Overview of automation & optimization

**THE POWER OF AUTOMATION**

Greater optimization of electric power generation is now paramount, with ever more advanced automation and I&C technologies playing a pivotal role in achieving it. Paul Breeze discusses the rapidly evolving power plant automation sector and explores the factors that are driving its development forward.

Automation systems for power plants have become increasingly sophisticated over the past 20 years on the back of major advances in computer hardware and software. Where once a power plant was controlled by an operator facing a bank of gauges and controls, today most plants are controlled largely by computer, while the operator performs an executive role. In addition to providing a greater degree of plant automation, these advances have also provided the ability to more closely control all the processes of a power plant. This, in turn, has meant that plant operations can be optimized against a variety of parameters to provide higher efficiency or greater flexibility depending upon the demands of the operator.

Computer power and sophisticated software suites are at the core of this new breed of automation system. Without the advances in both computer hardware and...
communications, such systems could not be built. However, other factors are also important. Advances in sensor and measurement technology have enabled many more power plant operating parameters to be measured and monitored than was possible in the past, providing a much more detailed picture of the state of a plant in real time. Meanwhile modern distributed control systems (DCS) provide the ability to regulate the operations of the plant more precisely than before. It is the integration of all these elements that has allowed modern power plant optimization technology to evolve to the level it has today.

**Model behaviour**

The availability of more plant data and the widespread introduction of DCS have created a foundation upon which an automation and optimization system can be constructed. However, it is the layer above these that provides the actual plant optimization. And at the heart of this supervisory layer in most advanced systems is a sophisticated model of the power plant.

Models of this type will aim to include all the key elements of the power plant. For a coal-fired plant this will embrace the coal mills and fuel feed systems, the combustion chamber and boiler, the steam turbine and all the emission control systems. The model will establish how the plant should operate for optimum performance against a particular set of parameters and to achieve a particular target such as fuel efficiency. The monitoring systems will then show whether the plant is operating at this point, while the control system will allow changes to be made based on deviations from the required behaviour.

**New and retrofits**

Advanced control systems are available for all types of power plant, but it is in steam-turbine-based combustion plants that they offer perhaps the greatest advantages. A good modern system will allow control of the combustion process in the boiler to maintain low nitrogen oxides (NOx) conditions and high carbon burnout, both of which are important for plant emission performance, as well as efficiency. It will control the steam temperatures and pressures throughout the steam cycle, allowing the best efficiency to be achieved while minimizing mechanical stresses, and it will monitor and control steam turbine operation. At the same time, real-time system parameters are collected and can be used for predictive maintenance.

Optimization can be used to control gas turbine and combined-cycle plants too. However, with modern gas turbines often operating at the limits of their materials capabilities and already closely controlled to ensure that they do not exceed these limits, there is often less scope here for innovative plant-wide changes to the mode of operation. “Not much can be done on combined cycle plants since the regulatory control is sufficient to keep the gas turbine at its optimum level,” says Samir Pandya, vice president for the power business at Invensys. “But with cogeneration plants, process optimization will help to improve the economic benefits. This is achieved by maintaining the plant at optimum efficiency for multiple fuel changes and for frequent power and steam demand changes,” he adds.

For renewable technologies, such as wind and solar, optimization strategies are being developed although the potential is more limited than for combustion plants. Innovation here is only just beginning. Meanwhile, automation providers and utilities are beginning to utilize fleet management tools that allow the optimization of power production not just in one plant but across all the plants operated by a company or across a region. This has advantages both for fossil fuel plants and for renewables, and is seen as an important growth area for the future.

While optimization technology is relatively new, the market for power plant optimization is not limited to new plants. Older plants can also benefit.

Power plants being built today are usually designed around the use of these sophisticated control systems. In contrast, many older plants still rely on much earlier generations of control and automation systems. Recent advances have been so significant that it is often cost effective to completely replace the original control system in a power plant more than 20 years old with a modern system. The cost can be recouped in more efficient operation, lower maintenance costs and greater ability to match grid operator demands.

