# Solar Power for Your Home

## A Consumer's Guide

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# Acknowledgments

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**Are you thinking about adding a solar energy system to your home to generate electricity? If so, this consumer guide will help you explore various options, ask important questions and make a well-informed decision.**

**Photovoltaic or PV, systems convert light energy to electricity. Other solar energy technologies, such as solar water heating systems, work by capturing and redirecting heat from the sun, but this guide is focused on systems to generate electricity for your home.**

**Although photovoltaic technology has existed for decades, its use in both rooftop solar and community size solar systems has been rising nationwide. Solar power offers valuable benefits, but there also are many things to consider when thinking about a solar photovoltaic system.**

# Why Go Solar?

The sun is a renewable source of clean energy and that's an increasingly valued benefit. Solar photovoltaic (PV) systems produce electricity without emissions of air-polluting gases, greenhouse gases and particles that are byproducts of combustion or burning fuels. The supply of "fuel" for solar PV systems – sunlight and solar heat – is endless and free. That doesn't mean the electricity is free, but you may be able to save money.

With the ongoing advancements in solar PV technology, the cost of solar power continues to drop and its use is on the rise. Since solar PV systems are long-lasting and require little maintenance, the cost of producing electricity remains relatively stable and predictable over a long time. Owning a home solar power system can be insurance against energy cost increases that affect other power sources. In addition, studies in various locations found that homes with PV systems sold for several thousand dollars more than comparable nonsolar homes.

Rooftop solar power creates a system of ***distributed generation*** (many small-scale power plants) that helps meet area power needs. Solar power that is produced at times of high electricity demand (typically late afternoon) is high-value electricity since it offsets energy purchase or generation when the cost is higher.

You may have personal motives to go solar. You may want to reduce your energy bills and/or increase your property value. You may like the idea of producing some of your own power at home. You may value the opportunity to do your part to conserve energy and promote environmental quality by using an eco-friendly renewable energy resource.

Because of these benefits and to promote energy resource diversity and green economic development, solar energy use is encouraged by public policy. There are many financial incentive programs to spur development of renewable energy, grow green jobs and make it more affordable for you to go solar.

Despite the benefits, there are several factors that can limit home solar power:

- Cost is the primary hurdle for solar power systems at every home. A solar system that can power a home is expensive. Financing may not be available or affordable or the homeowner may not qualify. Finding and evaluating financing options can be an intimidating and confusing process.
- Solar energy isn't continuous, since it's not available at night and is reduced greatly when it's cloudy or the panels are snow covered, shaded or dirty. As a result, another source of electricity must be ready to provide power whenever it's needed (such as an electric utility company, whole house generator or a large and expensive battery storage system). Also, rooftop solar is not equally effective in all areas and climates.
- Rooftop solar isn't feasible when neighboring structures or landscaping block access to sufficient sunlight exposure. Some roofing types, designs or orientation limit installation or efficient output.
- Solar access rights and regulations vary widely. Many states and cities protect solar access rights, but some local ordinances and/or homeowners association rules restrict installation of solar systems on homes to maintain an established aesthetic standard.

### 7 Basic Steps To Going Solar

1. Get a home energy checkup.
2. Complete cost-effective energy-efficient home improvements.
3. Understand your utility bills, local incentives (tax credits, rebates, etc.) and rules.
4. Explore solar system types and your available solar access.
5. Weigh buying versus leasing considerations.
6. Get proposals from several reputable, established solar system providers.
7. Analyze costs, projected savings and contracts to make the best choice for you and your home.

# When Should I Add a Solar Power System to My Home?

Even though solar energy offers many benefits, a rooftop solar power system is not the first step to saving energy, money and the environment. If your home wastes energy, improving its energy-efficiency should be your first priority.

An energy-efficient home reduces the amount of power you use from any source, so efficiency trumps renewable energy in being good for the environment, conserving nonrenewable resources, helping our nation's energy security and keeping more of your money for other things. A "high performance" home also could provide many other advantages such as greater comfort, quality, durability and indoor air quality.

It usually doesn't make good economic sense to install a rooftop solar system until your home is reasonably energy-efficient. Otherwise, you're spending money to produce electricity that you would not need if your home were more efficient. Investing in an effective home energy upgrade typically produces a greater return on investment and costs less than a solar power system for the same reduction in electricity use. Moreover, increasing the energy efficiency of your home reduces the size (and cost) of the solar system needed to supply your power needs.

An exception to this general rule would be when major solar incentives are available but will soon expire or may be reduced. In such a case, it may be reasonable to first install a solar energy system that can supply up to half of your annual power need so you can take advantage of the incentives while they are available. That would leave room to still increase your home's efficiency up to 50 percent, so you could make the energy improvements afterward and reap the full benefits of efficiency plus solar energy.

## So, Before You Go Solar…

Learn about the most effective ways to increase your home's energy efficiency in your climate at www.energystar.gov, www.energy.gov and www.eXtension.org. To optimize the efficiency of your home and get the most "bang for the buck" without creating air quality or moisture problems, it can be helpful to get a customized home energy checkup, home performance improvement plan and quality assurance testing by a trained home energy professional. You can find certified home energy pros at www.resnet.us and www.bpi.org. Find out if your local utility company offers energy efficiency programs, home energy assessments or discounts or rebates for energy-saving appliances, home improvements or new homes.

If you're planning a new home and want to include solar power, consider building a "*zero-energy ready home*" with an experienced high-performance home builder. For reliable information on high-efficiency building systems, technologies and detailed guidance, explore the Building America Program *Solution Center* at https://basc.pnnl.gov.

## Analyze Return on Investment (Savings and Payback)

By combining energy efficiency and a home solar power system, you could potentially produce much or all of the electricity you use on an annual basis. Whether you purchase or lease a home solar energy system, you're making a major long-term investment and should analyze all costs and likely savings or payback before making a decision.

Consider:

- Available tax credits, rebates and incentives from all available sources.
- Initial cost (equipment, installation, permit fees) or monthly costs (loan or lease payments) for the expected equipment life or lease term.
- Maintenance costs (monitoring, inspection, cleaning, landscape pruning, removal to reroof, etc.).
- Replacement costs of system components (inverters, batteries, etc.) with a shorter lifespan than the solar panels.
- Your average and annual electricity use and cost per kilowatt-hour, both current and projected.
- How much electricity per year the system is expected to produce.
- The rate or credit you will receive from the utility company when your system produces more energy than you use.
- How the solar system is likely to affect your home's appraised market value and how long you plan to stay in the home.
- The expected productive life of the solar power system or the length of the lease contract.

It can be tricky to calculate the return on a home solar investment, especially if leasing or financing a system. Purchased rooftop solar payback periods can range from seven to 20 years without incentives. Incentives shorten the time it takes to recoup the cost and see real savings.

You also may wish to consider timing for a solar investment. As costs of solar power systems decline, efficiencies increase and utility electricity costs rise, the payback period gets shorter. After a solar power system is installed, it may be impractical to upgrade the system to take advantage of a newer, improved technology.

## Find Incentives

A variety of incentives may be available to you that lower the cost or increase the return on investment for a home solar energy system. Common incentives include income tax credits, property tax exemptions, rebate programs from government agencies or utility companies, payments or credits based on electricity production, grants, loans, net metering policies and others. They vary by state and city and by whether the system is purchased or leased and they may change or expire.

Fortunately, there is an easy way to find incentives! Visit and browse the **Database of State Incentives for Renewables and Efficiency** at www.dsireusa.org to explore summaries of renewable energy and energy efficiency financial incentives, programs and policies available at the federal, state and local levels. Because new programs are formed frequently and not all may be listed, it's a good idea to check the database and your local utility provider periodically to find out what's available to you. Likewise, many incentives may change or phase out as the renewable energy industry grows and the technology becomes increasingly productive.

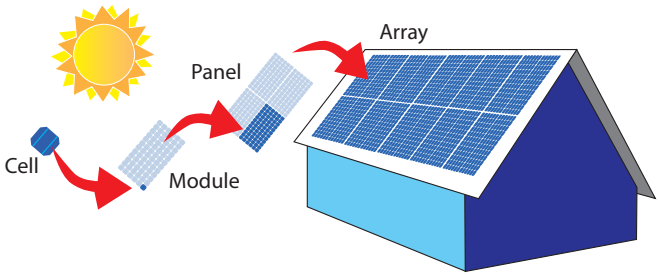
### Examples from DSIREUSA.org (in 2014)

1. Click on View Federal Incentives, then on Residential Renewable Energy Tax Credit to see information about the 30 percent federal tax credit available until Dec. 31, 2016. Click on your state to find available residential incentives and programs. For example:
2. If you click on Arizona, then narrow your search to see Residential Incentives Only, in 2014, it revealed:
   - A personal tax credit of 25 percent of cost of solar and wind devices, up to $1000.
   - An energy equipment property tax exemption of 100 percent of increased value.
   - A solar and wind equipment sales tax exemption.
   - Numerous utility rebate and loan programs. Several cities with green building and rebate programs.
3. If you click on Louisiana, in 2014, it revealed a variety of state and local financial incentives, including the state personal tax credit for solar energy systems on residential property.
   - Until 2018, homeowners can use a state tax credit (refunded even if in excess of taxes owed) of 50 percent of the first $25,000 spent to buy solar technologies, in addition to the 30 percent federal income tax credit. Using the state and federal tax credits, a home system valued at $25,000 can be purchased for about $5000.
   - If the solar system is leased, however, the leasing company receives a smaller tax credit.

