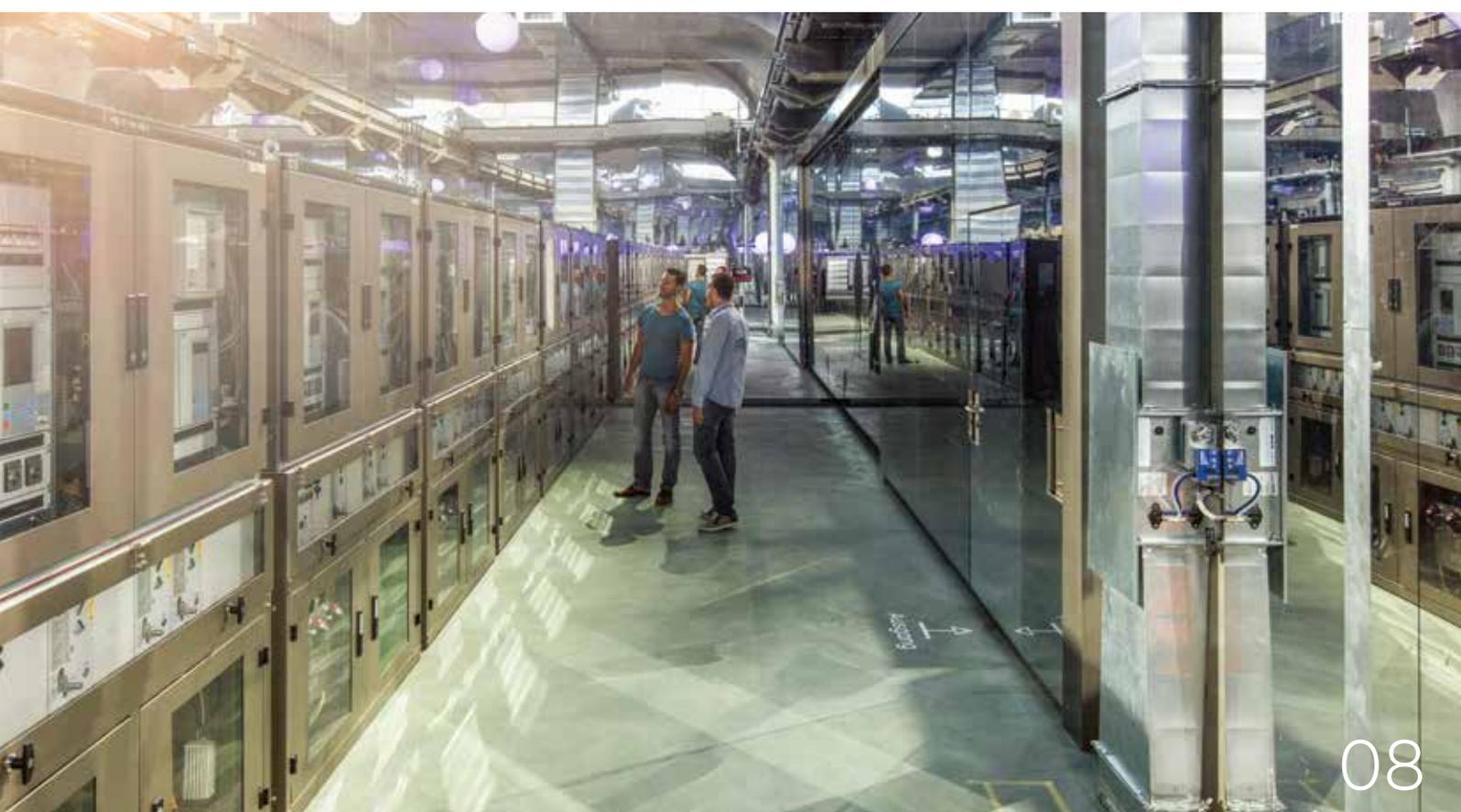


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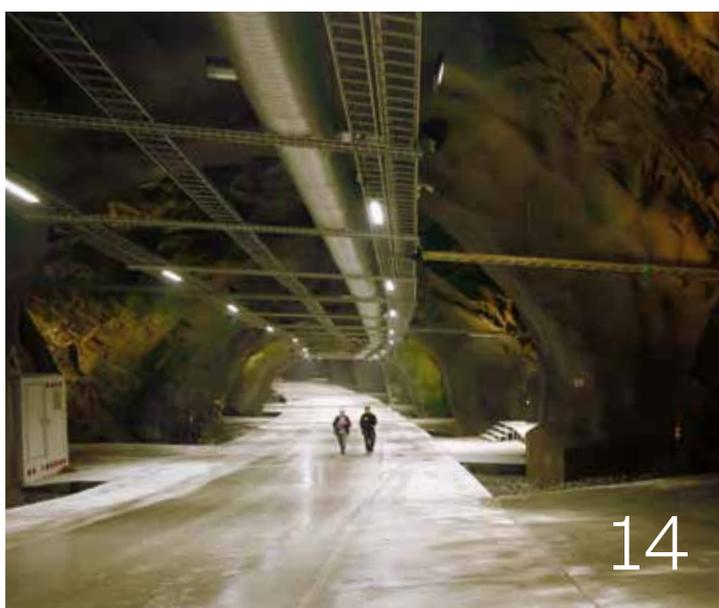
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## Data centers



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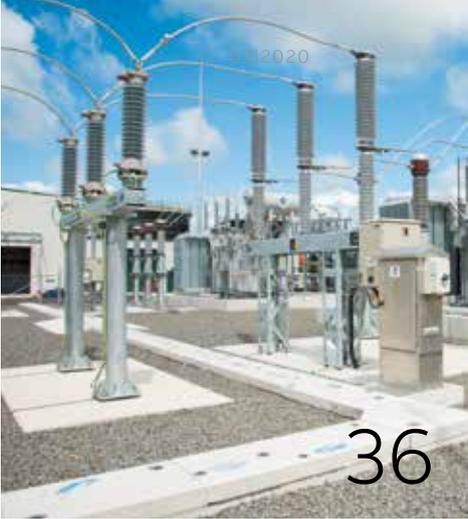


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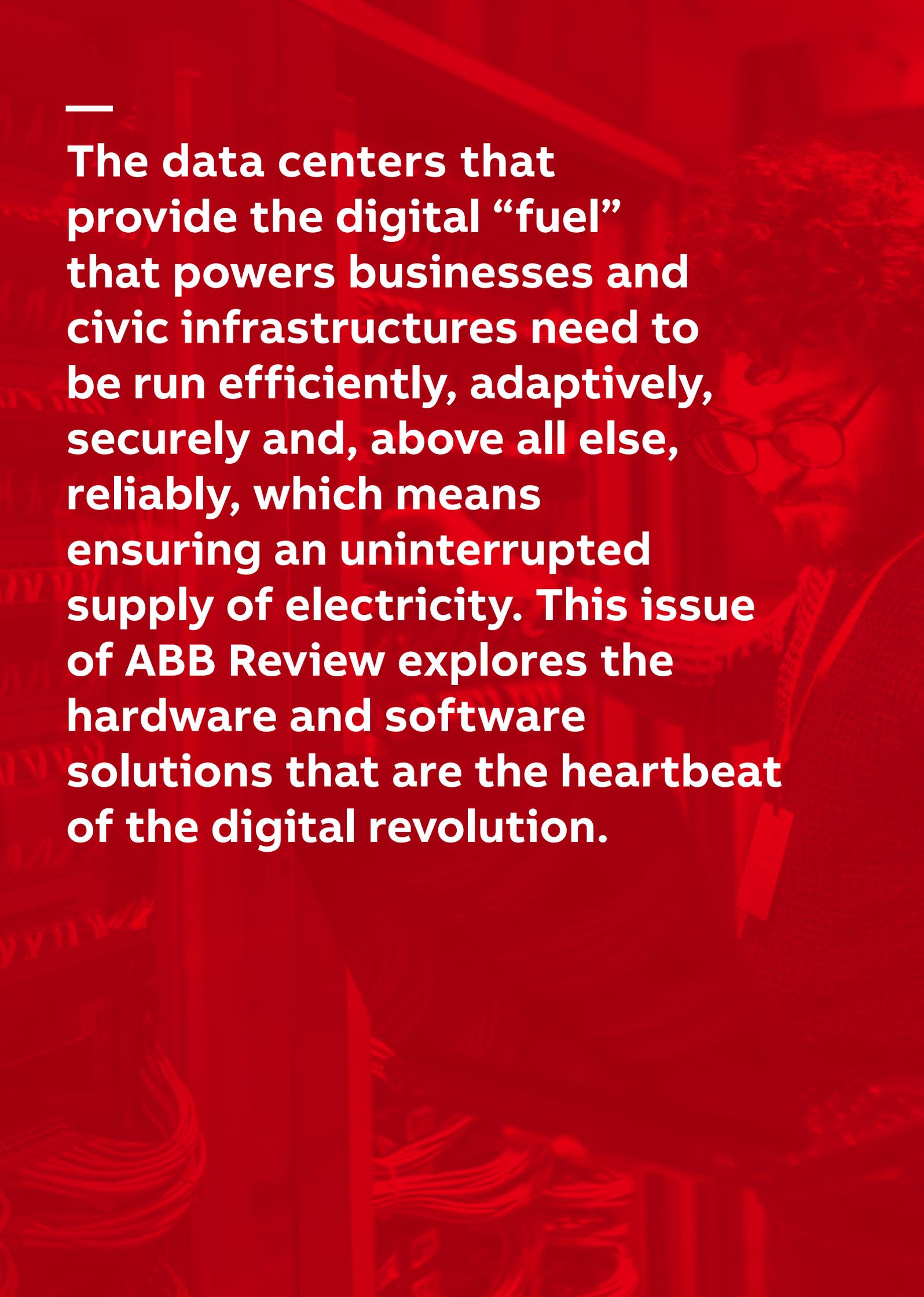
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**The data centers that provide the digital “fuel” that powers businesses and civic infrastructures need to be run efficiently, adaptively, securely and, above all else, reliably, which means ensuring an uninterrupted supply of electricity. This issue of ABB Review explores the hardware and software solutions that are the heartbeat of the digital revolution.**

A man with glasses and a beard, wearing a dark suit and a patterned tie, is looking down at a tablet computer. The background is a dark red color with a faint grid pattern. The text is overlaid on the left side of the image.

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EDITORIAL

# Data centers



Dear Reader,

We can hardly imagine today's world without social media, e-commerce and other Internet-based services (including the Internet of Things which is so important for the transformation of industry). In other words, ever greater quantities of data need to be transmitted, processed and stored.

Data centers are estimated to consume between one and two percent of the world's electricity. What does their rapid growth imply for carbon emissions? Fortunately, the trend is not as alarmist as might be feared: Despite data-center output increasing six-fold from 2010 to 2018, the associated energy consumption rose by only six percent. This achievement is attributable to a combination of energy efficient products and smarter operating and control strategies.

With its history and deep knowledge of both energy and automation, as well as its role in the transition to smart and autonomous systems, ABB is at the forefront of creating efficient and reliable data centers.

Enjoy your reading,

A handwritten signature in red ink, appearing to read 'Bazmi Husain', written in a cursive style.

**Bazmi Husain**  
Chief Technology Officer



# Data centers





Transforming data into knowledge, insights, and actions is a dynamic process that requires capabilities and integration that are as smart as the outcomes. ABB's spectrum of data center technologies equips customers to achieve these goals.

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DATA CENTERS

# The quest for energy efficiency reaches new heights

A recent study [1] of data centers around the world has found “that while their computing output jumped six-fold from 2010 to 2018, their energy consumption rose only six percent.” Contributing to this achievement are ABB’s industry-leading control system platforms and the embedded intelligence of its electrical systems, such as circuit breakers and uninterruptible power sources. Looking ahead, even greater energy efficiencies are on the horizon as the company moves into the field of mass energy-storage and becomes involved in new approaches to energy grid participation. In this interview, the head of ABB’s Global Data Center Solutions business outlines the company’s contributions to these and other areas.





## Ciaran Flanagan

Ciaran Flanagan is Group Vice President & General Manager of ABB's Data Center Solutions business. He is tasked with consolidating ABB as a key player in the global data center industry and growing ABB's presence to a top three player in electrification and automation solutions, globally.

Let us start out with a really fundamental question: Why do we need data centers?

The Internet boom and the economic boom are tightly coupled. The countries that have enjoyed strong economic cycles are those that have advanced information technologies. Powerhouse economies like Germany, South Korea, Japan and North America have IT-driven economies. Data centers are fundamental to that capability; they are essentially the digital factories that convert data and energy into services and value. Furthermore, they have an offset value in terms of reducing energy consumption by, for instance, replacing travel with communications, helping

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I think that as we work our way into this new decade, we will see the quest for efficiency go into even higher gear.

businesses to manage disparate resources effectively and digitally supporting our social fabric. Our internet-based call right now, for instance, is going through a data center. Our economies are strengthened by the fact that we can share data, store it and manipulate it to deliver new services and capabilities, such as mapping the human genome and planning the exploration of space. All these activities are facilitated by data centers.

**AR** What are the major factors driving the data center market and how have these factors changed over time?

**CF** Looking across the 2000s, the pervasiveness of digital services and the quantity of digital content have powered the transition to the public cloud and the exponential increase in data center services. The initial focus was providing services to the public and enterprises to make their existing activities and processes more efficient. In the future there will be a shift to machine-to-machine (M2M) communication. If you look at 5G, for instance, it will probably be dominated by M2M communication. Of course, ABB is itself part of this trend. Given our commitment to Industry 4.0

and remote services such as diagnostics and predictive maintenance, our own thirst for data and connectivity has grown rapidly. In addition, we expect to see similar demands developing as AI advances, as well as with the need to retool enterprise IT and also a natural cycle of renewal as facilities built in the 1990s are replaced.

As these trends have developed, data centers have become bigger, increasingly automated and more energy intensive. Twenty years ago, everyone was building data centers of about half a megawatt. Today, either they are building very big centers – 50 MW and up – or very small ones – 2 MW or less. All in all, the industry is looking for economies of scale in either size or distribution.

**AR** To what extent is energy minimization becoming a driving factor in your field?

**CF** The industry is doing a lot of good things. The mechanical and IT disciplines have driven out a lot of excess waste over the past few years. Now we are looking more closely at energy distribution and operations automation.

All in all, the industry's level of efficiency has been quite phenomenal. I think that as we work our way into this new decade, we will see the quest for efficiency go into even higher gear. Already, we are moving away from a purely return-on-investment mindset to a culture of incremental efficiency and a Six-Sigma type commitment to driving out waste.

**AR** You are convinced the critics of data centers were wrong about energy efficiency?

**CF** I think the critics will have an opportunity to assess some new and emerging research. A recent article published in the journal Science [2], which was based on research at Northwestern University, the Lawrence Berkeley National Laboratory and an independent research firm and funded by the U.S. Department of Energy, confirms what we in the industry have been witnessing – in other words that the energy consumption of the world's data centers is somewhere between one percent and two percent. I think that is about the most accurate measure we have. The article discredits those who were predicting an exponential rate of increase in data

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01 The previous issue of ABB Review dedicated to data centers was 4-2013. ABB has now been in the data center industry for around 25 years.



01

center energy demand and expresses a position we support.

To give you a ballpark idea of how energy-efficient data processing has become, which is the key function inside data centers, if the airline industry had demonstrated the same level of efficiency a 747 would be able to fly from New York to London on 2.8 liters of fuel in around eight minutes! There's always room for further improvements in energy efficiency.

**AR** The industry's level of efficiency may be impressive, but we're still talking about a heck of a lot of energy. What are data center operators doing to reduce their CO<sub>2</sub> footprint?

**CF** The industry has made great strides in this area. Thanks to power purchase agreements (PPAs) in North America, Europe and elsewhere, the big data center operators are working ever more closely with utilities and in fact, I see an opportunity for the data center industry to become a larger part of the utility industry than it already is.

For instance, we are starting to move into the area of mass energy storage and are developing systems that improve and enhance the efficiency of such systems. Why? Because that is probably the one area of green energy that has the potential to really move the needle. When industry cracks the nut of economic mass energy storage, the renewable energy adoption will take off.

ABB already sells battery energy storage systems. Here, the real magic from our point of view is in the control systems and software. We are delivering

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According to the journal Science, data centers consume between one and two percent of the world's electricity.

battery storage units that have intelligence and can interface with existing green energy generation plants.

**AR** Which ABB technologies are instrumental in terms of maximizing data center efficiency?

**CF** ABB has been in the data center industry for as long as the industry has existed – that is, roughly 25 years →01. We have focused on two critical areas: data center electrification and data center control and automation. We believe that in these two areas we offer the most modern, innovative, and energy efficient products and solutions for distributing energy. I'll give you a few examples.

First, our uninterruptible power supply (UPS) systems offer class-leading energy efficiency →02. For instance, our new Megaflex UPS solution delivers 97.4 percent efficiency regardless of load.

Circuit breakers are another key area. They protect people and equipment, but they themselves use energy. Our circuit breakers are class leading in terms of their own energy consumption. Beyond that, they are the most sophisticated in terms of data analytics. They provide our customers with outstanding access and visibility regarding what is going on. This intelligence

gives the customer the ability to make decisions regarding on where and how to use energy. And all of this is backed up by ABB's very robust and mature cyber security capability. In fact, ABB is one of the market leaders and most trusted brands when it comes to security in industrial control systems.

Finally, we offer a control system platform that is the eyes, ears and brains of many data centers. In fact, ABB Ability™ Data Center Automation is specifically designed for the data center industry. Nevertheless, given our decades of experience in other industrial applications, our strategy is to develop solutions for the broad industrial market and then apply them to different industries. As a result, our distributed control systems are effectively the same for a data control center as for a nuclear power plant or a skyscraper office block.

These systems are highly effective at gathering data and thus help our customers make energy-related decisions. The systems sit outside the electrical infrastructure and see everything from cooling to electrical to security.

One thing that is absolutely critical to the success of a control platform is the underlying infrastructure. That means that things like circuit breakers and transformers must have intelligence. So, when we develop new products, we look to embed connectivity, intelligence and accessibility in them so that these elements can interface seamlessly with the control system.

- AR** Concretely, how is ABB improving the energy efficiency of its major customers?
- CF** ABB is committed to supporting our data center customers and has emerged as a leader in energy efficiency. For instance, at the Mooresville, North Carolina (USA) GIGA Data Centers [3], ABB maximized scalability while helping GIGA achieve an ultra-low power usage effectiveness (PUE) rating. GIGA achieved a PUE of 1.15 per 50kW rack cabinet as compared with a 2019 industry average of 1.67.

Another great example is NextDC of Brisbane, Australia. ABB partnered with NextDC for their electrical infrastructure and automation technology systems to enable the company to monitor and tune their critical data center infrastructure. We have provided them with a comprehensive solution that includes complete power distribution systems, a critical services monitoring system (CSMS), and associated implementation and support services. The CSMS provides energy, cost and time savings.

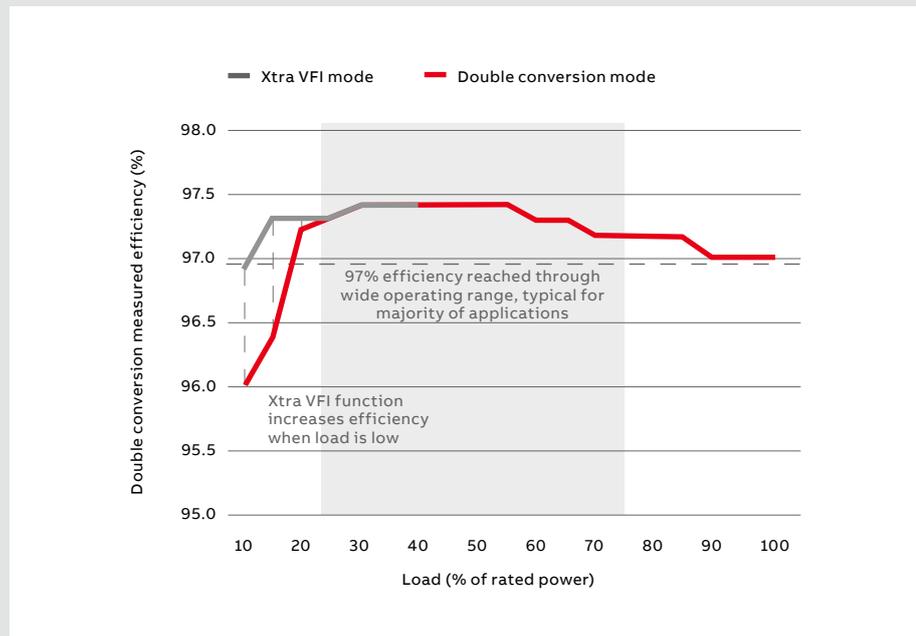
And near Stockholm, Sweden, Ericsson, one of the world's largest telecommunications network equipment suppliers, partnered with ABB to orchestrate its 20,000 m<sup>2</sup> Global Information and Communication Technology (ICT) Center [4]. Thanks to ABB Ability™ Data Center Automation, all three of the center's control systems –

—  
When we develop new products, we look to embed connectivity, intelligence and accessibility in them.

the building management system (BMS), the smart power management system (PMS) with automated functions, and the energy management system (EMS) – are handled through a single point of control. The Center has been able to achieve energy savings while reducing operational and capital spending. What's more, the facility provides heating and cooling services throughout its surrounding area through Stockholm's district heating system.

- AR** In what major ways do you expect the data center industry to develop over the next few years?
- CF** What we are already witnessing is the incremental quest to drive out energy waste. Data center operators are certainly becoming increasingly aware of the cost of wasting energy. As this trend

02 ABB's newest uninterruptible power solution (UPS) delivers 97.4 percent efficiency regardless of load.



02

expands, the data center industry will concentrate more and more on how it sources its energy, with an emphasis on using renewable energy. Furthermore, data center operators will increasingly engage with grid operators. That is where we get into new business models such as shared

The data center industry will concentrate on how it sources its energy, with an emphasis on renewables.

energy storage assets and share demand-response strategies. All in all, engagement with the public and consumers and stewardship of energy sources will be increasingly important, even as demand for services grows.

As for our role in all of this, the beating heart of ABB is that we are a customer-driven technology company. What ultimately drives us is our customers' goals. •

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## DATA CENTERS

# Data center automation

Few technical installations have evolved as quickly as the data center. In modern data centers, automation systems are replacing traditional control and monitoring solutions. But what is driving this change and how is ABB Ability™ Data Center Automation an improvement on the previous approach?



01 Located in what was once the world's largest olivine mine, the Lefdal Mine Datacenter is a 120,000 m<sup>2</sup> container-based data storage site in Måløy on the Norwegian West Coast. The site is projected to house as many as 1,500 containers with a cooling budget of up to 200 MW. It is in sites like this that data center automation is indispensable.

For the last six years, ABB has been pioneering automation that can replace traditional control and monitoring solutions for data centers. Now, many leading data center builders and operators rely on ABB's systems and expertise to ensure their facilities run efficiently and reliably.

But what is ABB Ability™ Data Center Automation and how is it an improvement on traditional methods? This article explains the differences between the two approaches and how the concept of converged, hardened, industrial systems will be applied to all data center facilities in the future.

#### **A brief history of data centers**

The multi-megawatt, custom-built data center behemoths of today grew out of the "computer rooms" and "server closets" that were simply rooms set aside as part of existing facilities. Power to these early "data centers" was provided

through a dedicated infrastructure and, when specified, an electrical power monitoring system (EPMS) was provided by the vendors of the electrical gear. Typically, these systems were closely tied to the particular vendor and it was difficult (and often impossible) to mix and match equipment from different vendors.

To get rid of waste heat, the heating, ventilation and air conditioning (HVAC) and the building management system (BMS) – or building automation system (BAS) – of the host facility were simply extended to include the data center cooling equipment.

Management and monitoring of the data center was largely a function of the IT organization. If there were concerns about hotspots, standalone temperature monitoring was put in place. Although they often provided detailed views of the data center temperature profile, these devices

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Many leading data center builders and operators rely on ABB's systems to ensure their facilities run efficiently and reliably.

were not tied into the BMS/BAS. If hotspots or uneven air distributions were identified, the responses were typically manual: computer room air conditioner (CRAC) setpoints turned up or down, floor vents moved around to change airflow, or fans positioned to redirect cold air.

Similarly, if IT personnel had concerns about power consumption, they would put the appropriate monitoring equipment in place. If detailed electrical observation was required, branch circuit monitoring (BCM) or in-rack monitoring methods were used. Again, these were typically

## BUILT FOR SUSTAINABILITY AND FLEXIBILITY: LAKELAND COMMUNITY COLLEGE DATA CENTER

In 2011, Lakeland Community College, Kirtland, OH, United States, moved the school's data center to a new campus facility and out of what Chief Information Officer Rick Penny [1] described as "mostly just a closet with some servers and move-in cooling units." The school needed an all-new, sophisticated data center with more space and more configurable flexibility [1]. The facility also had to be energy efficient and LEED-certified as a green building [2]. Lakeland chose ABB Ability™ Data Center Automation as its Data Center Infrastructure Management (DCIM) solution<sup>1</sup> →02a, "And now," Penny [1] said, "10 years later, I don't know what we'd do without it."

