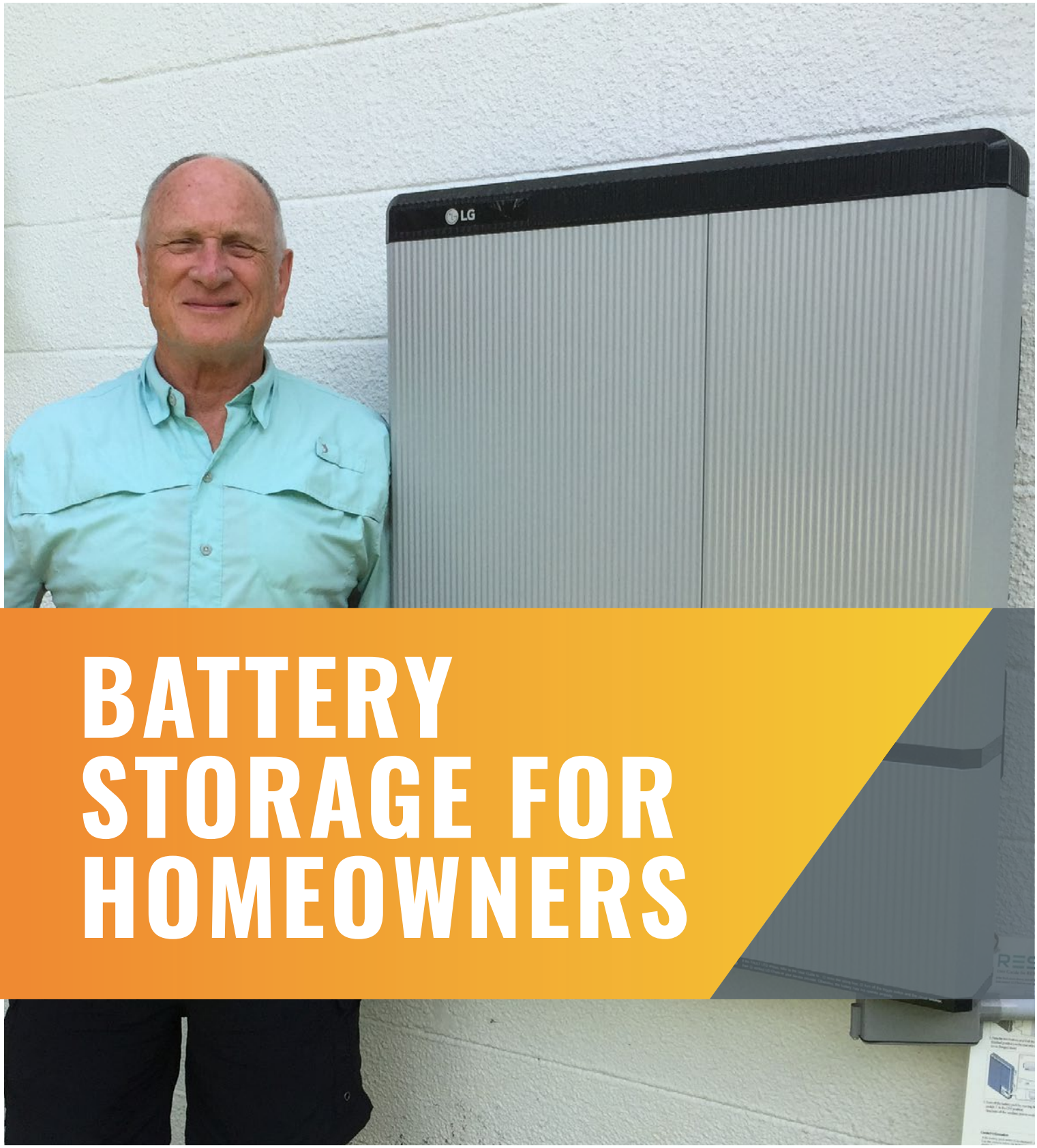


# BATTERY STORAGE FOR HOMEOWNERS

SOLAR UNITED NEIGHBORS

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# INTRODUCTION

The way we generate and consume electricity is changing. Technological advances are empowering individuals and businesses to take control of where their electricity comes from. We see this every day in our work helping people go solar. Solar homeowners are excited to be producing their own electricity. Battery storage is a natural compliment to solar. After all, if I can generate my own electricity, why can't I keep it?

Solar United Neighbors has developed this guide to educate homeowners about adding storage in their homes. We examine the types of batteries that are available and how they can be used in your home. We then dig into the economics of battery storage to help you understand if adding battery storage can make financial sense for you.

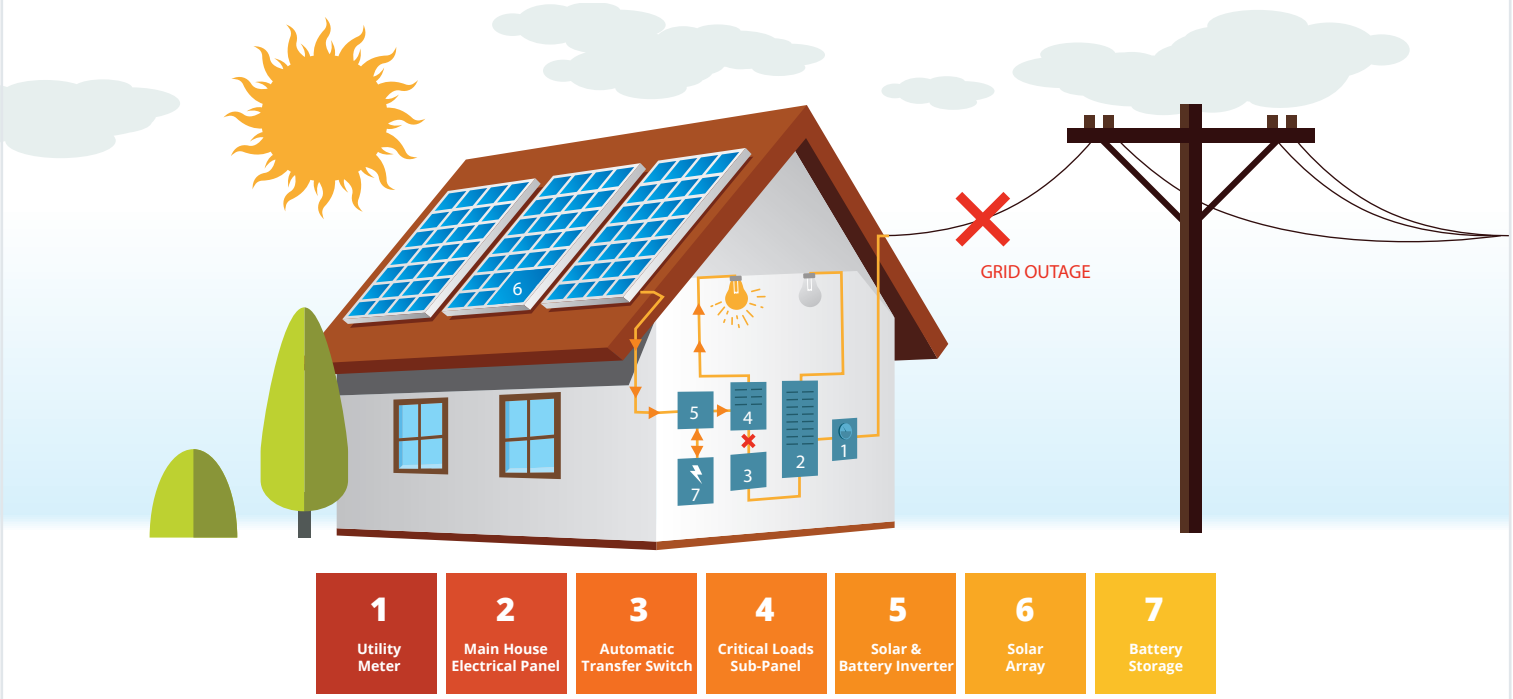
The information in this guide is not just theoretical. In 2018 we launched our first storage co-op. Built on the same model we use to help thousands of people a year go solar, this co-op helped Maryland homeowners add storage to their homes.

