29 Invertor

23 Portable

38 Home Standby

EMERGENCY GENERATORS

AUSTIN AMATEUR RADIO CLUB

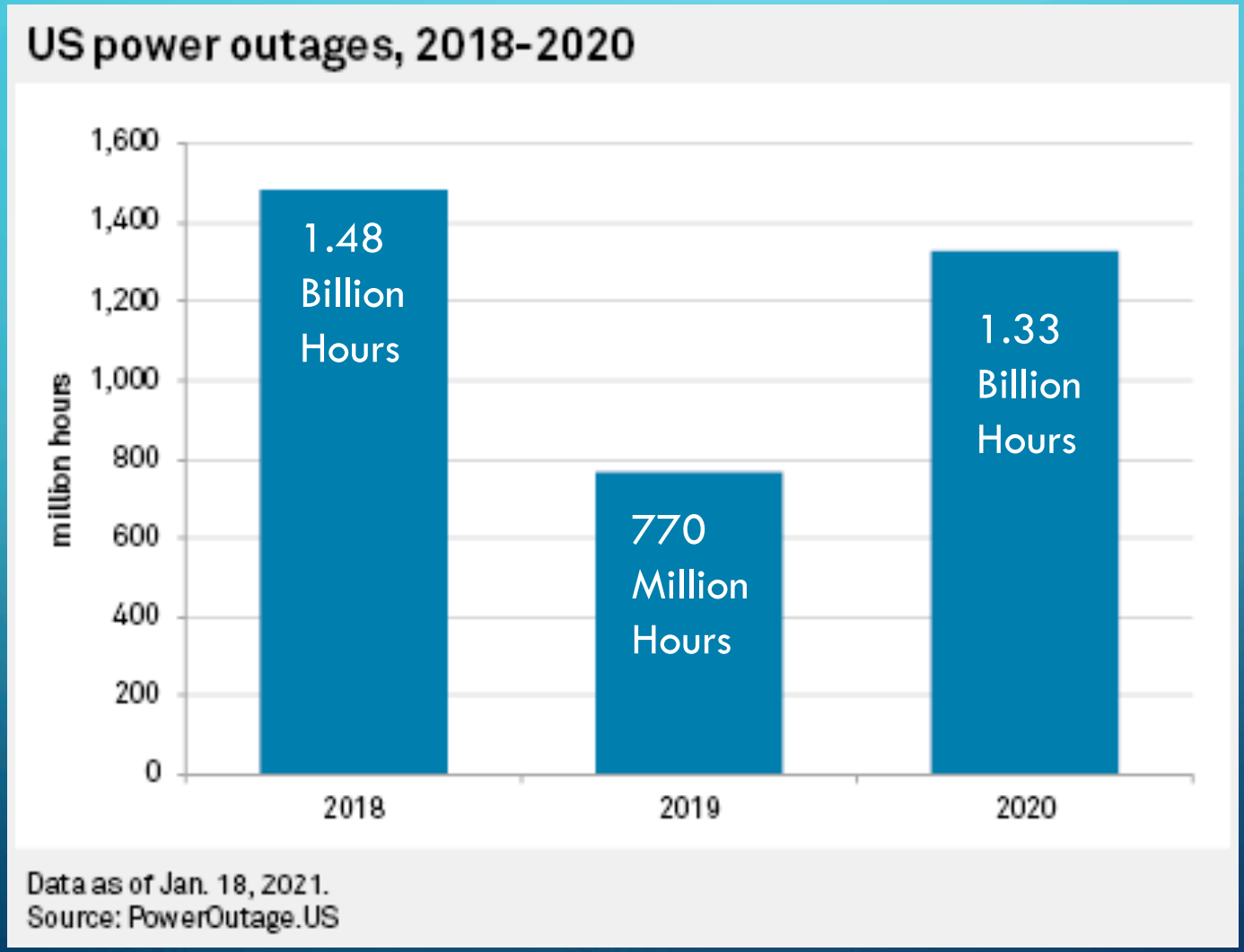
NOVEMBER 2, 2021

GENERATORS

What You Need To Know To Select The Best Option For You

- What causes power outages?
- Type of fuel to use
- Types of generators
- Generator size
- Operations & Maintenance
- Costs

U.S. POWER OUTAGES IN MILLIONS OF HOURS

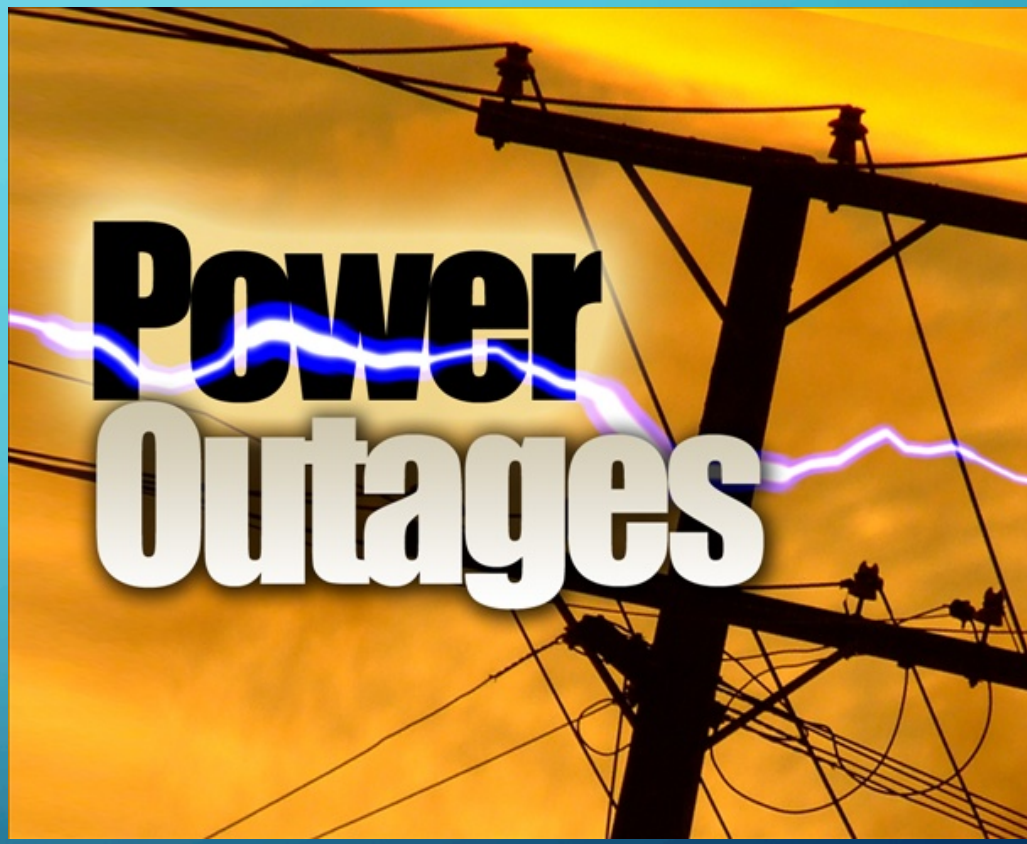


Simple Math
1.33B Hours
Divided by
128M Households
= 10.4 Hr. Avg.

