

The customer newsletter of
ABB Power Generation

1 | 16

in control



A new approach to service

Power Generation Care 10

A new way to get the most out of your plant, people and production process

The life-cycle approach to service 14

Incremental improvements are more efficient and less costly

Plant optimization 22

Proven ways to improve plant performance

Power and productivity
for a better world™



in control ¹ | 16



Kevin C. Kosisko
Managing Director, ABB Power Generation

Dear Reader,

Visiting our customers and partners is one of the most important and enlightening parts of our business. In doing so, we try to put ourselves in their shoes and see the world through their eyes. We want to know what challenges they face and what opportunities they have, so that we can help them achieve their objectives.

One of the key topics in our discussions is market and technology trends in the power generation and water sectors. As a global player in both we need to identify these trends and assess their likely impact over the coming years. You can read our views on these matters in the opening pages of this issue.

Providing smarter and value-added services for the power and water sectors is a vital part of our activities. These services are designed to get the best performance from the plant, the production processes and the people working there. We have two advantages in this respect: our huge installed base of automation systems and electrical products in power and water facilities all over the world, and our expertise in these sectors. Thanks to this technology and process know-how, we are now taking our service offerings to the next level.

ABB Power Generation Care and ABB Water Care are the names of our new service offerings. They are designed to take care of the facility's assets. They cover our automation systems and electrical balance of plant and are, we believe, the most comprehensive, customer-focused and expertise-rich service offerings on the market. You can read about them on pages 10-11, but the philosophy behind them is present in every article in this issue: on life-cycle management, cyber security, training, operator effectiveness, and on why and when to upgrade your systems, software and products.

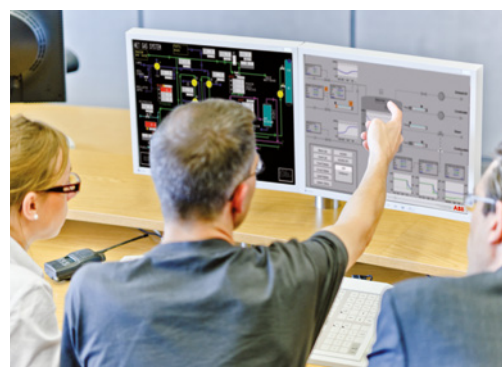
ABB is recognized by ARC Advisory Group as having the largest installed base of control systems for power generation. We are also a leader in the supply of electrical products for the power generation and water sectors. I want to thank you for putting your trust in us and assure you that we will continue to support and enhance your investments so you can achieve better results.

Our eight power generation service hubs cover the globe. They are supported by a network of global competence centers that is available to each hub and country. You can find the location of these hubs and the name of their service manager on pages 30-31. Please feel free to contact them. They and our entire team look forward to helping you improve the operation of your assets.

Thank you for your interest in ABB and I hope you take the time to explore this new issue of In Control. I trust it will give you some new insights into the dynamic range of support that ABB can offer.

With kind regards,

Kevin C. Kosisko
Managing Director
ABB Power Generation



20 The key to operator effectiveness

04 Looking into the crystal ball

Market and technology trends

- 4 **Looking into the crystal ball**
Global and regional market developments
- 8 **New technologies in the digital era**
Big data is transforming service

Life-cycle service

- 10 **Power Generation Care**
A new way to get the most out of your plant, people and production process
- 12 **Stepwise evolution**
How do you protect your investment in an automation system?
- 14 **The life-cycle approach to service**
Incremental improvements are more efficient and less costly
- 16 **Why and when to upgrade**
Keeping the DCS up-to-date and in prime working order

Improving performance

- 18 **From training to learning**
Creating a culture of continuous learning
- 20 **The key to operator effectiveness**
How to achieve significant increases in plant availability
- 22 **Plant optimization**
Proven ways to improve plant performance

Cyber security

- 24 **Facing up to cyber security**
Making the DCS secure, compliant and even more reliable

Electrical balance of plant

- 26 **Electrical balance of plant service**
Maximizing availability and reliability

Service worldwide

- 28 **References**
A selection of some of our service references
- 30 **Meet our global service team**
Our eight regional service hubs

“Our power of prediction is
so slight, our knowledge of remote
consequences so uncertain.”

J. M. Keynes



Looking into the crystal ball

Global and regional trends in power generation over the next five years

“Our power of prediction is so slight, our knowledge of remote consequences so uncertain,” wrote John Maynard Keynes, one of the most influential economists of modern times. He was referring to the difficulty of predicting what would happen in the future to the investments we make today.

Yet, plan and invest we must. Businesses have to identify the trends, assess the market and try to understand which way the economy and the world are going. Fortunately, the data is available in a way it wasn't in Keynes' lifetime; it makes forecasting an industry's future over the next 5-10 years less uncertain than before. Forecasts beyond 10 years are considered unsound; the unknowable variables are simply too many to allow detailed analysis.

ABB, like any other global company, continually assesses market and industry trends. Using data from our eight regional power generation hubs and other well-known industry analysts, we have gauged what we think will be the major industry developments over the next five years (2016-2020). We present an outline of some of the findings below.

Power generation is flourishing and growing

The number of units producing energy continues to grow healthily across all types of power generation between now and the end of the decade. The world's total generating capacity will grow significantly by around 22%, from

6,224 gigawatts (GW) in 2015 to 7,576 GW in 2020. About 300 GW of new capacity will be added annually, ranging from a low of 286 GW in 2016 to a high of 326 in 2019.

Trillions of dollars in investment

In financial terms, these investments in new capacity between 2016 and 2020 will be worth around \$2.4 trillion. Almost half of them (47%) will be made in the Asia-Pacific region, with China by far the single biggest investor in new capacity. In fact, China is the leading investor in all categories of power generation, from coal and nuclear to wind, solar and hydropower. Other countries that stand out as major investors are Japan in large-scale photovoltaic (PV) and the USA in natural gas.

Asia-Pacific is the engine

Unsurprisingly, the Asia-Pacific region – which includes China, India and Japan – will continue to be the engine for global growth in power generation. Almost half of all new power plants in the next five years will be built in this part of the world. This new capacity will be evenly spread between conventional fuels and renewables.

There will be no major shift in the way electricity is generated; established trends, such as the turn to renewables, will continue. Global power consumption will rise worldwide by

around 3% per annum, mainly in the Asia-Pacific region, less so in Europe and the Americas.

Coal remains king

Capacity additions in new conventional power plants – primarily coal, natural gas and nuclear – will decline moderately, by between 1-4% annually over the five-year period. Coal will account for half of those additions.

The use of coal in new power plants is restricted almost exclusively to the

The Asia-Pacific region will continue to be the engine for global growth in power generation.

Asia-Pacific region, primarily China and to a lesser degree India. China set a record for the amount of new coal-fired energy in 2015, and is set to break that record again in 2019. Even though the Chinese government has introduced measures to reduce the use of coal, we estimate the amount of new coal-fired power coming online will remain relatively high. It will peak at 49 GW in 2019 before dropping to 34 GW in 2020 when government targets start to make an impact.

Natural gas and nuclear

In the United States, the combination of domestic supplies of natural gas and

the government’s Clean Power Plan to reduce CO₂ emissions by a third has caused a switch from coal to natural gas in power generation, with coal-fired generation declining and natural gas generation hitting all-time highs. Large capacity additions of new gas-fired plants are also taking place in the Middle East, Africa and Russia in particular.

There is significant activity in the nuclear segment, with 66 nuclear units currently under construction worldwide. Twenty-four of these units are in China, followed by Russia, India and the USA. Even though nuclear accounts for only 9% of new capacity addition, it eats up 41% of the total amount of money invested in new power generation facilities, due to the high up-front cost of building a nuclear power plant.

The switch to solar

The switch to solar is a worldwide phenomenon. Between 2015 and 2020 global installed capacity will almost triple, from about 220 GW to 600 GW. The global trend of annual double-digit increases in new capacity will continue beyond the five-year period, with almost two-thirds of those investments being made in China and other Asia-Pacific countries.

Investments in small-scale PV installations will flourish in all markets, with the exception of Japan. But utility-scale

investments will not share the same upward path, peaking at 38 GW in 2017 before tailing off in 2020. New PV capacity additions will almost double in China, from 17 GW in 2015 to 31 GW in 2020. Although India’s target of installing 100 GW of solar generating capacity by 2020 seems ambitious, with our estimates predicting less than half that amount.

