ARC VIEW

AUGUST 9, 2018

Digital Technologies for Thermal Power Plants Improves Performance and ROI

By Ralph Rio

Introduction

The basic process for thermal power generation – boiling water and using the steam pressure to generate power – is over 130 years old[1]. One would think that the related systems would also be mature and well optimized. But dynamics in the power market have created new demands, changing the role of thermal power plants altogether. This is forcing the plants to improve their performance in multiple aspects. Fortunately, newer, proven technologies provide the means to respond to these needs.

With growing solar and wind generation in the grid, thermal power plants are being forced to change from fixed load to intermittent part loads. To support this transition in plants that - on average – are 40 years old, owners/ operators can layer on digital technologies.

Growing Fallacy of Fixed Base Load

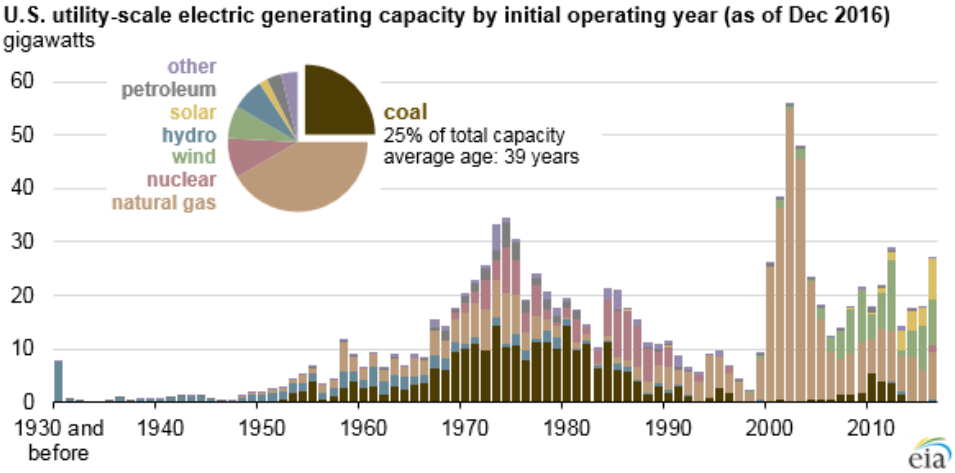
Gone are the days when a thermal power plant could run continuously at a fixed load and optimal efficiency. Nearly all thermal power plants were designed assuming one-way distribution of power from the plant through the grid and into distribution. Now, on average, 20 percent of power generation on the grid uses renewable energy like wind and solar. Wind and solar power generation has lower marginal cost than thermal power. This gives the utilities an incentive to use these green sources for base load. Also, government regulations mandate that grid operators give priority to the renewable generated power. However, production from wind and solar is unstable and volatile, causing high fluctuations in the grid. These drivers are pushing thermal power to part-load generation.

[1] The first commercially developed central electrical power station using coal and steam was in 1884 per wikipedia.org/wiki/Thermal_power_station.

Flexible and Part-load Operation Issues

This paradigm shift in operating of thermal power plants – from steady-state base load to intermittent partial load – creates many operating issues. The plants – including burners, boiler size, turbines, control systems, and more – were designed, sized, and optimized for a fixed, steady-state input and output. Variation creates a variety of operating issues including:

- Reduced fuel efficiency (operating the boiler outside of optimum parameters for its original design)
- Increased emission rates (related to lower fuel efficiency)
- Higher overhead rate (many fixed costs with lower output)
- Reduced reliability with increased failure rates and maintenance (changing output causes mechanical fatigue and electrical stress)



Start-up Year of Power Generation as of Dec. 2016
Source: https://www.eia.gov/todayinenergy/detail.php?id=30812

Compounding Challenges for Existing Thermal Power Plants

Thermal power plants contribute the highest level of emissions among the power generation sources, causing air quality and other environmental concerns. Though coal provides 30 percent of the power generation in the US, it accounts for 98 percent of SO2 emissions, 94 percent of mercury emissions, 86 percent of NOx emissions, and 83 percent of fine particulate emissions. Also, these plants have the highest age with an average approaching 40 years. These older coal and gas plants contain older designs and technologies designed for fixed baseload operation. Operating at partial loads exacerbates these issues.

Sustainable Part-load Power Generation

The design of newer power plants supports more efficient operation compared to the 40-year old designs. In areas of the world with new coal-fired plants, the efficiency averages 46 percent, 15 percent higher than the global average.[2] Unfortunately, obtaining this gain for existing thermal power plants would require a complete and prohibitively expensive retrofit.

