



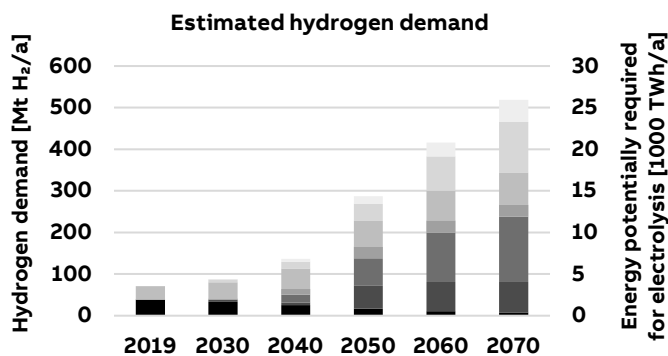
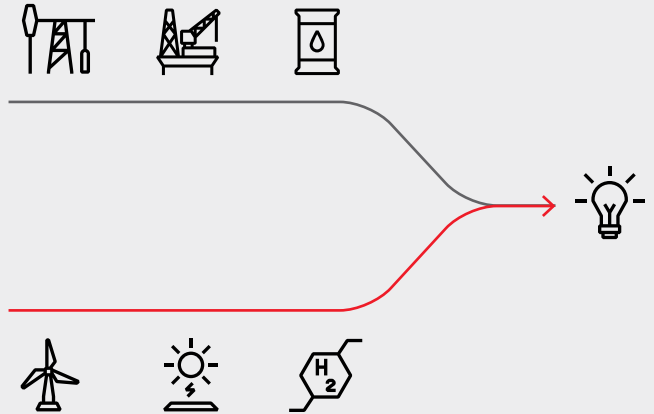
# High Power Rectifiers for Hydrogen Production

The best solution for efficient and reliable  
DC power supply for large scale industrial  
water electrolysis

# Scaling up H<sub>2</sub> capacity to power the future...

## Hydrogen is a key fuel for tomorrow's economy

Hydrogen electrolysis can serve as a sustainable bridge in the gap between electricity and chemical energy carriers, thus allowing fossil free powering where direct electrification is not feasible. This means hydrogen can play a crucial role in achieving government and corporate sustainability targets, with ABB supporting these aims by providing best-in-class electrification technology for the hydrogen economy of tomorrow.



Source: IEA, Energy Technology Perspectives 2020, right axis assuming hydrogen production from 100% water electrolysis with 50 kWh/kgH<sub>2</sub>

## Annual demand up to hundreds of millions of tons of H<sub>2</sub>

- Ammonia: Direct use for fertilizer production
- Synfuels: Replacement in combustion engines
- Industry: Chemical, steel, cement and others
- Buildings: Private and commercial heating
- Transport: Fuel for cars, rail aviation & ships
- Power: Energy storage for reconversion
- Refining: High quality fuels and feedstock

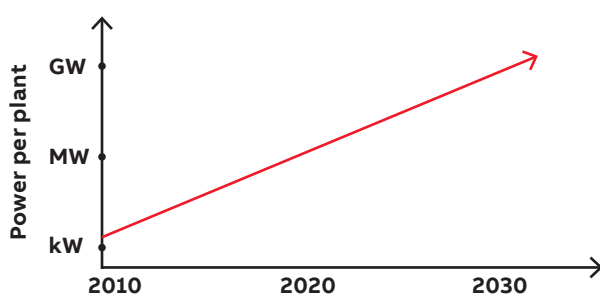
## Replacing fossil-based production

Hydrogen today is mainly produced by natural gas reforming or coal gasification<sup>1</sup>. Carbon capture may provide an interim solution to prevent the release of CO<sub>2</sub> to the environment. But only electrolytic production of H<sub>2</sub> allows to eventually eliminate fossil fuels from the energy value chain – and thereby full control of carbon emission and a steady pathway to a sustainable future.

<sup>1</sup>High carbon emission processes

## Water electrolysis classification

Term	Power source	CO <sub>2</sub> emissions
Yellow H <sub>2</sub>	Mixed	Low
Purple H <sub>2</sub> / Pink H <sub>2</sub>	Nuclear	
Green H <sub>2</sub>	Wind, solar, hydro, tidal, geothermal	None



## Electrolysis will move up to scale

The hydrogen council states that the annual demand for hydrogen could increase tenfold by 2050. This will require centralized gigawatt industrial production facilities that leverage economies of scale. Hundreds of megawatts or gigawatts of power per plant pose different challenges compared to existing installations. With our wealth of experience in industrial electrolysis, ABB is the perfect partner to expand the boundaries of H<sub>2</sub> production.