The pressures within the global power market are making this an important market for automation providers. As Pascal Stijns, power and energy consultant at Honeywell Process Solutions, observes, roughly one third of global fossil capacity today is new, one third is around 20 years old and one third is in need of replacing. This means that one third of existing fossil fuel generating capacity is ripe for an automation system retrofit so that it can meet new standards for emissions and for efficiency. That offers enormous potential for suppliers and is one of the most fruitful areas of the market today.

**Scope of power plant optimization**

It has always been the ambition of power plant operators to manage their plants in the optimum way to provide the highest heat rate or a high level of flexibility in order to generate the highest economic returns. In the past, however, this ambition was limited by the ability to integrate the operations of all the different parts of a power plant. In a fossil fuel combustion plant, for example, the combustion process, the steam cycle, the steam turbine and the emission control systems would be optimized, but often independently of one another. Any integration of this optimization across the whole plant would rely on the expertise of the plant operator and his or her understanding of how these components interacted with one another. Thus, the whole plant model, if there was one, resided in the operator’s head.

What modern automation systems have brought is the ability not just to optimize the elements of the power plant, piece by piece, but the ability to optimize the whole plant as a single unit. So today, when plant operators talk about power plant optimization, they are talking about this holistic view of plant control.

In practice this whole-plant optimization has clear aims, and two are emerging as the most important, namely efficiency and flexibility. So, for example, Invensys’ Pandya cites two key objectives when applying a modern control system to a combustion plant such as a supercritical or subcritical coal-fired power station.

The first aim, he says, is to optimize power plant efficiency. This allows the plant operator to meet power demand with less fuel. The second objective, he believes, is better and tighter steam temperature control because this will then allow for higher unit dispatch rate.

For Alexander Frick, Head of power plant optimization for ABB power generation,
optimization similarly means maximizing plant output or its availability. Again this boils down to maximizing efficiency (or heat rate) or maximizing the ability to respond quickly to grid operator demands. Both of these aims are determined by the prevailing conditions in the electricity markets, so they will vary in different parts of the world, but both are fundamentally driven by economic considerations.

Optimizing efficiency

Efficiency is at the core of all power plant operations and drives the advance of technologies across the whole of the power generation spectrum, from coal-fired plants to solar photovoltaics and wind power. For fossil fuel plants such as coal-fired power plants, this has led to the development of supercritical and ultra-supercritical boiler technologies based on ever higher steam temperatures and pressures, and relying on ever more sophisticated materials and technologies. A similar drive to higher operating conditions can be found in other generation technologies.

In a coal-fired plant, these advances come with the need for greater control of the steam cycle to ensure that the plant always operates within its capabilities. Further, optimum plant efficiency will often depend on maintaining the plant within a narrow range of steam cycle operating conditions. The more tightly the control can be maintained, the easier it becomes to maintain efficient generation. As Frick points out, the secret of a high heat rate and hence of high efficiency is to maintain operation at set points with as little variation as possible. Any variation leads to a lowering of the heat rate. This means a loss of efficiency and, at the bottom line, a loss of revenue.

High steam-cycle efficiency is crucial and, when talking about power plant efficiency, it is the headline efficiency figure that is mentioned most. But the potential for optimizing efficiency stretches well beyond this. Power plants are large users of electricity, which is consumed to drive a whole range of auxiliary systems, such as pumps and fuel preparation lines.

If the operation of all of these energy consuming power plant components can be controlled as part of the overall optimisation scheme, there are enormous savings to be made. It is by taking control of these auxiliary systems and operating them so that they do no more work than they need to, and only when they are needed, that modern automation systems score highly compared to their predecessors. This underscores one of the strongest business cases for optimization that companies can make. By operating each component of a plant as efficiently as possible, a new or improved automation system may be able to pay for itself in two years.

