Solar Electricity for Massachusetts Residents

a Buyer's Guide

Commonwealth Solar

Solar Energy Business Association of New England

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Introduction

Solar electricity today

Across the United States and Massachusetts, solar energy is supplying clean electric power to businesses, public buildings, and residences.

Solar electricity has long proven itself as a reliable power source, used widely and successfully for satellites and remote telecommunications. Now, with advances in system efficiencies and reductions in cost over the last few decades, installing a solar electric system has become practical and attractive for homeowners as well.

Massachusetts residents are installing solar electric systems, also called photovoltaic (PV) systems, on their homes in increasing numbers each year. Substantial rebates from the state of Massachusetts along with federal incentives have helped make these systems more affordable for hundreds of homeowners.

Residents who have already installed PV systems cite many different reasons for going solar, including:

- their concern about air quality and climate change;
- their belief in sustainable practices and the role that renewable energy should play in our society;
- the increasing cost of electricity they purchase; and
- their desire for energy independence and to increase personal control over their daily lives.

Installing a photovoltaic system on *your* home that converts clean, free sunlight to electricity not only reduces air pollution, but contributes to the local economy by creating local jobs and supporting local businesses.

About this guide

The Commonwealth of Massachusetts has prepared this guide to assist Massachusetts residents who are considering using solar energy to generate electricity to power their homes.

Our goal is to provide the background you will need to make informed decisions. This guide can help you determine whether PV is right for you, technically and ecomomically. It discusses the installation process and identifies resources for finding an installer and securing rebates, along with other useful information.

This guide was prepared by the Solar Energy Business Association of New England (SEBANE), a trade association of solar energy equipment manufacturers and installers, for the Massachusetts Renewable Energy Trust (the Trust), which administers the state's Commonwealth Solar rebate program.

It is the mission of the Trust to increase the supply and demand for renewable energy while stimulating economic growth in the clean energy industry, with the primary goal of generating maximum environmental and economic benefits to Massachusetts ratepayers. In addition to supporting solar PV projects through Commonwealth Solar, the Trust's other initiatives support wind, hydropower, bioenergy, and other renewable energy projects.

SEBANE promotes the use of solar energy and the development of the solar energy industry in the region. Its member installers and system designers and integrators have adopted a set of Member Principles that stress: compliance with laws and regulatory requirements; accuracy in representation of the technology's environmental and economic benefits, costs, and operational requirements; provision of clear, written warranties; professional workmanship; and respect for and protection of customer privacy.

Massachusetts Homeowners Talk about Going Solar

"With our solar PV system and energy-saving improvements to our home, we're using approximately half of the energy we used to."

-Christi Kemprecos, Dennis Port

"For less than $11,000—a lot less than the cost of buying a new energy efficient car—I can now generate my own power for at least the next 20 years."

-Girish Rao, Andover

"I've always been concerned about the environment, but that concern seemed very abstract in terms of my personal choices and how I lived my life. That all changed as the cost of energy kept increasing and viable options became available—I could now make reasonable choices that could have a positive effect on the environment and my life."

-Phil Reavis, Somerville

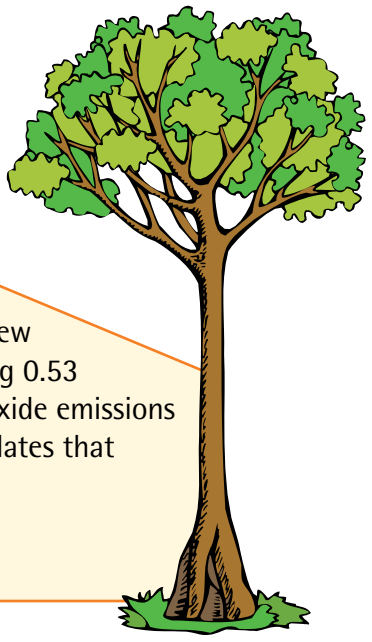
"It has been wonderful so far; I have saved quite a bit of money. This has been something I have wanted to do for a long time."

-Pearl Wishney, Florence

Environmental Benefits from PV Generation

Photovoltaic arrays generating electricity from sunlight cause no environmental damage to air, water, landscapes, or wildlife. This power production process produces zero emissions that contribute to pollution or climate change.

Compared to the mix of fossil fuel power sources typically used to produce power for New England consumers,[1] every 1,000 kWh generated by a photovoltaic system avoids sending 0.53 pounds of sulfur dioxide, 0.29 pounds of nitrogen oxides, and 999 pounds of carbon dioxide emissions into the atmosphere. In addition, photovoltaic systems reduce the production of particulates that contribute to respiratory problems.



