How Can Advanced Data Analytics Help Cost Reduction and Improve Operation & Maintenance of Large-Scale Solar Plants?

Beyond inspection

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Thirty-five percent (35%) – That is the percentage of modules exhibiting medium-to-long term risk of developing hotspots due to manufacturing defects on a PV plant commissioned last month in the USA. How can this have been prevented?

Operation and maintenance (O&M) is like a game of whack-a-mole. The O&M service provider constantly monitors the plant, looking for the factor limiting the power production, and fixing it. Hotspots developing in PV modules are, for that matter, a headache. Due to the non-linear evolution of hotspots (a small temperature elevation on one spot will snow-ball and grow into a hotspot), they seem to pop up randomly in the plant. Besides, the effect of hotspots on energy generation is diluted in the array and may pass unnoticed for weeks or months, reducing durably the return for the investors. Last but not least, a hotspot is a safety hazard. Although uncommon in large-scale projects, a fire start in a PV plant is topping the list of very worst-case scenarios for O&M providers.

Hotspot have been under scrutiny for many years, so much so that IEC 61215 includes a hotspot resistance mandatory test. Unfortunately, the test is very dependent on the module chosen, and in an inhomogeneous production lot, 2 modules apparently identical may behave very differently under this test. If the module under test does not pass this IEC standard test, the module supplier may simply reproduce the test until another module passes the test, and gets the certificate.

There are mainly 3 identified causes for hotspots: non-uniform soiling, cell cracks, and manufacturing defects (cold soldering, short-circuiting, finger grid interruptions, etc.). Non-uniform soiling is directly under control for the O&M provider. Cell cracks are today mostly originating from rough installation, or weather events. Again, the O&M provider may take the necessary precaution to avoid unexpected additional costs down the road: field electroluminescence imaging at commissioning, and after each serious weather event (potentially in combination with UV fluorescence) works well to identify newly-formed cell cracks. For manufacturing defects, however, the most effective way to avoid prevalence in the field is to capture the defects at the source: the production line.

That was not done for the US PV plant mentioned above, and the prevalence of manufacturing defects observed now in the field (by field electroluminescence) exceeds by one order of magnitude the one typically accepted in carefully factory-inspected lots. Analyzing the factory EL images through robust criteria (and for instance those set forth in the Industry Standard STS-STD-PVM1:2018), and comparing the EL images to large databases (and for instance STS has more than 50 million modules in their manufacturing database) can avoid the future O&M costs that will surely occur if the hotspots develop. The value of verifying production EL images is so attractive that several groups around the world are developing machine-learning algorithms to automatically detect EL defects in gigabytes of images. These algorithms are still under development today, but some are proving already very useful as a decision-support tool for the engineer-inspector.