WHITE PAPER

Making the switch to digital switchgear

Traditional switchgear may be costing your business more than you know. In this white paper, we help plant operators understand how digital switchgear can help overcome the hidden costs of traditional switchgear by improving your ability to collect, access, analyze and take action on the data your equipment and infrastructure creates, helping you achieve cost savings of up to 30 percent.

Read time: 15 minutes

Table of contents

Making the switch to digital switchgear

From industrial manufacturing and processing facilities to data center server farms and support systems like lighting and air conditioning, almost every aspect of the modern world requires a constant, reliable source of electric power.

As a foundational piece of electrical equipment, switchgear plays a key role in delivering dependable energy. Switchgear is used to distribute electricity safely and effectively from the high voltage of 6 to 36 kV coming from power plants and utility networks to low voltage distribution networks that are in the range of up to 690V.

Switchgear technologies typically contain a number of electrical devices, such as circuit breakers, power monitors, motor and feeder controls and protection devices. When evaluating these technologies, a plant operator has a range of options. Traditional switchgear devices are designed to disrupt an electrical circuit in case of a fault, making them an acceptable choice when working with processes that can withstand sudden interruption.

On the other end of the spectrum, mission-critical operations may lead a plant operator to select smart devices that can be monitored and controlled remotely while providing an alarm that is activated at a defined threshold, allowing the operator to prevent or mitigate the damage of an interruption.

Besides control function, smart devices can also collect a wealth of data related to the operational condition of circuit breakers, motors or feeders. However, there are various reasons that still lead many operators to choose traditional, simpler switchgear devices.

First, there is a perception that smart devices have higher complexity and lower reliability. Plant operators are sometimes worried that alarms would be issued too early or without a real need, creating a low level of trust. To avoid unnecessary alarms, time must be spent programming the smart device to operate appropriately.

Furthermore, configuring communication interfaces for things like process control or electrical monitoring only focuses on the few data points needed for control, which fails to utilize the device to its full capacity by wasting the data that is available. This may be caused by either not appreciating the value of the data a smart device can deliver or not being able to justify the extra costs of data collection.

But over the lifetime of the equipment, the cost of not having or using data is typically much higher than you expect.

—
01 Low-voltage switchgear

The hidden cost of traditional switchgear technology

A traditional switchgear can be of conventional design or be one that uses smart devices but not all the data they provide. There are many hidden costs of traditional switchgear that can add up over the life of the switchgear. These costs can include:

- **The initial cost** of device implementation and correct parameter value-setting, which can be time-consuming due to a lack of necessary information.
- **Coordination** between the engineering and commissioning team, which is often needed to reconcile information used to inform design versus on-site, real-world load and rating changes.
- **Switchgear testing,** including manual operational data collection and report creation, which can require costly and time-consuming coordination with the buyer, operator and manufacturer.
- **Operational costs,** including regular visual inspection, function checks and further maintenance that is sometimes conducted on a preventative basis rather than on a need basis.

Due to its complexity and always-on nature, it can be difficult and expensive to keep up with switchgear maintenance. For example, the manufacturer may recommend inspection and maintenance every two years, while plant shutdown can be scheduled for intervals of five years, creating conflict in planning. Without the ability to know what is happening with devices, operators are forced to conduct reactive maintenance, maintain a collection of expensive spare parts and keep a trained maintenance team available in the case of device failure. Despite being more expensive and disruptive, reactive maintenance is still far more common than preventative maintenance, which could keep the switchgear running in top condition and minimize downtime.

But preventative maintenance means more than just giving switchgear its annual check-up. It means identifying small symptoms and acting before it becomes a more serious problem, which may require further data.

For example, a temperature increase can indicate bad electrical joints due to loose connections, which leads to higher resistance in the conducting circuit. If undetected, this can lead to a dangerous situation such as arcing or fire. Even preventative yearly maintenance can miss this critical moment. The ability to monitor and respond to a small increase in temperature can make all the difference in avoiding catastrophe.

Another thing to keep in mind is that switchgear has an average life of 30 years. While conventional switchgear may be great for your CapEx, this can lead to a situation where your switchgear is engineered and built in accordance with your known requirements at the time of purchase, not the needs of your business in 10 or 20 years in the future. If you consider new machinery that is brought in, an added extension to the building, or a larger motor replacing a smaller motor in the manufacturing process, you can see how easy the power demand on the electrical assembly could increase, which can decrease the life expectancy of devices or put them at risk of failure.

