REWIRING AMERICA

# Electrify Everything: Rooftop Solar PV Panels

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# Rooftop Solar PV Panels

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|---|---|
| **DIFFICULTY:** | HARDER |
| **UPFRONT COST:** | $15,000-$30,000 before rebates |
| **IMPACT:** | High in places with lots of fossil fuel power plants |
| **CONTRACTORS:** | Solar Installer |
| **DO NOW:** | Use a website to check your address's potential for sun, and use energysage.com to get initial quotes. |
| **RENTER:** | Send quotes to your landlord, along with financing options. |

Solar "photovoltaic" (PV) panels turn sunlight's photons ("photo") into electric voltage ("voltaic"). People have been putting PV panels on their roof since the 1970s, but improvements in the technology and huge decreases in cost have made it much more accessible. The cost of rooftop solar in 2020 was only 33% of what it was in 2010 — it's no longer a luxury purchase.[1] Putting solar panels on your roof and batteries in your garage can make you more resilient against losing power, and it is an increasingly valuable resource to the grid. It's also possible to have your solar array installed on your garage or ground instead of on your roof.

You'll probably want your solar panels installed by certified professionals, which means you're going to need a solar installer (aka contractor). See below for the section "Finding a solar installer." Before you start talking to solar installers, you should do some research into your options. Some useful references to read are:

- → SEIA's (Solar Energy Industries Association) Residential Consumer Guide to Solar Power — **seia.org/sites/default/files/2018-06/SEIA-Consumer-Guide-Solar-Power-v4-2018-June.pdf**
- → A Vermonter's Guide to Residential Solar — **cesa.org/resource-library/resource/a-vermonters-guide-to-residential-solar**
- → Solar United Neighbors Go Solar FAQs — **solarunitedneighbors.org/go-solar/faqs**

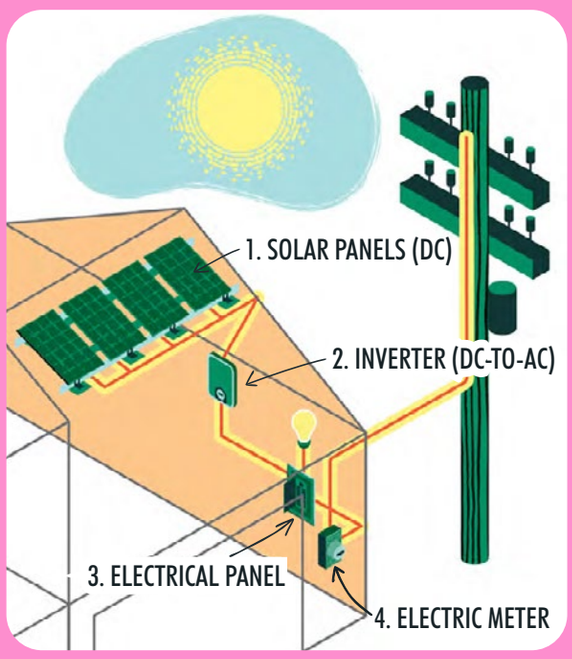
## HOW SOLAR WORKS

**1**—Solar panels on your roof convert sunlight into Direct Current (DC) electricity.

**2**—An "inverter" converts the DC into Alternating Current (AC).

**3**—Your home consumes this AC electricity through your electrical panel.

**4**—Your home is also connected to the electric grid through your electric meter, so that you can sell any excess electricity, and continue getting grid power when the sun isn't shining.[2]




## LIFETIME & WARRANTY

Solar panels typically have a production warranty of 20-25 years, which means they will produce the rated power for that long (though they might perform even longer). Panels also have a separate "workmanship" or product warranty that can range from 10 to 25 years, and covers defects. Check whether warranties are from the manufacturer or system installer.[3] System installers often provide installation warranties covering their work that can vary widely in length.

Inverters have a separate warranty, and can range from 5-25 years. This is discussed below under "Picking an inverter."

## FIX YOUR ROOF FIRST

Since solar panels can last 25+ years, you should find out if your roof is going

to need replacing soon so you won't have to remove the panels during that time. You can't include the roof cost as part of the Federal tax credit, but it will save you potential repair costs later.[4]

In fact, many solar installers won't even work on an older roof. There are some roofers, however, that also install solar, so there is potential cost savings to do them both at the same time. Solar PV panels can also increase the life of a roof. Since the lifespan of solar is a bit unknown but already surpassing expectations, consider getting a longer life roof to avoid uninstall/reinstall costs.