# What Is in a Home Solar Photovoltaic (PV) System?

## Solar PV Basics

The basic unit of photovoltaic or PV, technology that converts light to energy is the ***solar cell.*** Multiple solar cells are connected and sealed together to form a PV ***module.***




*The power-generating components of a solar photovoltaic system.*

Solar ***panels*** include one or more PV modules assembled as a pre-wired unit. In most systems, several solar panels are linked to provide the desired power capacity, typically measured in kilowatts. The complete set of panels that form the entire power-generating unit is called the PV ***array***. Most home PV systems are assembled as an array of multiple panels attached to the roof, so they are often referred to as a "rooftop solar system," even though the array can be installed on a free-standing frame or other structure on the property.

A PV array typically includes a mounting system attached to the roof and one or more ***inverters*** to convert the electricity it generates from direct current (DC, the type from batteries) to 120 volt alternating current (AC, the same as the electricity delivered to your home by your utility company). A central inverter system normally is sized for the entire array.

***Microinverters*** are an alternative approach to the single-inverter system commonly used on homes. Each microinverter operates with a single PV panel or module and connects to other independent units. This allows for simple future system expansion – without the need to change out much of the existing system – and provides improved installation and fire safety. It also avoids the possibility of being completely without solar power if an inverter fails and has a less expensive replacement cost than a single-inverter system.

With a single or central inverter, if one panel is shaded or malfunctions, that can greatly reduce the entire system's output. With microinverters, only the affected panels reduce output while the rest of the system continues full power production.

The conversion of power from DC to AC by the inverter consumes some of the solar power that has been produced. There is less energy loss when solar PV directly powers DC or "solar ready" appliances and equipment. LED bulbs and many electronics (computers, TVs, mobile phones, etc.) are powered by DC electricity, as evidenced by the AC to DC inverters commonly visible along the cord for those devices. Any direct DC interaction between a solar PV system and its connected equipment may require additional control devices and wiring.

**In the future,** homes may come with dual current electrical networks where a dedicated DC nanogrid or microgrid uses solar electricity and batteries to directly power solid state lighting, cooking, refrigeration and telecommunications alongside the typical utility connected AC macrogrid.

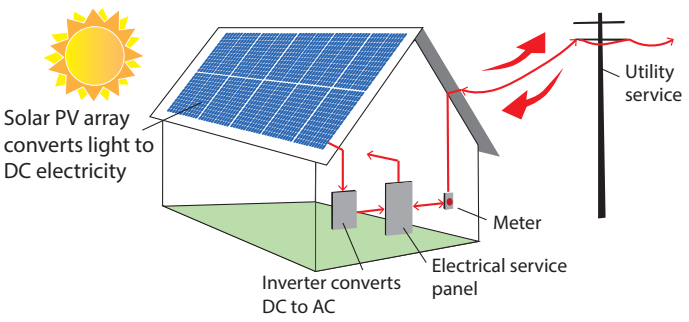
## Types of Home Solar Power Systems

The two basic types of home solar photovoltaic (PV) systems are stand-alone, also known as **off-grid** and utility-interactive, also known as **grid-tied.**

**Off-grid or stand-alone systems** are not connected to a utility power grid. They include a battery bank that is large enough to power the home at night and during extended periods when the panels don't receive sunlight. This adds substantial cost and maintenance requirements to a PV system but can be a more cost-effective alternative to having new utility lines extended to remote locations. Off-grid systems also can be designed to serve as a backup power system in place of fuel burning generators.

*Battery bank for an off-grid home solar power system.*

**Grid-tied or utility-interactive systems** are connected to the electric utility lines and are the most common and practical systems for most homes at this time. The solar electricity produced is supplied to the main electrical panel of the house, offsetting the purchase of power from the utility company. Since the home is still receiving some power and continuous power-support services from the utility, there will still be a monthly electricity bill (yet less than before).




*Grid-tied home solar power system.*

Additional meters may be installed or the original electric meter replaced with a "smart" digital meter, to separately measure power from the solar panels and electricity from the utility company. Some meters also can measure time of use for variable rate structures.

There are several important **benefits** to grid-tied systems versus off-grid systems:

- They are considerably less expensive, safer and require less maintenance. There is no need for a suitable safe storage space large enough for the battery bank.
- They combine solar power with the consistency of utility generated electricity to produce enough power to meet all needs, even when the solar system is not producing power.
- In most areas, surplus energy produced when the sun is shining (in excess of your home's use at the time) can create a credit on your utility bill.

At this time, most grid-tied systems are required by building codes to automatically shut down whenever there is a grid power outage. This is a safety measure to protect power-line workers and neighbors on the same utility circuit. That means your solar system does not provide power when the grid is down, contrary to what many assume.

**Hybrid systems** and new inverter technologies that allow the home to use solar power during a grid power outage are becoming available. Such a system would provide a valuable backup power system during daytime.

- *Emergency power inverters* are grid-tied inverters with a feature that allows a small amount of power to be drawn to a dedicated outlet when the grid is down. The solar electricity cannot be delivered through the building's wiring system, so it can't power major loads but can provide critical daytime charging of electronics and other small power needs.
- *"Islandable"* PV systems use a small battery bank, a bimodal battery inverter and sophisticated controls that can allow most or all of the solar system capacity to be used when the utility grid is down and the sun is shining.
- *Smart inverters* can receive and respond to grid signals to help keep the power grid stable. Inverters that can safely disconnect from the utility grid during a power outage but retain the ability to convert DC electricity into usable AC electricity for the entire home (without batteries) are in development and may soon be commercially available.

**Bidirectional battery storage or inverted demand** is an emerging alternative approach. As the technology matures, it could provide backup power to a building (with or without a solar photovoltaic system) and contribute to some of the goals of using solar energy. Batteries connected to the grid and charged at low demand times (night) could reduce peak demand during the day (when grid power is more costly). When there is a variable utility rate structure by time of day (higher rate at peak demand times), a bidirectional battery storage system could provide lower electricity costs for the customer, reduce peak demand costs for the utility and help conserve energy.

## Net Metering

When a grid-tied home solar PV system produces more power than is being used, surplus power is fed into the utility grid. Net metering is a solar incentive designed to increase the return on your investment in a PV system by crediting your bill for this surplus power at a predetermined rate.

Net metering legislation or regulations have been enacted by most states to jump-start renewable energy development, but policies vary by state. Net metering policies usually require electric utilities to effectively "run the meter backwards" when an eligible customer's PV system is producing more electricity than the home is using. With net metering, you are billed for the net amount of electricity you used during the billing period. In other words, you pay the difference between the electricity coming from the grid and the electricity you put back into the grid.

Depending on local policies, net metered customers may be paid or credited the full retail rate for surplus power they supply to the grid, while some may instead be paid or credited a lower wholesale rate. The wholesale rate is what the utility pays for other sources of electric power. It reflects the lower cost of producing power in bulk due to economies of scale. The retail rate includes the cost of generating power plus the fixed cost of the grid system (power lines and distribution system) that delivers power to and from each user. The retail rate also may include the cost of utility incentive and social programs.

When net metering applies retail rates for surplus power supplied to the grid, net metered customers avoid the fixed cost charges that support the power grid and programs. Since grid-tied solar customers rely on the grid network, some states have amended net metering or are considering policy changes that require everyone who uses the electric power grid to support its cost. This may take the form of a one-time fee, periodic surcharge or rate adjustment. Check with your local utility to find out how these policies would apply to you and evaluate how it would affect the return on your solar investment.

There is wide variation in state net metering policies and limitations. For example:

- Net metering **eligibility may vary** by system capacity, system type, customer category (residential, commercial, industrial), type of utility or how surplus power is handled in a billing cycle. Some states use a dual metering system. Also, many policies evolve over time. It's a good idea to evaluate how potential rate policy changes would affect your solar investment.
- Some policies include **net metering caps** at a certain percentage of a utility's power generation, solar system size or other limit. The purpose of caps is to limit the incentive to early adopters. When the cap is reached, new solar system households may receive the wholesale rate for their surplus power instead of the retail rate.
- Instead of net metering, some states and cities use a **feed-in tariff or FIT,** where the electricity used and the electricity generated by a customer are measured and priced separately. In such a case, you would have two meters, so all the electricity your solar system generates is metered separately from your home electricity consumption. You provide electricity from your PV system directly to the utility grid in exchange for a contract rate and you separately purchase electricity from the utility at the retail rate. A feed-in tariff may require the utility to credit rooftop solar power at a fixed (or decreasing over time) price that is higher than the retail rate, usually over a fixed time period.
- Some states have **carry-over credit limits** (such as surplus power credits are forfeited at the end of every 12-month period) to discourage oversizing of rooftop solar power systems.

