WHITE PAPER

Improving plant performance with digital technology

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Pushing the limits

Operating a power plant involves monitoring a lot of constantly changing variables. Manipulating any one of them could cause a chain reaction that throws everything out of whack. In some cases, managing the process can seem more like an art than a science. But technology has advanced to the point that it can actually paint a pretty compelling implementation picture. That is, digital systems can improve plant performance and help you operate closer to limits, thus maximizing profit for your company.

Digital solutions expand comfort zones

Most of today's power plants already have advanced digital technology built-in. They have sophisticated instrumentation, and the instrumentation is connected to networks, input-output (I/O) devices, controllers, human-machine interfaces, and historians. The data is displayed for operators to use in real-time to monitor equipment operation and adjust setpoints as they see fit.

The process has worked "well enough" for decades, but it isn't ideal. Most operators have a fairly conservative "comfort zone." They will push plants to a certain point, but they are primarily focused on staying within the limits. Operating on the edge is nerve-racking, and most workers prefer to have a little cushion so they don't trip a unit.

"It's kind of like walking up to the edge of a canyon," said Jon Towslee, ABB's digital engagement leader. "Most people are afraid to walk right up to the edge for fear of falling in. The problem is: the edge of the canyon blocks a good chunk of the view. That's kind of the way operators operate their units. They don't want to stress them. They don't want to trip them. So, they tend to operate them well behind the operating limits because they don't want to cause any upsets."

But just as putting up a glass barrier allows people to feel more comfortable walking closer to the edge of a canyon, digital technology can do the same for plant performance. "When you can start to model and look at the data on how your plant is operating, you can operate a little bit closer to that operational boundary or limit to get more out of the unit without necessarily being fearful and leaving what we call 'controllable losses' on the table," Towslee said.

The whole idea is that by taking the operational data and putting it into modeling software, asset performance software, and loop-tuning software—tools that all work together as building blocks for a more-effective operation—engineers can improve the plant's heat rate. Enhancements may only be in fractions of a percent, but those can quickly compound into millions of dollars per year in extra profit.

There are a lot of elements that factor into success. For example, a newer machine, such as a five-year-old combined cycle gas turbine (CCGT), may not reap benefits as great as a 30- or 40-year-old coal unit would from a technological upgrade. The reason is that the newer CCGT is likely to have had digital tools designed in, and it may still be operating close to factory conditions; whereas, the older coal unit is likely to have undergone a number of changes over the years and may operate far-removed from its design parameters. In other words, there's some "low-hanging fruit" that can be harvested from the older unit.

Performance monitoring

The first building block in the process is performance monitoring. That entails identifying key performance indicators (KPIs), capturing important plant data that feeds into those indicators, analyzing it, and establishing a baseline. The information can then be continuously updated and displayed in a dashboard so operators and managers have a visual picture of how the plant is performing.

“The first thing that a good digital software package will do is help you establish a digital twin of the current state of the equipment,” said Towslee. “If you can grab that data, normalize it, and compare it with other units of similar age, similar runtime, similar repair and maintenance schedules, then you know what to expect as a best-in-class operation for a plant, a unit, or a machine of similar vintage given its wear-and-tear.”

The digital twin is effectively a numerical echo or shadow of what is actually happening in the field. Having a digital twin allows operators to better understand how equipment is operating and how changes made to tuning parameters will affect performance. There are, quite frankly, things that humans can’t discern when sitting in front of a control panel, because they simply can’t see at the level of granularity required. But when data is captured and analyzed using advanced software, the effects of very subtle changes can be dissected and acted upon, which leads to performance improvements.

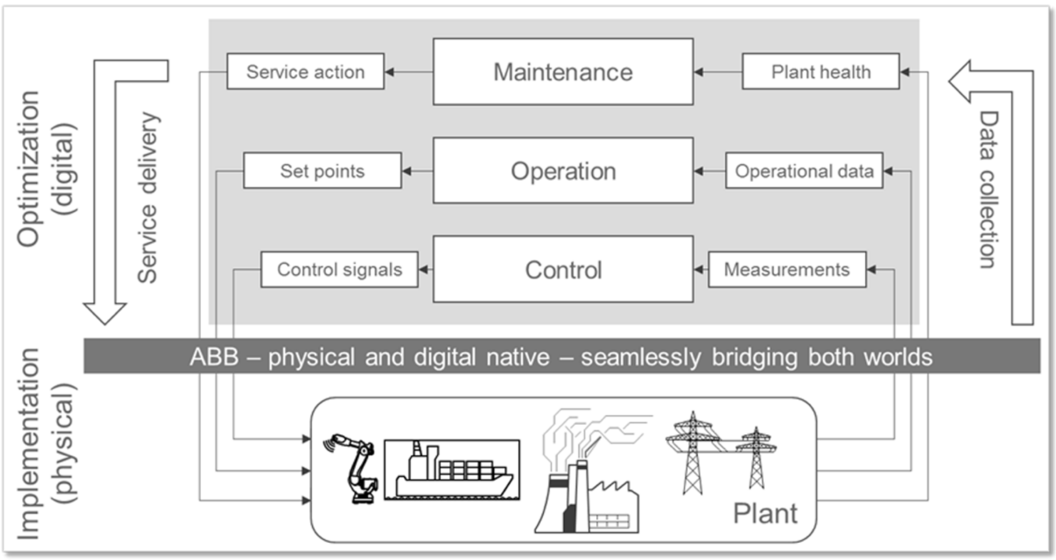

Figure 1: Optimizing a physical plant’s operation begins with performance monitoring, which requires data collection. Among other things, a digital twin can help operators understand how tuning changes will affect performance.