While switchgear can be extended by adding a new breaker in a spare space inside of the assembly or by adding a new section or panel, it can be difficult for operators to calculate if there is sufficient electrical and thermal capacity in the switchgear to add new components or if there is a need for more capable switchgear altogether. By using manual calculations instead of real data, operators risk making the wrong decision or delaying the right decision until it's too late.

Unlocking your data

Your electrical infrastructure is already capable of producing more data than you may realize. For example, protection relays not only operate the breaker under normal conditions, but also trip the breaker when critical situations are detected in the electrical network. While those relays count the operation and trip cycles, they can also be used to estimate contact wear and other breaker condition data.

Meanwhile, motor controllers used in everything from industrial operations to HVAC systems could collect not just operation and trip data, but motor load conditions that can help the operator detect problems in motors or attached machines. However, the data your devices create is only as useful as your ability to collect and access it.

In many cases, this data remains in the protection relay, motor controller and other devices throughout the facility, due to the need for additional communication network and processing systems to manage the collection and management of the data.

However, if accessed and incorporated into a single system, this data could be used to identify the right threshold settings and help drive cost-effective predictive switchgear maintenance based on actual condition information, which is far preferable to waiting for a costly failure to occur.

Of course, if it were that simple, you'd already be doing it. To access this data, it can often take specialized knowledge to set up and program smart devices, fieldbus and Ethernet communication inside of the electrical assembly. Process and electrical control teams often don't know or understand the need for condition monitoring, thus they configure and read only the data they need to keep their costs to a minimum.

—
02 Medium-voltage switchgear

The advantages of digital switchgear

Because smart devices are installed in many switchgear today or are being added as part of upgrade and retrofit activities that you have already scheduled, they should become a part of your strategy for any newly installed equipment moving forward.

Collecting and managing the right data is a precondition for the digital future. With a digital switchgear solution, you can not only collect all your data automatically, but also store and analyze it so your team can make data-driven decisions while applying lifetime analytics for further value creation. This data can be used to provide condition monitoring that allows you to:

- **Verify** switchgear function and performance before a factory acceptance test (FAT)
- **Demonstrate** switchgear condition with a condition report during factory acceptance tests and commissioning
- **Identify** areas that need repair before they fail during operation
- **Analyze** performance data to determine condition-based maintenance requirements
- **Better plan** maintenance in advance, shift from preventive to predictive maintenance

Moreover, with on-site data collection from day one that continues through the lifetime of the device, digital switchgear solutions provide the basis for asset management solutions that better estimate the remaining useful life of electrical equipment and the probability of failures.

One way to think about collecting data from switchgear devices is to envision a flight data recorder in an airplane, also known as a black box. Like the black box, a device in a switchgear continuously collects data and the status information of equipment, allowing operators and service specialists to access details when needed. Ideally, a black box has a one-time cost and installation fee, but no restrictions on the number of data points it collects.

An even more effective method is to add a complete condition monitoring solution to the switchgear or the complete electrical assembly at your site. This solution uses sophisticated data analysis and algorithms to automatically and continuously convert data from the black box into actionable insights that are easily accessible via a dashboard by your maintenance personnel.

Together with past lifetime data such as commissioning date, maintenance dates and performed maintenance types, this data will become actionable information you can use to drive decisions.

Switchgear digitalization is not only for new installation. Whether it is the switchgear you plan to buy and install in a new plant or it is an existing switchgear in your plant, any switchgear can be digitalized by adding smart devices and sensors as desired.

Digital switchgear use cases

Digital medium-voltage (MV) and low-voltage (LV) switchgear solutions not only distribute energy safely and reliably but also have the capabilities to monitor the condition of devices and other electrical equipment included in the switchgear. These devices are connected through Ethernet-based digital communication, including the widely used IEC 61850 for medium-voltage devices and Modbus TCP or OPC UA for all devices. Those communication protocols are commonly found today in industrial Internet of Things (IoT) platforms.

Intelligent electronic devices (IED) such as ABB's Relion® relays or ABB's low-voltage circuit breaker Emax 2 with Ekip control and protection unit not only perform control and protection functions but optionally include a feature for circuit breaker condition monitoring that provides an operator with data that can be analyzed and used for scheduling circuit breaker maintenance or function testing, while a runtime counter enables scheduling of time-based maintenance for the connected motor or transformer.

