MITSUBISHI POWER

GETTING MORE OUT OF EXISTING POWER GENERATION ASSETS

Mitsubishi Power is a power solutions company of Mitsubishi Heavy Industries.

MOVE THE WORLD FORWARD

MITSUBISHI HEAVY INDUSTRIES GROUP

Power plants have been constantly innovating for over a century. Many large plants initially ran on coal, but technological advances have enabled them to now use many different fuels, such as natural gas and renewables. Power plants have also increased their efficiency and reliability while keeping in step with various market and policy changes.

Amidst all this change, there is increasing pressure on power producers to assess their investments holistically and balance overall profitability with the emissions profiles of their portfolios. In some cases, they must consider extending the lifespan and maximizing the efficiency of their existing assets.

WHY TRY TO EXTEND THE LIFESPAN OF A POWER PLANT?

As demand for electricity continues to rise globally, one question constantly on the minds of power plants operators is whether to retire existing infrastructure in favor of building new ones. Some assets may not be enhanced to meet current best-in-class standards and may need to be mothballed, while others can be made operational for many more years through upgrades.

There may also be a need to maximize current plant assets to increase capacity or reduce operational costs. Supply chain issues and spiking fuel prices create major stress on power supplies, exacerbating already intense pressure to provide electricity cheaply and immediately. The situation is made even more complex by clarion calls to decarbonize and the need to adhere to tighter emissions standards. Greater use of renewables can result in power intermittencies and improving the performance of traditional power generation plants that are already on the grid can help mitigate this challenge.

One key constraint to building new plants is access to capital. New facilities can cost hundereds of millions of dollars and require long lead times to build. Zoning and environmental permits can be difficult to obtain for new sites, and sometimes it can take years to get government approvals extending the time to complete construction of new plants. Furthermore, in many countries, especially in Asia and the Middle East, communities are built around power stations, contributing to livelihoods and making the decision to retire plants not just an economic one but also political and social.

Power plant operators must therefore seriously consider options to maximize the service life of their power generation systems. In this regard, there are three approaches they can adopt:

APPROACHES

01 Improve plant maintenance.

02 Undertake strategic upgrades of different parts of the plant.

03 Leverage advanced tools such as digitalization, modeling and data analytics.

Power plant operators around the world are already investing in extending the service life of their assets. Case in point - the average lifespan of gas turbines has increased globally over the past two decades, which reflects both improvements in technology and equipment, as well as better planning and maintenance of plants.[1]

1 https://www.spglobal.com/marketintelligence/en/newsinsights/trending/gfjqeFt8GTPYNK4WX57z9g2#:~:text=Gas%2Dpowered%20steam%20turbine%20units,weighted%20average%20of%2047%20years

APPROACH 1: IMPROVE PLANT MAINTENANCE

Power plant maintenance is a term that refers to a range of functions including routine inspections, regular reporting, systems integrations and reviews, and scheduled preventative maintenance — all work required to help the plant stay active and in good working order from one day to the next.

Improving maintenance means establishing a clear program to track and monitor all important equipment as well as making constant upgrades that sustain or even raise the output, efficiency and reliability of a plant. The longer a plant can run, the more cost-effective it can be over time, and best-in-class maintenance plays a crucial role in maximizing the longevity of a plant. Plant operators may find that even just enhancing the maintenance process can be worthwhile to extend plant service life.

Implement a process of comprehensive maintenance

Comprehensive maintenance[2] is the foundation for extending the life of an existing asset. Broadly speaking, a robust maintenance program entails running diagnostics regularly for each equipment and proposing a course of action to improve aspects such as output and efficiency based on the diagnosis.

The longer a plant can run, the more cost-effective it can be over time, and best-in-class maintenance plays a crucial role in maximizing the longevity of a plant.

Some plant operators may look at it as added costs and opt to do minimal maintenance. While this may save money in the short run, it can degrade the lifespan of the plant assets. As plants age, shifting from a time-based maintenance strategy to a data-driven predictive maintenance strategy can also be valuable.

Mitsubishi Power has extensive global experience in improving plant maintenance and operations at both power plants and refineries in countries such as the Philippines and Kuwait. These improvements include retrofitting boilers, turbines and generators as well as repairing and updating control systems.

2 https://power.mhi.com/service/comprehensive-maint

MAKE HARDWARE AND SOFTWARE CHANGES TO ENHANCE OUTPUT, IMPROVE EFFICIENCY AND REDUCE EMISSIONS

Plant maintenance includes output improvements – hardware which enable a plant to work optimally. Introducing newer and more advanced components to an existing facility can help it meet higher efficiency and environmental performance targets.

