solar PERMITTING & INSTALLATION handbook FOR OWNERS

Installing Solar Electric Systems on Residential Multi-Unit Rental Properties

Prepared by Peregrine Energy Group, Inc., Zapotec Energy Inc., and the City of Cambridge

CAMBRIDGE, MA

Installing Solar Electric Systems on
Residential Multi-Unit Rental Properties in
Cambridge, Massachusetts: A Guide for Owners

INTRODUCTION

This Guide has been developed by the City of Cambridge to assist owners of residential multi-unit rental properties who are considering installation of a solar electric system (also called photovoltaic or "PV" system). The objective of the Guide is to help owners determine whether solar PV is right for their building and, if it is, how to get a system installed.

This how-to guide is divided into four main sections:

- **Section 1: *Is Your Building Right for Solar?*** focuses on evaluating whether installing a solar PV system is feasible on your building and the variables you should consider **(p. 3)**
- **Section 2: *Considering Project Economics and Ownership***, addresses financial and related issues that to be considered as you decide whether or not to proceed with installing the solar PV system **(p. 7)**
- **Section 3: *Project Design and Construction***, describes how to get a system installed, including how to select a solar installation contractor **(p. 11)**
- **Section 4: *Operating and Maintaining the System***, provides additional information on how to get the most out of your PV system **(p. 19)**

The development of this Guide reflects the City's ongoing commitment to encourage and support residents and businesses to adopt energy efficient and renewable energy technologies. In 2012, the City unveiled a web-based Cambridge Solar Tool (http://cambridgema.gov/solar) that maps the solar potential of rooftops throughout the City. The Tool shows that many roofs in Cambridge get enough sunlight to make installation of a rooftop solar electric system feasible. This Guide is intended to complement the Solar Tool and assist interested parties in installing solar systems on their buildings.

As you use this Guide, here are some additional thoughts to keep in mind:

- There are already many buildings in Cambridge with PV systems. As of December 2012, there were at least 500 homes, apartments, condominiums, businesses, and institutional buildings connected to photovoltaic systems in the City.
- To encourage and support the use of renewable energy technologies, both the State and the federal government have created tax credits programs and other incentives that improve the economics of solar projects. Having the ability to make use of these incentives will make a project more financially attractive.
- Like other building improvement projects, solar projects involve research, choices and decisions, approvals, contracts, and attention to detail.
- We provide a general framework here for installing a solar system on a residential multi-unit rental property, but there are many different types of such properties in Cambridge. Some are small 2 or 3 unit buildings that may be owner occupied and are similar in form to a large single-family residence. Others are more like commercial properties, such as high rises, connected row houses, or detached

low-rise buildings, each with multiple apartments. Still others are owned by non-profit organizations and rented to income-qualified tenants.

- Finally, the best time to incorporate a solar project is during the original design and construction of the building(s) on the property. Doing so ensures that the solar project is integrated with the roof structure, electric utility, and architectural aesthetics, thereby allowing maximum solar production over the lifetime of the system and fewer complications during installation.

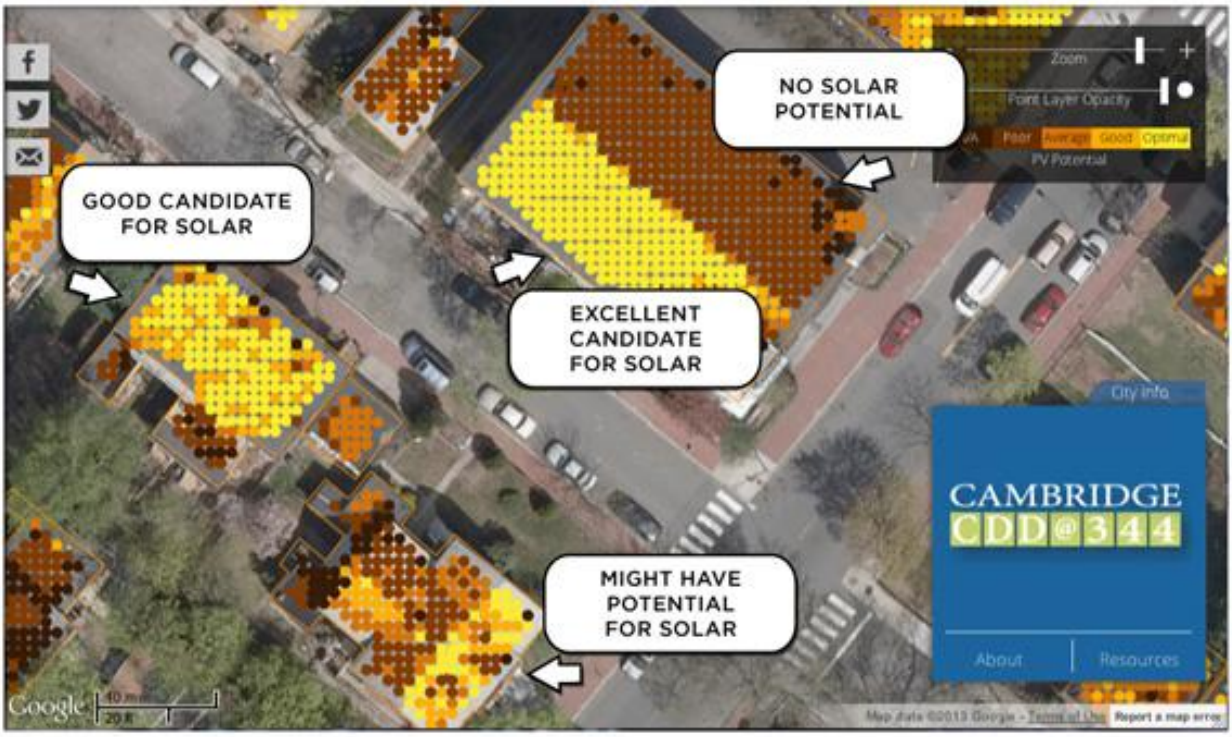
SECTION 1: IS YOUR BUILDING RIGHT FOR SOLAR?

