

review

04|2020 en

Industrial automation



- 06–51 Industrial automation
- 52–79 Utilizing knowledge





EQmatic Energy Analyzer



**Automation in
oil and gas**

**Intelligent Knowledge
Assistant IKA**





Analytics for cold rolling mills

05 **Editorial**

Industrial automation

- 08 **Digitalizing industrial automation**
- 16 **Sustainability with ABB products**
- 25 **Sustainable mining**
- 32 **Automation in oil and gas**
- 38 **Sustainability in the marine sector**
- 43 **Integrated cybersecurity**
- 46 **Navigating digitization**

Utilizing knowledge

- 54 **EQmatic Energy Analyzer**
- 63 **Analytics for cold rolling mills**
- 68 **Intelligent Knowledge Assistant IKA**
- 74 **Anomaly detection algorithm**

Buzzword Demystifier

- 80 **Quantum computing**

-
- 81 **Subscribe**
 - 81 **Imprint**

-
- 82 **Index 2020**

Industrial automation of the future is not just about repeating pre-programmed steps. It takes into account historical expertise, real-time and contextual awareness, and a capacity to anticipate, embrace, and learn. This issue of ABB Review presents examples of what is needed to achieve this goal.

EDITORIAL

Industrial automation



Dear Reader,

As CEO of ABB since March 2020, I'm pleased to present this issue of ABB Review.

Industrial companies are under perpetual pressure to balance multiple objectives. Prominent among these is productivity – doing more with less. Another goal is to protect our planet through better conservation of resources. The key to meeting these objectives is technology. Only by finding better ways of doing things can we continue to serve our customers, employees and shareholders, while conserving the environment.

The most fruitful field of innovation today lies in connectivity – sharing data across processes and domains to better monitor, control and optimize their execution. This issue of ABB Review presents examples from across the domain of industrial automation that illustrate how we are drawing on our long-standing knowledge of the industries we serve, while pushing the boundaries of technology and driving performance to new levels.

Enjoy your reading,

A handwritten signature in red ink, appearing to be 'Björn Rosengren'. The signature is stylized and written in a cursive-like font.

Björn Rosengren
Chief Executive Officer, ABB Group



Industrial automation





ABB is helping to lead the transition from seeing financial success as the principle purpose of business to delivering purpose. This change in paradigm is most evident in sustainability, as one of the keys to business outcomes. The companies that use sustainable practices to yield better productivity and more reliable performance often rely on automation. Here's how:

- 08 Digitization is making automation safer and greener
- 16 Efficiency and productivity for a sustainable future
- 25 Meeting the challenges of autonomous and CO₂-free mining
- 32 Automation brings safety and sustainability for oil and gas
- 38 Solutions for a sustainable marine sector
- 43 ABB's integrated approach to cybersecurity
- 46 Navigating digitization in big business





Bernhard Eschermann
Chief Technology Officer,
ABB Industrial Auto-
mation
Zurich, Switzerland

bernhard.eschermann@
ch.abb.com



Rajesh Ramachandran
Chief Digital Officer, ABB
Industrial Automation
Bangalore, India

rajesh.ramachandran@
ch.abb.com

INDUSTRIAL AUTOMATION

Digitalization is making automation safer and greener

It is often said that one should work smarter before working harder. Smarter operations are absolutely crucial in maximizing productivity, reducing production costs and mitigating environmental impact. Digital technologies such as artificial intelligence and the Internet of Things are enabling safer and more sustainable operations.

In the process, hybrid, energy and transportation industries, energy is often the highest contributor to production costs – more than raw materials in some cases – along with the costs of complying with regulations on emissions and waste. Automation has already established itself as a significant contributor to production efficiency and environmental compliance. By now adding digital technologies such as artificial intelligence and the Internet of Things (IoT), data can be analyzed and applied in ways never before possible, ushering significant improvements in productivity and environmental sustainability.

Since the ratification of the Paris Agreement on climate change in 2016, many governments have committed to reduce greenhouse gas emissions [1]. In addition, in 2019, the United Nations released the “Envision 2030 framework for achieving affordable and clean energy while stimulating economic growth” [2,3]. Goals include increasing the share of renewable sources in the global energy mix, and doubling energy efficiency through investments in infrastructure and technology →01. Industry is called upon to help realize these goals.

Already today, 60 percent of ABB’s global revenues come from technologies that directly address environmental sustainability. These technologies increase energy efficiency, integrate renewables into the energy mix, and conserve raw materials. ABB’s technology is used in

“Producers in the process, hybrid, energy and transportation industries look to increase safety, productivity, and environmental sustainability of their operations. We help them achieve these goals, combining economic outcomes with a positive impact on society.”

PETER TERWIESCH

President, ABB Industrial Automation

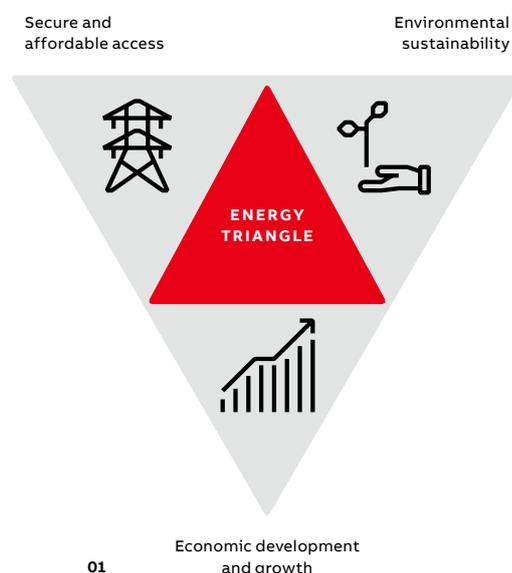
numerous projects all over the globe to keep operations running, supply chains open, the environment preserved and people safe. In cities around the world, ABB sensors and systems provide real-time information and control for utilities and transportation, enabling energy and water to be used wisely, and enhancing management processes and informed decisions by providing timely and actionable information.

Today, digitalization is evolving automation systems from “simply” reacting to the inputs received from operators and instruments, to predicting issues and prescribing actions in advance, preventing incidents that may impede production, impact costs or create operational or environmental risks.

The digitalization of automation

According to Fortune Business Insights [4], the global Internet of Things (IoT) market →02 for manufacturing was \$27.76 billion in 2018, and is projected to reach \$136.83 billion by 2026. Clearly, industries view digitalization as advantageous.

Having been involved in “digital” since the first use of microprocessors in automation offerings nearly 50 years ago, ABB has a long history of taking its industrial and automation experience, and developing – or acquiring – the technologies and competencies to further help industries improve production availability, process performance, safety, quality, energy efficiency and environmental sustainability.



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01 By integrating industrial automation technologies with digitalization and electrification, global economic growth is projected to increase.

01

GETTING TERMS RIGHT – WHAT IS THE INTERNET OF THINGS AND INDUSTRY 4.0 ANYWAY?

There are so many terms circulating that have to do with the internet and its associated industrial advances that it is amazingly easy to become confused. The Internet of Things (IoT) is the networking of physical objects, including consumer-oriented devices, eg, smart watches, kitchen appliances, etc., to communicate with resources like servers or applications. The industrial IoT (IIoT) is a subset of the broader IoT that pertains to connected physical assets and data from the industrial sphere such as motors, pumps, or factory robots, in sectors like manufacturing, energy, and transportation.

Although frequently associated with the so-called Fourth Industrial Revolution, a phrase coined by World Economic Forum founder Klaus Schwab, the term Industry 4.0 originated in 2010 in a strategic plan of the German government to boost manufacturing competitiveness. Where IIoT is primarily technical, Industry 4.0 is best thought of as managerial. As a vision for the future of manufacturing, it incorporates elements of IIoT, eg, machine-to-machine communication and data analytics, but also addresses higher-order strategic efforts necessary for advanced automation in industrial operations that span entire value chains, covering materials, machinery, and products. As such, Industry 4.0 encompasses a wide range of digital technologies such as sensors, artificial intelligence, cloud computing, augmented reality, advanced robotics, and additive manufacturing, and human domains eg, process change, organizational culture, business model innovation and public policy.

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The term “digitalization” as it is used today refers to technologies that communicate faster, store and process data in the cloud, perform remote services, conduct instantaneous transactions, empower users in a mobile fashion, etc. While some industries, such as media and finance, lead in digitalization, other industries are still at an earlier point on this path. These include many of the sectors served by ABB.

The best way to support these industries in unlocking Industry 4.0 potential is to start from their existing digital investment, in other words, their existing automation base. By enhancing automation offerings (such as

Distributed Control Systems (DCS), measurement devices, analytical equipment, specialized products and related services) with new digital products, systems and solutions, →03 ABB is helping customers reap the benefits of digitalization on their path toward a profitable and sustainable future. In the following, selected examples are discussed.¹

The energy sector

When speaking of sustainability, a good place to start is the energy industry, especially considering the wild ride that the oil and gas market has been experiencing this year. For upstream producers, the ABB Ability™ Wellhead

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60 percent of ABB’s global revenues come from technologies that directly address environmental sustainability.

Manager is a predictive analytics platform that allows small and mid-size producers to gain remote insight into production assets through a cloud-based Supervisory Control and Data Acquisition (SCADA) system. By providing immediate access to data, alarms and notifications, producers reduce downtime, costs and risk while improving personal safety and avoiding environmental issues [5].

IACX Energy, a midstream producer in the United States, deployed this tool on 1,500 wells to collect and compile field information, export files, monitor transmission lines and set up alarms. When new equipment was being installed, the system was kept online, ensuring continued production and minimizing environmental risk. IACX reduced project execution costs by 57 percent, and hardware, services, administration and energy costs by 34 percent [6].

Moving on from production to processing, ABB’s Process Power Simulator (PPSim) uses digital twin technology to support operator training, electric control room testing, verification and validation of control strategies [7]. By replicating the plant’s electric control system, operators are exposed to non-routine situations in a secure environment, improving operator effectiveness, productivity and efficiency. Operators verify and validate possible control strategies and compliance procedures, thus reducing commissioning time, downtime, and energy costs. First employed for British Petroleum’s Tangguh Liquid Nitrogen Processing plant in Indonesia, PPSim simulated three generators, 25 transformers

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02 Terms such as the Internet of Things, the Industrial Internet of Things, the Fourth Industrial Revolution and Industry 4.0 are explained and examples are provided ...

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03 The industrial operations digital ecosystem can be considered to have three main levels of technology. However, this ecosystem lacked enablers to unlock value across the layers of technology. ABB's investment in industrial analytics and artificial intelligence builds on this digital base to continue improving industrial efficiencies.

and 80 loads in real-time scenarios. By providing scenarios to determine the consequences of each operation, PPSim reduced commissioning time, lowered energy costs, improved personnel safety and mitigated environmental risk [8].²

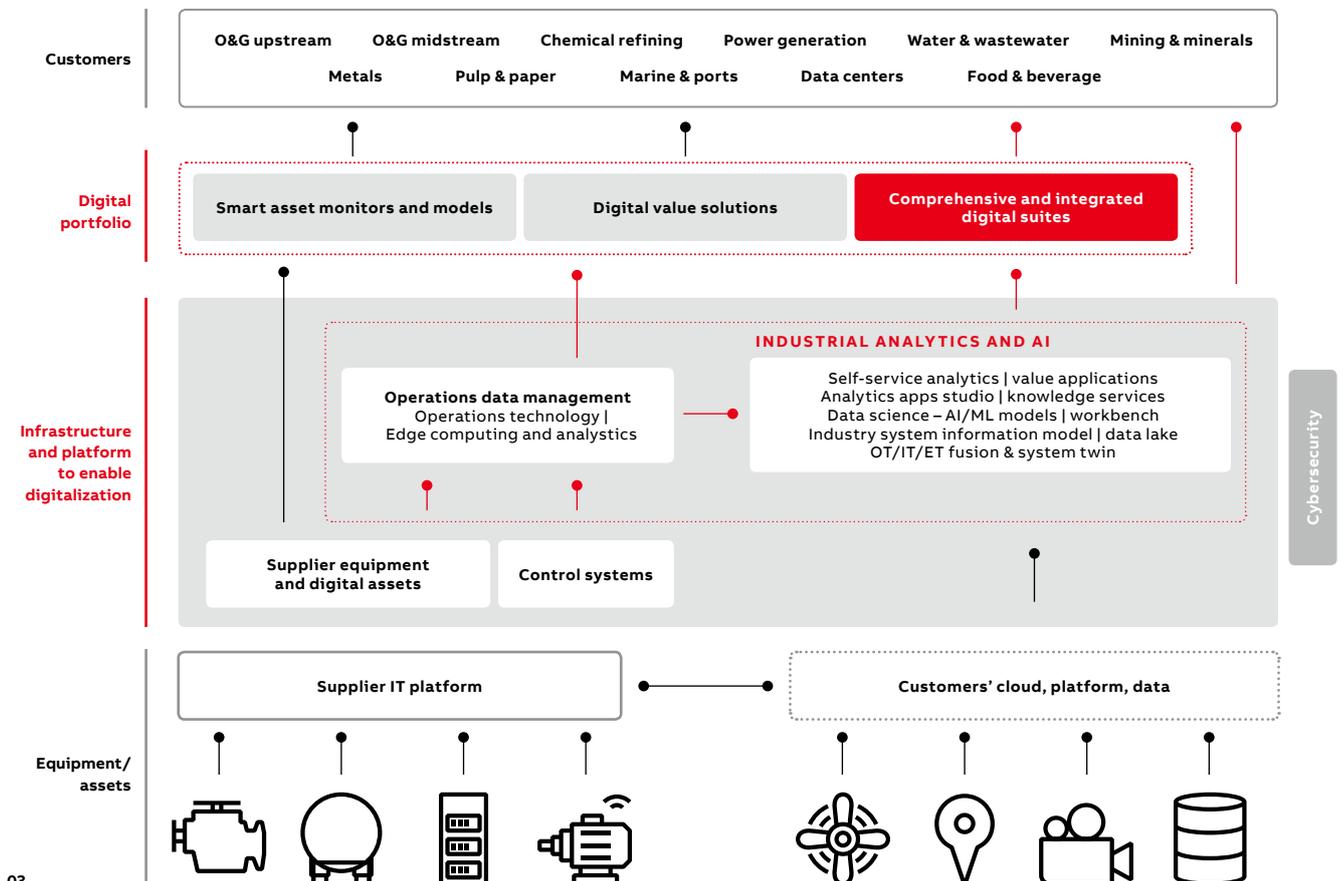
Moving on to power generation, today's mix of carbon, hydroelectric, wind and solar power transforms the traditionally centralized electricity grid into a decentralized one with energy and information flowing in both directions. This emerging mix of energy sources implies high variability in production levels and price points. These new dynamics demand a solution that addresses both consumer and producer needs. The energy management system, ABB OPTIMAX® [9], maps and controls these energy flows →04, 05. Easily integrated into existing infrastructures to improve energy efficiency at industrial sites, buildings, farms, transportation hubs and even entire cities, OPTIMAX reduces emissions by allowing more renewables in the energy mix without endangering reliability or grid stability, and lowers energy costs without impacting operations. With demand for electricity forecast to grow seven times faster than for other energy sources by 2050, de-carbonization of the electricity fuel mix is an important sustainability

goal. OPTIMAX aggregates and optimizes decentralized energy resources into a virtual power plant, so that producers can buy or sell as energy availability and price dictate, maximizing sustainable sources without disrupting supply [10].

This issue of ABB Review presents a selection of technologies that are being deployed in the energy industries, including subsea transmission, distribution, and power conversion systems for

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OPTIMAX allows more renewables in the energy mix without endangering reliability or grid stability.

underwater pumps and gas compressors. The journal also presents digital developments in the ABB Ability™ portfolio that support CO₂-free mining, such as the Stockyard Management System, Ventilation Optimizer and the Cyber Security Fingerprint. Transitioning from production to distribution, this issue also provides



insight into how the company helps steward the world's waterways with additional ABB Ability™ solutions, such as the Marine Advisory System and Marine Pilot Vision, as well as the engine analytics software Tekomar XPERT.

The next step to get more value from data

Up to now, ABB's digital offerings typically extracted data from assets and systems of the kinds the company itself supplies, and used these to produce analytics or actions for the industrial processes that the company supports. This was typically achieved through local solutions, rather than a complete and comprehensive portfolio that can scale up or down per a producer's line, plant, enterprise or business-wide process needs.

This has changed. July 2020 saw the launch of the ABB Ability™ Genix Industrial Analytics and AI Suite, a comprehensive and integrated collection of software, applications and services that help industrial producers unlock additional value from multiple data sources, by combining industrial domain knowledge, automation technology, and artificial intelligence. ABB Ability™ Genix helps asset-intensive producers to make better business decisions through deep data analytics and optimization across the plant and enterprise.

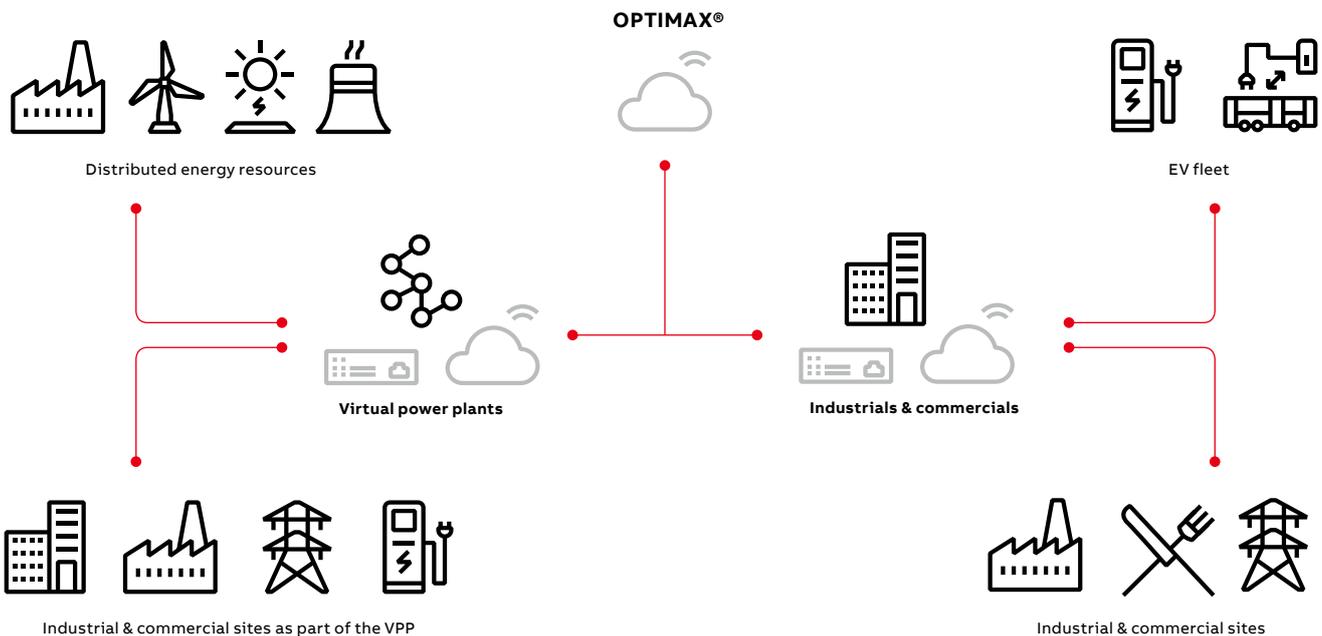
The key lies in collecting, combining and contextualizing diverse data sources, from engineering technology (ET), for instance, that incorporates regulatory compliance monitoring in plant design; operational technology (OT) data from,

for example, analyzers that give indicators of actual emissions; and information technology (IT) data that may manage supply chains for spare parts for analyzers. When an operational anomaly is detected, better actions can be taken when design parameters, inventory levels, information

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Humanity has a responsibility to build a world for future generations that is at least as healthy and prosperous as the one it inherited.

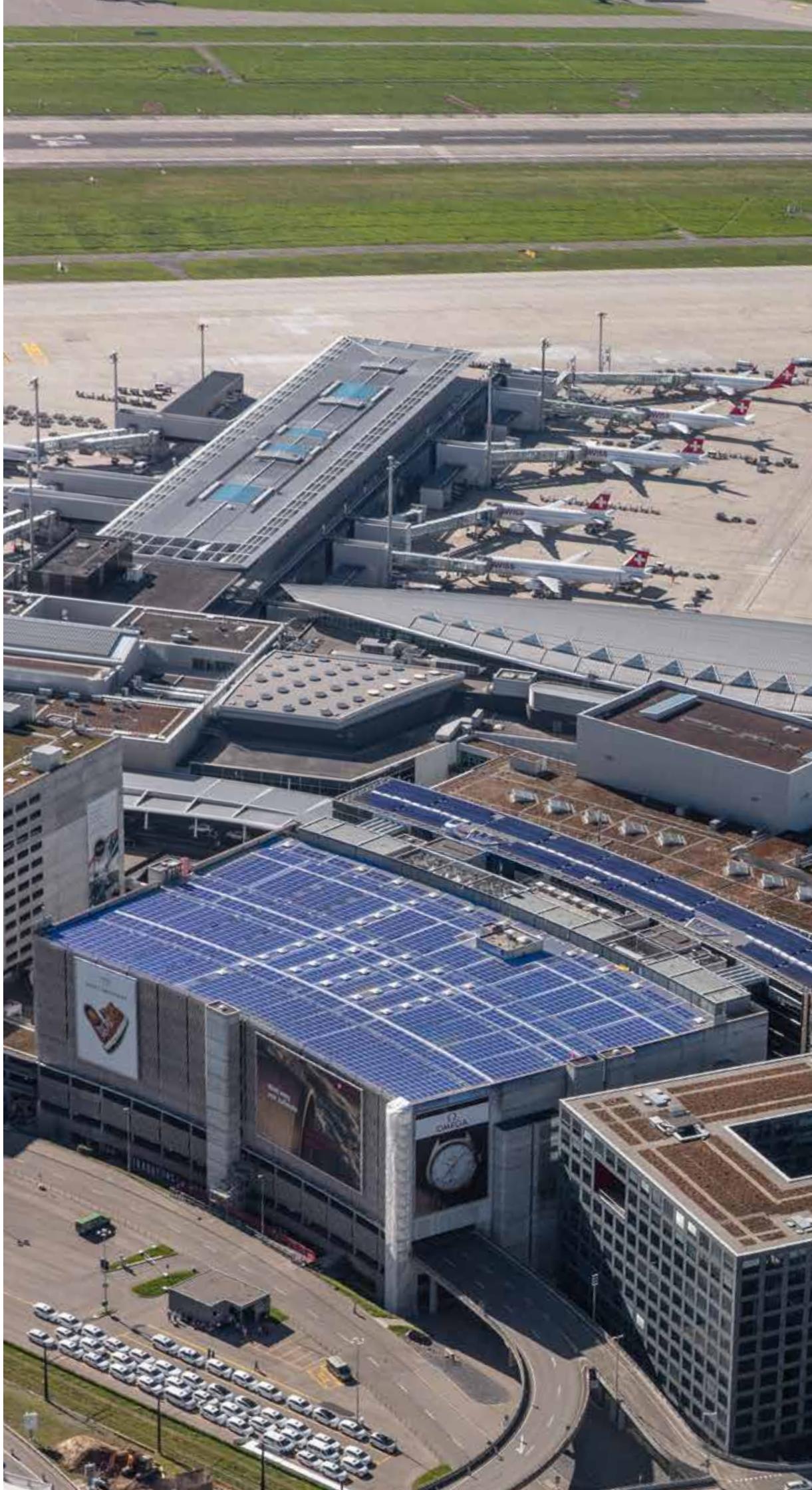
on relevance of the asset for the overall process as well as on financial implications are included in the analysis. When artificial intelligence models are applied, post-facto fixes are replaced by predictive and prescriptive advice. In addition to environmental compliance, ABB Ability™ Genix supports capital planning, facility design, supply chain management, production, maintenance, inventory management and more. This new suite improves ABB's ability to serve customers in their data utilization, digitalization and sustainability journeys.

