

# RAMPING UP TO RUN WITH RENEWABLES



## Impact of Renewables on the Grid

For the first time ever, monthly generation from wind and solar exceeded 10 percent of total power generation in the U.S. It happened in March 2017, and it marked a tremendous growth from under one percent in 2007 and less than five percent only five years ago, according to the U.S. Energy Information Administration.

The results in Europe are even more striking. By 2025, European Network of Transmission System Operators for Electricity analysts expect that 22 European countries will have 50 percent hourly load penetration by renewable energy sources (RES), and eight countries will have 100 percent.

Many Asian countries are experiencing significant expansion of renewables, tripling their capacity since 2000. Southeast Asia has a rising electricity demand that's double the pace of growth of the global average, and experts from the International Energy Agency believe 50% of that increase will come from renewables due to policy and incentivization efforts.

But this increased RES penetration poses uncertainty and puts pressure on grid system flexibility and stability. Coal and nuclear plants are limited in how much they can help the grid respond. Energy storage systems such as batteries can help but are still

challenged in capacity and cost. Gas turbine combined cycle (GTCC) power plants, even those that were designed to run at base load, can provide support, but partnering with renewable energy forces these plants to increasingly operate at part load and requires rapid load changes. Adding to that, regulations on emissions are getting stricter, requiring more stable and efficient combustion during startups, rapid load changes and part-load operation. Mitsubishi Power acknowledged this challenge and collaborated with its customers to build solutions that allow for partnering with renewables.

Based on Mitsubishi Power's experience, many natural gas-fired or oil-fired GTCC power plants are already moving from the continuous base-load operation seen several years ago to cycling operation with a reduced number of operating hours per year. Cycling includes more shutting down and starting up, rapid load changes and low-load operation to support grid requirements. These challenges force equipment designers and power plant operators to explore new means of flexible, sustainable and environment-friendly GTCC operation, going beyond the original design basis to allow GTCC plants to remain profitable.



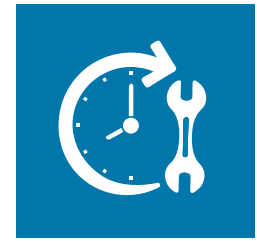
## Renewables Drive Digital Power Plant Solutions

In tandem with digital advancements, Mitsubishi Power collaborated with customers and software partners to develop solutions to address these and other challenges in an evolving power industry. This collaboration created TOMONI™, a suite of digital solutions that help thermal plant operators lower the cost of electricity, increase flexibility, improve efficiency and achieve performance goals by harnessing big data using advanced digital technologies.

The need for increased thermal power plant flexibility drove the creation of solutions that improve plant profitability and performance. They not only promote

lower costs overall but also increase responsiveness of the plant throughout the operation cycle.

The challenge for plant operators is to use advanced data management and analytics to sift through large amounts of operational data in real time to create actionable knowledge and control the plant with increased precision. This will allow plants to run more flexibly with reduced impact on hot parts and key component life, while simultaneously avoiding unplanned downtime, enhancing predictive maintenance and enabling condition-based maintenance.



**O&M  
OPTIMIZATION  
SOLUTIONS**



**PERFORMANCE  
IMPROVEMENT  
SOLUTIONS**



**FLEXIBLE  
OPERATION  
SOLUTIONS**

**TOMONI™ digital solutions help plant operators achieve more responsive, reliable and economically viable operation in the dynamic market, while maintaining reliability and availability comparable to base-load-operated units.**



## Flexible Operation and Performance Improvement Lead to Higher Utilization

Since 2011, Mitsubishi Power has implemented more than 125 flexibility and performance improvement solutions in GTCC plants to achieve faster startup and shutdown, lower combined cycle minimum loads and increased part-load efficiency while maintaining performance. These solutions have placed plants in a better position in the market, resulting in higher utilization and dispatch rates of those plants in recent years.

Increasing flexible operation while minimizing detrimental effects on critical components requires detailed data acquisition, expert analysis and precise control. Among other things, these are combined to allow operation closer to design limits and reduce the need for conservative margins used to allow for uncertain knowledge of actual operating conditions and historical operation. TOMONI™ was created using fleet-wide learning gathered through many years of remote monitoring and diagnostics using the three Mitsubishi Power Remote Monitoring Centers around the world as well as its own commercially operated GTCC power plant at T-Point. They provided the data and analysis to validate these flexibility solutions.

The rapid evolution of the power generation industry is driving many owners and operators of power plants to shift to more flexible operation modes while maintaining performance. Mitsubishi Power developed solutions that provide fast ramping rate, peak power, reduced minimum load and reduced startup time for plants to effectively pair with renewables.



### FAST RAMPING RATE

The power output from solar and wind facilities varies from day to day and often on an hourly or minute scale. In the absence of widespread installation of large dedicated energy storage systems, thermal power plants will need to provide most of the required load support and other ancillary services, such as frequency control, through improved operational response.

TOMONI™ offers digital solutions that speed up loading and unloading ramp rates on existing GTCC plants and can achieve nearly 20% of rated load per minute on some new plants.



### REDUCE MINIMUM LOAD

At times of low grid demand, especially when there is high renewable generation, wholesale power prices are sometimes below the incremental fuel cost of thermal power plants. Plants are forced to either take an expensive shutdown or operate at a loss to stay on-line and available to sell energy when the spot market price increases. Being able to operate as efficiently as possible at the lowest possible load during these periods can improve plant profitability, and staying on-line preserves the ability to take advantage of upswings in market prices.

TOMONI™ offers digital solutions that allow stable operation in a 20% load range and improve part-load efficiency, as well as increasing turndown by 10%-15%.

## O&M Optimization Increasingly Important

Cycling operation of today's power plants demands more vigorous, knowledge-based maintenance practices to prevent unplanned outages and maximize the useful life of equipment. A single unplanned unit outage can cause millions of dollars in lost power generation and repairs. This makes the increased use of historical and fleet-wide information for predictive maintenance beneficial. TOMONI™ solutions use advanced analytics to monitor and forecast the condition of power plant components and enable plants to implement a condition-based maintenance strategy, based on the combined knowledge, experience, data and data analytics of Mitsubishi Power and the plant owner and operator.

## Change Brings Opportunity

As the power market evolves and digital technology advances, the market will demand enhanced reliability, availability and maintainability for power plants, and the industry will have to respond. Mitsubishi Power is driven to tackle those changes by developing customized TOMONI™ solutions that target customer needs and allow thermal power plants to work more effectively with renewable energy sources, while sustaining or improving their profitability.



Mitsubishi Power is leading the development of the digital power plant of the future with 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.



### REDUCE STARTUP TIME

Fast startup will allow response to grid dispatch and maximize generation revenue, while reducing startup fuel cost and emissions.

TOMONI™ offers digital solutions to reduce GTCC startup times in existing plants, while some new plants can be near full load in 10 minutes.



### PEAK POWER

With rapid fluctuations in grid requirements and wholesale energy market prices, thermal power plant profitability sometimes relies more on capacity payments and less on energy payments. This makes the ability to select between preprogrammed operating modes that quickly increase power output the key to capturing market opportunities.

TOMONI™ offers digital solutions for peak power that apply increased inlet airflow and/or increased firing temperature.



### KNOWLEDGE TO RESPOND

Immediate response is required to avoid a trip when an alarm occurs, which means operators need access to real-time information.

TOMONI™ offers advanced analytics so plant operators can quickly make informed decisions and take action.