Creating the Smart Power Plant of the Future

As plants look to lower operating costs, respond to changing grid demands and maximize revenue, digital upgrades from controls all the way to AI will fuel their progress.

Evolving Power Markets Demand Progressive Technologies

As global power markets evolve, they demand enhanced reliability, availability and maintainability, as well as a lower cost of electricity, and power plants must respond. Today's plants are already benefiting from control upgrades and analytics that provide O&M optimization, performance improvement and flexible operation. As technology advances, exciting progress is being made on cognitive applications, leveraging artificial intelligence (AI) and machine learning.

Making power plants smarter, more cognitive and, ultimately, autonomous will be a big part of meeting market challenges that include retaining expert knowledge, pairing with renewable energy sources, lowering operating costs, responding to lower market prices and finding new opportunities to earn ancillary services revenue.

Mitsubishi Hitachi Power Systems (MHPS) is driven to tackle those challenges, and its MHPS-TOMONI® digital power plant solutions are aimed at steadily progressing towards a smart power plant that will be capable of autonomous operation. This paper will contemplate some of the ways to create a smarter power plant, knowing that the future holds countless possibilities.

Turning Data into Actionable Knowledge

With thousands of sensors available in a plant, there are already a vast number of data points, too many for human analysis, and the volume continues to grow. This increasing amount of data must be turned into knowledge and action. Data analytics and AI enable the consolidation of total plant and fleetwide knowledge to suggest or take optimal actions instantly. This consolidation of knowledge will give the plant management team immediate and actionable information to make more informed decisions and improve long-range revenue planning for the plant.

The expert knowledge of human engineers, operators and dispatchers has always been at the core of successful operation and maintenance and continues to be pivotal as technology advances. **Advancements in digital sensing, control, communication, machine learning and AI are increasingly enabling enhanced connections between physical equipment, digital systems and human activities.**

In short, a smart power plant operates as if it had an unlimited number of human experts on site who have full knowledge of the plant, similar plants from a monitored fleet, the transmission grid, the wholesale power market and the surrounding environment.

Adapting Plant Operations

A smart power plant can adapt because it:

- is self-aware of its limits, current operating status and plant-level operational options
- takes corrective action during operation
- uses real-time analytics to protect itself while maximizing revenue and minimizing emissions
- automatically alerts of compensation for the operational effects caused by the aging of critical components and gradual degradation of performance
- assesses and quantifies risk, using knowledge from itself and similar plants, to make important trade-offs based on profitability and equipment longevity
- proactively adjusts important operational parameters to optimally prepare for predicted weather events such as changes in ambient temperature and barometric pressure

Having a plant that is adaptive and self-sustaining based on its own data and fleetwide knowledge allows the plant management and engineers to focus on the most important issues and make better long-term asset-management decisions.

MHPS piloted the MHPS-TOMONI® boiler combustion tuning system in No. 2 boiler of the Linkou Thermal Power Plant in Taiwan. A successful trial has proven the effectiveness of autonomous action in the designated operating condition.

This digital solution uses machine learning and prediction models to achieve combustion tuning functionality that supports emission reduction, achieves an ideal gas/air balance and contributes to the economical plant operation while burning a range of coal compositions.

Advanced machine learning self-tuning systems have been in service for several years on MHPS gas turbines and can now be applied to thermal power plants.

Directing Maintenance

Maintenance is a key factor in the asset management of a plant. Equipment aging impacts competitiveness and availability to dispatch to the grid and take advantage of other revenue streams. **A smart plant's ability to access systemwide knowledge to recommend the best mix of time-based, predictive and condition-based maintenance will increase profitability while extending the life of equipment.**

Critical components wear and undergo dimensional changes during operation and between maintenance outages. This results in efficiency loss and increasing emissions. A smart plant self-adjusts important variables such as turbine disc cavity temperatures and critical combustion parameters to optimally offset these aging effects between outages, as well as documenting and prioritizing corrective action that should take place at the next planned outage.