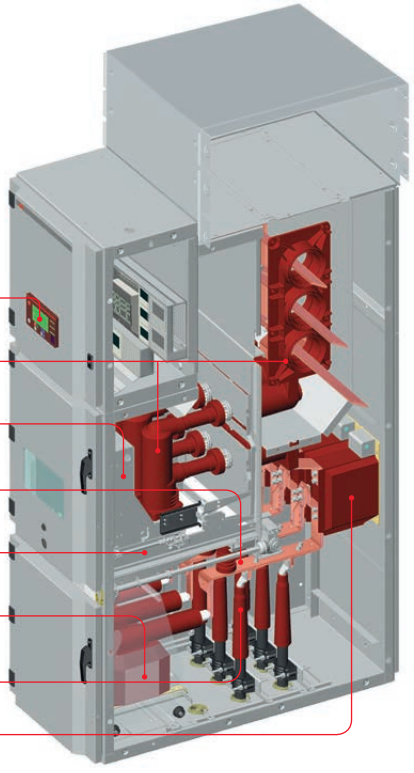
Data collected includes:

- Electrical parameters such as current, voltage and power
- Timestamped alarms and events
- Circuit breaker condition monitoring with real-time counter and values
- Loading levels

Moreover, collecting and monitoring data of other components in an MV switchgear assembly such as earthing switches, disconnectors, and the correct lock position of doors, provides further insights into the electrical and mechanical status of the assembly without the need to be present in the switch room, thus enhancing overall safety for the operation and maintenance teams.

With MV and LV switchgear section or panel condition monitoring, temperature and humidity data can be collected from both the switch room and from inside the switchgear. This provides insight into the operating conditions and potential impact on the switchgear over its lifetime. Monitoring your critical electrical connections 24/7 eliminates the need for manual maintenance tasks and ensures data is continuously recorded and analyzed.

In MV switchgear, monitoring insulation and partial discharge occurrences provide even more information.



— 03 Inside view of a MV switchgear section

LV switchgear is largely used to distribute energy to hundreds of loads such as motors or sub-distribution panels. Located in various areas of a building or plant, it is often exposed to temperature and humidity changes. While switchgear is designed to accommodate a certain level of heat caused by heat losses inside the switchgear, an extension during its lifetime will further increase the heat level. Traditionally, an operator must make calculations to determine the possibility of adding loads to avoid exceeding the thermal and electrical capacity of switchgear. However, digital switchgear can provide current and historical data as the basis for operators and planners when making the right decisions for extension planning.

LV switchgear also consists of various types of modules, feeding motors or external loads. This is another area where maintenance, although regularly required, is sometimes overlooked. Removable modules use specially designed contact systems for power connections that are designed to withstand a number of operations (as per IEC 61439 minimum 200 operations). These contact systems require maintenance like greasing, which is traditionally conducted in maintenance cycles that may not align with the actual maintenance needs of the component.

