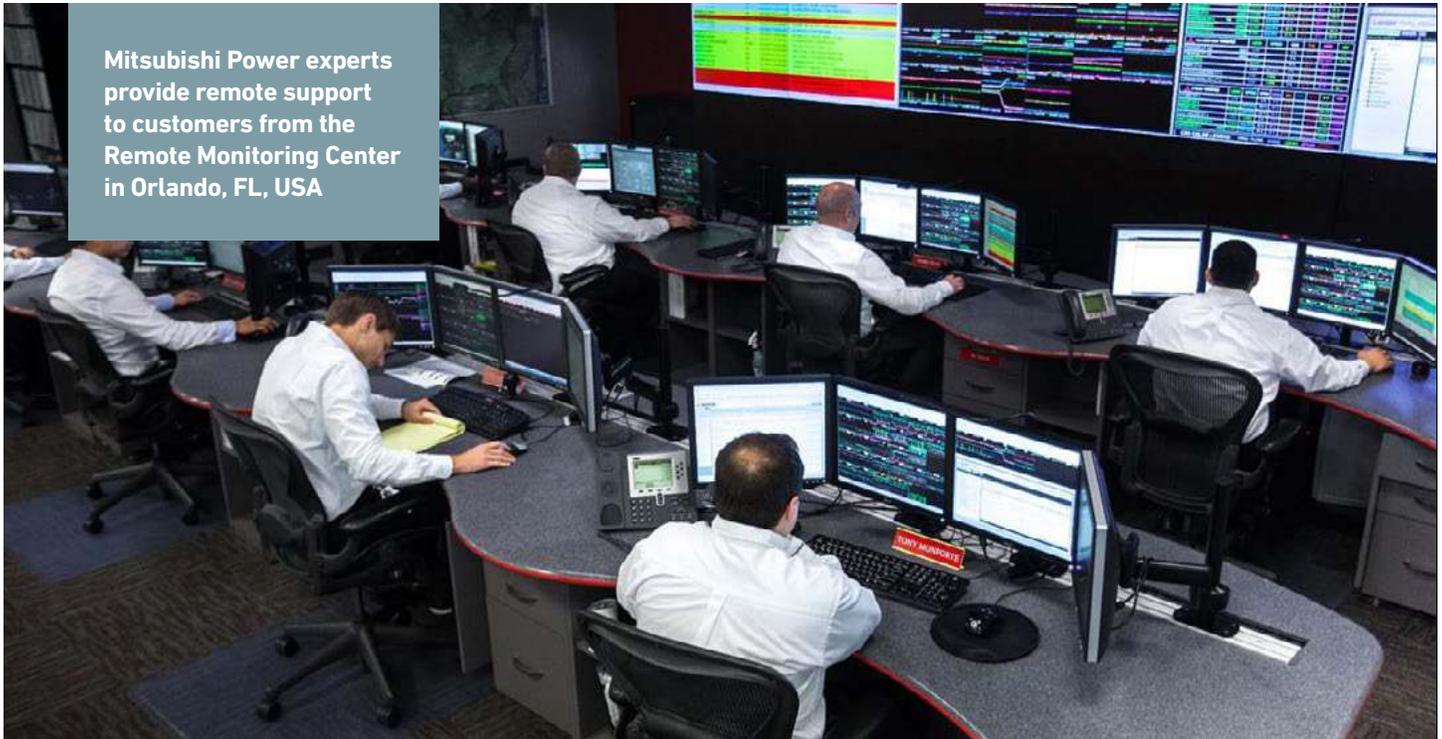


WHITE PAPER:

REMOTE OPERATION AND SUPPORT— THE NEW NORMAL?



Mitsubishi Power experts provide remote support to customers from the Remote Monitoring Center in Orlando, FL, USA

EVOLVING DEMAND FOR REMOTE TECHNOLOGY

Although operating and maintaining a power plant remotely is an emerging challenge, remote operations support is not a new concept. Power plants have implemented evolving remote monitoring and diagnostics technologies over the past 25 years as they fight to stay reliable and competitive. The focus was on executing early-warning diagnostics using advanced analytics and enabling access to off-site technical expertise for troubleshooting and response.

While some peaking or renewable-energy plants with relatively simple systems are already operated remotely today, the COVID-19 pandemic created challenges for many

more sophisticated power plants. It exposed vulnerabilities that spurred a demand for more comprehensive remote O&M solutions. Now, in addition to improving reliability and competitiveness, there is a focus on safety and quality decision-making.