This first series of steps is critical to determine if a building is a good candidate for a photovoltaic system.

Step 1: Confirm that your building gets enough sunlight

Installing a solar PV system on the roof of a property requires, first and foremost, that the roof receives enough direct sunlight. Without proper sunlight, a solar system will produce an insufficient amount of electricity to outweigh the expense of the system. To confirm that your building gets enough sunlight, consult the Cambridge Solar Tool on the web at: http://cambridgema.gov/solar.

1. Enter your building address.
2. Look at the map colors on your roof to determine potential. See the example below.



Your building has ***good solar potential*** if the roof:

- Is colored mostly light orange (good) or yellow (excellent) and has no major obstructions

OR

- Has large areas of yellow and orange, even if other areas are light brown/dark orange (poor) or dark brown (no potential)

Your building has ***little or no solar potential*** if the roof:

- Is mostly light brown/dark orange (poor) or dark brown (no potential) in color, i.e. does not face south or has obstructions

- **Go to the next step if you find that your roof has "good" to "excellent" solar potential.**
- **If your roof has little or no solar potential, installing a solar PV system is not recommended. The small amount of electricity a system may generate would not justify the cost of installing a system.**

If you are still unsure about the solar potential, ask a solar contractor to evaluate your building.

There are other ways to support the generation of electricity from renewable sources and to reduce your use of conventionally generated electricity.

- Investigate NSTAR Green—renewable power available for purchase from NSTAR. You can find more information at: www.nstar.com/residential/customer_information/nstar_green/nstar_green.asp
- Take steps to increase your building's energy efficiency through the Mass Save program offered by NSTAR (www.MassSave.com).
- Consider installing a solar hot water system, which is feasible sometimes where solar PV is not.
- Make a donation to a renewable energy project through New Generation Energy or some other similar organization.

Step 2: Confirm that your roof is ready for solar

After you have determined that the roof has enough sunlight, you will need to determine the age of the roof. Ideally, the remaining life of the roof will coincide with the lifetime of the PV system; otherwise, having a PV system on the roof will create additional expense during its lifetime when roof replacement is necessary. If the roof must be replaced 10 or 12 years after a PV system is installed, doing so will require removing all the panels, replacing the roof, and then reinstalling the panels. As the following Case Study illustrates, this can be quite expensive.

Case Study

In 2004, a PV system costing approximately $100,000 was installed on a flat roof of a commercial building in Cambridge. The roof was expected to last until 2020, but by 2008, for a variety of reasons, including extensive interior renovation work, the building owner decided to install a new roof with additional insulation.

The self-ballasted PV system had only one attachment to the building, at the point where the electrical conduit from the array entered the building. In order to replace the roof, however, the PV system had to be completely removed, stored, and then redeployed with some new electrical cabling. The total cost of the PV redeployment, not including the cost of the new roof, was 15 percent of the initial cost of the system, or $15,000. This was on the low side of the average cost for removal and redeployment, since the panels could be stored in an indoor space at roof level and did not need to be craned to the ground, and/or stored at another site. On the high side of average, the removal and redeployment could have cost as much as 30 to 40 percent of the initial cost, or $30,000 to $40,000.

This situation can be avoided by a careful assessment of the roof's remaining life and, if appropriate, by repairing or replacing the roofing material before the PV system is installed. Since the typical lifetime of a solar PV system is 25 years or more, PV systems should only be placed on roofs that are expected to last 15 to 25 years. When this is not the case, careful planning of cost implications is advised.

If you expect that the roof will need to be replaced within the lifetime of the solar PV system, the cost of removing and reinstalling panels should be factored into the economic analysis of the PV system. If you are unwilling or not ready to replace an old roof to accommodate a near-term PV project, installing the PV system should probably be put off until there is a plan for replacing the roof.

If you are unsure about the remaining lifetime of the roof and when replacement or major repairs are likely,

- ✓ Check the building's maintenance records to see if they include this information.
- ✓ Bring in a qualified roofer to provide a condition report on the roof

When you know the condition of the roof, use the following chart to decide next steps.

Roof Condition	**Recommendation**
Remaining lifetime is less than 5 years	- Replace roof now and install solar **or** - Wait until end of roof life to install solar.
Remaining lifetime is 5-15 years	- Replace roof now and then install solar **or** - Wait until end roof life to install solar **or** - Repair roof to extend its life (you want at least 15 years of remaining life) and then install solar **or** - Install solar now on the existing roof (factoring in future costs to remove and reinstall solar panels when you re-roof) and replace the roof later.
Remaining lifetime is greater than 15 years	You are good to go. Proceed to next step.

➔ **An additional note about roof warranties:**

This Guide urges prospective purchasers of PV systems to consider the age and condition of the roof as part of planning the project and, if possible, to install the system on a new or nearly new roof to avoid the cost of removing the system to replace a failing roof. This raises the question of how installation of a PV system could affect the warranty on a roof.

A roof warranty is a legal contract between a roofing-materials manufacturer or contractor and a building owner. It defines the limits of liability the manufacturer or contractor assume, should problems arise. This contract also defines specific requirements the roof's owner must fulfill to keep the warranty in effect.

