



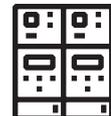
MOTION

# **Tunnel ventilation and drainage**

Securing safety, reliability and efficiency for critical infrastructures

# Solving diverse challenges facing modern tunnel design

From consultants responsible for designing tunnel engineering systems to system integrators combining components that function well together – all require reliable and energy efficient solutions. ABB PLCs, variable speed drives, motors and generators offer a commercial and technical advantage in any project.



## Consultant



“The tunnels I design should meet the strictest safety and reliability codes.”

### From safety advice...

- In-tunnel engineering systems aim to protect the health and safety of tunnel users.
- Under normal conditions, ventilation keeps the concentration of motor vehicle emissions low and visibility high. During a fire emergency, ventilation removes smoke and heat from the tunnel, maintains evacuation routes and gives emergency services access to the fire location.
- Drainage systems ensure the water entering the tunnel is disposed of under normal and emergency situations.

### ...to high energy efficiency...

- Because tunnel ventilation systems can have high operating costs and consume much energy, making them energy efficient is one of the project priorities.

### ...technology needs to be simple, yet all-embracing

- Controllers, variable speed drives (VSDs), softstarters, motors and generators are critical to the continuous operation of ventilation, drainage and fire suppression systems. The equipment should meet tunnel design requirements, while reducing power consumption and increasing safety for tunnel users.

## System integrator



“Component compatibility with common standards and interfaces ensures smooth integration and commissioning.”

### From easy connection and integration...

- Connecting and integrating components into ventilation, fire suppression and drainage systems must be straightforward, ensuring smooth interoperability.

### ... to high reliability ...

- Efficient tunnel management requires detailed access to fault logs and operational data for condition monitoring and troubleshooting.

### ...using world leading protocols and standards

- Support of all major communication protocols ensures VSDs and softstarters are an integral part of a tunnel automation system and can contribute to an overall control strategy together with PLCs.



### Tunnel safety inspector



“It’s critical to make sure the tunnel is safe, and its systems are compliant with the industry standards.”

#### Extreme risks demand...

- Even a small fire can have serious consequences in a confined space. Gases and heat build up quickly and are difficult to disperse. Trapped in a tunnel, toxic carbon monoxide concentrates to fatal levels in seconds.
- During a storm, water can rapidly fill a tunnel, disrupting traffic or even proving to be life-threatening if, for instance, an underwater tunnel leaks.

#### ... rigorous directives and standards...

- Global directives and standards for tunnel ventilation fans specify how long and at what temperatures the fans should operate in extreme conditions. Special attention is given to acceleration and braking time.
- Motors must be tested to EN 12101-3, which is considered the most demanding standard for smoke extraction.

#### ... and advanced safety features

- In emergency situations, VSDs should enter override mode, running fans according to a chosen strategy, ignoring warnings and faults. This extends fan runtime in adverse conditions for safe evacuation of tunnel users.



### Operating company



“Traffic should be continuous with a minimum risk of emergencies.”

#### Eliminate operating risks...

- Tunnels are mission-critical infrastructures ensuring vital transport connections, so demand 100 percent availability.

#### ...by utilizing smart functionality

- VSDs feature temperature monitoring, overload, overcurrent, and other protections and warnings which help prevent failures in the control of ventilation and drainage systems.
- Ultra-low harmonic (ULH) drives ensure power quality in tunnels making the power system more resilient.
- High availability PLCs prevent downtime thanks to hot-standby concept – redundant CPUs and I/O communication run in parallel with the main ones and always ready to take over.

“How to optimize costs?”

#### Lower expenses...

- Costs can be optimized without compromising tunnel operation continuity and safety.

#### ...through advanced solutions and maintenance regimes

- ULH drives allow for smaller supply transformers, backup generators and cables significantly reducing project costs.
- VSDs receive information on fume concentration from controllers and adjust fan speed based on the need, saving energy in non-rush hours. High efficient motors enhance energy savings further.
- ABB Ability™ Condition Monitoring service delivers information on VSD and motor events and proposes targeted maintenance eliminating regular inspections.
- ABB global service network and maintenance contracts relieve pressure on in-house teams.

# Demands of tunnel ventilation and drainage systems during normal operation and emergencies

Every day tunnel fans help remove vehicle exhaust fumes and maintain visibility. In the event of a fire, ventilation manages smoke extraction and supports evacuation. Pump stations dispose of water from tunnels that are below the water table on a constant basis or during storms.

