

POWER PREPAREDNESS

Power outages may impact local areas or the whole community. In addition to the obvious effect on electrically powered items, a power outage may also:

- Disrupt communications, water and transportation.
- Close retail businesses, grocery stores, gas stations, ATMs, banks and other services.
- Cause food spoilage and water contamination.
- Prevent use of electrically powered medical devices.

The above items have been discussed in other documents on preparedness. The intent of this document is to provide thoughts and considerations for you and your family to reflect on relative to having sufficient power for an emergency. Since an individual/families specific power needs are unique to individual circumstances, the document summarizes some best practices and suggestions. The material, which has been distilled from various government/society/industry sources with hyperlinked footnotes for further information, is divided into three sections:

- General Considerations
- Individualized Power Preparedness
- Whole Home Power Preparedness

A Few terms Before we begin:

Power Grid – The interconnected system of generators and transmission lines that brings power to your home

Power Bank – A small portable battery used to charge small electronics like phones or tablets.

Solar Array – A device which takes light from the sun and converts it to electricity.

Generator – A Device which uses gasoline, Diesel fuel or Natural Gas/Propane to generate electricity.

Electromagnetic Pulse (EMP) – A brief burst of energy that can damage electronic equipment

Uninterruptible Power Supply (UPS) – A device that is plugged into the wall and to which you plug your electronics into. It internally contains a battery internally. When the grid loses power, your electronics are powered by the backup battery.

GENERAL CONSIDERATIONS^{1 2 3 4 5 6}

As you consider your individual/family preparation for a power outage there are a number of factors that will influence your preparation choices:

- Duration of Power Outage
- What Needs To be Powered During a Power Outage
- Strategies For Minimizing Power Usage During a Power Outage
- Power Outage Preparations and Safety Considerations

WHAT DURATION OF A POWER OUTAGE SHOULD I PREPARE FOR

¹ <https://www.ready.gov/power-outages>

² https://www.ready.gov/sites/default/files/2020-03/power-outage_information-sheet.pdf

³ <https://www.fema.gov/blog/prepare-yourself-power-outage>

⁴ https://www.redcross.org/content/dam/redcross/atg/PDF_s/Preparedness_Disaster_Recovery/Disaster_Preparedness/Power_Outage/PowerOutage.pdf

⁵ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6181821/>

⁶ <https://www.consumerreports.org/home-garden/home-safety/how-to-survive-a-prolonged-power-outage-a1579830430/>

One of the most important factors in your preparedness for a power outage is the duration of a power outage you want to plan for. A power outage that lasts a couple of hours is a minor inconvenience and may only require slight modifications to your routine and little to no advanced preparation. A major power outage that lasts days requires advanced planning and some expense to weather. Some guidelines for determining the length of a power outage you may want to prepare for are:

Power Outage History – While history is not a perfect predictor of the future, it does offer a guide as to what you can expect in your area and can serve as a guide for how long to prepare for. Along the front range, most outages have typically been short term. Our power is transmitted below ground, and unlike power transmitted by above ground wires, is relatively immune (though not completely) from severe weather events. However, for those in our stake susceptible to flood⁷ and fire⁸ a preparation for a longer duration may be warranted.

Outage Tolerance – If you can tolerate a power outage, i.e., you have no critical activities like running a business in your home or medical devices that need to be powered, you can be more flexible in your power preparedness needs.

Cost – The cost of power preparedness will be determined by your individual circumstances. Solutions that protect against an outage of a few hours are relatively affordable and easily obtainable (see Individualized Power Preparedness below). Whole home solutions (also below) that protect against long duration outages cost substantially more.

WHAT NEEDS TO BE POWERED DURING A POWER OUTAGE

Another primary factor to consider is determining what you want to power during an outage. This is an individual/family choice and is influenced by convenience, cost and individual circumstances. This choice will preclude some of the power preparedness solutions in subsequent sections. These choices may range from:

- Nothing
- Only Critical Items
- Everything
- Something In Between

Some examples of critical items for your consideration might be:

- Medical Devices
- Refrigerators/Freezers (Especially if storing refrigerated medicines)
 - If the doors stay closed^{9 10 11}, food will stay safe for up to:
 - 4 hours in a refrigerator.
 - 48 hours in a full freezer; 24 hours in a half-full freezer
- Stove/Hot Water Heater
 - Some Gas Hot Water heaters and gas stoves use electricity to start.
- Communication Devices (Cell Phones, Computer, Landline...)
- Heating/Cooling Systems

STRATEGIES FOR MINIMIZING POWER NEEDS DURING A POWER OUTAGE

When power outages occur, below are some strategies for minimizing power usage, some are applicable if you have no backup system, others are applicable if you have a power backup system.