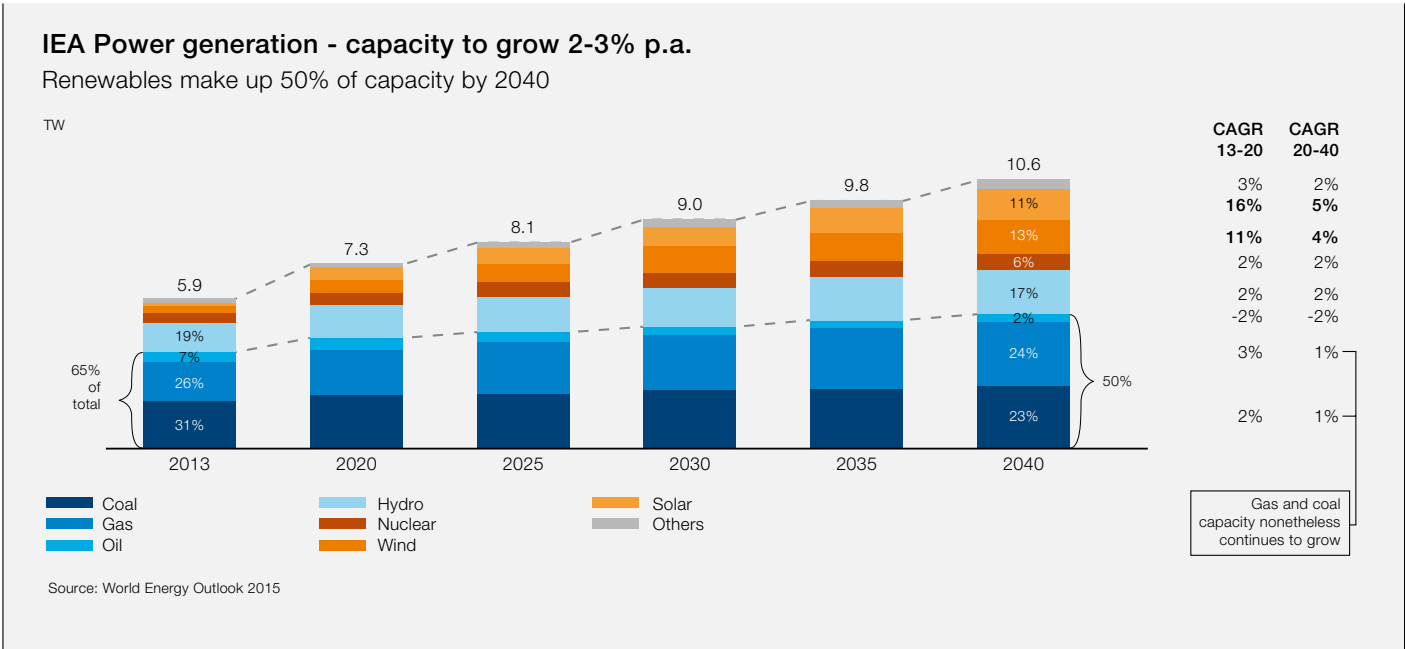
Government subsidies have been the key driver of solar investments and growth over the past 40 years. That trend will continue over the short and medium term. Even though huge cost reductions have been achieved, solar energy still remains more expensive to produce than power from conventional fuels and wind in most parts of the world.

Cost-competitive wind power

Around 60 GW of wind power were installed worldwide in 2015, setting a new record. This high level of new capacity is expected to continue over the next five years, diminishing slightly after 2018 when the US subsidy scheme comes to end. Around half of all new installations are in the Asia-Pacific region.

Like solar energy, most wind power installations are driven by government policy and subsidies. This is likely to continue in much of the world, but not everywhere. In some parts of Europe,

IEA forecast for 2040



Australia and the Americas, onshore wind power is already cost-competitive with coal and natural gas. In the coming years, most of the global onshore market is expected to become independent of subsidies.

Around 90% of new wind power installations are onshore. Offshore power, which has much higher investment costs, will grow by 10% annually over the next five years, mainly in Europe. Offshore wind installations will become cheaper to build over the next two decades, but will still require government subsidies for some time to come.

Looking ahead to 2040

The International Energy Agency (IEA) and Bloomberg New Energy Finance (BNEF) have both projected long-term trends for the next 25 years. Their forecasts for the power generation market in 2040 arrive at similar conclusions.

Both predict a decoupling of national economic growth from power consumption, with power demand falling or rising slowly in the developed economies of the northern hemisphere: the USA, Canada, Europe, Japan, but also Russia. Almost the entire southern half of the globe will expand capacity at a medium rate, with only India, of the major developing economies, increasing capacity at a high level. Global growth in new power generation will average 2-3% per annum over the 25-year period.

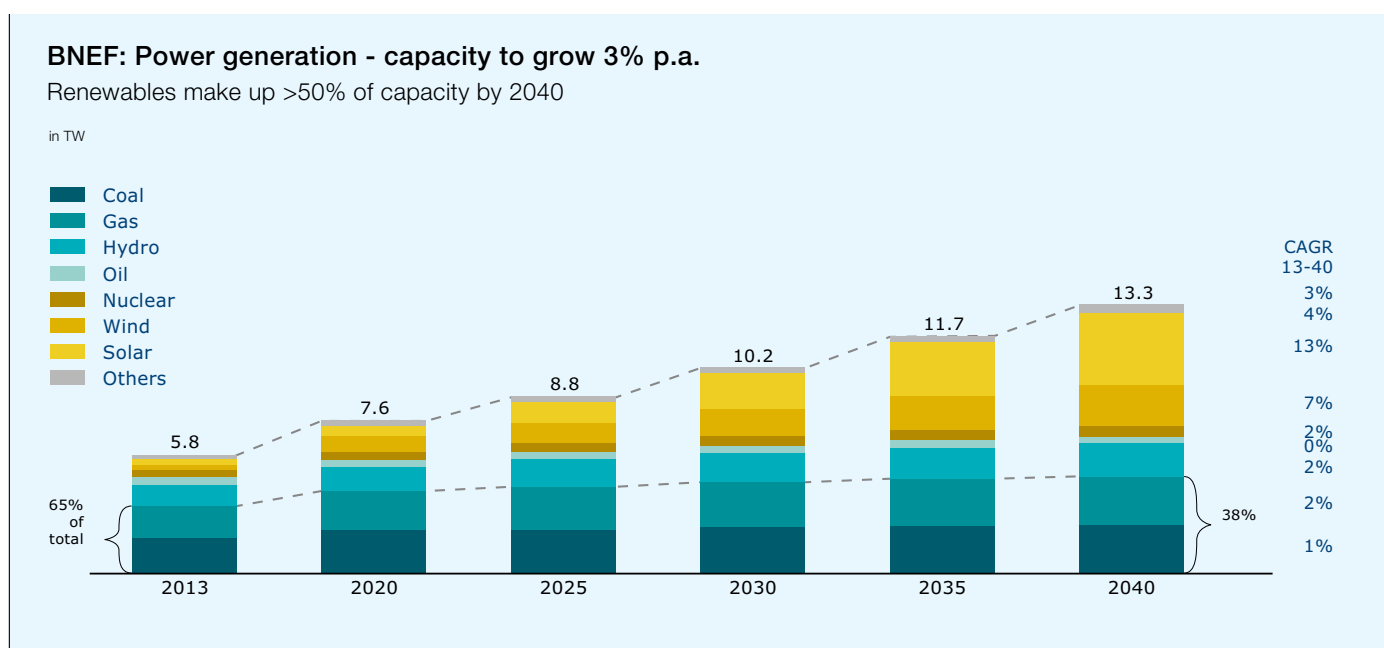
The best way for power generators to meet market challenges is to harness the opportunities provided for service and maintenance by big data and analytics in the Internet of Things, Services and People.

Both the IEA and BNEF agree that renewable energy (solar, wind, hydro, nuclear and others) will make up 50% of the energy mix in 2040, although BNEF predicts a faster growth rate than the IEA. Coal's share of the energy mix will fall from 41% in 2015 to 30% in 2040, although paradoxically the number of units in production will grow by about 1%.

In summary

A common challenge that power generation facilities face in the coming years - regardless of application, region or trend - is that they will have to operate at peak performance and with a high degree of flexibility in order to respond quickly to rapid market changes. The best way for them to meet this challenge is to harness the opportunities provided for service and maintenance by big data and analytics in the Internet of Things, Services and People.

BNEF forecast for 2040



New technologies in the digital era

Big data and smart devices are transforming service in the power generation industry

"We are in the midst of a major technology revolution, specifically a digital revolution," says Accenture, the global consulting services company, in its recently published 'Technology Vision 2016.' By 2020, 25% of the world's economy is forecast to be digital.

Power generation facilities now have the ability to generate vast amounts of digital data on equipment behavior and process performance. This data can be continuously uploaded in real time to the cloud, where sophisticated algorithms can analyze it to optimize production.

We take a brief look at some of the most important digital technologies impacting power generation and the potential they hold for service and maintenance.

Mobile computing

Mobile computing allows the transmission of data, voice and video via a laptop, tablet, smartphone or other wireless device.

The technology has been part of our daily lives for years, but the increasing sophistication of smartphones is opening up new avenues for service in the field. For instance, service technicians can use their smartphone to wirelessly measure vibration in rotating machines or the temperature and electromagnetic fields of equipment that may be faulty. The data can then be uploaded from the phone into the cloud for analysis.

Drones and remotely operated robots

are also likely to be used increasingly to undertake dangerous, heavy or unpleasant tasks. Drones can perform visual examinations of boilers and smoke stacks, and robots can clean boiler tube walls or inspect radiation zones in nuclear power plants.

The Internet of Things

The Internet of Things (IoT) is a network of devices, machines and equipment, which are embedded with sensors, software and network connectivity that enable them to collect and exchange data.

Power plants and other industrial facilities can use the Internet of Things to generate immense quantities of data. Thanks to cloud computing, this data can be stored affordably in the cloud and analyzed either in real time or later in order to improve plant operations, by reducing asset downtime or improving the deployment of service personnel.

But generating and analyzing data does not create value in itself. The data has to be made available in meaningful ways to people - plant managers, production managers, service personnel and others - so that they can translate the data into actions that improve plant performance and profitability.

Cloud computing

Cloud computing is computing based remotely on the Internet rather than locally in a computer or plant server. Its importance is growing rapidly and extends

way beyond email traffic, Internet banking or Facebook pages. According to a recent Cisco report, 83% of workloads will be processed by cloud data centers by 2019, a threefold increase on 2014.

Cloud computing has the potential to offer huge benefits for service and maintenance in particular. It enables all the data on, say, the motors and generators in a single plant or fleet of plants to be stored, analyzed, benchmarked and then acted on by service personnel.

