June 2010

GUIDEBOOK FOR

SOLAR PHOTOVOLTAIC PROJECTS IN PHILADELPHIA

SOLAR AMERICA CITIES

City of Philadelphia
LIFE • LIBERTY • AND YOU™

GREENWORKS PHILADELPHIA

NOTICE

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Celentano Energy Services

Governor Rendell's Solar Working Group

Kyle Sanphy, cover photography

Mayor's Office of Transportation and Utilities

Philadelphia Electric Company (PECO)

Pennsylvania Department of Environmental Protection

Philadelphia's Department of Licenses and Inspections

Philadelphia's Mayor's Office of Sustainability

Pennsylvania Solar Energy Industries Association (PASEIA)

Solar America Cities Program

Solar City Partnership Advisory Board

Philadelphia Zoning Code Commission

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1.0

INTRODUCTION

All life on earth is supported by the sun, which produces an amazing amount of energy. Only a very small percentage of this energy strikes the earth but that is still enough to provide all our needs. The City of Philadelphia enjoys over 200 days of sunshine annually. Solar energy use and energy conservation are essential components to sustainable building. The City of Philadelphia understands this connection and is committed to urban sustainability with the Philadelphia Solar City Partnership Program. The regulatory environment, financial incentives both statewide and federally, and the support from city planners will all enable more property owners to enjoy clean and reliable energy from the sun.

This guidebook is designed for developers of residential and commercial solar photovoltaic (PV) energy systems and addresses procedures for planning, siting, permitting, interconnecting, metering, and implementing solar installations.

The City's Commitment*: Philadelphia Mayor Michael Nutter with Solar City Partnership Director, Kristin Sullivan.*

Source: Katherine Gajewski, October 2008

1.1 The Solar America Cities Program

Through the U.S. Department of Energy's Solar America Cities partnership, Philadelphia is one of 25 major U.S. cities working to accelerate the adoption of solar energy technologies for a cleaner, more secure energy future. The Solar America Cities program has engaged over 180 organizations, including municipal, county, and state agencies, solar companies, universities, utilities, and non-profit organizations. The City of Philadelphia with its partners has made a commitment to power our city with clean, safe, reliable energy—solar energy.

The City of Philadelphia hopes to transform into a regional and national leader in clean energy development with a commitment to its community, job growth and renewable energy. Philadelphia's long-term goal for solar energy is to fully utilize the potential of solar energy to safely, reliably, and cost-effectively displace the use of energy generated by fossil fuels.

Through the Solar America Cities Program and Philadelphia Greenworks, the City of Philadelphia is committed to ensuring safe, reliable, and well designed PV systems

Philadelphia plans to transform the local market for solar energy with the objective of making solar technologies cost-competitive in the near- to mid-term. The Solar City Partnership will develop a plan to help Philadelphia generate 2.3 Megawatts (MW) of solar electricity by 2011 and 57.8 MW by 2021, the city's proportional share of the Commonwealth of Pennsylvania's solar installation goal.

This guidebook is intended to be a tool to overcome commercial and residential solar market barriers within the city and its partnering communities.

1.2 Is Solar Right For You?

While the cost of energy produced by PV systems continues to drop, kilowatt-hour for kilowatt-hour, and depending on where you live, PV energy still usually costs more than energy from your local utility. Yet there are many reasons to consider a PV system other than cost. Whether it is a commitment to more sustainable living, an appreciation of a stable cost for electricity that can be readily inserted in a building owner's budget, or a way to offset your peak demand, PV is a clear choice for a growing number of users.

You should definitely consider solar if:

- ☐ The proposed building is already as energy-efficient as it can be
- ☐ The roof is new or in good condition (if considering a rooftop system)
- ☐ The proposed space (roof or land) gets sufficient sunlight during the sunny hours of the day (an average of 6 hours is recommended)

There are many advantages to PV systems that consumers are becoming aware of:

Table 1: PV System Advantages

Site Access	A well-designed PV system will operate unattended and requires minimum periodic maintenance.
Modularity	A PV system can be designed for easy expansion. If your power demand could increase in future years, the ease and cost of increasing the PV power supply should be considered.
Fuel Supply	Transmitting conventional electricity to the site and distributing it can be much more expensive than the fuel itself. Solar energy is delivered free of charge!
Environment	PV systems create no pollution and generate no waste products when operating.
Peak Generation	Solar PV can offset the need for electricity during expensive peak demand hours.
Maintenance	Any energy system requires maintenance, but experience shows that PV systems require less maintenance than other alternatives.
Durability	Most of today's PV modules are based on a proven technology that has experienced little degradation in more than 15 years of operation.
COST	For many applications, the advantages of PV systems offset their relatively high initial cost.

2.88 kW; Residential Home, (Overbrook) Philadelphia

Source: Celentano Energy Services

System designers know that every decision made during the design of a PV system affects the cost. If the system is designed based on unrealistic requirements, the initial cost is unnecessarily high. If less durable parts are specified, maintenance and replacement costs will increase. The overall system life-cycle cost (LCC) estimates can easily double if inappropriate choices are made during system design. Don't let unrealistic specifications or poor assumptions create unreasonable cost estimates. System designers should be experienced and knowledgeable of proper design techniques, code requirements and implementation. There are many resources available for individuals interested in becoming qualified and educated designers. The City of Philadelphia encourages all contractors and developers to educate themselves so they are able to provide the best service to our citizens. This guidebook provides many informational resources and lists some avenues for getting proper training and certification to become a PV installer. Look for information at the end of each section that is relevant to the section's topic. The Pennsylvania (PA) Solar Sunshine Program created by the Commonwealth of Pennsylvania not only provides financial incentives but also valuable guidance for installers and developers.

1.3 What's In This Guidebook?

This guidebook is intended to serve as a reference for potential project developers (land/property owners, financiers) and contractors who are considering pursuing solar photovoltaic projects within the City of Philadelphia. It will answer many of the questions that these individuals will encounter along the way including:

- Who can install a PV system within the City of Philadelphia?
- What should I consider before installing a PV system?
- What permits will be required and when?
- Who do I need to contact before installing a system?
- What incentives are available for PV systems?

The guidebook is organized into the following sections:

- Solar Basics
- System Design Considerations (technical and design aspects of PV system implementation)
- Process Overview (codes, permitting and utility requirements)
- Incentives and Benefits

Figure 1-1: Eleven PV systems with total capacity of 26.6 kW at Rag Flats Condominiums, Philadelphia
Source: Celentano Energy Services

Additionally, a list of Frequently Asked Questions are included as an Appendix that installers and developers may find helpful and are encouraged to review.

The City of Philadelphia is committed to ensuring that safe, reliable and well-designed PV systems are installed on as many homes and business as possible as a means of creating a sustainable city for all Philadelphians to enjoy.

Finally, although this guidebook only addresses solar photovoltaic systems, the City of Philadelphia understands that solar water systems are a feasible technology for Philadelphia and are more cost effective than solar PV. Due to funding limitations, the City was not able to include solar water heating systems in this guidebook. Should funding become available at a later date, this guidebook will be amended to include similar information for solar water heating systems.

2.0

SOLAR PV BASICS

This section of the guidebook provides an overview of solar photovoltaic (PV) technologies and systems. The reader is encouraged to review the Additional Resources listed at the end of this section to delve deeper into many of the topics presented here as well as the glossary (Appendix A) and Frequently Asked Questions (Appendix B).

This section will answer the following questions:

- How does a PV System Work?
- What types of PV technologies are most commonly installed for residential and commercial buildings?
- What to look for during a site assessment?
- What safety issues should installers be concerned with?

2.1 How Does a PV System Work?

PV systems convert sunlight directly into electricity. PV systems allow homeowners and businesses to generate some or all of their daily electrical energy demand either on their own roof or somewhere on their property.

The majority of solar PV systems are "grid-tied." This means they remain directly connected to the power grid at all times and do not require battery storage. Grid-tied PV systems will generate electrical power to supply part of a building's energy usage during the day and provide the greatest benefit during crucial times when the price and demand for electricity is the highest. Figure 2.1 depicts an illustration of a solar PV system interconnected to the grid.

A solar PV system can provide power to a home or business, reducing the amount of power required from the utility; when the solar PV system power generation exceeds the power needs, then the surplus power automatically back feeds into the grid. This arrangement is called "net metering" for which PECO has a special tariff and will install a special utility meter that will essentially record the "net" power coming in from the utility and the surplus power flowing out from the solar PV system.

A solar PV system will not operate during a power outage unless it has battery backup. It ceases to operate during outages as a safety feature for utility personnel who might be working on electric lines trying to restore power (a PV system would energize electric lines that the utility assumes is not energized, and create a shock hazard to personnel).

Efficiency First!

Before considering a solar photovoltaic system energy-efficient measures should be incorporated into the building first

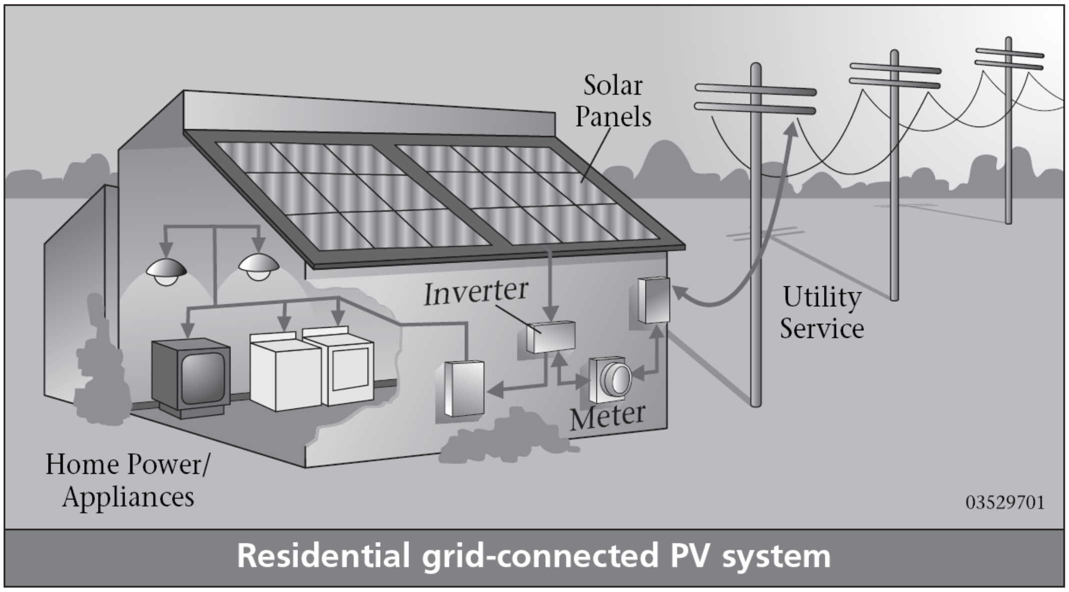

Figure 2-1: Residential Grid-Connected PV System

Source: A Consumer's Guide: Get Your Power from the Sun, US. Department of Energy, 2003

PV systems can also include battery backup or uninterruptible power supply (UPS) systems that can operate selected circuits in a building for hours or days during a utility outage.

The basic building block of PV technology is the solar "cell." Multiple PV cells are connected to form a PV "module," the smallest PV component sold commercially. A PV system connected or "tied" to the utility grid has these components:

- ***PV Array***: A PV Array is made up of PV modules, which are collections of PV cells. The most common PV module is 5-to-25 square feet in size and weighs about 3-4 lbs/ft2. Modules range in power output from about 10 watts to 300 watts (although higher wattages are available for utility-scale PV applications), with the power density ranging from about 5-to-18 watts per square foot.
- DC to AC ***Inverter***: This is the device that takes the DC power from the PV array and converts it into standard ac power used by the household appliances.
- ***Balance of System equipment (BOS)***: BOS includes mounting systems and wiring systems used to integrate the solar modules into the structural and electrical systems of the building. The wiring systems include disconnects for the DC and AC sides of the inverter, ground-fault protection, and overcurrent protection devices, junction boxes and possibly circuit combiner boxes. (See Figure 2-2).

Figure 2-2: Typical Residential Wiring System Layout

Source: Celentano Energy Services

- ***Metering:*** While meters indicate home energy usage, metering for a solar installation is used to record and display total electricity generation by the solar PV system and may provide indication of system performance.
- ***Batteries*** (optional) can provide energy storage or backup power in case of a power interruption or outage on the grid. (This guidebook does not cover solar PV systems with battery backup because of their increased complexity compared to **grid-tied** PV systems, and because they account for less than 5% of all the solar PV systems installed.)

Applications for PV systems are constantly expanding with new uses being identified all the time. In addition to offsetting loads for homeowners as described previously, PV systems also serve facilities such as commercial, educational, industrial, and government buildings. PV technologies are rapidly becoming installed at the utility-scale supplying power for utilities and retail electric providers in multi-megawatt capacities.

2.2 PV Technologies

Today's PV systems come in a range of efficiencies and configurations. PV systems with modules that are mounted on top of existing roofing are still the most common, but building integrated photovoltaic (BIPV) systems are gaining in popularity (See Figure 2-3). In a BIPV system, the modules do double duty—they generate electricity AND can replace traditional building materials such as roof shingles and windows. Table 2.1 presents a comparison of the main PV technologies commercially available today that are suited for this region, and Table 2.2 gives a comparison of the area needed to achieve the same output for PV modules of different efficiencies.

Figure 2-3: BIPV example, PV modules integrated into windows, Microsoft School, Philadelphia

Source: Celentano Energy Services

Table 2.1: Comparison of PV Technologies

PV Tech	Mono Crystalline	Multi Crystalline	Thin Film
Applications	Grid Connected	Grid Connected	Grid Connected
	Off Grid	Off Grid	Off Grid
	Distributed Generation	Distributed Generation	Distributed Generation
	Centralized Generation Building Integrated	Centralized Generation Building Integrated	Building Integrated Flexible Substrate
Advantages	High Efficiency	Low Capital Cost	Low Production Costs Installation Time Low Material Cost
	High Value in Area-Constrained Applications	Easier and Faster to Produce	May be less sensitive to shading impacts and high temperatures
Disadvantages	High Capital Cost	Slightly Lower Efficiency	Lowest Efficiency
	Silicon Price Dependant	Silicon Price Dependant	Less Reliability Data
	Cell Matching Losses	Cell Matching Losses	Sensitivity to Defects Toxicity of Materials
Efficiencies (approximate range)	14-18%	12-16%	4-12%

Table 2.2: Square Footage of Roof Area Needed for PV Modules of Varying Efficiencies

Roof Area Needed in Square Feet		
Technology	PV Module Efficiency (%)	Square Feet Needed per 1 kW
Thin-Film	4	300
Thin-Film	8	150
Multi-crystalline	12	100
Mono-crystalline	16	80

Source: U.S. Department of Energy, Energy Efficiency and Renewable Energy

New PV products are being introduced to the market at a rapid rate. The most common products available today are:

- Flat plate collectors (see Figure 1-1)
- Flexible PV laminates integrated into roofing products (membrane, metal roofs, shingles, etc.) or other surfaces (see Figure 2-4)
- Cylindrical cells (see Figure 2-5)
- Flat plate collectors that also serve as skylights or windows allowing dispersed amounts of sunlight into a building (see Figure 2-6)
- AC Modules (Flat plate modules with a DC to AC inverter mounted directly to the back of the module) (see Figure 2-7)

Figure 2-4: PV modules integrated into roofing materials (left: Uni-Solar roof shingles; right: SRS Energy Solé Pow er Tile roof tiles)
Source: Celentano Energy Services

Figure 2-5: Cylindrical PV Cells by Solydra, Inc.
Source: City of Tucson, Solar America Cities Program

Figure 2-6: PV Modules allow ing light to filter through interior w indows, Microsoft School, Philadelphia
Source: Celentano Energy Services

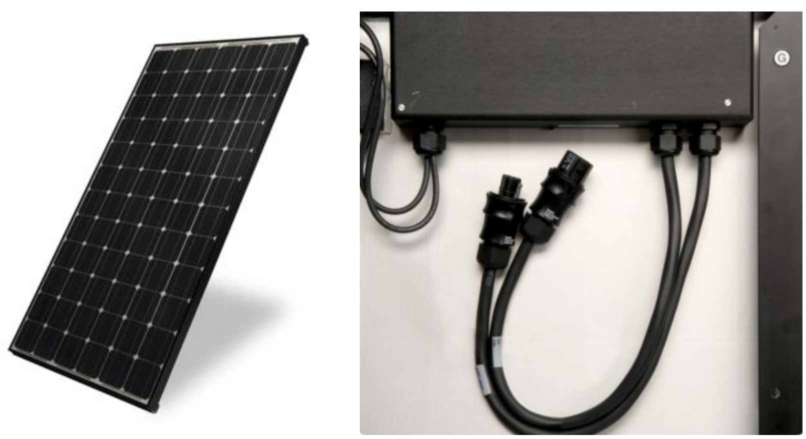

Figure 2-7: AC Module: Front of module (left) and inverter mounted to back of module (right)
Source: GreenRay, Inc. (http://www.greenraysolar.com/)

2.3 Installation Methods

Common PV array mounting methods for residential systems include:

1. Integral mounting (rooftop) (Figure 2-8)
2. Standoff mounting (rooftop) (Figure 2-9)
3. Rack mounting (rooftop or ground) (Figure 2-10)
4. Ballasted mounting (rooftop or ground) (Figure 2-11)
5. Pole mounting (ground) (Figure 2-12)

Large-scale flat roof commercial projects are often accomplished with fully engineered and certified systems, and some have no roof penetrations. For projects that require no roof penetrations, mounting hardware is either ballasted, interlocking or some combination of the two in order to withstand design wind speeds for a particular area. Non-penetrating ballasted systems require adequate roof structural integrity in order to withstand the additional weight of the ballast (see Figure 2-11). These interlocking systems are often limited to the maximum angle that the PV array can be tilted at in order to withstand design wind speeds. Non-penetrating mounting hardware can be installed on standing seam metal roofs with roof clips.

Mounting hardware can also be mechanically attached to the roof and underlying structural members. A structural analysis is highly recommended and often required for commercial systems.

Figure 2-8: Integral mounting system for rooftop (attach directly to roof rafters)

Source: Professional Solar Products, Inc.

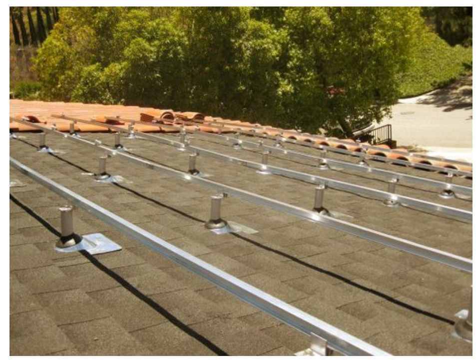

Figure 2-9: Standoff mounting system for rooftop (several inches off the roof surface allowing natural venting)

Source: Unirac

Figure 2-10: Ground Mounted PV System (Three Eagles-Nova Care)

Source: Celentano Energy Services

Figure 2-11: Commercial ballasted 8.5 kW PV system – Microsoft School

Source: Celentano Energy Services

Other Considerations

Often it is desirable that the array be mounted at the ground level either on a pole or a rack. In public places, ground-mounted arrays are more susceptible to vandalism than pole or roof-mounted systems. Philadelphia has recently upgraded to the 2008 National Electric Code (NEC), which requires that all wiring on a solar PV array, either mounted on the ground or on a pole, must be protected. Therefore fencing material will be required around the backs of the ground or pole mounted PV arrays, or that these arrays must be positioned at least 6 feet above the ground (see Figure 2-12). The addition of a fence, if placed in front of the PV array, may require a greater footprint so that the fence does not shade the array.

kW vs kWh?

