

EXION HYDROGEN

OUR QUEST FOR BETTER ELECTROLYZERS



DECADES OF EXPERIENCE AND A CLEAR MISSION

When we founded Exion Hydrogen in 2021, we brought together a team of skilled engineers with **decades of experience** in the hydrogen production industry. **Our mission** is to design and build new generations of water electrolyzers that offer more reliable, safe, user-friendly and scalable on-site hydrogen production for a broad range of applications and industries.

Our collective expertise allows us to approach the design of our electrolyzers with a **fresh perspective**, avoiding common drawbacks and compromises tied to legacy choices. From fundamental design elements to the selection of materials and parts, all our design and manufacturing decisions are directed by the Exion Hydrogen Manifesto you are reading.

The Exion Hydrogen Manifesto states that every design and production decision must adhere to 8 key variables. Every decision should move us closer to creating electrolyzers that are more **durable, high-performing, safe, compliant, easy to use** and **maintain**, and suitable for various project **sizes** and **specifications**.



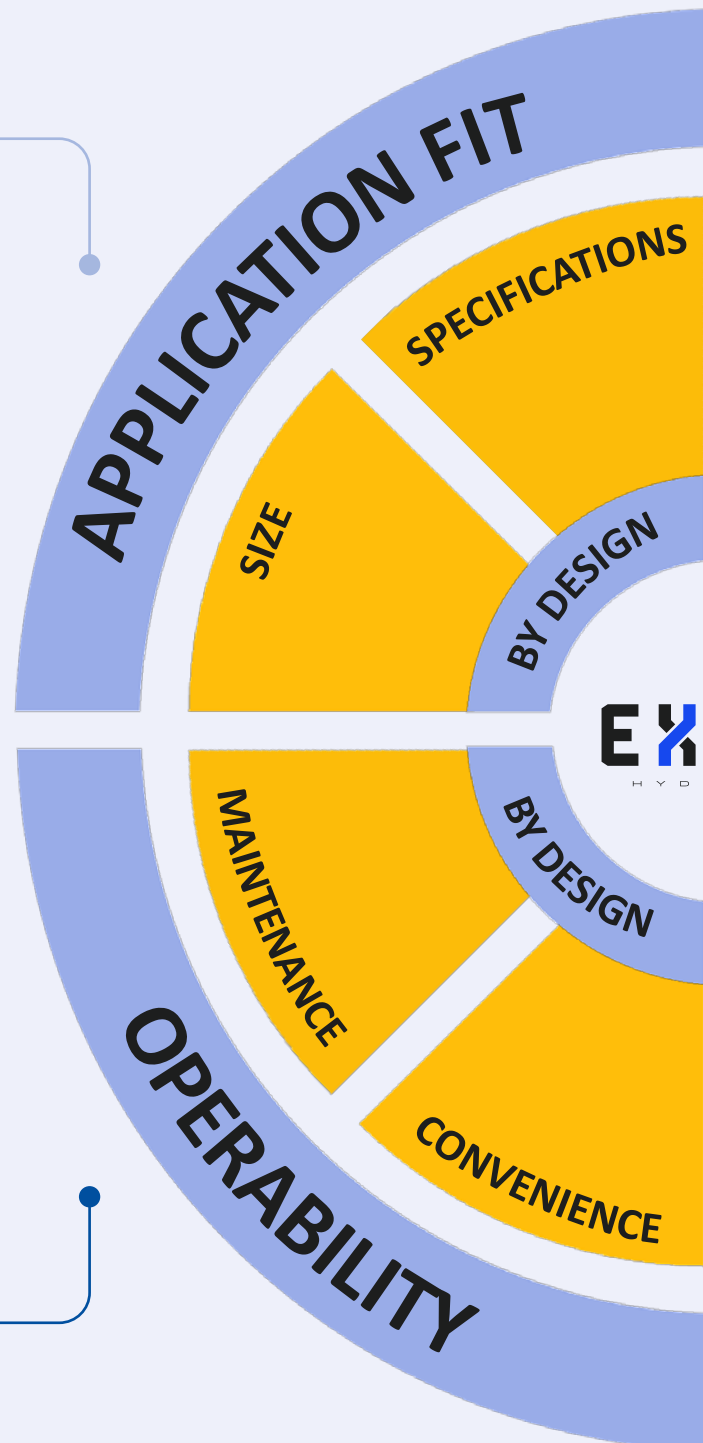
EXION HYDROGEN MANIFESTO

APPLICATION FIT

Hydrogen production capacity and purity are crucial factors when selecting a water electrolyzer for your project. Our HyGGe™ 100A alkaline and HyGGe™ 500P PEM electrolyzers are designed to **fit most industries and applications**. They respectively deliver up to 100 and 500 Nm³ of 4.8-grade hydrogen per hour at 30 barg. Both can also be deployed in a multi-unit setup to further scale production, which in combination with their respective technologies enables broad coverage across a wide range of industrial applications.

OPERABILITY

We designed the HyGGe™ 100A and HyGGe™ 500P water electrolyzers with operational convenience in mind. Our user-friendly designs allow for **easy access and on-site as well as remote monitoring**. To maintain optimal performance and minimize production interruptions, we provide **premium maintenance services**, including remote support, proactive preventive maintenance planning, rapid response times, and cost-effective emergency solutions.



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Our HyGGe™ water electrolyzers are designed with durability in mind. We use **premium materials** throughout the entire system, from the smallest components in our cell stacks to the large subsystems in the Balance of Plant. Our engineers meticulously optimize all components to achieve maximum efficiency at controlled stress levels. As a result, our electrolyzers boast **impressive availability and a long lifespan.**

Smart design, processes and documentation are all essential to achieve consistent and safe hydrogen production. We design, test, and evaluate every component of our electrolyzers, documenting each design decision along the way. Evidently, all our electrolyzers comply with safety, efficiency, environmental impact, and technical performance requirements set by industry and regulatory bodies.