For an automation service provider like ABB, cloud computing enables us to see how our automation systems are behaving and whether our customers are using those systems optimally. We can then use this information to refine our solutions and suggest ways to improve plant performance.

Cyber security

As societies become increasingly reliant on computer systems, the threat of attack on these systems grows. Vulnerability increases as ever more devices and machines become connected to the Internet of Things and computing moves from local servers to the vastness of the cloud.

Cloud environments face many of the same threats as traditional corporate networks, but due to the huge amount of data stored on cloud servers, providers become an attractive target. Attacks come in many forms: weak or broken authentication systems that allow unau-



ABB has expanded the standard IoT concept to one that incorporates services and people: the Internet of Things, Services and People (IoTSP).



thorized users to penetrate the system and access data, system vulnerabilities that admit bugs and other malware, account hijacking, and so on.

ABB's approach to cyber security is defense in depth: there is no single solution to cyber security, so multiple layers of security controls should be placed throughout the system. Cyber security is embedded in our systems; maintaining their defenses from attack is a constantly ongoing process.

Web-scale IT

Web-scale IT refers to the platforms that are used on a very large scale for cloud computing and the Internet of Things. The most widely used of these platforms are currently those operated by Amazon, Google, IBM and Microsoft.

But leading automation vendors are also developing their own Web-scale IT platforms. ABB, for instance, has millions of automation and electrical products and thousands of process control systems installed at production facilities all over the world. We are embedding our expertise in these products, systems and production processes into our own cloud-based platform to take IoTSP to a higher level.

The platform provides secure connectivity and data management. It is scalable to accommodate future needs

and includes advanced analytics for many plant applications. The information provided by these analytics enables experts to resolve technical issues faster and create new, advanced services to optimize maintenance and operations more efficiently.

Software infrastructure and applications (ecosystems)

An ecosystem is a collection of devices, software, companies and processes that together form and operate within that ecosystem¹.

For instance, a power plant ecosystem would include the plant itself, the fleet of which it is a part, the company that owns the plant, the transmission system operator to which the plant delivers power, the consumers that use the power, the companies that supply equipment and services to the plant, the people who work at the plant, and so on.

Cloud computing and IoTSP provide the foundation for new software apps that can improve operations within that ecosystem. For instance, if a Web-scale IT platform such as ABB's was installed throughout the fleet, the data from each plant would be continuously uploaded into the platform. An advanced service app to, say, generate 'More power at less cost' would read, analyze and correlate the data from each plant and provide in-

structions on how to use the plants more optimally in order to generate more electricity at reduced cost.

Context-rich systems

A context-rich system has intelligent devices embedded throughout the system and uses advanced analytics to provide a complete picture of what is going on at any one time within that system.

For example, a fan that is performing poorly will not provide the correct amount of cooling and will consume more energy than is necessary. It can also affect other parts of the process by causing equipment to overheat. An operator will be able to see that something is wrong, but will not be able to identify the cause of the problem. A context-rich system would generate sufficient data on the plant process and have the analytics in place to pinpoint the malfunctioning fan.

Conclusion

The principal benefit of these new digital technologies is that - within the context of IoTSP - they make it possible for power generation companies to manage their assets optimally and efficiently and in a way that was not previously possible. The challenge is to grasp the opportunities these technologies offer for integrating assets, people, knowledge and innovative services.

¹ The conventional definition of an ecosystem is a software application that enriches a digital tool without changing its intrinsic structure. Here, the same term is used with a wider meaning, extending the concept of ecosystem to hardware, processes and people.

Power Generation Care

A new way to get the most out of your plant, people and production process

Power Generation Care is a complete service offering that raises the performance of the plant's automation and electrical assets, its operations and maintenance staff, and the production process during the life cycle of the facility.

It is designed to meet the service requirements of ABB customers worldwide, whether they are a publicly or investor-owned utility or independent power producer, or whether they operate a single plant or a fleet of plants in one or more countries or regions.

Despite their differences and the varying opportunities in the markets they operate in, power generation companies the world over share three things in common with regard to their service requirements:

- Their plants require maintenance on a day-to-day basis to maximize plant availability and reliability and minimize the possibility of disruptions to production;
- They want to extract more value from their existing assets by extending the lifetime of the plant by an additional 5, 10, 15 or 30 years and be certain that the plant will continue to perform optimally throughout that extended lifespan; and
- They want to optimize the performance of the plant as a whole. This may include improving the production of steam or reducing the consumption of energy or enhancing the knowledge and skills of the workforce throughout their years at the plant.

Power Generation Care is ABB's response to these customer requirements.

Continuous collaboration

Partnership, life-cycle management and stepwise evolution of the plant's distributed control system are the defining principles of Power Generation Care.

Partnership and continuous collaboration between ABB and the customer is key. For its part, ABB contributes deep expertise in automation and electrical technologies and the power generation process:

- We are ranked by ARC Advisory Group as the global market leader in distributed control systems, both for the sector as a whole and for critical infrastructure industries like power generation, oil and gas, mining and pulp and paper;
- We are acknowledged by the market as the leader in the power technologies that make up the electrical balance of plant – transformers, generator circuit breakers, motors and drives, and so on; and
- We have vast expertise in power generation processes, based on more than 125 years in the industry.

Plant strategies

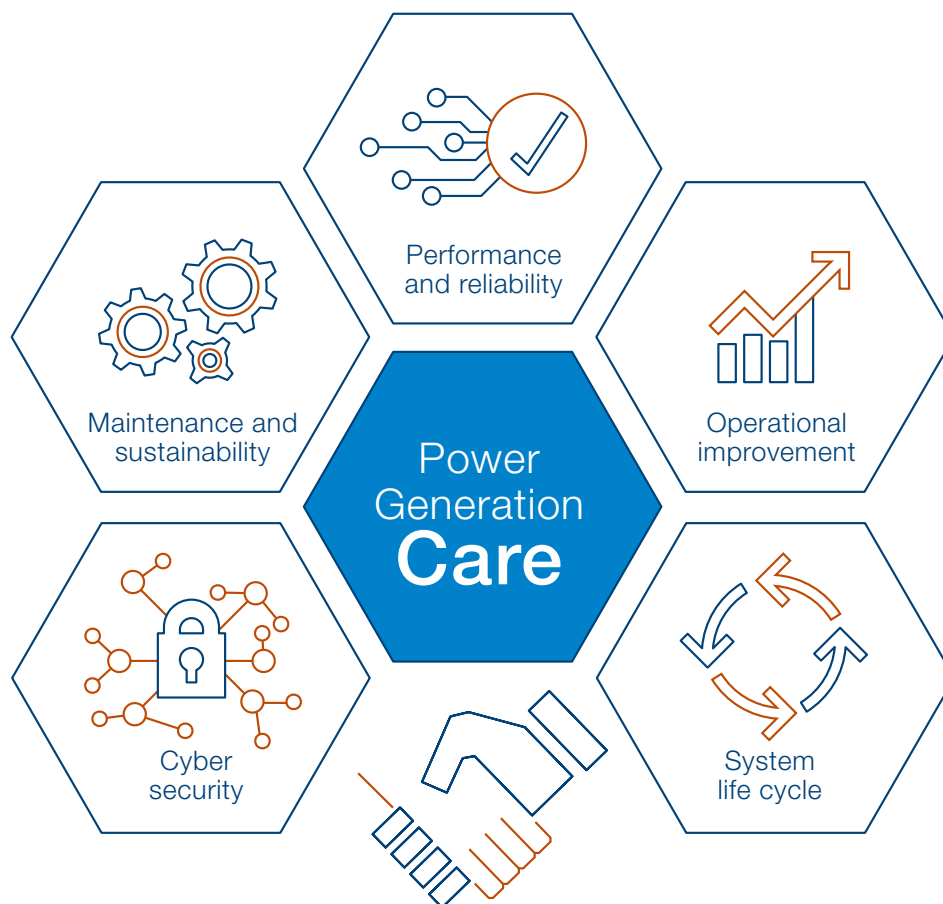
This expertise is on hand to meet each customer's specific requirements and business targets, in particular: their asset strategy for the plant in ques-

tion, which is usually based on the number of years the plant has left to run; the operating strategy of the plant, whether it runs at base load, peaking load or load-following; and the operations and maintenance culture of the plant or company.

For instance, a plant that has 25 more years of scheduled running time requires a different maintenance strategy than one scheduled for closure within the next few years. The former will require a long-term DCS service program with planned upgrades that evolve the system stepwise over time; whereas the latter may get by with refurbished parts rather than new ones.

Similarly, a plant that is running at maximum output around the clock requires a different service approach than one that is ramping up and down several times a day to provide power at peak demand.

And the operations and maintenance culture of a company may differ from one plant to another depending on the skill level of the operators and service engineers. Typically, 80% of the DCS is not used to its full potential. Learning programs can equip staff with the knowledge to use the system to its full potential. This is becoming ever more crucial as we enter the era of big data and the Internet of Things, Services and People, at the heart of which is the plant's DCS.



Life-cycle solutions for your plant

Service that meets requirements

Power Generation Care consists of a comprehensive range of solution packages that meet these individual plant strategies and the overriding requirements for day-to-day maintenance, life-time extension and performance optimization.

These solution packages are the key to our life-cycle approach to plant service and our philosophy of evolving the DCS in small incremental steps throughout its lifetime to ensure that it remains up-to-date and free from the risk of degradation and obsolescence.

The packages provide the flexibility to meet the requirements of a customer who operates a single plant and one who owns a fleet of plants of varying ages and in different applications. In both cases we can help identify which service investments are most critical to mitigate risk and reduce service costs. This could mean managing the supply of spare parts in a smarter way, raising the level of cyber security, evolving an outdated HMI to a state-of-the-art interface, or improving the skills and knowledge of personnel.

