Residential Generator Seminar

Part 1

Presenter: Carl Wahl

Welcome

This is a presentation offered by Fire Safe Occidental and will be available on our website. Please don't worry about taking notes. Please absorb and then do in depth review at your leisure.

The presentation consists of two hour long sessions with a 15 minute break in between, followed by a Q&A session. We have placed 3x5 cards on your seats. Please write down any questions you have. We will collect them at the ends of the rows at the end of each session, and will do our best to get to all your questions during the Q&A session.

Finally: Carl Wahl has generously researched and assembled the following information. We ask you not to follow up with him beyond the Q&A session today. As you will see and hear today, setting up what is essentially your own home power plant is complex. The decisions you need to make are yours to make in consultation with your family and energy experts. Neither Carl nor anyone else associated with Fire Safe Occidental can make them for you.

Residential Generator Seminar

Part 1

- **How a generator works**
- **Fuel Choices**
- **Types of home generators**
- **Sizing a generator for your needs**
- **Overall system costs**
- **Recurring costs**

Part 2

- Types of generator connections
- Generator start up and shut down procedures
- Safety Considerations
- Ways to Minimize Problems and Improve Reliability
- Maintenance Requirements

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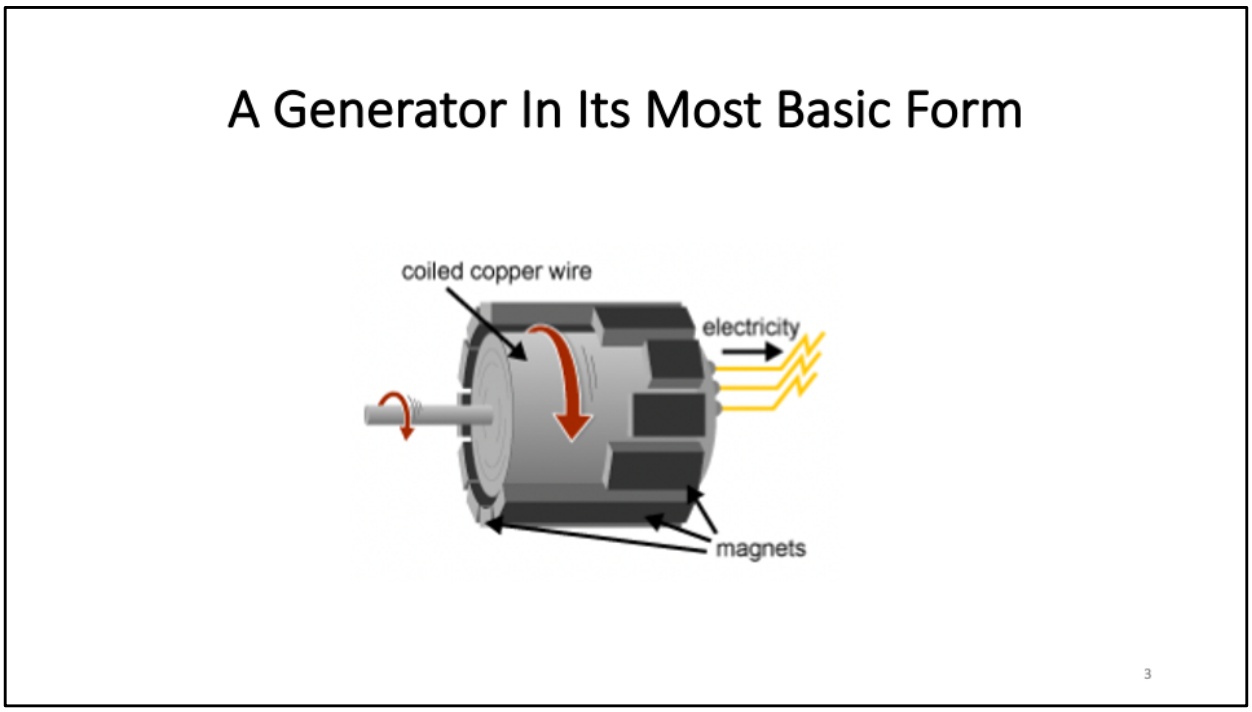
First, a disclosure: I do not profess to be a generator expert, and I've never been a licensed electrician.
However: I've owned and maintained a generator for over 20 years. I also own and maintain 7 additional small engines. I have a background in electronics and have done extensive electrical wiring. So, that said, let's see if I can live up to your expectations.

The purpose of this seminar is not to steer you to specific generator manufacturers or models. Rather, it's to provide you with the knowledge needed to make informed decisions in selecting the type of generator product that best suits your particular needs.

Another purpose is to alert you to safety and maintenance issues and also to provide you with tips on how to minimize problems and perhaps even enhance the performance of the generator you may already own.

There has never been a better time to buy a generator. Adjusted for inflation, generator prices have substantially dropped during the past 15-20 years and that's been coupled with better features, better warranties, and far more choices.

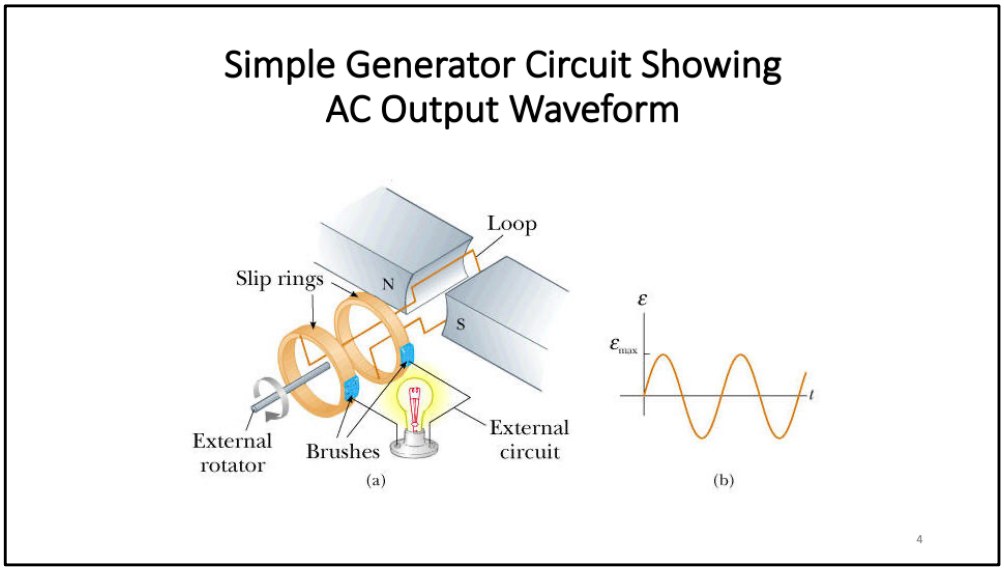
This is a very broad topic. To help narrow things down, the presentation will be geared toward the power situations typically encountered in the Occidental Community Services District area .