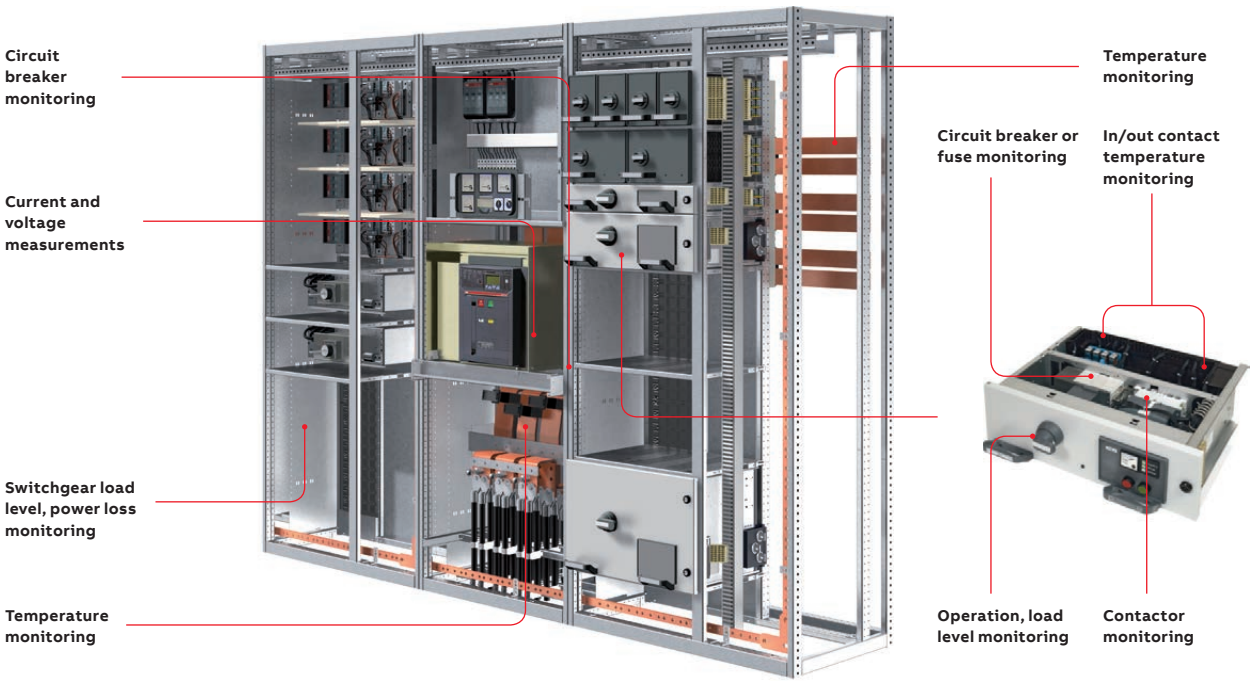
With digital switchgear, module data can be provided by smart devices such as a power meter and motor controller to monitor module insertions and temperatures so you can better understand conditions, calculate the correct maintenance cycles, and minimize maintenance efforts by working only on those modules in need, avoiding entire switchgear shutdowns.

Smart LV motor controllers are another group of devices that are often underutilized compared to their digital capabilities. While their primary function is motor control and protection, they are capable of collecting additional valuable data, such as:

- Motor current levels and imbalances
- Thermal loading levels
- Operating and insertion counter data
- Condition monitoring data
- Temperature, humidity and other data using additional sensors

Finally, motor current levels and imbalances can clearly indicate issues with the motor or the connected machine. With this data, you can go beyond switchgear monitoring to enable the monitoring of your complete power train.

—
04
Inside view of a LV switchgear assembly



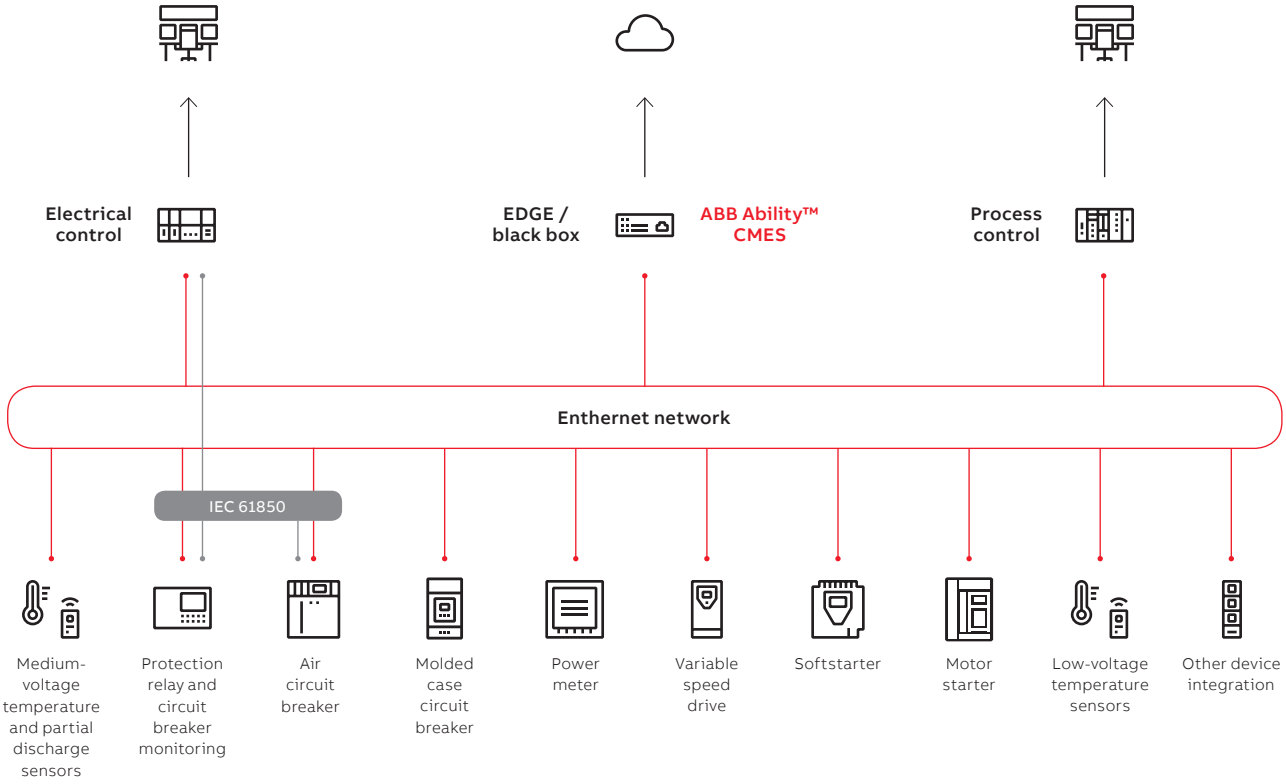
Condition monitoring on a digitized switchgear