# BATTERY AND ENERGY BASICS

## HOW BATTERY BACKUP WORKS

Storing electricity in a battery bank can serve many purposes. In most parts of the country, battery storage for residential homeowners is mainly used to provide backup power during power outages.

When the utility grid goes down and you lose electric service, you can use a battery system to power some or all of your household electricity needs (called “loads”). The battery backup system works by isolating certain loads from the main utility system with something called an “automatic transfer switch”. You are then able to power these loads with electricity stored in the battery bank. Loads can range from small (light bulbs, toasters, a hair dryer) to large (a refrigerator or a well pump). When the utility grid power returns, the backed-up loads in your home then automatically reconnect to the grid. The result is that these “critical” loads receive power even when the grid is down, switching seamlessly between utility electricity and stored electricity from your battery.




## BATTERY BACKUP VS. A GENERATOR

Battery banks in a home serve the same purpose as a traditional generator that runs on fossil fuels such as diesel, gasoline, propane, or natural gas. Unlike a traditional generator, a battery backup system does not require you to buy and store fuel, or rely on fuel delivery during an outage. When paired with a solar array, the battery will be charged with the solar electricity you produce. If you do not pair your batteries with solar, the battery will charge and recharge only from utility-supplied grid electricity. This limits its usefulness for backup power purposes during a utility outage as it will only be able to discharge once before needing the utility grid to be restored for it to recharge.

Two lithium-ion batteries installed in Florida.

Powering your entire home with a battery system can get expensive. This is why many homeowners install a smaller battery bank to power select "critical loads" in their home during the event of a grid outage. If you feel strongly about powering your entire home during an outage, a whole-house fossil fuel-powered generator may be more cost effective.

## BATTERY CHEMISTRIES

There are several different types of batteries available on the market to provide battery backup power to your home. Different battery types have different "chemistries". Some chemistries, like lithium-ion-based, are also suitable for other battery storage applications in addition to backup power. This flexibility may enable other uses for your battery system in the future, should regulations and electricity pricing structures change in your area. We discuss this topic further at the end of this guide under "The economics of the other uses for storage".

**Lead acid batteries**

Lead acid batteries have been around a long time. For decades, they've powered cars, tractors, submarines, and have been used to provide backup power to homes and buildings. The most common variety of lead acid batteries for backup power is called "sealed lead acid". These types of lead acid batteries do not require regular maintenance to keep them operational, unlike their "flooded lead acid" cousins. Flooded batteries typically require the owner to monitor fluid levels in the batteries and periodically add distilled water to keep the batteries healthy. Lead acid batteries have a lower upfront cost than newer lithium-ion batteries. But, they also take up more space than newer options. Depending on how often they are used (or "cycled"), they can last from 5 to 10 years.

**Lithium-ion batteries**

The market for lithium-ion batteries is growing rapidly and prices are dropping[1]. The technology offers a higher density of energy (more energy per unit of space) than traditional lead acid batteries and can be used (or "cycled") more often during their lifespan. The upfront cost of lithium-ion batteries is higher than that of lead acid batteries. However, because of their longer lifespan (~ 10 years) and their ability to be charged and discharged more frequently, lithium-ion batteries have a lower lifetime cost than lead acid counterparts.

**There are two main types of lithium-ion batteries on the market:**

Lithium Nickel Manganese Cobalt Oxide or "Li-ion-NMC" is the more commonly available lithium-ion battery type and is the least expensive lithium-ion battery on the market. It is important to recognize that Li-Ion-NMC batteries can overheat and catch fire in rare cases of overcharging or improper use. This is known as "thermal runaway". You may have heard of this phenomenon with cell phones, e-cigarettes, and other small consumer devices. However, home battery storage systems include sophisticated management software that is designed to prevent overcharging and thermal runaway problems. To date, there have not been any examples of home storage systems catching fire.

1 https://cleantechnica.com/2017/12/11/batteries-keep-getting-cheaper/

Lithium Iron Phosphate or "LiFePO" is more expensive than the Li-ion-NMC variety. This chemistry, however, does not experience thermal runaway. Sonnen, SimpliPhi, and Enphase are several of the manufacturers who use this chemistry in their battery backup solutions.

| COMPARISON | SEALED LEAD ACID | LITHIUM-ION |
|---|---|---|
| Average number of battery cycles | Less | More |
| Regular maintenance | No | No |
| Typical lifespan | 5 years | 10 years |
| Upfront cost | Less | More |
| Weight | Heavier | Lighter |

**What about recycling?**
Because they have been available for decades in the automotive and energy industries, lead acid batteries can be easily recycled. It is not as clear how available recycling options will be for lithium-ion batteries in the near term, but as adoption increases the number of options for recycling should as well. Be sure to ask your contractor about recycling options.

## USABLE CAPACITY OF BATTERIES

Batteries are typically rated in amp-hours (Ah) or kilowatt-hours (kWh). For example, you may purchase a 2 kWh or 5 kWh battery system for your home.