Most outages will only last a day or two, but some will last a couple of weeks

WHAT CAUSES POWER OUTAGES?

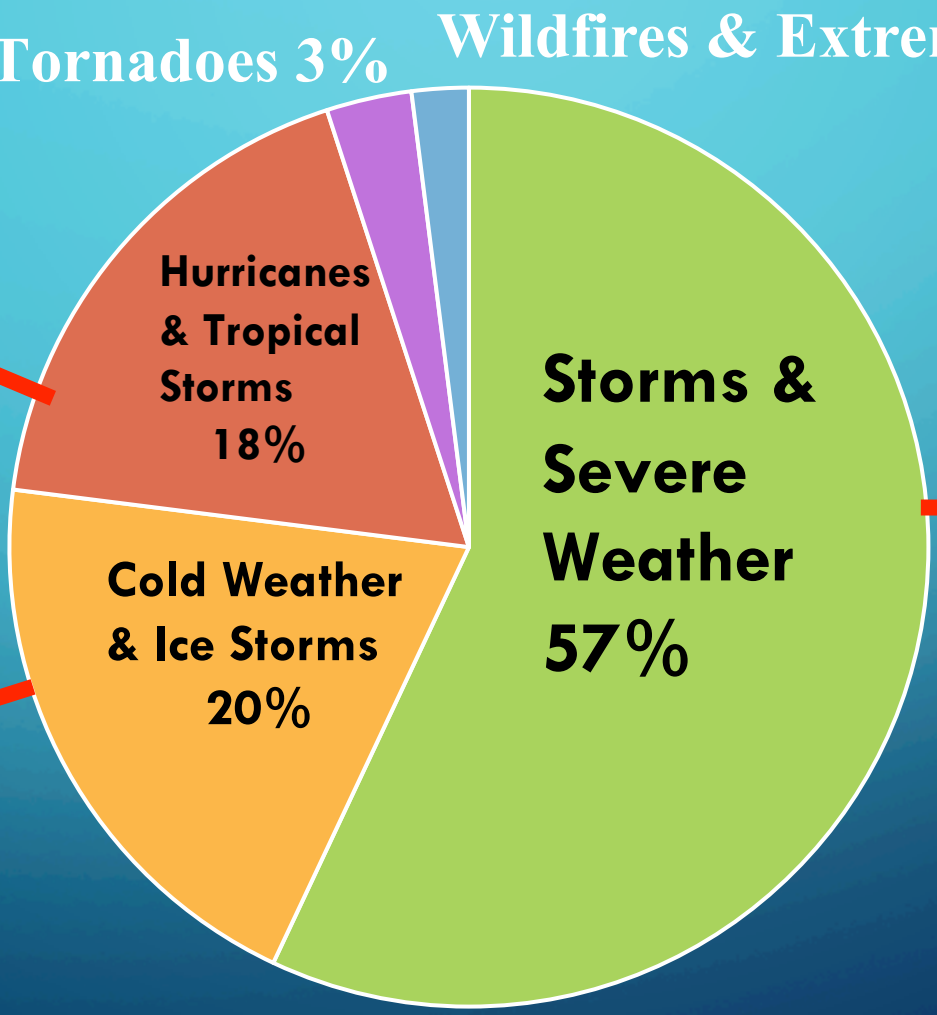
- Weather
- High Power Demand
- Transmission Infrastructure
- Cyber Attacks
- Electromagnetic Pulse
- Coronal Mass Ejection
- Construction Digging
- Animals



