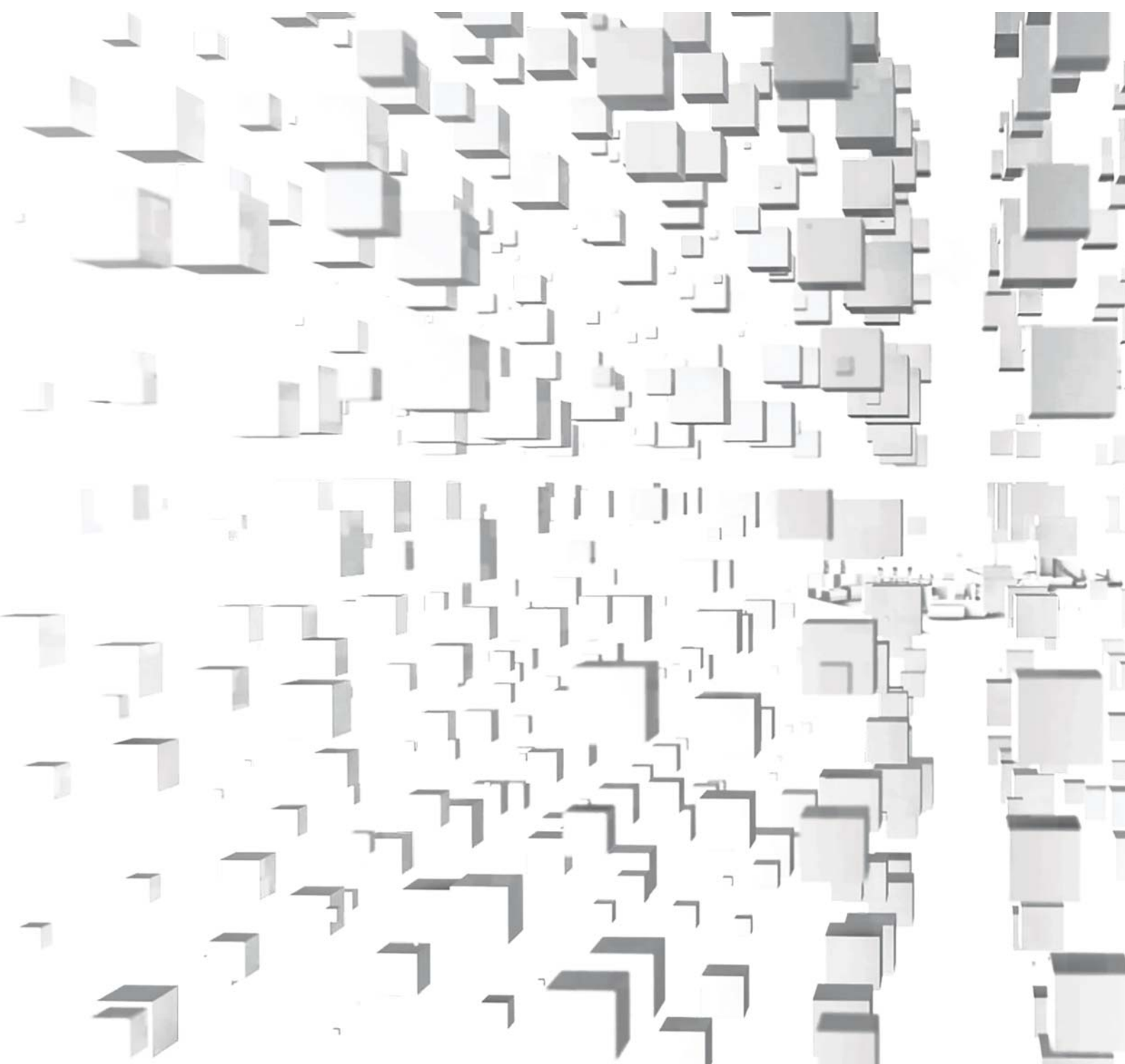


in control

The customer magazine of
ABB Power Generation & Water

01|17

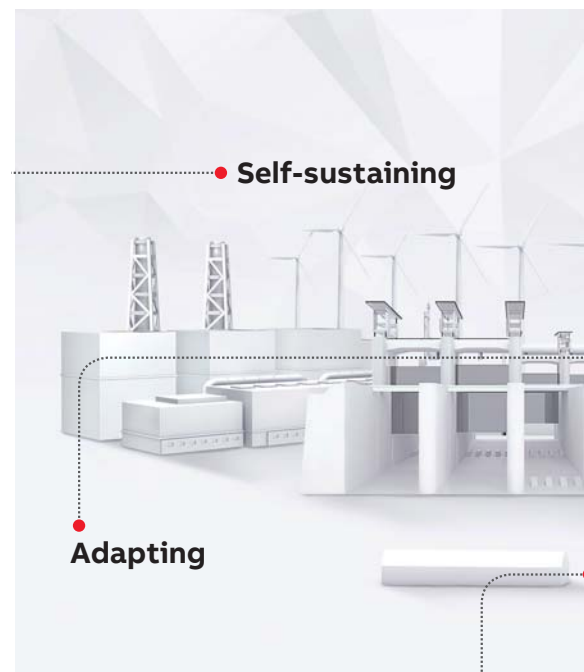




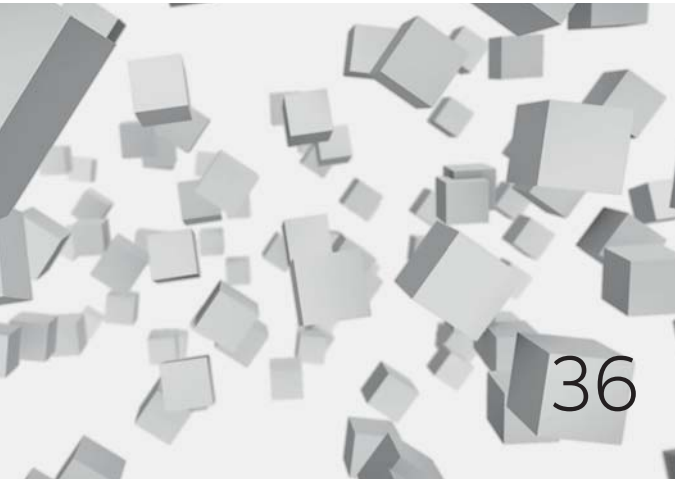
Interview: Enel's digitalization strategy



The key to digitalization is collaboration



Advanced alarm management



The digital power plant
is already here

05	Editorial
06	Does digital deliver?
08	The power plant of the future
10	Driving the energy revolution
12	ABB Ability™ – utilities
14	Making the most of water
16	ABB Ability™ - water
18	How to do digital
21	Digitalization is more about mindset than technology
24	Energy optimization
26	The key to digitalization is collaboration
28	Smart service
30	Making maintenance predictive
32	Lessons learned in cyber security
34	Cyber security and human behavior
36	Advanced alarm management
38	Virtual power plants
40	Digital excitation systems
42	Cyber Security Workplace

We are a leading provider of integrated power and automation solutions with unparalleled experience in partnering with the energy and water industries, bringing them improved operations and sustainable progress. We deliver integrated and secure digital systems, services and solutions to automate and optimize the performance of conventional and renewable power plants and water facilities.

EDITORIAL

Digitalization makes the difference



KEVIN KOSISKO
MANAGING DIRECTOR
ABB POWER GENERATION & WATER

Digitalization is a gamechanger. It is transforming the industry we work in and the world we live in, rapidly and radically. It is making our businesses better, stronger and more profitable, but it also exposes our weaknesses and vulnerabilities. The challenge is to harness the opportunities it offers, or run the risk of getting left behind.

By digitally connecting power plants and water facilities to people, companies can collect and analyze vast amounts of data about their equipment and operations in a way not previously possible. With the help of the right partners, they can turn this data into actionable information for the right people at the right time, making their company agile, optimizing production and predicting essential maintenance.

ABB has been a pioneer in digitalization for more than 40 years. As a result, we have the largest installed base of digitally enabled industrial products and devices in the world - more than 70 million - as well as 70,000 digital control systems and 6,000 enterprise-level software solutions. This installed base and our expertise are the foundation of what is probably the biggest and most advanced portfolio of digital solutions for industrial applications, ABB Ability™.

In this issue, we take a close look at the opportunities that digitalization offers to the power and water industries and the challenges these industries now face - in market complexity, regulatory compliance, cyber security, plant and process optimization, dealing with distributed energy resources, and maintenance and service.

I would like to thank our three guest interviewees for sharing their knowledge and experience of digitalization: Enrico Viale, head of Global Thermal Generation at Enel, one of the world's largest power generation companies; Matthew Littlefield, President and principal analyst of LNS Research, a leading research and advisory firm on digital transformation; and Alex Blau, Vice-President at ideas42, a behavioral science research organization.

Enjoy your reading.

With kind regards,

A handwritten signature in black ink, consisting of a stylized 'K' followed by a series of loops and a horizontal line.

Kevin Kosisko
Managing Director
ABB Power Generation & Water

Does digital deliver?



SUSAN PETERSON STURM
DIGITAL LEAD
POWER GENERATION
& WATER

Can digital solve power generators biggest challenges?

Yes, digital does deliver and yes it can solve power generators biggest challenges.

Over the past 20 years, there has been no shortage of challenges to solve: power market deregulation, increasingly stringent environmental constraints, the creation of wholesale power markets and the addition of renewable generation resources, to name just a few. As a result, the global power market is in transformation, with traditional business value streams and asset utilization models being turned on their heads. This piece examines how digital can help solve some of the biggest challenges facing power generators today.

Knowledge and expertise retention

A key challenge for companies operating in mature power markets worldwide is the retirement of experienced operations personnel. The ability to access expertise by remote is a huge enabler for these markets. ABB's Collaborative Operations Centers provide infrastructure as a service, securely allowing experts outside the plant to monitor performance, support troubleshooting and maintenance, and help optimize plant operations. They help improve health and safety at the workplace and reduce the number of technical experts required to run and maintain the plant, thus lowering operating costs.

Improving operational practices

Another challenge for companies operating multiple power plants is to ensure that best practices are applied and lessons learned are shared across the fleet. Power company leadership often wants better visibility of key performance indicators across the fleet and the ability to 'double-click' into individual plants or specific classes of equipment. They want to know how best practices of the most efficient plant can be implemented across the fleet, or how lessons learned from a forced outage can be applied in operational and maintenance practices.

Managing complexity

Power companies in highly complex markets want to grasp new opportunities and develop new business models. For example, distributed energy resources, like rooftop solar or even demand-side management, have made it difficult for traditional utility unit commitment or dispatching models to accurately forecast load and develop supply models. Pioneering power companies can use digital solutions to make accurate forecasts with data from smart meters. They can make unit commitment and bidding decisions more profitable with neural network generation forecasting modules. And, they can minimize labor and complexity by deploying advanced analytics that aggregate forecasts from many small renewable resources into a larger virtual power plant.

It starts at the top

Utilities are undergoing a cultural shift towards an information-based digital economy - where primary processes are digitalized - and moving away from the traditional business model that requires heavy investment in physical assets. In the face of this change, chief executives feel there is a real danger of getting left behind if they fail to rally their organization to the new digital order. The drive from leadership is key to the implementation of successful digital projects. It is vital that there is a clear link between any digital project and a company's strategic priorities.

Think big but start small

While it is crucial to have a big-picture vision for digital, companies that are in the lead started with small projects and pilots that quickly delivered tangible results. Results and success drive action and greater cultural adoption of digital solutions on the plant floor. With the organization on board, larger and more ambitious projects are easier to execute.



It is all about people, process and technology

Without changing their business process to get the results that digital solutions offer, companies will have great technology but little else. Digitalization should not make people feel alienated or excluded from the industry's digital future. Companies need digital programs, projects and pilots to engage the right stakeholders, which extend beyond operations and often involve information technology, compliance and finance. In other words, remember to bring the right team along on the digital journey.

