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### Translations of ABB Review

Due to the low distribution numbers in the Spanish and French translations of ABB Review, the company has decided that as from issue 1/2023, ABB Review will be offered only in its English, German and Chinese versions.

The editors would like to thank readers in the discontinued languages for their loyalty and trust that many will be able to continue to read and support ABB Review in a different language.

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## Connections

**Integrated systems in an inter-dependent world would not be possible without connectivity. This issue of ABB Review looks at ways that some of those connections come to be, and how they are getting smarter and delivering better results.**

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EDITORIAL

# Connections



Dear Reader,

Industrial processes rely on many different types of connectivity. They need energy to power them, data to steer them and human beings to maintain, control and operate them. If any one of these connections is disrupted or fails, the consequences can be costly and damaging, and in the worst-case scenario, catastrophic.

In power delivery, protection algorithms are becoming ever-more sophisticated. As well as ensuring continuity of supply, they safeguard people and equipment and optimize energy efficiency. Increasingly, they are being applied across the value chain from manufacturing and operations to recycling.

In this issue of ABB Review, we look at connections in typical industrial contexts as well as more unusual settings, such as maritime transport and the production and delivery of hydrogen.

Enjoy your reading,

A handwritten signature in black ink, consisting of stylized initials 'BR' followed by a horizontal line.

Björn Rosengren  
Chief Executive Officer, ABB Group

# Supply & protection







Energy distribution and use relies on connections that bring together the individual parts to function as a whole. Such connections can range from power delivery to data links and even monitoring and analysis. ABB combines the latest hardware and digital technologies to give users the ability to make their systems safer as well as more sustainable.

- 08      **Powering sustainability**  
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Investigating the Azipod® propulsion  
sealing system
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Smart temperature monitoring relay



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ABB PRODUCTS ACCREDITED WITH PEP ECOPASSPORT®

# Powering sustainability

ABB's power products are now accredited with the PEP Ecopassport®, a recognition of sterling environmental performance throughout their life cycle; this enables customers to make decisions about the sustainability of their product choices.





—  
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Achieving carbon neutrality is not simply a vision at ABB, it is a commitment [1]. With global technology sectors accounting for three quarters of global energy consumption, carbon reduction is an issue that ABB can do something about. Not only is ABB reducing its own operational carbon footprint by continuing to transition to renewable energy and vastly improving energy efficiency inhouse, it is also undertaking everything it can to help customers reduce theirs, without diminishing productivity.

How does ABB actually help customers achieve sustainability targets? By partnering with customers, suppliers and other leading organizations to reduce emissions, ABB actively works to implement sustainable practices across the

## ABB implements sustainable practices across the entire value chain and the lifecycle of their products.

entire value chain and the lifecycle of ABB's products and solutions. Such practices are especially important for industries such as global shipping and mission critical facilities eg, data centers,

that require vast supplies of clean and reliable power; by reducing their carbon footprint these industries can reduce their environmental impact while lowering energy costs.

In 2021, two of ABB's products: SureWave, a static frequency converter (SFC), designed specifically for the shipping industry, and HiPerGuard Medium Voltage (MV) Uninterrupted Power Supply (UPS), designed for data center use, secured the Product Environmental Profile (PEP) Ecopassport® accreditation; this assessment verifies the environmental performance of products throughout their life cycle, within an international reference framework [2]. With such accreditation, ABB enables their customers to make better decisions about the sustainability of power conditioning products based on established and verified criteria.

### Partnerships for sustainability

Together with PEP, an association of manufacturers, users, institutions and professional organizations, ABB demonstrates its commitment to sustainability and the ability to anticipate essential legislation [2].

Recently recognized as a permanent member of the Environmental Footprint (EF) sub-group of the European Union, PEP implements the Ecopassport® program; this initiative verifies stringent performance criteria throughout the

—  
 01 Growth in data centers is resulting in increases in power needs and with this comes sustainability challenges.

—  
 02 HiPerGuard MV UPS was designed to meet the requirements of a large data center: availability, performance, efficiency, cost effectiveness, flexibility and scalability while offering grid support functions; all with maximum sustainability throughout its entire life cycle.





03

electric and electronic components of a heating, ventilation, air conditioning (HVAC) product's life cycle: manufacturing, distribution, installation, use, and end-of-life [2]. By meeting reliability, transparency, comparability and verification

---

**In 2021, SureWave SFC and HiPerGuard MV UPS secured the PEP Ecopassport® accreditation.**

of environmental performance indicators, accredited products are fully aligned with the UN sustainability program and various international standards such as ISO 14025 and ISO 14040. The Ecopassport® is thus, an important tool to help customers choose appropriate suppliers based on sustainability.

#### **Winning power condition products**

In addition to participating in PEP, ABB has secured Ecopassport® accreditation for two power conditioning products: SureWave SFC and HiPerGuard MV UPS that achieve superior results in their specific target industries. Each of these products provides the end-customer

with the means to use cleaner power, reduce CO<sub>2</sub> emissions and lower their energy costs throughout the products' entire life cycle – all without having to sacrifice reliability, productivity, and overall cost-effectiveness.

#### **HiPerGuard MV UPS**

Data centers and other mission critical facilities are now, more than ever, in need of clean, continuous, energy-efficient, and reliable power – minimizing major losses both in terms of performance and finance [3]. Switching from a low voltage (LV) to a medium voltage (MV) design approach can help to attain these goals. More reliability results from the MV design of larger protected load blocks, lower switchgear count and the general operation of MV voltage systems. Moreover, installing power protection at the MV level, results in the most energy efficient configuration: Lower currents mean smaller cables and lower losses [4].

ABB's HiPerGuard MV UPS, which secured the Ecopassport® label in 2021, is the first industry MV UPS to provide continuous and reliable power supply of up to 24 kV, per block, for mission critical facilities, such as data centers, to protect servers and mechanical loads [3].



This MV UPS solution, launched in 2021, achieves the highest energy efficiency on the market today, thereby supporting customers in their quest for sustainability. HiPerGuard can reach 98 percent energy efficiency (for the load spectrum from 50 percent up to full rated load; and above 96 percent for a 25 to 50 percent load<sup>1</sup>) at a voltage up to 24 kV while eliminating power outages and reducing carbon emissions. Such energy efficiency could translate to a potential carbon emission reduction of 1,245 tons over a typical 15-year product lifespan<sup>2</sup>[3].

Thanks to its high-performance converters – designed using ABB proprietary power electronics technology, combined with the impedance (Z) isolated static converter (ZISC) architecture – HiPerGuard MV UPS ensures the regulation of output voltage even during input supply disturbances [5] thus, providing continuously regulated, filtered power.

PowerExchanger is a feature of HiPerGuard; this allows the UPS to interact with the grid to support the energy transition toward renewables. ABB's HiPerGuard has advanced integration capabilities with a wide range of backup power systems including generators, slow-paced gas generators and turbines [3].

—  
03 SureWave SFC technology can be applied to the marine and industrial sectors, eg, container cargo ships, anywhere conversion is appropriate.

—  
04 SureWave SFC unit.



### Combining the best of both worlds

HiPerGuard delivers all the well-known benefits of a classic dynamic rotary UPS, including protection against major grid events, yet has all the flexibility and capabilities associated with modern static converter systems. HiPerGuard is a high-performance medium voltage UPS that addresses power quality

—  
**HiPerGuard addresses power quality issues: protection is offered against voltage sags, swells, spikes and power interruptions.**

issues: Protection is offered against voltage sags, swells, spikes, and power interruptions. Overall, downtime and power outages are reduced [5].

Beyond massive energy efficiency, protection benefits, and integration capability, HiPerGuard is scalable (up to ten UPS units can be connected in parallel); this increases the overall system capacity without adding complexity [4]. Further, HiPerGuard has been designed for long term system availability, only requiring intrusive maintenance every seven years.

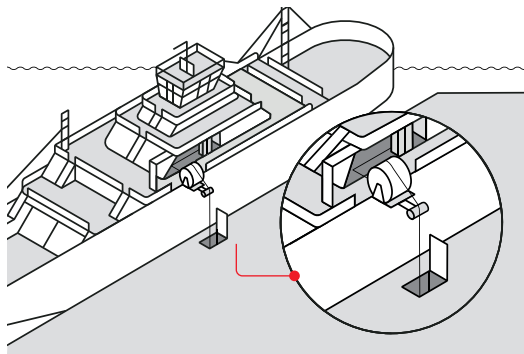
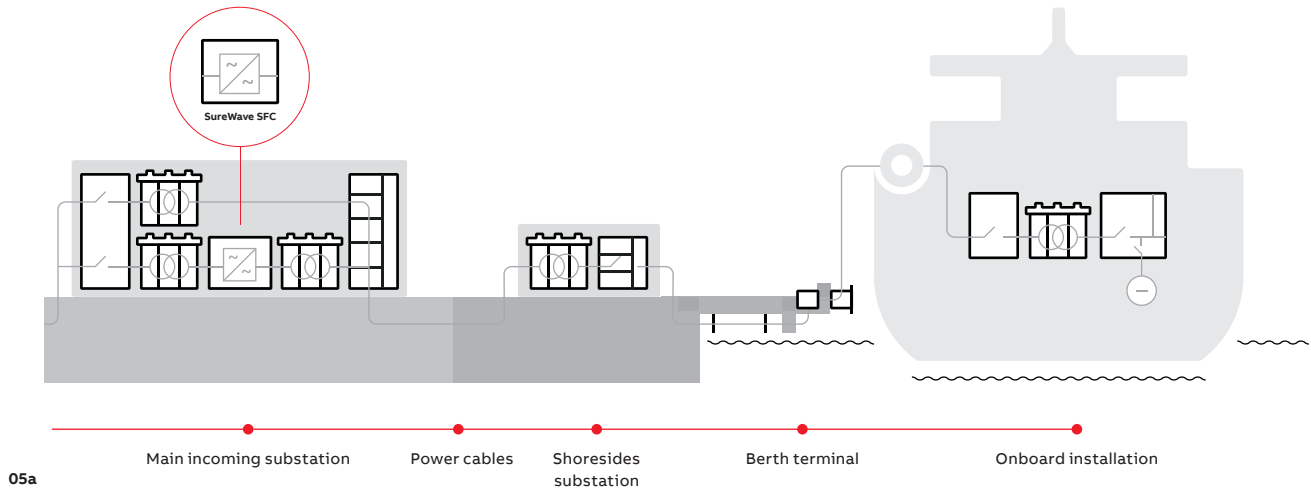
### All about trust

With the Ecopassport® label, customers can also be assured that when they choose HiPerGuard they are choosing a power protection product that fulfills international standards of sustainability (eg, ISO 14025 and ISO 14040) in addition to meeting the same high specifications associated with all of ABB's power electronic technologies: high efficiency and availability; minimal maintenance and cost-effectiveness.

### SureWave SFC

Despite being a cost-effective way of shifting goods over vast distances, shipping is a source of greenhouse gases and pollutants, accounting for approximately 30 percent of total global NO<sub>x</sub> emissions and approximately 2.6 percent of total global greenhouse gas emissions [6]. The maritime industry is clearly under consistent pressure to reduce their environmental impact: cleaner





and more efficient power conversion solutions can contribute significantly to reduce emissions, especially while ships are berthed →03.

Looking at ships that rely on diesel generators while docked to run cooling, heating, ventilation, etc, without the ability to switch to dockside power supplies in port, these vessels will emit high levels of CO<sub>2</sub>, generate noise and damaging vibrations meaning ship owners will possibly incur penalties.

SureWave SFC ensures the static, seamless, transfer of power from a ship's onboard generator to an onshore power source, eliminating the need to use diesel-burning generators in port. Such a seemingly simple task is in actual fact rather daunting because there are two different supply frequencies across the world, varying according to country. For example: power grids in Asia and Europe typically operate at 50 Hz, whereas power grids in North America operate at 60 Hz. Ships therefore require the means to

convert frequency in order to use portside electricity while berthed →05.

#### Sustainability verified

Like HiPerGuard, ABB's SureWave is accredited with the PEP Ecopassport®, having scored leading results for the frequency converter. This assessment measures SureWave's sterling environmental sustainability across its entire lifecycle – from its manufacture and distribution to its installation and use, all the way to its end-of-life, thanks to ABB. By choosing ABB's static conversion technology, ship operators can easily lower CO<sub>2</sub> emissions, ship vibrations and noise pollution while in port; and eliminate any penalties associated with using diesel burning genera-

During SureWave's lifetime it could potentially reduce operators' CO<sub>2</sub> emissions by approximately 350 tons.

tors while berthed. During SureWave's estimated 15-year lifetime, ship owners' and operators could potentially reduce their CO<sub>2</sub> emissions by approximately 350 tons and deliver operational cost savings of approximately 1.4M USD<sup>1</sup> (compared to traditional rotary systems over the same interval) [6-7].

#### More flexible, stable and greener

The ability to stabilize both frequency and voltage allows the proper operation of sensitive

—  
05 A variety of possible applications include shore to ship power, onboard frequency conversion, different frequency grid connections, electrification of shipyards and drydocks etc.

5a An illustration of a shore-to-ship power connection.

5b An illustration of an onshore power connection.

equipment even when the supply is not adequately regulated; this is an advantage over conventional rotary frequency converter systems [7]. Further, SureWave SFC has, like HiPerGuard, added flexibility compared to rotary counterparts. The modular design of SureWave allows higher power to be reached with a capacity rating from 250 kVA up to 2.25 MVA.

Thanks to the smart controller, SureWave SFC can be connected in parallel with other voltage sources, either generators or multi-SFC units. If required, SureWave SFC can also support higher

Added flexibility is assured as SureWave can be installed on the vessel or portside. It is the ultimate static frequency converter for small to medium port- and shipyard installations, and marine vessels ranging from super yachts to super tankers.

### Better decisions

With the Ecopassport® label, customers can not only be confident that HiPerGuard and SureWave meet established sustainability criteria, they can also make better decisions about their choice of products to ensure a more sustainable future, even as ABB moves further along its path toward carbon neutrality. •

—  
These products provide the end-customer with the means to use cleaner power, reduce CO<sub>2</sub> emissions and lower their energy costs.

loads up to 10 MVA with multiple system parallel connections. Parallel load sharing is attained by using frequency and voltage droop profiles programmed into the converters [7] → 05.

### Footnotes

<sup>1</sup> Assuming 25 percent of the time at 2 percent load, 50 percent of the time at 50 percent load and 25 percent of the time at 75 percent load, with no time spent at 100 percent, the average efficiency is 97.5 percent, rounded up to 98 percent.

<sup>2</sup> Using the reference value of 295.8 g CO<sub>2</sub> per kWh.

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01

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SACE INFINITUS FOR THE FUTURE OF ELECTRICAL DISTRIBUTION

# One of a kind

SACE Infitus, the premier all-in-one certified solution, gives new protection perspectives for DC grids today and in the future. With power electronic, mechanics, cooling, control, sensing and communication included, low voltage fault protection and isolation issues reach a new level.

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With the electrical transformation in full swing and expected to expand, efforts to reach carbon neutrality are intensifying. DC power solutions are expected to play an increasingly important

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DC solutions are enabling the electrification of a variety of loads, thereby fostering the integration of renewables.

role in electrical distribution systems – especially for low voltage (LV) systems. Characterized by high efficiency, compared to AC solutions,

DC solutions are enabling the electrification of a variety of loads, transportation, industry automation, heating, etc. This will foster the integration of renewables and the deployment of energy storage in the grid [1].

With economic benefits possible in various applications, DC technology has high growth potential; especially due to higher efficiency and reduced energy costs, which are improved by DC-coupled energy storage. Because of this efficiency edge, DC application solutions are increasingly applied to the marine transport sector →01. And yet, important hurdles remain: adequate fault protection and isolation.

The major challenge stems from the low-inductive nature of high-power DC applications



01 DC distribution is gaining in popularity within the marine transport sector ranging from cruise ships (shown here) to cargo ships.

02 From traditional IGCT bi-directional arrangement to the novel RB-IGCT of SACE Infnitus.

03 Comparison of loss of RB-IGCT against other semiconductors [7].

combined with additional high-power, directly-coupled, energy storage. In case of a short circuit, due to low inductivity (and low resistivity), the rise-time of the fault current is dramatically shorter than in AC applications: several microseconds or less – a significant challenge for a typical circuit breaker. To limit and extinguish the fault current, the device must quickly build up a counter voltage that matches, at least, the nominal operation voltage of the system. Existing DC and AC systems with electromechanical circuit breakers use arc quenching mechanisms to split, cool and dissipate the arc energy generated, via an arc chute. Despite this being an appropriate current interruption for most applications, this process requires tens of milliseconds to clear a fault – too slow for these emerging DC applications.

Instead, solid-state circuit breakers (SSCB) rely on microsecond-fast power semiconductor devices to achieve the required open-circuit disconnection and enable ultrafast and safe current interruption suitable for the aforementioned fast-rising current in DC [2-3].

Intended to enable the DC electrical systems of the future, thereby paving the way for the sustainable energy transition, ABB developed SACE Infnitus, a unique solid-state circuit breaker –

the premiere, all-in-one-device that solves these fault protection and isolation issues [1].

### RB-IGCT – a winning solution

Compared to conventional circuit breakers, one historical hurdle to the adoption of SSCBs has been the higher on-state losses resulting from the higher voltage drop across the power semiconductor, compared to the typically small resistance of the contacts inside an electromechanical breaker. Apart from the impact on efficiency,

Adequate fault protection and isolation is an important hurdle to applying DC application solutions to the marine sector.

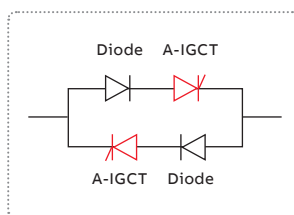
another drawback of increasing losses is the need to remove the dissipated heat; even an effective cooling system will result in an undesired increase of size, complexity and costs [3].

The insulated gate bipolar transistor (IGBT) technology can turn on and off rapidly, making it extremely effective at switching, as well as easy to control; IGBTs are state-of-the-art in converter technology. Nevertheless, they exhibit high on-state losses in circuit breaker applications – a serious challenge at high nominal currents.

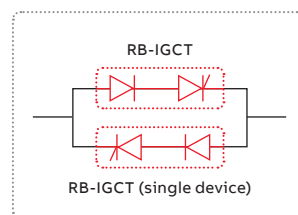
ABB introduced the integrated gate-commutated thyristor (IGCT) in 1996 in the context of MV power converters [4]. The IGCT integrates a low-inductance gate driver with a fully controllable gate. This enables the semiconductor to conduct current with very low losses, similar to a thyristor, while being able to turn on and off like an IGBT or a transistor [3-6]. This is a good foundation for a solid-state circuit breaker.

SACE Infnitus goes even further; it employs a special reverse-blocking IGCT (RB-IGCT) that integrates a thyristor and a diode in series for protection against reverse voltage all within the same silicon wafer. This wafer-level integration results in a best-in-class low on-state voltage drop. A second anti-parallel RB-IGCT is used to enable conduction and turn off of bi-directional currents →02 [6]. The result is 70 percent lower power losses compared to an equivalent IGBT's conduction →03 [7]. Consequently, ABB's IGCT solution features efficiency up to 99.9 percent, at 1 kA, 1 kV compared to 99.5 percent for

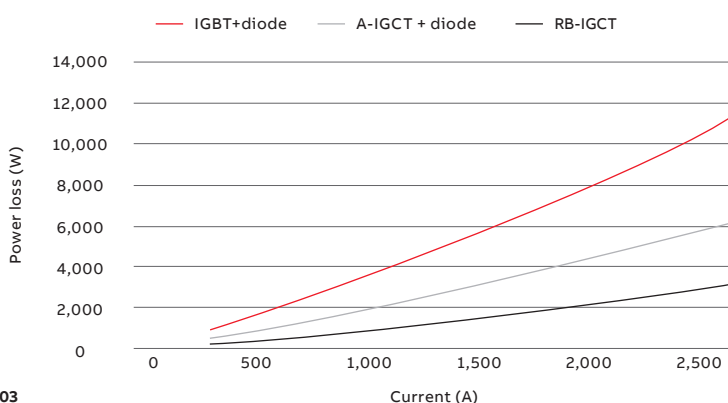
Traditional IGCT bi-directional arrangement



Novel RB-IGCT SACE Infnitus



02



03

IGBT-based solutions →03 [6]. This translates to a 70 percent reduction of power losses and related carbon footprint.

Employing this optimized RB-IGCT solution, ABB presented its ground-breaking solid-state circuit breaker concept to the public at the Hanover Fair in Germany in 2019 [7].

#### **All-in-one design**

Beyond overcoming the challenges of developing an optimal semiconductor and cooling system, integration is key. In 2022, ABB unveiled the revolutionary SACE Infinitus →04 – the premiere all-in-one protection solution that achieves the seamless integration of all necessary components – power electronic, mechanics, cooling, control, sensing and communication – to create an installation-friendly and compact all-in-one solution. Through simplicity of design, ABB aimed to minimize efforts and thus, cost gen-

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Unveiled in 2022, SACE Infinitus, with an optimized RB-IGCT, is an all-in-one protection solution that resolves fault challenges.

erated during the product deployment phase, compared to a custom-built complex and error-prone compound device solution. With SACE Infinitus, it is no longer necessary to provide space, and logic to coordinate an external switch for galvanic insulation, required for maintenance; this significantly improves ease-of-installation and safety, and lowers costs.