⁷ <https://coloradohazardmapping.com/map>

⁸ <https://co-pub.coloradoforestatlas.org/#/>

⁹ <https://www.cdc.gov/foodsafety/food-safety-during-a-power-outage.html#:~:text=Keep%20refrigerator%20and%20freezer%20doors,in%20a%20half%2Dfull%20freezer.>

¹⁰ https://www.cdc.gov/foodsafety/pdfs/eat_safe-r5-infographic2-h.pdf

¹¹ <https://www.foodsafety.gov/food-safety-charts/food-safety-during-power-outage>

- 1) Minimize opening and closing of freezers and refrigerators.
- 2) Use food in refrigerator first, then freezer
- 3) Use food supplies that do not require refrigeration.
- 4) Minimize hot water use. Your hot water tank may keep your water hot for 6-12 hours without power, but depends on tank size, usage, location, insulation, and recent hot water use.
- 5) Reduce your lighting usage, open blinds and shades during the day, use spot lighting (flashlights) at night.
- 6) Minimize going in and out of your house to maintain your house temperature
- 7) Dress appropriately inside - more layers during the winter, less during the summer.
- 8) If you have a whole home power system, dial set your thermostat as appropriate to reduce power usage.
- 9) Unplug all unused electrical apparatus. Most electronic devices draw some power when "off". These can drain your battery systems.
- 10) Turn off laptops/computers when not in use.
- 11) Put phones and tablets in standby or airplane mode when not in use.
- 12) Reduce use of appliances with a heating element (induction cooktops, hairdryers, and toasters).
- 13) Minimize use of your electric vehicle.

POWER OUTAGE PREPARATIONS AND SAFETY CONSIDERATIONS

Below are some suggestions for power outage preparation and safety. Some go without saying, but...

- 1) Have flashlights for every household member and know where they are. Make sure you have extra batteries. It is suggested to use flashlights, not candles due to the fire risk of candles.
- 2) Find out how long medication can be stored at higher temperatures and get specific guidance for any refrigerated medications that are critical for life.
- 3) Use a thermometer in the refrigerator/freezer to know the temperature when the power is restored.
- 4) If you are not sure food is cold enough, take its temperature with the food thermometer. Throw away any food that has been exposed to temperatures 40 degrees or higher for two hours or more, or that has an unusual odor, color, or texture.
- 5) Never use a generator, grill, camp stove or other gasoline, propane, natural gas or charcoal-burning devices inside a home, garage, basement, crawlspace or any partially enclosed area.
- 6) Locate these units away from doors, windows and vents that could allow carbon monoxide to come indoors.
- 7) Do not use a gas stove or oven to heat your home.
- 8) Disconnect appliances and electronics to avoid damage from electrical surges when power returns.
- 9) If needed, go to a community location with power if heat or cold is extreme. Check with local officials about locations open near you.

INDIVIDUALIZED POWER PREPAREDNESS

One class of power preparedness revolves around providing power for individual or groups of devices. These are devices that can be powered independently and do not require an entire home to be powered. For example, the home furnace or air conditioner usually cannot be independently powered, but a refrigerator can be independently powered. For lack of a better term, I am calling this category "Individualized Power Preparedness".

Spot powering critical individual items is generally the least expensive approach to powering essential items during a power outage. Some devices in the Individualized Power Preparedness category might include:

- Personal Electronics (Phones, Tablets ...)
- Computers (Laptops, Desktops, Network Storage Devices...)
- Home Network Equipment (Routers, Modems, Access Points...)
- Appliances (Refrigerator, Freezer, Stove...)
- Miscellaneous (Medical Devices, Emergency Lighting, Security Cameras, Other Smart Devices...)

Each of the above classes of devices may or may not be useful for your particular situation. You should however think about your circumstances, and decide if individually powering critical devices is appropriate. For example, personal electronics or computers may serve as your primary communication or news gathering device and be essential to you during a power outage. If your cell signal is poor at your home or if cell towers are down during a disaster, powering your network equipment to make WiFi calls, send emails/texts or get information may be required. Providing spot power to one or more appliances will lengthen the storage time for the food that you may have on hand.

