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Modern Monitoring Technology for Renewable Resources

by **Richard Harada**

As utilities transition to lowering their emissions, additional types of assets and technologies are being added to the network and the design of the network itself is changing to accommodate new generation sources and new ways to transport and store energy. There are new asset types that need to be monitored and maintained including those contained in renewable generation sites, HVDC, and BESS facilities.

As these new assets and technologies are introduced to the electrical grid, they add complexity to an already vast and complex system. Unique maintenance requirements, additional equipment and assets, and the need for specialized skills all mean that utilities must consider the way renewable energy sources will affect their system performance as they transition.

This article will highlight some of the ways that thermal & visual sensors can overcome the challenges associated with expanding wind and solar capacity by reducing maintenance costs, enhancing reliability, and mitigating the risk of asset failure by shifting to a condition-based maintenance plan.

Green energy sources such as wind and solar were once viewed as technologies with potential. They were exciting because they presented an opportunity to move away from high-emitting energy sources such as coal, oil, and natural gas. But, until recently, they had yet to prove that they were economically viable or efficient enough to make up a significant portion of the energy mix.

Today, sustainable energy sources not only compete with traditional energy sources, but in many cases surpass them.

Though important, governments alone are not driving the transition. Building and operating renewable generating facilities such as wind and solar are now largely more cost-effective than traditional coal-fired power plants. In fact, a 2021 Deloitte report showed that up to 91 percent of existing US coal-fired capacity had operating costs higher than new solar or wind.

Utilities now have a mixture of traditional (hydro, nuclear, and fossil–fuel) generating assets and new technologies (wind, solar, and others) that have completely different behaviors.

This mix, especially as utilities maintain and support existing investments, requires greater coordination, not only to ensure that energy is available to meet changes in demand, but also to conduct maintenance, repairs, and upgrades on a wider range of equipment.

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Looking at wind, for example, only 20-25 percent of the total production costs can be attributed to ongoing operations, compared to as much as 60 percent for a natural gas-fired plant. These higher operating costs become even more relevant as fuel prices continue to fluctuate in response to global volatility.

The Impact of Renewables on Energy Infrastructure

Despite the advantages and obvious need to shift toward renewable energy, introducing new generating sources also introduces more complexity.

Consider the maintenance requirements for wind turbines. It's not a simple task to dispatch a technician to conduct an inspection. They need special training to work at heights and must be familiar with both the internal and external components of the turbine. As a result, a single turbine can take hours to inspect, and with larger wind farms having tens or hundreds of turbines, this quickly becomes unsustainable. In the same way, large solar farms spread across wide geographic areas require a significant ongoing effort to maintain and repair.

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MONITORING TECHNOLOGIES FOR RENEWABLE SOURCES

Beyond the generating assets, newly installed capacity requires other equipment and infrastructure. Many new facilities are deploying large-scale batteries to overcome the challenges of intermittency associated with wind and solar. Batteries introduce further maintenance requirements and demand different skills and expertise from the technicians who work on them.

Finally, the added capacity must be transmitted and distributed to customers to be useful. This can be done in several ways depending on the needs of the utility. For example, they may decide to run a single, high-voltage line to a larger transmission substation, or they may decide to connect multiple lower-voltage lines to distribution centers closer to the point of use.

Regardless of the approach, each new connection introduces new assets and additional points of failure that must be managed by the utility.

How Thermal & Visual Sensors Ease the Transition to Renewables

Given this added complexity, utilities need to shift away from traditional, scheduled maintenance and manual inspections. Instead of relying on expensive truck rolls and frequent physical inspections, thermal and visual sensors allow utilities to conduct automated, remote monitoring of high-value and critical assets throughout the electrical grid.

With continuous, 24/7 data, utilities can detect potential issues and diagnose the cause before a catastrophic failure occurs. Repairs can then be prioritized based on the severity of the issue, ensuring technical resources are deployed efficiently and enhancing the overall reliability of the grid.

For example, **utilities can deploy sensors to monitor the condition of wind turbines** without sending technicians into difficult and remote locations. Small, low-power sensors with built-in communications can be installed in the nacelle of the turbine and monitor anything from the mechanical components such as motors and bearings to electrical components such as generators, transformers, and switchgear. These assets can be monitored continuously whether the wind farm is local or in the middle of the ocean and provide early notification of developing problems. As power from renewable sources is aggregated, monitoring the substations, transformers, and inverters will be critical as the power flows from generation sources to downstream consumers.

Due to its high efficiency, **High Voltage Direct Current, (HVDC), technology** is being increasingly used to transport power from remote generation sites to consumer locations. The HVDC converter halls are a challenge to monitor and maintain because once they are powered up, personnel cannot enter the buildings due to the hazardous, high-voltage conditions. Using modern sensors, the equipment inside the HVDC hall can be monitored continuously and most importantly, while the system is running and under load. Infrared monitoring can detect thermal anomalies in active components and detect issues or leaks in the cooling system. Using continuous, automated monitoring in HVDC converter halls can minimize the planned outage that would normally be scheduled for periodic inspections.