[1] ISO New England, Inc., 2006 New England Marginal Emissions Rate Analysis, May 2008

3.45-kW roof-mounted PV array on the Thwing residence in Hawley, MA

PV System Design Considerations

There are a variety of PV system designs available. Here are answers to a few common questions about system design.

Why are most of the PV systems I see on roofs?

For most Massachusetts homeowners, rooftop installations are the easiest and most practical way to use PV to power their homes. Rooftops provide a ready location for PV arrays and are unlikely to have competing uses. Roofs are usually tilted in this climate to shed water and snow, helping to keep PV modules clear. They allow for a simple interconnection to a home's wiring circuits. Their elevation also decreases the likelihood of shade falling on the array and reducing electricity production.

Ground-mounted PV array

What about ground-mounted installations?

Massachusetts homeowners with large amounts of open land around their house may choose to install a ground-mounted PV system. The advantage of such a system is that you can orient it in the optimal south-facing direction and at the ideal tilt to maximize your electricity production, without the limitations of your roof's exposure or slant. It is also easy to remove snow and even seasonally adjust the tilt of the array. Disadvantages are a higher cost due to the expense of the ground-based super structure the panels hang on, the potential for existing and future vegetation to cast shadows on a system, and the potential for damage or vandalism.

Does a PV installation mean that I can't get utility power?

Some homeowners who install PV do so because they are not connected to the utility grid and have no other way to obtain electricity. Such "off-grid" system designs are unusual in this area. PV installations are fully compatible with the electric grid; any time the system is not meeting the complete electric needs of the household, electricity from the grid automatically makes up the difference. There are specific installation requirements for interconnecting with the grid that your installer will explain.

The Reavis family in front of their 2.86-kilowatt rooftop PV system

Case Study: PV in Somerville

For Philip Reavis Jr., the decision to have a PV system installed on the roof of his Somerville home was the culmination of a series of energy-saving changes he made to his home and life.

Starting by conserving energy at home and replacing old windows with new double-paned energy-efficient ones, Phil found that although he was using less energy, rates continued to climb higher. Phil also purchased a hybrid-electric car to replace his old one.

"I went from a vehicle that averaged 20 miles per gallon to one that now gets 48 miles per gallon. That became the catalyst for me to aggressively look for alternatives to make my home more like my car. I began searching the web for any home efficiency improvements, and I stumbled on an article about the installation of solar panels on a house in West Roxbury," says Phil. "The article talked about rebates available in Massachusetts and also mentioned the contractor who did the installation. I then looked up the contractor, got his phone number and called. The rest is history."

With a helpful and informative contractor, a substantial rebate from the Renewable Energy Trust, and a $2,000 federal tax deduction, Phil was able to have a 2.86-kilowatt PV system installed on his roof. Before applying the incentives, Phil's system cost approximately $25,000 (plus $5,000 to replace his aging roof).

The PV system, combined with other recent energy-conserving steps Phil has taken, has proven to be highly effective at cutting his electricity usage: his bills are about half of what they used to be.

"I love my solar panels!" says Phil. "My only regret is that my roof wasn't larger to accommodate a larger array."

The photovoltaic system

A photovoltaic system consists of various pieces of equipment wired together and connected to a home's power distribution network. Components typically include:

Solar Array: A solar array is made up of two or more modules of individual solar cells that are the basic building block and power producer of the system. Systems generally include several modules wired together to achieve the desired system capacity or power producing capability. A rule of thumb is that 100 square feet of unobstructed roof area is required for a 1,000 watt system or "array."

Each solar cell converts sunlight directly into electricity. The cells work whenever sunlight strikes the semiconductor material inside the cells, which frees electrons, then captures the electrons in an electric current. The more intense the sunlight striking the cell, the greater the amount of electricity produced.

Solar cells are aggregated together to form a PV panel or "module." The power produced by PV panels is direct current (DC). This is incompatible with the alternating current (AC) that is supplied by electric utilities in the United States and used by our household electrical devices. Therefore, the DC power must be converted into AC power.

