Powering the future with smart monitoring

Words: Ian Humphery-Smith, CEO & Founder of LanneSolaire

Can the Internet of Things (IoT) help provide preventative maintenance to allow for the timely replacement of faulty modules and enhance the efficiency and performance of long-term power production? PES looks at how this technology can help improve return on investment.

Inverter outages at commercial and utility-scale solar installations are the cause of 81% of call-out service tickets requiring costly field-based technical interventions. This data is based on greater than one-third of all non-residential US solar facilities during 2020. The latter resulted in interruptions to significant portions of power-generating capacity at each affected site.

This phenomenon is measured in terms of annual Gross Availability. Notably, these service interventions vary in duration from days to weeks and even months as a function of the time to correctly diagnose and locate the cause of inverter shut-down, or 'tripping'. This may include faults at the level of the inverter, one or more solar panels, combiner boxes, cabling and or racking defects.

In turn, this figure is influenced by the availability of replacement parts and their associated delivery times. These delays can be further negatively impacted by varying degrees of the quality of after-sales support, access to suitably-qualified service technicians locally, or indeed the disappearance of an inverter manufacturer from the marketplace. To this, one must add the serious issue of panel under-performance, which continues to go largely under-diagnosed.

The DuPont 2021 Field Analysis reported an analysis of some 13 million solar panels during 2020 observed at 630 different sites around the world. Here, visual examination showed an alarming 35.2% presenting advanced defects for panels aged at less than 10 years. And this for what is effectively a highly insensitive assay of the problem at hand.

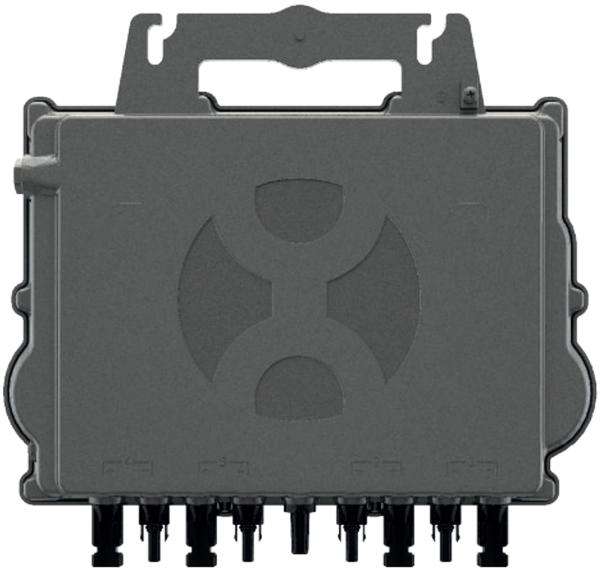
Can this situation be remedied?

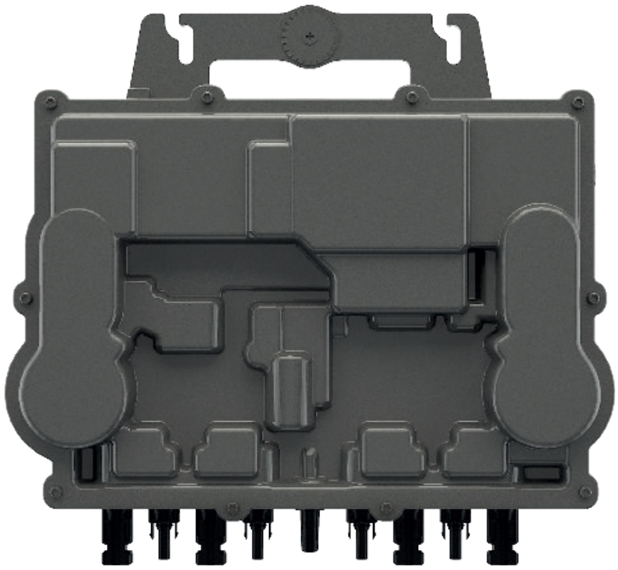
The answer is yes. However, the solution depends on implementation of the same approach as deployed in data centers and cloud computing, namely, avoidance of Single or Central Point of failure.