Despite significant challenges arising from the integration of such a broad variety of technologies, ABB created the first-of-its-kind solid-state breaker solution. The compartmentalized design within a single frame means the footprint is compact, and the breaker is easy to install, maintain and service. The well-established draw-out racking system is deployed in two mobile parts: one comprising the power electronics, with the integrated liquid cooling and the quick shut-off couplings; and the second containing the switch for the galvanic isolation →04.

Moreover, communication modules based on ABB's Ekip can be plugged-in, allowing integration of the SSCB into digital systems. The integrated voltage and current sensors of the breaker enable the continuous monitoring of the electrical parameters, including power.

#### **Cooling made simpler**

While conduction losses are significantly lower in SACE Infinitus compared to IGBT solutions, they are not trivial, about 3 kW for a circuit rated at 2,500 A. To keep the temperature of the semiconductor junction (where the highest temperature occurs during operation) in the safe operating area (SOA), integrated cooling is essential. For the package of a conventional IGCT, the power terminals also serve as thermal interfaces, enabling the cooling of the core. This comes at a cost; the cooling system must be insulated; typically with an insulating cooling fluid eg, deionized water for MV motor drives. But, cooling with deionized water can be impractical since it requires a purification circuit to be added to the system.

In response, ABB developed an innovative solution to alleviate space and weight issues yet insulate and cool without the disadvantages of the complexity of commonly-used approaches →04. In SACE Infinitus, the thermal management concept is based on aluminum-nitride cold plates that combine electrical insulation and high thermal conductivity, achieving properties close to that of aluminum. Thus, the cooling liquid can be the well-known mixture of water and glycol obviating the need for additional equipment and reducing complexity.

#### **Establishing control and protection**

The SACE Infinitus control and protection functionality stems from a microprocessor-based trip unit that fulfills both the conventional "slow" long range, short range, instantaneous and ground fault (LSIG) protection, in timescale of milliseconds and seconds, and the ultrafast short-circuit protection in the timescale of microseconds →04. Moreover, it ensures the crucial interplay of the power electronic and the electromechanical isolation switch of the SACE Infinitus. Ultrafast current measurement, a prerequisite yet challenge in DC systems, required the development of dedicated current transducers using Hall-effect sensors: the bandwidth is high enough to discriminate current transients up to 80 A/μs.

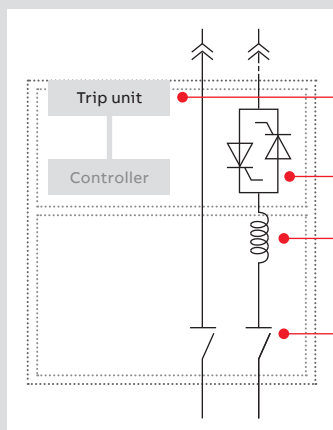
— 04 SACE Infnitus all-in-one device integrates cooling, protection, inductance, power electronic and insulation switch into one easy to install device. The withdrawable rack solution uses electrical and hydraulic connections/disconnections for the in/out motion.

**When interruptions occur, Infnitus steps up**  
SACE Infnitus clears faults lightning-fast, in tens of microseconds; but how? In DC systems, where sources are generally inverters with large DC capacitor banks located at their output →05, a short circuit on the bus will generate a high di/dt fault current that cannot be effectively managed by standard electromechanical breakers. Relying on a technological breakthrough, the SACE Infnitus protection system resolves this issue →04. Here, the breaking time is so short that the fault current is interrupted before it can reach more than twice the nominal current, typically. This ultrafast current limiting function will, in practice, act as an immediate DC disconnection mechanism during a fault event. SACE Infnitus can disconnect the circuit in about 20–50 µs – a remarkable result →05. The inductive energy of the grid is absorbed in the metal oxide varistor

— ABB's premier solution clears faults lightning-fast, in tens of microseconds – a remarkable result.

(MOV) path parallel to the semiconductor until current zero is reached.

In most installations, fault current rises at a much lower rate than the critical di/dt, ensuring that the semiconductor can operate in its SOA. At such di/dt rates, interruption capability is almost unlimited. In rare cases when this limit is exceeded, SACE Infnitus is equipped with an internal inductance limiting the di/dt to values within the SOA.



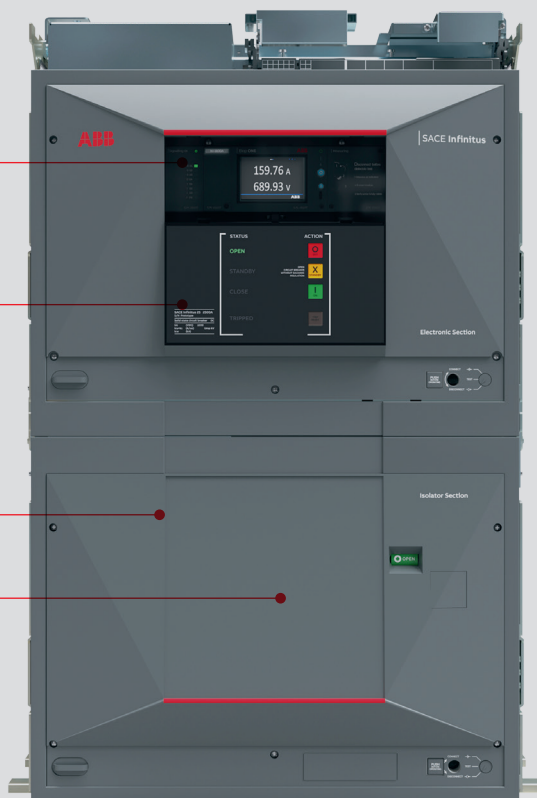
**Protection unit**  
• advanced protections  
• network analyzer  
• energy metering  
• communication ...

**Power electronic**  
• low-loss RB-IGCT technology  
• cooling system

**Inductance**  
• control of di/dt

**Isolator switch**  
• CAT IV  
• motor controlled

- Withdrawable frame; frame size: up to 2500A
- Rated voltage: 1.000 Vdc
- Fully bidirectional
- 1p and 2p switching, 2p isolation
- High-speed overcurrent protection:  
  <25 microseconds
- Power losses: 1.3 kW @ 1kA, single pole
- Liquid-cooling/ withdrawable version
- All-in-one solution for low total cost of ownership:
  - Advanced Protection w/ power, voltage, directional
  - Switch
  - Isolator
  - Energy metering
  - Connectivity: 7 communication protocols
  - IEC 60947-2 certification, DNV-GL





### One solution – unlimited protection – an economic advantage

Deployment of SACE Infnitus as a highly integrated protection device means:

- extremely fast breaking time – 100 times faster than traditional protection systems, and maximum service continuity
- isolation of the faulty zone – avoids full system shut down
- near zero arc energy exposure; this mitigates the risk of arc flashes
- maximal energy efficiency thanks to new switching technology with the lowest power

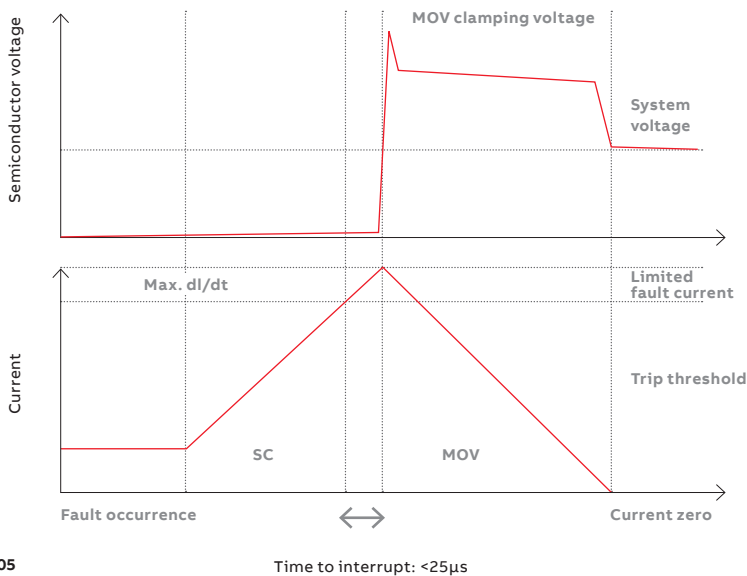
losses in the semiconductor-based breaker category

- more than 100 times better endurance – extraordinary electric life to match the future demanding needs of microgrids

As a result, ABB's customers benefit from total system efficiency with lower cost of ownership and improved availability as they transition to sustainable energy.

### Setting the standard

The SACE Infnitus circuit breaker is the world's first breaker certified according to IEC 60947-2 based on semiconductor interruption technology. Intensive work is underway to develop further specific standards. With their SACE Infnitus solid-state breaker project experience, ABB is co-driving the development of a new specific IEC standard – project PT60947-10 – for solid-state breaker technology (DC and AC applications) with an expected release in 2025.



ABB's technology is the world's first IEC circuit breaker based on solid-state technology; it offers nearly infinite possibilities.

### Marine application

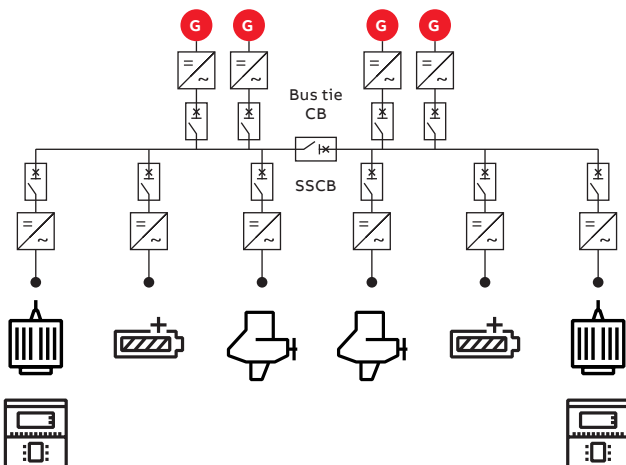
The marine segment is an early adopter of DC onboard grids with ABB at the forefront of this enabling technology. With energy savings up to 20 percent, ever more vessels are being designed with DC distribution systems.

In →06 a bus tie breaker connects the starboard and portside sections; this typically allows an optimal usage of the power generators. If a fault occurs, the sections must be protected by the circuit breaker to prevent a total outage and ensure service continuity by disconnection of the faulty section. In situations that are too challenging for traditional technology due to the high and fast rising (in milliseconds) short circuit currents, ABB's SACE Infnitus excels.

With low losses, arc-free, ultrafast current interruption speed, SACE Infnitus is ideal for preventing severe risks to people and assets. Elsewhere, when fault current is not the only major concern, it provides the fast protection needed to prevent the DC bus voltage from dropping to a level at

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05 Ultra-fast fault current interruption principle based on SSCB technology.

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06 Example of a DC distribution grid in a marine vessel with SSCB as bus-tie circuit breaker.

which the system becomes inoperative, ie, by the capacitors of the DC bus discharging. The DNV certification, relevant for marine applications, will be available for the circuit breaker.

#### With DC toward the future

The applications for ABB's new solid-state circuit breaker go beyond the marine transport sector, enabling a new level of sustainability. This revolutionary breaker will impact the evolution

SACE Infnitus has the potential to generate new perspectives for building DC grids in a safe and economical manner.

of electrical systems for ground transportation. The pilot installation of dynamic road-side EV-charging and a novel industry application that improves energy efficiency are some of the examples currently underway.

SACE Infnitus is a core component for mastering the challenges of DC protection; it has been created for high current DC applications with a view to the future; providing switching, insulation and DC protection in a single compact device up to a rating of 2.5 kA at a rated voltage of 1000 VDC.

With power electronics and advanced software algorithms that control the power, interrupting extreme currents lightning-fast, ABB's customers will be positioned to address the challenges of future energy requirements. With its simple and safe design, allowing ease of system integration, and ultrafast protection, SACE Infnitus satisfies the needs of new emerging applications economically.

By introducing an ultra-fast breaker solution that enables next-generation DC architectures, ABB demonstrates their commitment to the sustainable transformation of electrical energy. SACE Infnitus is the world's first IEC circuit breaker based on solid-state technology, and it has the potential to generate new perspectives for building DC grids in a safe and economical manner; this innovative all-in-one device offers customers nearly infinite possibilities. •

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INVESTIGATING THE AZIPOD® PROPULSION SEALING SYSTEM

# Sealing the future





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01 Azipod® propulsion (shown here) does not require a separate shaftline, rudder, stern thrusters or associated auxiliary systems; it is suitable for vessels ranging from ferries, to cruise ships, cargo carriers and icebreakers.



Using multiphysics modeling to understand the operation of the current Azipod® sealing system, ABB is able to create guidelines to help propel the design of this world-class propulsion system to the next level.

With capability to sustain performance even under the harshest marine environments, ABB's Azipod® propulsion system represents the best-in-class in propulsion technology on the market today. The performance of the sealing system is crucial to the reliable operation of this system. Recognizing this, ABB's experts are working together to push the boundaries of seal performance beyond current limits. Azipod® experimental experts and multiphysics modeling research scientists embarked on a collaborative investigation to dive deeply into the

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complicated physics of the sealing system; this is the account and the results of their journey with a view to the future.

#### **Azipod® propulsion: a history of innovation**

Launched more than 30 years ago, ABB's Azipod® propulsion system leads the global marine propulsion shipping market today. With the electric drive motor situated in a submerged pod outside the ship hull →01–2, the Azipod® system can rotate 360 degrees; this significantly increases the maneuverability and operating efficiency of

a vessel and reduces fuel consumption by up to 20 percent compared to conventional shaft-line systems. Because both the pod motor and its shaft are located completely outside of the ship's hull, the pulling propeller receives a steady undisturbed wake field; there is practically no vibration during maneuvering, and both noise and vibration from a stern thruster are eliminated.

For example, the hybrid-electric exploration cruise vessel, Le Commandant Charcot fitted with two ABB's Azipod® propulsion units →01–3, is not only the first exploration cruise vessel to reach the geographic North Pole, this vessel initiates a new era of sustainable and comfortable

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ABB's Azipod® propulsion system represents the best-in-class in propulsion technology on the market today.

cruising in extreme environments, eg, icy waters. Eliminating noise and reducing vibrations, increases passenger comfort and safety; and thanks to the enhanced Azipod® system's maneuverability, the vessel navigates smoothly, cruising in zero-emissions mode while exploring remote locations (here, the Azipod® propulsion system has a combined power of 34 megawatts).

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02 Azipod® propulsion is shown.

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03 Le Commandant Charcot with ABB's Azipod® propulsion system is the first exploration cruise vessel to reach the geographic North Pole.

### Exemplary performance

To ensure the smooth performance of Azipod® systems, the condition of the sealing system requires regular intense scrutiny, as vibration can have an effect on the sealing system. The sealing system comprises a series of elastomer seals mounted on the propeller shaft, which contain sealing oil between adjacent seals; this ensures high quality lubrication and cooling of the sealing system – so necessary for superior performance.

Although the currently used sealing technology for ABB's Azipod® propulsion system exhibits high performance even under adverse conditions, eg, during the vibration imposed by ice formations encountered by vessels, such as that experienced by ice-going vessels like Le Commandant Charcot and ice breakers, it is worthwhile to push the boundaries of safe and reliable performance to the highest possible limits. Given the ever-worsening and unpredictable climatic conditions observed [1], coupled with today's stringent global norms [2], ABB believes this to be essential.

### Innovative approach

Whereas much of ABB's expertise concerning Azipod® sealing systems is based on experience, advanced computational techniques, eg, multiphysics modeling, can help garner insight into seal physics for improvement. In mid-2021, ABB began to delve into the advanced physics and functional aspects that underly the Azipod® sealing system. ABB set out to pinpoint the parameters that

influence performance, through experimental tests and modeling, to understand the factors that impact operation of the current sealing

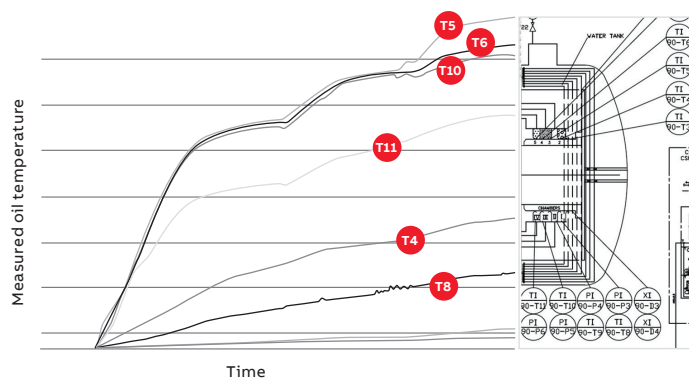
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To ensure smooth performance of Azipod® propulsion systems, the condition of the sealing system requires intense scrutiny.

system; to develop guidelines to optimize operational parameters and to improve the sealing system for the future.

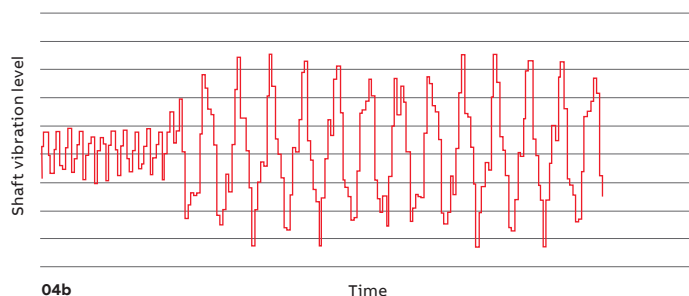
### ABB's holistic approach

Extensive tests were designed and performed on a sample Azipod® sealing system, housed in an ABB testing facility which would yield realistic information about the parameters that influence performance. In parallel, multiphysics models, which comprised a sequence of CFD (computational fluid dynamics) and structural dynamics modeling, were developed to simulate the performance of the sealing system under various, yet, specific conditions. In this way, ABB sought to bring forth a holistic view of critical parameters, such as oil flowrate, pressure, temperature and structural stresses. Critical analysis of the modeling results would yield invaluable knowledge regarding the complicated

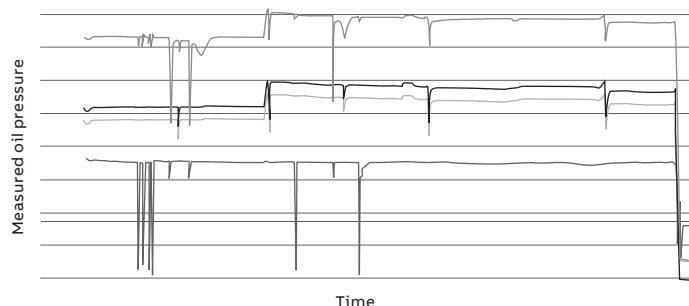




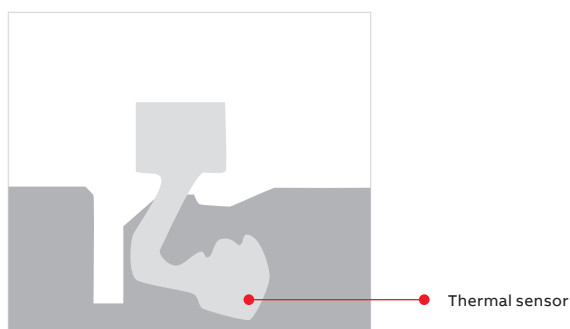
04a



04b



04c



04d

underlying physics of Azipod® to better equip ABB for future product upgrade efforts.

The models were initially validated using data from measurements; this established confidence in the modeling approach. Subsequently, the models were employed to evaluate several aspects of performance that were impossible to investigate using laboratory tests alone. In short, new insights into seal physics could be gleaned.

#### Tests, tests and more tests

Because experiments were integral to the project, tests were conducted rigorously: The sealing system was mounted on the rig and instrumented with temperature, pressure, vibration, and oil level sensors for an estimation of critical parameters. Analysis of these parameters provided a comprehensive understanding of

Experimental efforts and multi-physics modeling provide comprehensive and unprecedented insights into seal physics.

system performance under diverse situations: Initial tests replicated normal operation of the sealing system while subsequent tests simulated challenging scenarios such as those that occur during shaft vibration (replicating the impact of icy conditions) to understand performance of the system.

Temperature rise was measured at several positions and at varying shaft rotational speeds →04a within the seal material and in the oil chambers; this yielded valuable information about frictional heating effects at the seal-shaft contacts. The system was operated under normal- and vibrating conditions, to observe possible alteration in performance due to vibration. The level of vibration was monitored →04b at several shaft speeds, among other parameters, such as oil pressure →04c. The oil tank, (not shown here) which supplied oil to the seal, was monitored for level changes to detect possible oil leakage between adjacent chambers at the seal contact. Seals were individually examined for possible deterioration →04d by embedding sensors to measure temperature; and then by measuring the seal contact width to detect possible wear.



#### 04 Experimental test results.

04a Temperature measured at critical locations within the seal chambers in seal oil compartments.

04b Vibration level measured during vibration testing.

04c Oil pressure measured within the oil chambers in the sealing system.

04d Investigation at individual seal level. The seal was embedded with a temperature sensor and examined for possible wear after testing.