## KNOW (& REDUCE) YOUR LOAD BEFORE BUYING SOLAR

Look at your electric bills from the last 12 months to get a sense of your average monthly energy usage, how much your bill is and how much you pay for each kWh (kilowatt-hour) you use. If you don't have your bills, they might be available through your utility's web site, along with your daily or even hourly use.

Consider replacing any inefficient electric machines with better ones before you buy solar. For instance, it would be better to get a Heat Pump Water Heater that uses 100 kWh per month to replace an electric resistance water heater that uses 450 kWh per month. Over the course of a year, that's 4,200 kWh saved that doesn't have to come from solar. Consider all appliances, including:

- → Any machines you want to electrify that will increase your electricity use, especially car charging equipment.
- → Incandescent light bulbs (replace with LED lightbulbs).
- → Faucets and showerheads (replace with low-flow fixtures to reduce hot water needs).
- → Phantom loads (also called "energy vampires" and "standby power"), such as your TV and cable box, which can be put on a power strip to be fully shut off when not in use.

## ROOFTOP POTENTIAL

How much power could your rooftop generate? Here are some sites where you can enter your address to learn about your home's solar potential:[5]

- → Google Project Sunroof — **google.com/get/sunroof**
- → EnergySage's calculator — **energysage.com/solar/calculator**: Gives you some estimates on costs and return on investment, based on your current electricity use (though you should consider if your use will increase if you electrify everything).
- → PVWatts Calculator — **pvwatts.nrel.gov**: This is a more detailed analysis of potential rooftop systems — including being able to draw the area where it could go on your roof. It can be useful for evaluating designs from contractors.[6]

## PV PANELS, POWER (& ENERGY) OUTPUT

Buying solar panels is a little like buying a car, in that there are many options in price and performance. The best solar panels can turn over 22% of incoming sunlight into electricity (called the "efficiency"). Energy Sage has a Buyer's Guide that lets you sort solar panels by efficiency, search by brand, and download spec sheets — **energysage.com/solar-panels**. You can also compare updated lists of the best solar panels:

- → Clean Energy Reviews — **cleanenergyreviews.info/blog/best-solar-panels-review**
- → Energy Sage — **news.energysage.com/best-solar-panels-complete-ranking**

To give you a sense of scale, the average residential PV panel is a little over 5 feet long and 3 feet wide, and weighs about 40 pounds.[7] Using a mid-range power output of 290W per panel, it will require 17 panels to output around 5,000W.[8] How many panels you install will depend on your energy usage, the space available on your property, and your budget. Your selected installer will help you decide the best location for your installation.

As of 2021, solar in the U.S. costs around $2.76 per installed watt (including labor). For a 5,000 W array, that's $13,800, which comes down to $10,212 with the 26% federal solar tax credit (see "PV Incentives and rebates" section below).[9]

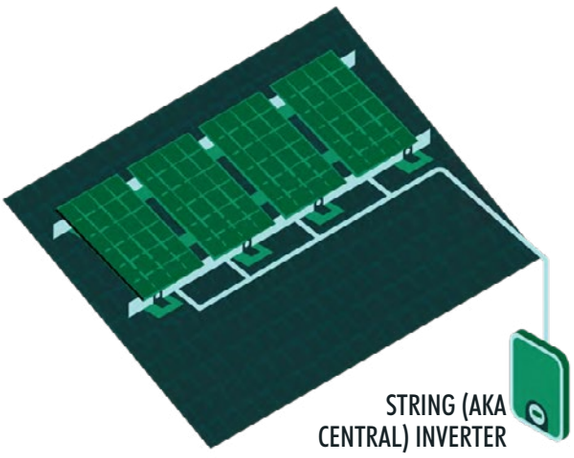
5,000 W can also be written as 5 kW (5 kilowatts), and the amount of energy a 5 kW PV system transfers to electricity in one hour is 5 kWh (kilowatt-hours).