In a pandemic, plants want to minimize the number of people on site, including operators, but especially external staff required for executing inspections and maintenance. And, in some instances, it may not be possible for external staff to reach the plant. This exposed the importance of having more digital connectivity and accelerated the need to perform some level of remote operation and maintenance support, allowing reduced presence at the plant. In addition to safer operation in a pandemic, reducing the number of people coming on and



Remote Monitoring Center
Takasago, Japan.

off the site can provide cost savings, reduce delays and allow plants more flexibility as they cope with workforce challenges and budget concerns.

A pandemic may be the most dramatic example of an event that can cause disruption, but history contains other examples of severe weather events or civil and social unrest which gave rise to similar concerns.

ADVANCED ANALYTICS: THE FOUNDATION

In 1999, Mitsubishi Power built the company's first Remote Monitoring Center (RMC) in Takasago, Japan, and several others have followed. The RMCs allow for the centralized collection and analysis of fleet-wide data from power plants around the world and established the foundation for increasingly digitalized power plants. The RMC was the first step in the routine utilization of advanced analytics for power plants. Since then, digital solutions, like the growing TOMONI™ suite of digital solutions, allow plants to leverage the massive amounts of data from the thousands of sensors in the plant to provide insights, solve complex problems and maximize overall power plant performance. Decades of experience gained from data analytics since 1999, throughout the fleet and on site at plants, has provided valuable lessons that lay the foundation for remote operation and increasingly automated maintenance, planning and support, while facilitating the training of automated digital operations support solutions that utilize artificial intelligence (AI) and machine learning.

SCHEDULED MAINTENANCE SHIFTED IN PANDEMIC

Altamira II, located in Mexico, had a planned major outage scheduled for March 2020. The COVID-19 pandemic made it difficult to have the appropriate crew on site for the inspection and maintenance. Through a technical relationship between the plant owner and Mitsubishi Power, the team at the RMC was able to access the data, through an already established, cyber-secure channel, to suggest a move of the planned outage to September, defining a new condition-based maintenance interval and providing condition-monitoring priorities for the interim period. This allowed for flexibility and time to plan and better support the outage around the global crisis.



Altamira II, Mexico

Mitsubishi Power's RMCs in Takasago, Japan, and Orlando, Florida, USA, use integrated analytics to expand the O&M staff "virtually" by supporting the power plant with a team of experts on demand 24/7, 365 days a year. Additional support is provided by RMCs in Alabang, Philippines, and Nagasaki, Japan. This allows for Mitsubishi Power engineers to troubleshoot and provide recommendations for operation and maintenance by utilizing the data from the plants to analyze, diagnose and predict operational issues based on their expertise. Power plants around the world have benefited from the RMCs. Due to the nature of an RMC, the team can support multiple plants without ever going on site, a significant advantage during a crisis like the COVID-19 pandemic. The RMC engineers can send settings updates to power plants by providing instructions and procedures for the on-site staff to implement. And, when a plant experiences issues, the RMC can support it remotely. The team can also use the real-time data streaming from the plant to determine if there is the flexibility to move maintenance schedules to a better time by working with equipment and plant designers to provide component-level risk assessments of maintenance deferral.

VALIDATION AT GRID-CONNECTED PLANTS

In addition to the progress in supporting remote O&M made through the RMCs, significant advancement in the development of remote O&M technologies has been made and continues at

the grid-connected power plants that Mitsubishi Power owns and operates. Located in Takasago, Japan, T-Point laid the groundwork for many of the TOMONI™ digital solutions of today, including remote operation. The new, digitally enhanced T-Point 2, which entered full commercial operation in July 2020, already incorporates technologies for remote operation and backup control rooms on its journey to becoming the first autonomous power plant. T-Point 2 will utilize a control room at the Takasago RMC to validate the use of remote operation on an advanced-class gas turbine combined-cycle plant (GTCC) and its control systems through long-term remote operation. It is also validating several innovative concepts that automate plant operation tasks and leverage remote asset performance management technology throughout the plant and its balance of plant (BOP) to more effectively manage plant maintenance.

During the construction of T-Point 2, augmented reality was utilized for site walkthroughs and equipment placement via mixed-reality headsets. This new approach was used to validate the technology to qualify it for the ongoing maintenance of the plant. Being able to observe equipment condition and have real-time access to design documentation and remote expert assistance would enable inspections and outage scope definition with fewer people in person, limiting exposure during the COVID-19 pandemic or other crises while still providing subject-matter expertise. This technology has subsequently been used to support outages at several customer-owned power plants accelerating the use of these remote support technologies and further refining them for

broader adoption at plants around the world.

