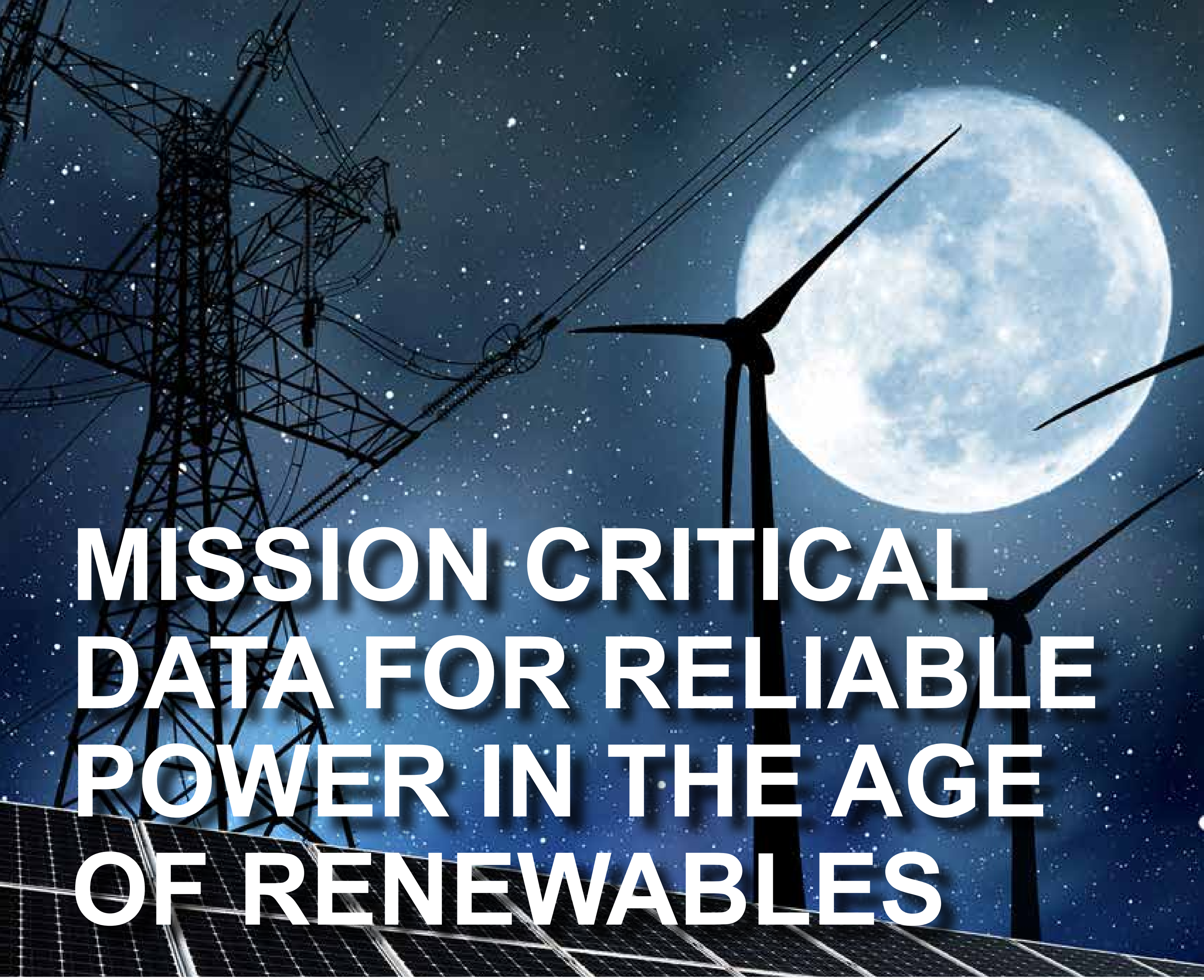

MISSION CRITICAL DATA FOR RELIABLE POWER IN THE AGE OF RENEWABLES

David A. Thomason | Industry Principal – Global Power Generation | OSIsoft

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The rapid growth of renewable energy 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 a decade ago.

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—and acted upon—thousands of times each day to ensure uninterrupted, 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.

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

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 2018 summer with a generating reserve margin of only around 11% during peak load. That narrow margin offered little room for error and heightened the need for accurate, data-driven weather and market forecasting to inform operational decisions.

Maintaining Asset Profitability in Competitive Markets

Here, 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.

Again, ERCOT offers a relevant example. Twelve times an hour, the grid operator manages Security Constrained Economic Dispatch, essentially an energy auction that ensures that the lowest-cost resources are dispatched. 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 distributed assets proves indispensable in helping asset managers and grid operators achieve real-time situational awareness and improve outage prevention and response strategies.