Global service network

Power Generation Care is available to customers worldwide and is supported by our eight regional power generation service hubs. Contact your local ABB service hub manager for more information (see pages 30-31 for their names and location).

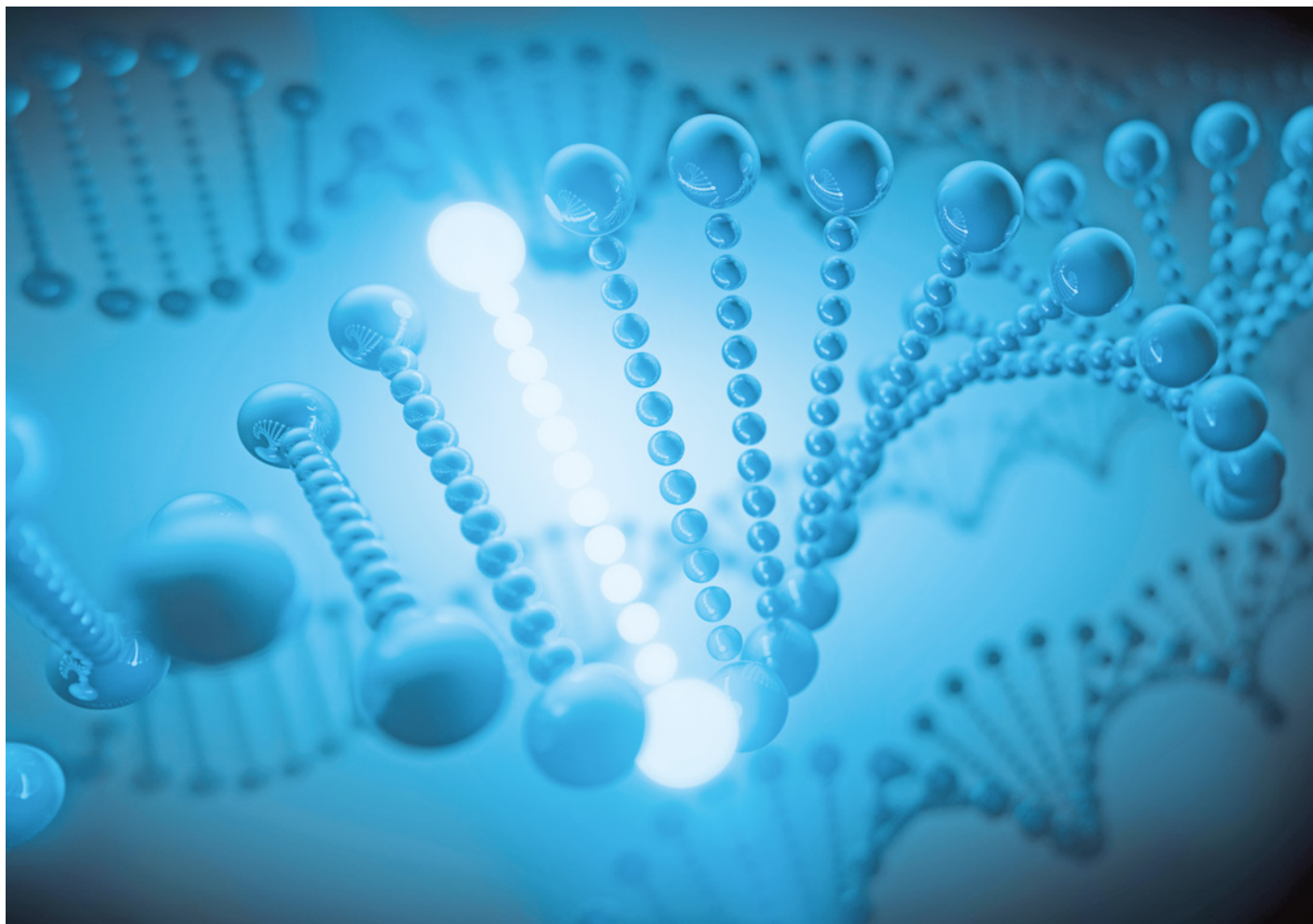
Power plants have three service needs in common: day-to-day maintenance, performance optimization and lifetime extension.

Water Care

Total world consumption of water is expected to increase by 40% by 2025. New types of treatment to meet changing regulations, enhanced recovery operations from treated wastewater, desalination energy and technology strategies, and the pumping and water transmission systems will all require proper investment and planning. Water Care is designed to meet this changing landscape for the complete water cycle.

Energy management (monitoring and conservation), preserving and extending the life of assets, improv-

ing availability/productivity, and system optimization – all while managing the costs of production, treatment, transfer and distribution for municipal utilities, private operators and developers to original equipment manufacturers (OEMs), EPC contractors, system integrators and industrial customers. Water Care fulfills the needs of the entire water sector in solution packages for the lifetime of your operation. Water Care is based on the same holistic approach to life-cycle maintenance as Power Generation Care.



Stepwise evolution

How do you protect your investment in an automation system over the 50-year life cycle of the plant, while continuously upgrading the system with the latest technologies at the lowest possible risk and cost?

The cost of a new power plant is immense. According to the US Energy Information Administration (EIA), a new power generation facility using the most basic coal-fired technology will cost around \$3 million per megawatt to build. For natural gas it is less expensive at around \$900,000 per megawatt, and for nuclear considerably costlier at about \$5.5 million.

The plant automation system is what keeps these huge investments productive and profitable. Along with the

turbines it is arguably the single most important item of equipment in a non-nuclear plant. It is the brain that keeps the plant running - efficiently, optimally and with maximum availability.

For the owner of the plant, continuity of production overrides all other priorities. Disruptions have to be kept to the minimum. But as time progresses and automation system hardware and software age or become outmoded, the likelihood of disruption increases. How can owners best protect themselves from disruptive downtime?

Intellectual property and operator expertise

There are many areas of the plant automation system that require protection from disruption and obsolescence. But two in particular stand out.

The first is the plant owner's intellectual property investments in HMI graphics, control logic, changes in configuration, historical data and the like. These investments are incremental and are made day-by-day over the operating life of the plant. They contain all the information that the operators need to run the plant efficiently.

The second is the expertise of the plant personnel. Their ability to operate, engineer and maintain the automation system is based on their knowledge of and familiarity with the system. This takes time, but with experience comes efficiency and the ability to make timely and correct decisions.

Evolution is cost-effective

DCS evolution is the most cost-effective way to avoid disruptions to production. The principle behind it is to make small, incremental upgrades to the hardware and software over the system's lifetime. This keeps the DCS up-to-date and well maintained, and it spreads the cost evenly over its life cycle, bringing stability to the maintenance budget and making costs predictable.

This evolutionary, life-cycle approach has been ABB's policy for 35 years, since the dawn of the distributed control system. Each generation of our flagship plant automation system for the power generation and water industries, Symphony Plus, is backwardly compatible with its predecessors in the family tree – Network 90, INFI 90 and Symphony Harmony in the Harmony branch of the family; and Contronic 3, Contronic E, Contronic S and Symphony Melody in the Melody branch. In fact, ABB has many customers whose control systems have evolved in this way, containing components from several generations of the Symphony Plus lineage.

When customers upgrade from an ABB legacy system to Symphony Plus, we retain the existing control system hardware – the wiring, marshalling cabinets and I/O cards, etc. The plant's intellectual capital does not go lost: HMI graphics, engineering configurations and control algorithms are imported from the previous system and reused. The knowl-

Landmarks in DCS evolution

This philosophy of 'Evolution without obsolescence' – of evolving the DCS to the latest technologies without making preceding hardware and intellectual capital obsolete – is further illustrated by two historical landmarks.

Some years ago, DCS communication networks were all based on proprietary technology. We introduced the latest communication technology by developing a solution that made it possible to evolve our legacy control systems to Ethernet, stepwise and without disrupting operations. The solution enabled customers to run both these previously incompatible

communication technologies on the same DCS, while gradually switching to Ethernet over several steps.

Following the same approach, we developed a solution that gave customers the opportunity to advance from rack-based mounting to DIN-rail mounting. Previously the two mounting technologies were incompatible, but our solution made it possible to switch from rack to DIN rail without renewing the wiring or affecting the behavior of the equipment, thereby minimizing the cost of the upgrade while maintaining operational continuity.

Each generation of Symphony Plus is backwardly compatible with its predecessors – Network 90, INFI 90 and Symphony Harmony in the Harmony branch of the family; and Contronic 3, Contronic E, Contronic S and Symphony Melody in the Melody branch.

edge and familiarity that the operators, engineers and maintenance staff have built up over the years in the legacy system is effortlessly transferred to the new, state-of-the-art Symphony Plus system.

Continuity or disruption?

In short, customers are able to evolve to new technology without sacrificing their previous investments in hardware, without abandoning their intellectual property and without losing the knowledge of their staff. In a word, they maintain continuity.

In contrast, the opposite approach to planned DCS evolution is that of making large-scale upgrades every few years, followed by a giant 'rip and replace' refurbishment when the system is considered not worth saving. Removing the DCS and replacing it with a new one from a different vendor is extremely costly and disruptive. Staff have to learn a new system and build up expertise, which takes years. The company loses its intellectual capital which it has accrued over the years in the previous system. There is no smooth transition from the old system to

the new; downtime is lengthy and commissioning and start-up protracted; and there are many hidden costs along the way.