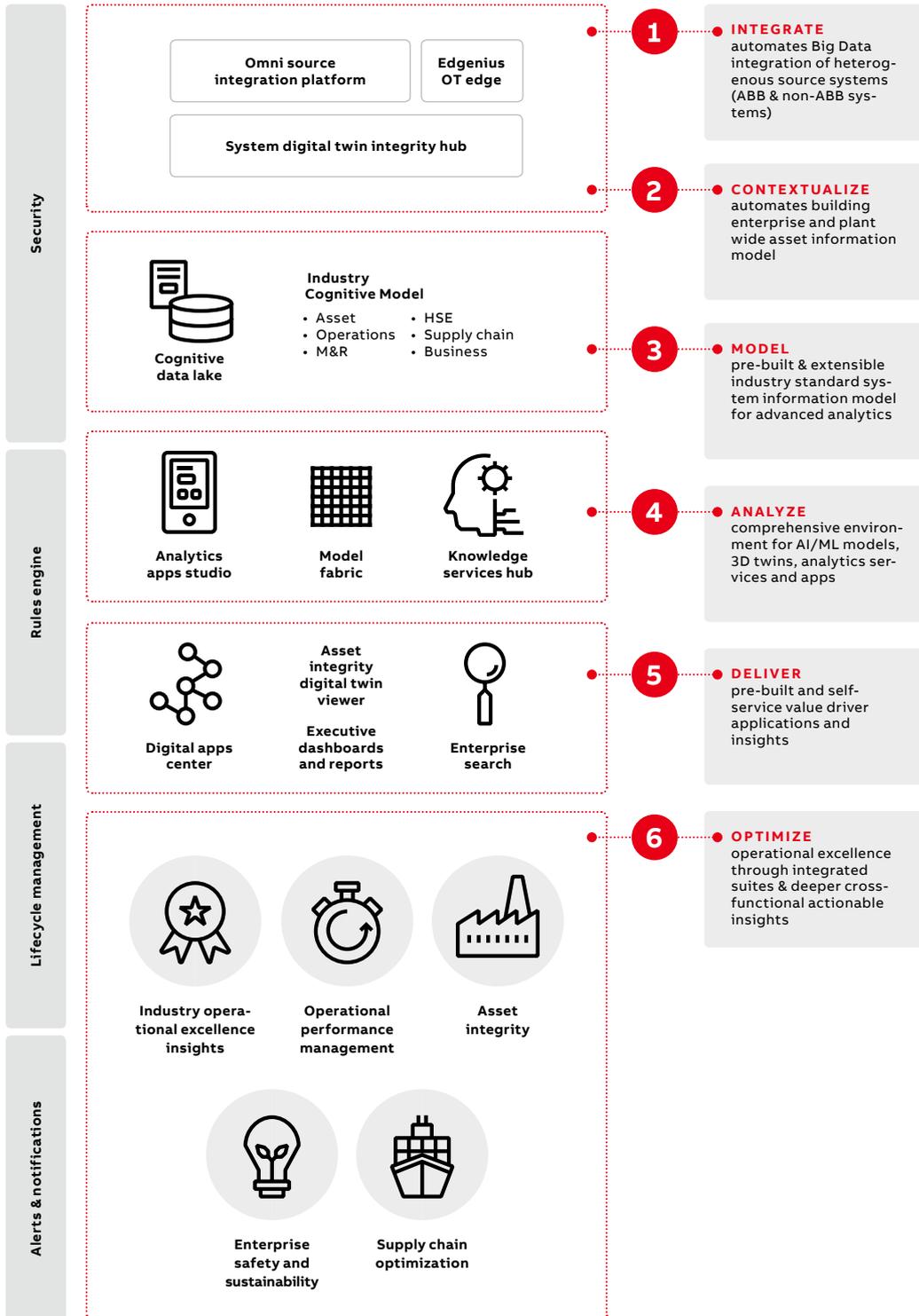
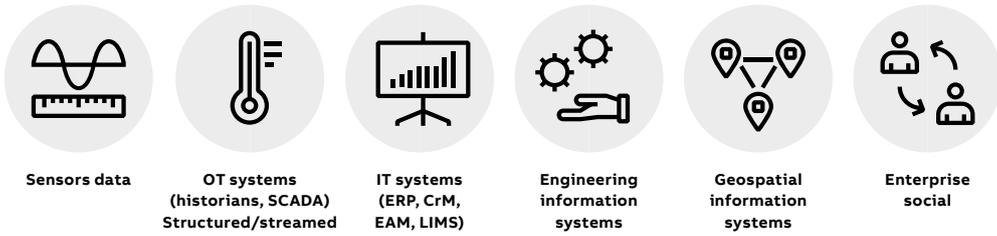
Building on the initial digital investment – the DCS with its connected devices – this is a natural engagement point to address better



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04 A Virtual Power Plant is a collection of power generation sources, energy storage devices and demand-response participants located in a distributed energy grid.

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05 The energy sources in a Virtual Power Plant consist of almost any power generating technology, including biogas, biomass, combined heat and power (CHP), micro CHP, wind, solar, hydro, power-to-heat, diesel engines and fossil fuel. The photo shows Zurich airport.





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06 The ABB Ability™ Genix Industrial Analytics and AI Suite collects data from heterogenous sources through purpose-built technologies such as the ABB Ability Edgenius Operations Data Manager.

data utilization. To this end, a key component of ABB Ability™ Genix is the ABB Ability™ Edgenius Operations Data Manager that connects, collects, and analyzes operational data at the point of production for near real-time mitigation. ABB Ability™ Edgenius pulls data from operational technology to produce analytics that help mitigate issues such as environmental risks immediately. ABB Ability™ Edgenius can be deployed on its own, or integrated with ABB Ability™ Genix as the delivery mechanism for the OT data that combines with ET and IT data for strategic business analytics [11] →06.

The digital future

Sustainability is embedded in ABB's business model and has been for a long time. It is critical to the company's license to operate. At ABB, we are committed to sustainability in our own operations. This affects the way we source and manage relationships with suppliers. It is also reflected through the impact of our products, services and solutions we provide to customers.

Inspired by the United Nations' Envision 2030 framework, ABB created its own sustainability objectives that underpin the company's commitment to establish itself as an exemplary sustainability practitioner; increase its impact where

it has the greatest leverage (the company's installed base); and by continuing to drive change in all dimensions where it can make a positive contribution to sustainability and prosperity around the world.

Humanity has a responsibility to build a world for future generations that is at least as healthy and prosperous as the one it inherited. For ABB,

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Thanks to artificial intelligence, post-facto fixes are replaced by predictive and prescriptive advice.

sustainability is both the right thing to do and a business opportunity. By supporting customers to become safer, smarter and more environmentally sustainable, the company will create new market opportunities, drive prosperity and build a sustainable future together [12]. •

Footnote

1) Please refer to "Efficiency and productivity for a sustainable future" on p. 16 of this issue of ABB Review for more information about this topic.

2) Please refer to "Automation brings safety and sustainability for oil and gas" on p. 32 of this issue of the ABB Review for more in-depth information.

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INDUSTRIAL AUTOMATION

Efficiency and productivity for a sustainable future

Sustainability is not only good for the planet – it is good for business. Committed to customer-driven technology, ABB has developed smart products that use near-real time data on process conditions, control system behavior and decision-making to lower environmental impact.

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Aiming for a sustainable future, the oil, gas and chemical (OGC) sector, among others, relies on products developed by ABB to help in their goals to reduce CO₂ and other greenhouse gas emissions; safe-guard water availability and purity; maintain worker and facility safety and become more energy efficient.

With most natural resources finite yet essential, the call to sustainability is beckoning, and both governments and society are heeding this call. Moreover, industries realize that to flourish, they must invest in a sustainable future, one that enables growth without sacrificing productivity and efficiency. ABB is committed to the development of innovative industrial automation (IA) solutions that can help industry in their sustainability efforts, thereby realizing better environmental stewardship of the planet.

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Purvang Upadhyay
ABB Measurement & Analytics
Abu Dhabi, UAE

purvang.upadhyay@ae.abb.com

Stephen Gibbons
ABB Measurement & Analytics
Frankfurt, Germany

stephen.gibbons@de.abb.com

Mark Bitto
ABB Process Control Platform
Wickliffe, OH, United States

mark.bitto@us.abb.com

With much at stake, governments and regulatory agencies are actively creating initiatives to promote sustainability. Recently, the US Environmental Protection Agency (EPA) implemented initiatives to reduce greenhouse gas emissions by 40 percent from the 2008 base level [1]. In June 2019, the United Kingdom became the first major economy in the world to pass a legally binding agreement to limit carbon emissions to net zero by 2050 [2]; in November 2019, New Zealand became the latest country to do so [3].

International organizations such as the World Bank have launched sustainability-driven programs, eg, Shared Infrastructure for Solar Parks, and Global Environment Facility (GEF). Thanks to







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the UN's 2015 Sustainable Development Goals, state governments are increasingly being held to account for their performance on a range of pollution control and natural resource management challenges. Use of sustainability measurement indices such as the Happy Planet Index (HPI), Quality of Life Index (QLI) and the Environmental Performance Index (EPI) help

ABB develops novel, smart products that focus on superior analytics and diagnostic capabilities.

make this possible. Nevertheless, the path to sustainability is awash with complex challenges and process-, power-, and transport- sector industries face a dilemma: They must reduce CO₂ and other greenhouse gas emissions; safeguard water availability and purity; keep workers, facilities and the areas impacted by operations safe; promote more energy efficiency and meet compliance in an ever-expanding regulatory environment, yet, maintain profitability.

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01 Automated industrial systems that incorporate advances in AI and machine-learning algorithms allow data gathering, analyses and decision-making with less human intervention. Ultimately, people, processes and technology work in synergy.

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02 ABB developed URAS and LIMAS, which use non-dispersive infrared and UV radiation technology, respectively, to help industries monitor hazardous gas emissions.

Supporting sustainability efforts with innovation

ABB realizes that to address the aforementioned challenges, industry must embrace more than sustainability. So, when new products are developed, focus is not only on superior analytics and diagnostic capabilities. Intelligence, connectivity and availability are embedded in these products to ensure that they interface with the control systems that are so critical for industrial operations. The resulting products enable more efficient energy and water use, reduce emissions and waste while helping industries meet their sustainability goals. By incorporating advances in artificial intelligence, and especially machine-learning, industries meet their sustainability goals. By incorporating advances in artificial intelligence, and especially machine-learning, with IA processes, industries can not only streamline the intellectual workforce, they can reach energy, emission, water and safety goals without sacrificing productivity or efficiency →01.

Today, data gathering, analyses from integrated and connected sensors, devices and instruments are combined with expanded control systems, eg, distributed control systems (DCS) and programmable logical controls (PLCs) in such a way as to enhance industrial process regulation and even foster remote decision-making, all with less human intervention. Such processes reduce waste, optimize energy and water usage and reduce hazardous emissions and pollutants by extending the life-cycle of industrial machines and optimizing their use through predictive monitoring of processes and optimizing product maintenance [4]. Employee safety can also be vastly improved through smart alarm management and by reducing the time people spend in hazardous environments. These analytical and measurement devices are engineered to incorporate technological advances for remote diagnostics and predictive maintenance and at the same time have a positive impact on costs.

Reducing hazardous emissions through monitoring and detecting

With 24 percent of total direct CO₂ emissions originating from industry in 2013; and predicted to reach 45 percent by 2050 [5], governments introduced compliance directives to reduce industrial CO₂ emissions, eg, the Large Combustion Plant Directive (LCPD) – Directive 2001/80/EC, and the Waste Incineration Directive (WID)

– Directive 2000/76/EC. ABB Measurement and Analytics has developed monitoring solutions such as the ACF5000 Continuous Emissions Monitoring System (CEMS)[6], which measures up to 15 components, including relevant pollutants, simultaneously, to help plant owners meet carbon emission compliance requirements. However, reducing CO₂ emissions does not solve all of industries' emission challenges – other greenhouse gases and pollutants produced by industries that rely on coal, gas, oil or biomass, for fuel come into play and ACF5000 delivers.

ABB's series of gas analyzer products are tailored to customer's compliance and sustainability needs in a myriad of industries, eg, power generation, pulp and paper, metals and cement production. Based on over 50 years of experience with non-dispersive infrared technology, ABB's flagship product, URAS [7], measures up to four compounds simultaneously, eg, CO, NO, SO₂ and CO₂. Another successful product, LIMAS, uses UV measuring technology

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ABB's series of gas analyzer products are tailored to customer's compliance and sustainability needs.

to measure both NO and NO₂, simultaneously, and SO₂ even if water or CO₂ are present in the sample →02 [7]. Furthermore, reliable and accurate real-time emission estimations are possible with use of the software solution Predictive Emission Monitoring Systems (PEMS), and the Inferential Modeling Platform (IMP), tailored for model creation and online deployment connected with an industrial control system through standard protocol. Better control of emission monitoring processes is the result.

Reliable and timely detection of leaks can also help industries reduce greenhouse gas emissions. The ABB Ability™ Mobile Gas Leak Detection System, with a digital mobile detection software application, uses ABB's patented laser-based technique, and is the only available system to measure both methane and ethane [8]. Hence, pipeline gas and naturally occurring methane can be differentiated and mapped. With sensitivity

a thousand times greater than legacy devices, leaks are located rapidly. More autonomy allows service anytime, anywhere, by any approved personnel. Detailed autonomous reporting without the need for human review, editing, or filtering means that customers can locate and prioritize a leak, thus reducing hazardous emissions and improving safety while increasing productivity and efficiency.

Making clean water available

With global demand for water rising at three times the rate of population growth, there is immense stress on the global supply of fresh

water. Industrial processes account for 22 percent of freshwater global water retrieval, with this proportion expected to rise [9]. Moreover, industrial processing usually degrades water even though it is usually available for re-use, if successfully treated. And yet, waste treatment capacity languishes as facilities and systems age – a notable challenge.

Improving quality and reducing the vast quantities of water involved in manufacturing is crucial and ABB recognizes that making products and processes more sustainable, with less- and purer water (and energy), is not only good for the environment it is good for business. Even slight reductions in usage can have a positive financial impact on a company's bottom line and foster connections with end users and stakeholders.

ABB's products such as Symphony Plus™ Automation solutions, water analysis products and flow meters, provide customers with more flexibility, reliability, and efficiency, thereby reducing industrial operating costs, while improving water quality and lowering the amount of water used.

Symphony™ Plus, the new generation of the Symphony family of DCSs, developed for the power and water industries, is a complete digital automation system ideal for the management of



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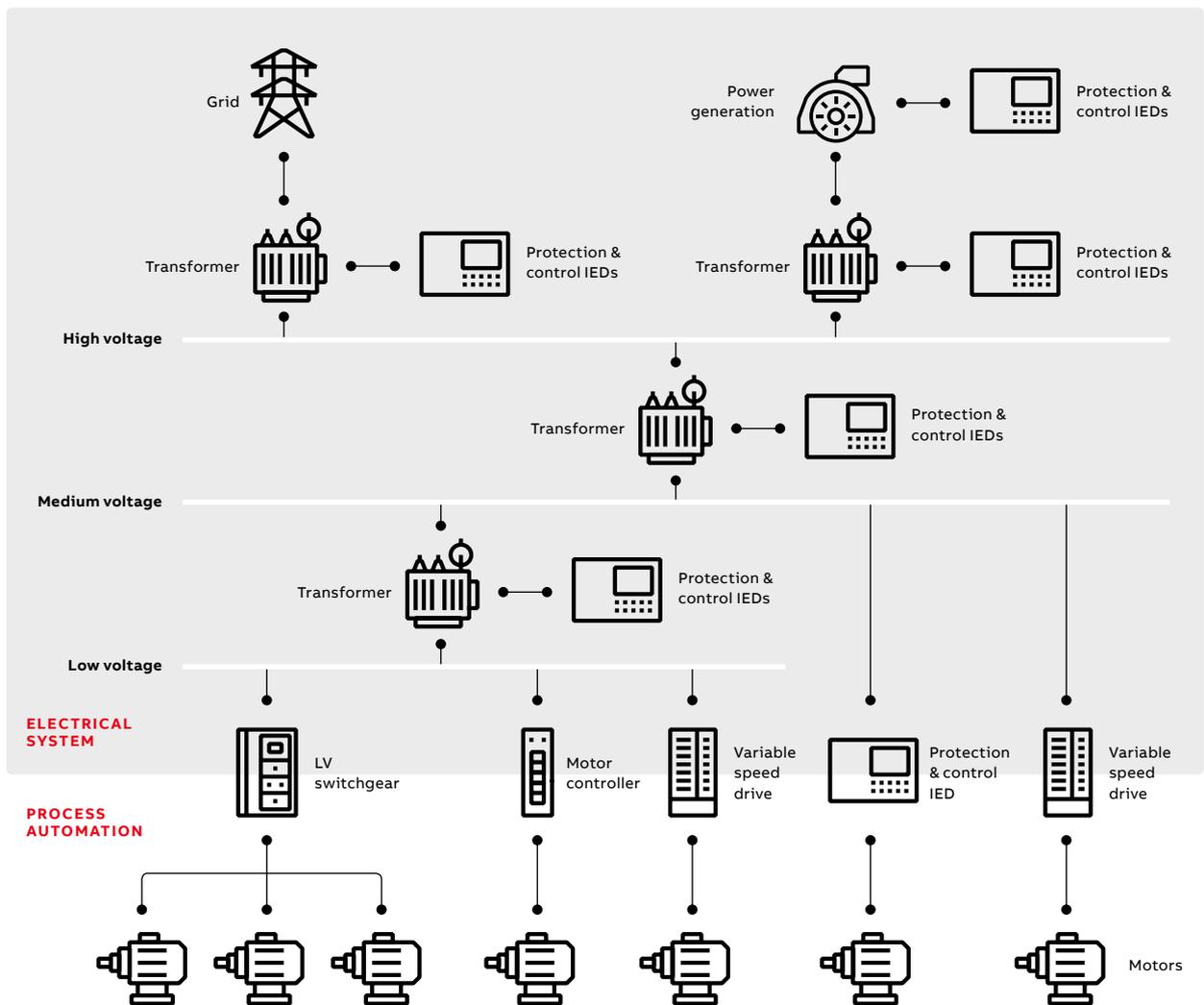


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The ABB Ability™ Mobile Gas Leak Detection system is the only available system to measure both methane and ethane.

the water cycle and can be used to increase performance of desalination and treatment plants, water distribution and transfer networks [10]. With more than 6,800 Symphony DCS installed world-wide and more than 4,800 in water and power applications, this automation platform is a tried-and-proven solution.

Incorporating essential components of a closed loop system; sense, analyze and act, the architecture of this solution is designed specifically for water applications (larger number of smaller modular units) this enables plant and network operators to achieve both sustainable and profitable growth.



05

03 ABB's AquaMaster flowmeter monitors the quantity of water intake, and is self-verifying.

04 ABB's non-invasive sensor allows accurate measurement without process intrusion. The result is reduced risk to safety, the environment and the equipment while boosting efficiency.

05 ABB Ability™ System 800xA Electrical Control solution allows insight into energy flows and loads. Thus, power distribution (eg, generators, transformers and circuit breakers) and consumers (motors) can be easily controlled.

The availability of quality-water and its continuous and accurate measurement is key to many industrial processes. ABB's water analysis solutions provide real-time data on process conditions that can be used to improve

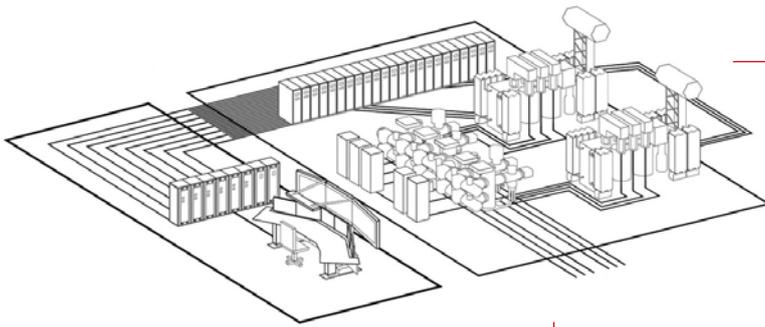
Symphony™ Plus is a complete digital automation system for the management of the water cycle.

efficiency, tighten performance and safeguard quality [11]. Because good quality water is not only required for drinking but is needed to generate power, ABB has developed a water quality analysis solution that uses a single parameter to complete steam water analysis, thereby ensuring

water purity to efficiently generate power. ABB's series of Continuous Water Analyzers also help maintain regulatory-compliant drinking-quality water to meet the growing demand.

With more than 70 years of experience developing pH sensors, ABB provides advanced digital pH/Oxidation Reduction Potential sensors for smart diagnostics to ensure water quality [12].

Water loss through leakage is another problem encountered and ABB's AquaMaster [13] is an intelligent solar/battery-powered flow meter that helps reduce water leakage, while lowering maintenance costs and enhancing performance →03. This electromagnetic flowmeter monitors the quantity of water intake in real time; thereby allowing early detection of waste. The AquaMaster 4 is the world's first self-verifying flowmeter; digital fingerprint technology enables an integrity self-check every 30 minutes.



 **42%**
less man hours

250 km
of cable savings
The distance between
Paris and Brussels

 **\$1,000,000**
total cost savings

06

for duplicating networks, operation interfaces and licensing, configuration training and maintenance of two separate systems. By integrated process control and safety automation, problems arising from use of two separate systems are eliminated; everything from graphics interactions to alarm management and system maintenance operate smoothly and reliably.

Balancing safety with cost-effectiveness is always challenging and ABB's non-invasive temperature sensor allows brownfield sites to accomplish both →04. This device, released in 2018, uses a double sensor architecture and algorithm to rapidly measure at the medium's surface, thus providing real-time data without the need for a thermowell [14]. This solution

Safety: balancing profit with the planet

Following major industrial safety incidents, there is an increased awareness of safety; as well as an increased global acceptance, implementation and enforcement of safety standards – nevertheless heavily regulated industries require economic growth. Innovative business strategies that integrate the safety, health and welfare of workers provide companies with an opportunity to simultaneously achieve safety and growth objectives. A tier above normal process control, safety automation can help industry to protect people, environment and their financial investment should normal operational control fail to maintain safe operating parameters.

Introduced in 2005, ABB's System 800xA High Integrity Safety solution gives industries a flexible, integrated architecture for diverse safety applications →01. In combination with ABB's lifecycle services, customers can achieve the certified safety solution they need. Capital expenditures are reduced by obviating the need

Safety automation can help industry to protect the environment, people and their financial investment.

reduces risks for humans, the environment, the medium and other components, thus, simplifying safety and environmental compliance. Not only is the cost of installation lower, but so are the system operating costs because there is no need to shut down for maintenance. Consequently, a reduction in CAPEX of up to 75 percent is achievable.

Increasing energy efficiency with integrated control systems

To reduce global energy demand and mitigate the damaging impact of excessive CO₂ emissions, energy efficiency is at the top of everyone's political and economic agenda [15].

06 ABB's IED solution eliminates the need for hardwired communication and complex software gateways for an ethernet-based solution; this results in substantial savings in terms of cost, manpower and materials, thereby leading to energy savings.

ABB Ability™ System 800xA Electrical Control solution allows plant operators to see and understand power usage.

With the ABB Ability™ System 800xA Electrical Control solution, ABB developed an integrated solution that allows plant operators to see and understand power usage and permits new energy-saving opportunities to be explored and existing reduction programs to be enhanced [16]. This solution monitors and controls the substations – necessary to provide energy to many process industry facilities – and ensures full availability with real-time applications →05.

Users can control a process, manage a field crew and deliver outstanding operational efficiency with a single system.

Supporting major communication protocols fosters interoperability between devices. Significant savings can be achieved through reduced hard-wired cabling on switchgear by connecting to intelligent devices →06. Asset management strategies can be extended to electrical equipment, reduce plant downtime and improve production. Overall, this electric control solution helps energy intensive industries to use energy cost-effectively.

ABB's products help industry achieve their sustainability targets, in all its facets, while improving efficiency and productivity, thereby fostering profitability through responsible action. •

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INDUSTRIAL AUTOMATION

Meeting the challenges of autonomous and CO₂-free mining

In mining, operational optimization and predictive maintenance are more urgent than ever, as is the need to improve energy efficiency and reduce CO₂ emissions.

How is ABB using cutting-edge automation, electrification and digitalization to address these challenges?

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Max Luedtke
Mehrzaad Ashnagaran
ABB Industrial
Automation, Process
Industries
Baden-Dättwil,
Switzerland

max.luedtke@
ch.abb.com
mehrzaad.ashnagaran@
ch.abb.com

Marcos Hillal
ABB Industrial
Automation, Process
Industries
São Paulo, Brazil

marcos.hillal@
br.abb.com

Mining companies face many challenges: easy-to-reach minerals are mostly gone and known ore reserves are dwindling; mines are often in remote locations; and labor and energy costs remain a constant overhead. There are pressures, too, to improve energy efficiency and reduce CO₂ emissions.