Below are six types of individualized power storage/generation devices, each with varying applicability to powering the above items. In order of increasing cost these include:

- Small Power Bank (Charges a Phone/Small Tablet)
- Larger Power Bank (Charges Larger Tablets/Computers)
- Portable Solar Array
- Uninterruptible Power Supply (UPS)
- Portable Generator
 - Certain appliances (those with motors) require more power to start them than run them. Care must be taken to ensure that the generator is large enough for the startup power requirements.
 - Remember to remove the Generator power when the grid power returns
 - Some generators have 110V and 220V output, never try to adapt one to the other.
- Your Car - your car battery may allow you to power certain devices during a power outage.
 - For example, if your car has a USB port you could charge your phone with your car battery.



Power Bank



Portable Solar Array

Due to the large number of specific devices represented by the above types of storage generation, I have not elaborated on the myriad of devices in each category. These can be researched for your particular needs and budget.

There are however some general considerations common to them all:

- 1) While individually powering devices is the least expensive approach to providing backup power, it generally:
 - a. Does not provide automatic failover (Except in the case of an UPS)
 - b. May require numerous power storage devices to provide the power that you need.
 - c. May requires numerous additional cords/adapters/extension cords to power all your devices.
- 2) Remember to consider all of the devices in the chain that need to be powered. For example, if you decide that your security cameras need to be powered, they may require separate power to the cameras, the recording device, your modem and your router to function properly.
- 3) Increasing degrees of home automation may also require increased diversity in your power needs as your smart devices are also probably required power to your home network as well as the device itself.
- 4) In general UPS systems are a short-term solution giving about 5-20 minutes of backup time to allow you to power down electronic systems or work through short power glitches.
- 5) Consider "testing" your setup to ensure that you have the equipment you need and the performance that you expect.



UPS

The following table shows applicability of these various types of power generation/storage devices to powering the individual items needing power.

Powered Item	Small Power Bank (<5000 mAh)	Large Power Bank	Portable Solar Array	Uninterruptible Power Supply	Portable Generator	Your Car
Phone or Small Device (earbud, Headphone, ...)	Yes	Yes	Yes	Yes	Yes	Yes
Tablet	No	Yes	Yes	Yes	Yes	Yes
Laptop	No	No	No	Yes	Yes	Maybe*
Desktop	No	No	No	Yes [#]	Yes	No
Network Storage Device	No	No	No	Yes [#]	Yes	No
Modem	No	No	No	Yes [#]	Yes	No
Router	No	No	No	Yes [#]	Yes	No
Network Equipment (Switch, Access Point,...)	No	No	No	Yes [#]	Yes	No
Refrigerator	No	No	No	No	Yes	Maybe*
Freezer	No	No	No	No	Yes	Maybe*
Stove	No	No	No	No	Yes	No
Portable Emergency Lighting	Yes	Yes	Yes	Yes [#]	Yes	Yes
Security Cameras	No	No	No	Yes [#]	Yes	No
Other Smart Devices	No	Maybe	No	Yes [#]	Yes	No

[#] - Short Duration only (5-20 Min Generally). Not a multi-hour or longer solution

* If Your Car Is Equipped with a 120V Plug, will depend on device power needs.

WHOLE HOME POWER PREPAREDNESS^{12 13 14 15 16}

Whole home power preparedness consists of systems that will power your entire home in the event of a power failure. There are two basic types of whole home power systems, solar arrays with or without battery storage systems and generators. Generators can be either permanent or portable. This is the most expensive class of power preparedness system. There are many possible options for whole home systems and a detailed discussion of them is beyond the scope of this document.

Proper sizing of whole home systems is important and will generally be done by the installer. These systems require a qualified electrician to design and install. Most (with the exception of a portable generator) will have automatic fail over capability that will automatically switch from grid power to your backup power system seamlessly.

It is important, that first responders are made aware that you have a backup power system or energy storage system (ESS) installed as it may pose a safety risk for them.

WHOLE HOUSE BATTERY STORAGE

As technology improves, the size, weight and cost of whole home battery solutions is reducing. These systems, sometimes called Energy Storage Systems, can power a home for a period of time governed by the homes power usage and the size of the backup batteries. There are a number of companies providing these systems. An average size ESS at this writing is 10 – 15 kilowatt-hours. This will provide battery backup for an average home for less than 8 hours depending on your power consumption.

All ESS require a source of power to charge the batteries. This power source can be either the power grid or solar arrays.

These systems are in general comprised of the following components:

- **External power source** to charge the batteries
- **Battery cells**, manufactured by battery suppliers and assembled in battery modules.
- **Battery racks**, made up of connected modules that generate a DC current.
- **Inverter** which converts a battery's DC output to an AC output.
- **Battery Management System** that controls the battery, and is integrated with the battery modules.