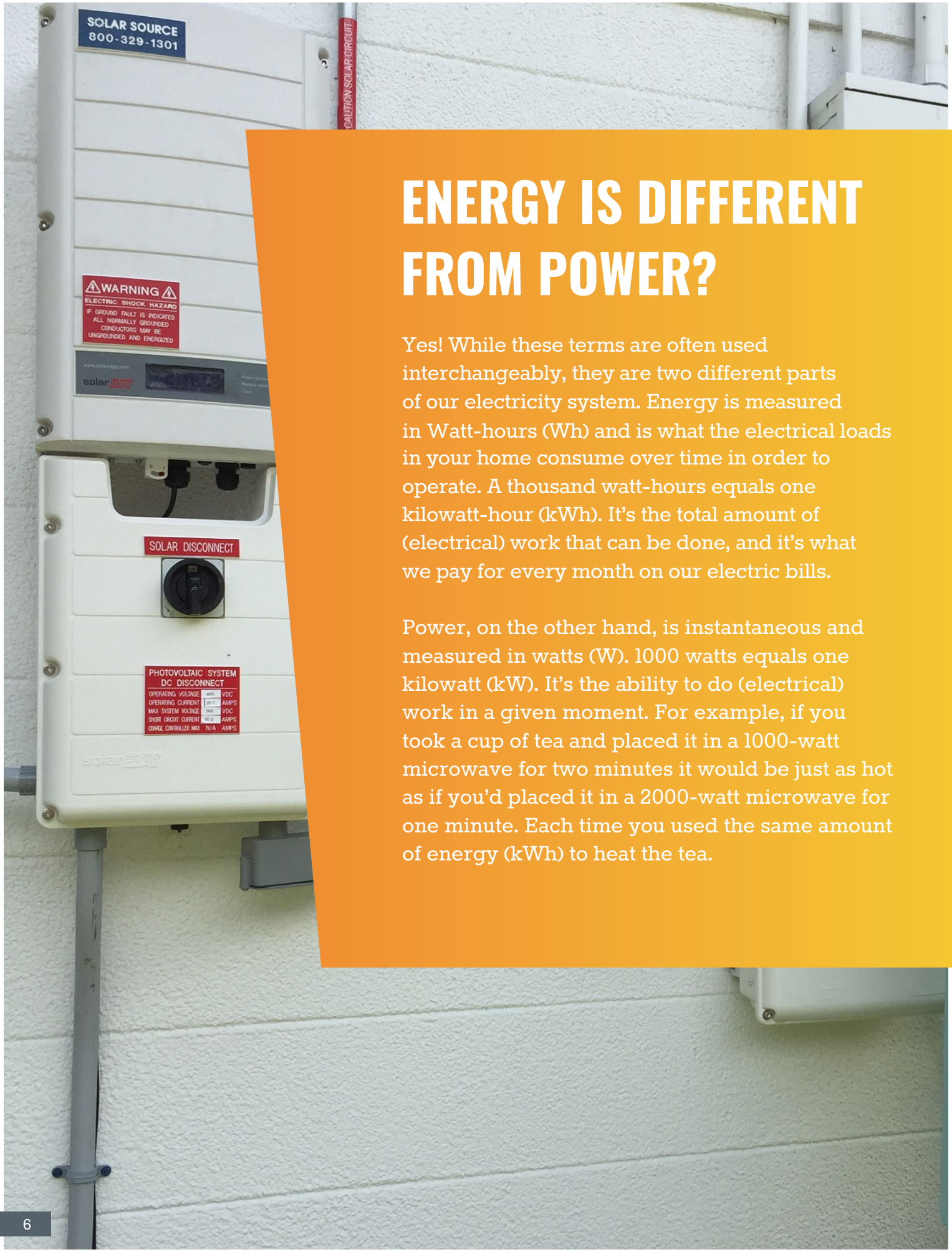
In addition to knowing the kWh size, it's also important to know the battery's "relative capacity". This refers to the amount of energy ("depth of discharge or, DOD") that can safely be drained from a battery before it needs to be recharged. For lead acid batteries, the DOD is around 50%. For lithium-ion batteries it is often 90% to 100%. A 100% DOD for a lithium-ion battery with a 2 kWh rating means it can deliver up to 2 kWh before needing to be recharged. A lead acid battery with a 2 kWh rating might only deliver around 1 kWh before needing to be recharged. Lead acid batteries can be discharged further than their recommended depth of discharge but doing so regularly will shorten their lifespan.

**Energy vs. power and how it relates to batteries**

In choosing a battery type and size for you, an energy contractor will consider two factors:

1. The amount of energy a battery bank can produce over the desired backup time period; and

2. The amount of power a battery bank can produce instantaneously to run all your desired electrical loads at the same time.




# ENERGY IS DIFFERENT FROM POWER?

Yes! While these terms are often used interchangeably, they are two different parts of our electricity system. Energy is measured in Watt-hours (Wh) and is what the electrical loads in your home consume over time in order to operate. A thousand watt-hours equals one kilowatt-hour (kWh). It's the total amount of (electrical) work that can be done, and it's what we pay for every month on our electric bills.

Power, on the other hand, is instantaneous and measured in watts (W). 1000 watts equals one kilowatt (kW). It's the ability to do (electrical) work in a given moment. For example, if you took a cup of tea and placed it in a 1000-watt microwave for two minutes it would be just as hot as if you'd placed it in a 2000-watt microwave for one minute. Each time you used the same amount of energy (kWh) to heat the tea.

## HOW TO SIZE A BATTERY FOR YOUR HOME

The size of the battery bank you need depends on several factors and is specific to your needs and to your home. A qualified energy contractor should look at the following to determine what you need:

**1) What kinds of loads you would like to run while the power is out**

Your contractor should look at what appliances, lighting, and other loads you want to power in an outage in order to determine how much energy they will use over the time period you want to keep them running. To size your battery system, the contractor will add up the required number of watt-hours per electrical load over the desired backup period.

Some electrical loads will likely use more energy than you can realistically provide from a battery system that fits your budget. Appliances with resistive heating elements (like electric stoves, electric water heaters, and space heaters) use lots of energy and can also draw lots of power all at once. Whole house air conditioners also use lots of energy and may not be realistic to power from batteries. As an alternative, you may choose to power a smaller window-based AC unit for a particular room.

**2) Suitable space in or outside your home to place batteries**

Depending on the type, batteries may need to be located inside or outside. If located outside, and depending on batter chemistry, they may need to be placed in a shaded, temperate area. Your contractor might need to adjust the size of your battery system to accommodate your available space.

**3) How long the batteries are able to run without being re-charged**

A battery system that operates your appliances and lights for one day would be smaller than a system that can operate the same equipment for two days without being re-charged. Your installer will guide you through how long you want to be able to run your appliances, but for most battery backup systems the standard length of run time is one day, especially if you have solar on site to re-charge your batteries.

**4) Your budget**

Because batteries can be expensive, most people size their systems to only power critical electrical loads while utility service is out. Your contractor will help you decide which loads you want to power with your battery given your budgetary constraints.

2 https://www.eia.gov/tools/faqs/faq.php?id=97&t=3

**How much electricity do I use in my home?**

You can see your monthly and yearly electricity usage in kilowatt-hours on your utility electric bill. The amount you use depends on the size of your home, your location, the appliances you have in your home, and your personal behavior. An average American household uses approximately 900 kWh per month.[2]

**What kinds of things do people typically power with battery backup?**

This depends quite a bit on the household but some standard and important items that can be reasonably powered by a battery system include:

- Some or all house lighting
- Ceiling fans
- Personal consumer electronics
- Cable modems/routers
- Food refrigeration
- Limited air-conditioning (window units)
- Well pumps
- Medical equipment

