isn't friendly. Onan says you can install one of their devices inside with a lot of plumbing, but that was out at this location, and probably isn't a great idea anyway. Mine came with a nice weatherproof shroud that contributes to the 70 dB maximum noise level from 20 feet away. It sounds like a lawnmower running from a distance, and I don't think it will bother the neighbors.

Electrical Considerations

When I built my current home, I installed a manual 100 amp transfer switch, which feeds a 100 amp breaker box. I placed all my critical circuits in that box. It contains almost all the 110 volt circuits for the new part of the house (kitchen/great room, dining room, hallway, bathroom, den), furnace circuits for the two gas furnaces on the first level, all the lighting circuits in the old part of the house on both floors, and several outlet circuits in the old part of the house. I don't have anything except air conditioning units with the furnaces that require 220 volts, and the heat pump for the second floor. It is fed from a sub panel in the old part of the house, so it wouldn't be feasible to try and power it anyway. Since heat rises (see, I did learn something in Physics class), I was not concerned about pipes freezing up there anyway.

When I decided to install the automatic system, it was a pretty simple matter to reroute the feeders from the manual switch into the new automatic switch panel and back out to the emergency panel. That way, if the big genset fails, I can still power the house with the smaller gasoline fired genset and the manual switch.

A word about transfer switches – **don't try to do this without one!** Code requires that your genset be completely isolated from the commercial mains, and a break-before-make switch with a minimum of two poles rated to handle the load you plan to throw at it is not optional. You can't backfeed this kind of system safely. Actually, you probably can't backfeed anything safely, but that's another story.

Most automatic switches come in two flavors – 100 amp and 200 amp. Most have two poles that are switched (single phase), which meets code in the Lynchburg, VA area. I decided that I wanted to switch neutral as well, and discussing that with the electrical inspector, was encouraged to do it. He said that what I planned would exceed code, and he approved. So I bought a tank of a switch go along with the tank of a generator.

An automatic switch takes the guesswork out of a backup system. Basically, the path through the switch when commercial power is available holds a relay open. When power disappears for more than 30 seconds, that relay closes and starts the genset. Once the genset has reached the correct voltage and frequency level, the switch, now being powered from the genset, transfers the power source to the genset, and your critical circuits are powered.

When commercial power returns for a sufficient length of time, the switch reverts to the utility position, the genset runs another 10 minutes to cool down, and shuts itself down to await the next time. These switches usually come with an exerciser program to allow the genset to run, loaded, weekly, semi-weekly or monthly. Weekly is the best idea. I was amazed at the speed of transfer in the test mode, expecting that I would be resetting clocks every week when the genset was powering the panel. Not so with the GE/Zenith switch that I am using – the transfer is so fast that you only see the lights flicker. Obviously, if you lose power, and the entire house goes dark for that long 30 seconds, you WILL be resetting clocks.

If you don't have critical circuits already in a separate panel, you have two ways to go:

1. Put in a panel, move the circuits you need, and wire in the switch/genset
2. Buy a switch that incorporates an emergency panel and extend your critical circuits through conduit to the switch/panel.

I prefer the separate box route, and I think you will spend about the same amount of money either way, especially if you have to hire an electrician to do the work for you. Another drawback to number two is that the number of circuits in the combined device is limited. The most I saw was something like ten 110 VAC circuits and five 220 circuits. You could probably replace the 220 breakers if you didn't need them, but this is a limiting factor if you have lots of circuits that you want to have available. Generac sells such a panel with their gensets.

A large consideration is the total draw from your emergency panel. Be careful that you don't set up a dangerous condition by overloading the panel and expecting the genset to run everything.

This work must be inspected to keep your fire insurance up to date!!! If you are not qualified to do electrical work, and don't know the electrical code, hire an electrician to do this part of it for you. We are not talking about 12 volts DC, this stuff can kill you or burn your house down if it is not sized correctly and installed correctly.

That being said, I did all of the electrical work myself, with the aid and assistance of Wally Hanson, who gave me advice and looked over my work. I also had a long conversation with the head electrical inspector for the City, Harold Hienkle, who was very helpful.

Figure your loads carefully, and make sure that your numbers are right. When the genset starts up with you and/or spouse out of town, it would be really nice if it ran without dying from an overload.