Installed on-premise either as a switchgear black-box or Edge based solution a condition monitoring solution collects and stores real-time data from connected devices and sensors in one or across multiple switchgear and make these data available for further analysis, eventually allowing the operator to make the right decision at the right time.

On top of that, it is paramount to have diagnostic algorithms capable of providing detailed insights and recommendations without user input, such as determining whether a temperature increase is a critical situation due to a loose connection or a normal situation due to increased load demand.

An on-premise condition monitoring solution enables switchgear operators and plant maintenance managers to monitor and manage electrical distribution systems, motor control centers and connected loads, all in real time, when needed and at your finger tips.

05 Communication architecture



—
06 Example of an ABB Ability™ CMES dashboard

Whether using the simple app from a smartphone or tablet or working with a more powerful workstation, a Condition monitoring solution allows you to prevent failures, predict conditions and manage energy consumption so you can reduce maintenance and operational costs.

Installed as an integral part of the switchgear assembly at the time of manufacturing, the solution monitors the complete lifetime of a switchgear from factory acceptance testing (FAT) through commissioning and operational life on site.

While traditional process control and supervisory control and data acquisition systems (SCADA) only read the necessary data points required for control functions, a Condition Monitoring solution reads every data point provided by devices and sensors in the switchgear.

—

An interactive user dashboard provides an immediate, real-time summary overview of the health index of all switchgear, as well as sections and devices, on a plant-wide, substation, or switchgear basis.

No programming knowledge shall be required to set up the solution. Moreover to increase usability and speedup troubleshooting, the Condition monitoring solution shall offer a ‘Knowledge Base’ guiding you through every alarm or event providing a detailed description of the issues, possible reasons, and suggested actions for remedy.

Digitalization and condition monitoring benefits

Simplicity
- Traditional hardwired connections are replaced by serial bus or Ethernet connection
- No programmable logic controller (PLC) required
- All data provided by intelligent electronic devices (IEDs) and sensors is collected, analyzed and presented through predefined dashboards and user interfaces
- Integrates with vendor and third-party devices

Safety
- Maintenance can be performed when needed to minimize the risk of unnecessary failures
- Add the ability to integrate online temperature monitoring and arc fault detection devices to eliminate further risk
- Instantly notify operation and maintenance personnel when a deviation from a defined condition is detected
- Access dashboards via mobile devices or operator panels installed in the switch room or control room to enable final condition checks before beginning any maintenance work

Flexibility
- Digital switchgear can be easily adapted and customized as requirements change, such as when loads are added to the switchgear
- Add sensors or smart devices to upgrade conventional feeders or motor starters without interventions on power parts like circuit breakers, cables or busbars
- Upgrade software to utilize new functionality without changing the equipment physically
- Support virtual factory acceptance testing, commissioning support, remote service and troubleshooting through digital services and tools

Customize
- Add switchgear panel, devices or functions all at once or incrementally
- Easily combine fixed, plug-in or withdrawable switchgear technology
- Easily exchange and upgrade components and devices in the switchgear without upgrading the entire system
- Add new features to an existing installation through software updates
- Connect to distributed control system (DCS), SCADA and other platforms, with each being non-intrusive to each other