Check www.dsireusa.org to find your state and utility company's current net metering or FIT policies, but don't assume current policies and rate structures always will remain the same. Since many states revise their initial policies, it's wise to check periodically and evaluate your solar investment knowing that rate policies could change. Policy changes to tariff rules or minimum monthly bills that occur can apply to you, even after your PV system is installed.

## Community Solar or Renewable Power Programs

If you'd like to support and use renewable energy without adding power-generating technology to your home, check to see if your utility company offers a voluntary utility **community solar** or **renewable power** program**.** Such programs are becoming more widely available.

In community renewable power programs, you can choose to participate and purchase electricity generated by renewable resources such as solar, wind and methane gas from decomposing garbage. The rate per kilowatt-hour typically is a little higher than the rate for fossil fuel

generated electricity but with no investment in home solar equipment. Customer participation encourages investment in community renewable energy systems that can more efficiently produce power than small home systems.

### Benefits of Community Solar

Utility scale solar is less expensive to construct than rooftop solar and savings can be passed on to customers.

It provides access to renewable, clean energy to households who are not in a position to install home solar power systems because of:

- Insufficient sunlight access due to unsuitable weather, obstructions, roof type or orientation.
- Living in rental property.
- Income or credit score limitations.
- Not planning to stay in the home long enough to justify the investment.
- Not wanting the responsibilities of choosing and owning a solar system.

## Types of Solar Photovoltaic Technologies

**Crystalline Solar Cells –** Traditional, first-generation solar cells are made from silicon crystal. The vast majority of home solar panels now in use have crystalline cells.

- Monocrystalline cells generally are the most efficient type (they produce more power per cell). They also are the most energy- and time-intensive to produce, so they tend to be the most expensive type. Their sunlight to electricity conversion efficiencies tend to fall in the range of 13 percent to 20 percent, with useful life spans of 25-35 years (based on rate of output degradation). Technology advancements are increasing the potential efficiencies.

*Monocrystalline solar panels.*

- Polycrystalline cells, made up of many smaller crystals, cost less and provide a similar life span, but they deliver slightly lower efficiencies in the range of 10-16 percent. With these, you might need to cover a larger surface area to get the same output you would get with a monocrystalline solar array. Advancements are increasing efficiency closer to that of monocrystalline cells, however.

**Thin Film Solar Cells –** Second-generation thin film solar cells are made from noncrystalline layers of semiconductor materials so thin that they are flexible. The market for thin film technology has been growing.

*Thin film solar materials.*

Because of the flexibility, thin film solar cells can be used in ways rigid crystals cannot. This film can be made to double as roofing shingles or tiles, to form adhesive sheets that fit within ridges of metal roofing or even can be used as glazing of skylights and building facades. This offers an attractive building-integrated option, often referred to as a BIPV (building integrated photovoltaic) system. Thin film also can be manufactured in metal-framed panels similar to crystalline cells.

Thin film can be produced faster and is less expensive than crystalline cells, but it has a lower efficiency – in the range of 5-9 percent – so about twice the surface area is needed per watt of power. Future efficiencies could increase its efficiency to 10-16 percent with technology advancements.

Despite the lower efficiency, thin film can use diffuse sunlight better than crystalline cells, is less prone to overheating (good for warm climates), is more shade tolerant and may be more resistant to hail damage. That can help improve output when the solar orientation is not optimal. Thin film output tends to degrade faster than crystalline cells, although some types now have 20-year warranties.

**Future Technologies –** There are other technologies being developed to harness the energy in sunlight, such as using nanotechnologies or chemical processes. Such advancements could offer higher efficiencies, lower costs or new uses in the future.

# Where Will My Home Solar System Work Best?

A solar photovoltaic system works best and delivers the most power where the most sunshine strikes its collection surfaces. Mid-day sun produces more power than early morning and late afternoon sunlight. Of course, sunny days produce more power than cloudy days, so the climate and daily weather matters. The clearness index is a measure of how much sunlight your climate receives.

## Placement of Your Solar System

**Orientation –** Solar panels work best oriented toward the south. When that's not feasible because of the roof orientation or aesthetics, facing 45 degrees west or east of

true south reduces energy output by less than 5 percent. Facing 90 degrees off of true south reduces annual energy output by only 10-20 percent. So a roof that faces south, southeast or southwest is fine and a roof facing east or west may be acceptable, depending on your expectations for the system.

If your utility has a time-of-use rate system, it could make good economic sense to design your PV system to face west to maximize production in late afternoon when wholesale electricity prices usually are highest. Some utilities may offer incentives for west-facing solar placement that increase output during the late afternoon peak demand time. West-facing solar power systems can generate about 50 percent more electricity during late afternoon than south-facing systems.

**Tilt –** The slope or tilt of panels also affects performance. The optimal fixed tilt in the United States is an angle a few degrees lower than the geographic latitude, but an exact tilt is not crucial. A 15 degree variation to suit a roof's pitch makes almost no difference in power output. While it may not provide optimal capture of solar rays, most rooftop solar panels are mounted parallel to the roof for the sake of simplicity and aesthetics.

**Tracking Arrays –** The output of a solar power system can be increased by having the system track the sun as the sun moves across the sky on a daily basis, and/or adjust the tilt of panels to the seasonal solar path, instead of being fixed in one orientation. Tracking arrays are not generally recommended for home PV systems, however, because of the added complexity, maintenance and costs compared to the energy benefits.

*Shading can greatly affect power output. Examine effects of seasonal sun angles, new buildings and growing trees.*

**Shade –** Shading can have a very large effect on the output of a PV system. Depending on the type of system, shade on 25 percent of an array could result in a 50 percent or greater drop in output. It's important to examine shading across the sun's path – not only in a day but also over a year since the angle of the sun is lower in winter. You should make sure your neighbor's house and trees won't shade your solar array in winter. Also, consider what might create shade in the future, such as growing trees or new buildings. It's a good idea to ask your neighbors if they have future remodeling or landscaping plans that could shade your solar panel location.

Many solar professionals use a tool called a solar pathfinder (www.solarpathfinder.com) to find optimal placement at a location. If seasonal shade is an issue, a microinverter system is preferred since only the shaded panels are affected.

## Your Geographic Solar Resource

Your location and the weather have a big effect on your solar power output. For example, homes in the northwestern United States may average only three to four hours of sunlight a day, while those in the Southwest average six-and-a-half hours. That means northwestern homes need a larger and more expensive array to produce the same power as southwestern homes.

Look into your area's solar resource (how much sunshine is available). The U.S. Department of Energy's National Renewable Energy Laboratory creates color-coded maps that illustrate approximate sunlight received in kilowatt-hours per square meter per day. Visit www.nrel.gov and search "solar maps" to see more.


*Source: National Renewable Energy Laboratory*

# HOW Do I Size, Install and Maintain My Solar System?

## Sizing Your Solar Power System

Sizing your home solar photovoltaic (PV) system depends upon a combination of factors, including: the PV system's efficiency, your location (solar resource), placement, available roof space, your electricity use, your utility rate and your budget. You will need to balance how much you're willing to invest with how much of your electricity needs you want the solar system to supply. This will be an important discussion to have with knowledgeable professionals.

A solar photovoltaic system design should take into account:

**PV Power Rating** – Photovoltaic systems are rated with a peak DC power generating capacity measured in watts or kilowatts. A kilowatt is 1,000 watts. It's important to know the actual operating capacity usually will be less than the laboratory rated capacity, so that should be considered in predicted output.

**Available Solar Resources –** The sun does not always shine at its peak intensity and solar intensity is reduced when the sun's rays strike cells at an angle. To estimate the likely output of a PV system, a solar professional uses ***peak sun hours*** which is the number of hours the sun must shine at peak intensity on a solar array to equal the amount of radiation that actually was received by the array during the day.

**PV Electricity Generation –** To estimate the output a photovoltaic module will produce, the expected operating power capacity (kilowatts) is multiplied by time. There are free software programs available to help estimate the electricity output of a PV system.