Since Lakeland Community College mandates that all new campus buildings be LEED-certified, they chose ABB due partially to the evidentiary reports of energy usage provided. Between

**Penny credits ABB Ability™ Data Center Automation with reducing energy usage by more than 53 percent.**

2006 and 2018, by focusing on sustainability and redesigning the way the heating and cooling works in its campus buildings, Lakeland could increase facility size by 18 percent while reducing electricity use 40 percent, natural gas use 49 percent, and water/sewer usage 30 percent [3].

According to Penny, ABB Ability™ Data Center Automation has been instrumental in helping significantly lower energy use and reduce costs. For example, by analyzing cooling data, they determined that the data center could reduce air conditioning demand by adding containment walls to the server rows →02b. Penny estimates that there is a 20- to 30-percent temperature differential inside the walled-off server containment areas as compared to outside these rows.

"We were able to shut down a big 10-ton AC unit that allowed us to save even more money than we were expecting," Penny [1] said. By

2014, Lakeland's new data center rated Silver LEED-certification status. Nearly a decade after moving into the new facility, Penny credits the ABB Ability™ Data Center Automation with helping reduce the facility's energy usage by more than 53 percent.

### Cool and cost effective

The increased operational visibility they got with the ABB solution, integrated with FNT Command from FNT Software, an ABB partner, has enabled Lakeland's data center operations to more efficiently add servers and take advantage of emerging hyper-converged infrastructure (HCI) technologies. While converged hardware is typically smaller, it runs considerably hotter than traditional hardware, with power supplies often rated above 1,000 W, eg, a full rack of 2U-high HCI boxes could be 25-30 kW, while typical 1U servers are about 350-500 W each [4]. The school's former data center was too small to support the additional air conditioning that HCI required.

Moving into the new facility with ABB Ability™ Data Center Automation enabled Lakeland to more efficiently arrange the data center layout and plan cooling configurations to better control energy usage without compromising uptime →02c. The college could take advantage of emerging data center trends and technologies, including shifting many of its servers to the cloud, reducing the number of servers they needed to cool, ultimately lowering energy cost.

### Increasing uptime

David Levine, Associate Director of Administrative Technologies for Lakeland, thinks that from an operations and maintenance point of view, ABB Ability™ Data Center Automation with FNT Software, has been a game changer for its monitoring, alarm capabilities and planning efficiency.

"Our air conditioner works off the water temperature and if the water temperature gets too high, it alerts us. I have temperatures of everything, including how many KW every row and every rack consume," Levine [1] said. "Plus, the DCIM has a water sensor around the racks so if there's any liquid that gets on the floor there, it will alert us."

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### Footnote

- 1) The original name for ABB's solution purchased by Lakeland Community College was ABB Decathlon® for DCIM, Education Edition.



02a

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02 Data Center Automation makes advanced functionality possible as demonstrated by its implementation in Lakeland Community College.

02a The system handles vast amounts of data; this enables rapid and accurate analysis and visualization of attributes.

02b The addition of containment walls (shown here with Penny) to its server rows helped reduce cooling demand at Lakeland Community College.

02c ABB's automation solution permits the college to track the inventory of all data center racks (shown here with Levine); this allows them to easily predict how additions and changes will impact the system.



02b

“The best thing is that our server uptimes are almost 100 percent. Things happen in the data center just because there are physical components. But now, we get alarm notifications and can resolve issues before these things can become

—  
ABB's automation solution has been a game changer for Lakeland's monitoring, alarm and planning capabilities.



02c

a disaster.” Penny [1] explained. Plus, Levine noted that his operators can more efficiently track inventory of all data center racks to understand the impact of adding something new.

What's next for the Lakeland Community College data center? Penny and Levine plan to capitalize on the efficiencies they get with the ABB Ability™ Data Center Automation system and HCI to reduce the data center footprint by 50- to 66-percent of its current size. “We are looking forward to the energy savings,” said Penny [1]. •

standalone arrangements. Often, there was no power monitoring in place and consumption was calculated by totaling up the estimated consumption of each server.

Throughout all this, the divide between IT staff and facilities management remained rigidly in place. The facilities team monitored the system enough to ensure the cooling systems functioned and sufficient electrical power was delivered. IT consumed the power and cooling and did its best to optimize its use.

#### **Dedicated data center construction**

As data center requirements grew, dedicated buildings started to appear. Inevitably, power consumption skyrocketed and the corresponding increase in waste heat drove more sophisticated cooling designs. These new data centers bore little resemblance to the server rooms of the past, yet three facts did not change:

- The building HVAC remained a dedicated, standalone system, managed by the same BAS/BMS that was used to manage HVAC in other types of buildings.
- Electrical monitoring was still provided by the vendors of the electrical equipment.
- IT staff still ignored the BMS and EPMS and installed their own systems, when required.

Why was this? It was because these three conventions derived from the tried-and-tested models used for constructing the commercial buildings that formerly housed data centers. These models involved, for the most part, traditional builders contracting with traditional vendors to equip traditional commercial, non-mission-critical buildings (such as office buildings or shopping malls) and not modern data centers with quite different requirements.

#### **Band-aid solutions**

Modern data centers do not resemble traditional commercial buildings in any way; they are large, purpose-built, power-hungry, mission-critical pieces of infrastructure, with much more in common with industrial facilities than with commercial ones. Because many data centers are still built using traditional methods, they adopt design strategies that make implicit assumptions about control system failures, often at considerable cost. For example, complicated, multi-tier cascading BMS designs, where upper tier and lower tier controls perform the same action

using parallel communication channels, each assuming the other can fail at any time, are common. Equally common are management systems that do not actually perform any management and in which individual subsystems manage themselves and exclude any possibility of mutual coordination.

These band-aid solutions all have the same underlying assumption: the control system is unreliable and cannot be counted on except for basic visibility or, at best, high-level coordination.

#### **Silos**

Traditional data center construction often causes the individual subsystems to be divided into standalone systems or “silos.” These silos correspond to the scope of supply of an individual vendor or subcontractor: the electrical contractor supplies the EPMS, the mechanical contractor the BMS and so on. No overall system supplier is tasked with unification or consolidation. The result is a duplication of material and effort since each system contractor will need to install, wire,

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**New data centers bore little resemblance to the server rooms of the past.**

program and commission separate systems that share common actions: read data from devices, move the data around the network, display the data on screens, inform users when the data is not what it should be and send data back to the devices when it needs to change.

#### **Revolution rather than evolution**

The evolutionary and piecemeal approach to data center control and monitoring described above scales up extremely poorly. Data centers are not just larger, more power-hungry office buildings. In fact, data centers manage critical data for global communications, financial transactions, government services, business operations and entertainment. Facility sizes of 50,000 m<sup>2</sup> (>500,000 sq. ft) and power consumptions of 50 MW are no longer uncommon →01.

From a size and criticality perspective, modern data centers have much more in common with



03

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03 Modern data centers need industrial-scale automation if they are to run efficiently and reliably.

industrial facilities – power plants and oil refineries, for instance – than they do with commercial buildings. Given this fact, it seems natural that industrial-grade automation systems should be used to monitor and manage data center infrastructure. Industrial automation systems are robust and highly hardened systems that can scale from small to extremely large and from simple to extremely complex. They are designed to talk to all kinds of equipment using many different protocols and have been designed for continuous operations over long periods, even while being upgraded. Furthermore, industrial systems are cyber-secure, needing to comply to the rigorous standards set in the various industrial environments in which they operate.

ABB Ability™ Data Center Automation systems are simply industrial automation systems adapted for use in data centers. They eliminate the requirement for band-aid solutions in the facility since they are designed to run continuously and reliably via built-in redundancy and are designed for scalability. Since they perform the functions of all the various siloed systems they replace, they are also cheaper to install, as only a single system is necessary to cover all building management and electrical monitoring tasks.

#### **Advanced functionality: optimize operations and reduce downtime**

By consolidating all the facility information in the ABB Ability™ data center, Data Center Automation systems also become the natural platform for advanced functionality. Since all the data on power consumption, cooling, performance metrics and status are managed, in real time,

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It seems natural that industrial-grade automation systems should be used to monitor and manage data centers.

by one system, advanced prediction and optimization can be performed. This data consolidation is especially important for energy saving and sustainability, as demonstrated in the case of the Lakeland Community College implementation →02.

Condition-based monitoring provides a good example of cost-savings technology. Here maintenance is triggered using predictive indicators, rather than after a set time interval. Health information is collected from the electrical and mechanical systems, aggregated, analyzed and compared to historical data to provide advanced warning of degrading equipment performance or

Predictive maintenance, energy optimization, etc., are possible only through consolidation of data center information.

impending failure. This approach optimizes operations, reduces the risk of downtime and eliminates waste associated with premature or unnecessary maintenance.

Predictive maintenance, energy optimization, dynamic load forecasting, etc., are possible only through consolidation of data center facility information – and consolidation is only possible when robust, reliable, industrial technologies are used →03.

**Intelligent data centers**

Technologies such as 5G and the Internet of Things are pushing data center designs to new levels of complexity. IT loads will become far more dispersed and fluid and the facilities that power them will have to be much more adaptable. Old efficiency metrics like power utilization effectiveness (PUE) will have little meaning in a world where IT load can transition from 0 to 100 percent and back to 0 percent over the course of a day to accommodate, say, telemetry data from self-driving cars during rush-hour (after all, how efficient can a fully powered data center with zero IT load be?) To be truly efficient, the facility itself has to be “self-driving” and predictive so it can deliver energy and cooling to handle such transient loads. Only through Data Center Automation can truly intelligent data centers that are sophisticated enough for these, and other, as yet unthought of, tasks be realized. •

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04 In contrast to the small-scale implementation in Lakeland Community College, Ericsson are exploiting the full spectrum of ABB’s Data Center Automation’s functionality in their ICT center in Sweden.

04a Ericsson’s Global Information and Communication Technology (ICT) Center in Rosersberg, Sweden, uses ABB Ability™ Data Center Automation.

04b ABB Ability™ Data Center Automation allows comprehensive monitoring and control of extensive data center facilities from a single point. The central control node at Ericsson’s Global ICT Center is shown here.

04c Ericsson uses ABB Ability™ Data Center Automation to monitor the chilled water flow from the municipality to the center to cool their servers.

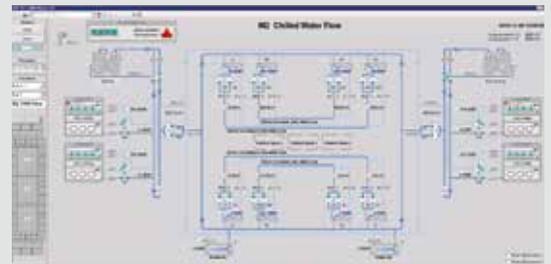
04d Ericsson’s PMS monitoring load-shedding activity.



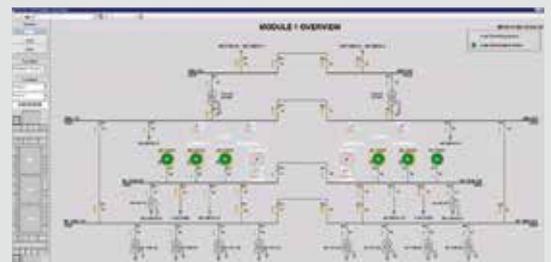
04a



04b



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## ABB'S DATA CENTER AUTOMATION FOR ERICSSON: AN ALL-IN-ONE AUTOMATION SYSTEM FOR EFFICIENT, SUSTAINABLE RELIABILITY

ABB Ability™ Data Center Automation is being used by Ericsson, one of the world's largest telecommunications network equipment suppliers, for its Global Information and Communication Technology (ICT) Center in Rosersberg, Sweden →04a.

The Global ICT Center is of critical importance to Ericsson as company engineers around the world use the facility remotely to test products and services, before releasing them to clients. The reliability of the site and its ability to operate efficiently without interruption are crucial to Ericsson's success.

The vast data center spans over 20,000 m<sup>2</sup> but all three of the site's control subsystems – the BMS, smart power management system (PMS) and energy management system (EMS) – can be monitored and controlled from one room, thanks to ABB Ability Data Center Automation →04b. As a result, Ericsson has been able to reduce energy usage by 40 percent while reducing operational and capital spending.

In this project, Ericsson leveraged ABB's expertise in powertrain technologies and automation, including magnetic flow meters (for cooling-water flow), substation transformers and medium-voltage switchgear – all controlled and monitored by the automation system.

### Energy management is key

ABB's technology enabled Ericsson to automate and control operations not only across hardware and software systems but also across power, cooling and energy management systems. This involves integrating data from equipment supplied by at least six different manufacturers.

The BMS manages ventilation and cooling. Heat removed from the Global ICT Center is recycled to provide heat and hot water to some 20,000 local residences. In return, Ericsson obtains cold water from the city to help cool the center's servers →04c. Efficient management of these thermal transfers is possible through ABB's control system, enabling a more sustainable and profitable operation for both Ericsson and the region.

The PMS is designed to support the 15 MW IT load and the BMS load, which includes monitoring of: the uninterruptible power supply (UPS) battery package, auxiliary power supply, generator-set fuel system and automatic transfer schemes,

All three control systems can be monitored and controlled from one room, thanks to ABB Ability™ Data Center Automation.

as well as advanced functionality to respond to failure situations. When the backup power is activated, load-shedding functions are triggered so that UPS power is available for critical loads →04d. All loads can be controlled from one screen and non-critical loads can be configured at a lower demand status. These smart power solutions were designed into the software, enabling Ericsson to optimize their infrastructure, thus reducing the quantity and size of their UPS and gensets.

Finally, the EMS collects power and energy measurements from all the meters within the facility. This gives Ericsson insights into their energy consumption and where they can improve efficiency. As data centers grow in size and number, owners and customers have a major incentive to manage their energy use wisely. It is estimated that energy accounts for up to 40 percent of the total cost of ownership of a data center. If centers do not become more efficient and innovative, their growth could be constrained by overloaded national power grids. •



DATA CENTERS

# Ensuring profitability with innovative data center solution architectures

ABB’s comprehensive pre-engineered solution, based on three topologies, addresses the data center industry’s electric needs: flexibility, scalability and cost-effectiveness to ensure timely start-up, operative reliability and maintainability.



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The data center industry has experienced unprecedented growth over the last decade. With the application of the Internet of Things (IoT) in all areas of work and play, the demand for computing power continues to accelerate – especially as the lure of big data gathers momentum. Recent advances in both IT hardware and software have

Attitudes about data centers have changed; they are seen as an integral part of business operations and revenue generation.

resulted in the virtualization of servers, cloud computing, and the ability to transfer some of the required reliability from the infrastructure layer to the software layer.

The data center market, once dominated by purpose-built on-premise enterprise data centers, has shifted to off-premise colocation and cloud data centers. With a global spend of over

USD 38 billion on colocation services predicted by 2023 and multi-tenant centers experiencing 5 percent growth in 2018, this trend will most assuredly continue [2].

The primary advantages of these increasingly popular services to enterprise clients is clear:

- Companies can easily rent colocation data center space from third parties or utilize cloud data centers, thus eliminating the need for infrastructure such as building, cooling and security.
- Companies can eliminate the need to manage IT components, including servers, data storage and firewalls.

### Data centers for profit generation

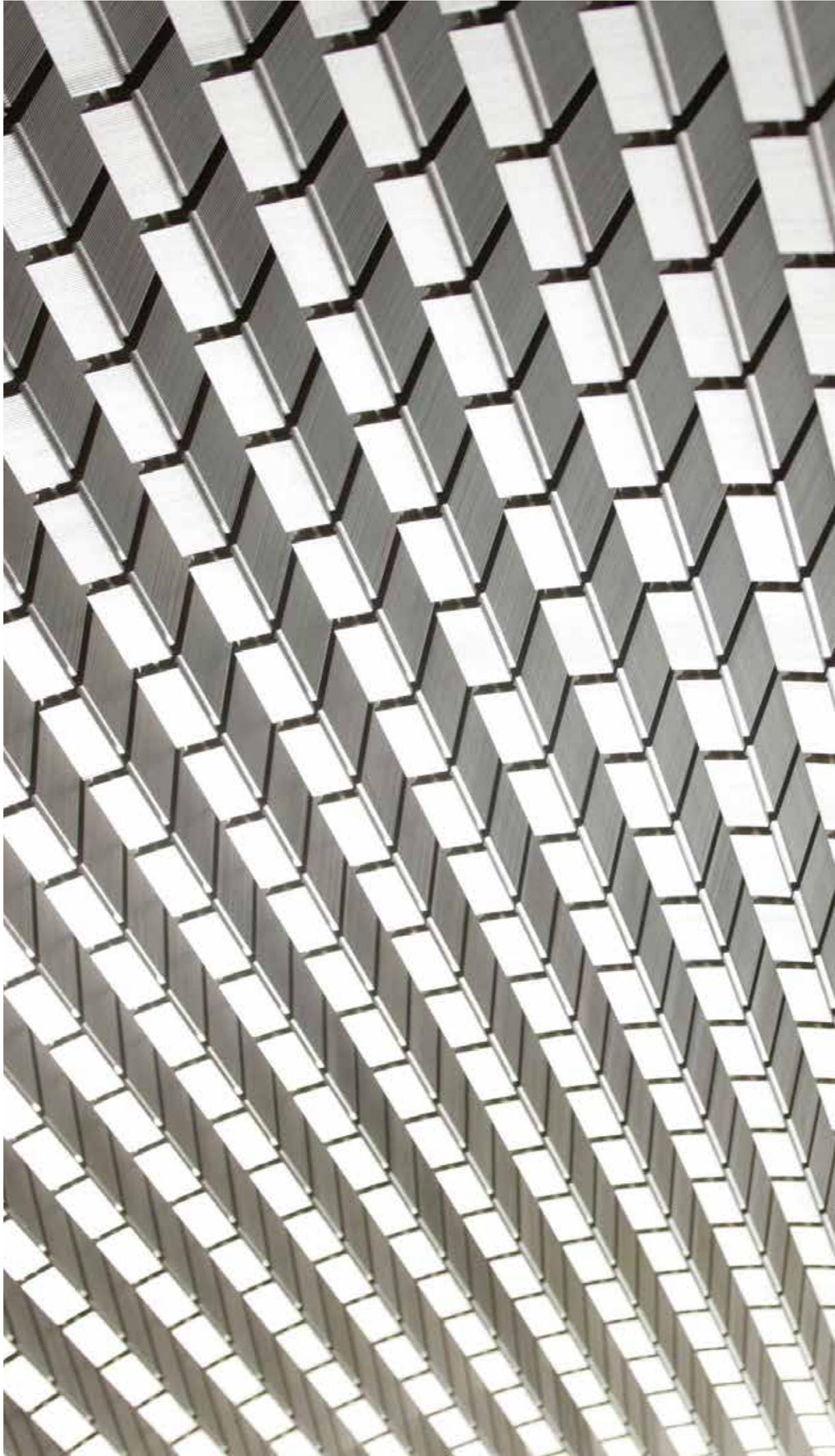
The overall data center construction market growth is predicted to increase by 9 percent between 2019 and 2023. Nonetheless, the market is consolidating [1]. Coinciding with the technological expansion, companies are increasingly applying sound business practices to the design and construction of data centers →01.

The purpose of data centers is still evolving; they are no longer just a necessary part of



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Nowadays, businesses can choose from on-premise enterprise centers to off-premise virtualized infrastructures that support applications and physical components across the cloud environment.

business operations, they are a profit generation center [1]. Attitudes about data centers within an enterprise have adjusted; they are now seen as an integral part of business operations and revenue generation. As a result, data center strategies are more attuned with business realities. Their costs – both capital and operational – are highly scrutinized. This scrutiny comes from both internal checks and balances with a company's finance office, as well as external environmental watchdog groups as greater attention is now paid to energy consumption [1]. To meet these expectations, the industry has had to revise its justification for data centers and incorporate new concepts about their design, construction and operation.

#### **Recognizing and meeting industry demands**

Reliability and maintainability are central to the successful operation of data centers and so companies must remain flexible. These centers must satisfy industry requirements for redundancy and fault tolerances: electrification designs must ensure that equipment replacement or removal from service will not impact the critical load.

ABB offers data center customers, including cloud and colocation industries, leading edge technologies to meet these challenges. By fulfilling modularity, flexibility and efficiency

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**ABB offers data center customers leading edge technologies to meet tomorrow's challenges.**

requirements for solution architecture, ABB ensures safe, secure and continuous operation in a rapidly evolving data center landscape.

#### **Design standardization**

The task of creating a flexible fortress-like data center that safely and securely stores and manages business-critical data and applications under every conceivable situation, while simultaneously accommodating both short-term and long-term growth, is daunting. Overall, this

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01 ABB and GIGA Data Centers developed an electrification solution of LV switchgear, dry-type transformers and UPS to support the IT server and network infrastructure of the GIGA Data Centers is shown.

02 A schematic system plus system topology is shown; this topology was the basis for the design of the packaged solution for GIGA Data Centers.

03 The shared redundant topology is similar to system plus system topology except that it uses multiple systems to increase utilization and reduce costs.

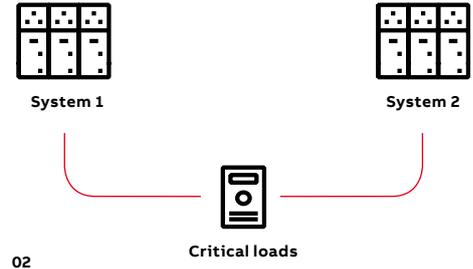
04 The block redundant topology is illustrated; this topology is commonly used in hyper-scale and colocation data centers.

necessitates electrification designs that are more flexible and scalable. These designs should incorporate a standard block of power, repeated throughout the design, to allow for any future expansion. These design concepts offer significant improvements over previously conceived data center designs.

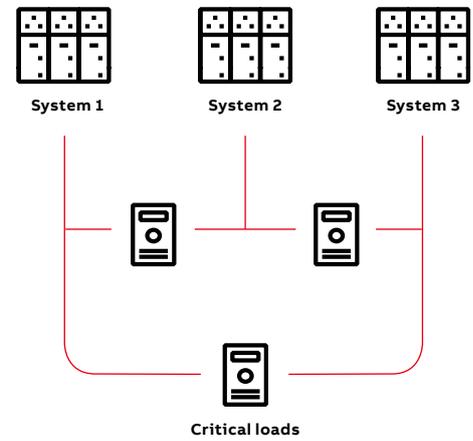
The standardization of design improves operational reliability, and yet these designs must be flexible enough to adapt to a myriad of site requirements. ABB's design experts recognize these challenges and take into account site variables, eg, utility voltage, total size of the data center, and the optimal design for cooling based on the local climate →01. Scalable and repeatable designs are based on a standard size IT load that is taken as a building block. By using this tried-and-proven process, ABB ensures reliability and maintainability.

**Short timeline**

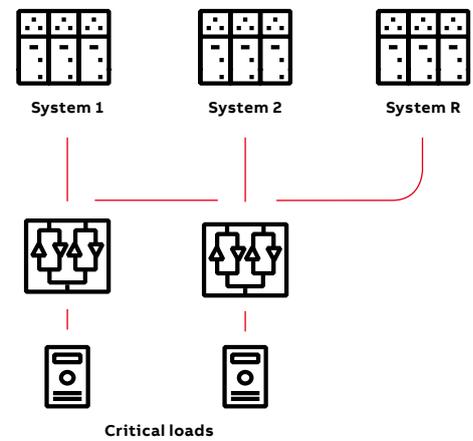
Fast track project execution, short cycle delivery times and the cost-effective utilization of assets are key to the success of data center projects as they have a direct impact on capital cost.



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Photo: GIGA Data Centers

In addition, design criteria will influence the electrification topology for the critical power distribution and impact cost.

Project implementation time is a particularly critical factor – one differentiated by uncertainty. Even though the demand for computing power

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### ABB fulfills modularity, flexibility and efficiency requirements for data center solution architecture.

continues to accelerate, growth is not easily forecasted. Determining the end-solution at the start can be difficult, especially for the colocation and cloud data center markets. Paradoxically, speed to market is a dominant requirement for new data center projects and for the expansion of existing ones. ABB takes all of these factors into account to create pre-engineered electrification solutions that are modular, scalable and efficient as well as versatile, thereby ensuring successful implementation on an extremely short timeline.

#### **Electrical topology choice: a matter of function**

Conventional electrical topologies, commonly used in data centers, can be implemented in several different configurations depending on exacting project requirements and site conditions. Factors that determine the actual configuration include: load kilowatts (kW), available utility service voltages, initial cost, etc.

Although most data center electrification systems are unique, there are only three main underlying topologies: system plus system, shared redundant and block redundant topologies.