Pick partners with expertise and experience

Customers have rich networks of multiple digital partners; this view contrasts with some competitors that push for a single platform. The partners selected should be able to demonstrate industry expertise, proof-points of challenges solved, and maturity in software development and cyber security. ●

ABB is privileged to have partnered with the world's leading utilities to develop, test and operate digital solutions that have allowed generators to develop new business models and thrive in market complexity.

ABB has spent the past 40 years working with power companies to create digital solutions that make sense for their organizations. We have established a strong reputation as the world's leading distributed control system vendor for power generation globally, and our industrial automation division has pioneered several firsts that have shaped the industry.

As an early adopter of digital and networked technologies, ABB has often been asked by customers to partner with them and use digital to solve some of their most pressing challenges.

The result is a digital product portfolio that has been tested by customers who have applied these solutions to adapt and thrive in the power industry's transformation.

The future is already here

The digital power plant of the future is already possible and ABB can deliver it



MARCO SANGUINETI
TECHNOLOGY MANAGER
POWER GENERATION
& WATER

The industrial Internet is about connecting machines with people and services. It is about harnessing big data, analyzing that data and turning it into actionable information. It is about optimizing the plant and production process and about making equipment and service smarter. And, it is about improving collaboration to enhance the expertise of the people who operate, maintain and manage it.

The digital power plant embodies the industrial Internet to achieve those objectives. It has five main qualities:

Evolving

- Continuously learns from the past to improve efficiency
- Has a technology foundation that evolves, never becoming obsolete
- Allows continuous and flexible DCS upgrades
- Lives longer and healthier, thanks to intelligent predictive maintenance

Self-sustaining

- Is aware of its operating status, all the time
- Knows its operating limits and capabilities
- Asks for maintenance at the correct time
- Does more with less - in operations and maintenance

Predictive

- Knows how much energy it needs to produce to meet market commitments
- Manages resources optimally in relation to operating status, weather and market constraints
- Knows when equipment has developed a fault and when it requires repair

Protecting

- Safe for people, the local community and the environment
- Conscious of its environmental impact, always minimizes emissions
- Safe for employees
- Cyber secure

Adapting

- Flexible in relation to market requests
- Anticipates market requests by forecasting external conditions
- Open and responsive to owner and grid requirements
- Can operate within a virtual power pool of renewable and conventional plants

Common platform

The digital power plant of the future is based on a common, open-source platform to facilitate collaboration between people and partners.

Our ABB Ability™ platform, for instance, uses the best industry-standard, open-source and proprietary ABB software. It combines our technology leadership and deep domain expertise with strategic partnerships - with Microsoft to use Azure as our cloud platform, and with IBM to jointly develop artificial intelligence and machine learning solutions for industrial applications.

This approach makes it easier for customers to integrate our solutions with other platforms they may already have deployed. It also enables system integrators that are certified developers on Microsoft Azure, IBM Watson and SAP HANA to create new applications that interoperate with ABB Ability™ solutions.

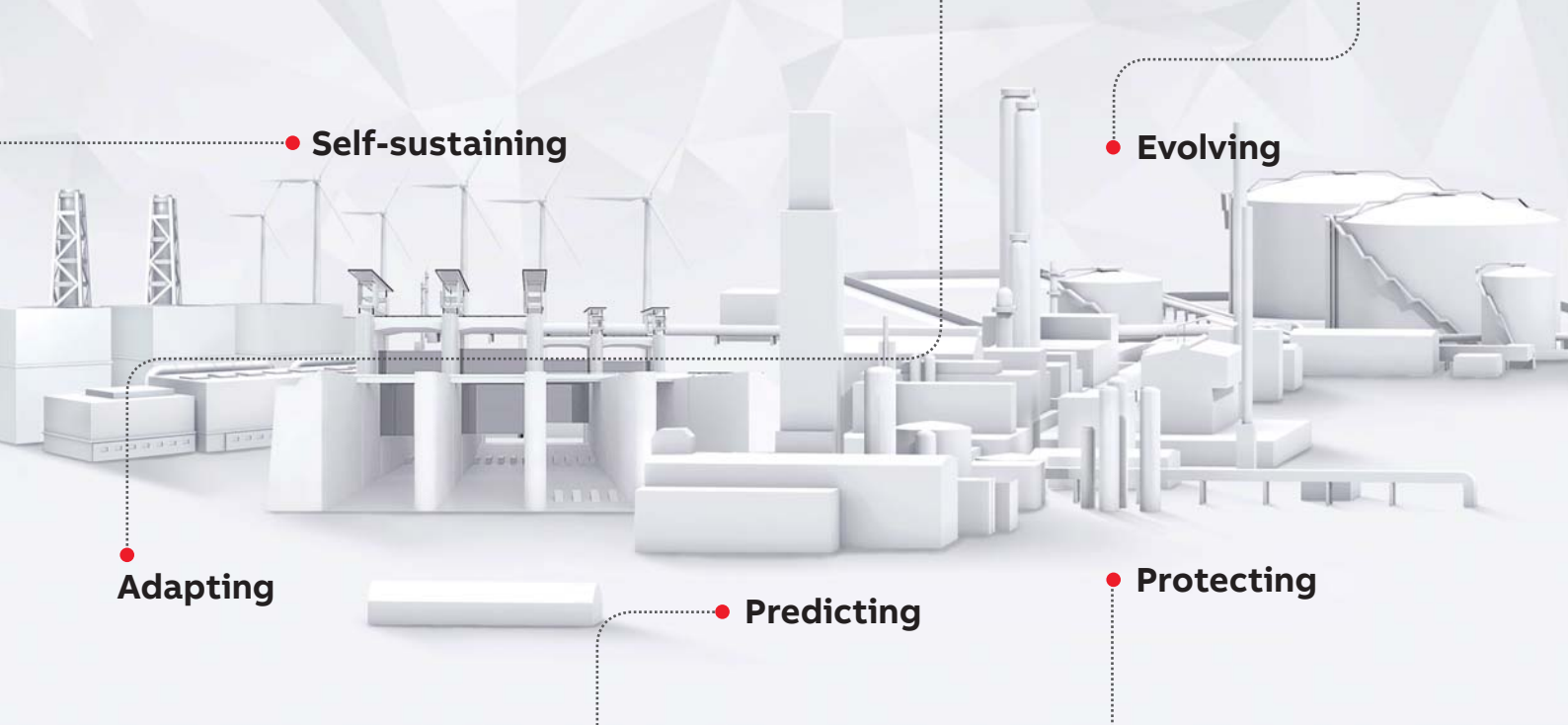
Such a broad, open and inclusive ecosystem delivers massive benefits to customers, compared to narrow, closed and exclusive proprietary systems.

Closing the loop

The digital power plant of the future closes the loop between data and action.

It is not enough to simply collect and analyze system data; the data have to be turned into actionable information to improve plant performance. Only by closing the loop with an action is value created.

Closing the loop does not only apply to devices and machines, it applies to people and service as well. Bringing them together - people, plant and



01

01 The digital power plant has five main qualities

production process - unlocks new opportunities to reduce downtime, improve energy and equipment efficiency, lower maintenance effort and improve productivity.

Collaborative operations

The digital power plant of the future is built on collaboration - within the plant, fleet and company, and with valued partners and suppliers.

Our collaborative operations center for power generation delivers those benefits. It connects the plant and fleet with company headquarters and ABB, enabling people to work together and improve plant performance.

Through a high-speed, cyber-secure connection to the plant's distributed control system, the center continuously retrieves and analyzes plant performance data, monitors key performance indicators, delivers actionable information for plant personnel and management, and - when needed - provides deep domain expertise from ABB within minutes.

Fog, cloud and intercloud

The digital power plant of the future uses the 'fog,' cloud and intercloud, together.

Mission-critical automation systems like the DCS and enterprise software systems are traditionally housed on-site, in what is called 'fog computing.' New digital solutions will increasingly feature functionality at the fog and cloud level, allowing data and functionalities to migrate from one to the other. This creates increased flexibility in deployment models based on customer preference.

ABB believes that no single IoT platform will provide all the capabilities that customers need. Instead, there will be an 'intercloud' of applications that interoperate across multiple IoT platforms. An

ABB Ability™ solution will be able to connect to one running on those other platforms, provided that interfaces and data formats are compatible.

Enabler technology and expertise

While others are only recently discovering the value of digital, we have long been experts in integrating digital components into our customers' control systems. These include sensors, software, digital networks and, now, the power of the Industrial Internet of Things.

We are world leaders in securing and using data via our installed base of around 70 million digitally enabled devices, 70,000 digital control systems and 6,000 enterprise-level software solutions. This expertise and installed base forms the strong foundation upon which ABB Ability™ is built.

THE DCS is key

Hand in hand with our long digital heritage is our 125-year history in power generation and our 100 years in control technology.

Our complete and fully integrated electrical and automation solutions for power plants comprise essential ABB Ability™ digital solutions that continuously provide actionable information on plant equipment, the production process and energy market, enabling the plant to operate optimally and profitably.

The key component in these integrated solutions - and the digital brain of the plant - is our ABB Ability™ Symphony® Plus total plant automation system, the number-one DCS in power generation worldwide, according to industry analysts, ARC Advisory Group. ●

Driving the Energy Revolution takes ability.

ABB Ability™.

ABB's deep domain expertise across the entire value chain

ABB HAS MORE THAN

120

years of experience delivering solutions across the electricity system value chain



OVER

50,000
experts



7,000+

distributed control system installations currently running worldwide

5,000

power and water industry installations worldwide

Utility challenges

Need to balance the input from renewables

Increasing complexity

Increasing distributed energy generation assets

Aging infrastructure

Evolving Power Generation Plan

Collection, consolidation and automation of disparate data

New business models and regulatory frames



ABB Ability™ solutions turn challenges into opportunities

Customer benefits across the entire value chain

ABB Ability™ solutions enable utilities to know more, do more, do better, together



Advanced process control leads to



15%
cost reduction
at start-up

1%

efficiency improvement
of boilers

5-15%

reduction of
NO_x emissions



Advanced diagnostics
can avoid unplanned downtime
at a power plant - saving
\$1 million per day



Advanced boiler control
of a 660 MW coal-fired plant
reduces CO₂ emissions by
900,000 tons/year



Asset management
solutions enable



operations
& maintenance

15%

savings



3
years increased
life of assets



2%

potential savings
of overtime costs

ABB Ability™ – utilities

Creating stability for the energy revolution takes ability. ABB Ability™

1 Virtual power plants

Central control and optimization for more than 4,500 producing and consuming units in 8 countries in Europe, generating and trading 3,200 MW of energy

2 Power plants and boilers

Reduce boiler startup cost by 15%, improve efficiency by up to 1% and reduce NO_x emissions by 5 - 15% through ABB Ability™ remote services

3 Power plants and turbines

Save up to \$1 million per day by avoiding unplanned downtime with ABB collaborative operations

4 Power plants and automation

Optimize processes, reduce risk, increase operator efficiency and plant availability by reducing 40% of abnormal events





Making the most out of every drop of water takes ability. ABB Ability™.