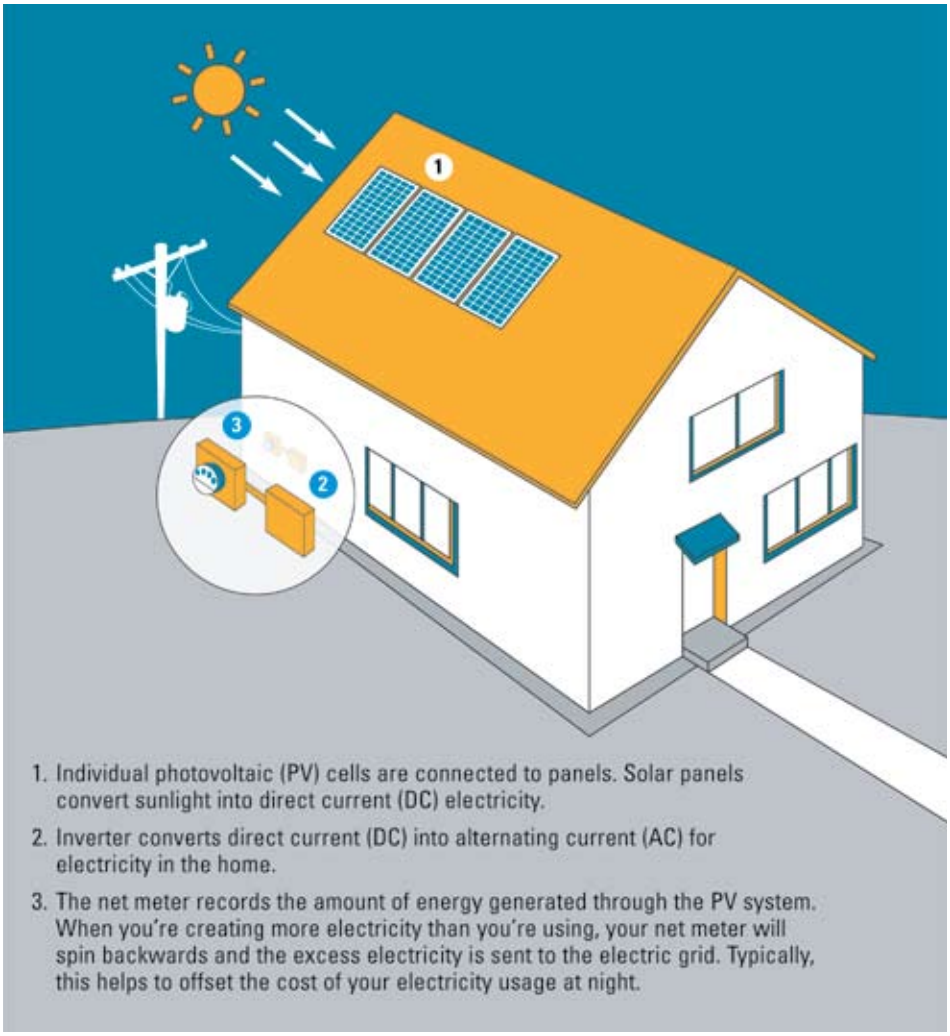
Inverter: One or more solar modules grouped together are wired to an inverter, which converts the power produced by solar cells from direct current to alternating current. Typically the inverter is located near where the electric service from the local utility enters the house (close to the electrical panel). In grid-connected systems, inverters are designed so that power production by the PV system is terminated when utility-supplied power is interrupted.

Shut-off: Some Massachusetts utilities require an external shut off for the PV system so that the power company can shut down the system if necessary when workers are fixing the power lines.

PV electricity production

Residential electric utility bills charge customers for kilowatt hours (kWh) of electricity consumed. 700 kWh per month is considered an average amount of electricity use in Massachusetts, though higher levels of consumption are not uncommon.

The electricity production from PV systems is a function of PV panel (or arrays of panels)



1. Individual photovoltaic (PV) cells are connected to panels. Solar panels convert sunlight into direct current (DC) electricity.
2. Inverter converts direct current (DC) into alternating current (AC) for electricity in the home.
3. The net meter records the amount of energy generated through the PV system. When you're creating more electricity than you're using, your net meter will spin backwards and the excess electricity is sent to the electric grid. Typically, this helps to offset the cost of your electricity usage at night.

orientation and DC to AC conversion losses. These factors are described in more detail below. Residential PV systems are generally sized between two and five kilowatts (kW) in size. One kW is equal to 1,000 watts.

In Massachusetts, one kilowatt of PV at the optimal orientation and tilt for maximum annual production will produce 1,000 to 1,500 kilowatt-hours of electricity per year.

Of course, PV systems only produce electricity in daylight. Cloud cover and shade reduce the amount of electricity production of a PV system. This is not a problem for grid-connected installations where any electricity requirement that exceed on-site production is automatically met by the serving utility, day or night.