It is recommended that the owner review the language in the existing roof warranty to understand any limitations that could result from installing a PV system. While a roof-mounted PV system should not increase the rate of wear of a roof (and might actually decrease it because it offers some protection from weather), roof penetrations required to fasten the PV system to the building structure could cause water leaks. Where roof penetrations are proposed to mount a PV system, you should have specific discussions with the contractor about how they will prevent future leaks and what warranties they offer against leaks. Ballasted systems (i.e. systems that are held down with weights on the roof) may pose less risk of roof damage, but this should be discussed with the contractor as well.

The bottom line is to understand what new or additional exposure you are assuming and to take steps to mitigate your risk.

Step 3: Engage a contractor to support your research

Once you know your building has good solar potential, you should enlist a solar contractor to provide expert technical advice and support. Although the project is still speculative and focused on project feasibility at this stage, a contractor will be willing to advise you for no charge if the contractor believes there is serious interest.

The purpose of engaging a solar contractor here is to get expert advice on whether solar is technically feasible. The contractor will address technical issues such as shading, cost, and permitting. Note that this step does not involve soliciting or selecting the contractor that will ultimately design and install your system. This solicitation and selection process happens after you have decided to proceed and is discussed separately in the section ***Project Design and Construction*** **(p. 14)**.

Although a solar contractor is providing free advice to you at this stage, you will be developing a relationship, and your experience will likely determine if you want this contractor to ultimately design and install your solar project. Consider the following when you look for this contractor:

- ✓ Previous experience in commercial building or multi-unit building installations (or residential experience if your building is more like a single-family home)
- ✓ Previous installation experience in Cambridge
- ✓ Knowledge of local codes and ordinances and enforcement practices

The Massachusetts Clean Energy Center has prepared an excellent, concise handbook on Residential Solar that describes system fundamentals and provides tips on how to select a contractor. While this

book targets single-family projects, much of the information is relevant to multi-unit rental properties. Go to www.masscec.com/index.cfm/page/Residential-Solar-Guidebook/cdid/13301/pid/11163.

Both the Solar Energy Business Association of New England (www.sebane.org) and the Northeast Sustainable Energy Association (www.nesea.org) have designer and contractor lists on their websites. You may also contact the Cambridge Energy Alliance, which maintains a list of contractors that have worked on multifamily projects in Cambridge.

Step 4: Address technical issues with the help of a solar contractor

The contractor you have chosen will determine if your building has any "show-stopper" technical issues. These issues include:

- Is your building located in a special NSTAR network distribution area?
- How much roof space is there for solar, eliminating areas that are shaded or have other uses?
- Will the roof structure support the weight of the solar panels?
- Will the Cambridge Historical Commission object to a solar project at that location?

See the ***Additional Information*** **(p. 20)** section of this Guide for more details about these issues.

If the contractor feels that the project is still viable after considering these questions, proceed.

SECTION 2: CONSIDERING PROJECT ECONOMICS AND OWNERSHIP

The first question most people have about solar often concerns project economics: What will the proposed PV system cost? How much electricity will it generate and what is the potential value of this electricity? Are there any other financial offsets that will improve the project economics? What ownership options are available for the PV system?

With the assistance of the installer, you should explore and evaluate potential project economics and ownership options. How the project is owned will affect project economics, and vice versa.

Ask the installer to prepare a rough estimate of the PV system economics. This estimate should include:

- ✓ The cost of any roof repairs and structural upgrades (if required and if known).
- ✓ A description of the proposed system with installed costs, including: mounting hardware, the PV modules, the inverter, monitoring equipment, and any other construction details associated with this particular installation.
- ✓ The value of power generated, including anticipated annual savings and cash flows.
- ✓ Estimated payback period (how long will it take to pay back the total installed cost).

To better understand project economics, review the following brief discussion of solar project ownership and financing. You may also consult your installer for more details.

For any PV system, it is important to understand the concept of "net metering." Every solar PV system on a building is interconnected to the NSTAR power grid through an electric meter. Net metering permits the sale of any excess electricity generated back to the grid at nearly retail value whenever the

PV system is producing more power than the owner is using. Go to www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/agencies-and-divisions/dpu/net-metering-faqs.html for more information.

Purchasing vs. leasing a solar system

For residential and commercial properties, there are two ways to acquire a solar PV system: purchasing and leasing.

- ***Purchasing*** means you own the complete solar PV system and have complete responsibility for its operation and maintenance; all power produced belongs to you to use or to sell.

  In many ways, purchasing a solar system is no different than any other equipment purchase or building improvement project: you are in charge of installing, operating, and maintaining all parts of the system. What makes a solar PV system different from other equipment that your return on investment depends on how much electricity your system generates. Your investment goals can only be realized if the system continues to produce the maximum amount of power possible. When the system is not generating power, the system is not creating a return on your investment.

- ***Leasing*** means that someone else owns the PV system and is responsible for installing, operating and maintaining it. You purchase the power produced at a negotiated rate and pay for the system through a long-term power purchase agreement.

  The owner takes full responsibility for sizing, designing, purchasing, permitting, and installing the PV system, as well as for the interconnection through your meter with NSTAR. You host the PV system on your roof. The owner and the owner's insurance protects your building and tenants against adverse impacts of the system, such as roof leaks or structural problems.

  You pay the owner for the power that the PV system produces over the term of your power purchase agreement, usually at a rate that is below the price of power you purchase from NSTAR. You save the difference between the NSTAR price for power and the price you are paying under your power purchase agreement. For example, you might pay NSTAR 13 cents per kWh of electricity used, and only pay the PV system Owner 9 cents per kWh of solar energy produced.

