Considerations

for PV Site Surveys

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The requirements of the local and national electrical and building codes determine how a solar-electric (photovoltaic; PV) system is installed. A site survey is an excellent time to integrate these requirements into the actual constraints established by the building, its location and orientation, the preferences of the owner, and any other site-specific restrictions.

Face South & Prevent Shading

For maximum energy production, PV modules need access to full sun, and should not be shaded. An unshaded roof with a "true south" orientation is often one of the premier sites for a solar-electric system, but, as in many situations, compromises are frequently necessary. In the continental United States, true south may differ from magnetic south, as obtained with a compass, by up to 18 degrees.

Examine potential array mounting locations (often on some portion of the roof) to determine if these sites will be shaded between 9 a.m. and 3 p.m. Shading wastes the sun's free renewable energy by limiting PV production. Although this loss has fewer consequences in a utility-interactive (grid-tied) system compared to an off-grid system, arrays should be located in shade-free locations to maximize their effectiveness. In a utility-interactive system, the utility grid will provide any needed energy that the PV system does not provide. In an off-grid system, if solar energy is not collected, then the electrical loads may not be supported without installing additional PVs or using some sort of backup system, such as an engine generator.

Assessing the solar window is especially important for shorter winter days, when the sun is low in the sky and even short objects far away may shade the PV array. If the site visit doesn't occur on one of these winter days, you can use other means to estimate the sun angles and shading. Sun-angle charts can be downloaded from the Web (see Access) and, with the use of a little trigonometry, can be used to estimate the potential shading at the selected location. Using other manual and semiautomatic devices is the most accurate way to determine shading at different times of the year (see Access). Keep in mind that trees and other vegetation may grow a foot or more per year, and consider this when you're siting a system.

An example of too much shading on a PV array.

Roof-Mounted Arrays

The weight of PV modules and mounting racks may add extra loads to the roof beyond its design load limits. Added loads are particularly important for some of the heavier glass-on-glass modules, and on roofs that already have several layers of shingles. Consult the *North American Board of Certified Energy Practitioners (NABCEP) Study Guide* for specifications on roof loading and attachments, which also lists resources for additional information (see Access).

Examine the attic of the house, if it has one, to determine the spacing of the trusses and to see if any extra materials will be needed to attach the array mounting rack to the roof. Pro installers should inspect the attic and document any existing roof leaks to the owner. The owner should have any leaks repaired and the roof put in good condition by a roofing contractor prior to the start of any PV installation. This can go far in preventing disagreements at a later date, should leaks occur.

Don't forget to measure the angle of the roof for both wind-loading estimates and to determine if an elevated mounting rack will be needed.

Measure the angle of the roof before installing the array and mounts.

Conductor Routing & Inverter Location

The location of the inverter in relation to the PV array and the AC load center will affect the conductor lengths between these components. The lengths of the conductors between the PV array and the inverter, and between the inverter and the AC load center will determine the voltage drops and energy losses in these parts of the system. Select a location for the inverter that shelters it from direct sun (to avoid solar heating, which will reduce output and efficiency). But, where possible, place it adjacent to the AC load center to minimize the number of AC disconnects required. If the AC load center and service disconnect are on the outside of the house, then the inverter should be placed in that location.

Inspect the wall where the inverter is to be mounted, noting construction type and the possibility of any internal objects, such as pipes or electrical conductors. Larger inverters are quite heavy, and must be carefully and firmly attached to the wall. New building and energy codes are allowing much lighter structural walls than have been required in the past. In some cases, the wall structure will need to be reinforced to carry the weight of the inverter.