## 1 TUNNEL VENTILATION

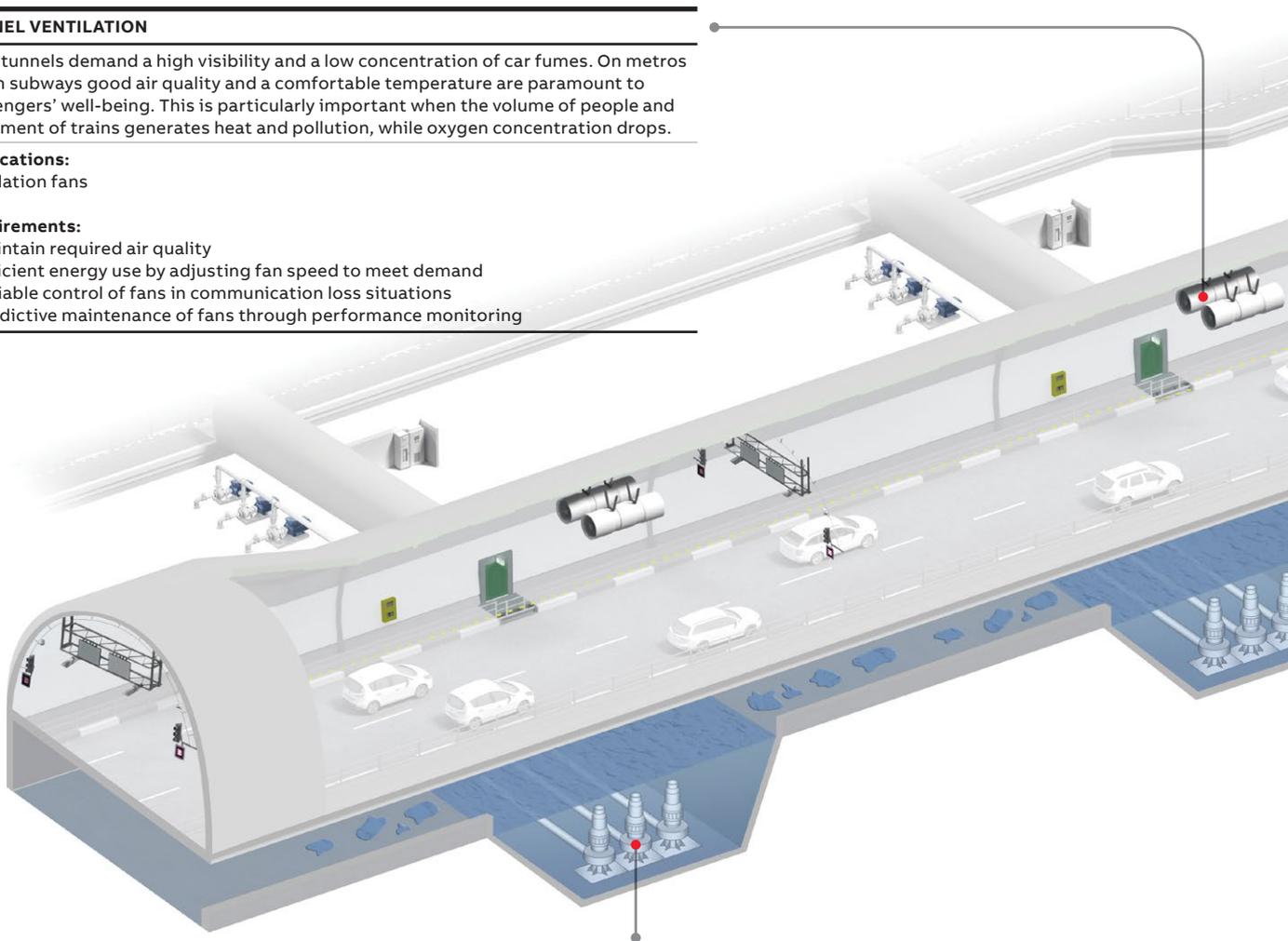
Road tunnels demand a high visibility and a low concentration of car fumes. On metros and in subways good air quality and a comfortable temperature are paramount to passengers' well-being. This is particularly important when the volume of people and movement of trains generates heat and pollution, while oxygen concentration drops.

### Applications:

Ventilation fans

### Requirements:

- Maintain required air quality
- Efficient energy use by adjusting fan speed to meet demand
- Reliable control of fans in communication loss situations
- Predictive maintenance of fans through performance monitoring



## 2 DRAINAGE

Protects tunnel users and underground control rooms/installations by removing water intrusion from infrastructures below the water table, either continuously or in emergency situations during storms.

### Applications:

Pumps

### Requirements:

- Control of tunnel's water level
- Continuous monitoring of pump availability
- Reliable control of pumps in communication loss situations
- Predictive maintenance of pumps through performance monitoring

## 5 EMERGENCY POWER SUPPLY

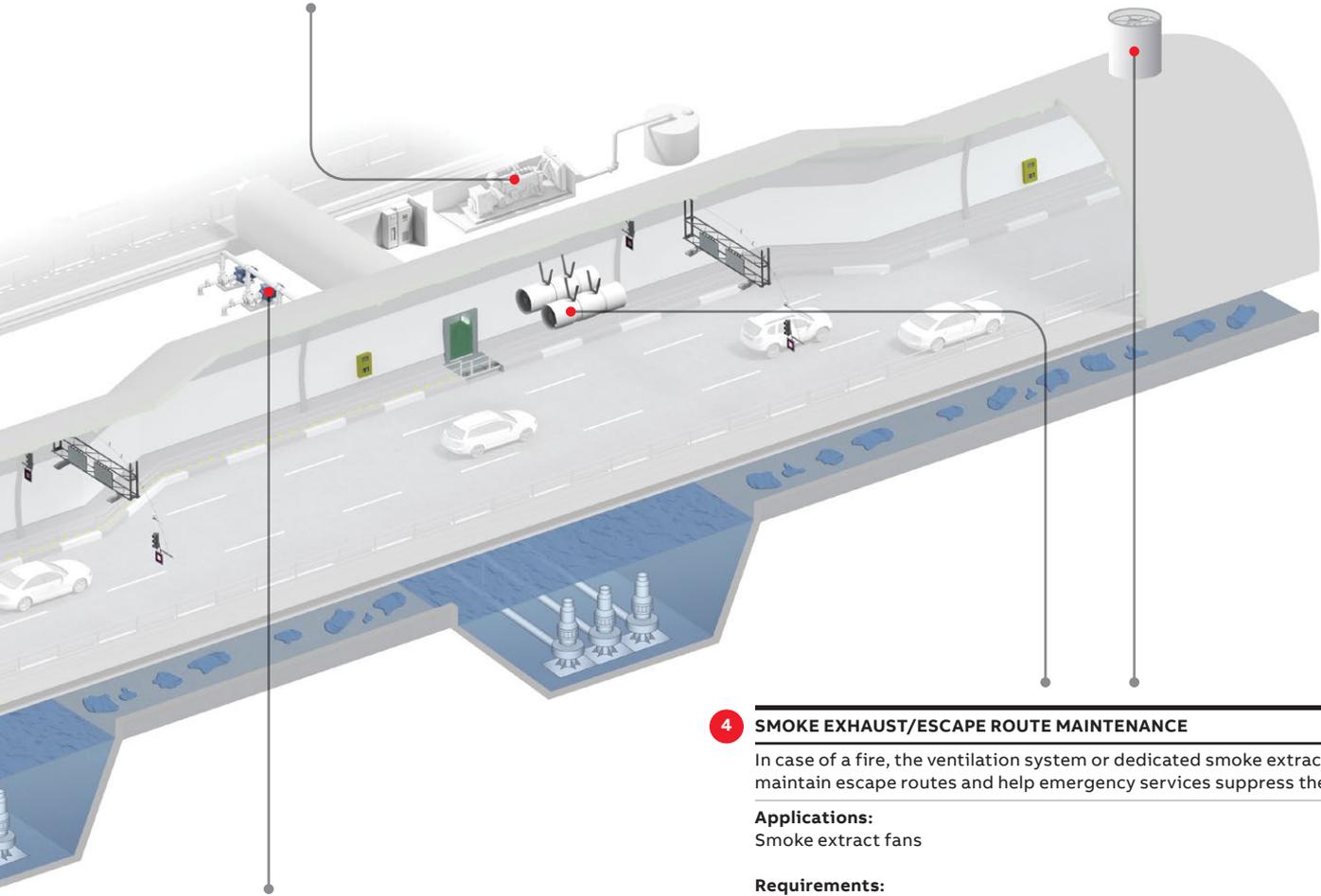
During heavy storms, the utility power is at its greatest risk of failure. Yet during this time the drainage system needs to be fully functional. The backup generator lies at the core of the entire emergency power system and operates critical loads during electric utility outages.