For instance, in Singapore, Mitsubishi Power upgraded two M701F gas turbines at a Senoko Energy Power Plant.[3] The upgrades, undertaken to align with the country's plan to decarbonize, will reduce about 15,000 tons of carbon emissions annually.

Senoko Energy GTCC Power Plant

There is also a range of upgrades that can be implemented to improve part-load efficiency and reduce unit turndown loads. For example, making of software and small hardware modifications on gas turbines to enable optimum control of compressor inlet guide vanes can significantly improve part-load efficiency and reduce part-load CO emissions to enable greater turndown.

Likewise, for the steam cycle, upgrades can be undertaken to assist with improving the reliability of older boiler pressure parts and overcoming the thermal performance losses from steam leaks, seal degradation and turbine blade fouling that become inevitable as a plant ages.[4]

3 https://power.mhi.com/news/20211202.html
4 https://power.mhi.com/service/boiler#anc02

APPROACH 2: INVEST IN STRATEGIC UPGRADES

Following comprehensive maintenance, making strategic upgrades over time to larger equipment such as turbines is essential. Without such equipment upgrades, plant operators will lose out on efficiency savings, and higher efficiency rates translate to less fuel wastage. These savings can be substantial given the rise in global fuel feedstock prices over the past two decades. As equipment ages, power plants can also become obsolete due to more stringent requirements in terms of national environmental policy.

For plant operators, all these factors necessitate constantly reviewing plant complexity and deciding whether to incorporate critical upgrades to boost plant performance.

SPOTLIGHT: 3D MODELS FOR LARGE RETROFIT PROJECTS

Servicing a Mitsubishi Power steam turbine

Plant retrofit projects, which may involve installing pollutant-controlling technology or replacing parts of equipment such as turbines, can take many months and be costly. For large-scale retrofit projects, 3D measurement technology can be used during the project design stage to reduce construction costs by determining how certain parts would fit within the larger system, especially when the upgrades or repairs are being done on units that are manufactured by different companies.

Models are created by CAD based on 3D measurement of existing parts to be reused. For instance, when considering upgrading the outer casing of a rotor, possible interference of small clearances can be detected with 3D models of the inner casings and fine adjustments in advance made to the design.[5]

In addition, based on the results of 3D measurement and stress analysis, this modeling can help shorten construction period by simulating the work before starting the actual project.

5 https://power.mhi.com/service/steamturbines#anc02

IMPROVE PLANT OUTPUT, EFFICIENCY AND AIR QUALITY

Plant operators can convert existing simple cycle plants to combined cycle plants which have higher efficiency and output. Doing so may involve installing new steam turbines, adding in a cooling tower or air-cooled condenser as well as implementing implementing upgrades to the electrical transmission system to handle the added power. Mitsubishi Power will do this for the Termocandelaria power plant in Cartagena, Colombia, improving efficiency of the facility by more than 35%.[6] The customized hardware and software solutions will also increase plant capacity from 324 to 566 MW, and lower fuel and maintenance costs.[7]

Another critical output improvement is installing control systems to mitigate NOx, SOx and dust particle emissions. In Serbia, Mitsubishi Power installed two 650MW flue gas desulphurization (FGD) units at the Nikola Tesla A Power Plant. While the power plant accounted for a quarter of Serbia's electric power, it emitted a high level of sulfur and ash, and our technology has helped reduce SO_2 emissions to less than 200mg/Nm^3.

UPGRADE SYSTEMS TO ENABLE USE OF CLEANER FUELS

Tighter emission standards have made fuel switching a necessity globally. Power plant operators may opt to upgrade their systems which have degraded over time with new equipment that can run on cleaner fuels, which have become more readily available over the years.