05 Modeling work-flow: CFD and structural models used to simulate sealing system performance, predicting physical parameters and trends critical to performance.

#### 06 Computational model results.

06a Computational fluid dynamics (CFD) modeling domain to investigate oil dynamics during operation. Flow dynamics within oil space, including narrow contact gap computed by model in 3-dimensional space.

06b Pressure field within oil space computed by CFD model.

06c Temperature field within oil, seal and supporting structure computed by CFD/thermal model.

### Multiphysics model-based investigations

To complement the extensive testing efforts, multiphysics modeling studies were performed to evaluate seal performance under conditions simulated in the tests. With the capability to compute critical parameters in three dimensional space and as a function of time, the modeling techniques, based on finite element and finite volume calculations, are considered, by far, to be the best models for multiphysics analysis. Initially, the models were compared with the test results for validation. With sufficient confidence in the modeling approach, the models were then extensively used to evaluate performance aspects impossible to evaluate by testing.

The modeling studies were performed in a specific sequence →05. CFD models were developed to understand fluid dynamics and thermal propagation within the oil space and seal structure, under various operating conditions, while

**Critical analysis of the modeling results yielded invaluable knowledge regarding the complicated underlying physics of Azipod®.**

structural dynamics models were used to analyze structural issues, eg, seal stress, deformation, and shaft-seal contact gap, and thus were useful in studying the impact of vibration. Depending on the particular investigation, structural

**CFD model:**  
Simulating flow within oil compartment, rotational effects, with capability to simulate vibration and thermal effects

To determine oil flow velocity and pressure field under shaft rotation, with and without vibration, temperature rise within oil and seal

**Structural model:**  
Simulating shaft rotation, vibrating and non-vibrating conditions

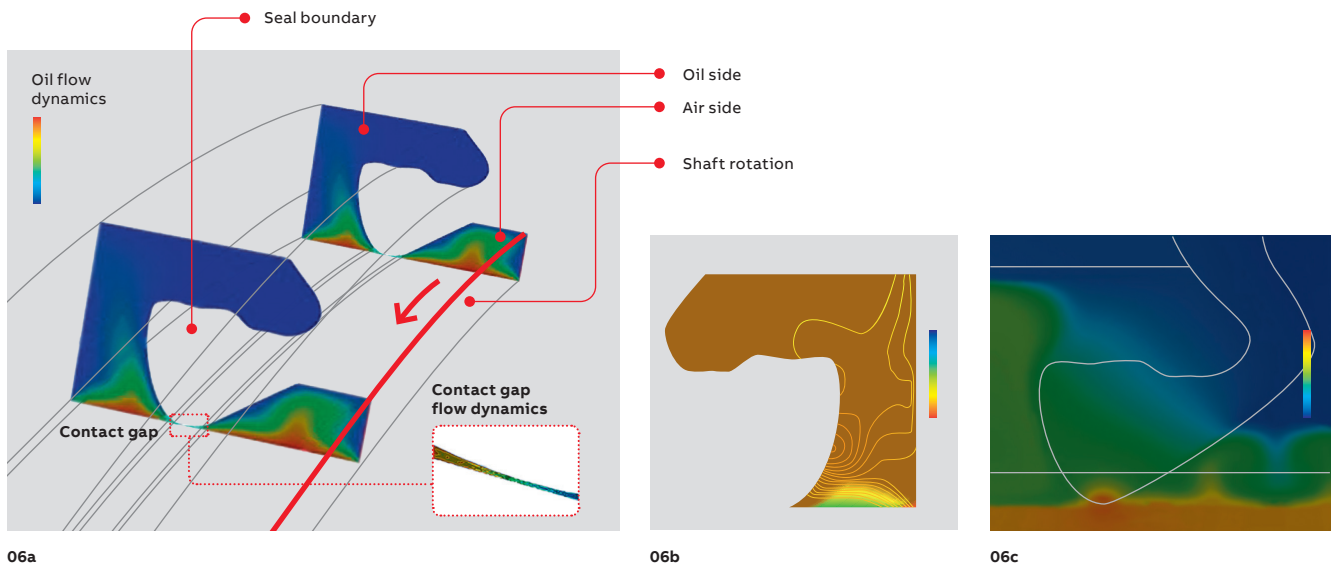
To determine seal stresses, deformation, seal-shaft contact gap, contact pressure

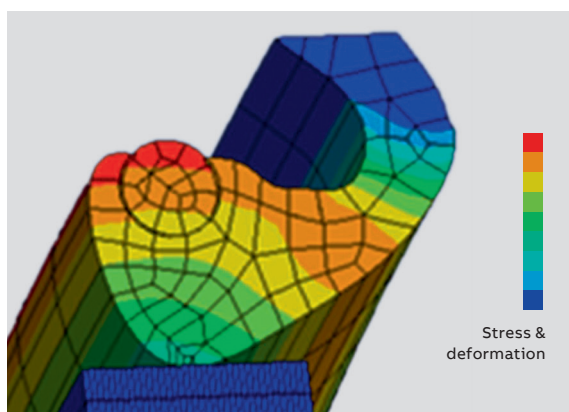
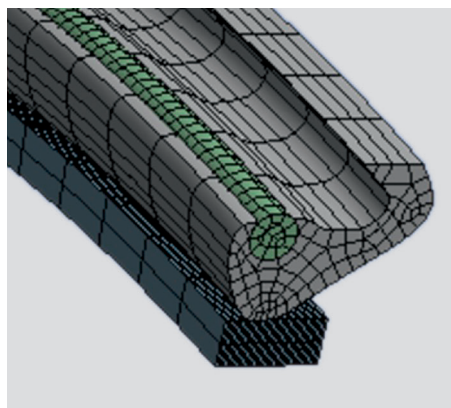
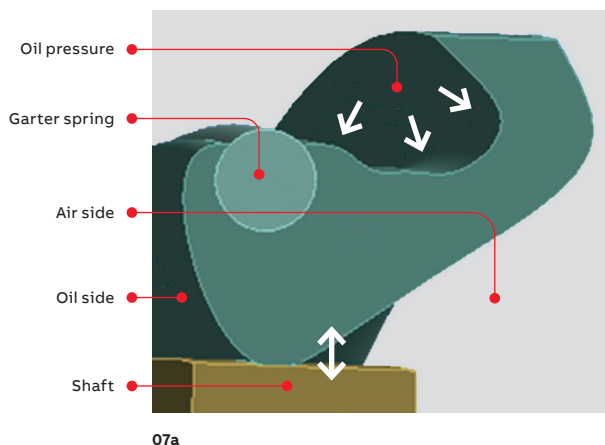
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dynamics modeling was conducted subsequent to CFD modeling or vice versa.

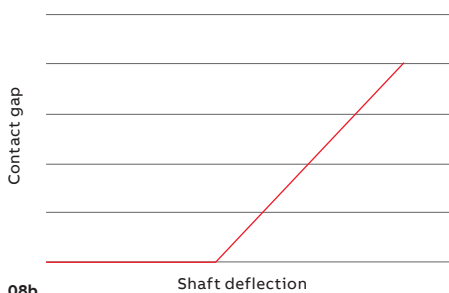
Flow dynamics within the oil chambers, and within the narrow seal-shaft gap →06a, was simulated by the CFD models, as was the pressure field →06b. Flow dynamic calculations were used to estimate the rate of oil transfer from one chamber to the other, under a given set of operating conditions, eg, oil pressure and shaft speed, for a selected oil variety. By including the frictional heating load and enabling thermal calculations, the CFD model computed the temperature field within the oil and the seal material →06c.

Because the primary focus of the investigation was to determine the impact of shaft vibration on performance characteristics, structural dynamic models comprising the seal, shaft and garter spring were developed →07a. The input data to the models were primarily the oil

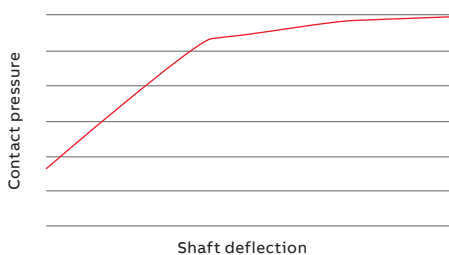




08a



08b



08c

pressure on the seal and the vibration frequency and amplitude prescribed to the shaft. Using advanced tools, the model was discretized →07b to solve the structural dynamic equations.

This resulted in the primary output of the structural dynamics model: seal stress and deformation →08a, the contact gap →08b and the seal contact pressure →08c as a function of shaft deflection – quantifying the vibrating condition.

An important purpose of the modeling approach was to confirm the test observations and therein the associated conclusions. For example, the fluctuation observed in oil pressure measurements

CFD and structural dynamics modeling results contributed to a deep understanding of the current Azipod® sealing system.

during shaft vibration was confirmed by similar observations →09a in the results obtained from the CFD model →09b with a moving boundary simulation capability to evaluate vibration effects.

The conclusions based on the CFD and structural dynamics modeling results have contributed to a deep understanding of the operation of the current Azipod® sealing system, and have been instrumental in helping ABB derive guidelines to optimize operational parameters facilitating future sealing design modifications.

07 Computational domain and discretization thereof is shown. Due to the software used, ANSYS, the resolution of the images is low.

07a Computational domain of structural dynamics model for analyzing structural issues during operation.

07b Discretization of computational domain.

08 Primary outputs of the structural dynamics model used to quantify the vibrational conditions.

08a Stress and deformation of seal during operation. Due to the software used, ANSYS, the resolution of the image is low.

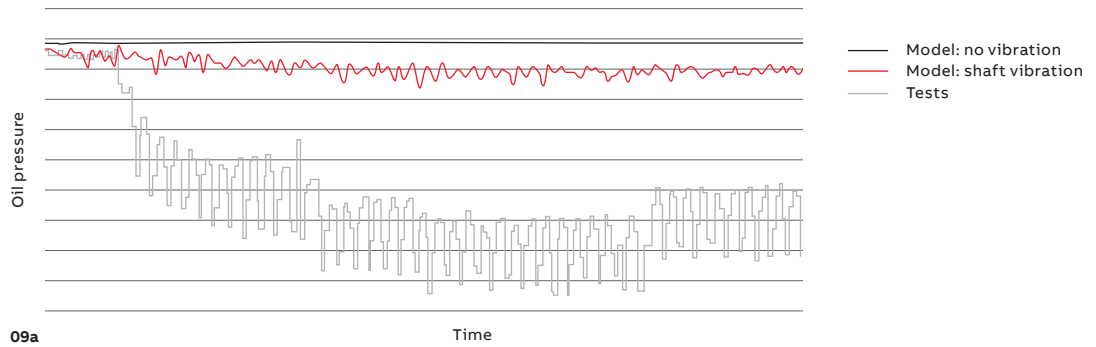
08b Seal-shaft contact gap variation with shaft deflection computed by structural model.

08c Contact pressure as a function of shaft deflection computed by structural model.

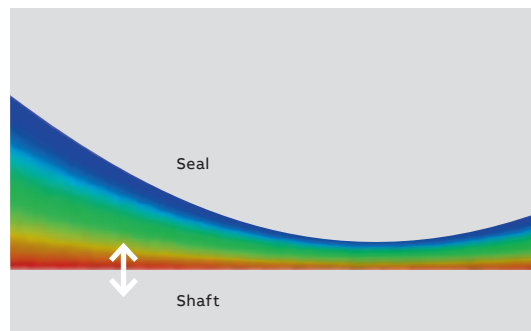
09 Comparisons were made of the observational test results and the models computed results, which agree.

09a Model reveals fluid pressure oscillation under shaft vibration, not seen during non-vibrating conditions. Confirms corresponding fluctuations observed during tests.

09b Oil dynamics within seal space, during shaft vibration computed by CFD model with moving boundary condition.



09a



09b

### Looking forward

While experimental methods are able to successfully evaluate sealing system performance, thereby providing invaluable information for developing guidelines to upgrade current seal systems, synergizing experimental and high-end multiphysics

In this way, ABB's Azipod® propulsion system will continue to be the preferred means of operating in sensitive and challenging marine environments, even as climate changes, and ABB demonstrates that their commitment to innovate is in good alignment with the current global call to promote sustainable performance. •

ABB's collaborative research efforts will help to propel the upgrade of future ABB propulsion systems.

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modeling techniques have allowed ABB to glean new insights into sealing performance. Being able to go beyond what can be tested experimentally, the results of ABB's collaborative efforts will help to propel the upgrade of ABB propulsion systems. ABB envisions that a knowledge-bank of seal performance physics will be an invaluable asset; one that will drive future endeavors to take Azipod® propulsion technology to the next level.





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SMART TEMPERATURE MONITORING RELAY

# Taking the temperature

Continuous temperature monitoring with ABB's new CM-TCN relays helps protect critical assets from expensive failures. The CM-TCN sets a new benchmark in ease of use and efficient setup. An embedded communication interface means the relay can be enabled easily in ABB Ability™ Energy and Asset Manager.





01

01 The CM-TCN relay.



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Temperature measurements are of interest in almost every industry because they help users understand and predict asset health. To help extend the advantages of temperature monitoring to more equipment and installations, ABB has introduced the CM-TCN temperature monitoring relay →01. The CM-TCN is equipped with up to three sensor circuits that accommodate inputs from common temperature sensor types and provide a convenient way to measure temperature locally. Relay outputs can execute appropriate actions when a particular temperature threshold is crossed. The relay can be set up via a smartphone or the integrated LCD and can connect to the cloud and ABB Ability Energy and Asset Manager to provide complete remote visibility of asset and electrical system behavior.

#### LCD for easy reading and parametrization

Ease of readout and setup were main considerations in the CM-TCN design philosophy. A back-lit LCD mounted on the front of the relay displays the currently measured values and maintenance data. The unit's symbol-based

menu structure can be accessed by depressing and turning the push-rotate button below the display with a screwdriver →02. A symbol-based interface eliminates language localization issues, increases efficiency in after-sales support and makes it easy to set thresholds and parameters. Password-protected access and a parameter lock improve security.

Event history, an operating hours counter, device statistics and other data are accessible from the menu. The relay offers predefined factory profiles (settings) to shorten installation times for fre-

Temperature measurements are of interest because they help users understand and predict asset health.

quently used applications such as temperature monitoring of transformers, or bearings and windings of electric motors. Parameters can also be individually set and saved in one of four user profiles. Further, an inbuilt simulation function lets the customer check that the relay setup is correct before it goes live.

#### Parametrization via a smartphone app

ABB's Electrification Products intuitive Configurator (EPiC) is a free smartphone app that allows

configuration, installation and commissioning of, and assistance with, ABB's low-voltage portfolio, such as the CM-TCN. The app communicates with the CM-TCN relay via near-field communication (NFC) → 02. NFC is an international transmission

Touching the smartphone onto the CM-TCN lets EPiC perform parametrization and copy settings between multiple devices.

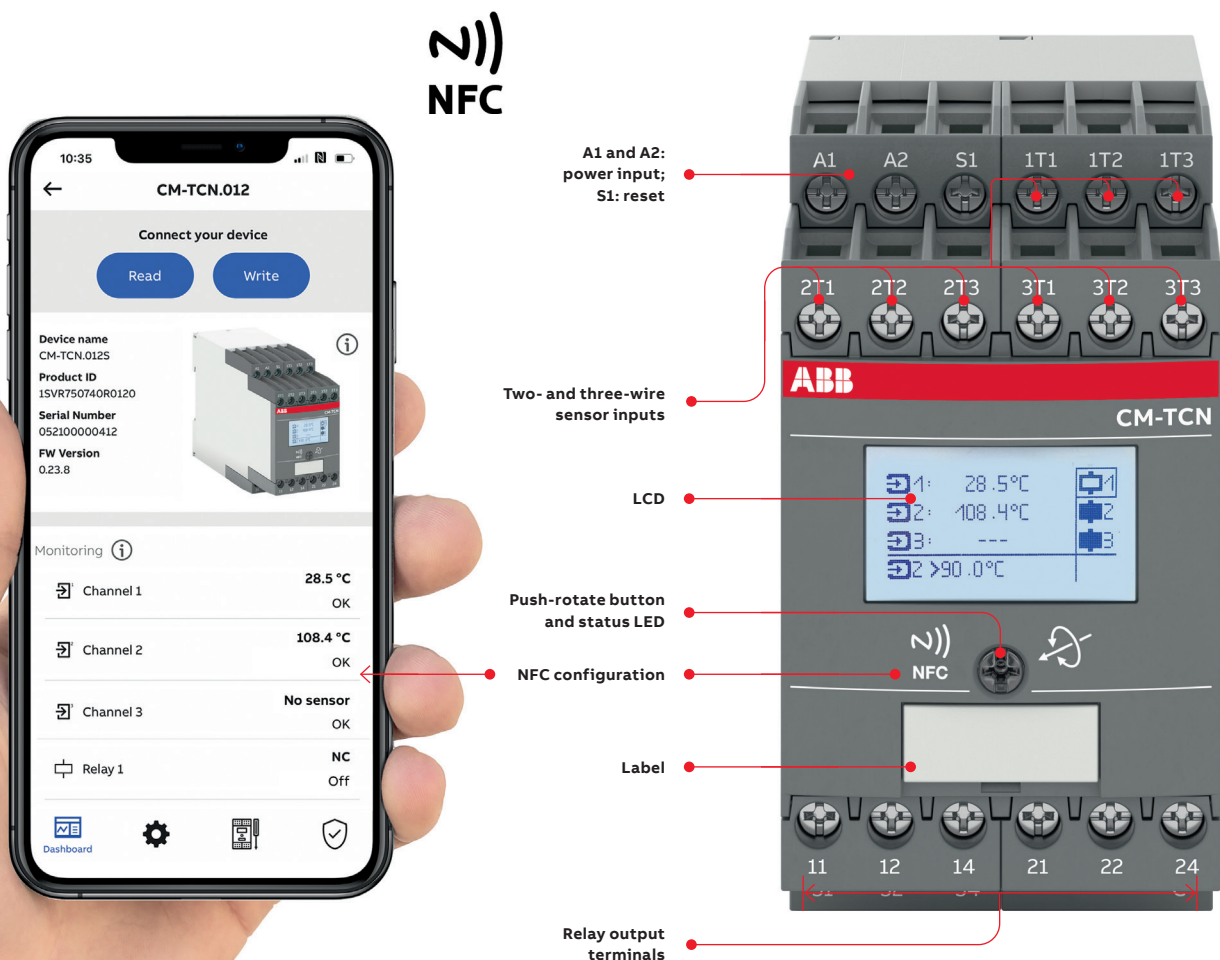
standard based on radio-frequency identification (RFID) technology for contactless data exchange. NFC is already integrated into most electronic devices, such as tablets and smartphones, and is part of everyday life – eg, for contactless payment. By simply touching the smartphone onto

the CM-TCN, EPiC can carry out parametrization and copy settings between multiple devices via NFC – even if the relay is not powered up. The ability to set up the relay when it is switched off allows relays to be configured off-site, thus significantly shortening installation time – by 80 percent in some cases. This is especially relevant for original equipment manufacturers (OEMs) and panel builders.

Relay status and measured values are displayed in the app and sets of parameters can be stored there and copied to other devices by simply tapping the smartphone on them. The user can also view historical data on the smartphone → 02.

### Thermal protection and condition monitoring

CM-TCN relays can measure temperatures in up to three sensor circuits, using the most common sensors (positive temperature coefficient (PTC) thermistors, Pt100, Pt1000 and NTC). The wide temperature measurement range of -200 to



— 02 The CM-TCN relay can be configured from a smartphone. The LCD home page displays current readings. Any data available via the LCD is also available via the app.

+850 °C covers almost all conceivable applications. The relay itself can withstand an ambient temperature range of -25 to 60 °C.

The relay's threshold settings are very flexible. Pre-alarm and alarm thresholds may be set according to application needs. For example, the first relay circuit can be assigned as a pre-alarm, the second as an alarm and the third as a sensor error alert. Nine signals are available for assignment to allow various combinations of tripping thresholds.

CM-TCN relays offer seven preconfigured factory profiles for the following applications:

- Motor winding protection with Pt100 sensors (factory profile 1 and factory profile 3)
- Motor bearing supervision with Pt100s (factory profile 2)
- Motor winding protection with PTCs (factory profile 4)
- Transformer supervision with Pt100s (factory profile 5)
- Transformer supervision with PTC thermistors (factory profile 6)
- Individual temperature supervision with PT100s

For example, factory profile 5 allows transformer supervision with three escalation steps. Threshold 1 is set to 130 °C and if the threshold is reached, relay 1 trips, which starts ventilation

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Temperature monitoring ensures that applications remain operational and asset lifetime is improved.

for cooling the transformer. Additionally, a cyclic switching function is assigned to relay 1 to switch the relay once a week for 15 min to keep the fan from clogging.

Threshold 2 is a pre-warning at 140 °C and a trip of relay 2. In addition to the threshold configuration, the sensor error signals are assigned to relay 2. A wire break or short-circuit in the measuring circuits will then cause relay 2 to trip. Threshold 3 is a critical temperature of 155 °C, at which value the transformer will power off by means of relay 3. Relays 1 and 3 operate as normally open contacts (ie, an open-circuit principle) and relay 2 as normally closed (closed-circuit). All relays automatically reset when temperatures

drop below the threshold values, taking hysteresis into account.