## HOW BATTERIES WORK WITH SOLAR

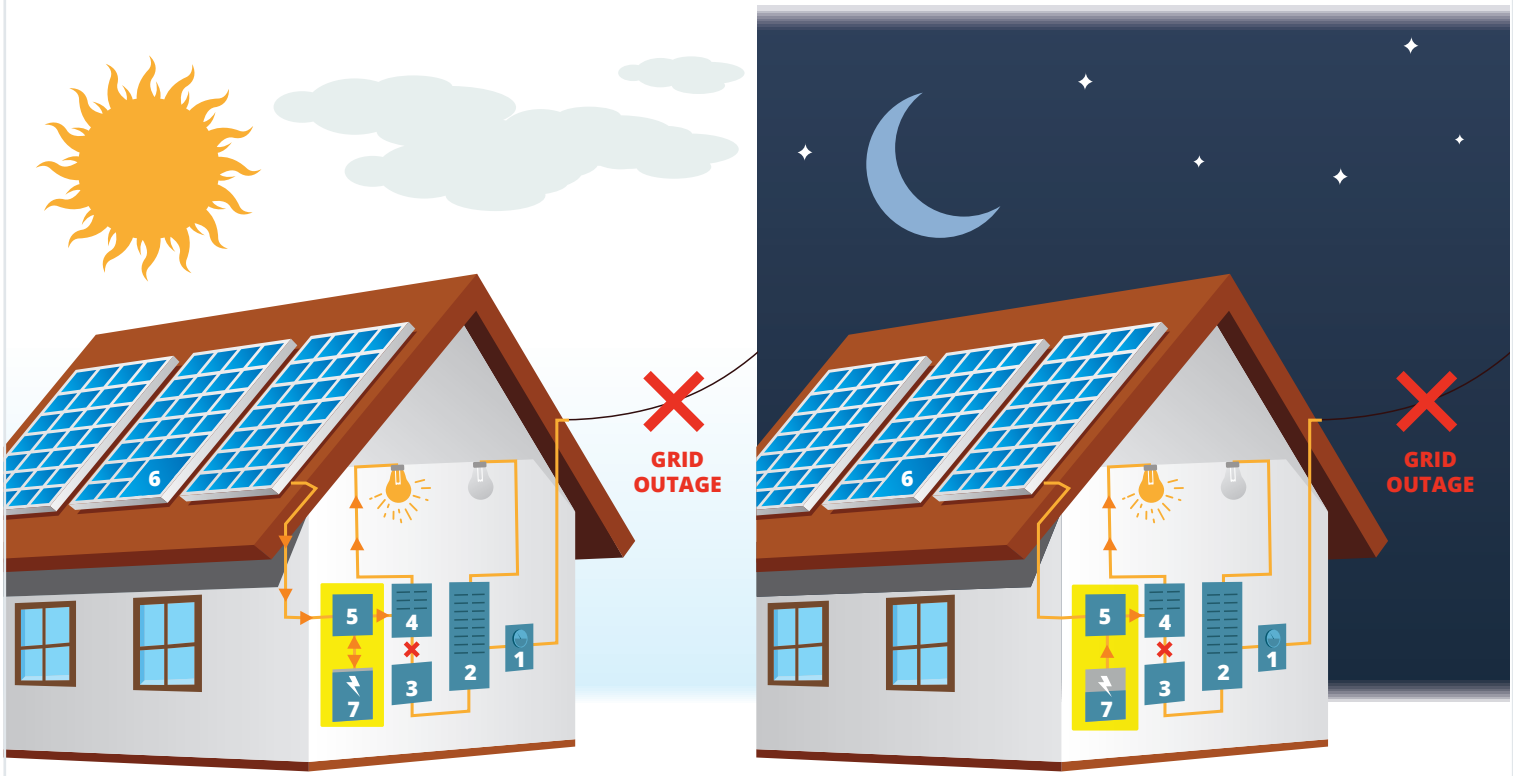
Solar is the perfect partner for battery storage. A properly sized and configured solar system will re-charge your batteries on a daily basis, providing the "fuel" to keep your battery fully charged and ready for use.

It's important to note that, without batteries, your solar system will not provide electricity to your home during a power outage. This is because solar systems are required to automatically shut off if the grid goes down. This is done to ensure that they do not "backfeed" power onto the lines and injure workers that are repairing the electric line.

To learn more about solar systems, check out our Go Solar Guide: www.solarunitedneighbors.org/gosolarguide

**During the day when there's a grid outage your solar array powers important house loads and charges your battery.**

**At night, your battery powers important house loads from the energy stored up during the daytime.**




| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Utility Meter | Main House Electrical Panel | Automatic Transfer Switch | Critical Loads Sub-Panel | Solar & Battery Inverter | Solar Array | Battery Storage |

# BATTERY DEPLOYMENT

## OPERATIONS AND MAINTENANCE/SPACE FOR YOUR BATTERIES/WHERE TO LOCATE YOUR BATTERIES

When thinking about installing a battery storage system, it is important to consider where the system will be located. Different types of batteries have different temperature requirements, space constraints, and siting conditions.

Technology is changing all the time. **Subscribe to our newsletter** and stay up with the latest information.

**Lead acid batteries**
Lead acid batteries are generally installed indoors because they have a preferred charging and discharging temperate range of 50°F – 80°F. While you can operate lead acid batteries outside of this temperature range, it will reduce the system's lifespan and efficiency. Manufacturers guidelines will give additional specific details on operating temperature requirements for specific lead acid systems.

Lead acid batteries are also less energy dense than lithium ion systems. This means they will take up more space per installed kW or kWh unit. A single lead acid battery takes up about as much space as a shoebox. Multiple batteries are strung together to make a system large enough to power multiple loads in your home.

It's best to mount lead acid systems off of the ground to minimize the potential for water damage. Lead acid batteries must also be connected to a separate inverter, which must be wall-mounted.

Sealed lead acid batteries are more common than their unsealed (or flooded) cousins because they do not require maintenance. If you own a flooded lead acid system, it is important to make sure you're properly venting the space and are maintaining the system monthly. This maintenance includes cleaning the battery terminals and adding distilled water to the batteries.

**Lithium-ion batteries**
Lithium ion batteries have a much wider preferred temperature operating range, typically between 32°F – 100°F. Additionally, lithium ion systems are more energy dense than lead acid batteries and are typically contained in one singular unit. Depending on the manufacturer, Li-ion batteries may or may not contain an integrated inverter. This further reduces the space required for these types of systems.

With lithium ion's wider temperature range and smaller footprint, some manufacturers have designed systems that can be installed outdoors, typically mounted on the side of your home near your electric meter or solar connection. If you live in a climate with extreme seasonal temperature swings, you may want to install the battery indoors to maximize operating efficiency and battery life.

Like sealed lead acid batteries, the lithium-ion technology requires no maintenance. Ongoing operations – cycling the battery on and off – will be controlled by a battery management system in the inverter component of the device. You won't be responsible for manually switching the battery on or off.