In Germany, Mitsubishi Power is switching two existing plants from coal to natural gas. This involves partial conversion of the boilers, replacement of the existing control system at the Rüttenscheid site, dismantling and disposal of the existing components, and installation, commissioning and trial operation of the new components.[8]

In Canada, we will also repower two units at Capital Power's Genesee plant. The units will combine our air-cooled combustion turbines and heat recovery steam generators with the existing steam turbine generators. With greater than 64% efficiency, the Genesee units will be part of the most efficient combined cycle plants in Canada, and carbon emissions intensity will decrease by approximately 60 % to a level below the Alberta Technology Innovation and Emissions Reduction regulation benchmark.[9]

6 https://www.changeinpower.com/our-heroes/
7 https://power.mhi.com/regions/amer/news/200117.htm
8 https://power.mhi.com/regions/emea/news/energy-transition
9 https://power.mhi.com/regions/amer/news/20201223.html

INTRODUCE EQUIPMENT WITH CO-FIRING CAPABILITIES

Co-firing in a power plant means having at least two different fuels to be combusted in the same facility. A cleaner but often more expensive fuel can be blended with a cheaper but more carbon-intensive fuel, thereby reducing the overall environmental impact of the power system.

Many of Mitsubishi Power's gas turbine designs can fire a mix including hydrogen. When hydrogen content is increased in power generation, carbon emissions are reduced, with potential of up to zero CO_2 emissions.

In June 2022, Mitsubishi Power together with Georgia Power and the Electric Power Research Institute successfully validated fuel blending of hydrogen and natural gas at both partial and full load on an M501G natural gas turbine at Plant McDonough-Atkinson in the United States. The demonstration project was the first to validate 20% hydrogen fuel blending on an advanced class gas turbine in North America. The largest test of this kind to date, the 20% blend provides an approximately 7% reduction in carbon emissions compared to natural gas.

Plant McDonough-Atkinson (Credit: Georgia Power)

Ammonia, which does not emit CO_2 when burned, can also be applied to reduce emissions from coal-fired power plants. Co-firing ammonia can be particularly beneficial in regions where the thermal fleet is young, which according to an IEA report, can allow existing assets to continue operating even when climate regulations are tightened, thereby diminishing the risk of creating stranded assets.[10]

Mitsubishi Power is already doing this with the H-25 gas turbine, the world's first commercialized gas turbine to make exclusive use of ammonia as fuel in a system of this scale.[11]

In Indonesia, we are also studying the feasibility of utilizing ammonia at the Suralaya[12] coal-fired power station and at an existing natural gas-fired power station in the country. The goal is to establish an integrated ammonia value chain encompassing production, transport, fuel consumption and CO_2 storage.

10 https://www.iea.org/reports/the-role-of-low-carbon-fuels-in-the-clean-energy-transitions-of-the-power-sector/executive-summary
11 https://power.mhi.com/news/20210301.html
12 https://www.mhi.com/news/220607.html

APPROACH 3: LEVERAGE NEW TOOLS AND TECHNOLOGIES

Digital technologies allow for a large volume of data to be collected, analyzed and stored for a long time. This data can aid in solving both immediate challenges as well as long term plant improvements planning. As such, digitalization is an important strategy to extend the lifespan of power plants and manage equipment life consumption as plants age.

Some existing power plants are unable to seamlessly tap the benefits of digitalization, especially if they have antiquated control systems. Manpower is also a major factor with many plants no longer able to support the full range of on-site technical expertise needed to most effectively create and utilize the knowledge enabled by the increase in available data.

Older power plants are perhaps the ones that will benefit the most from digitalization.

Yet, older power plants are perhaps the ones that will benefit the most from digitalization. Given the age of their systems, older plants are more susceptible to cybersecurity threats and being ransomed by hackers. Also, these plants have had more wear and tear, which means they may break down more often. Predicting the components most likely to cause near-term problems and applying effective maintenance to avoid those breakdowns can provide tremendous benefits.

Likewise, when energy prices spike, it is important for power plants to be available online, often on short notice, to remain profitable. For example, in many competitive power markets, when energy prices surge, power plants can make the equivalent of a month's profit in a few hours. Conversely, if they are not able to be online, the lost opportunity cost is immense.

SPOTLIGHT: TOMONI®

Mitsubishi Power offers an entire suite of intelligent digital solutions called TOMONI. By leveraging advanced controls, artificial intelligence and machine learning, TOMONI solutions make energy systems smarter, more profitable and ultimately more autonomous.[13]

Among the many TOMONI solutions is the Boiler Smart Inspection service package, which uses advanced data visualize analysis techniques to enable easier planning and implementation of maintenance work at power generation facilities, thereby helping operators increase operational efficiency. The solution helps to visualize past inspection records, improve searchability of maintenance-related materials and enable predictive maintenance. The package also includes training materials for new staff and has proven especially effective in resolving labor shortages and skill retention issues arising from the retirement of seasoned engineers and influx of new employees.

