The life of a PV system: thinking on a 20 year timeline

PES asked Tyler Ogden, Lux Research Inc. to give us his expert viewpoint on the longevity of PV systems. Lux Research is a leading provider of research and advisory services, helping clients drive growth through technology innovation.

Utility-scale systems are now a competitive choice for electricity supply, with bids undercutting conventional sources of generation in some regions, while other regions see competitive subsidy-free deployments. This has largely been the result of declining module costs. Manufacturers have obtained significant economies of scale and have continued to adopt higher efficiency cell technologies.

Meanwhile other players across the supply chain that offer balance of system components and developed projects have reached maturity, contributing to lowering the capital expense of new installations to a point where sub dollar-per-watt systems are now feasible. However, the rate of cost declines has begun to taper off. If solar costs are to continue to drop and maintain the precedent of low-cost renewables, the industry must look elsewhere – must look forward in time.

The standard lifetime for a photovoltaic installation is 20 to 25 years, nearly double the time from when the global solar industry began to mature in early 2010s. The focus has primarily been in reducing dollar-per-watt costs to drive installations to where we are now, what will likely be above 100 GW of annual deployments. Indeed, the vast amount of photovoltaic capacity is only a few years old, providing a limited data source to begin investigating how performance can be improved and costs can drop over the full operational life of a PV system. However, multiple initiatives are underway to address the long-term variables of degradation and maintenance.

Under these market conditions, the U.S.'s Department of Energy declared its cost target of less-than $1.00/W utility-scale solar achieved three years early in 2017, while utility-scale costs in India, Mexico, China, and Egypt have likely been below $1.00/W for longer. Given this early achievement, the Sunshot Initiative has set new goals focused on the cost of generated electricity over the lifetime of a PV system, aiming for $0.03/kWh by 2030. To achieve this, two key areas need to be tackled at once.

Degradation is considered as a constant, a number included in a manufacturer's linear power warranty that is accepted as is and passed on to cost of electricity calculation. However, the reality is unlikely to be so simple. A number of initiatives are underway to investigate how degradation may be climate dependent, and more significantly what type of materials may decrease climate-dependent degradation.

Led by NREL, the Durable Module Materials (DuraMat) Consortium will pool together resources across four national labs for the development of materials that can improve the durability and lifetime of photovoltaics. The consortium will receive $30 million across five years to support U.S.-based projects in academia and industry. DuraMat falls under the Energy Materials Network with the aim to accelerate the development, characterization, testing, and deployment of novel materials to reduce the LCOE of photovoltaic systems. The support from the Department of Energy (DoE) for the DuraMat consortium highlights the potential high payoff of materials to reach the cost goal of $0.03/kWh.

Moreover, the IEA PVPS's Task 13, Koentges et al. surveyed PV systems across the globe, attempting to determine how degradation varies across different climate regions. While conclusions are currently limited due to poor representation of extreme climates, the tasks ongoing research will provide guidance on which climates degradation can be reduced. Another initiative at Case Western Reserve University's Solar Durability and Lifetime

Extension Center is seeking to develop lab tests that can predict in-field lifetime through an epidemiological study. The university has already achieved some results, showing how different weather conditions can affect backsheet degradation.

DuPont recently joined the field of those investigating climate-based degradation in PV systems, the first major corporation to pilot its own effort. Pairing with Envision's EnOS internet of things (IoT) platform, DuPont is likely exploring the potential for deploying an IoT solution for performance improvements in addition to exploring how its backsheets degrade. The integration of technologies typically seen in industrial digital transformations can have broader benefits to PV systems as well.

The PV industry has been gradually building a foundation of data that can be used to better understand the performance and pit-falls of plant operation over the 25 years for which a system is contracted. Several players have begun to utilize the data to demonstrate how value can be extracted from improved analytics.