Your utility charges you based on the number of kWh you use. A 5 kW system in sunny Las Vegas, NV could produce almost 8,000 kWh of energy in a year, while it would be closer to 5,000 kWh a year in rainy Seattle, WA. The average U.S. household uses 10,649 kWh a year.

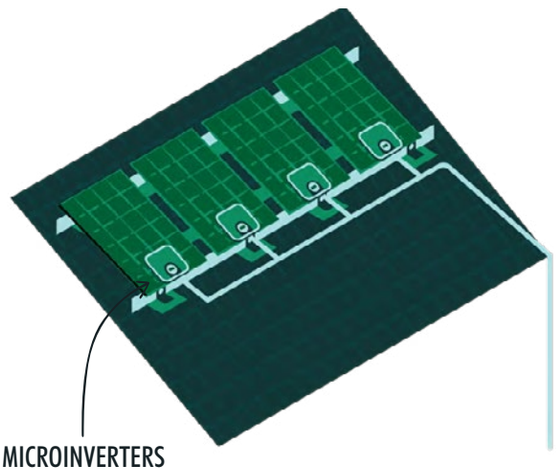
## PICKING AN INVERTER

Inverters take the DC output from solar panels and convert it to the AC power your home uses. They are an important part of the system, and three main options are available:

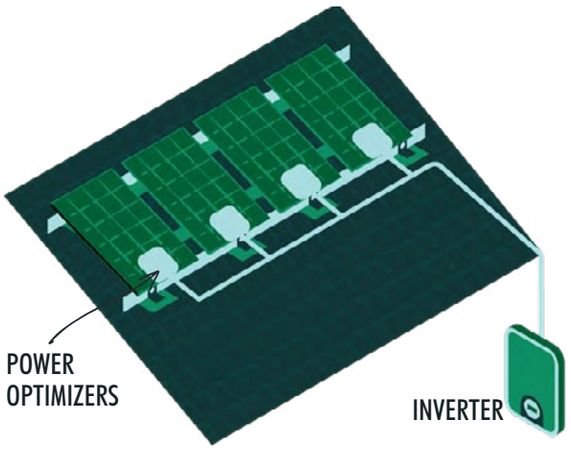
**String inverter (aka "central inverter"):** A standalone box that's usually installed at ground level and connects to a "string" of solar panels wired together. If one panel gets shaded they all reduce their output, and if one panel fails they all stop producing power. It is the least expensive option, with a 5-12 year standard warranty that can sometimes be extended to 20 years for a fee.

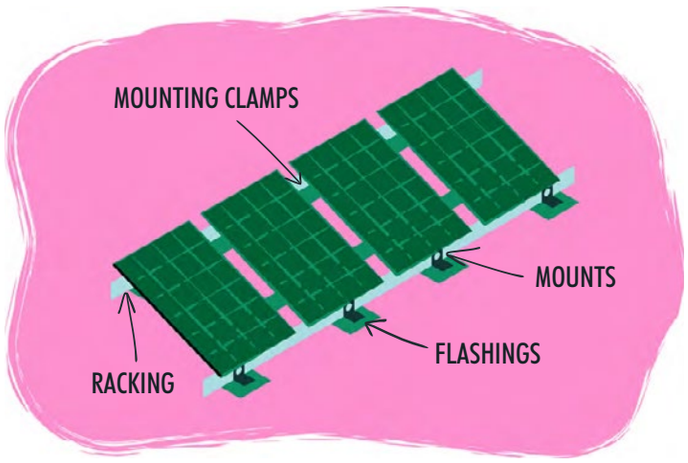



**Microinverters:** Smaller inverters built into each individual solar PV panel. This means the panels are independent, which can be good for later expansion. But there are more things that can fail, and finding and replacing a broken one on the roof can be challenging. They are more expensive up front, but can be more efficient than a central inverter and have warranties of 25-30 years — similar to the PV panels themselves.




**Power optimizers (aka module optimizers):** These are similar to microinverters in that there is one on each panel, but they "condition" the DC on its way to a central inverter. Their performance and cost is between microinverters and central inverters, with 25-year warranties.






## MOUNTING

The traditional way solar panels are attached to a roof is with racking that is mounted to the roof through water-tight flashings (see image). You should ask your solar installer detailed questions about their mounting plans (see the "Finding a solar installer" section below).