Siting for maximum production

Solar arrays generate electricity at their rated output only in bright sunlight. Because the sun moves across the sky at varying heights from sunrise to sunset and from season to season, the amount of electricity generated by a module varies during the daylight hours and over the course of the year.

PV installations are typically "stationary" and do not follow the track of the sun. Furthermore, they are generally "fixed" installations that are not adjusted to account for changes in sun angle from season to season. Therefore, to maximize the production of electricity, the design of individual PV installations must consider (and optimize) the factors of module tilt, orientation, and shading.

Tilt

For maximum annual generation at our latitudes in Massachusetts, a solar array should be installed at about a 30 degree angle to the horizon. Most homes in our climate have roofs that are pitched at 33 degrees or more to shed snow and ice.

Roof direction

Residential PV systems that are roof-mounted should be oriented to face as close to south as possible to maximize annual power production, but you can still get 95 percent of optimal production even if your roof faces southeast or southwest. East and west facing systems on shallow-pitched roofs can be productive, but they should be within 20 degrees of due south if possible.

Installing a system on a northeast, north, or northwest roof would not generate much, if any, electricity, and would be a poor investment.

Roof condition

The life of a PV system is 20 years or more. It is firmly attached to the roof to meet local code requirements. Once a system is in place, it is time consuming and costly to take it off, replace the roof, and reinstall the system, though not impossible. Therefore, before a system is installed, evaluate the structural condition of your roof and shingles to ensure that they will not require repairs or replacement any time soon. Make any necessary repairs before a PV system is put in place. Some installers recommend replacement if the roof has a remaining lifetime of eight years or less.

Shading

As previously discussed, PV systems only produce electricity when sunlight is shining directly on the solar cells. Systems should be sited to maximize their direct exposure to sunlight and to avoid shading by a home's structural elements (such as window dormers or chimneys), nearby trees and vegetation (large and smaller trees that could later become obstacles), or other buildings. Even a small amount of shading on solar panels will interrupt the production of power, reducing the system's productivity.

One rule of thumb is if the distance of obstructions to the east and west is more than twice a solar array's height and if the distance of obstructions to the south is more than three times an array's height, there should be no more than a 10% loss due to shading.

Roof-mounted PV array

No shade from 9 AM to 3 PM every day year-round is ideal. Shade is acceptable during the 90 minutes after sunrise in the morning and before sunset in the afternoon.

Your installer should conduct a thorough shading analysis of your home, identifying the best location and configuration to avoid shadows.

PV system life

PV systems have no moving parts and are designed for long life. Systems installed in Massachusetts in the 1980s continue to produce power today. Solar panels are typically guaranteed by manufacturer warranties for 20 years. While the inverter's life is shorter than panel life, manufacturing improvements have extended the inverter life to 15 years or more for some equipment, with warranties of 10 years.

In the end, equipment life will be a function of the equipment selected, the environmental conditions under which it is maintained, and overall system design.

Regulatory considerations

Electric grid connection and net metering

While the use of PV for off-grid electricity generation is cost effective in remote locations where it is impractical or uneconomical to connect to the electric grid, this Guide focuses on grid-connected systems. Homes with renewable energy electricity generation systems are allowed to interconnect with the grid and purchase whatever additional power they need from their electric distribution company. Utilities may require a special inspection prior to ensure that the PV system complies with established technical, performance, and safety requirements.

Customers with residential-scale PV systems can sell any excess power they produce back to their utility and receive a credit for the power produced. This practice is called "net metering." The customer is billed for the "net" electricity purchased from the utility. This is the difference between the amount of electricity delivered from the power grid and the electricity generated by the PV system and put onto the power grid.

Utilities are prohibited from imposing special fees on these net metered customers, such as back up charges, as long as the system meets the established interconnection standards.

Local permitting

Installation of a PV system will require the same local approvals as any other building construction and electrical work. Building or electrical permits (and sometimes both depending on preferences of local building department) will need to be pulled, and inspections will be required to verify that the installation meets state and local code requirements. State law also establishes certain licensing requirements for system installers. These are discussed in more detail in the following sections.

Case Study: PV in Andover

In October 2006, Girish and Denise Rao and their young daughter Anisha attended the Northeast Sustainable Energy Association's Green Buildings Open House at Smolak Farms in North Andover. The Green Buildings Open House features solar homes, wind turbines, and other green infrastructure open to the public during one weekend each year. The Raos' interest was captured by a demonstration on PV technology conducted by member installers of the Solar Energy Business Association of New England (SEBANE).