DURABILITY BY DESIGN

We build our water electrolyzers with durability in mind. We only use premium materials throughout the entire system, from the smallest components in our cell stacks to the large subsystems in the Balance of Plant. In addition, we vigorously control all internal parameters such as temperature and current density to minimize stress levels on the system. This greatly improves the lifespan and reliability of our electrolyzers.

PREMIUM MATERIALS THROUGHOUT THE ENTIRE SYSTEM

Both our HyGGe™ water electrolyzer platforms consist of four main parts:

1. A proprietary cell stack: the beating heart of our water electrolyzers

All metallic parts in our alkaline cell stacks are made of **pure nickel** instead of nickel-coated stainless steel, as pure nickel better withstands the corrosive conditions typical of alkaline environments. Our PEM stacks were the first to leverage our proprietary **HIFI™ technology**, featuring an enhanced flow design for an optimal gas-water ratio. For the same reasons, we only use high-standard catalyst coatings, membranes, gaskets, flanges and electrical connection plates from premium suppliers. We also developed **proprietary structural ring and sealing concepts** for both technologies to optimize gas production in the cell stacks and mitigate the risk of deformations under pressure.

2. A tailored Balance of Stack

To fully materialize the potential of our cell stacks, we have designed our Balance of Stack with the same high standards in mind. For the electrolyte loop, we use piping and gas separators in stainless steel, and **robust valves, fittings, and pumps** designed to withstand the distinct operating conditions of both alkaline and PEM technologies.

3. A carefully dimensioned Balance of Plant

For both technology platforms, our engineers **carefully dimensioned** the control, cooling, electrical and water purification systems to strike the optimal balance between durability, safety and performance. We only use the most **reliable components** from seasoned manufacturers to ensure long system lifetimes and strong service support.

4. Reinforced and insulated Housing

Our water electrolyzers are designed as **modular, reinforced and insulated containerized units** to ensure robust operation under all weather conditions. All containers and frames are standardized to facilitate transportation, and engineered for optimal use, maintenance and safety compliance, while shortening installation and commissioning time.

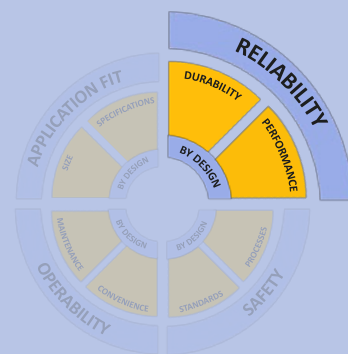
CAREFUL MONITORING OF INTERNAL PARAMETERS

Running water electrolyzers at elevated cell stack temperatures or higher current densities may improve production capacity or efficiency in the short term, but will ultimately accelerate system degradation. To avoid this, we **carefully monitor temperature and current density** across both alkaline and PEM systems, and optimize system cooling and thermal balance accordingly.