This allows the best experts to support multiple issues at plants geographically separated without the lost productivity and potential schedule impacts associated with travel to one plant at a time.

Mitsubishi Power is providing total plant O&M for its own power plant at T-Point 2 and continues to gain invaluable experience in applying remote operation and maintenance technologies that are minimizing the need for on-site manpower and leveraging remote technical expertise on this fully integrated GTCC.



ADVANCEMENT THROUGH DIGITALIZATION

The key role of digitalization is to enable data visibility, data analytics and automation that improve reliability and productivity, making power plants more profitable. Remote operation and maintenance support cannot exist without proper digital support tools in place. Digitalization is pivotal to advancing remote technology by reducing the need for a fully staffed, on-site workforce through automation and remote access to expert technical support. This will assist with a diminishing or less experienced workforce and managing crises that affect the workforce, while improving efficiency, increasing power plant competitiveness and boosting income.

The first and foremost priority of any digitalization initiative is cybersecure communications and the protection of data flow. Power plants need a system that protects their ability to continue to reliably produce power and keep hackers out while automating the monthly maintenance of the control systems as much as humanly possible. DIASYS Netmation® is the Mitsubishi Power control system platform, and recent upgrades such as the Netmation Secure Gateway and the Netmation Protect Pack, as well as the latest operating system upgrades, provide compliance with North America's NERC-CIP, NIST Cybersecurity Framework and other global requirements by providing server-level and client-level security. A global crisis like the COVID-19 pandemic can magnify cybersecurity issues. Controls upgrades become even more important to keep a power plant protected.

Once cybersecure connectivity is in place, the data flow enabled by digitalization makes data-driven condition-based maintenance and risk assessment of planned maintenance deferral possible. Such advanced maintenance planning is always valuable but is vital during emergencies. The option to safely postpone or eliminate a planned outage wouldn't be possible without data-driven risk assessment and decision-making. Data from the plant allows engineers to predict when issues may occur and adjust to a revised condition-based maintenance schedule that can often accommodate outside factors like a global pandemic, weather disruption or social unrest.

Enabling the automation of repetitive activities and record-keeping through digital solutions is an important step to shifting an operator's focus to more imperative tasks that are more difficult to automate. Understanding the operator's regular activities and the amount of time needed for execution will set the priorities for automated tasks. Combining automation with more focused on-site operators and remote support technology allows for a more effective on-site team to operate and maintain the plant.

Additional support to help on-site operators focus on things that only they can do effectively comes from the latest advances in digital control systems, such as the latest version of the Mitsubishi Power control platform, Netmation 4S. Among other advancements, "4S" self-performs continuous system diagnostics and adds capabilities for online logic simulation and loading, making on-site operators more productive and increasing opportunities for remote support.

NETMATION PROTECT PACK

The TOMONI™ cybersecurity solution Netmation Protect Pack stood up to all auditing and scanning testing to date. Third-party evaluators said that it is the only solution on the market that truly protects the control system. In 2020, after extensive evaluation, a large global power producer concluded that Netmation Protect Pack was more thorough than anything that had been applied previously in the power industry because of the technology employed and the comprehensiveness of the system.





Remote Support Station in Takasago, Japan

Digital solutions to support on-site staffing, such as remote combustion tuning, have already proven beneficial during the COVID-19 pandemic. These solutions work through a secure gateway to access computers at the plant to see the logic, manipulate fuel fractions, move load, access to the diagnostic monitoring system and monitor emissions changes. Remote rotor balancing is also being performed at distant sites that are difficult to get to, through balancing monitoring software that enables expert balancing assessments to be made remotely. Critical activities like combustion tuning and balance weight calculations can now be accomplished by specialized subject-matter experts without requiring them to travel to the plant. It is also important to be able to remotely introduce control settings changes, software patches, logic modifications and other crucial updates. During the COVID-19 pandemic, which limited personnel on site to only those essential, the RMCs were able to give procedures for controls updates to the on-site staff to manage the update and support any issues remotely.

The biggest advantage of providing remote O&M support is timing, even if there is not a major disruption taking place. With the travel component eliminated, technical experts can work with more plants in the same amount of time. Because of the importance of doing more O&M support remotely and expanding the reach of its technical expertise, Mitsubishi Power is focusing on additional technology development in this area.