  The owner takes all risk associated with whether or not the system produces power. You only pay for what the system produces: if the system produces nothing, you pay nothing. You also don't have to worry about maintaining the system.

Such lease arrangements are available to help buyers avoid the effort of installing and maintaining the solar project, as well as avoid issues associated with long term financing. Leasing companies find capital to finance the project and make use of tax incentives for solar installations.

Ask your solar company whether they can offer a lease arrangement for your particular case, and then decide which option is advantageous for you.

Economics of purchasing

A critical component in PV system economics for the purchaser / owner is making use of State and Federal tax credits that are specifically intended to make PV systems more economical.

The following two case studies illustrate the economics of purchasing a PV system. The key difference between the two examples is the ability to use tax credits. In the first case study, an individual owner purchasing a system has sufficient tax obligation to use those credits in the second case study, owner cannot take advantage of solar tax credits allowed for solar installations, due to a lack of sufficient tax obligations to claim the tax credits. .

The following table describes typical cost and potential benefits for a solar project and is used in both case studies.

Typical Cost and Potential Benefits for a Solar Project Note that the table also includes a potential revenue stream from Solar Renewable Energy Credits (SRECs). SRECs are "minted" when a PV system generates electricity. They are used as the record of solar electricity produced. Because there are Massachusetts goals and requirements for solar electricity production, these SRECs have market value. In order to receive credit for SRECs that are produced by a PV system, each PV system owner must sign up for an account with the Massachusetts Department of Energy Resources. For small residential systems, this is generally done through an Aggregator. Aggregators are businesses that have been established to gather and sell SRECs produced by smaller solar electric generators in exchange for a percentage of the proceeds. For more information about SRECs and Aggregators go to www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out/about-the-rps-solar-carve-out-program.html

System Size	5 kW
Total System Cost*	- $25,000
Estimated Energy Production	6500 kWh/ year
Savings on Electric Bill @ 14¢/kWh	+ $910/ year
Revenue from SRECs** @ 20¢/kWh	+ $1300/ year
Federal Tax Credit (30% of total system cost)	+ $7500
State Tax Credit (15% of total system cost or not to exceed $1000)	+ $1000

*Does not include costs for roof replacement or structural improvements that may be necessary
**SREC = Solar Renewable Energy Credit

Case Study

Suppose you purchase a 5-kW solar PV system installed on the roof of your building. You own the solar PV system and you pay taxes enough taxes to take advantage of State and Federal tax credits.

When you purchase the 5-kW system, the simple payback period is roughly 8 years. The simple payback period represents the time over which the system pays for itself. This value can be calculated from the numbers given in the table. If you add up the total amount saved and revenue generated in 8 years, you would get roughly $25,000.

Total $ saved and revenue generated after 8 years are calculated as follows (from the chart above):

$910/ year x 8 years + $ 1300/year x 8 years + $7500 + $1000 = $ 26,180

Case Study

Suppose you purchase the same 5-kW solar PV system that is installed on the roof. But in this case, you are not able to make use of available tax credits.

In this example, the simple payback period becomes longer, extending to 12 years without tax credits.

Total $ saved and revenue generated after 12 years (from the chart above):

$910/ year x 12 years + $ 1300 year x 12 years = $ 26,520

In this case, the inverter also needs replacement every 10 years. If inverter replacement costs are factored in, the payback period extends another 3 years. SREC pricing may also vary widely from year to year, creating more uncertainty in the revenue generated beyond 10 years.

Economics of leasing

In the case of a solar lease, responsibility for all expenses associated with the purchase and installation of the solar PV project stay with the leaser (the PV System Owner), who also gets to make use of all available tax credits and the sale of SRECs.

The lessee (you) enters into a Power Purchase Agreement (PPA) to purchase from the leaser all electricity generated by the PV system at a negotiated rate. This rate should be lower than the price paid to NSTAR to purchase electricity. The lessee has no risk when the system fails to produce power. Power production is documented through a data acquisition system installed with the PV system, therefore lessee buys the power produced and pays the negotiated rate. The lease could include a maximum number of kilowatt-hours that the lessee is obligated to purchase at the price negotiated and perhaps even a provision that kilowatt-hours in excess of that amount can be purchased at a lower rate.

PV power that is consumed on-site by you as it is produced is paid for at the advantageous PPA rate. Excess power that cannot be used is being sent back to the utility to be net metered and credited to your electricity bill.

This combination of low risk and no capital outlay has made leases and PPAs a very attractive option for property owners.

If you decide to purchase the PV system yourself, use this guide and the sections that follow to select a contractor and manage the installation process.

If you decide to lease a system and enter into a Power Purchase Agreement, the lessor will serve as the project developer and take responsibility for all installation details.

Whether you purchase or lease a PV system, you should consult with more than one installation company to request proposals, competitive pricing, and references.

You can use the information provided in the following sections to better understand what is being proposed and ensure that you are protected against damages caused during installation. Further, you should understand what will happen to the system when your contract ends or in the event that the system fails or is abandoned by the leaser.

For more consumer information on Power Purchase Agreements go to the following links:

http://www.residentialsolar101.org/power_purchase_agreements/

http://www.epa.gov/greenpower/buygp/solarpower.htm

http://www.seia.org/research-resources/solar-power-purchase-agreements

SECTION 3: PROJECT DESIGN AND CONSTRUCTION

If you decide to purchase a PV system, you must solicit bids and select a contractor to design and install the system. Note that regardless of who the owner is, the design, permitting, and interconnection requirements for installing a PV system will be the same. You should expect that the process of getting a PV system installed and operational could require four to ten months if you follow the steps outlined in this guide.

How long will it take to get a PV system installed and in operation at your building? You should expect this process could require four to ten months if you follow the steps outlined in this guide.

