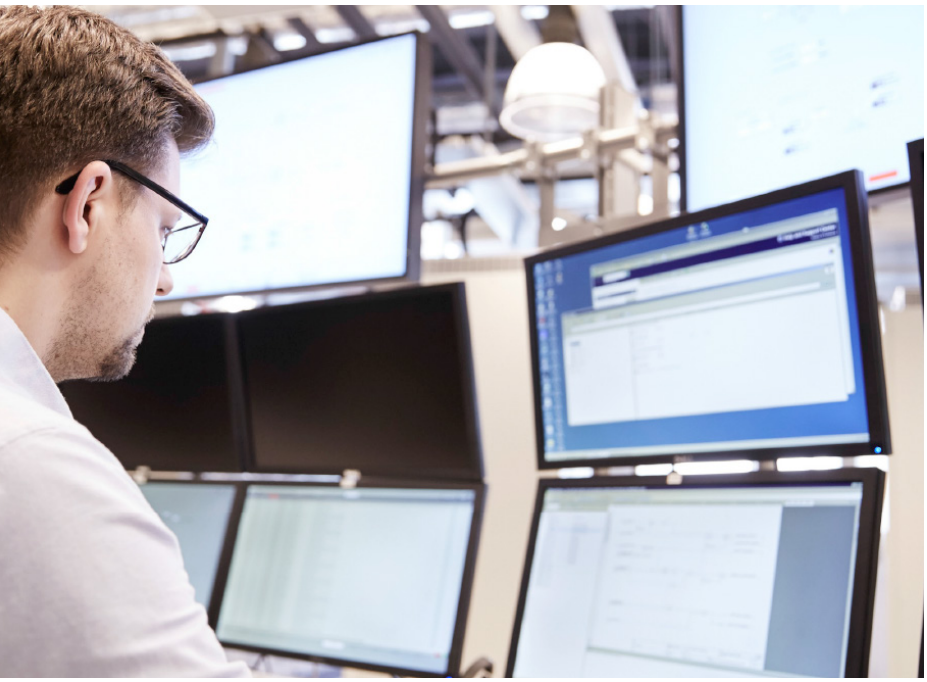
How digitalization improves steam power plant performance with advanced process control



Fossil steam power producers are turning to digitalization and APC to stay relevant and profitable in a power market being upended by renewables and trading.

01 With today's APC solutions steam plant operators can optimize thermal efficiency, reduce emissions and maximize participating in ancillary services markets without exposing units to increased thermal stresses or accelerating maintenance intervals.

Introduction

In most of the world today, power producers are operating in uncertain times. As traditional operating models are upended by new sources of energy, particularly wind and solar, steam power plant operators find themselves running plant and equipment in ways never intended by their designers. This stresses not only the equipment but also budgets and resources. The uncertainty produced by today's markets also leads to shifting priorities from management and a lack of operational predictability.

The result is an increasingly complex operating environment and fragmented marketplace driven by inconsistent and fluctuating demand. Operators face new challenges every quarter. Deregulation, power trading, decentralized power markets, competition from renewables, price volatility, fast-ramping, a retiring workforce, the loss of institutional knowledge, and the constant threat of cyberattack are among the most critical of these challenges.

This is especially true in mature markets where many steam power plants operate as back-ups to a power grid increasingly supplied by renewables. This leads to inefficient operation where plants must frequently ramp up and shut down as load demand fluctuates. In these markets, the days of plants operating continuously at base load are coming to an end.

In markets where steam power plants (i.e., fossil-fired boiler with steam turbine) still run at full capacity, optimizing performance to eliminate unplanned downtime, meet regulatory burdens and increase power output are still priorities that must be met, offering significant improvements in profitability.

In markets where plants participate in intra-day and day-ahead energy trading, providing reliable power generation schedules and the capability to deliver ancillary services, is the key to profitability.

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02 Advisory solutions can suggest best actions. But operators may disregard this advice, making sustained, repeatable efficiency gains hard to replicate fleet-wide.

Technology drivers and market demands
The advances in power plant control and optimization are being driven by a combination of technological (i.e., Internet of Things, cloud, faster computer processors, broadband networks, etc.) and market forces. Of these market forces, three are paramount: renewable generation, fuel costs and environmental targets.

Renewable generating capacity is growing rapidly. At first in Europe and the US, but now in most parts of the globe. With high renewable energy penetration comes greater challenges to grid management. For traditional baseload plants, this means changing output quickly. Only performance optimization solutions makes this economical.