### Applications:

Generator

### Requirements:

- Current and voltage harmonics in the tunnel network cause excessive heating in the generator meaning losses and shorter lifetime
- Harmonics affect the generator's ability to accurately sense its terminal voltage which results in voltage instability in the system
- Loads with high harmonic content require a larger generator if no harmonic mitigation is used in the system
- If the power factor is outside the generator's specification, its performance is at risk, so generator oversizing or other compensation measures are required



## 3 FIRE SUPPRESSION

Fire pump station delivers water to a fire sprinkler system.

### Applications:

Pumps

### Requirements:

- Prompt response in case of emergency
- Continuous monitoring of pump availability
- Securing stable pressure on the sprinkler nozzles
- Easy integration into a tunnel fire suppression system

## 4 SMOKE EXHAUST/ESCAPE ROUTE MAINTENANCE

In case of a fire, the ventilation system or dedicated smoke extract fans maintain escape routes and help emergency services suppress the fire.

### Applications:

Smoke extract fans

### Requirements:

- Monitoring of the smoke extract fan availability.
- Prompt reaction to the emergency situation – immediate fan stop or start, change of rotation direction, required speed
- For fan control, ability to catch a spinning load without wasting time on stopping it first
- Reliable control in communication loss situations for VSDs and controllers
- Override mode allowing to run until destruction ignoring faults and warnings
- Compensation for voltage drops over long cables enabling fans to be run at 100 percent capacity
- Motor ability to withstand high temperatures over a specified time span

# Unlock the potential of tunnel engineering systems

Variable speed drives, PLCs, motors and generators are critical for safe operation of road and rail tunnels. Alongside process continuity and energy savings, there are many application-specific benefits from using ABB solutions on applications in tunnels.

Application	Challenge	Solution	Benefit
 <b>Metro air conditioning equipment</b>	<ul style="list-style-type: none"> <li>High energy consumption</li> </ul>	<ul style="list-style-type: none"> <li>High efficient motor-drive package with motor efficiency up to IE5</li> <li>Air handler filter monitoring via a VSD alarming when pressure drops due to clogged filter</li> </ul>	<ul style="list-style-type: none"> <li>VSDs typically save between 20 to 60 percent energy compared to damper control system</li> <li>Avoiding clogged filters which can use 15 percent more energy</li> </ul>
	<ul style="list-style-type: none"> <li>Air handler uptime</li> </ul>	<ul style="list-style-type: none"> <li>VSDs include protection e.g. overcurrent, overvoltage, motor overheating and overload</li> <li>Less mechanical and electrical stress with VSDs, opposed to direct-on-line start</li> <li>Smart sensors collect information on fan performance enabling predictive maintenance</li> </ul>	<ul style="list-style-type: none"> <li>Improved passenger comfort at stations</li> </ul>
 <b>Tunnel ventilation fans</b>	<ul style="list-style-type: none"> <li>Road tunnel air quality</li> </ul>	<ul style="list-style-type: none"> <li>Using information from COx, NOx and particle concentration sensors through PLCs or directly, VSDs control fan speed</li> </ul>	<ul style="list-style-type: none"> <li>Low concentration of car fumes and good visibility in the tunnel</li> </ul>
	<ul style="list-style-type: none"> <li>High energy consumption</li> </ul>	<ul style="list-style-type: none"> <li>VSDs adjusting fan speed in accordance with tunnel air pollution</li> <li>High efficient (up to IE5) motors</li> </ul>	<ul style="list-style-type: none"> <li>VSDs typically save between 20 to 60 percent energy compared to fans constantly running at nominal speed</li> </ul>
	<ul style="list-style-type: none"> <li>Overly complex tunnel automation system and increased error risk</li> </ul>	<ul style="list-style-type: none"> <li>VSDs offer local control and can extend external PLC control tasks</li> <li>VSDs' fieldbus capability avoids need for external gateways</li> </ul>	<ul style="list-style-type: none"> <li>Decreased infrastructure complexity and costs</li> </ul>
	<ul style="list-style-type: none"> <li>Fan control reliability</li> </ul>	<ul style="list-style-type: none"> <li>Control backup in VSDs – in case of external communication loss, VSDs can take over control</li> <li>Hot-standby PLCs with redundant CPUs and I/O communication run in parallel with the main ones and always ready to take over</li> </ul>	<ul style="list-style-type: none"> <li>Fan continues to run regardless the issues in control systems</li> </ul>
	<ul style="list-style-type: none"> <li>Voltage drop over long motor cables decreasing the fan nominal power and available airflow</li> </ul>	<ul style="list-style-type: none"> <li>ULH drives with active front end (AFE) boost output voltage guaranteeing full fan motor voltage even when the supply voltage is below nominal</li> </ul>	<ul style="list-style-type: none"> <li>Avoid oversized cables needed to reduce voltage drop over the length to acceptable levels</li> </ul>
	<ul style="list-style-type: none"> <li>Brown outs in remote locations</li> </ul>	<ul style="list-style-type: none"> <li>ULH drives with AFE compensate supply voltage fluctuations, ensuring smooth operation</li> </ul>	<ul style="list-style-type: none"> <li>Reduced need for emergency power supply and improved resilience of operation</li> </ul>
	<ul style="list-style-type: none"> <li>Harmonics causing transformer overheating and subsequent power outage</li> </ul>	<ul style="list-style-type: none"> <li>ULH drives with AFE reduce harmonics content in the network to an absolute minimum</li> </ul>	<ul style="list-style-type: none"> <li>Network stability and elimination of large active filters for harmonics mitigation</li> <li>No oversized cables, transformers, generators to avoid harmonics related issues</li> <li>Compliance with stringent harmonics standards</li> </ul>
	<ul style="list-style-type: none"> <li>Fire emergency handling</li> </ul>	<ul style="list-style-type: none"> <li>VSDs' fireman's override allows regular ventilation fans to be part of a fire suppression system by converting them into smoke exhaust or pressurization units for escape routes maintenance</li> </ul>	<ul style="list-style-type: none"> <li>Safe evacuation for people</li> <li>Access to the fire location for emergency services</li> <li>No undesired tripping of drives in extreme conditions</li> <li>Flexibility in selecting evacuation / fire suppression strategy</li> </ul>
	<ul style="list-style-type: none"> <li>Escape route management in case of emergency</li> </ul>	<ul style="list-style-type: none"> <li>VSDs' override mode implemented such that required pressure/ fan speed is maintained to prevent smoke entering evacuation spaces</li> </ul>	<ul style="list-style-type: none"> <li>Eliminating door blockage / smoke propagation due to too high / low pressure</li> <li>Flexibility in selecting evacuation strategy in ever-changing tunnel environment</li> </ul>
	<ul style="list-style-type: none"> <li>Fast braking in case of emergency</li> </ul>	<ul style="list-style-type: none"> <li>Drives offer flux braking, braking choppers and regenerative braking techniques</li> </ul>	<ul style="list-style-type: none"> <li>Choose the most cost-efficient and technically feasible solution</li> <li>Regenerative braking eliminates brake resistors increasing installation size and complexity</li> </ul>