## ...by leveraging ABB's comprehensive experience

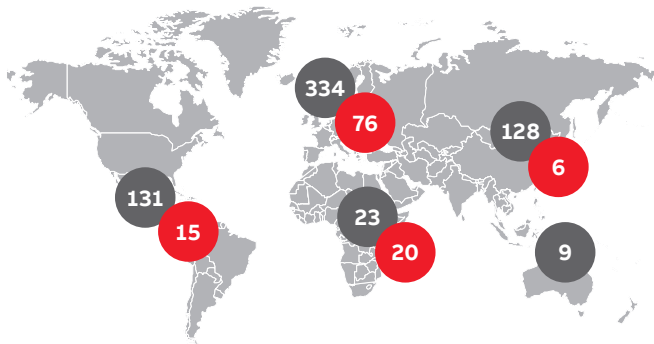
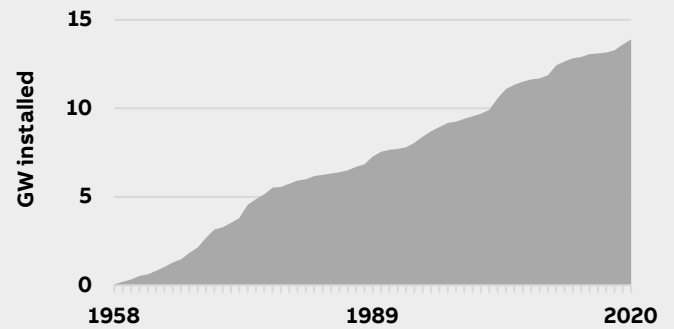
### Decades of experience in chemical production

ABB has supplied more than 750 rectifier projects for chemical plants since 1958 – a successful track record for our clients to benefit from as they scale up their H<sub>2</sub> production.

- 110+ DC power supplies for hydrogen production up to 140 MW per plant
- 625+ DC power supplies for chlorine applications<sup>2</sup> up to 350 MW per plant

<sup>2</sup>Process characteristics for making chlorine are nearly identical to hydrogen production

### ABB DC power supplies in chemical industry



### Customer satisfaction around the globe

For chemical industries alone ABB has provided DC supplies in more than 60 countries. We can deliver the perfect fit for any project regardless of extreme ambient conditions or specific local regulations.

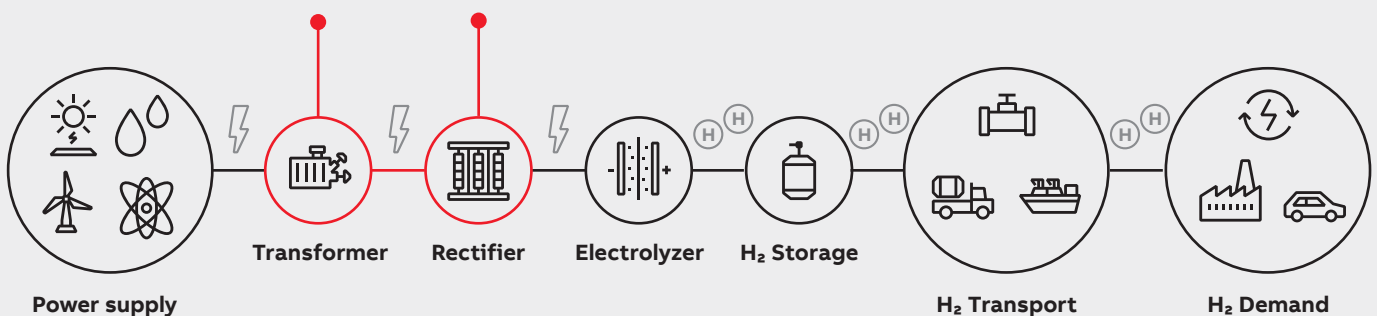
Regions: Americas, Europe, Africa, Middle-East & Asia, Oceanic

● Number of hydrogen/hydrochlorate projects

● Number of chlorine/chlorate projects<sup>3</sup>

<sup>3</sup>Process characteristics for making chlorine are nearly identical to hydrogen production