To meet these challenges, the mine of the future is envisaged as one that is CO₂-free and autonomous – a safe digital mining enterprise in which every operational detail is connected and which is built around sustainability. ABB already offers comprehensive, integrated solutions across electrification, automation, drives, motors and infrastructure to help optimize the overall performance of mining customers, from mine to port. ABB's digital technology boosts the power and productivity of mines, increases equipment



01



1

Partly automated



2

Local automated



3

Connected & optimized



4

Collaborative & mobile



5

Autonomous & economic optimization



	Partly automated	Local automated	Connected & optimized	Collaborative & mobile	Autonomous & economic optimization
Mining, open-pit and underground	Limited automation Disconnected electrification Independent mining services products	Mine hoist systems Pumping & dewatering On-site services	Fleet management Ventilation on demand Modular digital underground substations Remote diagnostics Operations management system	IT & OT integration & analytics Seamless data and process integration Collaborative and remote operation centers	Self-driving mobile equipment Robotic solutions for mining Robotic solutions for maintenance Mobile workforce solutions
Transport, yard and port	Basic automation Disconnected electrification	Semi-automatic stacking & reclaiming Drive systems On-site services	Automatic stacking and reclaiming Stockyard management system Conveyor asset management Remote services	Real-time production planning & scheduler On-demand dispatch to mobile operator	Machine learning for predictive maintenance & advanced process control Digital twin
Minerals processing, beneficiation	Islands of automation Disconnected electrification	Integrated process automation Separate electrical supervisory control and data acquisition (SCADA) Grinding systems On-site services	Integrated process & power control Central control room Advanced process control Plant asset management Information management Remote diagnostics	Equipment and workforce localization Cloud-based asset & production performance monitoring Intelligent sensors	Market price and process flow economically optimized Economic process control

02



—
01 Automation brings a whole host of benefits to mining operations.

—
02 Mining automation maturity.

availability and lowers lifetime operating costs by bringing people, equipment and services together. The company is also helping mines go all-electric and maximize energy efficiency by optimizing processes.

Moving toward autonomous mining

Currently, no mine is fully autonomous. Indeed, 100 percent mine autonomy is unlikely to ever be reached and, at present, many mines have only islands of autonomous equipment.

The benefits of autonomous operation in mines are manifold. For example, autonomous technology allows the relocation of personnel from unsafe, polluted and dusty areas to safer places. In the future, fewer people will work in the mine – instead, they will monitor the mine production remotely and more personnel will be located in comfortable centralized control rooms in urban areas, where employees are easier to recruit →01.

Autonomous operation also supports predictive maintenance, which reduces repair costs and unplanned downtime and can enable process optimization so that CO₂ emissions and resource use (eg, water) are reduced. Autonomous or semi-autonomous equipment is already starting to play a role in drilling and blasting and in the

stockyard →02. For example, the stockyard and belt conveyors system at MIBRAG's Schleenhain lignite mine in Germany are automatically operated by an ABB Advant System from a central control room. A recent upgrade to an ABB Ability™ System 800xA migrated all control and drive installations to the

—
Automation innovations have the potential to save the mining sector an estimated \$373 billion by 2025.

latest technology, opening new possibilities of further operational improvements. The two portal scrapers and one stacker at the Schleenhain mine are also operated autonomously and the scope of the project also encompassed drives, instrumentation, auxiliaries, closed-circuit television (CCTV), communication infrastructure and an early version of the ABB Ability™ Stockyard Management System.

When moving to an autonomous operation like the material handling process just described, collaboration between ABB's mining and technology experts and customers is essential. Original equipment manufacturers (OEMs) will play an important role, too, as product interoperability and standardization are indispensable.

Technology for mining automation

Innovations in artificial intelligence (AI), machine learning and the industrial Internet of things (IIoT) have the potential to save the mining sector an estimated \$373 billion by 2025 by automating machinery operation, facilitating predictive maintenance, improving traceability, harnessing the power of real-time data and analytics, and providing visibility across the mine-to-market value chain [2].

For automation in mining, access to accurate, real-time operational data is key. While such data has always been important, good business decision making now requires a steady input of data from physical assets, factories, plants spread across multiple geographies, industry domains and regulatory frameworks. This data



03

evolution has necessitated the vertical integration of traditionally separate top-down information technology (IT) and bottom-up operational technology (OT) models.

For the modern manufacturer, data has become unified and ubiquitous across the organization – from supply chain management to manufacturing operations to post-sales service – and is one of the most valuable assets it has. Today, data-optimized smart machines and processes can receive input from a wide range of sources to enable more agile manufacturing, improve production safety and efficiency, enable remote and mobile operations and provide greater insight into operational performance. Integrating data from equipment, processes, plants and business systems gives business leaders organization-wide visibility and control. Connected systems can communicate to detect unbalanced load flows and automatically make corrections to prevent outages. Integrating IT and OT is the starting point for the digital enterprise.

Another European mine provides a good example of how data and digitalization can transform a mature mining asset. At this mine, ABB installed

a distributed control system (DCS) to integrate data from all critical functions, such as water management, crushing, conveyor belt transportation, skip loading, pumping and the concentrator, into one efficient operation. Round-the-clock

—
ABB Ability™ Ventilation Optimizer recognizes the location of people and vehicles and delivers fresh air where needed.

remote monitoring services provide access to real-time data about mission-critical equipment, so engineers have the ability to make predictive maintenance decisions before something goes wrong.

A new ventilation-on-demand system, ABB Ability™ Ventilation Optimizer, now recognizes the location of people and vehicles in the mine and delivers fresh air where needed →03. Ventilation Optimizer can deliver up to 50 percent ventilation

—
03 ABB Ability™
Ventilation Optimizer
helps save energy
- for example, at
Codelco's Chuquica-
mata underground
copper mine, in Chile.

—
04 ABB trolley system.

energy savings (40 percent reduction of ventilation energy consumption at the mine mentioned). It also improves safety in case of fire by, for example, preventing the spread of smoke and enabling faster fume expulsion. Ventilation

—
As mines step up their efforts to cut costs and increase efficiency, the supply of energy emerges as one of their biggest challenges.

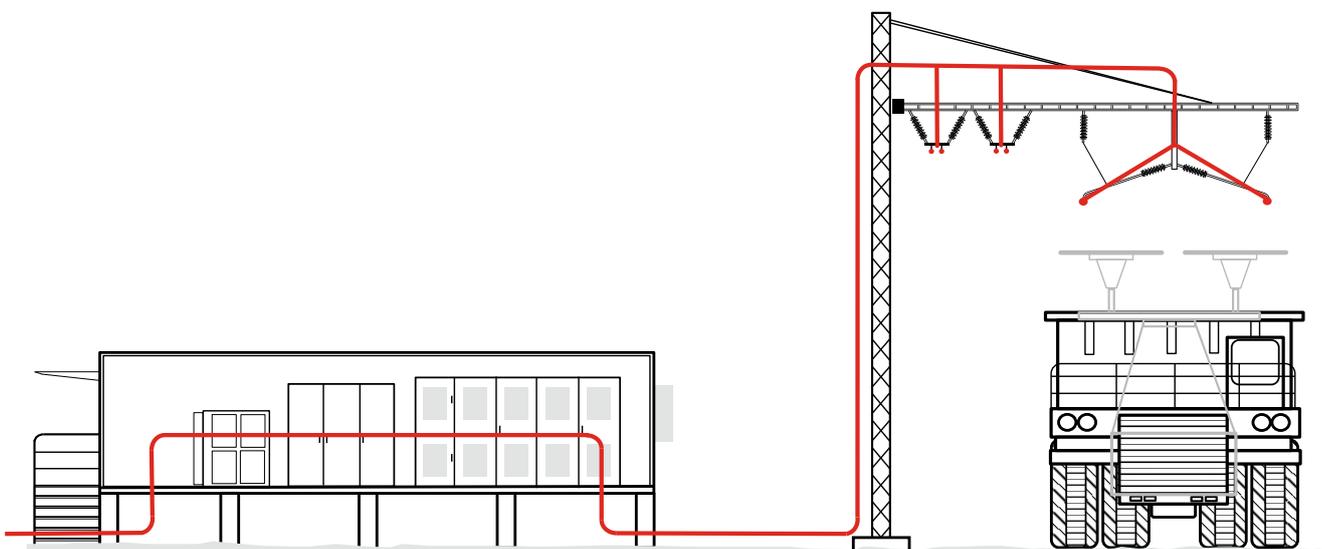
Optimizer easily accommodates additional fans, or fans that are temporarily moved to where they are needed most. In another mine, Ventilation Optimizer made ventilation energy savings of 54 percent, plus air heating energy savings of 21 percent, during its first year of use.

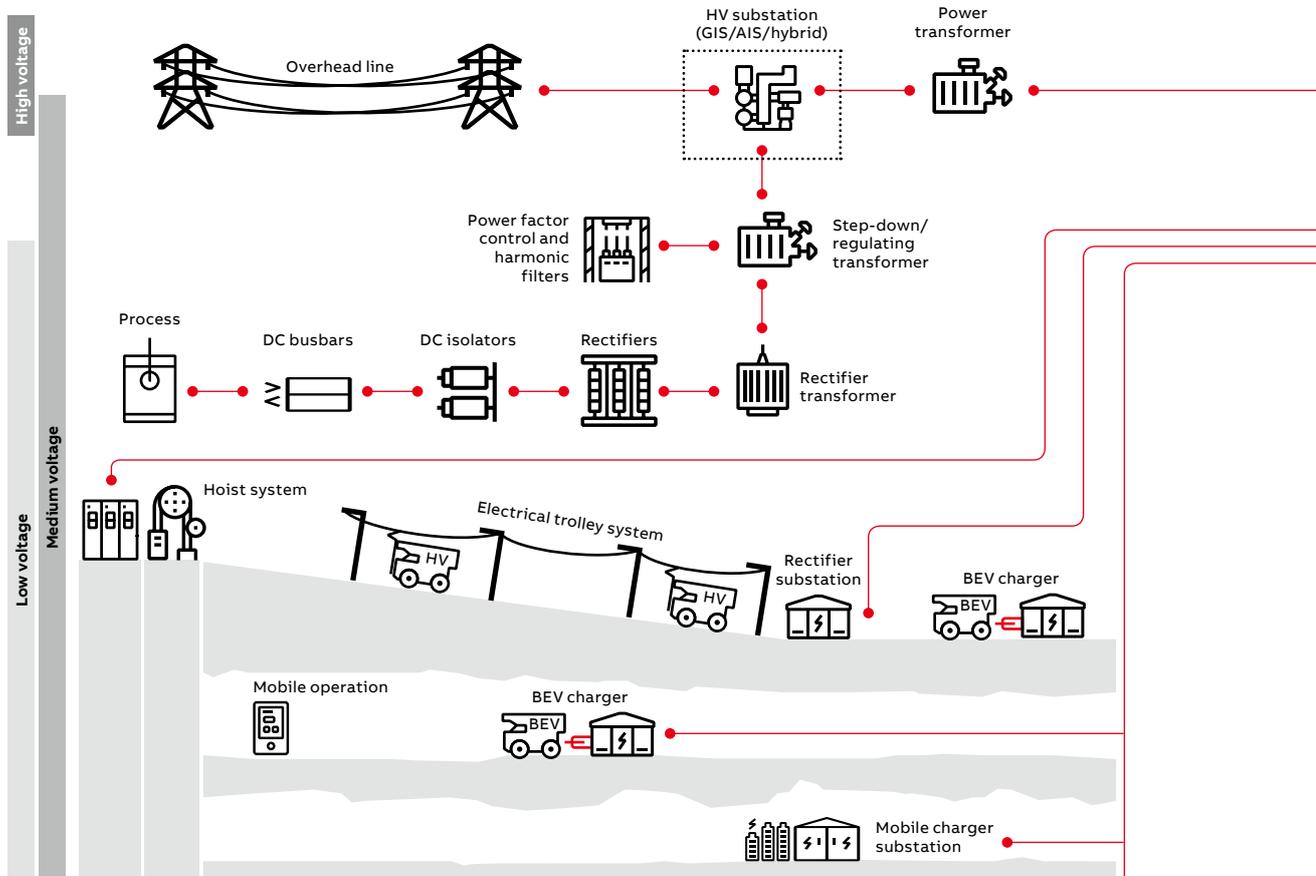
As mining becomes increasingly automated and digitalized, cybersecurity becomes critical to the running of the business. For this reason, companies need to embrace a cybersecurity framework, including the functions Identify, Protect, Detect, Respond and Recover, which is a way to provide proactive safeguards along with preparing for worst-case scenarios. ABB Ability™ Cyber

Security Fingerprint covers the Identify function as the service identifies critical control system vulnerabilities at mining facilities by focusing on three areas: procedures and protocols; group security policies; and server and workstation settings. The solution combines information from an ABB control system with insights gained from interviews with working personnel. The solution then generates a detailed report on gaps in the enterprise's existing cybersecurity measures and uses an analytics tool to compare the results with recognized industry standards. Utilizing this tool, a company can reduce vulnerabilities, and implement a focused and sustainable security strategy.

The age of all-electric mines

As mines step up their efforts to cut costs and increase efficiency, the supply of energy emerges as one of their biggest challenges. On top of the expense of delivering diesel fuel to remote sites, come also costs for the service, repair and replacement of diesel-powered vehicles. Moreover, mining is an energy-intensive industry and falling ore grades require more energy to be expended per ton of end product extracted. Tighter commodity prices narrow margins yet more. Further, rigorous standards apply to the allowable levels of air pollutants in mines – for example, diesel particulate matter, total carbon, elemental carbon and nitrogen





05

dioxide. Compliance with these standards incurs mitigation costs.

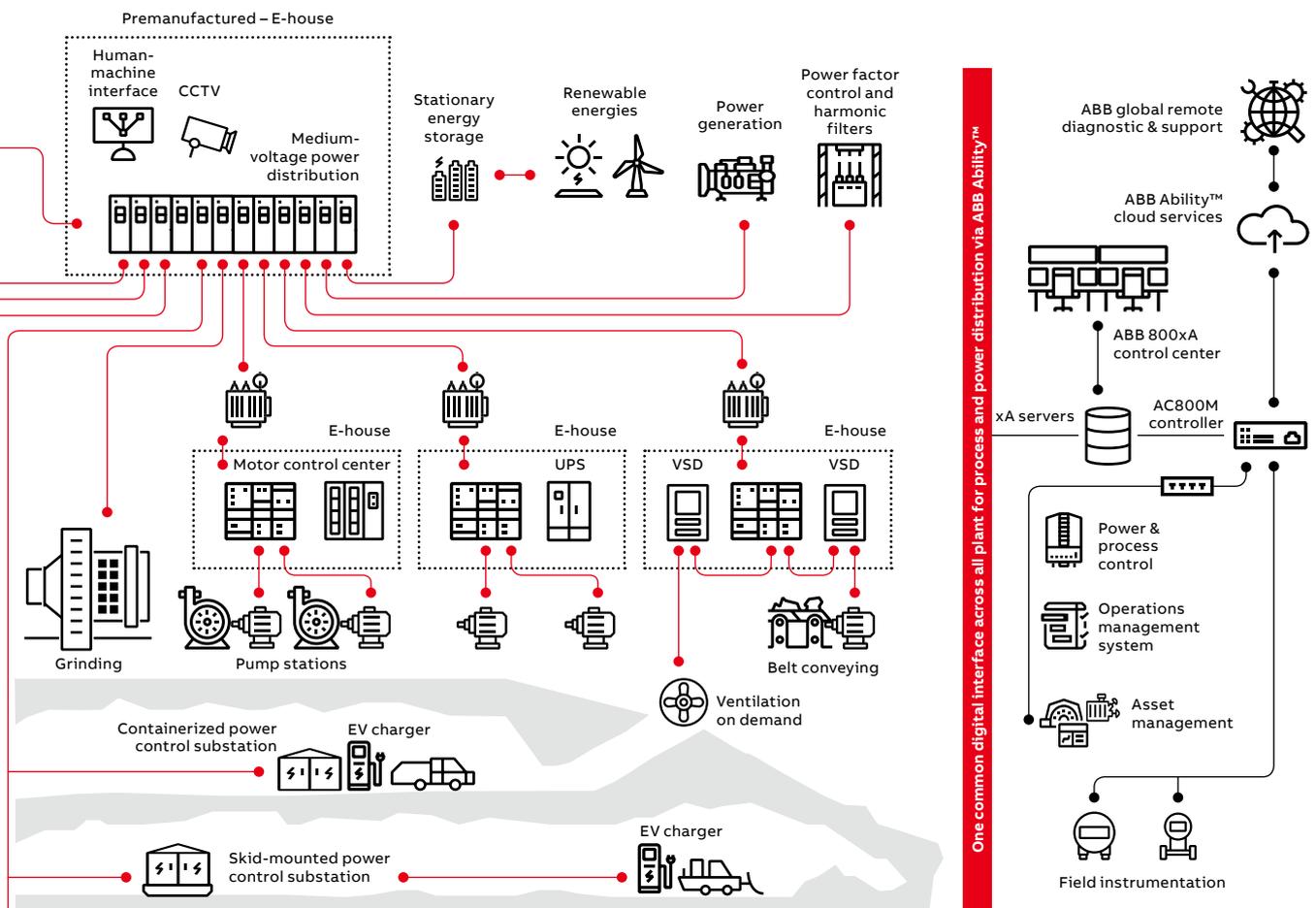
Electrification can help alleviate this situation. For example, electric vehicles (EVs) not only

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Electrification, digitalization and automation are helping the mining sector meet many challenges.

produce zero emissions but also produce less waste heat, thus reducing cooling costs. By 2028, it is expected that mining operations will employ over 30,000 EVs (hybrid and pure electric), with a market value of \$9 billion [2].

Such electrical assets, when connected to digital and automation systems, can monitor and control processes so that operations and energy usage can be optimized and made more sustainable.

In one particular copper mine, ABB’s electrification and automation efforts involving an electric trolley assist system for mine trucks help to save 830 m³ of diesel annually and reduce greenhouse gas emissions by 80 percent with a 700 m test lane and 2,700 V DC, 10 MW rectifier station →04. Four trucks, each rated at 4.5 MW (all four trucks will not run at the same time), are equipped with pantographs. Other benefits include improved local air quality, reduced production cost, less engine maintenance, higher velocities (almost double those of diesel vehicles), fewer trucks are needed, and reduced noise, vibration and cycle times.



UPS: Uninterruptible power supply
 VSD: Variable-speed drive
 AIS: Air-insulated switchgear
 GIS: Gas-insulated switchgear
 BEV: Battery electric vehicle

— 05 ABB Ability™ MineOptimize – integrated solutions from the mine to the port.

Digitalization, electrification and automation for mining

Digitalization, electrification and automation are helping the mining sector meet the challenges of declining ore resources, remote locations and rising labor and electricity costs. These technologies also help miners improve overall energy efficiency, reduce CO₂ emissions and thus operate in a more sustainable manner. ABB’s comprehensive and integrated offering – called ABB Ability™ MineOptimize – covers from electrification all the way to digital solutions and enables mining companies to achieve productivity and sustainability from mine to port →05. •

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INDUSTRIAL AUTOMATION

Automation brings safety and sustainability for oil and gas

ABB's automation, electrification and digital technologies enable energy operators to reduce carbon emissions, improve operational efficiency, lower energy consumption and integrate more renewables into the energy mix →01. Some examples demonstrate this transition to a safer and more sustainable world.



01



Stein Gulbrandsøy
ABB Energy Industries
Bergen, Norway

stein.gulbrandsøy@
no.abb.com

In 2016, global greenhouse gas (GHG) emissions were 31.2 percent higher than in 1990, with an average annual increase of 0.9 percent since 2010. The sectors that contribute the largest shares of GHG emissions are energy supply (35 percent) and industry (21 percent) [1]. There is a widespread recognition that these increases

The major energy companies are investing in low-carbon technologies and clean-energy start-ups.

cannot be stopped and reversed without significantly scaling up energy efficiency. In fact, the IEA estimates that energy efficiency could provide more than 40 percent of the emissions abatement required by 2040 to be in line with the Paris Agreement [2].

The achievement of climate goals will be also assisted by increased use of carbon capture and

storage (CCS) and renewable energy. The latter is growing particularly strongly: In 2017, 17 percent of the world's energy growth came from renewable sources – the largest increase on record – and investment in renewables is expected to reach \$7.4 trillion (cumulative) by 2040 [3]. The move to broader energy ecosystems could reduce annual CO₂ emissions by 900 million tons →02.

How are the energy majors reacting?

The major energy companies – including BP, Shell, Total, Chevron, Eni and Equinor – are increasingly investing in low-carbon technologies and clean-energy start-ups by nurturing companies working in areas such as CCS as well as wind and solar. However, strategy varies by IOC (an IOC is a privately owned international oil company, as opposed to an NOC, which is a national oil company) →03. Increasing cost pressures and an industry shift towards more remote and autonomous operations are also key drivers for this energy transition.

How ABB technology can help

In all the topics mentioned above – energy efficiency, CCS, low-carbon approaches and renewables – ABB technology helps customers

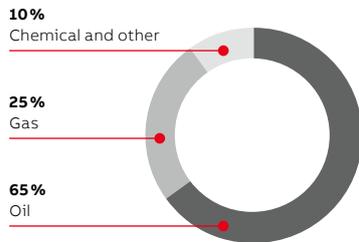


01 The Goliat floating production storage and offloading (FPSO) unit for which ABB supplied much of the electrification and automation.

02 Energy sources 2020 versus 2035. The data presented is derived from the Financial Times and various oil company press releases and reports.

03 Alternative energy and low-carbon strategies among global IOCs vary considerably.

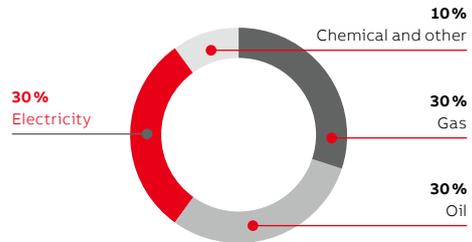
Major oil companies 2020 (10x)



02

Energy companies 2035 (16x)

Assuming 3 percent annual capex growth



Global integrateds: current activities in the low-carbon segment

	BP	Chevron	Eni	Equinor	Exxon-Mobil	Rapsol	Shell	Total S.A.
Reduce direct operational emissions	█	█	█	█	█	█	█	█
Promote natural gas and LNG	█	█	█	█	█	█	█	█
Solar	█	█	█	█	█	█	█	█
Wind	█	█	█	█	█	█	█	█
Biofuels	█	█	█	█	█	█	█	█
Geothermal	█	█	█	█	█	█	█	█
Hydropower	█	█	█	█	█	█	█	█
Power transmission/distribution	█	█	█	█	█	█	█	█
EVs/charging infrastructure	█	█	█	█	█	█	█	█
Batteries/storage	█	█	█	█	█	█	█	█
Fuel cells	█	█	█	█	█	█	█	█
Carbon capture, utilization and storage	█	█	█	█	█	█	█	█
Nature-based solutions (carbon sinks)	█	█	█	█	█	█	█	█

█ Current development focus and/or stated part of current strategy
 █ Existing area of research and/or discussed as potential investment area

03

on their energy journey so they can transition to a safer and more sustainable future. ABB’s innovative and integrated solutions digitalize, automate and electrify the oil and gas industry to improve safety, reduce carbon emissions and eliminate waste.

Automation and digitalization

Automation and digitalization are perhaps the most important methods used to support emissions reduction and increase sustainability, safety and efficiency. Here, ABB is assisting oil and gas operators to embrace low-carbon,

—
ABB is developing new power technologies for oil and gas customers.

energy-efficient production via process automation, asset management and digitalization solutions. These solutions address resource and consumption considerations, pinpoint optimal productivity levels,

drive down OPEX and provide digital insights that are key drivers in helping companies to increase environmental sustainability – ie, reduce energy use and emissions →04. The Aasta Hansteen case study presented below illustrates some of these points.

Electrification

According to the World Economic Forum, electrification is critical for decarbonization [4]. Up until 2050, demand for electricity is forecast to grow seven times faster than that for other energy sources. The primary driver of this growth is the electrification of the construction, transport and industrial sectors.

To meet the electrification demands of oil and gas customers, ABB is developing new power distribution and conversion technologies and solutions.

Accessing new energy markets

Many companies are now looking to broaden their energy mix. ABB supports automation and digitalization of the new energy markets, including wind, solar, geothermal and zero-emission hydrogen production. Though oil and gas will be around for a long time to come,

THE GOLIAT FPSO

ABB manufactured and installed all the Goliat FPSO platform’s transformers, drives and motors. Also delivered by ABB were all the field instruments and fire and gas equipment. For other equipment, ABB teamed up with specialist supplier Solberg and Andersen to provide Goliat’s control and safety valves – pneumatic, hydraulic and electrical – together with a “ValveWatch” system for monitoring them.