A few weeks later, the Raos had the installers conduct a site assessment at their house in Andover to determine if a PV system would work for them. The installers calculated that, although the site wasn't quite perfect, a roof-mounted PV system would still produce plenty of power. Just over a month later, the Raos became the proud owners of Andover's first grid-connected solar electric array.

"I come from a city in India which has the highest electricity rate in the country. As a result, I grew up being very careful about electrical use. It was always my dream to own a house powered by the sun," says Girish. "After finding out about Renewable Energy Trust rebates and state and federal tax credits from my installer, I found I could make my dream a reality."

The 2.88-kilowatt PV array cost a total of $21,000, which was then reduced by a sizable rebate from the Trust, plus $2,000 in federal tax credits and an additional $1,000 in state tax credits, drastically lowering the net cost of the system.

Since having the PV array installed and taking additional energy-saving measures, the Raos have been able to cut their electricity use in half, averaging just 250 kilowatt-hours per month. They now produce more than 3 megawatt-hours of their own solar electricity per year, and are selling their renewable energy certificates (RECs) to the Mass Energy Consumers Alliance. Following the installation of the solar electric panels, the Raos also installed solar hot water panels, which cover almost 70% of their annual hot water costs.

The Rao family's 2.88-kilowatt PV array (left), as viewed from the backyard, with solar hot water panels also visible at right

Sizing Your PV System to Meet Your Needs and Budget

What size system should I buy?

Most homeowners with PV systems are connected to the utility power grid to meet a portion of their electricity needs. You'll need to select a system that is well-sized for your particular interests and circumstances.

Understanding your electricity usage is important for determining the appropriate capacity for your PV system. Your monthly utility bill includes a summary of how much power you have used each month for the past year. Your installer will want a copy of a recent bill to determine an appropriate system size. Residential-sized systems range from as small as 500 watts to 10 kilowatts (10,000 watts) though 2 to 5 kilowatts (2,000 to 5,000 watts) is typical.

PV array in Amherst, MA

The system designer should present size options to you based on your site's characteristics, power needs, and budget. Since PV arrays are incremental, additional panels can be added as your power needs increase or your budget allows.

Conti residence's 3.4-kW PV array in Haverhill, MA

What happens when I produce more power than I can use?

It is not uncommon for a home PV system to produce more electricity at certain times than is being used by the residence. Likewise, there are times when you want to use more electricity than you can produce. As discussed on page 7, net metering allows customers to sell excess energy produced by their PV systems back to the grid. Customers with PV systems only pay for the electricity use that is not covered by their PV system.

Will my system supply power to me if the grid goes down?

Grid-connected PV systems are designed to be inoperable for safety reasons when utility power is not available. In those instances, electricity will not be available unless the PV system has been designed with special batteries and has been storing extra power. Unfortunately, the cost of such batteries is too high to make them economical in most cases.

PV System Economics

Think about your PV system's economics as fundamentally different from purchasing power from your utility.

What does a PV system cost?

When you purchase electricity from your utility, you are paying the cost of having power available when you want it and use it. This cost can increase in the future as fuel costs rise or as power becomes scarce. Purchasing a PV system is like paying for many years of electricity use in advance. Because the fuel (sunlight) is free and there is little system maintenance required, you know exactly what the cost of power you produce will be.

The typical installed cost of an average sized home system is around $8.00 per watt of system capacity. A typical 2,500-watt (2.5-kilowatt) system would cost approximately $20,000 (without any financial incentives). This cost will vary somewhat based on system size, site characteristics, permit fees, and any optional equipment additions.

Is state funding available to homeowners for PV systems?

Massachusetts has created the Commonwealth Solar rebate program, administered by the Massachusetts Renewable Energy Trust, to encourage and support system installations. These rebates can reduce the cost of PV to homeowners by thousands of dollars. Information about Commonwealth Solar is in the **Resources** section of this guide.

Buyers typically cover the balance of system costs after the state rebate using conventional financing, home equity loans, credit financing, or cash payment. Leasing options may also be available

Customers of electric utilities that pay into the Renewable Energy Trust are eligible for a rebate for systems installed in Massachusetts.

How about federal tax credits?

Federal tax credits currently allow homeowners who install PV to claim a credit equal to 30% of the net installed cost of the system. Please consult a tax professional for information on available tax incentives.

What other financing options are available?

Although incentives such as state rebates and Federal tax credits can offset the cost of purchasing a solar PV system, many homeowners still need assistance to meet the remaining cost. Some mortgage lenders offer an energy efficiency mortgage that takes into account value added to the home by the PV installation.

