WHITE PAPER

Mission-critical data for reliable power in the age of renewables

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The rapid growth of renewable deployments on grids worldwide has profoundly changed the electric-power value chain. Professionals at every link in that chain—from control-room operators to generating-fleet managers to regional transmission operators—face operational challenges that simply did not exist even 20 years ago.

Operations data is critical to navigate new challenges

Generation resources distributed across wide geographic areas and two-way power flows from inverter-based devices—along with the ever-present risk of extreme weather incidents that can disrupt power resources—combine to form a complex equation that must be solved thousands of times each day to ensure reliable power.

The traditional distinction between power provider and consumer also has shifted. In many cases, the role switches frequently, if unpredictably, throughout the day, particularly as output from distributed solar resources fluctuates.

With this increased complexity and uncertainty, the strategic use of operations data is critical to navigate three big new challenges:

- Meeting availability and reliability requirements.
- Maintaining asset profitability in competitive markets.
- Achieving real-time situational awareness of distributed generation assets.

Meeting availability and reliability requirements

This challenge is acute in cases where fewer generating reserves are available to meet peak load. For example, the Electric Reliability Corporation of Texas (ERCOT) operated its grid during the summer of 2018 with a generating reserve margin of only around 11% during peak load. That narrow margin heightened the need for accurate, data-driven weather and market forecasting to inform operational decisions.

Maintaining asset profitability in competitive markets

In competitive markets, the strategic use of data enables electricity providers to adjust operations in real time to address market conditions and keep their generating assets in the money.

At ERCOT, 12 times an hour, the grid operator manages Security Constrained Economic Dispatch, an energy auction that dispatches the lowest-cost resources. Key to making this model work has been a data-enabled market redesign that replaced a handful of zones across ERCOT with hundreds of nodes that provide actionable data to market players.

Achieving real-time situational awareness of distributed generation assets

The growing installation of distributed generating assets includes not only wind farms but also thousands of small-scale rooftop solar installations. Data from these helps asset managers and grid operators achieve real-time situational awareness and improve outage prevention and response strategies.

An era of renewables

Renewable technologies, too, have benefited from cost reductions, as innovative materials and engineering solutions are applied to solar photovoltaics and wind power. These enabling factors are paying off with impressive results for renewable energy.

The larger trend underlying all three challenges is the growing deployment of and reliance on renewable energy resources. International agreements such as the Paris Climate Accord, plus public-policy initiatives and government directives in the U.S., Europe, and Asia, are driving this global trend to a more sustainable energy ecosystem.

For example, the Paris-based International Energy Agency (IEA) expects renewable-electricity generation worldwide to rise by 920 gigawatts (GW) by 2022, an increase of 43% from 2017. And for the first time, additions of solar photovoltaic (PV) technology in 2016 rose faster than those of any other energy source.

In the U.S., utilities and independent project developers continue to develop wind-energy capacity, according to the *U.S. Wind Industry Second Quarter 2018 Market Report*, issued by the American Wind Energy Association (AWEA).

Texas leads the nation with nearly 23.3 GW of installed wind capacity, more than triple the amount of any other state. And among utilities, Xcel Energy is recognized as a leader in wind power. Company-wide, more than 20% of its energy supply comes from wind, about seven times the amount it had on its system as recently as 2005.

In addition to the utility-scale use of renewable generation, the North American electric-power system is transitioning to a mix that relies less on coal and nuclear power and more on wind, solar, distributed generation, and demand response. Traditionally, the power industry has viewed the distribution system as a relatively passive load source. However, the Essential Reliability Services Working Group of the North American Electric Reliability Corporation (NERC) says that is changing as distributed energy resources are being added to the distribution system. The result is bidirectional power flows that are intermittent.

Operational challenges

For operators and fleet managers, the rise of intermittent generating resources has proven to be challenging for traditional generating resources like coal and nuclear power. Those plants were designed and built to run continuously; no one expected them to ramp up and down any more often than for a refueling or maintenance outage. Now, however, many baseload units cycle on a regular basis as intermittent resources enter and exit the market.