First, the basics. In less than 3 minutes: What is a generator, and how does it work?

A generator is a device that converts mechanical energy into electrical energy by the movement of coiled wire within a magnetic field. A generator consists of two basic parts: a rotor (sometimes called an armature) and stator. The rotor consists of the coiled wire, which rotates inside of the stator, a stationary cylinder that provides a strong magnetic field.

Generators use an electromagnet to supply the magnetic field. The magnetic field *induces* a current into the rotating coiled wire. This is why the principle is known as *electromagnetic induction*.



This diagram shows how a generator connects to a circuit, via a slip ring and brushes. The filament in that light bulb represents the powered electrical devices in your home.

The graph to the right shows an AC generator's typical output voltage pattern. It is what that filament experiences over time.

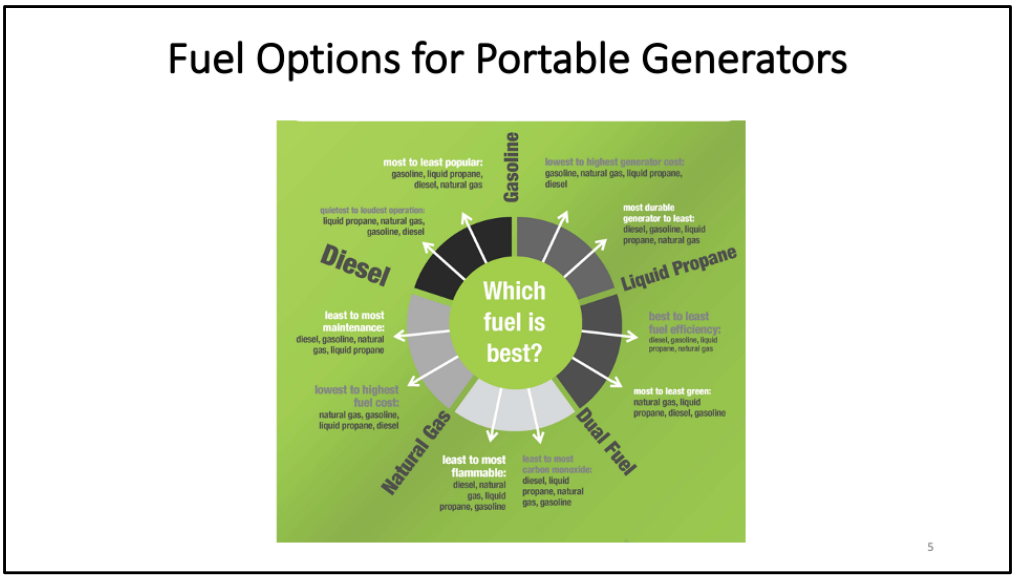
The X-axis indicates time. The Y-axis indicates voltage.

The vast majority of people in our district require a 240 volt generator due to the need to power 240V water pumps.

For 240V power, the E-max voltage would be 120 volts and there would be a corresponding E-minimum voltage of -120 volts. The differential/difference between the two is 240V.

The voltage fluctuation over time between these limits produces what is known as a sinusoidal wave pattern-or a sine wave. This is what is known as alternating current. The pattern shown represents about 2 cycles of a total of 60 cycles that would be produced every second by the typical home generator in the United States.

BTW: Voltage is represented by the letter "V" in electricity, but is represented by the letter "E" in electronics. Epsilon is the Greek symbol for E.



The three biggest issues to decide upon when purchasing or upgrading a generator are:

1. What fuel to use

2, What size generator is needed to meet your emergency electrical needs

3. How you wish to connect the generator to your desired devices

Let's start with the fuel issue.

There are 7 fuels that can power generators. This diagram shows the most popular four.

<u>Diesel</u>

Diesel powered generators are fantastic: They require the least maintenance, last the longest, are the most fuel efficient, and diesel fuel is the least flammable.
But: Diesel generators are *by far* the most expensive, the loudest, and *diesel fuel is not as available as the other fuels*. I therefore suggest not considering them.

<u>Natural Gas</u>

You need to be on a municipal hookup to have access to it. If you do, methane deserves serious consideration. (BTW: Natural gas is almost all methane, with trace amounts of ethane, propane, and butane.) Methane is the cheapest, cleanest fuel and one would *normally* have access to a never-ending supply.

However, in October 2019 during the Kinkaide Fire, PG&E shut off natural gas to over 24,000 properties—including homes in Forestville, Graton, and parts of Sebastopol.

That said, If you have access to natural gas, there is a simple workaround that can provide power even if PG&E shuts it off. You can easily convert a methane-powered generator to propane. How to do this is beyond the scope of this presentation, but there are on-line tutorials that show how it can be done.

The takeaway: For most of us, our practical fuel options are limited to gasoline and propane.

We've now narrowed our search to 240V, AC 60 HZ generators that run on either gasoline, liquid propane, or both.

A Typical Gasoline-Powered Portable Gen-Set

- 5000W 240V 30A twist lock
  Recoil start
- 3 year warranty
- free lifetime technical support
- $773 with free shipping

Running watts, rated watts, and continuous watts: All mean the same thing
Starting watts, surge watts, and peak watts: All mean the same thing

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This unit is professionally referred to as a “gen-set” because the generator only comprises a portion of the unit. The gen-set consists of the generator, an internal combustion engine, a recoil start and/or electrical ignition switch, a fuel storage tank, and an electrical output panel.

Generator terminology has been evolving since 1831 and has become a bit convoluted. The terms “running watts,” “rated watts,” and “continuous watts” all mean the same thing and are often used interchangeably. Likewise, the terms “starting watts,” “surge watts,” and “peak watts” all mean the same thing and are often used interchangeably.

Don’t rely on that bold 6,250 figure! This is only a 5,000W generator. If the continuous load exceeds 5,000W this generator will be driven into overload. If it doesn’t trip a circuit breaker, this can damage the generator—and may damage equipment you have running on it.

As for the 6,250W starting spec: “Starting watts” is like having a certain amount of “headroom”—but only for a couple seconds at most. Still, the generator’s ability to do this is very important when one has motors or compressors to power.