ABB's deep expertise in water and wastewater



A century ensuring clean and reliable water for people and industries

400+

ABB Ability™ Symphony® Plus

systems in water and wastewater/thousands of projects worldwide

Water and wastewater challenges

- Rapid urbanization in emerging markets
- Protection from flooding for coastal areas
- More people, higher water demand and aging infrastructure
- More desalination needed for cities, industry and agriculture
- Lack of stable water supply constrains economic development
- Wastewater facilities need to be more efficient and sustainable



ABB Ability™ solutions turn challenges into opportunities



Water distribution network
for accurate detection of leakage points and continuous water quality monitoring in real time



Flood barriers
with integrated automation and electrical solution controls flood protection systems



Wastewater treatment
with a sophisticated unified DCS provides operators with full control



Desalination
with ensured smooth transitions from renewable water to desalination plants



Water transmission
with central control system to ensure energy-efficient and reliable water supply



Water service
with DCS, reusing legacy system control logic and HMI programs and integrating third-party equipment and controls seamlessly



Pumping station
with DCS aggregates data across geographies and provides full visibility of water levels, pressure, flow and automated valves and pumps

Customer benefits



Tens of millions cost reduction
through real-time water distribution control



Protecting coastal cities
from tides up to 3 m above normal with accurate information at any time



Plant visibility and control
with no downtime through a unified control system



Reduced operational costs and downtime
through unified DCS and real-time data collection



Improved water reliability and life cycle costs
through total control of a 150 km transfer system

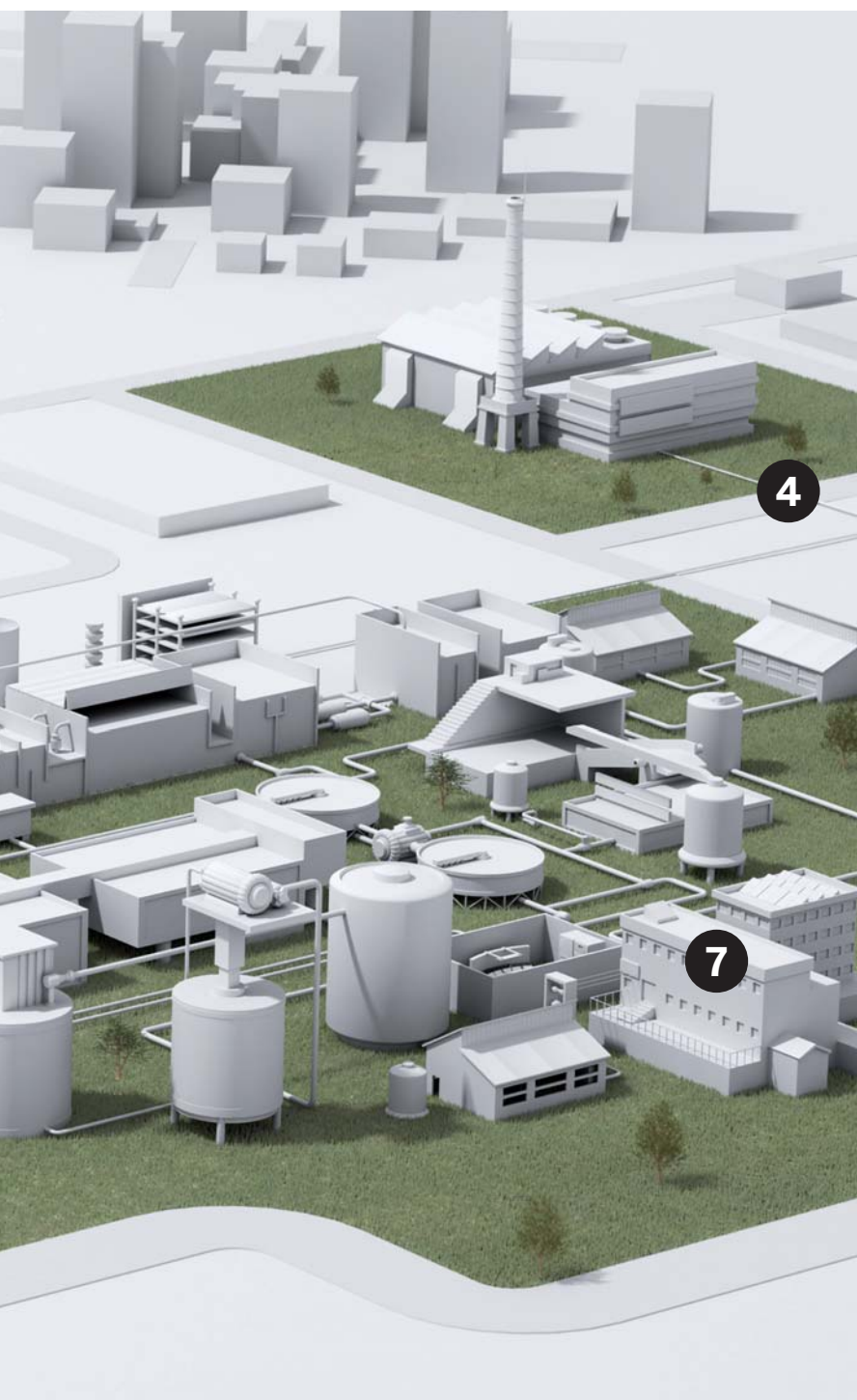
100%

available water
in the driest of deserts through
highly efficient desalination

ABB Ability™ – water

Protecting water resources takes ability. ABB Ability™



**1 Water distribution networks**

\$40 million cost reduction through real-time water distribution control

2 Flood barriers

Protecting coastal cities through accurate flood prevention solutions

3 Wastewater treatment

Plant visibility and control with no downtime through a unified control system

4 Water transmission

Improved water reliability and life cycle costs through total control of a 150 km transfer system

5 Desalination

100% available water in the driest of deserts through highly efficient desalination

6 Pumping stations

Real-time control of a 360 km water distribution system through an advanced DCS

7 Water service

Reduce operational costs and downtime through seamless DCS integration

INTERVIEW

How to do digital



MATTHEW LITTLEFIELD
PRESIDENT OF
LNS RESEARCH

ABB In Control (IC): Is digitalization optional or inevitable? What separates the hype from reality?

Matthew Littlefield (ML): According to our research, 60 percent of industrial companies will have a digital transformation initiative in place by the end of 2017.

Much of the hype comes from the concept of the Fourth Industrial Revolution. Although we have had three previous revolutions, none of them was completed in one year, or even five years. They took many decades to complete. But the reality is that the revolution has already started, and many companies are already well down the path of digitalization, so if companies don't move today – or in the very short term – they will fall too far behind to catch up.

IC: From your perspective, what is the state of digital adoption in power generation today?

ML: The power generation industry is quickly transforming. New intermittent energy sources coming online, dynamic pricing pressures and more data than ever coming from upstream demand; the opportunities and challenges are unprecedented.

According to LNS Research survey data, the low hanging fruit of implementing next-generation digital technologies are: predictive analytics to optimize asset performance, and remote monitoring and collaboration tools to address the lack of skilled workers.

Longer term, new data architectures and advanced analytics – artificial intelligence and machine learning – will provide opportunities for new business models and optimized decision-making across generation, trading, transmission and distribution, and energy efficiency.

IC: What are the best practices for a power generation company to follow when starting digital projects? How should a company do digital?

ML: To be successful, digital transformation has to be more than a technology project, it has to be a business initiative. It requires a formal framework to drive organizational structure and decision-making that impacts all levels of the business.

Digital transformation needs a CEO vision for how these next-generation technologies will impact strategy. It needs to build on existing operational excellence initiatives to ensure people, process and technology capabilities are aligned; it needs technologies to ensure there is an architecture in place to bring together both IT and OT; and it needs business leaders to build local business cases and select the right technology solutions that meet the needs (see Figure 1).

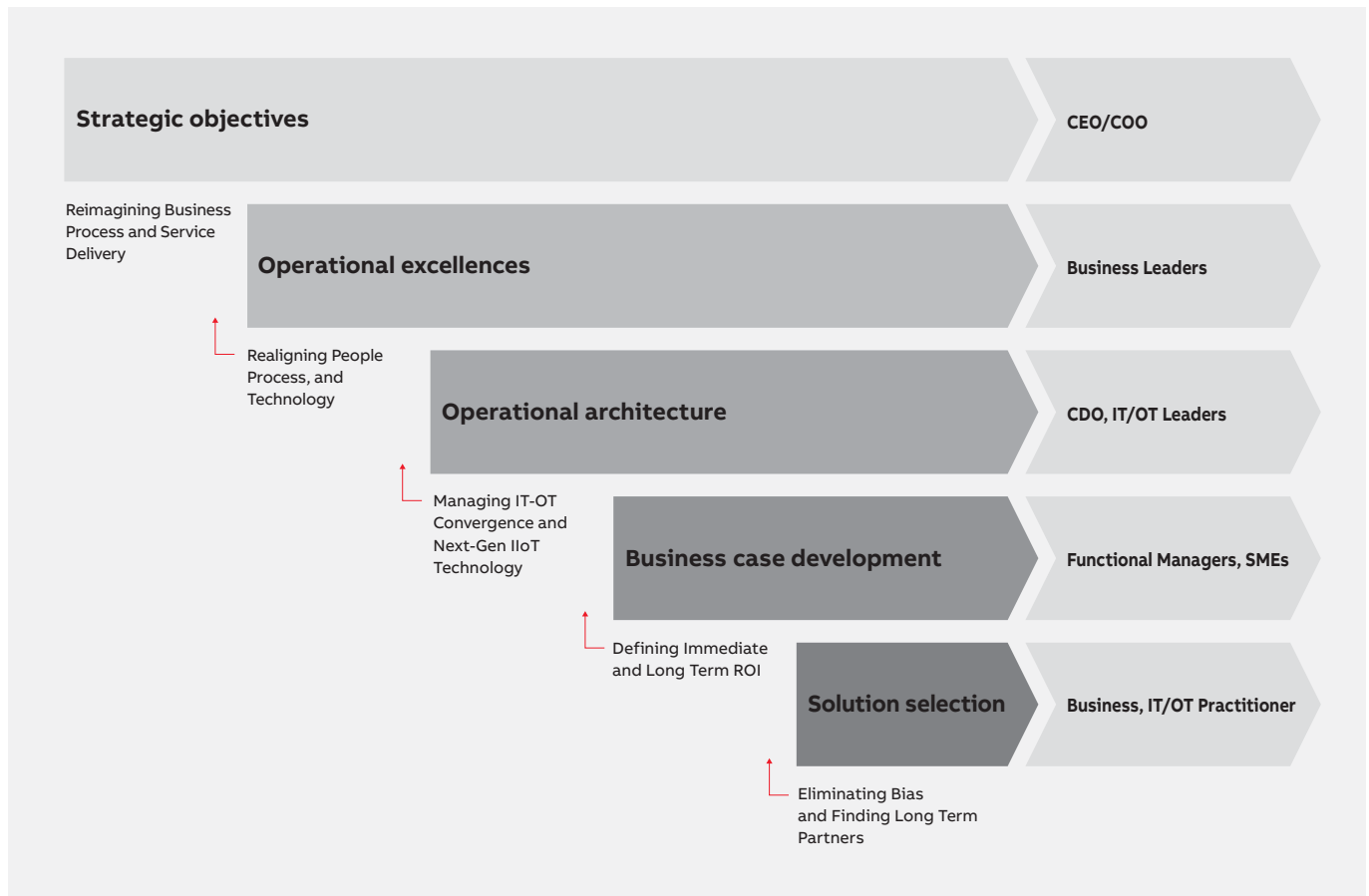
IC: What are the biggest challenges or lessons to be learned in industrial digital that power generation companies should be aware of?

ML: The biggest challenge to date facing digital transformation in the power generation industry is not technical, it is business-related: how to effectively build the business case and secure the funding (see Figure 2).

Much of this comes from the fact that the promise of digital transformation lies in the unknown. It is built on the idea that with more data and better analytics, companies will find previously unknown relationships – driving better business performance, all of which is very hard to quantify.

Early adopters bought on faith several years ago, which is good for them and the broader market. Now, more conservative companies don't have to buy on faith, they can base decisions on what other similar companies have already experienced.