> "Excellent operational performance is the linchpin for delivering on our financial, safety and environmental goals."
> Lynn J. Good, Chairman, President and Chief Executive Officer, Duke Energy
> Annual Report, March 9, 2018

Coal-fired plants that have been converted to natural gas have a relatively new boiler burner, but, the rest of the plant is still old, tired, and outdated. Operating these older facilities at partial loads further degrades their performance and reduces the overall plant reliability. Replacing equipment is impractical from engineering and cost viewpoints.

Transition from Fixed Load to Intermittent Partial Loads

With the increasing adoption of solar and wind power generation, the older thermal power plants must compensate to balance power grids. As renewables continue to be added, this issue increases in urgency. This drives the need for high flexibility and resilience to frequent start-ups, rapid load changes, and frequency control. Managing intermittent partial load operations includes improvements in:

- **Efficiency**: Dynamically adjust setpoints and other controls to improve unit efficiency and thereby emissions for full or partial-load operation based on current operating parameters
- **Flexibility**: Improve unit cycling performance including minimum load, ramp rates, turndown ratio, black start, and automation
- **Reliability**: Increase the electricity generating units' availability and maintainability for economical unit operation, uptime and safety

Digital Technology Adoption Enables Flexibility

Similar to the way grid operators are using technology to manage the addition of renewable energy sources, now is the time for baseload power generation to adapt. Rather than rip and replace equipment, a more practi-

[2] "How to Ramp up Efficiency and Profits" webpage by Siemens

cal approach involves newer digital technologies that support operating at partial loads to help optimize operations and asset management in today's energy environment. Examples include:

- Continuous combustion tuning with artificial intelligence
- Turbine operational optimization in real time using a combination of first principle analytics and machine learning
- Predictive maintenance to avoid unplanned downtime using machine learning
- Reducing stresses during variation on load to avoid failures and reduce maintenance needs
- Remote monitoring for visibility and analysis

About TCS and Digital Power Plant

As a well-known global service provider, Tata Consultancy Services (TCS) provides technology services, consulting, and business solutions. The company is part of the Tata Group, one of India's largest industrial conglomerates. TCS was established in 1968 as a division and became incorporated as a separate entity in 1995.

A Japanese Major announced a reduction in exhaust gas and cost with improvement in overall efficiency by deploying the TCS artificial intelligence-based solution.

TCS Digital Power Plant solution provides an intelligent digital infrastructure that optimizes performance of thermal power plants within the constraints of existing equipment and systems. The solution is built from individual AI-based digital twins of all equipment and sub systems of the power plant. These digital twins are constituted as various models – data-based, physics-based, and knowledge-based. It integrates both operation and maintenance aspects of the plant which enables better analysis of problems and early detection of faults.

The solution is supported by a cloud and IoT framework that helps develop and deliver the use cases with faster time-to-benefit. Deployments commonly include these accelerators:

- **PEACOCK** software for solving complex industrial analytics problems and building digital twin models of processes and equipment. It deploys both database and physics-based models to perform analytics.

- **PREMAP** (Platform for Realization of Engineered Materials and Products) provides modeling and simulation tools for materials and manufacturing processes for a comprehensive digital twin.

- **i-Sense** platform for multi-sensor visual analytics supported by machine-learning. It contains algorithms and models to normalize data and conduct pattern recognition.

TCS has used these accelerators to build digital twins for fossil-fueled thermal power generation equipment and sub-systems such as boiler, turbine, and flue-gas desulfurization units. The technology has helped the company's utility customers improve plant efficiency and reliability and comply with emissions standards. With the company's various forms of digital, product, service, and asset twins, TCS's solutions span the complete lifecycle of equipment.

Conclusion

The increasing use of wind and solar power on the grid has forced fixed baseload thermal power plants to transition to intermittent partial load operations. This has created new demands to improve the load flexibility, efficiency and reliability of thermal power generation. Layering digital technologies on existing systems can help power companies respond to these needs without massive expenditure and often impractical upgrades. Thermal power plant owner/operators should consider:

- Digitalizing old thermal power plants by layering on current digital technologies to improve flexibility and operational performance in real-time.

- Quantifying the potential savings and ROI that digital technologies could generate to develop a suitable business case for adoption across a fleet of thermal power generation assets.

For further information or to provide feedback on this article, please contact your account manager or the author at rrio@arcweb.com. ARC Views are published and copyrighted by ARC Advisory Group. The information is proprietary to ARC and no part of it may be reproduced without prior permission from ARC.