Here are the steps that I took and some of the pits that I fell into. This project took me about 2 months to complete.

After deciding on the size, manufacturer and supplier for the genset and switch, I ordered them. My supplier wanted 50% down and the balance when everything arrived. He was honest, even including a bank reference on his website, and I had no problems with the financial end of things. It was going to take some 4 to 6 weeks for everything to arrive, but I could get started on site preparation, fuel supply, etc.

I called the gas company and began what turned out to be a month of trial and tribulation with them. They had to schedule an appointment with one of their techs to conclude that what I told them really was true and a new meter was needed. They then dropped the

ball, didn't get back to me at all, and I had to fuss at them. One day they showed up, and I had a new meter in place, complete with a shutoff valve leading to a piece of 1 inch hard pipe, exactly what I needed to do the connections.

I had checked with Inspections and found that I could do the gas work myself. At least, as far as the City was concerned I could. The inspector said that the gas feed, since it was to be buried for the short distance between my house and the pad on which the genset would rest, had to be either plastic or a material called Track Pipe. After much looking and arguing, I was unable to purchase either material because I was not certified to install either. I love bureaucracy.

Several people suggested copper tubing, however, that does not pass code for natural gas. So, I had to hire a plumber to purchase the materials and install them. I ran the feed from the gas meter over to the point where the material would connect in and go down into the ground. I dug the trench, told the plumber what I wanted, and then rearranged it once he had finished so it ended up in the correct spot. He would return to hook it up to the set.

Wally came over and helped me and a young man who had worked on my house to dig and frame up a pad. Some of the smaller sets come with a poly pad that can be set on gravel. The larger ones don't, and I was leary of a pad that might wander around when the machine was running anyway. So, add a couple of yards of concrete to the total price.

Once the plumber got done, I ran two pieces of conduit, a ¾ line for the control wires and a 1 ½" line for the electrical supply. These required several bends, as they, too, would be buried and run up through the slab. I had very carefully measured things from the drawing, and, as the genset had showed up much earlier than expected, I was able to get exact measurements for where the lines would stub up. I mentioned that Onan's installation instructions were less than helpful. Their drawing showed the gas line coming up in the wrong place, so it had to be re-routed. Lots of head scratching and thought went into this placement, since once the concrete was poured, the phrase "…set in cement…" would be true.

The electrical inspector also told me that since I was switching the neutral, I had to drive a ground at the genset and bond it. Wally and I had some discussions about that line of thinking, but I did it, and also bonded the genset neutral to that ground. All is working properly, so I guess Harold was right. I would not have passed the inspection without that ground, however.

I had some difficulties getting the right switch – the package when it arrived indicated that there were three poles, but that was not true, and GE/Zenith was less than helpful about replacing it. Took another three weeks to get the right one here. This was NOT the fault of nooutage.com, rather it was a mistake at the plant. Richard worked very hard to work the problem out, and, finally, the new switch was here.

Once it arrived, I mounted it on the wall in the basement next to the emergency panel, and finished up the conduit runs to the outside. I waited to pull wires until I was much further along.

During all this, the mechanical inspector came to check the preliminary gas fittings so we could bury them. He didn't like the bushing type fitting that I had used to transition the 1 inch pipe to ¾ inch, but I fixed that, and he approved the rough in. I didn't think I needed an electrical rough in inspection. Now we could pour the slab.

After the slab was poured and cured for a week, I was ready to set the genset. I ended up hiring another contractor with a Bobcat and a set of forks to lift it from its shipping pallet, set it on the pad for me to get markings in place for the anchors, lift it back up while I put the anchors in place, and then placing it. That was tricky, but it got done in a reasonable amount of time. Now I had the set in place, with 4 concrete anchors preventing it from walking off the pad, and was ready to begin wiring.

Wiring is always fun, and this was no exceptions. This genset has a block heater that requires 110 VAC to keep the coolant warm for fast starting. So, not only did I need to pull three wires for the genset, I also had to pull three more for the AC outlet that was required. That went along pretty well – a fish tape is a useful thing to have. I pulled 3 number 2 wires for the main feed. On natural gas, the genset would not supply more than about 65 amps, however, I was tying it into a 100 amp panel, so I used 100 amp wire.