Without accurate data and forecasting capabilities, the swings in renewable generation can present operators with challenges. For example, almost a decade ago, Xcel Energy was turning down gas- and coal-generating resources to make room for hundreds of megawatts of wind energy when conditions were favorable. But operators found that at high wind speeds, the wind turbines would clutch and stop producing energy. The sudden loss of, in some cases, upward of 1 GW of energy meant that those turned-down coal and gas plants had to rapidly ramp up to compensate. The utility knew that it needed better data to forecast wind availability and optimally manage its generating fleet.

In the case of distributed solar generation, operators also must manage two-way power flows. Virtual power plants made possible by aggregating large amounts of rooftop solar capacity can rapidly turn a consumer into a power producer and back again, all depending on weather conditions and time of day.

What's more, public policy offers a variety of incentives that benefit the deployment of renewable generating resources and improve profit margins for many baseload generating assets. Too-narrow margins can exacerbate the impact of forced outages if managers must enter competitive power markets to buy replacement energy at times that are less than optimal.

Harnessing data

The amount of data available to power plant operators as well as fleet and grid managers is growing exponentially. In ERCOT alone, more than 570 generators report their status every two seconds, synchrophasors report voltage and current information up to 60 times a second, and roughly 10 million smart meters report consumption data four times an hour.

ERCOT is not alone when it comes to the volumes of data available for analysis and action. The increasing amount of renewable-energy capacity and the expanding deployment of distributed, customer-owned generation mean that more data and faster responses will be needed to make operational decisions to balance supply and demand.

Integrating increasing amounts of renewable energy requires treating data as a critical asset. Data changes the role of IT departments within utilities, as it is turned into a reliable and available enterprise asset that can inform decision-making for effective integration of renewable power.

570/2 secs
Generators in ERCOT report their status every two seconds

60/second
Synchrophasors report voltage and current information up to 60 times a second

10M
Smart meters report consumption data four times an hour

Data's expanding role

A recent paper explains how IT's role in electricity markets is expanding along three fronts: operations, planning and modeling, and forecasting.

Operations

Real-time tools allow for more dynamic market control. Assessment tools deployed in ERCOT run every 15 minutes and update the transmission system's operating limits to reflect real-time conditions. Just a few years ago, this sort of assessment was done annually, but this led to operators being too cautious and curtailing wind operations more than necessary.

Planning and modeling

The paper says that ERCOT estimates that by 2031 there will be between 15 and 30 GW of solar photovoltaics added to its system—as much as a 3,000% increase over 2017, mostly in the western part of the grid. At the same time, generating assets in central and east Texas are likely to decline in number. The result will be a rise in the volume of west-to east power transfers over long-distance transmission lines, which, the report says, will require significant real-time modeling and data analytics to maintain system stability.

Forecasting estimates plant output

The growing numbers of renewable resources are raising concerns that ERCOT might come up short in meeting peak demand. To address that concern, ERCOT developed the Reliability Risk Desk, which provides analysts with detailed, forward-looking wind and solar forecasts that are updated hourly for every wind and solar farm connected to the system. The forecasts help analysts estimate the expected output from these plants to ensure that adequate resources are available.

ERCOT is not alone in using data and analytics to achieve operational excellence. The following case studies offer additional examples of the successful use of data to inform operational decision-making.

‘Cruise control’ for Spanish wind

As wind-power shares increase across Europe, and especially in Spain, control challenges at both the turbine and transmission-network levels emerged during the past decade.

The goals of traditional wind-turbine control systems have been to maximize energy production and protect wind-turbine equipment. As more wind-generation capacity is deployed, however, interest is growing in having turbines actively control their power output. The goal now is for wind-generating assets to meet power-output setpoints established by transmission system operators (TSOs) and to assist in grid-frequency regulation activities.