## AC/DC COUPLING – WITH SOLAR

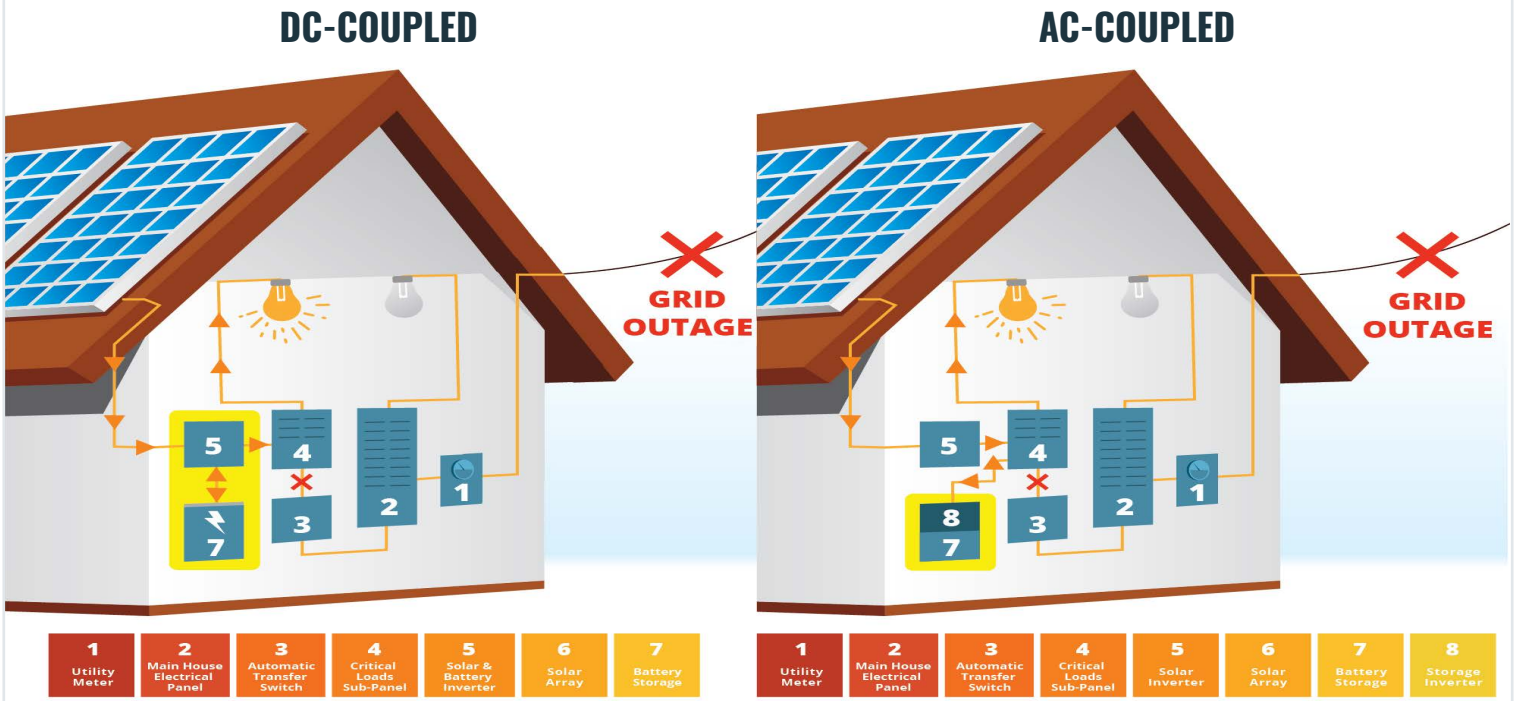
Battery storage systems receive and discharge direct current (DC), the same type of current that solar systems produce. However, the electric systems in our homes require alternating current (AC). Accordingly, you need an inverter to convert the current DC to AC so that it can be used in your home.

When you're thinking about integrating battery storage and solar, there are two ways to do it: DC coupling and AC coupling.

**DC Coupling**
DC coupled systems are most common when installing both solar and battery storage at the same time. In this setup, the solar electricity is fed directly into the battery system (in DC form) without the need for any conversion. Often in DC coupled systems, the battery and solar systems share one inverter. DC coupled systems also have an easier time ensuring that your battery is only charged by solar electricity (as opposed to utility electricity from the grid). This is important for qualifying for the federal tax credit. More information on the tax credit can be found in the economics section below.

**AC Coupling**
AC coupled systems are made up of a solar array and battery system that are independent of each other. The AC coupled configuration requires two inverters: one for the solar array (to convert the solar electricity from its natural DC form to AC so that it can flow directly into your home) and one for the battery (to convert the solar electricity back to DC so that it can be used to charge the battery). Typically, the energy produced from your solar system enters your house. Then, excess electricity not used by your home is stored in the battery.

When adding batteries to an existing solar array, many systems will be AC coupled. This is done to allow you to keep your existing solar inverter and wiring. You'll add a second inverter (to ensure the solar electricity takes DC form when charging the battery) in addition to your existing solar inverter. It's important to note that AC coupled systems make it more difficult to guarantee your battery is exclusively charged by solar which is an important factor for federal tax credit eligibility.




Virginia homeowner next to his battery system.

## SMART INVERTERS AND THEIR ROLE

Smart inverters are a vital – yet overlooked – piece of the battery storage system. Smart inverters have the ability to manage when and how your batteries run. All battery storage systems require an inverter and will be programmed to run based on your preferences (backup power, self-consumption, time of use).

Some batteries come with an integrated smart inverter, designed to give the battery owner more programming control over when and how their battery is used. As opposed to standard inverters that are programmed to work in a predictable, static manner, smart inverters can be programed via mobile apps and web portals to run when it makes the most sense, given physical, financial, or owner-preference signals. If your utility offers a rate structure that allows storage to provide you economic value, batteries can be programed with their smart inverter to take advantage of these rates (see the section on economics below for more information). However, in most utility territories there is not yet an economic incentive for storage and storage is only used for backup power.

## WARRANTIES

Warranties for batteries take two forms:  number of guaranteed operational years or number of guaranteed cycles. A “cycle” refers to the battery being discharged and then re-charged. The number of cycles used in a given year will depend on how you operate your storage system. For instance, if your system is only used to provide backup power during grid outages, you may only cycle your batteries a few times a year. However, if you configure your storage system to maximize self-consumption of any solar electricity you produce, your storage system may cycle once a day.

On average, lithium ion batteries are under warranty for 10 years or for 7,500 to 10,000 cycles. Lead acid batteries are under warranty for much less time, typically 2 to 5 years. Below are examples of battery storage warranties:

| EQUIPMENT | BATTERY TYPE | WARRANTY |
|---|---|---|
| Tesla Powerwall 2 | Lithium-ion | 10 years (unlimited cycles) |
| LG Chem RESU10H | Lithium-ion | 10 years (unlimited cycles) |
| Sonnen Eco 4 | Lithium-ion | 10 years or 10,000 full cycles |
| SimpliPhi | Lithium-ion | 10 years or 10,000 cycles |
| Enphase storage (x 3) | Lithium-ion | 10 years or 7,300 full cycles |
| Rolls AGM Lead Acid | Lead acid | 2 to 5 years (prorated after year 2) |

These product warranties are offered by the battery manufacturer. Your installer should also provide a warranty for their workmanship. This warranty covers things like wiring and electrical work. The length of this warranty is dependent on the installer and the local market.

## INSURANCE

Just as we recommend with solar, it’s a good idea to let your insurer know that you plan on installing a battery system. This way, your system can be added as an additional appliance in your home that is covered. Installing battery storage should not change your insurance payments.

## LOCAL PERMITTING AND UTILITY REQUIREMENTS

Your local permitting office will have requirements for how your battery system should be installed. Your installer is responsible for reaching out to them and securing the necessary permits. Because battery systems are relatively new, some local permitting jurisdictions may not have updated their code requirements to include residential battery storage. If there are hurdles along the way, your installer should help navigate through this process.

Some utilities may require interconnection review and approval for battery systems in addition to permitting by the local jurisdiction. Interconnection is the approval process you go through to connect an electrical resource to the electric grid. It is unclear whether utilities will require this step for systems used for battery backup purposes only when the grid is out. This is because residential battery systems are still relatively uncommon and they can be used for many different things, including services to the grid while the grid is working. You can work with your installer to identify your utility's requirements.