The life-cycle app

Why stepwise evolution of the plant automation system is more efficient and less costly than other service alternatives

Investment strategies, like corporate mission statements, should be long term. A plant owner's investment strategy for service and maintenance should begin on the day the plant starts production and end on the day it is decommissioned. Day 1 may strike some as early, but the alternative philosophy of waiting a few years before planning when and which assets to upgrade is too late. By then the assets are already growing old, and a carefully budgeted approach to incremental modernization is slipping out of reach.

There are many benefits to the life-cycle approach.

The first is planning. Take a plant automation system, for instance. It is an entity that consists of many different parts, both hardware and software. Each part will need to be serviced, updated and upgraded, some at regular intervals, others less frequently. A life-cycle approach will plan when these parts need to be upgraded to ensure that the part and the system continue to perform optimally and efficiently throughout their lifetime.

Second, the life-cycle approach brings structure and order to the service budget. It makes expenditure predictable and it flattens the cost of maintaining assets over many years. It allows small, incremental upgrades to be made annually in hardware and software to keep the plant running safely and optimally. By making these incremental upgrades, the risk of a part degrading and shutting down the system, or of the system being compromised because of inadequate cyber security, is minimized.



Third, technologies age and become obsolete, some faster than others. For instance, a vendor may retire an operating system and no longer support it with commercial off-the-shelf software; human machine interfaces become dated and more vulnerable to cyber-attack; without proper maintenance an aging control system may fail and reduce plant output; interfaces between a non-upgraded control system and newer technologies become increasingly difficult to make; and so on. The life-cycle approach eradicates all these issues of aging by updating or replacing the parts before obsolescence and downtime begin.

The life-cycle approach brings structure and order to the service budget. It makes expenditure predictable and it flattens the cost of maintaining assets over many years.

reach to service

Fourth, the life-cycle approach avoids the high-cost alternative:

ripping out the old control system and replacing it with a new one. The cost of installing a new system is rarely what it seems.

Besides the huge replacement of system hardware (I/O, controllers, communication infrastructure, HMI and I/O terminations), there are lots of hidden costs and risks along the way. Control applications have to be re-engineered or translated and new control documentation created; loops have to be retuned, which results in a long commissioning and start-up period; new algorithms result in new and unfamiliar process control behavior; operators and service personnel have to learn a new system, which takes time and requires lots of training; and process graphics, which are the valuable intellectual property of the plant owner, become redundant and have to be replaced.

Fifth, the potential disturbances to production of a changing workforce are avoided.

Over time the workforce at a plant changes. A mature, experienced generation of operators and engineers gradually retires and a new generation takes its place. The new generation may know all the latest technologies but does not have the hands-on experience and intuitive know-how of the older staff. Training is the solution, not piecemeal or ad-hoc, but a planned, long-term training strategy of continuous learning so that the staff can run the plant knowledgeably and efficiently.

So, how does the life-cycle approach work in practice?

ABB and the customer together draw

up an evolution program that reflects the customer's business goals.

After a comprehensive audit of the existing system, we:

- Submit a long-term plan that addresses near-term goals and that can be reviewed and revised as necessary;
- Identify and target which plants are at the greatest risk for production loss and those that have the greatest potential for increased production; and
- Review the long-term plan periodically and update it as required to reflect changing business needs and new system solutions. This approach takes the guessing out of budgeting.

Such an approach identifies which parts should be upgraded or replaced for the HMI, plant interfaces, engineering tools, optimization, alarm management and DCS interfaces year-by-year over the coming years. And it does so for each plant in the owner's fleet.

What do plant owners expect from their service investments?

Our research and experience show that plant owners require three main returns from their service investments. The investments should:

1. Maintain production at the plant and avoid downtime;
2. Maximize the lifetime of the plant at the required level of performance by an additional 5, 10, 20 or 30 years; and
3. Optimize the performance of the plant, equipment and staff.

Why and when to upgrade your DCS

How to keep the distributed control system up-to-date and in prime working condition without breaking the budget

“If you are not thinking about upgrading your legacy control system right now, you are making a mistake. Preparing for the future is the only option you have if you want to avoid downtime. Plus, being proactive on this issue will increase your plant efficiency and profitability.”

So concluded a 2015 article in Automation World on why control systems should be upgraded sooner rather than later.

As the world's leading supplier of distributed control systems, ABB agrees with this advice 100 percent – but with one adjustment: upgrades should be made in small, incremental steps in accordance with a budgeted program over the life cycle of the plant. They should not be made in one huge sweep that tries to rectify years of inactivity.

Incremental upgrades enable the plant to keep up with the latest features, functionalities and technologies.

Stepwise evolution

Incremental upgrades keep the system finely tuned and up-to-date and make maintenance predictable and easier. And, they avoid the budget-crunching alternative of ripping out the system after 10 or 15 years and replacing it with a new one because the old system is outmoded and its life is no longer perceived as worth saving. There is no reason why a control system cannot last the full life cycle of the plant, even one whose operating life has been extended to 40 or 50 years.

Take advantage of planned outages

In fact, most incremental upgrades can be done during the plant's short outage windows. To take full advantage of these planned outages we have developed small upgrade kits for cabinets, communication systems, controller and I/O clusters and other vital equipment. The kits for cabinets, for instance, contain new parts like power supplies that should be replaced every few years. For a plant with 50 cabinets, they can be changed in a controlled fashion of, say, five cabinets per year over a 10-year period. This not only minimizes the risk of cabinet failure and downtime, but makes maintenance costs predictable and gives budget stability, which are crucial to plant profitability.

Up-to-date and feature-rich

Another big benefit of incremental upgrades is that they enable the plant to keep up with the latest features, functionalities and technologies, including those required to protect the system from cyber-attack. An up-to-date, feature-rich system increases its value compared to

one that has not been improved for years and is becoming outmoded. It is also easier, quicker and less costly to upgrade an up-to-date system than one that is behind the times.

Of course, not all customers know when they want to upgrade their distributed control system. The plant may be scheduled for closure or its future – for a variety of reasons – may be in the balance. In these circumstances it is understandable that the owners want to minimize the service budget and adopt a just-in-time maintenance strategy of fixing something only when it breaks.

But, for the vast majority of plant owners, upgrading their control system in small, incremental steps should be the only option on the table. It is cost-effective, budget-predictable and – most importantly – it keeps the control system performing at the peak of its capability.



Can an automation system last a lifetime?

Certainly.

Symphony® Plus is compatible with all of its earlier generations – Network 90, INFI 90, Harmony, Contronic and Melody – delivering a simple, seamless, low-risk, and cost-efficient upgrade solution for your power or water plant. Whether your running system is 30 years old or newly installed, our industry leading “Evolution without obsolescence” life cycle program ensures new technology and features are always available to help meet changing business requirements, while protecting your valuable investments in hardware, software, engineering, and staff expertise over the lifetime of your plant – from commissioning to retirement.

www.abb.com/symphonyplus

From training to learning

Creating a culture of continuous learning for plant personnel



When – and how often – do you train your staff?

The usual answer is when new employees are hired or when a new product or control system is installed. Once the newness has been addressed, however, training becomes less of a concern and retreats into the background.

This in itself should be a concern for power generation companies because operations and maintenance staff in particular are vital to the correct running of the plant. If they are not properly trained, they cannot run the plant at optimal efficiency. Training deepens their knowledge and improves their ability to make timely and correct responses to unforeseen incidents.

Knowledge retention

Training is not the only issue. Retaining the knowledge and skills learned is just as important. Weeks or even months may pass before the knowledge learned in the

classroom can be applied to solve a real-time problem. By that time, it may be only dimly remembered or forgotten entirely.

ABB, like many other vendors, offers a comprehensive range of training programs for our automation and electrical products and systems. Where we differ is in our focus on knowledge retention and continuous learning – on bridging the gap between training in the classroom and executing and reinforcing those newly learned skills in the workplace.

We do this through a combination of conventional and unconventional approaches. These include:

- traditional classroom instruction through which we provide hands-on training at many different levels (beginner, advanced, troubleshooting, etc.,) and in many different product and system technologies. This takes place at ABB University facilities all over the world, always under the guidance of experts;

- on-the-job coaching, in which an ABB expert spends time working with staff at a specific part of the plant to build up their competence in that part of the production process;
- virtual training, through Web-based seminars or e-learning modules; and
- control system simulators, either cloud-based, low or high-fidelity, depending on the type of training required.

Taken individually, each of these approaches is a tool to address a specific customer need or preference. But taken together, they provide employers with the framework from which a program of continuous learning can be created for each category of employee. That program should be structured and ongoing over a longer period of time to ensure that employee expertise grows and that the knowledge and skills learned become second nature.



ABB is developing continuous learning programs for power generation companies and their personnel, in particular for control system operators, maintenance and engineering staff, technicians and IT managers. The objective of these programs is to create a learning path that boosts the competency of the individual over their working time at the plant.

Control system characteristics

The most common areas of expertise in need of a long-term approach to continuous learning are troubleshooting, maintenance and upgrading.

These specialties do not lend themselves to a one-size-fits-all concept of training. For instance, troubleshooting or maintaining a 10-year-old control system is far different to troubleshooting or servicing one that is new. The longer a system has been installed and running, the harder it may be to find the root cause of a process or equipment issue. The age

of the system should be reflected in the training program for operating and maintaining it.

What are the benefits?

So what are the advantages of a long-term approach to continuous learning?

The main benefit is that staff are more competent and better equipped to make timely and correct decisions. They learn to be effective and efficient, not only when things are going well, but more importantly when unexpected risks to production, people or property occur. Problems tend not to occur during normal working hours Monday to Friday, but at 2 in the morning on a public holiday when most staff are not at the plant. Having knowledgeable, competent employees who can solve the difficulty and keep the plant running whatever the hour is a huge return on the capital invested.