IC: We hear a lot about 'ecosystems' in the context of digital partnerships. For example, some automation vendors are positioning their plat-



01 Digital transformation framework

form as the only one to use, whereas others like ABB expect to be part of a diverse ecosystem that will connect many stakeholders and likely consist of many platforms. How should power generation companies select their digital partners and decide which platforms to invest in?

ML: There has been a lot of talk over the past several years about the emergence of Internet of Things (IoT) platforms and, even more specifically, of Industrial IoT platform providers.

"If companies don't digitalize today – or in the very short term – they will fall too far behind to catch up."

By the LNS definition, these platform providers are attempting to bring together and deliver as a service a rich set of capabilities across connectivity, the cloud, big data analytics and application enablement. To date, no single company is delivering all of the needed capabilities across IT

and OT, hardware and software, and across products and services to meet a power generation company's complete digital transformation needs.

For these reasons, it is important for power generation companies not to look at one specific vendor when making technology decisions, but rather the complete ecosystem and defined partnership between technology vendors that can be trusted to deliver a complete solution.

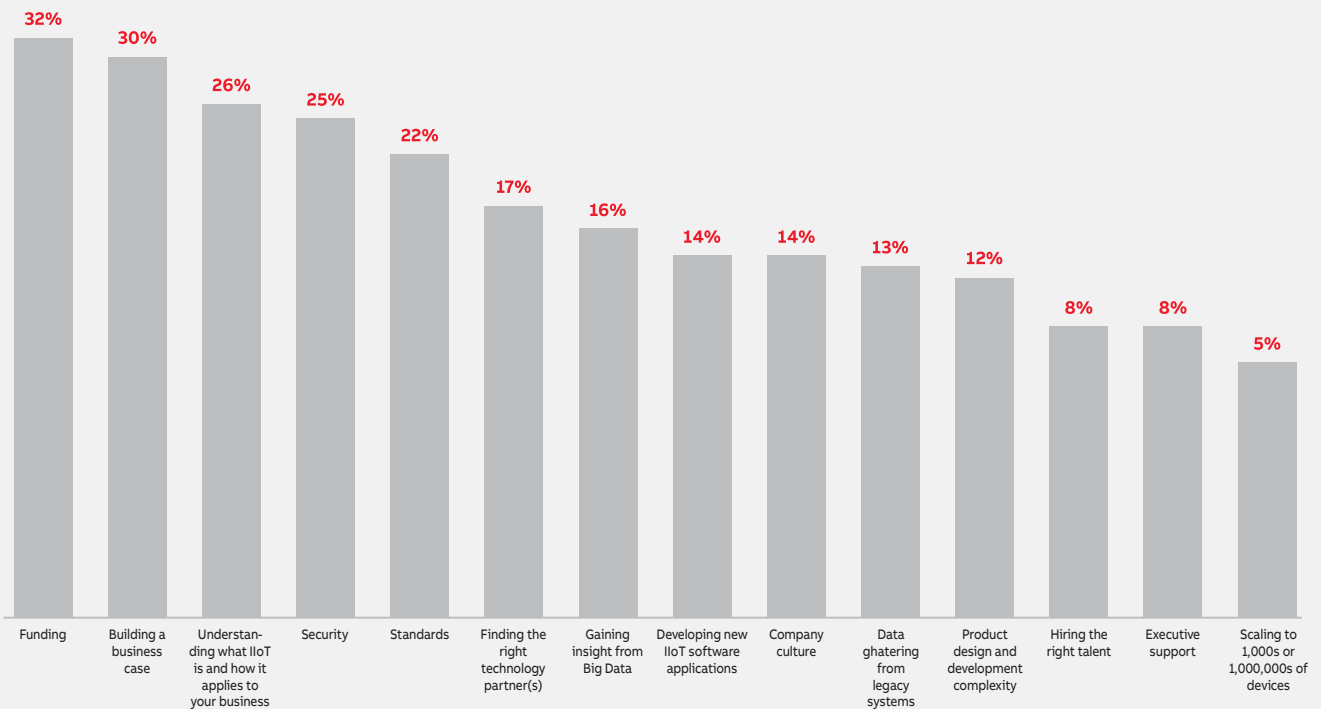
IC: Does digital hold benefits and potential that we have yet to experience or see?

ML: In our most recent research the benefits of digitalization have been significant. Across our use cases we have seen improvements in productivity, maintenance, reliability and more that exceed 10 percent; whereas often many companies without digitalization have been struggling to find 1-2 percent improvements year on year.

"Digital transformation needs a CEO vision."

What are the top challenges your company faces in deploying IIoT technology?

(N=269, all respondents)



02 The top challenges in deploying the Industrial Internet of Things

Looking ahead, we expect more and more companies to digitally enable more and more of their plant assets. Not just critical assets like turbines, boilers and generators, but equipment that is traditionally considered too marginal for investment in digitalization, like motors. However, with an IIoT platform approach, the marginal cost of digitalizing each asset quickly falls to almost \$0 and the return on investment rises to nearly 100 percent. Some early adopters are already digitalizing all their assets - even the so-called marginal ones - and the results are very impressive. ●

About LNS Research

“Our mission is to enable digital transformation for industry. We are the leading research and advisory firm delivering technology insights for business executives. Our analysts focus on identifying the metrics, leadership, business process and technology capabilities effecting change. Our practices focus on the needs of:

- Quality leaders
- Environment health and safety leaders
- Manufacturing and operations leaders
- Maintenance, reliability and engineering leaders
- Digital transformation leaders.”

LNS Research is based in Cambridge, Massachusetts.

www.lnsresearch.com

INTERVIEW

Digitalization is more about mindset than technology

Enel is one of the world's leading integrated electricity and gas operators, operating in 29 countries across four continents. The company generates around 83 GW of energy and distributes electricity and gas to about 64 million end users around the world.



ENRICO VIALE
HEAD OF GLOBAL
THERMAL GENERATION AT
ENEL

ABB In Control (IC): Enel has a strong belief in innovation and technology adoption. Please tell us about your Innovation Hub concept.

Enrico Viale (EV): Enel focuses on innovating the energy sector and the way to do so is with the best partners who can help us internationally. That is why we are setting up Innovation Hubs in those areas of the world with the highest concentration of innovation. This will enable us to keep track of technical trends and create business partnerships with the best start-ups and companies. The goal of the hubs is to create a genuine network of expertise, ideas and business opportunities.

We are already setting up hubs in Rio de Janeiro, Santiago, Tel Aviv, Silicon Valley, Italy and Spain among others. This network will allow us to be part of the most innovative ecosystems in the world and give us the chance to work with the best and most creative minds. We have already screened and evaluated more than 1,600 start-ups.

IC: Describe Enel's journey in digital technology and the lessons you have learned from the process.

EV: We started our journey in digitalization two years ago at two pilot plants: Torrevaldaliga Nord in Italy, a 1,980 MW coal-fired plant; and Besòs in Spain, a 1,270 MW combined cycle gas turbine (CCGT) plant. Our goal was to test the most promising digital services in seven areas - safety, the environment, operations and maintenance (O&M), cyber security, logistics, efficiency and e-mobility - and then quickly adopt those we selected in other parts of the fleet.

"Digitalization will play a key role in increasing the profitability of our fleet."

Although we have only recently started on the path to digitalization, it is already clear that digitalization is more a matter of people and mindset than technology. Communication, change management and training are more important than technology. Moreover, digital transformation requires a strong multifunctional approach: all our business families were involved in the project team.

IC: What types of digital technology are you testing or adopting, and what impact are they having on your operations?

EV: We are testing many digital technologies, some of which are on the market, others of which aren't. They include new types of sensor, analytics for predictive maintenance, model-based process control, virtual and augmented reality for workforce management, drones and robots, advanced tracking systems for trucks and materials, people localization and tracking devices, and monitoring tools to manage critical activities, reduce risk and detect accidents.

The objective of these pilot installations is to quickly test relevant technologies and services that can be integrated on a common infrastructure of high-performance and reliable communication systems (LTE, WiFi, LBE, UWB, LoRa), edge or fog computing, the cloud and data lake in a real operating environment.

We have already received positive results from some of the technologies and services we've tested and will deploy them in relevant parts of our generation fleet. For instance, an ABB advanced process control solution for combustion and gas treatment systems has increased the efficiency and flexibility of our coal and gas assets.

IC: In what ways is digitalization improving your response to market dynamics and regulatory controls?

EV: Digitalization allows us to respond efficiently to market dynamics - such as operating with greater flexibility at lower cost - and comply with regulatory demands for lower environmental impact and safety. It will, therefore, play a key role in increasing the profitability of our fleet by improving availability and flexibility. We expect its impact to be mainly in remote diagnostics and predictive maintenance and, secondly, in heat rate and asset performance management tools. The first will improve plant availability and change the way we plan and execute maintenance; the second will optimize combustion parameters and have a positive impact on flexibility.



IC: There is a lot of discussion in digital about the divide between information technology (IT) and operational technology (OT). How is Enel aligning IT and OT?

EV: One of the strongest messages of digitalization is that it shows there is a clear need to remove the borders between IT and OT. We are confident that within the near future there will be a full convergence between IT and OT. Working from that premise, we encouraged, some time ago, our IT and OT teams to share information, goals and ways of working. Our OT and IT people now work in close cooperation with each other. Collaboration is not always easy, but this convergence is one of the pillars of digital.

"Digitalization shows there is a clear need to remove the borders between IT and OT."



IC: Does digitalization require your workforce to develop new skills? Are you hiring professionals with different profiles compared to the past?

EV: There is no doubt that with digitalization new skills will emerge or need to be developed. Enel is currently finalizing a change management and training program to establish a digital mindset in our staff, leverage new skills and develop new capabilities.

IC: Which technologies and expertise do you seek in your digital partners?

EV: Flexibility, openness to new technologies, and with a strong knowledge of our processes and business. We need to digitalize our fleet and retrofit digital technologies in our power plants. Retrofitting is a brownfield environment, so choosing the right technologies and implementation strategy is the key to achieving the desired results - without risk to reliability and security. ●

Energy optimization

ABB Ability™ control and optimization solutions for distributed energy and storage resources are helping customers achieve significant energy savings and participate profitably in power trading markets



MARC ANTOINE
PRODUCT MANAGER
SERVICE
POWER GENERATION
& WATER

Virtualizing distributed energy resources

The energy market is changing - radically. It is moving from conventional, centralized and well-controlled bulk generation to distributed and weather-dependent production from multiple small-scale sources; from stable, well-defined load profiles to volatile and reverse power flows; from operations based on historical experience to production based on real-time data.

A glance at the energy system of Denmark says it all. The 15 conventional power plants of a generation ago are now working side-by-side with hundreds of wind turbines, solar photovoltaic units and municipal and industrial combined heat and power (CHP) plants.

The pace of change globally is not slowing. Energy storage and electric vehicle infrastructure will become widespread, sooner rather than later. As a result, the need for scalable solutions that allow fast and simple implementation of new business models for pooling, optimizing and trading the production of hundreds or thousands of generating units and energy storage devices is becoming critical.

ABB Ability™ Energy Optimization for Virtual Power Plants combines distributed energy units into a virtual power pool. It provides central control and optimization, links energy sources with markets, performs day-ahead and intra-day forecasting, and issues and updates commitment schedules to pool participants. The technology is highly customizable and scalable, enabling VPP operators to rapidly expand from a few units to thousands, seamlessly and without interruption to operations. (See pages 38-39 for more on virtual power plants.)

Cutting pump energy costs by 10-20%

All over the world, night and day, tens of thousands of pumps are at work, pumping raw water into treatment plants and drinking water into the distribution network.

Pumps use a lot of energy. Often, their power consumption is minimized by variable speed drives, but usually the pumps run at the same speed round the clock.

ABB Ability™ Energy Optimization for Pumping Stations determines the optimum number of pumps needed to meet production targets at the lowest possible power consumption. Customers consistently report significant pump energy savings of 10-20 percent.