Very subtle changes in sensor readings can be used to predict developing problems far earlier than typical power plant alarm settings, but the overwhelming quantity of sensor data makes it virtually impossible for human operators to be aware of all those changes. A smart power plant is capable of sensing very small pattern changes resulting from developing anomalies in the full range of sensors in the plant and able to prioritize and optimize the timing and profit impacts of needed maintenance.

Smart power plants can:

- determine and prioritize maintenance needs based on system-level implications
- assess risk and economic trade-offs of run versus maintain
- communicate status and assess risk based on asset criticality
- and request human maintenance support when needed to leverage limited resources

Automating maintenance recommendations will allow plants to plan ahead of issues, which decreases unplanned downtime and boosts profitability.

Total plant diagnostics optimizes Asian plant's O&M, saving annually.

The effectiveness of remote monitoring, which applies advanced analytics and fleet-wide learning to reduce both planned and unplanned downtime, is well proven on GTCC plants, with documented savings exceeding $1 million USD annually. In a recent application to a coal-fired plant in Asia, 43 anomalies were detected in the first year, preventing seven unplanned outages and identifying seven more opportunities to reduce thermal performance deterioration.

Optimizing Revenue

In addition to operations and maintenance, another driver of power plant profitability is its ability to take advantage of new revenue opportunities. **The smart power plant is aware of neighboring plants, grid congestion, power markets and weather forecasts and able to provide real-time insights and recommendations based on analytics to optimally support the grid and maximize revenue from energy and ancillary services markets.**

Noting that some opportunities may not be worth the risk, a smart plant learns from fleet issues and from similar plants to benchmark itself. This allows the plant to determine how to best operate equipment under specific conditions and make risk-based recommendations.

For example, during grid disturbances, all plants on the interconnected grid have an important role to support it. A smart power plant is aware of its peak power, frequency response, ramping and efficiency capabilities relative to neighboring units on the grid and able to cooperate in optimally responding in real time to grid disturbances.

A smart power plant predicts periods of high market prices and evaluates trade-offs between higher short-term income, component life consumption and increased maintenance costs to maximize cumulative profits from energy and ancillary services markets.

Looking to the Future

Overall, a smart power plant is ever-evolving and able to proactively adapt to changes and unforeseen circumstances to optimize operation and maintenance, sustain cybersecurity and drive profitability. Some key elements of a smart power plant are available today, while many others are being piloted. Each solution uses real-time data from internal and external sources to create actionable knowledge that drives informed decision-making and, ultimately, profitability.

The MHPS vision is to use AI and similar cognitive applications to create individual systems capable of autonomous operation, which are connected to work cooperatively and create a smart power plant that can operate largely without direct human control—with the potential for far less on-site manpower than today.

Technology is advancing faster than ever, and the energy market continues to evolve. As this happens, MHPS continues its mission to equip power generators with what it takes to meet their changing needs via MHPS-TOMONI® a suite of digital solutions geared to optimize assets, enhance O&M and enable autonomous operation.

Just imagine. Soon you may be able to see your digital power plant direct its own maintenance, adapt its operations to take corrective action, and seize opportunities to create more revenue. It could happen sooner than you think.

World's First Smart Power Plant

MHPS' smart power plant vision is being implemented in Japan at a new power plant under construction at the Takasago Machinery Works. It will be alongside the existing T-Point demonstration plant that has contributed so much over the years to creating the knowledge to maximize GTCC reliability and validate new designs, including many of the MHPS-TOMONI® digital solutions. Among other advancements, this new plant will incorporate the latest digital technologies and will be the flagship for the fleet's journey towards the autonomous power plant of the future.

MHPS-TOMONI®

MHPS is leading the development of the digital power plant of the future with MHPS-TOMONI®, a suite of digital solutions enabled by decades of O&M and plant knowledge. Our solutions are driven by customer collaboration and use advanced analytics and adaptive control to lower the cost of electricity and achieve environmental and business goals.

For more information about the MHPS-TOMONI® suite of digital solutions, visit **changeinpower.com/tomoni** or contact your MHPS representative.