01

Application	Challenge	Solution	Benefit
 <b>Smoke exhaust fans</b>	<ul style="list-style-type: none"> <li>Smoke exhaust fans availability</li> <li>High temperatures</li> </ul>	<ul style="list-style-type: none"> <li>VSDs and softstarters allow fans to start without power system overload</li> <li>VSD-based phase loss check</li> <li>VSDs are tested for operating 1 h at 70 °C</li> <li>Smoke extract motors are certified for operating at 200 °C for 120 min, 300 °C for 60 min, 400 °C for 120 min, 250 °C for 120 min</li> </ul>	<ul style="list-style-type: none"> <li>Smoke extract process continuity</li> <li>Tunnel users' safety</li> <li>Smoke extract process continuity even at high temperatures</li> </ul>
 <b>Drainage pump stations</b>	<ul style="list-style-type: none"> <li>Tunnel flooding</li> <li>Pump uptime</li> <li>Pressure shocks</li> <li>Pipe leakage or pipe blockage</li> </ul>	<ul style="list-style-type: none"> <li>VSDs and softstarters are ready to start the pumps once the water level exceeds safe limits</li> <li>VSDs supervisory functions indicate upcoming mechanical failures like bearing wear or events like stalled impeller</li> <li>Smart sensors measure pump motor health parameters like vibration and temperature</li> <li>VSDs or softstarters feature soft pump start and stop which helps avoid pressure shocks</li> <li>VSDs indicate if the pressure in a pipe increases to a maximum / drops to a minimum and sends an alarm</li> </ul>	<ul style="list-style-type: none"> <li>Control of the water level for tunnel safety</li> <li>Water disposing process continuity</li> <li>Tunnel users' safety</li> <li>Pump and piping system increased lifetime and decreased operating costs</li> <li>Motor, pump or piping system will not get damaged when the pipe is blocked</li> <li>Flood monitoring helps avoid infrastructure damage due to a leakage</li> </ul>
 <b>Fire pump stations</b>	<ul style="list-style-type: none"> <li>Fire suppression</li> <li>Fire pump station availability</li> </ul>	<ul style="list-style-type: none"> <li>VSDs and softstarters help a fire pump station become part of a tunnel fire suppression system acting as a whole</li> <li>VSD-based phase loss check</li> <li>VSDs and softstarters allow pumps to start without power system overload</li> <li>High availability PLCs with redundant CPUs and I/Os reduce the risk of control system failure</li> </ul>	<ul style="list-style-type: none"> <li>Keeping the people safe and the asset damage to a minimum</li> <li>Successful fire extinguishing</li> </ul>

02



01 Fire pump station is a vital part of a tunnel fire suppression system.

02 Ventilation in subway tunnels happens thanks to trains moving the air, but temperature at the stations and passages rises significantly if no air conditioning is involved.

# Features and functions benefiting tunnel ventilation and drainage systems

ABB offers an extensive range of devices from softstarters and VSDs to motors and generators. Choosing the right products and features is essential for ensuring a safe and energy-conscious tunnel environment.



## Variable speed drives

### Regenerative capability

- Eliminates the need for braking resistors – energy is fed back into the network. Everything needed for regenerative braking is included in the drive.

### Brake choppers

- Provide fast ramp down, together with brake resistors, by converting power to heat

### Flux braking

- Eliminates the need for external braking resistors in low-inertia systems

### Low harmonics

- Built-in active front end and integrated line filter eliminate harmonic disturbances in the network

### [Learn more](#)

### Voltage boost

- Full load operation of fans and pumps during voltage sags or voltage drop across long cables

### Flying start

- Reduces wear and saves time by starting a motor while the load is still spinning

### System efficiency

- VSDs increase system's efficiency by adjusting motor speed to the present need
- Advanced feature, Energy Optimizer, improves energy use by reducing motor magnetic losses
- Active front end eliminates harmonics-related losses

### Built-in PID control

- Extends external PLC control tasks to reduce automation system complexity and costs

### Fireman's override mode

- Makes the VSD part of a tunnel fire suppression system, protecting people and infrastructure
- Disables warnings and faults, allowing the drive to run in adverse conditions as long as possible