Global fuel prices are another factor. In order to maximize profits, all power plant operators want their plants to burn the least amount of fuel for the highest amount of energy output. This is a critical issue in some global power markets. In the US, for example, cheap natural gas from shale makes it increasingly difficult for coal plant operators to compete. While, in Europe, high natural gas prices are challenging gas-fired plant operators with the same problem.

In both cases, optimization that allows operators to maintain tight control over the combustion cycle while minimizing equipment stresses and holding maintenance costs down, can be the difference between operating economically or not.

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Finally, the same environmental concerns around climate change that have stimulated the rise in renewable generation are driving de-carbonization of steam power plants. Much tighter emission restrictions increase cost pressures on older coal-fired plants in particular. Newer plants find compliance less of a burden, but cost control still depends on the effectiveness of control and optimization systems.

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Digital solutions to common problems
The one thing all power generators in every market have in common is they are meeting these challenges head-on with digitalization. From integrated control systems drawing data from an army of sensors, to remote collaborative management of operations from anywhere on the globe, digital is how operators reduce costs and increase margins.

Advanced process control (APC) for power plants has become increasingly sophisticated over the past 20 years. Where once a power plant was controlled by an operator facing a bank of gauges and levers, today's plant control systems run on real-time data from thousands of sources. Today's operators serve more of an executive or orchestration role – overseeing operations to ensure safety and intervening only as needed. The result is more accurate control over all of a plant's processes, not just a select few as in days past. APC and new digital solutions allow for greater optimization of a greater number of parameters, leading to higher efficiency and greater flexibility to meet market demands than ever before.

How APC systems help operators meet these demands

The secret of a low heat rate and, hence, high thermal efficiency, is to maintain operation with as little variation as possible. Any variation leads to a loss of efficiency and revenue. That is why APC-based performance optimization is focused on maximizing efficiency and reducing variability. Efficiency is at the core of all power plant operations and drives technological advances across the entire power generation spectrum, from coal-fired plants to solar and wind.

For steam power plants, this has led to the development of supercritical and ultra-supercritical boiler technologies based on ever higher steam temperatures and pressures that rely on ever more sophisticated materials and technologies. In a coal-fired plant, for example, optimum plant efficiency depends on maintaining the plant within a narrow range of steam cycle operating conditions. The more tightly the control, the easier it becomes to maintain efficient generation.

When talking about power plant efficiency, steam-cycle efficiency is the headline figure that is mentioned most. But optimizing efficiency stretches well beyond this. Power plants are large users of electricity, which is used to drive a whole range of auxiliary systems, such as pumps, fans, compressors, drives, etc. If the operation of all of these energy consuming components can be controlled as part of the overall optimization scheme, there are enormous savings to be had.

This underscores one of the strongest business cases for optimization: by operating each component of a plant as efficiently as possible, an APC solution can pay for itself in as little as one to two years.

Steam power plants benefit the most

APC solutions are available for all types of power plants, but it is in steam power plants that they offer the greatest advantages. For example, APC allows boilers to maintain low nitrogen oxides (NOx) emission conditions and high carbon burnout, both of which are critical for plant emission performance and efficiency.

Depending on how they are configured, APC systems can also manage steam temperatures and pressures throughout the steam cycle, allowing the best achievable efficiency while minimizing mechanical stresses. Optimizing coordinated boiler/turbine control for grid frequency support also can be achieved. At the same time, system parameters and KPIs are collected to support predictive and prescriptive maintenance activities, lowering maintenance costs significantly.

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APC solutions can be used to control gas turbine and combined-cycle power plants, too. But modern gas turbines often operate at the limits of their material capabilities and are already closely controlled to ensure that they do not exceed these limits. Because of this, there is less room for operational changes which improve efficiency at base load. Instead, APC can improve load response (e.g., startup and ramping) as well as low-load capability of such units.

With cogeneration plants, APC will also improve plant economics by maintaining optimum efficiency for multiple fuel changes and for frequent power and steam demand fluctuations.

Holistic approach is key

Each of these improvements can lead to considerable operational improvement. In this approach, integration is the key to APC system effectiveness. It is always the goal of power plant operators to achieve the best heat rate and highest level of flexibility. But the inability to automate and optimize all the different parts of the plant as one is often an insurmountable challenge to achieving these goals. Any integration that does occur relies on the expertise of plant operators. Thus the whole plant model, if there was one, resides in an operator's head. However, today's solutions are capable to optimize the whole plant (or fleet of plants) as a single unit. So when plant operators talk about power plant optimization today, they are talking about this holistic view of "plant control".

