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**Title: LOWER LCOE OF UTILITY-SCALE PV WITH APPLICATIONS OF MACHINE LEARNING**

Introduction:

The past decade was transformative for solar Photovoltaics (PV) industry. The global solar cumulative PV installations has raised from 37 GWp in 2010 to over 600 GWp by end of 2019 based on the report from Wood Mackenzie. In the course of this growth, the cost of solar PV has dramatically declined. According to U.S. Department of Energy’s recent report, since 2010, solar PV costs have declined 70%~80%, and therefore it has become one of the most economical choices of new electricity generation. Levelized cost of energy (LCOE) of solar PV resource, which is the cost of electricity over the lifetime of the PV plant divided by the total energy output, can be further reduced by the means of 1) Reduction of PV module price; 2) Reduction of the balance of system cost; 3) Optimization of solar PV plants performance, operation & maintenance; 4) Expanding the lifetime of PV plants. General Electric (GE), as an inverter OEM and one of the largest Industrial IOT platform providers, is helping the PV industry to reduce the LCOE by increasing PV system’s performance and reliability, as well as lowering the operation & maintenance cost (O&M).

GE Renewable Energy’s Solar Plant Asset Performance Management (APM) solution, powered by AI/ML algorithms, aims to optimize the PV system performance via advanced performance analytics, and reduce the O&M cost by enabling proactive maintenance. Machine learning (ML), as a subfield of AI, develops methods that enables computer to perform tasks without programming by a human. ML techniques allow computers identify early system failure signatures before they become discoverable by human experts. With the help of ML technique, we achieved automated performance loss identification and loss category classification for PV power plants, alarming the asset operator with detailed and actionable recommendations. We also achieved days, even weeks ahead failure prediction, which enables proactive site maintenance.

 Methods:

The data brought into the advanced and predictive analytics were collected in two methods: historical data from supervisory control and data acquisition (SCADA) system provided by customers, and a direct connection to the customer’s SCADA system and/or PV inverters via a GE’s connectivity edge device.

A digital representation of the system’s operation or a “digital twin” was developed with power plant design parameters and historical training data. A performance model of the power plant was built and fed with live site weather data to indicate theoretical energy production of the power plant. The gap between the modeled performance and actual performance is further analyzed to categorize sources of production losses. The classification of the production losses is performed through a pattern recognition technique. Recoverable production losses are reported to the end users through alerts. The alerts contain not only detailed loss information, such as time of occurrence, duration, and charts of key parameters, but also recommended actions to have the issues mitigated or fixed.

Digital twin also used to estimate the normal operational conditions of all the parameters being measured from the asset. System historical faults and malfunctions were analyzed to learn how much the system performance deviate from their normal operation conditions. Warnings and alarms were set by study the deviation of the real-time performance from the digital twin.

Results:

Case studies demonstrated that GE Renewable Energy’s Solar Plant APM solution increases the energy production of a solar PV plant via early detection of production losses and component failures. Empowered by automated production loss categorizing and estimating, a significant boost in staff productivity is achieved. Moreover, general O&M costs can be optimized by replacing preventative and corrective maintenance with proactive maintenance and reduce unexpected maintenance activities.