Ramping up rooftop, reliably

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New survey data indicates reliability is a key concern with rooftop solar energy systems. Steven Padlewski finds out why material matters to mitigate risk

As the rooftop solar market continues to grow, serious concerns are surfacing regarding system quality and safety. In this article, I'll address some specific areas of concern including system lifetime, efficiency, safety and cost implications. We will also cover some best practices to mitigate risk, while optimising system performance and payback for rooftop systems.

A growing trend

According to industry estimates, around 35-40% of global solar installations are currently on rooftops, and rooftop installations will continue to grow at a faster pace than ground mounted installations, reaching close to 50% of annual installations over the next five years.

Growing concerns

A recent survey was conducted by Solar Power Portal, PV Tech and DuPont Photovoltaic Solutions, where 70 engineering, procurement and construction (EPC) firms, project developers and installers in the UK revealed some important insights about the challenges that most concern them. Participants indicated they were involved in several different market segments, including 40% percent residential and 58% percent commercial. Here are some of the key findings:

Approximately half of the UK respondents reported they have experienced quality issues on their solar installations.

When asked, what are the areas of improvement for solar panels which are relevant to your rooftop installations?

- 93% of participants stated performance related to lifetime
- 87% of participants stated performance related to efficiency

When asked, how important are the following benefits in your solar panel purchasing decision-making?

- 95%, reliability and durability of the panels
- 81%, reliable power output over lifetime
- 81% warranties

Many of the concerns listed can be addressed with the selection of solar panel materials that can play a key role in helping systems safely and reliably produce their optimal power output over their 25 year expected lifetimes. System owners need to select and specify materials carefully to mitigate risk of performance and safety issues. And while this is important for all systems, it is especially critical given the unique challenges inherent with rooftop systems.

System longevity

Operating temperatures on building-integrated rooftop installations can be up to 25ºC (77ºF) higher than ground-mounted systems, primarily because the solar panels are fixed closer to the rooftop surface, with a limited air gap and hence, limited ventilation.

Solar panels are also subjected to thousands of thermal cycles and thermal stresses over their 25-year expected lifetimes that have a higher amplitude compared to ground-mounted solar installations. This can create fatigue and accelerate the deterioration of critical materials such as backsheets, which protect and electrically insulate solar panels. Deterioration of the backsheet can lead to performance and safety issues.

There is also a higher risk of partial shading on rooftops due to the presence of physical obstacles such as antennae, chimneys or the proximity of trees that can induce hot spots. A solar cell subjected to shading becomes resistive and will generate heat if current continues to be pushed through. While this situation should not occur with correctly-functioning bypass diodes, a field study conducted in 2010 by PV ResQ, a research team in Japan, demonstrated that 47% of all bypass diodes would not function properly under such circumstances. With current pushed through a shaded cell, the resulting hot spot can exceed 100ºC, a temperature that can affect the integrity of the protective backsheet and its adhesion to the encapsulant, especially if the materials selected are thermally sensitive.

Degradation of the backsheet is particularly critical on rooftop installations because a cracked or delaminated backsheet could expose conductors inside the solar panels, operating up to 1000 volts to the environment. This represents a serious safety hazard given the proximity of the solar panels to the rooftop and the building itself, with risks of current leakage and even electrical arc formation. The backsheet is a composite film, designed to provide robust electrical protection over the expected lifetime of the panel. Therefore, electrical insulation materials, specifically backsheets, need to be selected based on their resistance to higher operating temperatures, thermal cycling and resistance to hot spots, particularly prevalent in rooftop applications.

Polyvinyl fluoride (PVF) film-based backsheets are proven to be very robust under thermal stress. Specifically, TPT backsheets, made using two layers of PVF film on either side of a core polyester layer, offer a very stable inner layer interface with the highest softening point temperature in the industry (170ºC or 338ºF), which provides a robust and consistent adhesion to the encapsulant layer, even at high temperatures.

It is important to note that not all backsheet materials have been proven to protect panels over 25 years, especially in harsh conditions. Field studies have shown that unproven and inferior backsheet materials can break

down within a few years. Common issues observed in the field include micro cracking, deep cracks, front and rear side yellowing and delamination that can lead to premature power degradation, system failures and electrical safety issues.

Most rooftop solar systems are relatively small and do not normally involve formal operations and maintenance procedures. Also, it is not always easy to conduct proper rooftop inspections, in particular on the back of the panels, owing to the proximity of the panels to the actual roof. But just because a problem can't be observed does not mean there is not one there. Specifying proven materials for rooftop installations is one of the best ways to help ensure the safe and reliable long life of solar panels in rooftop applications.

Efficiency matters

On rooftops, where space is typically limited, it's important to get the most power possible from each panel. The key to maximising power output is in optimising the efficiency with which the solar cells convert sunlight into electrical energy. This can be determined by the type of solar cell and the type of metallisation paste materials that are utilised.