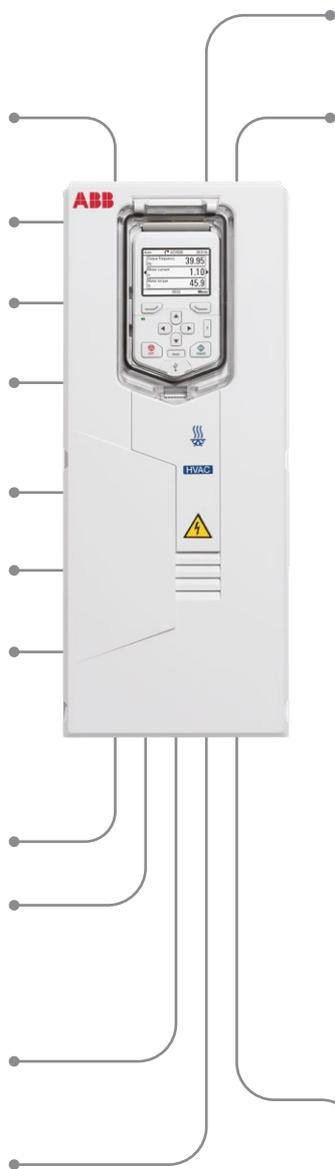
### [Learn more](#)

### Built-in redundancy

- External communication loss is handled seamlessly by a VSD taking control until the external communication is recovered

### Long motor cable support

- Reliable application control even at large motor cable lengths common for tunnels



### Harsh environment use

- VSDs are tested for operating 1 h at 70 °C
- IP55 units withstand humidity and dust
- All VSDs have coated circuit boards

### Embedded communication

- Control, monitoring and diagnostics for applications through embedded Modbus RTU, BACnet MS/TP and other optional protocols

### [Learn more](#)



## Softstarters



### Soft start and stop

- Minimized mechanical and electrical stresses at starts and stops

### Built-in bypass

- Reduced system size and complexity
- Reduced heat generation from internal losses by activating bypass at full speed

### Harsh environment use

- Process continuity in dusty or wet environments with IP66 keypad and coated electronics

### Embedded communication

- Control, monitoring and diagnostics for applications through embedded Modbus RTU and other optional protocols

### Emergency mode

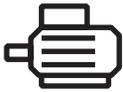
- Protection features are tuned off to supply power to the motor in adverse conditions

### Standstill brake

- Prevents fans from free-wheeling and always starts from stand still position

### [Learn more](#)





## Motors

### High reliability

- Protection against external conditions with IP55 as standard
- Wide range of surface treatment and corrosion protection solutions available
- Protection against bearing currents with an extended portfolio of solutions including insulated bearings and shaft grounding
- Bearings locked at D-end to avoid axial play

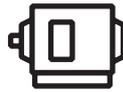
### Efficiency

- Up to IE5 efficiency to reduce energy consumption and improve total cost of ownership

### Easy installation

- Oversized terminal box as standard to ease installation
- Flexible cabling solutions
- Various mounting arrangements including direct drive, belt or transmission
- Horizontal and vertical mounting

[Learn more](#)



## Generators

### High reliability

- Meet demands for low voltage ride-through events, vibration, mechanical and electrical stresses, fast response times and frequent starts
- Improve the quality of an electricity supply reducing harmonic content

### Efficiency

- Reduced fuel consumption for a longer operation in emergency situations

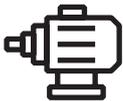
### Compactness

- The best kWh production at given size and weight

### Wide offering

- Available over a large range of operating parameters and enclosures, complying with all internationally accepted standards

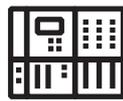
[Learn more](#)



## Smoke extraction motors

- Operate reliably even at high temperatures of a fire zone
- Comply with smoke and heat control systems standard EN 12101-3, classes F200-120, F300-60, F400-120, T250-120
- Maximum performance in both normal and emergency conditions
- Designed for direct-on-line and VSD operation, both in normal and emergency situations

[Learn more](#)



## PLCs

### High availability

- Hot-standby PLC concept with redundant CPUs and I/Os prevent downtime and reduce the risk of total system failure, thus enhancing system availability

### Modularity

- Hot swap terminals allow no-load swapping of faulty I/O modules during operation
- The I/Os can be installed decentrally with a communication interface module or be connected directly to the PLC CPU
- Support of different fieldbuses makes it possible to use I/O modules with PLCs from different manufacturers

### Safety

- Integrated safety PLC (SIL3, PL e)
- Flexible and safe communication using PROFINET/PROFIsafe
- Separate safety CPU with safety functions which remain active even if non-safety control is inactive

[Learn more](#)



## ABB Ability™ Smart Sensors for motors and pumps

### Minimized unplanned downtime

- Upcoming failures can be detected well before equipment fails

### Reduced maintenance costs

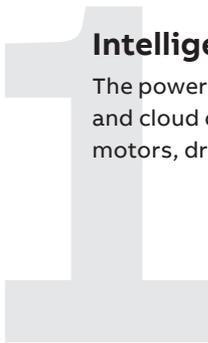
- Eliminate the need for manual motors and pumps check-ups
- By changing from scheduled to condition-based maintenance, service costs can be reduced

[Learn more](#)



# From the facility to the cloud and beyond

ABB Ability™ Condition Monitoring for powertrains optimizes the performance and efficiency of electric motor-driven rotating equipment. It enables better decision making by providing real-time access to data on all parameters for drives, motors and general machinery.