Control loop tuning and optimization

Once the performance monitoring piece is in place, experts can focus on tuning control loops, using specialized software designed for the purpose. The software runs analytics on individual control loops, and it determines if loops are hunting or if they have noise, process, or instrumentation accuracy issues. In fact, there are about 17 to 20 different parameters that ABB’s software package can analyze on every control loop.

“You can’t optimize the plant, an area of the plant, or even a specific asset, if the individual control loops on that asset aren’t running correctly and running tight,” Towslee said. Therefore, ABB recommends having all important control loops monitored by its package.

Once managers have sound and reliable data, the process of plant optimization can really begin. “What we’re doing at this stage is trying to run the plant at the ‘sweet spot’ that allows us to look at the big picture,” Towslee explained. “How much fuel are we getting in? How fast are we ramping up? How much energy are we getting out? Where’s the best place to run this unit? And then we can start to employ control changes, which allow us to adjust tuning parameters depending on the setpoint.”

That’s important because many older units were originally designed to run at full load most of the time. Therefore, they were often tuned to be most efficient at 100% power. However, today many units are being ramped up and down throughout the day as renewable energy resources and market prices fluctuate. The way a plant runs at 25% capacity can be quite different from how it operates at 50%, 75%, or 100%.

“When you understand, through the optimization process, the ideal setpoints to achieve a given output, then you can place automation logic in the distributed control system’s fundamental programming to adjust tuning parameters appropriately depending on plant load,” said Towslee. “So, there may be one set of tuning parameters that makes the unit run really, really well at 25% output, but that same set of tuning parameters doesn’t work very well at any other level and vice versa. Instead of picking the least common denominator, which is the one set of tuning parameters that seems to work ‘OK’ over the whole operating range, engineers can insert the tuning parameters that work best in each of the individual operating ranges, so that depending on where the unit is operating at any given time, the system will recognize and apply the ideal set of tuning parameters to maximize output.”

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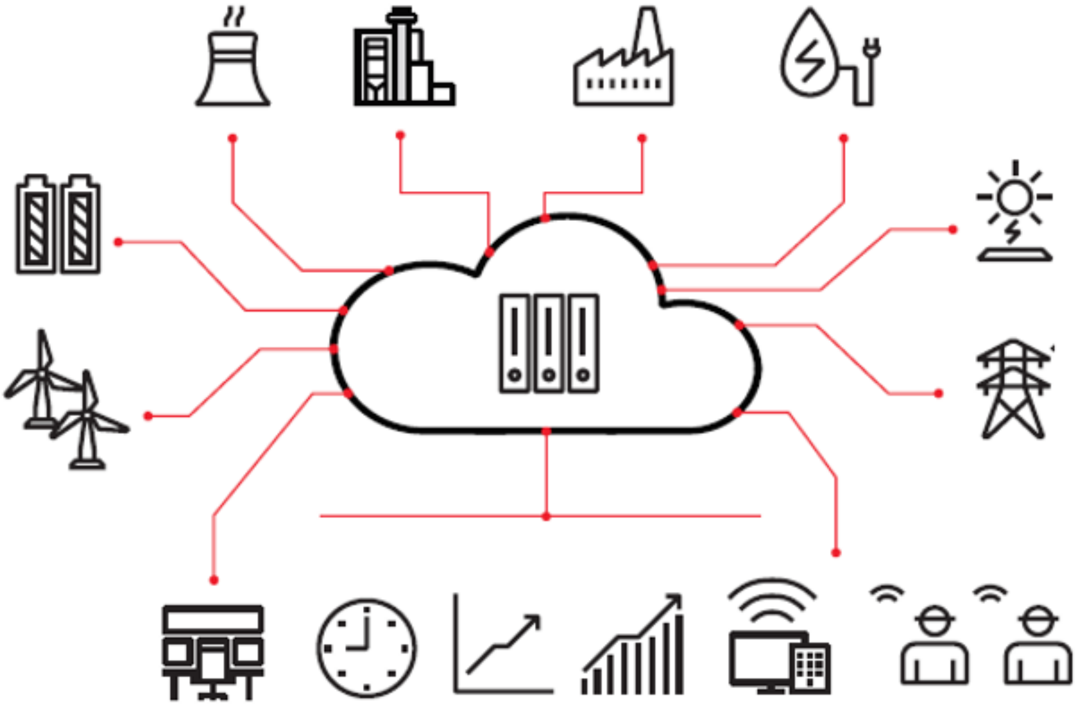
Figure 2: The power grid has evolved greatly over the years. Thermal power plants that used to operate as baseload units are now being asked to cycle more frequently due to the growth of intermittent renewable resources. That’s one reason why optimizing performance throughout a unit’s load range is so important.