A kilowatt (**kW**) is a unit of **power**

A kilowatt-hour (**kWh**) is a unit of **energy** used over time

*kW denotes how much power a PV system is generating at a given point in time.

*kWh indicates how much energy has been generated or the average amount of power generated over a period of time.

So, under ideal conditions, a 3 kW PV array that produces power for 3 hours will generate 9 kWh.

Figure 2-12: Pole-mounted PV system for a Middle School

Source: City of Austin, Solar America Cities Program

2.4 Site Assessment Overview

One of the first steps that must occur when considering a PV system for a property is a site assessment. A well-conducted site assessment will determine the viability of a solar PV installation for a particular property and can always be used to identify fatal flaws that may cause problems during project implementation and for the property owner. In addition to the steps listed below, a project developer should determine if there are any competing uses for the proposed or adjoining space that might hinder the implementation of the project. For example, it may be possible to determine if there will be any new construction planned that might shade the proposed site in the future. Or a land area might be better used for housing development, urban agriculture, public open space, etc. These issues should be explored as part of a site assessment.

The primary goals of a site assessment are to:

- Determine whether the array would be shaded during critical times.
- Determine the location of the array (should be free from vandalism or able to be protected from vandalism without compromising energy production)
- Determine the mounting method for the array
- Determine where the Balance-of-System (BOS) components will be located
- Determine how the PV system will interface with the existing electrical system
- Identify issues that could jeopardize the viability of a project or result in increased design and installation complexity and implementation cost such as insufficient electric service (based on local electric code or utility requirements—*see Section 4.3 PECO Interconnection*) or insufficient structural support requiring costly upgrades

Figure 2-13: Solmetric Sun Eye: Device (left) and Screen Capture (right)

Source: Solmetric

- Identify any concerns of the building owner that may impact the design such as aesthetic concerns or financing options.

Shading calculations can be performed by hand by taking accurate measurements, noting surrounding objects and their position relative to a potential area, and using a sun path chart for the specific area. Several tools are also available to assist installers with easily identifying areas that will be shaded during crucial times of the day and throughout the year. The most commonly used tools include the Solmetric Sun Eye (Figure 2-13), the Solar Pathfinder (Figures 2-14 and 2-15) and the Acme Solar Site Evaluation Tool (Wiley Electronics).

Section 3 addresses some additional design points that installers and developers must consider.

Figure 2-14: Solar Pathfinder On-Site Close-Up – on top of Friends Center, Arch St., Philadelphia (objects shading the site are reflected in dome of device)

Source: Celentano Energy Services

Figure 2-15: Solar Pathfinder On-Site (circled in red) Friends Center (10.25 kW)

Source: Celentano Energy Services

Where can I learn more about PV and get the necessary credentials to install systems?

Education	The first step is education. There are many different PV training programs that will provide interested individuals with a fundamental understanding about solar PV. Then there are other programs that can provide advanced training that can be used towards earning certification by the National American Board of Certified Energy Practitioners (NABCEP). Some of these programs are listed below: • The Mid-Atlantic Renewable Energy Association: offers seminars on basic solar fundamentals primarily geared towards the general public http://www.themarea.org/education.shtml • Infinite Solar Training Center: offers entry level NABCEP exam preparation and teaches installers how to design, install, upgrade and maintain renewable energy power systems for residential, commercial, mobile and specialty applications. http://www.solarschoolpa.com • Electric Education Center: Registered Provider for the NABCEP Entry Level Exam and also offers NABCEP Entry Level Exam preparation http://www.electriceducationcenter.com/ • Solar Energy International (SEI): offers entry level and advanced level solar PV training courses; is a registered provider for the NABCEP Entry Level Exam; also offers a variety of courses to design, build and maintain renewable energy systems and energy-efficient, sustainable homes. http://www.solarenergy.org/ • North Mid Atlantic Solar Training Center: A newly created U.S. Department of Energy sponsored solar training center will offer solar education and installation training programs; will develop and deliver hands-on "train the trainer" professional development workshops for post-secondary educators, including developing and maintaining solar training facilities; assist community and technical colleges and other post secondary education and training providers to develop and deliver programs to address industry needs for solar education and workforce development (Tip: Look for an Interstate Renewable Energy Council ISPQ (IREC) accredited training program.)
Certification	Next step is to get the proper certification. NABCEP is the national certification organization for professional installers in the field of renewable energy. NABCEP offers the following: • Entry Level Program: for individuals wanting to get into the solar field, this allows them to demonstrate they have achieved a basic knowledge of the fundamental principles. ***Note: Passing this exam does NOT designate an individual as a "NABCEP Certified PV Installer"*** • PV Installer Certification Program: for highly experienced individuals who are eligible to take a rigorous examination and have demonstrated the capability to supervise complete PV system installations, and have a detailed working knowledge of electrical codes, standards and accepted industry practice associated with PV installations. Although this is a voluntary certification program, it is highly recommended because it allows professionals to demonstrate their competence in the field as well as their commitment to upholding high standards of ethical and professional practice. (To learn more about their requirements, visit their website: http://www.nabcep.org)
Registration	Once the necessary certifications and training have been obtained, the last step is to become registered on the required lists including: • Pennsylvania (PA) Sunshine Solar Program Qualified Installer Registration • Pennsylvania Attorney General's List of Registered Contractors • (Note: Only licensed electrical contractors can pull an electrical permit with the City)

Additional Reading Material and Resources

A Consumer's Guide Get Your Power from the Sun, U.S. Department of Energy, December 2003 • DOE/GO-102003-1844

Photovoltaic Power Systems and the 2005 National Electrical Code: Suggested Practices, SAND2005-0342, February 2005, Sandia National Laboratories, Photovoltaic Systems Assistance Center, Albuquerque, NM 87185-0753. Also available in PDF format only from the Southwest Technology Development Institute, http://www.nmsu.edu/%7Etdi/Photovoltaics/Codes-Stds/PVnecSugPract.html

A Guide to Photovoltaic System Design and Installation, California Energy Commission Consultant Report 500-01-020, June 2001 http://www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF

Installing Photovoltaic Systems (Course Manual), 2002, Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922-5703 http://www.fsec.ucf.edu

Solar Site Evaluation Tools & Techniques to Quantify & Optimize Production, M. Galli, P. Hoberg, SOLARPRO Optimal Design, Installation & Performance, December/January 2009

Home Power: The Hands-on Journal of Home-Made Power, Home Power, Inc., PO Box 520, Ashland, Oregon, www.homepower.com

Solar Ready Buildings Planning Guide, L. Lisell, T. Tetreault, and A. Watson, National Renewable Energy Laboratory, Technical Report NREL/TP-7A2-46078 December 2009

A Homebuilder's Guide to Going Solar, U.S. Department of Energy, December 2008, DOE/GO-102008-2744

Solar Energy Systems A Guide for Pennsylvania Municipal Office Here comes the Sun! Governor's Solar Working Group, 2010

Expedited Permit Process for Photovoltaic Systems, Solar American Board for Codes and Standards (Solar ABCS), 2009 http://www.solarabcs.org/permitting

3.0

SYSTEM DESIGN CONSIDERATIONS

This section of the guidebook provides an overview of some of the major technical aspects that should be considered when developing a PV project.

3.1 Solar in Philadelphia

The potential for solar generation in Pennsylvania is relatively consistent across the Commonwealth although it is higher in the Philadelphia region than the Pittsburgh region. This is partly because Philadelphia has many reflective surfaces and receives about 9% more solar radiation on an annual basis than Pittsburgh as is graphically illustrated in Figure 3.2.[1]

When Philadelphia became designated a Solar America City in 2008, it set a goal to install 2.3 MW of solar generation capacity by 2011, which will be enough to provide electricity to more than 350 households. In 2009, the entire state had 4 MW of installed solar capacity[2]. To meet this commendable and aggressive goal, local solar contractors and developers must have a clear understanding of Philadelphia's Permitting requirements and unique attributes of the City that might impact project development such as:

This section will answer the following questions:

- ☐ Are there any considerations unique to Philadelphia?
- ☐ Why should a building be energy-efficient before considering PV?
- ☐ What are the key components impacting PV system performance?
- ☐ How can I estimate how much energy a PV system will generate?
- ☐ What is system commissioning and why is it important?

Los Balcones, Philadelphia (Norris Square)
Source: Celentano Energy Services

1 Solar Energy Systems A Guide for Pennsylvania Municipal Officials Here comes the Sun! 12/1/2009 Governor's Solar Working Group)

2 Cleantech GROUP LLC http://cleantech.com/news/4713/pennsylvania-quadruple-solar-capaci

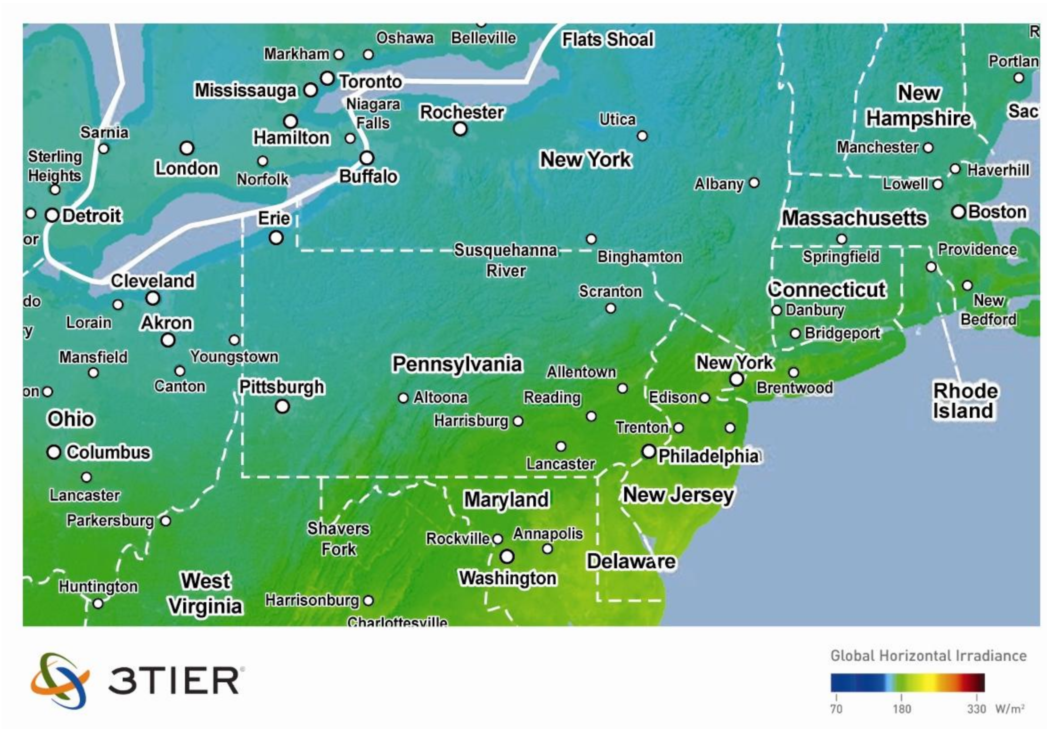

Figure 3-2: Pennsylvania Solar Insolation Map (Global Horizontal Irradiance in Watts/square meter)
Source: 3TIER, Inc.

- Complying with local rules and regulations and in the right order (refer to Section 4 of this guidebook for a detailed description of the process flow and requirements)

- Historical buildings: Solar collecting devices installed within designated historical buildings, structures, sites, objects and districts must be reviewed and approved by the Philadelphia Historical Commission[3]

- Structural ability of buildings to accommodate additional weight of PV modules because of high anticipated snow loads: Residential flat roofs may present additional challenges when anchoring typical stand-offs and tying into roof rafters that are several inches below the roof deck. A thorough analysis will be required to ensure a code-compliant installation.

- Within the PECO service territory, there are several secondary network distribution systems that may limit the ability and capacity of PV systems installed. (*See Section 4.3 for more information about PECO requirements.)*

- Prevailing Wage Law: The state's Prevailing Wage law, which was established in 1964, sets $25,000 as the threshold above which Prevailing Wages must be paid to workers, if any state (i.e. taxpayer) money is involved. The Prevailing Wage law applies to projects of all classes, including residential and small commercial.[4] Projects that use state rebate funds would require prevailing wages to be paid to workers for projects over $25,000 and will usually increase the labor costs of those projects.

[3] City of Philadelphia BILL NO, 060698 Ordinance

[4] Philadelphia Solar Energy Association http://phlsolar.org/Incentives.html

3.2 Efficiency First

Before considering a solar photovoltaic system for a building (particularly a residential building), energy-efficient measures should be incorporated first. Energy-efficiency is not only a cost-effective means of reducing carbon emissions (reducing energy usage thereby reducing the need for electric generation) but a home may also not need as large a PV system to meet its loads. Weatherization and conservation are low hanging fruit to achieve both energy and dollar savings. Figure 3-3 shows the profitability of energy efficiency upgrades and highlights the top 5 efficiency measures with the greatest return on investment:

- 1 – High efficiency lighting & fixtures
- 2 – Duct Sealing
- 3 – Energy Star® clothes washer
- 4 – Programmable thermostat
- 5 – Water heater tank wrap

Zero Energy Buildings

…use as much energy as they generate from on-site renewable energy systems like solar PV. To achieve this, the building must be as energy-efficient as is practical.

Source: NREL Photographic Information eXchange

Additional measures include replacing older refrigerators and inefficient room air conditioning units which can also be very cost effective. Implementing energy efficient measures are much more cost effective and less capital intensive than installing a solar PV system, and therefore should be done first or in concert with installing solar PV.

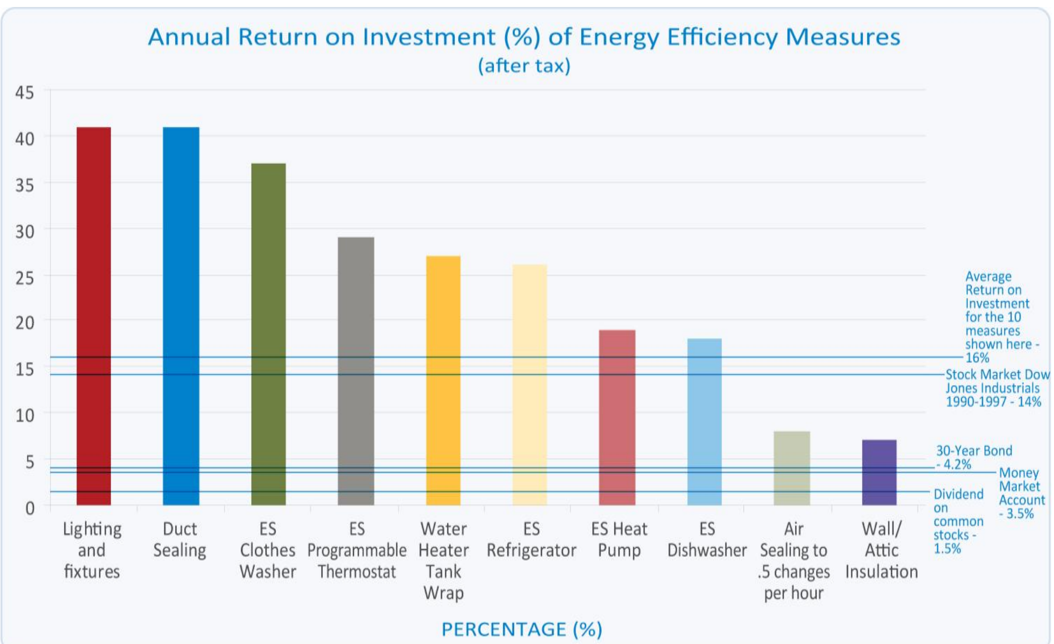

Figure 3-3: The Profitability of Energy Efficiency Upgrades (ES = Energy Star)
Source: the Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory.

These measures are contrasted with other familiar investments such as 30-year bonds, money market accounts and dividends on common stocks to give perspective of the positive return on investment these actions can provide.

There are also many opportunities for efficiency within commercial buildings. Advancement in lighting, air conditioning, and control technologies has resulted in large increases in efficiencies. A PV system will have a synergistic effect when installed in conjunction with energy-efficiency measures for any building type.

Contact the following groups for more information about energy efficiency recommendations:

- Energy Coordinating Agency
- Delaware Valley Green Building Council

3.3 Factors Impacting PV system performance

There are many variables that affect the output of a PV system. Some of these factors are discussed in Section 3.5 *Estimating PV System Performance* of this document. The key factors that have the greatest impact on how a PV system performs are described here.

3.3.1 Sunlight Intensity (Irradiance)

The performance/output of a PV system is relatively proportional to sunlight intensity. Therefore these systems can generate electricity even on cloudy days. Greater amounts and duration of sunlight increase system performance. Sunlight intensity is called irradiance, which is measured in watts per square meter (W/m^2). In summer, when the sun is nearly directly overhead, its irradiance at the surface of the Earth, at sea level, is approximately 1000 W/m^2. This irradiance is defined as "full" or "peak sun," and it is the standard irradiance for testing and rating PV modules. At peak sun conditions, roughly 70% of the sun that is incident at the top of the atmosphere penetrates to the surface of the Earth. If PV modules are mounted perpendicular to the sun's rays, it is possible to receive close to peak sun nearly every sunny day at noon for much of the continental United States.[5]

Over a one year period, PV modules in Philadelphia will receive the most perpendicular sunlight when the PV array is facing due South and is tilted at an angle that is slightly less than the latitude of the region (for Philadelphia, 5 degrees less than the local latitude – 39 degrees – is recommended). However, tilting the PV array at or below the angle of latitude is not always the best solution for a project.

- Some rooftops may not be able to structurally withstand the additional forces imposed (wind, snow, etc.) as the tilt angle of a PV array increases.
- PV arrays tilted at lower angles will not need to be spaced as far apart to avoid shading from adjacent rows, therefore a greater quantity of modules can be installed. This may be desirable if a property has limited space. There are several modeling tools that can estimate the energy output of a PV system based on proposed design parameters (i.e. quantity of modules, electrical characteristics of specific PV technologies, tilt, local climate, etc.). These tools can

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[5] *Study Guide For Photovoltaic System Installers and Sample Examination Questions*, Revision 3.0, North American Board of Certified Energy Practitioners, http://www.nabcep.org/

help determine the best configuration that provides the best possible kilowatt-hours generated per area for the project.

3.3.2 Shading

Shading portions of a PV array will have the most adverse effect on the system's performance. It is important to determine during the site assessment if a potential location for the PV array will be shaded, especially between the hours of 9 a.m. and 3 p.m. This is important, as the output of PV modules may be significantly impaired by even a small amount of shading on the array.

A careful assessment using an hourly computer simulation program is necessary to determine the benefits of westerly orientations. A minimum of six hours of unshaded operation is important for best system performance.