To size your home solar power system:

- As a starting point, determine your total electricity use in kilowatt-hours for the past year (your demand). Check your electric bills or contact your utility company. Then you can compare how much a new solar PV system is expected to produce (in kilowatt-hours) with your annual electricity use.
- Check what you're paying per kilowatt-hour. U.S. electric rates in 2014 ranged from 7 cents to 38 cents per kilowatt-hour, with a national average rate of 13 cents per kwh. Compare your utility rate with the cost per kwh of solar power to evaluate cost versus benefit over the life of the system. Ask your utility about its historical rate increases and compare that to savings assumptions made by solar companies. (See *Solar Leasing Versus Ownership Calculators* section.)
- Consider how much of your energy use you want to produce with a home solar system. Measure your suitable unshaded roof area (Note: Solar panels can't be installed over roof vents, pipes and valleys). A small starter system might use only 50 square feet of roof area, where a large output system may need 1,000 square feet. A rough rule of thumb is 100 square feet of clear roof area for every kilowatt.
- If your roof limits the size of your system, you can choose high-efficiency crystalline PV panels. If you have ample roof area, you may opt for a lower efficiency, less expensive or more attractive thin film system.
- If you plan to use net metering or other incentives, check the rules for any size limitations.

### The NREL PVWatts® Calculator
(pvwatts.nrel.gov)

This free online calculator can be used to help determine the energy production and cost savings of a grid-connected solar system. It estimates monthly and yearly energy production in kilowatt-hours and the energy's dollar value. You may select your location and use the default or choose actual values for your proposed system size, electricity cost, solar array type and panel tilt angle. The calculator also uses weather data for your location.

As an example, a 2014 Phoenix, Ariz., default calculation using a 4 kilowatt system with a 20 degree tilt and electric rate of 12 cents per kilowatt-hour produces a month-by-month estimate of solar radiation, AC energy (kwh) and annual electric bill savings of $828. A comparable calculation for Seattle, Wash., produces an annual electric bill savings of only $337.

## Installation Considerations and Tips

A solar array can be **roof mounted, ground mounted** or **building integrated:**

*Roof-mounted solar array for large power capacity.*

Rigid crystalline solar modules can be installed on most any type of roofing, but some types are easier to deal with than others. Composition shingles are easy to work with; clay tile and slate are difficult and more risky (for roofing damage). Solar panels can be attached to the ridges of standing seam metal roofing so there are no penetrations in the roof.

- Most roof-mounted crystalline modules are installed on racks made of aluminum. Racks should create an air space of about 3-4 inches under the array to help lower the PV module temperature. Cooler modules produce more electricity than hotter modules.
- If your roofing is worn or aged, it should be replaced before installing the solar panels to postpone or avoid the cost of removing and reinstalling the solar

*Crystalline solar modules mounted on aluminum racks, with airspace to keep them cooler.*

system to reroof. The typical life of an asphalt shingle roof is 14 years in hot climates or up to 20 years in cooler climates.

Another option is to completely cover a porch or patio with a solar array, without roofing underneath. There are several advantages to having a solar porch or patio covering instead of installing panels on the main house roof. It can create a more attractive architectural appearance. This placement avoids the need to remove and reinstall solar panels to replace roofing. It also can keep the panels cooler, which helps improve performance.

*A solar porch or patio roof is an attractive option and avoids placement of system components over roofing.*

Installing a ground-mounted or pole-mounted (also called stand-alone) array can allow optimal orientation and tilt when the house roof is less suitable. It can be made adjustable to vary tilt for the season. It also avoids two of the major drawbacks of a roof-mounted array – the potential for roof leaks at connection points and the need to remove it when the roofing needs to be replaced. It can be installed a few feet above the ground or raised high enough to use as a landscape shelter. But keep in mind that a ground-mounted array requires a site without any nearby trees or buildings to the east, south or west.

*Ground-mounted solar array allows optimal tilt and avoids placement of panels over roofing.*

There are expanding options for integrating thin film solar systems into a building itself. Solar shingles both blend in and have the benefit of offsetting the cost of roofing material. Adhesive PV sheets can fit between metal roofing ridges, blend in color and require no penetrations in the roof.

*Thin film solar shingles can replace roofing material.*

Consider your risk of high wind (especially in hurricane zones) and hail and make sure the type of material and its mounting hardware can withstand wind and hail hazards without damage. Check your homeowners insurance policy to see if it would cover the cost of replacing a damaged system.

*Flexible thin film solar panels blend in between the ridges of metal roofing.*

Find a protected location for the inverter(s). If not in the garage or on the north-facing side of the home, add a shade structure for the inverter to enhance its longevity.

Regardless of mounting location, be sure to check fire codes, zoning restrictions, permit requirements, insurance requirements and utility grid connection rules and procedures. Some communities require a certain amount of your roof to remain uncovered by solar panels to ensure firefighters can walk on or cut into a roof safely when venting smoke, flames or extreme heat from a house fire.

## Operation and Maintenance

Most home solar systems are designed to operate automatically, with little or no user intervention, other than inspection and cleaning maintenance. You may opt for a monitoring system that allows you to see the system's daily, monthly and annual production and the resulting savings. Some firms may charge a fee for monitoring service.

**External issues**, such as encroaching shade from growing trees and dirty modules, are common developments that can reduce energy output. Modules that are not periodically cleaned can have an average annual energy loss of five percent in some regions. Areas with sufficient rain tend to have little need for cleaning.

- Trim tree branches and clean the array annually to maintain full solar power production.
- Annually inspect for wires damaged by rodents, bird droppings on modules, weeds sprouting between the module frames, broken cells or other damage.

**Internal problems,** such as module or cell damage, can reduce system output. Sometimes these problems are easy to spot, but often they are not. Each year, look for cracks in the glass, brown/burn spots on the modules, burnt solder joints on the cell grid and signs of delamination and cell damage. Do NOT attempt to repair such problems yourself, however. Check your warranty terms and get a qualified professional to diagnose and repair a problem.

Most system installers provide an optional monitoring system that enables you to check your system output on your smartphone or computer. Routinely checking your system's output can alert you to problems.

# Who Should I Hire To Install My Home Solar System?

If you are buying a home solar system, you choose your installer. If you are leasing a solar system, the third-party company might choose the installer. Either way, it's crucial to choose carefully to ensure a quality installation that will perform properly and not cause damage to your home or the equipment. Note that bids and site assessments typically are free, so don't hesitate to get multiple quotes. Investigate every company you are considering:

**Search** for local solar firms through the Solar Energy Industries Association (www.seia.org). In addition, explore local solar industry associations and seek recommendations from energy efficiency organizations, your utility company, online referral and review sites and people who have solar systems. Some utility companies and nonprofit organizations with green energy initiatives install rooftop solar systems.

**Look for reputable, professional** solar suppliers and photovoltaic system installers who have an electrical contractor's license plus documented training and field experience installing residential PV systems. Solar system installers who are certified by the North American Board of Certified Energy Practitioners have passed a rigorous exam and demonstrated a high level of training and experience (www.nabcep.org). Contractors and suppliers who have been in the PV or electrical contracting business a long time may be more likely to be around in the future to back up their products and installation.

**Verify the license or credentials** of the installer or company you're considering with your state's contractor licensing agency. Some states have licensing requirements specifically for solar equipment installers. Check the Secretary of State's office to see if required reports are up to date.

**Find out if there are any judgments or complaints** against the company submitted to the licensing board and the Better Business Bureau (BBB) and check the BBB rating of the business. Read online customer reviews for insights and patterns, but keep in mind that extreme and outlying reviews may not be reliable. Check with your state licensing agency or local building official to find out about local regulations and requirements.

**Get written proposals** from several companies, with clear specifications, costs and estimated annual energy production (and how it was derived). Ask questions and get details in writing. Ask for customer references and talk to them. Never let a vendor rush or pressure you into a quick decision!

## Get a Strong Contract

**Get a written contract** once you select your firm. Make sure it specifies all needed components, services and permits; the payment schedule and terms; a timeline for completion; a statement of workmanship, code compliance, warranties and guarantees; who is responsible for replacement of any components under warranty; and a lien waiver to protect you in the event suppliers have claims against the contractor. If you are leasing a system, get in writing who is responsible to remove and reinstall the system when roof repair or replacement is needed and who should do post-installation roof inspection.

**Know the permitting requirements** in your locale and make sure the contractor you select completes the permitting process. In some cases, it can be a time-consuming process with a significant cost. Your installer needs to be aware of local building and fire codes to ensure compliance.

## Examine Warranties

Whether you buy or lease your solar system, the vendor or leasing company should provide you with a copy of the warranties. **Read all warranties very carefully and ask questions.**

- System warranty terms typically are for 20-25 years at 80 percent or more of original system capacity on solar panels and 5-10 years on inverters, but may have limitations. There may be manufacturer warranties on equipment for varying durations that cover parts and labor or just parts. Find out if the warranty covers the entire system or only selected components. (Note that the actual lifespan of solar panels is likely to exceed the warranty period.)
- The warranty may contain maintenance and repair requirements you (or the leasing company, if applicable) are required to complete.
- Be sure you know who is responsible for fulfilling system warranties (installer, dealer, manufacturer or leasing company) and understand what you need to do to enforce the warranties.