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AN ERA OF RENEWABLES

The macro trend underlying all three challenges is the growing deployment of and reliance on renewable energy resources. This global trend is part of the move to a less carbon-intensive and more sustainable energy ecosystem driven in part by international agreements such as the Paris Climate Accord, as well as multiple public policy initiatives and government directives in the U.S., Europe, and Asia.

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.

For example, 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 fuel.

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

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. More than 20% of its energy supply company-wide comes from wind, about seven times the amount it had on its system as recently as 2005.

Besides the addition of thousands of megawatts of utility-scale renewable generating resources, the North American electric power system is in transition to a mix that relies less on baseload resources such as coal and nuclear 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 North American Electric Reliability Corp's (NERC's) Essential Reliability Services Working Group says that is changing as distributed energy resources are being added to a the distribution system. The result is an bi-directional power flows that are intermittent by nature.

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. 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, upwards 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.

> 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.

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 that is 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 2 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.

Meeting the challenge to maintain availability and reliability, while integrating increasing amounts of renewable energy, requires treating data as a critical asset. The importance of data is changing the role of IT departments within utilities as they are responsible for turning data into a reliable and available enterprise asset that can inform decision-making for effective integration of renewable power.

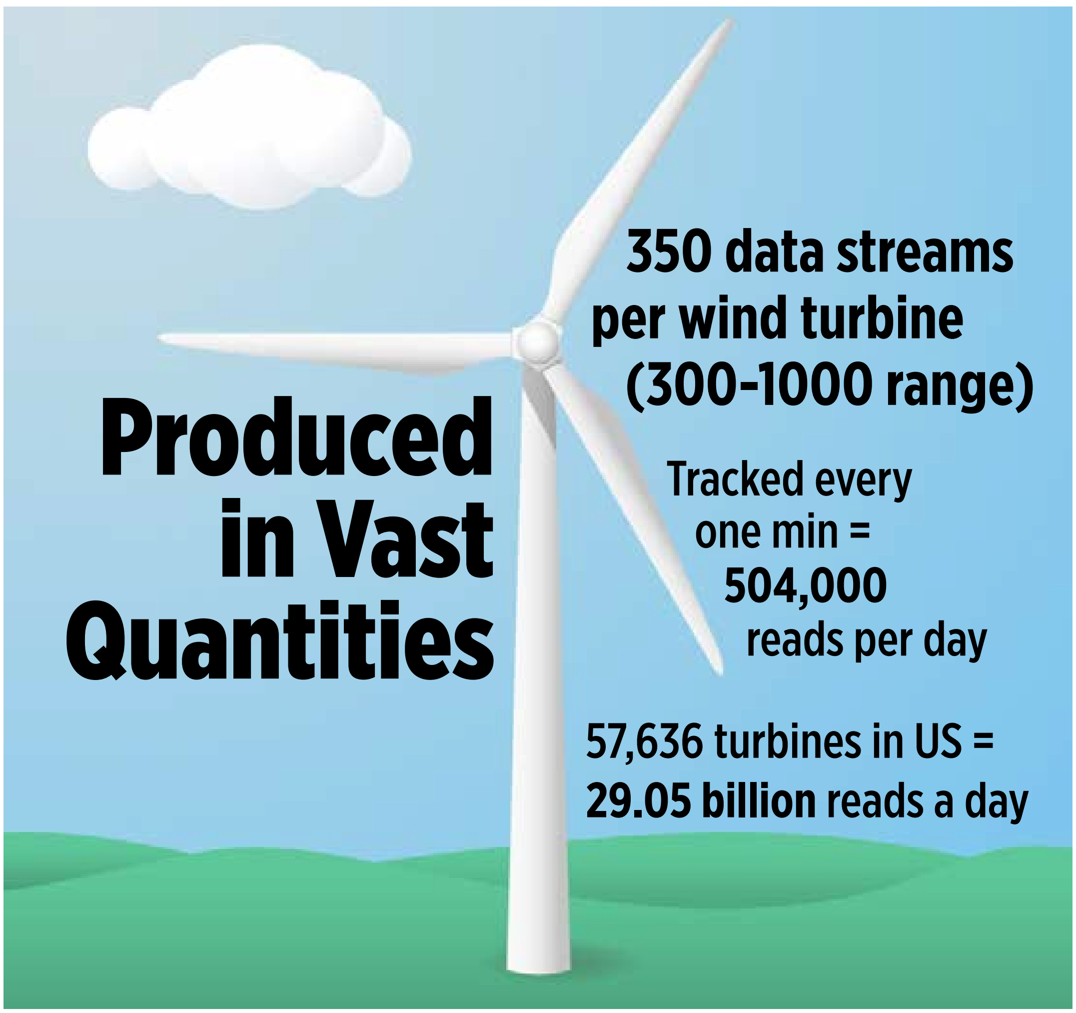

Figure 1: Real-time Insight into Turbine Conditions

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. That proved disadvantageous, as the lack of more frequent insights into grid dynamics led operators to be too cautious and curtail 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 PV added to its system, as much as a 3,000% increase over 2017. Most of that likely will be added 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

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.

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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.

SPANISH WIND

With wind power shares increasing 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.

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But high wind penetration across Europe, including in Spain, have led their TSOs to require wind farms to be capable of providing frequency regulation services when ample wind resource is 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 for and the utility consistently produced less energy than what was mandated by the setpoint.

> To meet the grid operator's setpoint requirement, while still maximizing economic performance, Iberdrola implemented real-time information solutions in its Renewable Energy Control Center in Toledo, Spain.

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 turbines that support voltage dip regulation, or approximately 99% of the wind 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.

XCEL ENERGY

With headquarters in Minnesota, Xcel Energy serves around 3.5 million electric and 2 million natural gas customers in eight states. It ranks among the top 5 in the U.S. in terms of wind energy provided, solar capacity installed, and energy efficiency programs 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.

