It Is Time for the Roofing Industry to Embrace Rooftop Solar

By Brian J. Whelan and Rocco Gerhardt

MANY OF US in the roofing industry have been brought up believing it is best to minimize the amount of equipment and penetrations on a low-sloped roof. Rooftop penetrations are common sources of leaks, and equipment on the roof leads to additional rooftop traffic and potential for damage to the roof. A rooftop covered by solar panels can be a scary proposition for many building owners, their facility managers, and roofing professionals (**Fig. 1**).

There are valid reasons for this fear: rooftop solar has had a checkered history. In most instances, the root cause for rooftop solar – related issues was a lack of teamwork and insufficient communication among the parties involved in the project. These parties include the building owner (who typically does not have a lot of roofing expertise), the solar developer (whose expertise will be in engineering, procurement, and construction), and various subcontractors (who may know very little about roofing besides the fact that it is the location where solar equipment will be installed.) Additionally, in cases where the owner does not own the solar array, a financing company may be involved. Representatives of financing companies tend to focus on the return on investment and likely do not have experience in commercial roofing projects. Everyone involved is typically focused only on their own areas of work and responsibility, and not necessarily on the project as a whole. Similar teamwork and communication challenges may arise in cases where owners of very large properties have one team with in-house roofing expertise and a separate energy team. The energy team may not decide what type of solar energy system to install until the roof is already installed, and roofing problems can occur if the two teams do not collaborate. Hiring a Registered Roof Consultant (RRC®) could be beneficial to oversee the coordination between the roof and solar systems.

Figure 1. Rooftop solar project.
Photo courtesy of Centroplan

Some may recall that in the 1990s, the roofing industry was very concerned with rooftop solar and who was going to own the roof. Many costly mistakes were made with rooftop solar in those early days. Solar was being installed over existing roofs of all types and ages, even though it makes little sense to install solar on a roof that is near the end of its service life. The roof life cycle should be aligned with the solar energy system's lifespan, which is typically 20 to 30 years.

KEYS TO A SUCCESSFUL SOLAR ROOF

The good news is that both the solar and roofing industries have gained considerable experience and now understand what is needed to make a rooftop solar project a success. The following are general recommendations for a successful solar roof:

- The roof and structure must be capable of supporting the weight of the solar array and

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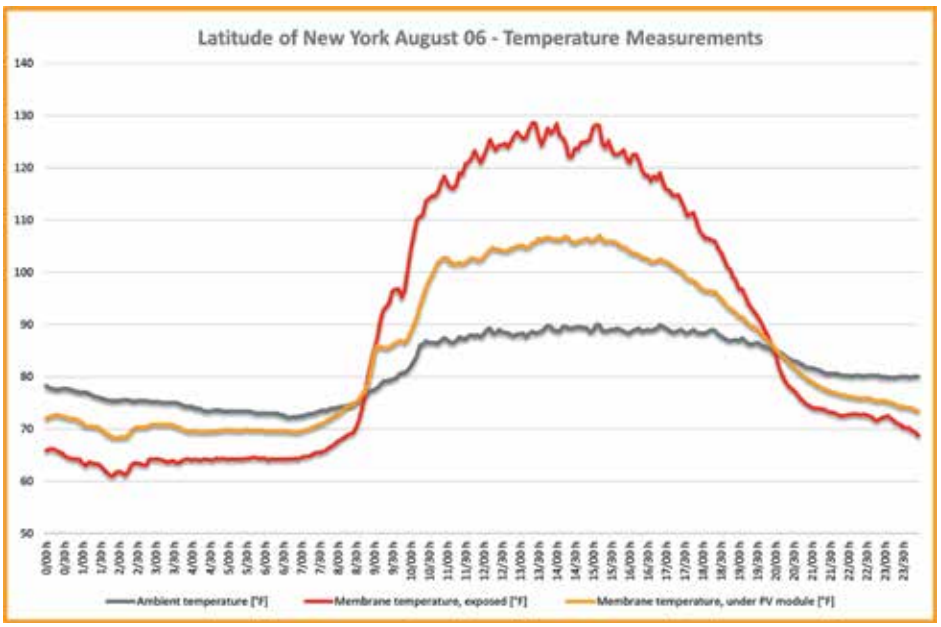