- It's important to have a roof warranty that states what responsibility your installer has for damage to your roof or any other structures during installation, any damages to your home or its contents that result from installation and any crew or public injuries. It should name the types of safety standards the installer should follow during installation.
- If you are leasing a system, make sure the roof warranty covers system removal as well as installation. The lease contract should state who is responsible for removing the system and restoring your roof and home at the end of the lease.
- Check to see if damage from nearby lightning strikes and other electrical surges are covered by your warranty, especially for inverters since their electronics may fail under these stressors.

Ask about the contractor's bonds and other financial arrangements that help ensure warranties are honored. Remember, a warranty never guarantees the company will remain in business. Find out who to contact if there is a problem.

# Which Is Better for Me – Buying or Leasing?

Since a home solar power system can cost anywhere from $5,000 to $50,000, how you pay for it is a big deal! There are many considerations to weigh and different costs and benefits of buying versus leasing a home solar system. Local and state incentives and how they apply to a purchase versus leasing should be factored into your decision.

**When purchasing** a home solar system, you own it. The main expense is upfront, so you may need to get a loan to finance it and you are responsible for its maintenance.

A big advantage of ownership is that once your electric bill savings recoup the initial cost, the remaining electric bill savings are all "profit" (return on your investment). There also may be incentives for purchasing that are not available when leasing.

**When leasing** a system installed on your home, the leasing company owns it. You have little or no upfront cost and you could start saving some money right from the start – and as long as the energy produced results in utility bill savings that are greater than your monthly lease payment. Since your lease payments continue throughout the lease term (typically 20 years), however, there is no payback point where the purchase cost is recouped and your utility bill savings grow sharply.

## Leasing a Home Solar Power System

A solar lease is third-party financing where the company pays the cost of a solar system on your home in exchange for a monthly payment, usually with no money down. Some offer an option to make a small down payment in exchange for lower monthly payments. Some offer prepaid leases that compress the yearly payments into one discounted upfront payment. There may be a minimum credit score requirement to be eligible for a lease. The lease term typically is 20 years.

Since the leasing company owns the solar system, the company gets whatever tax credits, rebates and other incentives are available. These financial benefits and other factors typically enable the company to set your initial monthly payments lower than your initial utility bill savings and still make a profit.

The leasing company monitors and is responsible for maintaining and repairing the solar system. Some provide the homeowner a means to monitor energy production, savings, carbon emissions avoided, etc.

Some leasing companies sell their leases to third-party investment groups, so it's wise to ask who could be the future owner of your solar system. Verify that they have the expertise and capacity to fulfill the maintenance and other responsibilities under the lease agreement.

A lease normally is structured in one of two ways, although the label *solar lease* often is used interchangeably for either type – a ***solar lease (rental) contract*** or a ***power purchase agreement***.

- With a solar lease, you sign a lease contract (similar to leasing a car) and agree to a specified monthly payment schedule for the right to use all the power produced by the system. Your payments are predictable, like rent. If the system produces less than the company predicted, however, you may still be obligated to pay the full rent (making your actual cost per kilowatt-hour higher and reducing your savings), unless the lease provides a production guarantee.
- With a power purchase agreement, you agree to buy the power generated by the system at a set price per kilowatt-hour. You pay only for the electricity produced by the system and used by you. If the system produces less than predicted, you benefit less than expected but your cost per kilowatt-hour for the solar power is the same.

**IMPORTANT:** With either type of lease, the contract typically includes an **escalation schedule** that defines how the rental amount or price per kilowatt-hour will be increased over time. It usually is in the range of a 2 percent to 4 percent increase each year.

If the power purchase agreement rates or monthly payments rise faster than the actual cost of power from the grid, your cost savings per month decrease over time. In that case, the solar lease payment eventually could cost more than power from the grid. On the other hand, if electric rates from the grid rise more than your contract escalation schedule, your cost-saving benefits increases.

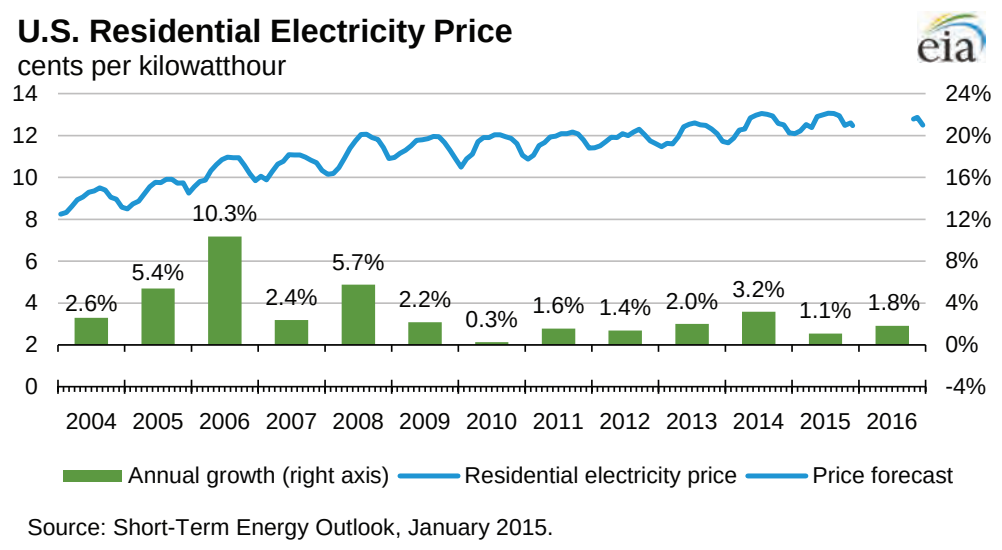
## *Be Cautious About Predicted Savings*

Projections of your total savings over the term of a lease usually are based on a prediction that the cost of electricity from the grid will rise at a rate higher than the contract's escalation rate. If the prediction is wrong, so is the estimated savings. Of course, no one knows the future, so predictions are just that – predictions. A 20-year lease is a long time.

For example, a power purchase agreement may have an annual 3 percent increase in your payment rate but base your predicted savings on a 4.5 percent annual increase in the cost of electricity from the utility for the next 20 years. Assuming a high growth of utility rates inflates the projected savings. If utility rates were to actually rise less than 3 percent per year, your utility bill savings benefit would shrink over time.

Historically, the rise in utility rates has slowed over the past 20 years. Since 2008, the national average increase ranged from 0.3 percent to 3.1 percent per year. Although higher rate increases occurred and are likely in some years and areas (such as the northeastern United States), a low national average growth of electric utility rates is possible due to slower demand growth and lower fuel costs.

Ask for the assumptions used to predict savings and verify how the solar power system's expected production was determined. Ask your utility company how rates have changed in the past few years and compare to the power purchase agreement's escalation rate.




*Source: U.S. Energy Information Administration* – www.eia.gov.

## Additional Solar Lease Contract Provisions

A right to rescind the contract (the right to change your mind and back out after signing) within a specific number of days after signing may be required in some states or specified in some leases. For example, in Louisiana, state law requires a three-day right to rescind contracts resulting from door-to-door sales. Check your state's applicable law.

> **Consumer Alert: Before you sign anything, read it. There have been cases of consumers signing contracts when they thought they were only signing an acknowledgment of receiving information.**

Operation and maintenance requirements assigned to the homeowner in a lease agreement may include tree trimming, panel cleaning, no modifications to your home that result in shading, prevention and correction of any condition that can inhibit system operation, a functioning Internet connection and visual inspection and notification to leasing company of any system damage or concerns.

In the event of system malfunction, faulty installation or damage to your home, your contract should require timely repair and state your rights when that doesn't happen. It also should state whether or not there will be any suspension or reduction of monthly payments when your system is not operating.

> **Consumer Alert: Common complaints include damage to roofs, holes in walls or soffits, sloppy hole repair, exposed conduit or wires, poorly secured or fallen solar panels, unsafe work practices and delayed installation or repairs.**

Lease renewal and purchase provisions may allow you to buy the system or renew the lease for a specific number of years at the end of the lease term. The contract may specify a minimum price or "fair market value," whichever is higher. Early purchase typically is allowed but may be restricted to certain times or conditions.

**Consumer Alert: Find out how the company will determine fair market value. With continuing advancements in solar energy technologies, it can be difficult to predict the future market value of a solar system.**

Termination provisions should list circumstances when and how you or the leasing company can end the lease. It should describe what is required if you sell your home, want to buy the system, have a catastrophic property loss or die. Look for provisions about your rights and remedies in the event the leasing company ends the lease, sells the lease, goes out of business or engages in deceptive practices. The lease also should detail what will happen if you default on the lease or make late payments.