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As we've already seen, 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, upwards of 1 GW of wind energy as a result of this turbine clutch 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 on an entire weekend because they were confident in 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 operational data, to drive multiple applications including Predictive Analytics, Process Screens, Controllable Parameters, and On-line 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.

DATA FOR PREDICTIVE ANALYSIS SAVES MONEY

Predictive analytics paid off in a big way for an Australian utility. Founded in 1837, Australian Gas Light Energy (AGL), based in Sydney, manages one third of the energy of the country's populous eastern seaboard. The utility's generating capacity grew from 300 MW in 2005 to 5,500 MW by 2012, and planners are looking to further expand that amount to 9,000 MW. Even so, the utility had little actionable data to help it assess performance.

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The utility began to correct that deficiency first by implementing the PI System as a data infrastructure so employees could create drag-and-drop custom visualizations of real-time data. Then, in April 2015, with an Operational Diagnostics Center, which enabled analysts to engage in predictive modeling. The utility deployed anomaly detection software for advanced pattern recognition, and built some 2,700 models to monitor 12 times an hour some 45,000 critical data points.

In three years, AGL has saved AUD$18.7 million ($13.5 million) in reduced forced outages and optimized maintenance. Additionally, in 2017, analysts caught and prevented a potentially catastrophic failure in a hydrogen-cooled stator.

In that incident, system alarms started ringing and the analytics team noted anomalies in the hydrogen exit temperatures. After recalibrating the instrument, operators put it back online, but the data showed a worsening problem. The team planned an outage to investigate, and, after a partial dismantle, found that the stator was mere days from having a number of its coils catch fire. A forced outage, which was avoided thanks to predictive analytics, could have cost anywhere from AUD$50 to AUD $70 million ($36 to $50 million).

DYNAMIC MARKET CONTROL

Competitive power markets are top of mind for operators of the Scrubgrass Generating Plant, a 35-employee, 85 MW waste-coal-fired power plant in Pennsylvania. Scrubgrass has used data to confront market challenges that shuttered similar plants.

Scrubgrass opened in 1993 and operated under a power purchase agreement (PPA) that gave it a profitable price for the electricity it generated. The PPA expired in 2013, putting the plant at the mercy of the competitive energy market. In that market, low-cost natural gas often drove prices below what it cost Scrubgrass to produce energy, tipping the plant toward widening financial losses.

To optimize operations in the face of these market realities, Scrubgrass's operators integrated data from multiple sources to drive real-time decision making in the plant's control room. Operators captured and combined data from plant operations, commodity and energy prices available on the web, data about energy markets, and long-term financial data.

By modeling plant operating costs against the dynamic energy market, operators developed a system to track the plant's profit margin in real time. That data was displayed in the plant's control room, allowing operators to see the financial effects of decisions as they were made.

One trend forecast saved the plant $160,000 in a single week by building a business case that showed how a planned boiler shutdown would lose money for the plant. Based on the insight derived from the data analysis, senior managers revised their outage plan and kept the plant open.

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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 understand that you can no longer do one without the other.

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