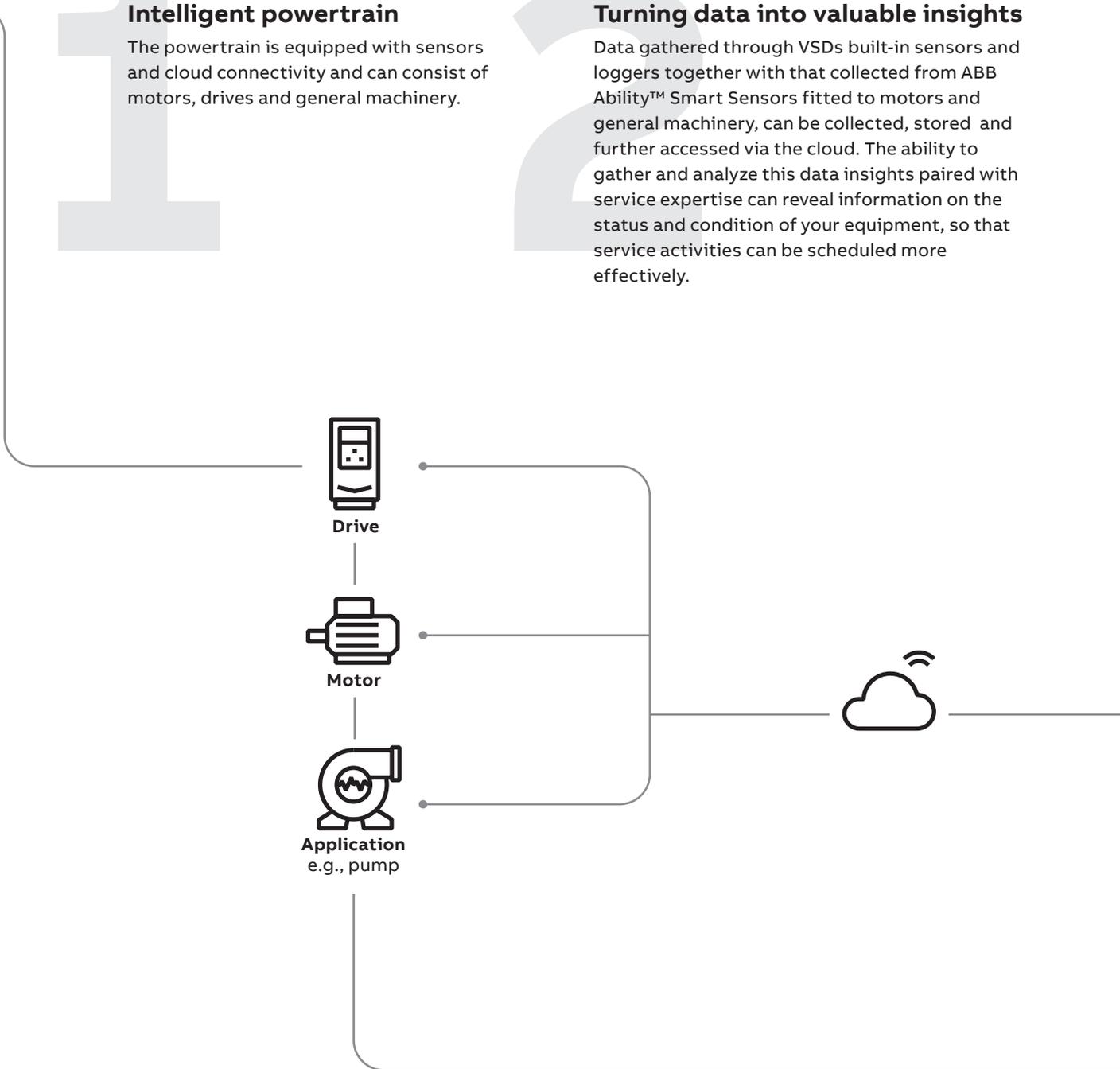
## Intelligent powertrain

The powertrain is equipped with sensors and cloud connectivity and can consist of motors, drives and general machinery.



## Turning data into valuable insights

Data gathered through VSDs built-in sensors and loggers together with that collected from ABB Ability™ Smart Sensors fitted to motors and general machinery, can be collected, stored and further accessed via the cloud. The ability to gather and analyze this data insights paired with service expertise can reveal information on the status and condition of your equipment, so that service activities can be scheduled more effectively.



### 3 Accessing data for analytics

You have access to a monitoring portal to view key operational parameters of individual assets as one unified system. Detailed dashboards give full transparency so that you can take actions that lead to less downtime, extended equipment lifetime, lower costs, safer operations and increased profitability.

### 4 Gain a digital advantage

Ensuring that the right person is exposed to the right information at the right time brings:

- Appropriate response to process challenges, minimizing operating costs
- Greater insight into various aspects of the process, thereby improving system performance
- Lower risk of process failure, while changing your maintenance from reactive to predictive



**Consultant**



**System integrator**



**Tunnel safety inspector**



**Operating company**



# Our service expertise, your advantage

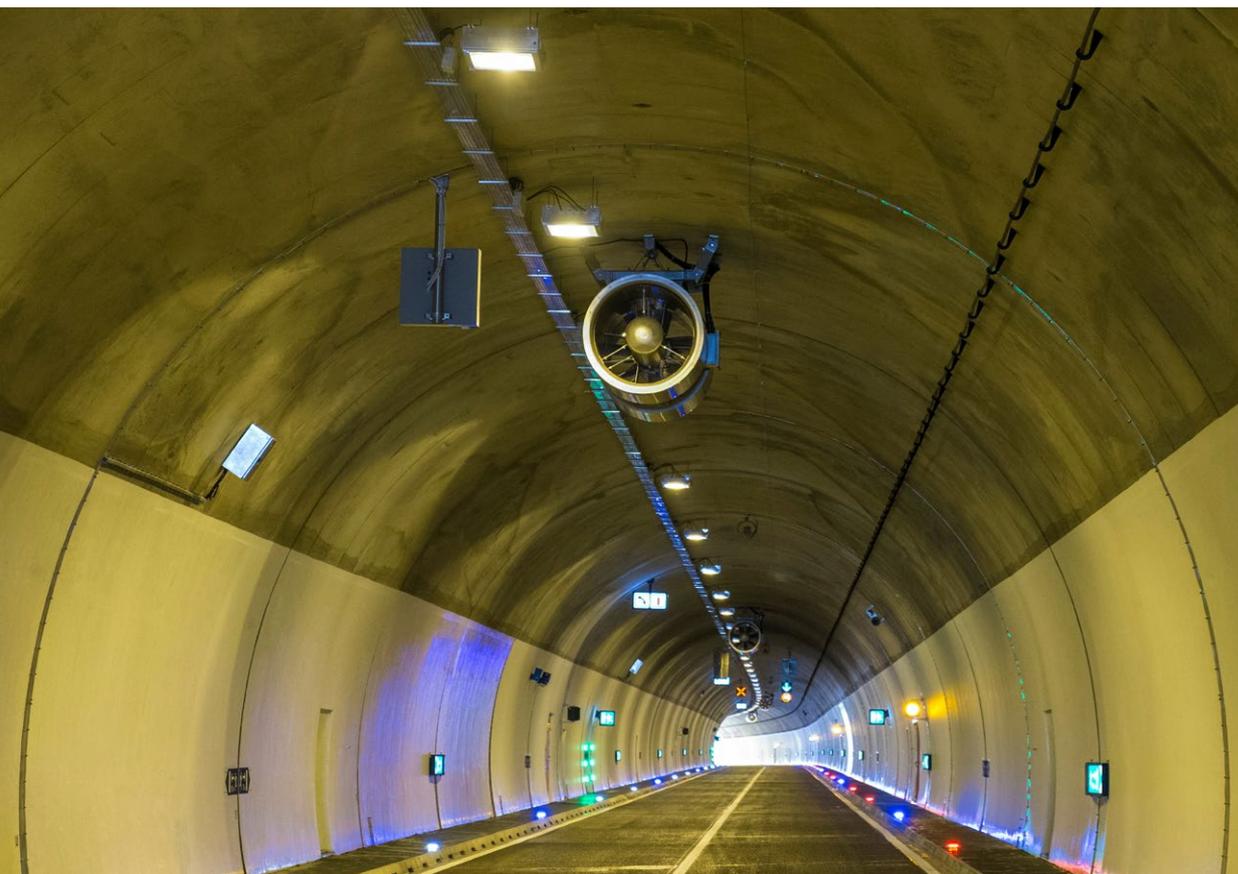
ABB Motion Services helps customers around the globe by maximizing uptime, extending product life cycle, and enhancing the performance and energy efficiency of electrical motion solutions. We enable innovation and success through digitalization by securely connecting and monitoring our customers' motors and drives, increasing operational uptime, and improving efficiency. We make the difference for our customers and partners every day by keeping their operations running profitably, safely and reliably.