Figure 2. Comparison of roof membrane temperature to ambient air.
Figure courtesy of Centroplan and Sika Sarnafil

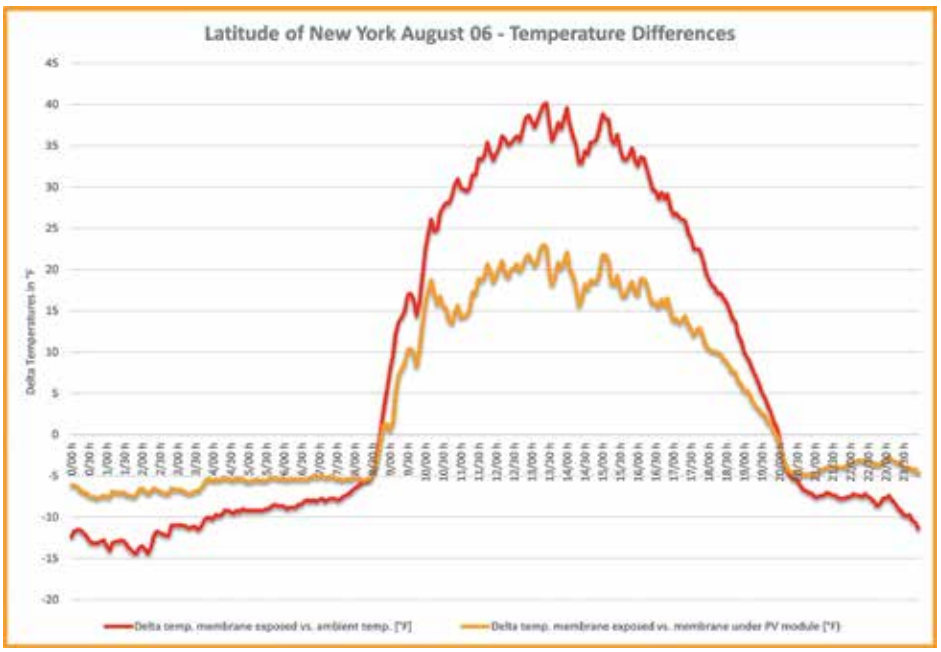

Figure 3. Comparison of roof membrane temperature with and without photovoltaic panels.
Photo courtesy Centroplan and Sika Sarnafil

any additional snow loads that could occur from drifting snow (in cold climates). (Note: As discussed later, there are solar racking systems that do not require any weight/ballast to hold the solar array in place, which lessens the load on the roof structure.)

- The solar PV system should not impede rooftop drainage.
- The roof and the solar energy system should be tested and meet code requirements for both fire and wind. Today there are roof systems inclusive of the solar racking system that have passed FM 4478, *Approval Standard for Rigid Photovoltaic Modules*,[1] and pass UL 2703, *Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels*.[2]
- All parties involved with the roof and solar should be in communication and in agreement regarding project objectives.
- If roof installation and solar installation are two separate events, consult with the roofing manufacturer or an RRC to obtain recommendations and determine whether the solar energy system will have any impact on the roof or its warranty.
- The roof is the foundation for the solar energy system, and the roof's life expectancy should be aligned with the solar energy system's life span. A roofing system with a proven track record of lasting at least as long as the intended solar energy system should be selected.
- The roof assembly should be designed with the solar energy system in mind. Some people use the term "solar-ready roof" for this type of design, which usually includes a thicker roof membrane (72 or 80 mil [1.8 or 2.0 mm] for single-ply materials) for additional weather and traffic resistance. We recommend placing a gypsum hardcover board over the insulation to protect the insulation from solar installation traffic, provide a solid support for the solar array, and improve fire resistance of the roof system.
- Using a roof membrane with excellent fire resistance properties is also recommended. A solar array is a small electrical system/plant. Selecting a roof membrane and system that provides fire resistance is a smart investment. There are roof membranes that support combustion and others that do not.
- Install a light-colored reflective roof membrane to reduce rooftop temperature. Solar panels are more energy efficient at cooler temperatures.[3] And where bi-facial solar panels (solar panels that capture sunlight from both the top and bottom of the panels) are used, solar energy reflected from the light-colored roof membrane can add to the overall energy efficiency of the panels.
- Fire testing of solar panels with glass on both the top and bottom sides (known as glass-glass panels) has confirmed that these types of panels are significantly better at reducing fire/spread of flame from the panel bottom side compared to glass on the panel top side only. Use PV modules with glass back sheets as recommended in FM Global Property Loss Prevention Data Sheet 1-15, *Roof-Mounted Solar Photovoltaic Panels*.[4]
- Install roof walkways in areas where traffic will occur between solar arrays and in areas of expected solar maintenance and cleaning.
- Install a second layer of compatible roof membrane as a protection layer beneath the ballasted solar racking system.
- All roof penetrations should be round-shaped for ease of flashing.