Up to 30% of Power Outages are due to squirrels

WEATHER RELATED CAUSES

8/29/21
Hurricane Ida
1.2 M Lost
Power



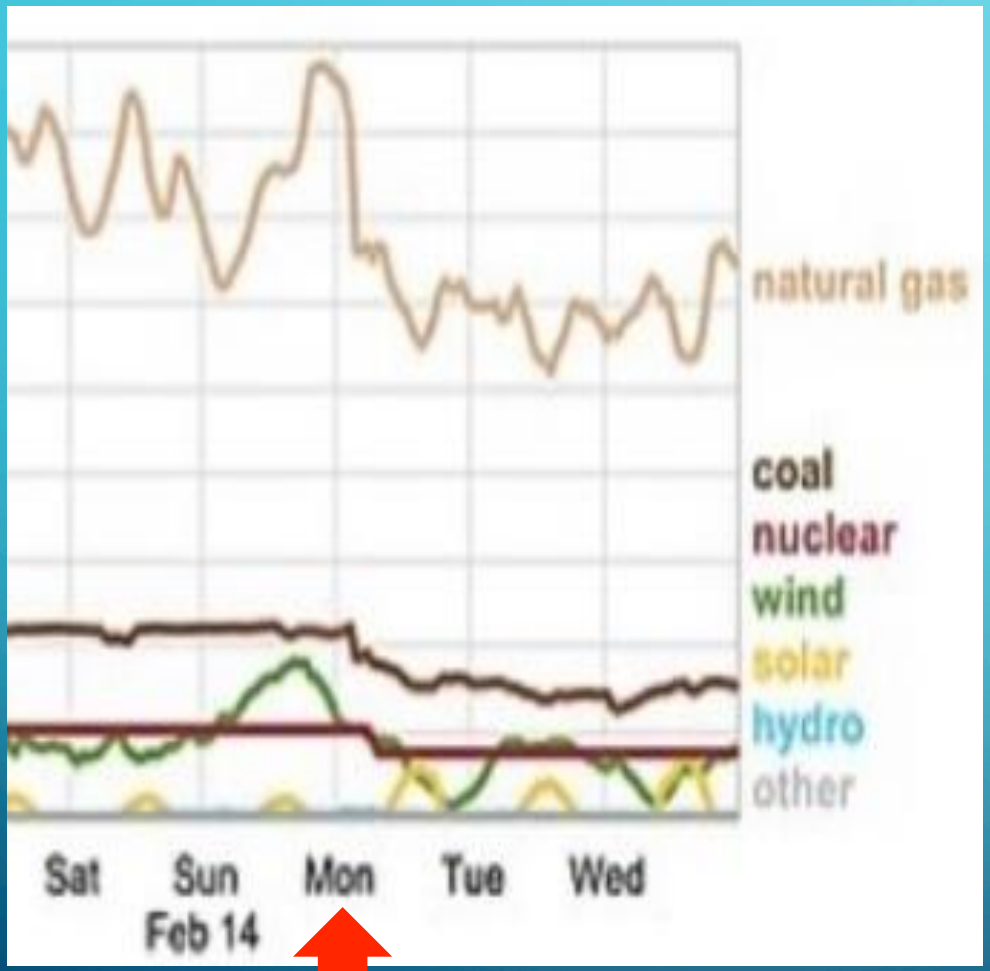
10/27/21
311 outages
10,940 customers

2/15/21
70% of Texas
Households
Lost Power

BIG FREEZE SEQUENCE OF EVENTS

- **February 14 – ERCOT requests energy conservation due to expected demand**
- **February 15**
  - **1:20am ERCOT initiates Load Sheds after steep declines in gas, coal and wind generation capacity**
  - **11:00am Demand hits 77GW above planned peak of 67GW**
  - **8:00pm Wind generation falls to 0.6GW out of 7.1GW planned capacity**
  - **10:11pm State outages impact 35% of customers (4,395,193 households)**
- **February 16**
  - **11:00am Load shed peaks at 29GW; 70% of ERCOT customer without power**
  - **2:00pm Gas generation falls to 47% of capacity**
- **February 19**
  - **10:35am Return to normal operations**

LOAD SHED BY SOURCE

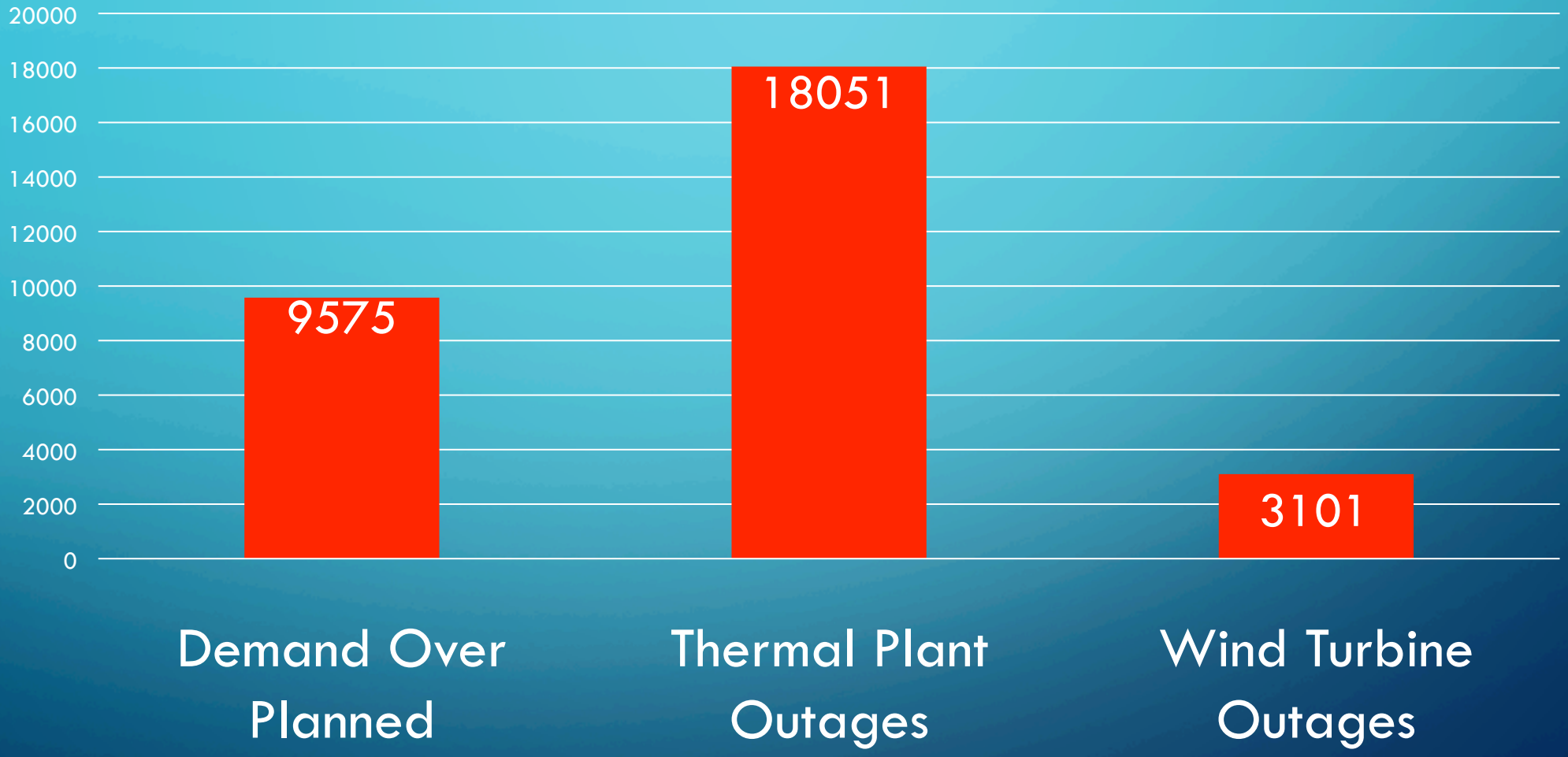


- Natural gas – multiple reasons
  - Gathering & Processing freezing
  - Power outages due to prioritization forms not completed
- Coal – frozen water feeds to steam turbines
- Nuclear – Shutdowns due to frozen cooling system
- Wind – Turbine blade icing

1:20am Mon. 2/15

Sources: North America Electric Reliability Corporation
Texas Tribune

CONTRIBUTION TO 29GW LOAD SHED AT PEAK DEMAND



Source: Resilient Society Analysis

HIGH POWER DEMAND

- Current Conditions
- Forecast Capacity & Demand
- Notifications
- Alerts
- Archive

ERCOT offers a free phone app to track capacity & demand

2021 REPORT CARD FOR AMERICA'S INFRASTRUCTURE

The American Society of Civil Engineers report that many electric transmission and distributions lines were constructed in the 1950s and 1960s with a 50-year life expectancy. The average age is 40 years and 25% are age 50 or more

Dr. Joshua Rhodes of the University of Texas Energy Research Department estimates replacement cost to be 1.5 – 2 Trillion dollars.