The operating logic and the settings are displayed in →03.

If the factory profile settings do not fully meet the application requirements, they can be modified. For example, the temperature values of the thresholds can be changed, while keeping sensor type selection and relays assignments as defined by the factory profiles.

CM-TCN devices also allow free configuration:

- Sensor setting – definition of sensor type used for each measuring channel (Pt100, Pt1000, PTC, NTC, bi-metal or none).
- Signal configuration – definition of threshold values, on/off delays and hysteresis.
- Relay assignment – mapping of signals (thresholds), sensor error signals and a bus fault signal to the three relays available in CM-TCN devices.

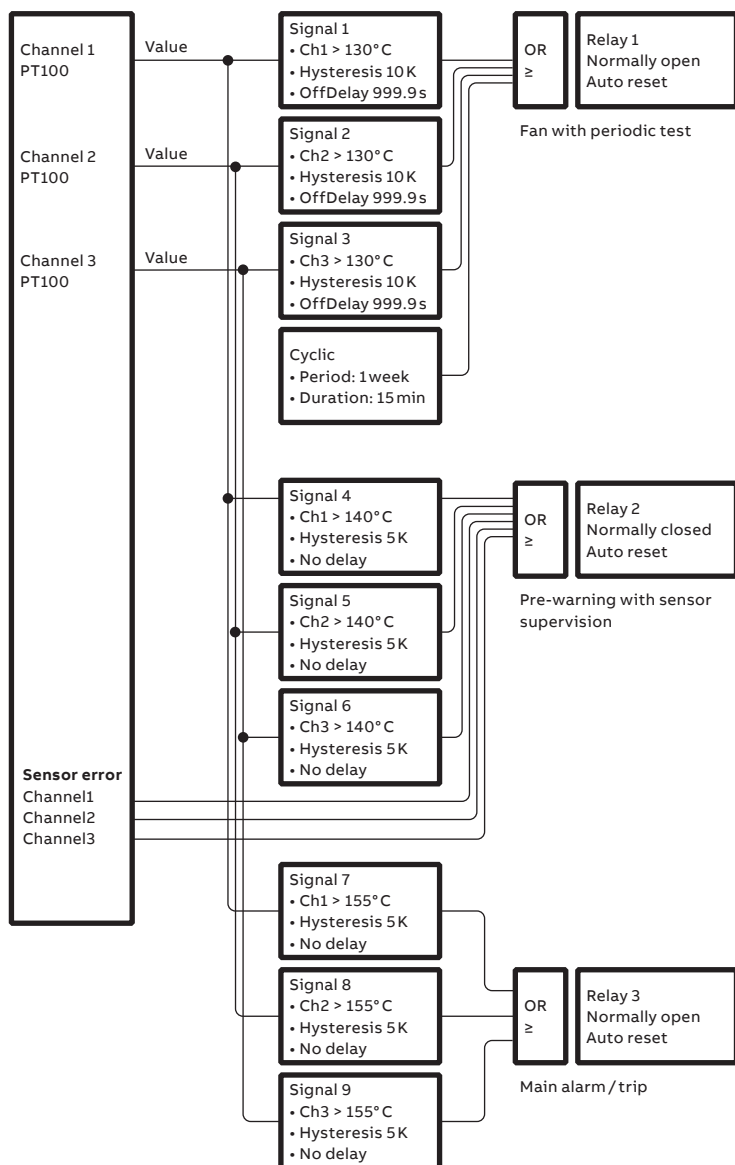
By providing early detection of unacceptable temperature rises and alerting the operator to the need for maintenance, temperature monitoring ensures that applications remain operational and asset lifetime is improved. Thermal protection and condition monitoring can also be accomplished remotely via a Modbus link and ABB Ability Energy and Asset Manager. Remote management improves safety as personnel no longer need access to the switchboard to read measurements.

The relay can detect unacceptable temperature rises that shorten the lifetime of electrical motor bearings and windings. But due to its flexible configuration options it can also be used, for instance, for temperature monitoring of busbars and cables, allowing early detection of issues related to tightening, which result in the need for maintenance.

#### **Built-in connectivity**

The CM-TCN temperature monitoring relay uses the Modbus RTU communication protocol over RS-485 to support data transfer. An RS-485 communication interface is embedded in the relay and requires no additional installation →04. This communication interface makes it possible to remotely:

- Read temperature measurements, the relay state and temperature sensor status.
- Access condition monitoring data such as event history, operating hours counter, maintenance counter, or statistics.
- Configure the monitoring relay.



- Reset the history and settings (trip counter, event history, etc.)
- Read system information (serial number and firmware version).
- Control output relays remotely.
- Define bus fault reaction of output relays if a communication bus error occurs.

#### Cloud integration with ABB Ability

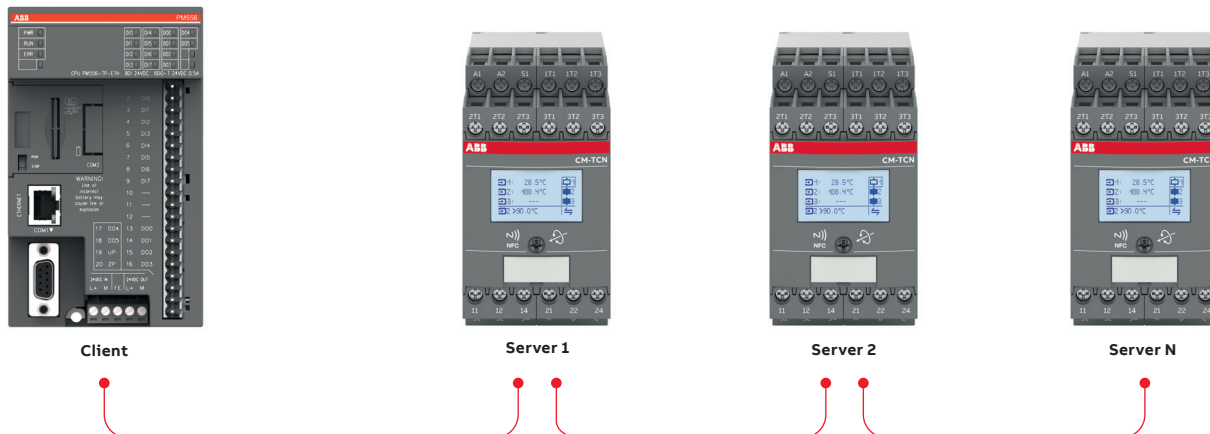
As stated above, the ABB Ability Energy and Asset Manager cloud solution gives remote visibility of electrical system behavior. This visibility provides insights that help operators minimize costs and risks and maximize performance and safety across all operations. Communications between an ABB Ability Edge Industrial Gateway,

Remote visibility helps operators minimize costs and risks and maximize performance and safety.

for example, and the relay is conducted via the relay's embedded Modbus RS485 communication interface. The edge gateway itself uses a state-of-the-art cybersecurity protocol built on ABB and Microsoft expertise to exchange data with the ABB cloud platform.

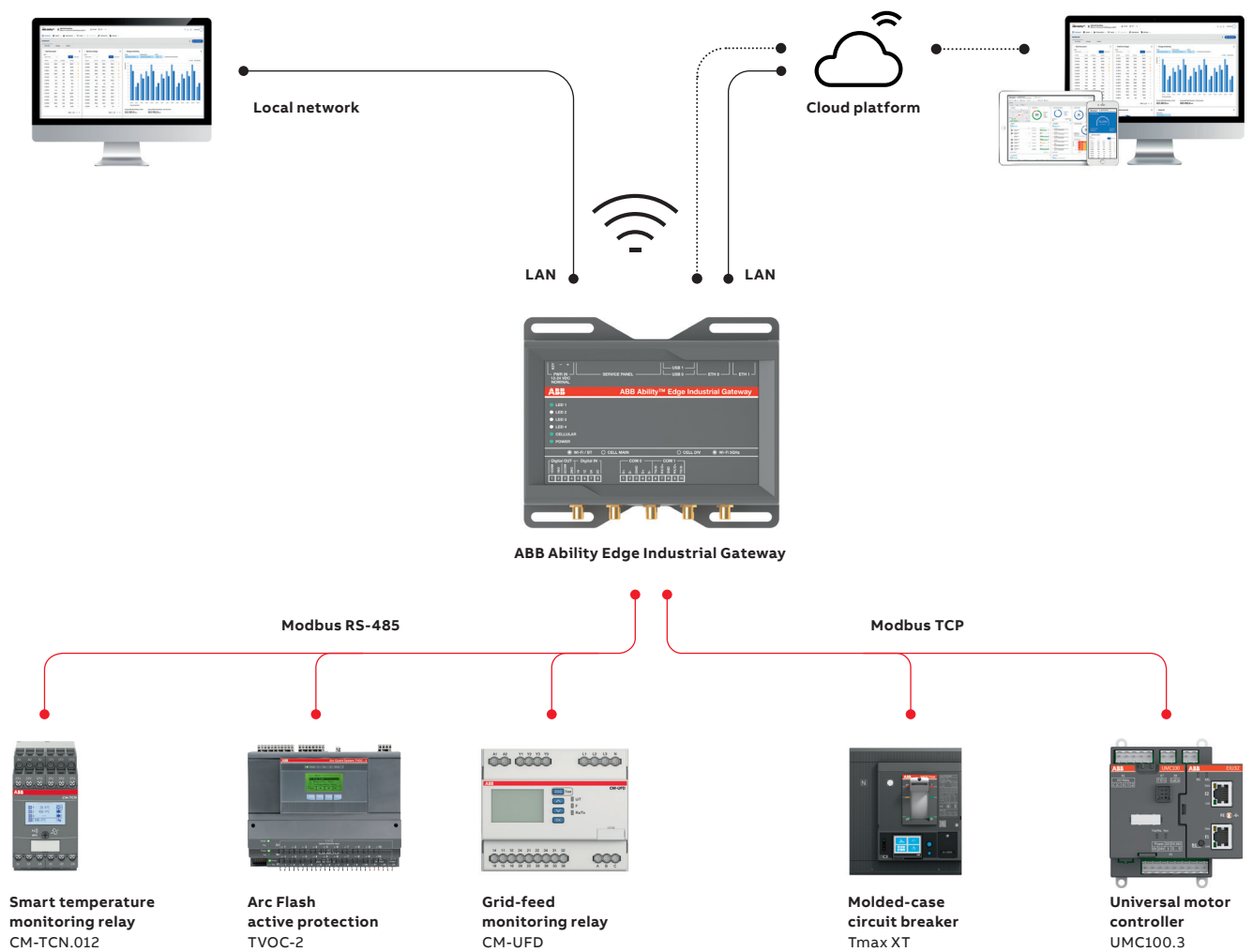
→05 shows an example communication architecture that integrates a range of devices into the ABB Ability Energy and Asset Manager and local network. In this setup, the data received

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03 Block diagram of factory profile 5 – transformer supervision with Pt100s.

04 Multiple relays can be connected via RS-485.

05 Configuration example.

in the cloud from the CM-TCN is organized as a user-friendly widget for the remote temperature monitoring of a variety of assets. In such an architecture, temperature sensor readouts can be compared in order to identify trends, giving valuable insights about asset temperature

Since configuration can be performed without powering up the device, installation times can be significantly shortened.

behavior. Additionally, the user can set up SMS or email alerts to notify key personnel should a relay trip or sensor errors occur. A periodic report with temperature values can also be scheduled.

### Rewriting the rules

By keeping an eye on temperatures – either from the cloud, in a control room, or locally – operators can help minimize cost and risk while maximizing performance and safety. Setup via the relay's LCD or with a smartphone is simple and since configuration can be performed without powering up the device, installation times can be significantly shortened. Because this one relay covers such a wide range of applications, inventory costs are reduced.

The ABB CM-TCN relay rewrites the rules of temperature monitoring in industrial settings. •

# Food & beverage



Connected digital energy monitoring and use can yield greater safety, operational efficiency, and regulatory compliance. ABB has deep experience in smart metering and manufacturing solutions.

- 36      **Energy diet**  
Smart metering and monitoring for energy efficiency
- 42      **Safe hands**  
Smart safety for the food and beverage industry



36







## SMART METERING AND MONITORING FOR ENERGY EFFICIENCY

# Energy diet

Energy consumption and unplanned downtime are major concerns in the food and beverage industry. ABB's smart metering and monitoring products accurately measure the electrical behavior of an entire food and beverage plant to optimize energy use and ensure uninterrupted production.

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01 Smart metering and monitoring reduces energy consumption and keeps production running in food and beverage plants.

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02 ABB's Tmax XT MCCB.

With their sheer scale and high production rates, it is little wonder modern food and beverage plants consume significant quantities of electrical power. Fortunately, the benefits of digitalization provide a way for these plants to optimize their energy usage. Digitalization allows detailed metering and monitoring of a plant's entire electrical system and is the key to improving energy efficiency. With a digitalized system and ABB smart metering and monitoring in place [1], all relevant electrical parameters can be measured with high accuracy and devices can

Detailed metering and monitoring can also guarantee the uninterrupted availability of electrical energy, which is business critical for food and beverage companies. Unplanned interruptions or disturbances in the power supply can incur significant costs related to product loss, production downtime, or supply chain interruption.

Digitalization allows detailed metering and monitoring and is the key to improving energy efficiency.



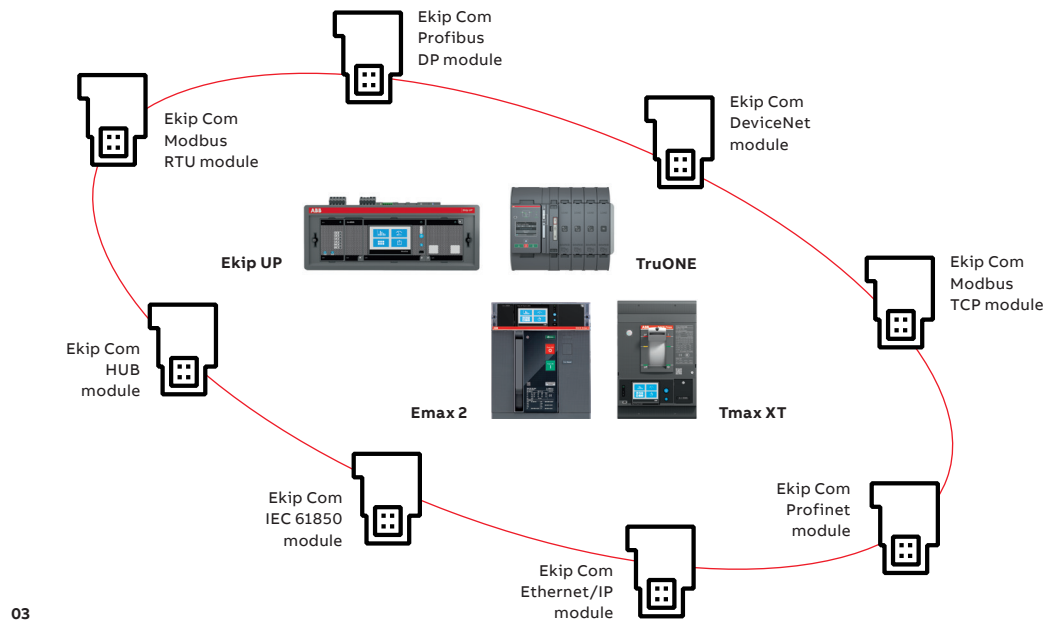
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freely exchange information between themselves, the cloud, an energy management system and an asset performance management platform →01. As a further motivation to digitalize, it has become clear that up-and-coming standards will require high-accuracy monitoring of electrical parameters and power quality at many acquisition points.



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This potential exposure to business disruption and financial loss is another reason why food and beverage companies give very careful thought to a site's electrical distribution system and how it is monitored and managed.

#### Standards for energy management systems

International standards, such as ISO 50001 Energy Management Systems, make it easier for industries to integrate energy management into their quality and environmental efforts. The framework of requirements provided by ISO 50001 helps companies develop a policy for

- Increased energy usage awareness among staff members at all levels.
- Improved operational efficiencies and maintenance practices.

For low-voltage applications, metering requirements are set out in the IEC 60364-8-3 standard, which states that, for the incoming part of the facility, it is necessary to have detailed monitoring of all electrical parameters. This mandated supervision includes advanced power and power quality monitoring, and network performance analysis – a further incentive for food and beverage companies to digitalize.

### ABB metering and monitoring products typically deliver a short payback time.

more efficient energy use, define ways to meet the policy and use data to make good decisions regarding the policy. ISO 50001 expands previous standards with new data-driven sections related to energy planning, operational control, measuring and monitoring. By adopting ISO 50001, companies can benefit from:

- Energy reduction, (of up to 10 percent within 12 months, in some cases).
- Reduced greenhouse gas (GHG) emissions and carbon footprint.
- Assistance in compliance with current and future voluntary and/or mandatory energy efficiency targets.
- Improved corporate image and credibility among customers, clients and stakeholders.
- Informed decision-making processes from system design to operation and maintenance.

#### Comprehensive products and connectivity

For the food and beverage industry, ABB has a full range of solutions, software, digital tools and devices that measure and analyze energy consumption in great detail, improving data-driven decisions and optimizing maintenance scheduling. ABB metering and monitoring products typically deliver a short payback time, a 7 percent improvement in energy efficiency [2] and ensured access to certification under LEED (Leadership in Energy and Environmental Design – the most widely used green building rating system in the world). Furthermore, these products enable authorized persons to connect a facility to the cloud in under a day and initiate monitoring of the entire electrical system. In fact, cloud connectivity is emerging as a necessity for compliance with newer international standards and regulations.

Thanks to the measurement accuracy of ABB metering and monitoring devices, the user can easily:

- Better identify any inefficiency within the electrical distribution system

03 Ekip communication modules along with the ABB TruONE automatic transfer switch, which incorporates switch and controller in one unit.

04 ABB Ability Energy and ABB Ability Asset Manager widgets.





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- Better identify inefficiencies at a single component level
- Make the right decisions to improve energy efficiency and avoid unnecessary actions.
- Exploit predictive functions to anticipate and avert potential failures and issues in the electrical infrastructure. In this way, continuity of production is ensured, which is crucial in the food and beverage industry.

#### **A full set of local monitoring and control tools**

For local monitoring and control, ABB offers a full set of flexible solutions to fit all installation requirements. For instance, devices in the Tmax XT molded-case circuit-breaker (MCCB) family

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**ABB Ability Energy Manager facilitates multi-utility monitoring, energy audits and cost management in a single dashboard.**

deliver information about current, voltage and operational parameters – eg, temperature, pressure and vibration – that can be digitalized at the device level and stored, analyzed, visualized or downloaded →02.

These digital breakers come equipped with a color touch screen and connect to smartphone and tablet-based apps that allow users to navigate menus of information about why a circuit has tripped. This is a huge improvement in terms

of ease of use and value-added information available for customers.

Tmax XT MCCBs have embedded native communication protocols (Modbus RTU, Profibus DP, DeviceNet, Modbus TCP, Profinet, Ethernet/IP and IEC 61850) that allow interconnection between all relevant ABB and third-party devices. ABB's range of Ekip communication modules further extends the Tmax XT's capabilities →03.

#### **Bringing it all together**

ABB Ability™ Energy Manager and ABB Ability Asset Manager are solutions that enable an on-premise or cloud approach to monitoring and analyzing site equipment. Together, these solutions allow managers to control an entire site's electrical distribution system (and multiple energy sources). ABB Ability Energy Manager facilitates multi-utility monitoring, energy audits and cost management in a single, intuitive dashboard that helps organizations understand their energy consumption and identify areas for improvement – in one location or across multiple sites →04. ABB Ability Asset Manager alone can deliver a 30 percent savings in operating expenses.

Across a range of facility types, including food and beverage plants, ABB Ability Energy Manager and ABB Ability Asset Manager provide not just device-level visibility, but empower insights at the system level. The associated cloud architecture was developed in partnership with Microsoft to guarantee world-class reliability and security from end to end.

One of the most valuable functions offered by ABB Ability Asset Manager is predictive maintenance, which allows the monitoring of the overall plant health condition through a smart visualization (traffic light display). With this visualization, the user can monitor the system at a glance and benefit from proactive alerts. Operation and maintenance cost savings are achieved thanks to optimized scheduling and spare parts management – customers know exactly what components they might need, avoiding unnecessary spare parts purchases and saving time.

#### **Fiorentini feasts on energy savings**

One of Europe's leading manufacturers of crackers, cereals and rice cakes, Fiorentini, has specified ABB Ability Energy Manager to control the entire electrical power distribution across its new sustainable 56,000 m<sup>2</sup> production facility in Trofarello in Italy →05. The installation will support Fiorentini's ambitious commitments to reduce energy consumption by 400,000 kWh each year.



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05 The Fiorentini  
factory in Trofarello.

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06 The ABB CMS-700  
circuit monitoring  
system.

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07 The ABB Emax2.



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Monitoring almost 100 intelligent devices across the factory, the ABB Ability Energy Manager provides a real-time digital twin to remotely monitor the status of all critical power distribution and consumption points, and the performance of critical assets on the factory floor. This total visibility across all assets allows Fiorentini to make informed decisions on production line performance and energy consumption, maximizing energy savings and making the factory as sustainable as possible.