There is yet another important role that optimization can play in ensuring high efficiency, and that is by enabling a power plant to operate with fuels of varying quality. Most modern fossil fuel plants have to be able to burn fuels that have come from a variety of different sources, often with varying compositions and combustion properties. Managing fuel provision is particularly important for coal-fired power plants where substantial variations in fuel quality can be found. However, this can equally be applied to plants fired by natural gas, which are increasingly also seeing variations in fuel quality. Optimization for different fuels improves both generation efficiency and plant emissions, and each has an impact on the overall economics of power plant operation.

Drive towards greater flexibility

The other key driver of power plant optimization technology today is flexibility. Again the main focus for most automation system providers today is fossil fuel-fired stations, old and new. Traditionally, fossil fuel-based plants, both coal- and gas-fired, were designed for baseload operation. A plant was expected to operate with little variation in output, which was generally maintained at or close to the maximum. But changing system demands in some parts of the world mean that this is no longer the case. Instead plants are being asked to start up and shut down regularly. They must be able to operate at a range of part loads, and they must be able to change output, either up or down, rapidly.

These new demands have a profound effect on plant operations. During startup and shutdown a plant will often operate at lower efficiency when that at its steady-state operating position. The changing conditions will increase fuel consumption and also make the combustion process much more difficult to control, increasing emissions. This has an impact on both efficiency and the plant’s ability to meet its environmental standards. A similar situation arises during fast ramping. Meanwhile all of these modes of operation place much greater stress on plant components than would be experienced under steady-state operating conditions.

Plant optimization provides the tools to enable a coal-fired combustion plant or a gas-fired combined-cycle plant to operate flexibly to meet grid demands, while still ensuring that the best efficiency and the lowest emission performance is maintained. This is particularly important for coal-fired power plants. Many of the oldest coal-based plants in operation are incapable of adapting to these new demands, but more recent plants can be modified to enable this type of operation. Plant optimization can mean the difference between shutting a plant and being able to continue to operate it.
Predictive maintenance
As noted above, a power plant that was designed for baseload operation but finds itself having to operate in a flexible manner will be subject to much greater levels of stress than anticipated when it was built. Power plant optimization systems can help alleviate this by ensuring that the plant always operates within certain parameters that keep stress to a minimum. During startup, for example, if temperature gradients within the parts of the furnace boiler can be limited, then thermal stresses can be reduced.

By maintaining tight control of conditions during startup and shutdown, and when a plant is ramping, an automation system can help extend the lifetime of plant components.

In addition to this, the recording of the conditions experienced by each plant component during each cycle can be used to build up a historical picture of its evolving state of health, and this can be used for predictive maintenance, anticipating the health of a component before it fails.

The underlying model used as the basis for the automation of a plant is of vital importance here too. The normal operating conditions of all plant components are hardwired into the model so that any deviation from normal behaviour can quickly be pinpointed, be it a pump or a bearing running at a higher temperature than expected, or a broader change in combustion or emission conditions.

“We can follow the whole plant or just one of the processes to see if there is a change of behaviour that might lead to a fault,” elaborates Dieter Fluck, vice president for product management of instrumentation and electrical at Siemens Energy. Stress reduction and predictive maintenance allow a power plant to operate more efficiently by reducing downtime for outages and by reducing overall maintenance costs, which all feed into the bottom line and therefore achieve economic efficiency.

Technology and market demands
While automation systems’ ability to control power plant operation has advanced, it has not done so simply in response to the technological advances which have made it possible. Behind it at every step have been market forces. Massimo Danieli, global business unit manager for power generation at ABB, identifies three such forces, which he considers of primary importance in driving optimisation technology today: the advance of renewable generation, global fuel costs and the effect of environmental concerns and legislation.

According to ABB’s Danieli, renewable generating capacity is growing rapidly, particularly in Europe and the US, and with high renewable energy penetration come greater challenges to grid management. In order to manage this, traditional baseload plants such as coal-fired and gas turbine units must act in a grid support role. They must be able to change output quickly, a demand also highlighted by Juha-Pekka Jalkanen, director of plant performance solutions at Metso Automation. Only with advanced power plant optimization is it possible to economically operate such plants in this way.

Global fuel prices are the second factor. All power plant operators want their plants to burn the lowest amount of fuel for the highest amount of energy output, maximizing their returns.