## SOLAR NEEDS BATTERIES IN A GRID OUTAGE

For safety reasons, grid-connected PV systems must be rapidly shut down during a grid outage, to make it safe for workers trying to bring the power back up. Inverters sense when grid power is out and stop producing solar power until the grid is back online. Unfortunately, this means your rooftop solar PV CAN'T power your home by itself when the grid is down.

However, if you have a home battery backing up your PV system, you CAN charge the battery with your solar panels.

## PV FINANCING OPTIONS

While the cost of solar PV panels has dropped a lot in recent years, it's still an expensive purchase that can run over $10,000 — comparable to a new car. But since you're locking in free electricity for the 20+ year life of the panels, and also increasing the resale value of your home, think of it more like an investment than as a home appliance. Rooftop solar can even generate cash by selling your excess power back to the grid (see "Net Metering" section below).

CESA (Clean Energy States Alliance) has "A Homeowner's Guide to Solar Financing" that provides details about the three main ways to finance rooftop solar — **cesa.org/wp-content/uploads/Homeowners-Guide-to-Solar-Financing.pdf**. For the first two options where you don't own the panels, you should clarify with the installer the maintenance and service responsibilities (including who is responsible for the inverter); whether the payments increase over time; and what your options are if you sell your home before the agreement is over.

- **Solar lease:** A solar developer installs and owns the PV on your roof (not you), so you don't have to pay the upfront installation cost. Instead, you pay a monthly payment, which ideally replaces your monthly electric bill (unless you need more power than the panels provide and buy it from the grid).
- **Power Purchase Agreement (PPA):** Here too a solar developer installs and owns the PV on your roof (not you). Instead of a monthly lease payment, you pay your installer for the electricity you use at a fixed rate, which should be lower than from your utility. Ask the installer to calculate projected rates and savings, and consider whether your utility's rates will increase in the future.
- **Buy with a Loan:** Here you *do* own the PV on your roof, and the loan for the upfront purchase and installation cost is paid back like any other loan. A "home equity loan" would be one where your home is used as collateral, while an "unsecured loan" might have only the solar equipment itself as the collateral. Consider taking out two loans, as suggested by Clean Energy Credit Union:[10]
  - A bridge loan with a 12-18 month term, to cover the time until you get your 26% federal tax credit back (see "PV Incentives and rebates" section below), and
  - A second loan with a 12-20 year term, to cover the operational life of the solar panels themselves. Your monthly loan payment plus your remaining utility bill could be less than what you previously paid for electricity.

## SELLING YOUR SOLAR HOME

When you're ready to sell your home with solar panels, you should consider getting a realtor with a "Green Designation," and an appraiser who is trained in evaluating the impact of solar. If you don't own the panels, you'll need to consider whether to transfer the lease or PPA to the homebuyer, prepay it, or move it to your new home. Solar United Neighbors has a guide with more details and considerations — **solarunitedneighbors.org/sellingsolarhomes**.

## CONSIDER GOING SOLAR IN A GROUP

In addition to Community Solar project, there are also groups of individuals who band together when looking to get solar panels on their own roofs. Being in a group can help you make informed decisions, and negotiate better prices.

- → Solar United Neighbors has a list of solar co-ops in a number of states, along with "The Ultimate Solar Co-Op Guide" for going this route — **solarunitedneighbors.org/co-ops**.
- → "The Solarize Guidebook" from the Department of Energy has planning templates and case studies for collective group purchases — **nrel.gov/docs/fy12osti/54738.pdf**.

## PV INCENTIVES AND REBATES

There is a federal tax credit for buying residential PV. Until the end of 2022, you can deduct 26% of the total cost — including the solar panels, inverter & mounting hardware, batteries, and installation. You can take the credit even if you finance the system, but you can't if it's leased or a PPA. The credit will drop to 22% in 2023. Read more in the "Homeowner's Guide to the Federal Tax Credit for Solar Photovoltaics." — **energy.gov/eere/solar/homeowners-guide-federal-tax-credit-solar-photovoltaics**. You can talk with a tax professional to make sure you're eligible.