Analyze
- Data monitoring from commissioning throughout the entire life of the device
- Analysis will improve over time as more details are collected and new functions are added through updates and subscriptions
- Access your data even in the event of a switchgear device failure thanks to all data being stored on-premise separately

Optimize

- Shift from planned maintenance to condition-based and predictive maintenance
- Reduce cost impact of unexpected shutdowns with faster fault analysis
- Plan ahead with condition reports and maintenance date calculation
- Improve energy management using energy consumption data available from each connected motor or load
- Prioritize investment and optimization steps by identifying less efficient equipment
- Achieve continuous operation by avoiding unplanned outages while optimizing operating costs and reach savings of up to 30 percent

Economize

- Replace only specific components instead of entire devices based on individual condition situations
- Upgrading devices can cost up to 30 percent less than full replacement of a switchgear at later stages
- Reduce infrastructure requirements as Ethernet-powered infrastructure are less expensive to purchase, install and maintain compared to hardwired connections
- PLC-free design further reduces infrastructure investment by up to 20 percent

By using a digital switchgear solution from ABB, you get the visibility and knowledge necessary to make data-driven maintenance decisions so you can identify and solve minor issues before they become a major problem. In doing so, you can help increase uptime, decrease maintenance costs and spend more time focused on high-value tasks instead of manual monitoring and data collection.

Learn more about ABB Ability™ CMES.

To the Edge and beyond

Digitalization and the adoption of the Industrial Internet of Things (IIoT) in electrical systems requires careful analysis. Keep in mind that data collected from electrical systems reflect site operational and maintenance conditions. Any analysis that takes place on-premise is limited to what it gets from that premise, while situations and experiences from other sites are not considered.

While this may be sufficient for your operation and maintenance planning today, it may not be in the future. So, should all the data be sent to a larger data center for further analytics, machine learning and the application of artificial intelligence? Not necessarily. Here, Edge computing plays a critical role. Instead of being transmitted to a far-off data center, your data can be processed in real-time on a local computer, server or even the device that collects it.

An Edge device is relatively inexpensive to install and operate while still providing a suitable level of on-site calculation power and data storage, making it an effective solution whether used solely on-premise or connected to the cloud.

Many users of digital switchgear adopt Edge computing as a crucial part of their hybrid data architecture thanks to its ability to vastly reduce latency, reduce the need for data centers and cut down on costly bandwidth requirements. And with connectivity to ABB Ability™ cloud-based solutions, you can extend predictive capabilities that help you understand probabilities of failure across multiple sites and switchgear, enabling you to further reduce operational costs while making your switchgear capable for the future needs of Industry 4.0.

—

ABB Ability™ gives the best of both worlds. Because ABB Ability solution are also installed on Edge devices, you have the option to connect to on-site systems or cloud-based solutions for maintenance management.

Learn more about ABB Electrification and ABB Ability™.

Your digital switchgear transformation checklist

Integrate digitalization into your strategy
Digitalization must be properly integrated into your business strategy and overall approach from electrical systems to the whole business.

Focus on identifying where condition monitoring has the potential to accelerate and enhance business objectives.

Create a robust data architecture
Build a secure, integrated data architecture that combines operational and information technologies. Switchgear data are only a basis. This process will require engineers with significant experience at industrial facilities.

Data quality is key. Without internal confidence in your data, you will struggle to transform operations and your culture as you deal with skepticism and false alarms on the factory floor.

Manage expectations
Ensure your organization accepts digital switchgear at its early stage. Not every algorithm or model will work as expected if there is not enough data to start with or if you are adopting the technology late. This needs to be recognized and understood by all involved.

Leverage existing expertise
Data analyzed in digital switchgear require verification and qualified user input to get better every time. Enable retention of existing experience, knowledge and expertise within your organization.

Nurture collaboration and partnerships
Establish what external partnerships are required to meet business objectives. Make sure external partners will safeguard your data and intellectual property and understand the complexities and risks involved in the industrial space.

ABB Ltd.
Distribution Solutions
Electrification
P.O. Box 8131
CH-8050 Zurich
Switzerland

new.abb.com/medium-voltage/by-customer-segment/abb-ability
solutions.abb/abb-ability-electrification

9AKK107680A7251 ENa