Examples of when starting watts come into play include: Well pumps, jet pumps, storage tank pumps, sump pumps, refrigerator and freezer compressors, air conditioning compressors, forced air heater blower motors, and clothes dryers.

Keep this picture, the 5000W rating, and the $773 price in mind.

A Typical Propane-Powered Fixed/standby gen-set (with transfer switch)

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Propane-powered stationary gen-set

Now, by comparison, consider this stationary generator. ("Stationary," "standby," and "fixed" gen-sets all mean the same thing.)

This type of unit can typically run on either propane or methane. Many come with a mating transfer switch to tie the generator into your home's electrical system. I will explain how this works in the second half of the presentation.

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A Typical Diesel Generator

6,500W Aurora/Perkins

- **Liquid cooled**
- **1800 RPM, AVR +/- 1%**
- **oil pressure switch**
- **coolant sensors**
- **fuel sensors**
- **SS hardware**
- **over 600 lbs.**
- **5 yr. warranty**
- **expected lifecycle 20,000+ hrs.**
- **$8,500 (10Kw model: $9,600)**
- **Output: 240V 33A**

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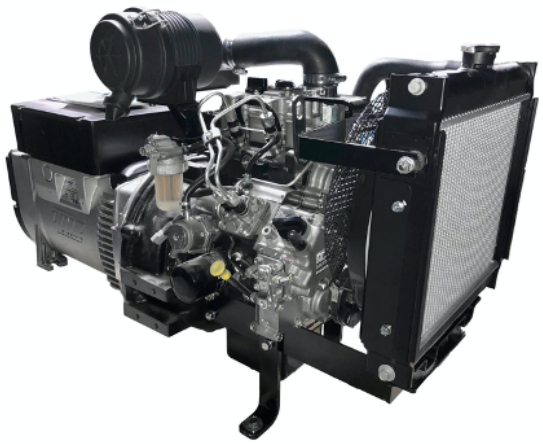
This shows why, although they are fantastic generators, diesel generators are not geared for the average homeowner—unless you demand Mercedes quality.

Why do they cost so much?

For starters, it's liquid cooled, has a pressurized oil delivery system, and runs at only 1800 RPM. Every other generator I'll be discussing runs at 3,600 RPM. These stats help explain why a generator like this will last 10X as long as a portable generator and at least 3x as long as most standby generators. This gen-set also has automatic voltage regulation of plus or minus 1%--which is almost unheard of, has all SS hardware, and it comes with a 5-year warranty.

Perkins Diesel Engine for the Aurora gen-set



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A picture is worth a thousand words. Here is what's under the cover of the diesel generator shown on the previous slide. Great machines but they are not practical for residential use.

Occidental Area Power Outage
Gasoline Availability

Only 4 gas stations near us can provide gas during power outages:

- 76 Station at Occidental Rd. at Hwy. 116
- 76 Station in Guerneville on Main St. across from Safeway
- MD Gas. 16430 Main Street, Guerneville
- 76 Station in Bodega Bay (Hwy. 1 across from Tides restaurant)

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Gasoline! Still by far the most commonly used fuel. However, out of the nine closest gas stations to our area, these 4 are the only ones that will be operational during a power outage.

Further: During the October outage, none of these 4 stations would answer phone calls. So, even *gasoline* availability appears to be an issue.

The Two Classes of Home Generators

- **The portable generator - Four types to consider:**
  - Gasoline fueled
  - Dual fueled (gasoline and propane)
  - Inverters
  - Parallel-linked generators (gasoline or dual fueled)

- **The stationary/permanent/standby generator - Two types:**
  - Methane (natural gas) fueled
  - Propane fueled

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There are two main classes of residential generators: Portable and stationary.

I'll now review each of four portable generator types and discuss the pros and cons of each type.

I'll then similarly discuss stationary generators – also known as standby or permanent generators and their pros and cons.

Typical Mid-Power Portable Generator

Champion Portable

- 7500-Watt
- Electric Start
- 25-ft. Extension Cord
- $833 and free shipping

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First: Portable gasoline-fueled generators

In the Champion lineup, this generator is one model above the one I showed earlier. But: It delivers 2,500 W more power, has an electric start, (which the other one doesn't have), and includes a generator cable. Yet it costs just $60 more than the other one.

The point: **As you go up in price from around $600 to around $1200, what you get in terms of power and desirable features usually *more* than offsets the price increase.**

Also, for anyone with a pump or an electric water heater, that 5,000W generator would probably be insufficient.

Gasoline-Fueled Portable Generators

PROS:

- Less expensive than comparable inverters and standby generators
- Portable
- Easier to fix than standby generators
- Gas is 26% more fuel efficient than propane

CONS:

- Must be manually started by either a battery or a recoil start
- Limited to a maximum of *about* 17Kw rated/running power
- Nosier than comparable-sized inverters and standby generators
- Stale gas issues and associated maintenance
- As with all portable generators, although they are water *resistant*, they should be protected from rain

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Pros:
Easier to fix partly because it's portable: You can easily wheel it into your shop or bring it to a repair shop.
It takes 1.26 gallons of liquid propane to deliver the same amount of power as 1 gallon of gas.

Cons:
17kW is not much of a "con." For most households, any generator rated at around 10kW or more can power your entire home **if you practice power management**. Our home is 4,200 sq. ft. and I power it all, plus an outbuilding, with a 10kW generator. I have 4 loadcenters housing 76 circuit breakers. It's called power management, and I'll be discussing power management shortly.

(BTW: more terminology - A loadcenter is the same thing as a circuit breaker box or if you are old enough to remember, a fuse box.)

I'll discuss stale gas later and will discuss rain protection options in Part 2 of the presentation.

Typical Mid-Power Dual-Fuel Portable Generator

Champion Dual-fuel portable

- Electric start
- 7500W rated/running
  9575W peak/surge using gasoline
- 6750W rated/running
  8400W peak/surge using propane
- $930 and free shipping

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Now let's discuss option #2: Dual-fuel generators. In this case, for $97 more, you get the same power and features as the gas-only model I just showed, but this can additionally run on propane.

Note the 4 wattage numbers shown on this gen-set. The two upper yellow numbers are the gasoline ratings, both the surge and running specs. The lower, two green numbers refer to the propane ratings—again both surge and running watts. **The span in these specifications is almost 3,000 W!!** Presumably, most people who would opt for this generator would desire to use propane so as to avoid the stale gas issues. **So, if you primarily plan on using propane, remember that this is only a 6,750 W generator. You need to understand this.**

The good news is that there are after-market conversion kits to convert your existing gasoline-fueled generator to propane. They are generator make and model specific. Those kits cost around $100-$300.