Figure 4. South-facing photovoltaic panels.
Photo courtesy of Sika Sarnafil

Figure 5. East-west-facing photovoltaic panels.
Photo courtesy of Centroplan

DOES ROOFTOP SOLAR HELP OR HURT THE ROOF'S WEATHERING PERFORMANCE?

Experience suggests that if a solar-ready roof is installed and the solar installer takes reasonable precautions during solar staging and installation, the solar energy system will have little to no impact on the quality of the roof system. The roof should be inspected right before and after the solar install. Most roofing manufacturers will provide a roof inspection for a nominal fee, provided they are given adequate time to schedule the inspections.

A common question asked by customers regarding the solar panels is, "Do the dark solar panels create more heat and therefore weather the roof membrane prematurely?" Temperature measurements taken throughout the day on low-sloped roofs, using a light-colored, reflective roof membrane, have been taken by Centroplan and Sika Sarnafil of the roof membrane temperature directly below the solar panels and between the solar arrays where the membrane is exposed directly to the sunlight.

Figure 2 shows the temperature, which was measured throughout the day. It shows an increase in ambient temperature during the middle of the day (gray line) typical for a sunny summer day. The temperature of the membrane located below the solar panels (yellow line) shows a lower temperature profile than the membrane exposed to direct sunlight (red line).

In **Fig. 3**, the actual temperature difference between the membrane below the solar panels (yellow line) and the membrane not below the solar panels (in direct sunlight) (red line) was measured. During the period of the day that exhibited the highest temperatures, we observed an approximately 20°F (11°C) cooling/shading effect from the solar panels on the roof membrane. This reduces the heat load on the membrane and somewhat shields it from ultraviolet light, which could help the long-term weathering performance of the roof membrane directly below the solar panels. Every roofing project is different, but from our observations on low-sloped roofs, the solar panels are not expected to add more heat load to the roof membrane below the panels.

DOES SOLAR PANEL ORIENTATION IMPACT EFFECTIVENESS?

Historically, the most popular orientation for solar arrays in the northern hemisphere has been south facing (**Fig. 4**). However, in the past few years, there has been a growing trend to use east-west-configured solar arrays (**Fig. 5**). East-west configurations typically allow for more panels to be installed on a roof, and compared with south-facing configurations, east-west configurations can capture more energy from the sun's rays throughout the day.

Table 1 is a case study by the authors that compares the use of east-west-oriented and south-facing solar panels and shows that the solar coverage or installed capacity on a roof can be improved by 16% by using east-west-oriented panels on the same-size roof. We also

Table 1. *Case study comparing the capacity and annual production of solar panels installed on an 80,000-ft² roof in Ohio and Arizona in the south-facing versus east-west orientation.*

	Ohio		Arizona		Increase
Orientation	**South**	**East-West**	**South**	**East-West**	
Installed capacity, kW	860	1000	860	1000	16%
Annual production, kWh	1,023,000	1,127,000	1,550,000	1,701,000	10%
kWh/kW	1189.5	1127	1802.3	1701	

Note: 1 ft² = 0.0929 m²

studied the same-size projects in both Arizona and Ohio. The installed capacity is the same in both locations, but the annual solar output is greater in Arizona. In all cases, even though the kWh-to-kW ratio (kWh/kW) for the east-west system is slightly less compared than that for the south-facing system, the east-west system's increased annual kilowatt-hour production of 10% could be more financially beneficial for the building owner and investor. The solar-panel provider will most likely design and install the most financially beneficial panel orientation and density. If unsure which orientation is best, it is not difficult for the PV provider to calculate both orientations for the project.