Photo: Systems With Intelligence

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Utility-scale, Battery Energy Storage Systems, BESS supports the deployment and operation of renewable power generation. Integrating BESS with wind and solar power systems has the potential to increase the overall efficiency, reliability, and economic viability of these technologies while reducing greenhouse gas emissions.

The flexibility that BESS provides will help utilities overcome the variability of wind and solar. BESS facilities can respond almost instantaneously, making it easier to match supply with demand. The systems also allow operators to take advantage of price differences between peak and off-peak periods, stabilize the grid, or provide backup power for critical services.

Already, battery deployment in the power sector increased by more than 130 percent in 2023, adding a total of 42 GW to electricity systems around the world. However, accidents, fires, explosions, and arc flashes have occurred at BESS facilities which have damaged equipment and put workers at risk. These incidents, if not avoided in the future, pose serious threats to the development and adoption of BESS. In BESS sites, it is crucial to deploy continuous condition monitoring to avoid accidents and failures and not be dependent on periodic inspections.

Thermal sensors provide early detection and warning of sudden or prolonged temperature anomalies outside of a set range, while visual sensors allow operators to remotely view the condition of the asset, check gauges, verify the issue, and assess safety risks before dispatching a crew to the site. Having grid edge security with alarm management integrated into the overall solution ensures these valuable assets can be operated reliably in remote areas.

Utilities now have to manage a mix of traditional generating assets, renewable energy sources, and large-scale energy storage facilities. Each of these systems has completely different behaviors, lifespans, and maintenance requirements.

As a result, utilities require greater levels of coordination, oversight, and responsiveness. Given the nature of BESS facilities, the potential consequences of a catastrophic failure can be significantly higher than a typical substation.

Energy 4.0 Will Modernize Asset Monitoring

Energy 4.0 is a general term for the collection of hardware, software, and technologies that leverage connectivity, data, and computing power to modernize the grid. The Industrial Internet of Things (IIoT) is a network of physical devices or sensors that collect, exchange, and transmit contextual data.

Cloud computing is the on-demand delivery of computing services over the Internet, including servers, storage,

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databases, networking, software, analytics, or other IT services. Data and analytics allow utilities to collect, store, and use data from multiple sensors to improve decision-making, business processes, and performance. A recent study found that 32 percent of electric utilities had already or were currently implementing big data analytics. [iv]

Artificial Intelligence (AI) allows computers to analyze and contextualize data to provide information or automatically trigger actions without human intervention. Machine learning (ML), on the other hand, is a subset of AI that uses algorithms to automatically learn and recognize patterns to make increasingly better decisions.

Advanced thermal and visual sensors allow utilities to monitor the condition

There are significant advantages to this approach, not least of which is that it does not require utilities to build and manage a network for each substation.

Embracing Technology for Long-Term Success

Accelerating trends toward renewable energy, distributed grids, labor shortages, and more frequent and severe weather events are taking a toll on aging infrastructure that was not designed to meet the challenges of the future.

Remote Asset Monitoring using contactless thermal and visual sensors provides utilities with a continuous view of high-value, critical assets while minimizing the need for physical inspections.

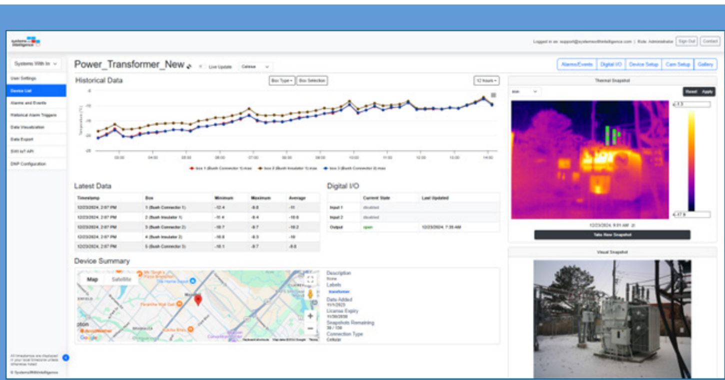

Photo: Systems With Intelligence

of remote assets from a centralized location. With continuous, real-time thermal and visual data, operations and maintenance teams can allocate resources more effectively, reduce the cost of maintenance and repairs, and improve reliability through condition-based maintenance programs.

Utilities have two primary choices to connect to the sensors and access the data. Traditionally, they would turn to their IT department to build an internal network, invest in IT infrastructure, install software on user devices, and individually update software whenever a new version was available.

Today, however, many utilities are transitioning to the cloud and accessing their data through an easy-to-use online dashboard.

With greater access to historical and real-time data, utilities can mitigate the risk of catastrophic failures, prioritize strategic investment decisions, and reduce the burden on scarce technical resources.

By implementing effective security policies and IIoT architecture, utilities can achieve the benefits of Energy 4.0 technologies without compromising sensitive data or critical equipment. Energy 4.0 technologies including IIoT, cloud computing, data and analytics, and AI/ML are changing the way that electric power and its critical assets are managed and maintained. By making the right investments today, electrical power utilities will be better positioned for long-term success and profitability.