FYI: There's a highly-rated WEN dual-fuel generator, model DF11000T, that is rated at 7,500 W on propane and costs over $100 less than this one.

Duel-Fuel Portable Generators

PROS:

- Less expensive than comparable-sized standby generators
- Portable
- Easier to fix than standby generators
- Choice of two fuels
- No need for a large propane storage tank, can use exchangeable propane bottles
- Able to obtain propane during a power outage when gas pumps may not be working....but this is misleading
- Stale gas issues eliminated if using propane

CONS:

- Cost about $100 to $300 more than its gasoline-only counterpart
- Must be manually started by either a battery or a recoil start
- Limited to a maximum of *about* 12.5 Kw rated/running power
- Noisier than comparable-sized inverters and standby generators
- Stale gas issues still apply if one does not use propane
- 26% less efficient if using propane
- Again, exposure to the rain is an issue

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Pros:
(Concerning the ability to obtain propane during a power outage): This option may not be possible if one is exchanging 20 lb. propane tanks at a hardware store. In our area, one would realistically desire changing out 4-6 tanks at a time, and the supply for doing so may not exist. Also, during a prolonged outage, retailers may limit the number of exchanges.

Therefore, for our area, this bullet is only a “pro” if you either have a residential propane storage tank or own at least 3 or 4 40 lb. propane bottles.

Exchangeable Propane Tank Use Considerations – 20 lb. Tank

- 20 lb. propane tank stats
  - Weight: About 22 lbs. empty/37 lbs. full
  - $34.47 at Lowe's/ Cotati
- One gallon of liquid propane weighs 4.23 lbs
- A 20 lb. tank of propane therefore contains about 4.7 gallons of LP
- You will only receive 15 lbs. (3.53 gal.) in a tank exchange

How many tanks or refills would you realistically need during a 4-day outage?

- Exchanging 5 tanks at once will provide 17.6 gallons of propane which should produce *about* 30 hours of power—or *about* 10hrs./day for 3 days. (at a 0.6 gal./hr. consumption rate)

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You'll only receive 15 lbs. of propane in a 20-lb. tank exchange. This 25% reduction began around 2011. It has nothing to do with the space needed for gas expansion. The tank is made for 20-lbs. of fuel.

In my opinion, this is an inconvenient option.

Exchangeable Propane Tank Use Considerations – 40 lb. Tank

- 40-lb. propane tank stats
- Weight: about 73 lbs. full
- $80.17 at Home Depot
- Full, this tank contains 40 lbs./9.45 gal. of propane
- Refilling 3 tanks will provide 28.3 gal. of propane
- This should produce *about* 48+ hours of power—or *about* 10 hours/day for almost 5 days at the same 0.6 gal/hr. consumption rate

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Now consider this alternative option.

(BTW: I mention running your generator for 10-hrs. a day because, other than for standby generators, they are not meant to run continuously. I'm assuming a typical daily generator usage of from around 7 am to noon and from 5-10 pm. With that regimen, your perishable food should remain fine if you minimize opening your refrigerator.

With this option you have the tanks filled at a place like Blue Star gas and get a full 40-lbs. of propane. The tanks can be safely stored indefinitely without any degradation. Propane never degrades. You can keep it stored in a tank like this for decades. You can therefore *always* be prepared for a long outage.

In short:

Three 40-lb. tanks can deliver 5 days of 10-hr. run time while five 20-lb. tanks can only deliver 3 days. Plus: With this option, you own your own tanks that you can maintain in pristine condition. If you own 4 of them, you can probably weather a 7-day outage without any refills. The only downside is the weight of the full tanks: 73-lbs.

Now for some unpleasant news.

Gasoline and Liquid Propane Storage Restrictions

Gasoline:

- You are permitted to store up to 5 gallons of gasoline in an approved container in a garage or outbuilding.

OR:

- You are permitted to store up to 10 gallons of gasoline in an approved container(s) outside your buildings.

Propane:

- You are permitted to store up to a total of 70 gallons of liquid propane (300 lbs.) in approved containers in a garage or outbuilding. There are no restrictions on cylinder size.
- Outdoor propane storage can be as large as 1,000 gallon tanks (provided proper clearances and safety requirements are met).

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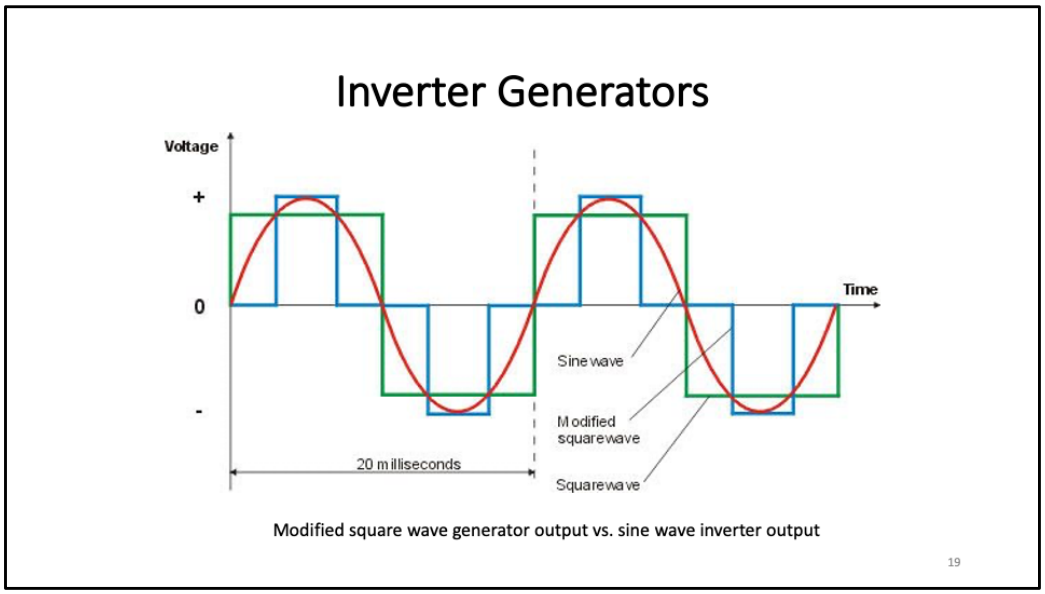
There are codes that set limits to both gasoline and propane fuel storage.

These codes have been set by the NFPA (National Fire Protection Association) and have been adopted by Sonoma County.