A setpoint works the same way as an automobile’s cruise control: Set a speed and go. As speed limits change based on driving conditions, the setpoint may be adjusted up or down.

As for frequency regulation, grid operators require conventional utilities to balance generation output and load, which in turn regulates the grid frequency. In the past, wind power was not called on to provide so-called regulation services. Most wind turbines do not intrinsically provide the grid-regulation services that are available with conventional generating units.

High wind penetration across Europe, including in Spain, has led the TSOs to require wind farms to be capable of providing frequency-regulation services when ample wind resources are available.

In Spain, the TSO required all production facilities with an installed capacity of more than 10 MW to have a control center capable of meeting TSO-mandated setpoints within 15 minutes. At first, setpoints were established for individual wind farms. That meant that Spanish utility Iberdrola Renovables had to curtail production at individual turbines. That practice presented control challenges and increased turbine wear and tear. Despite Iberdrola’s best efforts, however, inefficiencies could not be fully compensated and the utility consistently produced less energy than what was mandated by the setpoint.

To better meet the TSO’s setpoint requirements while still maximizing economic performance, Iberdrola implemented real-time information solutions in its Renewable Energy Control Center in Toledo, Spain. Those solutions enabled the utility to obtain real-time information on expected and actual wind power produced. In the meantime, Spain’s wind-power industry reached a new agreement with the grid operator, meaning that Iberdrola would now receive global setpoints for two groups of wind farms.

The primary group includes wind turbines that support voltage-dip regulation, or approximately 99% of the turbines. Instead of curtailing individual turbines within many farms, the company halts production at a few farms that are chosen according to their capacity to curtail. This control action can be done quickly because of the visibility enabled by the solution created using the PI System, a real-time-data infrastructure. Beyond reducing equipment wear and tear, the new scheme avoids unintentional curtailing beyond the setpoint, representing incremental revenue to the utility. Iberdrola estimates that the bump in wind power generated during curtailment periods averages 30%, with peaks of up to 60%, all without exceeding its setpoint mandates.

Wind forecasting at Xcel Energy

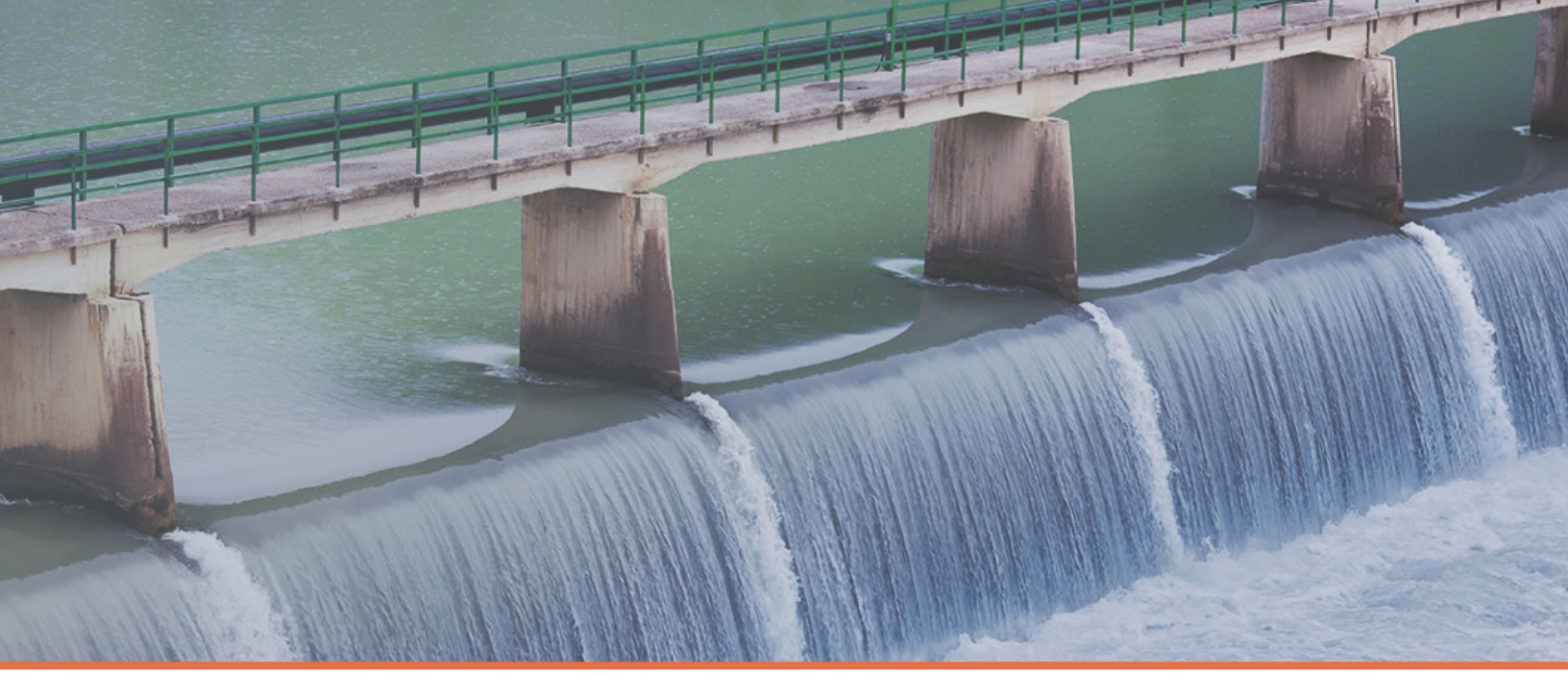
Xcel Energy, headquartered in Minnesota, serves around 3.5 million electric and 2 million natural gas customers in eight states. It ranks among the top five in the U.S. in terms of wind energy provided, solar capacity installed, and energy-efficiency programs put in place.