## HOW TO SELECT AN INSTALLER

When looking for an installer for battery storage, it's important to consider their background, experience, and qualifications. Here are a few things you should look for:

- Experience in your area (number of installs)
- Experience with the specific technology/equipment you are interested in
- Availability of equipment
- Access to your preferred equipment (if you have a preference)
- Installer workmanship warranties
- NABCEP certification, a common certification for solar installers

## WHAT SHOULD BE INCLUDED IN YOUR PROPOSAL

A thorough battery proposal should contain:

- Full cost of the storage system, installation, and additional equipment
- Payment milestones
- Equipment details
  - Battery size (kW and kWh)
  - Battery model and manufacturer
  - Inverter model and manufacturer (if separate from battery)
  - Battery management system (if used)
- List of all warranties (battery, inverter, installer workmanship)
- Details of additional work needed (electrical work, inverter swap, etc.)
- Pricing guarantee for all equipment
- Installer information (office location, point of contact, contact information)


**Equipment availability**

Lead acid batteries are used in a number of different applications and are therefore typically widely available. In contrast, the supply of some lithium-ion batteries may fluctuate with increased demand. You'll want to confirm with your installer that they are confident in their ability to supply your storage system at the price and in the time frame they outline in their proposal.

# BATTERY ECONOMICS

For most homeowners, battery systems are valuable because they provide backup power. Batteries offer peace of mind that you will still have electricity during power outages. While a few states and utilities have implemented programs or rate structures that allow battery owners to make money with their systems, the typical home battery won't regularly save you money or generate revenue. Become a **member** of Solar United Neighbors and we will alert you as new programs and incentives become available. We can also work with you to help get those programs enacted in your area to make battery back up more widely affordable.

## ECONOMICS OF BATTERY STORAGE FOR BACKUP POWER

**What goes into the cost of installing battery backup?**
When thinking about the cost of adding battery storage to your home, it's important to remember that there's more than just the cost of the battery itself. There are:

- Soft costs, like installation, permitting, and system design;
- Non-battery hardware costs, like that of additional inverter equipment; and
- Long-term maintenance costs.

**A SIMPLE WAY TO THINK ABOUT THESE COSTS IS:** TOTAL COST = HARDWARE COSTS + INSTALLATION COSTS + LIFETIME MAINTENANCE COSTS

**Hardware costs**
Much like solar, batteries are priced based on the amount of electricity they provide. Unfortunately, there's not a standard way this pricing is given. Batteries are sized according to their:

- Power (kW) - How much capacity they can provide at any given moment, or
- Energy (kWh) - How much electricity they provide over time.

For example, a 12 kW battery will be able to power twice as much in any given moment than a 6 kW battery. Similarly, a 12 kWh battery will be able to provide consistent power for a longer duration than a 6 kWh battery. You'll be able to work with your installer to design the proper battery size for your home, both based on your power and energy needs.

The cost of that battery hardware will reflect the price-per-unit of power ($/kW) and the price-per-unit of usable energy ($/kWh) associated with the battery technology of choice. Should you receive multiple proposals from installers, you'll be able to gauge their competitiveness by comparing the $/kW or $/kWh price across the different proposals.


Two inverters that convert the DC electricity produced by the solar system into AC to power the home.

In practice, battery hardware costs vary significantly between manufacturer and chemistry/type. Costs range from $3,000 to more than $10,000 for the battery alone. Today lead acid batteries are cheaper per unit than lithium-ion batteries. While this is true now, the cost of lithium-ion batteries is falling rapidly and may soon reach cost parity with lead acid.

Finally, AC coupled battery systems added to existing solar arrays will often times require a second inverter. This extra inverter equipment will typically cost an additional $3,000 - $5,000 (on top of the cost of the battery itself). While many AC coupled battery systems will require an additional inverter, there are some manufacturers that integrate this inverter functionality into the battery itself. This eliminates the need to purchase and install a second inverter in these cases. Manufacturers who offer this integrated inverter for AC coupled systems include Tesla and Sonnen.

The hardware costs of a battery installation fall anywhere from a few thousand dollars to more than twenty thousand dollars and will vary between battery chemistry and manufacturer. Calculating the price-per-unit of energy and the price-per-unit of power for different batteries helps you compare cost competitiveness across different offerings. In most cases, these hardware costs will be the largest cost associated with a battery installation.

**Installation costs**

After hardware costs, the second biggest cost to add battery storage are the installation costs. Referred to as "soft costs," these include the costs of design, installation, permitting, and project administration. Battery installation soft costs vary significantly between geographies and between battery types. While it is hard to estimate a standard installation cost, Solar United Neighbors suggests budgeting $3,000 - $5,000 for a standalone battery installation. These costs may drop if the battery is installed at the same time as a solar array. There may also be extra installation costs associated with AC coupled battery systems if a second inverter is required. These will vary, but it's safe to budget an additional $1,000 - $2,000 for the installation costs of the second inverter.

**Lifetime maintenance costs**

The more commonly used chemistries for battery backup (sealed lead acid batteries and Lithium Ion) require little to no routine maintenance but you should be sure to ask your contractor what the manufacturer's recommendations are for your particular system. Flooded lead acid batteries, which are uncommon in battery backup systems and more commonly used for off-grid applications, do require routine maintenance.


Example of a lead acid battery bank.

While it is difficult to predict what the lifetime maintenance cost of your battery will be, Solar United Neighbors recommends budgeting $1,000 over the lifetime of your system for maintenance-related activities. One example of these is a system check-up by the contractor during its lifetime.

It's also important to keep in mind that most batteries are warranted for far fewer years than solar panels. Whereas most solar panels today come with a 25-year power production warranty, the product warranty for lithium-ion batteries is about 10 years and the product warranty for lead acid batteries is typically 2-5 years. This means that if you pair battery storage with solar panels, you will likely have to replace the batteries at some point during the life of the solar array. That will not only incur hardware costs, but the labor costs associated with installing a new battery.

**Pairing a new solar array with battery storage vs. retrofitting an existing array**

Battery systems paired with solar that are installed at the same time (DC coupled) or later retrofitted to be DC coupled are undisputedly eligible for the federal Investment Tax Credit (ITC).

The federal Investment Tax Credit provides a non-refundable credit you can count towards your federal tax burden worth a percentage of the total installation cost of your battery system. You file for the tax credit when you file your taxes for the year the battery was installed. The tax credit is 30% for 2019 and is scheduled to decline to 26% in 2020, 22% in 2021, and sunset after that.

For example: You install a $15,000 lithium ion battery system along with solar panels at your home. When you're doing your taxes, you submit the necessary paperwork for the tax credit, worth $4,500 (30% of $15,000). You're then able to credit that $4,500 to your tax burden. In essence, you've saved $4,500 off the cost of the battery system itself. Should the 30% credit value exceed your federal tax burden for the year, you can roll over the remainder to subsequent tax years.

There are a few important provisions regarding the federal tax credit. First, when you install solar and battery storage at the same time, the tax credit applies to total cost of both. That is, you'll be able to reduce the combined cost of both the solar panels and the storage system by the credit amount.

Second, and most importantly, there are strict specifications for eligibility based on how much the battery system is charged by solar. According to the IRS, a battery system must be 100% charged by solar energy (i.e. the solar panels it's connected to) in order to qualify for the full tax credit.

Given these specifications, it's important to work with your installer to ensure your battery system is designed to meet these standards if you want to apply for the tax credit. There should never be any manual switching necessary to determine what source you charge your battery from (solar energy vs. utility energy). This should be automated and programmed into your system.

While it's widely agreed upon that the federal Investment Tax Credit is available for battery storage systems that are installed at the same time as solar panels (and meet the solar charging stipulations), there has been long-standing industry confusion around the eligibility of batteries that are installed later with a pre-existing solar array. The IRS issued a positive clarifying statement in March 2018 indicating that battery storage "retrofits" are indeed eligible for the tax credit. It's worth noting that the clarification took the form of a private letter ruling, not an official amendment to the tax code. While this leaves some room for debate, the industry feels confident that these retrofitted solar + storage systems can qualify for the tax credit. As with any tax matter, you should consult your own tax advisor to determine whether you can take the tax credit in your specific situation.