The east-west solar panel configuration also improves the wind resistance of the solar energy system compared with south-facing panels. The higher back edge of the panel on a south-facing array is more prone to catching greater amounts of the wind force, whereas the two high backs of the panels in an east-west configuration are back to back, creating a smoother aerodynamic flow of the wind over the panels. Simulated wind testing by Centroplan and Sika of both configurations using the same conditions confirms that the east-west configuration can reduce the wind uplift on the roof/solar energy system by as much as 20% to 30%.

SOLAR RACKING SYSTEM AND DEVELOPMENTS

Selecting the appropriate racking system to hold the solar panels in place is critical to both the performance of the solar energy system and the roof system.

Solar racking systems can generally be classified as follows:

- Nonpenetrating systems: In this type of system, a thermoplastic base plate or clicks made of the same material as the roof membrane are heat-welded to secure the solar rack (typically made of metal) to the thermoplastic single-ply roof membrane (**Fig. 6**). The number of clicks is determined based on project conditions and the local building code. This type of racking system has been successfully used by Centroplan and Sika on more than 1000 projects worldwide for close to a decade. One manufacturer that offers a nonpenetrating racking system includes the racking system in their 20-year roof warranty. The nonpenetrating system requires no ballast so it can be used on most projects minimizing the weight on the structure. This system does not penetrate the roof, eliminating any potential for thermal bridging or condensation.

Figure 6. Nonpenetrating solar racking system.

Figure 7. Ballasted solar racking system.

- Ballasted systems: In this type of system (**Fig. 7**), concrete pavers are added as ballast to the base of the metal stand to hold the solar rack (typically made of metal) in place. The amount of ballast needed is determined by project conditions and the local building code. Ballast weight will affect the roof's structural load-bearing capacity and could compress the roof insulation (if no hardboard is used), leading to ponding water or eventually stressing the roof membrane. It should be noted that a ballasted system is not attached to the roof or structure, so the solar array could move during wind or seismic events. Any movement of the solar array is a potential hazard and could damage the roof membrane. Over time, the concrete pavers can also break down as a result of cycles of freezing and thawing.
- Mechanically attached or secured systems: In this type of system (**Fig. 8**), the solar rack (typically made of metal) is held in place by a metal fixture that penetrates the roof and attaches to the roof deck or structure. The number of penetrations is determined by project conditions. Mechanical attachments