Case Study

The following timeline for a recent condominium project in Cambridge illustrates the timeline for a sample solar project. While a property owner will avoid the need for approvals from a condominium association as in this example, all other steps in the process will have similar timeframes. Small multi-unit buildings generally require much less time than large ones.

Two small PV arrays, rated at 6 kW each, were installed on the flat roof of a 15-unit condominium building in Cambridge. The building is 100 years old and underwent extensive renovation when it was converted to condominiums 10 years ago. The systems began to generate electricity in August 2012. This was the project timeline:

- **October 2011.** Several members of a condominium in Cambridge decided that they were ready to move forward with a PV installation.
- **November 2011.** The proponents contacted a Cambridge firm with significant local experience and arranged a site visit. This firm was subsequently hired to design the PV systems and to coordinate the structural engineer's evaluation.
- **Mid-December 2011.** A condominium meeting was held where the plans were presented, followed by a one-hour Q&A session. The proposal was received favorably, and a resolution authorizing the construction was drafted.
- **January 2012.** All 15 members of the association, consistent with the condominium documents, authorized the project.
- **April 2012.** A final design for two 6-kW systems was submitted to the City of Cambridge for a building permit and materials were ordered.
- **Mid-June 2012.** The installation on the roof began
- **Mid-July 2012.** Construction completed after four weeks, with some delay due to rainy weather.
- **August 2012.** All permits and utility interconnections were completed by the end of the month, approximately 10 months after the initial site visit.

Step 1: Select a solar PV installation contractor

Installing solar is much like any other construction project. The first step is to qualify several solar contractors and secure quotes from them. Consult www.energysage.com or the MassCEC Residential PV guide: www.masscec.com/index.cfm/page/Residential-Solar-Guidebook/cdid/13301/pid/11163

The installation contractor will be responsible for both design and construction of the project. Quotes from contractors should include separate prices for the Design Phase and Construction Phase, so that if the buyer decides to opt out of the project after the Design phase and not proceed to construction, he or she only will be obligated to pay design costs.

One of the prospective contractors you are considering could be the one you worked with earlier during the feasibility phase of the project. Though this contractor is the most familiar with your building and

could be your favorite to install the project, we recommend getting at least two other quotes for comparison.

When asking for quotes, you should provide prospective bidders with all information gathered to date. However, you should also require that bidders confirm that this information is correct and they should take responsibility for its accuracy. Providing this level of specification to prospective bidders will help get “apples-to-apples” pricing to compare.

Prospective contractors also should visit the site before preparing quotes in order to verify building details. This site visit should be scheduled as part of the solicitation process. Generally, once the site visit is held, the bidders should be able to provide quotes within two weeks.

In choosing a contractor, you will want to evaluate cost, qualifications, and work style. The quote with the lowest price might not be the best option for your building. Try to find a contractor with experience installing solar in Cambridge and/or surrounding areas. Work style is also important because successful solar projects require the buyer to work closely with the contractor throughout construction. The buyer should select a contractor that understands the building’s needs and requirements (work hours, noise, parking, staging areas, building access, etc.) and appears willing to cooperate with your needs.

Overview of Contractor Selection Procedure:

1) Select three qualified contractors and request quotes.

2) Schedule site visit for contractors.

3) Receive quotes (2 weeks after site visit).

4) Evaluate and select contractor.

The following outline addresses the type of information the buyer should provide and request in securing quotes and selecting a Contractor and should be reflected in your Request for Proposals.

General Information (to be provided to prospective bidders)

- Project address and brief description of association
- Interconnecting utility (in this case NSTAR)
- Existing conditions (e.g. description of building, energy use, roof, potential PV roof area)
- Any known project constraints such as location in historic district, line of sight requirements, structural issues with the roof (contractor to confirm)

Bid Logistics (to be provided to prospective bidders)

- Contractors required to confirm existing conditions
- Proposal due date
- Submission requirements
- Mandatory pre-bid site visit

Qualifications (requested from bidders)

- Proof of licensing
- Prior experience developing PV projects in comparable buildings
- Other successful projects in the City of Cambridge
- References regarding past performance
- Any subcontractors to be used, identifying who they are and providing their qualifications
- Proof of Liability and Workers' Compensation insurance coverage?

Equipment and Project Specifications Proposed (requested from bidders)

- System size (kW)
- Estimated Energy Production
- Equipment to be installed with cut sheets (including but not limited to panels, inverter(s), monitoring equipment such as a web-enabled Data Acquisition System)
- General design of layout of equipment

Scope of Work (requested from bidders)

- Contractor responsibilities
- Schedule proposed, including progress meetings with the Association and/or owner

Project Pricing (requested from bidders)

- Price for structural analysis
- Price for full design
- Price for project construction
- Timeline for payments

In summary, when choosing a contractor, consider the following questions:

- ✓ Is the contractor fully licensed and insured?
- ✓ Has the contractor had prior experience developing PV projects in comparable buildings?
- ✓ Has the contractor had successful projects in the City of Cambridge or surrounding communities that demonstrate familiarity with local inspection and approval requirements?
- ✓ What do the references say about the contractor's past performance?
- ✓ Will the contractor be doing the work themselves? If no, who are the subcontractors that will be used and what are their qualifications?
- ✓ Will all parties that are employed on the project carry Liability and Workers' Compensation insurance coverage?

Step 2: Contract execution

Generally, the contractor will bring a contract to you for execution. Review the contractor's proposal and negotiate any additional details that are critical to you. The buyer must ensure that the contract confirms all representations made by the contractor during the proposal process and any subsequent negotiations. It should also reflect any requirements by the buyer for how and when work is performed.