PV Source & Output Conductors

Routing the conductors from the roof requires some planning, and may depend on what edition of the *National Electrical Code (NEC)* is in force in the locality. Prior to the 2005 edition, the *NEC* required that PV source and output conductors remain *outside* of the building, until they were routed to the readily accessible main DC PV disconnect (usually at ground level). This disconnect could be located inside or outside the house (local jurisdiction preference), at the location where the conductors penetrate the building's skin. Always-energized PV conductors had to be treated like AC service entrance conductors—which must remain outside of the building until reaching the AC service disconnect. Plan the routing of the conduit carrying these conductors to minimize the circuit length and to keep them as unobtrusive as possible.

The *2005 NEC* allows these circuits to penetrate the roof at the array and be routed inside the house to a readily accessible disconnect only if they are installed in a metallic raceway. Due to the difficulty of installing metallic raceways like electrical metallic conduit in existing walls, this technique is generally limited to new construction. Flexible, metal-clad cable (type MC) is not allowed because it is not considered a metallic raceway, but flexible metal conduit (type FMC) is, so the adventurer could possibly route those PV conductors out of sight in a retrofit situation.

The Utility-Required Disconnect

For those areas in which the utility requires a lockable disconnect, locate the disconnect in the vicinity of the utility kilowatt-hour (KWH) meter. The location of this disconnect with respect to the inverter and the AC load center will dictate the number of additional AC and DC PV disconnects that may be required and the routing of the various circuits.

A minimalist installation would be one in which the local jurisdiction requires the house AC service disconnect and AC load center to be located on the outside of the building near the AC KWH meter. If this location is not in direct sun, or the inverter can be shaded, the inverter and a single DC PV disconnect (as well as the utility-required disconnect) could all be located in the same area. This type of installation requires minimum conductor lengths and no additional switchgear. If the load center is mounted in an outside location, and, for some reason, the inverter must be mounted inside the house, an additional DC PV disconnect and an additional AC disconnect, both located at the inverter, could be required.

It is important during the survey to examine the exterior wall where cable and conduit penetrations will be made and where switchgear will be mounted. The wall surfaces and construction materials will dictate what mounting systems must be used.

Off-Grid & Battery Backup Systems

Any device, such as batteries, that might give off explosive gases (such as hydrogen) and corrosive fumes (sulfuric acid) should be located in a well-vented area. A moderate temperature environment is recommended, since batteries enjoy their best life and maximum efficiency between 77°F and 80°F (25°C and 27°C). Batteries should *not* be installed in living areas, due to the potential for cracked batteries to leak acid and the possible liberation of hydrogen gas. An insulated exterior location or a garage is best.

Currents between the batteries and inverters are typically high because these systems operate at low voltages and high power levels, so the cables must be kept short. If a wall separates the batteries and the inverter, code usually dictates that a disconnect and overcurrent protection be placed in both locations.

Other Questions or Comments?

If you have questions about the *NEC* or the implementation of PV systems that follow the requirements of the *NEC*, feel free to call, fax, e-mail, or write me at the location below. See the STDI Web site (below) for more detailed articles on these subjects. The U.S. Department of Energy sponsors my activities in this area as a support function to the PV industry under Contract DE-FC 36-05-G015149.

Access

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The 2005 *National Electrical Code* and the *NEC Handbook* are available from the NFPA • 800-344-3555 or 508-895-8300 • www.nfpa.org

Photovoltaic Power Systems & the 2005 National Electrical Code: Suggested Practices • www.nmsu.edu/Research/tdi/public_html/Photovoltaics/Codes-Stds/PVnecSugPract.html

2008 *NEC* Proposals PDF • www.nmsu.edu/~tdi/pdf-resources/2008NECproposals2.pdf

Sun charts • http://solardat.uoregon.edu/SunChartProgram.html

NABCEP Study Guide • www.nabcep.org/resources.cfm

Solar Site Assessment Tools:
Solar Pathfinder • 317-501-2529 • www.solarpathfinder.com

Solmetric SunEye • 877-263-5026 • www.solmetric.com

Wiley Electronics Acme Solar Site Evaluation Tool • 845-247-2875 • www.we-llc.com/ASSET.html