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Photo Voltaic Systems

Introduction

The energy crisis of the 1970s saw the beginning of major interest in renewable energy source including free energy from sun. Energy from sun can be converted thermal or electrical energy. Photovoltaic (photo = light; voltaic = produces voltage) or PV systems convert light directly into electricity using semiconductor technology. However, the cost of electricity produced from the sun was cost prohibitive, nearly 30 times higher than the conventional electrical cost for last decades, until now. According to the latest edition of Tracking the Sun, an annual PV cost tracking report produced by the Department of Energy's Lawrence Berkeley National Laboratory, the installed price of solar photovoltaic (PV) power systems in the United States fell substantially in 2012 and through the first half of 2013. PV system has the potential to become mainstream power source in very near future. This article will discuss PV systems basics and installation considerations.

PV system basics

Light carries energy into the solar cell, which and the cells converts sun's light energy into electric current. PV cells do not store energy. Traditional PV cells are fabricated with thin wafers of silicon similar to computer chips. Second generation cells are fabricated from amorphous silicon or non-silicon materials such as cadmium telluride. Thin film PV cells use layers of semiconductor materials only a few micrometers thick, making them flexible to allow their use in rooftop shingles and tiles, building facades, or glazing for skylights.

A PV module is a group of PV cells connected in series and /or parallel and encapsulated in an environmentally protective laminate. Panel is a term used for a group of modules that can be packaged and pre-wired off-site. The size of the panel (or large modules) is often related to how much weight and size two workers can effectively handle on a roof surface. Two common methods of mounting PV systems are racks and poles. Some pole mounts may also have the ability to track the sun across the sky.

PV cells produces direct current (DC), which needs to be converted to alternating current (AC) for utilization of energy produced within a facility. Inverted performs the task of conversion from DC to AC. The inverter is the heart of the PV system and is the focus of all utility interconnection codes and standards.

Code and Standards applicable to PV systems

- Electrical codes - NEC Articles 690, 230, 240, 250, 300
- Photovoltaic Systems – NFPA 70
- Uniform Solar Energy Code – ICC
- Building Codes – ICC, ASCE 7-05
- UL Standard 1703, Flat-plate Photovoltaic Modules and Panels
- IEEE 1547, Standard for Interconnecting distributed resources with electric power systems
- UL Standard 1741, Standard for distributed generation

PV system considerations

In designing a PV system, it is important to consider the system as a whole: how the components work together and how the PV system fits in with the building.

Pre-engineered PV Systems – It is important to properly size and match each component such that the overall system operates optimally. To address this concern, many distributors offer pre-engineered systems in which components are selected to work together as a unit. Pre-engineering may not guarantee a flawless system, but the concerns over product compatibility and specification of individual components would have been addressed up front.

PV Modules and the Building Design – The builder or PV designer must also consider the PV system and the building as a system. The PV array should be located considering the aesthetics of the building. As well, the modules must be located so that building features such as gables and overhangs do not shade the modules. This usually means locating the array on the roof as close as possible to the ridge.

Special considerations in wiring PV systems

In wiring solar PV systems, following must be considered:

- The system on the array side of the inverter must be designed for DC power, which requires larger wire sizes than for AC power at the same voltage.
- For PV systems, wiring in exterior locations must be suitable for outdoor, wet environment; suitable for exposure to sunlight; and able to operate in temperatures in the range of 65-80 deg. C
- NEC allows exposed, single conductor cables for interconnecting PV modules. This allows PV modules to be manufactured with permanently attached pigtail conductors on the ends which significantly reduce the labor required for installing the array.
- Particular attention should be paid to sealing around roof penetrations for conduit. As with sealing around the array mounting brackets, this is best handled by the roofing contractor to ensure the roof warranty is not voided.

Advantages and Disadvantages

Advantages:

- Electricity produced by solar cells is clean and silent. Because they do not use fuel other than sunshine, PV systems do not release any harmful air or water pollution into the environment, deplete natural resources, or endanger animal or human health.
- Photovoltaic systems are quiet and visually unobtrusive.
- Small-scale solar plants can take advantage of unused space on rooftops of existing buildings.
- PV system is highly reliable, powering nearly every satellite in space for long periods of time with virtually no maintenance.
- Solar energy is a locally available renewable resource.
- A PV system can be constructed to any size based on energy requirements.

Disadvantages:

- Some toxic chemicals, like cadmium and arsenic, are used in the PV production process. Proper recycling and disposal can mitigate some of the environmental impacts caused by the manufacturing process.
- Solar power is a variable energy source, with energy production dependent on the sun. As a result, solar powered facilities require alternate power source.

References

1. http://web.mit.edu/taalebi/www/scitech/pvtutorial.pdf
2. http://www.nrel.gov/learning/re_photovoltaics.html
3. http://www.energy.wsu.edu/documents/solarpvforbuildersoct2009.pdf
4. http://www.energybc.ca/cache/solarpv/www.cetonline.org/Renewables/PV_pro_con.html