Luca Perri, operations manager for the Fiorentini factory said: “With our new ABB digital platform we can set up the cost plan on a daily basis to quantify real-time energy consumption. This allows us to optimally allocate energy resources and assets, which will help us to achieve our ambitious energy saving targets.”

In an industrial setup, such as that at Fiorentini, the ABB Ability Energy Manager is not only able to monitor consumption at the main power distribution switches, but, in combination with ABB’s circuit monitoring system CMS-700 →06, is also able to track energy use all the way down



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Fiorentini to make informed  
decisions on production perfor-  
mance and energy consumption.**

to the lowest branch of the electrical system, such as the building’s lighting. Other ABB components, for example, open-air Emax 2 circuit breakers →07, as well as Tmax T4 and T5 MCCBs further assist customers in achieving their energy usage targets.

With its full range of smart metering and monitoring solutions, ABB is well placed to measure and analyze energy consumption throughout an entire food and beverage plant, or even across geographically separated plants [3]. In this way, food and beverage producers can not only optimize their energy consumption while complying with all relevant standards but also select the best maintenance strategy and eliminate unplanned downtime to ensure their plants keep delivering quality produce for their customers. •

#### References

[1] ABB, “Smart Metering and Monitoring.” Available: <https://new.abb.com/low-voltage/launches/smart-metering-and-monitoring>. [Accessed February 16, 2022.]

[2] N. Kampelis and D. Kolokotsamar, Eds., “Smart Zero-energy Buildings and Communities for Smart Grids.” New Jersey: John Wiley & Sons, 2022.

[3] ABB, “Food & Beverage.” Available: <https://new.abb.com/about/our-businesses/electrification/electrification-food-beverage>. [Accessed February 16, 2022.]

## SMART SAFETY FOR THE FOOD AND BEVERAGE INDUSTRY

# Safe hands

ABB smart manufacturing solutions – such as safety controllers, digitalization modules and robust communications – provide food and beverage producers with an ecosystem that allows them to improve operational efficiency and conduct operations safely and in compliance with regulatory requirements.



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The investments in production equipment made each year by food and beverage producers are substantial. Often, these acquisitions have to be customized to suit the particular requirements of a production line, which can further increase cost and complexity. However, for production lines large or small, complex or simple, two important factors influence the choice of equipment: safety and the need to comply with increasingly strict regulatory requirements that apply across the entire value chain, from the raw material to the finished product. These factors can be successfully addressed by ABB smart manufacturing solutions – for instance, an integrated control system that covers the entire production process, combined with ABB

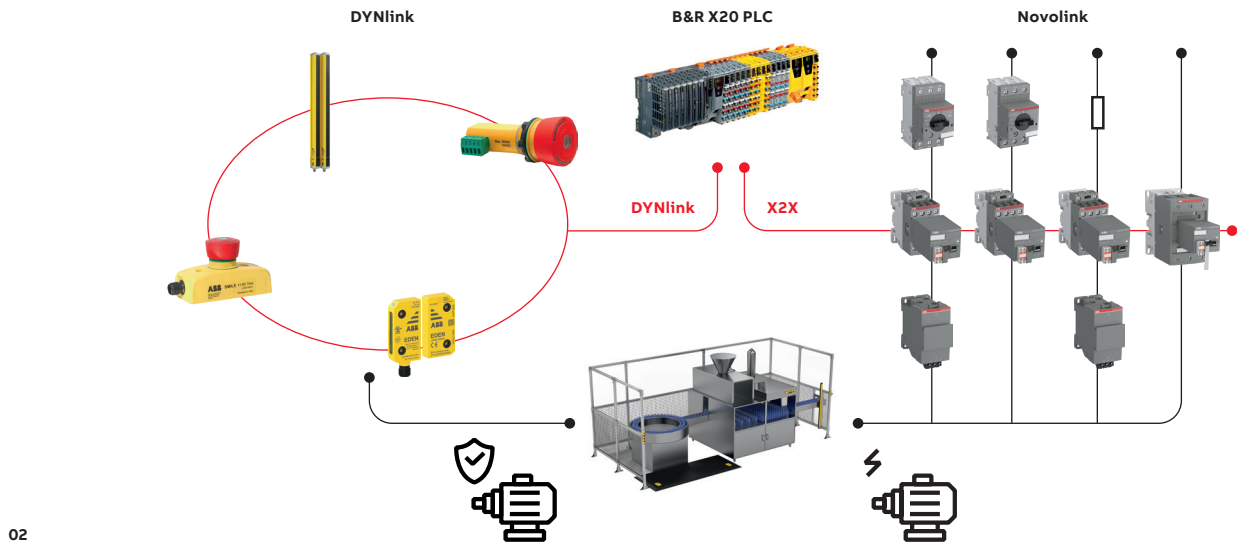
low-voltage components and B&R X20 programmable logic controllers (PLCs) →01–02.

## Smart safety from ABB

If incorrectly managed, a food and beverage production facility can present health and safety challenges as machinery, chemicals, spillages, dust, etc., can pose potential hazards. For these facilities, ABB offers a combination of solutions to manage machine automation and safety, from the simplest to the most complex setup:

- Small machines and simple safety applications
- Standalone safety independent from the control platform
- Complete production lines with factory-wide integrated automation and safety





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01 ABB's ecosystem for smart manufacturing helps power safety for the food and beverage industry.

02 The ABB ecosystem for smart manufacturing.

03 Overview of safety and ABB/B&R approaches to it in smart manufacturing.

### ABB relays and controllers for safety

For the simplest safety system, with only a few I/Os and limited requirements, standard safety relays are adequate. The Sentry series of safety relays from ABB is widely used in these cases. The Sentry has an economical and straightforward design and can be put to use immediately since setup is easy and no programming is needed.

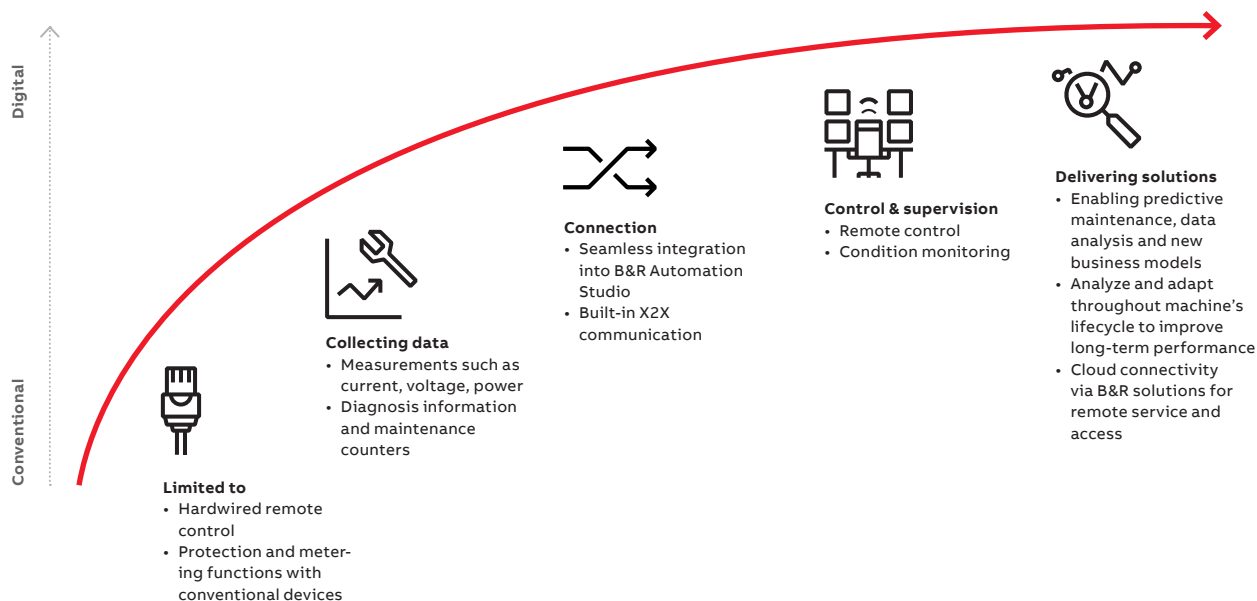
When a larger number of safety sensors and I/Os are needed, or if more advanced functions are required, particularly in terms of communication with the PLC, programmable safety controllers are a good choice. An example of such a controller is ABB's Pluto, which can be directly connected to the most commonly used safety equipment. Pluto is a powerful standalone safety controller that comes with free programming software and is simple to use.

PLC control systems with integrated safety are used for the most complex situations. These systems are versatile and offer the

same number of safety functions as safety controllers. Because both machine control and safety functions are performed in the same PLC, reliable intercommunication between these two features is facilitated and the entire configuration can be executed in a consistent

**PLC control systems with integrated safety are used for the most complex situations.**

programming environment. Moreover, the advanced diagnostic facilities available in these PLCs help engineers and end-users in their everyday work. The B&R X20 system is a highly capable and compact example of such a PLC that has integrated safety and proven compatibility with ABB safety sensors →03.



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### Communication interfaces

In the sometimes harsh environment of a food and beverage plant, robust communications are essential if safety is to be maintained and data relating to compliance with regulatory requirements is to remain secure. If compliance data is lost, traceability can be lost and facility certification jeopardized. ABB offers two communication interfaces that reliably connect safety sensors to safety controllers: OSSD and DYNlink →03.

## Novolink modules connect electric motors into higher-level automation and smart manufacturing systems.

The OSSD communication protocol is widely used for different types of safety sensors. OSSD enables the connection of multiple sensors in series while maintaining a high level of safety. Most safety controllers on the market (including ABB's Sentry and Pluto, and the B&R X20) can connect to and monitor OSSD-based sensors.

DYNlink is a communication protocol unique to ABB. It is a sensor communication and cabling approach that attains the highest level of safety using the minimum number of cables and controller inputs. DYNlink is compatible with ABB's Vital and Pluto controllers and the B&R X20.

Compared to OSSD, DYNlink requires only half the number of inputs, while still maintaining the highest safety level in serial connections.

Furthermore, DYNlink also enables add-on functions, such as StatusBus, to get status information from each sensor without adding any extra wires. For example, using just one of the existing leads in an M12-5 cable, StatusBus can keep track of the status of all devices connected in series. This feature provides a cost-effective way to monitor the status of doors, emergency stop buttons, etc.

### ABB Novolink™ devices digitalize industrial electric motors

Motor starters are ubiquitous in food and beverage facilities. Often, however, these essential production line elements are not intelligent. This situation can be remedied by ABB Novolink modules, which digitalize motor starters to gain insights into the connected loads and maintain a safe working environment. The modules are easy to design into existing wiring plans and they simply snap onto any AF contactor. Engineering efforts are minimized thanks to reduced wiring and fewer components compared to traditional methods of retroactive digitalization.

Novolink modules connect electric motors into higher-level automation and smart manufacturing systems, giving customers the real-time data and analytics they need to implement energy-saving strategies and operate safely. The modules enable the predictive maintenance, remote control, fault diagnostics and data analytics required for the world of Industry 4.0.

There are two Novolink modules: the SFM1 and the SCV10. The SFM1 Novolink contactor module monitors key maintenance statistics, including motor operating hours, contactor switching cycles and trips.



— 04 The ABB path from conventional to digital.

— 05 5 B&R Automation Studio software.

The SCV10 Novolink current and voltage module provides motor protection and monitors the status of connected equipment. This module connects to the SFM1 module and measures line voltages, phase currents, power, frequency, total harmonic distortion and other important parameters. The SCV10 uses a ribbon cable to connect via an X2X port to the SFM1, from which it draws

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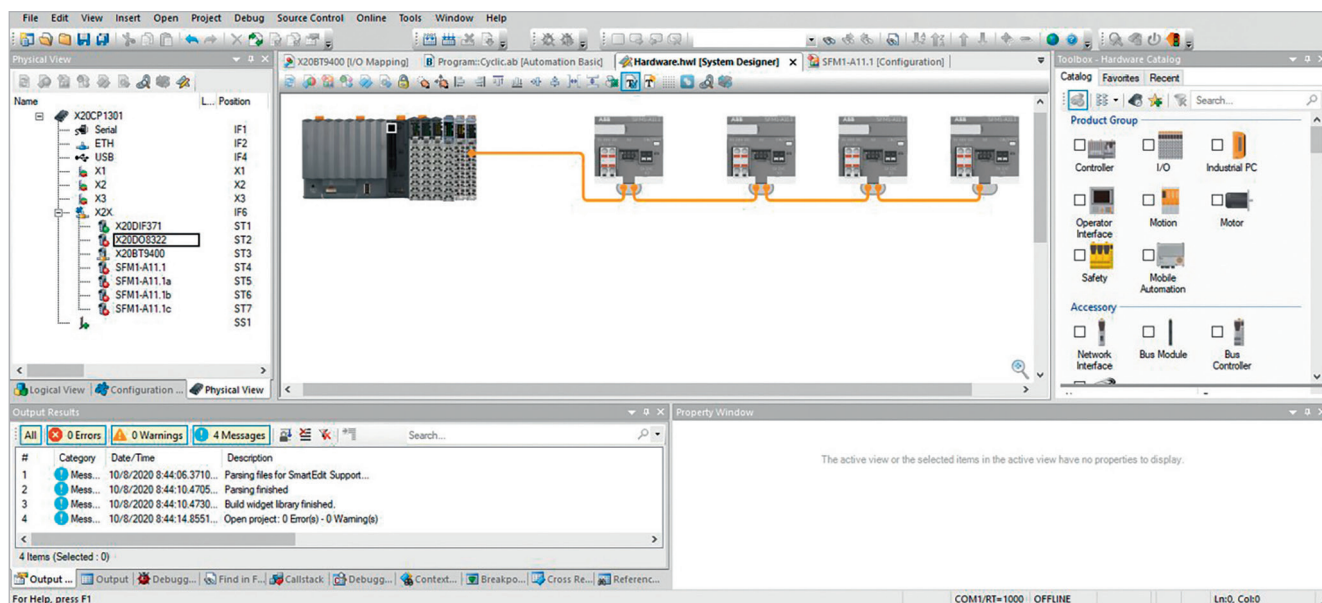
its power. The SCV10 module also offers thermal overload protection according to IEC/EN 60947 for single- and three-phase induction motors. The device also integrates current transformers that measure up to 40 A nominal current and voltage up to 690 V AC.

Novolink modules are compatible with 24 V DC coil contactors – from AF09 up to AF96 in screw versions and from AF09 up to AF38 in push-in spring versions. ABB's AF contactors have an advanced, electronically controlled magnet system that covers the complete power range and are complemented by a full list of accessories. Novolink modules can be connected in a daisy chain with multiple devices working in sequence using standard Ethernet cables.

The Novolink modules are fully integrated with the B&R automation system and help detect load, supply or feeder issues, thus reducing the time needed for problem-solving.

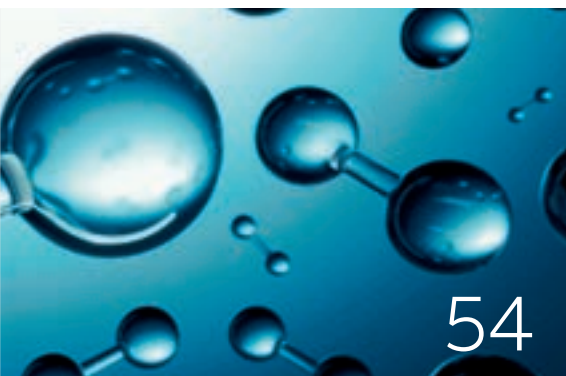
### The future lies with smart manufacturing

The migration from the traditional world to the new world of digitalization and smart and safe manufacturing results in shorter installation times, simplified engineering and preventive maintenance that is easy to implement. Measurements of principal parameters – such as current, voltage, power and energy consumption – are complemented by a wealth of diagnostic information. The solutions described in this article benefit from full compatibility with B&R Automation Studio (a software development environment) and B&R's integrated safety technology →04–05. Connectivity via B&R solutions facilitates remote access and service. It is now easier than ever to implement safety concepts with either OSSD or DYNlink communication protocols to allow customers to enhance safety, benefit from more flexibility in their production lines and be assured they adhere to regulatory requirements. •



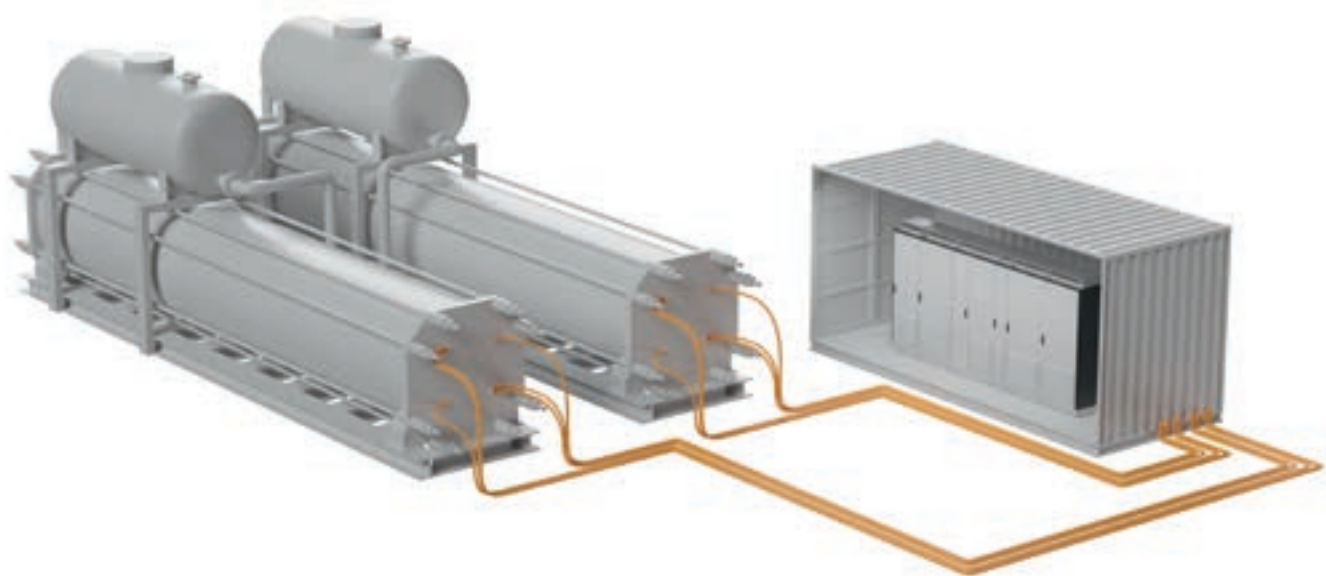
# Hydrogen





Hydrogen continues to gain attention as a source of green energy. ABB Review asked some of the company's experts on the topic to share insights on its potential impact in terms of decarbonizing major applications, the associated roles of advanced sensing systems and power supplies, as well as a key customer's plans for producing and using hydrogen to generate power.

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Hydrogen solutions that optimize applications
- 54      **Elusive molecule**  
How ABB sensing technologies ensure H<sub>2</sub> purity and safety
- 60      **Hydrogen production**  
State-of-the-art power supplies for electrolyzers
- 64      **Switch it on!**  
Two U.S. plants will produce 60 tons of green hydrogen per day



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HYDROGEN SOLUTIONS THAT OPTIMIZE APPLICATIONS

# Decarbonizing the future

As a clean-burning renewable fuel, hydrogen will play a key role in securing the target of achieving “net-zero” carbon dioxide emissions by 2050. Emerging applications such as near-grid energy storage, fuel-cell-powered mobility, heating, and direct reduction of iron (DRI), will become common as hydrogen progressively substitutes traditional fossil fuels in these processes. ABB offers measurement and analytics solutions that help to optimize all of these areas.





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Today, ammonia production accounts for approximately 50 percent of all global hydrogen use, while methanol production accounts for an additional 25 percent. Other major uses include refining, heat treatment processes to produce metals and glass, the hydrogenation of oils to fats in the food sector, and, increasingly, transportation and mobility applications; the latter, however, amount to less than five percent of total global hydrogen use.

In order to establish hydrogen as a cost-competitive energy solution, the capital cost of electrolyzer units must be reduced. Clearly, cost reductions will be achievable as the power of electrolyzers increases from the current 10 MW range to the 100 MW and 1 GW scale. For instance, plans call for a 50 MW electrolyzer powered by wind energy at the BP Lingen refinery at Emsland, Germany to be scaled up to 500 MW, which will be sufficient to supply the refinery's existing hydrogen demand while also enabling synthetic e-fuels production.

Hydrogen for refinery and petrochemical applications accounts for approximately 20 percent

of global hydrogen consumption today. Although this application is likely to decline over the coming decades, hydrogen's application in liquid biofuels processing is likely to grow. In both cases, the combination of carbon capture and sequestration (CCS) with hydrogen production by means of steam methane reforming methods (SMRs) will be essential to reduce the environmental impact of hydrogen production.