However, the changes being experienced in some global power markets are making this a critical issue. In the US, cheap gas is making it more and more difficult for coal plant operators to generate for a profit, while in Europe high gas prices are challenging gas-fired plant operators. In both cases the ability of an optimization regime to maintain tight control of the combustion system while minimizing stresses and holding maintenance costs down can be the difference between economic and non-economic operation.

Finally, environmental concerns that have stimulated the rise in renewable generation are also having a direct impact on fossil fuel-based plant operations as a consequence of environmental legislation.

Much tighter emission control restrictions in the US are starting to drive older coal-fired plants out of business. Newer plants have a greater chance of meeting the new restrictions, but the cost of compliance may well depend on the ability of an automation system to regulate the station’s operation. Similar considerations are affecting coal plants in Europe too.

Taken together, all these trends are creating a great deal more complexity in power systems. Take the number of units attached to a grid. In 1990 in Germany, Fluck said, there were 1000 generating units on the German grid. By 2011 there were 1 million, many of them wind and solar. Grid interventions to maintain stability on the German grid numbered two in 2003. In 2011 there were 1024 examples of action being taken.

This additional complexity, and the economic issues it raises, means that power plant optimization techniques are likely to become more and more central to generation and to grid operations too. “Everybody expects a reliable supply based on an ever-increasing share of volatile resources,” observed Fluck. Achieving that will not be possible without sophisticated control systems.

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THE TECHNOLOGY BEHIND AUTOMATION & OPTIMIZATION

As our power stations use ever-more sophisticated automation solutions to optimize how they operate, Paul Breeze looks at the software modeling and technology behind this growing trend.

When a Brazilian wood pulp mill, Cenibra in the state of Minas Gerais, wanted to improve the operational efficiency of its combined heat and power (CHP) system, it chose to install a plant optimization system to help control the complex steam supply network. Cenibra wished to reduce the losses caused by the venting of steam to the atmosphere due to excess production when the steam system became unbalanced. This was not a simple problem because the plant had a number of processes that required steam and the demand from each could change regularly and in unpredictable ways.

The plant’s steam demand was met by a mixture of biomass-fired boilers using waste generated at the plant, gas turbine cogeneration systems and auxiliary boilers.
burning oil. Under normal operation these auxiliary boilers would only be used when the other sources could not supply the required steam. Running them was expensive and often led to excess steam. However, keeping them offline could leave some mill processes lacking steam. In both cases plant efficiency and, ultimately, turnover were affected.

The solution, provided by Metso, was an advanced process control (APC) system utilizing a software suite that can operate as a supervisory layer on top of a plant’s existing distributed control system (DCS).

The APC uses a multi-variable predictive control (MPC) approach, also known as model predictive control, in which a model of the plant is constructed, including all the loops and variables that can affect steam production and consumption. An operating target is then set based on various parameters such as steam temperature and pressure or power output, and the control system takes charge of the whole plant using control loops to maintain the system at the target point while steam production and demand change.

The automation system installed at the wood pulp mill exemplifies the type of APC system that has the potential to improve operations of CHP and power plants across the globe. In the case of Cenibra, the new system reduced steam venting to the atmosphere by 90 per cent while still maintaining overall plant stability, something the operators could not do themselves.

Elsewhere an APC system might be used to control the operation of a fossil fuel-fired boiler to ensure both low nitrogen oxides (NOx) production and efficient fuel combustion or to maintain the stability of a combined-cycle power plant providing grid support services, such as renewable support and fast ramping, or even to control a multi-fuel biomass plant to maintain efficiency and emissions as the fuel mix changes.

This type of automation system has been in use in process industries for several years, but is less common in the power sector which has its own traditional ways of working. In some cases this has led to reluctance to adopt the new technology. Overcoming such innate conservatism is vital if such advanced systems are to be used widely in the power sector.