You should expect that it will take around two weeks from when you select a contractor to when you sign a contract, but this can take longer if contract details require negotiating. Expect to execute a single contract with the contractor that will cover both the Design and Construction phases of the project. The contract should specify what is covered in the Design Phase and in the Construction Phase, including deliverables, separate prices for each phase, and payment schedule. It should also allow the buyer to opt out of Construction at the end of Design and pay only the design price (not the full project cost).

The description of both the Design and Construction Phases covered in the contract should clearly address the following:

- ***Responsibilities—***Responsibilities of the contractor.

- ***Subcontractors—***Any subcontractors that will be brought on to the job.

- ***Insurance—***Insurance carried by all parties (including certificates of insurance from the contractor and any subcontractors naming the owner as an additional insured).

- ***Schedule and Milestones—***Start and completion dates for Design and Construction, with specific milestones identified, including, as applicable:
  - Roof structural analysis and introduction of the structural engineer being used.
  - Completion and delivery of the structural analysis report.
  - Component selection and configuration.
  - Completion of final design documents and drawings.
  - Owner authorization to proceed to construction.
  - Introduce electrical subcontractor or electrical foreman.
  - Deliver materials and lift to roof.
  - Mount racking on the roof.
  - Install the solar panels and inverter.
  - Complete wiring.
  - Complete project commissioning.
  - Set-up data monitoring.
  - Complete inspections and closeout.
  - Operation and maintenance training.

- ***Commissioning and Interconnection—***Project commissioning and interconnection approval requirements and procedures, as well as the contractor's obligation to commission the project and get it interconnected.

- ***Budget—***Itemized budget, with confirmation that this includes all anticipated project costs, including structural engineering analysis, permits, and interconnection-related fees.

- ***Payment schedule—***Progress payments including amounts to be held until the system is fully operational, inspected by the City, and interconnected with the NSTAR grid.

- ***Warranty—***Terms for the project as a whole and individual project components.

For your protection, consider having your attorney review the final contract prior to your signing.

Do not allow construction to begin until you receive the certificates of insurance for the contractor and subcontractors.

Step 3: System design

After selecting the contractor and signing a contract, the Design Phase of the project begins. The contractor will prepare a final system design for your review and approval. The design process includes equipment selection and layout of the system on the roof.

Roof structural analysis

The first task in the design phase is structural analysis of the roof. The structural analysis will determine what structural improvements, if any, will be required and what these improvements will cost. Cambridge Inspectional Services building inspectors require a report on the roof's structural characteristics before he/she will issue a building permit. This is to ensure that the roof can support the solar structure proposed.

A Massachusetts-registered structural engineer must prepare this analysis and report. The contractor will choose a structural engineer to complete this work. You should confirm ahead of time if this expense for a structural analysis is included in the contract.

The full structural engineering analysis will determine:

- The reserve capacity of the roof and the exact costs of structural upgrades, if necessary.
- How the solar mounting system will attach to the building structure.

The structural engineer will first confirm the reserve capacity of the roof. To do this, the engineer will inspect the underlying roof structure.

- If there is no reserve capacity, the solar project cannot move forward unless specified structural improvements are made. The structural engineer would advise on next steps here.
- If there is limited reserve capacity, the contractor may need to modify the mounting solution or increase the structural capacity of the roof.

If structural upgrades are required, the structural engineer and contractor will determine the exact costs and provide these costs to the property owner. Any necessary structural improvements will need to be factored into the construction budget and timeline and could adversely affect the attractiveness of the project.

The contractor and structural engineer will also discuss the most appropriate mounting solution for this PV system and plan for how the PV system will be attached to the building structure. All this information is included in the final design documents provided to you by the Contractor.

Component selection and configuration

The contractor will propose the components for the system (i.e., modules, inverters, and monitoring devices) and identify where they will be located. Some components will be on the roof while others, such as inverters and metering equipment, may be in the building mechanical room near the electric service panel. You should talk to the installation contractor about issues and options associated with location of this equipment. Often, there are concerns about the equipment location and appearance. For example, should components or conduits be painted in order to conform to historic ordinances or to meet your aesthetic concerns?

By the end of this effort, the contractor should have a drawing set for construction.

Step 4: Approve final design and authorize start of construction

You should review and formally approve the design documents prepared by the contractor. After approving the design, you can authorize start of construction.

Step 5: City building permits and interconnection application to NSTAR

The contractor is responsible for submitting all paperwork necessary to start construction. This includes: 1) obtaining building permits from the City and 2) submitting an application to NSTAR for interconnection approval. The costs for the building permits and interconnection application should be already included in the construction contract.

Your contractor will coordinate with you to complete the necessary paperwork. For the NSTAR interconnection application, the contractor will want information about the NSTAR electric account the PV system will connect to. Whether the PV system is interconnected through the common meter or a meter for an individual unit, you will need to sign the interconnection application as the owner.

Step 6: Construction

You should schedule regular meetings with your contractor where the installation contractor provides updates on construction progress. A construction schedule should have been part of the project contract. The contractor is responsible for keeping this schedule current, and you should formally approve any changes to the schedule.

Step 7: Commissioning the system

Once the construction is complete, you should require that the Contractor commissions the equipment to confirm that all components are operating properly.

Step 8: Inspections and interconnection to the power grid

The contractor's work is not yet complete until the City inspects the system and confirms that all aspects of the installation conform to the building code. The project will require a final wiring inspection, followed by a final building inspection. The contractor will coordinate these inspections.

Once these inspections are successfully completed, the contractor notifies NSTAR, and NSTAR must agree that the PV system can interconnect to the power grid. The contractor will coordinate the final interconnection approval.