In addition, many solar PV integrator companies and solar financing companies will offer third-party financing or solar leasing options. Solar leasing offers homeowners the benefit of no up-front capital outlay and a reduction in monthly electricity costs. In a solar lease, the homeowner pays a monthly charge for the solar PV system and the solar leasing agent will own and maintain the system. An option to buy the PV system outright is usually offered after the term of the agreement. Third-party ownership is similar to solar leasing; however, in a third-party agreement, the third-party owner sells the electricity directly to the homeowner, usually at a discount from their current rates.

What are Renewable Energy Certificates and how can they make PV systems more affordable?

For every 1,000 kilowatt-hours of power generated by a renewable energy system, including PV, a Renewable Energy Certificate (REC) is created. Because of the special value attributed to clean, renewable energy generation, a market has emerged for selling and trading these RECs. Sometimes, individuals and businesses that are unable to install renewable generation systems

PV array in Great Barrington, MA

themselves, but want to "green" some or all of the power they use, will purchase RECs from producers.

Please visit *www.masstech.org/renewableenergy* for more information.

Will my property taxes go up if I install as PV system?

Massachusetts law exempts PV systems from the determination of property tax by assessors, so your property taxes will not increase.

Will my home be worth more with a PV system on it?

A PV system can increase your home's market value if prospective buyers understand the financial benefits that the system creates. Market conditions and the interests of particular buyers will ultimately determine the sale price of your home.

Is my home as energy efficient as possible?

Remember that increasing energy efficiency is the most cost-effective way to reduce your electricity use and cost. The less energy you use in your house and life, the less your utility needs to generate or buy.

To improve efficiency, you can understand and manage your biggest electricity-consuming devices, maintain equipment so it operates optimally, purchase the most efficient products including those with Energy Star® labels, install timers and other controls, and use the most efficient lighting available. Visit *www.energystar.gov* for lists of energy-efficient appliances and lighting.

The Commonwealth Solar rebate program requires homeowners receiving PV rebates to complete minimum energy efficiency measures.

Where can I get help with energy efficiency improvements?

Massachusetts utilities offer free energy efficiency advice and services to customers. Call MassSave at 1-866-527-7283 or visit *www.masssave.com* for more information.

Homeowner's PV Checklist

- ☐ Do I understand how much electricity I use and need?
- ☐ Do I have a south-facing roof or a large, open, sunny yard that is suitable for a ground-mounted array?
- ☐ Do I know where it is shaded at different times during the day and at different times of year?
- ☐ Is my roof going to need to be replaced any time soon?
- ☐ Am I comfortable with the installation contractor's knowledge and experience?
- ☐ Do the installer's references check out?
- ☐ Is the installer adequately insured to protect me and also the installer's employees and subcontractors?
- ☐ Where rebate money is being applied for, does the contract with the installer indicate that it is only valid if a rebate is approved?
- ☐ Does the contract include performance specifications for the system being installed, including an estimate of the power that will be produced annually or under different conditions?
- ☐ Does the installation contract clearly lay out what is included and what is not included in the price?
- ☐ Do I want an automatic monitoring device installed to measure, track, and record power produced?
- ☐ Does the proposed payment schedule protect me by allowing payment to be withheld until the system: 1) passes local code inspections, 2) receives utility interconnection approval, and 3) is shown to be operating properly?
- ☐ Are all warranties clearly stated with information on how to exercise them?
- ☐ Has the installer left descriptive materials and equipment operating manuals as reference materials?

PV on the rooftops of Pathways CoHousing condos

Case Study: PV for Condos in Florence

Pathways CoHousing of Northampton, built in 2000, is a neighborhood of detached condominiums in which members live in an environmentally sustainable manner and share community duties.

In 2005, cohousing member Peggy MacLeod, who had long wished for her own PV system, came up with the idea of not only purchasing panels for her home, but seeing if some of her neighbors would also like to purchase panels.

With eight other households interested in going solar with her, Peggy and her neighbors were able to get discounted pricing on the systems because they were placing multiple orders for panels at once. The neighborhood was also able to get a PV system for the roof of their common house.

The systems, which range from 2.3 to 2.99 kilowatts, were installed in mid-2006. Homeowners were not only able to benefit from discounted pricing; each household and the system for the common house also received a Renewable Energy Trust rebate and federal and state tax incentives that helped make the systems even more affordable.