“Operator acceptance of new ways of working is important,” stresses Juha-Pekka Jalkanen, Metso’s director of plant performance solutions. This was echoed by Julio Ribeiro, recovery line and utilities coordinator at Cenibra. “There was a change in the operating paradigm because the operators were used to doing it their way. At first they were a little sceptical about it but soon they saw it brought benefits.”

**A new paradigm**

It is easy to understand why these systems might be viewed with a little suspicion. The key to the new paradigm is that the control system, not the operator, controls the plant; the operator’s role becomes that of an executive overseeing the operations. In order for this to be possible, the operator’s knowledge of the plant and how it functions must be programmed into the control system. This knowledge forms the basis for a ‘model’ of the power station that is created in software and mimics all the processes in the plant. Such models can take different forms depending upon what is known or understood about the process.

One of the most important types of model is the mechanistic model, derived from the underlying principles of the process being modelled. In the case of a power plant, these will be the physical and thermodynamic principles that govern the operation of furnaces, steam generators and turbines. Such a model is only possible if the processes are well understood and reasonably stable. It requires experts that can provide the necessary understanding and can be time consuming to create, but where it is possible to construct such a model it will provide the best foundation for an automation system.

“I would prefer first principles,” says Pascal Stijns, power and energy consultant at Honeywell Process Solutions. “If you do not understand first principles,” he adds, “something is wrong”.

A mechanistic model in which conditions are not necessarily stable can also be accommodated, in this case by using ‘fuzzy logic’, which allows for a degree of variability in each process loop rather than precise fixed points. This might be applied, for example, to a fluidized bed boiler burning a variety of different fuels where the precise operating conditions will vary with the fuel mix.

There are other situations where it is impossible to build a mechanistic model, either because the process is too complicated,
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insufficiently understood, or simply there is nobody available who understands it. In this case, the only solution is some form of ‘black box’ model. A black box model considers the power plant as a box with inputs and outputs. Its contents are unknown.

All that can be known about the black box must be extrapolated from the various sensors and measuring instruments within the plant. These provide the inputs and outputs of the black box. Special software techniques can then be used to generate relationships between the inputs and outputs by first collecting data to show how these vary during normal operation, and then calculating how they interact with one another. Once the model is generated, it will allow stable operation to be established without actually knowing what is going on inside the box.

One of the key tools applied in the situation is neural networks. A neural network creates a model by ‘learning’ how the outputs of the black box should respond to particular inputs. Given sufficient training, a neural network can develop an operational model of the power plant. Neural networks can be tricky to use without any knowledge of the underlying processes, but if used intelligently they can provide consistent models for power plants where no other solution is available.

The need for a black box approach to model creation highlights one of the dilemmas facing the power industry today: the availability of specialists capable of providing the fundamental understanding necessary to build models for automated control systems. As Honeywell’s Stijns points out, the power industry is ageing and many of the specialists who understand how these plants operate are retiring. One solution is to train new specialists and, ironically, it is the models at the heart of modern automation systems that may provide the key resource for training in the future.

If the model-based automation system accurately mimics the power plant in all its details, it can be used not only to control the plant, but also as a simulator. “This can be used as a training tool and as an engineering tool,” says Tomasz Kosik of Emerson Process Management. As an engineering tool it can be used to explore any problems which may arise or to experiment with a plant reconfiguration offline rather than with the actual plant. But the same simulator can be used to train new staff.

While this offers a way forward, specialists who have been trained using a simulator may lack inner knowledge of the plant, so that when they come to take charge of the actual plant they see it as an IT system rather than a series of physical processes. Then they may be tempted, as Kosik suggests, to ‘play’ the plant without realizing exactly what the real-world consequences may be.

Meanwhile, recognizing the problems associated with a lack of experts, many automation system providers are seeking ways of creating the systems needed to control a plant without access to the specialist knowledge that model building requires. As Alexander Frick, Head of power plant optimisation at ABB power generation, notes, “today the power industry is mostly still a people’s industry”. That places limitations on the spread of more conventional automated control systems. ABB, like other companies, is trying to distil the knowledge of the specialists that are available today and package it into software tools that can then be used by people with less specialist power plant knowledge.