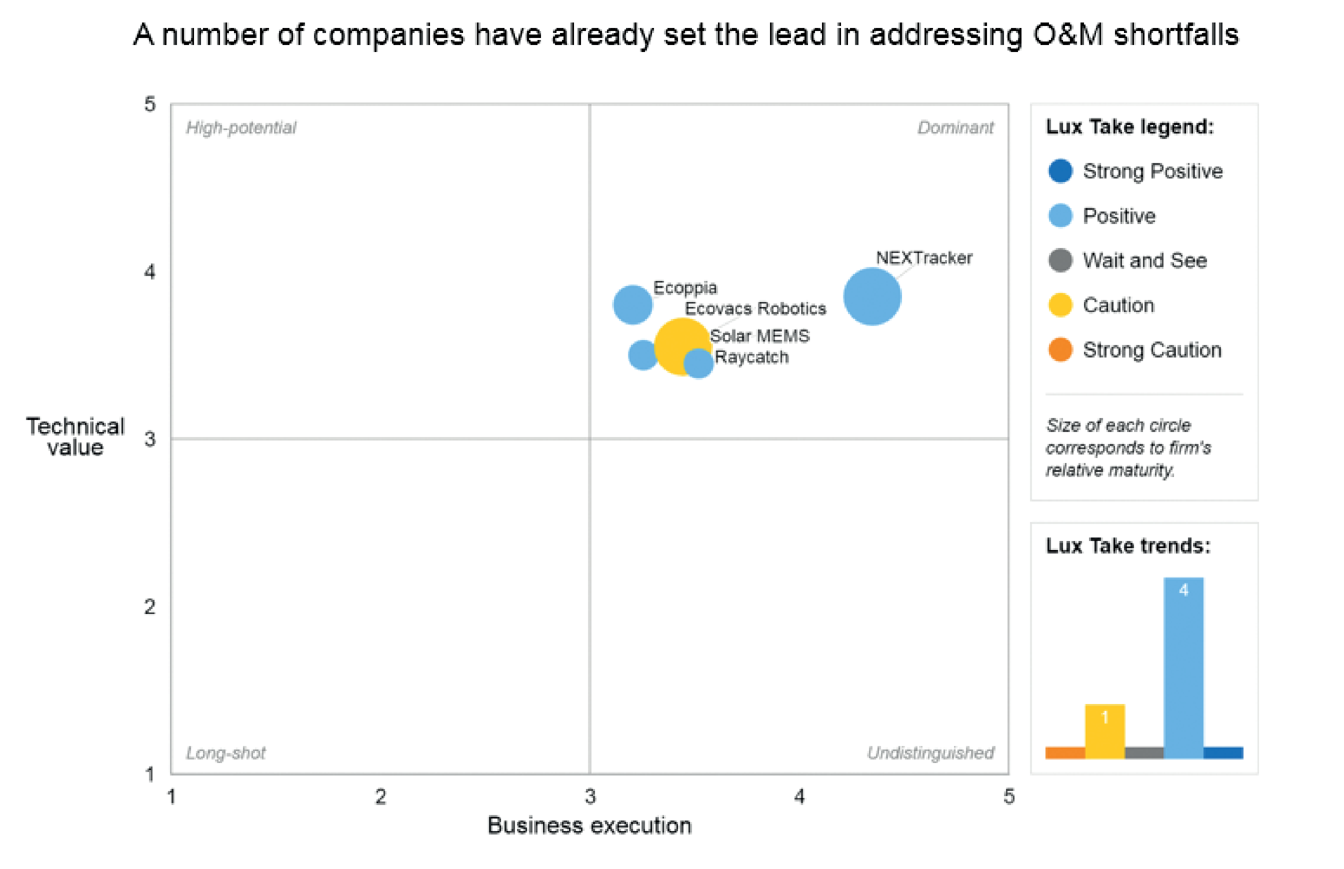
High-efficiency PV manufacturer SunPower partnered with KryptonCloud to deploy its data aggregation, processing engine, monitoring application across a 2.5 GW portfolio. This resulted in a 50% decrease in false performance alarms, improving O&M response time to actual faults. The companies are now working to integrate predictive maintenance capabilities into the platform. Additionally, renewable developers Invenergy partnered with General Electric to deploy its Predix platform on a 20 MW PV system. The deployment aims to create a digital-twin of the system and improve revenue by $200,000. Beyond adding analytics to existing systems, a number of other solutions from the digital world can reduce operation and maintenance costs.

By applying machine learning algorithms to existing performance data, developers are evolving software capability from simply monitoring a system or portfolio to providing predictive maintenance recommendations to reduce O&M costs and improve performance.

One of the first developers to offer an AI-enhanced software-as-a-service product for predictive maintenance, Raycatch, is in the early stages of introducing software for utility-scale system. The software applies its algorithms to data currently available from system operators, and does not require any additional hardware. The data primarily comes from various balance-of-system components in the PV system, including: inverters, combiner boxes, and radiation & temperature sensors. The software is then able to make maintenance recommendations on the string-level, which are passed on O&M providers.

Quadcopter drones are being increasingly adopted by operation and maintenance providers to reduce labor costs for

Methodology : The Lux Innovation Grid (LIG) below evaluates companies based on primary research done by Lux Research analysts. These interviews allow Lux to conduct in-depth evaluations, resulting in the LIG chart's x-axis scores for business execution (focusing on factors like partnerships, momentum, management team, and more). Meanwhile, the LIG chart's y-axis scores each company's technology (focusing on the technology solution itself as well as IP position, key metrics, and more).



inspections, while start-ups are driving coupling analytics with imaging to improve fault identification. A case in point: Cleandrone offers two drone-delivered services: an inspection service dubbed Sherlock, and a cleaning service called Cleandrone.

Sherlock provides infrared imaging of photovoltaic plants for fault identification and preventive maintenance. The surveys are conducted autonomously and image processing algorithms can identify disconnected panels and hot spots, or bypass diode failures. Cleandrone is equipped with a squeegee and cleaning fluid to wash the surface of dirty modules. The system has incorporated computer vision and artificial intelligence to detect module surfaces and is able to recollect cleaning fluid.

In addition to these start-ups, existing suppliers of balance of system components have a natural avenue to introduce digital services. For instance, leading single-axis tracker supplier NEXTracker acquired Bright Box to improve its tracking controls. Machine learning algorithms were implemented to maximize production per row when weather fluctuations obscure direct sunlight. While this currently offers a 2% to 6% gain in electricity yield, the company is likely planning to expand this capability to offer predictive maintenance services for the entire system.

Another existing opportunity is via cleaning robots. Multiple companies are developing water-free robotic cleaning systems, reducing operation and maintenance costs compared to manual cleaning in desert environments. Ecoppia is an early mover in the space, having now reached over 300 MW of deployments in India and the Middle East. Standard operation consists of sending out cleaning order to the robots at a regular cadence or after a soiling event, such as a dust storm. However, there is opportunity to make this autonomous through a combination of weather forecasts and performance monitoring. Introducing machine learning software here can optimize a system's yield by how many cleaning runs is needed based on site-specific conditions.

Companies introducing digital technologies to solar plant operations are just in early stages, as is the research on reducing degradation through the adoption of new materials. However, both initiatives will positively impact solar economics: reducing annual costs by optimizing operation and maintenance procedures and increasing energy generation by eliminating different modes of degradation. Low systems costs are here to stay, reducing the need for subsidies; but the lifetime challenge remains.

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