There are *many* NFPA regulations on flammable fuel storage, and it's beyond the scope of this presentation to discuss them. That said, I advise you to review them. (Example: NFPA Code 58 includes propane storage)

You need to decide what *you* wish to do about this. I'm not going to comment. I'm just the messenger.



Now for the third portable generator option: Inverters

Inverters are a superior type of generator. One of *several* inverter advantages is shown here.

The ideal power output is the sine wave pattern I showed you on the second slide and shown here again in red. However, most portable generators are notorious for a distorted power output that resembles the blue line in this diagram—which is known as a modified square wave. You may have heard the term "dirty power." This is what it refers to.

The good news: Dirty power is no longer quite the problem it used to be because most consumer electronics have evolved to run on distorted power.

But this is *not* the case for electronics that use the sine wave as an electronic clock. That clock is synchronized every time the sine wave crosses the "X" axis. A square wave disrupts that timing. This is very important with some home medical devices like oxygen concentrators and also micro-chip based appliances like variable speed heating and air conditioning units.

The specification that quantifies this signal distortion is called "harmonic distortion." The spec is shown as "THD"-- "total harmonic distortion," and it's expressed as a percentage. The lower the number, the cleaner the power. Many portable generators have a THD spec of greater than 10%. Inverters have THDs of less than 6%, and better units have THDs of less than 3%.

In short: Inverters deliver much "cleaner" power.

A High-Powered Inverter Generator

- Champion 5000W inverter
- Both recoil and electric start
- Intelligauge ® display: Voltage, frequency, and operational hours
- 3-year warranty with lifetime technical support
- 4.8 stars based on 14 reviews
- $836 with free delivery

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Unfortunately, inverter generators are only available in low power outputs. Most inverters are rated below 3,500W. This is one of two exceptions that I'll show you.

(BTW: I'm not a champion of Champion. I know nothing about their reliability. The company was founded in 2003 and their products are make in China. I'm only showing them because they have nice graphics.)

Inverter generators are only available in low power outputs. This is a slight exception.

Here's a high-powered inverter with an *exceptionally* low price. It's almost like the price is missing a digit. It is rated at 5,000W and 6,250 starting watts. However: Fourteen reviews don't make the very high rating statistically valid, and, unfortunately, they're all Amazon ratings. The more meaningful reviews come from companies that deal exclusively, or primarily, in generators.

High-Output Inverter Generator

Honda EU7000IS Inverter

- 5,500W rated/running
- 7,000W peak/surge. 52-60 dBA at 7m
- 4.9 stars (based on over 300 reviews from Northern Tool, Electric Generators Direct, and Amazon)
- $4,449

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I'm showing this inverter because it's quite unique. For one, this is the highest rated generator, **of any kind,** I found throughout my research and over 250 of the reviews were from Electric Generators Direct. It's also the highest power inverter I've found. It's also the first inverter *ever* to have electronic fuel injection – so there are no carburetor issues. It also boars onboard diagnostics and has a three year residential and three year commercial warranty.

In November I saw this inverter in operation and can testify to its extremely low noise level.

BTW: A quick noise level primer. Decibels are a logarithmic function. A sound level doubles in volume with each 10-decibel increase.

To put that in perspective: My buddy has a 3,000 W Champion dual-fuel generator with an 83 dBA low load noise rating at the same 7m distance as this one is tested at. So, that would correspond to the Honda's 52-decibel value. In short, my buddy's 3,000W generator is about 8 times as loud at this 5,500W Honda.

If you have *modest* power needs, but are of more than modest financial means, and desire awesome reliability coupled with exceptionally low noise, clean power, ease of operation, probably minimal gas problems, and portability, this unit deserves serious consideration. BTW: This will be my only "thumbs-up" opinion in this presentation.

Last, if purchased from a company called Genconnex, they can convert this unit to run on propane prior to shipping.

Inverter Generators

PROS

- More efficient than comparable size gasoline or propane generators
- Quieter than all comparable size generators
- Purer sine wave (less THD) than other types of generators
- Reduced size and weight

Cons:

- More expensive than comparable standard gasoline and propane generators
- Not available in power outputs above about 5,500W
- All the issues associated with gasoline still apply: stale gas, flammability, availability, CO poisoning

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Pros: In addition to cleaner power and lower noise, inverters have other pluses:

Inverters produce power differently than other generators. They do an AC to DC to AC power conversion and, in the process reduce distortion and also become more energy efficient. (Incidentally, the second conversion, that from DC back to AC is referred to as an "inversion"—hence the name "inverter.")

(So far, I showed you 2 graphs of generator *voltage* vs. time. Now, instead, picture a graph of *wattage* vs. time. Other than for a surge demand, the wattage output a typical generator is a flat line. Your home's electrical load, however, varies *wildly*. The vertical distance between these two lines is wasted power.

However, an inverter's output constantly varies to meet the load demand. The inverter's power stays in sync with power consumption. The vertical distance between the demand an supply power graph lines is quite small.

Result: Inverters have minimal wasted power and, consequently, greater efficiency and less fuel usage.

Typical Portable 120V Duel-Fuel Inverter Generator Capable of Parallel Hookup

120V Champion 3100-W RV Ready Duel-Fuel Generator

- Electric start
- 3100W rated/running
- 3400W Peak/surge/peak
- 59dBA at 23 ft
  THD<3%95.7 lbs
- Parallel Kit: Uses a "parallel block" to tie two "like" inverters together
- $1007
- 4.5 Based on 388 reviews

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Here's the last of the *portable* generator types under discussion: the parallel-hookup generator.

For this option to work, you need two *identical* generators capable of parallel hookup. Also, as shown in the right photo, you need to have a "parallel block kit" to connect them together.

A number of companies make them. For that matter, even the Honda EU7000 I just reviewed is capable of parallel-hookup

You pay substantially more for this 120V generator because it is also a dual-fueled inverter.

Using an identical pair of parallel-ready generators provides several advantages:

1. You could power your home with one unit while simultaneously powering an outbuilding like a studio, shop, or granny unit with the second—without the need of a very long extension cord. But bear in mind that **this unit cannot power pumps** because it's only 120V.
2. Using a "parallel block" you could connect both generators together and, in this example, have a combined power output of about 6,200W for one's home in, say, the evening hours.
3. Also, if one unit fails, you have a backup unit.

This completes my *portable* generator discussion. Now let's discuss the *stationary* (aka standby or permanent) generator.

Typical Permanent/Standby LP or NG-Fueled Generator

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Stationary or standby gen-sets include their own protective enclosure and some, like the one shown here, come with a composite base to mount them on.