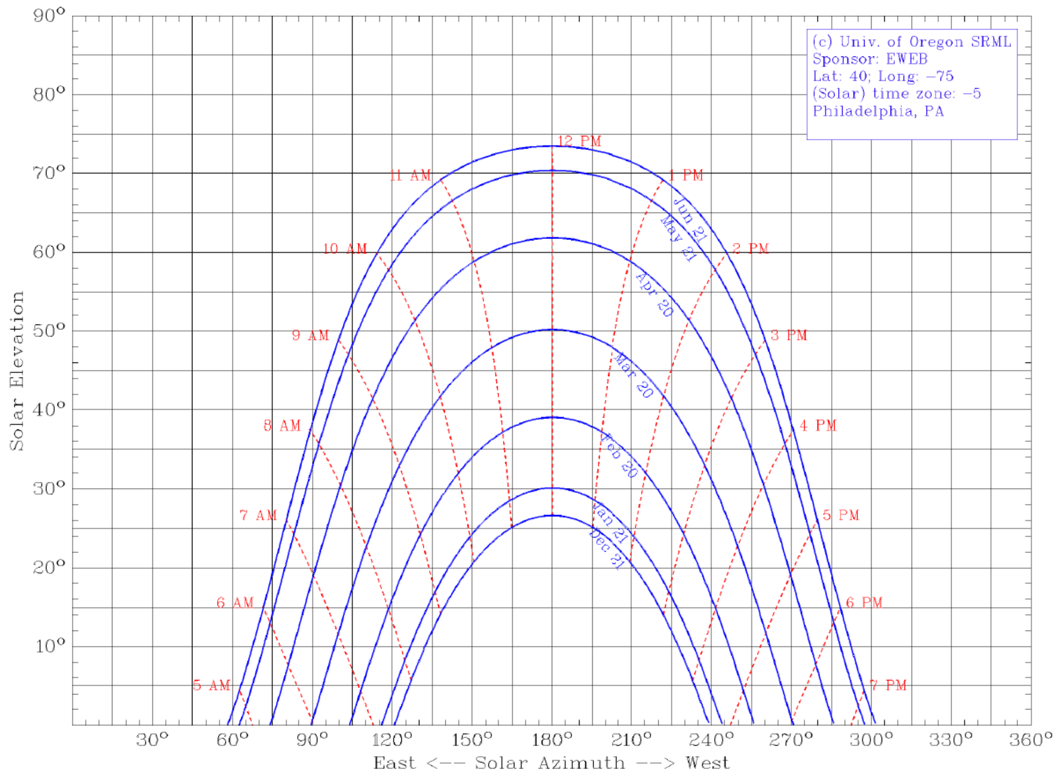


Figure 3-4: Sun Chart for Philadelphia

Source: University of Oregon, Solar Radiation Monitoring Laboratory

Figure 3-4 shows the location of the sun in the Philadelphia sky relative to a particular point (as noted by the Solar Azimuth on the x-axis). For example, at 12 noon on December 21st, the sun will be due south and at an angle (relative to the horizon) of approximately 25°. On this same day at 3pm, however, the sun will be at an approximate angle of 12° and will be located slightly southwest in the sky. These angles should be used to determine how far apart rows of PV modules should be located to ensure adequate energy

Energy yield and occupation of land/roof area are two parameters that must be optimized when designing a large PV plant and when space constraints are an issue.

generation during the winter months and minimize shading (when the sun is the lowest in the sky).

However configuring a PV array to avoid shading 100% of the time is not always possible given space constraints both on building rooftops and on open land. For PV arrays that consist of multiple rows of PV modules and array structures, the losses that occur when one row shades an adjacent row should be accounted for when estimating the performance of the PV system.[6] (Accounting for these losses is discussed further within this guidebook in Section 3.5 *Estimating System Performance*.)

3.3.3 Orientation

Next to shading, orientation of the PV array is one of the more important aspects of the site assessment. Facing the PV array due South is ideal; however, slight deviations can also be feasible. For example, an unshaded PV array with a tilt of 35 degrees and facing +/- 45 degrees away from due South (SE or SW) will still receive 92% of the annual solar radiation as compared to the PV array facing due south.

Fully understanding what the orientation will be at construction must be understood very early in the project. Often the roof tilt is used as the orientation of a residential rooftop system due to the improved aesthetics of a parallel standoff roof mounted array rather than an array that is tilted at an angle greater than the roof tilt. Most roof orientations are not the most ideal for the array orientation so the impact of a less than optimal orientation must be understood prior to solidifying the system orientation.

3.3.4 Other Factors

There are several other factors that affect the performance of a PV system that should be communicated to potential system owners so they have realistic expectations of how their system will perform and the resulting economic benefits they can expect over time. These include:

- **PV module nameplate DC rating:** PV modules are rated under specific conditions that are easily recreated in a factory and allow for consistent comparison of products known as Standard Test Conditions (STC). This value can be used to determine the DC power rating of the PV array. Since PV modules produce direct current (DC) electricity, their rating is designated in terms of watts DC at STC. For example a 100 watt PV module will have an output of 100 watts when conditions are identical to STC (cell temperature 25 degrees Celsius, solar irradiance 1000 W/m^2, air mass 1). If these conditions are not present, then the actual output will be different based on the remaining factors below.
- **Temperature:** PV module output power reduces as module temperature increases. The change in output varies based on the electrical characteristics of the specific PV technology.
- **Dirt and dust:** can accumulate on a PV module surface, blocking some of the sunlight and reducing the output. However, this tends to be more of a problem in the Southwestern part of the U.S. (the Philadelphia region receives sufficient rainfall to minimize this impact).
- **Mismatch and wiring losses:** There are inconsistencies in performance from one module to another (mismatch) and typically results in at least 2% loss. There are also losses

[6] "How to Change PVWatts Parameters", National Renewable Energy Laboratory, http://www.nrel.gov/rredc/pvwatts/changing_parameters.html

associated with the resistance in system wiring which can be minimized by increasing the size of the wire.

- **DC to AC conversion losses:** The DC electricity generated by PV modules must be converted to AC electricity to match requirements of common building loads. This is accomplished by an inverter. Currently, inverters have peak efficiencies of 92-98% (higher efficiencies are typically associated with larger inverters used in commercial and utility-scale projects).

Note that in most all cases, the actual DC power generated will be less than the nameplate rating of the PV modules; however, when the ambient temperature is very cold and the sky is very clear, which sometimes occurs in the months of October or February, it is possible for the PV modules to generate power above their nameplate rating.

There are also other factors used in determining how much the DC power of a PV system will be derated as it is converted into AC power (also known as the derate factor). The derate factor and its impact on system performance is examined in Section 3.5 *Estimating PV System Performance* in this document and includes a range of typical losses associated with each factor.

3.4 Other Factors to Consider When Designing a System

There are other variables that affect the design, cost and constructability of a PV system. In addition to optimizing the output of a PV system, other considerations that designers and installers should take into account include:

- ***Space available for the PV array (roof or ground):*** Optimize the use of space by configuring the PV system for an acceptable shading derate factor (can be based on the Ground Cover Ratio (see call-out box *"Shading Derate Factor and Ground Cover Ratio as a Design Tool"* for details). Tilting a PV array at latitude is not always the best solution particularly in space constrained areas.

2.94 kW Rooftop PV System, Philadelphia
Source: Celentano Energy Services

- ***PV array string sizing.*** The number of PV modules that comprise a basic circuit (the building block of the PV array) should be determined based on the maximum system voltage expected by the system. The maximum system voltage is based on the lowest expected ambient temperature for the region[7]. (Note: One source for obtaining this value is the ASHRAE Handbook – Fundamentals. For the City of Philadelphia, this value is -15 degrees Celsius.[8])

- ***Ability for the existing electric service to accommodate a PV system:*** If the PV system delivers electricity to a building via a breaker in the existing service panel, the breaker size (as determined by the maximum current output from the PV inverter) is limited based on the

7 National Electric Code, Article 690

8 2009 ASHRAE Handbook Fundamentals "Extreme Annual Mean Minimum Design Dry Bulb Temperature" Philadelphia

rating of the panel [9] according to the electric code. Often times older homes may require upgrades to their existing electric service in order to accommodate a new PV system.

- ***Current energy usage:*** Based on current net metering regulation in Pennsylvania, a PV system should not be designed to generate more annual energy than the building uses otherwise the cost-effectiveness of the system will be reduced.
- ***Structural integrity of the roof:*** For rooftop applications, determine if the roof is able to accommodate the additional weight of the PV array and how the system should be attached to the existing structure.
- ***Project Budget:*** Whether it's a homeowner, business owner or commercial or industrial user, the owner's bottom line for a budget will have the most impact on the system size.

[9] NEC 690.64 (B)(1)

Figure 3-5 presents the basic principles and steps to follow when designing a quality PV system. Although originally developed for California, it is applicable for Philadelphia as well.

Basic Principles to Follow When Designing a Quality PV System

- ☐ Select a packaged system that meets the owner's needs. Customer criteria for a system may include reduction in monthly electricity bill, environmental benefits, desire for backup power, initial budget constraints, etc. Size and orient the PV array to provide the expected electrical power and energy.
- ☐ Ensure the roof area or other installation site is capable of handling the desired system size.
- ☐ Specify sunlight and weather resistant materials for all outdoor equipment.
- ☐ Locate the array to minimize shading from foliage, vent pipes, and adjacent structures.
- ☐ Design the system in compliance with all applicable building and electrical codes.
- ☐ Design the system with a minimum of electrical losses due to wiring, fuses, switches, and inverters.
- ☐ Properly house and manage the battery system, should batteries be required.
- ☐ Ensure the design meets local utility interconnection requirements.

Basic Steps to Follow When Installing a PV System

- ☐ If roof mounted, verify that the roof is capable of handling additional weight of PV system. Augment roof structure as necessary.
- ☐ Properly seal any roof penetrations with roofing industry approved sealing methods. Check on roof warranty if necessary.
- ☐ Install equipment according to manufacturers' specifications, using installation requirements and procedures from the manufacturers' specifications.
- ☐ Properly ground the system parts to reduce the threat of shock hazards and induced surges.
- ☐ Check for proper PV system operation by following the checkout procedures on the PV System Installation Checklist.
- ☐ Ensure the design meets local utility interconnection requirements
- ☐ Have final inspections completed by appropriate authorities

Figure 3-5: Basic Principles to Follow/Basic Steps to Follow
Source: California Energy Commission's Guide to Photovoltaic (PV) System Design and Installation, 2001

3.5 Estimating PV System Performance

There are several computer modeling tools that will estimate the performance of a PV system in a particular region of the country and the world. Some of the more commonly used tools in the industry for grid-connected PV systems are listed below:

- **PV Watts**: Version 1 – allows users to select a location from a map or text list of pre-determined locations throughout the world. Version 2 allows users to select any location in the United States by selecting a site on a 40-km gridded, interactive map. (Developed by the National Renewable Energy Laboratories)
- **Solar Advisor Model**: Combines a detailed performance model with several types of financing (from residential to utility-scale) for most solar technologies (Developed by the National Renewable Energy Laboratories and Sandia National Laboratory)
- **Solar Design Studio**: Simulates PV system operation based on user selected climate and system design and provides information on likely system power output and load consumption, necessary backup power during the operation of the system, and the financial impacts of installing the proposed system (Developed by the Maui Solar Energy Software Corporation)
- **PVSYST**: Software package for the study, sizing, simulation and data analysis of complete PV systems (Developed by the University of Geneva) This software is oriented towards architects, engineers, and researchers

When estimating the kWh output of a PV system for a client…

…provide an output range rather than a single figure. The range should be based on an upper and lower derate factor that reflects realistic expected losses of the system in the specific application.

It is important to thoroughly understand how these tools operate and the limitations of their results based on the users inputs.

(Note: For a more comprehensive list of computer software tools, visit NREL's Solar Technology Analysis Models and Tools http://www.nrel.gov/analysis/analysis_tools_tech_sol.html)

The performance of a PV system depends on many variables as was discussed earlier. When estimating the energy savings that a PV system will achieve for a customer, it is better to not "over-sell" the performance. Many of the performance modeling tools that are available allow the user to input the amount that the DC output of a PV array will be reduced (or derated due to losses in the system) by the time the power is delivered to loads. This ***derate factor*** should not be used as a hard-fast value to estimate the amount of power or energy that a PV system will generate. Instead it is recommended that contractors provide an output range that the actual expected performance will fall within.

PV Watts provides a default derate factor based on losses associated with the system parameters it models. Although some designers consider it a conservative estimate, it is considered by others to be a reasonable estimate. Based on local experience, when comparing solar site assessment results and the actual annual performance of hundreds of PV installations in Southeastern Pennsylvania, an overall derating factor of 0.80 has been found to be a conservative value (not including shading impacts). This means that in this area, one can expect to get 80% of the output of a system. Table 3-1 summarizes the system parameter losses that determine the default derate factor.

Table 3-1: Derate Factors for AC Power Rating at STC

Component Derate Factors	PVWatts Default	Range
PV module nameplate DC rating	0.95	0.80–1.05
Inverter and transformer	0.92	0.88–0.98
Mismatch	0.98	0.97–0.995
Diodes and connections	0.995	0.99–0.997
DC wiring	0.98	0.97–0.99
AC wiring	0.99	0.98–0.993
Soiling	0.95	0.30–0.995
System availability	0.98	0.00–0.995
Shading	1.00	0.00–1.00
Sun-tracking	1.00	0.95–1.00
Age	1.00	0.70–1.00
Overall Dc-to-AC derate factor	0.77	

Source: Renewable Resource Data Center, National Renewable Energy Laboratories

Some tools (such as Solar Design Studio, SAM and PVSYST) will model the output of the PV system based on the electrical characteristics of specific equipment such as PV modules and inverters. This is helpful when evaluating PV modules of different electrical characteristics (such as temperature coefficients for voltage, current and power). Ambient temperature has a greater impact on the output and performance of some modules than others, which can be helpful (and often necessary) when completing the electrical design.

Rag Flats, Philadelphia

Source: Celentano Energy Services

Reinhart Street, Philadelphia

Source: Kyle Sanphy

Shading Derate Factor and Ground Cover Ratio (GCR)

(Note: This section presents a methodology to examine the shading derate factor as it impacts system performance. To determine spacing between the rows to prevent inter-row shading during critical hours of the day, a detail shading analysis must be performed.)

When trying to optimize available space with energy yield for a large PV array or a rooftop with space constraints, an industry-accepted practice is to optimize the space by configuring the PV array for a GCR that corresponds to a shading derate factor of 0.975 (or a 2.5% loss). The GCR is defined as the ratio of the area of the PV array to the area of the total space available. Figure 3-5 can be used to estimate the recommended GCR for a project based on a desired shading derate factor (0.975 if going with industry practice) and the preferred tilt of the PV array. Then based on the space available, the PV array area can be calculated (and thus the number of PV modules and potential system capacity). The tools mentioned in this section can be used to compare the kWh output of systems designed at various tilts with PV kWdc-stc input (based on different shading derate factors) and varying the tilt of the array to optimize the available space with the energy yield.

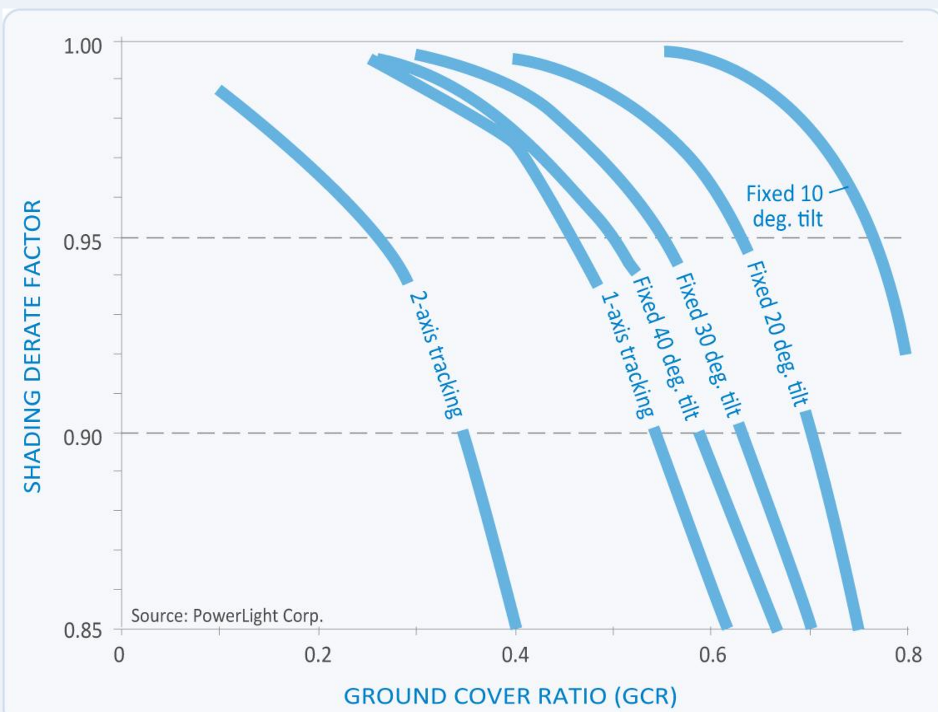


Figure 3-5: Shading derate factor for multiple-row PV arrays as a function of PV array type and ground cover ratio

Source: How to Change PVWatts Parameters, National Renewable Energy Laboratory, http://www.nrel.gov/rredc/pvwatts/changing_parameters.html

3.6 System Commissioning

The commissioning process is well-accepted in the building industry and is typically applied to entire buildings. The process begins at project inception (during the pre-design phase) and continues through the life of the facility.

The main objective of commissioning is to assure the safe and orderly handover of the unit from the constructor to the owner, guaranteeing its operability in terms of performance, reliability, safety and information traceability.

The main objective of a commissioning plan is to assure the safe and orderly handover of the unit from the constructor to the owner, guaranteeing its operability in terms of performance, reliability, safety and information traceability. According to the Building Commissioning Association, "The commissioning process includes specific tasks to be conducted during each phase in order to verify that design, construction and training meet the owner's project requirements." [10] Additionally, when executed in a planned and effective way, commissioning normally represents an essential factor for the fulfillment of schedule, costs, safety and quality requirements of the project.

Translating this to the PV industry allows a means to formalize quality control of installed PV systems. It ensures that systems have been installed in a safe manner and will be high performing. Commissioning encourages integrators to be responsible for their installations and facilitates project closeout.

Although the initial start-up of a PV system is often referred to as "commissioning the PV system," the final commissioning event should occur after all inspections have occurred (utility and per local code) and permits are signed off. However, the commissioning plan provides details throughout the development of the system about the events, requirements and timeline.

3.6.1 Verifying the Actual Performance compared to the Expected Performance

Determining whether a PV system is performing as expected is one of the most important aspects of commissioning a PV system. There are several ways of accomplishing this, including web-based tools and calculators such as PVWATTS. Other available tools include performance calculators that account for electrical rate schedules and provide financial

At a minimum, a PV commissioning plan should do the following:

- Establish performance benchmarks
- Verify that all components of the installation are robust and permanent.
- Verify that the installation is safe.
- Verify that the installation is aesthetically acceptable.
- Verify that the installation is complete.
- Verify proper system operation.
- Verify that the system performs as expected.
- Complete any required acceptance documentation.
- Document as-built conditions.
- Ensure that the system meets L&I requirements (electrical, building, zoning) and passes all required inspections
- Ensure that the system meets PECO interconnection and metering requirements
- Train the system owner on basic

[10] Building Commissioning Association (tinyurl.com/mrbw68)

analyses. There are also calculations that can be performed in the field based on simple measurements to adjust the output based on actual conditions at the site (irradiance, temperature, assumed derate factors, etc.).[11]

System Commissioning
Source: CH2M HILL

Part of the commissioning process should include some basic tests in the field. Before starting up a PV system for the first time, the following tests should be conducted to establish baseline data about the PV system:

- **Open Circuit Voltage and Polarity Test:** determines if each string is producing the expected voltage and if polarity of the strings (+) and (-) at each combiner box is correct
- **Conductor Insulation Test** (also known as a "Megger" test based on the megohmmeter device used): verifies there are no leakage currents between the conductors and earth.
- **Ground Continuity Test:** ensures continuous ground continuity between PV module frames and mounting hardware.