**Consumer Alert: If the lease is sold to a third-party investor without notifying you, you would be unaware of who to contact for repairs and other needs.**

If you sell your home with a solar lease:

- The homebuyer may need to meet the solar leasing company's credit requirements and be willing to assume the lease agreement and payments.
- You, the home seller, may be able to move the solar lease panels to your new home (if located within same utility district) at your expense.
- You might pay off the lease and transfer the solar rights to your homebuyer.

Some potential homebuyers may be hesitant to assume a lease on a system that is not as efficient as newer technology. Ask the leasing company if they offer an option to upgrade your solar system when there are advances in efficiency during the term of the lease.

In the event of homeowner default, leasing contracts may include remedies such as requiring you to return the solar system at your expense, filing for court action to enforce performance of the lease contract and seeking reasonable compensation. The company also may submit a negative credit report to credit reporting agencies.

Most solar leases state they will not take a lien on your home since the company owns only the leased equipment. It may still file a Uniform Commercial Code instrument, if needed, however, to give public notice that it has or may have an interest in the personal property of a debtor and a right to take possession and sell certain assets for repayment of the debt.

In the event of leasing company default, your rights, remedies or limitations may include right to judge or jury trial, class action participation, attorney general action, arbitration or trial allowed only in a certain jurisdiction, filing or attorney fees, limitations on damages or waivers of certain rights. You may wish to consult a legal adviser before signing a contract to ensure adequate protections.

## Purchasing a Home Solar Power System

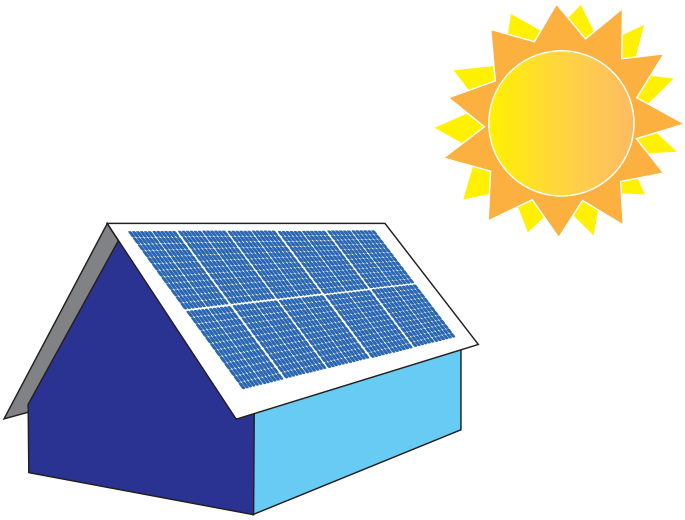
If you purchase a solar energy system, you can take advantage of the available incentives and programs to reduce the purchase cost (see Find Incentives section). Be sure to examine the limits and details of incentives before you select your system. It can be helpful to consult your tax adviser – to determine your capacity to use tax credits, as well as whether or not you will owe taxes from receiving incentives.

If you plan to finance the purchase, many states offer low-rate and zero-down-payment incentive loans that can apply to home solar purchases. Check www.dsireusa.org.

Some local governments may offer **PACE** (Property Assessed Clean Energy) financing programs that make loans to consumers for renewable energy or efficiency upgrades, which are repaid through an assessment on property taxes. Concerns about how PACE impacts home mortgages (deemed nonconforming to mortgage underwriting guidelines) is an issue that stalled many PACE programs, but some cities and states have re-established residential PACE programs with disclosures, reserve funds and other measures to address such concerns.

Another financing option is a home equity loan or second mortgage. Such loans obligate your home as collateral, but they have lower interest rates than other types of financing, and the interest may be tax deductible, further reducing your finance cost. Federal Housing Agency, or FHA; Veterans Affairs, or VA; U.S. Department of Agriculture, or USDA; and other lending agencies may offer specialized loan programs with favorable terms for renewable energy.

**Consumer Alert: Before you sign a loan agreement to purchase a grid-tied photovoltaic system, be sure to obtain an interconnection agreement with your utility company. Otherwise, you could wind up obligated to make loan payments before your system is approved for interconnection by the electric utility.**



## Sample Scenarios

These sample scenarios from two states with different incentives illustrate how you could figure and weigh the costs and benefits of buying a specific home solar energy system.

## Buying a Home Solar Power System

These factors (1-5) are the same for both situations:

1. The home electricity use averages about **1,000 kilowatt-hours (kwh) per month**.
2. The local utility's rate for electricity **is 10 cents per kwh**, so the average **monthly bill is $100,** and the annual electricity cost is $1,200.
3. Both people plan to buy a 4 kilowatt solar system that will cost **$15,000 installed** (at $3.75 per watt).
4. The system for each household is expected to **produce about 500 kwh per month**, which is half of the household's average power use.
5. Both are eligible for net metering, so the average monthly electric bills are expected to be cut in half – which translates to a reduction of **$50 per month or $600 per year**.

### Joe's Situation

6. Joe plans to use the **federal tax credit of 30 percent,** which **lowers his net purchase cost to $10,500** ($15,000 x 0.30 = $4,500; then $15,000 - 4,500 = $10,500). There are no additional tax credits in his state.
7. For Joe's net purchase cost of $10,500 and utility bill savings of $600 per year, it would take **17.5 years to recover his investment ($**10,500 / $600 = 17.5**).** After that, he benefits $600 per year for the remaining useful life of the system (typically three to eight more years).

   NOTE: If the electric utility rate rises, Joe's annual savings rise, too, and the payback period would be shorter. For example, if the utility rate increased to 30 cents in 20 years, he saves $1,800 per year by then, and his payback period could be less than nine years.
8. If Joe borrows $10,000 at 5 percent interest for a 20-year term, his monthly loan payments would be $66. That's **$16 more than his initial monthly utility bill savings**.

   At any point where the utility rate rises to 13.2 cents per kilowatt-hour, Joe's solar power system with net metering would offset the entire $66 monthly loan payment. If the utility rate increased to 30 cents in 20 years, he would save $84 per month (half of a $300 utility cost or $150 - $66 = $84).

### Jean's Situation

6. Jean's state provides a **50 percent state tax credit** (which means a return for her of $7,500). In addition, she will apply the **30 percent federal tax credit**, **reducing her net purchase cost to $3,000** ($15,000 x 0.8 = $12,000, then $15,000 - 12,000 = $3,000).
7. For Jean's net purchase cost of $3,000, it would take only **five years to recover her investment** ($3000 / $600 = 5) and for her to then begin to profit. After that, she benefits $600 per year for the remaining useful life of system (typically 15-20 more years).

   If the utility rate increased to 30 cents in 20 years, Jean would save $1,800 per year by then, meaning her payback period might be shorter and her savings greater.
8. If Jean borrows $3,000 at 5 percent for a 20-year term, her monthly loan payments would be $20. That nets her an **initial monthly savings of $30 per month.** If the utility rate increased to 30 cents over time, her monthly savings would be $117.

**Note:** In reality, solar power production, savings and payback from Joe's and Jean's solar systems would vary. Maintenance expenses may be incurred, and production varies with weather and shade changes. Electricity rates could rise more than expected, which would increase the annual savings from the solar power produced and shorten the payback period. Conversely, if utility electric rates fall or expenses rise, the reverse happens (savings would be less and the payback period lengthened).

## Comparing Buying Versus Leasing

**When weighing buying versus leasing,** be sure you compare "apples with apples," so to speak, meaning that you compare the same type and size system and thus the same solar power output in both financial scenarios. Consider the following:

- Figure out the effects of all tax credits and other incentives on your purchase cost or how much they would reduce your needed loan size. Determine whether any of the available incentives can still benefit you if you lease (such as property tax exemptions).
- Compare the monthly cost of getting a loan versus leasing the system for the same time span. A loan will identify the interest rate and monthly payment so you easily can compare. Factor in the effect of your tax deduction of the interest portion of a home equity loan, if applicable.
- A purchased solar system tends to be an asset that increases the property value and shortens time on the resale market. The added value also could be tapped as higher home equity to borrow against.
- If you might sell your home in the future, a leased system may be considered a liability the new owners would have to assume and may complicate the closing process.
- During the day, many home solar systems produce more electricity than the home is using. If that's likely, the availability of net metering could have a considerable efffect on the savings you expect.
- In leasing, you may expect your lease payments to be less than the cost of electricity from the grid – both initially and throughout the term of the lease. If the contract includes annual rate or payment increases, determine projected monthly payments throughout the full lease term.
- In financing a purchase, you may be willing to accept a monthly payment that initially is higher than expected utility bill savings because your loan payments will not increase over time, so your bill savings will grow as utility rates rise. Then, once the loan is repaid, monthly loan payments stop.
- Check your local tax laws or consult your tax adviser to find out if owned and leased solar systems are treated differently.