More than 20 years ago, the utility began to install the PI System as a data infrastructure across four power plants. By 2003, it had a centralized PI System installation for its Colorado Transmission Operations. That was followed by similar deployments in Minnesota and Texas. Power-generation and market-pricing data are used by its commercial-operations analysts to address market changes in both the Southwest Power Pool (SPP) and the Midcontinent Independent System Operator (MISO) regions, where the utility operates.

Xcel Energy was turning down many gas-and coal-generating resources to make room for hundreds of megawatts of wind energy when conditions were favorable. At wind speeds of around 55 miles per hour, however, the wind turbines would stop turning to safeguard against damage from excessive speed. The sudden loss of, in some cases, upward of 1 GW of wind energy meant that coal and gas plants would have to rapidly ramp up to compensate.

To better predict its renewable wind resources, the utility began wind forecasting in 2008 with collaborative help from the National Renewable Energy Laboratory and the National Center for Atmospheric Research, both based in Colorado. Using data-driven tools, Xcel reduced its forecasting errors by more than one-third and realized operational savings and efficiencies in excess of $45 million over a six-year period. The data-driven approach even allowed Xcel Energy to shut down a coal plant for maintenance for an entire weekend because it was confident about meeting demand through wind generation.

More recently, a monitoring and diagnostic center relies on data from the utility's PI System —a data infrastructure for operations data— to drive multiple applications, including predictive analytics, process screens, controllable parameters, and online heat-rate monitoring. The analytics extend beyond renewables and are deployed at major baseload power plants, enabling analysts to access plant data for use in troubleshooting and analysis.



Real-time data fuels hydropower maintenance strategies

Vattenfall Hydro Power represents more than 50% of Sweden's energy production and is the backbone of the country's energy system. Vattenfall's team understands the important role maintenance strategies play in optimizing asset performance, increasing efficiency, and mitigating unplanned failures. While the company deployed condition-based monitoring strategies nearly two decades ago, that strategy was missing one critical element: real-time data.