By automatically optimizing the number of pumps needed and running each one within its upper and lower flow limits and at optimal pressure, Energy Optimization PumpFit avoids unnecessary wear and tear and reduces maintenance costs. It also releases operators from monitoring decisions and manual operation. And it automatically aligns pump operating hours, ensuring each pump works the same number of hours over time.

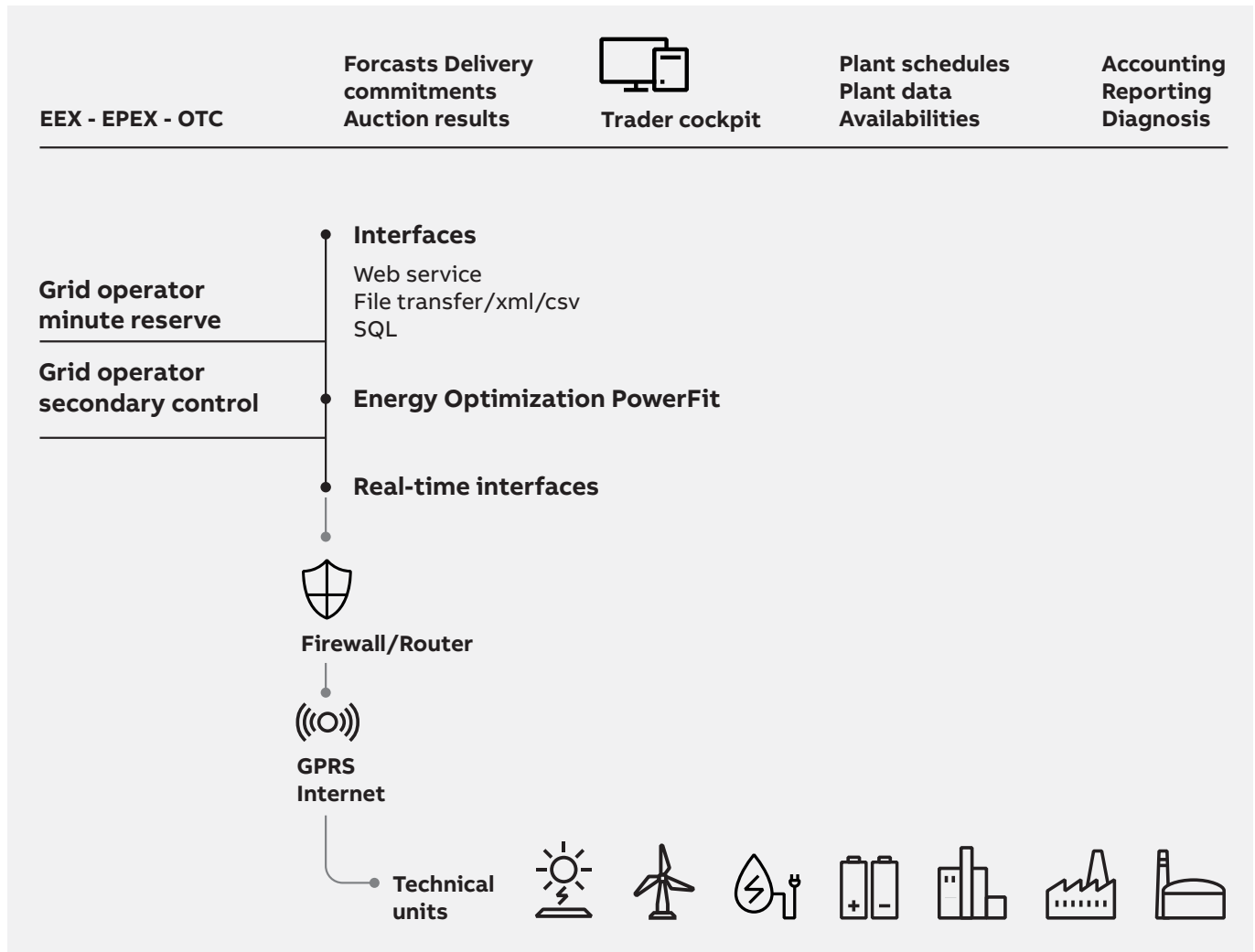
Pump operating data is stored and analyzed in the ABB Ability™ platform and converted into actionable information on pump performance.

Reducing energy costs at industrial sites by 5-10%

Energy-intensive industries like cement, steel and pulp and paper are cutting their energy costs by 5-10 percent, thanks to Energy Optimization PowerFit solutions. For a site with an annual energy bill of tens of millions of dollars these are huge savings.

Many large industrial plants have their own power generation units - often a combination of conventional and renewable sources - as well as heat production and energy storage devices.

Through a combination of production planning, energy management and energy trading they can minimize energy costs and maximize energy revenues without impacting production targets or delivery schedules.



01

01 ABB Ability™ Energy Optimization for Virtual Power Plants

For instance, ABB has tailored a PowerFit solution that can reduce the \$24 million annual energy bill of a large manufacturing site in Europe by 10 percent. The solution optimizes the site's energy production - wind turbines, CHP plants, steam turbines and energy storage devices - four times a day to match factory production data and changes in weather. It also optimizes CHP and steam production at 15-minute intervals and lowers the power consumption of air conditioning by adjusting the site's indoor temperature in response to energy availability or pricing.

Flexibility for the future - eBus infrastructure

Cities all over the world are electrifying public transportation to reduce carbon emissions and improve air quality. By 2020, China plans to have 200,000 electric buses in its cities, and India, Japan, the Netherlands and Sweden all have pilot eBus fleets.

As the number of electric buses expands and bus charging networks grow, the need to aggregate bus batteries into a single virtual battery that can trade electricity increases.

Buses typically spend the night parked in depots, when the energy isn't needed and could be sold to the grid. Energy Optimization PowerFit solutions are already under development to pool, manage and optimize distributed eVehicle battery resources and trade unused power on the energy market. ●

The key to digitalization is collaboration

Manufacturing and production in the digital age require a new way of working based on collaboration - one that allows people to know more, do more and do better, together



ENRICO MANTERO
HUB SERVICE MANAGER,
SOUTHERN EUROPE
POWER GENERATION
& WATER

What are collaborative operations?

ABB Ability™ Collaborative Operations links your plants, processes and people with ABB in real time.

It makes the right data available to the right people in your company, enabling them to collaborate more effectively and work hand-in-glove with ABB to make operations and service more efficient.

It turns big data into actionable information that improves availability, increases productivity and raises operator efficiency, while reducing risk, safety incidents and downtime.

Collaboration makes your operations faster, safer and more profitable.

What is an ABB Collaborative Operations Center?

ABB Ability™ Collaborative Operations Center is a remote operations and maintenance center that helps power generation and water companies reap the full benefits of digitalization to improve plant performance and operator efficiency.

Through a high-speed, cyber-secure connection to the plant's distributed control system, the center continuously monitors key performance indicators (KPIs) to ensure that the plant is operating within regulatory, load, environmental and cyber security requirements, automatically notifying the operator if a KPI is underperforming or a reference limit is broken.

The center continuously retrieves and analyzes plant performance data, turning it into easy-to-use dashboards that make the data actionable for plant personnel and management.

When responding to queries, the center provides immediate access to ABB experts with deep knowledge of the plant's process, systems and equipment. Each query is ticketed, tracked and closed in a case management system to ensure transparency and efficiency.

Uniquely, everything is housed in one center of competence – remote monitoring, ABB process and technology expertise, data analysis, dashboard creation and case management – and operated through a single cyber-secure platform.

ABB Collaborative Operations Center is part of ABB's portfolio of digital solutions, ABB Ability™, which helps customers turn the potential of digitalization and the Industrial Internet of Things, Services and People into real, tangible value.

Located in Genoa, Italy, the center is part of a global network of ABB Collaborative Operations Centers that serve a broad range of industries, including cement, chemicals, manufacturing, marine, metals, mining, oil and gas, ports, and pulp and paper.

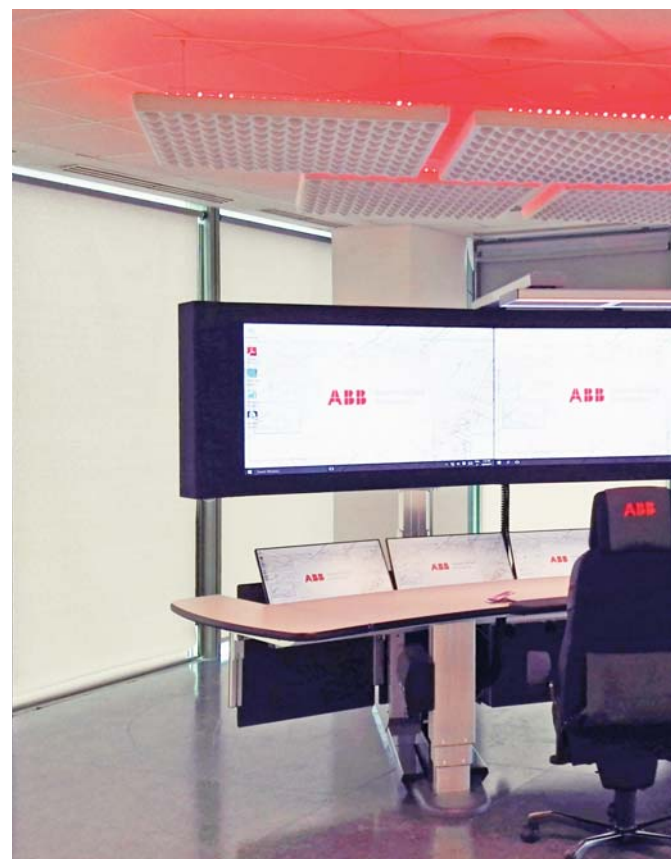


ABB asked some of its biggest power generation customers for their thoughts on collaborative operations in the digital era

Collaboration centers are the future

“Collaborative operations add value and are the way forward,” is a common response from the customers we questioned. Having experienced the benefits of ABB Collaborative Operations Centers, some are even thinking of starting their own collaborative operations centers and are looking to ABB as a partner with the expertise to help them do that.

It is, they say, all about protecting their plant assets. And, the best way to do that is with advanced machine learning applications that collect, analyze and learn from plant data to predict future behavior and enable predictive maintenance.

Machine learning requires powerful computing capacity. ABB provides that capacity through its global partnership with Microsoft and use of the Azure cloud-computing platform. Customers do not need to build their own data centers, but they do need to manage their machine learning applications from a collaborative operations center like ABB’s.

You decide where the data is stored

Thanks to our global partnership with Microsoft, our collaborative operations customers can store their data in enterprise-grade, cyber-secure cloud infrastructure, one that benefits from billions of dollars of annual investment. Alternatively, the data

can be stored in a server at your plant(s) or corporate HQ. The choice is yours.

Data ownership and security

Data integrity, data ownership and data accessibility are key issues for our customers.

With ABB, the data is always owned by the customer - it is their intellectual property. Data integrity follows ABB cyber security rules and standards; as does data accessibility, but with the option that ABB will integrate any additional requirements the customer may have.

Deep domain expertise within minutes, 24/7

Customers appreciate the speed at which ABB Collaborative Operations provides access to a specialist with deep domain expertise. Our objective is to provide access to that expertise within 15 minutes of receiving the request, worldwide and round the clock.

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“This is much more than phone or online support,” said one customer. “On the occasions we have asked for support, a highly experienced and knowledgeable ABB expert has been helping us within minutes.”

To make the service even better, we are enhancing our portfolio of support technologies with virtual and augmented reality devices, which will enable a plant technician and ABB specialist to see and work on the same faulty component in real time, regardless of their respective location.