Effective utilization of plant data to sustain performance and improve profitability can also be accelerated by use of advanced diagnostics and cybersecure remote support capabilities available from our TOMONI HUB Analytics and Performance Centers.[13]

13 https://solutions.mhi.com/power/tomoni/background-and-future-prospects/

SPOTLIGHT: T-POINT 2 DEMONSTRATION PLANT

Part of introducing new tools and technologies to a power plant is ensuring that they are properly designed and tested before even reaching the customer site.

Located at Takasago Works in Japan, T-Point 2 is the smartest power plant in the world and is getting steadily smarter. It is a combined cycle power plant validation facility, enabling robust validation of advanced-class gas turbines. It is the only facility in the world that performs full-scale long-term reliability verification for gas turbines. Connected to the actual grid, it is also the only plant of its type in the world to function as both a technology demonstrator and an electric power producer and supplier. Also housed within Takasago Works are centers for R&D, design, manufacturing, and short-term component testing.

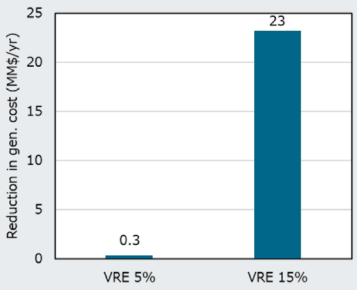
SPOTLIGHT: GRID SIMULATION AND MODELING

Data from digitalizing power plants can also be fed into larger grid models that provide macro insights aiding in operational decision-making. Artificial intelligence and data visualization capabilities used in grid modeling have now enabled plant operators to study different variables and predict grid-level outcomes. This in turn can help both in planning for new plants as well as in retrofitting older plants.

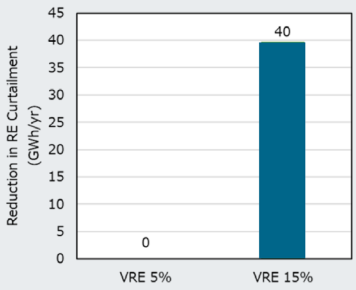
Plant operators can use grid simulation to analyze how introducing less carbon intensive energy sources such as hydrogen and solar can help meet decarbonization target requirements. They can also use it to assess power generation solutions as well as the most feasible time to implement those solutions.

Mitsubishi Power conducted a study on gas-fired power plants in Vietnam to compare the total generation cost and renewable energy curtailment if the plants were upgraded to be more flexible and operated with different levels of variable renewable energy (VRE) in the grid. Total generation costs fell the most with the higher VRE ratio of 15%. Renewable energy curtailment also rose the most at 15% VRE. Overall, the simulation showed that upgrading gas plants would be better at 15% VRE instead of 5%, a data point potentially helpful in capital budgeting discussions for plant upgrades.

Reduction in total generation costs



Reduction in RE curtailment



Reduction in total generation costs

	VRE 5%	VRE 15%
	MM$/yr	MM$/yr
Gas Upgraded	0.3	-23

Reduction in RE curtailment

	VRE 5%	VRE 15%
	GWh/yr	GWh/yr
Gas Upgraded	0	-40

FINAL THOUGHTS

Modernizing energy systems requires significant investment, and most countries cannot instantly pivot. In some cases, it may be feasible to build new power plants but in others, a better option will be to try extending the lifespan of existing assets. Power plant operators can opt to prolong the service life of their assets by implementing a solid plan that involves comprehensive plant maintenance as well as strategic equipment and technology upgrades. It is also important to be able to make data-driven decisions, utilizing tools such as grid simulation and modeling.

From Canada to Colombia, from Serbia to Singapore, we have seen power plant operators make this choice to extend the life of their assets and reap the benefits. For instance, transitioning the existing Termocandelaria plant from simple cycle to combined cycle operations will not only improve efficiency by more than 35% but also raise plant capacity by more than half. Moreover, the switch will lower fuel and maintenance costs.

Intertwined with plant efficiency and profitability is environmental performance – an increasingly important consideration given ever-stricter emissions regulations as well as rising fuel prices. With hefty resources needed to build a new plant, upgrades that allow an existing one to meet stricter regulations can be a viable option, and innovation in this space is vibrant. For example, we at Mitsubishi Power are investing in the development of hydrogen power generation. To date, have obtained a landmark 20% hydrogen blending at Plant McDonough-Atkinson, and 100% hydrogen firing is due to be achieved by 2025 with commercialization by 2030. All these we are doing to create an energy future that works for people and the planet.

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