**Local incentives**

States and utilities have begun developing programs to incentivize residential battery storage in recognition of the value it can bring to customers and the wider electric grid. These programs are important because the cost of adding storage in residential applications is often prohibitively high. Below we highlight two incentive programs active as of 2018.

**Maryland Storage Tax Credit[3]**

Available starting in 2018, the Maryland Storage Tax Credit was the first of its kind in the country. The tax credit is for 30% of total system cost with a maximum award of $5,000. Tax credit certificates are issued on a first come, first serve basis with separate funding allocated for residential and commercial projects. There are no restrictions on battery type/manufacturer.

**Jacksonville Electric Authority's Solar Battery Incentive Program[4]**

Available starting in 2018, this program is for existing and new solar customers and offers a $4,000 rebate for homes and businesses.

**Looking for an incentive in your area?**

Incentives come in many different forms from various types of tax credits (income and property), tax exemptions, and rebates. Storage incentives are still very new so there may not be one in your area yet. Check these resources to see and be sure to follow up with your local state and local government if there isn't one in your area. Join Solar United Neighbors as a **member** we will keep you up to date as new incentives are rolled out.

DSIRE incentive database: http://programs.dsireusa.org/system/program

3 http://energy.maryland.gov/business/Pages/EnergyStorage.aspx
4 https://www.jea.com/Ways_to_Save/Residential_Rebates/Solar_Battery_Incentive_Program/

**The economics of resiliency**
Losing power to your home does have a cost. Going without electricity in your home can lead to a host of situations that have economic and quality of life impacts during an outage.

| ITEM | VALUE |
|---|---|
| Spoiled food | $50 - $500 |
| New refrigerator | $500 - $1,000 |
| Hotel stay | $500+ |
| Clean-up of a flooded basement because of an unpowered sump pump | $5,000+ |
| Life-sustaining home medical equipment | Priceless |

## FINANCING OPTIONS

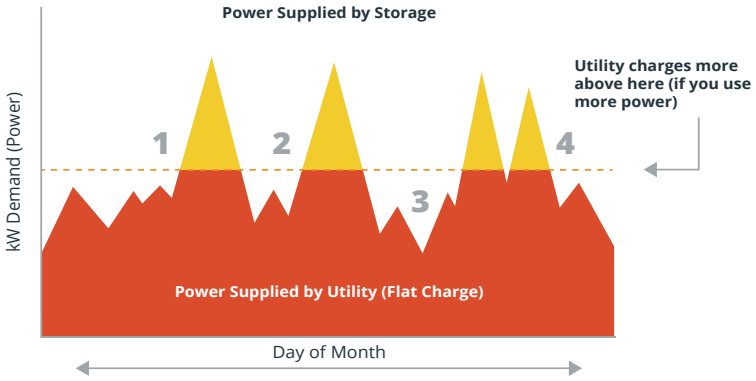
Unlike solar, for which there are numerous loan financing options, the number of options available for storage are more limited. Typical options like home improvement loans and home equity lines of credit are available for use. Some solar loan providers, like Mosaic, offer financing for storage as well. If you have PACE (Property Assessed Clean Energy) financing available in your area this may also be available for storage. Ask your installer about financing options they can offer from the manufacturer or from third-party financers and compare them to what you can acquire on your own.

**The economics of the other uses for storage**
In this guide we have focused primarily on battery storage as a means to provide backup power in an outage. But batteries, particularly lithium-ion systems, are flexible and can provide additional value. Whether or not you're able to capture that value depends your state's electricity regulations and whether your legislators encourage and support the move toward a more distributed and resilient electricity grid. Below are some examples of the potential value of your storage in the future.

**Managing energy costs with the utility**
In some parts of the country with high solar adoption, regulators and utilities are starting to change the way electricity is charged to residential customers. New rules that vary the price of electricity throughout the day (Time of Use or TOU tariffs) or charge you for the maximum amount of power you draw from the system at any given moment in the month (demand charges) make battery storage more valuable. Having a way to store your electricity from solar locally in your home lets you use that electricity whenever you want.

**DEMAND CHARGE AND STORAGE**

- Flat demand charge (same no matter how much power your need)
- Variable demand charge you avoid because your battery provided it



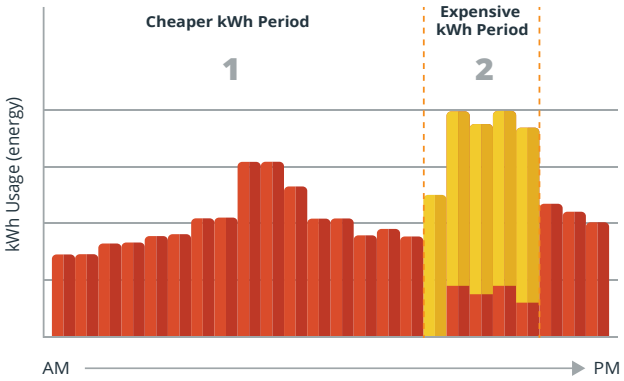

**1 & 2** Really cold days and you had your space heaters on.

**3** You were out of town.

**4** You ran the dryer, your microwave, your oven, and your blow dryer all at once.

**TIME OF USE AND STORAGE**

- kWh Supplied by Utility
- kWh Supplied by your battery




**1** You are getting ready for work in the morning.

**2** You are home from work, making dinner, kids are watching TV, and you just turned your AC back on.

## Protecting the value of your solar array

Most states have adopted a policy known as net metering. Net metering allows you to receive a credit on your electric bill for power you provide to the electric system. For every kWh that you produce and don't use (i.e. send out to the electric wires to be used by your neighbors), you receive a credit. Typically that credit is equal to what you pay for electricity (for example, 11 cents/kWh).

Net metering has been a key underpinning to the growth of solar by enabling solar producers to receive fair compensation for the electricity they generate. This growth has not gone unnoticed by utilities who stand to lose from greater rooftop solar adoption. As a result, these utilities have flexed their significant financial and political muscles to persuade regulators to unfairly reduce the compensation solar homeowners receive through net metering. Doing so reduces the economic return of solar. If you have batteries, though, battery storage would allow you to keep that valuable, solar-generated electricity in your home for later use, instead of sending it back to your neighbors and be compensated at a lower rate.

## Providing services to the grid

In addition to helping control your costs with the utility in the future, your battery storage system may also be valuable to the utility. Electricity systems are required to operate within certain defined ranges of voltage and frequency in order to provident consistent, safe, and usable electricity for electrical loads. These requirements are critical to maintaining grid performance. In times of high or low use and other stressful conditions, grid operators can pay others to provide these helpful services. These include things like boosting voltage locally in your area of the grid, or using less power at the request of the utility at times of high overall system demand. Right now these kinds of services are only provided by other utility companies or by large utility customers. As energy resources like solar and storage spread and the grid's resources become more distributed, you may also be able to participate in providing these helpful services and be compensated accordingly. It's unclear when this will be possible or how much that compensation will be, but having a system that can provide those services may allow you to participate.

HOMEOWNER STORIES:

"Producing our own power makes me more aware of where it's all being used, and where our home could be more efficient."