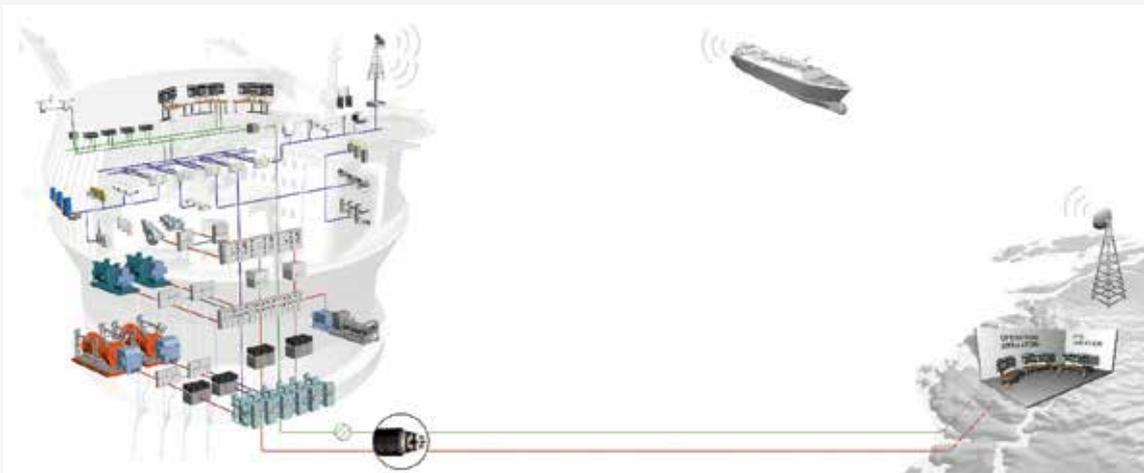


Photo fig 05: ©istockphoto.com/industryview

—
04 The Goliat FPSO.

—
05 Woodside's
Goodwyn A platform,
Australia.



05

—
ABB's pioneering subsea power distribution and conversion technology system is now commercially viable.

ABB's efforts help companies focus on how to integrate more renewable energy sources into their portfolios.

Managing availability and resilience of supply through storage

ABB is actively involved with projects that harness and store energy to ensure power is always available. Core competence here includes smart control, planned management of charge/discharge cycles and the capability to island individual sites or an entire local network from the main power grid. With an effective spinning reserve, ABB can ensure energy resilience is maintained with a level of charge suitable to cover a generation or transmission outage.

ABB will provide Woodside, Australia's largest independent oil and gas company, with a containerized, plug-and-play ABB Ability™ PowerStore™ battery storage system that is capable of remote management of operations and service. The system will be installed on the Goodwyn A platform, shown, located about 135 km northwest of Karratha in Western Australia and will replace one of the six existing gas turbine

generators. A dedicated ABB Ability™ Microgrid Plus control system will act as the brain of the solution and it will also be possible to operate the microgrid remotely →05.

CCS

ABB is currently supporting the CCS pilot project at Imperial College London (ICL), where the Chemical Engineering department is leading the charge in developing a best practice for capturing and storing CO₂. ICL's CO₂ pilot-scale absorption plant has an extensive selection of the same ABB proven products and systems that are used in a broad range of industrial applications worldwide. The plant gives students hands-on experience of the wide range of equipment ABB supplies to CCS projects – for example, Statoil's pioneering large-scale CCS process at the Sleipner field, Equinor's Snøhvit field in the inhospitable southern Barents Sea and Statoil's European Carbon Dioxide Technology Centre at Mongstad in Norway, which Statoil jointly owns with Shell and Gassnova. ABB automation systems monitor and control all three sites, to manage not only the complex carbon capture process but the production processes as well. At Snøhvit, for instance, ABB supported delivery of control and monitoring of the three subsea fields, the sea-to-shore multiphase pipeline, the liquified natural gas processing plant and ship loading. The company also supplied safety automation systems (SASs), incorporating a process and control data acquisition system, and an electrical control and supervisory system (ECSS). As a result, the entire development, under normal



conditions, is controlled by just three or four operators in the control room. The ICL training plant is ideal for familiarizing students with the very diverse set of technical challenges found in sophisticated applications such as these.

The extent of ABB's commitment to safety, efficiency and sustainability in the oil and gas business is best illustrated by reference to some projects that use the power of automation, digitalization and electrification to help customers operate more efficiently and with less energy intensity.

Subsea JIP for electrification – Norway

In 2013, ABB entered a five-year Subsea Joint Industry Project (JIP) with Equinor, Total and Chevron to design and deliver subsea transmission, distribution and power conversion systems for underwater pumps and gas compressors. These systems were to be used for upcoming and existing oil and gas processing fields in the Norwegian Continental Shelf (NCS), the Gulf of Mexico and several other offshore regions.

Following the completion of a 3,000-hour shallow-water test in late 2019, ABB's pioneering subsea power distribution and conversion technology system is now commercially viable, bringing groundbreaking potential for cleaner, safer and more sustainable offshore oil and gas production.

When pumps and compressors are moved to the seabed, production of oil and gas from new and existing deepwater fields is improved and costs lowered. With subsea operations, oil and gas producers may realize about 20 to 30 percent savings on overall expenses over a 30-year operational life, as well as a 25 percent faster project execution and completion.

Having oil and gas processing facilities on the seabed reduces overall maintenance, with substantial cost savings.

ABB's complete subsea power distribution and conversion system includes a step-down transformer, medium-voltage variable-speed drives and switchgear, low-voltage power distribution, power electronics and control systems. The new subsea electrical

— 06 The Aasta Hansteen platform, Norway's deepest field development. These systems massively reduce manual interventions and the time saved can be used for production.

infrastructure and equipment is controlled by ABB's all-in-one ABB Ability™ 800xA system, which collects real-time data to use for condition monitoring and predictive analytics that optimize performance and productivity. The system gives oil and gas operators access to a reliable and safe power supply of up to 100 MW as far as 600 km offshore and at depths of 3,000 m that is designed to withstand harsh underwater conditions.

Having oil and gas processing facilities on the seabed reduces overall maintenance, with substantial cost savings. The subsea power solution could offer CAPEX savings of more than \$500 million, for example, if eight consumers, such as pumps or compressors, are linked through a single cable over 200 km from other infrastructure, according to a specific field development case.

This world-first means that moving the entire oil and gas production facility to the seabed is no longer a dream. Remotely operated, increasingly autonomous, subsea facilities powered by lower carbon energy are more likely to become a reality as we transition toward a new energy future.

Operational efficiency gains with ABB Ability™ System 800xA on Aasta Hansteen – Norway

Located in 1,300 meters of water in the Norwegian Sea, about 300 kilometers west of Sandness-jøen, Aasta Hansteen is Norway's deepest field development. It comprises two subsea templates connected to a spar platform with Norway's first steel catenary risers →06.

Aasta Hansteen is operated by majority-partner Equinor, along with Wintershall, OMV and ConocoPhillips. It holds about 51 billion m³ of dry,

ABB's flagship digital platform reduced manual interventions by 98 percent.

low-CO₂-content recoverable gas reserves that will be transported through the Polarled pipeline to Shell's Nyhamna onshore gas plant in Norway.

On Aasta Hansteen, ABB has installed integrated safety, automation, electrical and telecommunication systems based on ABB Ability™ System 800xA. The platform includes a condition

monitoring system for over 100,000 maintenance conditions from 4,000 pieces of equipment, tools for alarm management and alarm rationalization, several safety-critical applications, and a data storage solution to store all alarms and events.

ABB's flagship digital platform reduced manual interventions by 98 percent, saving more than a month in commissioning time. Production availability can increase, corresponding to one or two days of production as full productivity is reached faster with each start-up (production value per day is approximately \$5 million).

Aasta Hansteen will strengthen the position of Equinor and the NCS as a long-term, reliable supplier of gas to Europe and the United Kingdom.

A transition to a safer and more sustainable world

The JIP and Aastad Hansteen examples described above are world-firsts but are only some of the many projects in which ABB's innovative and integrated solutions have digitalized, automated or electrified oil and gas applications. ABB is working energetically with all customers to ensure their plants operate more efficiently and with less energy intensity to make the use of our planet's resources safer, smarter and more sustainable by reducing carbon emissions and lowering waste. •

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INDUSTRIAL AUTOMATION

Solutions for a sustainable marine sector



Margarita Sjursen
ABB Marine and Ports
Oslo, Norway

margarita.sjursen@
no.abb.com

ABB's electric, digital and connected solutions in the marine sector allow vessel and port operators to improve energy efficiency, reduce emissions and operate in a connected, integrated and sustainable way.



Mei Juan Lee
ABB Turbocharging
Baden, Switzerland

mei-juan.lee@
ch.abb.com

When greenhouse gas (GHG) emissions are discussed, the contribution of the shipping industry is sometimes neglected. After all, most people do not visit ports, and ships spend a great deal of time at sea, out of sight. Nevertheless, the marine sector contributes 2 to 3 percent of the world's total GHG emissions.

Prompted by social, political and industrial factors, awareness of emissions from marine traffic is, however, increasing and action is being

taken. For example, the International Maritime Organization (IMO), the United Nations agency responsible for regulating shipping, has set a global target to cut annual GHG emissions by at least 50 percent (from 2008 levels) by 2050. Also, many marine companies are actively driving a change to a more environmentally friendly future.

Ambitious measures to reduce emissions, improve efficiency and attain sustainability can only be realized by the targeted use of

technology – in particular, automation, electrification and digitalization, in which ABB has many decades of experience →01.

Backbone for ship electrification

A good example of how automation, electrification and digitalization can work together to improve efficiency, safety and sustainability is provided by ABB's electrical propulsion concept.

ABB's electrical propulsion concept provides the backbone of ship electrification: encompassing engines, generator sets, switchboards and propulsion drives, it operates as an integrated system. The flexibility of such a system allows optimization of electric plant operations by switching the engines on and off based on the power demand – which cannot be done with a conventional mechanical setup. This capability saves fuel, with emissions cut as a result, and is particularly helpful for vessels with a variable operational profile.

Azipod® propulsion system – the driving force behind safe, efficient and sustainable operations

Thirty years ago, ABB transformed shipping by introducing Azipod propulsion [1] →02. With Azipod, the electric motor that drives the propeller sits in a pod outside the ship's hull, where it can rotate 360 degrees, thus increasing maneuverability and operating efficiency.

Azipod propulsion has a proven ability to cut fuel consumption by up to 20 percent, reducing emissions as a result. An independent study by marine consultancy Deltamarin revealed that the ABB Azipod electric propulsion system for ferries could save up to \$1.7 million in annual fuel costs per vessel and reduce CO₂ emissions by

Electric, digital and connected solutions offer dramatic gains in efficiency, safety and sustainability.

approximately 10,000 tons per year, equivalent to the CO₂ produced by about 2,200 automobiles annually [2]. Additionally, it has a minimum environmental footprint in production: about 95 percent of the material used in Azipod units is recyclable.

Today, over 25 vessel types utilize Azipod propulsion, including cruise ships, icebreakers, ice-going cargo vessels, ferries, mega-yachts, offshore supply fleets, research vessels and others.

Electric, digital and connected ship

As part of the company's pioneering role in electric transportation, ABB has provided electric systems on board vessels for more than 110 years. Today, well over 1,300 ships employ ABB electric systems and newbuilds are increasingly based on electrical architectures that expand their range of viable energy sources beyond traditional fuel – to batteries and fuel cells, for instance.

Electrical onboard systems make it easier to integrate automation and control solutions, letting operators collect and analyze more data, make better decisions and ultimately improve vessel performance. Electric, digital and connected solutions are redefining shipping, offering dramatic gains in efficiency, safety and sustainability. Here, ABB Ability™ – ABB's unified, cross-industry, digital offering – provides the marine industry with a comprehensive decision support software suite that gives vessel crews the right tools to monitor and optimize vessel efficiency.

For example, ABB Ability™ solutions help owners and operators to optimize route planning, comply with environmental regulations and improve

—
01 ABB's electric, digital and connected solutions help reduce marine industry contributions to GHG emissions.

—
02 ABB's revolutionary Azipod electric propulsion system. Shown is the Azipod DO system.



the safety of both crew and cargo. A ship's data can be sent back to a land-based control center – such as an ABB Ability™ Collaborative Operations Center – for expert analysis and preventive

OCTOPUS finds the optimal transit based on weather and wave conditions.

maintenance support →03. Round-the-clock remote support for ships anywhere in the world has become standard for over 1,000 vessels that connect to ABB Ability™ Collaborative Operations Centers, where an engineer is always available to help with any questions.

Some 500 vessels currently improve the safety and efficiency of their operations with ABB Ability™ Marine Advisory System – OCTOPUS, a digital solution that helps vessel owners gather and analyze data to optimize operations. OCTOPUS software helps find the most optimal transit based on changes in weather and wave conditions, making it a vital tool for ship safety and route planning.

ABB Ability™ Tekomar XPERT

ABB Ability™ Tekomar XPERT is an engine analytics software →04. When installed on every vessel in a fleet, Tekomar XPERT can quantify deviations in engine performance and provide simple guidance on running engines at optimum levels of efficiency. The software also offers recommended corrective actions for the realization of potential fuel oil savings of typically 0.5 to 3 tons of fuel per day, per vessel – which translates into lower emissions.

Tekomar XPERT for fleet is available via a web app interface that offers fleet functionality specifically developed to support middle and top management decisions. The software allows company-wide engine performance assessment with consolidated analysis across a fleet.

Tekomar XPERT also facilitates the benchmarking and ranking of engines, vessels and fleets and the user-friendly dashboard can be customized according to user role.

An associated, recently introduced, continuous evaluation service allows the cloud-to-cloud



03



04



05

— 03 An ABB Ability™ Collaborative Operations Center.

— 04 ABB Ability™ Tekomar XPERT engine analytics software saves fuel and cuts emissions.

— 05 ABB turbochargers, here a Power2 800-M turbocharger, are designed to be straightforward to install and maintain.

transfer of engine data from edge computing platforms to Tekomar XPERT. The service gathers data for evaluations automatically, which ensures greater accuracy and more frequent reporting, along with a reduced crew workload.

Turbocharging

Vessels powered by internal combustion engines can benefit from ABB's turbocharging technology. ABB's record-breaking Power2 two-stage turbocharging system can increase marine

Automation complements and supports seafarers, who are freed up to do other tasks.

engine efficiency significantly →05. In fact, ABB turbochargers are around 2 percent more efficient than the industry standard, while Power2 offers a turbocharging efficiency above 75 percent (compared to 65 percent efficiency with a conventional turbocharger) and is undoubtedly the most powerful energy multiplier for engines. The turbocharging efficiency of Power2 easily translates into yearly six-figure savings in fuel and significant cuts in emissions – eg, up to 60 percent less NO_x emissions.

ABB's turbocharging's service concept is moving towards smartly enabled services that are tuned to customer needs. The focus will be on individualized offerings that optimize maintenance, performance and customer experience.

Towards autonomous operations - augmenting human potential

Recent developments in sensor technology, data analytics and computing power are enabling ABB to increase the level of automation in ship navigation, steering and control. An autonomous vessel

would not necessarily be unmanned but may have a periodically unattended bridge, providing certain conditions are met. The automation complements and supports seafarers, who are freed up to do other tasks. The overall result is to make operations safer and more efficient.

ABB currently has products to support autonomous operations such as ABB Ability™ Marine Pilot Vision – a situational awareness solution – and ABB Ability™ Marine Pilot Control, an intelligent maneuvering and control system that enables safer, more efficient ship operations.

The technology for introducing autonomous operations for short-route vessels is already available today, but implementation on ocean-going vessels will take longer as international regulations are involved and real-world experience is needed to ensure automation systems work reliably.

Shore connection

ABB's shore connection technology already enables zero-emission port stays for vessels [3]. In fact, ABB delivered the first shore-to-ship power solution to the Swedish port of Gothenburg as far back as 2000 and has installed many others since. One constraining factor is that the local power grid has to be capable of supplying the extra power needed, which can be considerable in the case of a large passenger vessel, for example. In addition to enabling green port calls, ABB's shore-to-ship technology will also help reduce vibrations on board vessels and noise pollution in the port areas.

Energy storage

Energy storage solutions for zero-emission hybrid operations are already in use and will continue to grow, also in combination with fuel cell technology.

For smaller vessels that cover short distances, fully electric solutions are already being deployed. One recent example is Niagara

— 06 ABB zero-emission technology powers the next-generation, fully electric ferries, for the iconic Maid of the Mist tour at the Niagara Falls.

Falls tour operator Maid of the Mist, which ordered two new passenger vessels sailing solely by high-capacity battery packs, enabled by ABB's technology, making them the first fully electric vessels ever built in the United States providing a more pleasurable experience for tourists sailing up to the Horseshoe Falls →06.

—
For smaller vessels that cover short distances, fully electric solutions are already being deployed.

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Another example is Iceland's first electric ferry operating on a route known for its harsh conditions: ABB has supplied integrated power and electric storage solutions to the Icelandic Road and Coastal Administration's new ferry MF Herjólfur that takes over 3,000 annual trips in the rough waters between Landeyjahöfn on the mainland and the Westman Islands, covering 13 km in about 45 minutes. ABB's power distribution system Onboard DC Grid™ ensures the high efficiency of the new ferry by allowing the batteries to connect directly to the DC link, which helps avoid losses of power during charging and discharging.

Similarly, ABB converted the San Cristoforo, a passenger and car ferry on Lake Maggiore in

Italy, to diesel/hybrid operation, helping reduce emissions and increase overall energy efficiency. The conversion utilizes ABB's propulsion solutions, including batteries and an energy storage control system.

Sailing into a sustainable future

Pressures of global climate change, emerging-market economic development and growing urbanization demand new and more environmentally sustainable ways to move people and goods. ABB has become one of the world's leading enablers of sustainable transportation for all modes, including marine vessels. ABB's role as a frontrunner in sustainable transportation is to equip the marine industry with electric, digital and connected solutions that maximize the full potential of vessels and ultimately enable a safe, efficient and sustainable maritime industry. •



INDUSTRIAL AUTOMATION

ABB's integrated approach to cybersecurity

As the advantages associated with digital services have proliferated, so too have the risks of cyber-attack. Indeed, the threat of such attacks has become ubiquitous and is now a common C-suite and board level topic, regardless of business vertical. Nevertheless, cyber risks are manageable, and their control is a critical part of any digital transformation. This article highlights the core beliefs that underpin ABB's approach to cybersecurity and to keeping its customers' operational integrity and data safe.



Ragnar Schierholz
Cybersecurity Council,
Industrial Automation
Minden, Germany

ragnar.schierholz@
de.abb.com

At the center of ABB's methodology are people, processes, and technology. ABB has long been a trusted partner for industrial automation and control technology and has a deep understanding of the industries it serves and the challenges they face. Around the world, the company has delivered more than 70 million connected devices, 70,000 digital control systems and 6,000 enterprise software solutions. As a leader in the industrial space, it has four decades of experience creating secure digital solutions for customers across all sectors of industry.



Robert Putman
Cybersecurity Council
Products and Service
Zurich, Switzerland

robert.putman@
ch.abb.com

Over the years, cybersecurity has become an integral part of ABB's product portfolio in much the same way as seatbelts and airbags have become an indispensable element in every vehicle. Today, cybersecurity is front and center at every phase, from design and development to product maintenance and support. Furthermore, this applies not only to new installations but to legacy facilities as well. Indeed, many industries are facing the challenge of how to retrofit or upgrade legacy environments that were

WHITE-NOISE ATTACKS

There are two major categories of threats – targeted attacks, for example, the Stuxnet attack about 10 years ago, and so-called white noise attacks.

White noise attacks have grown tremendously in number over the last ten years and pose a very real threat to many organizations. Many of these attacks – also known as ransomware – are essentially forms of extortion run by organized crime. The danger they pose derives not so much from their sophistication but from the sheer number of targets they reach and from the weakness of their victims' defenses. An example is the WannaCry ransomware, which infected thousands of computers in 2017 and cost victims hundreds of millions of dollars.

In the industrial automation systems context, white noise attacks typically strike the HMI level, since they are usually directed at operating systems such as Windows or Linux, whereas targeted attacks are generally nation-state raids based on deep knowledge of a specific business; they are designed to, for instance, penetrate all the way into the lower levels of a distributed control system (DCS) or cause inaccurate information to be generated by sensors, actuators and closed-loop control or even safety systems or to entirely disable them. Thus, the consequences of targeted and white noise attacks are different. In the industrial space, the risk is that physical processes will be affected that can result in danger to people, the environment, and infrastructures. On the other hand, when it comes to attacks on enterprise IT systems, the bad guys are usually after either personal or monetizable information.

01

designed and installed before cybersecurity was a priority against targeted attacks and so-called white noise attacks (see box →01). With this in mind, ABB provides guidance, products, and services to address both green field and brown field applications →02.

Secure reference architecture

As part of ABB'S cybersecurity offering in industrial automation, the company has developed a Secure Reference Architecture and standard. This is a template for the entire ABB control suite and builds on the company's ability to deliver effective technologies and solutions.

—
ABB has four decades of experience creating secure digital solutions for customers across all sectors of industry.

Covering everything from access control definitions to data flows, ABB'S Secure Reference Architecture is based on years of expertise in deploying and maintaining such systems. It defines how to configure and manage technologies securely, and, thanks to its ability to visualize architecture levels, allows users to add layers of security and functionality, such as remote access, to a design.

Industrial partnerships and collaboration

The control landscape contains many third-party tools and solutions that can be integrated and validated within ABB'S Secure Reference Architecture design. Validated designs can be achieved based on the company's domain knowledge and technical expertise. In addition, as part of its design strategy, the company helps its customers select third party suppliers to optimize their integration and validation and to source and select best-of-breed solutions while applying equivalent-or-better technology as market or technology conditions evolve. Furthermore, in order to deliver an integrated technology package, ABB works closely with key technology partners. These partnerships are critical to the company's vision from a business as well as a technology perspective.

More than standards

Effective cybersecurity is more than simply adhering to standards and regulations. While ABB understands the essential role that regulations such as IEC 62443, NIST 800-82 and ISO 27002 play in ensuring cybersecurity compliance, it works closely with its customers to ensure that



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01 The threat of white noise attacks.

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02 ABB provides guidance, products, and services to address green field and brown field applications.

its designs and configurations will fully support its customers' compliance needs based on their chosen standard.

ABB realizes that its customers are concerned about protecting against and minimizing the risk of a cybersecurity incident. While asset owners have prime responsibility for any incident response procedures, ABB actively monitors for any cybersecurity threats that pose a potential impact to ABB control systems. It also proactively communicates with customers when a situation is deemed to be critical and maintains a mechanism

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ABB has the domain knowledge and experience to provide defense-in-depth security.

whereby customers can communicate any potential concerns or threats to the ABB product security group via two-way communication. All in all, ABB is well positioned as a systems integrator – a factor that is foundational to the company's cybersecurity strategy in the industrial controls arena. There are two aspects to this. The first is that the customer can trust that implementation of a 3rd party solution in ABB's reference architecture will result in optimal value.

The second is that the customer can rest assured that if there is a failure or a problem with implementation, it will, in all probability, not impede the availability or safety of assets and will ease their recovery.

Achieving the full benefits of digitization

Cybersecurity comes down to people, processes, and technology. ABB has the domain knowledge and experience to provide the defense-in-depth security that is a prerequisite for modern companies. As the digital age becomes more mature it is apparent that cybersecurity means much more than protection against cybercrime; certainly, connections need to be safe, but the value of the associated data should also be protected. ABB's view is that customers should not have to forfeit safety, value, or control in order to realize the benefits of digitization. With this in mind, ABB closes the loop between these needs with an innovative, multi-layered approach to security. •

INDUSTRIAL AUTOMATION

Navigating digitalization in big business

Digitization and automation are the enablers of the dramatic transformation of industry that is currently underway. ABB's Chief Digital Officer (CDO) for Industrial Automation, Rajesh Ramachandran, explains to ABB Review how the company is driving digital strategy.



Rajesh Ramachandran
Chief Digital Officer
for Industrial Automation

AR Many thanks for talking to us today, Rajesh. To start, you could perhaps tell us something about your background and how you came to be the ABB CDO.

RR I'd be delighted to. My childhood days were spent in small towns in India and I was highly focused on academic achievements. I topped off my degree in Electrical and Electronics Engineering with a Master's in Computer Science from the Illinois Institute of Technology, Chicago. Over the three decades of my career, I drove technology and innovation in the organizations I was part of. I started my career in operational technologies with Siemens global R&D, in Germany, before moving to Oracle in 1998, where I led Oracle's Fusion middleware and Fusion cloud platform R&D for 12 years. In 2010, I moved into big data, heading R&D for platforms for eBay and PayPal. Two years later, I joined Rolta and was given the entrepreneurial freedom to build and develop their digital industrial analytics business by combining the power of OT, IT, engineering, geospatial and Big Data.

I joined ABB in February 2019 as the CDO for Industrial Automation and I am proud of what



we have achieved so far in the digital area and excited to be a part of driving ABB's digital strategy, platform, solution innovations and business growth.