As the name implies, the system plus system topology utilizes two completely independent systems to feed the critical load →02. The design is based on deploying IT equipment with redundant power supplies (sometimes referred to as dual corded loads). This topology is the basis of design for on-premise data centers, for example, enterprise-, financial- and government data centers as well as colocation companies.

Although the system plus system design has a proven reliability record, costs can be prohibitively high: a maximum utilization of assets is 50 percent. Thus, a variant of this topology is often

employed to reduce overall cost: system + utility. Here, the “system” has N+1 uninterrupted power supplies (UPS) while the “utility” has no UPS.

Colocation, hyperscale and cloud data centers generally use the shared redundant topology, which comes in a variety of configurations →03. The design is normally designated by the number of systems over the number of loads, eg, 3N/2 for three systems and for two loads, or 4N/3 for four systems and for three loads, etc. For example, using 1 MW blocks of IT load, a 3N/2 system would have 3MW of capacity feeding 2MW of IT load.

With this configuration, customers can improve utilization by up to 66 percent; 75 percent is possible with 4N/3. Consequently, this topology serves as the basis for the design of many colocation and hyperscale data centers and for hyperscale computing because the goals of big data and cloud computing environments are maximum performance, lowest possible cost, and peak power efficiency. While the use of the shared redundant topology does improve asset utilization, it nonetheless requires the operators to monitor loads.

Block redundant topology, also known as catcher topology, utilizes a static transfer



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05 Data centers paradoxically require extremely flexible yet standard solutions so they can expand or shrink as their needs change. ABB provides standard solutions that evolve with their customers' needs.

switch (STS) to transfer the critical load from the primary or active system to the reserve or catcher system →04. Such a topology is used by both hyperscale and colocation data centers. For data centers with single corded loads this topology is usually the most cost-efficient design. With the block redundant topology,

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**ABB's package solutions ensure safe, secure and continuous operation in a rapidly evolving data center landscape.**

an asset utilization of 80 percent is possible and there is no need to constantly monitor loads to maintain redundancy. The primary disadvantage of this topology is the reliance on static transfer switches; this increases the cost and complexity of the design. Block redundant depends on the ability of the catcher or reserve UPS module (or modules) to handle a step load. The active UPS can be loaded to full capacity. The reserve UPS has no load in normal operation. The reserve

system can be larger than the active systems. Block redundant can be applied with single cord or dual corded IT loads. As such, if single corded IT loads are used, the static transfer switch is a single point of failure.

**Pre-engineered solutions: limited site-work and smooth startup**

ABB developed standard solution architectures, a pre-engineered integration of products for all electrical distribution needs from the utility service to the rack, based on these three topologies. ABB's comprehensive solutions are the answer to the data center industry's specific electric needs: flexibility, scalability and cost-effectiveness to ensure a short and sweet startup along with operative reliability and maintainability. Flexibility also helps customers to address future needs as the data center grows and IT needs evolve →05.

All pre-engineered solutions can be easily duplicated or slightly modified to serve most data centers on the market →06. A package includes: substations, medium voltage (MV) switchgear, transformers, low voltage (LV) switchgear, LV switchboards, UPS systems, power distribution units (PDU), remote power panels (RPP), and IT busways.

**Solution architecture: a collaboration story**

In 2018, ABB with its acquisition of GE Industrial Solutions, began collaborating with GIGA Data Centers to develop a critical power distribution design for their new data center in Mooresville,

**In 2018, ABB and GIGA Data Centers collaborated to develop a critical power distribution design for a colocation data center.**

North Carolina, USA. As a colocation data center company, GIGA endeavors to make flexible and modular data center technology available at a competitive cost to all its customers, not just to

hyperscale data center customers. GIGA turned to ABB because of their solid expertise in providing flexible, innovative technical electrification solutions within a challenging time frame.

Having acquired a long rectangular building suitable for conversion into a data center, GIGA and ABB jointly worked to design a system that would support 60 MW of IT load. Amazingly, the first phase of data center conversion was completed in less than six months. Subsequently, ABB's expert team and GIGA's mechanical, electrical and plumbing consultants collaborated to design a flexible, scalable and efficient packaged solution based on a system plus system topology. This design is scalable and has the capability of expanding in increments of 2 MW of IT load. ABB's electrification solution for GIGA Data Centers included LV Spectra Switchboards, TLE UPS modules (to support the customer's IT

**ABB'S EHOUSES AND SKIDS FOR COLOCATION DATA CENTER**

Colocation data center customers prefer scalable electric equipment to fulfill their various sizing needs and meet delivery and commissioning goals. ABB's skid units and electrical house (eHouse) packages enable data centers to address these challenges. Common to traditional construction methods, packaged solutions are typically supplied as individual components with installation and interconnections provided by third parties.

Such a solution is an open frame mounted, compact unit with factory installed equipment and interconnections. Because they are pre-engineered, pre-installed and pre-tested, indoor skid solutions can be built off-site parallel to other construction efforts, thereby accelerating the construction schedule.

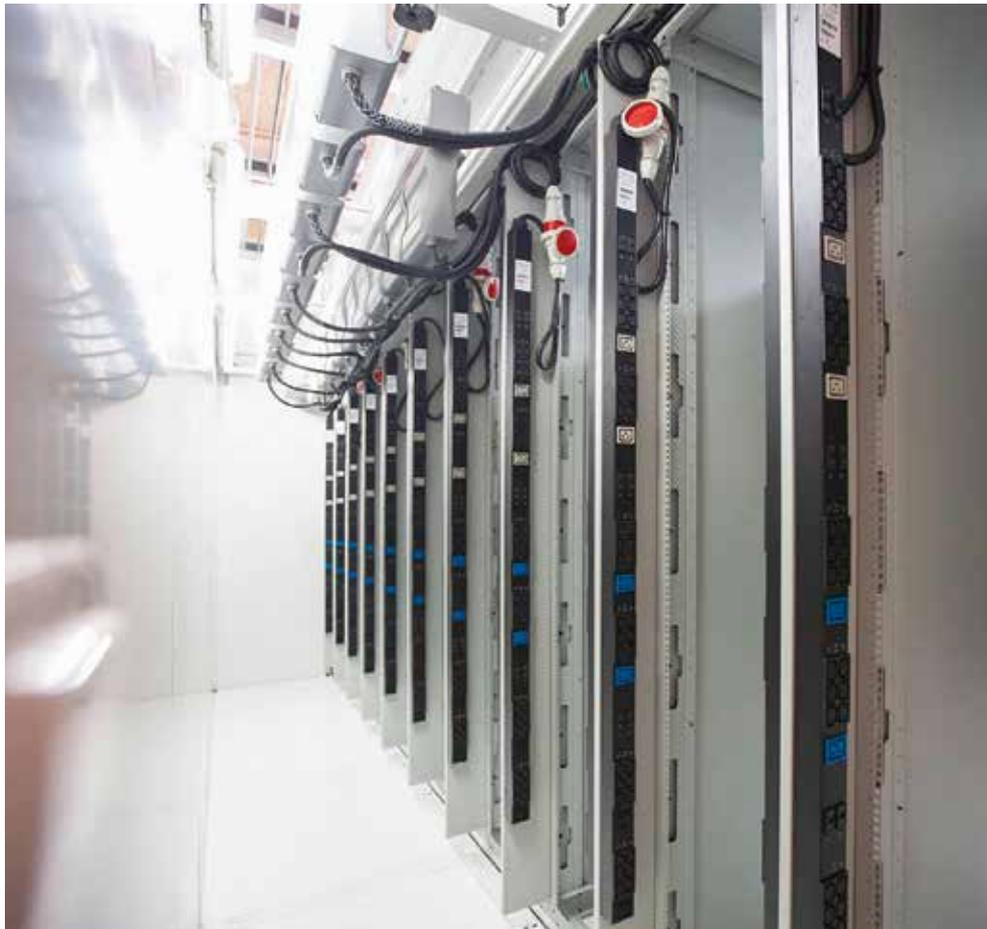
The eHouse is a pre-fabricated, pre-engineered and pre-tested system; it is an environmentally controlled building with factory installed equipment and interconnections. By testing all components prior to shipping, ABB ensures that risks in the field are minimized. These units are easy and cost-effective to install and can be placed close to



the main loads. Although, usually permanently installed, they can be relocated as a colocation center grows or a customer's IT equipment is changed.

With eHouses, customers can accelerate their construction schedule and save space. Such one-piece systems are suited for data center projects that must reduce on-site work, eg, remotely located centers where qualified personnel are unavailable or labor is expensive or difficult to manage. By optimizing layouts through modular design and leveraging skidding and eHouse technologies, ABB helps customers reduce cost.

Photo p. 29: GIGA Data Centers



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06 Electric package solutions, such as skids, and eHouses, help customers meet sizing and commissioning goals.

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07 GIGA Data Centers located in North Carolina, USA depended on ABB to achieve start-up on a tight timeline.

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server load), Decentralized Parallel Architecture (DPA) UPS (for the site server load: facility optic fiber and network), UPS maintenance bypass cabinets, lithium-ion battery systems, lighting panel boards, and dry-type transformers. The DPA

and commissioning of all equipment to the commissioning of all systems. ABB's successful end-to-end solution is a compact and efficient data center that delivers the power distribution and protection performance GIGA needs today with the potential to expand in the future →07.

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**ABB's end-solution is a compact and efficient data center with the power distribution and protection performance GIGA needs.**

ABB's complete electrification package solutions based on standard designs provide data center customers with flexibility and scalability so they can build and run data centers efficiently today and gives them the ability to react swiftly to market changes. •

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[2] C. Flanagan, "Gaining a Competitive Edge", ABB white paper, 2017, pp. 1-11.

UPS was chosen as it is more effective for lower power requirements and can scale as GIGA expands. Lithium-ion batteries were the logical choice: they are smaller and lighter and can run at higher temperatures than lead-acid batteries, thereby obviating the need for an additional cooling system.

ABB's packaged solution included all project management and field services from the start-up



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## DATA CENTERS

# How data centers can minimize their energy use

Although data centers have managed to keep their collective power demand at about two percent of the world's electricity use, their energy consumption could grow exponentially if computationally intensive applications, such as video on demand, autonomous vehicles and advanced 5G technology gain wider popularity, as is expected. To manage these challenges, data centers will need to implement every possible strategy to maximize their energy efficiency.

When ABB entered the data center sector over 25 years ago, the major factors driving the market were uptime and reliability. Shortly thereafter, however, concerns about energy demand quickly stole the show. Starting in 2007, with the publication of the US EPA's seminal Report to Congress on Server and Data Center Energy Efficiency Opportunities [1], inaccuracies regarding projected data center energy use →01 resulted in the impression that the industry was becoming an insatiable energy eater. Fortunately, this impression turned out to be far from reality.

Indeed, according to the June, 2016 United States Data Center Energy Usage Report [2], combined use of electricity by all US data centers has increased only minimally in the last six years from 70 billion kWh in 2014 (representing about 1.8 percent of total U.S. electricity consumption) to an estimated 73 billion kWh in 2020 →02. What's more, this statistically minor uptick in energy demand, which has held steady at approximately two percent of overall US energy usage, has occurred in the context of a vast proliferation in the number of smart devices and the expansion of online culture to the point of near ubiquity.



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Key to these gains have been the exploitation of some fairly low-hanging fruits such as running data centers at higher temperatures, using virtualization to cut down on the number of underutilized servers, improved efficiency of uninterruptible power supplies (UPS), and the use of frequency drives vs dampers to control fan loads.

Other factors have also contributed to keeping data center power demand in check. For instance, servers, storage devices and infrastructures have become steadily more efficient. In addition, the industry has benefited from the trend toward larger and more efficient cloud and hyperscale centers. The latter, according to the IEA, consume proportionally much less energy for cooling compared to smaller data centers and, according to recent statistics, represent a steadily growing proportion of all data traffic. However, striving for the ultra-high efficiencies found at the state-of-the-art data centers of large web-based companies is usually not technically or economically

feasible. For them every watt counts. What, then are the short-term, tactical actions that can provide immediate benefit, yielding significant electric utility cost savings?

### Measuring efficiency

For years, lowering power usage effectiveness (PUE) has been high on data center operators' wish lists. Simply put, PUE is a measure of a facility's total power delivered divided by its IT equipment power usage, and all agree that the lower this figure is, the better. A PUE rating of

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Over the last six years, combined use of electricity by all US data centers has increased only minimally despite vast proliferation of smart devices and online culture.

1.0 would be equivalent to a 100 percent efficient facility. Typically, however, data centers average about 1.67, which means that for every 1.67 watts of electricity drawn by the facility, only 1 watt is being delivered to IT equipment.

Total facility power is measured as the power dedicated to operating an entire data center. IT equipment power is defined as the power required to operate devices used to manage, route, store, or process data within a data center.

These measurements provide a baseline that allows a facility manager to compare an installation's power usage levels to that of other data centers. The only problem is that there is more than one way to calculate PUE, making it difficult to compare one facility with another.

### A comprehensive approach

What is needed are performance metrics that are more holistic than PUE in measuring data center efficiency. The key limitation of PUE is that it measures the overall efficiency of an entire

building infrastructure supporting a given data center, indicating nothing about the efficiency of the IT equipment itself. IT efficiency, on the other hand, is the total IT output of a data center divided by the total input power to IT equipment.

But how can IT power consumption be measured? According to the Green Grid, IT efficiency can be measured accurately after all power conversion, switching, and conditioning is

complete. Thus, to correctly gauge the total power delivered to server racks, the measurement point should be at the output of the power distribution units (PDU).

Alternatively, IT output refers to the true output of the data center, in terms of the number of web pages served, or number of applications delivered. In real terms, IT output shows how efficiently the IT equipment delivers useful output for a given electrical power input. Site infrastructure efficiency indicates the

30 percent of servers worldwide are unused. The result: \$30 billion in wasted electricity per year.

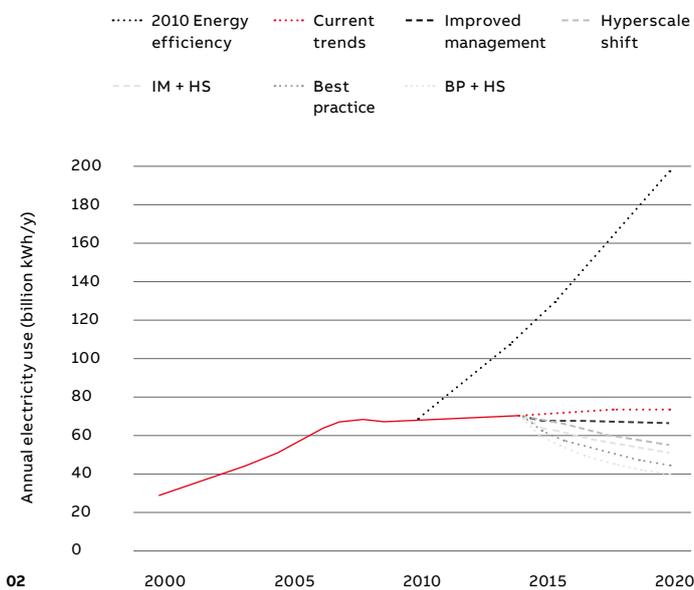
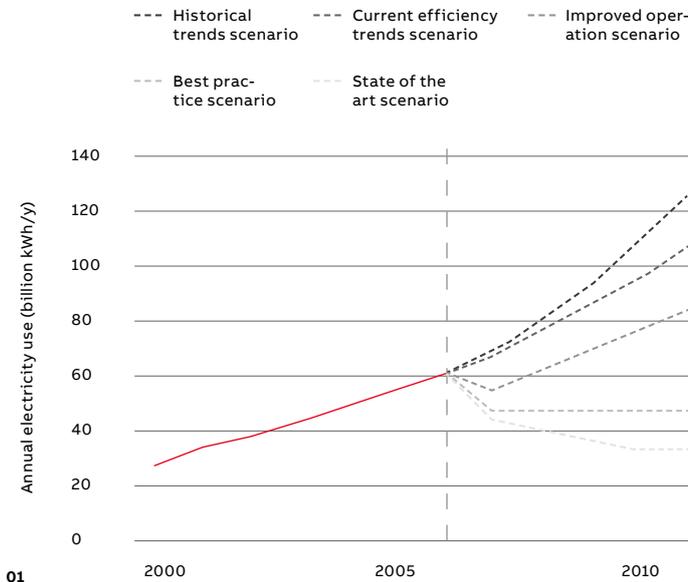
amount of power that fuels actual IT equipment, and how much is diverted into support systems like back-up power and cooling. These two figures make it possible to track efficiency over time; they can also reveal opportunities as to how to maximize IT output, while lowering input power by reducing losses and inefficiencies in support systems [3].

**Minimizing idle IT equipment**

IT equipment is usually very lightly used relative to its capacity. For instance, servers tend to be only five to 15 percent utilized, processors 10 to 20 percent, storage devices 20 to 40 percent, and networking equipment is 60 to 80 percent utilized.

However, whenever such equipment is idle, it still consumes a significant portion of the power it would draw at maximum utilization. Indeed, a typical server consumes 30 to 40 percent of maximum power even when doing no work at all.

The Uptime Institute has found that 30 percent of servers worldwide are unused. This does not affect a data center's PUE but results in a loss of \$30 billion in wasted electricity per year worldwide. One approach to dealing with this is distributed computing, which links computers to work as if they were a single machine. Scaling up the number of data centers that work together increases their processing power, thereby reducing or eliminating the need for separate facilities for specific applications.





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— 01 Future electricity use by U.S. data centers as projected by the U.S. Environmental Protection Agency in 2007 [1].

— 02 Actual electricity use in all U.S. data centers, including energy used for servers, storage, network equipment, and infrastructure. Solid line represents historical estimates from 2000-2014. Dashed lines represent five scenarios through 2020 [2].

— 03 ABB SMISLINE power distribution equipment. More than 50 percent of the power required to run a server is used by its central processing unit.

### Virtualization of servers and storage

Across the industry, we can see many instances of dedicated servers and storage systems inefficiently deployed for a single application – just to maintain physical lines of demarcation. However, with virtualization, servers and storage systems can be aggregated onto a shared platform while maintaining strict segregation among operating systems, applications, data, and users.

Most applications can run on separate “virtual machines” that, behind the scenes, share hardware with other applications. Virtualization can bring great benefits for most data centers, dramatically improving hardware utilization and enabling a reduction in the number of power-consuming servers and storage devices. It can also improve server use from an average of 10 to 20 percent to at least 50 to 60 percent [4].

### Consolidating servers, storage, and data centers

At the server level, blade servers can really help drive consolidation as they provide more processing output per unit of power consumed.

Compared to traditional rack servers, they can perform the same work with 20 to 40 percent less energy.

Consolidating storage provides another opportunity. Since larger disk drives are more energy efficient, consolidating storage improves memory utilization while reducing power consumption.

And last but not the least, if underutilized data centers can be consolidated in one location, operators can reap vast savings by sharing cooling and back-up systems to support loads.

Data centers' electricity demand has remained roughly level in the past five years, in part because of a shift toward ‘hyperscale’ facilities, which are super-efficient due to an organized, uniform computing architecture that easily scales up to tens of thousands of servers.

On average, one server in a hyperscale center is said to be able to replace 3.75 servers in a conventional center. In a 2016 report, the Lawrence Berkeley National Laboratory estimated that energy usage would drop by a quarter if 80 percent of servers in small U.S. data centers were moved to hyperscale facilities.

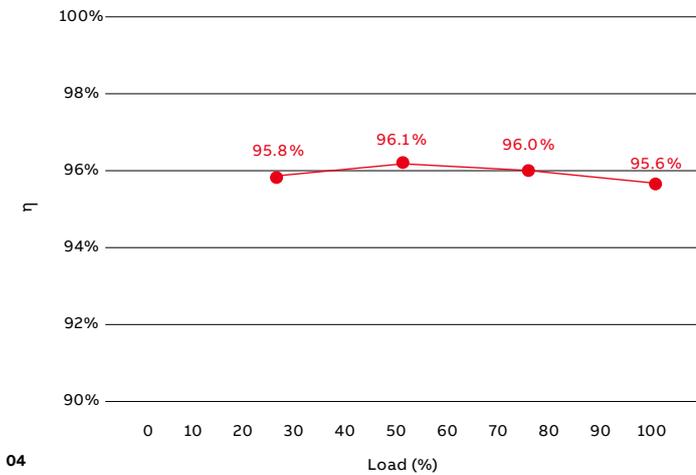
### Managing CPU power usage

More than 50 percent of the power required to run a server →03 is used by its central processing unit (CPU). Chip manufacturers are developing

— Virtualization can improve server use from an average of 10 to 20 percent to at least 50 to 60 percent.

more energy-efficient chipsets, and multi-core technology enables the processing of higher loads using less power.

Other options for reducing CPU power consumption are also available. Most CPUs have power-management features that optimize power consumption by dynamically switching among multiple performance states based on utilization. By dynamically ratcheting down processor voltage and frequency outside of peak performance tasks, the CPU can minimize energy waste.



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Such adaptive power management reduces power consumption without compromising processing capability and results in significant savings when CPU utilization is variable.

**Toward improved power supplies**

The power supply unit (PSU), which converts incoming alternating current (AC) power to direct current (DC), consumes about 25 percent of the server’s power budget, second only to the CPU. The point-of-load voltage regulators, which convert 12V DC into the various DC voltages fed to processors and multiple chipsets, is another power hog. Several industry standards, such as “Class 80+” are in place to improve the efficiency of server components.

Power drawn by a data center facility typically passes through uninterruptible power supply (UPS) and power distribution units (PDUs) before it reaches the IT equipment. PDUs generally operate at a high efficiency of 94 to 98 percent, and thus energy efficiency is primarily dictated by power-conversion in the UPS.

However, when evaluating a UPS, focusing on peak efficiency is misleading, as PDUs are unlikely to operate under a full load. Indeed, many IT systems use dual power sources for redundancy, resulting in utilization levels as low as 20 to 40 percent. In view of this, experts rely on an efficiency curve →04 to tell the whole story and to properly evaluate UPS systems. As a result, work in UPS power electronics has led to shaping

the efficiency curve to be flatter and consistently higher across the range of loading.

**Distributing power at higher voltages**

To adhere to global standards, virtually all IT equipment is designed to work with input power voltages ranging from 100V to 240V AC. The higher the voltage, the more efficient the unit. By operating a UPS at 240/415V three-phase four-wire output power, a server can be fed directly, and an incremental two percent reduction in facility energy can be achieved [5].

**Adopting best cooling practices**

The cooling system of a data center contributes as much as 30 to 60 percent of its utility bill. Many facilities might have some ready opportunities to reduce cooling costs through well-established practices. But looking ahead, as server rack density keeps rising, it may be time to consider liquid cooling technologies. Traditional air-cooling systems have proven very effective at maintaining a safe, controlled environment at rack densities of two kW to three kW per rack, all the way to 25 kW per rack. But operators are now aspiring to create an environment that can

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On average, one server in a hyperscale center is said to be able to replace 3.75 servers in a conventional center.

support densities in excess of 30-50 kW, a level at which air-cooling systems are no longer effective [4]. In these cases, alternate cooling systems such as rear door heat exchangers may provide a solution.

**Warming up to higher ambient temperature**

Server rooms are usually kept at an ambient temperature of around 22°C, leading to air conditioning unit outlet temperatures of 15 to 16°C. However, the American Society of Heating, Refrigerating and Air Conditioning Engineers recommends temperature ranges from 15 to 32°C for most new devices, with a humidity tolerance of eight to 80 percent.

**Plugging into the smart grid**

Smart grids enable two-way energy and information flows to create an automated and

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04 A UPS efficiency curve. Experts rely on this information to evaluate UPS systems [6].

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05 Data center operators are increasingly installing renewable power generation systems at their facilities and becoming power suppliers.

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distributed power delivery network. They can become a key enabler for deep integration of renewable energy and distributed power generation. Furthermore, with the help of integrated

—  
**A data center's cooling system contributes as much as 30 to 60 percent of its utility bill.**

monitoring and control, a smart grid can tackle the fluctuations of renewable energy, maintaining a consistent and stable power flow over the electrical grid →05.

Data center operators can not only draw clean power from the grid, but can also install renewable power generators at a facility to become

an occasional power supplier. Generators and consumers can interact in real-time, providing effective tools to receive incentive-based supply or emergency load reduction signals.