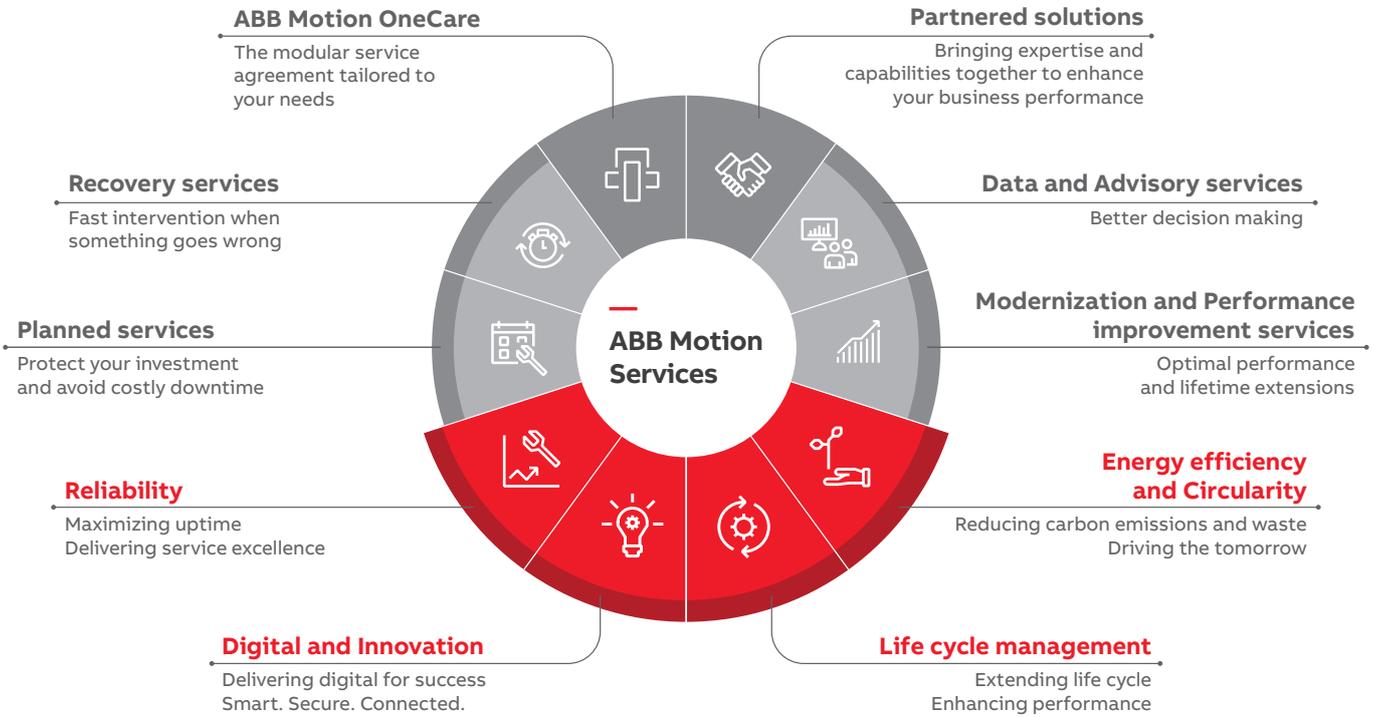
With a service offering tailored to your needs, ABB Motion Services maximizes the uptime and extends the life cycle of your electrical motion solutions, while optimizing their performance and maximizing your energy efficiency gains throughout the entire lifetime of your applications. We help to keep your applications turning profitably, safely, and reliably.

Digitalization enables new smart and secured ways to prevent unexpected downtime while optimizing the operation and maintenance of your assets. We securely connect and monitor your motors, drives or your entire powertrain to our easy-to-use cloud service solutions. Connecting your applications also gives you access to our in-depth service domain expertise.