Here, the ability to precisely determine the composition of the incoming natural gas feedstock in order to quantify its energy value is essential. The BTU value of the natural gas coming into an SMR process is best measured using a rapid response gas chromatography system such as ABB's PGC1000, which is optimized for natural gas BTU analysis. Direct read infrared gas analyzers are ideal for measurement of final hydrogen purity. It is generally taken for granted that the

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gas coming off the SMR will be hydrogen but what really matters is the absence of CO and CO<sub>2</sub>. These are poisons to the hydro-treating catalysts in the subsequent processes where the hydrogen is used in a refinery. Typically, the final hydrogen product specification will have a maximum total combined CO and CO<sub>2</sub> content of 10 parts per million by volume. Simultaneous measurement of these two components can be achieved using ABB's Uras26 infrared gas analyzer module mounted in an Advance Optima AO2000 system.

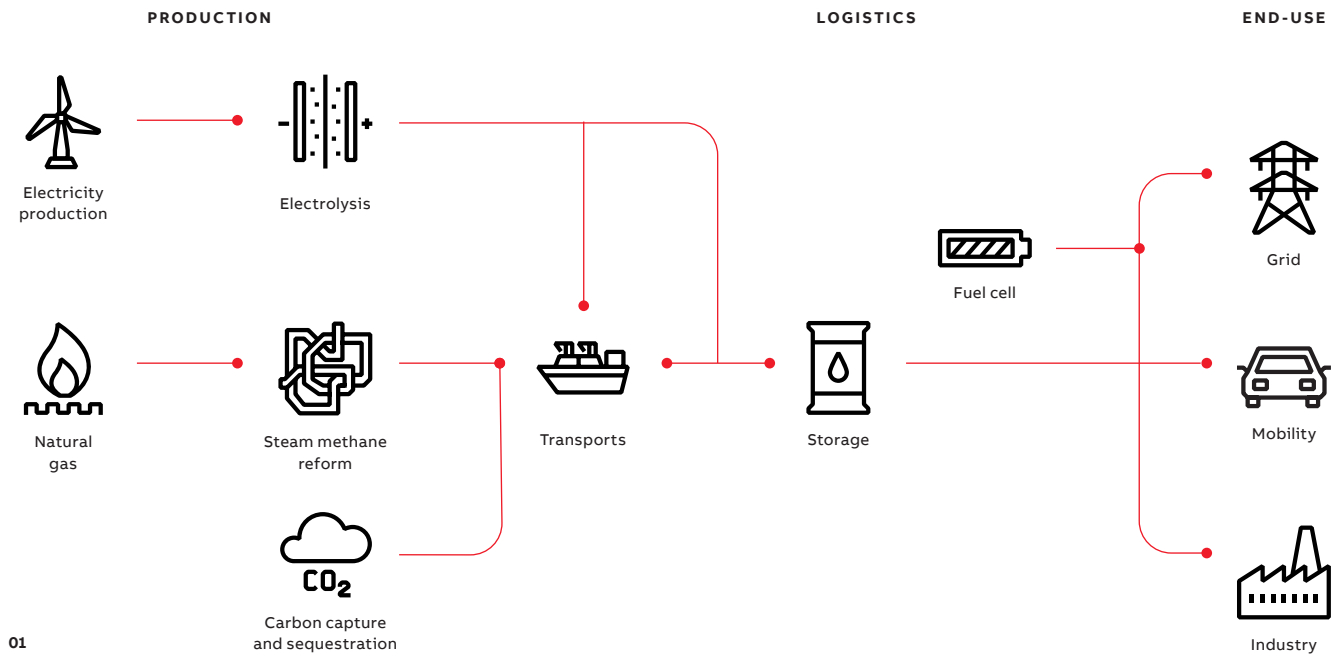
#### **Ammonia and methanol production**

As mentioned above, hydrogen's primary current application is in ammonia and methanol production. Ammonia is the number one petrochemical in terms of volume of production, and in fact is the second most common chemical of any kind



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in these terms. Ammonia consumption is tied directly to agriculture, where, in one form or another (liquid ammonia, “nitrogen” solutions, ammonia nitrate, or urea) it is used as fertilizer. However, although approximately 75 percent of the world’s hydrogen production capacity is

Current decarbonization trends make it clear that the steel sector is set to become a major consumer of hydrogen.

locked into the methanol and ammonia value chains, there is an increasing shift toward “clean” hydrogen, either through capturing carbon dioxide emissions from SMR or autothermal reforming (ATR) operations, or by moving toward electrolysis powered by renewable energy. Below are examples from several key industries that illustrate this point →01.

#### Decarbonizing iron, steel and cement production

Current decarbonization trends make it clear that the steel sector is set to become a major consumer of hydrogen in coming years. For instance, as an alternative to the CO<sub>2</sub>-intensive production and use of coke, hydrogen can be used in a process referred to as “direct reduction of iron” or DRI →02. Here, the hydrogen reacts with ore to produce iron and water vapor. An ArcelorMittal

facility in Hamburg, Germany is one of several plants worldwide that is conducting tests to establish the viability of this process.

As a number of pilot studies indicate, hydrogen is also expected to play a major role in decarbonizing cement production. Here, analyzers and instrumentation will continue to play an important role in ensuring safe, efficient, and compliant operations. The gas composition at different points in a cement production process can vary, which requires adapted or new solutions from equipment vendors such as ABB.

#### Decarbonizing aviation

With regard to hydrogen’s mobility applications, attention has largely focused on trucks, buses, cars, rail, and shipping. However, although aviation is one of the most challenging areas to decarbonize, a few hydrogen-powered drones and small-scale transporters have been proposed and piloted. Government programs and a handful of corporations are exploring possible renewable fuels for the aviation sector, including green hydrogen and synthetic e-fuels produced using a solid oxide electrolyzer (SOE), combined with a Fischer-Tropsch reactor.

#### Hydrogen admixing into the natural gas grid

Hydrogen gas is, of course, also entering the lives of individual consumers. For instance, in a project at Levenmouth, Fife, UK, green hydrogen will soon be used to heat 300 homes. The idea is to use renewable electrical power from a nearby wind farm to drive an electrolyzer that produces hydrogen. The hydrogen will then be mixed with

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02 Hydrogen can be used as an alternative to the CO<sub>2</sub>-intensive production and use of coke in a process referred to as "direct reduction of iron" or DRI.

natural gas and distributed through the existing gas distribution network. This makes good sense for countries that have embraced natural gas as a heating medium and have invested heavily in gas pipeline distribution infrastructures.

But hydrogen is not a panacea – at least not yet. Although admixing of hydrogen into existing natural gas grids is technically possible, several countries have set an upper limit of two percent hydrogen in existing natural gas pipeline grids.

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Eventually, much of the natural gas infrastructure will be converted to transport 100 percent hydrogen.

In Australia, gas pipeline operator Jemena has considered mixing up to ten percent hydrogen in the existing grid. And over time, much of the established natural gas infrastructure worldwide will be converted or replaced to transport 100

percent hydrogen. But this will call for major investments in new or refurbished pipelines since, depending on the type of steel involved, hydrogen can cause embrittlement that may lead to cracking and rupture.

Another concern is that the thermal heating energy value of hydrogen per unit of volume is less than that of natural gas. That means that existing metering systems would deliver less energy for the same invoiced monetary value. In other words, as the concentration of admixed hydrogen increases, gas composition measurement and gas metering systems will need to be transformed to ensure a fair supply of energy and accurate invoicing.

With this in mind, ABB's PGC1000, a rapid-response process gas chromatograph with a thermal conductivity detector that is ideal for monitoring the gas mixture composition in natural gas distribution and transmission systems, is an ideal solution. Established applications for this type of gas analyzer include monitoring the thermal value of natural gas in burner control systems to ensure the correct combustion stoichiometry.



Other ABB process gas chromatographs, such as those in the high-precision NGC8200 range, can be used for monitoring natural gas pipelines containing admixed hydrogen.

#### **Why hydrogen purity is essential**

Among its many potentially game-changing applications, hydrogen could be used to smooth out the seasonal imbalance between renewable electricity generation and energy demand. Production and long-term storage of green hydrogen produced on electrolyzers is a potential solution. However, a precondition for this scenario is the application of the international standard known as “ISO14687:2019 hydrogen fuel quality – product specification,” which includes a range of application-specific purity specifications. For example, with regard to hydrogen destined for use in fuel cell electric vehicles and other fuel cells, impurities such as CO and H<sub>2</sub>S are capped at levels that will guarantee the hydrogen is

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Hydrogen could smooth the seasonal imbalance between renewable electricity generation and energy demand.

compatible with standard modern fuel cells and does not poison sensitive catalysts. Nitrogen too must be managed because this inert gas would otherwise accumulate in fuel cells, resulting in a less active area for power production, which would lead to a gradual deterioration of fuel cell performance. Many of the standard’s specifications are easy to achieve with hydrogen produced in an electrolyzer, but they become more challenging when hydrogen is produced on an SMR or ATR – processes that demand careful gas analysis with sensitive equipment.

Having supplied instrumentation and analyzer solutions for hydrogen applications for decades, ABB’s portfolio offers a range of solutions for this increasingly important market →03. Examples include “H-shield” for pressure, level, and flow products, which ensures extremely high resistance against hydrogen permeation. In the area of gas analyzers, ABB products ensure the

safety, efficiency and reliability of hydrogen production and downstream processes in hundreds of installations around the world. Furthermore, in line with the evolving hydrogen environment, ABB offers associated software solutions that harness the power of measurement and diagnostic data to monitor and inform regarding the health of devices.

#### **Conclusion**

Hydrogen will clearly play a major role in a decarbonized future. Green hydrogen produced from renewable power and water will be one part of the solution. Blue hydrogen produced from natural gas, combined with CCS will also play a significant role. The precise routes to the goal are still unknown and each region is likely to follow its own path to 2050 and beyond. In each route to decarbonization, gas analyzers and instrumentation will be required to ensure safe, successful, and environmentally compliant operations. Products and services from ABB Measurement and Analytics will be at the heart of the action, as will a myriad of power management solutions and process control systems from the wider ABB Group.

Moving forward, ABB is not standing still on sensor technology development to meet evolving measurement needs and is leading the way on digital software solutions to harness the power of data with a view to improving the energy efficiency of customers. •



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03 ABB's portfolio offers a wide range of solutions for the hydrogen market.

## ABB'S "HYDROGEN-READY" SOLUTIONS



### ANALYZERS

- Continuous gas analyzers
- Continuous emission monitoring systems (CEMS)
- ICOS laser technology
- Process gas chromatographs
- Standardized, system solutions – Containerized "Analyzer-houses"



### INSTRUMENTATION

- Thermal mass flowmeters
- Variable area flow
- Pressure & temperature measurement
- Level transmitters and switches
- Digital products with latest communication standards
- Platform concept: Same look & feel across portfolio



### SERVICE & DIGITAL

- Measurement Care Service Agreements
- My Measurement Assistant
- ABB Ability™ Remote Insights for service
- ABB Ability™ Condition Monitoring for measurement devices
- ABB Ability™ Verification for measurement devices



### MAIN ELECTRICAL AND AUTOMATION CONTRACTORS (MEC, MAC)

- Plant control (DCS solutions)
- Containerized modular electrical and automation infrastructure
- Compressors/pumping station control
- Telecom, security and monitoring for pipelines
- Full project execution
- Life cycle service



HOW ABB SENSING TECHNOLOGIES ENSURE  
H<sub>2</sub> PURITY AND SAFETY

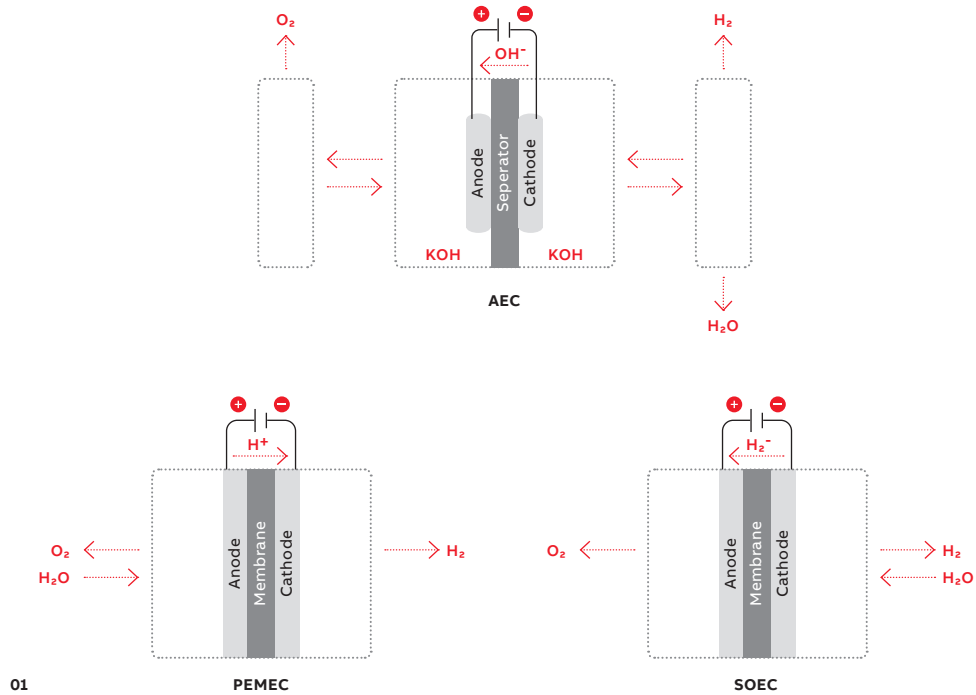
# Elusive molecule

The production of hydrogen from green electricity holds the potential to deeply reshape transportation, power, gas, chemicals, and fuel markets. But as the smallest and most elusive molecule in the periodic table, hydrogen presents a number of sensing challenges in terms of production, transportation, storage, and end use. ABB offers a range of instrumentation and analyzer solutions.

Hydrogen is set to play a central role in enabling a decarbonized energy system. It can store energy, provide flexibility, and transport high volumes of energy over long distances via pipelines and ships, making it possible to exploit renewable energy sources (RES) in remote locations.

But hydrogen's contribution extends much further than energy storage because it can be converted into fuels and chemicals. Furthermore, the production of hydrogen from electricity will deeply reshape current power, gas, chemicals, and fuel markets [1]. In short, hydrogen is the best candidate to be the "clean molecule" able to complement "clean electrons."

Although hydrogen use is largely CO<sub>2</sub>-free, it is produced using a range of energy sources and technologies each of which has a different impact on greenhouse gas emissions.



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01 Water and gas flows in the main types of commercial electrolyzers.

Ultimately, however, the real game-changer is represented by electrolysis, where hydrogen is produced through an electrochemical process that splits water into hydrogen and oxygen, with zero CO<sub>2</sub> emissions. If electricity can be certified to have come only from renewable energy sources, the resulting product can be defined as green hydrogen – the Holy Grail of the decarbonization effort.

While less than 0.1 percent of global hydrogen production comes from water electrolysis and is mostly used in markets with specific high-purity demand (for example, electronics and polysilicon) [2], green hydrogen is attracting wide attention and unprecedented investments. The European Commission, for instance, has earmarked unprecedented resources to develop a hydrogen strategy aiming at raising the value of its hydrogen sector from the current 2 billion to 140 billion Euros by 2030, with more than 140,000 jobs expected to be created as a result [3]

From a technical perspective, three H<sub>2</sub> production technologies are presently available:

- alkaline electrolyte cells (AEC),
- polymer electrolyte membranes (PEM, or PEMEC), also known as proton exchange membranes, and
- solid oxide electrolyzers (SOE or SOEC) → 01.

AEC electrolyzers have a lower CAPEX than the other two technologies. They are also the most mature technology, which means that large scale

AEC electrolyzers have a proven track record of reliability that the PEM and SOE processes have not yet had the time to accumulate.

PEM systems offer a quick ramp-up. When operated at pressures of up to 30 bar, which some other electrolyzer technologies can also achieve, they offer a smaller physical footprint

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The European Commission aims to raise the value of its hydrogen sector from the current 2 billion to 140 billion Euros by 2030.

compared to atmospheric pressure electrolysis systems. This means that subsequent high pressure gas compression costs are minimized if the hydrogen is intended for gas grid injection or high-pressure storage.

Solid oxide electrolysis (SOE) cells are fundamentally the reverse of solid oxide fuel cells. Most SOE equipment operates in the range of 650 to 850 °C using water in the form of steam and deriving a significant percentage of its energy from the heat of the steam. High-temperature electrolysis has significant advantages over low-temperature technologies, including high efficiency and no need for expensive noble metal



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electrocatalysts. This means that approximately one third less electrical power is required, compared to a PEM or AEC electrolyzer, to produce the same amount of hydrogen [4]. However, SOE is still behind in terms of industrial development.

### The green hydrogen value chain

Production is just the beginning of the hydrogen economy value chain, which also includes transportation, storage and end-use → 02. Most of the business and technical issues associated with H<sub>2</sub> come from the molecule's chemical and physical properties, since it is the smallest and lightest molecule in nature. Thus, hydrogen features a

Green hydrogen has a crucial role in reducing CO<sub>2</sub> emissions in hard-to-abate industries, such as steel production.

very low boiling point and, under normal conditions, very low density. In order to make it a significant energy vector it must be pressurized and either liquified or converted into some other chemical carrier.

Typically, H<sub>2</sub> is transported from a production site to end use via pipeline, over roads, in cryogenic liquid tanker trucks or in gaseous tube trailers, by rail or by barge. Pipelines are the most economical means of inland transport in bulk,

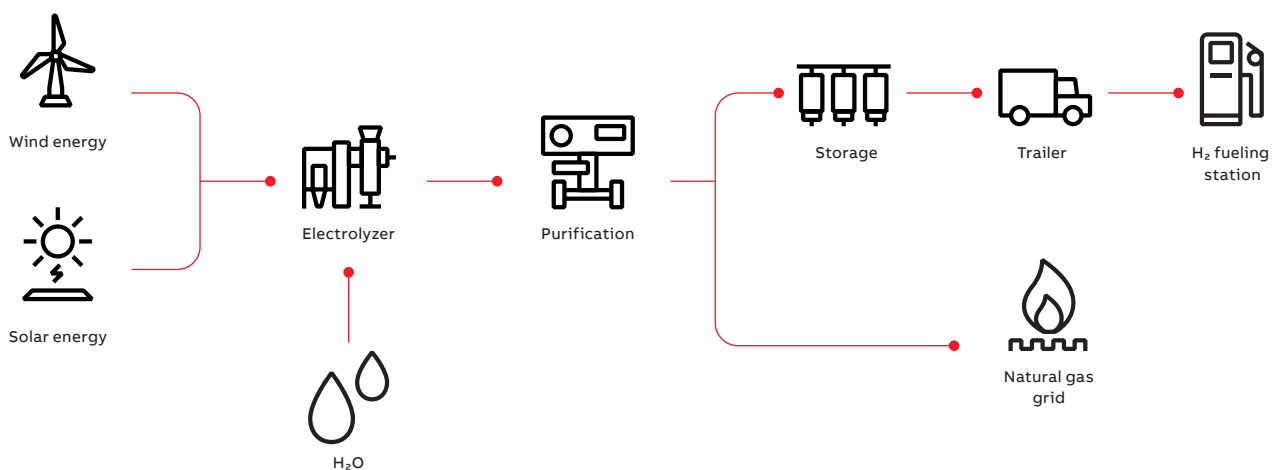
but for longer distances and overseas shipping, in order to be economical, H<sub>2</sub> must be either liquified or converted into some other carrier such as ammonia or benzyltoluene.

Depending on storage duration requirements, hydrogen may be realized in:

- Gaseous form: This is the cheapest option. In this form it can be stored underground in salt caverns or depleted gas fields, or in pressurized tanks such as in fuel cell vehicles.
- Liquid form: Here, gaseous hydrogen is converted to its pure liquid form to increase its energy density. This mode of storage is more efficient than gaseous storage but more expensive because it requires three steps: a liquefaction stage where gaseous hydrogen is cooled down to below -253 °C and converted to a liquid, liquid storage, and a regasification stage during which it is converted back to a gaseous form.
- Chemical form: In this case, H<sub>2</sub> is bonded to another atom or molecule. Ammonia and liquid organic hydrogen carriers (LOHC) are among the most promising molecules that allow liquid storage.

The last step in the green hydrogen value chain is end use. Without entering into details, we can identify three main application areas:

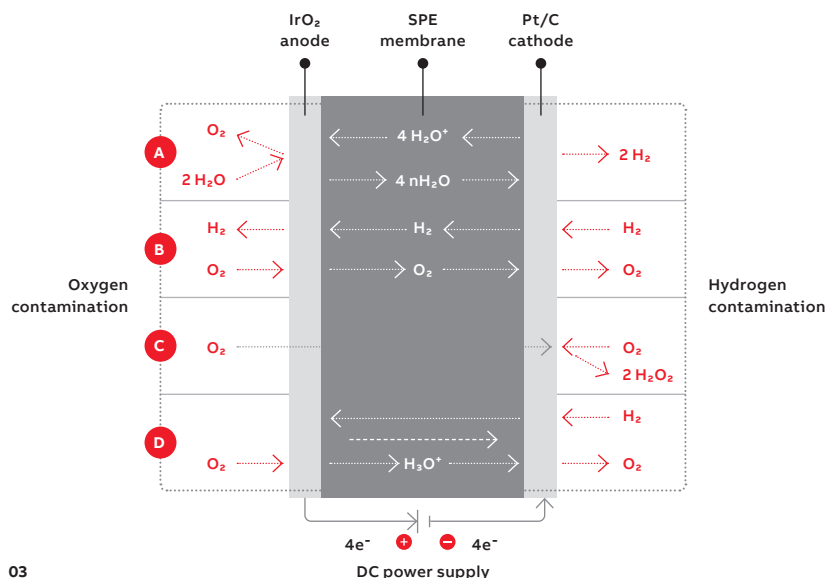
- Mobility: Green hydrogen is being used in transportation by exploiting fuel cell technologies. Fuel cell-powered electric vehicles have a hydrogen tank that feeds a fuel cell, where the electricity that powers the engine is generated. Presently the focus is on public transportation





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02 How hydrogen is produced and where it is used.