#### Every watt counts

From a cost and stewardship perspective, every watt counts. Taken together, all of the incremental improvements mentioned above can add up to a very significant energy-reduction impact. •

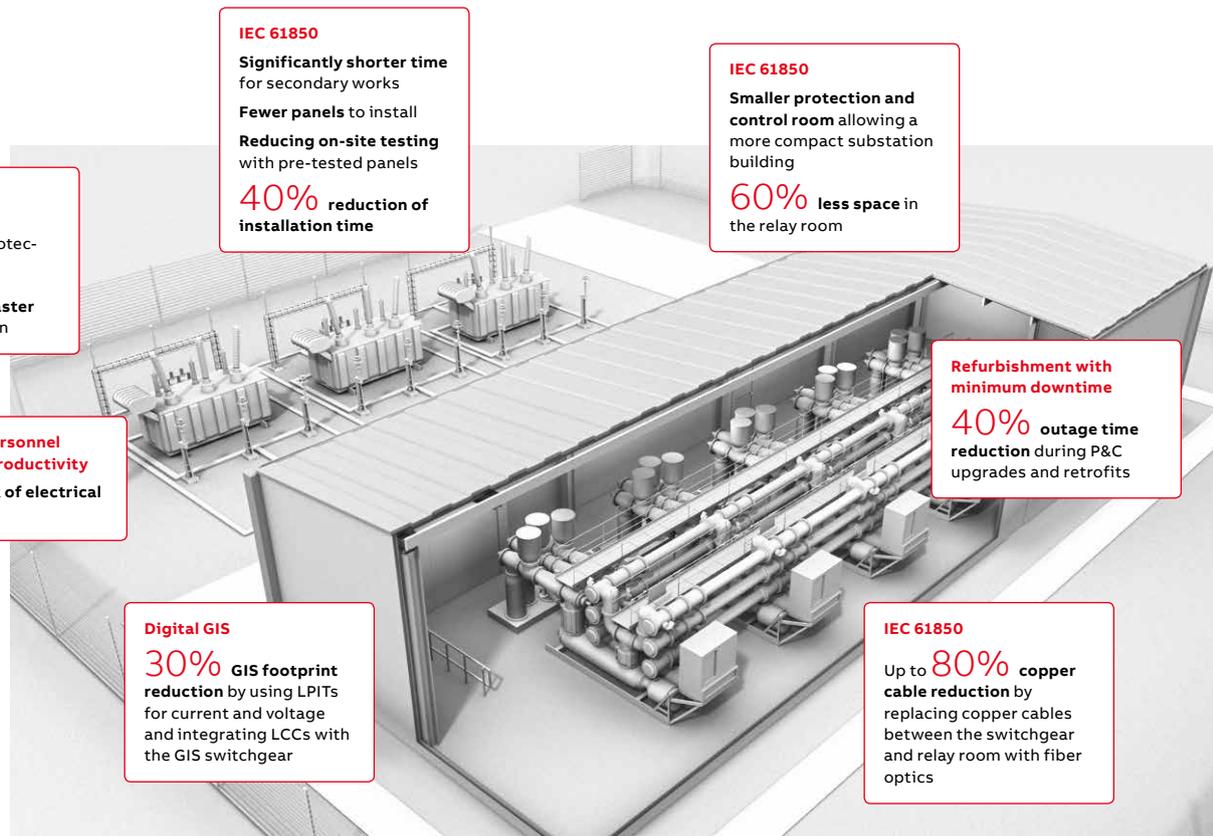
## DATA CENTERS

# Purpose-built substations for the data center industry

As demand for data centers increases, ABB Power Grids\* is helping to reduce the carbon and real estate footprint of these facilities. The company's latest generation of smart data center substations [1] meets these challenges by using smart modular components while reducing the quantity of copper control cables by over 50 percent. Furthermore, ABB's smart substations provide a high level of reliability and are set to streamline maintenance work through the use of digitized data and condition-based asset management.

\*a planned joint venture between Hitachi and ABB.





**IEC 61850**  
**More efficient and reliable control, protection and operation**  
**3 times faster control & protection**

**IEC 61850**  
**Significantly shorter time for secondary works**  
**Fewer panels to install**  
**Reducing on-site testing with pre-tested panels**  
**40% reduction of installation time**

**IEC 61850**  
**Smaller protection and control room allowing a more compact substation building**  
**60% less space in the relay room**

**Increased personnel safety and productivity**  
**Reduced risk of electrical shock**

**Refurbishment with minimum downtime**  
**40% outage time reduction during P&C upgrades and retrofits**

**Digital GIS**  
**30% GIS footprint reduction** by using LPITs for current and voltage and integrating LCCs with the GIS switchgear

**IEC 61850**  
**Up to 80% copper cable reduction** by replacing copper cables between the switchgear and relay room with fiber optics

01 ABB's 145kV digital substation.

02 Purpose-built for the data center industry, ABB's new substation design offers many substantial advantages.

02



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 United States

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Recent innovative developments in key substation assets, such as gas insulated switchgear (GIS) [2], power transformers (PT), high-voltage circuit breakers (HVB) and fiber-optic current sensors (FOCS) have all moved into the digital age →01. For instance, the ABB Ability™ Power Transformer (TXpert™) →04 is the first native digital PT to offer real-time data on load, temperature, and dissolved gas analysis (DGA) of transformer oil or fluids.

Several of these assets, including high-voltage circuit breakers, switchgear, and other electrical equipment, have traditionally used SF<sub>6</sub> (sulfur hexafluoride), an inorganic, colorless, odorless, non-flammable, non-toxic gaseous dielectric medium. However, SF<sub>6</sub> is also an extremely potent greenhouse gas. In view of this, ABB Power Grids has introduced eco-efficient switchgear with new AirPlus™, a groundbreaking gas mixture with 99.99 percent lower global warming potential (GWP) than SF<sub>6</sub>.

Furthermore, with a view to offering tailored solutions to the rapidly growing data center industry, ABB has introduced a purpose-built substation →02 that is designed to be highly reliable and safe, while facilitating efficient

operation and maintenance throughout its entire lifecycle. The new smart substation is over 30 percent smaller than its predecessor and uses 50 percent less copper on control cables. Fewer

**The new substation is over 30 percent smaller than its predecessor and uses 50 percent less copper on control cables.**

cables means fewer field electrician man-hours stripping cables, crimping connections, testing out contact points, etc. In short, the new substation design reduces site construction time and lowers risk.

ABB's new smart data center digital substations offer many advantages compared with traditional substations. They:

- require 30 percent less physical space for digital GIS →03–04 by using non-conventional low-power instrument transformers (LPITs) for current and voltage measurement and for



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integrating local control cubicles (LCCs) with high-voltage switchgear.

- use 50 percent less copper cabling by replacing copper cables with fiber optics and reducing

—  
**ABB Ability™ Ellipse® APM Edge is a cost-effective entry into data center substation transformer asset management.**

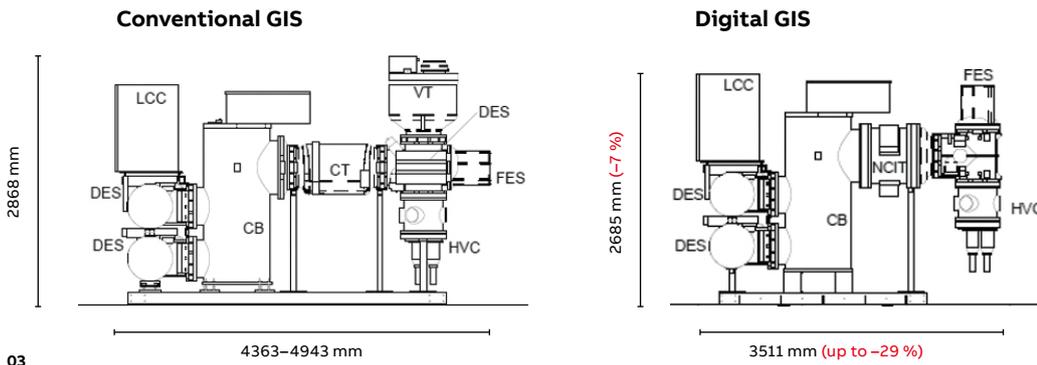
the number of physical connections through digitization. A typical data center substation equipped with two HV feeders yields savings of ~4,000 lbs. (~1,800 kg) of copper control wires.

- require 60 percent less physical space for relay control rooms because:

- fiber optics replace copper cables
- modern intelligent electronic devices are smaller, allowing more units per rack, and are multi-functional, allowing one unit to replace multiple older legacy relays
- require fewer and lighter components and smaller foundations
- result in a reduced carbon footprint due to diminished material weight to be transported and elimination of harmful SF<sub>6</sub> gas handling

**Sustainable asset performance management**

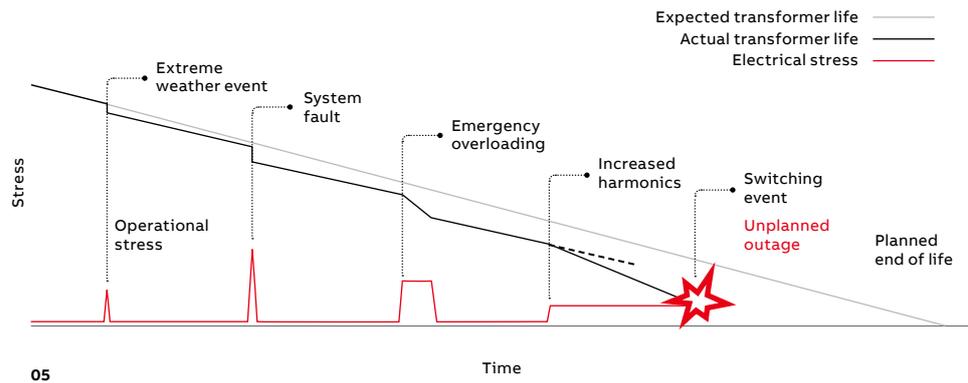
To round out the sustainability picture for smart data center substations, it is important to take a look at how condition-based asset performance management (APM) saves resources by reducing man hours and contributes to improved safety by reducing human interactions with high-voltage equipment.



03 Compared with systems in traditional substations, digital gas insulated switchgear (GIS) saves more than 30 tons of material transport for an average substation with seven feeders.

04 Digital gas insulated switchgear uses 30 percent less physical space than comparable systems in traditional substations. Pictured: the TXpert™ Power Transformer.

05 ABB's Ellipse APM Edge features a human-trained deterministic model that correlates data components to each other and known failure modes, thus delivering actionable intelligence – including maintenance recommendations.



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[1] ABB Substation Automation Systems, "We are bridging the gap." Available: <https://new.abb.com/substation-automation/systems/digital-substation/bridging-the-gap>

[2] ABB Power Grids, "Eco-efficient switchgear with innovative insulation gases." Available: <https://new.abb.com/grid/technology/eco-efficient-gas-insulated-switchgear>

[3] ABB Smart Transformers, "Smart transformers." Available: <https://new.abb.com/products/transformers/transformer-events/smart-transformers>

[4] Calculation is based on a typical data center HV substation with 400 hardwired connections, 12 gauge.

[5] ABB Power Grids, "ABB Ability™ Power Transformer – the world's first digitally integrated power transformer." Available: [https://www.youtube.com/watch?v=j2DL\\_DVZ3-E](https://www.youtube.com/watch?v=j2DL_DVZ3-E). For additional ideas see: <https://new.abb.com/distributed-energy-microgrids>

ABB Ability™ Ellipse® APM Edge →05 [4] is a quick and cost-effective entry into data center substation transformer asset management. It combines ABB's industry-leading asset performance management software (Ellipse® APM) with the company's proven transformer expertise in a compact package that grows with the customer's needs [3].

Ellipse Edge runs on the customer's premises and interacts with most industrial communication standards over low-cost, standard hardware. It offers a quick and efficient way to run Ellipse APM with minimal capital expense. For instance, it features a plug-and-play capability with ABB sensors and direct-to-sensor connectivity,

**Ellipse Edge features a human-trained deterministic model that delivers actionable maintenance recommendations.**

eliminating the need for a dedicated historical database and enhancing the value of existing transformer sensors and hardware. By combining online and offline data into a common scheme, Ellipse Edge plots and trends data using globally recognized standards (IEEE, IEC). A dashboard accurately identifies and predicts risk probability while helping to optimize asset performance. Ellipse Edge also features a human-trained deterministic model that correlates data components to each other and known failure modes, thus delivering actionable intelligence – including maintenance recommendations [5].

All in all, Ellipse Edge provides the following advantages:

- Improved asset availability with minimal-to-zero planned and unplanned outages, which is crucial for mission-critical installations such as data center substations
- Extended asset life – it is greener to run assets longer instead of replacing them prematurely
- Enhanced predictive maintenance, which reduces waste and diminishes routine tasks
- Prevention of catastrophic failures that are often accompanied by environmental impacts
- Integration of renewable energy resources for self-consumption
- Reduction of overall energy consumption from the grid with smart energy management

Whether a data center's substation operates one transformer or a fleet of dozens, the operator can scale up on-premises or in the cloud as demand grows, benefiting from Ellipse Edge software without significant capital investment. Furthermore, since the platform runs on an independent network or intranet, it reduces security risks by meeting ABB's stringent cyber security standards, which are based on industry requirements.

All in all, smart data center substation design reduces an installation's dimensions and material requirements, which results in considerably less weight, both in terms of metal enclosures and internal insulating gas volume. Furthermore, digital substitutions use fiber optic wires to connect the GIS to freestanding control panels, thus eliminating the need for hundreds of copper control cables. This reduces installation costs as well as the costs associated with decommissioning and recycling. •

DATA CENTERS

# Sodium-ion batteries: Reshaping design and operation

A new sodium-ion battery is set to free up space and enhance design flexibility in data centers and other mission-critical facilities. Such batteries can reliably and safely provide tens of thousands of cycles at very high peak-power discharges with no potential risk of combustion, explosion, or outgassing, thus allowing them to be deployed in locations unthinkable for lead and lithium battery types.



01



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Lead acid batteries have been a mission-critical element for decades in electrical system applications ranging from healthcare and communications to manufacturing and data centers. However, despite significant efforts to improve them, these workhorses present shortcomings in terms of electrical life, power density and peak power. In view of these limitations, essential facilities are designed and operated with high levels of redundancy in mind.



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But things are changing. Recent advancements in battery chemistry are opening new horizons in terms of the design and operation of data centers and other critical facilities. It is therefore worth looking at which technologies offer the best mix of performance, availability, life cycle and cycle-rate capabilities, energy and power density (two different characteristics), not to mention reliability, safety, sustainability and efficiency.

### Three battery types

There are three battery chemistries that align well with mission-critical electrical systems: lead acid, lithium-ion, and sodium-ion.

Lead acid batteries are well known and, despite drawbacks, are the standard when it comes to short- and medium-duration energy storage for essential operations.

Some infrastructure operators are experimenting with a combination of lithium-ion batteries and battery energy storage systems (BESS). Their results have varied. The relatively quick acceptance of this battery type has led to emerging safety codes, electrical standards and guidelines that have difficulties keeping up with the specific characteristics of these batteries. Furthermore, it is not currently feasible to recycle lithium ion batteries and their use in industries such as EVs and mobile phones is constraining supply.

—  
01 The unique peak-power capacity of sodium-ion batteries can be utilized to enable new solutions, such as ABB's Edge distributed data center power architecture.

—  
02 Thanks to their high power-to-energy ratio, sodium-ion batteries enable data centers to use less space and cooling than with lead or lithium batteries.

—  
03 Capable of tens of thousands of cycles, sodium-ion batteries significantly surpass lead and lithium batteries.

—  
04 Thanks to their superior safety characteristics, sodium-ion batteries can be deployed in areas where lithium batteries are not allowed and where lead batteries offer insufficient life expectancy to carry the load.

Recently, however, a new battery chemistry has emerged: sodium-ion →01. This battery utilizes Prussian Blue analogs for cathode and anode. These offer extremely low internal resistance, a high cycle-rate, high peak-power capacity, are nonflammable, and exhibit no thermal runaway characteristics by design. This chemistry is not only safe – passing UL9540A and NFPA855 requirements – but checks the sustainability

—  
**Sodium-ion batteries surpass lead and lithium in peak power, cycle rate, cycle count, charge/discharge times, and more.**

box as it is comprised primarily of aluminum, manganese, iron, Prussian Blue (a commodity dye), and sodium-ions. Such batteries are not compromised by dependence on rare earth metals, conflict minerals or questionable supply chain implications.

From a performance point of view, the new sodium-ion battery surpasses both lead and lithium in peak power →02, cycle rate, cycle count, charge/discharge times, →03 round-trip efficiency, safety, and operates over a much wider temperature range. These characteristics, particularly with regard to peak-power capacity, enable data centers and other space-constrained mission-critical facilities to free up power and floorspace since peak-power and reserve starting/bridging capacity can be realized in a much smaller volume and do not add any cooling load.

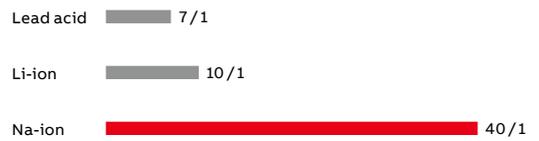
The sodium-ion battery's ability to repeatedly, reliably and safely provide very high peak-power discharges with no potential risk of combustion, explosion, or outgassing under frequent, repetitive use means that it can be deployed in locations and architectures unthinkable for other battery types →04.

Sodium-ion batteries can and are being deployed in data and communication centers within the “white space” inside IT/Telecom equipment racks – an area where lithium batteries are often not allowed, and lead batteries don't have the performance required to carry the load.

**Reducing space, power and cooling demands**

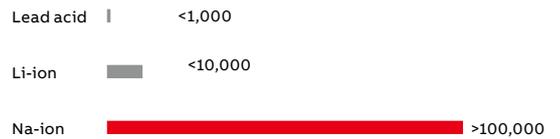
The unique peak-power capacity of sodium-ion batteries can be utilized to enable new power architectures. One example of where this is possible is in ABB's Edge distributed data center power architecture →01.

**4x higher max power-to-energy ratio**



02

**10x longer deep discharge cycle life**



03

**Nonflammable during failure and abuse**

	Lead acid	Li-ion	Na-ion
Heating	✓	✗	✓
Overcharge	✗	✗	✓
Short circuit	✗	✗	✓
Nail penetration	✓	✓	✓

04

When using sodium-ion batteries, peak-power capacity can provide over twice the total system power of either lead or lithium batteries. In addition, should any battery fail, there is enough peak power capacity within the remaining battery (n=2) or batteries (n=3+) that they can carry the entire load in the event of an outage without the need for a back-up battery.

These innovative 4-kW rack-mounted-batteries could be suitable for data center, telecom, and industrial applications. In the near future, larger form-factor sodium-ion batteries will become available from Natron in 300-kW battery cabinets designed for data center applications. Sharing the same inherent characteristics as current rack-mounted batteries, these cabinets will open new perspectives in terms of designing mission-critical facilities in ways that reduce space, power and cooling requirements.

With their rapid recharge capabilities and tens of thousands of cycles, sodium-ion batteries create a framework for data centers, telecom/network systems, and edge compute nodes to deploy software-defined-power-creating revenue opportunities from what are traditionally considered to be fixed costs and stranded assets. •

## DATA CENTERS

# The secret ingredient behind smart cities

In order to make the most of the vast quantities of data generated by digital services, smart cities need massive data storage and processing capabilities – in short, they need data centers. However, since such facilities require enormous amounts of power, energy-saving technologies are a must. ABB has helped customers around the world achieve exceptionally high levels of efficiency. Two examples illustrate how.

With over 50 percent of the world's population living in cities, urban areas are under pressure to improve the efficiency of their infrastructures. Probably the best way of achieving this is the smart city concept – the integration of information technology and the Internet of Things (IoT). This, in turn, sets the stage for the seamless

—  
**ABB supplied Lefdal's power infrastructure, which provides energy generated by hydropower stations and wind farms.**



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integration of services such as traffic control, smart parking, electric vehicle charging and mass transit; and building and neighborhood energy management with wind and solar parks.

Smart city services generate data that results in a virtuous circle, producing ever-improving analytics that in turn improve services. But smart cities require massive data storage, and processing capabilities – in other words, in order to make the

most of all the technologies they've implemented and to realize the full capabilities of the data they collect, advanced cities need data centers.

## Europe's greenest data center in Norway

The Lefdal Mine data center [1], which has been in operation since May 2017, is built 150 meters into a mountain in what was formerly an olivine mine →01. Olivine is a green, high density-mineral used in steel production. Located on Norway's west coast, between Måløy and Nordfjordeid, the six-story mountain hall facility sets a new standard for the data center industry.

The massive data center (about 120,000 m<sup>2</sup> or 1.3 million square feet), which is capable of storing an estimated 30 billion GB, is powered exclusively by renewable energy produced locally, while being cooled by water from a nearby fjord. ABB supplied the critical power infrastructure, which provides clean energy generated by four glacial hydropower stations and two wind farms, which have a combined capacity in excess of 300 MW.

The Lefdal Mine is remarkably energy efficient, because it uses cold water from the 565-meter-deep fjord as a coolant. The result is that the data center's cooling solution will have a power

—  
01 The 120,000m<sup>2</sup> Lefdal data center in Norway is powered exclusively by locally-produced renewable energy and is cooled by water from a nearby fjord.

usage effectiveness (PUE) – the industry standard for energy efficiency – of between 1.08 and 1.15, making it among the greenest data centers in the world.

To meet the powering challenges of such a huge plant, ABB built a medium-voltage backbone for the entire facility. To meet any emergency situation, ABB has also provided a decentralized

—  
Capable of storing an estimated 30 billion GB, the Lefdal Mine data center will have an expected peak power of 300 MW.

UPS (uninterruptible power supply) system, which means that each section inside the data center has its own UPS installation. If there is

a problem with the grid, the UPS ensures reliable power supply until backup generators come online.

ABB has been an integral partner from the beginning of the project, providing tailored power supply solutions and extensive knowledge and expertise. It has supplied a powering system that will remain reliable as the center grows to an expected peak of 300 MW. When it reaches its maximum capacity, Lefdal will be among Europe's largest data centers.

The Norwegian government's 'Powered by Nature' data center strategy stresses that attracting data centers and international investments is an important part of its industrial policy. Thanks to this strategy and the world's rapidly growing need for more data centers powered by renewable energy, Lefdal Mine will have an edge with its unique location and engineering. As more of the world becomes digital, ABB expects to power Lefdal and Norway for a long time.



— 02 ABB is providing NextDC with a comprehensive solution that includes complete power distribution systems, a critical services monitoring system and associated implementation and support services.

### Helping NextDC deliver energy savings and 100 percent uptime to Australia

ABB has been selected to partner with NextDC →02, a Brisbane, Australia-based data center operator, to provide its electrical infrastructure and automation technology, which enables NextDC to monitor and tune its critical data center infrastructure in real-time [2]. All of this is critical to delivering on NextDC's 100 percent uptime brand promise guarantee.

As Asia's most innovative data center-as-a-service provider, NextDC delivers enterprise-class colocation services to local and international organizations. With a focus on sustainability and renewable energy, NextDC is building an infrastructure platform for the digital economy.

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[1] ABB Solutions, "ABB solutions power Europe's greenest data center in Norway," June 28, 2018. Available: <https://new.abb.com/news/detail/5407/abb-solutions-power-europes-greenest-data-center-in-norway>

[2] "ABB supports NEXTDC in delivering Australian businesses with 100% uptime," March 10, 2020. Available: <https://new.abb.com/news/detail/58276/abb-supports-nextdc-in-delivering-australian-businesses-with-100-uptime>

ABB is providing the company with a comprehensive solution that includes complete power distribution systems, a critical services monitoring system and associated implementation and support services.

### Integrated solution

As NextDC's data centers enter service, the company's goal is to reduce its overall cost-per-megawatt with every new facility it builds. ABB's integrated power distribution and critical services monitoring system (CSMS) solutions, particularly its ABB Ability™ Data Center Automation solution, are helping NextDC achieve its goals by providing energy efficiency and cost and time savings.

### Cost, energy and time savings

Monitoring the power usage, temperature and relative humidity in the data halls is a primary function of the CSMS, which ensures reliability and enables energy savings in every data hall.

The CSMS utilizes data aggregation and visualization, providing real-time visibility, including both high level (aggregate) and low level (granular)

### The ABB Ability™ Data Center Automation system integrates data from IT, power, cooling and building systems.

views of the data center infrastructure – including enterprise, floor plan, zone, system and component views.

All in all, the ABB Ability™ Data Center Automation system integrates data from IT, power, cooling and building systems, thus eliminating the need for manual data entry when calculating utilization metrics and other KPIs – factors that are helping NextDC meet its efficiency and sustainability goals. •



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01 Adoption of IEC 61850 for data center power protection and supervision greatly enhances performance and reliability and reduces cost. Shown is medium-voltage switchgear at a data center.



01

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## DATA CENTERS

# IEC 61850 simplifies data center power infrastructure

IEC 61850 is a well-established communications standard for substation automation. The high reliability, integrated diagnostics, fine selectivity, shorter fault reaction times and better fault tolerance delivered by IEC 61850 makes it ideal also for data center power infrastructure.



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It is fair to say that the publication of the IEC 61850 standard in 2004 transformed the world of substation automation. IEC 61850 – to which ABB made significant contributions – provides a standardized framework for substation integration that specifies the communications requirements, the functional characteristics, the structure of data in devices, the naming conventions for the data, how applications interact and control the devices, and how conformity to the standard should be tested.