There are also calculations that can be performed in the field based on simple measurements to adjust the theoretical power output based on actual conditions at the site (irradiance, temperature, assumed derate factors, etc.).[12] The theoretical or calculated power can then be compared to the actual power output indicated by the inverter. Also, the DC current and DC voltage values can be measured to verify the inverter displayed power output is correct.

Thoroughly commissioning the PV system and documenting the results will also provide reassurance to the owner that their system is performing to their expectations. The commissioning results can be a useful resource for troubleshooting potential problems in the future.

3.7 Safety Concerns

Photovoltaic systems produce direct current (DC) power from sunlight. Some grid-connected PV arrays use hundreds of modules connected in series and parallel to produce large amounts of power. Operating voltages may exceed 600 volts dc and currents at the subfield level may be hundreds of amperes.[13] Working safely with PV systems requires a fundamental understanding of electrical systems coupled with common sense. There should always be a licensed electrician employed on any solar PV installation project to perform some if not all of the electrical work. Some of the interlocking plug-in wiring can be safely carried out, but it is essential that proper lockout/tagout procedures are followed when making the final wiring connections for a grid-tied system. There are the usual subtle hazards, as well. These include nicks, cuts, and burns from sharp or hot components. As such, gloves should be used when handling anything that might be sharp, hot, rough, or that might splinter. More importantly, special insulated gloves and eye protection should be used when testing or working with the electrical parts of the PV system.

[11] PV System Commissioning, B. Gleason, SolarProfessional Journal, October & November 2009

[12] PV System Commissioning, B. Gleason, SolarProfessional Journal, October & November 2009

[13] Working Safely With Photovoltaic Systems, Sandia National Laboratories, http://photovoltaics.sandia.gov/syso/ESafety1.html

There is always the possibility of dropping tools or materials on either oneself, someone else, or on sensitive equipment or materials. Dropping tools across battery terminals is an especially dangerous hazard.[14]

Other safety measures that should be observed include:

- OSHA Regulations
- Safety in Attics
- Working Space for Electrical Systems
- How Photovoltaic Systems Work, and Associated Safety and Testing Issues
- Fire code safety

Exercise Common Sense:

- If the workplace is cluttered, the possibility of tripping over something is significantly increased.
- If the workplace is a sloped roof with clutter, the possibility of falling off the roof is significantly increased.
- If tools are left lying out on a roof, the chance of them falling off the roof and injuring someone below is increased.
- If the workplace is a rooftop in bright sunshine, the chance of sunburn is increased, so a good layer of sunscreen is in order.

Fire code requirements in Philadelphia, based upon OSHA regulations, require that a three foot perimeter around the roof edge is maintained on residential units for Fire Department access. For non residential roofs, a 6 ft. perimeter needs to be maintained.

3.8 Required Project Coordination

Once a site has been deemed suitable for a PV installation, the following coordination must occur:

- Assemble the project team
- Prepare Preliminary Design Plans
- Coordinate with PECO to ensure the proposed design can be accommodated by PECO lines
- Submit appropriate applications for State Solar Sunshine Program (if applying for a rebate), the Philadelphia Department of Licenses and Inspections (L&I), and PECO. See Section 4 for more details.
- Await results of submittal review from all entities before proceeding further
- Upon approval from all entities, begin constructing the PV system
- Arrange for appropriate inspections and PECO meter installation
- Finalize the start up and acceptance testing as part of the Commissioning Plan

Nesmith & Company – South Philadelphia
Source: Kyle Sanphy

[14] Study Guide for Photovoltaic System Installers And Sample Examination Questions Rev 3.0, North American Board of Certified Energy Practitioners

- Place the PV system in operation
- Ensure the owner understands and is trained regarding how the system will operate and transfer commissioning test results, O&M manuals and contact numbers.

Section 4 of this guidebook details the steps that solar contractors must follow to ensure compliance with all local codes, regulations and requirements.

Additional Reading Material and Resources

Photovoltaic Power Systems and the 2005 National Electrical Code: Suggested Practices, SAND2005-0342, February 2005, Sandia National Laboratories, Photovoltaic Systems Assistance Center, Albuquerque, NM 87185-0753. Also available in PDF format only from the Southwest Technology Development Institute, http://www.nmsu.edu/%7Etdi/Photovoltaics/Codes-Stds/PVnecSugPract.html

A Guide to Photovoltaic System Design and Installation, California Energy Commission Consultant Report 500-01-020, June 2001 http://www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF

Installing Photovoltaic Systems (Course Manual), 2002, Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922-5703, http://www.fsec.ucf.edu

Working Safely with Photovoltaic Systems, January 1999. Sandia National Laboratories, Photovoltaic Systems Assistance Center, Albuquerque, NM 87185-0753 http://www.sandia.gov/pv

Home Power: The Hands-on Journal of Home-Made Power, Home Power, Inc., PO Box 520, Ashland, Oregon, www.homepower.com

Solar Ready Buildings Planning Guide, L. Lisell, T. Tetreault, and A. Watson, National Renewable Energy Laboratory, Technical Report NREL/TP-7A2-46078 December 2009

PV System Commissioning, B. Gleason, SOLARPRO 2.6, October & November 2009

Study Guide for Photovoltaic System Installers and Sample Examination Questions Revision 3.0, North American Board of Certified Energy Practitioners, http://www.nabcep.org

In My Backyard, National Renewable Energy Laboratory tool that provides quick estimates of the electricity that a solar photovoltaic (PV) array or wind turbine can generate at a home or business at locations throughout the continental United States, Hawaii, and northern Mexico. http://www.nrel.gov/eis/imby

4.0

SOLAR INSTALLATION PROCESS CODES AND REGULATIONS

The legal and regulatory framework in Philadelphia provides a foundation for building a sustainable solar infrastructure. Local rules and regulations help reduce installation costs and significantly improve the market environment for solar energy technologies.

Now that you've determined whether solar is right for you, this section describes the solar installation process and discusses the applicable codes and regulations that require implementation for a successful installation. Philadelphia, in conjunction with the Commonwealth, has reviewed its rules and regulations to streamline and improve the process for residential and small commercial installations. This section also describes when a streamlined process may be allowed for electrical and building permits, and outlines the steps contractors must follow for a "Streamlined Permit" and a "Standard Permit."

This section will answer the following questions:

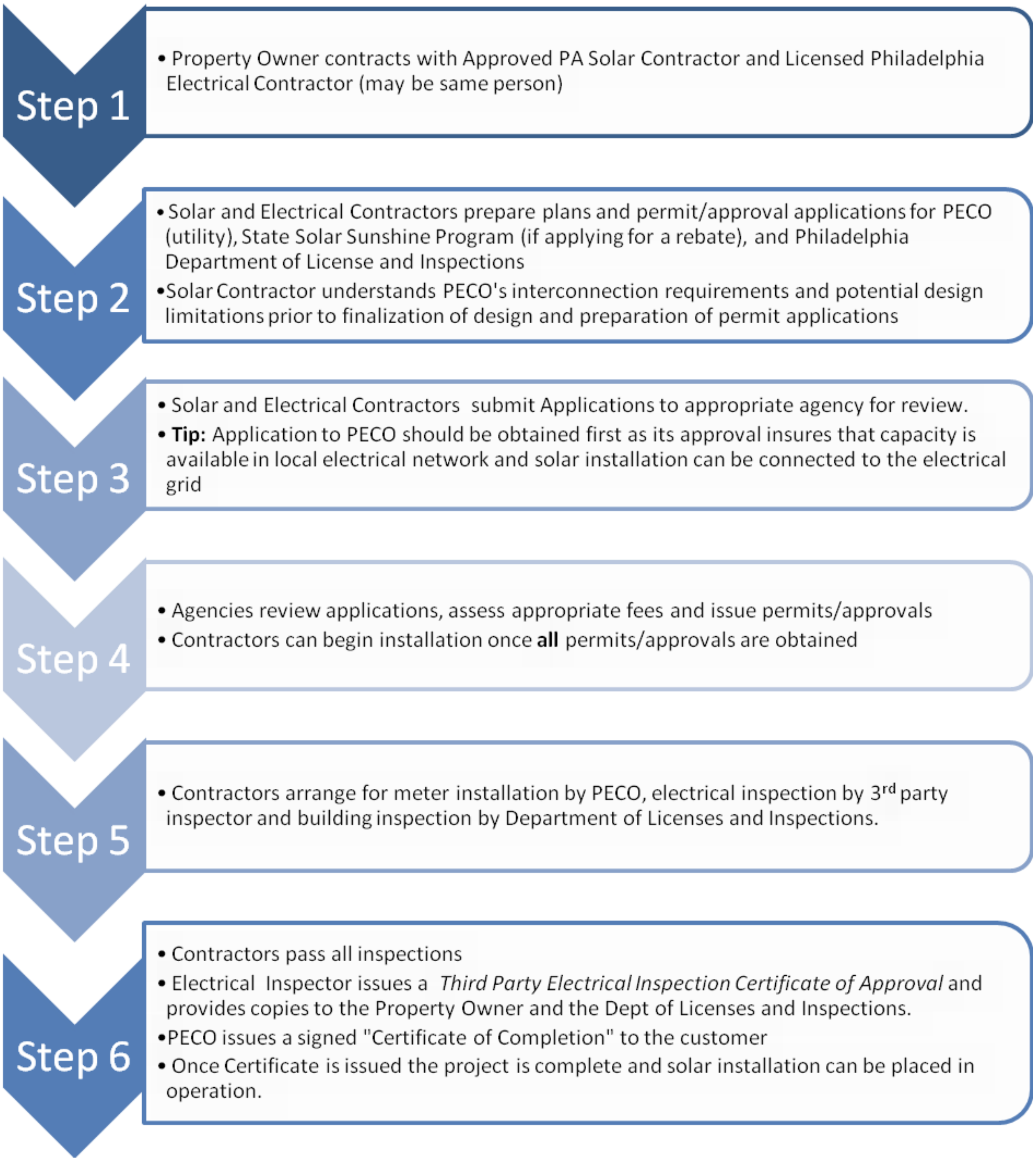
- What are the key steps in the solar installation process?
- What licensed contractors are required?
- What permits and applications must be submitted?
- What are the applicable codes and regulations?
- What is the PECO approval process?
- What are the L&I permitting processes?

Twenty-two 1.11 kW systems – Philadelphia Housing Authority (left: Brown Street; center and right: Mifflin Street)

Source: Celentano Energy Services

4.1 Solar Installation Process Overview

Figure 4.1 presents a process diagram that identifies the six key steps for the implementation of a solar project. (Note that these are steps that will occur after a property has been thoroughly assessed by a qualified solar contractor and has been identified as a feasible site for a solar PV system. For additional details, see Sections 2 and 3 of this guidebook.) Each step is briefly described below:



- ☐ **Step 1. Assembling the Project Team.** In order to procure all the necessary permits and approval applications that are required to implement a PV system, a property owner will need to contract with a Pennsylvania Approved Solar Contractor and a licensed Philadelphia Electrical Contractor. Property owners will usually contract with an approved Solar Installer who also provides or subcontracts the licensed electrical contractor.

- ☐ **Step 2. Preparation of Design Plan.** In this step, the solar contractor prepares a design plan that is specific to the building structure and that meets the energy requirements of the property. The plan should include the safe and orderly handover of the unit from the constructor to the owner, guaranteeing its operability in terms of performance, reliability, safety and information traceability as mentioned in Section 3.6 of this guidebook, System Commissioning. This plan must meet all applicable codes and regulations as further presented in this section of the guidebook.

  During the design phase, the contractor should review and understand PECO requirements to ensure compliance with their interconnection policy. (See Table 4.1 for a summary of potential scenarios that may cause complications with a PECO interconnection.)

- ☐ **Step 3. Application Submittals.** For residential and small commercial systems, the solar and electrical contractors prepare applications that must be submitted to:

  – The Philadelphia Department of Licenses and Inspections (L&I) for electrical and building permits. (Note: The contractor should verify zoning permit applicability, as in some cases, a zoning permit may also be required. See Section 4.4 for details.)

  – PECO to assure that capacity is available in the local electrical network and solar installation can be connected to the electrical grid.

  If the project meets certain criteria, it may be possible to have a streamlined review for electrical and building permits. See section 4.4 *City of Philadelphia Requirements* for details.

  If pursuing a rebate through the Pennsylvania Department of Environmental Protection's (PA DEP's) Solar Sunshine Program, the solar/electrical contractor prepares applications that must be submitted to the Program.

- ☐ **Step 4. Application Review.** Each agency reviews the applications that are submitted, assesses the appropriate fees, and issues a permit or approval. Projects that are eligible for a streamlined review by L&I will take less time than a standard review. Once *all* the permits/approvals have been obtained, installation can begin.

10.2 kW – Schuylkill Center

Source: Celentano Energy Services

- ☐ **Step 5. Inspection and Meter Installation.** The solar contractor arranges for:

  – building inspection,

  – electrical inspection (through an L&I approved 3rd party electrical inspector),

- PECO meter installation, and,
- [If pursuing a rebate and randomly selected], inspection by the State Solar Sunshine Program's 3rd party inspectors.

☐ **Step 6. Placing Solar Unit in Operation.** Before a PV system can be placed in operation it must pass all inspections and receive documentation indicating such:

- L&I's 3rd party electrical inspector will provide a Third Party Electrical Inspection Certificate of Approval.
- PECO will provide a ***Certificate of Completion*** to the contractor/system owner. Copies of these signed and completed approvals should be provided to the PA DEP Solar Sunshine Program (if applying for a rebate), PECO, the Property Owner and L&I as necessary.

(Note: The contractor should submit to PECO the Interconnection Application/Agreement - Part 2 in addition to L&I's Third Party Electrical Inspection Certificate of Approval. PECO may opt to conduct an inspection, which would include a witness test to assure that the inverter will disconnect form the grid if there is a grid outage. However, PECO may waive this test and approve the system. If the submitted Part 2 – Interconnection form is not challenged by PECO after 10 business days, the witness test is automatically waived and the system is approved for operation.)

Licenses/Registrations Required in Philadelphia:

- ***State Home Repair Registration*** (by the State Attorney General's Office) for projects on 1-2 family dwellings and for contractors who perform at least $5,000 worth of home improvements – ***State Requirement***
- ***Business Privilege License*** (by L&I) for all companies associated with any project within the city of Philadelphia – ***City Requirement***
- ***Contractor's License*** (***City Requirement*** by L&I) for all projects that are:
  - Not performed by an electrical contractor
  - Performed on all projects other than 1 and 2 family dwellings
- ***Electrical Contractor's License*** (by L&I) for all projects involving electrical work – ***City Requirement***
- ***Approved List of Solar Contractors*** (by the PA DEP Solar Sunshine Program) recommended for all projects, required for projects pursuing state rebates – ***State Rebate Requirement***

Contractors must meet insurance requirements as determined by L&I.

Finally, PECO will replace the existing utility meter (IN meter) and install the utility meter (OUT meter). The Contractor should perform the final system commissioning steps and train the property owner on operating and maintaining the system. (See Section 4.3 PECO Coordination for details.)

The following sections explain the permitting and approval process that all solar installations must follow with the City of Philadelphia's Licensing and Inspection (L&I) Department.

4.2 Licensing and Codes Requirements

Codes regulating PV installations include the construction code (Uniform Construction Code for the Commonwealth of Pennsylvania) and the zoning code (The Philadelphia Code).

[Note: Pennsylvania and Philadelphia Electrical Codes are incorporated within the UCCCP and are based on the NEC, with some differing or additional requirements particular for Philadelphia. While there is a specific section (Article 690) of the NEC that is dedicated to PV systems, the majority of the remainder of the NEC is also applicable to PV systems.]

The Commonwealth (through the PA DEP Solar Sunshine Program) develops and maintains the Approved List of Solar Contractors for projects that pursue rebates through the program. (Even if a project does not pursue a rebate, it is highly recommended to use a contractor from this List because it provides some level of assurance to a property owner that the contractor has met certain eligibility requirements and has had proper training and/or certification.).

The Solar Contractor applies for building permits. As part of the building permit application, the City requires the solar contractor to provide evidence that they are on the Approved List and registered with the Attorney General's Office. *(Note: Pennsylvania law requires that all Contractors who perform at least $5,000 worth of home improvements per year are registered with the Pennsylvania Attorney General's Office.)*

The project electrician must be a licensed City of Philadelphia electrician and is responsible for obtaining the electrical permit.

In addition to applying for City permits, the Solar Contractor must also submit an application to PECO for connection approval and meter installations. If pursuing a rebate, the Solar Contractor must also submit an application to the PA DEP Solar Sunshine Program.

4.3 PECO Interconnection

It is important that Solar Contractors understand PECO's interconnection requirements BEFORE the design is finalized. This understanding is essential to ensure that the electric lines serving the home or building can accommodate a customer-sited generating unit. An application must be submitted to PECO before they can identify any potential site limitations for interconnection. Contractors are encouraged to review PECO's Yellow Book for small generators rated at 50 kW or less [the Yellow Book is a condensed version of the requirements contained in the procedures for 2 million volt amps (MVA) or less].

Staggered Row Homes each 3.13 kW PV, Northeast Philadelphia
Source: Celentano Energy Services

Even if the system is never anticipated to export power to the grid, PECO must be aware of and understand potential faults in the system that may impact their lines and determine if their lines have enough capacity to accommodate the net flow of energy from a PV system. Failing to coordinate with PECO before the design is finalized may result in additional work or additional costs (if equipment has already been purchased).

There are scenarios seen in an interconnection review that, per *The Pennsylvania Code* may limit a lot's ability to have a small generator facility (such as a solar PV system) or that may require upgrades to the electric lines serving the building ***at the customer's expense***. Some of these scenarios are presented in Table 4.1. *(Note: The Pennsylvania Code is an official publication of the Commonwealth of Pennsylvania that contains regulations and other documents filed with the Legislative Reference Bureau including Pennsylvania Interconnection Standards. There are 4 levels of interconnection review per the PA Code. For more information about Levels 1 through 4, see 052 The Pennsylvania Code § 75.34 through § 75.40.[15])*

[15] The Pennsylvania Code 052 § 75.34. Interconnection Review Procedures
http://www.pacode.com/secure/data/052/chapter75/s75.34.html

Table 4.1: Scenarios that may cause potential complications for a PECO interconnection

Scenario	Description	Limitation
PV Connected to an Area/Secondary Network **(Common supply to small residential and commercial buildings in portions of Center City)**	An *area* or *secondary network* is an electric distribution system served by multiple transformers interconnected in an electrical network circuit and is often used in large metropolitan areas that are densely populated.	If a proposed building falls within an area or spot network, the PV generation when aggregated with other generation (from PV or other types of generating systems) must not exceed 5% of the network's maximum load. **If PECO determines that a PV system under review causes the network's maximum load to be exceeded by 5%, they can deny interconnection. PECO can require the installation of reverse power relays or other protection functions, or both, that prevent power flow beyond the point of interconnection at the expense of the customer.**
PV connected to a Single-phase shared Secondary Lines (240 VAC) **(Common in residential neighborhoods)**	A *Secondary Line* refers to the secondary conductors connected to a transformer that serves more than one customer.	If a PV system will be installed on a single-phase shared secondary line, the aggregate capacity of all small generators interconnected through the same transformer (PV and other types) must not exceed 20 kW. **If PECO determines that a PV system under review results in an aggregate generation capacity of greater than 20 kW, they can deny interconnection or require system upgrades at the customer's expense.**
PV connected to a Radial Distribution Circuit **(Typical supply for most customers except those served by the Center City secondary network)**	A *Radial Distribution Circuit* is the most common type of connection between a utility and load (in which power flows in one direction from the utility to the load). It is common in residential and commercial/ industrial areas.	If a PV system will be installed on a radial distribution circuit, the aggregate generation of all small generators (PV and other types) must not exceed 15% of the line section's annual peak load (as measured most recently at the substation). **If PECO determines that a PV system under review results in an aggregate generation of more than 15% of a radial distribution circuit's annual peak load, it will require upgrades to the lines at the expense of the customer.**

4.3.1 General PECO Requirements[16]

- Inverters must meet IEEE1547/UL1741 standards or equivalent—these are U.S. solar industry accepted standards

- The system shall include a visible break disconnect switch on the inverter AC output, which can be locked in the open position. The switch shall be located outdoors, next to the PECO "IN" and "OUT" meters (see meter descriptions below). This disconnect switch may be installed in a different location on the property, provided a placard is mounted at the PECO meters indicating the location of the switch. The switch location is negotiable with PECO for institutional, commercial, and industrial installations where service is provided by a dedicated PECO pad mounted transformer or by customer owned primary service equipment. The switch may be installed indoors for installations with indoor PECO meters.