Vattenfall's aged maintenance strategy relied on static data collected from periodic inspections, tests, and a historian. The lack of real-time insights resulted in reactive maintenance, which was less efficient and more costly. Vattenfall needed to move to a real-time condition monitoring solution to reduce operational costs and improve efficiency.

The company piloted a PI System project to capture real-time data from modern DCS systems, analog DCS systems, a dam instrumentation system, and a vibration monitoring system. The company also imported its existing Conwide maintenance data into the PI System. Vattenfall used this information in the PI System to enable operators to perform on-demand trend analysis on approximately 25 basic conditions for each unit. Now, operators can quickly visualize real time asset condition using PI Vision, perform root cause analysis, and take preventive action.

Vattenfall's PI System pilot program was a huge success. The PI System successfully replaced the Conwide maintenance system and will support a future Hydro Information Portal to make process data, analyses, and KPIs available in real time. By minimizing unplanned maintenance events, the PI System is projected to reduce total maintenance costs by at least 1.5%. In addition, real-time PI System data improved Vattenfall's continuous-monitoring capabilities for each hydropower plant while increasing equipment accuracy.

Finding hidden revenue in real-time data

EDF Renewables provides grid-scale power across the United States, Canada, and Mexico. The company has used the PI System since 2009 to collect operations data from its turbines and solar storage facilities. However, operations control center (OCC) employees were unable to use PI System data to make informed decisions about when to send after-hours maintenance crews. Late night turbine outages in Canada made it clear that money was being left on the table.

Previously, the OCC relied on tables that measured the number of offline wind turbines against the current site wind speed. OCC employees used this information to determine whether to place after-hours calls to maintenance crews. However, the tables didn't account for speed fluctuations in wind speed, which can change projected power generation over a period time. The tables also didn't consider crew availability, distance traveled, and any associated costs. EDF needed to combine all of this information into one place so OCC employees could make cost-effective maintenance decisions.

EDF first identified any factors that affect how much revenue is lost when a turbine is down and no crew is available. The team imported wind-speed forecasts for each site into the PI System and used it in conjunction with existing turbine data. Lastly, they looked at factors that predict the amount of power a turbine is expected to produce at a given wind speed, such as active power status, long-term downtime status, turbine fault codes, and power-curve forecasts. All of this information was combined with dynamic power pricing information to create a "lost revenue" call-out for OCC team members.

Building on PI System data, EDF partnered with Diemus to create a custom dashboard inside Orca, a custom application that visualizes turbine data. The dashboard shows which turbines are down at each site and predicts how much an outage will cost. The dashboard combines this information wtih the defined factors that affect revenue loss and then indicates whether to perform a call-out. In the first six months there were close to 700 call-outs. When extrapolated over twelve months, EDF estimates that the new dashboards will save the company about $2 million per year.

The future belongs to those who realize that electric companies are now in the business of managing data as much as power.

Data-empowered decision-making

At every stage of electric power generation and distribution, data is empowering better decision-making and optimizing costly, long-lived assets. The rise of renewable energy, two-way power flows, and distributed resources has sharpened the focus on the need for actionable data.

The future belongs to those who realize that electric companies are now in the business of managing data as much as power. The most progressive companies understand that you can no longer do one without the other.

About OSIsoft

The world's most essential and complex industries rely on OSIsoft to manage the lifeblood of the industrial enterprise: operations data.

OSIsoft is a pioneer in data-infrastructure strategy and a global leader in operations data management software. The company brings over 40 years of experience helping industrial organizations meet next-generation demands for efficiency, reliability, security, sustainability, and resilience.

OSIsoft's market-leading PI System is the proven system of record for operations data in essential sectors such as power generation and utilities, water, oil and gas, mining, metals, manufacturing, pharmaceutical, facilities, transportation, food and beverage, and more. Every day, industrial professionals in 146 countries rely on the PI System to improve performance, protect health and safety, keep the lights on, and make the world run more smoothly.

Learn why two-thirds of Fortune 500 industrial organizations choose PI System at www.osisoft.com.

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