AR That is the focus of your role in ABB?

RR Yes. In ABB's Industrial Automation, I am responsible for driving the digital vision, strategy, thought leadership, platform and solutions portfolio. Our aim is to move up in the customer value chain as a trusted partner for digitalization to deliver the true value of digitalization while evolving toward safer, smarter and more autonomous operations. I take pride in the digital team we have managed to build and, together, we are confident we can drive exponential business growth!

AR How is digitalization changing how companies operate, adopt technology and manage risk?

RR That is a short question with a very long answer! But I'll try to give a brief response.

In today's highly competitive landscape, industries strive for operational excellence that enables output of the highest quality, maximized

asset performance and top reliability. And all done in the most productive, cost-effective, safe and sustainable manner. The key to achieving these aims is digital transformation, but many companies struggle to leverage its potential.

The core issue, as well as the solution, is data. Data drives digitalization. Today, an average plant uses less than 20 percent of the data it generates.

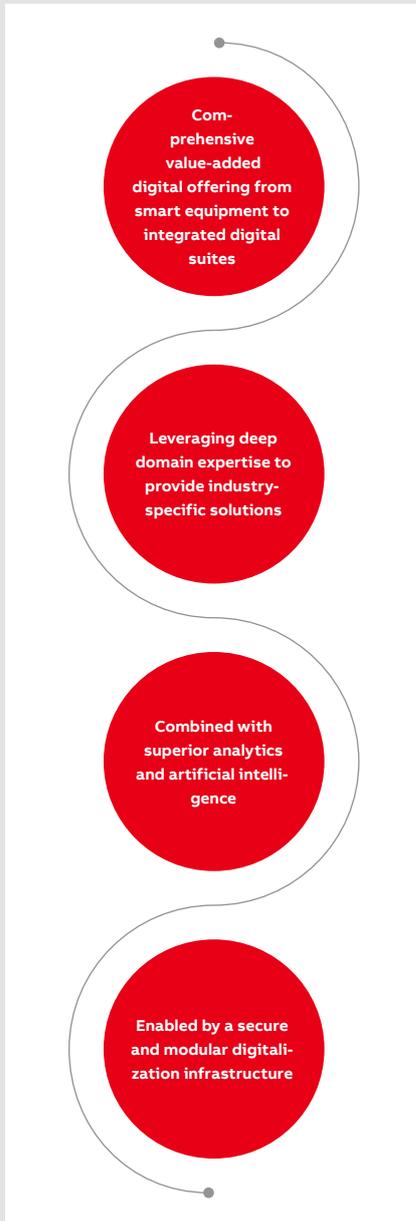
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The core issue, as well as the solution, is data. Data drives digitalization.

Successful companies will be those that can transform this data into actionable insights at the right time and thus optimize performance and reduce costs.

To gain deeper insights into a plant, a platform-driven approach is necessary to integrate and contextualize data coming from a variety

of systems such as operational, information and engineering technology – what we call OT, IT and ET. Furthermore, to unlock the true value of the data, we need to aggregate it across the enterprise, covering all units and plants. In order to produce meaningful, actionable insights, we need to automate the integration and data contextualization before applying artificial intelligence – AI – and analytics.

AR And ABB can supply the technology for such a transformation?



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RR Definitely, yes. In fact, ABB is probably uniquely placed to provide certain digital solutions for some of the complex problems in the industries. This is due to our strength in data-domain technology capabilities →01. ABB is able to address the spectrum from smart digital assets and equipment to integrated digital systems →02. We have hundreds of digital solutions powered by the ABB Ability™ platform. Also, we recently launched the ABB Ability™ Genix Industrial Analytics and AI Suite, which combines the company’s industrial automation and deep-domain expertise with Internet of Things technology and advanced analytics investments to help customers realize a safer and more productive and profitable future.

AR What digital transformation programs have you been involved with at ABB and what impact have they had for the customer?

RR As you might expect, these activities are many and varied. During the last year, for example, we implemented strategic initiatives to strengthen our capabilities. As part of this move to accelerate digitalization growth, a new ABB Industrial Automation business-level digital startup called IA Digital was set up. This new team introduces strong skills in industrial analytics, AI platform development, digital product and portfolio

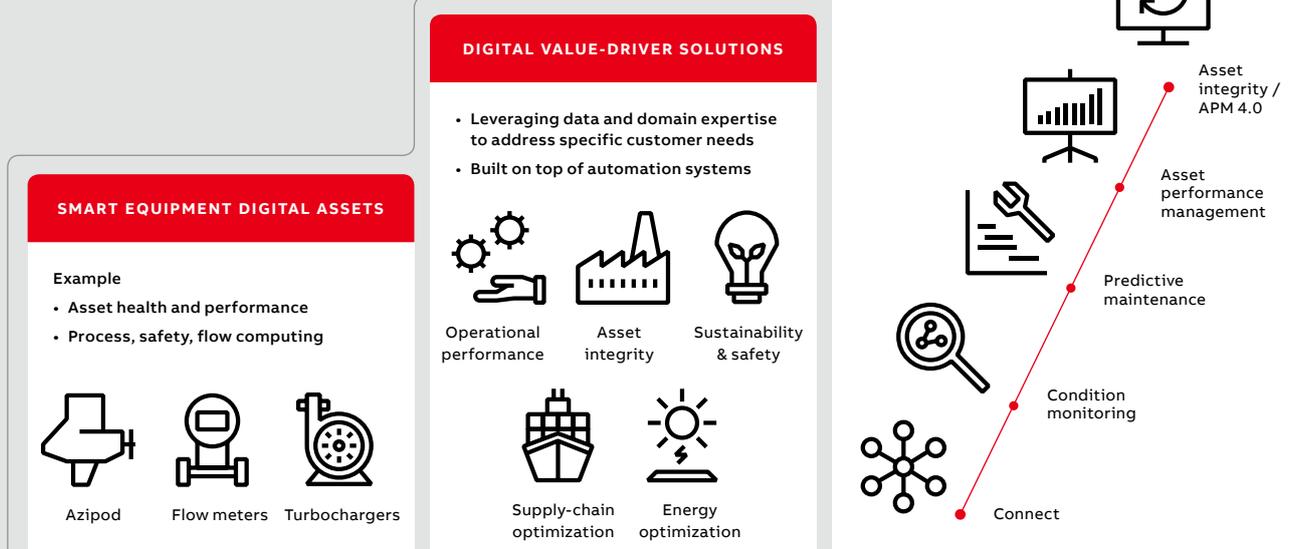
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ABB is probably uniquely placed to provide certain digital solutions for some of the complex problems in the industries.

management, industrial value engineering and solution engineering for enterprise-scale integrated systems. Additionally, the ABB Industrial Automation Process Control Platform Team was set up to innovate next-generation automation and OT digitalization capabilities. As I mentioned above, we also recently launched the ABB Ability™ Genix Industrial Analytics and AI Suite, which unlocks the power of contextualized data coming from operational, IT and engineering systems, together with domain expertise and advanced analytics to accelerate Industry 4.0 digital transformation.

AR Do you have an example of a digital transformation that is making a big impact?

01 Harnessing ABB strengths to enable powerful outcomes for industry.

02 Entire digital value chain from smart equipment to integrated digital systems.



02

RR Again, there are many. One that has a significant customer impact is ABB Ability™ Collaborative Operations →03. With this, we are helping our customers to transform as well as improve the way we serve them, with 24/7 access to experts. Through this offering, we are now connected to over 900 industrial plants, 1,200-plus marine vessels and more than 40 mines – helping them achieve increased productivity, higher uptime and safety, lower maintenance costs, improved operational performance and reduced energy and fuel costs.

AR Are there any other factors speeding the digital transformation?

RR In order to accelerate our digital journey, we have defined a strategic framework built on six pillars. These cover the enrichment of our digital offering, strengthening go-to-market and sales capabilities, innovation in the digital business models that are aligned to customer buying patterns, development of a rich and modular digital solution platform, investment in people’s digital capabilities and enhancement of digital maturity and culture.

AR What struggles do companies have with the digitalization agenda?

RR The main struggle is that some have a hard time dealing with change. But we can help our customers to change and change always starts with doing something differently. Everyone agrees that digital is the way forward and many enterprises have transformation programs ongoing. Companies across industry strive to

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ABB Ability™ Collaborative Operations transforms how we help customers, with 24/7 access to experts.

be cost-competitive, achieve greater customer intimacy and provide better products and value-added services. On the other hand, they have pressures to be flexible and agile, sustainable and resource-efficient, while ensuring their

assets can run in a safe and reliable manner. Achieving a few of these objectives is a challenge, but achieving all at the same time would truly differentiate them.

AR And data can help them out?

RR A recent report suggests that 80 percent of data in an enterprise remains unutilized and up to a 40 percent productivity gain can be achieved by harnessing this data through analytics and AI. However, the greatest challenge is the effort involved in properly integrating and contextualizing the data for it to be meaningfully analyzed. Organizations have spent millions of dollars to

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Increased productivity will make people’s jobs more secure and more valuable.

create large data warehouses and data lakes but have failed to create a noticeable business impact. Creating a well-defined digital transformation journey so that data can be turned into actionable insights requires a fine blend of technology and data knowledge, and deep industry-specific domain expertise.

AR Do industrial businesses understand the value that can be gained from digitalization and automation?

RR Most businesses see the advantages right away, especially when we outline how they can digitally reinvent themselves and transform their business for the better.

AR How should companies ensure their employees engage with the process? People might be worried that more automation might mean fewer jobs?

RR This question often comes up. Each successive innovation causes a job evolution – and this process continues today. Digitalization is clearly a must for organizations that want to gain a competitive advantage. It is critical to show how data and insights empower every role to excel. In the end, increased productivity will make jobs more secure and more valuable.

AR How should companies go about finding the right automation partner to help them with the process?

RR Well, I’d recommend they call ABB! With our vast experience – built up over a period of 130-plus years – and pioneer work in the four industrial revolutions, we deliver the integrated systems



Photo fig. 03: ©agrus/stock.adobe.com; fig. 04: ©TMLsPhotoG/stock.adobe.com

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03 An ABB Ability™ Collaborative Operations Center is a service delivery model that connects people in production facilities, headquarters and ABB to deliver objective data insights that ultimately increase customer profitability by improving plant efficiency, increasing safety, reducing risk and lowering costs.

—
04 Enterprises that have a well-defined digitalization strategy can increase productivity, reduce uptime, lower maintenance costs, improve operational performance and lower energy and fuel costs.



04

that uniquely combine the power of electrification, motion, automation and digital to drive safe, smart and sustainable operations in a

—
We have a well-defined digital strategy, unique value propositions and differentiated domain-rich offerings.

variety of industries. ABB is clearly well placed to embark on such digital journeys with its customers through its unique value proposition of data, domain knowledge, scalable platforms and technologies, proven solutions and strong capabilities to drive large transformation programs.

AR Sustainability is a very important topic. How can automation processes help customers on their journey toward more sustainable operations in terms of environmental sustainability as well as safety and business continuity?

RR Safety and sustainability are indeed high priorities for ABB. Today, close to 60 percent of ABB's revenues are generated with products that have a positive impact on energy efficiency. ABB advanced analyzers and automation products

facilitate energy optimization, emission control, renewable energy and CO₂ reduction.

AR The digital landscape seems to be developing at an unprecedented speed. Do you have any closing words for us as to what the future holds, Rajesh?

RR There is no doubt that everything that can be digitalized, will be digitalized. We need to find new growth pockets and complement what we are already doing well with innovative approaches that are dramatically different to drive disruptive value to our customers. We have a well-defined digital strategy, unique value propositions and differentiated domain-rich offerings and are poised to write the digital future together with our customers!

AR Thank you for the interview, Rajesh. •

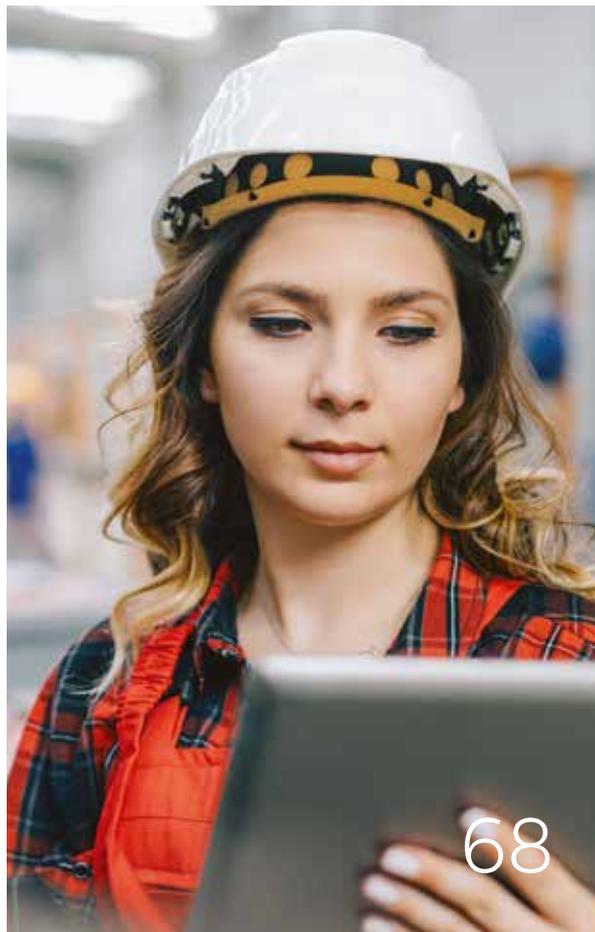
Utilizing knowledge





Just like natural ecosystems, industrial processes must evolve in order to survive, not only to continuously tighten existing performance requirements but to anticipate and address variable or new ones. A smart system needs to be able to learn, and ABB is working with customers to help them achieve the resulting insights and put them to work.

- 54 More sustainable energy usage with ABB's EQmatic Energy Analyzer
- 63 Better performance with advanced data analytics for cold rolling mills
- 68 Unleashing efficiency with ABB's Intelligent Knowledge Assistant, IKA
- 74 Anomaly detection algorithm keeps robots in the pink





UTILIZING KNOWLEDGE

More sustainable energy usage with ABB's EQmatic Energy Analyzer

EQmatic extends smart building efficiency by analyzing historic and instantaneous data. Available in three models for communication with any meter on the market, this analyzer helps customers reach intelligent energy efficiency in homes, businesses and installations of all sizes.



In today's world, it is essential for residential and commercial buildings to manage energy usage proactively to achieve sustainability and lower costs. With energy savings of between 13 and 66 percent [1], intelligent efficiency applied to smart buildings is the ultimate way to boost sustainability and maximize building energy efficiency. If data is the currency needed, then these intelligent interconnected devices and systems used to accumulate, store, analyze and visualize relevant data are the transaction hubs and banks that make these energy assessments and savings possible. ABB's EQmatic Energy Analyzer is just such a device for energy monitoring and diagnostics in today's smart buildings. This compact solution is designed to monitor, log, visualize and analyze energy and consumption data originating from electric, gas, water or heat meters in homes, industries and facilities – anywhere meters can be installed.

The EQmatic range of analyzers

The EQmatic solution is available in three main models using either an M-Bus, Modbus or KNX communication protocol to accommodate the diversity of meters on the market →01. Individually configurable to web-based user interfaces, each EQmatic model is also available in two variations depending on the maximum number of connectable meters: 16 or 64. In this way,

ABB offers a range of analyzers to fit the installation size and meter type customers utilize. Accurate monitoring of energy flows and costs allows customers to identify energy losses, thereby optimizing usage and reducing expenditures while fostering sustainability →02.

Released in 2018, EQmatic Energy Analyzer, is the first digital management solution for data collection via M-Bus meters. Customers benefit from rapid and easy installation and commissioning along with the support of ABB's portfolio of energy

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ABB's EQmatic Energy Analyzer is the ultimate device for energy monitoring and diagnostics in today's smart buildings.

management systems. Especially suited for companies that endeavor to fulfill ISO 50001 certification, the EQmatic Analyzer can be integrated with any meter (electric, gas, water or heat counters) independent of the meter manufacturer, via a customized meter configuration.

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Dominiak Lis
Marek Wrzesniak
 ABB Electrification,
 Smart Buildings
 Krakow, Poland

dominik.lis@pl.abb.com
 marek.wrzesniak@pl.abb.com

Stefan Vogel
 ABB Low Voltage
 Products
 Heidelberg, Germany

stefan.vogel@de.abb.com



01

EQmatic main features:

- Automatic detection of ABB EQ meters (A- and B-Series) and M2M network analyzers
- Load control function, alarm function and monitoring of environmental parameters (KNX)
- Local data storage and data-sharing options
- Integration into ABB Ability™ EDCS
- Graphical data analysis via dashboard/chart diagrams and data export options

EQmatic hardware

The core of the EQmatic Analyzer is a base module with a MICROCHIP SAMA5D3 Cortex-A5 processor. This processor is equipped with 512 MB of DDR2 Random-access memory (RAM) with 256 MB NAND memory available for the operational system. There is an additional 8 GB eMMC flash for local storage. The

hardware's robust design, essential in today's market, was confirmed by electromagnetic compatibility (EMC) laboratory tests performed according to International Energy Commission (IEC) standards.

Depending on the connected meter type, customers can choose between EQmatic M-Bus, MODBUS-RTU or KNX-TP communication protocols. All versions communicate with the external world over a Transmission Control Protocol (TCP)/Internet Protocol (IP). An ethernet link provides access to a web-user interface via a HTTP/HTTPS application protocol; this link is used to share data with external systems via Representational State Transfer Application Programming Interface (REST-API) or MODBUS TCP/IP →03.

EQmatic communication protocols

Recognizing the trend to foster cooperation between manufacturers and products; hardware and software and the interfaces between these components, ABB has designed EQmatic Analyzers to boost compatibility. Depending on

The EQmatic solution is available in three main models to accommodate the diversity of meters on the market.



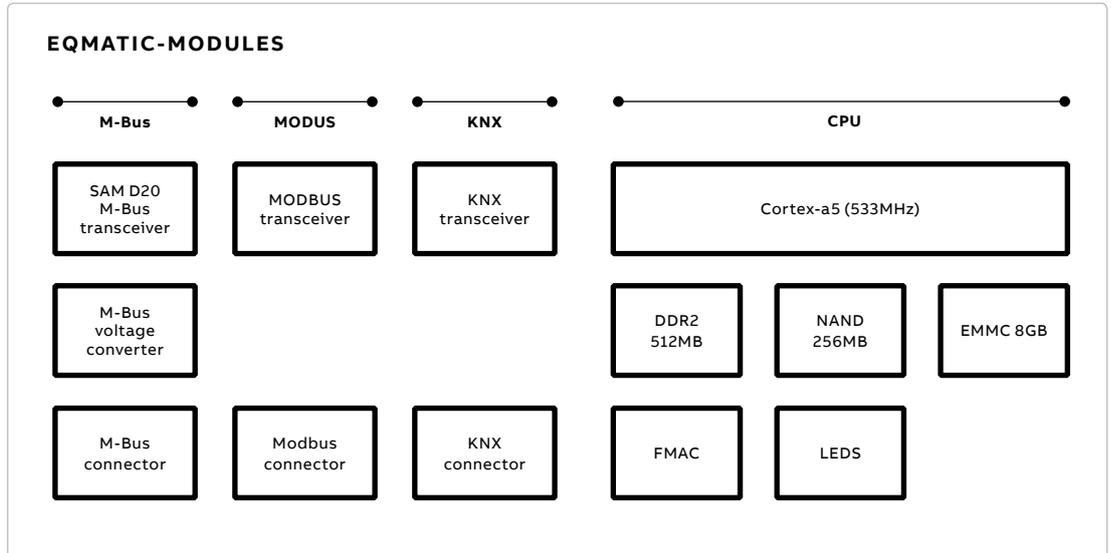
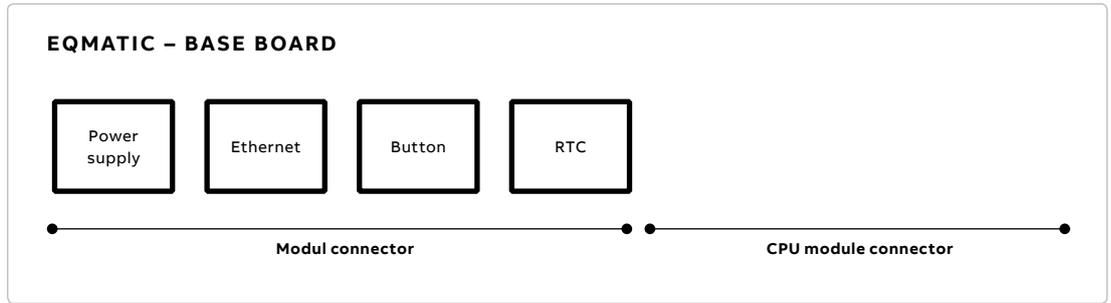
02

the application, ABB's EQmatic relies on Modbus-RTU, RS-485 standard, the Modbus/TCPm the M-Bus MDRC or the KNX protocol standards to ensure customers have the data diagnostic functions they require to reach their sustainability goals cost-effectively.

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01 EQmatic comes in three models differentiated by communication protocols: Modbus, Knx and MBus.

—
02 The EQmatic user interface allows customers to view significant data.

—
03 The EQmatic analyzer baseboards and modules are illustrated.



03

The M-Bus communication solution

The M-Bus is a standard protocol with a dedicated interface created for the remote reading of utility meters. In such a network there can only be one client device: the master. This master initiates commands with multiple servers, termed slaves; these servers respond to requests and commands; and provide data. Here, EQmatic fulfills the main role as client/master. In accordance with the M-Bus master requirements, EQmatic is able to power up to 64 meters, connected within a bus topology. All communication aspects related to the M-bus interface have been implemented in an external transceiver based on a MICROCHIP SAM D20 microprocessor. This chip has internal modules such as an A/D converter, D/A converter and analog comparator used to setup bus voltage references. Working with as little software as possible, EQmatic is able to create dynamic impedance, which is necessary to handle M-Bus communication.

The Modbus communication solution

By developing an EQmatic with Modbus communication, a standard serial communication protocol originally published by Modicom, ABB ensures compatibility with a variety of industrial electronic devices and prevalent high-level management systems,

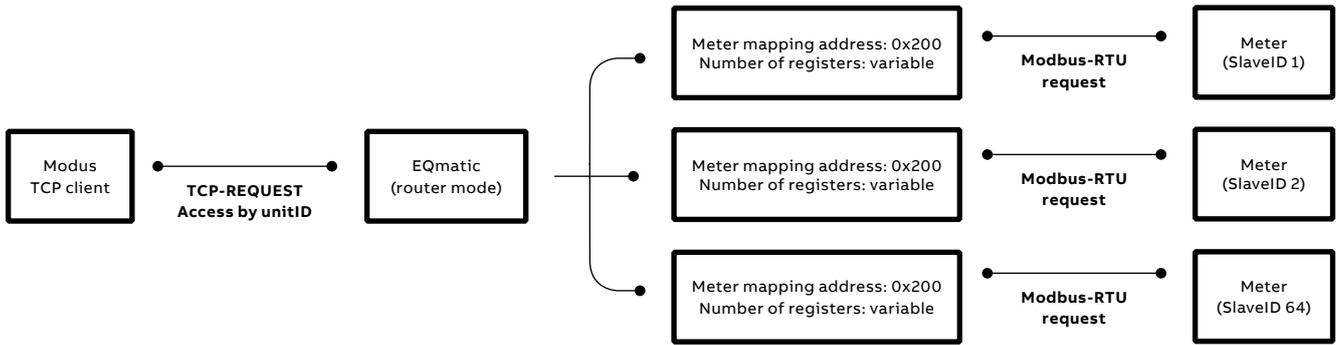
eg, Supervisory Control and Data Acquisition control system architecture (SCADA).