- An interconnection customer may elect to provide PECO access to an isolation device that is contained in a building or area that may be unoccupied and locked or not otherwise readily accessible to PECO, by providing a key in a lockbox installed by PECO that shall provide ready access to the isolation device. The interconnection customer shall permit PECO to install the lockbox in a location that is readily accessible by PECO and the interconnection customer shall permit PECO to affix a placard in a location of its choosing that provides clear instructions PECO operating personnel on access to the isolation device.

- PECO requires the installation of a second meter at the service address to record excess energy being exported to the grid (OUT meter) if the customer wants to receive billing credit through net metering. However, if there is no expectation of any excess energy being exported, PECO needs to be aware of this at the time of the interconnection application, as PECO may not require the out meter.

- PECO will install a detented OUT meter and detent the IN meter (prevent the IN meter from recording the flow of electricity back to the grid) when the following has been completed:
  - Contractor has completed the meter installation second or OUT meter socket meter installation. *(Note: PECO will reimburse the customer the cost of installing the OUT meter socket in order to comply with the net metering regulation. This is a fixed agreed cost of $400, which should be invoiced to PECO at the time the Part 2 – Interconnection Completion Form is submitted).* Reimbursement will only be given to the customer and not to the installer.
  - The system has been inspected by an L&I third party electrical inspector, and

Figure 4-1: PECO Meters (OUT – left; IN – right) Row Home; Northern Liberties, Philadelphia

Source: Celentano Energy Services

[16] For the complete Terms and Conditions for Interconnection, visit PECO's website for Net Metering and Interconnection requirements: http://www.peco.com/pecores/energy_rates/Net+Metering+and+Interconnections.htm

– PECO has received the "*L&I Third Party Electrical Inspection Certificate*" (sent to the appropriate PECO New Business Office)

- ☐ Contractor must download a "[*PECO Certificate of Completion*]" form from PECO's Net Metering website. This form must be completed and submitted to PECO with proper signatures after the customer's PV system and PECO's meter have been installed.

- ☐ Witness Testing: After PECO receives the completed *PECO Certificate of Completion*, systems rated greater than 50 kW shall be required to perform a "witness test" to prove the UL1741 listed inverter's IEEE 1547 over/under voltage and frequency and anti-islanding protection are operating properly. The witness test will require the contractor to monitor the AC inverter output and simultaneously disconnect all inverters from the grid, using the inverter AC disconnect switch. A recording transient power disturbance analyzer shall be used to capture the inverter AC voltage wave forms to prove that the inverters shut down within the required 10 cycles (.167 seconds).

- ☐ After waiving or witnessing a successful "witness test," the "*PECO Certificate of Completion*" shall be signed by PECO and returned to the customer when the customer's PECO account has been properly set up for Net Metering.

4.4 City of Philadelphia Requirements

The Philadelphia Department of Licenses and Inspections (L&I) evaluates the need for zoning and grants zoning, electrical and building permitting for PV systems.

Electrical and building permits are required in all installations. The need for zoning permits will be decided upon review (see Section 4.4.2.2 Zoning Requirements for more details). Fire Department safety requirements that enable safe emergency response need to be incorporated into the design. The requirements for each permit are discussed separately in this guidebook.

To facilitate the preparation of the various L&I permit applications, this guidebook contains checklists, process flow diagrams and worksheets summarizing the requirements for electrical, building and zoning permits (see Appendices C, D and E, respectively).

4.4.1 Electrical Permit

Electrical Permits are required for all PV installations and, as mentioned previously, must be obtained by a Philadelphia licensed electrical contractor. L&I has developed a Streamlined permit process for installations that meet ALL of the following criteria:

1. The PV system size is 10 kW or less and the inverter has a continuous AC power output of 10 kW or less (to coincide with PECO cut-off criteria)

Inverter, electric panel and disconnects (IBEW 98 – South Philadelphia)

Source: Celentano Energy Services

2. PV modules, utility interactive inverters, and combiner boxes are listed and identified for use in PV systems
3. The PV array is composed of 4 series strings or less
4. The AC interconnection point is on the load side of the service disconnecting means
5. The standard electrical diagram can be used to accurately represent the PV system (See Appendix C, Exhibit C-4)
6. Property is a 1 or 2 family dwelling or a commercial property with total square footage < 2000 ft^2

If the project meets all of the criteria listed above, then a Streamlined Permit process may be allowed. Both Streamlined and Standard Permits require the same information to be submitted to L&I for review. A Streamlined Permit allows for a quicker review time (usually over the counter or same day) while a Standard Permit will require up to 20 business days. However for an additional fee, a Standard Permit may be expedited.

Appendix C contains the following information to assist the electrical permit process:

- Electrical Permit Flow Diagram (Streamlined and Standard Permit)
- Electrical Permit Checklist (includes all the documentation that must be submitted to L&I)
- Sample Site Plan (required for submittal)
- Standard Electrical Diagram (required for submittal)
- Notes for Electrical Diagram (required for submittal)

4.4.2 Building Permit

L&I receives applications for building permits for PV installations. Within the review for building permits, zoning and fire requirements are evaluated. The following three subsections discuss these three requirements.

4.4.2.1 Building Requirements

Building Permits are required for PV installations. Permitting for the building portion of the installation is regulated by the Philadelphia Building Construction and Occupancy Code (BCOC).

L&I has developed a simplified (Streamlined Permit) plan review and permitting process for pre-engineered systems that meet the following criteria:

- Less than 10 KW
- Weighs less than 5 pounds (lb) per square foot

Los Balcones – Philadelphia
Source: Celentano Energy Services

- Imposes less than 50 lb point load in any location
- Height is less than 18 inches above the adjacent roof
- Will be installed as per manufacturer's instructions/configuration

A Streamlined Permit can be granted within 1 to 3 business days. A Standard Permit will require a full plan review and will require 20 to 25 business days. A Standard Permit will also require additional calculations to be submitted for review.

Appendix D contains the following information to assist the building permit process:

- Building Permit Flow Diagram (Streamlined and Standard Permit)
- Building Permit Checklist (includes all the documentation that must be submitted to L&I)
- Structural Submittal for Streamlined Permit
- Structure Worksheet WKS1

[Note: L&I is preparing to allow installations on 1 and 2 family dwellings to be done without a building permit if the licensed electrician will accept responsibility for meeting the criteria for building codes listed above (4.4.2.1). L&I will use the electrical permit application as a means to incorporate the building permit requirements.]

4.4.2.2 Zoning Requirements

Presently solar installations are allowed in all zones within the City; however some PV installations may need to obtain a zoning permit. See Appendix E for the *Zoning Permit Checklist* for ground mounted PV systems. Rooftop systems will likely not need a zoning permit. Ground mounted PV systems should comply with the setbacks required in the property base zoning designation as noted in The Philadelphia Code.

If during the building permit review, a PV project triggers a zoning review or is in conflict with the zoning code, then L&I will review the permit application, determine that the limitations are exceeded, issue a refusal, and advise the contractor to obtain a zoning variance. The contractor must then apply for a zoning variance from the Zoning Board of Adjustment (ZBA). A ZBA review includes a public hearing and may range in time from several weeks to several months.

4.4.2.3 Fire Department Requirements

The Fire Department does not require permits. However, L&I provides comments on PV systems related to the ability of the fire department to respond to emergencies safely as part of the building permit review. PV systems shall meet the following fire department requirements:

- Provide four (4) foot clearance around fire department connections.
- Provide three (3) foot clearance around other roof top equipment.

5.0

BENEFITS AND INCENTIVES

Although the cost of solar energy systems is expected to decrease significantly over the next decade, financial incentives and policies that stimulate demand still drive solar energy purchases in Philadelphia today. This section provides an overview of benefits and incentives that are currently available to property owners who install solar systems and should be considered when developing a PV project.

This section will answer the following questions:

- What are the benefits of installing solar energy systems?
- What incentives are available to encourage the use of solar energy?
- Where can I find information about these incentives?
- What is the PA Solar Sunshine Program?
- Where can I find information about rebates offered through the PA Solar Sunshine Program?
- How can I obtain financing for a solar installation?
- What is Net Metering and how can I participate?
- What are Alternative Energy Certificates?
- How can I participate in Alternate Energy Certificates?

5.1 Benefits of Solar Energy

As pointed out in the US Department of Energy's Consumer Guide for Solar "Get Your Power from the Sun," people decide to buy solar systems for a variety of economic, environmental and philosophical reasons. Some people want to reduce our dependence on finite fossil-fuel resources and prevent the negative associated consequences that come with extracting it and converting it into electricity. Others like the security of reducing the amount of electricity they buy from their utility because it makes them less vulnerable to future price increases. And some people just appreciate the independence that a PV system provides.

Despite these opportunities, there are challenges to installing solar systems. An initial investment is required, paybacks can be long, and paperwork is required for permits and interconnection reviews.

To encourage the use of solar energy and to make PV systems even more affordable, several states and utilities offer financial incentives through solar rebates, net metering, feed in tariffs and other programs. Up-front cash incentives encourage customers to install renewable energy technologies by helping reduce high equipment costs. Rebate and grant amounts are often based on system size or system cost and the funding is typically awarded at the time of installation.

5.2 Database of State Incentives for Renewables and Energy Efficiency (DSIRE)

Funded by the US Department of Energy, the North Carolina Solar Center and the Interstate Renewable Energy Council maintain this comprehensive source of information on state, local, utility and Federal incentives and policies that promote renewable energy and energy efficiency. This database, presented for each state, is accessible to the public at www.dsireusa.org . For example, Figure 5.1 presents a comparison of grant programs by states. Selecting a particular state allows the user to drill down to particular programs available in that state. Links are maintained on the site to further information for the conditions for applying for each incentive that is available. When considering a solar project, the DSIRE site should be checked to determine the most up-to-date incentives that are available for the project.

When considering a solar project the DSIRE site should be checked to determine what incentives are available for the project

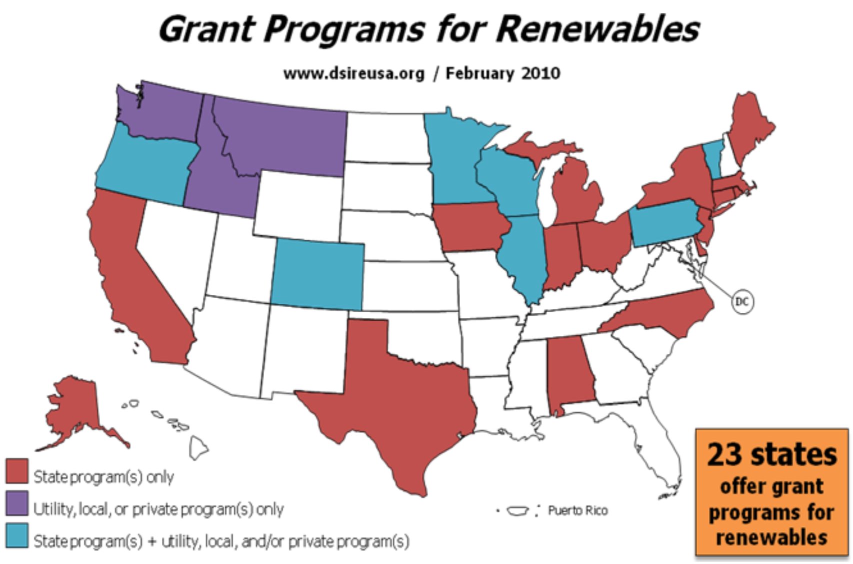


Figure 5.1: Grant Programs by State

Note: Philadelphia's local utility, PECO, does not have a rebate program but the City does have a local program called Greenworks Loan fund that provides loans, grants & rebates to eligible applicants.

5.3 Federal Incentives

To encourage consumers to invest in renewable energy or reduce their energy consumption, the US Congress created a Federal Investment Tax Credit (ITC) for Consumer Energy Efficiency that allows for a 30% credit on federal income tax returns. Applicable to solar energy systems, the credit is based on the full cost for the installation, not just the incremental cost after accounting for rebates from the PA Sunshine Solar Program. rebates (see Section 5.4 State Incentives in Pennsylvania). However there is still some uncertainty whether the Sunshine Program rebates are considered taxable income, which would affect the cost basis to apply the 30% ITC against. The tax credit can be combined with other

US Tax credit allows for a 30% credit on federal income tax returns based on the entire installation cost, not just the incremental cost after the Sunshine Program rebate.

energy improvements, such as the purchase of energy star appliances. Presently there is not a maximum limit on the total amount of the credit. More detail about the tax credit is available at www.energystar.gov/taxcredits.

5.4 State Incentives in Pennsylvania

Through passage of the Pennsylvania Alternative Energy Investment Fund, the State established the PA Sunshine Solar Program fostering solar power to create jobs, promote business development and stimulate energy independence, as well as reduce the environmental impacts from electricity generation and fossil fuel usage. The Pennsylvania Alternative Energy Investment Fund provides the following funding for our solar energy future:

- $100 million through the PA Sunshine Solar Program to provide loans, grants and rebates that cover up to 35 percent of the costs residential consumers and small businesses incur from installing solar energy technology. It is important to note that these rebate levels are established by DEP and will change over time.
- $80 million in grants and loans for economic development projects in the solar sector. These solar grants are administered by the Commonwealth Finance Authority.

> To obtain rebates or incentives from the Commonwealth of Pennsylvania, the solar installer must be on the PA Department of Environmental Protection's (PA DEP) approved solar installers list. Installers interested in participating in the program may obtain an application at www.depweb.state.pa.us by selecting "Energy Independence."

PA DEP recommends also using the US DOE DSIRE website (www.dsireusa.org) to gain access to the Solar Sunshine Program information as installers/property owners can learn about other rebates and incentives besides the Solar Sunshine Program.

According to the PA Governors Solar Working Group, incentives offered through the Pennsylvania Sunshine Solar Program will reduce the purchase cost of a PV system by a maximum of 35%[17]. The program has several steps of rebate levels for both the residential and small commercial systems which decline in their amounts based on aggregated capacity levels approved. Originally, the Step 1 rebate level for residential systems was $2.25/watt for PV systems 10 kW or less; however it has dropped into the Step 2 by March 2010, with the rebate level of $1.75/watt. (Note: At the time of publication, all Sunshine program funding for the small commercial has been reserved.) Visit the PA Sunshine Solar website to see current rebate levels available.

> Pennsylvania Sunshine Solar Program will reduce the purchase cost of a PV system by a maximum of 35%.

The PA DEP maintains the "Guide to Energy/Green Technologies Funding Programs In/For PA." This list should be reviewed to determine funding sources that are best suited for specific projects.

As noted above, the rebate levels in the PA Sunshine Program will decline over time based on the accumulated blocks of solar PV capacity installed; refer to the PA Sunshine Program website

[17] Governor's Solar Working Group, Solar Energy Systems, "Here Comes the Sun! A Guide for Pennsylvania Municipal Officials", 12/1/2009

(www.depweb.state.pa.us/pasunshine) for further information or current status of the rebate level.

It is worth noting that the price for solar PV modules has dropped by about 20% or more during 2009 which will make solar PV systems more cost effective.

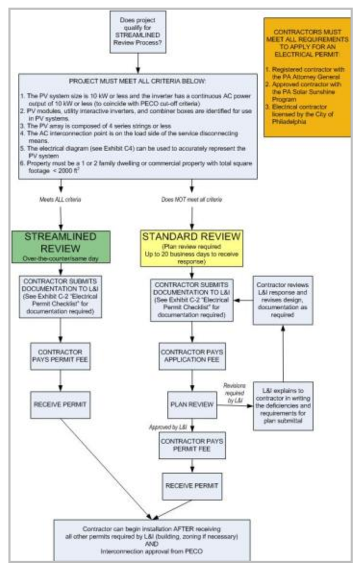
5.5 City of Philadelphia Incentives

Philadelphia has committed to purchasing green power to supply 20% of its electricity by 2015, Target 4 of Greenworks Philadelphia. Philadelphia's goal includes 57.7 megawatts (MW) of solar power by 2021.

In addition to purchasing green power for city owned buildings, Philadelphia has developed several incentives to encourage property owners to invest in green power. Currently Philadelphia offers four types of incentives:

- **Reduction of permit fees:** The City is reducing its permit fees to $25 per $1000 of labor (rather than per $1000 of equipment and labor). Given that the majority of solar installations costs are for equipment and materials, basing the fee on labor costs is a noticeable incentive that further reduces the overall project cost.

- **Development of streamlined permit process for small systems:** The Department of License and Inspections has developed a streamlined process for small systems (meeting criteria in Section 4), that eliminates the need for an unnecessary and lengthy plan review process. As such, contractors should be able to obtain permits on the day they submit their application, providing the application is complete. Contractors should use the checklists provided in Appendices C, D and E to assure that all necessary information is submitted.



- **Potential financing through the Greenworks Loan Fund:** Businesses may obtain reduced rate loans for energy efficiency improvements, including PV installations. This loan is further detailed in Section 5.6: *Financing Alternatives*.

- **10 yr tax abatement** : A 10 year tax abatement on property value increases resulting from solar improvements can be obtained through the City of Philadelphia, Bureau of Revision of Taxes (BRT).

5.6 Financing Alternatives

Property owners may be able to obtain public and/or private financing to help with alternative energy improvements or additions to new construction. New programs or updated information on existing programs is maintained by the Database of State Incentives for Renewables and Efficiency. Programs that are currently available in the Philadelphia area are identified below:

Keystone Home Energy Loan Program. Pennsylvania homeowners who own and are making qualifying improvements to their primary residence located in Pennsylvania and whose combined annual household income is $150,000 or less are eligible to apply for a loan or rebate under the Keystone HELP program. These low-interest loans are funded by Pennsylvania Treasury

Department for home efficiency projects and the installation of alternative systems. This program is managed by AFC First, a private lender.

Improvements must be made to 1 to 2 unit owner-occupied dwellings. Work under the secured "Whole House Improvement Loan" or Renovate and Repair Loan programs must be done on a 1-2 unit owner occupied, deeded property.

Applicants also agree to:

- Complete or provide data on energy usage for completion of the Energy Star Home Energy Yardstick or equivalent;
- Grant access to utility and fuel consumption data to the Department of Environmental Protection or its designees for 12 months from the date of the rebate or loan (not applicable for Renovate and Repair Energy Star Loan); and
- Complete a follow up survey in approximately 12 months from the date of the loan or rebate.

More information on the Keystone Help program can be obtained at www.keystonehelp.com.

The Sustainable Development Fund. The Pennsylvania Public Utility Commission created the Sustainable Development Fund (SDF) in the Commission's 1998 final order of the PECO Energy electric utility restructuring proceeding. The Reinvestment Fund, Inc. (TRF), which was formed in 1985 to build wealth and opportunity for low-wealth communities and low- and moderate-income individuals, administers the SDF.