### DC Power Supply with ABB High Power Rectifier Systems



**ABB provides electrification, automation and digital solutions**

⚡ Electricity  
 (H) (H) Hydrogen

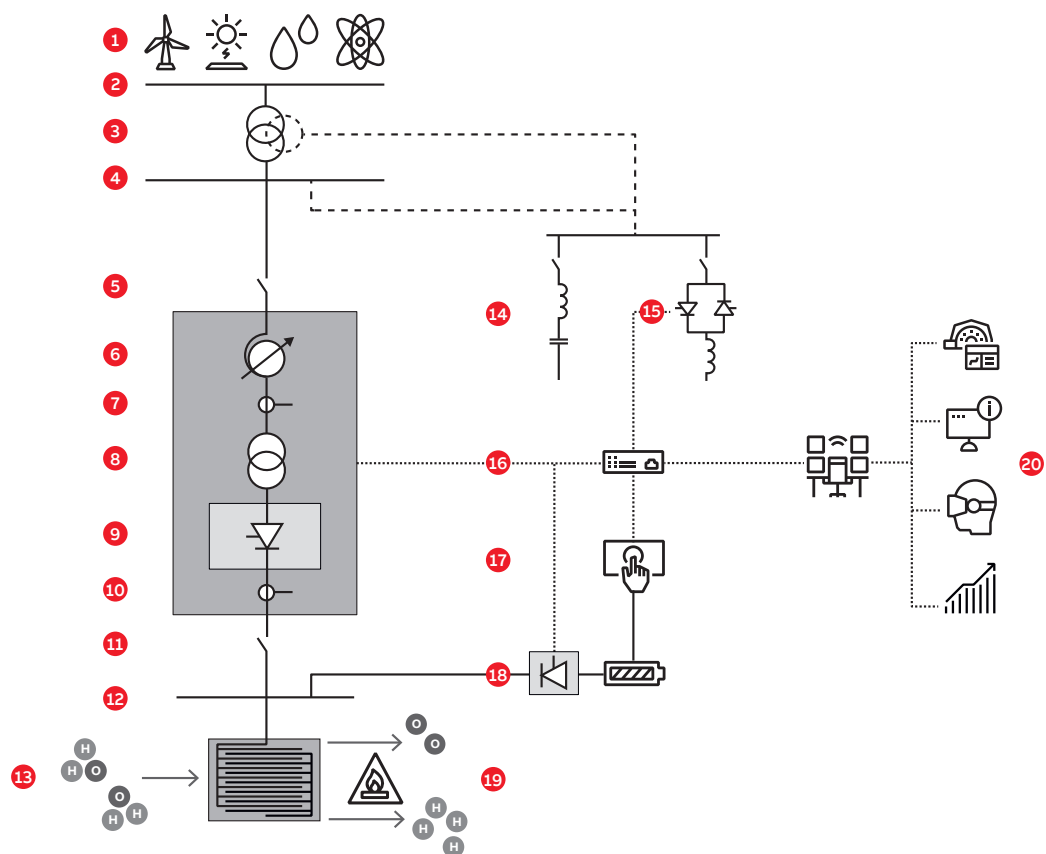
# ABB helps making hydrogen production robust, simple and cost efficient...

## Every plant is unique, and so are our customers and their needs for electrification.

Whether you want to produce hydrogen for re-sale, for on- or off-site industrial utilization, as a reserve for electricity generation or you are supporting customers in building such plants – getting ABB on board ensures an optimal electrical subsystem. We take a holistic approach to system design, so that all possible eventualities are fully considered. The solution we propose for you is tailor made to meet your requirements and based

on close collaboration with you as our client. We always strive for a perfect understanding of your needs, your process and the surrounding conditions to configure the optimum solution, which you can trust 100%.

Here are some of the places where ABB fits into the H<sub>2</sub> electrolysis process. We know it well and have the track record to prove it.



- |                                       |  |
|---------------------------------------|--|
| 1 Grid/on-site generation integration | 11 DC isolator                                   |
| 2 HV connection and grid compliance   | 12 DC bus  |
| 3 HV/MV substation                    | 13 Electrolyzer stack                            |
| 4 Medium voltage distribution         | 14 Passive power quality systems                 |
| 5 Medium voltage circuit breaker      | 15 Active power quality systems (as required)    |
| 6 Regulating transformer (optional)   | 16 Local rectifier control system                |
| 7 AC current metering                 | 17 HMI & distributed control system              |
| 8 Rectifier transformer               | 18 Back-up power supply & polarization rectifier |
| 9 Rectifier                           | 19 Expertise in flammable environments           |
| 10 DC current metering                | 20 Full digital portfolio with ABB Ability™      |

# ...by offering solutions that successfully address the challenge of water electrolysis

## Water electrolysis challenges

Electric energy input should be fully utilized.



Revenue

## Our solutions

We optimize systems for continuity, efficiency, reliability and cost to achieve maximum overall revenues at the lowest cost of ownership.

Flammable, aggressive or corrosive environments pose danger to the equipment and persons in the field.



