DESIGN AND CONSTRUCTION GUIELINES AND STANDARDS

DIVISION 7 • THERMAL & MOISTURE PROTECTION

07 07 00 • SOLAR PHOTOVOLTAIC SYSTEMS

SECTION INCLUDES

Solar PV Sustainability Grants
Third Party Solar PV Installations
Technical Criteria for Selecting Solar Mounted PV Sites
Preparing for Potential Future PV Installation
Building Integrated Photovoltaic Systems
Ground Mounted Solar PV Systems

RELATED SECTIONS

07 30 00 Asphalt Roof Shingles
07 50 00 Membrane Roofing

REFERENCES

The following links may be helpful in designing a Solar PV System:

Massachusetts Clean Energy Center- www.masscec.com
National Training & Education Resource- www.nterlearning.org
Solar-Massachusetts.org- www.solar-massachusetts.org

INTRODUCTION

Installation of solar photovoltaic systems on existing and new construction buildings should be considered a building enhancement after attention has been given to making the buildings more energy efficient with wall and roof insulation, new energy efficient windows and mechanical systems. In a retrofit situation, it may be more effective to replace the windows and add additional insulation before adding a PV system to the roof of the building. Planning for new PV arrays should include replacing any older roofs, to make the roofs solar ready and investigation to the roofs orientation and shading from surrounding trees and other buildings. Funding for solar photovoltaic systems can come from sustainability grants or third party solar PV installations as outlined below. Solar renewable energy certificates (SRECS) also generate a stream of income once the panels are installed. .

SOLAR PV SUSTAINABILTY GRANTS

DHCD's Sustainability Initiative works with housing authorities interested in installing solar photovoltaic or solar thermal/hot water systems with supplemental funding from federal, state or utility grants or rebates. Since these resources are not always available in the timeframe that roof replacement projects are being bid, DHCD expects designers to provide conceptual or schematic design details about how solar panels could later be retrofitted to the roof. In addition to the roof-related construction involved with solar panel installation, the designers should indicate where the associated electrical equipment and inverters could be located for PV systems, and where piping, heat exchangers and storage equipment could be located for solar thermal systems.

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THIRD PARTY SOLAR PV INSTALLATIONS

In some cases, housing authorities may pursue the development of solar PV systems through a third party roof lease and power purchase agreement (PPA). This "Third Party" is usually a private solar development company that installs and maintains the solar panels over a 15-20 year timeframe, and the authority commits to purchase at below-market rates the kilowatts generated on the roof. Below–market rates are possible since the vendor is able to take advantage of federal and state tax credits and solar renewable energy certificates (S-RECS). Even when the development is to be third party, the LHA should take advantage of using DHCD's technical assistance in planning and reviewing their project.

RESEARCH AND INVESTIGATION

Technical Criteria for Selecting Solar Roof Mounted Photovoltaic (PV) Sites:

- ❑ Orientation of the Existing Roof.

  The basic parameter for roof orientation is idealy between Southeast to South to Southwest.

  Roofs with orientations between Southeast to South to Southwest will produce close to optimum energy production. Flat roofs are typically rectangular in nature and have an associated orientation when using a mounting system that holds modules at a set non zero pitch. A zero pitch mounting system is acceptable.

  Advantages of mounting flat to the roof include: being less susceptible to wind loads, greater density of modules as they can be butted together, and products that add an insulation layer.

  Although mounting flat to the roof is considered acceptable, it is less desireable because there is less output than tipped system per installed watt, longer retention of snow, and potential for less effective cleaning of dirt by rain water.

  Roof orientation can be determined in a number of ways. Maps including aerial photo maps by Google Maps, MapQuest, etc. show true North as the top of the page.

  Shadows at solar noon will point toward true North. Solar noon is roughly 12 noon during standard time and roughly 1 PM during daylight savings time. Actual solar noon factors in a small offset due to the earth's non circular orbit around the sun. A compass will show magnetic North, which in Massachusetts is approximately 15 degrees West of North.

- ❑ Condition of the Existing Building Roof.

  The existing roof should have greater than 20 years of rated life left. Re-roofing offers an opportunity to select long life roofing prior to installation of roof mounted photovoltaic arrays.

  For sloped roofing replacement it is advisable to use 40 or 50 year (lifetime) architectural asphalt roofing shingles. If a roof has been recently replaced, the LHA should check the existing roofing warranty to determine the remaining useful life to the roof.

  Flat roofs with rubber or other membrane roofing should be in good condition and it should be a requirement of the roofing contractor to add an additional layer of membrane roofing on the area of the roof where a PV array will be installed.