# JOHN HEDLUND

John Hedlund went solar in 2017 with a solar co-op in Virginia. He was one of five group members who decided to add battery storage to his system. Hedlund has a 25 kW solar array consisting of 84 panels.

His battery is rated at 9.3 kWh. The system has two inverters. One provides AC power during normal operation. The other provides AC power during grid outages. The system includes grid surge protection. The batteries are installed in the garage and all other components on the outside wall.

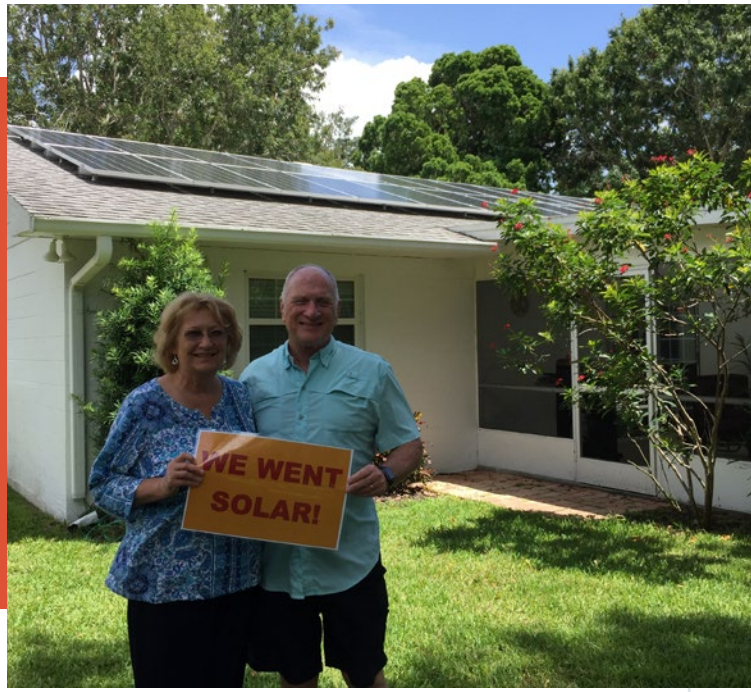
"We live in a coastal area that occasionally suffers power outages from storms — many of our neighbors have power backups. I chose a battery backup option because, in an extended outage, it would not run out of fuel (the sun)."

Hedlund sized his system so that during an outage he could power his water pump, refrigerator, the air handler for his propane furnace, electrical support for his propane stove, and several general circuits for lighting, device charging, etc.

"Producing our own power makes me more aware of where it's all being used, and where our home could be more efficient."

HOMEOWNER STORIES:

"I chose a battery backup option because, in an extended outage, it would not run out of fuel (the sun)."




# STEPHEN MURPHY & BETTY JO HENSON

Steve and Betty Jo Henson were persuaded to go solar by a former neighbor of theirs that had a system. When they moved to a new home in Bradenton, Florida they decided the time was right.

As they were going solar, their installer suggested battery storage.

"We experienced hurricane Charlie in Gainesville where we were out of power for two weeks, Betty Jo said. "It was miserable. During hurricane Irma, we were out of town but lost power in Bradenton. We didn't want to go through that again."

The couple has a 10 kW battery that powers six circuits in their home. This is enough to cover the majority of their home except for guest rooms, central air conditioning, stove, and dryer. In the event of a power outage, they have a portable AC unit that can run off their battery.

The couple estimates the battery cost is about $1.40/day. "Think of it like an insurance policy," Steve said. "For the price of a cup of coffee, you'll have power during the next outage."

# GLOSSARY

- **AC coupled** – A battery storage system that is connected to a house electrical system separately from the inverter and system components that directly control the solar array.
- **Automatic transfer switch** – Equipment that automatically isolates the battery backup system and loads to be powered by it from the rest of the home and the grid in the event of an electrical outage; This switch may be a standalone component or, more commonly, integrated into the inverter that controls the battery bank.
- **Battery bank** – One or more battery cells combined to store electrical energy. Battery banks can be pre-packaged (most common with lithium ion systems) by the manufacturer into common sizes or custom built (most common with sealed lead acid) to meet the particular needs of a customer.
- **Critical loads sub-panel** – The electrical distribution equipment (similar to your main AC panel) which connects all the electrical loads you want to keep running when the power is out.
- **Cycle life** – The number of cycles (discharge and recharge) a given battery will allow before degrading.
- **DC coupled** – A battery storage system connected to the inverter and system components that directly control the solar array.
- **Depth of discharge** – The percentage of a battery's total amount of stored energy that can be discharged at any given time without damaging the battery.
- **Electrical current** – The flow of electricity, measured in Amperes or Amps.
- **Electrical load** – Any device that consumes energy such as a home appliance, cell phone charger, lights, etc.
- **Energy** - The total amount of (electrical) work that's been done. This is what you pay for every month on your electric bills. Measured in watt-hours (Wh), this is what the electrical loads in your home consume over time in order to operate. A thousand watt-hours equal one kilowatt-hour (kWh).
- **Inverter** – The electrical equipment that converts direct current (DC) electricity (from solar panels and batteries) into alternating current (AC) electricity which is the form your house uses.
- **Kilowatt (kW)** – The instantaneous (in any given moment) power output of an electricity-generating technology. Note: 1000 watts = 1 kilowatt.
- **Kilowatt-hour (kWh)** – The amount of energy generated or consumed by electrical equipment over time. Note: 1,000 watt-hours = 1 kilowatt-hour.
- **Lead acid** – A re-chargeable battery chemistry which uses lead and acid to generate an electric current. This chemistry has been around for many years and is used in a variety of applications including car batteries and solar energy storage.
- **Lithium-ion** – A re-chargeable battery chemistry that uses Lithium and a variety of other elements, depending on the type, to generate electric current.
- **Li-ion-NMC** - Lithium nickel manganese cobalt oxide, a type of lithium ion battery chemistry. This chemistry is commonly used in consumer electronics like cell phones, e-cigarettes, and other devices as well as electric vehicles and home electricity storage devices.

- **LiFePO** - Lithium iron phosphate, a type of lithium Ion battery chemistry. This chemistry is still less common but increasing in availability and uses. It inherently does not have any risk of thermal runaway like that can happen for Li-ion-NMC batteries if they are overcharged or misused.
- **Photovoltaic (PV)** – The type of solar technology that generates electricity from the sun's energy.
- **Power** – The ability to do (electrical) work in a given moment; Its measurement is instantaneous and measured in watts (W). 1000 Watts equals one kilowatt (kW).
- **Smart inverter** – An inverter with enhanced capabilities for energy management. In battery systems, they offer the ability to manage when and how batteries are used. Smart inverters are also compatible with new standards that will allow them to more fully contribute to the transition of our electricity grid to widespread renewable adoption.
- **Thermal runaway** – A feedback loop where increasing temperature causes a further increase in temperature and eventual equipment failure, sometimes in a destructive fashion.
- **Watt** – The measurement of electrical power.

Solar United Neighbors is a community of people building a new energy system with rooftop solar at the cornerstone. We help people go solar, join together, and fight for their energy rights.

**www.solarunitedneighbors.org**

SOLAR UNITED NEIGHBORS

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Solar United Neighbors is a 501(c)3 nonprofit. We are the only nationwide organization dedicated to representing the needs and interests of solar owners and supporters.