Continuous learning makes the staff more competent and better equipped to make timely and correct decisions.



The key to operator effectiveness

The new generation of high-performance human machine interfaces with integrated alarm management is improving operator decision-making and achieving significant increases in plant availability

In the era of big data and the Internet of Things, power plants have the capacity to produce more data in a single day than they did in a month 10 years ago. Intelligent equipment, smart devices and sophisticated control systems continuously monitor plant performance, producing a constant flow of measurements and readings on every asset in the plant. But if this data is not provided in context, it can result in information overload and lead to poor decision-making, production loss and reduced profitability.

Staff in all parts of the power plant are dependent on speedy access to the information they need when they need it, none more so than the plant opera-

tors. The challenge for HMI vendors is to provide staff - and operators in particular - with the information they require to make correct and timely decisions, while excluding all the information they do not need. The new generation of high-performance HMIs is designed to do this.

Customized and contextualized information

ABB's S+ Operations HMI, for instance, combines fast, intuitive navigation with simplified gray-scale graphics and integrated alarm management to eliminate information overload and heighten operator awareness. It allows users to personalize their overview of the plant process,

so that they can immediately gain access to the information they need.

Closely related to personalization is contextual navigation, through which different user groups like operations, engineering, maintenance and management can access graphic displays and information that are optimized for each group. This enables them to collaborate more easily in their own user-specific environment and share relevant information with colleagues.

Gray-scale graphics

It is no exaggeration to say that the human machine interface is the key to operator awareness. Compare the two graphic in-

interfaces in the photo at the top of page 20. Conventional graphics like the one on the left use different colors to highlight different states or parts of the process. It may be colorful and attractive on the eye, but it provides the operator with far too much information. Each color has to be looked at and its meaning interpreted, a process that can take several seconds. Far more efficient are gray-scale graphics like the one on the right, which reserve color for alarms and abnormal situations. The operator sees the color instantaneously and can respond immediately.

Detecting abnormal situations

High-performance graphics also provide operators with easy recognition of plant and product health. This enables each operator to maintain the process at higher performance levels, leading to real economic gains for the plant owners. Research underscores this point, showing that operators are five times more likely to detect abnormal situations before an alarm occurs with the new generation of high-performance HMIs than with conventional graphics. Once an alarm is triggered, operators solve the problem in about half the time than with traditional interfaces.

High-performance HMIs not only make abnormal situations immediately visible on the screen, they also significantly reduce the number of alarms that vie for the operator's attention. The maximum number of alarms that the human mind can deal with is just seven, give or take two in a given 10-minute period. Unfortunately, as seen in table 1, operators are bombarded with a

constant stream of alarms. In the power industry alone, operators typically deal with 2,000 alarms per day and 350 in a 10-minute peak alarm period. It is therefore not surprising that operators become ambivalent to the constant drone of alarms, tending to ignore 'nuisance' alarms and run the plant on instinct. Clearly, operators cannot do their job effectively when critical alarms are intermixed with hundreds or even thousands of non-critical or nuisance alarms.

Eliminating unnecessary alarms

Standards like EEMUA 191 and ISA SP 18.2 have long recognized the need to reduce the number of alarms to match the operator's cognitive capacity. In this way, the operator is focused and able to act on critical alarms when they occur. High-performance HMIs like S+ Operations have advanced alarm handling and analysis tools that support implementation of alarm management strategies based on EEMUA 191 and ISA 18.2 requirements, thereby ensuring that each alarm generated will alert, inform and guide the operator to take the proper action. An advanced alarm management strategy should fulfill the following objectives:

- The purpose of an alarm system is to direct the operator's attention to plant conditions requiring timely assessment or action;
- Alarms should be presented at a rate that operators can deal with;
- Each alarm presented to the operator should be useful and relevant to the operator; and
- Each alarm should have a defined response.

Case studies in cost savings

There are scores of examples and customer testimonies of how measures to improve operator effectiveness have increased productivity and reduced operating costs. Here are two examples from ABB's portfolio of case studies.

In example 1, a gas plant improved control room operations and corrected its record of poor alarm management. Missed alarms, among other operational and ergonomic issues, were singled out as a major contributor to compressor trips that resulted in downtime and lost production. Fixing the problem reduced the compressor trips from 27 to 7 over a one-year period, saving an estimated \$2 million.

Example 2 is a study of plant operators that measured and compared their situational awareness in a conventional distributed control system environment against one in a high-performance HMI environment using simplified gray-scale abnormal situation graphics and integrated alarm management. The figures in table 2 speak for themselves. They translate into estimated cost savings of \$800,000 per year.

	EEMUA	O&G	PetroChem	Power	Other
Average alarms per day	144	1,200	1,500	2,000	900
Average standing alarms	9	50	100	65	35
Peak alarms per 10 minutes	10	220	180	350	180
Average alarms / 10 minute interval	1	6	9	8	5
Distribution % (Low / Med / High)	80/15/5	25/40/35	25/40/35	25/40/35	25/40/35

Table 1: Average number of alarms in selected industries (source: MatrikonOPC)

Task	With traditional HMI	With high performance HMI	Result
Detecting abnormal situations before alarms occur	10% of the time	48% of the time	39% increase
Success rate in handling abnormal situations	70%	96%	26% over base case
Time to complete abnormal situation tasks	18.1 min	10.6 min	41% reduction

Table 2: Comparison of operator effectiveness in a conventional DCS environment and one using high-performance HMIs

Plant optimization

Proven ways to improve operational and financial performance

Timely and reliable information is critical to making the right decisions when operating a power plant. During recent years, optimization tools have matured and are used to create solutions that improve financial and operational performance and reduce risk exposure for utilities.

Optimization allows operators to look at component lifetime as a cost factor in plant operations. For instance, starting up boilers and turbines quickly puts more stress on them and reduces their operating life. Using optimization tools to work within the allowed margins of the component makes it possible to start a boiler or turbine much faster without damaging it.

Balancing input and output

Model predictive control (MPC) tools lie at the heart of optimization. MPCs employ a set of algorithms (multivariate mathematical equations) to simulate the complex interactions within plant components; these models can be built in a number of ways. Unlike traditional single-input, single-output controls, MPCs can take into account multiple inputs and outputs as well as the constraints on them. So by simultaneously solving the complex equations for a set of desired future outputs, it is possible to calculate the inputs needed to produce them. When optimizing a process in real time, MPCs monitor the output data and continuously adjust the inputs to move the output closer to the desired result.

That means that an MPC tool like ABB's BoilerMax can accurately predict how a boiler will respond to certain inputs based on its 'knowledge' of the process-

es and the constraints involved: combustion, maximum permissible loads of critical thick-walled components, or minimum flow rates in steam tubes to avoid high thermal stresses. As a result, it can calculate and automatically manage the optimum start-up sequence based on the balance of outcomes desired by the operator, such as start-up time versus lifetime costs.

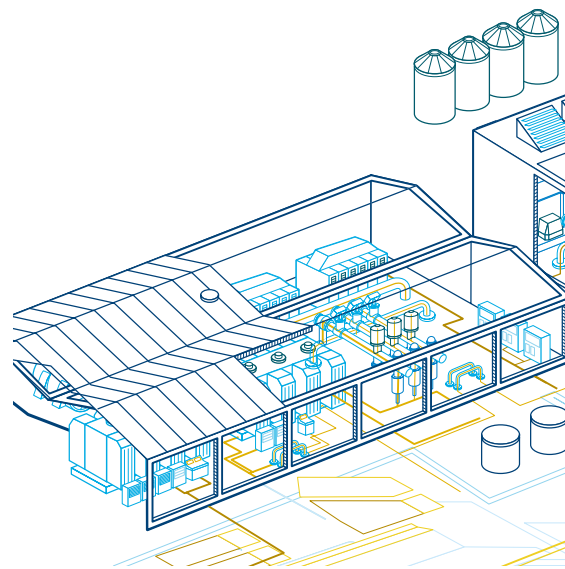
Reducing process variations

MPC techniques go way beyond traditional control techniques. They add a new dimension by being able to predict the consequences of control actions, and are able to react and correct in an optimal way.

The main goal in using MPC tools at component level is to reduce process variations. This gives improved process stability and reliability and reduced thermal cycle stress on high-pressure parts.

With reduced variance, the power generation process can be operated closer to the optimal level, which means safely running closer to a constraint like maximum steam flow or generator power. For example, a higher steam temperature may allow improved heat rate, higher generation capacity and lower emissions – or help start a boiler faster. ABB quotes savings of 10-20% on normal fuel and auxiliary power costs through using MPC techniques to optimize start-up.

Combustion optimization – that is, distributing fuel and air in a boiler to minimize emissions (particularly NOx), while improving combustion efficiency – is also a common application. Other applications include main and reheat temperature control and boiler-turbine coordination.