Machine learning makes the difference

For customers, the key value-added of ABB Ability™ Collaborative Operations is the powerful machine learning algorithms that learn from past and current equipment behavior to predict the performance of the asset. This enables the plant to reap the benefits of predictive maintenance by catching the first symptoms of faulty behavior and - by learning from and following that behavior - predict when the optimal time for repair will be. ●



Smart service

Digitalization and collaborative operations turn monitoring data into actionable information and enable service to make the leap from corrective to predictive maintenance



BOB WELLS
SOLUTION
MANAGER I&C
POWER GENERATION
& WATER

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

Power Generation Care is designed to fulfil these three common needs, regardless of plant application, size or location. It covers the entire portfolio of ABB products and systems for power generation facilities including distributed control systems, instrumentation and electrical balance of plant. But when the day-to-day crosses paths with the digital highway, how do you get up to speed and find your way?

Power Generation Care is the vehicle through which we deliver ABB Ability™ digital solutions. These solutions can periodically and continuously monitor, collect and analyze data and turn it into actionable information. Going beyond the data to actionable information allows operations, maintenance and management to make the business decisions to improve availability, efficiency, safety, security and profitability.

Digitalization enables service to make the leap from corrective to predictive maintenance. It allows deep collaboration between partners. Our ABB Ability™ Collaborative Operations Center for power generation links plants, processes and people with ABB in real time, making operations and service more efficient.

Three use cases illustrate how digitalization and Power Generation Care are helping customers predict problems and improve the performance of their plant, process and people.

Predicting boiler degradation

A 600-megawatt coal-fired unit is experiencing boiler performance degradation. This generates an alarm at the ABB Collaborative Operations Center that is remotely monitoring the plant.

After investigating performance and lifetime data, the root cause is identified as a stress increase in the superheater steam section due to a leaking spray water valve.

ABB alerts the plant about the potential damage. After the unit is taken offline for the predicted maintenance, the ABB Center recommends starting up a standby unit, which although older has been revamped with a startup and combustion optimization package.

The early detection of degradation meant damage was avoided and plant downtime and revenue losses were not incurred. The shorter boiler startup also reduces startup costs, and combustion optimization reduces excess air. This in turn increased boiler efficiency by 0.3%, reduced NO_x emissions by 5% and lowered emission control costs.

Detecting a turbine fault

Severe damage occurred in a utility turbine bearing but indications of the problem were subtle and hard to detect.

As part of a predictive maintenance service contract, the ABB Collaborative Operations Center noticed the bearing was running hotter than normal.

ABB turbine engineers examined shaft orbit and shaft centerline plots. They noted that after a temperature spike, the change in shaft position exceeded the available clearance in the bearing and concluded that the bearing was badly damaged.

As a result of advanced monitoring, diagnosis and engineering skills, a potentially expensive and dangerous incident was avoided. Repair

costs, although inevitable, were minimized and unplanned downtime did not occur.

Cyber security and alarm management

Customers are seeing cyber security grow in urgency, alongside the need to prevent other causes of downtime. Gaps in their resources and skillsets are increasing. Furthermore, personnel can be overloaded with nuisance alarms and suboptimal control loops in the control system.

ABB offers a unified approach to security, compliance and change management. By reviewing and optimizing the alarm system and tuning off-spec control loops, ABB has helped achieve operational benefits and increased uptime.

One customer said: "I have been working on fine-tuning the alarms by utilizing the alarm management tools in Symphony Plus. When we first started, the plant was in the 'Reactive' zone. Over the past month of utilizing the tools, we are now in the 'Robust' zone and the control room operators notice a big difference from before Symphony Plus and now with Symphony Plus."

ABB Water Care

ABB Water 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.

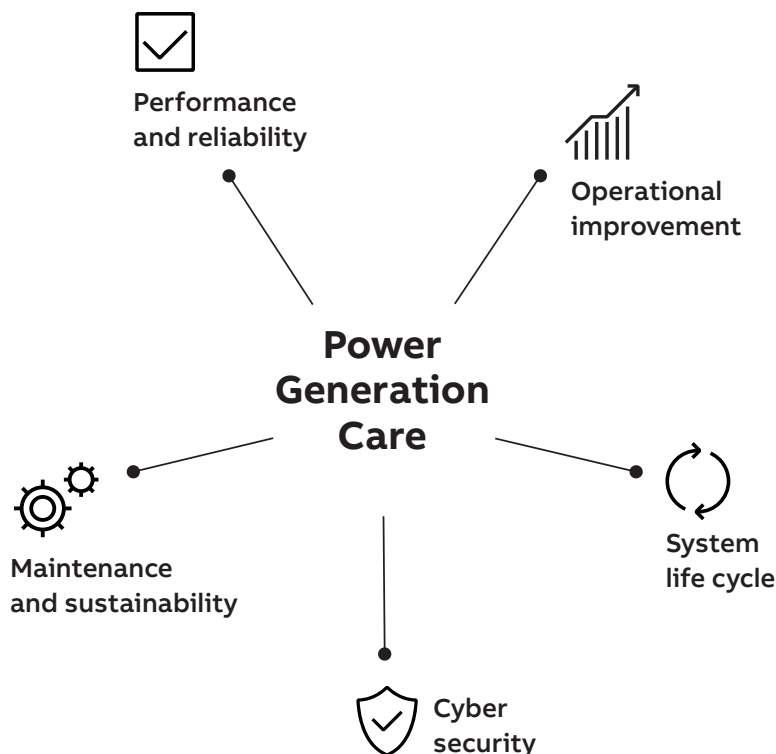
This life cycle approach to plant service:

- Improves plant performance and reliability
- Extends asset and plant operating life
- Protects equipment and intellectual investments
- Brings budget stability and predictability
- Supports plant operations and engineering staff

ABB Excitation Care

ABB is the world's leading supplier of automatic voltage regulators and static excitation systems for all types and sizes of power plant. Our excitation service program, Excitation Care, is designed to increase return on investment and keep plant equipment levels of efficiency and availability throughout their life cycle.

Solutions for the life cycle of your operations



Making maintenance predictive

Digitalization makes condition-based predictive maintenance possible. The savings for continuously monitoring rotating machinery can be huge, as several ABB references show



MAURIZIO BARABINO
ADVANCED APPLICATION
& ENERGY EFFICIENCY
MANAGER
POWER GENERATION
& WATER

Rotating machinery - critical but costly

Rotating machinery is the backbone of almost all critical plant operations. Steam and gas turbines, motors, generators, agitators, fans, pumps and compressor systems are all rotating machines.

They are also the source of much of the plant's operations and maintenance costs. Their behavior can be unpredictable. Reliability studies show that two-thirds of all machine failures occur randomly – with early but often undetected warning signs.

These warning signs can be picked up. Measuring the machine's vibration levels can detect degrading performance – the greater the vibration, the greater the potential for equipment failure or unplanned shutdown.

More than monitoring

ABB Ability™ Predictive Maintenance consists of a suite of diagnostic and prognostic solutions that use process and vibration data to monitor the health of rotating equipment, identify the early signs of a potential problem, diagnose the root physical cause of the problem, analyze the probability of failure and its severity, and suggest when and how to correct or repair the problem.

The suite does this by managing two kinds of data: process data such as temperature, pressure, differential pressure, etc., which are transmitted in real time or at intervals of a few seconds; and harmonics vibration, which is typically transmitted at intervals of several minutes.

This complete condition-based predictive maintenance solution is modular by design, enabling customers to install either the full suite or specific modules to match their requirements.

Data from the modules are seamlessly linked to the ABB Ability™ Symphony® Plus high-performance HMI, S+ Operations, where they are transformed into meaningful information and presented in intuitive user-specific desktop displays to enable fast and correct decision-making.



Correct information about the health status of the equipment not only reduces machine breakdowns and plant downtime, it optimizes production by allowing maintenance to be performed during the least profitable times of the day.

Use cases

20% reduction in maintenance work

As part of a collaborative operations project between ABB and a global energy company, the predictive maintenance solution was installed in a small 5.5 MW hydropower plant in Europe, whose three turbines were built in 1927. The solution's initial purpose was to monitor plant health for a year to determine the difference between actual and potential performance.

During this time, the solution detected cavitation in a pump impeller, which was unknown to staff and detectable only by monitoring. Having discovered the fault, the solution performed a root cause analysis and forecast the time left before the condition became critical. This enabled

the plant to adjust its maintenance schedule and repair the fault at the optimal time.

Overall, the solution improved the baseline performance of plant equipment, made maintenance more efficient and reduced maintenance working hours by 20 percent.

\$1.5 million per year savings in energy costs

An ABB performance monitoring system, part of a larger predictive maintenance solution and collaborative operations project, was installed in a combined cycle power plant in Europe, comprising two 380 MW units.

Each unit has an air condenser, which requires a large fan to extract air. In the summer, the fans were often running at maximum speed round the clock. Performance monitoring detected that this was unnecessary, and that excessive dirt in the fan was the reason for the fans overworking.

Instead of cleaning the fans just once a year in winter, the maintenance schedule was changed to twice a year, thanks to the performance monitoring results. This new maintenance policy significantly reduced the fans' energy consumption and carbon dioxide emissions by \$1.5 million and 8,000 tons per year respectively.

Recovering 10 MW of turbine output

A gas turbine with a rated output of 250 MW at a combined cycle plant in Europe was underperforming by 10 MW.

Working collaboratively with the customer, ABB installed its Symphony Plus turbine monitoring module to monitor performance and diagnose the reason for the 10 MW loss in output.

The solution pinpointed the source of the loss to a compressor. After repair, the turbine regained its maximum output of 250 MW, an improvement worth about \$1.5 million annually in revenues. ●



Lessons learned in cyber security

Ten years after the introduction of the North American Electric Reliability Corporation's critical infrastructure protection (NERC CIP) standards, what conclusions can be drawn about cyber security compliance?



WALTER SIKORA
CYBER SECURITY
MANAGER
INDUSTRIAL
AUTOMATION

NERC introduced its critical infrastructure protection standards in 2008. These standards apply to owners and operators of the bulk electric system, including generators and transmission system operators. The standards cover protection from physical and cyberattack.

NERC CIP is notoriously difficult and costly to comply with, yet is mandatory for power generators in the United States and Canada. Penalties for non-compliance can be as much as \$1 million per day per violation, and standards are under continual revision.

As a global leader in power and automation technologies, ABB has helped many utilities develop and sustain cyber security programs that support compliance with NERC CIP. This includes helping to develop audit reporting for critical assets, identifying vulnerabilities and potential threats, and developing plans to monitor and protect the assets.

While ABB's expertise in cyber security is not confined to North American standards, after 10 years of enforced regulations we want to illuminate the lessons power generators have learned over the past 10 years. What conclusions can we draw?

Lesson 1

Collaboration between IT and OT is critical

The need to bring information technology (IT) and operational technology (OT) departments closer together has been voiced for some time, with little effect. But as cyberattacks increase

and digitalization expands, close collaboration between IT and OT is essential.

Their roles and responsibilities are different. IT is part of the corporate organization, responsible for cyber security at the business level. OT operates at plant level and is focused on reliability, availability and safety, and on ensuring that the plant is cyber-secure.

Often, IT and OT do not see eye to eye. IT considers the plant a business asset, whereas OT focuses on the nuances of daily operations and production. IT systems are usually renewed after four or five years, whereas OT systems have longer lives, being upgraded after 10, 15 or even 20 years. IT may wish to introduce new measures to improve security, which OT sees as an imposition that might impact reliability and availability.

ABB understands both departments and their respective roles and responsibilities. We help them come together, communicate with each other and understand one another. We can explain to OT why the new measures are needed, but we can also explain why OT is concerned about the disruptions those measures may cause. We help them solve the dilemma and arrive at the best possible solution, for the company and the plant.

Lesson 2

Start with a strategy

'Start with a strategy' may seem obvious, but in our experience the journey to cyber security is rarely straightforward or well mapped.