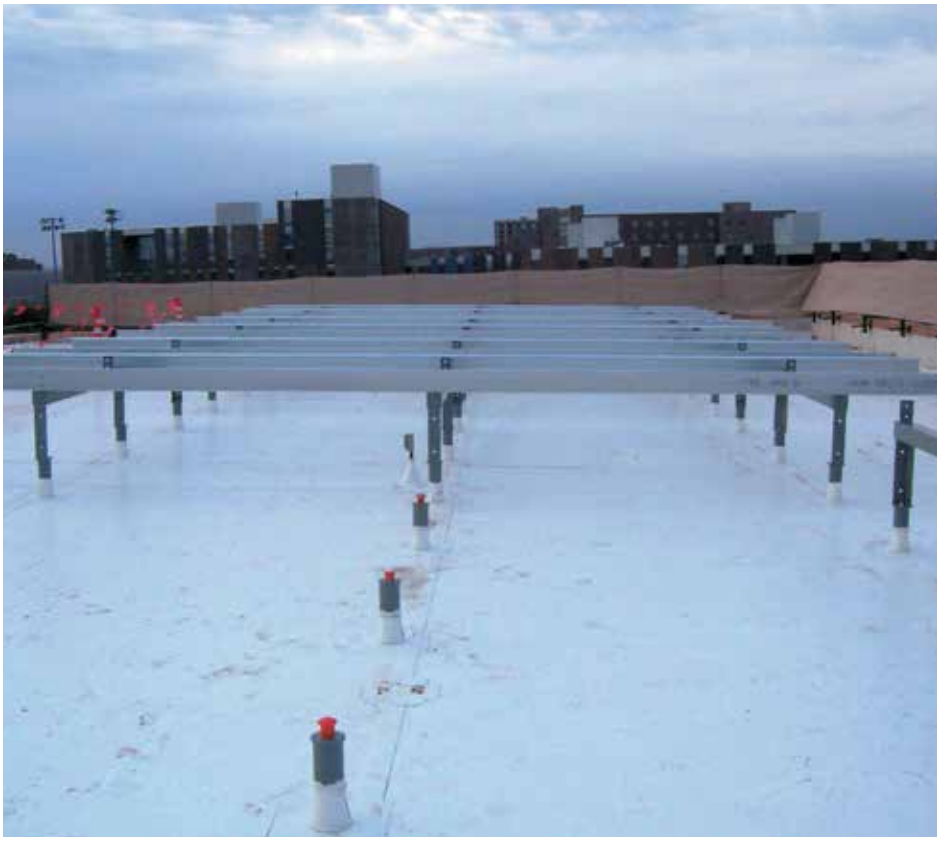

Figure 8. Mechanically attached solar racking system.

can be used as additional securement for ballasted racking systems as a hybrid system; their use is required by law in some areas prone to seismic activity. Mechanically attached racking systems pose a greater risk for roofs because they involve penetrations in the roof membrane and have the potential for creating thermal bridging.

All three types of racking systems can be used over standard low-sloped roof systems.

WHY SHOULD THE ROOFING INDUSTRY EMBRACE ROOFTOP SOLAR?

It is time to acknowledge that more widespread use of rooftop solar is inevitable. The expanding impact of solar-friendly policies and incentives in a growing number of states and localities nationwide will likely lead to more use of solar energy. The Federal Investment Tax Credit (ITC) or Production Tax Credit (PTC) for solar energy for the next nine years will make the solar business even more stable.[5,6] There is a renewed awareness of the benefits of solar power as corporations look to reduce their greenhouse gas emissions. Many companies have or will be implementing environmental, social,

Special interest

Is the "Triple-Peak" Workday the New Norm?

Have you noticed that golf courses and restaurants are packed by 4 p.m.? Think of it as flex time for workers who will resume their daily productivity after their kids go to bed.

"The hours that bookend the traditional close of business have become a dead zone at many companies, but employees aren't just blowing off work to relax for the rest of the day," wrote Callum Borchers in the *Wall Street Journal*. "Workers say the 4–6 p.m. flex time they use to take a turn in the kids' carpool, hit the gym, or beat traffic often requires a third shift at night to finish the day's tasks."

Microsoft describes the new working hours as a "triple peak," noting that the traditional morning and afternoon spikes in keyboard activity have been joined by a third peak around 10 p.m. Data from the company's Teams software also show a 7% drop-off in the past year for office meetings scheduled between 4 and 6 p.m.

"The tech giant predicts this pattern is here to stay," Borchers wrote.

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and governance priorities into their company philosophy and operations.

As resiliency becomes more of a consideration in how we design, build, and operate critical buildings and infrastructure, in the future, rooftop solar could help keep our customers' businesses running and our communities safe by having rooftop solar energy and a storage system available should the traditional grid-supplied energy not be available or interrupted.

Now is the right time for the roofing industry to start looking at rooftop solar as a new opportunity. When best practices are followed and we consider the roof and solar to be one complete system, high-quality solar-ready roofs can reduce energy costs for owners and occupants. As mentioned earlier in this article, teamwork and collaboration are critical to the success of a rooftop solar installation. Building enclosure consultants and engineers will be critical team members in this journey to expand the purpose of roofing beyond being a way to keep water out of the building. Rooftop solar done right could be one of the best things we can do for our owner customers and part of our contribution to environmental stewardship.

Sunny and bright days are ahead for rooftop solar.

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