The abilities of IEC 61850 to marry protection and supervision in low- and medium-voltage

installations were quickly recognized and the standard is now being increasingly used in applications in low voltage, medium voltage and high voltage. Equipment now benefiting from IEC 61850 functionality includes protection relays, circuit breakers, communication gateways, programmable logic controllers (PLCs) and supervisory control and data acquisition (SCADA) architectures. Together, these devices make it possible to design and operate a fully integrated protection and supervision system that spans the voltage ranges just described. This comprehensive approach is made possible by exploiting IEC 61850 to create features such as advanced

logic selectivity based on device-to-device communication, real-time diagnostics and integrated engineering.

IEC 61850 is ideally suited to the automation of data center power infrastructure →01.

**IEC 61850 and data centers**

The world is experiencing a data explosion. Not only is the quantity of data increasing at a dizzying rate, but the extent to which society relies on that data is also growing by the day. These trends elevate the data center to the status of critical infrastructure in many countries. If a data center fails, chaos ensues, which makes a reliable power supply indispensable. Generally, data centers do have well-thought-out power backup provisions – such as uninterruptible power supplies (UPSs), diesel generators, etc.

By employing IEC 61850-enabled devices and IEC 61850-based GOOSE (generic object-oriented substation event) communication to automate the data center power infrastructure, significant improvements can be made: better power

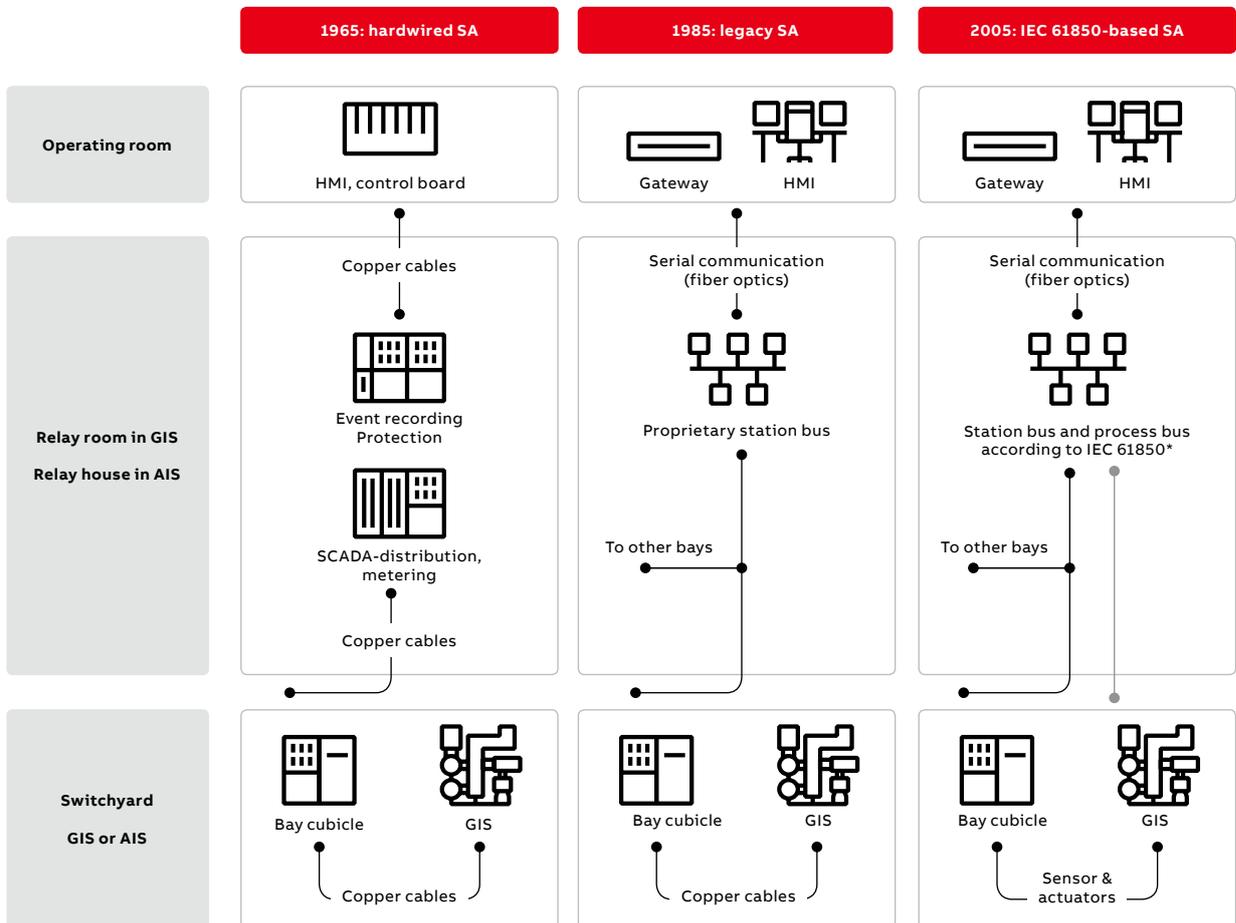
supply reliability, greater operational control and reduced cost, to name but a few →02.

**GOOSE**

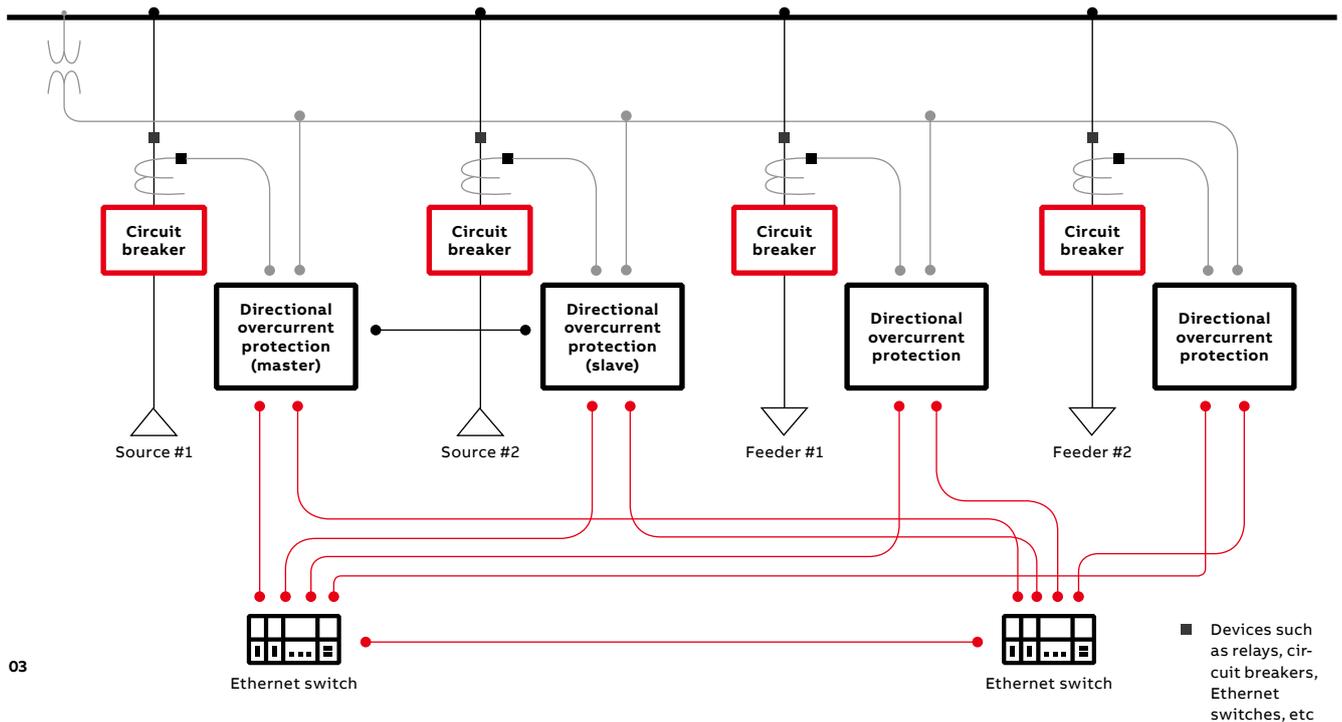
When a fault occurs in a data center power component, the protection device that detected it must transmit fault information as quickly as possible to the devices that decide which breaker should trip. Arranging such transmissions in a round-robin – or other cyclic fashion – that

—  
Instead of cycle time, with GOOSE messages the key engineering consideration is latency.

requires the device to wait its turn for access to the communication media would introduce unacceptable delays. The effective handling of such unscheduled, on-event communication is one of the differentiating features of IEC 61850



\* The process bus is not a must in IEC 61850 but only an option



02 Substation automation (SA) – from hardwired through proprietary protocols to IEC 61850.

03 Simplified single-line diagram showing existing feeder relays to form a GOOSE-enabled bus protection scheme.

and it is implemented using special data packets called GOOSE messages. Instead of cycle time, with GOOSE messages the key engineering consideration is latency, ie, the delay between an event and the transmission of relevant information on the network.

A key feature of GOOSE messages is that they can be used for horizontal (ie, peer-to-peer) communication between devices in addition to the usual vertical communication from device to supervision

**GOOSE messages can also be used to implement a built-in diagnostic mechanism in the data center power protection system.**

system. So, a logic selectivity or an interlock between two circuit breakers can be implemented by direct message exchange between the relevant devices without relying on a central processing unit to manage the process. Horizontal communication improves both performance (shorter overall reaction time and more efficient use of the communication channel) and reliability (as a failure of the central processing unit would impair the whole protection scheme).

In addition to fault signaling, GOOSE messages can be used to implement a built-in diagnostic

mechanism in the data center power protection system. Each device can be configured to send a “ping” message to others regularly (eg, every second) to report that their status is normal. If the relevant devices fail to receive the appropriate message, they may, in turn, send alarm messages, switch to a predefined safe mode, or take other actions as required. Diagnostic messages use the same communication medium as other data packets, so no additional hardware is required.

#### Practical GOOSE-enabled bus protection

IEC 61850 allows the data center’s dedicated bus protection relay to be eliminated. Instead, each breaker’s relay, such as the feeder protection relay or breaker failure relay, is relied upon. A “master” relay performs the bus-protection role, with another relay assigned as a backup to the master. All relays involved in IEC 61850-enabled data center power bus protection communicate via GOOSE protocols →03.

IEC 61850-compliant relays, such as ABB’s Relion relays and Emax 2, are usually equipped with multiple Ethernet ports with parallel redundancy protocol (PRP). PRP enables double-star network topologies using self-healing rings that effectively achieve 100 percent communication availability. Of these two approaches – double-star and self-healing – the former configuration creates less network disturbance during future expansions, offers faster troubleshooting, has minimum communication latency and is easier to maintain.

A data center power protection scheme based on IEC 61850 also has other advantages over traditional approaches: Because it uses a fiber-optic Ethernet network, the expensive, space-consuming, complicated and error-prone point-to-point copper wiring found in traditional data center power arrangements can be reduced or eliminated. The reduction (or elimination) of this cross-wiring of related relays also brings substantial savings in engineering, installation labor and time, and materials. The reduction in copper wiring alone has a significant positive financial impact as well as major benefits when it comes to increased reliability and decreased life cycle costs. For new installations, costs are also reduced by avoiding the expense of additional protective relays. IEC 61850 bus also makes future modifications or expansion simpler.

#### **Automatic transfer switch (ATS)**

Another example of an IEC 61850 application can be found in the ATS. Power availability and stability are critical to data center operations so, typically, the site is fed by two incoming utility sources, usually in a medium-voltage Main-Tie-Main (M-T-M) bus configuration →04. The ATS offers an effective and reliable way to automatically transfer to a healthy bus from one that has lost its incoming source. To seek out quickly the available alternate source and transfer loads from the lost-source bus to the healthy bus, relays exchange GOOSE messages containing condition data such as the source-voltage-loss event itself, state of health of the alternate source, pending overcurrent or bus protection trips, normal status of main and tie circuit breakers, etc. Utilizing IEC 61850 in this way delivers the following benefits:

- Reduction of wiring materials and labor.
- Minimization of system loss time.
- A secure operation that minimizes the stress on standby generators and UPSs.
- Full IEC 61850 data visibility of relays for system reporting, monitoring and analysis.

#### **Engineering and configuration made easy**

Additional advantages of IEC 61850 are related to engineering and configuration processes. Because of the complexity and number of the devices involved in a typical data center power system, designing a protection system without a structured, computer-assisted process is difficult; the sheer number of configuration and operational details invites critical errors. To prevent these errors, IEC 61850 relies on standardization of objects and data types, and formal electronic descriptions.

IED (intelligent electronic device) complexity is managed in IEC 61850 by describing each

device as a set of logical objects, which can be published in the final application. Such objects are abstract enough to be applicable to devices of different types or from different vendors, yet realistic enough to be applicable to the engineering job in hand. Examples of such objects are overcurrent protection, current and voltage measurement, control of a switch, etc.

A cornerstone of the IEC 61850 data model is a catalog of standardized logical objects with well-defined meanings, and applicable parameters and data items. All devices compliant with IEC 61850 use the same objects to implement the same function, making it possible to combine objects in a common way in a final data center power implementation. Such standardization

—  
**All IEC 61850 compliant devices use the same objects to implement the same function.**

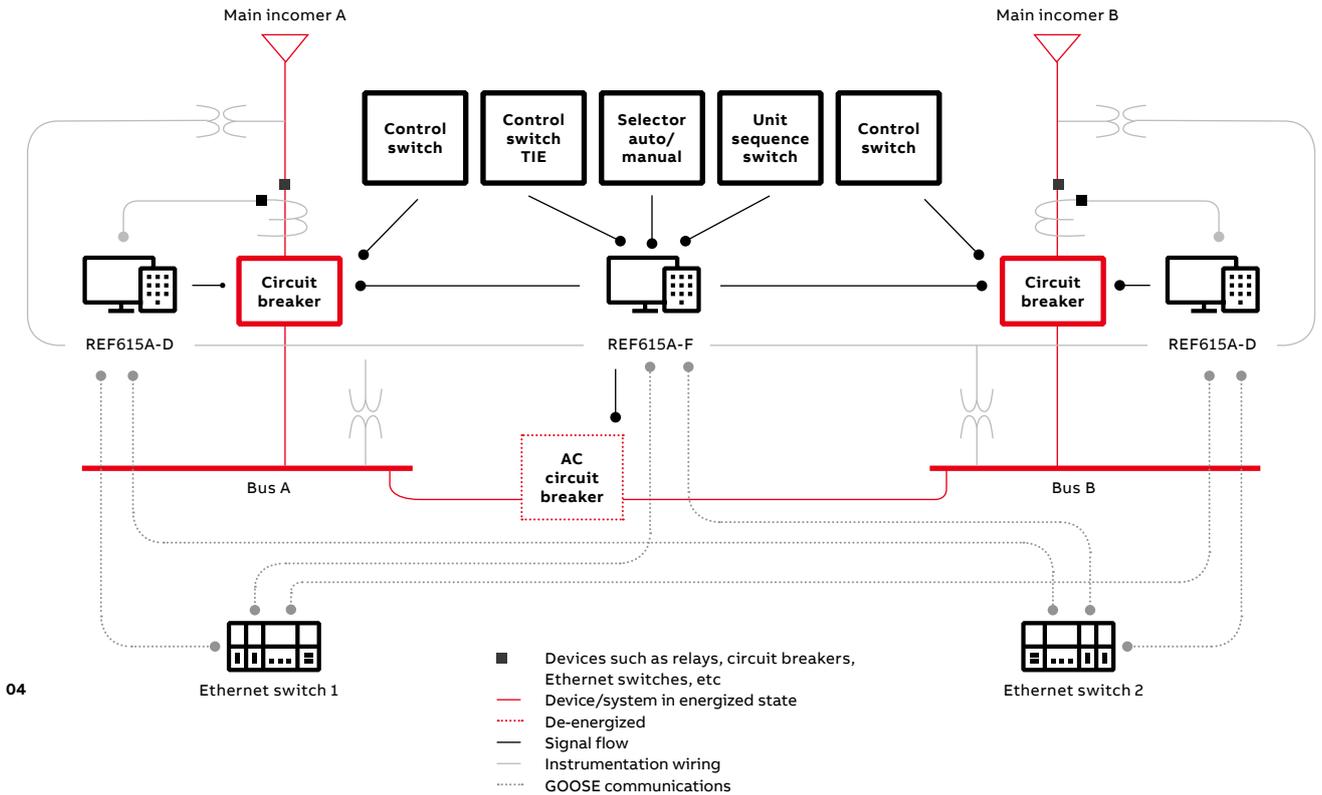
goes down to object names (eg, PTOC always represents an overcurrent protection), which makes them easy to recognize and use by the design engineer. Data types are also set by IEC 61850, so that, for example, the result of a measurement is defined together with its name, measurement units, quality indicators and so on, thus reducing the probability of errors.

To complement this standardization, IEC 61850 describes a common electronic format in which devices and systems are described. All devices – IEDs – are each described by a file, written in SCL (Substation Configuration description Language), that lists all its properties and logical objects. SCL files can be read and manipulated by IEC 61850 software engineering tools, allowing a smooth process and a reduced number of errors.

Such a formalized electronic description language has the important side benefit of easing interoperability between devices from different vendors that are installed in the data center: As long as the objects they implement are described by the SCL file, the user need not be concerned with their inner workings.

#### **Ideal for data center power infrastructure automation**

IEC 61850 is eminently suited to data center power infrastructure automation, where it can form the bedrock of a complete electrical design



04

04 Typical single-line diagram of an M-T-M ATS configuration.

concept that includes the entire protection, control and supervision system as well as cyber security – using just one protocol.

By using optical fiber instead of copper wire, wiring costs are lowered, space requirements are substantially reduced and safety is increased. IEC 61850 also delivers the capability to monitor

By using optical fiber instead of copper wire, wiring costs are lowered, space requirements are reduced and safety is increased.

and control IEDs remotely, and the convenience that devices supplied by different manufacturers can communicate with each other without custom-designed gateways or other engineering-intensive complications.

Taking a wider perspective, the IEC 61850 standard allows digitalization of the data center power system in a way that opens it to

collaboration with other digital entities in the data center, such as a building management system (BMS), power management system (PMS), data center infrastructure management (DCIM) or ABB Ability™ Data Center Automation. These are all important parts of the final goal: the “single plane of glass” that orchestrates the entire data center. Decathlon for Data Centers, for instance, gives power and cooling visibility, and IEC 61850’s open protocols allow integration of existing equipment and systems. With IEC 61850 peer-to-peer communication capabilities in components like ABB’s Relion relays and Emax circuit breakers, one can go from the DCIM system controlling or supervising software to having real-time interaction with the subsystem (such as a UPS breaker) itself.

Increased reliability, finer selectivity, shorter fault reaction times and the possibility to implement fault tolerance and integrated diagnostics as well as a host of other advantages make IEC 61850 the ideal standard for data centers. •



01

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DATA CENTERS

# Security beyond the borders – data center cyber security

Cyber security is woven throughout the ABB Ability™ Data Center Automation solution and includes product design, project execution and operation. ABB supports data center customers to secure networks, servers and data in addition to perimeters.

To operate dependably and efficiently, data centers require their electric infrastructure as well as the building automation and industrial control systems (ICS) that manage this infrastructure to deliver an uninterrupted power supply (UPS). Integration of Operational Technology (OT) with Information Technology (IT) leads to greater reliability, control and enhanced performance, but also exposes data centers to unprecedented challenges: cyber threats. The real possibility of malicious entities or persons accessing mission-critical systems like data centers that

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**A decade ago, data centers focused solely on securing their physical perimeter and the data they stored and managed.**

rely on connected controls creates raw angst and this can drive the market. For instance, the global industrial cyber security market, which includes network security, industrial control systems (ICS), hardware- and software solutions, is expected to hit USD 24.41 billion for the period between 2017 and 2023 [1].

Today, the data center cyber security landscape is diverse, whereas a decade ago centers focused exclusively on securing their physical perimeter and the data they stored and managed (information security). Open IT standards for automation systems that encourage connectivity to external networks were not yet established and enterprise data centers dominated the landscape. What was sensible then is now alarmingly insufficient. Nowadays, data centers include cloud-based servers and interconnected ICSs that expose cyber risks not previously encountered. Currently, perimeter and data security are not enough to protect data centers from failures and blackouts [2].

ABB applies a comprehensive approach to cyber security for data centers with security woven throughout the design, development and deployment phases of industrial automation and control systems, including all electrification products. Relying on international standards and a knowledge-based systematic approach, ABB uses best practices to ensure that cyber security has a starring role in its data center automation products.

As the largest enterprise asset management and distributed control system (DCS) supplier

in the world, with a 20 percent market share [3], ABB is ideally suited to provide reliable and secure automation and control systems while maintaining transparency and interoperability. ABB achieves these goals with its Data Center Automation solution, thereby supporting the availability and continuous optimization of data center mission-critical systems and products. ABB's automation system provides core technology for the ABB Ability™ Data Center Automation solution for on-premise and hybrid cloud environments.

Thus, ABB can deliver industrial strength, mission-critical converged solutions for mechanical controls (BMS), electrical monitoring (EPMS), electrical controls (ECS) and Data Center Infrastructure Management (DCIM) to data centers. This open platform allows automation and data exchange among systems, equipment, components and applications to:

- Integrate data center tool sets faster; this includes the ability to upload assets into tracking tools.
- Visualize and manage physical assets within a 'single pane' view of the entire data center, including multiple sites.
- Automate cooling and electrification systems for continuous optimization and improved uptime.

#### **Cyber threats: the nitty-gritty reality**

Over the past decade, the severity and sophistication of cyber threats toward existing ICSs and associated infrastructure have increased [4]. While industrial communication involves a myriad of hardware and software products and protocols to establish communication between industrial automation devices and standard computer platforms, systems were originally built to meet performance, reliability, safety and flexibility requirements without much thought to secure communication capabilities. By focusing solely on securing perimeters and data, these legacy ICSs and their infrastructure are woefully pervious to cyber attacks and incidents.

Despite this predicament, companies must exploit real-time process- and system information to increase the interconnectivity and predictable interoperability between different automation systems, and combine legacy systems with new ones. This communication landscape raises the level of security threats that data center customers face dramatically.

Nowadays, electrification infrastructure and industrial controls are an integral and continuous part of the entire ICS system lifecycle from



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Users & environments



Operations center



Portals & web client



Local operations



Industrial IoT cloud



End-to-end applications & functions



Building management (BMS)



Power & energy management (PMS, EPMS)



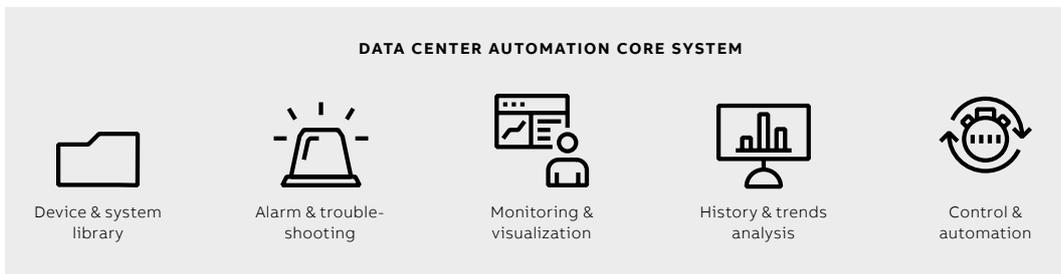
Predictive maintenance



Change management & capacity planning (DCIM)



Structured cabling management



Data & communication interfaces



Mechanical equipment & systems



Electrical equipment & systems



IT equipment & systems



Enterprise applications & systems

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design and development, through testing and commissioning, to lifetime support service and future adaptations. By providing holistic cyber security solutions, ABB helps customers on their journey to identify, mitigate and manage changing cyber risks that could impact their systems. ABB's cyber security approach for all offerings, including data centers, focuses on three areas: product design, project execution and plant operation.

**Securing data centers: recognizing the challenges**

The upswing in intense and diverse cyber threats experienced recently, require networks, servers, data and perimeters to be secure [2].

Perimeter security includes safe-guarding the electric infrastructure and controls by means of mechanical and/or electronic systems in addition to safe-guarding the physical perimeter. Because security management within a facility is coupled with individuals and their roles, having employees with different authorization roles is a crucial challenge.

In addition, industrial and proprietary protocols often lack proper measures for data security of electric infrastructure and controls, eg, authentication or integrity checks; or support of cryptography mechanisms.

It is also quite a feat to secure the communication network and protect data from attacks originating from any other communication

The recent upswing in intense and diverse cyber threats require networks, servers, data and perimeters to be secure.

network; this includes cryptographic operations management. Additionally, to ensure client and server security for electrical infrastructure and controls, patches must be applied and

01 ABB Ability™ Data Center Automation system architecture provides customers with automation strategies for all their power, electric, mechanical and building systems.

