Consider a new roof system when installing a roof-mounted PV system

by James R. Kirby, AIA
Interest in site-specific electricity generation has increased significantly during the past few years through federal and local incentives and an increased demand for energy efficiency and reduced energy costs. And one way to achieve site-specific electricity generation is through roof-mounted photovoltaic (PV) system installations.

However, homeowners and building owners who are interested in rooftop electricity generation often overlook the need for an appropriate substrate that will provide equivalent service life for the roof-mounted PV system. Many existing roof systems are not adequate to provide a substrate for the expected life of roof-mounted PV modules, which could last as long as 30 years.

A typical roof system may not be designed to take the abuses inherent with the installation of rooftop equipment of any kind. Worker traffic, using the roof surface as a work platform, additional load on the roof structure, drainage and the possibility of ponding water are concerns when adding any type of rooftop equipment. When a roof-mounted PV system is installed, these same concerns need to be assessed and resolved appropriately on a project-by-project basis. In addition, there are concerns specific to PV system installation that need to be addressed.
Equivalent service life between a PV system and its substrate is important not only to the PV system’s success but also to the roof system’s success. And let’s not forget, the primary purpose of a roof system is to weatherproof a building. If weatherproofing is compromised, electricity generation likely will lose its appeal. Building owners and homeowners may not recognize the need for a new roof system or the benefits a new roof system can provide when partnered with a PV system.

**NRCA guidelines**

NRCA’s *Guidelines for Roof-mounted Photovoltaic Roof System Installations* provides specific recommendations for enhancing a roof system to make it appropriate as a substrate (or platform) for roof-mounted PV systems.

For membrane roof systems, NRCA recommends high-compressive-strength insulation and a thermal barrier board above the insulation beneath the membrane. High-compressive-strength insulation provides a rigid base that is less likely to crush or depress over time. The thermal barrier resists high-heat transfer from the PV roof surface into the roof assembly, as well as benefits performance by acting as a separator between the roof membrane and primary roof insulation.

NRCA also recommends membranes of increased thickness for single-ply membrane roof systems. Increased membrane thickness generally translates to overall toughness and should lead to longer service life. Roof system manufacturers that are including adhered and rack-mounted PV systems within their product offerings are requiring “membranes of increased thickness” to be used under roof-mounted PV systems.

NRCA recommends through-fastened (penetrating) attachment of rack-mounted PV modules or PV modules adhered directly to a membrane. Job specifics (number of penetrations, existing insulation quantities, etc.) will help determine the relative costs for installation of penetrating attachments as part of roof system repair, re-cover, or tear-off and replacement.

Installing adhered PV modules on an existing single-ply roof membrane, given a typical roof system exists, likely will compromise a roof system manufacturer’s warranty unless the manufacturer’s specific directives and requirements are met before adding a PV system.

Adhered PV modules commonly use single-ply membranes as substrates. Because the inherent nature of PV modules is to collect the sun’s energy, they will become hot, similar to dark-colored membranes (in the range of 170 F to 200 F). Because many single-ply membranes are light-colored or white, roof surface temperatures are lower (in the range of 90 F to 110 F); as a result, the sheet’s heat-resistance capability is rationally limited to about 140 F to 160 F.

If a PV module capable of reaching temperatures of 170 F to 200 F is adhered to a roof membrane that
only is capable of handling temperatures up to 150 F, the long-term success of that roof membrane as a substrate for a PV module is significantly compromised. It is imperative the roof membrane can handle the expected temperatures of adhered roof-mounted PV modules. Because of this, NRCA recommends using single-ply sheets with higher than commodity-grade levels of stabilizers, including heat-aging stabilizers, as recommended by the roof membrane manufacturer for PV module applications.

For adhering PV panels to single-ply membranes, NRCA recommends a minimum membrane thickness of 72 mils, a thermally resistant insulation cover board just beneath the membrane and high-temperature-resistant insulation.

Metal panel roof systems can be appropriate substrates for PV systems. Installing rack-mounted PV panels over existing metal panels is one method for combining PV modules and metal panel roof systems. A concern is the added load, not only to the overall structure, but also, more importantly, to the clips holding the metal panels to the roof deck. The added weight of PV panels, especially rack-mounted systems, adds drag load to the existing metal panels (the PV panels want to drag the metal roof panels down the roof slope), possibly exceeding their structural capacity.