Solutions independent of the control system
This holistic approach is made possible by performance optimization solutions that are control system agnostic. In the past, software applications ran directly on the control system infrastructure. Today, these applications are model-based and are implemented on top of the control system (usually running on a PC or server), and interact with the control system via industry-standard real-time interfaces to read inputs and send outputs to the underlying basic controls. This allows the use of a variety of digital modeling techniques (e.g., data-based or physical equations), to create a "digital twin" of the plant.

Lowering maintenance expenses
Because of fast-ramping and other operational demands, power plants today are subject to stresses that exceed their original design criteria. This leads to increased equipment wear and higher maintenance costs. Digital twins and other APC systems help keep these expenses under control by ensuring the plant always operates within certain limits. During startup, for example, if temperature gradients within the boiler can be limited, thermal stresses are reduced.

By maintaining tight control of conditions during startup and shutdown, and when a plant is ramping, APC solutions extend the lifetime of plant components. In addition, the data collected during each cycle can be used to build up a historical picture of component health that can used to predict equipment failure before it happens – keeping unplanned downtime to a minimum and allowing maintenance personnel to schedule needed repairs at optimum times.

APC solutions for the real world
To help plant operators achieve all of these benefits discussed in this paper, in 2018, ABB introduced ABB Ability™ Performance Optimization for power generation to the market. Performance Optimization focuses on four critical areas of plant operations: increasing fuel efficiency and operational flexibility, and reducing maintenance budget risk and emissions.

Increased fuel efficiency and reduced emissions are achieved by Combustion and Soot Blowing optimization. These two services ensure operator consistency in counteracting recoverable degradation (due to soot in the boiler). This also minimizes the variability that increases maintenance risks and unplanned downtime.

Increased plant flexibility is achieved through Steam Temperature Optimization, which allows an increase of steam temperature setpoints, to move closer to design limits, as well as expanding the plant ramp rates. This gives plants the opportunity to sell power into competitive ancillary service markets, expanding revenues from the wholesale market.

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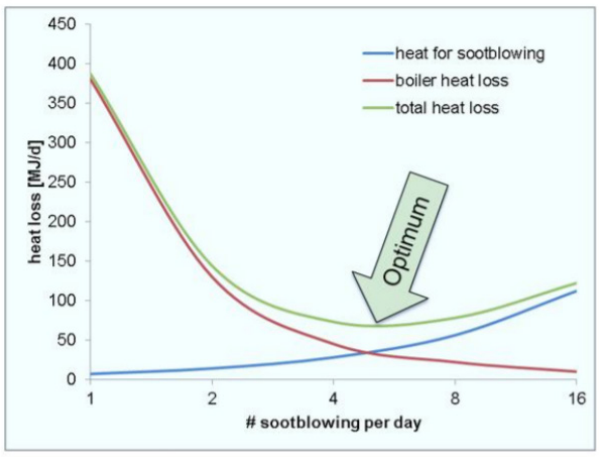
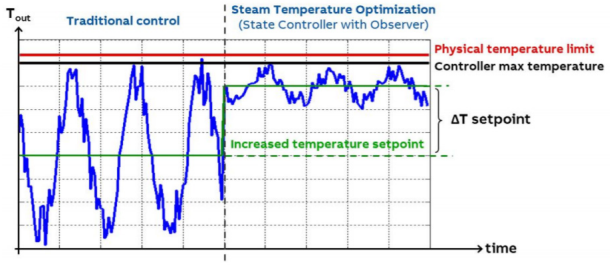
03 Examples of APC applied in real world applications





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Collaborative Operations
No discussion about APC and plant optimization would be complete without talking about Collaborative Operations. This new operating model brings together the best and brightest minds in each discipline – operations, engineering, system architecture, maintenance – into a single team devoted to continuously improve the state of customer operations. Collaborative Operations also serves as a delivery platform for ABB Ability™ applications and services.

ABB's network of global Collaborative Operations centers are staffed with experts who have in-depth knowledge of industry best practices, processes, and equipment and systems from different vendors. This means that plant operators no longer have to wait hours or days for outside experts to arrive. ABB's teams can see the same screens the operators see and work with the same data to find and fix problems quickly.

In a nutshell, Collaborative Operations achieves better business outcomes faster by closing the loop between people, data and organizations.

Conclusion
Even though the future for steam power plants is challenging, there is a path forward. Driven by market forces beyond their control, plant operators are embracing digitalization to improve performance, save money, and reduce emissions.

This is nothing new. The power industry has been adopting technological solutions to solve problems for years. What has changed is the urgency at which they must now proceed. Speed is essential. Steam power plant operators in particular are facing market demands their facilities were never designed to meet.

ABB believes that today's APC solutions provide the best route to success, empowering flexible, economical operation for years to come. The challenges are here now but, fortunately, so are the solutions.

Let's write the future. Together.

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