- Strength of the Existing Roof.

Roof strength must be adequate to support the additional weight load from the solar PV arrays. In addition the roof must be capable of meeting wind uplift loads for attached systems during hurricane force winds.

The local building inspector may require a professional engineer to verify that a roof can take the additional load of a PV system. A typical PV system mounted on a sloped roof adds about 3 lbs. per square foot which is approximately equal to an additional layer of shingles in the area where the PV is mounted. Lag screws attached to roof rafters must be selected for a potential wind upload during hurricane force winds. Alternate attachment methods must meet the same engineering requirements such as shroads or heavier mounting frames etc.. Every roof should be investigated for its own unique characteristics.

Ballasted PV on a flat roof relies on the weight and interconnections between sections of the mounting system to keep the array from blowing off the roof may range in weight from near 3 lbs. per square foot to as much as 10 lbs. per square foot. Mechanically attached PV system arrays should be avoided if possible since additional roof penetrations are required and provide additional locations for water to enter the building envelope.

- Roof Pitch with Orientation of Roof.

Both flat roofs and sloped roofs are acceptable for PV systems installations. A South facing sloped roof will naturally tilt modules towards the sun for good energy production and good snow shedding. A 30 to 40 degree pitch on a South facing roof is optimum for energy production.

A steep roof has low energy production when it is oriented East or West off of South. A Southern orientation of a sloped roof is ideal. No PV systems should be mounted on sloped roofs with orientations that have any Northern component.

A roof with a low pitch (below 15 degrees) will tend to retain snow. A roof with a steep pitch will loose snow quickly. Consider potential hazardous sheets of icy snow coming off a steeply pitched PV array. Leaving exposed shingle roof below an array can reduce the chances of snow falling quickly off the roof.

Mounting PV system arrays on EPDM or single membrane flat roofs is not acceptable since the warranties for these roofs is limited to 15 years. Mounting on flat roofs is most often done with mounting systems that do not penetrate the roof membrane or only penetrate the roof membrane at a limited number of locations. A ballasted system does not require roof penetrations and relies on the weight of the system to keep the system from blowing off the roof. A second method is to attach the system to the roof. In either case, the system must meet building code for worst case wind conditions. Systems on sloped roofs are typically more cost effective a producing energy than systems on flat roofs.

- Shading of Existing Trees or other Buildings.

Shading is equally important as roof orientation. Roofs must be clear of shading between 9 AM and 3 PM standard time for most of the year.

Energy production is maximized when shading is minimized. At our latitude, the winter sun at the December Solstice reaches a maximum angle of 25 degrees above the horizon. Ideally tree tops will be below this angle. A variety of charting tools allow one to determine the effect of shading on annual energy production. The best known tool is called Solar Pathfinder. http://www.solarpathfinder.com/ .

When considering the removal of trees to improve photovoltaic system output, one must consider the intrinsic value of the trees as well as beneficial shading that keeps buildings, grounds and people cooler.

Shading can come from other homes and buildings nearlby. A house in a valley can be shaded by a house on a hill. Tall buildings will cast long shadows in winter months.

Located on the same roof or building, vent pipes, chimneys, and roof features can cause shading of photovoltaic arrays. A module may be caused to be electrically bypassed if only one or two cells of that module are shaded. If several modules are shaded this way at the same time, the output of the entire array may be reduced to a small fraction of its potential output.

- ❑ Electrical Installation Requirements.

Electrical code specifies required space for inverter and metering equipment. Inverters and support equipment are typically outside of living area, removed from heat sources (e.g. attics are not suitable), and secure. Electrical code must be followed with particular attention to amperage ratings of electrical panels and circuit breakers.

The inverter is typically mounted next to the main electrical distribution panel of a building or unit. An inverter and disconnects may be mounted on the outside of a building or in a shed. It may not be appropriate to have an inverter mounted where there is a strong possiblility that it may be tampered with. An exterior North wall will help the inverter run cool by providing shade.

- ❑ Additional Considerations.

Finding an Installer - There are 3 resources that are available in Massachusetts to find installers who might bid on your solar project:

SEBANE- Solar Electric Business Association of New England
http://www.sebane.org

NESEA- Northeast Sustainable Energy Association
http://www.nesea.org/sgp/ (Sustainable Green Pages)

NABCEP- North American Board of Certified Energy Practioners
http://www.nabcep.org/acknowledge.cfm?normalflag=yes

Meet Interconnect Standards- the local investor owned electric utilities such as National Grid, Norteast Utilities/ Nstar have interconnection procedures with documentation that must be followed. If your community is served by a municipal electric compny, investigate the interconnection procedures during the design phase.