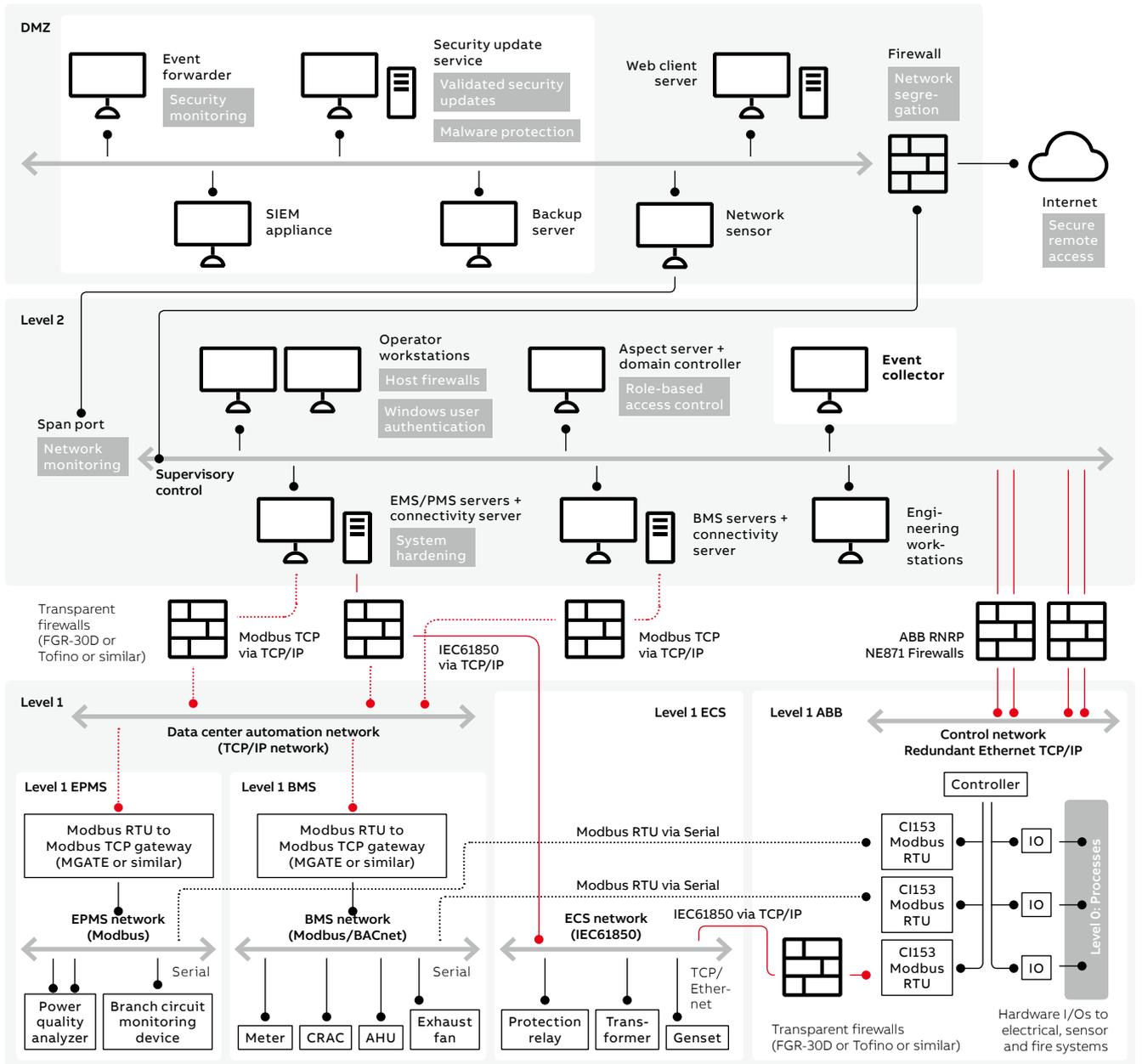
02 Schematic of a reference architecture for ABB's cyber-secured Data Center Automation solution.

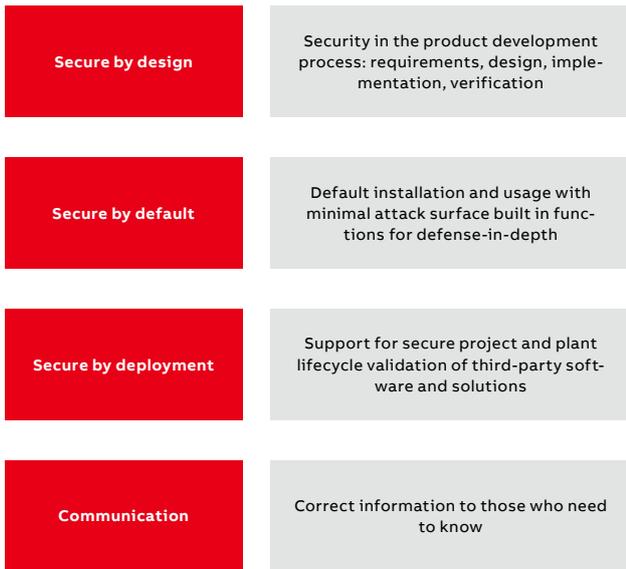
snit-malware definition files used to scan. And, if an unforeseen disaster strikes, proper backup mechanisms must allow recovery. Virtual environments are especially challenging and require excellent monitoring solutions. ABB provides safeguarding solutions to address all these challenges.

**ABB's cyber security solution for data centers**  
 ABB's Ability™ Data Center Automation solution provides customers with the means to engineer, commission, monitor, control and operate automation strategies for their systems, →01 by delivering ECMS that include Energy Management System (EMS), Building

Management System (BMS) and Power Management System (PMS). ECMS capture all information/data for the purpose of recording, controlling and reporting.

Clearly, technology alone cannot eliminate cyber risks. By defining the means to deploy a data center automation system with the appropriate security controls, ABB supports customer's cyber security efforts →02. ABB's reference architecture can also be customized according to individual project requirements. To accomplish this, customers should contact ABB's project team. Thus, people, processes and technology are at the heart of ABB's fortified cyber security approach.





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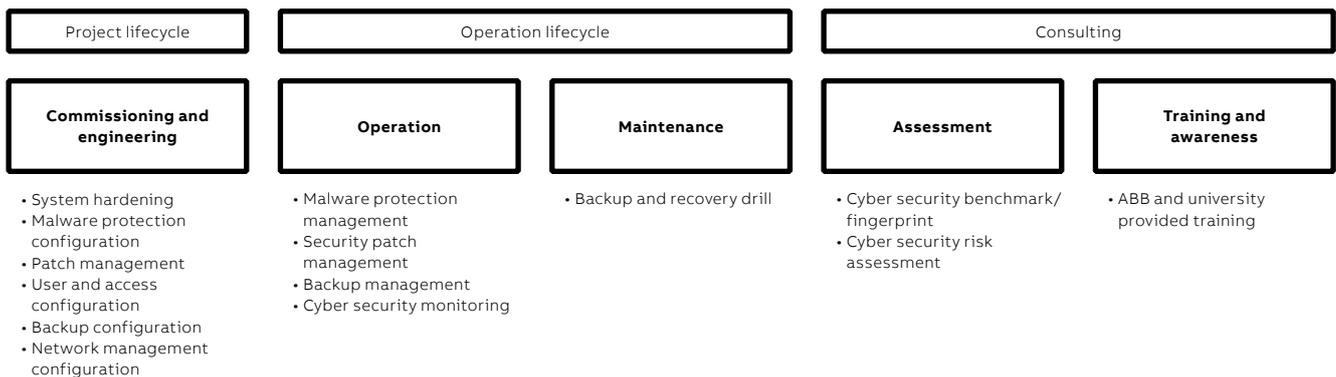
**Secure by segregation**

ABB’s reference architecture places all the components of the data center in a specific network level →02. This widely used security concept segregates secure from insecure networks with firewalls and demilitarized zones (DMZs). For data center automation systems, the internal network has different devices with varying security levels; here, network zoning with a hardened system is critical. Network connectivity within a level is governed by the host firewalls (software firewall residing on individual computers); data can only pass to another level via a (hardware) firewall. The ABB data center architecture implements user-, software- and device authentication; account management, authorization enforcement, malicious code protection and network segmentation and continuous network monitoring to ensure against cyber incidents →02. The operation and maintenance phase of

the data center automation lifecycle with different security controls are part of ABB’s architecture →02. This layered approach uses different cyber controls to successfully address security issues at the server-, network- and data level:

—  
**ABB’s cyber security approach focuses on three areas: product design, project execution and plant operation.**

- Patch management – by using validated system security updates of the server from third-party software, namely, Microsoft, EXSi and Adobe products, users can be confident that the control system is always updated.
- Anti-virus updates – servers should include the latest updates.
- Backup management – includes documentation of procedures, testing of backups, and storage of qualified backups in a safe offline location; thereby ensuring that system failures or extended downtime do not result in loss of data. ABB supports applications that schedule, manage and operate data backup processes on computers, servers or network devices regularly. These steps are in accordance with the organization’s system recovery plan.
- Hardening – the hardening process reduces the attack surface, the number of software applications, disables non-essential services, utilizes host firewalls, and changes default passwords. Only necessary applications and services are installed.
- Manage user accounts and user access rights and roles – a critical security challenge.
- Monitor the automation systems with the security information and an event management



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03 SD3+C Security Framework is depicted.

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04 ABB's data center cyber security value chain is illustrated.

platform – new threats emerge continually and intrusions happen daily, so continuous monitoring keeps control systems safe and secure.

- ABB adheres to the SD3+C Security Framework, created by Microsoft to ensure and improve security of its products; →03, eg, reduce the number of security bugs or vulnerabilities present in new software; make default product installations and configurations more resistant to attack; ensure that products can be installed, configured, operated and maintained securely; and promote responsible communication.

#### Delivering the best possible value

Cyber security services are integrated within the lifecycle of ABB Ability™ Data Center Automation solution and include: project execution lifecycle, operation lifecycle and consulting services →04. The commissioning and engineering phase can provide a onetime configuration for the cyber security setup, whereas the plant life cycle deals with the renewal of cyber security services for regular operation and maintenance.

These cyber security services ensure that the data center infrastructure is operated according to best practices that are based on international standards and rely on ABB's vast experience. The goals are to verify, provide, address, and support:

- Verify that updates do not interfere with the operation of the data center infrastructure system.
- Provide services with consistent quality and assure that tasks are performed by skilled personnel.
- Address cyber security throughout the development lifecycle of ABB products and solutions.
- Support security throughout the operation lifecycle of the solutions delivered by ABB.

#### Customer concerns and the way forward

Ensuring network-, server-, data- and perimeter security for electric infrastructure and controls is what data center customers need now and in the future. Because the network segregation is a primary objective of ABB's reference architecture →02, firewalls are used to control and moderate the traffic in different network levels; this improves the network traffic visibility. Network security is also improved through network monitoring to allow the detection of unusual events.

A three-stage model has been established for cyber security management of ICS environments. The first stage is to establish a basic level of technical and organizational security controls. If those controls are suitably implemented and maintained, they will thwart the majority of generic threats. The second stage

is to continuously manage and maintain these controls and add more sophisticated controls as needed. The third stage is the collaborative operation of cyber security controls with managed security services via ABB's Collaborative Operations Center.

ABB's reference architecture implements user-, software- and device authentication, account management, authorization enforcement, and malicious code protection to improve the posture of security levels in the server. Regular updates of security-patches and anti-malware definition files also improve the security postures. The backup management server in DMZ enables data backup and recovery from catastrophic incidents using ABB's recommended platform. Ensuring data security for the electric infrastructure and controls is a top priority as is perimeter security. The secure, encrypted and compressed data transfer between data collector node and history server enables secure communication; event

—  
ABB delivers data center customers innovative solutions that resolve the most vexatious cyber security challenges.

monitoring occurs in ICS. To ensure perimeter security for the infrastructure and controls, ABB recommends enforcing physical security while deploying the automation system in data centers.

ABB's cyber security efforts don't end with this comprehensive approach. ABB recognizes that cyber threats will continue as cloud adoption expands. Currently, ABB's experts are exploring a tamper-proof solution: a trusted platform module, that stores Rivest-Shamir-Adelman (RSA) encryption keys. Such a solution will provide customers with a safe computing environment for the cloud. Hence, ABB delivers data center customers innovative solutions that resolve the most vexatious cyber security challenges today and tomorrow. •

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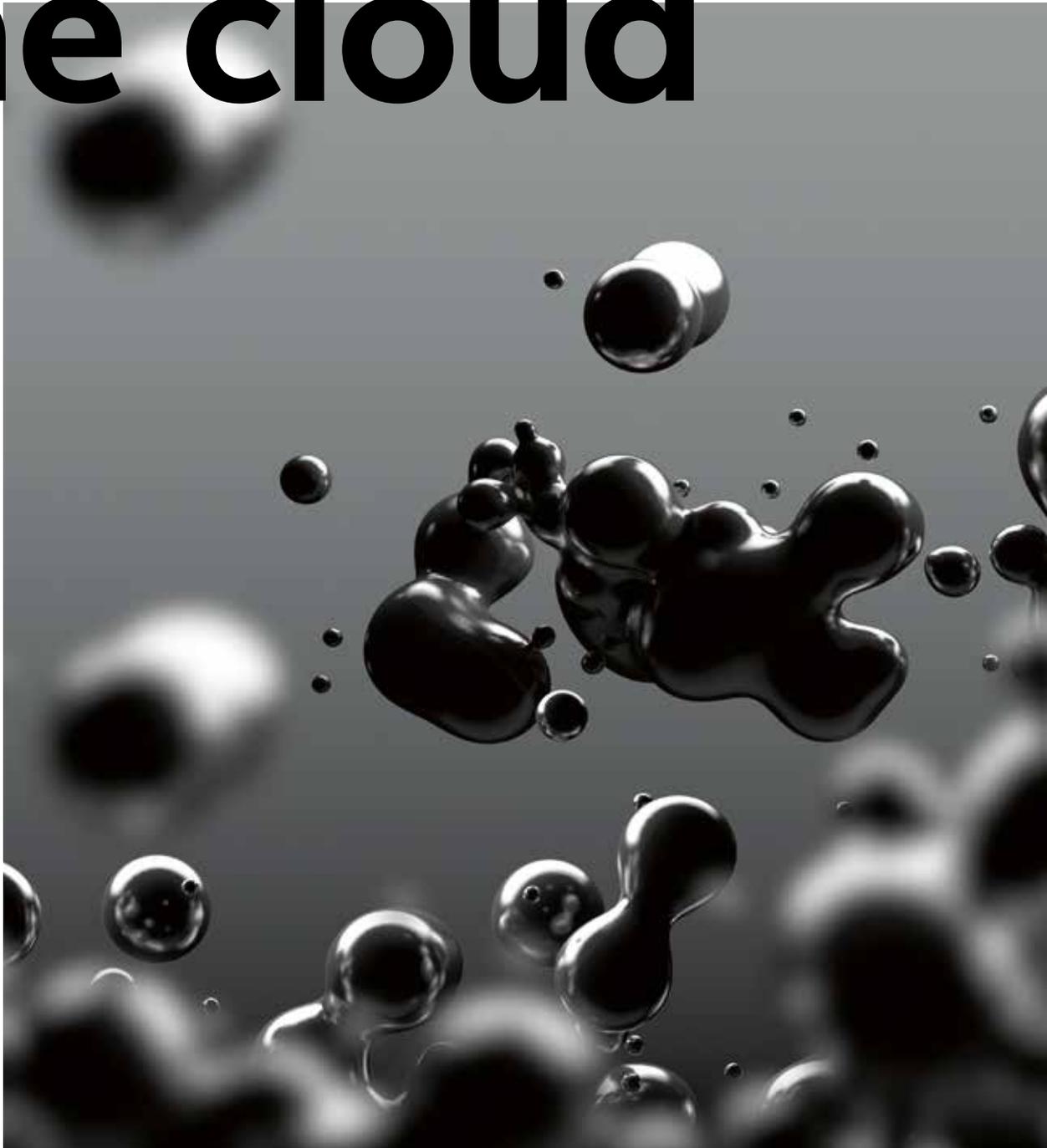
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# Inside the cloud





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Every day, countless terabytes of data are created by e-mail providers, government bodies, financial institutions, private companies and social media sites and so on. To help cope with this flood of data, more – and more massive – data centers are being built. Because this digital data backbone has become so mission-critical, downtime is not acceptable. This leaves data center owners with a responsibility to provide their services in the safest, smartest, and most sustainable and reliable way. These goals can only be achieved by exploiting a wide range of technologies: data center automation; condition-based and predictive maintenance; standardization that reduces complexity; smart grids and smart electrical infrastructure; and cyber security, to name but a few.

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69

## DATA SECURITY DOWN TO THE VERY LAST BRANCH

Working with any miniature circuit breaker (MCB) and ABB's SMISLINE TP busbar system, the Circuit Monitoring System (CMS) is the first measurement system that offers end-to-end encryption with SNMP version 3 (SNMPv3) for a data center's entire network of measurement data – down to the very last branch.



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Whereas great care is taken with client data in a data center, the importance and criticality of infrastructure data can sometimes be forgotten. Such data can be vulnerable to cyber-attack, the consequences of which could be very grave indeed – both for the data center operator and their clients.

Now, ABB's CMS protects installations such as data centers against cyber-attacks on infrastructure data by using the end-to-end encrypted SNMPv3 communication protocol (SNMP stands for Simple Network Management Protocol). SNMPv3 provides commercial-grade security authentication and privacy and is easy to configure. SNMPv3 improves on the two previous versions (SNMPv1 and SNMPv2c) in terms of security (authentication and privacy) and administration.

CMS is an ultra-compact and high-performance multichannel measurement system for AC and DC branch monitoring – ie, current measurement in electrical lines. Power measurements gathered by CMS are used to optimize energy usage and asset utilization and thus reduce costs.

CMS consists of a control unit – for example, the ABB CMS-700 – and sensors with different measurement ranges, up to 160A →01. In mission-critical applications like data centers, CMS typically runs alongside ABB's modular busbar SMISLINE TP system, whose touchproof character allows hazard-free maintenance work during operation

without any power interruption. The CMS sensors are mounted directly on the SMISLINE miniature circuit breakers and there is no need for conventional expensive and cumbersome cabling thanks to the internal Modbus.

ABB's new range of open-core sensors helps to add branch monitoring into existing installations – without the need to power off the system. The ability to simply plug devices into any MCB, as is possible with the universal CMS adapters, saves time and money. Compared to other power distribution and monitoring systems, CMS and SMISLINE TP can achieve up to 50 percent space savings.

As data is transmitted using the end-to-end encrypted SNMPv3 communication protocol – usually to the data center infrastructure management system (DCIM) – data integrity and cyber-security are assured.

CMS, combined with SMISLINE and exploiting the power of SNMPv3, delivers an infrastructure data collection method that is not only secure but that also allows optimization of energy usage and the best possible utilization of assets in the data center. A flexible architecture and ease of installation and maintenance round off the advantages of these products that ensure data center operators get the best performance from their capital investments and that resilience and availability are maintained. •

01 The ABB CMS-700 control unit, which aggregates current readings from the CMS and power quality values to create consumption data and generate any required alarms. Shown with associated sensors to the right.



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01 The ABB Megaflex DPA UPS. Here, a 1.5 MW configuration is shown.



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## MEGAFLEX – AN EFFICIENT AND RESILIENT UPS FOR HIGH-POWER DATA CENTERS

ABB's new MegaFlex uninterruptible power supply (UPS) is aimed at applications such as data centers that have high power demands. MegaFlex is simple, compact and resilient – and delivers the excellent availability, reliability and efficiency that is a hallmark of all ABB's power protection products.

The quantity of data added to data centers around the globe each minute of every day is staggering. This deluge of data has to be stored in a safe and rapid way and has to be retrievable just as quickly – 24/7 and 365 days a year – so it

center concept often cannot provide the replication, data traffic, reliability and resiliency capabilities demanded by some customers.

### Data center requirements

Data center operators have many requirements in common, the most important being:

- Business continuity and zero downtime: All systems have to be always up and running – and whatever happens on the infrastructure side, load-drops are not an option. This is to guarantee safe data transaction, storage and recovery. It is not uncommon for data center outages to cost tens to hundreds of thousands of dollars, and cases that incur costs in the tens of millions of dollars are no rarity.
- Reduction of investment and operating costs through higher energy efficiency: Better efficiency not only reduces energy losses and operational costs but also eliminates the capital investment that would be needed to purchase higher-performance temperature-conditioning systems. Such investments profoundly impact upfront investment.

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Growth in the number and size of data centers is accompanied by a move to cloud-based, hybrid and distributed data centers.



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can be utilized in one of the many applications upon which day-to-day life depends. The dawning of this new era is the reason why data centers are proliferating around the world. Growth in the sheer number and size of data centers is accompanied by another trend: a move toward a sophisticated world of cloud-based, hybrid and distributed data centers. The single, standalone data

A data center has to store data in a completely safe and reliable way. For this reason, the ability to provide an unbroken supply of good-quality power to the data center is critical. Indeed, when they do occur, the most common cause of outages in data centers is a power supply problem.

ABB is a market leader in the UPS technology that ensures power keeps flowing no matter what. The company has pioneered many advanced concepts in modern UPS design – for example, distributed parallel architecture (DPA™).

DPA has worked well for ABB: Users whose power requirements increase can simply add modules to reach power capacities of several MW. However, as larger data centers drive UPS power requirements ever higher – to 30 or 40 MW – the need has emerged for a UPS that has a base power level of at least 1 MW and that can be expanded or configured to cater for applications requiring up to 6 MW. Five such installations can cover the energy needs of a 30 MW site.

Further, as data centers evolve into larger facilities that are denser, scalable, more networked and more converged, operational costs can

— Customers seek a power distribution solution that is highly efficient, scalable, flexible and easy to install and maintain.

increase. An appropriate choice of UPS and associated power infrastructure helps control these costs.

Other considerations involve the move away from the standalone data center toward geographically distributed facilities, global traffic management, critical data replication, virtual storage, cloud computing and other complicating factors. This evolution places new demands on resiliency, provokes new thinking and, most importantly, motivates customers to look for a power distribution solution that is highly efficient, scalable, flexible and easy to install and maintain.

To satisfy these evolving customer demands, ABB has developed the MegaFlex UPS for the UL and IEC markets →01.



02a



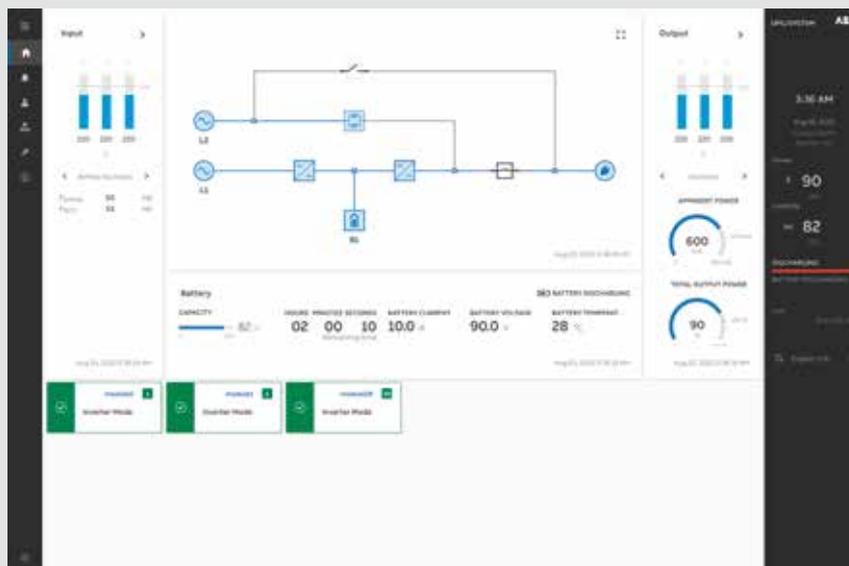
02b



02c



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02 Space in data centers is usually limited, so the flexibility of the MegaFlex DPA UPS is valuable when it comes to layout.

02a 1,000 kW, system with four power modules, connection frame on left.

02b 1,000 kW, system with four power modules, connection frame on right.

02c 1,500 kW, six-power-module system with connection frame in center.

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03 Compared to an ABB DPA 500 UPS solution, the MegaFlex DPA has a footprint around 45 percent smaller.

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04 The operator has a comprehensive overview via a HMI but can also access the same information via a Web page.

### ABB's MegaFlex DPA IEC UPS

The MegaFlex DPA design brief included the following basic tenets:

- Develop, manufacture and sell a high-efficiency UPS with a rated power of 1 MW, 1.25 MW, or 1.5 MW that is suitable for large data center facilities.
- Standardize power distribution architectures in compliance with the Uptime Institute classification system and EN 50600.
- The UPS must be compact, highly energy-efficient, flexible, easy to install and maintenance needs must be predictable.