Power plant optimization has always been high on the agenda of both operators and suppliers, but according to Frick, “a lot of people want it but only a very few people can do it”. Thus, creating tools that can replace the specialists will be vital for the future, particularly when trying to sell tools to countries that do not have the pools of experts available. ABB has had some success in India with this approach and is aiming to extend it further.

Five senses of a control system

If the APC system is the brain of an advanced power plant control and optimization system, then the sensors and measuring devices are its fingers, eyes and ears, i.e. the means by which it gauges the state of the power plant in order to be able to control it. Here some of the greatest advances have taken place.

According to Metso’s Jalkanen there are more and more new instruments being used in power plants today, and it is these that provide the foundation for plant control. It is only by knowing the state of a plant, in real time, that it becomes possible to control it. Further, the
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more data is available from different parts of the plant, the tighter and more accurate the control regime can be.

Take a power plant’s boiler, for example. In the past, there was only a limited amount of temperature data that could be acquired from within the boiler itself. Much had to be inferred from operations downstream. Today, however, it is possible to create a profile of the temperatures within the boiler using cameras, infra-red detectors, lasers and acoustic measurements. These provide an extraordinary level of detail that can support a much more sophisticated control regime, which in turn provides better boiler control.

Modern sensors and measurement techniques make almost any variable within a plant accessible. For example, by measuring variations in the concentration of corrosive gases within a plant’s flue gas and combining these with other measurements such as boiler temperature gradients, it is possible to assess the corrosion rate of boiler components.

New techniques can also make older ones redundant. In the past it was important to take live steam measurements even though this was difficult and costly. With the thermodynamic measurements available today, it is possible to predict live steam conditions and there is no need to measure them.

Renewable optimization

The technologies that are being developed to enable power plant optimization are most often targeted at combustion plants of various sorts. This is partly because these are the most difficult to control, and partly because new grid demands – that gas- and coal-fired plants should be able to ramp quickly and to operate at variable outputs, for example – mean that optimization is essential if these plants are to be able to generate economically.

Some automation developers are now beginning to look at the application of optimization technology to renewable energy plants. There is less scope here but opportunities are beginning to be recognized.

In a large solar photovoltaic plant, there will be a large number of individual solar panels divided into groups, with each group supplying power to a single inverter that interfaces with the grid. Inverter efficiency varies with the amount of input power, which will change as the light intensity changes. By making ‘soft’ connections between solar panels and inverters it is possible to use an automation system to reconfigure the connections as the light level changes in order to run more or fewer inverters at their optimum efficiency. This helps raise overall efficiency and provide a higher quality feed to the grid.

Other possibilities exist with wind power. Turbines tend to lose efficiency when the wind direction or speed changes. Maximum efficiency is only recovered when the turbine has yawed to meet the new wind direction or the blade pitch has been adjusted to optimize the rotor for a change in wind speed. By integrating weather forecasting and software optimization tools it is possible to predict the wind changes in advance and anticipate them by making wind turbine blade pitch or yawing adjustments so that overall higher efficiency of energy capture is achieved.

Grid support is another area where optimization tools can be deployed. In the past, the main operational objective of a renewable energy-based plant was to produce “as much power as possible by deploying as many megawatts as possible, seeking quantity above quality”, as Massimo Danieli, global business unit manager for power generation at ABB, aptly describes it.

More and more, however, solar and wind plants are being asked to provide quality, as well as quantity. This can be provided at a local level by operating solar power plants and wind farms differently. It can also be achieved over a much wider area by using a pooling or fleet management approach.

Power plant pooling

The principle of power plant pooling is a simple extension of the concepts that underpin plant automation. What an automation and optimization system can achieve within a single plant can be extended to a group of power plants. These can then be managed from a single control room. Not only does this allow greater gains from plant optimization, it also allows systems to be extended to cover asset management. With this there is “potential for customer profitability and cost reduction”, said Dieter Flick, vice president, product management, instrumentation, controls & electrical at Siemens Energy.