Some, also like the one shown, include a matching switch to couple the generator to your home electrical system. I will explain these switches in detail in Part 2 of the presentation.

Standby LP-fueled Generator

Pros:

- Wide range of power options
- A matched automatic transfer switch is often included in the price and can provide for total hands-off generator operation
- Somewhat quieter than comparable gas-powered generators
- Lifespan typically longer than all but diesel generators
- Propane:
  - burns cleaner than gasoline
  - produces less carbon monoxide than gasoline
  - does not get stale

Cons:

- Higher cost ($3K to over $12K) than all but diesel generators
- Propane gas piping is needed to the generator
- Propane generators are complex and can be harder to fix
- Not portable
- On-site repairs and maintenance
- Fuel can be costly if the unit is run for an entire multiple-day outage

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Pros:

With respect to power output: There are a vast range of power options—ranging from about 8kW to at least 200kW. (To put that into perspective, PG&E delivers 48kW to most rural homes.)

With respect to carbon monoxide: Propane will only produce CO if the unit is not properly tuned and causes incomplete combustion.

Cons:
Concerning the third bullet, complexity: This has more to do with the electronics that gives it the ability communicate with the transfer switch and, on some models, also communicate remotely with the homeowner.

Typical Standby Generator

17Kw Cummins RS17A standby generator

- Includes 200A Automatic transfer switch
- 39L x 36W x 30H. AVR: +/- 1.25% <5% THD
- Remote monitoring possible
- $4,000 through Costco

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Here's another typical standby generator.

Cummins/Onan makes several small standby generators that have this same very compact footprint. Cummins also makes many larger units.

I'd like to call attention to the second bullet: These specs show that this unit delivers very clean power. The THD spec is in the realm of that for an inverter. AVR stands for "automatic voltage regulation." A spec of plus or minus 1.5% means that the output voltage fluctuation will vary by no more than 1.25% from it's rated output. That means that the voltage will always remain in a range of 237-243 volts, which is excellent.

Last, the unit is capable of remote monitoring. For example, you can power it on or off from a remote device.

Fuel Consumption Comparisons

RS13A: 13kW $3,200/Costco with 100A automatic transfer switch

- ¼ load = 1.4 gal. propane/hr. 4.5 days = 108 hrs. = 151 gal. At $3/gal. = $454 or $101/day
- ½ load = 1.7 gal. propane/hr. = 184 gal. = $551 or $122/day

RS17A: 17kW $4,000 Costco with <u>200A</u> automatic transfer switch

- ¼ load = 1.5 gal. propane/hr. 4.5 days = 108 hrs. = 162 gal. At $3/gal. = $486 or $108/day
- ½ load = 1.9 gal. propane/hr. = 205 gal. = $616 or $137/day

RS20AC: 20kW $4,500/Costco with 200A automatic transfer switch

- ¼ load = 1.5 gal. propane/hr. 4.5 days = 108 hrs. = 162 gal. At $3/gal. = $486 or $108/day
- ½ load = 2.0 gal. propane/hr. = 216 gal. = $648 or $144/day

13kw/17kW = 0.76 or 76%. The 17kW generator delivers 24% more power than the 13Kw but only consumes about 9% more fuel.
13kW/20kW = 0.65 or 65%. The 20kW generator delivers 35% more power than the 13Kw but only consumes about 15% more fuel.

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Here I'm comparing 3 Cummins/Onan gen-sets in a similar power range. The slide I just showed is the RS17A. However, most homes in our area above around 2,000 sq. ft. could probably be well-powered by the 13kW model.

There are 3 variables to consider here: Power output, fuel consumption, and price.

First, power: Standby generators often don't have a surge power rating. For example, the RS17A delivers 17kW. Period. Keep that in mind when sizing a standby generator.

Second: Fuel consumption. I'd like to dispel a common misconception on fuel consumption. Although a more powerful generator in a specific generator manufacturer's series consumes more fuel to produce more power, fuel consumption is not directly proportional to the size of the generator. For example, a 10kW Generac generator does **not** consume twice the fuel as a 5kW Generac generator in the same model line.

For example, as this slide shows, at a ¼-rated output load, the 13kW generator consumes 1.4 gal. of propane/hr. whereas both the 17 and 20kW generators consume only 1.5 gal. The 20kW generator consumes a mere 0.1 gal. more, yet it delivers 35% more power than the 13kW unit. In short, and this applies to portable generators as well: Within the same generator series, as power increases, there is an *economy of scale* in fuel consumption. (Continued next page.)

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And third, price: Up to about 20kWs, the value you receive for purchasing a larger model in a manufacturer's standby generator series *usually* justifies the increased cost. For example, the $800 difference between the 13 and 17kW generators delivers 4,000W additional power and includes a heavier duty transfer switch. I think that's a fair deal—provided your situation really requires that much power. If not, you're wasting money.

And since I'm mentioning it:

Calculating the Power You Need

To determine your basic home power needs, start with these three questions:

- **Do you use city or well water?**
  - *Well pumps require a larger 240 volt generator (rated 3800 watts or above)*
- **Is your heating system electric, heat pump, or gas forced air?**
  - *Gas forced air systems can get by with a very small generator – as little as 2500 watts. The power needed is based on the size of the furnace fan motor*
  - *Electric furnaces and heat pumps typically need 15,000 watts or more to run and cannot be powered by a portable generator*
- **Is your hot water heater electric or gas?**
  - *Gas heaters use less power – as little as 2500 watts*
  - *Electric heaters often require at least 4500 watts*

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Sizing a generator for your needs is the second big decision you need to make.

This slide is *not* my handiwork. This was copied from a Honda website.

There are several takeaways here:

- If you need to have either electric space heaters or heat pumps running during an extended winter outage, you need a *standby* generator.
- If you have a well pump or water storage tank pump, factor-in about 3,800 starting watts for *that motor alone*.
- If you want an electric water heater available during an extended outage, like a 50-gallon tank, factor-in about 4,500 *running* watts. This water heater alone will consume the entire power output of many mid-sized generators.

Should you opt for a minimal-sized generator?

Pros:

- Less cost
- Less fuel consumption per hour
- Possibly less noise
- Possibly less maintenance

Cons:

- Restricts what you can simultaneously power
- Usually requires active power management
- Impacts your lifestyle to a higher degree

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These are all very valid reasons for opting for a minimal output gen-set.

Another “pro”: Smaller portables are lighter and easier to maneuver.

Cons: These three points are all related. The main takeaway here is that you need to assess the degree of time and thought involved in practicing **active power management**. To avoid potential damage, you need to monitor the aggregate power your energized devices are using and not exceed the generator’s rated power. If you can live with that, a minimal-output unit may be a good choice.