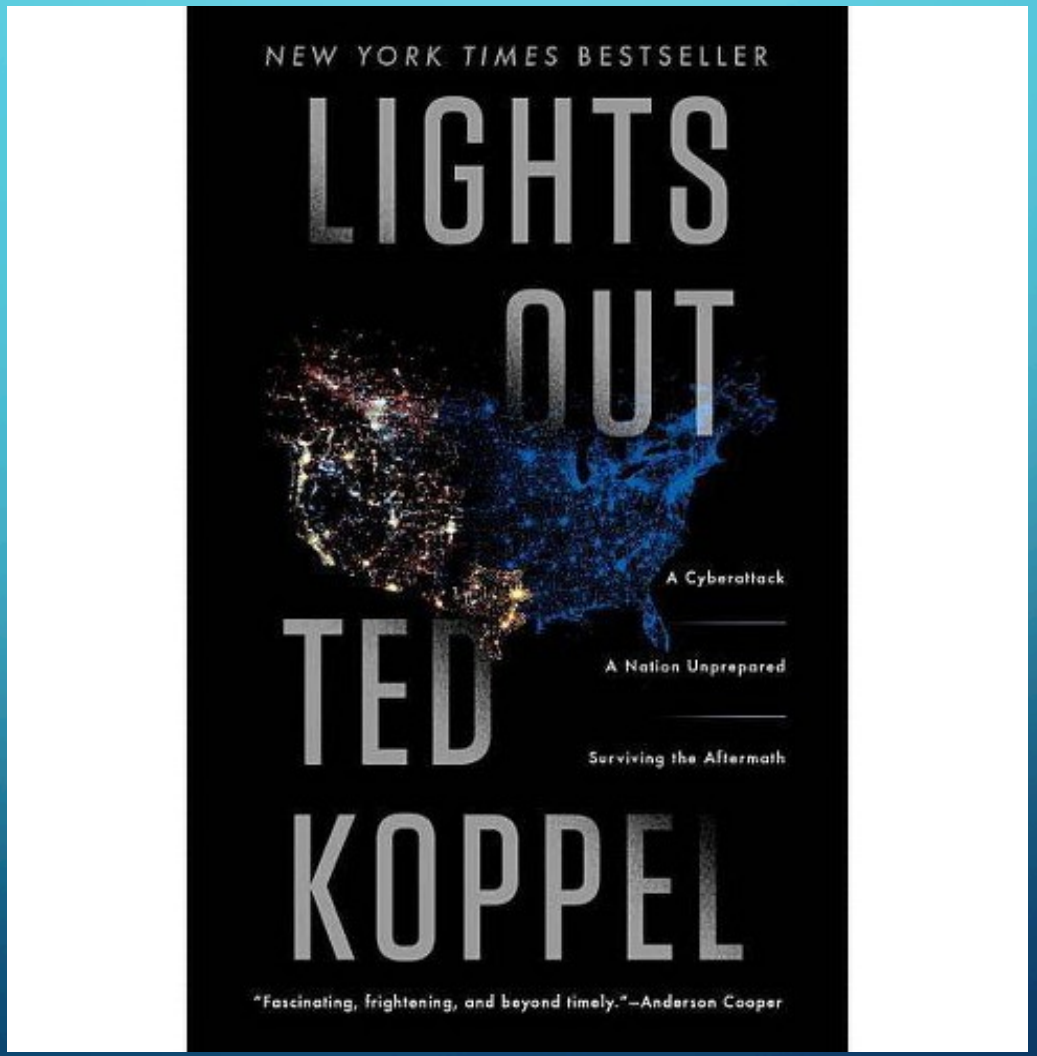
The 1.5 Trillion Infrastructure Bill includes $73 Billion

NOTABLE POWER GRID CYBER ATTACKS

- 2014 South Korea nuclear & hydro plants attacked by North Korea
- 2015 & 2016 Ukraine grid attack by Russia
- 2017 Saudi Arabia oil fields power attacked by Iran
- 2020 European Union “Successful Cyber Intrusion”
- 2021 Mumbai India attack by China

IF YOU WANT TO KNOW MORE

Cyberattack
A Nation
Unprepared
Surviving
The Aftermath

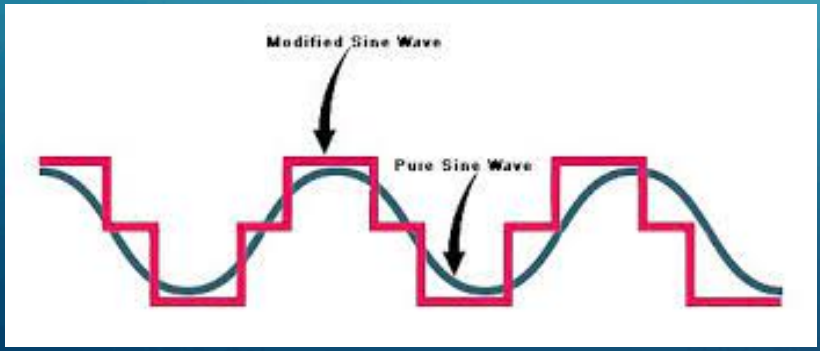


Interviews with
Top Government
& Industry
Officials

CONVENTIONAL VS INVERTER

CONVENTIONAL

- Invented in 1831 by Faraday
- Produces one block wave of AC power for each rotation of the generator
- To produce US standard 120V/60Hz it must turn at a constant 1800 or 3600 rpm