Safety first

ABB makes no compromises on safety. We have deep experience with hazardous environments, safe low-maintenance solutions and can support in addressing all related risks.

Power outages directly interrupt production – and possibly subsequent processes, with costly consequences.



Robust design

ABB delivers best in class reliability and robustness, and ensures superior redundancies to prevent outages.

Electricity prices are the dominant factor in levelized hydrogen production costs.

**>98%**  
Efficiency

ABB's DC power supplies can deliver combined transformer and rectifier system efficiency of >98%<sup>4</sup>.

<sup>4</sup>Based on experiences in reference projects

Renewable energy resources exhibit dynamic and intermittent behavior, which poses additional challenges in system integration.

**25 ns**  
Controller speed

ABB's specialized power electronics controls react fast to dynamic and unpredictable behavior under the toughest conditions.

Hydrogen production should be integrated with other industrial production.



Industry know-how

ABB is active in almost all process industries, allowing us to bring in-depth understanding to many downstream processes.

Harmonics in the electrical system can damage other installed equipment or cause power instability.



Solid experience

ABB has over 50 years of experience with static and dynamic power compensation equipment, and hundreds of electrical experts to support you.

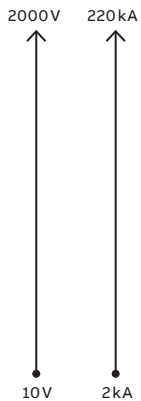
Hydrogen utilization requires a complete infrastructure from electricity generation to final demand.

**1**

Company

ABB's automation and electrification portfolio is available across the whole hydrogen value chain.

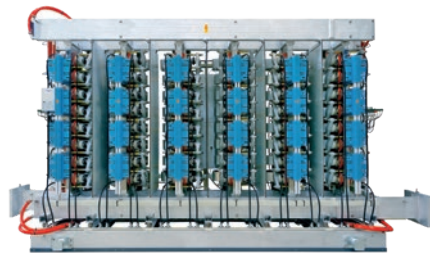
## An industry leading portfolio...



- Possible ratings per rectifier unit
- Modularization allows ultra high current scaling



Rectifier enclosure



High current rectifier stack

### Rectifier systems

ABB provides DC power supplies for a comprehensive range of voltage and current ratings.

- High power densities
- In- and outdoor installation
- Modular construction or all in one
- ⊕ Small & optimized footprint for your site
- Minimized number of components
- High EMC immunity by optical gate pulse transmission
- Ultra-flexible fuse connections
- ⊕ High reliability for you process
- Minimum amount of cooling hoses
- Minimum number of bolted connections
- Quality material, high comparative tracking index and appropriate IP class for all components
- ⊕ Increased safety and low maintenance needs



### Simulation, studies and consultation

ABB offers decades of knowledge on plant electrification and electrochemical processes to support your successful project

- Feasibility studies
- Studies and simulations of dynamic electrical behavior
- Time-varying magnetic field studies
- ⊕ Verify your planning to proactively prevent problems in the early stages
- Investigate grid compliance
- Experience with nearly all international and local standards
- Supply of interoperable simulation models
- ⊕ Investigate and prove operating characteristics in the planning stage
- Health and safety analysis
- Defining of risk mitigation actions
- Specifications about access restrictions and safety zones
- ⊕ Ensure the safety of your equipment and personnel



## ...to make your job easier

### Power quality solutions

ABB's active and passive solutions to achieve adequate compensation

- Static Var Compensation
- Static Power Compensation
- Passive filter element

⊕ Combined in a suitable solution for your process

Compensation of

- Load fluctuations
- Sudden voltage drops
- Flicker
- Current imbalance
- Power factor deterioration
- Harmonics

⊕ Protect your equipment from damage and achieve compliance to grid codes and local regulations



Example of ABB active power quality system



Example of passive filter installation

### Control, automation and digital solutions

ABB helps to keep your processes under control and enables full insight and knowledge about your plant

Rectifier controllers with

- High processing power for ultra-low cycle times
- Fiber optic links and IEC standard EMI immunity
- Phase locked loop to avoid undervoltage shutdown

⊕ Precise operation even with fluctuating renewable power supply and under harsh operating conditions

- Broad compatibility with input and output signals
- Automation integration with the central control center
- Remote monitoring of process and equipment conditions

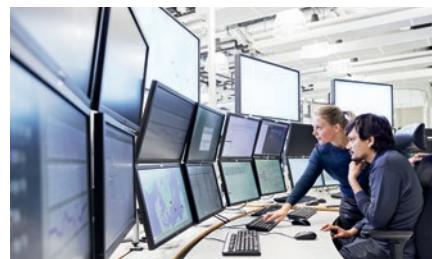
⊕ Full information about your plant, wherever and whenever you need it