"I've had four months with zero dollars in electricity use costs, and many other months with maybe 40 to 100 kilowatt-hours of total usage," says Peggy. In addition to the PV panels, she attributes some of the electricity savings to her house-wide highly efficient compact fluorescent lightbulbs, Energy Star® appliances, and high-efficiency furnace and water heater.

Another homeowner, Pearl Wishney, says having her PV system "has been wonderful so far; I have saved quite a bit of money. This has been something I have wanted to do for a long time."

Gale Turner, who owns another of the condos, adds, "I want to be a part of our planet's solution and while getting a PV system is a small step, it makes me feel good."

Getting the Job Done

Contractor selection

Finding a contractor

Massachusetts homeowners are fortunate in that there are experienced local contractors who specialize in solar system design and installation, and who are knowledgeable about the relevant codes and regulations and government programs.

Interconnection with your home's electrical service will require the services of licensed electrician (and the pulling of an electrical permit). If you contract with a PV system installer that does not employ a licensed electrician, that firm will need to bring in a licensed electrician as a subcontractor on the job.

Both the Solar Energy Business Association of New England (*www.sebane.org*) and the Northeast Sustainable Energy Association (*www.nesea.org*) have lists of designers and installers on their websites.

Multiple bids

A homeowner may choose to get multiple bids or at least meet with more than one installer to find someone he or she is comfortable working with. Ask for a written description of what the installer will be doing, the proposed timeline, pricing, and any potential expenses not included in the price.

References and licenses

Always ask for references from previous customers. Call and, if possible, visit one or more of the installer's previous installations. The primary vendor should, by law, be a registered home improvement contractor and have a Licensed Construction Supervisor on staff and on site if the vendor is subcontracting to a licensed electrician. Ask if your vendor employs a licensed electrician. If the installer plans to use subcontractors, find out who they are and get their references as well.

Liability and workers' compensation insurance

Protect yourself by insisting upon a certificate of insurance for general liability insurance. Also, verify that workers' compensation insurance is carried to protect against liability for any on-site work related injuries. These are required to pull a building permit and to receive a Renewable Energy Trust rebate.

Written contract

The written contract with your installer should specify the exact equipment you are having installed with the respective warranties provided by manufacturers and the installer; the project's start and completion dates; the itemized budget with any exclusions or potential adders; subcontractors that are going to be used; and a progress payment schedule.

Construction

Securing state rebates

State rebates for residential-scale PV systems are available through the Commonwealth Solar rebate program.

Applications are usually submitted on the owner's behalf by the system installer. Links to program descriptions and application materials are provided in the **PV Resources and Links** section of this Guide.

In your installation contract, you can specify that going forward with your project would be contingent on the project being awarded a Commonwealth Solar rebate.

System design

Prior to installation, the contractor will prepare a design for the PV system. The design can range from a simple site plan and electrical diagram to a more detailed set of plans and specifications, depending on the nature of the PV project and site.

Where PV is being incorporated into new construction, it is advantageous to integrate the PV design process into the overall site planning and building design process to realize certain construction economies, ensure optimal orientation and tilt of the system, and to help preclude system shading.

Interconnection process

Interconnecting the PV system is required for a state rebate and to take advantage of net-metering laws. State regulations govern the procedures for the interconnection between a PV system and the serving electrical distribution company. This includes the application process, technical specifications for the interconnection, and inspection requirements.

The installer will be responsible for securing the approval to interconnect from the utility. In some cases, where the residence does not already have a bi-directional meter in place, the utility will install a new electric meter that will credit the customer for power sent back to the grid.

Permits and inspections

PV installations require local building and electrical permits and inspections by a local inspector. The licensed electrician on the job is responsible for ensuring that the installation meets state electrical code requirements. The installation contractor must secure all necessary approvals from local code officials prior to the system being put into service.

Please refer to the Commonwealth Solar Program Manual and Minimum Technical Requirements, available at *www.commonwealthsolar.org* for more information.

Installation

System installation will require participation of a licensed electrician, though a non-electrician PV installer can sub-contract portions of the work to a licensed electrician.

Installation typically involves delivery of materials to the site, site preparation, electrical work (wiring, inverter installation, etc.), and installation of the PV array. PV installations can occur over a short period of time relative to other construction projects, but, as noted above, the written contract should be clear about when a job will be completed after it has been started.

Commissioning

System testing and warranties

When the installation is complete, the homeowner should require the installer to test the equipment to confirm that it is operating properly. The owner also should ensure that the installer provides copies of equipment technical manuals and warranties. Many installers will provide a copy of commissioning test results to the owner and register the warranties. Finally, the installer should educate the owner about safety and operations and maintenance requirements.