Maintenance management best practices

There are a number of maintenance strategies employed at power plants. Perhaps the oldest and least effective is purely reactive maintenance, that is, when something breaks, you fix it. Most companies have moved away from strictly reactive maintenance to at least some form of preventive maintenance. Often, preventive tasks are performed on a routine schedule, such as monthly, semi-annually, or annually. Generally, there is a prescribed set of maintenance activities recommended by the original equipment manufacturer, which are completed whether they're actually needed or not. In some cases, this type of maintenance has introduced problems to equipment that had been functioning just fine prior to the work.

Thus, to save time, money, and effort, a lot of utilities have moved to condition-based maintenance, in which equipment is monitored, and as long as there are no problems identified, it's left alone. If an unexpected condition arises, such as a high vibration reading, unusual temperature measurement, or unsatisfactory oil sample result, maintenance is scheduled to correct the issue. But many companies would like to take that process a step farther and utilize predictive maintenance. Based on a concept similar to condition-based maintenance, predictive schemes not only identify conditions that warrant maintenance, but also use computer algorithms to estimate when the condition will ultimately result in failure. This is an important distinction, because it could mean the difference between shutting a unit down to fix a problem immediately or running it for months, or even years, until a more-opportune maintenance window opens.

Asset performance and asset management

Executing a sound predictive maintenance program requires implementing the last performance improvement building block we'll talk about, which focuses on asset performance and asset management. In this realm, software can be used to identify patterns of "running excellence," that is, the "gold standard" of operation. The program also captures patterns in which something started to fail, and patterns that led to a shutdown. Then, using predictive analytics, it begins to quantify runtimes to failure, so managers can maximize resources and minimize downtime without jeopardizing reliability.

"We're looking at that same stream of data that we've been looking at all along—first to establish the KPIs, then to tune the loops, then to optimize the plant—that same stream of data can feed into a model, using machine learning and heuristics, to determine when a particular asset is likely to fail," said Towslee.

There aren't a lot of utilities that have taken the plunge and embraced predictive maintenance completely. Some are using it in conjunction with condition-based monitoring to extend runtimes, but they haven't pushed equipment operation to the limits that the software suggests are achievable. Nevertheless, the programs to optimize maintenance schemes exist and are available today.

"When you look at the ABB Ability™ suite and how it can improve plant performance, it really ties all of these building blocks together: loop performance monitoring, performance monitoring KPIs, plant optimization, and asset management and asset performance," Towslee said.

Proving it pays

But, as the old proverb goes, "the proof of the pudding is in the eating." To really understand how much digital technology can benefit your plant, you need to install systems and monitor results. And Towslee had some advice for companies interested in doing just that.

"We see customers that want to 'prove it out' and do some 'toe-dipping.' They often want to do so with a combined cycle plant, because there's less I/O and it's easier. The problem is: the amount of gain that you're going to get—the business case you're going to get—is probably not going to be nearly as compelling as on an older plant," he said.

"So, the secret is to implement the test on an older plant that offers the best opportunity for real financial gains. Because when you start looking at the return on investment, the digital solution will shine head-and-shoulders above other plant performance improvement options simply because it doesn't cost as much and isn't nearly as interruptive to the business as a major mechanical overhaul would be," Towslee concluded.

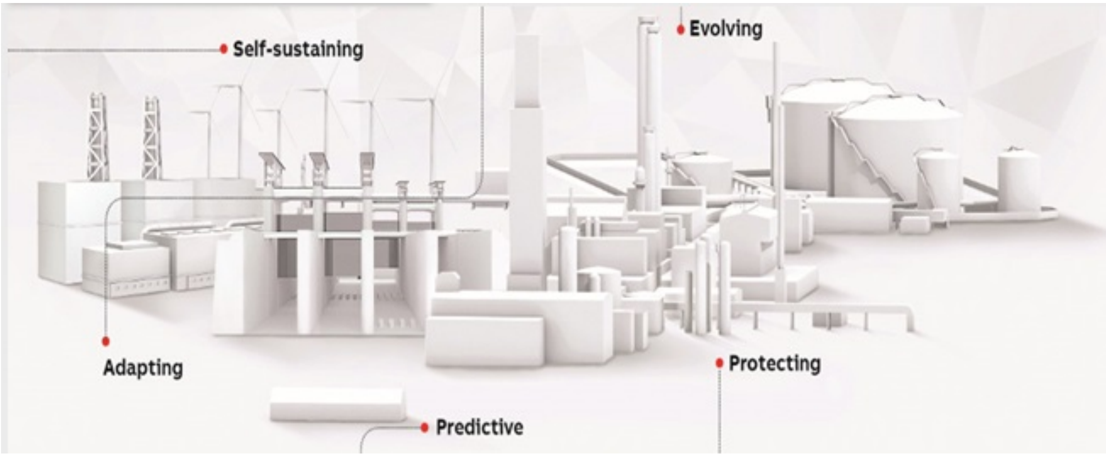


Figure 3: In this competitive age, companies must embrace technology and utilize all available tools to enhance plant performance.

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