When all these approvals are secured, the system can officially be turned on and begin producing power.

Step 9: Project closeout

The PV system is now producing electricity. Before making a final payment, you should confirm that the contractor has completed all contractual responsibilities.

Ask the contractor for guidance regarding SRECs and securing an Aggregator, in addition to using the resources identified in this guide.

As part of the project closeout process, the contractor should provide copies of technical manuals, equipment specification sheets, as-built design drawings, and warranties. The contractor should also provide you with training about safety and system operations and maintenance requirements.

Step 10: Homeowner insurance

Notify your property insurance company that the PV system has been installed on the roof. This ensures that in the case of damages to the system or related to the system, an insurance claim can be filed. The insurance company will confirm whether the system is protected with existing coverage or whether a separate rider is needed to cover the system.

SECTION 4: OPERATING AND MAINTAINING THE SYSTEM

One of the great features of a PV system is that, once installed, it requires little maintenance. It is recommended that the contractor inspect the system once a year to ensure that all hardware and wiring is intact and that the system is functioning properly. There will likely be a charge for this service. Beyond this, the solar panels, inverter, and mounting system require no routine maintenance.

Take care that no shading of panels occurs over time due to vegetation growth or future placement of equipment or obstructions on the roof that block the panels from direct sunlight. Any such shading, even when it is temporary (i.e. only for a short time during the day) will reduce the electricity production of the system.

The following additional information is provided to supplement Operations and Maintenance Manuals provided by the contractor as part of the closeout process.

A system disconnect is required on the outside of the building

Per requirements of NSTAR, a means of disconnecting the PV system from the utility grid is required on the outside of the building. This disconnect is intended to be used only by NSTAR technicians and is usually locked by your solar contractor to prevent unauthorized opening of the protective enclosure.

The PV system will not supply your building with electricity during power outages

Unless you have invested in battery storage, which is typically quite expensive, your grid-connected PV system will not produce electricity for on-site use when utility power is not available to your building (i.e. during a power outage). This auto-disconnect feature is to protect the safety of utility line crews that may be working to repair the electrical distribution system. The inverter's grid monitoring and fault detection capabilities prevent islanding (the flow of power from the PV system onto the utility grid and to your building) when the grid's power is down. Thus, when the neighborhood experiences a utility power outage, the solar PV system will immediately stop producing power.

You can monitor the status of the PV system on the internet

Solar PV systems will typically come with a Data Acquisition System that allows for web-based data monitoring. This should have been specified in your contract. The Data Acquisition System can be configured to send email alerts when the system is not working properly or requires maintenance. Talk to your contractor about email alert options. Also, you can use the internet to view the daily energy

production as well as factors that affect production such as how much sunlight there is (solar irradiance) and the ambient air temperature.

NSTAR will credit your utility account for any excess power the PV system produces

It is important to try to maximize the production of the PV system at all times. PV systems that are interconnected to the grid are allowed to "net meter" the production of excess power. That means that any power that the system produces that is not used on-site can flow back across the electric meter to the NSTAR grid for a credit against power purchased.

Most grid-connected PV systems do not include battery storage. Power must be used as it is produced. During daylight hours, the PV system may be producing more electricity than the building can use at that time. This net surplus of electricity flows into the NSTAR electric grid, turning the electrical meter backwards and, thereby effectively reducing the power purchased from NSTAR. Every kilowatt-hour produced saves the customer on electricity supplied by and purchased from NSTAR.

Solar Renewable Energy Credits (SRECs)

Solar Renewable Energy Credits are an additional source of revenue from a PV system you own. When a system is leased, these SRECs are usually the property of the party that owns the system. SRECs are "minted" when a PV system generates electricity. They are used as the record of solar electricity produced.

Because there are Massachusetts goals and requirements for solar electricity production, these SRECs have market value. In order to receive credit for SRECs that are produced by a PV system, each PV system owner must sign up for an account with the Massachusetts Department of Energy Resources. For small residential systems, this is generally done through an Aggregator. Aggregators are businesses that gather and sell SRECs produced by smaller solar electric generators in exchange for a percentage of the proceeds.

Once a month, the Data Acquisition System will report the production data from your PV system to the Production Tracking System (PTS) of Massachusetts. The PTS records solar energy production from your system every month for SREC purposes.

For more information about SRECs and Aggregators go to www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out/about-the-rps-solar-carve-out-program.html

Additional Information

Approximately how large should my system be?

The size of the system on your building, measured in kilowatts (kW), will determine how much power it will produce, measured in kilowatts per hour (kilowatt hours or kWh). The Cambridge Solar Tool can only get you so far in estimating system size, so you will need an experienced solar contractor to estimate the appropriate size for the system. Among the issues that are relevant are shading, rooftop equipment, and open roof area. The ultimate size of a system can affect how the system is owned, the economics of the project, and its physical design.

Some contractors will make these determinations with the assistance of satellite imagery, and some will want to visit the property. Still others will ask you to take a few photographs and email them to the contractor's office.

Will my roof need costly structural repairs or upgrades in order to carry the equipment?

A PV system adds weight load to the roof and this additional load needs to be within the roof's structural carrying capacity. The contractor should examine the building's roof structure and review existing building plans to determine whether your roof structure requires major alterations to accommodate a PV system. With recent updates to the Massachusetts Building Code, guidelines for solar PV systems have become more stringent. Such improvements could make the project financially infeasible.

Generally, a full structural analysis by a Massachusetts-registered structural engineer is necessary to identify these structural upgrades and determine their costs. The contractor should be able to estimate the cost for such an analysis by a licensed engineer.