Ask your solar installer for help finding and getting rebates. Check these sites for incentives that might be offered from your state or utility:

- → Energy Sage's "Solar panel incentives, rebates & tax breaks" (scroll down to find your state) — **energysage.com/solar/benefits-of-solar/solar-incentives/**
- → SEIA's "Solar State By State" — **seia.org/states-map**
- → Let's Go Solar's "Ultimate Guide to Solar Panels" — **letsgosolar.com/solar-panels**

## NET METERING

If your PV system generates more electricity than you can use, many states let you sell that power back to your utility and receive credit on your electric bill. This is called "net metering" (or "feed-in tariff") and it varies widely by state. As of 2020, 34 states plus Washington D.C. and the U.S. territories had some kind of net metering, with most of the rest offering some kind of compensation.[11] Check with your solar installer about the net metering rules for your location, and how it affects the size of your PV system.

## SRECS (SOLAR RENEWABLE ENERGY CREDITS)

When your solar cells generate electricity, they also generate a financial instrument called a "Solar Renewable Energy Credit," which can be sold like a stock on the stock market. Utility companies buy SRECs to try to meet statemandated clean energy standards (called "renewable portfolio standards"), and corporations also buy them to offset their carbon footprint. Some states let you sell the SRECs from your rooftop solar. If you're buying Solar PV outright, ask your installer who gets the SRECs. If it's you, consider not selling them (aka "retiring" them) to force polluters to purchase and install more solar.12 If you're getting a lease or power purchase agreement (PPA), make sure you know who controls the SRECs. Typically in lease deals, the solar company will sell the system's SRECs for income as part of their financing model. Read more about SRECs here — **solarunitedneighbors.org/srecs**.

## MAINTENANCE

Solar PV panels need very little maintenance but like any investment, should be inspected periodically. Check if your solar installer performs periodic inspections to look for any loose fittings or potential roof leaks, and periodic cleaning.13 How frequently you need to clean your panels depends on your local conditions and how the panels are mounted — it could range from a few times a year to yearly or longer. Check with your installer for what they recommend. If they suggest doing it yourself, becareful if you have to go on your roof. Here's a maintenance guide — **solarreviews.com/blog/solar-panel-maintenance-everything-you-need-toknow**.

## DIY INSTALLATION

You're probably not going to want to install your own solar PV, but if you were curious about going down that path, Solar Wholesale sells complete DIY kits — **solarwholesale.com**. And if you have a large lawn or land you want to use instead of a roof, PowerField makes stand-alone modular racks that get filled with rocks, but can later be emptied and moved — **powerfieldenergy.com**.

## FINDING A SOLAR INSTALLER

The process for finding a solar installer is similar to that for finding a contractor to install a heat pump. You should get referrals from friends and family, and then get quotes from at least three potential installers.

installer, it can take two to four months to plan and permit, then the installation itself takes 1-2 days, plus time after the installation for inspections and utility company approval before you can turn your system on.

One easy route for getting some quotes is to use Energy Sage, where you type in your address and contact info, and installers will send back quotes — **energysage.com**.

Here are some questions to ask when interviewing potential installers:[14]

### ABOUT THE INSTALLER:

- ☐ How much experience do you have installing residential solar systems? How many systems have you installed?
- ☐ Can you give me references (with phone numbers) for similar systems you've installed recently?
- ☐ What are your licenses or certifications?
- ☐ Will you be using subcontractors? For which parts of the project? What are their qualifications?
- ☐ Who specifically will be working on my roof?
- ☐ Do you have workers' compensation insurance? Can I have a copy?
- ☐ Is the installation company licensed and insured?
- ☐ Does your company follow the SEIA Solar Business Code? Do you agree to abide by SEIA's Complaint Resolution Process?

### ECONOMICS, FINANCING, AND OWNERSHIP:

- ☐ What is the total cost of the system? Is that with or without the federal tax credit?
- ☐ How much is the total cost of the solar system if I add battery storage?
- ☐ What's the upfront cost?
- ☐ What will my monthly payment be? For how long?
- ☐ What will my net savings be? What utility rate assumptions are included in your calculations, and what are they based on?
- ☐ Does installing battery storage change how much money I can save with this system? If so, how much?
- ☐ Who gets the tax credit?
- ☐ Will my system be net-metered? How will I be compensated for excess electricity generated by the system?
- ☐ What financing options do you have available?