Whole House Battery Storage System

In general, solar power battery storage works as follows:

- 1) The solar panel is connected to a controller.
- 2) When excess power is available, the controller charges the batteries storing the excess power.
- 3) When needed, current from the batteries flows through an inverter, transforming the direct current (DC) from the battery to alternating current (AC) that your home runs on.

¹² https://www.esfi.org/energy-resilience-ess-photovoltaics/?gclid=CjwKCAjw6p-oBhAYEiwAgg2Pgu-bnnM6Spd61r8I2gbuhoz6bxKylBtppCfi4d9nkoNiE8m5-xJlfBoCSXcQAvD_BwE

¹³ <https://www.nrel.gov/docs/fy20osti/75704.pdf>

¹⁴ <https://www.cnet.com/home/energy-and-utilities/backup-battery-vs-generator-which-emergency-power-option-is-better/>

¹⁵ https://en.wikipedia.org/wiki/Home_energy_storage

¹⁶ <https://www.consumerreports.org/home-garden/generators/portable-vs-standby-generator-which-is-right-for-your-home-a1183970467/>

Grid powered battery storage systems operate similarly. ESS are quiet, run independently, don't produce any emissions and don't require any ongoing maintenance. They typically have no moving parts, but will deteriorate over time as charge-discharge cycles are applied (think about how your cell phone battery life drops over time). They generally last for 10 years or more. A few other considerations are:

EV Considerations: Electric vehicles used during the day, may need recharging overnight. Generally, homes with solar panels and battery storage with low daylight-hour electrical consumption can charge EV's at night. During a power outage, car charging may need to be curtailed to run your home.

Energy Arbitrage: With power providers charging different on-peak and off-peak rates for electrical power, a home with a battery storage system can store electricity when costs are low, and use or sell that energy when costs are high. Energy arbitrage becomes more lucrative as the price difference between off-peak and on-peak electricity increases. As this price difference becomes smaller, the potential savings and profits achieved with energy storage are less.

WHOLE HOUSE SOLAR ARRAYS & BATTERY BACKUP SYSTEMS

There are many companies that provide home solar array systems and ESS. For the purpose of power preparedness, the following types of system are available, in increasing order of cost:

- **Grid Connected Solar System:** In general, houses with solar systems are connected to the power grid to maintain power at night when solar panels do not generate power or more power is required than your panels produce.
 - These systems allow excess power to be sent to the grid for a credit.
 - For safety reasons, these same systems shutdown (i.e. generate no power) when the grid is down, so they are unusable during a power outage.
- **Solar System with Battery Backup:** To have power during an outage with a solar system you would need to supplement the solar arrays with a battery backup system. There are two types:
 - **Off-Grid Solar System with Battery Backup:** Any additional power the solar system generates is used to charge the battery backup system.
 - This system is immune from a power outage as it is not connected to the grid.
 - **On-Grid Solar System with Battery Backup:** This system is the best of both systems.
 - It is connected to the power grid to maintain power at night when solar panels do not generate power or more power is required than your panels/batteries produce.
 - It allows excess power to be returned to the grid for a credit.
 - It uses solar array power or grid power to keep batteries fully charged.
 - During an outage, the house disconnects from the grid and your house draws power from the battery backup system, just as it does during the night.
 - The battery system is generally sized for a few hours to a few days so power availability is a function of your battery size.

GENERATORS

WHOLE HOUSE (STANDBY) GENERATORS

Whole home generators are generally much larger than portable generators, specifically designed to power your entire home.

Whole home generators connect to your home's electrical panel and kick on automatically when the power goes out. There are a number of companies that provide whole home generators that typically run on natural gas, liquid propane or diesel. Some generators have a "dual fuel" feature, meaning that they can run on either natural gas or liquid propane. Certain natural gas and propane generators can connect to your home's gas line or propane tank, eliminating the need to refill them manually. Diesel generators, however, will need to have a separate fuel source and be topped up in order to keep running.

Whole home generators upfront cost including installation are usually less than battery systems but more than portable generators. They tend to last about 15 years, and upon home resale they recoup about 50 percent of their cost. They do require some maintenance, and may require an annual inspection. After long term usage (~10 days) you may need to change the oil and filters.

Generators do create some noise when operating and depending on the fuel can emit exhaust or fumes. But they do create less carbon monoxide, as compared to portable generators. Also, standby generators are installed outdoors, eliminating this risk. They also require a concrete slab to sit on.



Whole House Generator

A standby generator is designed to provide power for up to several days depending on its size, fuel source, and brand. They are more fuel efficient than a portable generator, as unlike portable generators, are made specifically for use in longer-span emergency situations. Good-quality standby generators have a useful life of 3000 hours, as long as they're well maintained.