INVERTER

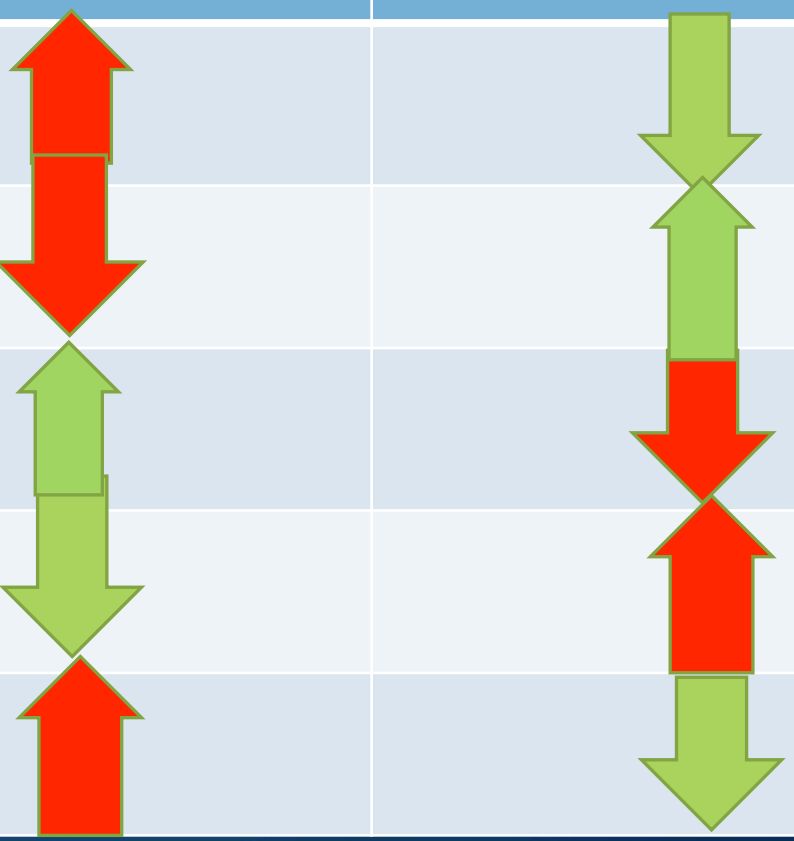
- Invented in 1987 by Honda
- Step 1 produces AC power which is converted to DC
- Step 2 an electronic inverter converts it back to 120v/60Hz AC power
- This produces a pure sine wave with less harmonic distortion and protects sensitive electronics

WHAT DIFFERENCE DOES IT MAKE?

Better

Not as Good

Feature	Conventional	Inverter
Fuel Cost		
Efficiency		
Power Capacity		
Cost		
Noise Level		



COMPARISON

CONVENTIONAL

- Straight AC power
- Available 700 – 60,000 watts
- Runs full throttle
- Significantly less initial cost for equal power output
- Less complex

INVERTER

- AC converted to DC inverted to AC
- Available 1000 – 7000 watts
- Variable Speed based on load
- Clean, consistent power
- Works on devices with microprocessor controllers
- Can be run in parallel
- More expensive

WHICH IS BEST?

Depends on your use and budget

WHICH TYPE FUEL ?

- Gasoline
- Diesel
- Natural Gas
- Liquid Petroleum Gas (LPG)/Propane
- Dual Fuel (Gasoline/Propane OR Natural Gas/Propane)
- Multiple Fuel (Gasoline / Propane / Natural Gas)

GASOLINE POWER

PRO

- Lowest initial cost
- Wide availability
- Fuel normally easy to obtain

CON

- Availability during event
- 12-month fuel shelf-life
- Highly flammable storage
- Refueling danger due to spillage on a hot engine
- E10 gas gunks up the carburetor & engine, E0 gas high cost,

DIESEL FUEL

PRO

- Fuel easy to obtain
- Runs at 1800 rpms instead of 3600 rpms
- Most suitable for long term use
- Low storage fire risk

CON

- Higher initial costs
- 18-24 month fuel shelf life
- Needs glow plugs for cold weather

LPG/PROPANE

PRO

- Fuel stored on site
- Unlimited shelf-life
- Runs clean without carburetor fouling

CON

- Regulator subject to freezing in cold weather
- High fuel consumption rate
- Power output less than a gas or diesel fueled generator
- Fuel tanks only filled to 80% capacity

NATURAL GAS

PRO

- No fuel storage issues
- No refueling issues
- Lowest fuel costs
- Best for cold weather use

CON

- Fuel supply delivery outside your control
- In an emergency delivery is subject to prioritization and containment
- High fuel consumption rate

DUAL & MULTI-FUEL

PRO

- Take advantage of preferred fuel type, with a back-up capacity if that fuel is unavailable
- Better manage refueling issues

CON

- Higher initial cost
- Power is 10% less when running on natural gas or propane
- Storing multiple fuels more complex

WHY A MULTI-FUEL GENERATOR PRODUCES VARYING AMOUNTS OF ELECTRICITY DEPENDING ON FUEL TYPE

- Different fuels require varying volumes to run a generator for an hour at the 3600 rpms necessary to produce 120v/60hz standard.
- The more energy a fuel has, measured in BTUs/hour, the less fuel is required to turn the generator at 3600 rpms for an hour
- 1 BTU = 0.293 watt
- Propane produces 92,000 BTUs per gallon
- E10 gasoline produces 111,836 BTUs per gallon (E0 114,000)
- Diesel produces 129,500 BTUs per gallon
- Natural Gas 100,000 BTUs per 100 cubit feet

COMPARING FUEL COSTS (1/2 LOAD)

Factor	Gasoline	Diesel	Propane 4.2lbs/gal	Natural Gas
Generator Size	5 kW	20kW	20kW	22kW
Unit Cost	$2.98/gal	$3.15/gal	$2.75/gal	$0.60/ccf
Use/Hr.	0.75 gal	0.9 gal	1.89 gal	228cf
Cost/Hr.	$2.24	$2.84	$5.20	$1.37
Cost/Day	$53.64	$68.04	$124.74	$32.83
Cost/kWh	$0.45	$0.14	$0.26	$0.06

HOW MUCH POWER DO YOU NEED

1. Choose Devices you want to run at the same time
2. Record the running and starting watts for each device
3. Add the total running watts
4. Select the device with the highest starting watts and add to the total watts

Device	Running Watts	Starting Watts
Refrigerator	700	2200
Space Heater	1800	
Window AC 180 BTUs	3250	3950
Box Fan	100	
Cell Phone Charger	25	
Coffee Maker	1000	
Microwave	1000	
Computer	800	
Radio 30A Power Supply	300	
Six 75watt light bulbs	450	

- Total running watts for devices that will run at the same time, PLUS highest starting watts device
- Allow at least 25% above the wattage total
- Note lowest fuel cost will is running at 50% load

EXAMPLES TO CONSIDER

Basic Items

	Running Watts	Starting Watts
Refrigerator w/freezer	700	2200
Deep Freezer	500	1500
Six 75w light bulbs	450	
Radio 30A power supply	300	
Phone charger	20	
TOTAL Needed	4470 Watts	

Optional Items

Laptop	200 watt
10,000 BTU Room A/C	1200/3600
Box Fan	200
Microwave	1200
Coffee Maker	1000
Space Heater	1800
TV 27”	500
DVD	100

SOURCE: Lowes Website

SMALL INVERTOR 2000W

CHOOSE WHAT YOU CAN RUN

Basic Items

	Running Watts	Starting Watts
Refrigerator w/freezer	700	2200
Deep Freezer	500	1500
Six 75w light bulbs	450	
Radio 30A power supply	300	
Phone charger	20	
TOTAL Needed	4470 Watts	