Meet Electrical Code. NEC 2005 Article 690 – Solar Photovoltaic Systems. Article 690 points to other sections of the electrical code.

Meet good practice – Recommendations:

1. Avoid creating habitat for birds and squirrels- accessible spaces under a PV array that have a horizontal rail close to the roof allow animals to creat nests that are supported by the rail.
2. Keep wires off the roof using wire ties, etc..
3. Use lightning arrestors on the roof.
4. Confirm that module string sizing for an invertor is within the voltage range, perferable not at the bottom of the voltage range.
5. For large PV systems in new construction, it is advisable to properly size electrical service to meet the electrical code. This may require a larger service to be installed.

Preparing for Potential Future PV Installation:

- ❑ There are several minor measures that can be adopted during new construction or significant rehabilitation work that can greatly reduce the cost of adding solar PV generation or solar hot water at a later date. Consultants with PV expertise should evaluate the following components:
  1. Install metal conduit for DC power from attic or roof to basement or electrical room. Determine conduit sizing with the intended scale of PV system array.
  2. Reserve space next to targeted electric service panel for inverter, meters, disconnect and other electrical equipment.
  3. In new construction or renovation, consult with PV integrator to determine if electrical service should be larger to accommodate potential PV system.
  4. In new construction, design roof to be strong enough to accommodate the additional weight of PV system.
  5. In new construction, keep roof areas designated for PV clear of vent pipes and other obstructions in the design phase and during the construction process.
  6. Additional signal wire/or conduit may be installed for sensing physical parameters such as sunlight, temperature, wind speed, etc..

- ❑ Estimating potential PV array size for a roof:
  1. For a rectangular roof with no features in it and no shading, should have a minimum of 60% of the roof area covered by a PV array. This would allow for some open roof from the top of the array to the peak of the roof, open roof from the bottom of the array to the eave of the roof, and some area of exposed roof on either end of the array. Conservatively

every 100 square feet of roof space will accommodate 1 kW DC of PV array. The same 100 square feet of roof space will accommodate 1.5 kW DC of PV array using the most efficient PV modules.

2. Flat Roof- vent pipes, elevator shafts, HVAC equipment, skylights, etc, may significantly reduce the potential usable area for mounting a PV array. If possible, place roof walkways on North side of roofs. Roughly a PV array should be 3 times the distance away from a roof obstruction as it is tall to avoid shading. Ballasted PV systems should typically be a least 6 feet from the edge of a roof with 10 feet from the edge of a roof being a more conservative approach. It is advisable that a PV integrator be involved in this decision. PV systems may be installed flat to the roof or tilted. Tilted mounting take more space but produces more energy per installed watt than flat mounted systems. A PV mounting systems that tilts the modules 5 to 10 degrees will use approximately 50% more roof space than a flat mounted system per kW.

- ❑ Designing for PV on new construction building roofs:
  1. Orient sloped roofs to near South if possible.
  2. Plant trees types that do not grow tall enough to shade roofs.
  3. Cut trees to accommodate solar access for PV or abandon PV if the trees are highly valued.
  4. Design buildings so that they do not self shade. One wing of a building might shade a South facing roof of another part of a building for a significant part of the day.
  5. Reduce interruptions in South facing roofs, such a dormers, vent pipes, skylights, etc. within reason or abandon PV if other features are of higher value and leave little South facing roof space.
  6. Study PV mounting systems to determine best ways to perpare for PV. Accurately recording the framing layout is often useful.
  7. Allocate space for inverter and electrical gear near electrical distribution panel.
  8. Run metal conduit for DC power from attic to basement (typical installation) before closing in walls.
  9. Properly size the electrical distribution system to accommodate the size PV system to be installed. This step must happen early in the construction process.

BUILDING INTEGRATED PHOTOVOLTAIC SYSTEMS

Building integrated photovoltaic systems are photovoltaic materials that are used to replace conventional building materials in parts of the building envelope such as the roof, skylights, or facades. The term building-applied photovoltaics (BAPV) is sometimes used to refer to photovoltaics that are a retrofit integrated into the building after construction is complete which is primarily the case with DHCD PV systems installations.

GROUND MOUNTED SOLAR PV SYSTEMS

A ground mount system might be appropriate near a housing development if the housing authority owns land that could not foreseeably be needed in the future for residential use.

Instead of depending on the pitch and orientation of the roof, a ground mount system can be installed to capture as much sunlight as possible and maximize electrical output. Ground mount solar systems allow for more air circulation around the solar panels, which actually perform best in cooler temperatures. They are also easier to clean if a good rainfall doesn't do the job.