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What Circuits to Power During a Long Power Outage

This is a matter of personal preference.

Consider:

- Refrigerator/freezer
- Receptacle(s) for any powered medical devices
- Microwave oven (or cook top, if electric)
- Pump (submersible or jet) for your water storage tank (If no storage tank, the well pump should probably be powered)
- At least one extra 120V receptacle (for computer, phone recharging, lamps, etc.)
- Electricity to one bathroom
- Optional: Water heater (tankless or similar)

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In our area, the first four items are virtually mandatory. The last three, less so.

Concerning the last bullet: The type of water heater is important to consider. A propane-fueled tankless water heater requires just need a few watts for the electronics. By comparison, an electric tankless water heater requires a huge amount of electricity—typically its own 60A circuit.

Resistive Loads vs. Reactive Loads

Resistive Loads: Devices that require the same amount of power to both start and run the equipment. Examples:

- Light bulbs
- Coffee makers
- Toasters

Reactive Loads: Devices that employ an electric motor, which requires additional power to start, but which requires significantly less power to run after start-up.

Reactive load devices draw anywhere from 2x to 5x the amount of rated power upon startup. Examples:

- Refrigerators / freezers
- Furnace fans
- Well pumps: submersible and jet pumps
- Air conditioners
- Air compressors
- Power tools

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An electrical device can be classified by the type of load it presents to the power source. There are two classes of electrical loads—resistive loads and reactive loads. You need to know the difference between them.

Resistive loads:
Other examples of resistive loads include microwave ovens, and video and stereo equipment.

Knowing this, the first step is to now make a list of the devices you desire to be powered during an extended electrical outage. You also need to identify which of those devices will present a reactive load to the generator.

Wattage Calculating

Add up the power consumption for all items in your home that you would realistically need during an extended power outage. These will all be the item's "running" loads. To find this information:

- Look for the wattage information on the item, in the owner's manual, or on line
- If there is no wattage information on the item's label or in the owner's manual, calculate it by multiplying the voltage (E) by the current (I): W=E x I

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This is the next step: Locate or calculate the wattage requirement for each desired device on your list.

As stated on the slide, if you cannot locate the wattage load of the device, use the W = E x I formula to calculate it.

Example: If you have a toaster, and the only information you can find is a plate on the underside that states it uses 7 amps, the wattage would be 120V x 7A or 840 watts. Simple.

Again, just remember that wattage equals voltage times current.

Wattage Guide*

Generator Wattage Guide

+ Add All Running Watts for Items You Wish to Use
+ Add Single Highest Starting Watts out of Items You Wish to Use

= Sum the Total of All Running Watts & Highest Starting Watts to Calculate Total Starting Watts Needed

Wattage Needs

*A hyphen indicates there is no additional starting watt requirement for this device

Essentials	Running	Starting
Incandescent 60w Bulb	60	-
LED 60w Bulb	10	-
Refrigerator / Freezer	700	2200
Sump Pump (1/2 HP)	1050	2200
Water Well Pump (1/3 HP)	1000	2200
Electric Water Heater	4000	-

Entertainment/Electronics		
Smart Phone Charger	25	-
Stereo	200	-
LED TV 42 in.	85	-
Laptop computer	250	-
Inflator	50	150

Heating/Cooling		
Space Heater	1300	-
Furnace Fan Blower (1/2 HP)	800	2350
Window AC (10,000 BTU)	1200	1800
Central AC (24,000 BTU)	3800	4950
Heat Pump	4500	4700
RV AC (11,000 BTU)	1010	1600

Cooking		
Microwave Oven (1000 Watts)	1000	-
Coffee Maker	1000	-
Electric Stove	2100	-
Toaster	850	-
Blender	400	850

*For more in-depth information reference Honda's "Wattage Estimation Guide"

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This is how to calculate the peak/surge/starting generator power you need for the devices you wish to run during an extended outage. Let's review the instructions.

Importantly, **don't use these figures for your own power need calculations**. The numbers shown are for for illustration purposes only. To calculate your own needs use the power specifications for the equipment you own and wish to power.

Notice that the arrows point to three devices that have a reactive power component which require a lot of startup power—even if they have capacitor start motors. Those three devices, the refrigerator, pump, and the A/C unit are rated at 2200, 2200, and 4950 watts respectively. The product literature will not state the starting power demand for reactive load devices. A good way to *approximate* the starting power demand is to *multiply the running wattage by three.*

If you wish to have all three of these devices available during an outage, just factor the starting watts for the A/C unit—the one requiring the most power. For the other two, just add the running watts, which are 700 and 1,000 watts. Why? The odds of having two or more reactive load devices starting up at *exactly* the same time are *very* small. As the instructions state, just use the starting wattage for the highest powered device and use the running watts for the rest.

This will give you the generator's *minimum starting* watts. So, if your total adds up to, say, 9,200W, an 8,000W generator may be adequate provided the generator's surge rating is at least 9,200. (continued next page)

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All this said, **I** advise you to add *at least* 10% to your total to allow some headroom for future expansion. Some pros advise factoring 20%. For example, you do what we did and replaced a 700W microwave with a 1,250W model. This added over 600W to our generator needs. **Err on the positive side.** Don't undersize your generator power needs. But also remember not to go overboard. It's usually wasted money unless your goal is to power your entire home.

One error on this table is the microwave oven. No electrical device is 100% efficient. (The magnetron may put out 1000W of microwave energy, but the appliance requires more than 1000W to do so.) Honda's chart lists a 1000W microwave as consuming 1,500W of power.

Desirable Generator Features

- Reliable, ample power
- Overload protection
- Appropriate outlet configuration and twist lock plugs
- Ease of recoil start
- Electric start
- Low oil shutoff
- Idle mode switch (or equivalent)
- Fuel efficiency
- Low noise
- Fuel gauge
- Sine wave purity (if needed e.g., for sensitive medical equipment)
- Hour meter

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Many quality generators these days come with most of these features.

Four things of note:

1. IMHO, the paramount feature is generator reliability.
2. Each generator output circuit should have overload protection—basically circuit breakers. Without overload protection, and driven into overload, the generator may overheat, and in the extreme, may catch fire.
3. A recoil start is desirable even if the generator is electric start. Otherwise, if your battery fails, your only option is a jump start- or getting another battery.
4. Sine wave purity may not be an issue for most people.

Concerning the last feature in the list, the hour meter…..

Hour Meter

$13.99 on line. An easy retrofit.