The Modbus-RTU RS-485 standard has been implemented to retrieve data from utility devices. Another variation, the Modbus/TCP provides communication through TCP/IP networks, which, by default, use port 502. The TCP Modbus

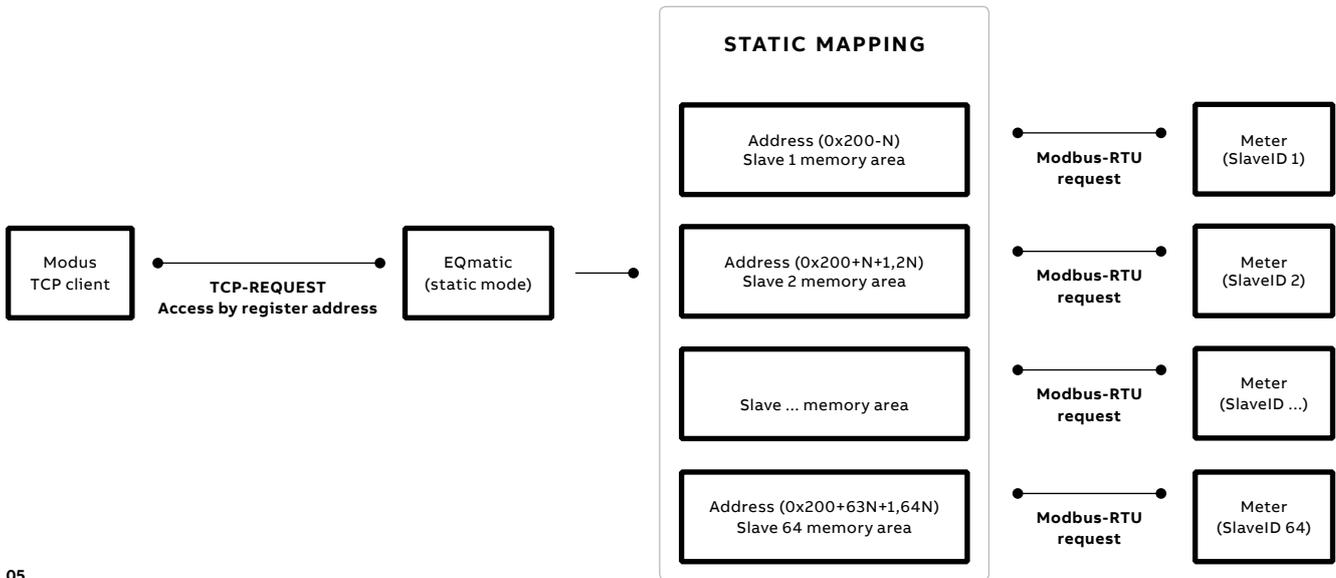
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Released in 2018, EQmatic is the first digital management solution for data collection via M-Bus meters.

allows the design of the client to be as simple as possible. Compared to the MODBUS-RTU, the Modbus TCP does not require checksum algorithms to verify the integrity of the data because lower-level software layers already provide checksum protection.

EQmatic Modbus/TCP acts as a data server that can be integrated with any client, eg, SCADA, to retrieve available data – a clear advantage.



04



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Moreover, the end user can employ any third party meter with this analyzer, even those meters with different register lists. The result is enhanced compatibility between devices.

Further, to help customers get the most from EQmatic, ABB’s software provides users with two modes of data sharing: router mode and static mode. In the first mode, the software acts as a

To get the most from EQmatic Modbus, ABB’s software permits two modes of data sharing: router- and static mode.

“router” to the meters and all meter data points are available in a Modbus/TCP register mapping →04. The request requires unitID (slaveID in MODBUS-RTU equivalent), the register address

and number of registers. Additional information about data points like coding or multiplier are consistent and values are mapped in accordance with the meter types →04.

The second mode, “static register mapping”, permits the user to read all meter data points. Although usually an advantage, this ability can be unfavorable; such as a case in which a variety of coding is used for the same data point type; typically, the result of using diverse meter suppliers. EQmatic’s answer is to create a static register mapping, organized to provide linear addressing ability for every connected meter. All data points are predefined in EQmatic’s memory and each meter has a dedicated address space. This obviates the need to know the unit ID to receive the required data →05.

The KNX communication solution

The KNX is an open standard commonly used in commercial and domestic building automation systems to operate lighting, blinds, HVAC, audio systems or remote controls. The communication

protocol can use twisted pair, Powerline or IP links. On such networks, there is no master device; interaction is achieved in distributed applications implemented via models with standardized data points and objects.

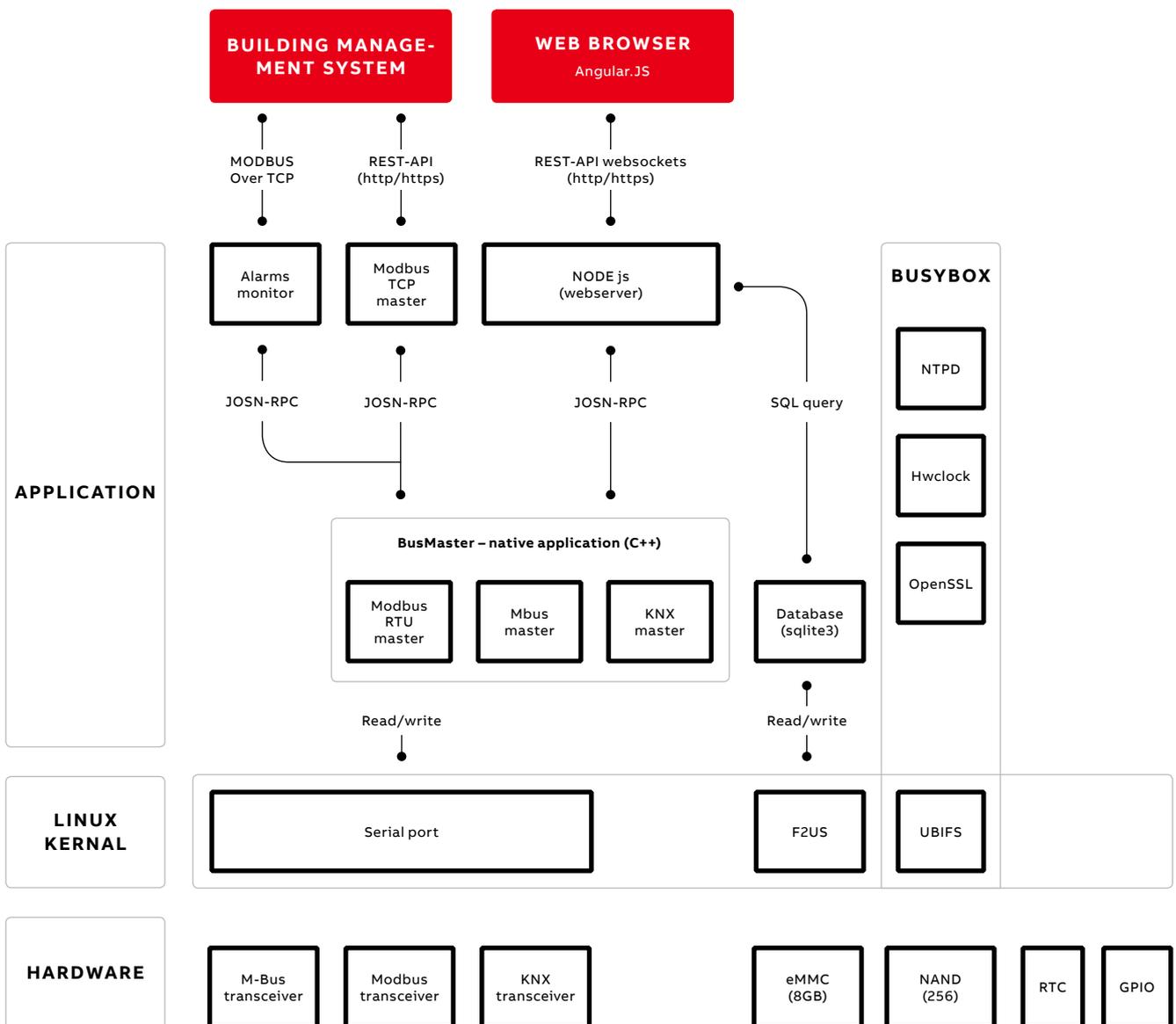
ABB's EQmatic Analyzer uses twisted pair cabling to fetch the meters' data and send control objects. The IP link is dedicated to speed up the downloading configuration, which is created in an ETS configuration tool delivered by KNX organization. This KNX Analyzer is the only device from the entire EQmatic range that provides customers with a load control function. To realize power management, EQmatic connects with end-devices like SE/S, by sending the load shedding stage. When power exceeds the configured limit for longer than the configured time, the

controller sends the load shedding stage 1 to the KNX bus. If there is no follow-up reaction or the reaction is too small to drop the power below the limit, then the next shedding level, level 2, will be

With up to eight shedding stage levels possible, EQmatic KNX Analyzer allows customers to easily create a power control plan.

transferred. If the network contains a sub-device in which the shedding state is equal to that which QA/S sends, then the device switches off the line.

- 04 The router mapping mode for sharing data.
- 05 The static mapping mode for sharing data.
- 06 The system overview is illustrated.



Because up to eight shedding stage levels are possible, customers can easily and efficiently create a power control plan.

Added reliability with Linux

The EQmatic is controlled by an embedded software that runs on a customized Linux system due to this system’s track record of reliability and stability. The system contains a bootloader, a Linux kernel and the root file system. Thus, the complete system has been created with an opensource, easy-to-use and efficient Buildroot environment, where all components are collected and linked to the single Linux Image.

The system runs on a separate 256 MB NAND chip, and uses the UBIFS file system. Memory is divided into two 120 MB areas with two installed systems. During runtime, only one system is activated; it runs in read-only mode

Because only one system is activated in read-only mode during runtime, product lifetime is vastly improved.

without the possibility to perform write operations. This setup improves product lifetime cycle since these memory types tend to degrade most when write operations are performed. Updating the system is a snap, the complete Linux Image is installed into the inactive memory compartment.

There is an additional eMMC memory with a capacity of 8GB that has both read and write permission; data is stored separate from other

operations that require persistence. Having two different memory areas increases reliability by providing a separation between system operations and user activities.

Software architecture

Because the system has been designed to work under Linux control, the web-user-interface is realized in the application layer; it is based on Node.js (backend) together with Angular.js (frontend) →07. All communication differences between the three hardware variations are organized as a single process: BusMaster. The latter, a core for transferring data received from utility meters to a higher layer of application, is equipped with JSON-RPC with an easy extendable API. Thanks to this separation, ABB’s experts can easily add other services that use meter data to meet customer needs, eg, meter value monitors (alarms) or additional data sharing functionality – Modbus/TCP.

Web user interface

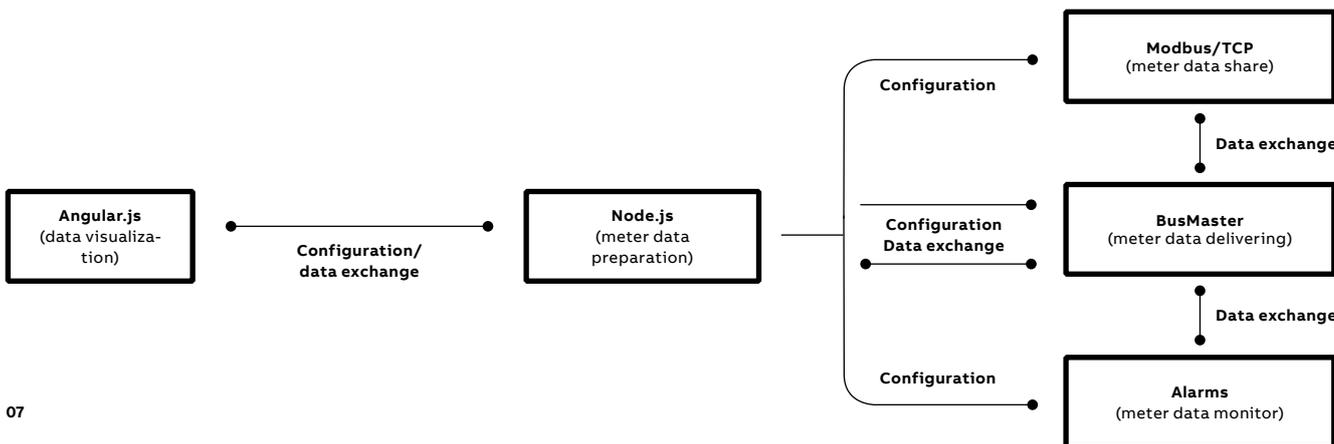
The user interface has been organized into four main sections: dashboard, analytics, management and system:

Dashboard contains:

- Freely configurable view for every system user via widgets

Analytics contains:

- Historic data – review history with several chart options
- Usage split – split history
- Instantaneous values – real meter values
- Benchmark period – historical periods
- Benchmark consumer – consumer’s history
- Reports – automatic/scheduled reports via email or FTP
- Alarms – value monitoring with notifications
- Manual data export (.csv, .xlsx, JSON, PDF)



DASHBOARD – CONFIGURABLE VIEW

- Organized with widgets
- Shows real time meter values
- Shows historic consumption/cost values
- Shows cost split
- Consumer ranking



08

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07 Schematic illustrates the basic communication flow.

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08 An overview of EQmatic's main functionalities.

LOAD CONTROL (KNX ONLY) – POWER CONTROL

- Sets power limit when load should be OFF
- Sets hysteresis and reactions times
- Configurable from ETS or web UI
- Visualizes real power
- Sets limits on chart

**ALARMS – VALUE MONITOR**

- Multiple thresholds for value monitoring
- Over limit/under limit timer configuration
- Configurable activation date
- Sends notification to the web UI
- Sends notification by email
- Alarm visualization on dashboard widgets
- Alarm events history

**ANALYTICS – HISTORICAL DATA**

- Selectable metering tree structure
 - History review:
 - Cost/income
 - Consumption/generation
- Imported/exported power
- Export functionality
- Two axes for data visualization
- Compare data from up to 5 meters
- Data split analyzes possible
- Two period comparison

**ANALYTICS – INSTANTANEOUS VALUES**

- Selectable metering tree structure
- Visualization of real time values
- Selectable meter data points

**Reference**

[1] Buildings, Smarter Facility Management “Networked systems lead to greater energy efficiency”, 11 Jan. 2015, Available: <https://www.buildings.com/article-details/articleid/19537/title/how-smart-buildings-save-energy>, Accessed: 4 Feb. 2020.

Management contains:

- Meter management – add/remove data source from the system
- Metering structure – creates tree structure and assigns meters
- User management – creates administrator or normal user with limited access
- Tariffs and units – utility prices used for cost calculation
- Consumer groups – utility consumer
- Data sharing – User Modbus/TCP or REST/API to share data with external system

System contains:

- Data and time settings
- Network settings
- Update – select update package or configure automatic update server
- SMTP configuration – configure SMTP to allow sending emails
- SSL certificate – generate or upload SSL certificate
- Erase data – restore factory settings
- System log/diagnostics – history of events

Intelligent energy efficiency with EQmatic

By choosing an EQmatic model for their commercial or residential building, customers get a smart energy analyzer characterized by a full range of functionality: historical and instantaneous analysis as well as configurable dashboard views →08.

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Whatever EQmatic model customers choose, they get a smart energy analyzer characterized by a full range of functionality.

ABB's EQmatic Energy Analyzers are just what customers need: these smart digitally connected and future-proof devices ensure the perpetual whole-building energy optimization to meet sustainability goals and cut costs. •



D
25

 UTILIZING KNOWLEDGE

Better performance with advanced data analytics for cold rolling mills

ABB's new digital service, ABB Ability™ Data Analytics for cold rolling mills, helps customers identify suboptimal production and quality. Available on-site or as a cloud service, this flexible digital tool allows expert engineers' knowledge to be utilized directly.

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01 Cold rolling mill customers can depend on ABB's experience and expertise to find ways to enhance performance and quality.

Cold-rolling mills (CRM) are an integral part of the metal production process, especially for steel production. To stay competitive, customers demand increased product quality; this means that acceptable thickness and flatness tolerances must decrease while surface quality must improve. And yet, increasing product diversity means that mills must handle a variety of materials while maintaining or even improving throughput and yield. To meet global market demands and remain competitive, producers of flat rolled products increasingly seek inexpensive ways to improve performance and product quality [1]. Responding to these business and technical needs, ABB has developed the next generation CRM digital solution: ABB Ability™ Data Analytics for cold rolling mills →01.

ABB's advanced data analytics tool is rooted in the basic idea that CRM operators would gain crucial insight about performance, especially about deviations in product quality or problems with the production process, if they could observe equipment status in near-real time. But, achieving this goal is more easily said than done.

Exploiting the full production potential of CRM in today's extremely competitive market requires a connected and integrated approach to automation, optimization, control and decision-support tools. The rolling process itself uses an upper and

lower roll to reduce the thickness of a metal strip to a desired uniform thickness at a temperature below the crystallization temperature of the metal or alloy. Despite the conceptual simplicity of the goal, the rolling mill process is complicated and depends on a multitude of factors [2].

Nowadays, CRMs are equipped with modern control systems that include multiple sensors that continuously record vast amounts of data from measurements of flatness, tension, speed, strip thickness, etc. Control loops are put in place

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To meet global demand and stay competitive, CRM customers demand increased product quality and performance.

that react to this data. With sampling times in the range of milliseconds; approximately a thousand measurements of different sensor values are taken for each time-instance. Consequently, more than 3 GB of data are generated daily during mill operations. The available data is routinely exploited by ABB service engineers for the commissioning and maintenance of rolling

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Felix Lenders
Nuo Li
Dennis Janka
Andrew Cohen
ABB Industrial Automation
Ladenburg, Germany

felix.lenders@
de.abb.com
nuo.li@de.abb.com
dennis.janka@
de.abb.com
andrew.cohen@
de.abb.com

mill devices with use of control loops. Nevertheless, this vast and valuable data is not regularly analyzed for performance purposes because manual analysis and data pattern screening require extensive effort and deep-domain knowledge – a tedious and costly endeavor.

To help customers unlock the enormous insight potential from raw data and to efficiently analyze the performance of their systems, ABB leverages the exceptional deep-domain knowledge of its engineers and draws on advances in neural network and advanced analytics applications for operational data to create an innovative digital service solution for process industries: Digital Solutions for Industrial Processes (SODA). Some key concepts derived from ABB’s research

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By recognizing anomalies and best case circumstances, SODA allows CRM operators to manage their production process.

project, SODA, have been integrated into the new release of ABB’s CRM Data Analyzer: the ability to monitor and to detect problem signatures. In this way, the new CRM digital tool provides customers with the data they need to check the status of their cold rolling mills to assess productivity and product quality. By quickly guiding users to relevant information and providing interactive diagrams and plots, the CRM analyzer permits engineers to focus rapidly on relevant details: This simplifies analysis and fosters swift decision-making. Hence, actions can be taken to correct problems with less manpower.

Monitoring CRM operation

Because product quality and system productivity are critical key performance indicators (KPI) that directly impact profitability for CRM customers, operators continually monitor metrics to be able to detect deviations as early as possible. The goal is to recognize any perturbation that indicate possible industrial process degradation.

SODA is a sophisticated digital solution that helps customers fulfill their monitoring demands. By recognizing anomalies and best case circumstances, CRM operators can better manage their production process. In a first step, SODA synthesizes a “golden coil” from available historical data. The golden coil is a fictional coil that consists of time segments of varying lengths retrieved from the historical data at a time when product quality and mill productivity were maximal. Thus, these segments represent those operation modes in which the highest quality and productivity values were attained.

With this golden coil as a reference, SODA analyzes deviations within the historical data, thereby automatically learning a range of functional process behaviors, which are classified from poor to excellent. Currently, up to 100 different performance indicators are extracted from sensor measurements to compute the productivity and quality key performance indicators (KPIs) →02.

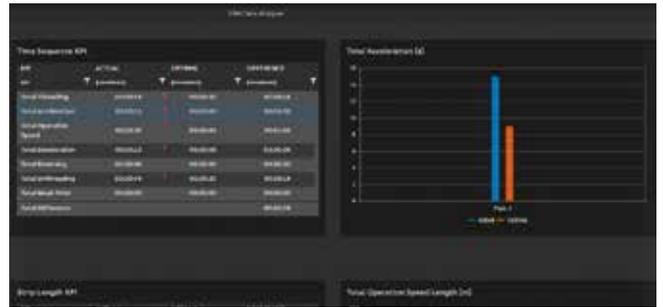
Once KPIs are calculated, SODA permits the user to assess the performance of the coil currently in operation by comparing it with the calculated golden coil and with examples of historical coils produced from the specific device being assessed. Coils can then be clustered according to performance (expressed by several indicators). This information is mapped to an instance of rolling a coil. By using the interactive graphical user interface (GUI) views provided by SODA, engineers can easily explore all relevant data. For instance, coils that demonstrate poor performance can be readily assessed and engineers can visually recognize patterns and any deviations; this makes troubleshooting easy.

With multiple ways to explore data, SODA allows CRM engineers to thoroughly evaluate performance quickly and accurately →03a–c. For instance, a coil characterized by poor performance can be selected; the velocity profile of this coil can be superficially compared to the golden coil. The engineer can also delve into detail and compare the selected dysfunctional coil with the optimal golden coil of any performance indicator →03b and, as a result, ascertain the reason for





03a



03b



03c

02 A CRM Data Analyzer example of golden coils are clustered according to their productivity and quality KPIs.

03 Engineers can explore a variety of performance and product quality issues with the CRM Analyzer.

03a Velocity versus time for an individual dysfunctional coil is compared with the optimal golden coil. Poor performance is due to slower velocity and a longer period of acceleration than would be acceptable.

03b Detailed view of time-dimension KPIs and length-dimension KPIs. Blue refers to the actual coil while orange indicates the "golden coil".

03c A spectral analysis example used to detect roll eccentricity.

poor performance →03a–b. Roll geometry problems are also challenging and difficult to detect. Roll eccentricity can cause periodic variations in the roll gap; this can lead to undesirable variations in the thickness of the rolled product, negatively affecting both quality and productivity. Using spectral analysis, ABB's digital solution for CRMs helps engineers detect roll eccentricity in near-real time →03c.

Detecting problem signatures in CRMs

SODA uses sophisticated algorithms to detect various characteristic and common problem signatures in time series data that arise from measurements: changing properties of incoming materials, eg, changing hardness of incoming material, or measurement mismatches due to improper tuning of control loops. Some of the algorithms are based on conventional signal processing while others rely on a machine learning-based approach rooted in deep and recurrent neural networks. The latter approach is especially suitable for time series data analysis due to its ability to model discrete time dynamic behavior. The process follows a conventional machine-learning approach in which a model is created during a training phase. The actual pattern of interest, which is intended to be detected, is characterized by examples as determined by a domain-expert and used to train the model. Finally, the model locates patterns within

the time series data that are similar to those machine-learned examples.

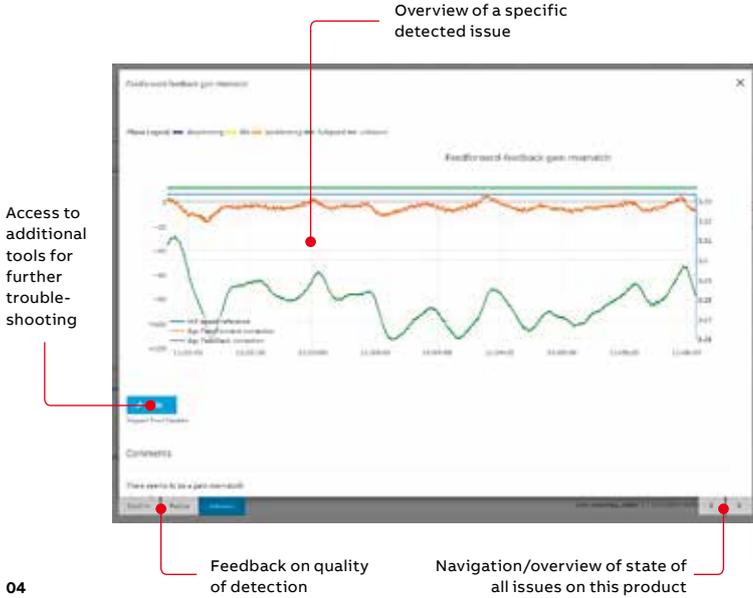
Operators can rely on ABB's newest CRM tool to swiftly detect improperly tuned control loops →04. At times, the magnitude of the correction of the feedback control loop can be much larger than that of the feedforward control loop, yet correlate (having the same visual appearance) to the correction in the feedforward control

With multiple ways to explore data, SODA allows CRM engineers to thoroughly evaluate performance quickly and accurately.

loop. Here, the CRM tool visually indicates that both control loops are performing the same function; this is an undesirable state that leads to productivity losses. For the feedforward control loop to optimally fulfill its functional potential and perform the correction without the need for feedback control, the operator can tune the feedforward control to increase the gain. By detecting such problem signatures, any decline in performance or productivity can be comprehensively explained and service engineers can take actions to resolve problems.

AI assists feature detection in SODA

Despite its present unavailability for CRM, the use of artificial intelligence (AI) is another key concept developed in SODA with radical potential for CRMs. While conventional signal processing methods such as Fourier decomposition, correlation analysis and filtering are very effective and efficient for certain limited use cases, they are ineffective at detecting many relevant problems



04

encountered in industry. For example, overshoot is an important characteristic of a control system related to step changes. In theory, overshoots have damped sinusoidal shapes for low-order linear systems. Common in CRMs →05, measured overshoots all have similar visual appearances, but their shapes, waveforms and durations vary; this makes them hard to detect with classical linear signal processing methods.