Multi-MPC management

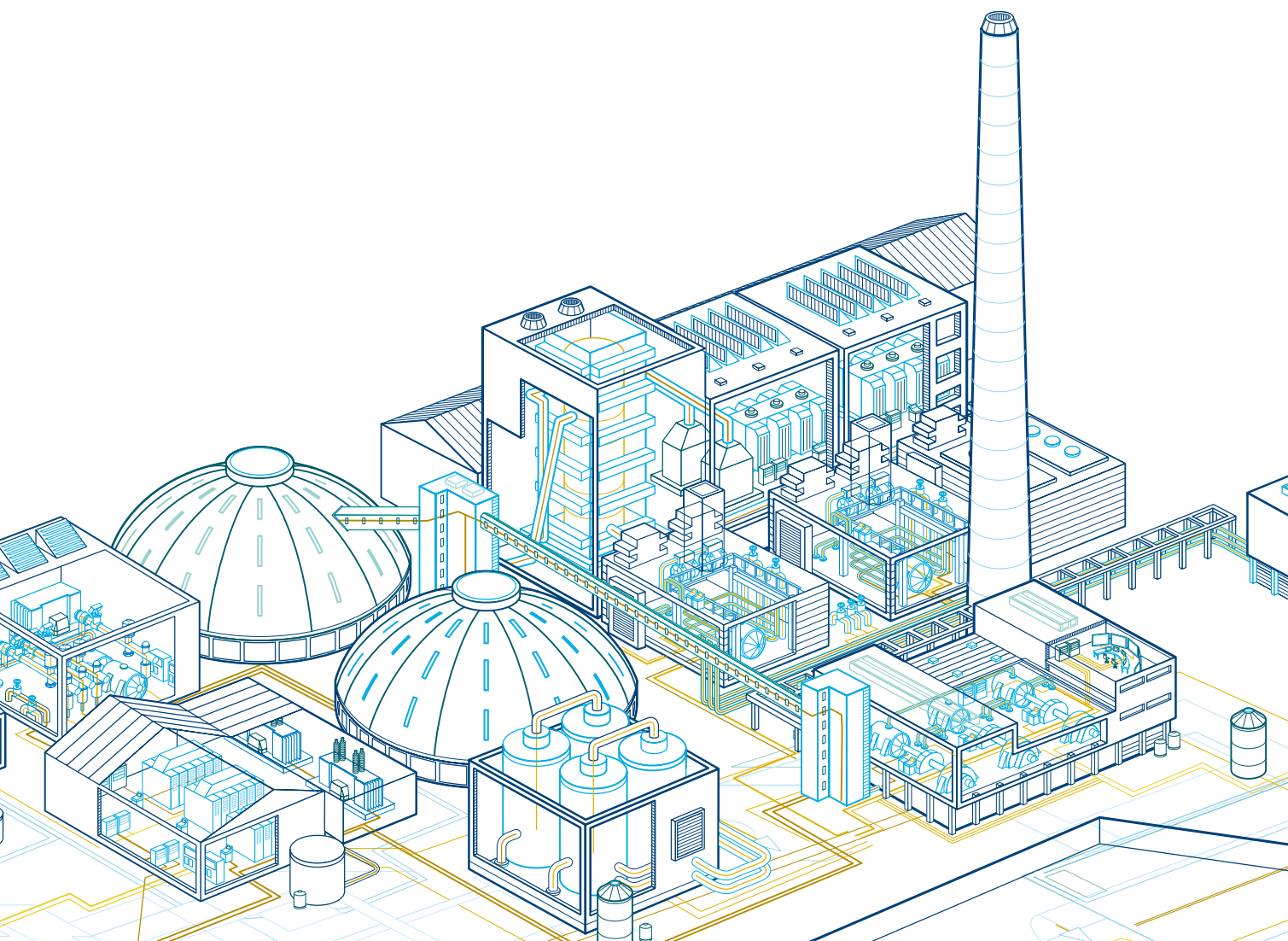
To obtain the desired load profile at plant level, optimization applications manage many MPCs to coordinate the control of multiple boilers, fuels, turbines, steam headers and power flows to and from the grid.

Load scheduling optimization determines day-ahead plans for power production and trading. It calculates the plant's most economical load profile by balancing generation costs – and the costs attributable to decreased service life of critical components – against the revenue from energy sales.

Risk can be factored into the optimization calculation too, typically where minimal cost is the goal. Examples might be the risk of an unplanned outage or of not being able to connect to the grid after a plant shutdown.

Condition monitoring supported

Optimization systems also support condition monitoring, helping to detect problems early and isolate their causes. That might mean detecting performance



losses in thermal equipment or alerting operators to vibration problems in rotating machinery. Condition monitoring improves plant availability by avoiding unnecessary shutdowns.

An allied function is component life-time prediction and monitoring. Rather than adhering to fixed maintenance schedules, optimization systems can calculate the reduction in service life for key components based on their operating modes (for example, taking account of high temperatures and pressures that reduce service life) and so accurately predict when maintenance is required.

Integrating renewables

The growth of renewables has placed new demands on utilities and their optimization systems. With many more small generating units on the grid, power production needs to be continually re-planned. To support the grid in response to fluctuations, optimization tools must be able to ramp up supply or to shed load in seconds or even fractions of a second.

Powerful hardware and improved

mathematical techniques allow 'online' optimization tools like ABB's OPTIMAX PowerFit to manage extremely complex processes like secondary frequency control in real time. To maximize performance, the entire optimization system runs on a single PC which is connected directly to the plant control systems. Operators now only supervise, rather than transfer optimization results to plant control systems manually as they did in the past.

Operators, however, must be able to intervene if required. They can also adjust bounds or constraints using regular process graphics and immediately see the effect on the optimization results on their operator screen.

Today, online optimization applications can control individual plants or whole fleets that combine different types of generation. Optimization is now a standard requirement from customers and is used even at small plants. It is a well-proven technology and, with its ability to manage renewable generation, the incentives to fully exploit optimization are now stronger than ever.

ABB quotes savings of 10-20% on normal fuel and auxiliary power costs through using MPC techniques to optimize start-up.

Facing up to cyber security

How to make ABB distributed control systems secure, compliant and even more reliable

Cyber attacks on critical industrial infrastructure are a fact of life. They are happening with increasing frequency and are a global phenomenon, affecting developing and emerging economies as well as wealthy developed countries alike.

In the European Union, for instance, the losses caused by these intrusions can be as high as 1.6% of gross domestic product, costing tens of billions of dollars annually. The sectors most prone to attack are finance; information, communication and technology (ICT); and energy, including power generation. About half of all incidents in the EU are attempts to disrupt operations at a target through denial of service (DoS) or overwhelm the target with traffic from multiple sources in a so-called distributed denial of service (DDoS).

The number of cyber attacks on a daily basis can be seen at www.digitalattack.com, which shows live data of DDoS attacks around the world. On August 25 2016, for instance, there were large-scale DDoS attacks on the USA, Chile, Ireland, the UK, Denmark, Romania, Saudi Arabia and Hong Kong; and unusually high volumes of attempted disruptions in Jersey (the Channel Islands), the Philippines, Morocco and Mozambique.

Cyber attacks are now so common that the US National Cybersecurity and Communications Integration Center, in a 2015 report, says "For many industrial control systems (ICSs), it's not a matter of

if an intrusion will take place, but *when*."

The same report lists seven strategies through which companies can protect their industrial control systems from 98% of all incidents. Three of these strategies alone would prevent 84% of cyber attacks. These are: implementing application whitelisting to prevent unauthorized programs from running; ensuring that a proper patch management program is in place; and reducing the attack surface area of the control system by isolating it from untrusted networks like the Internet.

Cyber security compliance

In many countries the main factor driving power plants to strengthen their cyber security is compliance with the guidelines of national regulatory bodies or adherence to the minimal requirements imposed by IT companies or the plant's corporate IT department.

Whereas many companies and plants have already attained a high level of security and have the skills and procedures in place to maintain it, there are many others who do not have the expertise and tools to meet those guidelines or requirements.

This is where ABB can deliver considerable value by helping customers to implement their compliance program and meet the required regulatory guidelines or IT requirements, including the seven strategies identified by the US National Cybersecurity and Communications Integration Center for repelling 98% of attacks.

Unique expertise

ABB has a unique position in distributed control systems, especially those for critical industrial infrastructure. The company is, according to ARC Advisory Group, not only the global leader in distributed control systems, but the number-one DCS vendor for big infrastructure industries like power generation, oil and gas, pulp and paper, mining and metals. This automation and process expertise, in combination with long-established system security know-how, allows ABB to minimize the cyber risk for its customers' control systems and production processes.

ABB's philosophy is essentially two-pronged: to work with customers to create a defense-in-depth approach to cyber protection, where multiple security layers detect and deter threats; and to embed cyber security at each stage of the DCS product life cycle, from design and development to operation and maintenance.

Securing the workplace

A key component of ABB's cyber security offering is Security Workplace, which is designed specifically for the power generation industry. It helps customers with ABB or multi-vendor systems to achieve and maintain cyber security compliance without risking system reliability.

Security Workplace comprises an integrated suite of security applications and tools for assessing and strengthening DCS cyber protection.



These include fingerprinting to gauge the ability of the control system to withstand attack; patch delivery to evaluate all software updates from Microsoft and other vendors for relevance and system compatibility; application whitelisting to ensure that only approved software and processes are allowed to run; and file sanitization to minimize the risk of introducing an infected file into the control system.

Global and local resources

One of the strengths of ABB's cyber security resources is that they are both global and local in extent. On a global level ABB has long played an active role in defining and implementing cyber security standards for power and industrial control systems worldwide. And our independently operated Device Security Assurance Center tests the robustness and resilience of the devices we embed in our control systems.

On a local level, each of our eight power generation service hubs has dedicated cyber security expertise, with deep knowledge of local regulatory requirements and power generation markets, ready to help customers with their cyber security issues.

A secure system is a reliable system

When we ask customers to evaluate Security Workplace, their most common response is that "It makes our DCS run better." This is not as surprising as it may seem, because making a control system cyber-secure requires updating critical parts and fine-tuning system performance. A secure system is by definition more efficient and more reliable than one that is not.