## The Bottom Line…

Energy efficiency and conservation trumps all and should be your first priority in green living and lowering home energy costs. When you want to do more, use this guide and the attached list of Questions to Ask to help you make a good investment and choice for going solar at your home.



# Resources

## For more information on solar power and energy efficiency, visit these sources:

American Solar Energy Society – www.ases.org

Building America Solution Center (U.S. Department of Energy) – https://basc.pnnl.gov

Database of State Incentives for Renewables and Efficiency – www.dsireusa.org

Energy Star (U.S. Environmental Protection Agency) – www.energystar.gov

eXtension Learning Network's Home Energy Section – www.extension.org/home_energy

Florida Solar Energy Center -- www.fsec.ucf.edu

National Renewable Energy Laboratory – www.nrel.gov

North American Board of Certified Energy Practitioners – www.nabcep.org

PVWatts® Calculator –http://pvwatts.nrel.gov

Solar Energy Industries Association – www.seia.org

U.S. Department of Energy – www.energy.gov or www.solar.energy.gov

U.S. Department of Energy / Energy Savers – www.energysavers.gov

U.S. Energy Information Administration – www.eia.gov

# Bibliography


Arizona Attorney General's Office. Consumer Alert: Residential Solar Panel Systems. Issue brief: 2014.

Arlein, Jacob. "Energy Efficiency Versus Renewables: The Great Green Debate." CleanTechies, October 2009. Web. August 2014. (www.cleantechies.com).

"Average Retail Price of Electricity to Ultimate Customers by End-Use Sector (Table 5.6.A.)." EIA. U.S. Energy Information Administration, September 2014. Web. 15 September 2014. (www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a).

Chu, Yinghao. Review and Comparison of Different Solar Energy Technologies (2011): Global Energy Network Institute, Web. August 2014. (www.geni.org/globalenergy/research).

Cory, Karlynn. Solar Leasing for Residential Photovoltaic Systems (Fact Sheet – Revised 2009): National Renewable Energy Laboratory. Web. 2013. (www.nrel.gov/docs/fy09osti/43572.pdf).

Coughlin, J. Homeowners Guide to Financing a Grid-Connected Solar Electric System (Brochure), Solar Energy Technologies Program (2010): Web. 2013. (www.eere.energy.gov/solar/pdfs/48969.pdf).

Coughlin, Jason. Solar Photovoltaic Financing Residential Sector Deployment (2009): National Renewable Energy Laboratory. Web. 2013. (www.nrel.gov/docs/fy09osti/44853.pdf).

Critical Consumer Issues Forum. New Consumer-Focused Principles on Distributed Generation. (Issue brief: 2014).

Denholm, Paul. Break-Even Cost for Residential Photovoltaics in the United States: Key Drivers and Sensitivities (2009): NREL, U.S. Department of Energy. Web. 2013. (www.nrel.gov/docs/fy10osti/46909.pdf).

Desmarais, Lisa K. The Impact of Photovoltaic Systems on Market Value and Marketability: A Case Study of 30 Single-Family Homes in the North and Northwest Denver Metro Area (2013): Colorado Energy Office. Web. August 2014. (www.colorado.gov).

Ellingson, M. Compendium of Best Practices: Sharing Local and State Successes in Energy Efficiency and Renewable Energy from the United States (2010): ACORE, NEEP, Alliance to Save Energy. Web. 2013. (www.acore.org).

Grant, Casey C. Fire Fighter Safety and Emergency Response for Solar Power Systems (Revised 2013): National Fire Protection Association. Web. 2013. (www.nfpa.org).

Hois, Emily. "Selecting the Size of Your Solar PV System." Solar Reviews. 30 May 2013. Web. July-August 2014. (www.solarreviews.com/news/selecting-the-size-of-your-solar-pv-system).

Holladay, Martin. "Making Your Own Electricity: Onsite Photovoltaic Systems." Building Green. November 2009. Web. July 2014. (www.buildinggreen.com).

Homebuilder's Guide to Going Solar (2008): U.S. Department of Energy. Web. 2013. (www.eere.energy.gov/solar/pdfs/44792.pdf).

"Installing and Maintaining a Home Solar Electric System." (www.energy.gov). July 2012. Web. 2013.

Lawrence Berkeley National Laboratory. An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California (2011): Web. 2013. (http://eetd.lbl.gov/sites/all/files/publications/lbnl-4476e.pdf).

Lawrence Berkeley National Laboratory. "Exploring California PV Home Premiums." Electricity Market and Policy Group. 12 December 2013. Web. August 2014. (http://emp.lbl.gov/).

Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory. Photovoltaic System Pricing Trends: Historical, Recent, and Near-Term Projections (2013): Sun Shot, U.S. Department of Energy. Web. 2013. (http://emp.lbl.gov/sites/all/files/presentation.pdf).

"Local Solar Permitting." Solar Energy Industries Association. n.d. Web. August 2014. (www.seia.org).

"Model Inspection Checklist for Rooftop PV Systems." Interstate Renewable Energy Council. September 2013. Web. 2013. (www.irecusa.org).

Own Your Power! A Consumer Guide to Solar Electricity for the Home (Brochure – 2009): U.S. Department of Energy. Web. July 2014. (https://www.eere.energy.gov/solar/pdfs/43844.pdf).

"Photovoltaic Energy Systems for Homes." eXtension. April 2010. Web. 2014. (www.extension.org/pages/27300/photovoltaic-energy-systems-for-homes#.VJI2SSvF_Hd).

Power Purchase Agreement Checklist for State and Local Governments; Energy Analysis; Fact Sheet Series on Financing Renewable Energy Projects (2009): National Renewable Energy Laboratory. Web. 2013. (www.nrel.gov/docs/fy10osti/46668.pdf).

"Pricing and Financing a Solar Electricity System." Go Solar California. n.d. Web. August 2014. (www.gosolarcalifornia.ca.gov/solar_basics/pricing_financing.php).

"PV Value®." Sandia National Laboratories, 2012. Web. August 2014. (http://energy.sandia.gov/tag/pv-value-tool/).

Sanchez, Justine. "Potential PV Problems." Home Power. July 2011. Web. August-September 2014. (www.homepower.com).

"Solar Access Rights." Solar Energy Industries Association. n.d. Web. August 2014. (www.seia.org).

"Solar Electric Systems Positively Impact Home Values: Appraisal Institute." Solar Energy Industries Association, 31 October 2013. Web. August 2014. (www.appraisalinstitute.org).

Solar Powering Your Community: A Guide for Local Governments (Second Edition – 2011): U.S. Department of Energy, Solar America Communities. Web. 2013 (www.eere.energy.gov/solar/pdfs/47692.pdf).

Speer, Bethany. Residential Solar Photovoltaics: Financing Innovations and Options (2012): National Renewable Energy Laboratory. Web. 2013. (www.nrel.gov/docs/fy13osti/51644.pdf).

Stanfield, Sky. Model Inspection Checklist for Rooftop PV Systems (2013): Interstate Renewable Energy Council.

Stankus, Dona. Photovoltaics for the Southeast Home (2007): North Carolina Solar Center.

"Tax Credits." DSIRE Solar Portal. U.S. Department of Energy and the North Carolina Clean Energy Technology Center, n.d. Web. August 2014. (www.dsireusa.org/solar/solarpolicyguide/?id=13).

"The Basics of Solar Power for Producing Electricity." n.d. Web. August-September 2014. (www.sunforceproducts.com/Support%20Section/Solar%20Panel%20&%20Charge%20Controllers/The%20Basics%20of%20Solar%20Power%20for%20Producing%20Electricity.pdf).

The National Renewable Energy Laboratory. A Consumer's Guide: Get Your Power from the Sun (Brochure – 2003): U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Web. July-August 2014. (www.nrel.gov/docs/fy04osti/35297.pdf).

"The Photovoltaic Power System for the NCSU Solar House." North Carolina Clean Energy Technology Center. June 2000. Web. August 2014. (http://nccleantech.ncsu.edu/wp-content/uploads/PVSolarHouse.pdf).

"Third-Party Solar Financing." Solar Energy Industries Association, n.d. Web. August 2014. (www.seia.org).

Wiseman, P. Eric. "What Can I Do About My Neighbor's Trees Blocking My Solar Panels?" eXtension. 30 July 2013. Web. 11 December 2014. (www.extension.org).


Web search of solar consumer issues via YELP – www.yelp.com, Better Business Bureau – www.bbb.org, Ripoff Report – www.ripoffreport.com, Solar Reviews – www.solarreviews.com, and Run on Sun – www.runonsun.com.