Optional Items

Laptop	200 watt
10,000 BTU Window A/C	1200/3600
Box Fan	200
Microwave	1200
Coffee Maker	1000
Space Heater	1800
TV 27”	500
DVD	100

MEDIUM GENERATOR 4500W

CHOOSE WHAT YOU CAN RUN

Basic Items

	Running Watts	Starting Watts
Refrigerator w/freezer	700	2200
Deep Freezer	500	1500
Six 75w light bulbs	450	
Radio 30A power supply	300	
Phone charger	20	
TOTAL Needed	4470 Watts	

Optional Items

Laptop	200 watt
10,000 BTU Window A/C	1200/3600
Box Fan	200
Microwave	1200
Coffee Maker	1000
Space Heater	1800
TV 27”	500
DVD	100

LARGER GENERATOR 7000W

CHOOSE WHAT YOU CAN RUN

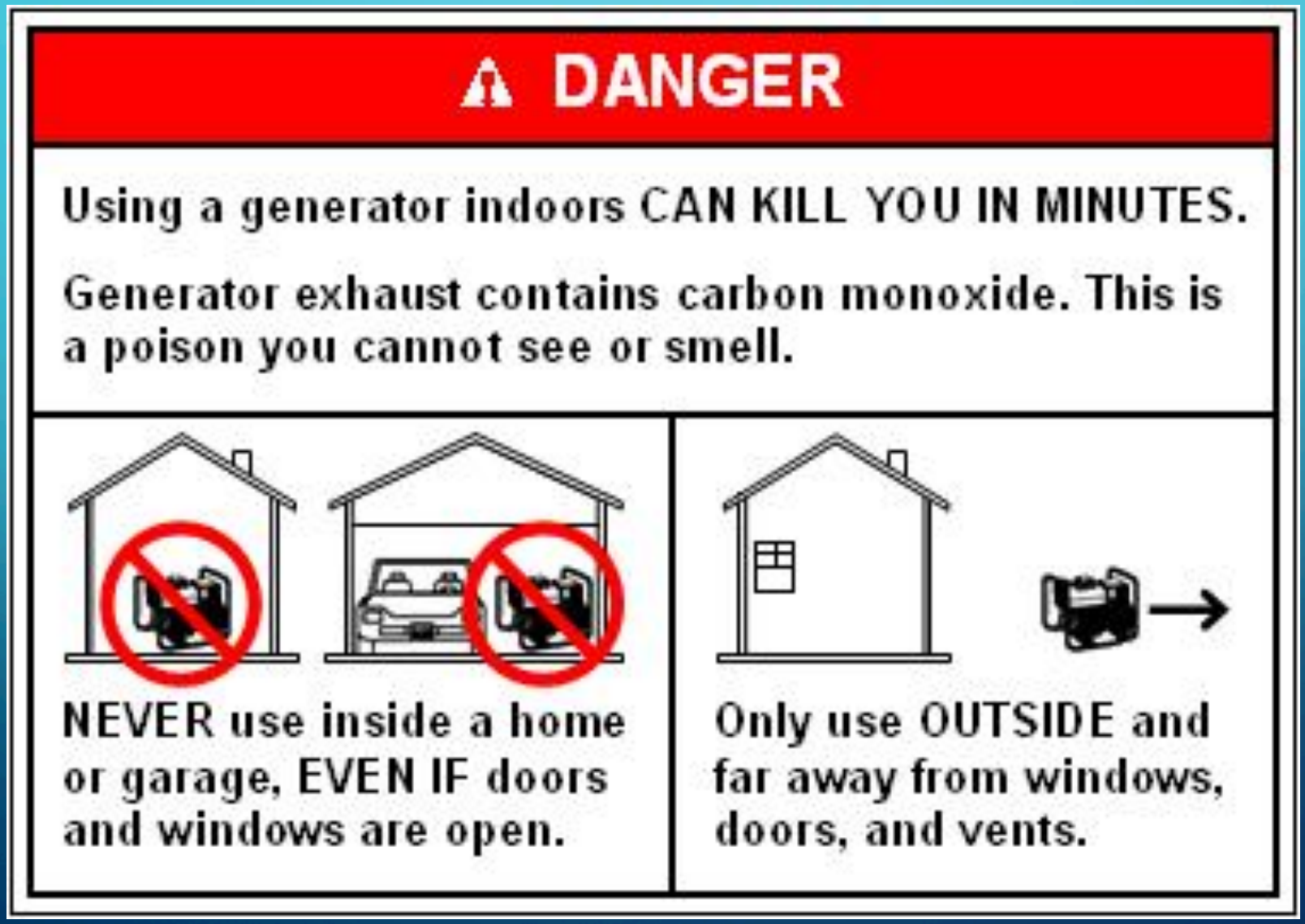
Basic Items

	Running Watts	Starting Watts
Refrigerator w/freezer	700	2200
Deep Freezer	500	1500
Six 75w light bulbs	450	
Radio 30A power supply	300	
Phone charger	20	
TOTAL Needed	4470 Watts	

Optional Items

Laptop	200 watt
10,000 BTU Window A/C	1200/3600
Box Fan	200
Microwave	1200
Coffee Maker	1000
Space Heater	1800
TV 27”	500
DVD	100

PORTABLE GENERATOR SAFETY

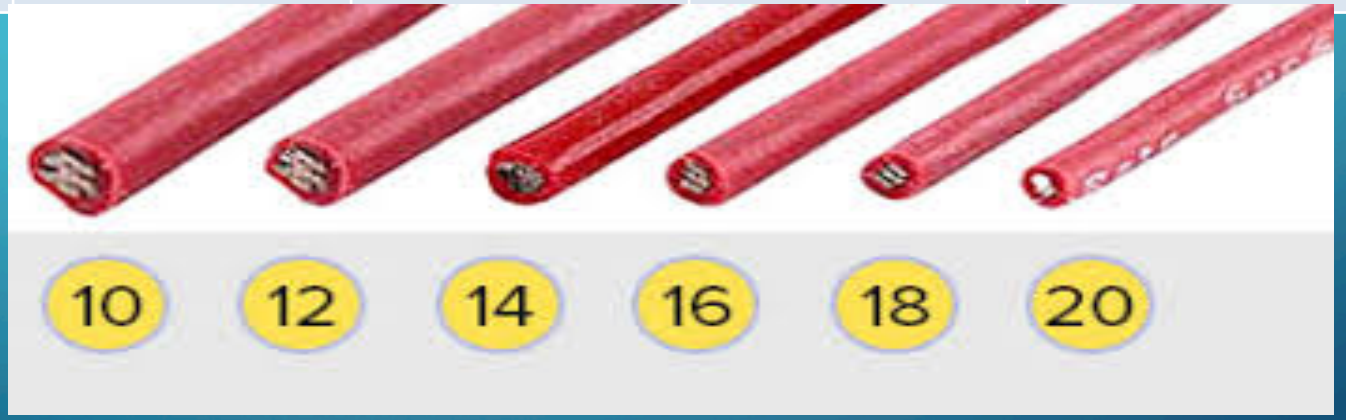


Place Generator 20' away from house to avoid CO_2 poisoning

DEVICE REQUIREMENTS & MAX CORD LENGTH BY WIRE GAUGE

Amps	Watts	#10	#12	#14	#16
10A	1200	250’	150’	100’	50’
20A	2400	125’	75’	50’	-
30A	3600	65’	-	-	-