PV panels on metal panel roof systems also can act as snow fences, adding the weight of snow to the drag load. Before adding rooftop loads, especially permanent installations, it is important to conduct a structural analysis.

**Equivalent service life**

Many roof-mounted PV systems are being installed over existing roof systems that are nearly 10 years old (and some even older). In such cases, a legitimate estimate of payback and return on investment within six to eight years generally is provided. These payback estimates are valid but often stop short of providing the full story to the building owner.

For example, say a PV system was installed on a 9-year-old roof system. That roof system will need to be replaced in about 10 years. At that time, the now 10-year-old PV system, which is warranted to generate electricity for 20 to 30 years, will need to be decommissioned and reinstalled. This can add a significant cost to a reroofing project and means the PV system will not be generating electricity while roofing work is being done.

When investing in rooftop electricity generation systems, building owners need to be aware of the financial ramifications they will face for the 20 to 30 years of the system’s life, not just until a return on initial investment is complete.

**Production and efficiency**

Many building owners who are interested in rooftop electricity generation own existing buildings that are not energy-efficient. A building’s energy efficiency should be
a higher priority than energy production; therefore, a request for a roof-mounted PV system is an opportunity to upgrade a roof’s insulation layer.

Each building should be assessed individually for energy efficiency or production measures to be cost-effective. A number of items should be considered:
- What is the roof-to-wall area?
- What is the existing insulation’s R-value?
- Is there any wet insulation?

Wet insulation not only means loss of R-value in the wet areas, it also can mean deterioration of roof assembly components such as insulation, roof decks and fasteners. At a minimum, wet insulation should be removed and replaced before installation of a re-cover roof system or roof-mounted PV system.

A high roof-to-wall ratio means the addition of high-R-value roof insulation significantly could increase a building’s energy efficiency. The result is a building...
that uses less electricity; the PV systems will produce a larger percentage of the building's electricity needs and likely improve the return-on-investment analysis. The following example will help explain this.

Say an owner of a one-story, 10,000-square-foot warehouse would like to install a 5-kilowatt (kW) roof-mounted PV system. At this location, a 5-kW PV system will generate about 6,000 kilowatt hours (kWh) of electricity each year. The warehouse uses 18,000 kWh of electricity each year. In this case, a 5-kW PV system will provide about 33 percent of the warehouse's current electricity use.

Let's assume a new roof system is installed before PV system installation. With a high-R-value insulation layer in the roof, the building now uses 14,000 kWh of electricity each year. And with an upgraded insulation layer, the same 5-kW PV system now provides about 42 percent of the warehouse's electricity use. And depending on the price of electricity, the 4,000 kWh saved each year because of the new insulation quickly could pay back the cost of the insulation layer.

### Breakdown

If you take into account NRCA's guidelines and recommendations for roof systems used with roof-mounted PV systems and the likelihood of an existing roof system being underinsulated, it is likely an existing low-slope roof system (unless specifically designed to be PV-ready) should be removed and replaced before installation of a roof-mounted PV system.

NRCA divides its roof-mounted PV system recommendations into low- and steep-slope and further delineates between rack-mounted and adhered systems in each category. Roofing professionals and PV installers might use additional categories, such as the following, to assess a specific roof-mounted PV system installation:

- New construction (vs. retrofit) provides the best opportunity to install roof and PV systems with equivalent service lives. PV system installation on existing roof systems clearly has many challenges.
- Commercial and residential roof-mounted PV systems can have vastly different types of sales processes and financial risks. PV systems for residential use are commonly 3 kW to 5 kW of direct current in size. Commercial rooftop PV systems are more commonly 10 kW to 150 kW of direct current in size.
- Depending on the size of the roof and PV system, a PV array might occupy a small percentage of a rooftop or virtually the entire roof area. It will be more difficult to sell a new roof and insulation if a PV array occupies only a small percentage of the rooftop.
- A developer may want a PV system to entice a quick sale and only want the least expensive option whereas an institutional owner (such as a university) will likely look well into the financial future and make different buying decisions.

No two jobs are identical, and there often are non-technical discussions that affect the design and installation of roof-mounted PV systems.

### An opportunity

Many existing roof systems are not PV-ready according to NRCA guidelines. And many existing roof systems have minimal R-values. A homeowner's or building owner's request to install a roof-mounted PV system can be an opportunity to upgrade insulation, install a roof system that is designed to be appropriate for roof-mounted PV systems, and install a roof system and PV system with equivalent service lives.

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