Los Balcones – Philadelphia
Source: Celentano Energy Services

SDF later received additional funding and responsibilities as a result of the PECO Energy/Unicom merger settlement. That settlement added funding for new wind development, for solar photovoltaics and for renewable energy education, as well as a lump-sum payment and an increase in SDF's core fund. In total, SDF has received approximately $31.8 million in income from PECO. In addition to the PECO funding, TRF is receiving an additional $21.3 million in federal Recovery Act funding for a revolving loan fund to finance energy conservation improvements in commercial buildings. Between 2003 and 2009, the SDF Solar PV Grant Program provided funding to offset the installation cost for over 225 solar PV systems, totaling over 800 kW of PV capacity mostly in the five county area around Philadelphia. This included over 70 solar PV systems, totaling over 170 kW of PV capacity in Philadelphia alone.

The Reinvestment Fund (TRF) is committed to building a clean and sustainable energy future for our region. TRF provides a variety of financial products and services for businesses, nonprofit organizations, and housing developers to implement energy conservation and efficiency measures and the use of renewable energy and other advanced clean energy technologies. (www.trfund.com/energy)

Greenworks Program Loan Fund. Philadelphia created two sources of green funding for small businesses:

- $9 million in Greenworks Loans available in amounts from $100,000 to $1 million, and
- $500,000 in Greenworks Rebates available in amounts up to $10,000.

The funding is a blend of Recovery funds from the Energy Efficiency and Conservation Block Grant and private capital from The Reinvestment Fund.

Applications for both Greenworks Loans and Greenworks Rebates are available now through the City's Business Services Center.

Private Lenders. Currently only a few private lenders offer loans for alternative energy improvements. In Philadelphia, they can be obtained at several banks including PNC, Beneficial Bank and Sovereign Bank.

5.7 Net Metering

Net metering allows the electric customers who generate their own electricity to receive value for the power that the PV system generates but is not used on the property. Currently by Pennsylvania law, investor-owned utilities (such as PECO) must offer net metering to customers that generate electricity.

The Public Utility Commission regulates the terms and rates that utilities provide for net metering. For PECO, residential customers purchase agreements are currently capped at 50 kW; while non-residential customers are capped at 3 MW. Net metering must also be offered to customers with systems greater than 3 MW, but no more than 5 MW, who make their systems available to the grid during emergencies, or where a microgrid is in place in order to maintain critical infrastructure.

> ***Net Metering***
>
> Net metering allows for the flow of electricity both to and from the customer which means that when a PV system generates more power than is needed, the excess goes to the utility grid and the meter runs backward

If a PV system generates more than the building consumed, then the extra electricity generated ("Net Excess Generation") is carried over to the next month as a credit to the customer's bill at the full retail rate. At the end of the year, the customer is compensated for any net excess generation that is on a customer's bill at the "Price To Compare" which is determined at the end of the PJM year which is May 31. The price to compare is most likely less than the true worth of the solar generated kWh, so sizing your system to the building usage is best.

Pennsylvania net metering law also allows for ***Virtual Net Meter Aggregation*** – whereby a single electric account holder with several accounts (meters) within a 2 mile radius, can take full credit from surplus generation from a PV system interconnected at just one of those accounts. This is a great application for multiple homes, farms, campuses, apartment complexes, townships, and possibly the City of Philadelphia itself.

For the complete Terms and Conditions for Interconnection, visit PECO's website for Net Metering and Interconnection Requirements.

5.8 Solar Renewable Energy Credits

Another benefit of installing a solar PV system is that there is a monetary value associated with its positive impact on the environment as a source of clean energy. In Pennsylvania, this value (or attribute) is known as a Solar Alternative Energy Credit (Solar AEC or SAEC). (Note: This value is known throughout the country under different terms such as Solar Renewable Energy Credit (Solar RECs); however generally speaking they have the same meaning. Renewable Energy Credits (RECs) is a commonly used term throughout the country for credits that are generated from renewable energy sources including solar, wind, small hydro and biomass. RECs are widely used to meet various state renewable portfolio standards and are traded in both compliance and voluntary programs in wholesale and retail markets across the U.S.) A Solar AEC represents 1 MWh generated from a certified source of solar electricity (similarly Solar RECs also typically represent 1 MWh generated by a certified solar electricity source). It is measured through either estimated or actual metered production.

Bradley 5.12 kW PV System, Philadelphia
Source: Celentano Energy Services

SRECs are designed to provide incentives for individuals and businesses to invest in the development of the solar energy industry in Pennsylvania

Pennsylvania has an Alternative Energy Portfolio Standard (AEPS) which requires an annually increasing percentage of electricity sold to retail customers in Pennsylvania to be generated from renewable and alternative energy sources. The legislation, Acts 213 and 129, which implemented the AEPS named the credits that qualify for the program, Alternative Energy Credits (AECs). It is important to note that AECs in Pennsylvania are not exclusively derived from renewable energy resources but also include other Pennsylvania-specific alternative resources (such as landfill gas). Goals of the AEPS are accomplished by Electric Distribution Companies (EDCs) and Electric Generation Supplies (EGSs such as Hess, Exelon, etc.) who are required to purchase a certain amount of credits in order to meet their obligation.

As an economic mechanism of Pennsylvania's Alternative Energy Portfolio Standard (AEPS), EDCs and EGSs can buy and sell Solar AECs within the Pennsylvania Compliance Market in order to fulfill their solar share requirements stipulated under the AEPS. This provides incentives for renewable energy marketers, private businesses and individuals to invest in the development of the solar energy industry in Pennsylvania. This compliance market for solar credits makes it easier for individuals and businesses to finance and invest in clean, emission free solar power.

If a solar PV system is installed at a home or business, the owner can apply for the system to be certified in the PA AEPS program. It is important to note that an owner cannot earn Solar AECs until they submit their application to the PA AEPS program (any electricity generated by the system before an application is submitted will not earn SAECs). Once the system receives a certification number the owner can start tracking and reporting the solar production in order to earn Solar AECs. As mentioned earlier, Solar AECs are issued for every 1MWh of solar electricity through either estimated or actual metered production. SAECs are sold separately from generated power, and can be sold and traded by individual entities, or they can be aggregated and sold through agreements with agents commonly known as "aggregators." Like any commodity, the price of SAECs is a function of supply and demand. More information about the PA AEPS program can be obtained at www.paaeps.com.

The State of Pennsylvania currently utilizes the PJM-EIS GATS credit registry to issue and track and SAECs/SRECs. Their website is www.gats.pjm-eis.com.

APPENDIX A

GLOSSARY OF TERMS

Glossary of Terms

Alternating Current: Alternating current is an electric current whose direction reverses cyclically, as opposed to direct current (DC), whose direction remains constant. AC is the form of electricity that is delivered to your home or business. Solar photovoltaic (PV) systems produce DC power, which must be converted to AC by an inverter.

Alternating Current Module (AC Modules): A complete, environmentally protected unit consisting of solar cells, optics, inverter, and other components, exclusive of tracker, designed to generate ac power when exposed to sunlight

Amorphous Silicon: A very thin layer of silicon that is deposited on a substrate (glass, metal or plastic) in a manner to create a PV module. This is one of the technologies used in making thin-filmed PV modules.

Azimuth: Azimuth is the horizontal angular distance between the vertical plane containing a point in the sky and true south. The azimuth angle is the location of the sun in terms of North, East, West or South.

Array: An interconnected system of PV modules that function as a single electricity-producing unit. The modules are assembled as a discrete structure, with common support or mounting. In smaller systems, an array can consist of a single module..

Balance of System: the components in a PV system (other than PV modules) that include source-circuit combiner boxes, inverters, disconnects, overcurrent devices, electrical wiring, junction boxes and support structure.

Ballasted Mounting: A type of PV mounting system that is held on the roof using weights and does not require roof penetrations.

Batteries: In the context of PV systems, batteries are used for storing excess electricity generated by a PV system when the building is using less electricity than the system generates; batteries can store electricity for use when utility power is unavailable such as during a grid outage or for off-grid systems.

Building-Integrated Photovoltaics (BIPV): A term for the design and integration of photovoltaic (PV) technology into the building envelope, typically replacing conventional building materials. This integration may be in vertical facades, replacing view glass, spandrel glass, or other facade material; into semitransparent skylight systems; into roofing systems, replacing traditional roofing materials; into shading "eyebrows" over windows; or other building envelope systems.

Capacity rating: The maximum expected energy production from a PV system.

Cell Matching Losses: The loss in potential production due to the gaps in discrete solar cells.

Centralized Generation: A method of producing electricity with large, remote power plants that require high-voltage transmission lines to deliver the power.

Conservation: In the context of energy, using energy resources in such a way as to minimize energy consumption in relation to benefits gained.

Crystalline Photovoltaic: A type of photovoltaic cell made from a slice of single-crystal silicon or polycrystalline silicon.

Derate Factor: The value that represents the losses from the DC nameplate power rating to determine the AC power rating; the system derate factor is the mathematical product of derate factors of individual components in a PV system.

Direct Current: Solar PV systems produce electricity in direct current (DC), which is defined as the continuous flow of electricity through a conductor. In DC, electricity always flows in the same direction, which

Distributed Generation: A method of producing electricity with small, efficient power plants located near or at manufacturing facilities, universities, hospitals, and other large institutions.

Energy: Energy is the ability to do work or the amount of work actually performed. For our purposes here, energy is given in kilowatt-hours (kWh) of electricity produced by a PV system or consumed in a home or business. When most people pay their utility bill, they pay for the electricity they consumed in kWh.

Energy-efficiency: The use of a lower level of energy to accomplish the same task

Flat Plate Collectors: An arrangement of photovoltaic cells or material mounted on a rigid flat surface with the cells exposed freely to incoming sunlight.

Flexible Substrate: A flexible base on which thin film PV is laminated

Grid-connected/Grid-tied: A solar electric or photovoltaic (PV) system in which the PV array acts like a central generating plant, supplying power to the grid.

Ground Continuity: A test that is performed to verify that the safety ground is present in an electrical system.

Ground Cover Ratio: the ratio of the PV array area to the total ground area

Insolation: The amount of energy that shines on a building or area, equivalent to energy an usually expressed in annual kilowatt-hours per square meter.

Insulation Test/Megger: A test to see is the insulation of a conductor has been injured in any way to cause a short circuit when normal power is applied to it (performed by a megometer)

Integral Mounting: a method for mounting PV modules on a building where the modules are integrated into the roofing or exterior of the building itself.

Interconnection: The process of connecting an electricity-producing technology (like a PV system) to the electricity grid.

Inverter: Equipment that is used to change voltage level or waveform, or both, of electrical energy (such as converting direct current (DC) electricity produced by a solar system into the alternating current (AC) electricity that can be used in a home or building). Commonly, an inverter [also known as a power conditioning unit (PCU) or power conversion system (PCS)] is a device that changes dc input to an ac output. Inverters may also function as battery chargers that use alternating current from another source and convert it into direct current for charging batteries.

Irradiance: Sunlight intensity; the direct, diffuse, and reflected solar radiation that strikes a surface; usually measured in watts per square meter.

Isolation Device: Usually a disconnect switch that is used to cut off the PV system from the grid

Kilowatt (kW): A unit of electrical power equal to 1,000 Watts, which constitutes the basic unit of electrical demand. The Watt is a metric measurement of power (not energy) and is the rate (not the duration) at which electricity is used. 1,000 kW is equal to 1 megawatt (MW).

Kilowatt-hour (kwh): A unit of electrical energy, equivalent to the use of 1 kilowatt of electricity for one full hour. Utilities measure customers' electric energy usage on the basis of kilowatt-hours, and electricity rates are most commonly expressed in cents per kilowatt-hour...

Life-cycle cost: The estimated cost of owning and operating a photovoltaic system for the period of its useful life.

Loads: Describes the amount of power (amps) consumed by an electrical circuit or device. Loads are usually expressed in amps but sometimes in watts. Also describes the amount of power carried by a utility system or the amount of power consumed by an electric customer at a specific time.

Losses: The discrepancy between energy or power produced at a source and the energy or power delivered to an end point; in PV systems losses are caused by individual components in the system including wiring, inverter/transformer efficiency, diodes and connections, soiling, etc.

Mismatch: The loss is solar production caused by having solar cells of differing sensitivities in the same array.

Megawatt (MW): Unit of electric power equal to 1,000 kW, or 1 million Watts.

Meter: A device used to measure and record the amount of electricity used or generated by a consumer.

Module: A complete, environmentally protected unit consisting of solar cells, optics, and other components, exclusive of tracker, designed to generate dc power when exposed to sunlight. A module is the smallest protected assembly of interconnected PV cells..

Monocrystalline: A type of photovoltaic (PV) cell technology produced by melting highly refined silicon. For a Monocrystalline silicon cell, a "seed" is dipped into molten silicon and allowed to solidify into a silicon "ingot," which is then sliced into wafers. The wafers are laminated between sheets of glass to produce a monocrystalline silicon cell. Compare with polycrystalline silicon cells.

Multicrystalline: A semiconductor (photovoltaic) material composed of variously oriented, small, individual crystals. Sometimes referred to as polycrystalline.

MVA: Apparent power expressed in million volt-amps

NABCEP: North American Board of Certified Energy Practitioners, the certifying body for solar photovoltaic and thermal installers.

Net Metering: Net metering is a billing mechanism that credits solar system owners for the electricity exported onto the electricity grid. Under the simplest implementation of net metering, a utility customer's billing meter runs backward as solar electricity is generated and exported to the electricity grid and forward as electricity is consumed from the grid

Off Grid: A renewable energy system designed to meet the full electrical requirements of a site. Requires batteries to store energy for use at times of lower production (e.g., nighttime). May also be coupled with a generator to provide additional power supply. Often an economical alternative in locations without direct access to utility lines. Compare with grid-connected system.

Open Circuit Voltage: The voltage that occurs in a module when it is not supplying any current (i.e. when the module is disconnected from all loads). The open circuit voltage of a module can also be used to determine the open circuit voltage of a circuit/string or the entire PV array.

Orientation: A term used to describe the direction that the surface of a solar module faces. The two components of orientation are the tilt angle (the angle of inclination a module makes from the horizontal) and the azimuth (based on true South, not magnetic North/South).

OSHA: The Occupational Safety and Health Administration. Regulatory body that provides construction standards and are covered in Chapter 29 of the U.S. Code of Federal Regulations, Part 1926, Safety and Health Regulations for Construction. All PV installers should be familiar with OSHA construction standards.

Panel: A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit

PA Solar Sunshine Program: A program offered by the Commonwealth of Pennsylvania that provides rebates to help fund solar electric (solar photovoltaic, or PV) and solar hot water (solar thermal) projects for homeowners and small businesses in Pennsylvania. This program was authorized by section 306 of the Alternative Energy Investment Act, Act of July 9, 2008

PECO: Based in Philadelphia, PECO is an electric and natural gas utility subsidiary of Exelon Corporation. It serves 1.6 million electrical customers in southeastern Pennsylvania and is the state's largest utility. All PV systems that are grid-connected in Philadelphia must meet PECO's requirements for net metering and interconnection.

Pennsylvania Approved Solar Contractor: An installer that has been approved to participate in the PA Sunshine Program. A list of approved installers can be found on the DEP website. Installers need to meet certain criteria before being listed.

Philadelphia Department of License and Inspections (L&I):

Photovoltaic: The technology that uses a semiconductor to convert light directly into electricity.

PJM: PJM Interconnection is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

Polarity: Having an indicated pole (as the distinction between positive and negative electric charges); Polarity of all source circuits should be checked during installation (improper polarity can cause severe damage to the array and system electronics and has been known to cause fires in some systems).

Polycrystalline Photovoltaics: See **Multicrystalline**

Power: Power is the rate at which energy is generated or consumed, that is, kilowatt-hours per hour (kWh/h) or kilowatts (kW)

PV Cell (also called a solar cell): The basic photovoltaic device that generates electricity when exposed to light.

PV Laminates: Flexible and lightweight PV modules that typically use triple-junction

REC: Renewable energy certificates (RECs), also known in Pennsylvania as alternative energy credits (AECs) represent the environmental attributes of the power produced from renewable energy projects. When a homeowner or business owner installs a renewable energy system (such as solar), they become the owner of these environmental attributes, or RECs, which have value in the marketplace, and, in most cases, will help reduce the cost of a system.

SREC: Solar Renewable Energy Credit: RECs generated from a solar energy system including photovoltaic and solar thermal.

RPS (Renewable Portfolio Standard): A policy set by federal or state governments requiring that a certain percentage of the area's electricity come from renewable sources.

Short Circuit Current: The current of a module measured when it is disconnected from the rest of the system. Measuring the short circuit current of a module is one way to test for good or bad modules. The short circuit current of a module can also be used to determine the short circuit current of the string/circuit or entire array.

Single Crystalline Photovoltaics: See **Monocrystalline**

Soiling: The accumulation of dirt on solar panels

Standard Test Conditions (STC): A set of controlled conditions under which PV modules are tested in a laboratory. The output rating of modules is typically based on output measured when subjected to these conditions.

Standoff Mounting: A method of mounting PV modules on a building where modules are mounted above and parallel to the roof surface.

String Sizing: Designing the basic electrical circuit of a PV array typically includes PV modules electrically wired in series; relevant for PV system design because the string size determines the maximum DC system voltage that the PV system will generate (important for electric code compliance).

Sun Chart: a chart denoting the position of the sun in the sky for a particular area with the altitude on the y-axis (typically 0 to 90 degrees) and the azimuth on the x-axis (typically -120 to +120 degrees or East to West). Graphs of the sun's position in the sky can be made at different days of the year and by time of day.

System Commissioning: A quality oriented process for achieving, verifying and documenting that the performance of a system and assemblies meets defined objectives and criteria.

Thin Film Photovoltaics: A layer of semiconductor material, such as copper indium diselenide or gallium arsenide, a few microns or less in thickness, used to make photovoltaic cells.

Uninterruptible Power Supply: (UPS) — The designation of a power supply providing continuous uninterruptible service. The UPS will contain batteries.

Utility Grid (Grid): An integrated system of electricity distribution, usually covering a large area.

Utility-Scale: Utility-scale solar energy facilities are facilities that can generate large amounts of electricity to be put directly into the electricity transmission grid.

Watts (W): a standard unit of electrical power, named after physicist James Watt.

- **Kilowatts (kW):** a standard unit of electrical power equal to 1,000 watts
- **Megawatts (MW):** a standard unit of electrical power equal to 1,000 kilowatts

Weatherization: Modifying a building envelope to reduce energy consumption for heating or cooling; involves adding insulation, installing storm windows and doors, caulking cracks and putting on weather-stripping.

APPENDIX B

FREQUENTLY ASKED QUESTIONS

Frequently Asked Questions

1. **What type of permits will we need to do the installation? Building permit? Electrical permit? Both? etc**

   Currently both types of permit applications are required. Electrical requires 3 sets of plans to be submitted along with the completed application.

2. **Will we need to submit engineering files? Ex. CAD file?**

   Engineer sealed plans are not required for systems 10kwh or less. Plans must be hard copy, black and white or blueprint, no electronic or digital files can be accepted.