Harbor Freight
#10 x 50’
$75
#10 x 100’
$135



Harbor Freight
#12 x 50’
$45
#12 x 100’
$85

Make Sure the Power Cord is Rated for Outdoor Use

KEEP THE GENERATOR DRY

- Keep outlets 100% dry
- Maintain air flow
- Be sure the enclosure can handle the elements and wind

CONNECTING TO THE GENERATOR

1. Start the generator
2. Allow it to run for 2-5 minutes to stabilize
3. Plug in the highest draw item
4. Allow the engine to stabilize
5. Repeat plugging in one item at a time, followed by allowing the engine to stabilize

STOPPING THE GENERATOR

1. Turn off and unplug each electric load, one at time
2. Run the generator at no load for several minutes
3. Turn off the fuel valve until fuel starvation has stopped the engine
4. Turn off the engine switch

Continue if a gasoline engine

5. Remove the spark plug cap
6. Crank the engine to drain any gasoline from the carburetor jets
7. Clean the carburetor
8. Drain the fuel tank

PORTABLE GENERATOR RUN TIME

- Generator will last for 1000 to 2000 hours before engine replacement
- Continuous run time limited to 6-12 hours, before you must let it cool down
- One option is to have 2 generators and switch back and forth every 8 hours.

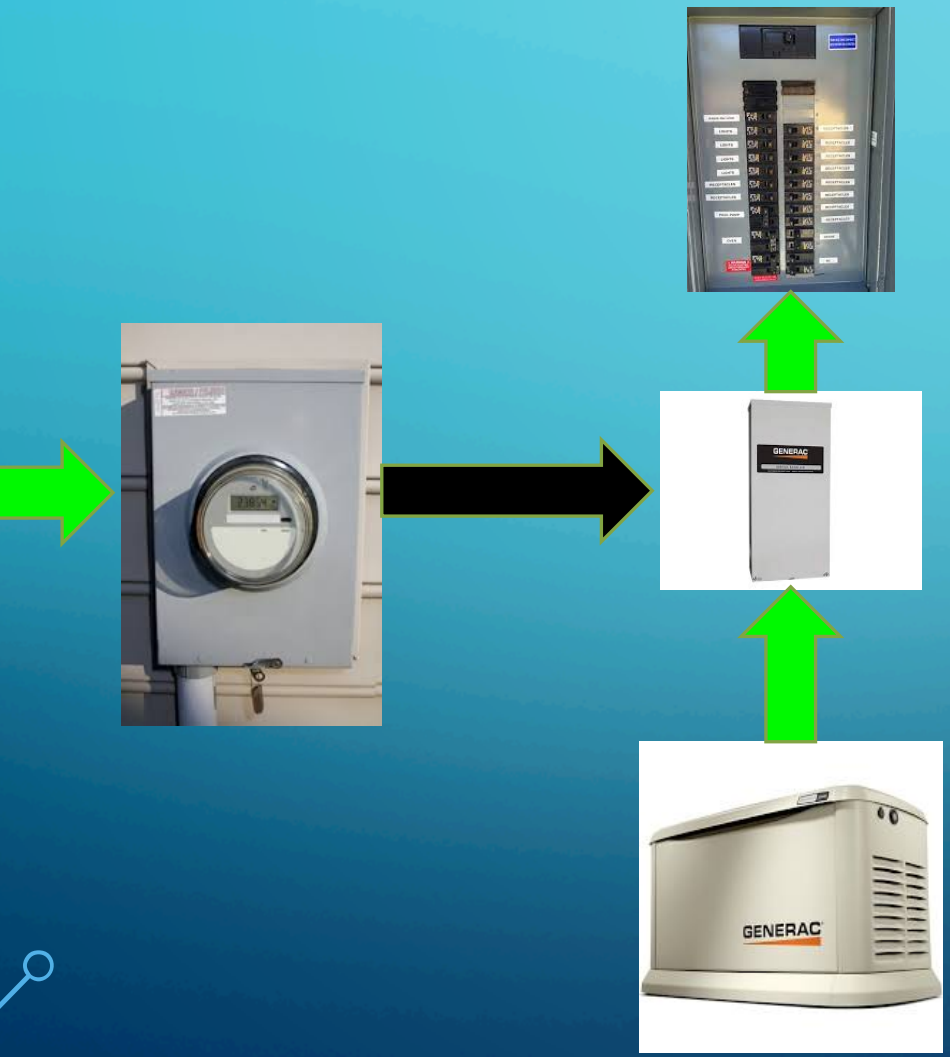
HOME STANDBY GENERATORS

- Air Cooled Critical Circuits 7.5 – 15kW
- Air Cooled Whole House 17 – 22kW
- Liquid Cooled Whole House 24 – 60kW
- Liquid Cooled Generators Cost $10K Extra
- Requires a Manual or Auto Transfer Switch

HOME GENERATOR DETAILS

- Allow extended run time
- Can run your whole house or only critical circuits
- May Include your A/C
- Requires a starting battery
- Maybe air cooler or water-cooling
- Requires a transfer switch which must be installed by a licensed electrician

AUTO TRANSFER SWITCH



1. ATS detects utility outage
2. IF power still out after 10 seconds, auto engine start
3. Engine warms for 5 - 20 seconds, depending on temperature
4. Generator starts and is at full capacity in 5 seconds
5. ATS switches to generator power

IMPACT OF LOAD ON FUEL COSTS

TEXAS NATURAL GAS FOR 22KW GENERATOR

	12 mo. fixed Cost/100 cft	Fuel Consumption Per Hour	Cost Per Hr.	Cost Per Day
½ Load	$.60	228cft.	$1.37	$32.88
Full Load	$.60	309cft.	$1.85	$44.50