# Appendix 1
# Solar Leasing Versus Ownership Calculators

It can be helpful to search online for *solar leasing versus ownership calculator* websites or apps. Look for and try a few that factor in and allow you to adjust assumptions and enter your information on loan terms to purchase versus leasing terms (including escalation rate) to provide a financial comparison. Be sure you compare similar type and size systems! The calculator should include the following input factors:

## Solar Power Output:

_____ Kilowatt PV system size (kilowatt power capacity)

_____ Kilowatt-hour annual estimated solar power production (calculator may derive from your location and system size)

_____ Percentage of annual output degradation (expected decrease in production per year – typically 0.5 percent)

## Electricity Rates:

$_____ Per kilowatt-hour electric utility retail rate (what you pay for electricity from the utility)

$_____ Per kilowatt-hour solar power purchase rate (rate utility credits or pays for surplus solar power)

Note: If net metering applies, solar power purchase rate is same as utility retail rate.

## Solar Power System Cost and Incentives:

$_____PV system installed cost (equipment and installation; may be derived from an average cost per watt)

$_____Federal tax credit (30 percent of system cost; applies to you if you buy or to leasing firm if you lease)

$_____State tax credit if you buy system (your state's percentage credit of system cost, subject to limits)

$_____State tax credit to leasing company (your state's percentage credit of system cost, subject to limits)

Note: Calculator may assume state tax credit applies equally to homeowner or leasing company. Separate calculations are needed if the state credit is different.)

$_____Rebates or other system cost reductions

## Loan Terms to Purchase the System

$_____ down payment

_____ % interest rate

_____ years (to pay off loan)

## Solar Leasing Terms

$_____ Down payment

_____ Years of lease term (length of lease agreement)

$_____ Initial monthly lease payment (for solar lease; or for power purchase agreement, it may be calculated from power purchase agreement rate per kilowatt-hour times monthly solar power production)

_____ Percentage of lease price escalation (annual increase of lease payment or power purchase agreement rate in lease agreement)

_____ Percentage or utility price inflation (predicted average annual increase in your utility company's electricity rate)

$_____ Purchase price at end of lease (optional)

## Other Economic Factors (optional financial calculations to determine investment value over time)

_____ Percentage of inflation rate (projected overall inflation rate for estimating long-term investment value)

_____ Percentage of discount rate (an economic measure of how much future dollars are worth today

# Appendix 2: Questions to Ask

## When Considering a Solar Power System for Your Home

1. What **energy efficient improvements** should be made to my home before investing in a solar energy system?
2. What renewable energy **alternatives** are available such as community solar or utility renewable energy programs?
3. How much electricity did my home use last year? How much is it likely to use in the next year (considering energy efficiency and household changes)? What is my **average kilowatt-hour use per month** (estimate for next year)?
4. What is the current rate I pay for electricity (cents per kilowatt-hour) from my utility company? What is my **average monthly electricity cost** (estimate for next year)?
5. What is the history of electricity price changes for my utility company? What **annual electricity inflation rate** trend is predicted by my utility company, state regulators, U.S. Department of Energy, local university or other reliable source?
6. Would my home be eligible for **net metering**? If so, are there system size limits to qualify? Could it change or expire for me in the future? How does the program treat energy I produce in excess of my use? If I'm not eligible, what is the rate (cents per kilowatt-hour) the utility will credit or pay for surplus power I generate? Is the rate higher at peak demand times (usually late afternoon)?
7. How much **solar power (kilowatt-hours per month)** would I like to generate? Should my home solar PV system be sized to avoid producing more power than I use (surplus)?
8. What **incentive tax credits, exclusions and rebates** are available that would reduce the cost of buying a home PV system? What are their limits and requirements? When does each expire?
9. What is my area's **solar resource** (average amount of sunshine per day)?
10. Does my community have any restrictions on placing solar panels? How much **unshaded roof area** facing south, southwest or southeast is available? How much faces west? What is the roof slope?
11. Should my **roofing** be replaced before installing a solar system? Will installing a PV system void my roofing warranty?
12. Would I prefer a thin film system that blends into my roofing or a crystalline **type of photovoltaic technology** for higher efficiency in less area? Can it withstand hail and my area's wind risk? What is the expected service life? What are common problems with each type of system? What is the reputation of the manufacturer?
13. Do I need **batteries** for an off-grid or hybrid backup power system? What are the associated costs, hazards, space requirements, maintenance and service life of the batteries and other components?
14. Does the system use one **central inverter or micro-inverters** on each module? What is the expected life and what will it cost to replace it?
15. What **monitoring systems** are available? What information do they provide? What do they require and what do they cost?
16. What **solar power capacity (kilowatts)** will fit on my available roof area (of the type I want)? How much electricity (kilowatt-hours) is it expected to generate **(energy output)** in the first year? How was that determined? What is the expected annual **degradation rate** (reduction in electricity produced)?
17. What is the **total installed cost** of the PV systems I'm considering? What is the typical cost per watt in my area? How much will the available tax credits, exclusions and rebate **solar incentives** reduce my cost?
18. Are there any low cost **solar loan programs** available to me? If not, do I qualify for a VA, FHA, USDA or HUD home improvement loan? Or could I qualify for a home equity or second mortgage loan? What are the available interest rates, down payment requirements, closing costs, other terms and tax advantages?
19. What is the **monthly payment to finance** the net purchase cost (after incentives), with and without a down payment? How does that compare to predicted monthly utility bill savings – both initially and as electric rates rise?
20. How many years will it take to recoup my net purchase cost **(payback period)**? What will my annual utility bill savings be after payback? What is the equipment's expected service life? What is my estimated **total return on investment**? (Use an online calculator.) Does the return on investment factor in general inflation?

21. How will a rooftop solar system affect my home's **market value**? Do I need to inform my **homeowners insurance** company? How will a solar system or batteries (off-grid) affect my premiums? Will my **property taxes** change?
22. Will the firm providing a quote on the system install it or hire installers? What are the **qualifications, certifications and licenses of the installers?** Are they bonded and have liability and workmen's compensation insurance? How long have they been installing PV systems on homes? How long have they been in business?
23. Have any **complaints** been filed against the vendor, manufacturer or installer with the state licensing board, consumer protection agency or the Better Business Bureau? Are their customers satisfied with their work quality and follow-up service?
24. What does the **warranty** cover (solar panels, inverter, mounting rack, labor, etc.) and how long? Who is responsible to make warranty repairs? What maintenance does the warranty require?
25. Does the **contract state in detail** the system components, timeline for completion, payment schedule, a lien waiver and who is responsible for any damages, injuries and permitting? What are my rights if my roof, home or contents are damaged, the installation is poor or someone is hurt by the installation? Who will be responsible for repairs?

# Additional Questions to Ask

## When Considering a Solar Lease

*When considering a solar lease, first ask the previous questions and then ask the following questions to help you compare the initial and long-term costs and benefits of buying versus leasing for your home and needs.*

26. Can I lease the **solar system type, capacity and installer** of my choice? If the leasing company makes the choice, why is its selected system recommended?
27. What is the **lease term** (years)? What happens at the end of the lease? Is it renewable? If I don't renew, who is responsible for removing the PV system and restoring my home?
28. Would I rather pay a set amount each month (rental-type **solar lease**) or pay only for the solar power my home uses (**power purchase agreement, or PPA**)? Which method would likely result in a lower total cost over time?
29. What **incentives** will the leasing company receive? With a solar lease, am I eligible for any incentives such as property tax exclusions or others that the leasing company cannot use?
30. What will be **my monthly payment or power purchase agreement rate** (cents per kilowatt-hour) for the first year? How does that compare to my electric utility rate or average monthly bill? How does it compare to a loan payment amount (Question 19)?
31. What is the lease **annual escalation rate** (percentage the payment or power purchase agreement rate will rise each year)? What will my payment or rate become each year of the lease (payment escalation schedule)? When will it exceed a loan payment amount?
32. How does the lease escalation rate compare to my **utility company's historical and predicted inflation rate** (Question 5)? What are the basis and assumptions of the leasing company's projected utility inflation rate and **total predicted savings** over the entire lease term?
33. Do I have a legal **right to rescind** (back out of) the lease after signing it? If so, how many days is the right in effect?
34. Could my lease be **sold to another company** or investor? Who could be the future owner of my system? Do they have the expertise and capacity to fulfill all obligations under the lease agreement?
35. What are **my responsibilities in maintaining** and operating the solar system? What are the leasing company's responsibilities? What do I do if the system isn't working or is damaged? Will my monthly lease payment be reduced or suspended when the system is not operating?
36. When my **roofing needs replacement**, who is responsible for removing and reinstalling the solar panels?
37. Under what circumstances can the lease be **terminated** (ended) by me or the leasing company? What can I do if the company doesn't maintain the system, goes out of business or uses illegal or deceptive practices?
38. What happens if I can't make payments and **default** on the lease? What if my payment is late?
39. If I want to **sell my home**, what does the lease require from the buyer and from me? What if the buyer doesn't want to assume the lease? How will a leased solar system affect my home's marketability and value in my location?
40. If I ever want to buy the leased system, how is the **fair market value** determined? Can I buy it at any time?

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