Initially, many companies seek a quick fix by buying a solution off the shelf that will help them comply with some CIP regulations.

Others go to a consultancy that helps them make security assessments and close the gaps they find. Having secured the gaps, the consultants and the customer move on, usually without a long-term sustainable security program in place.

Some companies are more diligent. They perform a security assessment, realize their risks and vulnerabilities, and then invest in implementing a project team to manage cyber security. Having trained the staff, they forget about continuous training programs and keeping their staff motivated. In a market where skilled cyber security people are in short supply, staff are hard to retain and replace.

A sound cyber security strategy avoids these traps. It is a long-term commitment that focuses on processes, people and technology, and invests optimally in all three.

Lesson 3

There is no silver bullet

There is no single technology, method or solution that can provide 100-percent protection, all of the time. What is possible is a multi-layered, defense-in-depth approach to ensure assets are protected and secure.

To protect something, you have to know what it is you have to protect. Many companies struggle to do this. Assessments can be time-consuming and costly, but they provide essential information on the software inventory and cyber risks for an operation. A large power plant can have hundreds or thousands of assets that require physical or digital protection.

People too are a critical part of the defense-in-depth approach. Because cyber security is a non-stop, fast-moving industry, the people responsible for it at the plant should be afforded the tools, training and resources needed to manage cyber threats. Unfortunately, they are often oversubscribed with other responsibilities to effectively manage the cyber risks.

Lesson 4

Test your resilience frequently

Once your strategy, compliance program, protection and people are in place, it is easy to be drawn into a false sense of security. This is where you are at your most vulnerable. Responding to an Incident after an attack is a poor time to learn how to manage that incident.

Resilience is like fitness. You have to train regularly and exercise your muscles. Try to be ahead of the opponent by breaking through the plant's protection to ensure it is secure. Test your incident response plan to foresee challenges and pressure points. Practice frequently to be aware of what could happen if an attack succeeds and the plant shuts down. Draw up response plans for each department - legal, communications, human resources, etc. - and for local stakeholders like the municipality and service providers. Everyone should know how to respond in a stressful situation that is evolving by the second. Ideally, incident response scenarios should be sufficiently challenging to expose gaps; gaps found are an opportunity to act before your attacker does.

Lesson 5

Choose your partners wisely

There are many potential partners out there; hundreds of millions of dollars have flowed into funding industrial control system cyber security start-ups over the past 10 years. Some do many things well, others do one thing expertly. Few have the know-how that crosses all the relevant domains - power generation, transmission, distribution and automation systems, cyber security, digitalization and the cloud. Do not fall into the 'new shiny technology' marketing hype some of these start-ups claim. Look for those who understand your business, your challenges and you can trust.

ABB has that know-how. We are ready to put that knowledge and experience at your service. ●

INTERVIEW

Cyber security and human behavior

How can companies protect themselves from hackers and the cyber security errors of their own people?



ALEX BLAU
VICE-PRESIDENT
AT IDEAS42

ABB In Control (IC): You are a behavioral economist who has studied how leaders' perceptions of risk can bias their cyber security investment decisions. In the power generation industry, plant operations teams are often more aware than their leadership of the cyber security challenges or weaknesses at the plant. What advice would you give operations teams seeking greater investment from company leadership in their plant cyber security programs?

Alex Blau (AB): The biggest challenge that operations teams face is learning how to justify their investment request in terms that are meaningful to their leadership. One important insight from behavioral science is that people are often motivated by information that pulls at their emotions – something called an 'affect bias.' If the justification that is given does not speak of the risks that the senior leadership cares about, the answer will often be 'no.' As an example, imagine that a chief information security officer (CISO) goes to the chief financial officer (CFO) because they want to replace a set of legacy servers. If the CISO simply says that the legacy servers are old and are no longer safe to use, the CFO may not appreciate why it's important to replace them. If the CISO had instead explained that these servers are used for the organization's accounting system, and that if the servers go offline the organization would lose all of its accounting information, the CFO might appreciate the real risk to the organization and approve the investment. If senior leadership is not completely bought-in or fully knowledgeable about cyber and technical risks, it's the responsibility of the operations team to take a step back, understand how those risks map meaningfully onto the risks senior staff care most about, and connect the dots for their decision-makers.

IC: Showing a return on cyber security investments (ROI) is not easy. Why is this and how can chief information security officers (CISO) best deal with it?

AB: Trying to justify cyber investments in terms of ROI is the wrong approach. Cyber investments are made to avoid attacks, but rarely will we know when an attack was avoided – that just looks like business as usual, right? So, how can we put a value on the things we avoid without knowing we avoided them? Instead, I think it's better to think about investment in cyber as an insurance policy. We shouldn't be thinking about cyber investment as a way to increase revenue, but instead we should think about cyber investment as a way to avoid potential costs. What companies can do is to consider costs that could be incurred through a disruption to operations brought on by a cyberattack, and then make some informed assumptions about the likelihood of the attack. With this information, you can get closer to how much you should spend to avoid that outcome, and that might be the most important thing to consider.

IC: Using risk management best practices, can you provide some guidance on how a power generation company should build a resilient cyber security program that invests adequately in people, process and technology?

AB: Really it comes down to a shift in mental models. Investment in cyber security shouldn't be seen as a risk mitigation process. There's no amount of infrastructural investment that will prevent cyberattacks forever. There is no way to 'measure twice and cut once' when it comes to cyber programs. Instead, organizations should focus on risk management, which I see as having two key components. First, is maintenance – building and maintaining

the existing infrastructure, keeping all the systems in check, ensuring staff are adhering to the various policies and practices established by the cyber program, etc. Second, is stress testing – always searching for ways to break, undermine and otherwise disrupt the cyber security program. Both components are necessary, but if you're only focused on maintaining, you'll be more likely to get caught unprepared. To be one step ahead of the hackers, you have to find the vulnerabilities before they do and remediate them. Adopting a break-it and fix-it culture will keep cyber teams diligent in ensuring the resiliency of the cyber program.

IC: Having achieved such cyber security resilience, how should that company ensure it maintains best practice? How can it stay at the front edge and avoid complacency?

AB: Cyber security resilience is always short-lived. There will always be another hacker out there who will figure out how to get around what you've built. In that sense, no company should ever be satisfied with their level of cyber security. If you think it's possible to buy all the right hardware and software, then relax and watch as attackers fall by the wayside, you'll be sorely mistaken. That is why I always advocate for a break-it and fix-it approach. If you're constantly asking, 'How can I break this and build it stronger?' you'll never be complacent about the quality of your cyber security system.

IC: According to your company's research, 70-80 percent of the costs resulting from cyberattacks are due to human error. How can companies best protect themselves from the errors and negligence of their own people?

AB: Unfortunately, there isn't a silver bullet here, but one thing organizations should be doing is to implement robust awareness programs that aren't limited to one-day training once a year. While awareness training can help to increase employees' knowledge of cyber risk, knowledge alone does not guarantee behavior change. Instead, awareness programs should really focus on providing ongoing feedback about specific user behavior so that employees can be informed in real time about errors they make and ways to fix their behavior. There are a number of software solutions that already exist to help provide feedback to users about phishing, which usually involve sending fake phishing emails to employees and seeing who opens them and their attachments. Those individuals who fall for the fakes are provided with feedback about their behavior, and given specific information about what they should look out for in the future to avoid this vulnerability. This same principle can be applied to other prioritized vulnerabilities that organizations face.

IC: Cyber security experts are in demand. There is a shortage of skilled people and competition to hire them. What is your advice to companies that lack skilled personnel?

AB: Well, the economist in me says you should simply offer to pay them more! But, I think that building an internal culture that supports cyber teams and treats them as a core asset across the business is a great starting point. There are too many examples of cyber professionals being treated more like technical consultants than key operational staff. I can imagine that a young and talented cyber expert would much prefer working in an organization that sees them as an integral part of the organization's risk management strategy, as opposed to another member of IT staff. ●

Alex Blau is a Vice President at ideas42 and co-author of *Deep Thought: A Cybersecurity Story*, a 'true-crime'-style short story that dramatizes human behavioral threats in cyber security. He has extensive experience applying insights from behavioral science to solve design and decision-making challenges in a broad array of domains. His current foci at ideas42 are in the areas of cyber security, financial inclusion, public safety and A/B testing (comparing two versions of a Web page to see which performs best). www.ideas42.org

Tens, hundreds or thousands?

How many alarms do your operators deal with in a typical shift? And how can you make their job - and your operations - simpler and more effective?



LEONARDO AMBROSI
PRODUCT LINE
TECHNOLOGY
MANAGER FOR DIGITAL
POWER GENERATION
& WATER

Picture the control room at one of your power plants, then ask yourself the following:

- Do the operators acknowledge or silence the alarms without looking at or acting on them?
- Have you experienced any incidents or near-incidents because the operators did not detect or respond to alarms?
- Are some of the alarm horns turned off?
- Are some of the alarms disabled or suppressed for long periods without review?

Most of us with experience of power plant control rooms will answer Yes to one or more of those questions. What we may not know is the number of alarms that operators typically have to deal with in a shift. Nor, how many alarms the human brain can deal with at any one time.

How many alarms can the brain handle?

Research shows that the maximum number of alarms that the human mind can deal with is just seven, give or take two, in any 10-minute period.

Ideally, according to the ISA SP 18.2 guidelines, the maximum number of alarms an operator should face is no more than two in a 10-minute period. In reality, most process industry operators are subjected to a constant stream of alarms. In power generation alone, operators typically deal with 2,000 alarms per day and 350 in a 10-minute peak alarm period.

It is therefore unsurprising 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.

Standards and guidelines like EEMUA 191, ISA SP 18.2 and IEC 62682 have long recognized the need to reduce the number of alarms to match the operator's cognitive capacity. And automation system vendors like ABB have long recognized the problem and developed advanced alarm management strategies and technologies for their customers.

ABB takes a two-pronged approach to alarm management:

1) Focus on the operator

The operators are among the plant's most important assets. Their ability to make the correct decision at the right time has a huge impact on plant profitability, safety and reliability. Conversely, by taking the wrong decision at the wrong time the operator could harm others and the environment, and impact plant profitability.

At ABB, we've been working on the issue of operator effectiveness for many years, looking at how to empower the operators so that they can





do their job more efficiently and make correct, informed and timely decisions. To remove the clutter and make it easier to develop a strategy, ABB has grouped its technology and best-practice solutions into four core disciplines known as the Four pillars of operator effectiveness. These are:

1. Plant system integration: Integrating plant operations into a single automation system that transforms raw data into actionable information in context;
2. High-performance HMI: Delivering a high-performance human machine interface that is designed to provide clear, intuitive process graphics, user-context navigation and simplified alarm management;
3. Operator competency: Improving operator knowledge and decision-making through training and process simulation; and
4. Human factors and ergonomics: Designing ergonomic control rooms to enhance operator performance and reduce stress and fatigue.

2) Develop a long-term alarm management strategy

Alarm management is not a product, set of features or a one-time implementation activity. It is part of a long-term plant strategy, established by management. It begins with an alarm philosophy that clearly defines the owner, pro-

cedures and the roles and responsibilities of all involved.

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.

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.

What lies ahead in alarm management?

Alarm management is a process of continuous improvement - for the plant and for ABB.

As the world's market-leading distributed control system in the power generation sector, Symphony Plus already has an advanced alarm management system and high-performance HMI that reduces unnecessary alarms and improves the effectiveness of operators.

Currently, we are developing new analytic models and graphics to enhance analysis of why specific alarms are generated, reduce the number of alarms and fine-tune their ranking by importance, to simplify the job of the operator.

These models and graphics include functionalities like:

Deep de -chattering: Is alarm D a chattering candidate to be removed from the operator's view?

Similar flood: Do alarms A, B and C occur in alarm flood episode E?