Hence, ABB developed and implemented a novel approach for feature extraction based on moving windows and recurrent neural networks that

can learn arbitrary patterns in time series data. During the analysis, the engineer tags patterns of interest such as overshoots; these are then used to train a classifier based on recurrent neural networks [3].

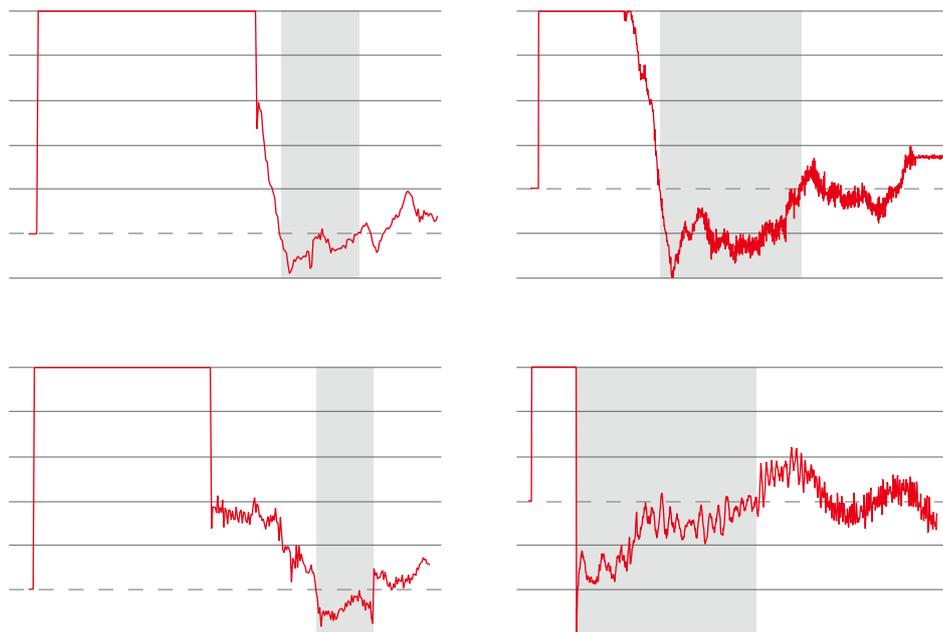
This advantageous approach can be used generically to capture arbitrary patterns in univariate- and multivariate time series analysis based on

Using spectral analysis, ABB's digital solution for CRMs helps engineers detect roll eccentricity in near-real time.

an engineer-specialists' inputs. This obviates the need to develop and tune specialized detection algorithms. Instead, this approach permits the expert's domain knowledge to be utilized directly and, in addition, makes this knowledge widely accessible.

SODA software architecture

Using state-of-the-art technology and usage paradigms, SODA was developed as a modularized application with a web-based user interface. Divided into a client application, a middleware and an analytics engine →06; communication is handled by a web-based Representational State

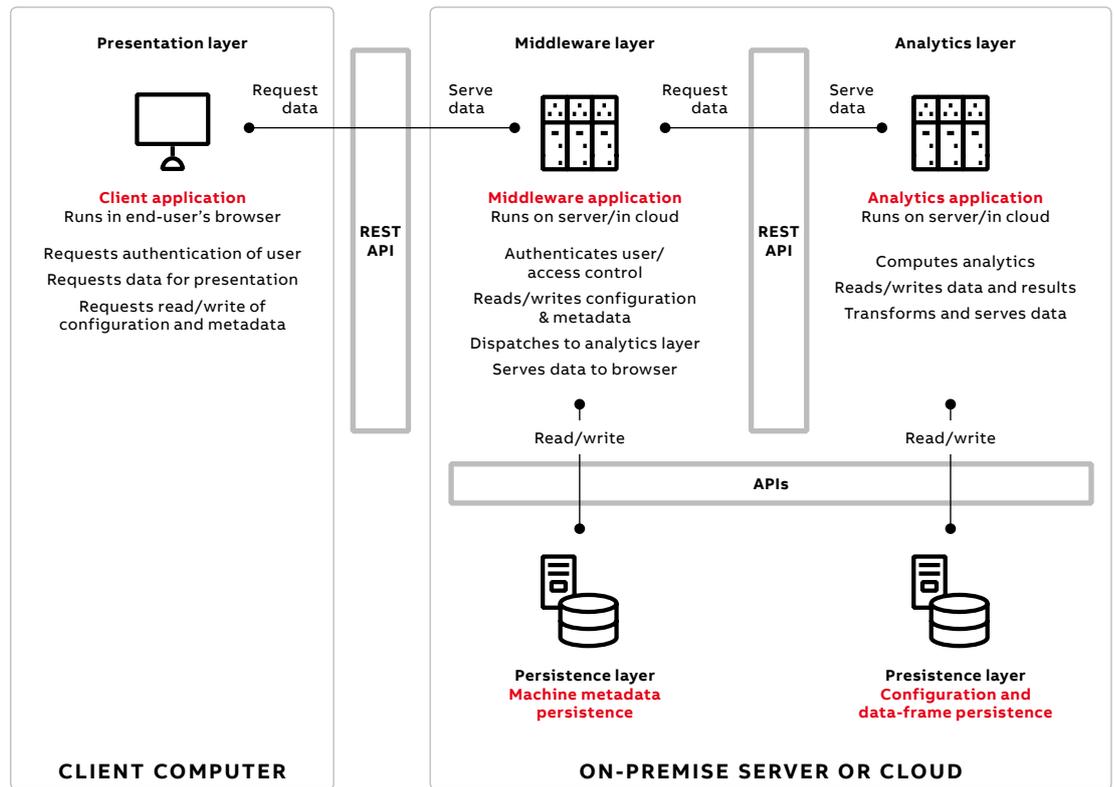


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04 An automatically detected change in material hardness from the raw data is visualized. The correction of the feedback control loop (green) is compared with the correction in the feed forward control loop (orange).

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05 Examples of overshoot are depicted (shaded area). In these cases, the transitory values are lower than the final value.

—
06 The SODA software architecture is illustrated.



06

Transfer Architecture Application Protocol Interface (REST API). This modular framework can be run on-site or in the cloud, according to the customer's privacy, flexibility, and scalability needs. This flexible, generic framework is easily

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SODA uses sophisticated algorithms to detect common problem signatures in time-series data.

—
adapted to other applications, eg, by reconfiguring the middleware, the framework can be adapted for use in other industries. Moreover, the analytics engine can run independently of other components, thereby forming the basis for any future application that requires similar types of analysis.

SODA advances and vision

As the world's largest automation provider for metal processing, ABB has completed more than 450 projects over the past 20 years. It is this vast experience and accumulated deep-domain knowledge about operational data that has enabled ABB to develop best practices to glean valuable insight from available data: how to display data

in meaningful ways, in the right context; how to simulate relevant scenarios; and how to act on insights from analytics to make informed decisions, to improve mill uptime, production speed and yield. By developing SODA with input and feedback from expert-engineers, ABB ensures that engineers' work is optimally supported.

Currently, CRM customers can access the newly developed functions for monitoring operations and detecting problem signatures in the newest version of ABB's CRM Data Analyzer.

Despite these significant advances, ABB continues to develop digital support technologies for CRMs by adding an artificial intelligent-assisted detection feature, already developed in SODA. This technology is planned for a future version of the CRM Data Analyzer.

Not stopping there, ABB is expanding its digital offerings. Having created a tool that provides an overview of the production performance, and detects anomalies accurately, ABB's newest challenge is to create a digital solution that will identify the root causes of these anomalies. Always at the vanguard of innovation, ABB is researching this solution right now. •

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[3] D. Janka, et al., "Detecting and locating patterns in time series using machine learning", in *Control Engineering Practice*, vol. 93, Dec. 2019.

UTILIZING KNOWLEDGE

Unleashing efficiency with ABB's Intelligent Knowledge Assistant, IKA

Rooted in Industry 4.0, IKA converts data and information to suitable, easy-to-digest, situation-specific, high-quality, tailored knowledge for industrial users. Once integrated into ABB's products and services, IKA will aid industries to exploit the full power of data.

Benedikt Schmidt
Marco Gärtler
ABB Corporate Research
Ladenburg, Germany

benedikt.schmidt@
de.abb.com
marco.gaertler@
de.abb.com

David Funderburg
ABB Industrial
Automation
Chemicals and Refining
Cleveland, OH, USA

david.funderburg@
us.abb.com

Zied M. Ouertani
ABB Industrial
Automation
Chemicals and Refining
Mannheim, Germany

mohamed-zied.
ouertani@de.abb.com



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01 The future technological and societal challenges faced by industries are addressed by ABB's IKA system.

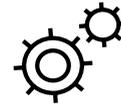
The Fourth Industrial Revolution promises a massive increase in efficiency through digitization of industrial processes. Initially, the lure of large-scale digital data collection by plant sensors is dizzying – think of the integration of data flows and data availability. But, if Industry 4.0 stops here, then digitization will fall short and those promises of unleashed productivity and increasing top-line will be just a memory. More worrisome, the breath of information available could complicate plant operations. Consequently,

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The lure of large scale digital data collection by plant sensors is dizzying – think of data-flows and availability.

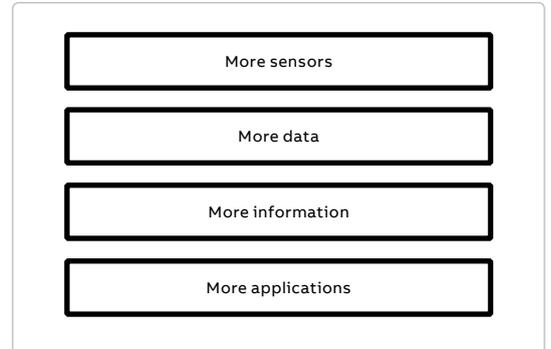
workforce efficiency could plummet as employees struggle to integrate data and information into their time-critical work processes. Information overload from chatty applications that complicate operations are well-known, eg, tackling alarm floods can delay the resolution of operational issues. To combat this, industry 4.0 must do more than increase data volume, variety and speed of transmission; it must optimize data access and enrich the information provided by adjusting the knowledge level of data and information supplied. The information needs to remain valid and correct for the domain on the one hand and yet be able to be efficiently applied by the workforce on the other. Leading edge assistance applications are one valuable way to accomplish this. These applications take raw data, from various sources, and service information; this information/data is transformed to a suitable, easy-to-understand, situation-specific, high-quality-form of knowledge for users.

A potential boon for industry, these applications address both domain-specific and technology-oriented challenges as well as the overarching societal changes facing industry: aging workforces, loss of expertise and fears about regrowth. By adapting to the user's expertise level and domain understanding, assistance applications generate tailored, enriched responses and a positive user experience.

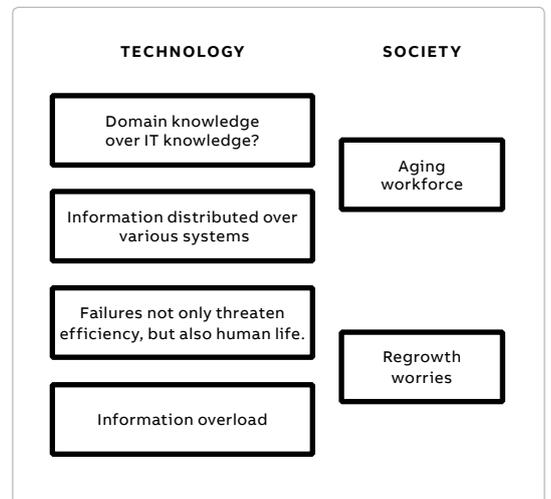
To explore such applications, ABB initiated a research project, in 2018, that focused on the architecture, feasibility and usability of the industrial digital assistant concept. ABB's result is a research prototype of the Intelligent Knowledge Assistant (IKA) with a customer tested proof-of-concept. IKA is a digital sage, a workforce



**DIGITIZATION AND INDUSTRY
4.0 CHANGE INDUSTRY**



**EFFECTS OF DIGITIZATION
ON THE WORKFORCE**



01

companion that stands by with advice and action as needed. Rooted in Industry 4.0 infrastructure and recent advances in artificial intelligence (AI), IKA has situational awareness and integrates with the information of industry's process-specific needs.

Solving challenges with digital assistance

Industries that apply digital solutions observe an increase in heterogeneity and lack of data control; this seeming chaos can translate to

high-risk problems. Even though these solutions initially lead to very targeted and isolated systems, complexity increases rapidly; and there's the rub: Because newly developed systems are connected in networks, users are confronted with dozens of applications and hundreds of databases – an overwhelming situation. The process that initially brings targeted value to a plant or industry morphs into a needle in a haystack of systems and dumbfounds employees who lose the overview →01.

Although most jobs require some basic ability to handle computer programs, just how much expertise is needed is a matter of debate. Clearly, IT knowledge should not supersede domain expertise, especially in industrial engineering and operations. So, industrial

Efficiency could plummet as employees struggle to integrate data and information into time-critical work processes.

software tools target experts and are tailored to domain requirements: usability and user-experience have traditionally played an important role in the design of industrial systems. Examples are the early work of NASA on interface design and cognitive workload [1] or the enduring tradition

of designing air traffic controller applications for maximal usability [2]. ABB takes this insight even further.

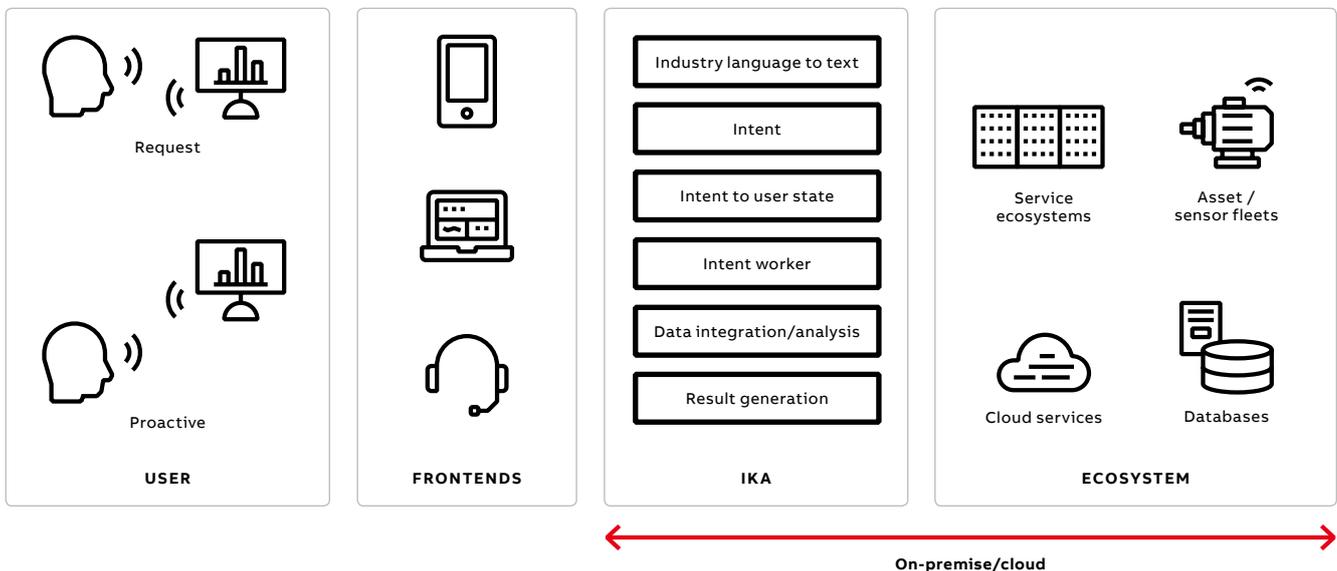
As a driver of Industry 4.0, ABB grasps the need to ensure safety and maximize efficiency as industries accelerate their digital transformation. Their core values: serving customers and providing product quality, enable ABB to maximize usability and user experience. IKA is ABB's answer to these needs. This system provides targeted support for the workforce; a diverse population with various competencies who must grapple with an increasingly complex digital infrastructure to ensure the safe and efficient operation of industrial devices and processes.

The rise of integrated assistant systems

With the advent of cheap personal computers in the 1980s, mobile phones in the 2000s and the expansion of smart devices (smart phones, tablets, wearables) over the last decade, digitization is unstoppable. Simple, intuitive and easy-to-use, these products and services target a massive audience of broad competencies. Today, consumer digitalization is a commodity and users have quickly adapted their behavior to reflect this. They expect mutual product integration and ways to create information flows that span multiple components. The digital assistant grew out of this digitalization ecosystem and consumer anticipation.

Nowadays, assistance applications are ubiquitous in the consumer domain: wizard dialogs,

IKA STRUCTURE FOR PROACTIVE AND REACTIVE SCENARIOS





03a



03b

— 02 IKA system components are purpose-built to support the user actively and proactively.

— 03 IKA is currently being integrated into various industrial systems with the focus on the user and ABB's valuable customers.

03a A view of IKA being employed on a tablet by a field operator (4.0 App).

03b IKA has been integrated into a dashboard specifically for the OGC industry.

static and interactive, help systems. Wizard dialogs guide the user through a set of questions and input options to obtain all necessary parameters to trigger an action. Such digital assistants are common to industrial installation procedures and multi-step workflows, eg, ordering. Static and interactive help systems support users to answer specific questions, educate themselves to achieve certain outcomes or become familiar with services or products. Initially reliant on simple (hypertext) manuals, frequently asked questions, etc., this type of assistant currently introduces scenarios and tutorials that permit walk-through experiences: chatbots and interactive avatars drive the conversation. Consisting of invisible routines that fetch additional helpful information or execute auxiliary steps in the background, these assistants perform spell-checks, auto-completion, filter for inputs and recommendations. Although the immediate benefit of these products and their service usability is considered minor and non-critical, they are crucial for user acceptance and convenience and hence widely available.

An integrated assistant for industry

Can industries more gainfully apply assistance application principles gleaned from the consumer domain? And, if so, how? Clearly there are obstacles. Firstly, an assistance system needs to obtain information from different data sources, background and value-added services and make them available in concise, aggregated and filtered ways to a broad range of applications.

Secondly, the system should respect the various domain specific languages and seamlessly translate between them. For example, the type of language used in a process plant is very specific and differs significantly from usual conversational language. Moreover, the type and

— IKA is a digital sage, a workforce companion that stands by with advice and action as needed.

presentation of the answer should reflect the level of competency and experience of the user. Thirdly, the system should actively notify the user about relevant items that require attention, while simultaneously factoring in the potential information flood from related systems.

The IKA system architecture

IKA is an industrial virtual assistant grounded in consumer domain principles that successfully addresses the aforementioned problems: it is built upon the principle of shared responsibilities; ie, the focus is on the accessibility of fetched, filtered and aggregated information that originate from existing, established services and early prototypes; there is no need to re-implement functionality from the ground up. Monitoring, describing, prescribing and

forecasting are all relevant functions in line with the automation pyramid. Moreover, in the foreseeable future, ABB envisions IKA's functionality to extend further, to the level of control →02.

The system receives questions in natural language given in text or spoken form and transforms them to a notation of intents that can be mapped to technical requests. Those queries will be sent to several services that provide a corresponding technical answer. These answers are then filtered and aggregated before they are translated back into natural language. Additionally, images, links and recommendations can be

—
By focusing on user competence, ABB's system design ensures that IKA services both experts and novices.

adjusted to further enhance the experience and usability of the textual/spoken answer. Natural language is used in a common and ubiquitous way to express requests and intents intuitively; the user has no need to learn an artificial set of interactions.

On a technical level, the assistant acts as an application programmable interface (API); it

focuses requests to a single homogeneous endpoint while internally delegating tasks to the various back-end services. As such, it is represented in a microservice architecture that uses internal components for the natural language part and external components for knowledge retrieval. This design guarantees customers a large degree of freedom; ensures the rapid development of standalone applications, easy integration into existing applications and use in a broad range of platforms, eg, classical desktop, smartphones, tablets, wearables, and augmented reality devices.

Use cases foreshadow a shiny new world

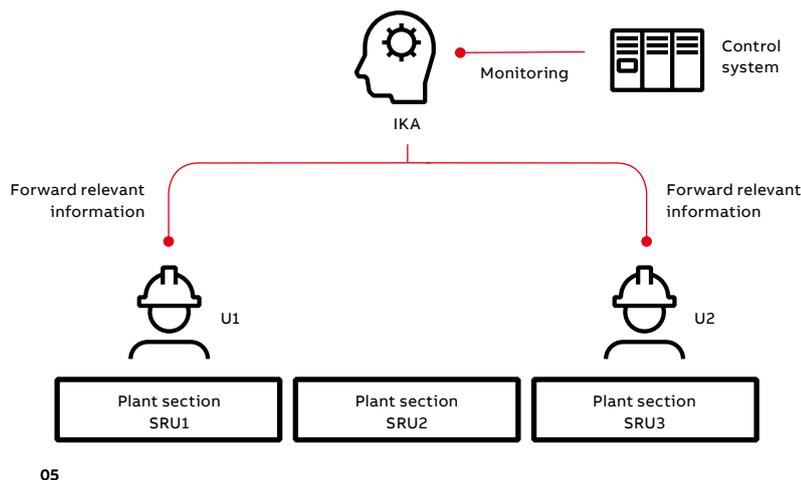
ABB's IKA system can be deployed in any domain that already has an ecosystem of services and databases or in those that are transitioning to a service ecosystem. For instance, IKA can extend the function of a field engineer executing a process or a company dashboard →01. Because monitoring abilities are embedded, IKA can be readily adapted to realize user support.

Use cases demonstrate IKA's easy and situation-aware data access and decision-supportive properties →03. IKA allows the workforce to focus on tasks using domain language: IKA automatically translates domain-specific language to infrastructure protocols, eg, Distributed Control Systems (DCS), key performance indicators (KPIs), etc. The plant operator simply asks the system about options to handle a specific situation; IKA looks up historical data in the audit



—
04 IKA provides valuable information that can enable operators to react more swiftly to alarms or events; thereby improving uptime and safety.

—
05 A schematic illustrates how IKA filters alarms based on the location and current activity of a user. A field engineer is working in plant section SRU 1. All alarms for the section will be forwarded to him/her, while other alarms are filtered. The engineer working in plant section SRU3 receives pertinent alarm information.



trails and operator notes and IKA delivers a reliable answer. If a process variable behaves unusually, IKA proactively informs the operator and asks if a forecast should be displayed. In these cases, the operator focuses on their role – the efficient plant operation – no need to memorize which sub-system analyzes the process status or where to find relevant historical data. Thus, IKA performs the seamless integration of services and information infrastructure into the workflow and work situation. With IKA, users really do “get what they ask for”.

By focusing on user competence, ABB’s system design ensures that IKA services both experts and novices. Experts are not bothered with information they already know by heart and novices can receive a detailed situation explanation and instructions. For instance, a field operator asks IKA to support his/her execution of a maintenance procedure. IKA checks how often the person successfully executed the task at hand. If executed for the first time, more information is provided about success factors and involved equipment. Without a history of successful task execution, the information is limited and focused on the dynamic control system information. And, if desired, the user can always override the system settings to get another support level.

IKA can also improve alarm management. Vital to most process industries [3,4], alarms are customarily monitored by dedicated access applications like terminals or dashboards associated with control system. Alarm information is propagated to the user, an experienced domain expert, irrespective of the current situation, location or workflow. But, alarms are considered standalone objects that require contextualization. Because IKA has situational awareness based on the integration of various data sources, both – near-real time and historical – alarms are aligned with the system

—
Use cases demonstrate IKA’s easy-to-use and situation-aware data access and decision-support properties.

and user situation; these can be combined to inspect the related domain and provide much needed decision-support →04–05. In this way, the operator is not only informed that, eg, a pressure value exceeds a threshold, additional valuable information is supplied, eg, the frequency of overshooting the threshold value, and/or hints about ways colleagues previously resolved such events, thus, alleviating confusion.

By providing users with easy access to a plant’s evolving information landscape, IKA will allow businesses to heighten productivity and workforce efficiency, thereby keeping the promise of Industry 4.0.

Outlook

Currently, ABB is integrating IKA with existing ABB products and value-added services to conclusively verify the viability of the system. Although preliminary, IKA working prototypes and demonstrators yield encouraging results. Successful customer field tests and trade fair demonstrations, eg, ABB Customer World and CERA week, indicate that ABB is on the right track with IKA – focusing on customers and a digital future. •

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 UTILIZING KNOWLEDGE

Anomaly detection algorithm keeps robots in the pink



ABB has developed an automated data-driven anomaly detection system to diagnose and inspect the product quality of robots with a view to boosting their operational health. Thanks to the ABB Ability™ Analytics Framework, the detection system has evolved from a prototype running on a single computer into a robust service characterized by superior scalabilities in terms of processing speed and data volume.