To help optimise efficiency, some leading solar cell and panel manufacturers are developing panels made using new high-efficiency, multi-crystalline passivated emitter rear cell (PERC) solar cell designs, enabled by specialised metallisation pastes or paste systems. Using PERC technology, one manufacturer recently achieved a 19.6% total efficiency in the production of 60-cell panels featuring a record-setting 286 watts of power.

Efficiency also has an important impact on system cost and can help reduce the balance of system (BoS) cost by making better utilisation of the mounting, cabling and installation costs per panel installed. Continued advances in new solar cell architectures such as PERC and n-type technologies and new high-efficiency paste materials have resulted in solar systems requiring about half the number of panels to produce the same power output as they did years ago. As a result, for each panel installed, the relative cost of less racking, mounting, weight to transport, and labour involved in installation has been reduced by a factor of two. Innovations in paste technology also have resulted in up to 50% less material needed for each solar cell which can help reduce costs even further, without sacrificing power output.

Cost implications

Incentive programs and support mechanisms for solar energy are gradually phasing out across the globe. To sustain growth, the solar industry needs to compete on a cost basis with other sources of electricity, including fossil fuels. As the cost of a solar panel captures approximately 50% of the total system cost, it is important to reduce its cost on a Watt peak (Wp) basis. But while we find ways to reduce the cost of panels, it is equally important to ensure that these cuts do not adversely impact the reliability, durability and operational lifetime of solar systems.

Cost-per-watt (or £/Watt) is often used to express the cost of a solar energy system. However, cost-per-watt only describes the purchase price for the initial power capacity for a solar panel, it does not express the overall cost of system ownership. Many experts advocate the use of Levelised Cost of Electricity (LCOE), measured in cost-per-kWh (or £/kWh), as a much better performance metric. LCOE takes into account the total system cost divided by the cumulative power output of the system over its actual lifetime.

The industry's use of £/Watt creates a short-term focus that overlooks system quality and field failures that can seriously degrade investor returns. LCOE by contrast provides a more accurate measure of costs and cash flows that better reflects true system performance and therefore true investment returns. Evaluating systems based on LCOE enables the best cost/performance decisions.

Since the economics of solar are driven by how much power is produced by a system over its lifetime, materials are critical. They impact LCOE in three ways:

1. More durable and reliable protective materials such as TPT backsheets help increase system lifetimes
2. Advanced materials such as specialised metallisation pastes have achieved a 4x reduction in metal laydown, saving costs, while solar panel power has increased by 25%
3. Greater efficiency also reduces the number of panels required to achieve the needed power output for a system. Using fewer panels reduces related BoS costs.

Cutting costs by cutting corners on materials, component design, and/or manufacturing practices may lower the £/Watt of a system, but can result in significantly higher LCOE based on decreased lifetime, faster power degradation or electrical safety issues.

Warranties

Typically, warranties are provided for peace of mind. However, in the climate of consolidation that the solar industry has, and continues to experience, warranties are not always as reliable as they should be. Within a span of 25 years, companies can become insolvent, and panel designs can change to such an extent that matching the size and voltage is no longer possible after an extended period of time.

When the panel manufacturer or installer is no longer in business, the consequences can be very serious and very expensive for the system owner. Take this example: eight panels with shattered glass were found during an inspection of a 37kWp installation in Delaware. The system owner found itself in an increasingly common predicament when it was discovered that both the panel and inverter manufacturer were insolvent and the installer had been purchased by another company. Unfortunately, this situation left no recourse - the responsibility to safely mitigate the problem was left to the system owner. Ultimately, the smallest subarray containing 14 panels was dismantled for use as replacement panels.

The company estimated the issue translated to a lost value of $35,000USD, due to a combination of less energy produced and increased operation and maintenance costs for this sized system. Clearly, costs for larger system failures can run significantly higher.

Best practices to reduce risk

Rooftop is a key area of focus, due to its unique characteristics and continued strong growth projections. Additional research in all regions is ongoing and DuPont will be sharing its learnings, insights and best practices for improving system safety and performance at the upcoming Solar Energy UK exhibition and conference in Birmingham.

Insisting on transparency to understand what materials are used for rooftop solar systems, specifying those materials with a track record of proven reliability over time and verifying that the specified materials are in fact used in all panels in the system are three key steps to effectively mitigate risk of panel failures long term. Solar manufacturing and installation best practices are also critical to minimise risk of system failure on rooftop solar systems.

Decisions that trade-off quality for cost may save projects a few cents per Watt, but they can put system performance and safety at risk. For these reasons it is increasingly important to be aware of (or even influence/specify) the materials used particularly in rooftop solar installations.

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