Will the Cambridge Historic Commission allow my project?

Cambridge has two historic districts and four neighborhood conservation districts that limit the type of renovations that can be made to visible areas of buildings. The Cambridge Historic Commission is responsible for determining if and how rooftop solar systems can be installed on a building within one of these districts.

Ask the solar contractor to determine if your building is within one of these districts and review the ordinances that apply to alterations to your property. Note that many PV systems already exist within these districts throughout Cambridge. However, it does take time and careful consideration to meet the specific requirements of these City ordinances, so plan accordingly.

Is my building located in a special NSTAR network?

The solar contractor will need to consult NSTAR Electric about whether your building is located in a special area network. If you are within such a network, you may have limitations to installing solar. Contact the Cambridge Energy Alliance for more information.

How will my PV system connect to the power grid?

A PV system is generally connected to the NSTAR power grid through the building's electric meter. This allows the building to receive power even when the sun is not shining and the system is not producing power (e.g. evening hours). It also permits any excess electricity to spin your electric meter backwards when the PV system is producing more electricity than the building needs. As your meter spins backwards crediting your electric account, electricity is being sold back to the grid at nearly retail value.

Residential Multi-Unit Rental Property PV Checklist

IS YOUR BUILDING RIGHT FOR SOLAR?

Step 1: Confirm that your building gets enough sunlight

- If your roof has good to excellent solar potential, proceed to Step 2.
- If your roof has little or no solar potential, the project is not worth pursuing at this time.
- If you are still unsure about the solar potential, ask a solar contractor to evaluate your building.

Step 2: Confirm that your roof is ready for solar

- ***If remaining roof lifetime is less than 5 years***,

  Replace roof now and install solar **or** wait until end of roof life to install solar.

- ***If remaining roof lifetime is 5 to 15 years,***

  Replace roof now and then install solar
  or wait until end roof life to install solar
  or repair roof to extend its life (you want at least 15 years of remaining life) and then install solar
  or Install solar now on the existing roof (factoring in future costs to remove and reinstall solar panels when you re-roof) and replace the roof later.

- ***If remaining lifetime is greater than 15 years,***

  Proceed to Step 3.

Step 3: Engage a contractor to support your research

Step 4: Address technical issues with the help of a contractor

- ✓ Is your building located in a special NSTAR network area?
- ✓ How much roof space is there for solar, eliminating areas that are shaded or have other uses?
- ✓ Will the roof structure support the weight of the solar panels?
- ✓ Will the Cambridge Historical Commission object to a solar project at that location?

CONSIDERING PROJECT ECONOMICS AND OWNERSHIP

Step 1: Estimate the project's economics

Step 2: Decide whether purchasing or leasing is more attractive for you

PROJECT DESIGN AND CONSTRUCTION

Step 1: Select an installation contractor

- Qualify several solar contractors and secure quotes from them.
- Quotes from contractors should include pricing for both design and construction.

- Bidders should confirm building information and take responsibility for its accuracy.
- Schedule a site visit for prospective bidders
- Select a contractor based on cost, qualifications, and work style.

Step 2: Contract execution

- Review the contractor's contract and negotiate additional details as necessary.
- Ensure that the contract confirms all representations made during the proposal process and subsequent negotiations.
- Ensure contract specifies what is covered in the Design phase and in the Construction phase, including deliverables, separate price for design and for construction, and payment schedule.
- The contract should allow the buyer to opt out of construction at the end of the design phase.
- Consider having your attorney review the final contract prior to your signing
- Do not allow construction to begin until you receive the certificates of insurance for the contractor and subcontractors

Step 3: System design

- Confirm in advance if the contract includes the cost for a structural analysis by a Massachusetts-registered structural engineer. Such an analysis is necessary to determine whether the building and roof structure can support the weight of the proposed solar PV system.
- If structural upgrades are required, be sure that the structural engineer and contractor provide exact costs and the scope of work to factor into the construction budget and timeline
- Contractor produces design and construction drawings

Step 4: Approve final design and authorize start of construction

- Review and formally approve the design documents prepared by the contractor.
- After approving the design, authorize start of construction.

Step 5: City building permits and interconnection application to NSTAR

- Confirm that costs for the building permits and interconnection application were in the contract.
- Confirm that contractor completes all paperwork necessary to start construction, including obtaining building permits from the City and submitting interconnection application to NSTAR.

Step 6: Construction

- Hold regular meetings where the installation contractor provides updates on progress.
- Formally approve any changes to the construction schedule included in the contract.

Step 7: Commissioning the system

- Be sure that the Contractor tests all equipment to confirm it is operating properly.

Step 8: City inspections and interconnection to the power grid

- Ensure that the contractor arranges for City wiring and building inspections
- Ensure that the contractor coordinates the final interconnection approval by NSTAR.

Step 9: Project closeout

- Before making final payment,
  - ✓ Confirm the contractor has met all contractual responsibilities.
  - ✓ Be sure you have received technical manuals, equipment specification sheets, as-built design drawings, warranties
  - ✓ Insist on receiving training about safety and system operations and maintenance.

Step 10: Homeowner insurance

- Notify your property insurance company that the PV system has been installed on the roof.
- Add supplemental coverage if advised to do so by your insurance agent

OPERATING AND MAINTAINING THE SYSTEM

- Have your system inspected once a year to ensure that all hardware and wiring is intact and the system is functioning properly.
- Take care that no shading of panels occurs over time due to vegetation growth or future placement of equipment or obstructions on the roof that block the panels from direct sunlight
- Use the web-based Data Acquisition System (DAS) to view energy production
- Have DAS configured to send you email alerts when the system is not working properly or requires maintenance.