Nevroz Sen
Sriharsha Vardhan
 ABB Robotics
 San Jose, CA, USA

nevroz.sen@us.abb.com
 sriharshavardhan.t@us.abb.com

Felix Mutzl
 ABB Ability™ Analytics
 Ladenburg, Germany

felix.mutzl@de.abb.com

It is an exciting time to be in the robot manufacturing business. The global industrial robotics market has been growing at a CAGR of 9.4 percent since 2017 and is expected to continue at that level to 2023 [1]. What is more, multi-purpose, re-programmable industrial robots, an important part of the automated production systems market [2], are evolving rapidly thanks to advances in machine learning. In this regard, one of the key application areas is performance characteristics and related test methods for manipulating industrial robots, which include pose and path characteristics and application-specific performance criteria. In addition, the precision performance of a robot's manipulator can be described by pose accuracy and pose repeatability [3].

In the course of developing performance test methods, signals are collected at high frequency and analyzed to gain critical insights. Such insights help to enable experienced production

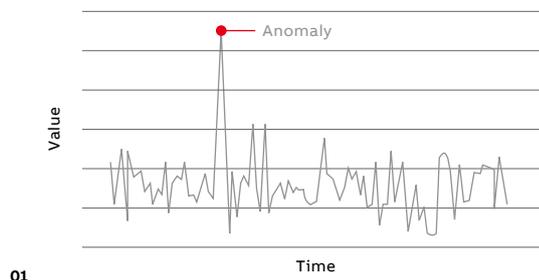
The global industrial robotics market has been growing at a CAGR of 9.4 percent since 2017.

personnel to classify a robot's performance as normal or abnormal →01. The analysis involves observing general patterns and relationships among signals for specific robot types during specific test conditions. However, the large volume and complexity of the resulting data make human manual analyses unfeasible.

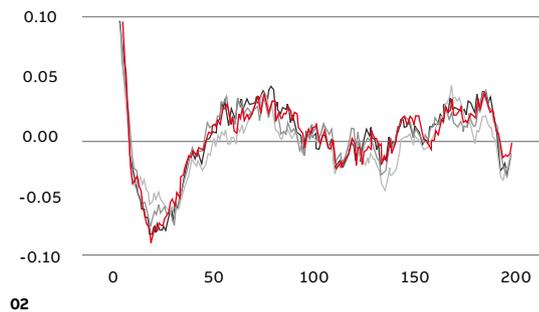
In the following pages, this article will describe how ABB is applying machine learning (ML) techniques to anomaly detection. In general, machine learning describes a process whereby a computer uses statistical models and algorithms to perform a task by relying on patterns and



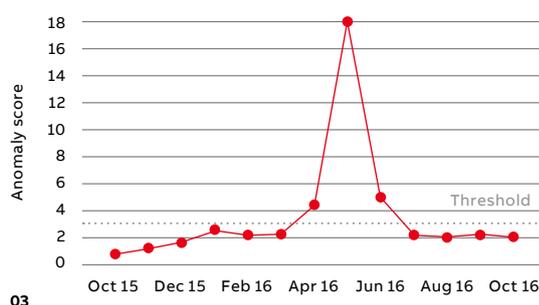
- 01 Anomaly in a time series signal.
- 02 Multi-variate time series signals.
- 03 Robot anomaly score indicator.



01



02



03

inferences instead of explicit rules. However, before a computer can perform a given task, its associated machine learning program will typically require a very large amount of data.

For the purposes of the present study, years of data that had been accumulated as part of the inspection of newly produced ABB robots served as the source for detecting collective and contextual anomalies [4] [5]. Broadly speaking, the data had to support the following goals:

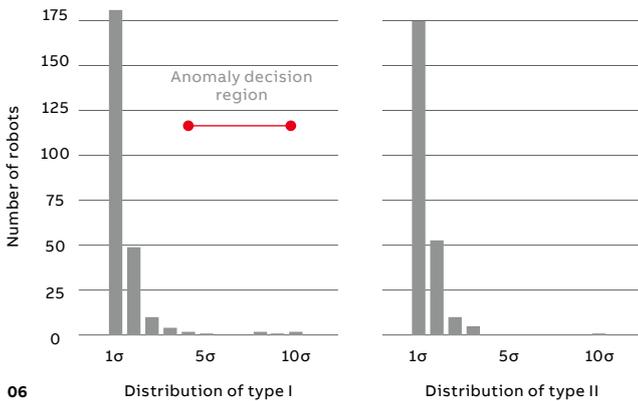
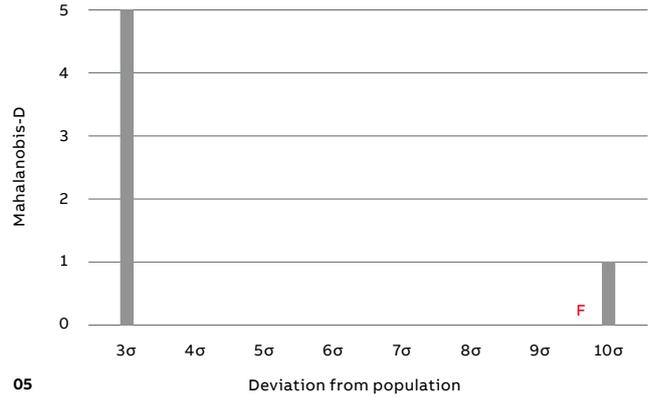
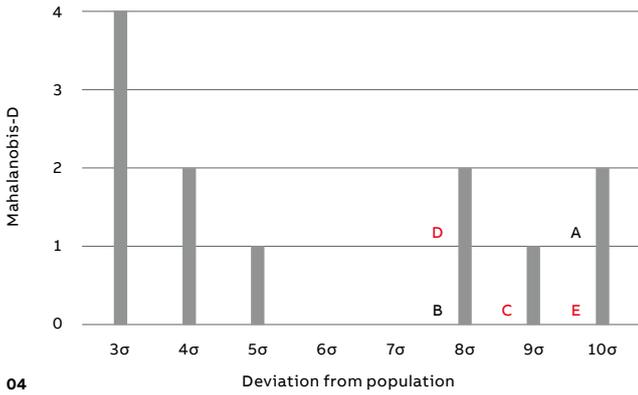
1. For a population of manufactured robots, could it be used to devise an automatic technique to detect anomalies by means of data-driven models?
2. For a newly manufactured robot, could it detect anomalies based on the use of historical inspection data, or of a model built on such data?
3. For a selected group or context, could it be used to detect the operational performance of manufacturing systems and equipment?

Development of a data-driven model capable of meeting these goals is indeed feasible, but the development technique varies depending on the scope of the anomaly being detected and the quality of historical data available. The effectiveness of a

Once a model has been developed and tuned, data specialists can begin finding patterns in the anomalies.

model in detecting an anomalous robot behavior with a high level of reliability and confidence depends on the identification of optimally synthesized normal operating thresholds.

Once a model has been developed and tuned to pinpoint anomalous behaviors in robots, data specialists can begin finding patterns in the anomalies [6] with a view to understanding



the cause(s) of faults and failures. Although the next step may be the development of an automated data-driven anomaly detection and diagnosis system, developers should keep in mind that, due to the variability in anomalous behavior and associated corrective actions, such systems can quickly become extremely complex, especially if they are required to orchestrate dynamic workloads.

Broadly applicable algorithm

As an unsupervised or semi-supervised machine learning algorithm, the method developed by ABB analyzes data based on only limited knowledge and hence is applicable to a wide range of scenarios. This is indeed an important factor when it comes to anomaly detection in robot behaviors since even defining a proper notion of abnormal data is non-trivial due to the complexities involving different operations, operator errors and external factors. It is therefore paramount to develop a monitoring system that requires minimal human supervision and yet is robust enough to eliminate false positives. How can this be achieved?

The first step was to define the data type and analyze multi-variate time series data →02, such

as the signals collected from a robot’s controller, i.e. those for torque, position and speed or from external sensors such as a vibration sensor.

Given the data collected during the test, the first step the algorithm must take is feature extraction from the raw time series data. This is a key step in the performance of the algorithm since many physical failures, such as backlash and high friction in motor components, become more visible in such a feature space.

The feature extraction process begins with time scale analysis on signals. This step is designed to separate slowly developing variations in component output from rapidly developing ones. This is followed by the generation of time-localized frequency components. The final set of features

The method developed by ABB analyzes data based on limited knowledge and hence is applicable to a wide range of scenarios.

is then constructed by measuring the collective behavior of these components. Obviously, there are several parameters to be set for the above-mentioned steps. These parameters are computed directly from the data. Hence, the algorithm is fully autonomous.

Once the feature space has been constructed, an anomaly score for each sample is computed to identify those anomalies that deviate from the distribution →03. This is achieved by modelling a subspace covering each variation in the data through principal component analysis and

- 04 Production quality inspection for robot Type I.
- 05 Production quality inspection for robot Type II.
- 06 Comparison of deviations in manufacturing processes for two robot types.
- 07 ABB Ability™ Analytics Framework.

then computing the distance of each sample to the subspace. The anomaly scores for each sample can be thought of as deviations from the subspace measured in terms of configurable statistical parameters.

To determine the algorithm's performance, two scenarios were considered. The first involved an examination of the quality of a robot's operations over a period of one year during which the

The algorithm can be used to determine the relative robustness of production lines for different robot types or axes.

algorithm triggered an alarm in April 2016 when a statistical threshold was exceeded. The second was identical, with the exception that, in May 2016, the alarm was amplified to a significant value →01. Inspection of the robot in question revealed a high level of metallic particles in the oil sampled from the corresponding axis, with the particles being attributable to a

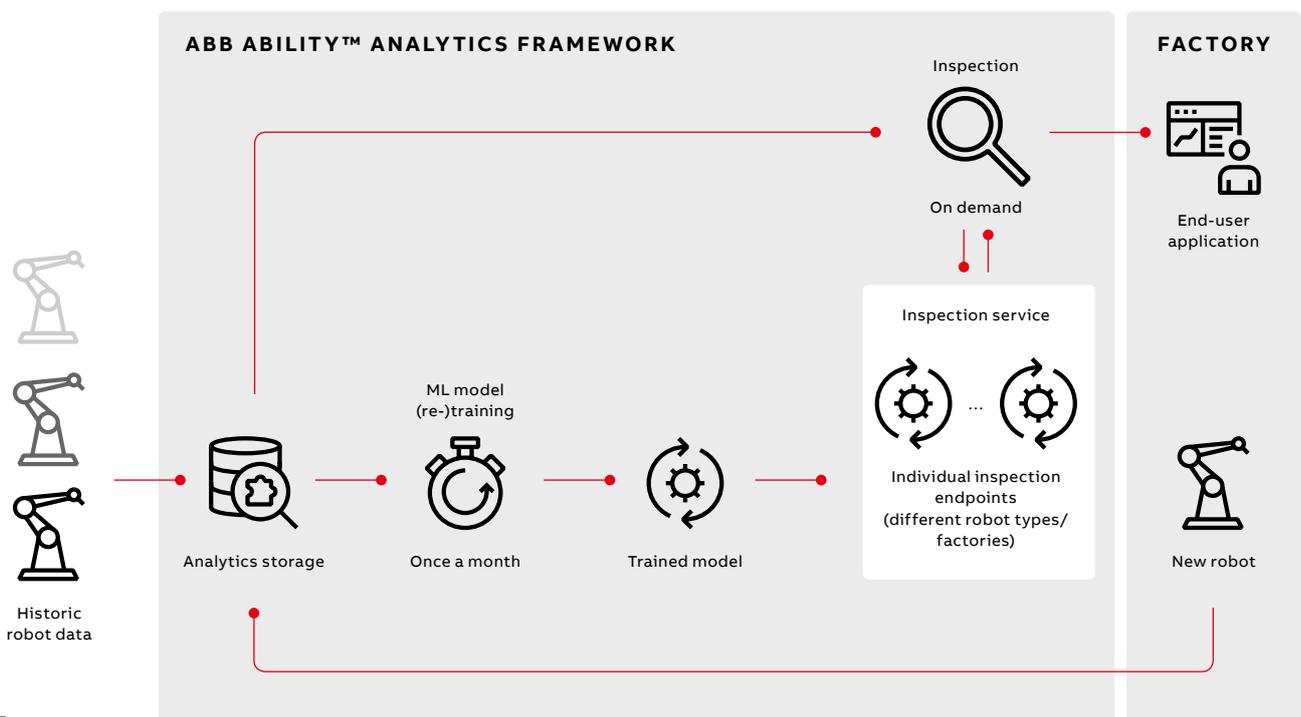
completely worn-out gearbox. The gearbox was replaced in late June after which the robot's anomaly score returned to normal values.

In the above situation, the deviation was sought in the context of assumed normal behavior on the part of the robot. The immediate question that follows is: how can a system generalize this approach to a case where the difference between normal and abnormal results is not known in advance?

One way of doing so is to improve the algorithm by adding a randomization step in which a number of subspaces are produced by the features generated from a randomly selected micro population of robots in which the deviation for each robot is calculated over all these subspaces and to which a simple voting scheme is added in order to determine whether a robot's behaviors are abnormal or not.

The results displayed →04 over a histogram represent the distribution of deviations of the robots per axis per robot type.

It should be noted that among these, robots A and B are known to be malfunctioning and that the algorithm identifies a further set of





three abnormal robots, C, D and E, with a high level of confidence.

In →05, an axis from another robot type is analyzed. Here, with a high level of confidence, robot F is found to be an outlier by the algorithm, and it is verified that the robot is indeed malfunctioning.

Beyond identifying whatever is abnormal, the algorithm can be used to gain additional insights, such as, for instance, determining the relative robustness of production lines for different robot types or axes.

→06 displays the distribution of the whole population of robots. Here it can be observed that a significant number of robots of both Type I and Type II are in the normal range. However, the

Model training was reduced from days to around one hour per robot type.

production line for Type I seems to have a slightly higher level of variation than that of Type II. Once such distributions from different types and axes are obtained, further analysis can be performed, such as correlating data with components that may be causing anomalies and failures.

However, it is worth mentioning that the production quality inspection training phase is computationally intensive and needs to be repeated hundreds of times in order to obtain a reliable production quality inspection model.

Accelerated scalability and automation

Due to the computational intensity of this phase, training the production quality inspection model for one robot type required about two days when run on a simple laptop. However, when performed using the ABB Ability™ Analytics Framework →07 it was possible to scale and parallelize the model training process, thereby reducing the execution time from days to around one hour per robot type. This enabled a more frequent model re-training for every robot type →08, thereby improving the overall model in terms of its quality inspection capabilities.

—
08 Frequent model retraining leads to improved quality inspection capabilities.

The model training pipeline runs on Azure Databricks and is orchestrated by means of Azure Data Factory. The pipeline includes the following steps:

- Collection and pre-processing of data from thousands of newly produced robots →01–02
- Training of a new machine learning model for every robot type based on the latest data →03
- Deployment of a dedicated webservice for each robot type based on individual production quality inspection models →04

It also provides visual process diagrams that make it possible to monitor performance and failover with a high level of granularity. Following the completion of its testing phase, the trained production quality inspection model was deployed as a cloud-based webservice that ensures high availability and flexibility. The service can be used via a web/mobile application →07 to either inspect a batch →05 of robots (daily production) or during ad-hoc tests directly on the shop floor →06.

—
The quality inspection model was deployed as a cloud-based webservice that ensures high availability and flexibility.

The ABB Ability™ Analytics Framework thus made it possible to transition from an initial prototype to a robust service offering capable of scaling machine learning processes and saving a significant amount of time and money. •

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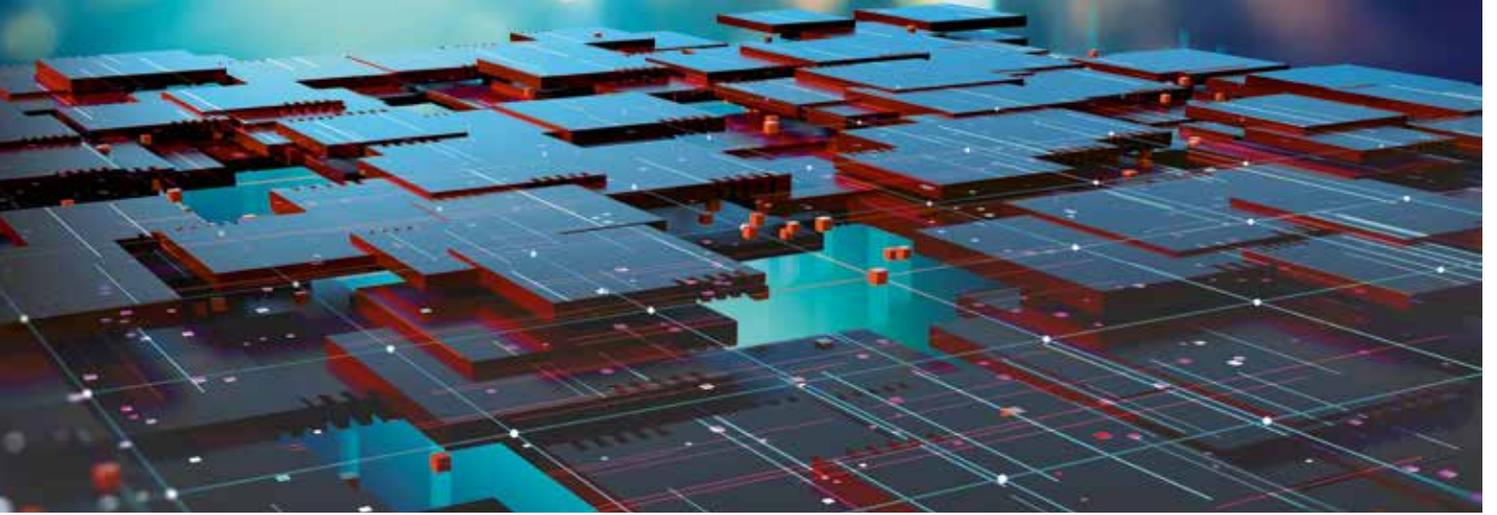
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BUZZWORD DEMYSTIFIER

Quantum computing

The hype and hopes behind an emerging technology.



Elsi-Mari Borelli
Theoretical and Computational Methods
Baden-Dättwil,
Switzerland

elsi-mari.borelli@
ch.abb.com



Thorsten Strassel
Switchgear
Baden-Dättwil,
Switzerland

thorsten.strassel@
ch.abb.com

Anybody following the tech news will have encountered the topic of quantum computing. Whether in IT magazines, science news, business reports of mainstream media, the promising new technology is regularly explained, hyped over, or debunked. The spectacular news of Google in 2019 achieving “quantum supremacy” stirred wild excitement, with the achievement even being compared to Apollo 11’s landing on the moon.

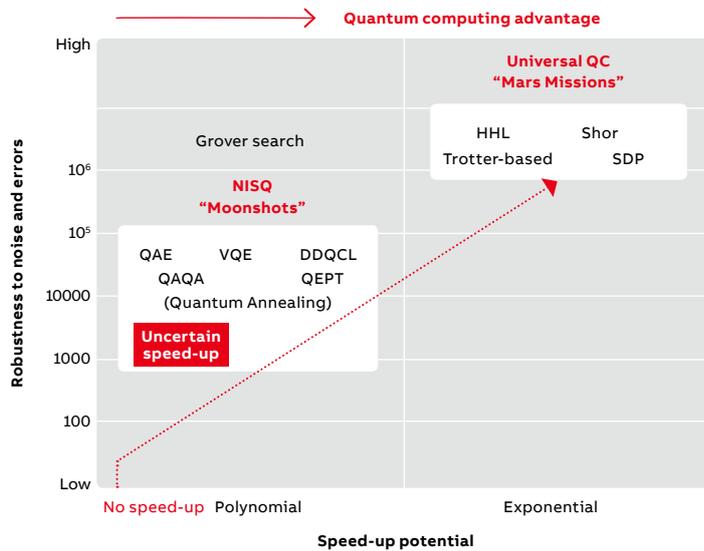
From the moon, it is good to bring one’s feet back on the ground and take a deeper look into the question on the “nuts-and-bolts” impacts of quantum computing for future industrial applications from a present-day perspective.

First, quantum computers are not anticipated to be a turbo-boosted replacement for one’s laptop, not even in the long-term. Second, they are not universal supercomputers replacing all big-cluster computing. They are large special purpose machines, aiming to get an edge over conventional hardware (and its successors) in dedicated computational problems. They make use of principles of quantum mechanics to crack problems in minutes for which the fastest super computers would need thousands of years or longer. But in order to benefit from the speed-up, the algorithms of today will not do the trick. Special algorithms are required that harness the laws of quantum physics.

The idea of quantum computing is not new by itself: It was triggered by the Nobel Laureate in Physics Richard Feynman in 1982. Rather than digital bits that either have a value of zero or one, a qubit can hold multiple values at different probabilities - until it is measured. Logical operations that can be performed on these qubits thus cannot follow the ones on classical computers.

Quantum computing has received widespread attention due to the theoretical threat it poses to all present-day encryption systems (Shor’s algorithm). However, factoring cryptographically significant numbers require computation with around one million high-quality qubits. Today’s best in the business quantum chips, such as Google’s 54-qubit Sycamore design, are still light years away in terms of size and low noise for such applications →01. In September 2020, IBM released their quantum computing roadmap, which foresees a 1,000-plus qubit device, called IBM Quantum Condor, by 2023 [1].

There is, however, evidence that even so-called noisy intermediate-scale quantum (NISQ) computers can help solve complicated combinatorial optimization problems with quantum heuristics. Quantum chips in this scale are already in the intermediate-term roadmaps of many companies. Even if the speed-up on NISQ hardware is less pronounced, when tailored to the right application, the technology may have a major commercial



01

01 Selected quantum computing algorithms and their estimated hardware needs.

impact. Therefore, many companies and government agencies are advancing research with the aim to have solutions ready in the medium term.

Quantum computing may therefore play a key role in building autonomous systems in the future. But it is not the only technology that has the power to revolutionize computational achievements.

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Quantum computers are probably best known for the theoretical threat they pose to existing encryption systems.

Innovations in the optimization algorithms can themselves deliver much more bang for the buck, even on classical hardware. In fact, the algorithms developed for quantum hardware have recently inspired a new breed of optimization algorithms that have proven to provide great speedups for some problems.

The topic of quantum computing (and its potential role in industrial automation) will be covered in greater detail in an article in an upcoming issue of ABB Review. •



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01|2020

Inspiring tomorrow



02|2020

Leveraging connectivity

Innovation highlights

08 Selected innovations in brief

Digital future

20 Digital transformation
 24 Rethinking innovation
 30 OPC UA and TSN
 36 Co-innovation adds value to automation

Extreme performance

44 Subsea electrification
 50 Subsea power conversion
 56 A200-H single-stage turbocharger

Buzzword demystifier

62 Additive manufacturing

Leveraging connectivity

08 Intelligent Alarm Management
 14 Boosting buildings' energy efficiency
 22 Smart Sensor for hazardous areas
 28 Network researcher gains award

Connecting power

32 Zenith automatic transfer switch
 36 Universal motor controller software
 40 PEGS tests power equipment

Robots and handling

48 Precise depalletization
 with machine learning
 52 How to rev up your robots

Buzzword demystifier

56 4D printing



03|2020

Data centers

Data centers

- 08 Interview: Energy efficiency
- 14 Data center automation
- 22 Data center solution architectures
- 30 Data center energy use
- 36 Purpose-built substations
- 40 Sodium-ion batteries
- 42 The secret ingredient
- 45 IEC 61850 for data centers
- 50 Data center cyber security

Inside the cloud

- 58 Data security down to the last branch
- 59 MegaFlex UPS
- 64 MNS-Up
- 66 Medium-voltage UPS
- 69 Nanofluid cooling for data centers
- 72 Transfer solution for a data center
- 74 Transient-protected transformers

Buzzword demystifier

- 78 5G



04|2020

Industrial automation

Industrial automation

- 08 Digitalizing industrial automation
- 16 Sustainability with ABB products
- 25 Sustainable mining
- 32 Automation in oil and gas
- 38 Sustainability in the marine sector
- 43 Integrated cybersecurity
- 46 Navigating digitalization

Utilizing knowledge

- 54 EQmatic Energy Analyzer
- 63 Analytics for cold rolling mills
- 68 Intelligent Knowledge Assistant IKA
- 74 Anomaly detection algorithm

Buzzword Demystifier

- 80 Quantum computing

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Next 01/2021

Powered by knowledge

Driven by the COVID-19 pandemic, innovation is no longer an option or aspirational goal, it is a daily necessity. Not surprisingly, calls to innovate faster and more often are already common. What is less well-known and shared are the keys to doing it better. The next issue of ABB Review, the company's annual exploration of innovation, will explain how this can be achieved.