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03 Hydrogen reactions and mass transfer mechanisms. SPE: solid polymer electrolyte. Pt/C: particles catalyst.



03

and special purpose vehicles for airports, shopping centers, etc.

- Industrial use: Beyond replacing gray hydrogen in traditional sectors like refining and fertilizers, green hydrogen has a crucial role in reducing  $\text{CO}_2$  emission in so-called hard-to-abate industries (ie, where electricity is not applicable or practical), such as steel, glass, and ceramic production.
- Domestic use: Hydrogen blending into natural gas (NG) for domestic households is an effective way to generate heat and power with lower emissions than using NG alone and many gas utilities are investing in this area. Admixing of hydrogen into existing natural gas grids is technically possible and permitted at limited percentages in many countries. At present, several countries have set an upper limit of two percent hydrogen in existing pipeline grids.

#### Measurement Challenges

As the smallest and most elusive element in the periodic table hydrogen features some peculiar physical-chemical properties that entail a number of measurement problems. To make the hydrogen economy a reality, a number of sensing challenges must be overcome. These are outlined below.

Electrolyzers need sensitive gas analyzers for safe operation. Broadly speaking, they produce oxygen at the anode and hydrogen at the cathode. However, this is a simplification of some very complex electrochemistry. Many reactions that take place in an electrolyzer can cause small concentrations of oxygen to build up in the hydrogen stream and vice-versa. Furthermore,

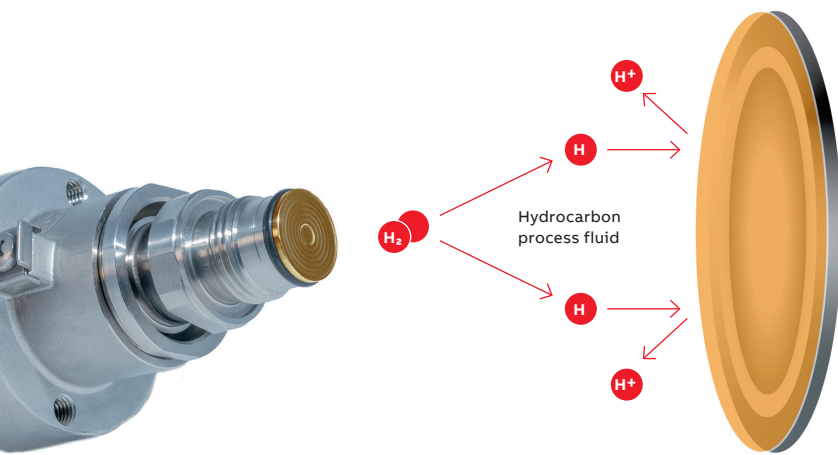
the electrolyzer stack assembly can leak gas from one side of the electrolyzer cell to the other, resulting in significant safety risks → 03.

#### Production

Process control of a hydrogen electrolyzer performs several duties: safe operation, efficient power-to-hydrogen conversion, and hydrogen and oxygen gas purity quality control. ISO22734:2019 explicitly specifies many parameters that must be measured to ensure safe and reliable hydrogen electrolyzer operation [5]

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As electrolyzers produce oxygen at the anode and hydrogen at the cathode, they need gas analyzers for safe operation.

While many of the measured parameters are common to all electrolyzers (eg, temperature in the electrolyzer stack to avoid over-heating, gas impurities, etc.), others are specific to the electrolyzer technology seen in the first section of this article. For example, hazardous liquid leak detection is more relevant when handling highly concentrated potassium hydroxide solutions on an AEC electrolyzer than when working with pure water on a PEM system for which water purity is of paramount importance. For its part, SOE technology, when operating at high temperature, is more demanding in terms of steam supply management measurements.



04

### Storage and Transportation

Storage and handling of hydrogen involves safety issues that must be understood and mitigated to ensure secure operations. Hydrogen presents some potential hazards because:

- It has a low ignition energy (0.017 mJ against 0.25 mJ for hydrocarbons). Leaks from piping flanges, for example, are particularly hazardous because the simple friction induced by a leak itself can be a source of ignition. Additionally, in case of ignition, hydrogen can burn with an invisible flame and low radiated heat, making it difficult even to spot the flame.
- $H_2$  is a tiny molecule that dissociates into ions. At high temperatures it can diffuse and permeate metals, leading to embrittlement of equipment and pipelines [6].

Accurate and reliable infrastructure monitoring is therefore mandatory. Furthermore, there are still many unresolved problems regarding, eg, monitoring of long and/or underground pipelines [7]. In addition to rigorous leak detection, storage facilities require preliminary drying in order to remove moisture, thus requiring hydrogen purity analyzers.

### End use

Different end uses trigger different problems. With regard to mobility, the main challenges are related to accurate flow metering and to fuel cell protection by measuring  $H_2$  impurities at very low levels (for example total sulphur at 4 nmol/mol) at each refueling station [8]. Probably the lowest-hanging fruit for hydrogen use is its blending in natural gas distribution networks. The main measurement issues here are related to:

- Providing an accurate and effective blend ratio and ensuring  $H_2$  quality measurement.
- Extending and tailoring custody transfer procedures for blending; this is essential

since the thermal heating energy value of hydrogen per unit of volume is less than that of natural gas.

- Preventing hydrogen-induced cracking. For some grades of steel, too much hydrogen, particularly at higher temperatures, can cause embrittlement that may lead to cracking and rupture.

### ABB Solutions and success stories

ABB has an established range of instrumentation and analyzer solutions for hydrogen applications. Among the products specifically addressing green hydrogen-related challenges is the company's "H-shield" option for pressure, level and flow products, which ensures an extremely high level of resistance against hydrogen permeation →04. Applied using the vapor deposition process,

ABB's "H-shield" option for pressure, level and flow products, ensures resistance against hydrogen permeation.

for instance, H-shield forms a protective coating at a uniform thickness across the surface of the diaphragm, while offering sufficient flexibility for the diaphragm to move in response to changing pressure conditions [9].

With regard to fuel-cell-powered vehicles, ABB offers Sensyflow FMT700-P, a compact thermal mass flowmeter, which is the latest addition to a product range already proven for measuring engine intake air on test benches. The device is ideally suited to fine-tuning the efficiency of fuel cells. Thanks to its unrivalled response time (25 milliseconds), the device is used by leading automobile manufacturers worldwide to measure intake air in quality assurance, test bench applications, and research and development [10].

ABB contributes to the safe management of electrolyzers through its analyzers, which are able to provide accurate measurement of impurities in the  $O_2$  and  $H_2$  streams in hazardous areas. These measurements can be combined into one device if semi-continuous measurement is acceptable [11].

Finally, as mentioned earlier, hydrogen blending into the NG grid is already a mature option for reducing  $CO_2$  impact. ABB's PGC1000 is ideal for monitoring the gas mixture composition in natural gas distribution and transmission systems. It is a rapid-response process gas chromatograph with a thermal conductivity detector. Established

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04 Isolation diaphragm  
with ABB's H-shield  
coating and pressure.

—  
05 An ABB gas  
chromatograph with a  
thermal conductivity  
detector.



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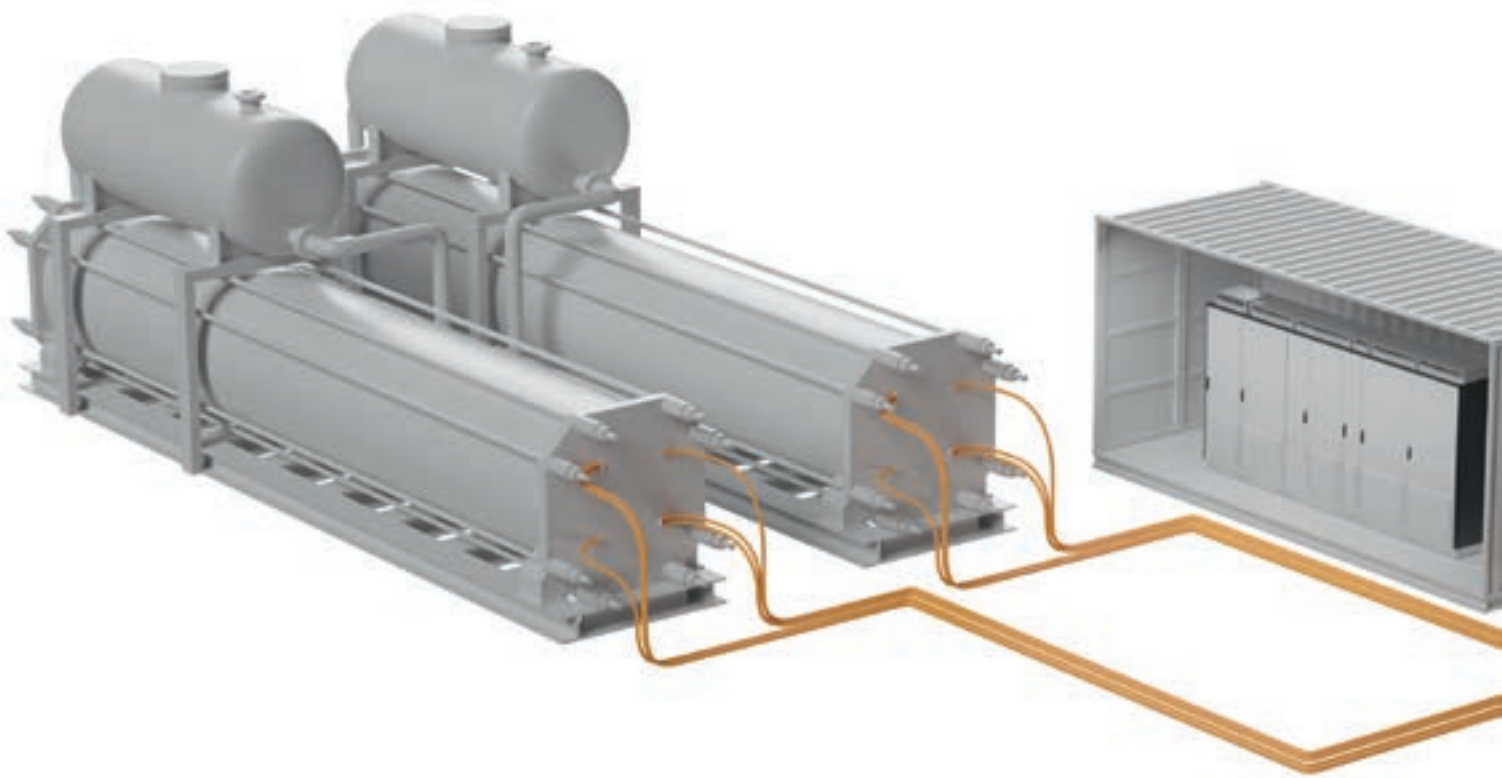
applications for this type of gas analyzer include monitoring the thermal value of natural gas in burner control systems and ensuring the correct combustion stoichiometry →05.

The track record that ABB has developed with these gas analyzers can be transferred to monitoring natural gas pipelines containing admixed hydrogen. Market acceptance is extremely encouraging. In Italy, where gas transmission and distribution companies are investing in ambitious H<sub>2</sub> blending programs, more than 35 analyzers have been provided in recent months. •

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ABB's PGC1000 is ideal for monitoring the gas mixture composition in natural gas distribution and transmission systems.

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STATE-OF-THE-ART POWER SUPPLIES FOR ELECTROLYZERS

# Hydrogen production

Considering that it is the world's cleanest energy source, hydrogen is set to play a key role in the decarbonization of several industrial sectors. Crucial to this rapidly developing process is the development of electrolyzer power supplies, which must be capable of managing unregulated low DC voltage under megawatt-scale power levels. This article presents an overview of state-of-the-art power supplies for electrolyzers, while examining the pros and cons behind each configuration.





Decarbonization of major energy-consuming sectors is a top priority of the 2015 Paris Agreement and the Intergovernmental Panel on Climate Change (IPCC) climate change 2022 report. Perhaps the most promising strategy for addressing this challenge is the implementation of hydrogen production technologies. These are seen to be a solution for many sectors, including so-called “hard-to-abate” areas in which it can be used as a feedstock or directly as a fuel [1].

Hydrogen is the world’s cleanest energy source, with around 80 million tons currently being produced annually [2]. Furthermore, production is expected to exceed 200 million tons by 2030, and 500 million tons by 2050 [3].

There are different ways of producing hydrogen, but water electrolysis, which today accounts for only around 0.3 GW, is expected to account for more than 60 percent of global production by 2050 [3]. In view of this, global electrolyzer capacity is expected to reach 850 GW by 2030 and 3,600 GW by 2050 →01.

Among the many important factors that must be considered in terms of enhancing electrolyzer performance while reducing cost is power supply. Different power supply configurations can be utilized, with each configuration having pros and cons as seen from both the grid and the electrolyzer perspectives.

With a view to making sense of these complex circumstances, this article presents a general classification and review of the state-of-the-art power supplies that can be utilized with grid-connected water electrolysis systems, while highlighting the pros and cons behind each configuration.

### Water electrolysis technology and types of electrolyzers

Electrolyzers and fuel cells have a lot in common, but they also have a fundamental difference. The former use electrical energy to split the bonds of water and oxygen to release hydrogen →02, whereas fuel cells use hydrogen to produce electricity.

There are different types of electrolyzers, with alkaline, proton exchange membrane (PEM), and solid-oxide systems being the most common technologies. Alkaline electrolyzers represent a mature technology compared to PEM systems and have lower investment costs. Currently, PEM electrolyzers are behind their alkaline

counterparts in terms of efficiency and cost due to their dependence on noble material. However, this is expected to change over the next few years. On the other hand, PEM electrolyzers have better dynamics and offer higher power density, meaning that they require 20–25 percent less space than alkaline systems [1].

Compared to alkaline and PEM electrolyzers, solid-oxide systems can offer higher efficiencies and can also be reversed to be fuel cells, thus generating electricity from hydrogen by using about 25 percent of the electrolyzer’s capacity

Water electrolysis is expected to account for more than 60 percent of global hydrogen production by 2050.

[1]. On the other hand, solid-oxide electrolyzers operate at much higher temperatures compared to their alkaline and PEM counterparts, which still operate in the kW scale.

### Classification of power supplies for electrolyzers

Electrolyzers are characterized as low-voltage (LV) equipment, where a typical 5 MW unit can have a maximum DC voltage of 1 kV by end-of-life. Hence, connecting it to a medium-voltage (MV) network is typically accomplished through a step-down transformer along with an AC/DC converter. Such a converter can be a single-stage solution, where the AC power is converted to DC in a single step as shown in →03a, where the DC power should meet the electrolyzer’s requirements.

On the other hand, the converter can be a two-stage solution, where the AC power is converted to DC and then this DC power is converted to another DC level that meets an electrolyzer’s requirements as shown in →03b.

Each of these configurations can utilize different converters, as illustrated by the state-of-the-art options highlighted in this article. In addition to the above-mentioned AC supplied systems, electrolyzers can be coupled to a DC distribution system. This requires only DC/DC converters for the voltage level matching.

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01 Hydrogen production by water electrolysis is expected to grow considerably.

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### Single-stage power supplies

As described in the prior section, single-stage solutions convert AC power from a transformer to DC power that meets the electrolyzer's requirements under different operating conditions.

Different converters can be utilized for this purpose, as illustrated in →04 where four configurations are utilized as state-of-the-art options.

The first option is the six-pulse thyristor rectifier, whose topology is shown in →04a. Despite its simplicity, this option introduces higher harmonic current content on the grid-side and high current ripples on the electrolyzer side along with high reactive power requirements. Such harmonic content can be reduced using the twelve-pulse thyristor rectifier option, which is presented in →04b. Moreover, the twelve-pulse thyristor rectifier can enable higher power through the parallel operation of two six-pulse rectifiers, although this requires a more complex transformer.

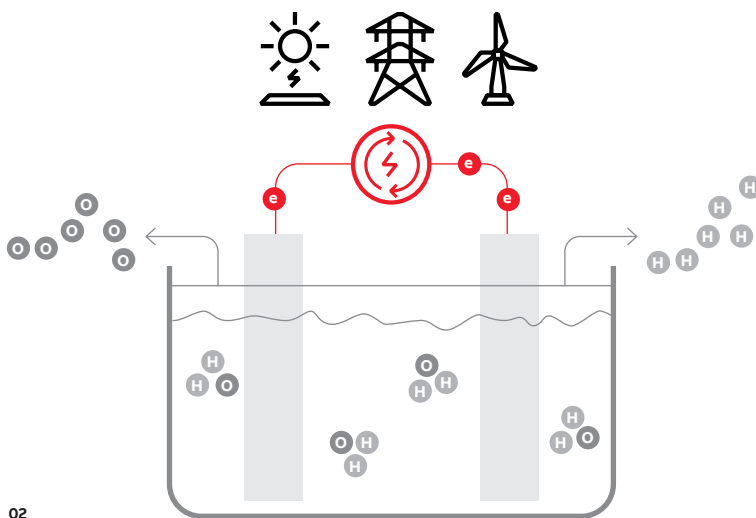
On the other hand, fully controlled options can be utilized, where, eg the two-level or three-level active voltage source rectifiers can be utilized as shown in →04c–d. Both options provide smoother electrolyzer current, whereas the prior options present a low frequency component in the electrolyzer current. Furthermore, both options significantly improve grid-side performance in terms of reactive power and current harmonics. However, lower efficiency is expected under these options due to increased semiconductor losses. In addition, both active options suffer from higher current stress due to the boosting nature of these topologies.

### Two-stage power supplies

Compared to the prior single-stage options, the two-stage options convert the AC power from the transformer to DC power using an AC/DC converter, and then convert this DC power to another DC voltage level that matches the electrolyzer requirements as shown in →05.

The first option is presented in →05a. It is based on a twelve-pulse diode rectifier as an uncontrolled AC/DC converter, followed by an interleaved DC/DC buck converter. This solution enhances the reactive power content on the grid side compared to a 12-pulse thyristor rectifier, resulting in a compatible, yet slightly less efficient solution to power the electrolyzer.

In spite of these positive results, the current harmonic remains a challenge and additional harmonic filters must be utilized especially for weak grids. These reactive power and current harmonic challenges can be further addressed by replacing the twelve-pulse diode rectifier with a two-level active voltage source rectifier as shown in →05b. This solution, compared to the prior



02



03a



03b

The two-stage solution utilizes an additional DC/DC converter in order to enhance overall system performance.

boosting single-stage two-level voltage source rectifier, avoids the increased current stresses in the AC/DC conversion stage. In other words, the single-stage two-level active rectifier requires a lower voltage on the AC side compared to the two-stage option that is depicted in →05b. Furthermore, the two-stage solution introduces an additional current stress to the DC capacitors as the AC/DC and the DC/DC stages both share the common DC link.

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02 Illustration of water electrolysis theory.

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03 General classification of electrolyzer power supplies.

03a Single-stage solution.

03b Two-stage solution.

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04 State-of-the-art single-stage power supplies for electrolyzers.

04a Six-pulse thyristor rectifier.

04b Twelve-pulse thyristor rectifier.

