用于太阳能电池阵列的诊断和维护的实时组件子串监控

到2019年底，光伏发电的安装量达到651吉瓦，并且将继续快速增长以应对气候变化。出于节省成本考虑，当今大多数光伏阵列直流工作电压可达1000 V向逆变器供电，该串中的任何太阳能电池板的参数差异都会阻止太阳能发挥其最佳性能。

为了确保一串中的所有太阳能电池板的参数尽可能地一致，人们已经做出了巨大的努力，但是，在运行的多年中，还会出现差异，因为电池板/电池之间的不均匀衰减，灰尘，雪，鸟屎的不均匀阴影遮盖，障碍物（如附近的树木）可能会影响整个PV性能。

通常，使用多个“旁路二极管”作为解决这种非理想的不均匀太阳辐射情况的方案，这可以缓解大多数严重的不均匀太阳辐射问题。但是，我们不知道光伏发电串当中的不均匀情况发生在什么时候，在电池串中的哪个面板，以及严重到什么程度。而且，旁路二极管通常无法解决任何“温和”的不均匀太阳辐射问题。

事实上，在没有任何有意义的数据指导的情况下，通常的做法是定期检查太阳能电池阵列，以发现由异物引起的任何意外阴影/异物遮挡，并在视觉上可能发现任何问题的情况下纠正该问题。

我们提出的解决方案是为每个PV面板安装几个传感器。在最简单的情况下，我们测量每个旁路二极管的电压，并无线传输实时数据以及相应的设备序列号到云平台进行自动分析，软件会定期检查数据的完整性，并对每个组件内的子单元不平衡的工作状况进行评估和排序。通常是针对72电池片组件中的三（3）个24电池子单元，或60电池片组件中的三（3）个20电池子单元。从数据模式中，我们通常可以推断出导致这种性能不均衡问题的原因。

进一步的，如果这样的子单元电压数据再用电流和温度数据进行补充，它将描述太阳能电池板的更详细的工作状态，并揭示许多以前未知的信息。有了这些信息，我们就有足够的基础和信心进行提升光伏发电的效果。

一旦获得了严重不均匀的工作单元数据列表，并且知道了可能发生的位置和时间，我们就可以直接来到确切的位置，如果有必要，可以检查核对症状，并通过清洁面板，移除障碍物来纠正问题，或更换有问题的面板。这将大大降低了光伏维护成本。它还可以为任何可能的灾难性故障提供早期警报。此外，如果有必要，由于有足够的数据，我们可以重新排列整个PV阵列，现在可以将具有几乎相同参数的面板排列成一串，以便获得最佳的一致输出。

作为结论，我们可以收集和分析子面板太阳能工作状态数据，以提高光伏发电性能，大大减少光伏电站维护工作量和时间，这是提高光伏生产率的新工具。

Real time subpanel monitoring for solar array diagnosis and maintenance

Photovoltaic installation reached 651 GW by the end of 2019, and that will continue to rapidly grow to fight the climate change. For economical reason, most PV array nowadays reaches 1000 V DC working voltage to feed the inverters, any solar panel parameter discrepancy in that string will prevent solar to perform its best.

Great efforts have been made to make sure the parameters of all solar panels in a string be as consistent as possible, however, during years of operation, discrepancy occurs, as uneven decay among panels/cells, uneven partial shadowing from dust, snow, bird poo, obstacles like trees nearby, which may impact the whole PV performance.

Usually multiple “bypass diodes” are implemented as the solution to such non ideal uneven solar radiation situation, that can alleviate any acute non-uniform solar radiation problem. However, we do not know when, which panel(s) in the string, and to what extent the uneven situation occurs. Also, any “mild” non-uniform solar radiation problem usually could not be solved by the bypass diodes.

Instead, without any guidance by any meaningful data, the common practice of PV maintenance is to periodically inspect the solar array to find any unexpected shadow caused by foreign objects, and to correct the problem if any problem could be visually spotted.

We propose to implement a few sensors to each PV panel. For the most simple case, we measure the voltages of each bypass diode, and wirelessly transmit the real time data together with corresponding device serial number to the cloud platform for automated analysis, software routinely check the integrity of data, and evaluate and rank the uneven working condition of each PV sub-unit, typically the three (3) 24 cell sub-unit in a 72 cell panel, or three (3) 20 cell sub-unit in a 60 cell panel. From the data pattern, we usually can figure out what would be the cause for such uneven performance problem.

If such sub-unit voltage data could be complemented with current and temperature data, it would describe a more detailed working condition of the solar panel, unveils a lot of information that were unknown before. With such information, we have enough basis and confidence for improvement during years of PV operation.

Once we have a list of the severely uneven working cell data, and we know the location and time it may occur, we can go directly to the exact spot, verify the symptom if necessary, and correct the problem by cleaning the panel, removing any obstacle, or replacing the problematic panel. That greatly reduce the cost for PV maintenance. It can also provide early alert for any possible catastrophic failure. Furthermore, if necessary, we could rearrange the whole PV array since we have enough data so that panels with nearly same parameters could be now arranged in one string for best unison output.

In conclusion, sub-panel solar working condition data can be collected and analyzed for improving PV performance, greatly reducing PV maintenance effort and time, it is a new tool to increase the PV productivity.