Fleet optimization may involve a fleet of fossil fuel power plants, but it could also involve a heterogeneous group of both renewable and conventional generation plants. Flick cited a project for Origin Energy in Australia which involved the control of plants at 13 locations and included wind, coal and gas-based generation with different control systems and operating regimes. By optimizing these as a group, the strengths of each can be exploited; the renewable plants provide cheap power whereas the fossil fuel plants can react fast to changes in demand. “Pooling allows an increase in profitability,” said Flick.

Elsewhere this type of approach can be used to create ‘virtual power plants’ that aggregate a disparate group of generating units and operate them as a single power plant. The virtual power plant might bring together wind generators from across a wide region to increase reliability, or it might be an agglomeration of small diesel units providing auxiliary services to the grid, something the individual units would not be able to do.

Fleet management can solve problems too. When the South African utility Eskom was faced with the problem of controlling emissions from its 13 coal-fired power stations it turned to fleet management. Emissions are now measured at each plant and relayed to a central control room, where performance is monitored and correlated with the plants’ operation status. The emissions monitoring system was built using software from Invensys.

The system allows the company’s environmental management team to anticipate when emissions are likely to exceed limits for each plant, such as during startup or shutdown, so that the appropriate exemptions can be obtained. It also allows the load to be spread during peak demand periods so that the emissions from an individual plant do not exceed its absolute cap. Otherwise a plant might have to be shut down, affecting both supply security and profitability.

Centralizing the control and monitoring of power plants allows teams of experts to be assembled at a single point, instead of needing such experts at each plant. With expertise and experience set to dwindle, this approach is likely to become much more commonplace in the future.

In one way and another, advanced automation and optimization systems are clearly changing the face of power generation.

Visit www.PowerEngineeringInt.com for more information
Modern control systems can optimize power plant efficiency, availability, flexibility and cost, and may be one answer to the instability arising from increased amounts of variable power generation on the grid. Here we highlight key innovations in automation projects across power sectors.

Automation upgrade for Russia’s largest thermal power plant

To help improve operational efficiencies and reliability, an 800 MW unit of Russia’s Surgut-2 plant, one of Europe’s largest thermal power plants, went from vintage controls to an upgraded automation system using Emerson Process Management’s Ovation expert control system.

Emerson, the main automation contractor for the project, completed the upgrade during a four-month shutdown. A team of specialists from Emerson’s St Petersburg Engineering Center used their experience on power-industry projects to ensure the timely implementation of the control system. Special software tools, standardized approaches to automation challenges, and the modular architecture of the Ovation system helped minimize adjustments and reduce overall project execution time.

The Surgut-2 station uses natural gas coming from the Tyumen Region’s oil fields. Based on annual output, the plant is one of the biggest thermal power stations in the world, producing more than 35 billion kWh per year.

The new integrated system enables automated operation of the entire power unit, including electrical controls for turbine generators and pumps, boiler and burner controls, and unit power and frequency control and coordination. It also provides real-time monitoring of equipment and timely notification of abnormal situations, and helps determine equipment health so technicians can schedule maintenance and repairs more efficiently.

The upgrade helped to enhance the manageability of station equipment, tighten control across all operating ranges, and improve the unit’s dynamic behaviour.

The upgraded automation enables the Surgut-2 power plant to adjust the unit’s output to meet market needs. As the plant supplies power and heat to Western Siberia and the Ural region and is the most powerful thermal plant in Russia, customers in those regions should notice the improvements soon.

New control system modernizes super-efficient Danish power plant

DONG Energy’s Avedøre 1 combined heat and power plant, in Denmark, was commissioned 22 years ago. To boost the plant’s efficiency and performance, ABB replaced its control systems with the Symphony Plus system with AC 870P controllers.

The plant consists of two units, which produce electricity and district heating for Copenhagen using mainly coal, but also some oil, as primary energy sources.

Avedøre 1 produces 250 MW of power without district heating, and 215 MW of power plus 330 MJ/s of heat in combined operation.