ABB Security Workplace

For security, compliance and reliability

- A single, comprehensive tool for DCS cyber security
- Minimizes system vulnerability while increasing system reliability
- Simplifies regulatory compliance
- Supported globally by ABB cyber security professionals in 8 regional hubs

Electrical balance of plant service

The purpose of EBoP service is to help increase plant performance by maximizing availability and reliability – safely and without risk to people and property

Electrical equipment and machines are mission critical to plant reliability, availability and operational safety. Several components like the grid connection from generator to substation exist as a single configuration and failure could result in severe revenue losses and / or penalties. Emergency and black-start systems are mandatory for plant safety and restart in case of major external grid disturbances.

There are many other items of electrical equipment in a power plant, each one a vital node in an electrical system that powers a specific part of the generation process. These systems are interconnected to form a whole that includes the switchyard where the power is delivered to the grid. According to NERC statistics, three of the top ten outage causes for power plants can be attributed to electrical equipment.

Reliably and safely

ABB has a very clear approach to electrical balance of plant service: to ensure that the electrical equipment and systems operate with maximum availability and reliability and without risk to people and property.

We help our customers achieve that

goal by using a combination of preventive and predictive maintenance, a life-cycle management approach to service, and by minimizing the cost, complexity and downtime of making changes to the electrical systems during plant refurbishments.

Preventive and predictive

Preventive maintenance takes place at specified intervals to keep the equipment in good working order and reduce the likelihood of it failing. Predictive maintenance uses techniques such as real-time condition monitoring to determine when maintenance should best be performed.

Previously, retrieving hand-written information from past shifts or days was a time-consuming and error-prone activity. Now, electronic shift book and shift log in the DCS HMI allow operators to attach alarm data, trends and other information to their entries. All entries can be transferred to the plant's maintenance management system (CMMS) and create maintenance messages that streamline work processes, thereby reducing maintenance costs and increasing quality.

Seamless integration with the CMMS allows the creation and transfer of operating hours, switching cycles and so on

to maintenance applications, improving asset life cycle by allowing performance-based maintenance rather than time-based or failure-based.

This data enables us to follow the condition of the equipment and compare its baseline performance with its actual performance. If the gap between the two starts to grow and performance deteriorate, we can keep the equipment under observation and make an inspection at the most optimal moment to avoid disrupting production.

Based on design, procurement and installation experience of more than 400 electrical systems comprising a broad portfolio of our own and third-party equipment, ABB has a distinct advantage in servicing electrical systems in power plants. We know how these products function and how best to maintain them - and the system of which they are a part - at optimal performance over their lifetime.

We also have many retrofit solutions for these products. This allows us to maintain their core components and replace only the faster-aging ones. For example, we can change only the control and protection on switchgear, while maintaining the switchgear itself, or re-





place only the automatic voltage regulator on an excitation while keeping the core power electronics.

Life-cycle management

Power generation companies the world over are under pressure to produce more energy from their existing plants. This can only be achieved by increasing plant availability and adopting a life-cycle approach to service.

There are two ways to increase plant availability when servicing electrical equipment:

- by minimizing the outage period when carrying out maintenance on a device; and
- by minimizing the modifications made to other parts of the electrical system whenever an item of equipment is replaced or upgraded. This could entail, for instance, minimizing mechanical and logic changes or ensuring that the new part does not require a new and larger cabinet or bigger electrical room.

Both ways are essential tools to reduce maintenance outages and costs. For them to be fully effective they require advanced skills in reverse engineering and that maintenance and system modifications are carried out during planned outages.

Plant refurbishment

Plant updates for increased output, compliance with new grid codes like ENTSO-E or with environmental requirements like emissions reduction require many equipment modifications. These are typical results of the ongoing transitions in the energy system to renewable generation and environmental protection. These changes affect equipment sizing, new operating modes and load ranges of the electrical systems.

As an electrical service provider we support customers in all stages of the modification. This can start with advisory services like feasibility studies, system recalculation, conceptual design and budget estimates. For implementation, we can provide detailed design, procurement, dismantling, installation and re-commissioning. We can also supply new electrical components and ensure that they are properly integrated in the electrical system and correctly validated in the electrical layout. If components are not correctly dimensioned, they can deteriorate rapidly and even be a safety risk. During the entire refurbishment process, we strive to minimize the number of equipment modifications and the time it takes to make them in order to keep the total cost of investment as low as possible.

The value of expertise

These three ingredients of service – preventive and predictive maintenance, life-cycle management, and electrical modifications during plant refurbishment – are the foundation of our Power Generation Care Electrical portfolio for EBoP service, which is available worldwide from our eight dedicated power generation service hubs.

This portfolio in turn rests on some unique expertise that ABB brings to electrical service. We are the world's leading supplier of distributed control systems and of most of the power and automation technologies that make up the electrical balance of plant. This gives us a deep and holistic knowledge of DCS and EBoP and of the interfaces and protocols that interconnect them. We are also a leading designer of EBoP solutions, as well as of the substations and transmission systems to which they are connected.

Helping our customers achieve their service goals

A selection of references from around the world

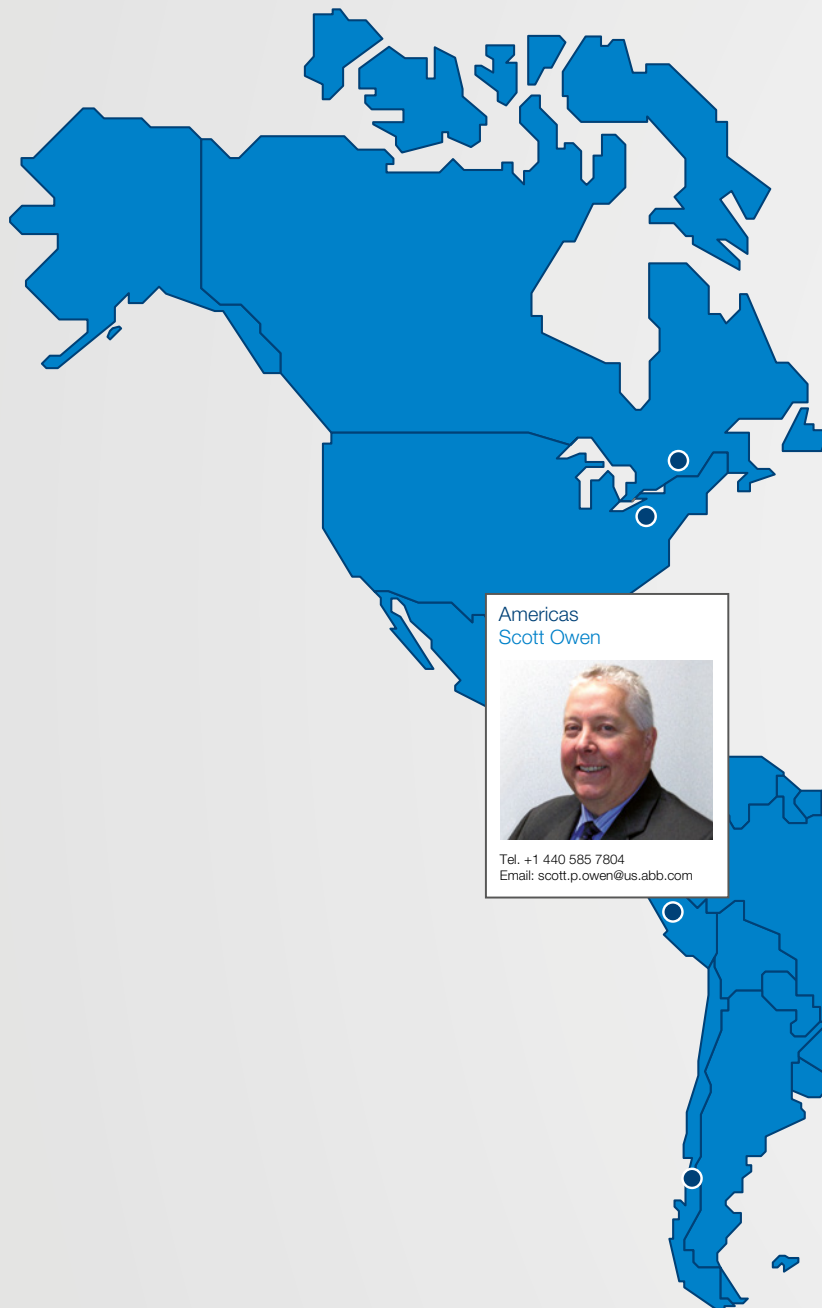




Meet our global power generation service team

We have eight dedicated power generation service hubs, so that we can be close to our customers and understand the markets they operate in and the opportunities they face. Each hub is supported by a network of global competence centers in power generation technologies. Please feel free to contact our service manager at your ABB regional hub. They and our entire ABB Power Generation team look forward to working closely with you.

Find your local contact on www.abb.com/powergeneration



Northern Europe
Martin B. Petersen



Tel. +45 4450 4450
Email: martin.b.petersen@dk.abb.com

Southern Europe
Enrico Mantero



Tel. +39 010 60731
Email: enrico.mantero@it.abb.com

Americas
Scott Owen



Tel. +1 440 585 7804
Email: scott.p.owen@us.abb.com

Africa
Ben Kayembe Momat



Tel. +27 10 202 5000
Email: ben.momat@za.abb.com



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32 ABB in control 1 | 16

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Can service really improve performance?

Definitely.

ABB Power Generation Care is a complete service offering to raise the performance of the plant's automation and electrical assets, its operations and maintenance staff, and the production processes. Our service programs provide high-value solutions and expertise that maximize availability and reliability throughout the asset life cycle. This minimizes risk, stabilizes maintenance costs and empowers personnel to make timely and correct decisions. Power Generation Care really does improve the performance of your plant, process and people. new.abb.com/power-generation/service