I wired the outlet into a panel that would not be powered if I lost commercial power, as I didn't want to chance the power hungry block heater coming on and robbing precious power from the genset when not needed. The 110 VAC outlet also runs a battery charger for the starting battery, two more items that had to be purchased separately.

Onan makes no provision for the external wiring to come into the set, something I thought was kinda stupid, so I ended up punching two holes in the electrical box on the genset to accommodate the conduit runs in with all six wires and out with the three wires to the 110 VAC outlet, which had to be a ground fault type. In order to get the wires placed in the 75 amp on board breaker, the entire breaker has to be removed from the housing, because the lugs to tighten the wires are UNDERNEATH the breaker. Stupid design.

Once I was wired at the genset end, I tackled the wiring on the panel end. I had to lengthen the feeds from the manual switch so they would reach into the automatic switch, and after routing them through the switch contacts, return them to the emergency panel. Not hard to do, but time consuming. Once that was finished, I got the plumber to come back and finish up the gas piping.

Onan recommends a second solenoid fuel cutoff valve and an external fuel strainer fitting. The plumber installed these, but I had to trace out the wiring and determine how to wire the second valve. Got it right the first time, as when I installed the battery and hit the switch, the genset fired right up.

I tested everything out, and called for a final mechanical and electrical inspection. The job was done! Well, almost done. The City notified me several months later that my "closed" permit was about to expire. There was a mistake make by the department and compounded by the mechanical inspector that left the mechanical permit open. Another letter and copies of what Mr. Smoot had left behind got that problem fixed. I should have called them and made sure I was complete. Another lesson learned.

Maintenance Considerations

Oil (and in my case, coolant) has to be changed on a regular schedule with any genset. This is vital to keep things running correctly. I mentioned exercising the machine regularly. This is also vital to make sure it is going to meet your electrical demands and that it will run when needed. I run mine weekly for ten minutes with load. The automatic switch handles this without intervention from me.

My switch came with indicator lights, very helpful in determining what state it is in. I recommend a minimum of indicators that tell you that commercial power is available and hooked to the switch, that emergency power is available and hooked to the switch. This is handled on the GE/Zenith switch with LED indicators, and they are pretty easy to read and understand.

My genset also has an hour meter that allows easy indication of when things should be maintenanced. Onan's manual specifies maintenance items in terms of the number of hours on the genset.

Checking voltage and frequency from time to time is also a good idea. I have meters that do both, and these can be obtained without a lot of expense. Some panels have full metering to tell you these things, but they tend to add a lot of cost to an already expensive item.

Don't skimp on the switch. If it doesn't function correctly, you have nothing.

I hope that this information will be helpful to someone who is considering the purchase and installation of a large genset. Caveat – if you are not comfortable with all aspects of the installation, get a contractor to do the job. Fred Hickey (Hickey Electric) specializes in these things, and does good work. I sweated a lot over this job, but I know it from one end to the other and can fix whatever breaks, for the most part. I do have the electrical knowledge to handle that end of it. If you don't, hire an electrician.

Don't avoid an inspection. If you have a problem down the road, it will be on record with the City or County that the job was done correctly and signed off on by the right people. You can void your homeowners insurance with an uninspected job. Don't take the chance.

Good luck!

A Safety Consideration

Several weeks ago, Doug Harrington emailed me concerning his installation, which was done by Hickey Electric. He had Fred install two disconnect switches for the two generators he installed, and place them next to the service entrance. His thought was that if the fire department ever had to respond to a fire in his home, they would probably pull the meter right off the bat, or at least at some point, depending on how bad the fire was. Power goes, generators come on, power is back again. Not good! This is an excellent idea on Doug's part.

I had a chance to talk about that with one of the City fire captains several days later, and he thought Doug had a good point. He said that they don't train for this eventuality, and would ask the training officers to include it in their SOP in the future.

I didn't install a cutoff outside because code didn't require it, but in hindsight, I now wish that I had. Instead, I am going to place a notice on the service entrance panel, warning that the generator will activate when power is removed, and suggesting that the gas be cut off at the meter. Since the genset, service entrance and gas meter are all close together, that shouldn't be an issue.

If you are planning an installation, an outside cutoff, as well as a notice to the fire department are excellent ideas. Doug also recommends storing a fire extinguisher rated for electrical fires at the generator. Thanks, Doug!

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