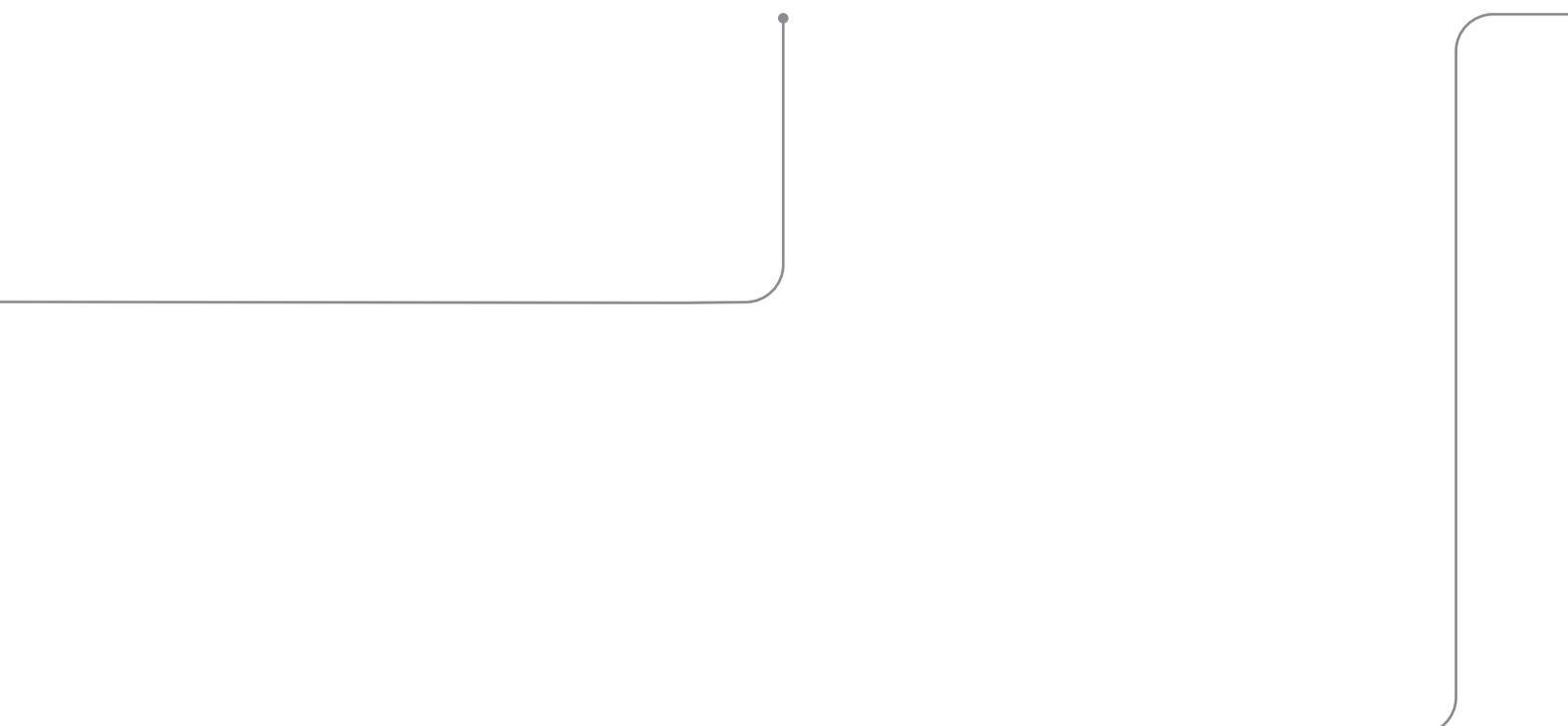
We quickly respond to your service needs. Together with our partners, local field service experts, and service workshop networks, we provide and install original spare parts to help resolve any issues and minimize the impact of unexpected disruptions.

Our tailored to your needs service offerings and digital solutions will enable you to unlock new possibilities. Not only are we your premier supplier of motion equipment, we are your trusted partner and advisor offering support throughout the entire life cycle of your assets. We ensure your operations run profitably, safely, and reliably and continue to drive real world results, now and in the future. Our service teams work with you, delivering the expertise needed to keep your world turning while saving energy every day.





**OUR EXPERTISE**  
**YOUR ADVANTAGE**



# With you, wherever you are in the world

Partnering with ABB gives you access to some of the world's most innovative technology and thinking.

## Global reach

ABB operates in over 100 countries with its own manufacturing, logistics and sales operations together with a wide network of local channel partners that can quickly respond to your needs. Stock availability is good, with short delivery times for many products backed by 24-hour spare parts delivery.

In addition, ABB interacts closely with rail and road tunnel industry players including consultants, system integrators, safety inspectors and operating companies to help increase tunnel safety and its engineering

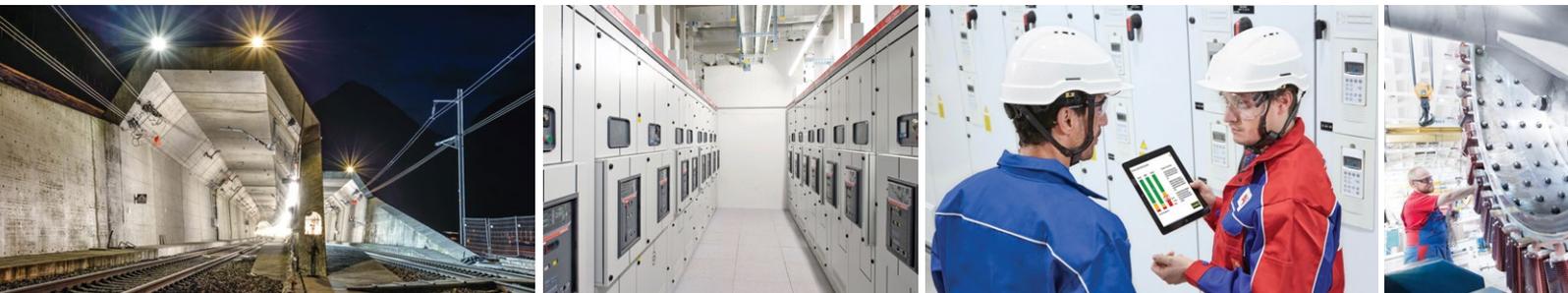
systems reliability and efficiency to an absolute maximum.

ABB has seven global R&D centers with more than 8,000 technologists and invests \$1.5 billion annually on innovation.

## End-to-end product portfolio

Alongside its diverse portfolio of VSDs, PLCs, HMIs, softstarters, motors and generators, ABB offers tunnels:

- Medium voltage components and systems such as air- and gas-insulated switchgears, uninterruptible power supply units, relays,



ultra-fast earthing switches, Is-limiters to reduce high short-circuit currents and more.

- Low voltage components and systems such as switchgears, uninterruptible power supply units, breakers, industrial plugs and sockets, RCD blocks, power distribution units, remote power panels, and more.
- Digital solutions including ABB Ability™ cross-product and system offering providing intelligence all the way to the component level, improving overall visibility and making the system safe, reliable and efficient.

### **Streamline sourcing**

ABB's end-to-end product and services portfolio streamlines your sourcing and purchasing activities and standardizes processes across multiple sites, saving you money on spare part inventories while reducing maintenance costs.





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For more information, please contact your local ABB representative or visit

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