The result was a transformer-less UPS consisting of 250 kW power blocks, a central static bypass with a rated power of 1,000 kW or 1,500 kW and an I/O connection frame with power ratings of 1 MW and 1.5 MW. The input feed can be single or dual (option). The MegaFlex DPA UPS can use lithium-ion or valve-regulated lead-acid (VRLA) batteries as external storage. Backfeed protection is provided as

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An option provides redundant power capacity of 1,000 kW N+1 or 1250 kW N+1.

standard. An option provides redundant power capacity: 1,000 kW N+1 or 1,250 kW N+1. A product variant – which will be released first – features distributed bypass switches, resulting in a smaller footprint.

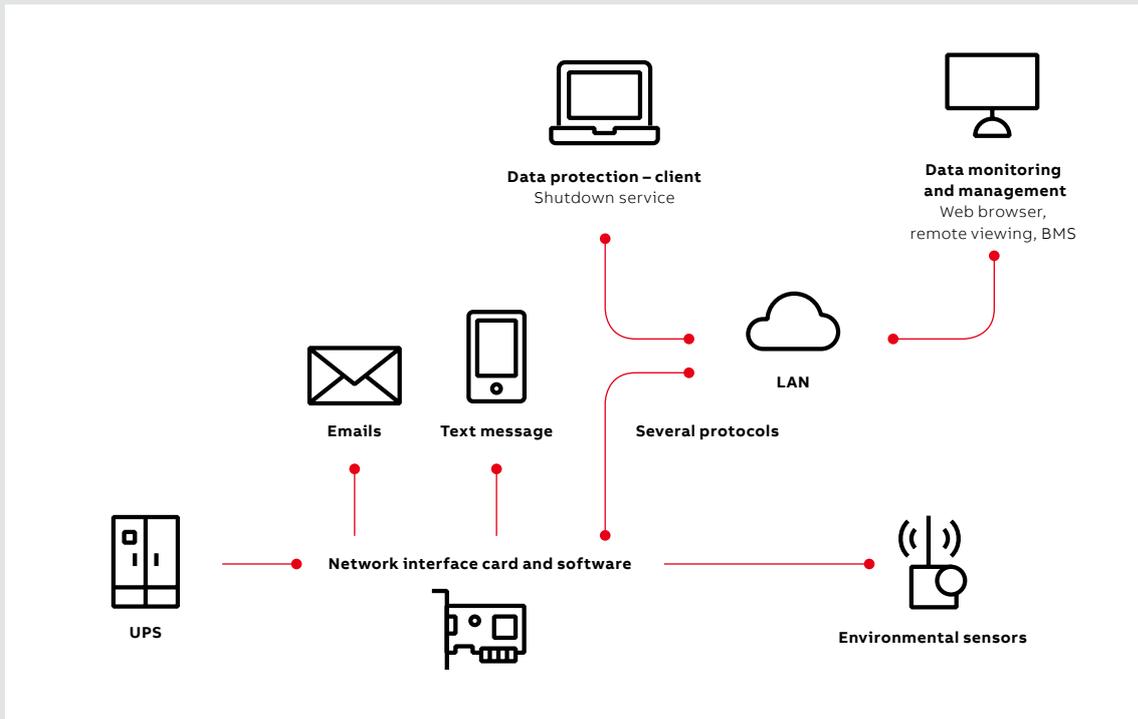
Further salient MegaFlex DPA features include:

- High-efficiency converters – in VFI mode (see below) > 97.4 percent.
- Optimized footprint and flexibility in component layout →02–03.
- Simple, safe and quick installation with high adaptability to the building infrastructure.
- Enhanced power measurement that provides comprehensive information to the data center operator so that energy consumption can be tracked.
- Intelligent predictive maintenance program to plan and reduce maintenance throughout the product life.
- Enhanced self-diagnostics to minimize human intervention during maintenance and start-up.
- Full lifetime service provision via local ABB-trained specialists.

### Intelligent energy management

Due to the vast amount of energy large data centers consume, energy efficiency is a particularly important topic. Every percentage point improvement in efficiency brings with it significant cost savings. The default operating mode for the MegaFlex DPA is voltage- and frequency-independent (VFI) double conversion mode, which has an efficiency of up to 97.4 percent. Alternatively, the UPS can operate in its voltage- and frequency-dependent (VFD) ECO mode to attain 99 percent efficiency.

When a UPS is operating significantly under capacity, its energy efficiency can be negatively impacted. ABB's Xtra VFI operating mode is a smart way to minimize losses and improve



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efficiency safely when running in double conversion mode.

When the MegaFlex DPA UPS runs with Xtra VFI mode enabled, the UPS automatically adjusts the number of active modules according to the load power requirements. Modules that are not needed are switched to a standby state of readiness, primed to transfer back to active mode if the load increases. The efficiency improvements

**To increase reliability, extend service life and equalize aging, the system rotates modules between active and standby mode.**

achieved by this mode of operation are especially significant when the load is less than 25 percent of full UPS system capacity – an operating regime in which traditional UPS systems fare poorly. The switching scheme parameters can be configured by the user. To increase reliability, extend service life and equalize aging, the system rotates modules between active and standby mode at fixed intervals. Should there be a mains failure or other

abnormal situation, all modules revert to active mode within milliseconds.

#### Control and monitoring

The MegaFlex DPA human-machine interface (HMI) allows the operator to display measurements, events and alarms (primary input failure, battery status, overtemperature, overload, input and output protection status, etc.) as well as the UPS status and primary component status →04.

Also measured and displayed are:

- Input, output and battery voltage and currents.
- Output kW/kVA.
- Thermal monitoring for the main converter and critical components.

Connectivity is accomplished via two slots for optional communication boards, eg, SNMP, Modbus TCP/IP or Modbus RS-485. These ports can make measurements and alarms available to the electrical power monitoring system (EPMS), the building management system (BMS) and the data center infrastructure management (DCIM) – all of which integrate with ABB Ability™ Data Center Automation via, for example, the local area network (LAN) →05. The UPS is also equipped with dry inputs for remote shutdown, generator operation and external switchgear; I/O dry ports; a Castell interlock function; and a preconfigured (battery) temperature sensor input.

### Resiliency

Resiliency refers to the ability of the entire power structure to prevent failure – and to recover quickly and fully from failure – or to keep running even with a certain level of faulty equipment or software. A system-wide approach becomes essential if resiliency is to be maintained as the concept of the standalone data center is overtaken by new trends – for example, hybrid and distributed architectures and advances in virtualization; strategies that shift data from one geographical location to another to take advantage of cheaper energy tariffs; and real-time data replication in different sites for hyper-critical applications.

ABB's MegaFlex DPA UPS and associated ABB support infrastructure – such as intelligent switchgear, smart sensors, cloud-based predictive maintenance algorithms, enterprise-wide and site-specific monitoring, transformers, smart sensors, short-circuit isolation selectivity, etc. – help deliver the high level of system-wide resiliency needed.

Measures taken to improve resiliency can also have other benefits. For example, a good monitoring strategy creates a predictive insight that not only flags a component replacement need (rather than unnecessarily replacing it after a prescribed period) but also increases availability while reducing energy consumption. Here, emergency maintenance is also reduced and customer satisfaction increased. This approach also allows remote monitoring of energy consumption and costs, making the implementation of energy management strategies easier and faster.

Another critical aspect of resilience lies with ease of maintenance and the elimination of human error. The design of the MegaFlex DPA UPS has placed great emphasis on these factors. For example, module cabinets can be easily moved to the UPS location using a pallet truck and then slid into place on their integrated wheels →06. Connection is made via docking connectors so cabling faults cannot arise during the procedure.

—  
A predictive insight flags component replacement need, thus increasing availability while reducing energy consumption.

For mains cabling, there is entry top and bottom and the cabinet is IP20 protected. Further, the fan array is located on a pull-out drawer for easy access. Fan failure detection and speed regulation are provided as standard. Timely indication is given of the need to replace consumables such as fans and AC and DC filters, thus improving reliability. All in all, continuous UPS monitoring, smart design and intelligent diagnostics lengthen the UPS lifetime significantly.

### MegaFlex DPA – a UPS for tomorrow's data center

High power, simplicity of use, efficiency, reliability, availability and resiliency are the watchwords that underpin ABB's high-power MegaFlex DPA UPS. MegaFlex DPA is designed to work with the rest of ABB's power infrastructure products to ensure a continuous flow of clean power to a data center and provide the system-wide resiliency needed for modern data storage solutions that implement distributed, cloud or hybrid approaches. By paralleling units, MegaFlex DPA can provide up to 6 MW and the UPS satisfies the "six-nines" requirement of the most demanding data centers.

Most important of all, MegaFlex DPA provides peace of mind for customers with the assurance that their power is guaranteed by the very best power protection technology on the market. •

—  
05 Example of Megaflex DPA connectivity.

—  
06 The Megaflex DPA. Power modules slide in on integrated wheels and lock in place using docking connectors.



## MNS-UP: LOW-VOLTAGE SWITCHGEAR COMBINED WITH MODULAR UPS

MNS-Up combines ABB's Conceptpower DPA500 uninterruptible power supply (UPS) and ABB's MNS switchgear with Emax2 circuit breakers into one product. This flexible, integrated product delivers a host of benefits.

Although the data center market is continuously growing and changing, the demands on site electrification have not altered much. The principal demands are:

- Power availability, as the nature of the data center business means that unplanned outages are unacceptable.
- Reduction of footprint to increase the space available for IT equipment.
- Flexibility to adapt the power supply to continuously changing demand.
- Reduction of installation time to make a "pay as you grow" approach to power expansion fast and easy.

To accommodate these requirements, ABB has introduced MNS-Up. MNS-Up combines ABB's MNS low-voltage switchgear and ABB's Conceptpower DPA500 modular UPS into a single product, which means a large part of the power

MNS-Up combines ABB's MNS low-voltage switchgear and ABB's Conceptpower DPA 500 modular UPS into a single product.

infrastructure can be installed as one integrated unit →01.

At the core of ABB's electrification business is the MNS switchgear platform, which has been evolving for over 40 years. The full breadth of ABB technology – including automation products, breakers, switches, control products, connection technology, protection and wire management – is leveraged in the MNS design.



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02

— 01 MNS-Up combines ABB's MNS low-voltage switchgear, with Emax 2 circuit breakers, and ABB's Conceptpower DPA500 modular UPS into a single integrated product.

— 02 DPA 500 UPS modules can be removed or added without powering off.

MNS-Up integrated UPS and switchgear is an MNS variant intended for critical power applications. For a 500kW installation, MNS-Up can save up to 10 percent of the space needed versus a conventional setup; for 2 MW or more, the saving

— **With DPA500, each 100 kW UPS module contains all the hardware and software required for full system operation.**

can be up to 30 percent. MNS-Up provides all the switchgear feeders (eg, network incoming, generator incoming and bus tie) as well as line starters, motor starters and modular capacitor banks.

The DPA500 UPS modules are located in dedicated sections but with the same busbar systems as the switchgear. This direct coupling is a key aspect of creating a single product. Usage of the MNS standard busbar system also guarantees maximum layout flexibility, allowing UPS sections to be placed in the middle or side of the layout.

Connections between the UPS modules and busbars are part of MNS-Up, so they are completed and tested in the factory, eliminating the potential for the trouble that can sometimes

accompany the site works required by conventional solutions when connecting switchgear and the UPS using cables or bus ducts.

To maximize scalability and reduce the number of spare parts required, only one size of UPS module (100 kW) is used. Each section can host up to five modules and by paralleling six sections a total power capacity of 3 MVA can be attained.

With DPA500, each 100 kW UPS module contains all the hardware and software required for full system operation, which eliminates potential single points of failure. Modules can be replaced without powering down, which makes maintenance and replacement straightforward →02.

Even though each UPS module has its own bypass, the switchgear also includes a central bypass that is common to all the UPS sections that might be accessed during maintenance operations. To maximize the integration of the switchgear and UPS, this bypass is in a standard switchgear bus tie, creating a direct connection between the incoming and outgoing busbars of the UPS modules.

The advantages of the MNS-Up single-product approach are evident even in the tendering phase, in which the customer only has one purchase procedure instead of two (switchgear and UPS), and continue right up to the test phase in which the factory acceptance test merges switchgear and UPS testing procedures, saving time and cost.

The advantages of MNS-Up do not end with the delivery and installation of the product: The benefits of a low total cost of ownership for the data center operator last throughout the entire life cycle of the product. Further, conventional solutions have different life expectancies for switchgear and UPS (30 and 12 to 15 years, respectively) and at the UPS end-of-life interconnections also must be checked and possibly renewed. With MNS-Up, these interconnections are an inherent part of the switchgear, so are guaranteed for 30 years. Thus, the UPS replacement at end-of-life is faster and more cost-effective compared to the conventional solution. •

—

## MEDIUM-VOLTAGE UNINTERRUPTIBLE POWER SUPPLY

A large data center needs a power protection scheme that can supply a sizeable amount of power in a very reliable and efficient way. A power protection and distribution approach at the medium-voltage (MV) level provides the perfect solution.

Continuous growth of the data center industry, particularly in the hyperscale space, is resulting in a dramatic increase in data center facility power needs. This trend is driving new strategies to

—

The output voltage is regulated no matter what input supply disturbances are present.

fulfill customer ideals pertaining to higher efficiency, higher availability and minimal maintenance – in parallel with the insatiable need for reduction in capital investments. With all things considered, the natural next step for power protection for large critical power facilities is an MV-based system.

ABB's PCS120 MV uninterruptible power supply (UPS) – based on the revolutionary impedance (Z) isolated static converter (ZISC) architecture – is the most recent addition to ABB's MV product portfolio and represents the next generation of MV UPS intended for multi-MW power protection →01.

The UPS's high-performance inverters – designed using ABB proprietary power electronics technology – combine with the ZISC architecture to ensure that the output voltage is regulated no matter what input supply disturbances are present. The PCS120 MV UPS provides continuously regulated, filtered power.

To maximize scalability and minimize spare parts, the PCS120 MV UPS system is built using UPS blocks, each with a rated power of 2,250 kVA. Up to 10 of these blocks can be paralleled in a so-called hard-parallel configuration to give



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02

— 01 The PCS120 MV UPS.

— 02 Operating at MV levels allows the PCS120 MV to supply power protection to large data centers – at lower overall cost.

22.5MVA or 20 can be arranged in a ring-bus configuration to give 45MVA.

The PCS120 MV UPS was designed to meet the typical requirements of a large data center:

#### Maximum availability

The PCS120 MV UPS offers a high uptime that is driven by a robust MV design approach that delivers high power levels from single blocks, a lower switchgear count and a modular design

—  
The PCS120 MV UPS's flexibility allows it to accommodate several common data center architectures.

that allows the loss of up to two converters without automatic transfer to bypass mode. Other internal redundancies for fans and switched-mode power supplies further increase system availability.

For large parallel or ring-bus systems, if the system designer includes a redundant module in the system, module maintenance is possible while keeping the system online and the load fully protected, thus yet further increasing system availability.

#### High performance

The PCS120 MV UPS delivers a clean output voltage in accordance with IEC62040-3 class 1 and can also supply high fault currents for downstream protection and fault clearing of up to five times nominal current.

#### Efficiency

The PCS120 MV UPS has a class-leading efficiency of 98 percent for the load spectrum from 50 percent up to full rated load and better than 96 percent for 25 to 50 percent load. Low no-load losses and modular design ensure a near-flat efficiency curve, allowing maximum foreseen capacity to be installed on day one, whilst minimizing energy wastage if the initial loading is low.

#### Operating cost-effectiveness

Because the power protection is at the MV level, facility build and operation costs are reduced as currents and electrical losses are lower at this higher voltage and cables can be thinner →02. An MV UPS can be placed on less expensive real estate – for example, in an electrical room or substation – distant from the loads. Furthermore, because MV requires less infrastructure, reliability is inherently improved.

#### Flexibility and scalability in large power applications

The PCS120 MV UPS's flexibility allows it to accommodate several common data center architectures, such as "distributed redundant,"

03 Power support for the grid.

03a Power flow in normal mode of operation.

03b Power flow with grid support functionality.

or “shared redundant” or “catcher.” These are in addition to the hard-parallel and ring-bus configurations mentioned above. Utilizing groups of 22.5 MVA configurations in hard-parallel mode gives a new perspective on using known architectures – and on a significantly higher power level as large backup systems such as diesel or gas generators are supported by the architecture.

Indoor and outdoor PCS120 MV solutions are possible as are versatile energy storage options with autonomies that range from a few seconds up to several minutes.

**Grid support functions**

With the rise of renewable energy generation comes a potential for UPS equipment to provide

grid support functions in addition to their primary task of load protection.

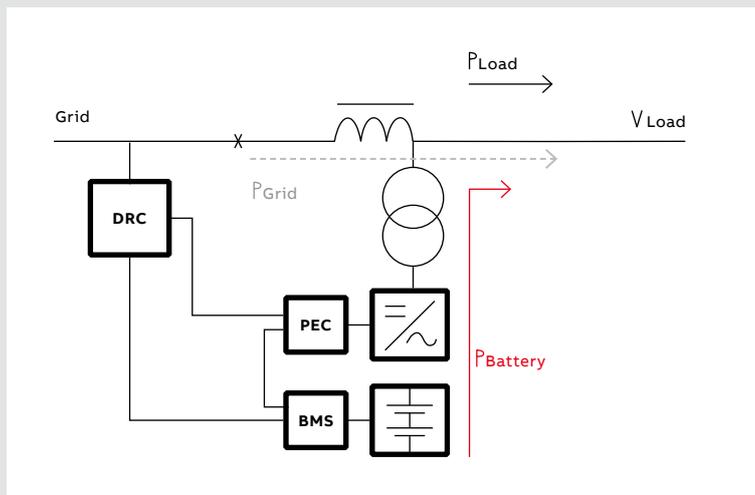
Large data centers have a significant stranded power generation capacity due to their redundant design and battery systems. This infrastructure can generate an income stream through grid support services such as demand management and frequency regulation, as well as increase engagement in corporate social responsibility by helping out local community power schemes.

In addition to its core purpose as a load protection system, the ABB PCS120 MV UPS ZISC topology is also ideal for injecting real power into – or absorbing it from – the electrical network on request from an external power plant controller when network stability is threatened. On request,

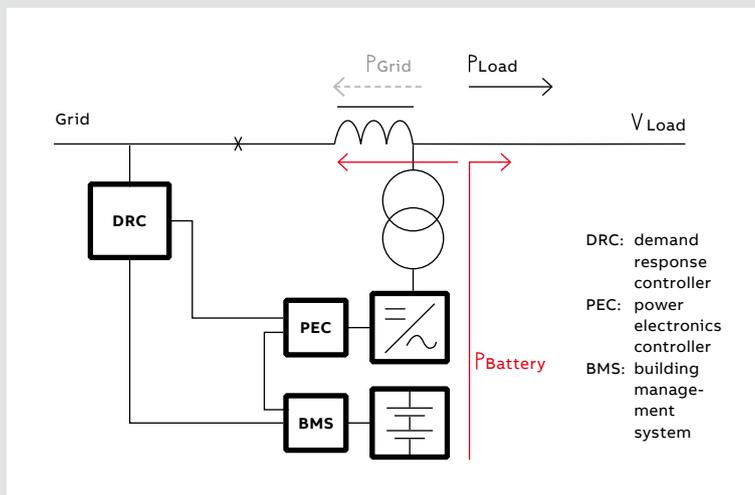
The PCS120 MV UPS is the ideal solution for data centers that need power protection in the multi-MW range.

the PCS120 MV UPS will step in to supply power to the site critical load, thus reducing the drain on the grid, allowing it to recover. If the power relief requested would leave the critical load short, the UPS will support the full load and inject just any excess capacity into the grid – ie, the maximum available power to be injected into the grid is the PCS120 MV UPS system rating minus the required load power →03.

The PCS120’s modular approach allows unparallelized serviceability and redundancy while maximizing uptime. The PCS120 MV UPS is the ideal solution for large data centers that need power protection in the multi-MW range and the UPS covers every aspect the data center needs over the 20 years’ lifetime of the product with minimized maintenance and maximized efficiency, leading to an optimal total cost of ownership. •

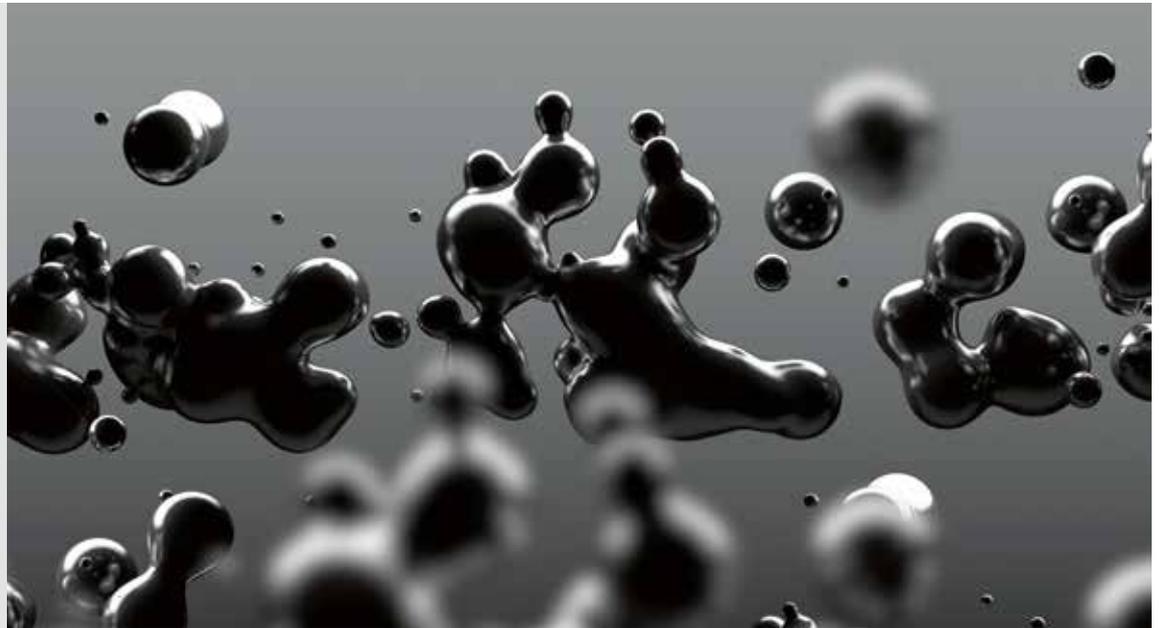


03a



03b

—  
01 External collaborations have become an essential activity for ABB. One such joint enterprise is with FlexeGRAPH, whose innovative nanofluid will change the face of liquid cooling.



01

## NANOFLUID COOLING FOR DATA CENTERS

Collaboration with promising startups complements ABB in-house R&D. One such startup is Australia-based FlexeGRAPH, whose innovative nanofluid could lead to entirely new approaches to cooling in data centers.

ABB's innovation growth hub, SynerLeap, helps startups to accelerate and expand in a global market. SynerLeap offers unique access to ABB's networks, customers and technology, and provides industrial mentorship to support startups in taking the big leap. Through SynerLeap,



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—  
FlexeGRAPH has developed a graphene-enhanced nanofluid for advanced cooling applications.

ABB has already collaborated on more than 100 startup projects, from industrial proof-of-concept projects to customer business projects. "Collaboration between top industrial startups and ABB unlocks a lot of value in terms of faster innovation, add-ons and new products. In a nutshell, innovation, collaboration and speed are the key pillars and the project outcomes are great too – 95 percent of the fulfilled projects have

reached their targets and half of them have already led to increased collaboration," says Peter Löfgren, SynerLeap CEO. One such startup is Australia-based FlexeGRAPH, whose innovative nanofluid could lead to entirely new approaches to cooling in data centers →01.

### **FlexeGRAPH: revolutionary material for enhanced cooling**

FlexeGRAPH is a 2015 spin-out from the Australian National University in Canberra, Australia. The company has developed a graphene-enhanced nanofluid for advanced cooling applications. Suspended graphene particles conduct heat 10,000 times better than water does, thus providing a significant improvement in thermal conductivity over standard liquid coolants that has application across many industries. The core focus for development is in two key areas:

- Electric vehicles, and their batteries and charging infrastructure.
- Cooling for electrical systems where heat limits performance – from high-power HVDC systems to 5G and edge computing applications, and liquid-cooled computing for data centers.



**Shannon Notley**  
FlexeGRAPH  
Canberra, Australia

### Material properties

Graphene is known for its high thermal conductivity, but, previously, its dispersion in fluid had been unsuccessful due to clumping and sedimentation. FlexeGRAPH developed an innovative technique to suspend graphene and bring the high thermal capacity of graphene to cooling fluids.