- ☐ Who gets the SRECs and how do they factor into the (financial) equation? Will you retire the SRECs on my behalf?
- ☐ If I want to sell my home and don't own the SRECs, how can I describe my home to potential buyers?
- ☐ Is residential Property Assessed Clean Energy (PACE) financing available in my state and locality?

## SYSTEM DESIGN, PERMITTING, AND APPROVALS:

- ☐ What are my rights under state law?
- ☐ Can my HOA stop me from installing solar?
- ☐ What permits are needed? Who's responsible for securing the permits?
- ☐ Who deals with the utility and arranges for interconnection, inspections, and permission to operate?
- ☐ When will the installation be done, and how long will it take?
- ☐ Who's responsible for repairing my roof if it's damaged during installation? Do you replace any broken roof tiles?
- ☐ Who is the manufacturer of the solar panels and the inverter?
- ☐ What is the system size?
- ☐ How much electricity will the system generate in its first year?
- ☐ How much production decline is expected each year?
- ☐ Do system output calculations consider actual installation details of the system?
- ☐ Do you guarantee a minimum amount (a production guarantee)? Are there any other guarantees?
- ☐ If there is a grid outage, what will happen to my system?
- ☐ If I need battery storage in case of a grid outage, what size system and system attributes do I need?

## INSTALLATION:

- ☐ What will the system look like once installed? Will I receive a system design for my review and approval before installation?
- ☐ Will I be required to make any changes to my home (e.g., roofing upgrades)?
- ☐ Do you use the SEIA residential disclosure form? Can you provide a completed copy of the form?
- ☐ What type of flashing will you use on my roof?
- ☐ What type of mounting hardware/footings will you use to attach the panels to my roof?
- ☐ What kind of rail system do you use to connect the footings to the solar panel?

- ☐ What do you use to seal the flashing to the roofing?
- ☐ What kind of conduit do you use? Where will you install the conduit?
- ☐ What type of inverter will you use? If there's a central inverter, where will you install it?
- ☐ Are the solar panels above the roof, or do they go directly on the roof?
- ☐ What disconnects are required, and where will they be located?

## MAINTENANCE AND PERFORMANCE:

- ☐ What type of warranties come with the solar system? What do the warranties cover and what are their durations?
- ☐ Are there separate warranties for parts and labor?
- ☐ What type of maintenance or cleaning is required? Are any maintenance services included? If not, who should I contact?
- ☐ Is performance of the system monitored and, if so, by whom? How can I monitor system performance?
- ☐ Who should I contact if I have a question about the system following the installation? Who should I contact if my system stops working?
- ☐ If the company fails, who should I contact regarding panel and inverter warranties and replacement?

## FOR LEASES AND PPAS ONLY:

- ☐ What is the length of the lease or PPA?
- ☐ Will my payments increase over time? How much will they increase?
- ☐ What happens if I wish to end the lease or PPA early?
- ☐ Can I purchase the system, either during the agreement or once it ends?
- ☐ What are my options when I sell my home?
- ☐ Am I free to sell my home or do I need the system owner's permission?
- ☐ Do I have to pay off the lease when my home is sold?
- ☐ Can you explain the UCC-1 filing to me? What happens if I want to refinance my mortgage?
- ☐ Are there fees to transfer the PPA or lease agreement to the new homeowner?
- ☐ What are the conditions for a new homeowner to take over the lease or PPA?
- ☐ Who is responsible for repairs and maintenance on the system?

# Endnotes

1. https://www.nrel.gov/news/program/2021/ documenting-a-decade-of-cost-declines-for-pv-systems.html

2. From https://www.solarunitedneighbors.org/ go-solar/download-our-go-solar-guide/

3. See "Warranty: What to Look For": https://www.letsgosolar.com/solar-panels/ home-and-residential/

4. https://southern-energy.com/solar-federal-tax-credit-what-is-and-isnt-eligible/

5. Additional options: https://www.energy.gov/ eere/solar/solar-rooftop-potential

6. This site has recommendations for how to use PVWatts to get even more detailed results: https://www.solarreviews.com/blog/ how-to-use-pvwatts-to-figure-out-the-ideal-size-for-your-solar-system

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