- ABB Ability™ platform as your digital backbone for device, edge & cloud
- Cyber security by design
- Continuous upgrades and development of digital portfolio

⊕ Get yourself and your plant ready for the digital future



Depiction of ABB's AC 800PEC controller



Example of plant control center

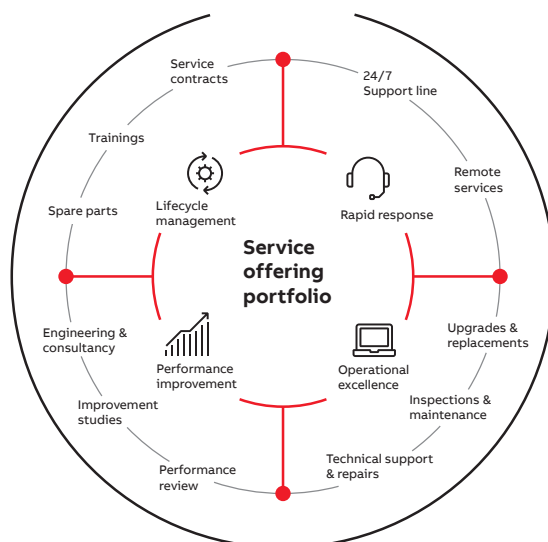
## Life cycle services for your plant...

You can count on ABB as your partner for the entire lifetime of your plant.

ABB rectifier systems are designed for a service life of 25 years or more. One of our key objectives is to maximize your production by maximizing your plant's operating time.

- Throughout the entire lifetime of a rectifier system, ABB will provide training, technical support and professional service contracts – backed by a world-class global sales and service network.
- Our systems are specifically designed to use a minimum number of components and exceptionally robust, to reduce the need for spare parts. We also make sure customers that those parts are available to our customers throughout the full lifecycle.
- ABB's preventive maintenance programs increase equipment lifetime. Replacement costs are minimized by identifying wear of individual components, allowing for targeted replacements before problems occur. We ensure that limited lifetime of single sub-components will not limit overall system lifetime.

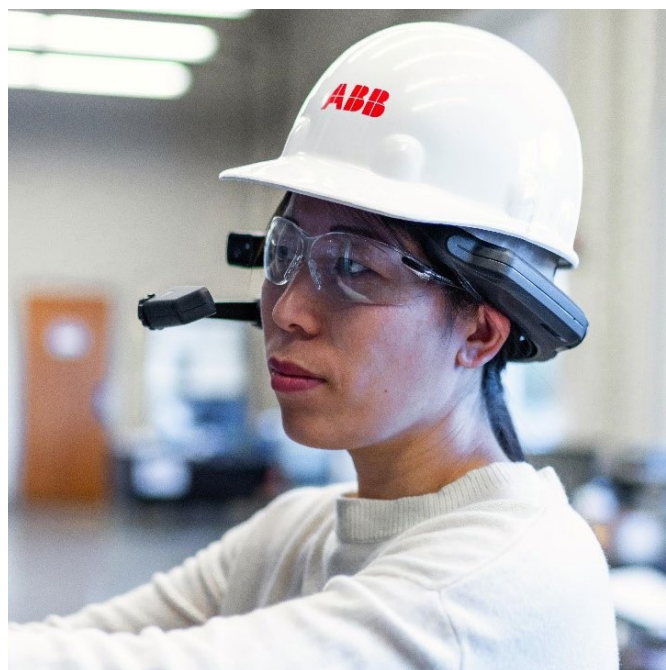
- Many ABB rectifier systems stay in operation much longer than initially projected. A major reason for this are upgrades and add-ons for controls and power components which we offer to help our customers keep up with rising demands.



Overview of ABB's service offering

A properly maintained ABB rectifier system can last more than 25 years.

Remote assistance with augmented reality



## ...as high uptime translates to high production

### Local presence around the globe to keep your plant running at all times...

With presence in more than 100 countries worldwide, ABB is perfectly placed to offer the best technical advice and local support around the clock. Further reinforced by selected local

companies and local sourcing we can provide a fast and cost effective response to any eventualities.



### ...and provide remote assistance for immediate support wherever you are.



During the stress test of the COVID pandemic, we have repeatedly proven, that at ABB we will do whatever is needed to keep our customers' processes up and running. ABB offers advanced remote support services, ranging from software and control trouble shooting to full guidance in the field via virtual reality applications. For further details about all our services, please contact your nearest ABB office or visit us at [www.abb.com/rectifiers](http://www.abb.com/rectifiers).



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