Delivery of such results in what is termed operational systems resilience and thereby affords a capacity for dependable continuity of solar power generation, a process underwritten and assured by micro-inverter redundancy.

To some extent, this trend has already been adopted across the solar industry through the widespread replacement of Central inverters with String inverters, but has yet to be extended to the level of individual solar panels using increasingly affordable multi-module micro-inverters (MMMIs).

Operational systems resilience means that if one micro-inverter fails then this has negligible impact on overall power generating capacity, nor is there any urgency to instigate repair or replacement of these lower-cost items. More importantly, the latter can be knowingly accessed with





respect to the cost effectiveness of deploying field-based interventions. As such, predetermined intervention thresholds for the number of panels and or micro-inverter malfunctions can allow for deployment of technical teams in a fully-automated manner.

Using high-granularity performance monitoring in a data center, for example, individual central processing units (CPUs) are subject to preventative maintenance and not allowed to degrade to a point whereby under-performance beyond strict limits or indeed failure become an issue. Here, avoidance of unpredicted failure is mission critical to computational service provision and it should be considered of equal importance for achieving efficiencies in solar power generation.

A major advantage regarding the use of micro-inverters and multi-module micro-inverters (MMMIs) is their ability to facilitate mixing and matching of solar panel makes and models without giving rise to debilitating mis-match currents.

As such, operational systems resilience can contribute meaningfully to extending the durability and economic viability of solar installations, but not that of individual solar panels. In the absence of individual panel monitoring, it remains difficult and expensive to activate panel manufacturer and/or installation guarantees and warranties. Micro-inverters can contribute positively to this process.

Not all solar panels will attain their guaranteed lifespan performance, which is generally 25 to 30 years. Traditionally, panel replacement has depended on the pre-purchase of identical make and model panels to cover future decades of panel replacements. This is both excessively costly and impractical, nor does it allow for the insertion of cheaper and higher performance solar panels, i.e., as they become available in the future.

Because of today's omnipresent system's architecture at utility scale of solar panels being connected in String Series, such discontinuities result in the creation of mismatch currents between solar modules and cells that can lead to overheating and a higher risk of fire generation. Therefore, the durability of solar installations is currently limited by the lifespan of individual panels.

Elsewhere, significant costs are associated with repowering, or revamping, the bulk of power generating infrastructure. This usually occurs in advance of the guaranteed lifespan of solar panels and due to their collective under-performance. On the other hand, Continuous Performance Up-grading with some of the associated costs being offset by panel manufacturer guarantees becomes a feasible option once string series are replaced by micro-inverter redundancy. The ensuing operational systems resilience has major benefits in terms of collective management of one or more solar energy facilities, or indeed distributed power generation, encompassing potentially hundreds of

thousands of rooftops or C&I installations located across distinct geographies.

Thus, operational systems resilience allows for discretionary upgrading and repowering of under-performing solar panels at any time. Indeed, solar energy facilities can potentially be managed without a predetermined end-of-use date. Programmed panel replacement becomes possible for a portion of the worst-performing panels annually, or after one or two decades.

Directing service teams to specific panels instead of lengthy field-based fault searches can further reduce the costs of this continuous performance up-grading. To these significant savings, one can add no need for biennial, infra-red, heat-sensing drones flights for detection of hot spots; field-based IV-curve monitoring of individual panels and field-based electro-luminescence assays one panel at a time.

It is important to note that no amount of extreme reliability testing can replace effectively continuous monitoring of individual solar panels in the field. Notably, continuous monitoring facilitates informed decision making by project owners, solar developers, and investors at all times.

To summarise, operational systems resilience can overcome the two most significant short-comings of solar power generation today: an inherent lack of reliability and durability. Operational systems resilience functions by de-risking and better protecting solar energy investments. The latter are increasingly linked to higher project costs due to their increased size and density of power generation, which is a higher Wp per solar panel per unit area, plus the associated costs of large-scale energy storage and or solar-tracking solutions. As a direct consequence, any short-falls in the level of energy generation will in absolute terms cost increasingly more per project.