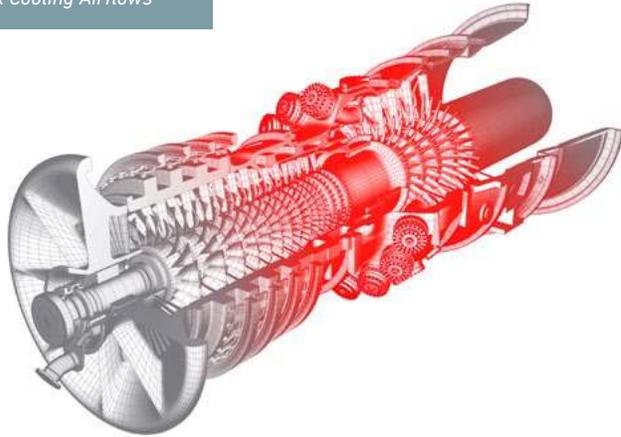
One such development activity is the creation of a digital ecosystem that allows rapid digital access to the mass of important data related to the plant such as manuals, procedures, root cause analyses, key maintenance and

operational experience, as well as fleet experience of similar plants, will provide further support to on-site O&M activities and help to fully leverage the benefits from remote operation and maintenance. This ecosystem includes an off-site data historian, cloud-based data, digital manuals and inspection reports, in addition to the ability to quickly search for the appropriate document. Every day, all of these different data sources, many currently paper-based, are being accessed to make decisions. Not only will creating this digital ecosystem benefit remote technology, but it will also make the information more readily available on mobile devices, which could transform how business is done today. Without the digital ecosystem, full automation is not possible, as humans are relied on to seek out and input the information. This is another repetitive task that could free up a plant operator's time and give them the right information to make decisions on plant operation and maintenance.

FUTURE DIRECTION FOR TOTAL PLANT REMOTE OPERATION AND MAINTENANCE

While technology is well on its way to enabling remote operation and maintenance, some important steps are needed. Robust communications need to be in place beforehand, so off-site operators and subject-matter experts can help, making cybersecurity a prerequisite. Cybersecurity is an ever-changing

Complex Cooling Airflows



ENABLING REAL-TIME OPTIMIZATIONS

Some critical processes that benefit from real-time optimization, such as combustion dynamics management and part-load heat rate management, have already been automated using advanced edge-computing technologies and are able to operate autonomously.

Modern gas turbines utilize complex airflows to manage energy inputs to the power turbine and perform cooling of critical rotating and stationary turbine components. The precise control of these airflows affects combustion stability and combined cycle system efficiency, especially during load-following operation and at partial outputs. Historically manually controlled, these airflows are increasingly controlled automatically to provide real-time process optimization. One example is a TOMONI™ digital solution installed on T-Point 2, GT Cooling Air AI-Optimization, which uses Gaussian process regression (GPR) machine learning to actively optimize turbine cooling flow. This improves plant efficiency, especially during partial-load operation, and eliminates manual cooling airflow adjustments and potential unplanned downtime.

issue that will need constant support and maintenance to ensure data and communication channels remain safe. A secure and stable connection will be critical as well. A loss in connectivity during remote support could cause major issues at the plant. Operating procedures will need to be implemented to ensure the best balance of remote and local operation, as well as the best balance of automation and human intervention.

The biggest step needed is a real-time integration of all systems, including integrating and automating documentation and remote record searching. There needs to be an updated, centralized resource to document everything

done in the past and the current settings throughout the power plant. This all-encompassing record of plant status and history will fuel AI-based O&M strategies and is critical to total plant automation. It can be used to build a virtual model of the plant. By documenting all changes in a virtual model, a plant can connect simulation tools to understand the result of changes before they are made at the plant. When there is an issue, like a trip, a virtual model reflecting total plant performance will allow a subject-matter expert to determine an issue without going on site.

The future holds a wealth of opportunities for making power plants smarter, better supported and more resilient to disruptions such as global health emergencies, major weather events and social conflicts. Mitsubishi Power is committed to steadily applying the latest technological advances to make those opportunities a reality. At T-Point 2, Mitsubishi Power is validating the building blocks of the smarter power plant of the future, which will be capable of various levels of remote support and autonomy, and applying those building blocks to make existing and new power plants more resilient.



Mitsubishi Power is leading the development of the smart power plant of the future with TOMONI™, a suite of intelligent solutions enabled by decades of O&M and plant knowledge. Our solutions use advanced analytics and are driven by customer collaboration to deliver powerful financial and environmental advantages.

For more information about TOMONI™ intelligent solutions, visit changeinpower.com/tomoni



Data Foundation & Enablers
O&M Optimization
Performance Improvement
Flexible Operation