3. **What are the cost of the permit/permits required?**

   Electrical

   Streamlined review fees (based upon labor costs only*): $25.00 per $1000.00 worth of work
   $3.00 City surcharge
   $4.00 State surcharge
   $4.00 per page of the plan
   Standard review fees (based upon labor costs only*): $100.00 due at time of application.
   $125.00 additional due for rough wire option*
   $540.00 additional due for accelerated review option*
   $25.00 per $1000.00 worth of work
   $3.00 City surcharge
   $4.00 State surcharge
   $4.00 per page of the plan

   **The associated costs of electrical equipment, conductors, conduit and material shall not be included in the construction cost calculation.*

4. **How long does it take to get the permit/permits? Estimate on lead-time?**

   A streamlined review (systems < 10kwh) could take a few days. A streamlined review for Electrical Energy Systems typically includes a technical conversation about the installation. It is suggested that the Electrical contractor be present for the review. Currently, a streamlined review is conducted at the time of submittal. A standard review can take up to 25 business days. There is an option for accelerated review of standard submittals that can take up to 5 days at an additional cost of $540.00 for accelerated review.

5. **We have relationships formed with qualified, certified installers/sub-contractors in Philadelphia. Are there any requirements in terms of who we use as solar sub-contractors and installers?**

   Only Electrical contractors licensed by the City of Philadelphia can obtain electrical permits.

6. **I'm planning to install a PV system on a roof using a pre-engineered mounting product made by a company that specializes in PV mounting systems. Do I need a building permit?**

   Yes, currently a building permit is always required. L&I is planning to combine the electrical and building permit applications into one application form if the licensed electrician will accept responsibility for meeting the criteria for building code requirements.

7. **How do I know if my project will require a zoning permit?**

   Zoning permits are not required for rooftop PV systems, but are required for ground-mounted PV systems.

8. **How long does it take to get permits from the City of Philadelphia?**

   Electrical permits: streamlined up 3 days (but may be same day); standard up to 25 days
   Building permits: streamlined 1-3 days; standard up to 25 days

9. **Why do I need to coordinate with PECO so early in the process?**

   To ensure that the electric lines serving the home or building can accommodate a customer-sited generating unit.

10. **If I'm NABCEP certified, do I need any other credentials, licenses or registrations to install a PV system in Philadelphia?**

    Yes, the City of Philadelphia requires licensing/registration from the following:

    A. State Home Repair Registration (by the State Attorney General's Office) for projects on 1-2 family dwellings and for contractors who perform at least $5,000 worth of home improvements – State Requirement

    B. Business Privilege License (by L&I) for projects on 1-2 family dwellings all companies associated with any project within the city of Philadelphia – City Requirement

    C. Contractor's License (City Requirement by L&I) for all projects that are:

       1. Not performed by an electrical contractor

       2. Performed on all projects other than 1 and 2 family dwellings – City Requirement

    D. Electrical Contractor's License (by L&I) for all projects involving electrical work – City Requirement

    E. Approved List of Solar Contractors (by the PA DEP Solar Sunshine Program) recommended for all projects, required for projects pursuing state rebates – RState Rebate Requirement

    F. Contractors must meet insurance requirements as determined by L&I.

11. **What if I have questions about the code or process for L&I?**

Contact the City at buildingcodeofficial@phila.gov. Please contact us for L&I related matters, not PECO related matters.

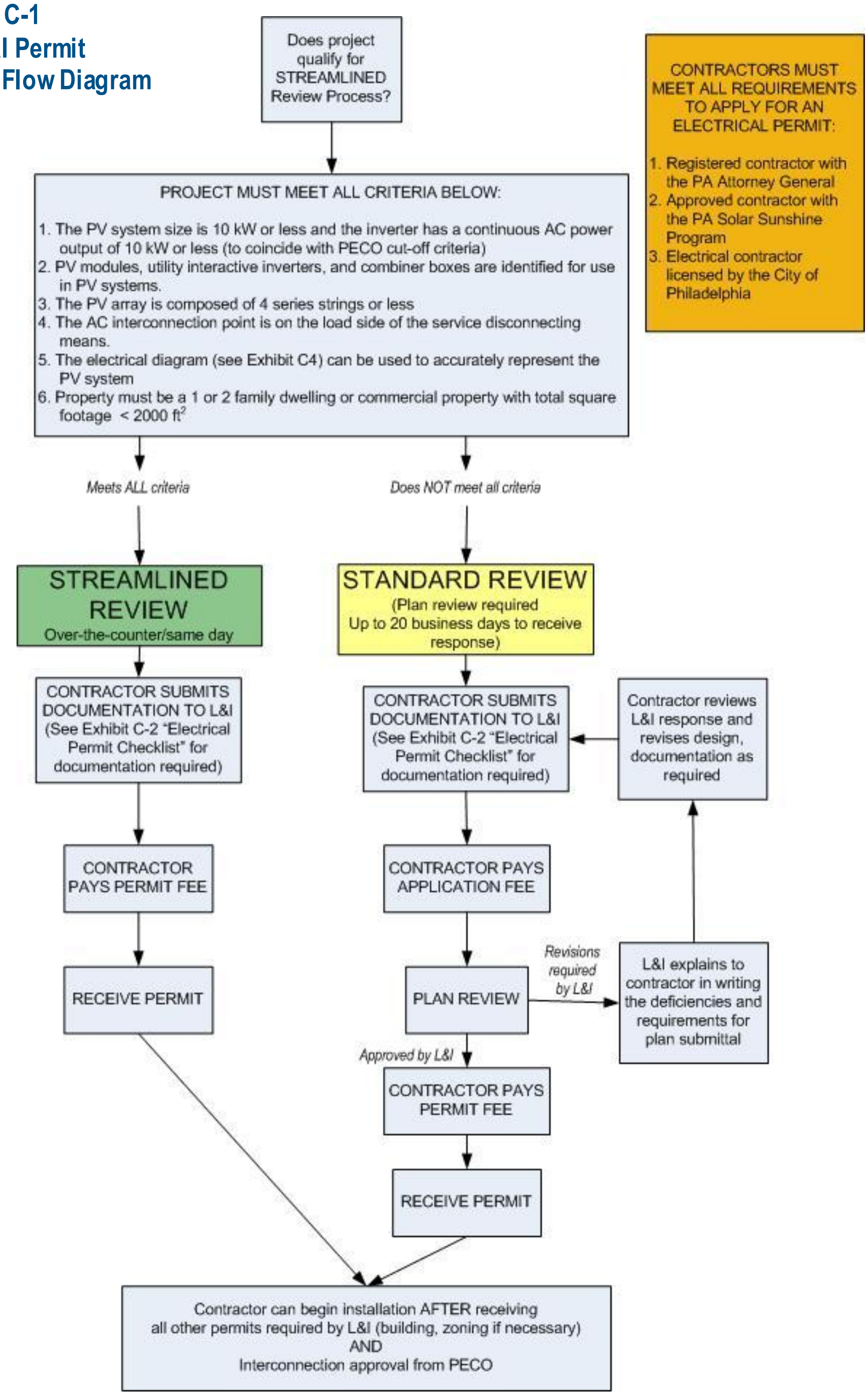
12. **Where should I apply for permits for my solar project?**

    L&I is located on the Concourse of the Municipal Services Building at 1501 JFK Blvd. It is open Monday through Friday from 8 AM to 3:30 PM except for the last Wednesday of each month.

APPENDIX C

ELECTRIC PERMIT REQUIREMENTS FOR THE CITY OF PHILADELPHIA DEPARTMENT OF LICENSES & INSPECTIONS

EXHIBIT C-1
Electrical Permit Process Flow Diagram



Notes:

1. A streamlined review for Photovoltaic Systems typically includes a technical conversation about the installation. It is suggested that the Electrical contractor be present for the review.
2. The issuance of an electrical permit and inspection approval does not guarantee approval from the local utility.

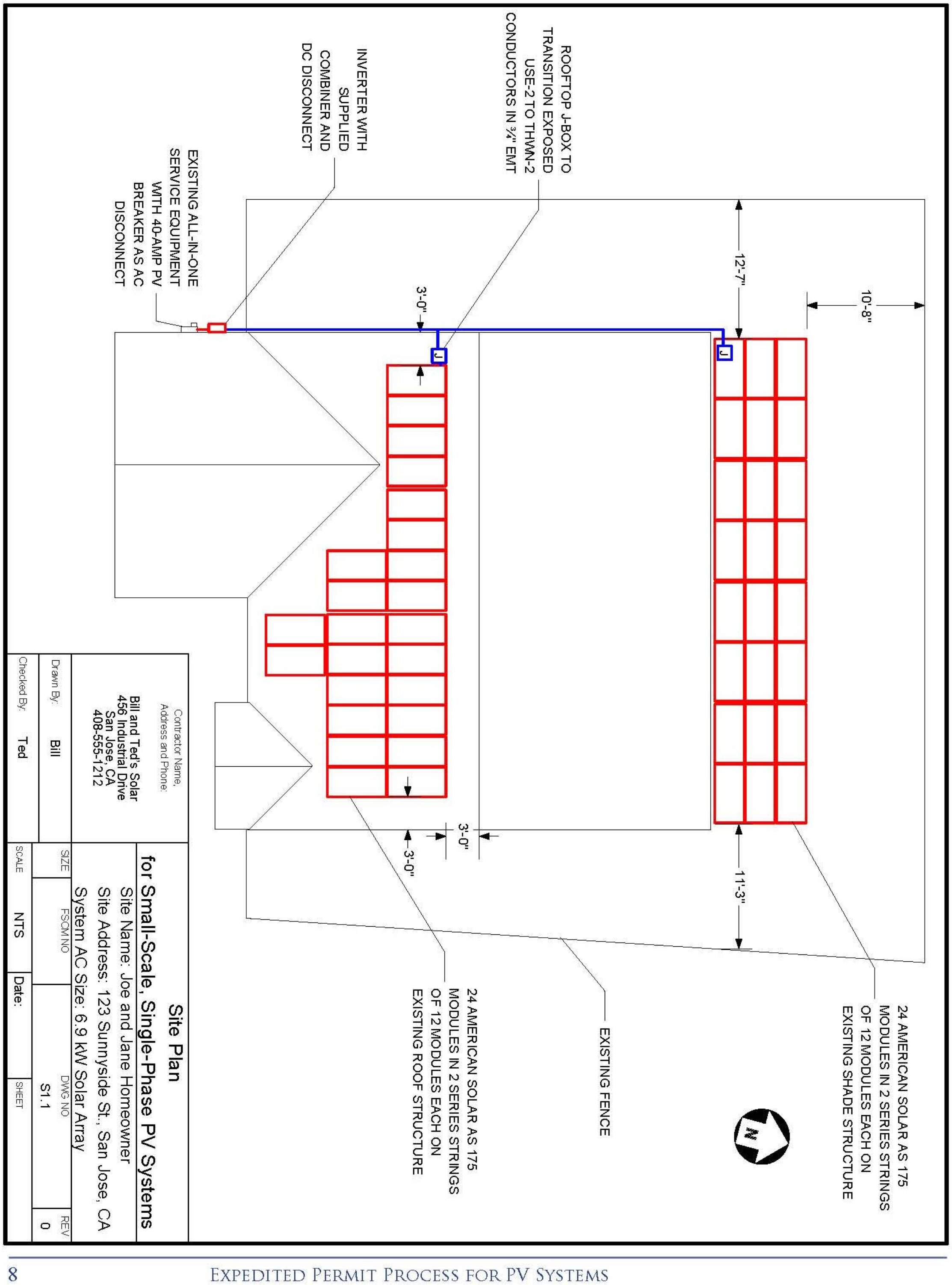
EXHIBIT C-2
Electrical Permit Checklist

Electrical permits are required for all PV projects. The following information must be submitted for Streamlined Permits and Standard Permits (any exceptions are noted in the requirements).

1. You must be a registered Electrical Contractor in order to obtain a permit with the City of Philadelphia.
2. Application for Electrical Permit
   - Available for download at L&I's Electrical Permit website
   - Provide the following information on the application:
     - Location of Property – Provide the house number(s) and street name. [Note: Only addresses issued by the Board of Revision of Taxes will be accepted]
     - Explain any alteration or construction [Note: such as add a 10 kW Photovoltaic solar array]
     - Location of the construction within the building
     - List the present use of the existing building.
     - Provide the name, address, and telephone number of the owner(s), architect, engineer, and the name of the person filing the application. [Note: If you are not the registered owner of the property, you must have the permission of the owner of record to file the application.]
     - Electrical Contract License Number
     - Attorney General Registration Number
3. Electrical Site Plans (3 copies)
   - Provide the following Information (see Exhibit C-3 *Site Plan* drawing for an example):
     - Location of major components on the property and in system (including PV Array, junction boxes, disconnects, inverter, connection with existing service) and noting 3 foot perimeter space at roof ridge and sides for rooftop systems.
     - AC connection with the building
4. Electrical Diagrams *(For details regarding calculations and other information required for this submittal, see "Expedited Permit Process for PV Systems" by the Solar America Board for Codes and Standards)*
   - Submit a single-line diagram.
     - For Streamlined Permit, submit Exhibit C-4 Standard Electrical Diagram if the project qualifies for the Streamlined Permit.
     - For Standard Permit, electrical diagram must include the following details at a minimum:
       - PV array configuration
       - Wiring system
       - Overcurrent protection
       - Inverter disconnects
       - AC connection to building
   - Submit electrical diagram notes (see Exhibit C-5)

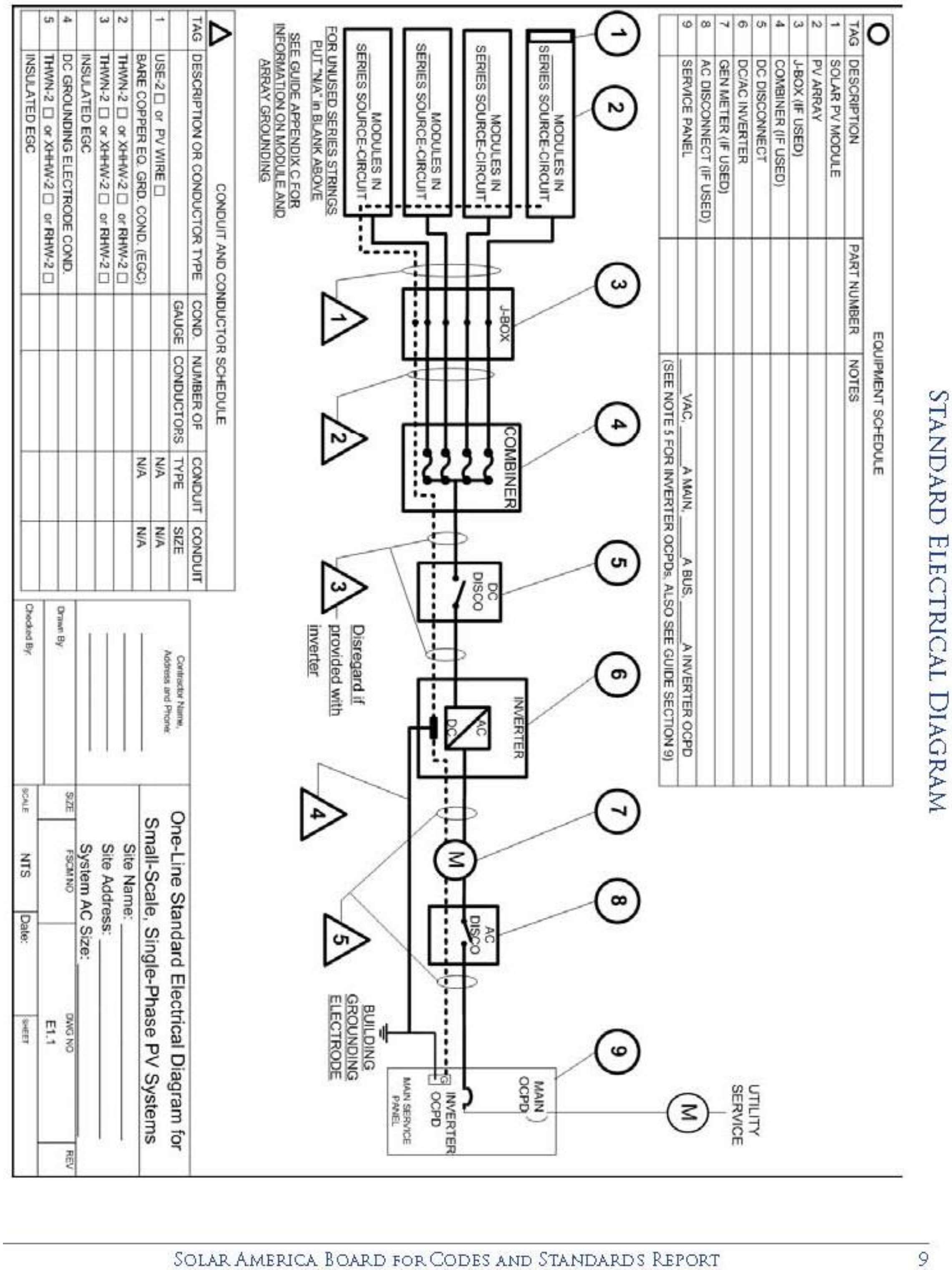
5. Specification sheets & Installation Manual
   - Provide the following Information:
     - PV Module – specification sheet must include the following (attach a digital photo of the module listing label when possible)
       a. MODULE MANUFACTURER: This is the manufacturer's name (e.g. BP Solar, Evergreen, Solar World, Sharp, SunPower, Suntech etc.)
       b. MODULE MODEL #: This is the model number on the listing label: (e.g. BP175B,, EGS185, SW175 Mono, ND-U230C1, SP225, STP175S, etc.)
       c. MAXIMUM POWER-POINT CURRENT (IMP)
       d. MAXIMUM POWER-POINT VOLTAGE (VMP)
       e. OPEN-CIRCUIT VOLTAGE (VOC)
       f. SHORT-CIRCUIT CURRENT (ISC)
       g. MAXIMUM SERIES FUSE (OCPD)
       h. MAXIMUM POWER (PMAX)
       i. MAXIMUM SYSTEM VOLTAGE
     - Inverter(s) - specification sheet must include the following (attach a digital photo of the inverter listing label when possible)
       a. INVERTER MAKE: This is the manufacturer's name: (e.g. Motech, PV Powered, SMA, etc.)
       b. INVERTER MODEL #: This is the model number on the listing label: (e.g. PVP 5200, SB7000US, etc.)
       c. MAX DC VOLTAGE RATING: Provided either on listing label or specification sheet.
       d. MAX POWER @ 40ºC:.
       e. NOMINAL AC VOLTAGE
       f. MAX OCPD RATING: This is the maximum overcurrent protective device (OCPD) rating allowed for the inverter. This is either stated on the listing label or in the installation
     - Combiner Box
     - Disconnects

EXHIBIT C-3
Sample Site Plan



Source: "Expedited Permit Process for PV Systems", Brooks Engineering for the Solar America Board for Codes and Standards, 2009

EXHIBIT C-4
Sample Electrical Diagram



Source: "Expedited Permit Process for PV Systems", Brooks Engineering for the Solar America Board for Codes and Standards, 2009

EXHIBIT C-5
Electrical Notes for Electrical Diagram

PV MODULE RATINGS @ STC (Guide Section 5)

MODULE MAKE		
MODULE MODEL		
MAX POWER-POINT CURRENT (I_{MP})		A
MAX POWER-POINT VOLTAGE (V_{MP})		V
OPEN-CIRCUIT VOLTAGE (V_{OC})		V
SHORT-CIRCUIT CURRENT (I_{SC})		A
MAX SERIES FUSE (OCPD)		A
MAXIMUM POWER (P_{MAX})		W
MAX VOLTAGE (TYP 600V_{DC})		V
VOC TEMP COEFF (mV/°C ☐ or %/°C ☐)		
IF COEFF SUPPLIED, CIRCLE UNITS		

NOTES FOR ALL DRAWINGS:

OCPD = OVERCURRENT PROTECTION DEVICE

NATIONAL ELECTRICAL CODE® REFERENCES SHOWN AS *(NEC XXX.XX)*

INVERTER RATINGS (Guide Section 4)

INVERTER MAKE		
INVERTER MODEL		
MAX DC VOLT RATING		V
MAX POWER @ 40°C		W
NOMINAL AC VOLTAGE		V
MAX AC CURRENT		A
MAX OCPD RATING		A

SIGNS–SEE GUIDE SECTION 7

SIGN FOR DC DISCONNECT

PHOTOVOLTAIC POWER SOURCE		
RATED MPP CURRENT		A
RATED MPP VOLTAGE		V
MAX SYSTEM VOLTAGE		V
MAX CIRCUIT CURRENT		A
WARNING: ELECTRICAL SHOCK HAZARD–LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION		

SIGN FOR INVERTER OCPD AND AC DISCONNECT (IF USED)

SOLAR PV SYSTEM AC POINT OF CONNECTION		
AC OUTPUT CURRENT		A
NOMINAL AC VOLTAGE		V
THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)		

NOTES FOR ARRAY CIRCUIT WIRING (Guide Section 6 and 8 and Appendix D):

1.) LOWEST EXPECT AMBIENT TEMPERATURE BASED ON ASHRAE MINIMUM MEAN EXTREME DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. LOWEST EXPECTED AMBIENT TEMP ______°C

2.) HIGHEST CONTINUOUS AMBIENT TEMPERATURE BASED ON ASHRAE HIGHEST MONTH 2% DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. HIGHEST CONTINUOUS TEMPERATURE _____°C

2.) 2005 ASHRAE FUNDEMENTALS 2% DESIGN TEMPERATURES DO NOT EXCEED 47°C IN THE UNITED STATES (PALM SPRINGS, CA IS 44.1°C). FOR LESS THAN 9 CURRENT-CARRYING CONDUCTORS IN ROOF-MOUNTED SUNLIT CONDUIT AT LEAST 0.5" ABOVE ROOF AND USING THE OUTDOOR DESIGN TEMPERATURE OF 47°C OR LESS (ALL OF UNITED STATES),

a) 12 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 7.68 AMPS OR LESS WHEN PROTECTED BY A 12-AMP OR SMALLER FUSE.

b) 10 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 9.6 AMPS OR LESS WHEN PROTECTED BY A 15-AMP OR SMALLER FUSE.