Final inspections

A local wiring inspector signs a certificate of completion, which is copied to the utility. The building inspector may also require a final inspection. Commissioning is not complete until the system is satisfactorily inspected by the wiring inspector and the utility has confirmed that the system can interconnect to the power grid.

System monitoring

A homeowner may want to consider installing electronic monitoring equipment that enables the owner to track the PV system's production and to compare actual power production against pre-installation estimates to confirm that the system is operating properly. Monitoring equipment can also be used to automate recording and tracking of kilowatt hours generated, which can be useful in monetizing the value of Renewable Energy Certificates created.

Note that these systems can add significantly to the total system cost and may require periodic re-subscription fees.

Case Study: PV on the Cape

When Christi and Paul Kemprecos of the Cape Cod town of Dennis Port returned after being away for 10 days in January 2005, they were shocked to discover that—in spite of having lowered their heat and turning off appliances—their electric (and gas) bills had doubled over the previous year.

"That was the 'straw that broke the camel's back,'" says Christi, and, as Paul puts it, "We were sick and tired of paying the electric company!"

The couple decided to take steps to reduce their personal dependence on fossil fuels by exploring renewable energy. After reading in their local newspaper about rebates available from the Massachusetts Renewable Energy Trust, as Christi says, "the rest was relatively easy."

In February 2006, the Kemprecos family had a 2.0-kilowatt PV system installed for $18,000, plus about $4,500 in related expenses such as upgrades to their roof and electrical system.

These costs were then reduced with a large rebate from the Trust, combined with a $2,500 Massachusetts state tax rebate and a $1,500 federal tax rebate.

During the system's first year in operation, the Kemprecoses cut their electricity bills by about half. Their savings have been even greater since they had their electric utility conduct a second energy audit and took some additional energy saving steps—some months, their electricity bill is just one-third of what it used to be.

Paul and Christi Kemprecos are very happy with their PV system, and hope that more people will take advantage of the benefits of solar energy in Massachusetts.

The Kemprecos house with rooftop PV

PV Resources and Links

Rebates for solar PV systems

The Commonwealth Solar rebate program offered by the Massachusetts Renewable Energy Trust provides rebates for residential PV systems up to 5 kilowatts: *www.commonwealthsolar.org*

The Renewable Energy Trust website also is an excellent source of information on solar PV and other renewable energy technologies such as wind energy, hydropower, and bioenergy: *www.masstech.org/renewableenergy*

State and federal tax incentives

Additional information is available at the Database of State Incentives for Renewable Energy (DSIRE) website, which is a comprehensive source of information on state, local, utility, and selected federal incentives that promote renewable energy: *www.dsireusa.org*

This site is maintained by the Interstate Renewable Energy Council (IREC), funded by the U.S. Department of Energy, and managed by the North Carolina Solar Center.

Note: System purchasers are advised to consult with tax attorneys, accountants, or other experts to confirm if a particular energy project is eligible for each tax incentive and how these tax incentives may impact one another.

Finding a PV system designer, installer, and supplier

The Solar Energy Business Association of New England (SEBANE) website hosts its searchable Solar Yellow Pages. Listings include designers, installers, manufacturers, consultants, and other professionals and suppliers in the solar energy field: *www.sebane.org*

The Northeast Sustainable Energy Association website hosts a searchable Sustainable Green Pages that lists a broad range of solar professionals, services, and suppliers. *www.nesea.org*

The North American Board of Certified Energy Practitioners (NABCEP) awards PV installers a professional credential based on their experience and knowledge. Installers who have received this voluntary certification are listed by state: *www.nabcep.org*

Background information on PV technology

In addition to information available on the Renewable Energy Trust's website, the National Renewable Energy Laboratory (NREL) of the U.S. Department of Energy hosts an excellent website with information on solar technology: *www.nrel.gov/solar*

Energy efficiency

The Renewable Energy Trust strongly encourages residential customers interested in solar PV to explore implementation of energy efficiency measures, in addition to a PV system, as a way to provide greater energy savings at the project site. For more information on local energy efficiency audits and programs available to residential Commonwealth Solar applicants, please visit MassSAVE: *www.masssave.com*



Left to right: Joyce residence's 6.3-kW PV array, Tewksbury; Hochman residence's 3.28-kW PV array, Provincetown; Piasecki residence's 2.4-kW PV array, Stockbridge

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Solar Energy Business Association of New England

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