Buying a larger generator will save on fuel consumption costs

Available Sizes By Brand

- All Brands rated 5 of 5 on Power Delivery and Power Quality
- Major differences enclosure materials and LCD display languages

Air Cooled Critical Circuit

Air Cooled Whole House

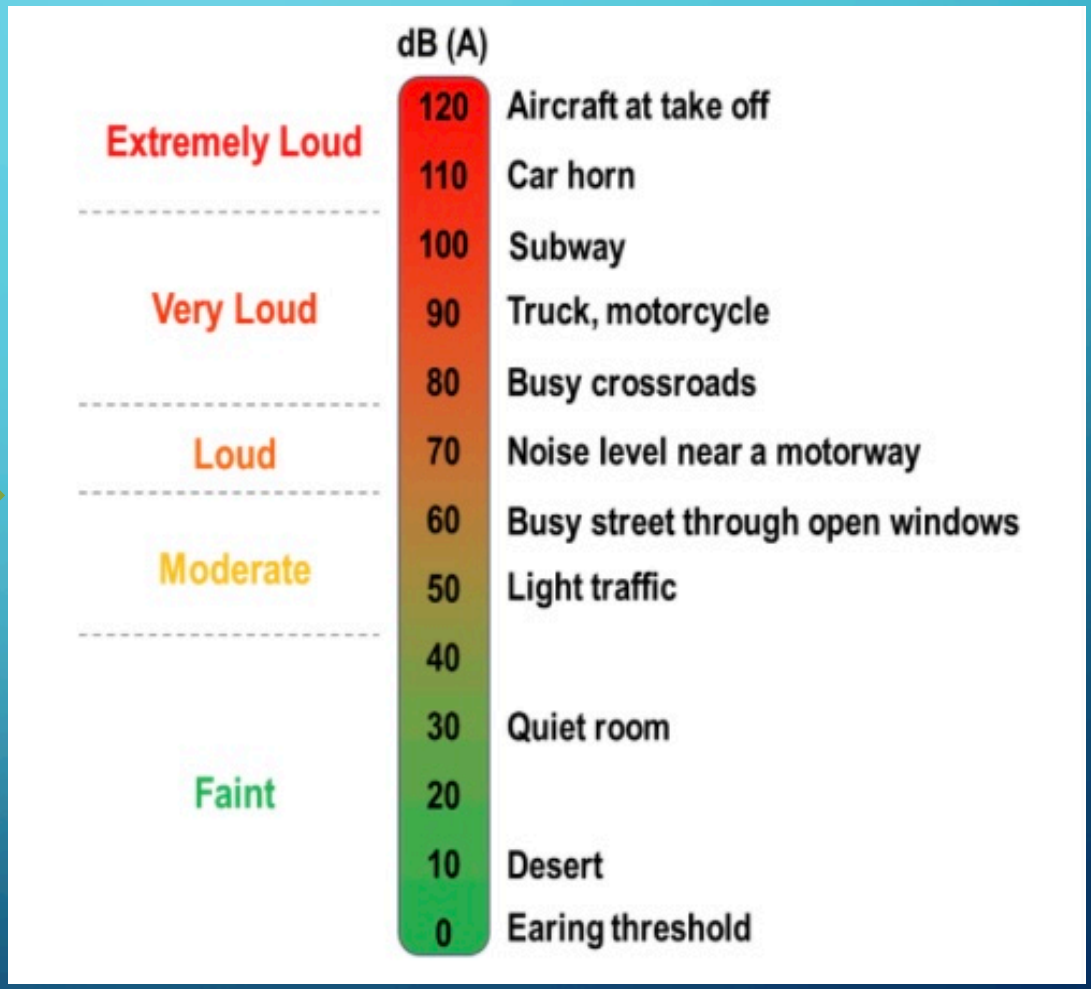
Liquid Cooled Whole House

Generac	Kohler	Cummins	Briggs & Stratton	Champion
7.5kW				8.5kW
10kW	10kW		10kW	
	12kW	13kW	12kW	12.5kW
14kW	14kW			14kW
15kW				
18kW			17kW	
20kW	20kW	20kW	20kW	
22kW				
24kW	24kW			
25kW			25kW	
27kW				
30kW	30kW	30kW	30kW	
32kW				
36kW				
38kW	38kW			
45kw				
48kW	48kW			
60kW	60kW			

NOISE LEVEL

Home Standby Generators Are Rated at 64dB to 69dB At 21 feet

70 dB is 10 Times Louder than 60 dB



GENERATOR PLACEMENT

- Must be 5 feet from a window
- Must be 5 feet from the gas meter
- Distance between generator, gas meter and breaker box is a major factor in installation costs
- Gas line must be 1” or larger
- Noise level factors (distance to neighbors, brick vs shrubs)
- Requires two 8 foot ground rods, 6 feet apart

WHOLE HOUSE GENERATOR MAINTENANCE

Bi-Weekly Auto Test Run

- Programmed to run at day/ time certain to keep engine lubricated & battery tested
- Run Time 5 minutes
  - 3600 rpm for 10 sec.
  - 2400 rpm for 30 sec.
  - 1800 rpm for 4 min. 20 sec.

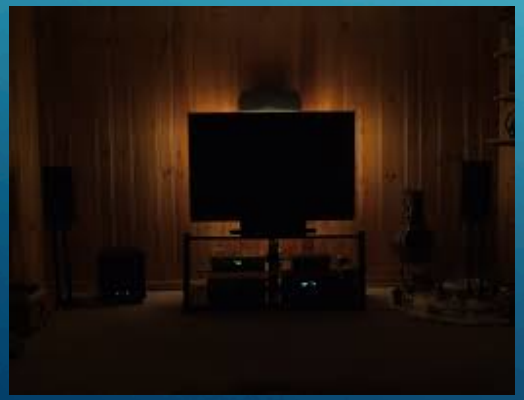
Run Time Maintenance

- After 200 hrs. run time
  - Change oil & filter
  - Check battery electrolyte level
- After 400 hrs. run time
  - Change air filter
  - Check sparkplug gaps or replace if necessary

BASIC PLANNING COSTS

Generator	Estimated Cost
Portable 2000 watt	$300 - $1300 + extension cords
Portable 4500 watt	$500 - $2500 + extension cords
Portable 7000 watt	$600 - $5000 + extension cords
Standby 10 Kw	$5600
Standby 15 Kw	$9000
Standby 22 Kw	$12,000

What is the cost of NOT having a generator?



QUESTIONS/COMMENTS