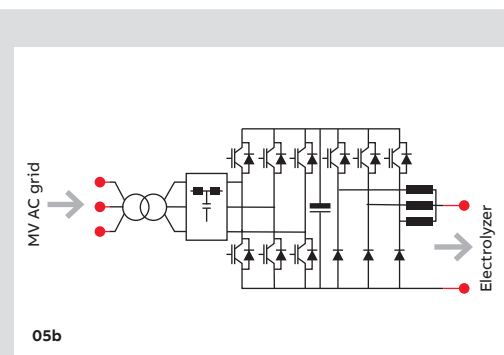
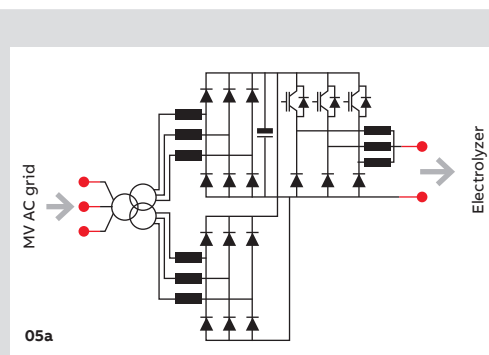
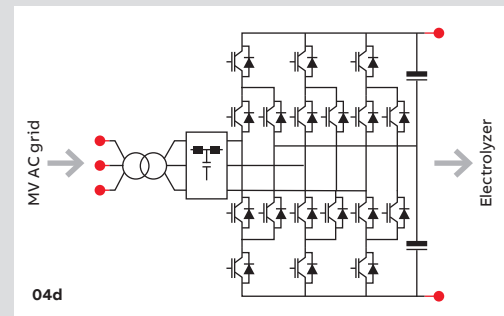
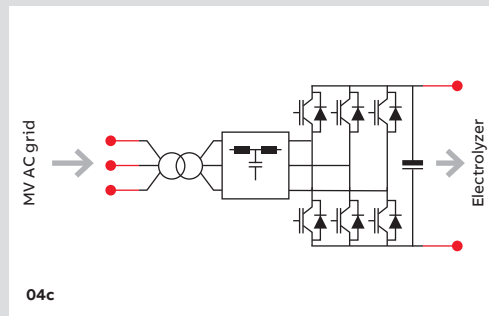
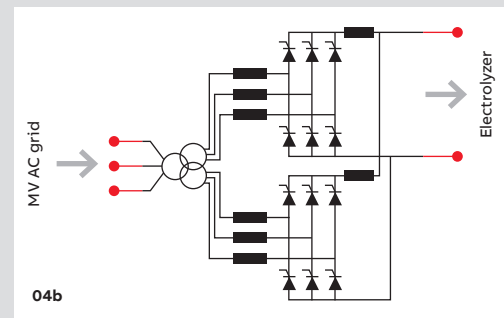
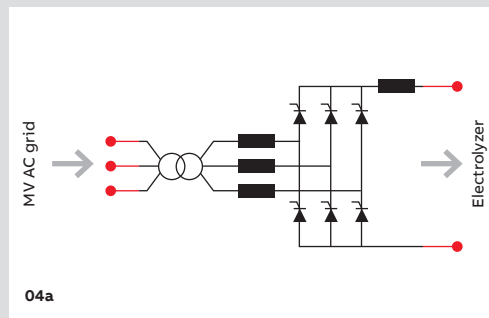
04c Two-level voltage source rectifier.

04d Three-level active neutral point-clamped voltage source rectifier.

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05 State-of-the-art two-stage power supplies for electrolyzers.

05a Twelve-pulse diode rectifier-fed interleaved buck converter.

05b Two-level voltage source rectifier-fed interleaved buck converter.



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## Conclusion

Power electronics will play an important role in terms of coping with and accelerating current and future plans for hydrogen production. Although the state-of-the-art power supply architectures that have been reviewed here can

Power electronics will play an important role in terms of accelerating current and future plans for hydrogen production.

cope with the dynamic behavior of an electrolyzer, solutions with higher power density and efficiency that also offer lower weight at lower cost will be fundamental.

Special attention should be paid to applications in which hydrogen is produced with renewable energy. The inherent fluctuations of such energy sources will also demand new electrical layouts. Control methods, together with new semiconductor materials such as silicon carbide and novel power converters may result in solutions that are compatible with both the grid and the electrolyzer, while simultaneously reducing complexity. •

## TWO U.S. PLANTS WILL PRODUCE 60 TONS OF GREEN HYDROGEN PER DAY

# Switch it on!

Demand for hydrogen, which has grown more than threefold since 1975, continues to rise. But while green hydrogen, which is produced without fossil fuels, represents only the smallest sliver of today's hydrogen production pie, it is, according to the International Energy Agency, enjoying unprecedented momentum [1]. Two new green hydrogen production centers now under construction in the United States will rely on multiple ABB systems – illustrating the rise of a potentially game-changing power source.

Thanks in large part to the steadily declining cost of renewable energy, green hydrogen is expected to play an essential role in meeting greenhouse gas emission targets worldwide. Indeed, scaled-up production could deliver hydrogen for a benchmark cost of \$2/kg in 2030 and \$1/kg in 2050 in many parts of the world [2], making it competitive with natural gas prices. In the

Scaled-up production could deliver hydrogen for a benchmark cost of \$2/kg in 2030 and \$1/kg in 2050.



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meantime, exponential growth in the hydrogen economy is expected to accelerate, reaching up to 500 to 800 million tons per year by 2050 [3], thus potentially supplying 20 percent of global energy demand.

In view of these trends, Plug, the leading provider of comprehensive hydrogen fuel cell (HFC) turnkey solutions, has established North America's first green hydrogen supply network. That network is slated to be expanded with the

opening of two new production facilities that will jointly produce 60 tons of green hydrogen daily. The hydrogen will replace some 170 tons of fossil fuels in the logistics and transportation sectors.

Already the largest buyer of liquid hydrogen globally, Plug has built more hydrogen refueling stations than any other company in the world. When its new green hydrogen production facilities enter service – one in the town of Alabama, New York, and the other in Peachtree, Georgia – they will help to fulfill its strategic plan of offering green hydrogen that is cost-competitive with fossil fuel energy to customers looking to meet sustainability goals.

The New York plant – which will be the largest green hydrogen production facility in North America – will be located in the New York Science, Technology and Advanced Manufacturing Park (STAMP), and will have its own electric substation. Producing 45 metric tons of green liquid hydrogen daily for the U.S. northeast – the equivalent of 126 tons of gasoline – the plant will use 120 MW of Plug's state-of-the-art proton exchange membrane (PEM) electrolyzers to split water into hydrogen and oxygen through an electrochemical process, using clean hydropower.







The production facility is designed to lead the way in decarbonizing freight transportation and logistics in New York state, thus supporting the state's path to achieving carbon-neutrality by 2050.

Located in Camden County, Georgia, Plug's second facility will produce 15 tons of liquid green hydrogen per day for customers in the southeastern U.S.

The New York and Georgia production facilities will join Plug's other plants under construction in the southern and western United States, as well as its PEM stack and electrolyzer Innovation Center in Rochester, New York. The network aims to supply

eHouse solution – a prefabricated, walk-in, modular outdoor power distribution center hosting a range of electrical, automation and ancillary equipment that provides site and process power. The pre-tested eHouse is designed to reduce both the costs and time needed for installation and commissioning.

ABB will also supply gas- and air-insulated switchgear, low voltage motor control centers, along with a low voltage variable speed drive for auxiliary applications. In addition, a medium voltage VSD will be applied to multiple motors in sync bypass mode. Used as a compressor starter, this drive will allow smooth process control, and will reduce stress to equipment and utility loads by limiting inrush current and power demand during the process start.

The Georgia plant will have a similar scope of work. As with the New York plant, its hydrogen will be used by the logistics and transportation sectors, enabling users to replace fossil fuels in on-road applications, such as heavy-duty freight vehicles and logistics equipment.

All in all, the New York and Georgia projects are an important part of Plug's plans to build additional plants around the U.S. to offer green hydrogen that is cost-competitive with fossil fuel energy.

For its part, ABB is collaborating with customers and partners around the world to develop and integrate technology that will make hydrogen an accessible and affordable component of the world's low carbon energy mix. •

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[3] Reuters. \$15 trillion global hydrogen investment needed to 2050-research. Available: <https://www.reuters.com/business/energy/15-trillion-global-hydrogen-investment-needed-2050-research-2021-04-26/> [Accessed August 11, 2022].

The new facilities will join a network that aims to supply 500 tons per day of green hydrogen by 2025.

500 tons per day of green hydrogen by 2025 and 1,000 tons per day globally by 2028. When fully built, the network will enable pricing competitive to diesel for its transportation fuel customers.

#### Scaling up

With a view to supporting Plug to scale up its technologies while bringing its overall production costs down, ABB is providing the Alabama facility with a full electrical system encased in an ABB

## RESULTS OF THE 2022 READERSHIP SURVEY

# Readership trends

ABB Review has been in continuous publication since 1914, possibly making it one of the world's oldest corporate technical journals in the world, 899 issues have been published to date. The journal has undergone numerous changes during this time. To be able to continue to develop the journal and better meet the expectations of its readers, a readership survey was launched with issue 2/2022.



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Among the topics surveyed were general satisfaction with the content of the publication, the choice of languages in which the journal should be offered, and the balance between the traditional print edition and developing digital formats. The survey could only be completed online, and may thus present a bias towards the digital readership.

## Languages

ABB Review is presently offered in five languages (English Chinese, German, Spanish and French). All of these languages are provided in both print and digital formats, except Chinese which is digital only.

According to the survey, more than one third of readers want to read ABB Review in English →01. Besides the five languages of publication, small numbers of readers expressed interest in (in order of significance) Italian, Swedish, Finnish, Dutch, Turkish, Greek, Japanese, Russian, Urdu, Sinhala,

majority of readers are also satisfied with article length →03, technical content →04 and frequency of publication →05.

## Digital versus print

The main method of print distribution remains personal subscription →06-09. The survey showed more readers reading digitally, although this finding may be skewed by the survey being online. There are also clearly many readers using both the print and digital editions.

Finally, the survey raised the topic of a “new, more interactive offering” of the digital version →10, and permitted readers to indicate what precisely they imagined such an offering might be. The favorite choice here was updated articles, followed by spotlights on topics and video content →11.

## Participation matters

The staff of ABB Review would like to thank all readers who participated in this survey for taking time to share their opinions.

The findings of the survey are flowing into the editorial process, and first changes will be rolled out next year. These include an increased digital content, and also a streamlining of the languages offered. It is with great regret that ABB Review announces the discontinuation of the French and Spanish editions. This has become necessary due to the very low distribution numbers in these languages (in reality lower than the feedback from this survey suggests). As from issue 1/2023, ABB Review will be offered in English, German and Chinese only. The staff of ABB Review trust that as many readers as possible will continue to read and support ABB Review. •

The main method of print distribution remains personal subscription.

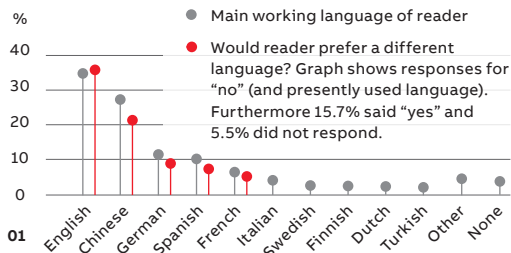
Croatian, Arabic, Norwegian, Brazilian Portuguese, Danish, Polish, Hungarian, Romanian, Lithuanian, Persian, Hindi and Marathi – indicative of the worldwide and diverse readership of the journal.

## Content

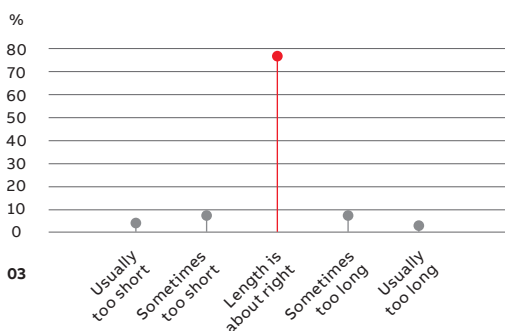
77 percent of readers use ABB Review to better understand ABB's technologies →02. The vast

**01** "What is your main working language?"  
"Would you like to have access to ABB Review in languages other than what you read now?"

(Note that presently offered languages are English, Chinese, German, French and Spanish)

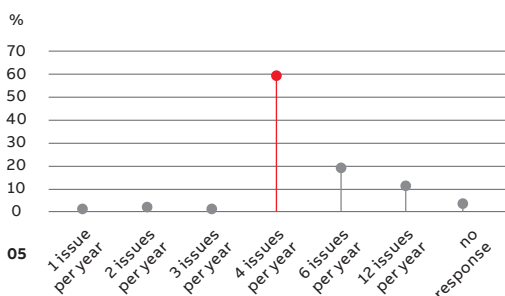


**02** "What are the main purposes of ABB Review for you?" (multiple responses permitted)

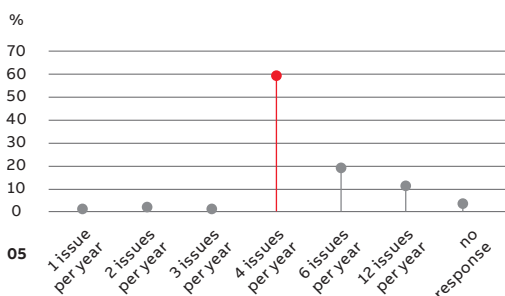


**03** "How satisfied are you with the typical length of ABB Review articles?"

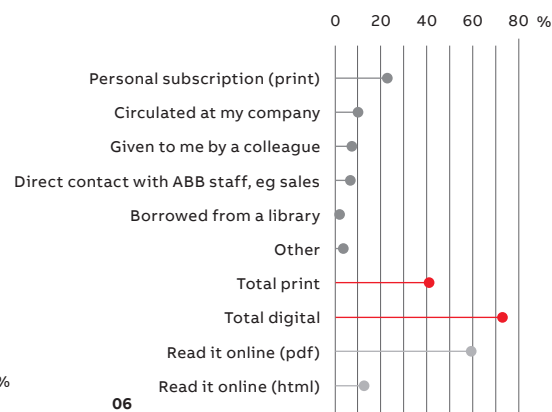
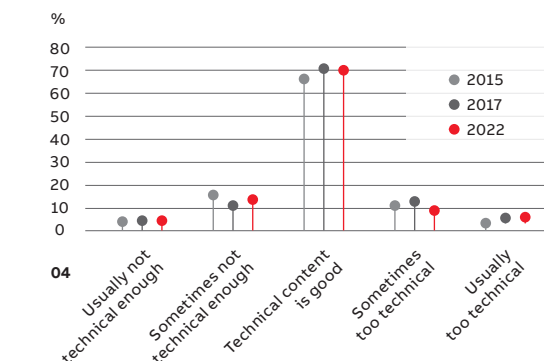
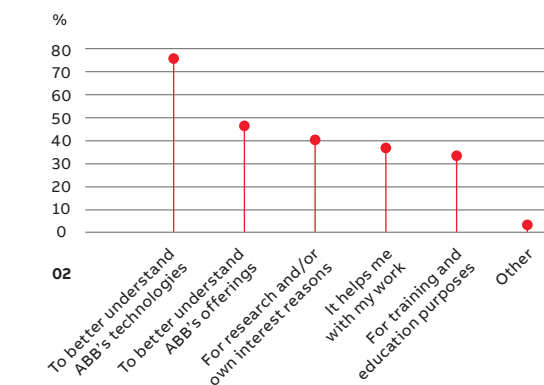
**04** "How satisfied are you with the level of technical content in ABB Review articles?"



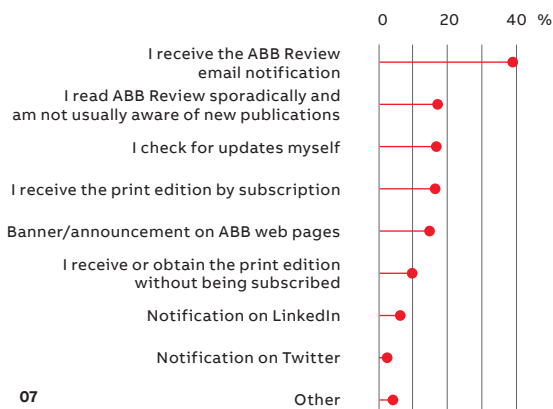
**05** "Are you happy with the current frequency of publication (four per year) or would you prefer?"



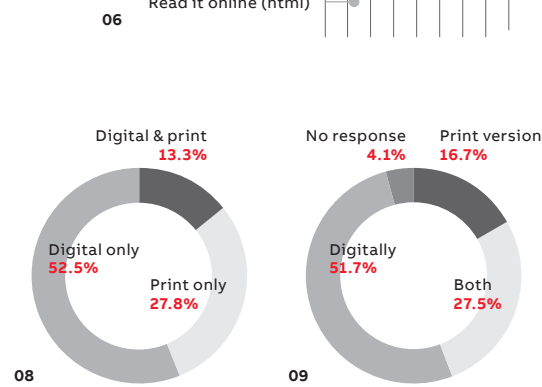
**06** "How do you receive your copy of ABB Review?" (multiple responses permitted)



**07** "How are you typically informed of the publication of a new edition?" (multiple responses permitted)

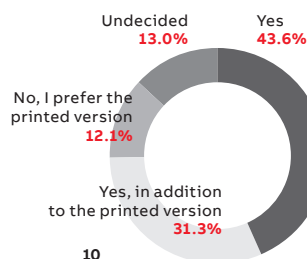


**08** "How do you receive ABB Review?"

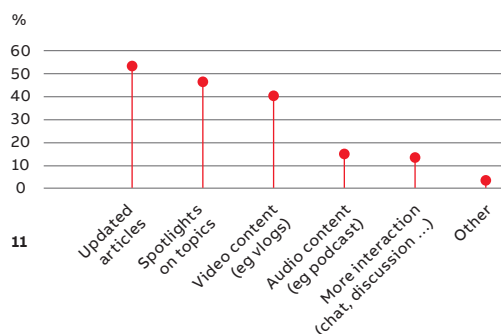


**09** "How do you prefer to obtain ABB Review?"

**10** "New online offering: Would you be interested in a new, more interactive online offering of ABB Review?"



**11** "New online offering: Which content and formats would be of particular interest to you?"





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## BUZZWORD DEMYSTIFIER

# 6G

The rollout of public 5G is ongoing and 5G's value propositions relating to industry are well known. But what of 6G? What role will 6G play in the digitalization of industry and IT/OT convergence?



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The game-changing connectivity and data exchange capabilities of 5G are transforming the world. Ultra-reliable low-latency and high-bandwidth communication, universality, scalability, determinism and high device density are just some of 5G's characteristics that technology companies such as ABB are looking to adopt.

While the continued standardization, development and rollout of 5G will take the greater part of the current decade, the telecom industry and academia have already started working on 6G. What new horizons in the digital world could 6G open up?

In a nutshell, 5G provides a universal "connect and compute" infrastructure with a performance an order of magnitude beyond 4G. In contrast, 6G might be summarized to postulate a "perceive, localize, and understand" ecosystem, fueled by artificial intelligence (AI) and radio innovations but no longer limited to cellular technology. Connectivity and computation should feel ubiquitous and unlimited, and the human experience is at the center more than ever.

Technically, 6G aims to consolidate and upscale aspects that 5G already claims: integrating (real-time) connectivity with (edge) computation; virtualized software-defined networking; network-sharing between operators and users;

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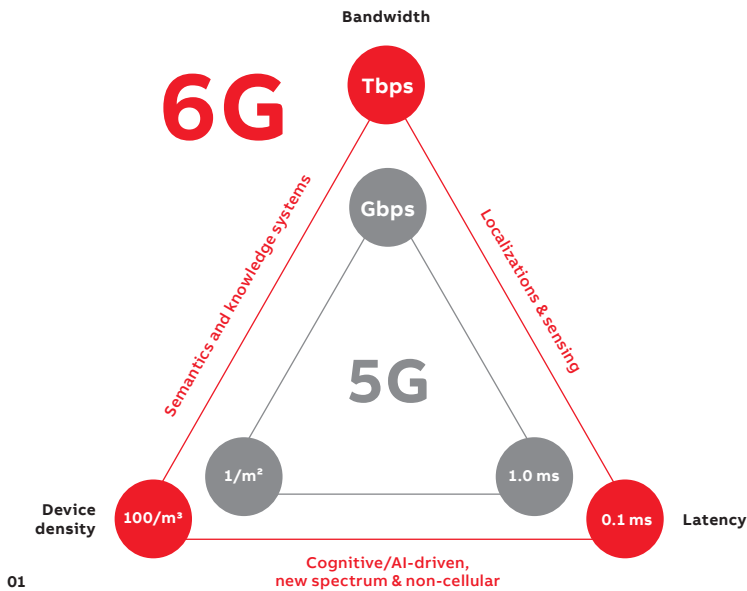
6G will embrace non-cellular communication and provide intelligence rather than merely transmitting data.

integration of wireless and (external) wired networks; localization; and machine-to-machine communication. Furthermore, 6G will embrace non-cellular communication and provide intelligence rather than merely transmitting data.

6G specifically aims to innovate in the following technologies and features to evolve and disrupt the "5G triangle" in →01:

- Terahertz radio and new spectrum space, leading to higher bandwidth (100 Gbps to 1 Tbps) and lower latencies (0.1 ms)
- Extreme ultra-reliability (to be quantified)
- Ultra-massive device density (100 per m<sup>3</sup>)
- High-resolution localization (10 cm indoor) and sensing
- Communication and computation co-design driven by AI
- Semantic communications and knowledge systems, delivering intelligence, not just data
- Non-cellular communication (WiFi 6, satellites, reflective surfaces, etc.)





01 Evolution and disruption of 6G.

6G is still in the initial concept stage, with standardization expected to begin around 2025 and commercial availability at the end of the decade at the earliest.

If, in the long run, “everything is 6G,” this might complete the trend of IT/OT convergence, where automation and telecommunication infrastructures become one. So, monitoring 6G standardization progress and maintaining strategic partnerships are important tasks that ABB has already started with 5G and cloud computing. Subscribing

6G is still in the initial concept stage, with commercial availability at the end of the decade at the earliest.

to the value propositions of cellular technology, the next step remains to verify the capabilities and value of 5G in pilots with ABB customers. This must be the starting point for the continuous integration of cellular technology, whether 5G or 6G, as part of ABB’s solution offering. •

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01|2022

Inspired by technology



02|2022

ABB Ability™

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Better decisions

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