Elsewhere, silicon-based technologies are nearing their physical performance threshold due to the Shockley-Queisse black-body limit of semiconductor band gaps, while the price per Wp has plateaued at close to a near-term bottom limit. Thus, reliability and durability will take-on more importance as the solar industry evolves.

Avoidance of down-time helps assure revenue generation and therefore can be justified as part of initial project CAPEX. Furthermore, the long-sought-after Holy Grail of avoidance of unforeseen failure can become a reality for solar power generation through adoption of operational systems resilience. Such a deliverable should allow for lower insurance premiums to protect, for example, 90% of annual projected power generation.

Elimination of central and or string inverters overcomes the cost of their initial purchase and regular replacement. Multi-modules micro-inverters such as the one offered by APsystems for example are sold with 20 year guarantees, unlike the majority of their central and string cousins. As project durations are extended, a bonus is that the Levelised Cost of Energy is reduced.

In this area, LanneSolaire defends intellectual property. It is focused on computational methods designed to enable solar performance monitoring totally divorced from fluctuations in the levels of solar irradiation during the day, over seasons and or due to weather fluctuations.

The bulk of solar performance monitoring tools currently available are overly influenced by variations that reflect predominantly weather or the time of day. Our methodology features data segregation and sequential treatment to reduce dimensionality and computational intensity of the complex data-sets being analyzed.

As anyone who has examined DC/DC optimiser or micro-inverter data for just a few dozen or more solar panels would have immediately noted, different solar panels under-perform at different times of the day. For example, early-morning dew, wind, and rain can reveal under-performance linked to cabling and moisture infiltration thereof.

However, the latter are most frequently observed under lower light conditions and are thus heavily obscured by observations recorded at midday on sunny days.

About APsystems

APsystems, the global leader in multi-modules microinverters for the solar industry, announced earlier this year that it has surpassed 2 gigawatts (GW) of installed capacity to date in 2022. APsystems now has more than 150,000 solar installation sites in over 100 countries utilizing its groundbreaking microinverters and rapid shutdown devices (RSDs).

The company is now working on the launch of its 2nd Generation of native 3-phase QUAD microinverter called the QT2. The QT2 which will be available globally this summer is reaching unprecedented power outputs of 2000VA to adapt to today's larger power PV module.

With balancing 3-phase output, encrypted ZigBee signals, the new QT2 is interactive with power grids through a feature referred to as RPC (Reactive Power Control) to better manage photovoltaic power spikes in the grid. In addition, it provides 97% peak efficiency with 20% less components compared to the last generation product. A 24/7 energy access through apps or web-based portal facilitate remote diagnosis and maintenance. at the module level. The QT2 benefits from an entirely new architecture and will be particularly adapted to commercial PV rooftop projects.

Intermittent under-performance is equally very difficult to detect when diluted by time of day, fluctuating light conditions over years and decades and or for panels located on different aspects of a rooftop or hillside.

LanneSolaire's methodology produces irrefutable statistical evidence associated with exquisite sensitivity based on potentially billions of control observations as a function of the size of a solar installation and the passage of time. As a direct consequence, fault prediction becomes a valuable by-product of high-resolution, high-sensitivity, continuous performance monitoring of solar energy production.

https://en.lannesolaire.com/

Biography

Ian Humphery-Smith is CEO and Founder of LanneSolaire a French start-up that intends to modernise the way solar energy facilities (SEFs) are managed. In 2001, Ian featured in TIME Magazine's 'Top Digital 25' for his work on the next phase of the Human Genome Project, namely, the contribution of each gene and its various protein products in health and disease. Like the arrangement of solar panels, this work focused on large numbers of recombinant proteins immobilised in rows and columns located on biochips.

LanneSolaire has protected intellectual property covering computational procedures designed to resolve highly-complex datasets derived from potentially millions of individual solar panels. The approach allows for exquisitely-sensitive parallel detection of constant or intermittent levels of under-performance at utility-scale SEFs or across hundreds of thousands of roof-top installations. This process works independently of constantly-varying levels of solar irradiation during the day, over seasons or due to weather. It is based on the Internet of Things, more affordable Multi-Module Micro-Inverters, and data segmentation to reduce computational intensity.