NOTES FOR INVERTER CIRCUITS (Guide Section 8 and 9):

1) IF UTILITY REQUIRES A VISIBLE-BREAK SWITCH, DOES THIS SWITCH MEET THE REQUIREMENT? YES ☐ NO ☐ N/A ☐

2) IF GENERATION METER REQUIRED, DOES THIS METER SOCKET MEET THE REQUIREMENT? YES ☐ NO ☐ N/A ☐

3) SIZE PHOTOVOLTAIC POWER SOURCE (DC) CONDUCTORS BASED ON MAX CURRENT ON NEC 690.53 SIGN OR OCPD RATING AT DISCONNECT

4) SIZE INVERTER OUTPUT CIRCUIT (AC) CONDUCTORS ACCORDING TO INVERTER OCPD AMPERE RATING. (See Guide Section 9)

5) TOTAL OF _____ INVERTER OCPD(s), ONE FOR EACH INVERTER. DOES TOTAL SUPPLY BREAKERS COMPLY WITH 120% BUSBAR EXCEPTION IN 690.64(B)(2)(a)? YES ☐ NO ☐

Contractor Name, Address and Phone: ____________ ____________ ____________ ____________	Notes for One-Line Standard Electrical Diagram for Single-Phase PV Systems Site Name: ____________ Site Address: ____________ System AC Size: ____________			
Drawn By:	SIZE	FSCM NO	DWG NO E1.2	REV
Checked By:	SCALE NTS	Date:	SHEET	

Source: “Expedited Permit Process for PV Systems”, Brooks Engineering for the Solar America Board for Codes and Standards, 2009

APPENDIX D

BUILDING PERMIT REQUIREMENTS FOR THE CITY OF PHILADELPHIA DEPARTMENT OF LICENSES & INSPECTIONS

EXHIBIT D-1
Building Permit Flow Diagram

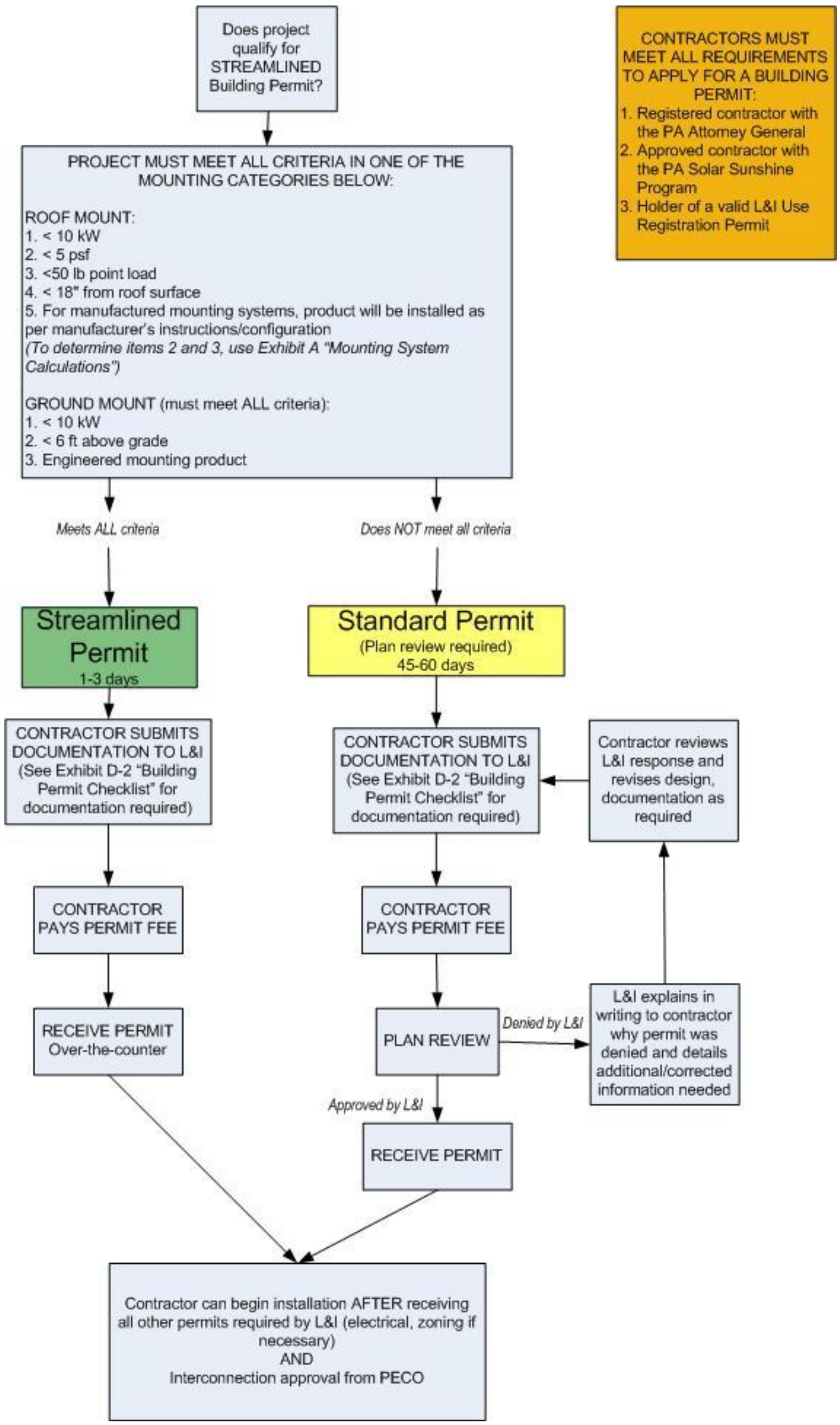


EXHIBIT D-2
Building Permit Checklist

Building permits are required for all PV projects. The following information must be submitted for Streamlined Permits and Standard Permits (any exceptions are noted in the requirements)

1. Application for Building Permit
   - Available for download at L&I's Building Permit website
   - Provide the following information on the application:
     - Location of Property – Provide the house number(s) and street name. [Note: Only addresses issued by the Board of Revision of Taxes will be accepted]
     - Explain any alteration or construction [Note: such as add a 10 KW Photovoltaic solar array]
     - Provide the height in feet and stories of the existing building and proposed array.
     - List the present use of the existing building.
     - Provide the name, address, and telephone number of the owner(s), architect, engineer, and the name of the person filing the application. [Note: If you are not the registered owner of the property, you must have the permission of the owner of record to file the application.]
2. A Valid L&I Use Registration Permit
3. Building Plans (3 copies)
   - Provide the following information:
     - Drawn to scale
     - Minimum size is 18" x 24"
     - Black and White or Blue Prints
     - Show Location of PV array on the building/property
     - Identify roof system
     - Modifications to existing structure to accommodate PV mounting system
     - Indicate loads that apply to the structure including modification of dead load, uniform distributed live load, concentrated load, roof loads, snow load, wind loads
4. Structural Review Submittal – for Streamlined Permit only (See Exhibit D-3; and D-4 if required)
5. Design Calculations (2 copies) – for Standard Permit only
   - Calculations shall include all design factors listed in the Uniform Construction Code of Pennsylvania – Building Provisions Chapter 16 Structural Design that contribute to the calculations of the loads applied to the design of the structure.
6. Mounting Hardware Specifications
   - For engineered product designed to mount PV modules, submit manufacturer cut-sheets for mounting hardware
   - If not an engineered product designed specifically for PV modules, submit details of structural attachment certified by a design professional.

EXHIBIT D-3
Structure Review Submittal for Standard Permit

EXPEDITED PERMIT PROCESS FOR SMALL-SCALE PV SYSTEMS

The information in this guideline is intended to help local jurisdictions and contractors identify when PV system installations are simple, needing only a basic review, and when an installation is more complex. It is likely that 50%-75% of all residential systems will comply with these simple criteria. For projects that fail to meet the simple criteria, resolution steps have been suggested to provide as a path to permit approval.

Required Information for Permit:

1. Site plan showing location of major components on the property. This drawing need not be exactly to scale, but it should represent relative location of components at site (see supplied example site plan). PV arrays on dwellings with a 3' perimeter space at ridge and sides may not need separate fire service review.

3. Specification sheets and installation manuals (if available) for all manufactured components including, but not limited to, PV modules, inverter(s), combiner box, disconnects, and mounting system.

Only spec sheets for mounting systems are required for building permits

Step 1: Structural Review of PV Array Mounting System

Is the array to be mounted on a defined, permitted roof structure? ☐ **Yes** ☐ **No**

If No due to non-compliant roof or a ground mount, submit completed worksheet for the structure WKS1.

Roof Information:

1. Is the roofing type lightweight (Yes = composition, lightweight masonry, metal, etc…)_____________
   If No, submit completed worksheet for roof structure WKS1 (No = heavy masonry, slate, etc…).
2. Does the roof have a single roof covering? ☐ **Yes** ☐ **No**
   If No, submit completed worksheet for roof structure WKS1.
3. Provide method and type of weatherproofing roof penetrations (e.g. flashing, caulk)._____________

Mounting System Information:

1. Is the mounting structure an engineered product designed to mount PV modules? ☐ **Yes** ☐ **No**
   If No, provide details of structural attachment certified by a design professional.
2. For manufactured mounting systems, fill out information on the mounting system below:
   a. Mounting System Manufacturer ___________Product Name and Model#_____________
   b. Total Weight of PV Modules and Rails ___________lbs
   c. Total Number of Attachment Points____________
   d. Weight per Attachment Point (b ÷ c)________________lbs (if greater than 45 lbs, see WKS1)
   e. Maximum Spacing Between Attachment Points on a Rail ______________inches (see product manual for maximum spacing allowed based on maximum design wind speed)
   f. Total Surface Area of PV Modules (square feet)________________ ft^2
   g. Distributed Weight of PV Module on Roof (b ÷ f)______________ lbs/ft^2
   If distributed weight of the PV system is greater than 5 lbs/ft^2, see WKS1.

SOLAR AMERICA BOARD FOR CODES AND STANDARDS REPORT 7

Source: "Expedited Permit Process for PV Systems", Brooks Engineering for the Solar America Board for Codes and Standards, 2009

EXHIBIT D-4
Structural Worksheet – WKS1

If array is roof mounted

This section is for evaluating roof structural members that are site built. This includes rafter systems and site built trusses. Manufactured truss and roof joist systems, when installed with proper spacing, meet the roof structure requirements covered in item 2 below.

1. Roof construction: ☐ **Rafters** ☐ **Trusses** ☐ **Other**: ________________________
2. Describe site-built rafter or or site-built truss system.
   a. Rafter Size: ___ x ___ inches
   b. Rafter Spacing: ________ inches
   c. Maximum unsupported span: _____ feet, _____ inches
   d. Are the rafters over-spanned? (see the IRC span tables in **B.2**.) ☐ **Yes** ☐ **No**
   e. If ***Yes***, complete the rest of this section.
3. If the roof system has
   a. over-spanned rafters or trusses,
   b. the array over 5 lbs/ft^2 on any roof construction, or
   c. the attachments with a dead load exceeding 45 lbs per attachment;

   it is recommended that you provide one of the following:
      i. A framing plan that shows details for how you will strengthen the rafters using the supplied span tables in B.2.
      ii. Confirmation certified by a design professional that the roof structure will support the array.

If array is ground mounted:

1. Show array supports, framing members, and foundation posts and footings.
2. Provide information on mounting structure(s) construction. If the mounting structure is unfamiliar to the local jurisdiction and is more than six (6) feet above grade, it may require engineering calculations certified by a design professional.
3. Show detail on module attachment method to mounting structure.

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Source: "Expedited Permit Process for PV Systems", Brooks Engineering for the Solar America Board for Codes and Standards, 2009

B.2 Span Tables

A framing plan is required only if the combined weight of the PV array exceeds 5 pounds per square foot (PSF or lbs/ft²) or the existing rafters are over-spanned. The following span tables from the 2003 International Residential Code (IRC) can be used to determine if the rafters are over-spanned. For installations in jurisdictions using different span tables, follow the local tables.

Span Table R802.5.1(1),

Use this table for rafter spans that have conventional light-weight dead loads and do not have a ceiling attached.

10 PSF Dead Load Roof live load = 20 psf, ceiling not attached to rafters, L/Δ=180							
Rafter Size			2 x 4	2 x 6	2 x 8	2 x 10	2 x 12
Spacing (inches)	Species	Grade	The measurements below are in feet-inches (e.g. 9-10 = 9 feet, 10 inches).				
16	Douglas Fir-larch	#2 or better	9-10	14-4	18-2	22-3	25-9
16	Hem-fir	#2 or better	9-2	14-2	17-11	21-11	25-5
24	Douglas Fir-larch	#2 or better	7-10	11-9	14-10	18-2	21-0
24	Hem-fir	#2 or better	7-3	11-5	14-8	17-10	20-9

Use this table for rafter spans that have heavy dead loads and do not have a ceiling attached.

20 PSF Dead Load Roof live load = 20 psf, ceiling not attached to rafters, L/Δ=180							
Rafter Size			2 x 4	2 x 6	2 x 8	2 x 10	2 x 12
Spacing (inches)	Species	Grade	The measurements below are in feet-inches (e.g. 9-10 = 9 feet, 10 inches).				
16	Douglas Fir-larch	#2 or better	8-6	12-5	15-9	19-3	22-4
16	Hem-fir	#2 or better	8-5	12-3	15-6	18-11	22-0
24	Douglas Fir-larch	#2 or better	6-11	10-2	12-10	15-8	18-3
24	Hem-fir	#2 or better	6-10	10-0	12-8	15-6	17-11

Source: "Expedited Permit Process for PV Systems", Brooks Engineering for the Solar America Board for Codes and Standards, 2009

Span Table R802.5.1(2),

Use this table for rafter spans with a ceiling attached and conventional light-weight dead loads.

10 PSF Dead Load Roof live load = 20 psf, ceiling attached to rafters, L/Δ=240							
		Rafter Size	2 x 4	2 x 6	2 x 8	2 x 10	2 x 12
Spacing (inches)	Species	Grade	The measurements below are in feet-inches (e.g. 9-10 = 9 feet, 10 inches).				
16	Douglas Fir-larch	#2 or better	8-11	14-1	18-2	22-3	25-9
16	Hem-fir	#2 or better	8-4	13-1	17-3	21-11	25-5
24	Douglas Fir-larch	#2 or better	7-10	11-9	14-10	18-2	21-0
24	Hem-fir	#2 or better	7-3	11-5	14-8	17-10	20-9

Use this table for rafter spans with a ceiling attached and where heavy dead loads exist.

20 PSF Dead Load Roof live load = 20 psf, ceiling attached to rafters, L/Δ=240							
		Rafter Size	2 x 4	2 x 6	2 x 8	2 x 10	2 x 12
Spacing (inches)	Species	Grade	The measurements below are in feet-inches (e.g. 9-10 = 9 feet, 10 inches).				
16	Douglas Fir-larch	#2 or better	8-6	12-5	15-9	19-3	22-4
16	Hem-fir	#2 or better	8-4	12-3	15-6	18-11	22-0
24	Douglas Fir-larch	#2 or better	6-11	10-2	12-10	15-8	18-3
24	Hem-fir	#2 or better	6-10	10-0	12-8	15-6	17-11

Use the conventional light-weight dead load table when the existing roofing materials are wood shake, wood shingle, composition roofing or light-weight tile roofs. (The rationale for allowing these tables to be used is that the installation of a PV system should be considered as part of the live load, since additional loading will not be added to the section of the roof where a PV array is installed.)

Where heavy roofing systems exist (e.g. clay tile or heavy concrete tile roofs), use the 20 lbs/ft^2 dead load tables.

Source: "Expedited Permit Process for PV Systems", Brooks Engineering for the Solar America Board for Codes and Standards, 2009

APPENDIX E

ZONING PERMIT REQUIREMENTS FOR THE CITY OF PHILADELPHIA DEPARTMENT OF LICENSES & INSPECTIONS

Zoning Permit Checklist

Zoning permits are required for some PV projects. The following information must be submitted for a zoning permit.

1. Application for Zoning Permit
   - Available for download at L&I's Zoning Permit website
   - Provide the following information on the application:
     - Location of Property – Provide the house number(s) and street name. [Note: Only addresses issued by the Board of Revision of Taxes will be accepted]
     - Explain any alteration or construction [Note: such as add a 10 KW Photovoltaic solar array]
     - List the present use of the existing building.
     - Provide the name, address, and telephone number of the owner(s), architect, engineer, and the name of the person filing the application. [Note: If you are not the registered owner of the property, you must have the permission of the owner of record to file the application.]
     - Prepare a plot plan, which is a scaled drawing of the project, with applicable dimensions. [Note: You must submit six (6) copies of the plan for each individual application form proposing construction]
2. Plot Plan (6 copies)
     - Scale 1" = 10', 20', 40', 50', 60' or 100'
     - Minimum sheet size 11" x 17", Maximum sheet size 24" x 36"
     - Lot lines and dimensions of the property according to the property deed
     - All streets, alleys, or driveways bordering the property
     - Curb lines and their distances from lot lines
     - Exterior dimensions of buildings and structures from lot lines and/or existing and proposed dimensions of other buildings and structures on the same lot
     - Location and dimensions of all driveways and curb cuts, if applicable
     - Name and address of property owner - Signature of applicant

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