The graphene coolant is competitive with traditional coolants in corrosion and sedimentation prevention. A traditional coolant for a car engine, for example, has over a dozen ingredients to prevent corrosion, growth of microbes and algae, and degradation due to pressure and temperature changes. FlexeGRAPH's extensive testing ensured its coolant could also prevent these effects – without degrading cooling performance and with a fluid with a much lower environmental impact.

Testing also showed that the product remains stable without clumping or sedimentation. In a static environment, an even particle distribution of 98 percent was observed after five years. Virtually no sedimentation in pumped systems was observed over the same period. This remarkable performance is due in part to the small size of the graphene particles in the FlexeGRAPH

fluid. To maximize the benefits of the product, FlexeGRAPH targets applications with operating temperatures at or above 35 °C.

### Testbed: the world of motorsports

FlexeGRAPH also partnered with Formula One and Indy race car manufacturers for pilot testing. Because race car manufacturers are challenged to maximize engine performance but are limited by the heat production of high-power engines, the racing car arena provides a perfect testbed for the fluid. In high-performance engines, an increase of a few tenths of a degree in operating

---

The graphene coolant is competitive with traditional coolants in corrosion and sedimentation prevention.

temperature can have a measurable positive impact on performance. When the existing cooling fluids were replaced by FlexeGRAPH graphene nanofluid, cooling performance was improved →02. This improvement enables higher

02



—  
02 FlexeGRAPH's nanofluid improves race car performance.

—  
03 Graphene's nanofluid is suitable for cooling data centers large and small.



03

engine output or other performance benefits through system redesigns such as lower weight and reduced aerodynamic profile.

#### Cooling systems for data centers

Data centers provide a perfect application example for FlexeGRAPH. As the data center industry continues to grow, so too does its cooling and energy use. Cooling accounts for over 30 percent

—  
The FlexeGRAPH nanofluid can deliver high cooling capacity in small-footprint data centers in metropolitan areas.

of the average data center's energy usage [1]  
→03. The increased thermal capacity of FlexeGRAPH means that data center owners could cool the same servers using significantly less energy and simpler infrastructure.

As in the motorsports example, the increased cooling capacity can also enable system redesigns that deliver other benefits. For example, in cooling systems using rear-door heat exchangers, the server computing density can be increased, which could be an enabler for the

high computing power needed for the many new AI applications now appearing. In a similar vein, the ongoing massive expansion of 5G will drive the demand for small, compact data centers in metropolitan areas where real estate is expensive. Here, FlexeGRAPH can deliver high cooling capacity on a small footprint.

#### Is graphene the future of cooling?

The FlexeGRAPH product could be applied anywhere a bespoke coolant system is used. As FlexeGRAPH expands into new applications, testing and some customization will have to be performed to ensure compatibility, optimization and compliance with geographic- or application-specific regulations or requirements. In the markets in which the FlexeGRAPH product has been tested, this customization and testing were done relatively easily, opening the door to massive savings in cooling costs. •

#### References

[1] Vxchnge, "How to Improve Data Center Power Consumption & Energy Efficiency." Available: <https://www.vxchnge.com/blog/power-hungry-the-growing-energy-demands-of-data-centers> [Accessed March 23, 2020.]



01

## APPLICATION EXAMPLE: TRANSFER SOLUTION FOR A DATA CENTER

To keep data centers up and running, a reliable and redundant power supply is necessary. For this reason, the most common data center designs include two redundant power supplies for IT and mechanical loads. Switching the backup supply in and out is a critical task.

Around one-third of data centers with N+1 architecture (ie, where there is a backup module in case one fails) experience at least one outage per year, with an average estimated cost of \$900,000

ABB's TruONE ATS is the world's first true ATS to package all the necessary sensors, controllers, switches and operator interfaces into a single, easy-to-install device that not only simplifies the installation and significantly reduces the installation time but also maximizes the ATS reliability →01.

The fully integrated and flexible nature of the Emax2 and TruONE combination provides a highly reliable ATS.

The TruONE ATS has the same user interface and software environment as the ABB Emax2 smart air circuit breaker, which allows it to take advantage of the high short-circuit performance of the Emax2 to deliver a compact and reliable solution. For the first time, Emax2 and its intelligent protection units integrate protection features and automatic transfer switching programmable logics into one single device.

per event. The most usual cause of outages – up to one-third of the total number of occurrences – is a power supply failure inside the data center premises. In the event of a power outage, reliable automatic transfer switches (ATSs) are needed to transfer the power source for both IT loads and cooling systems to the backup power supply.

Typically, Emax2 circuit breakers would be placed in the main power distribution board as incoming protection devices. The Emax2vs are equipped with embedded ATS functions – eg, delayed



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01 TruONE is the world's first true ATS to package all the necessary sensors, controllers, switches and operator interfaces into a single, easy-to-install device that helps improve protection and makes installation simpler, more reliable and faster.

02 Advantages of the embedded ATS solution.

03 Solutions for chillers: TruONE ATSs are installed inside the chiller control panel to keep up the required cooling capacity in case of power outages.

04 This example shows a typical electric distribution design for a redundant data center, with a total facility input power of 1 MW and an IT load of 550 kW.

TruONE ATS is the first to package all necessary sensors, controllers, switches and interfaces into one, easy-to-install device.

transition (known as "open transition" in the IEC market), Main-Gen, etc. – to manage automatic switching in case of main power supply failure.

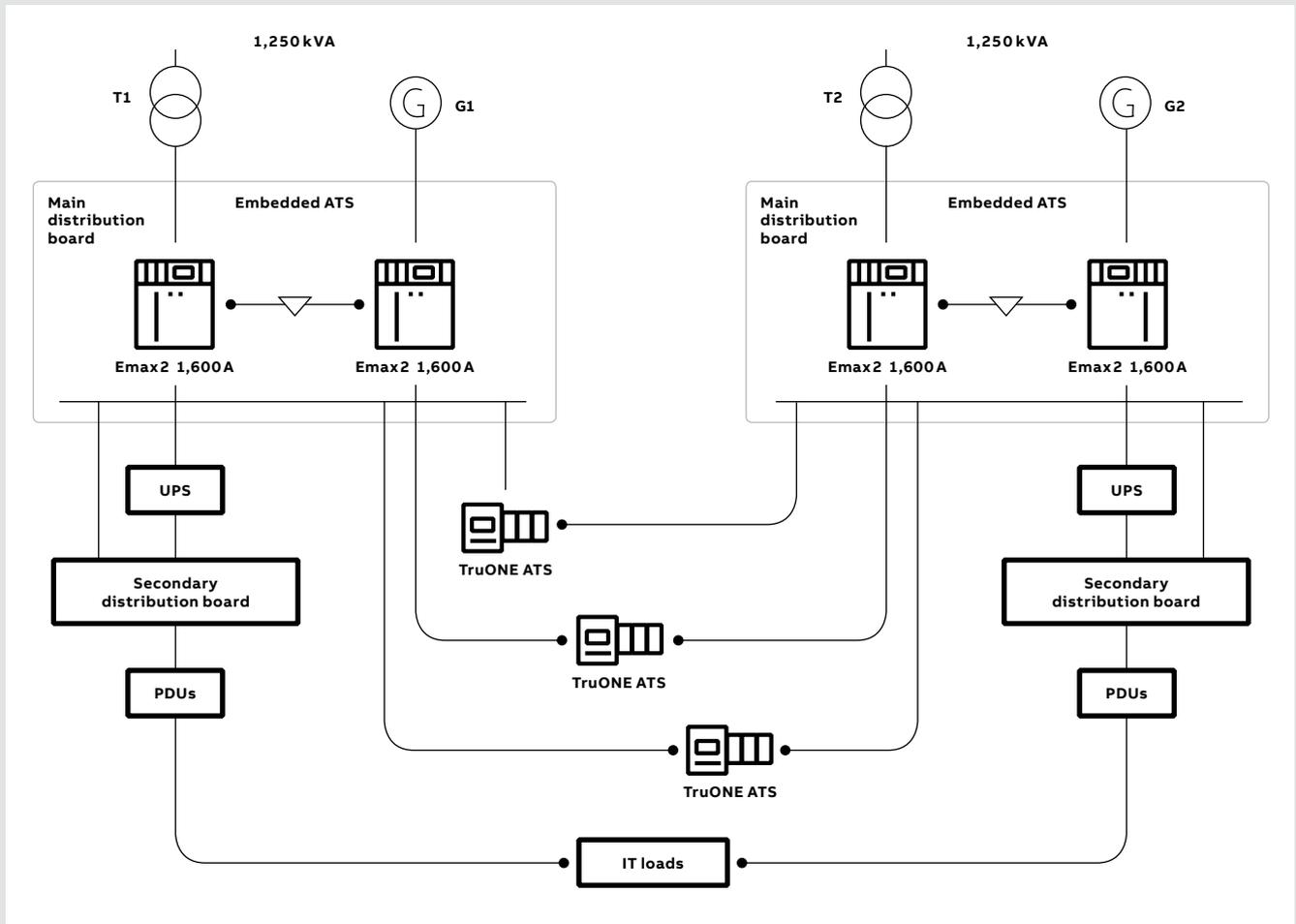
The fully integrated and flexible nature of the Emax2 and TruONE combination provides a highly reliable ATS for even the most demanding data center applications →02–04. •

Feature	Benefit
Fully integrated solution, no need for external devices	Up to 30 percent space saving on the power switchboard
Plug-and-play, ready to go application template	95 percent estimated time and cost savings on ATS engineering
Self-diagnostics of all connections	Enhanced reliability thanks to fewer potential points of failure

02

Feature	Benefit
All-in-one solution, including the controller with detachable HMI	Installation time shortened by up to 80 percent
Automatic commissioning feature and pre-made configuration files	Shortens programming time by 80 percent and reduces risk of human error
Predictive maintenance and quickly replaceable critical modules	Significantly lower downtime and service costs

03



04

## SAFE AND RELIABLE TRANSIENT-PROTECTED TRANSFORMERS

Depending on system characteristics, switching medium-voltage (MV) fast-acting breakers may produce fast transient overvoltages that can damage transformers. By introducing varistors along the windings of the transformer, ABB Power Grids\* can eliminate such transient and associated effects →01.



01



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One of the most intimidating tasks faced by a data center manager is that of switching actions within the site's electrical network. Depending on system characteristics, switching of MV fast-acting breakers (either vacuum- or gas-insulated) can produce fast-transient overvoltages throughout system equipment that damage electrical insulation and, over time, may lead to failures. These failures are typically not repairable in the field, resulting in prolonged outages.

### A complex problem

This issue with distribution-class switching transients dates back to the arrival of vacuum circuit-breaker technologies in the early 1990s. The ability to interrupt current under vacuum was a step change for electrical network design

because it allowed for much higher currents to be interrupted safely and much faster than was the case with air breakers. It was not until a decade later, however, that it was discovered that this new current-chopping ability was subjecting network electromagnetic devices to extreme voltage transients. New failure modes were being observed in distribution transformers, control and measurement transformers and motors. Closer investigation showed that switching transients had become the worst voltage stress that equipment could experience during typical operation.

All circuit breakers interrupt the current somewhat before a natural current zero crossing at an amplitude referred to as the "current chopping

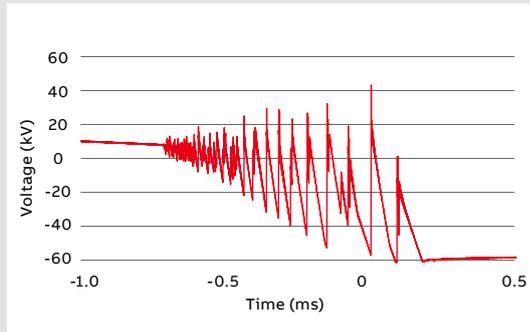
\*A planned joint venture between Hitachi and ABB.

—  
01 TVP for distribution transformers places varistors strategically along the windings of the transformer to limit transient overvoltages from reignitions that may occur inside of the breaker or from any amplified voltages from harmonic resonance inside the transformer.

—  
02 Multiple reignitions with resultant voltage transients in an unprotected distribution transformer during a single switching event. If experienced frequently, over time, these transients lead to insulation failures.

—  
03 Capture of harmonic resonance occurring across the terminals of the distribution transformer.

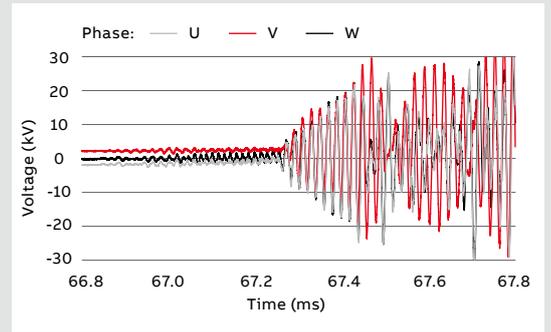
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04 Dry-type distribution transformer equipped for winding varistors (red highlight) and traditional surge arresters (red dotted highlight).



02

level.” As the current is chopped, magnetic energy is trapped in the inductances on the load side of the circuit breaker, where it gives rise to a current that circulates between the capacitances and inductances there. This current flow can generate a transient overvoltage. The difference between the voltage potential upstream of the circuit breaker and these transient overvoltages is known as the transient recovery voltage (TRV). If the circuit breaker contacts are not far enough away from each other when current chopping occurs, the TRV may cause a reignition across the breaker contacts. Further, if the TRV increases faster than the increasing electrical withstand capability of the opening circuit breaker contacts, multiple reignitions may occur →02.

Exacerbating the problem, all three poles of the circuit breaker do not interrupt at the same instant. When the current in the first pole is



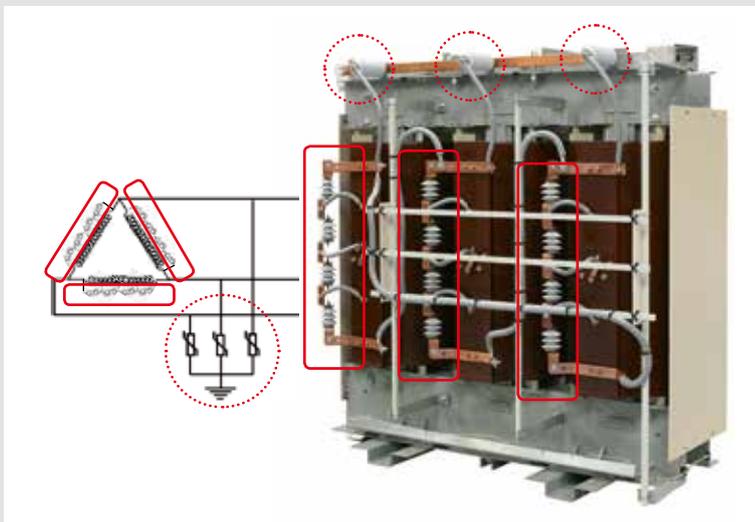
03

interrupted somewhat before its natural current zero crossing, current continues to flow in the two other poles. If a reignition occurs in the pole that interrupted first, this will give rise to a high-frequency oscillating current that could also flow through the two poles that have not yet

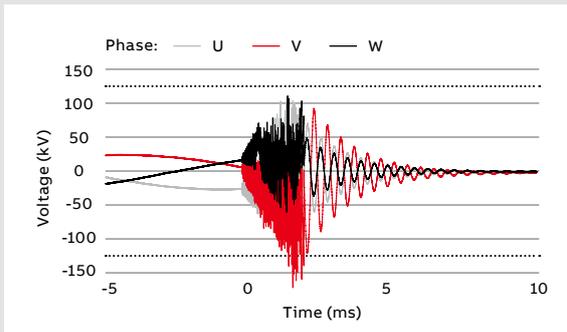
—  
As the current is chopped, magnetic energy is trapped in the inductances on the load side of the circuit breaker.

interrupted. This contribution of high-frequency currents may cause current zero crossings and extinguishing of the arcs in the two other phases. This zero crossing can be regarded as a type of chopping of the current at a significantly higher amplitude than the ordinary chopping level. This level could be close to the peak value of the load current and is referred to as “virtual current chopping.” It occurs due to the unique property of the vacuum circuit breakers’ ability to interrupt high-frequency currents and could generate overvoltages of significantly higher amplitude [1].

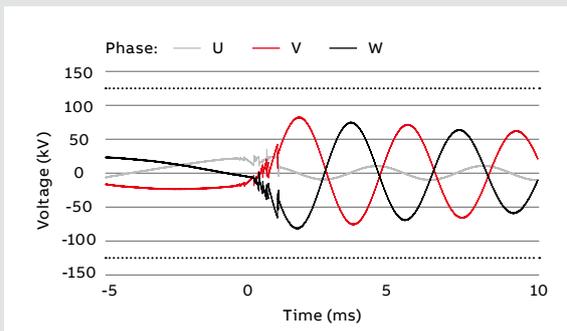
A last challenge is presented by the trapped currents circulating between capacitances and inductances on the load side of the circuit breaker. These currents oscillate at sweeping, high frequencies (into the MHz range) within magnetic equipment. Typical natural frequencies of distribution transformers are between 30 and 40 kHz. Since the trapped circulating currents sweep through these ranges, they may excite the natural frequencies inside the equipment, causing voltage amplification due to harmonic resonance →03.



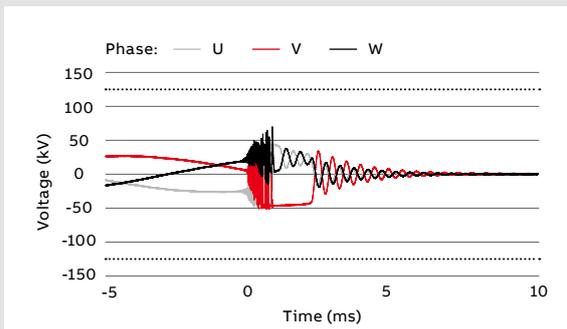
04



05a



05b



05c

### Simple solution

To meet the need for reliable commissioning and load-bank switching operations commonly found in data centers, ABB set out to develop a solution for transformers that can operate safely with fast-acting breakers. ABB evaluated many existing solutions in their 20kV distribution network test lab in Vasteras, Sweden. All existing solutions (such as RC snubber circuits, MV chokes, surge arresters and transformer hardening) were found to be insufficient in controlling peak voltages during switching and/or unable to prevent voltage amplification from harmonic resonance. Some approaches also had the added burden of first requiring a system study in order to arrive at a proper design.

With insights gleaned from over 10 years of testing existing and new solutions, ABB engineers were able to address the voltage stress from network switching with a simple technology: winding varistors. ABB's Transient Voltage Protection™ (TVP™) for distribution transformers

Winding varistors act as pressure relief valves that provide a secondary current path.

places varistors strategically along the windings of the transformer in proprietary arrangements to limit transient overvoltages from reignitions that may occur inside of the breaker as well as from any amplified voltages from harmonic resonance inside the transformer →01, 04.

Winding varistors act as pressure relief valves that provide a secondary current path and prevent voltage peaks inside the winding from reaching levels that could damage the transformer insulation →05. Combined with advanced winding design, the TVP technology controls peak voltages that might occur without expensive system studies or the need to know the characteristics of the connected system. Also, since the varistors provide a secondary path for fast transients, they protect all other magnetic equipment on the same side of the breaker.

Combining the TVP with dry-type transformers also eliminates additional potential catastrophic failure modes – eg, fires, explosions, or environmental leaks – by doing away with liquids for dielectric insulation and cooling, making this solution the safest transformation for distribution networks. Risk of liquid-filled capacitor failures (inside RC snubber circuits) is also removed. Because of these additional safety features, dry-type transformers equipped with TVP not only eliminate switching failure modes but also provide the safest form of distribution transformation →06.



06

— 05 Comparison of transformer switching protection methods.

05a Unprotected distribution transformer during network switching.

05b Distribution transformer with a close-coupled RC snubber circuit.

05c Distribution transformer with ABB's TVP.

— 06 TVP installed on a new transformer at an ABB factory.

#### References

[1] E. Lindell and L. Liljestrand, "Effect of different types of overvoltage protective devices against vacuum circuit-breaker-induced transients in cable systems," IEEE Xplore, volume 31, issue 4, pp. 1571 - 1579, 2015.

#### The future of safety

The next step in providing safe network distribution is to not only protect the system from harmful events (such as switching transients) but to identify the level of risk before a potential failure

— **The transformers self-monitor voltage, current, temperature, pressure and climate.**

event occurs. Advancements in digitization are enabling network managers to identify potential problem areas and act before they lead to significant costs.

Digital transformers, like ABB's TXpert™, are equipped with advanced monitoring and analytics to feed cautionary information to managers on slow-developing or fast-acting network issues. The transformers self-monitor voltage, current, temperature, pressure and climate and

convert those signals into a power quality assessment, a measure of transformer consumed life and maintenance needs. All processing is done at the transformer or in an edge network for the fastest and most secure response.

Such digital features allow analytics that enable network managers to put condition-based maintenance onboard the transformer and achieve more predictability of asset life consumption. In time, the goal is to give network managers full confidence in the functionality of their systems and to remove any routine outages in the future. •



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## BUZZWORD DEMYSTIFIER

# 5G

5G is the buzzword on everyone's lips. This new technology promises great things – but what are these things? And is 5G not just 4G made a little speedier? No, it is quite definitely not. In fact, it is hard to overstate the impact 5G will have on the industries with which ABB is involved.



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With the world depending ever more on connectivity and the exchange of data, the communications industry is moving to provide an entirely new type of wireless network: 5G, the fifth generation of cellular communication technology. With, for example, the ability to serve many devices nearly simultaneously and even run different logical networks for autonomous driving, voice and industrial applications on one physical infrastructure, 5G is a key ingredient for the digital transformation of industries.

This performance improvement is needed to accommodate the current megatrend of digitalization. Apart from the consumer applications of 5G, the technology is vital for vertical industries looking to improve competitiveness by deeper integration of value networks, operations processes and production equipment. More than ever, automation systems are expected to enable flexibility, increase productivity and decrease operational risk for their owners. There are three key aspects of 5G performance that make it able to do this:

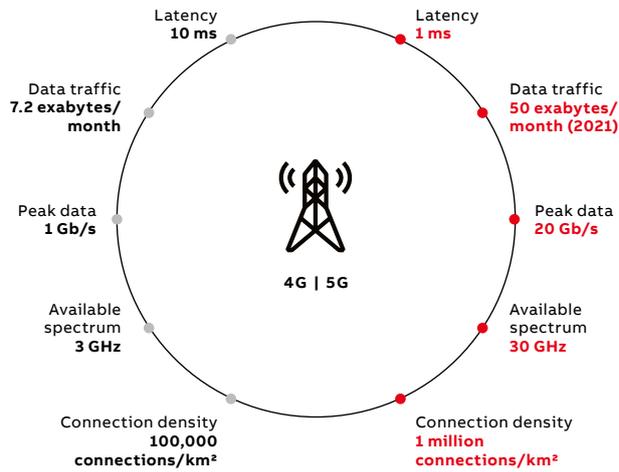
- Enhanced mobile broadband (eMBB) increases bandwidth by an order of magnitude over 4G – ideal for, say, high-definition (HD) video-streaming or augmented reality (AR).
- Ultra-reliable low-latency communication (URLLC) reduces latency and enhances the reliability of communication. URLLC targets

process- and safety-critical applications like closed-loop process and motion control, safe communication and autonomous logistics with automated guided vehicles (AGVs).

- Massive machine-type communication (mMTC) aims to increase the number of devices in a given area by orders of magnitude. This aspect of 5G is primarily aimed at sensor applications with low data rates but high spatial density.

In practice, applications demand a combination of these performance features. A good example is the streaming of augmented-reality content, which requires both high bandwidth for content itself but also low latency to prevent motion lag – if the delay between head-motion and the AR image is too great, the technology becomes unusable in the field. Similarly, closed-loop control applications require both a high density of sensors and high reliability (but rather low data rates).

Beyond the mere improvement of protocol performance described above, 5G cellular ecosystems offer automated industrial systems scalability, sharing of networks between applications (eg, autonomous driving and autonomous plants could share a 5G network) and wide-area precision time synchronization. 5G will incorporate low-power and low-data-rate protocol variants



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01 5G has a performance about 10 times better than that of 4G. 5G can address the needs of a converged digital ecosystem of verticals, from distributing power to automating smart cities with their plants, factories, utilities, roads, commercial and residential buildings.

that support vastly increased device densities and flexible positioning of sensors, machines, or production modules.

5G also helps to improve productivity. The ability to reliably add and connect sensors without added infrastructure cost delivers added insight into processes and products that can be used by machine-learning algorithms to predict and prevent system downtime and quality issues.

**Making 5G a reality**

5G is a complex yet versatile communications ecosystem that incorporates a range of different radio technologies, wire-bound wide-area networks, powerful computers and a significant amount of intelligent software functions. 5G surpasses by far the performance of existing communication technologies for industrial applications.

Today, cellular technology is already a part of many ABB products. To exploit the 5G opportunities ahead, ABB partners with world-leading companies to drive standardization, regulation and technology development of 5G. The new products emerging from that work will radically change the face of industrial automation. •



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