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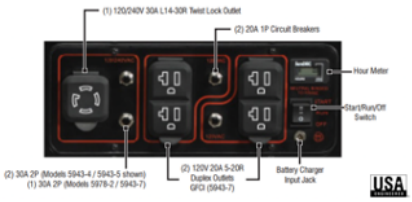
If you have a generator without an hour meter, this is a simple solution for keeping track of maintenance. It only involves connecting two wires.

Now let’s look at 4 well-appointed generators.

Example of a Well-appointed, Medium-Output Home Generator



Generac 7500W/9375W Both electric and recoil start

- Fuel gauge
- Hour meter tracks maintenance intervals
- 7.5 gallon steel fuel tank with incorporated fuel gauge provides durability and extended run times
- Run time at 50% load: 11 hour
- AVR
- Low-oil level shutdown automatically safeguards engine from damage
- Covered outlets provides added protection from the environment and rugged working conditions
- Hardened 1 1/4" steel tube cradle for added durability and strength
- Fold-down, locking handle for sturdy portability and compact storage
- Heavy-duty, never-flat wheels for reliable portability
- Plug-in battery charger jack keeps battery charged and ready to go
- 2-year warranty

$799 and free delivery (factorypure.com) 36

The desirable features in this inexpensive 7,500W gen-set include:

- Fuel gauge
- Hour meter
- Long run time (11 hrs. at 50% load, which equates to approx. 15-17 hrs. at typical 25% load)
- AVR (automatic voltage regulation)
- Covered outlets

A note on the battery charger feature:

The best way to charge a 12V battery during an outage is to run a proper 120-volt battery charger off the generator's AC output. This will recharge the battery much faster and more accurately. Also, most chargers regulate themselves down, so as charge builds in the battery, the charger won't be pushing the same amount of amps. This is a much better way to go.

A Well-Appointed, Medium-High Output Home Generator

Westinghouse Wgen 9500

- "Up to" 17. 5 Hours of Run Time on a 6. 6 Gallon Fuel Tank
- Both electric and recoil start
- All Outlets Have Rubber Covers for Added Safety
- Powered by a Heavy Duty 457cc Westinghouse 4-Stroke OHV Engine Featuring a
- Long-Lasting Cast Iron Sleeve With Automatic Low Oil Shutdown.
- Plug-and-Play: Comes With a Remote Start Key Fob
- VFT meter: Voltage, frequency and time (hours) digital display
- Two 5V USB charging Ports
- 12V Battery Charger,
- Oil, an Oil Funnel, a Tool Kit
- 3-Year, Nationwide Customer Service and Support Network warranty
- $949 and free delivery
- 4.4 stars out of 533 reviews

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This Westinghouse has 2,000W more power that the Generac I just showed. Most features are similar to the Generac, but it also can be remotely turned on from as far away as 300-ft. It also has a 3-year warranty compared to the Generac's 2-year warranty. Yet it costs just $150 more.

Keep the $949 price in mind.

A Similar Well-Appointed, High-Output Generator

Westinghouse WGen12000 Ultra Duty Portable Generator

- 12000 Rated Watts & 15000 Peak Watts
- $2,199.00 and free delivery
- 4.4 stars based on 533 reviews
- The number one best selling portable generator on Amazon (out of 100)

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This Westinghouse gen-set has the same features as the preceding Westinghouse, except that it's rated at 12kW—2,500W more. That's about the only difference.

I'm including this generator because, even though it costs $2,200, *well over twice as much*, it is the number one best-selling generator on Amazon. The only reason I can think of for this is probably because this generator can power most large homes with little or *no* need for power management. Then too, some people always equate bigger as being better. But this is *not* necessarily the case with generators.

And last, we have this:

A Very Well-Appointed High-Output Generator

Product Specs

Voltage	120/240 Single-Phase
Frequency	60 Hertz
THD	<5%
Peak/surge Watts	15000 Watts
Rated Watts	12000 Watts
Rated Amps	50 Amps
Portability Kit	Never Flat Wheels
Fuel Type	Gasoline
Tank Size	13.2 Gallons & all metal
Run Time @ 50% Load	11.7 Hours
Fuel Gauge	Yes
Idle Control	Yes
Battery	Included
Hour Meter	Yes
Voltage Meter	Yes
Receptacle covers	Yes
Lifting Eye	Yes, removable
Grade Type	Semi-Pro

Engine Brand	Caterpillar
Starting System	12-Volt Button Start
CC	670 CC
Consumer Engine Warranty	3 Years
Commercial Engine Warranty	3 Years
Engine RPM	3600 RPM
Low Oil Alert/Shutdown	Yes
Fully pressurized oil system	Yes
Made in USA	No
Weight	353 Pounds
Consumer Warranty	3 Years
Commercial Warranty	3 Years

Price: $2,399 via Electric Generators Direct

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This Caterpillar gen-set has the same output as the Westinghouse I just showed, but is semi-commercial quality and comes with a 3-year *commercial* warranty. It has a host of desirable features, which I have underlined in the specification list.

Of special note is a *pressurized oil delivery system* for long engine life. This unit appears built to last a long time and can probably power most larger homes with little, if any, need for power management. This unit appears built to last a long time and can probably power most larger homes with little, if any, power management.

It currently costs about $300 more than the Westinghouse.

Calculation of Total Emergency Power System Cost & Ongoing Costs

System Cost

- Gen-set
- Battery (usually included with gen-set)
- Cable(s) & other accessories
- Power transfer switch (sometimes included with standby generators)
- Power inlet box
- Electrical installation
- For a standby home generator, add:
  - Gas line installation
  - (Perhaps) concrete pad
  - (Perhaps) propane tank installation

Ongoing costs:

- System maintenance
- Fuel

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You should be aware of what a complete generator installation may cost. Unless you only wish to connect your system using extension cords, the total system cost may well be twice the cost of the gen-set alone.

With respect to ongoing costs: Most handy homeowners can perform portable generator maintenance, and the parts are inexpensive. Standby generator maintenance, however, should be done by a professional and may involve considerable expense—and so would any service calls. You should factor in those costs.

Also: If you're installing a transfer switch, you may also wish to consider factoring in a generator transfer surge protector at the same time. It would also serve as a whole house surge protector. In addition to lightning strikes, it protects against surges caused by downed power lines, power grid switching, and utility line over-voltages. It also protects against the myriad of daily power fluctuations that over time, although unnoticed, take their toll on electronic equipment.

End of Residential Generator Seminar - Part 1

Part 2 begins in 15 minutes

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