The plant originally used two different control systems for boiler and turbine automation. With the new system, both boiler and turbine will be automated with Symphony Plus. The AC 870P controllers will be used in combination with the operator control system S+ Operations. This harmonization provides significant advantages in operation, maintenance and spare parts inventory.
Enipower’s combined-cycle power plant at Ferrera Erbognone in Italy has installed an innovative system to monitor and control the performance of main components, allowing optimization of the overall plant performance.

The system from ABB is based on Symphony Plus, the newest plant automation platform for the power and water industries, designed to provide maximum system flexibility, reliability and efficiency. Symphony Plus provides operators with a complete overview of the plant as well as immediate access to all site assets in real time.

Ferrera Erbognone is composed of three combined-cycle units: two 390 MW twin natural gas fired units and one 240 MW unit that can be fed by syngas or natural gas. The plant’s total capacity is about 1000 MW.

The plant’s power is currently dispatched to the power market, with only 50 MW diverted to a nearby refinery owned by Eni. The gas accounts for 93 per cent of the total plant expenditure and represents the highest cost item: each unit consumes 450 million m\(^3\)/year of natural gas.

In a strongly competitive power scenario where margins are loose, there is a need to use advanced tools to detect any kind of inefficiencies in the performance of the plant in order to immediately react. ABB’s solution is able to calculate performances and compare them in real time to those expected according to specifications. ABB’s solution has been selected by Enipower for all its combined cycle plants, i.e. Mantova, Ferrera Erbognone, Brindisi, Ravenna and Ferrara.

The monitoring and control system provides the highest accuracy on plant efficiency as it allows for monitoring of the activity of each plant component: gas turbine, heat recovery steam generator, steam turbine and condenser. The system detects the performance ratio and consumption level of each component and highlights main deviations. The real-time calculation takes into account all possible setups. At Ferrera the optimization capacity has been exploited to reduce gas consumption during the winter.

The gas consumption reduction obtained thanks to ABB’s solution has been calculated at over 4 million m\(^3\)/year, which equals 3547 TEP/year and a CO\(_2\) emission reduction of 8500 tonnes/year.
Automatic power UK electricity demand

SSE’s Keadby power station at Scunthorpe in England, which began commercial operation in 1996, is a 720-MW combined-cycle gas turbine generating facility. It includes two GE frame 9FA gas turbines, one Alstom steam turbine, two Babcock three-pressure waste heat recovery boilers and a Siemens GT10B auxiliary gas turbine.

When the facility’s moderate-sized Distributed Control System (DCS) was approaching plant-wide obsolescence, SSE decided to upgrade to Invesys’ Infusion environment. Infusion is a delivery mechanism for enterprise control. It consists of the hardware and software components necessary to provide a true aggregated view of information across an organization.

The new DCS had to address the pressing obsolescence issues and remain current for the remainder of the plant’s expected service life. Sufficient expandability in terms of controller memory, I/O capacity and network bandwidth together with simplified online configuration was also a key requirement. Because of the potential impact on operating procedures and other human factors, engineers also specified that the new plant solution should maintain the existing control strategies and HMI interface standards.

“We now have a supportable system with the capacity we need to proceed with control improvements,” said Hugh Ferguson, C&I engineer and DCS upgrade project manager at the power station.

“It has been possible to retain much of the look and feel of the previous system but make improvements to consistency, operability and system configurability,” he added.

Total automation for French coal-fired plants

French utility EDF has initiated an extensive programme to modernize its Le Havre 4 and Cordemais 4 and 5 coal-fired units in order to extend the plants’ operating life by 20 years to 2035.

The plants are the largest coal-fired units in EDF’s fleet and were built to an identical design in the early 1980s. Each has a generating capacity of 600 MW.

As part of the modernization programme, which includes revamping the electromechanical and process equipment, obsolete distributed control systems will be replaced with state-of-the-art total plant automation systems from ABB.

The Symphony Plus solution for each unit consists of a distributed control system, turbine control and protection, S+ Operations HMI and a process optimization package. ABB will also supply a simulator for operator training and process simulation.

The new systems will be installed during scheduled annual shutdowns over a four-year period ending in 2016.