PORTABLE GENERATORS

Portable generators are generally used for providing power to one or more individualized devices in your home, but they can also be used for whole home power. They can be used in any location and put in storage when not in use. Portable generators are considerably less expensive than whole home generators or battery backup options.

Set-up isn't too difficult, but it depends on the how the generator is intended to be used. To provide power for individual appliances and devices that have their own power cords, you can run extension cords or generator cords from the generator to the home or building. If you want to connect your portable generator to entire rooms and circuits, you will need to install a transfer switch or interlock kit. A transfer switch allows you to safely switch an entire home's main power source to that of your generator.



Portable Generator

An inconvenience of a portable generator is that it will not automatically come on at the start of a power outage, so your home will be without power until the generator is up and running. Portable generators generally run on gasoline, using about 10-20 gallons a day, depending on the size of the generator and the power requirements. This means multiple filling of the generator tank per day. They are less efficient than either a whole home generator or solar/battery system.

Portable generators tend to be noisier and to produce less power than whole home models and if used with a transfer switch to connect to a home, will only be able to power a subset of the homes devices. They are also not meant for long-term continuous usage (generally 6-18 hours at a time) and are generally noisier than whole home models.

Portable generators require little or no maintenance, other than checking that the fuel is out before storage and checking that there is no corrosion or loose wires before operation. They do produce large amounts of carbon monoxide gas during operation. Therefore, always use your generator outdoors, away from doors and windows, and never in an enclosed environment such as a garage.

ELECTRO-MAGNETIC PULSE (EMP) SURVIVABILITY^{17 18 19}

In general, the earth's magnetic field protects us from solar flares and coronal mass ejections (pieces of the sun that fly off). However, in 1859 there was a solar flare that was the equivalent of 10 billion atomic bombs. This flare resulted in a massive geomagnetic storm that overwhelmed the earth's magnetic field showering the earth with charged particles. There was no power grid at the time, but there was a network of telegraphs. The geomagnetic storm rendered the telegraphs inoperable.

As our society's reliance on electronics increases, we are more and more vulnerable to disruption due to an EMP. A sun induced solar flare or a human induced EMP can short out the power grid, send spurious damaging electrical signals into your home, disable your car, and damage cell phone towers and the internet. If there is an EMP the only solutions for power will be either a home solar system, battery system or generator.

Below is a list of things that can be done to protect you and your family from an EMP event:

- 1) Systems are available that are EMP shielded/resistant for powering your home. These can be evaluated if you are considering a whole home power system. Some considerations are:
 - a. Have either EMP protected backup power or a generation source that is not connected to the grid or that is not vulnerable to EMP coupled through the power grid with one (1) week of on-site fuel or equivalent (e.g., renewable source).
 - b. Use an uninterruptible power supply (UPS) that will protect your systems from an EMP.
- 2) Vehicle Safety – Newer vehicles (meaning any vehicle with a computer) may stop working after an EMP. Consider how you might deal with that situation if you were away from your home in your car (drinking water, food, emergency blankets, flashlights...)
- 3) Think Analog – Basically anything with a computer/processor/memory is susceptible to an EMP. Consider:
 - a. A solar-powered, or hand-crank AM/FM radio can provide communication.
 - b. Manual can opener
 - c. Ways to cook without electricity (Solar oven, wood, grills,...)
 - d. Hand crank flashlights
 - e. Etc...
- 4) Faraday Cage – A faraday Cage protects its contents by preventing electromagnetic energy from getting inside. Storing critical backup items in a faraday cage can protect them. There are numerous sources available to show you where to buy one or how to build one.
- 5) From EMP Protection and Resilience Guidelines for Critical Infrastructure and Equipment:
 - a. Unplug power, data, and antenna lines from spare equipment where feasible.
 - b. Turn off equipment that cannot be unplugged and is not actively being used.
 - c. Use at least an EMP rated surge protection device (SPD) on power cords, antenna lines, and data cables; maintain spare SPDs.
 - d. Wrap spare electronics with aluminum foil or put in Faraday containers.
 - e. Store one week of food, water, and other supplies.
 - f. Use battery operated AM/FM/NOAA radios to receive Emergency Alerts.

¹⁷ <https://techprotectbag.com/how-to-prepare-for-an-emp-a-comprehensive-guide/>

¹⁸ <https://www.news9.com/story/5e98764ecc9ea5695635cd76/7-ways-to-protect-yourself-against-emp-threats>

¹⁹ https://www.cisa.gov/sites/default/files/publications/19_0307_CISA_EMP-Protection-Resilience-Guidelines.pdf