Critical event: Is event A or action N before or after critical event C?

Generic sequence: Is sequence P→Q→R responsible for alarm/event S?

Parent-child: Does critical event C typically occur after alarm A?

Hiding rules: Is alarm B or action M contained within the duration of alarm A? ●

Virtual power plants

VPP operators can pool and trade production from thousands of small-scale generators, municipalities and microgrids can optimize their energy networks, and industries can cut their energy costs by 5-10 percent - all through ABB Ability™ solutions for virtual power plants



SLEMAN SALIBA
BUSINESS
DEVELOPMENT
MANAGER VPP
POWER GENERATION
& WATER

More people, more energy, more renewables

Virtual power plants, also known as virtual power pools (VPP), are fast becoming a driving force in the power industry, due to rising demand for energy and the global turn to renewables.

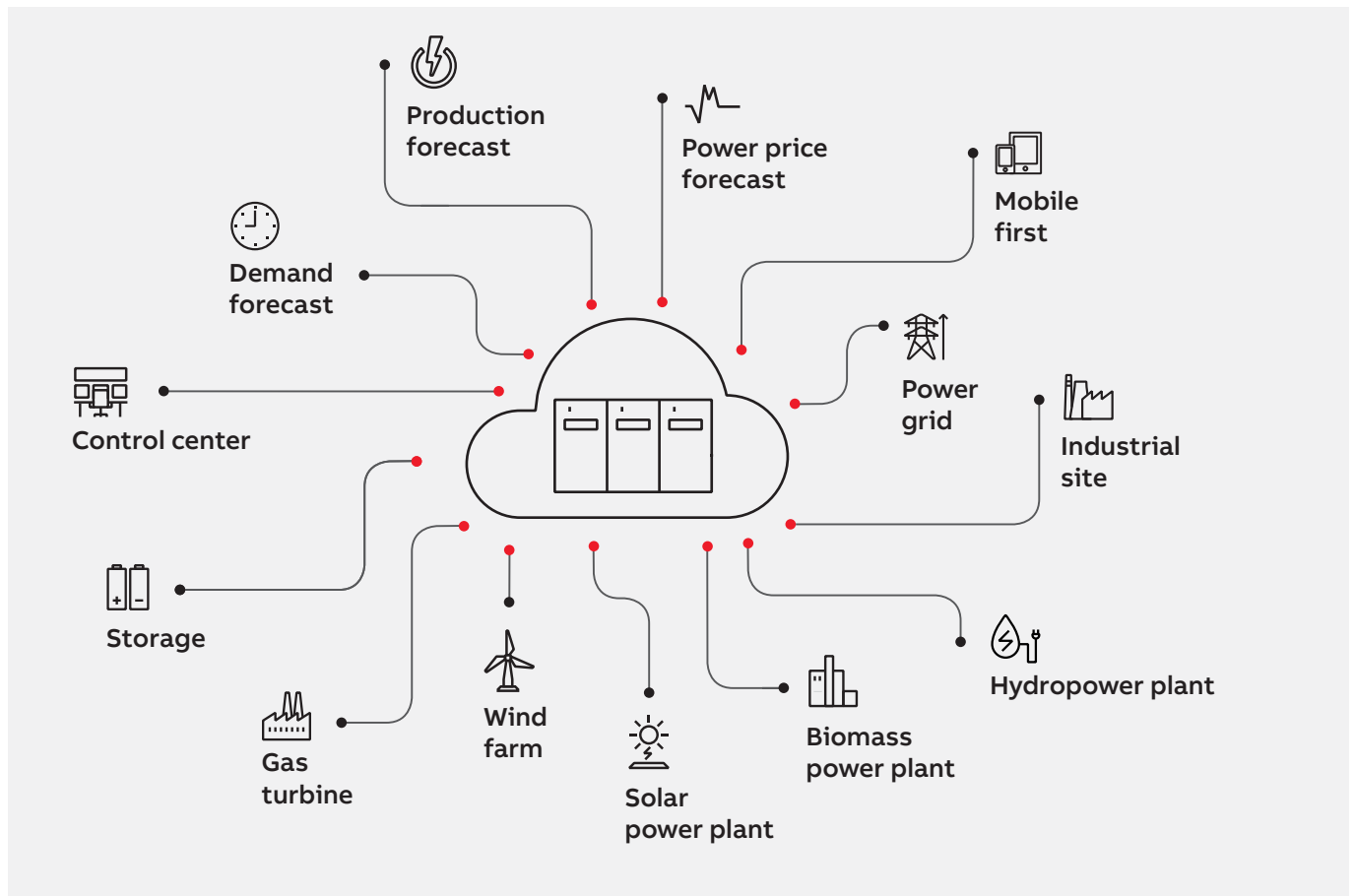
By 2025 there will be 1 billion more people on the planet, all requiring electricity. And by 2040, 60 percent of the power generated worldwide will come from renewable sources, almost half of which from wind and solar photovoltaic. Much of this solar and wind power will be generated by small-scale producers - individuals, businesses and municipalities.

As a result, the need is escalating for virtual power plants that combine multiple, geographically dispersed production units into a single optimized entity that can plan and adjust production dynamically and trade intelligently on the energy market.

Together, they do more and do it better

A virtual power plant/pool is a collection of power generation sources, energy storage devices and demand-response participants located in a distributed energy grid.

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01 ABB's central control and optimization system connects, controls and optimizes the power pool

Almost any power generating technology can be in a VPP, including biogas, biomass, combined heat and power (CHP), micro CHP, wind, solar, hydro, power-to-heat, diesel engines and fossil fuel.

Energy storage facilities can also be incorporated into a VPP. Any type of energy storage technology can be applied, including batteries, thermal storage, compressed air or pumped storage.

Municipalities, microgrids and industry

Typically, VPPs pool production from tens, hundreds or even thousands of small and medium-sized renewable energy plants into a network that has the scale and flexibility to participate in the electricity market.

But they also serve other applications as well. ABB solutions enable municipalities to optimize and manage their electricity, steam and heat production from multiple sources and to buy and sell energy when prices are advantageous.

Microgrids, which traditionally rely on costly and emission-producing diesel and gas generators, can integrate renewable sources and maximize their use by switching to fossil fuel only when needed and in real time, should poor weather or high demand require.

Energy-intensive industries that generate their own electricity are also realizing the benefits of virtual power pools. By combining production planning, energy management and energy trading

they can reduce their energy costs by 5-10 percent, without changing production targets or delivery deadlines.

And conventional multi-unit power plants can improve their flexibility, reduce fuel consumption and lower their carbon dioxide emissions by pooling the units internally to optimize the performance of the plant, much as a virtual power plant.

Central control and optimization

The goal of a VPP is to operate its pool of units optimally and cost effectively and to generate maximum revenues for its participants by bidding informedly and smartly on the energy trading market.

—
ABB has the expertise, hardware and software that cover the entire scope of VPP operations

ABB Ability™ Energy Optimization for Virtual Power Plants allows VPPs to do this. It provides central control and optimization, links energy sources with markets, performs day-ahead and intra-day forecasting, and issues and updates commitment schedules to pool participants. The technology is highly customizable and scalable, enabling VPP operators to rapidly expand from a few units to thousands, seamlessly and without interruption to operations. ●

One of Europe's biggest VPPs

The ABB solution for the Next Kraftwerke VPP links more than 4,500 producing and consuming units in eight countries in Europe. The network has a production and trading capacity of around 3,200 MW of renewable energy, and has grown seamlessly from a few units in 2009 to one of the largest in Europe, thanks to the solution's scalability.

Balancing municipal energy production

Integration of a hybrid energy system for the German city of Trier. The ABB solution provides intra-day optimization for balancing power production in an energy system comprising wind power, solar PV, biomass, combined heat and power, battery storage, DC charger network for electric vehicles, hydropower and pumped storage, and consumers.

Optimizing an island microgrid

Optimization and simplification of a diesel/wind/solar-powered microgrid for the island of Aruba in the Caribbean. The ABB solution enables the microgrid to use more renewable energy by switching to diesel only when renewable generation is insufficient. It provides day-ahead optimization for the production schedule based on load and weather forecasts, improves grid stability and power quality, and significantly reduces the island's carbon emissions.

Industrial sites

ABB has provided VPP solutions for energy-intensive industrial plants, enabling them to significantly decrease energy costs by raising or lowering production rates according to the cost of electricity - without affecting overall production volumes and delivery deadlines.

Digital excitation systems

Improve plant response to variable grid conditions and raise operator awareness



VALERIJS KNAŽKINS
PRODUCT MANAGER
EXCITATION
POWER GENERATION
& WATER

Traditional synchronous machine-based power generation is gradually being replaced by renewables like wind and solar energy. Wind and solar, however, are intermittent and do not provide the required system inertia for transient rotor angle stability, nor the reactive power needed for voltage stability support.

To ensure the stability and reliability of a power system containing a large volume of renew-

ables, it is crucial that the synchronous generators maintain stability over a broad range of operating conditions. In addition, the grid operator should be able to monitor operating parameters, such as loading angle, in real time in both normal and transient states.

In conventional excitation systems, the excitation control system parameters are set during the commissioning process and remain fixed



— 01 UNITROL 6000 is part of the most comprehensive portfolio of excitation and synchronizing products on the market

throughout the lifetime of the system. The fact that the power system evolves and changes its properties over time is rarely taken into consideration.

Breaking with tradition

ABB's latest generation of excitation systems, UNITROL® 6000, breaks with this tradition of inflexible parameters. Equipped with fast and accurate measurement sensors, UNITROL 6000 continuously measures the electrical output variables of the synchronous machine and analyzes the data collected. Using advanced transducers, measurement techniques and built-in algorithms, UNITROL 6000 automatically tracks changes in external grid impedance (X_e). Awareness of the correct X_e -value is important as it influences the settings of the key excitation system controllers.

Knowledge of X_e is also instrumental to the operation of the Extended Kalman Filter-based (EKF) state estimator. The state estimator allows for rapid and accurate calculation of the generator states that are important for the

proper operation of the power system stabilizers (PSS). For instance, correct calculation of the generator's angular speed enables the PSS to operate over a broad range of frequencies.

In addition, the state estimator provides fast and reliable estimates of the generator's load angle, which informs the power plant operator of the closeness to the steady-state stability limit of the generator. This information raises the operator's situational awareness and helps maintain reliable and safe operation of the power plant as it contends with uncertain and variable grid conditions.

UNITROL 6000 is part of ABB's offering of excitation products and synchronizing equipment for the power generation industry. The portfolio is the most comprehensive and proven on the market, extending from the smallest to the largest power requirements and covering all power generation applications. ●



UNITROL 6000

- Automatically regulates generator output
- Stabilizes the grid
- Avoids critical generator states
- Communicates potential problems early to operators

Cyber Security Workplace

Features

Security patch management

- Patches are tested in ABB labs to validate applicability and compatibility
- Patches are delivered to site through the ABB Security Patch Disc service
- Cyber Security Workplace provides a management console to easily deploy the ABB Security Patch Disc to the system on-site

Anti-virus management

- Deploys the updated Malware Definition Files (DAT) to the system on-site

Backup and recovery

- Configures and automates backup routines and schedules for the system on-site

System hardening status and deployment:

- Details the secured deployment of ABB Ability™ Symphony® Plus in terms of unused software, operating system services, and firewall settings

Status monitoring

- Dashboards showing traffic light and details for each node
- Detailed report for each node on user request

Advantages

- **Reduces internal labor** required to maintain and update system security by a minimum of 12 hours or more per month
- **Provides greater visibility** to access system security status reporting
- **Minimizes risk** of updates not being completed on a timely basis
- **Minimizes risk** of potential operational impacts from manual application of an unapproved patch
- **Supports international standards and national regulations** by adopting best practices for hardening, backup and patching



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