We spare no expense or effort when it comes to the durability of our water electrolyzers. By carefully considering every design decision, using only the best components, and integrating continuous control and optimization into our systems, we reduce the overall stress levels on our electrolyzers, thus improving their lifespan and reliability.

PERFORMANCE BY DESIGN

The performance of water electrolyzers can be measured in terms of net efficiency and availability, and it is influenced by a myriad of design choices, material selections, and process flow decisions. Our engineers meticulously optimize all components of our electrolyzers to achieve maximum efficiency at controlled stress levels. As a result, our electrolyzers boast impressive availability and a long lifespan.



PREMIUM MATERIALS FOR OPTIMAL PERFORMANCE

Simulations helped us improve the efficiency of our electrolyzers by selecting the right materials and making smart design decisions. For instance, we further enhanced cell stack performance through the development of our proprietary HIFI™ technology, first implemented in our PEM systems and serving as a cornerstone for future cell stack designs, while continuously reducing stress levels. **This positively impacts degradation and thereby the systems' lifetime.**

Since Balance of Plant (BoP) power electronics are a known efficiency drain, we use **high-standard rectifiers** to convert AC power to regulated DC. In-depth technology evaluations and supplier benchmarking allow us to **minimize harmonic distortion** to the connected grid and reduce energy losses in the form of heat, even under variable grid conditions.



REDUCTION OF STRESS LEVELS TO INCREASE PERFORMANCE

Despite the robust construction of our water electrolyzers, we keep temperature-related stress levels in our systems under control. Our designers implemented **carefully dimensioned cooling concepts** to dynamically maintain safe cell stack temperatures and optimal thermal balance. This ensures stable operating conditions and minimizes energy losses.

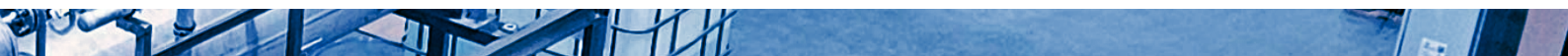
In addition, we apply **dedicated gas cooling** where required, supported by a two-stage gas purification process: first, a catalyst removes residual oxygen, followed by a molecular sieve dryer that eliminates moisture. This results in hydrogen purity of 99.998%, reducing the need for additional downstream purification and facilitating compression.

OPERATIONAL AVAILABILITY AND FLEXIBILITY

Our water electrolyzers feature a robust operational mode that maximizes uptime through **smart redundancy and remote monitoring**. Additionally, automated logs and predictive checks enhance the long-term reliability of our systems.

Our electrolyzers are designed for modular expansion, capable of **managing hydrogen production based on real-time grid and user demand**. This ensures availability and energy optimization across varying operational states. Smart capabilities to support grid balancing and autonomous power modulation ensure continuous and efficient production. Additionally, our units can automatically enter an 'idle' mode during periods of low demand or seamlessly restart when demand increases.

*Since our industrial clients rely on the availability of high-purity hydrogen on-site, we only use premium materials and smart designs to **maximize the efficiency and availability** of our electrolyzers. Leveraging decades of experience, our engineers have crafted ultra-reliable water electrolyzers with **a healthy cost of ownership**.*



CODES AND STANDARDS BY DESIGN

Designing and producing water electrolyzers is a serious undertaking, as is their operation and maintenance. That's why we prioritize codes and standards to ensure our systems comply with safety, efficiency, environmental impact, and technical performance requirements set by industry and regulatory bodies.

SAFETY BY DESIGN

We integrate all essential safety measures into our design process to ensure our water electrolyzers are optimally safe from the outset.

HAZOP to identify and assess hazards and operational issues

We carefully examine every process drawing using the HAZOP (Hazard and Operability Study) methodology to identify and assess potential hazards and operational issues. Guided by external, accredited bodies, our R&D team scrutinizes all processes to detect deviations from normal operation, and the associated risks. Any safety attention points are then subjected to a LOPA (Layer of Protection Analysis).

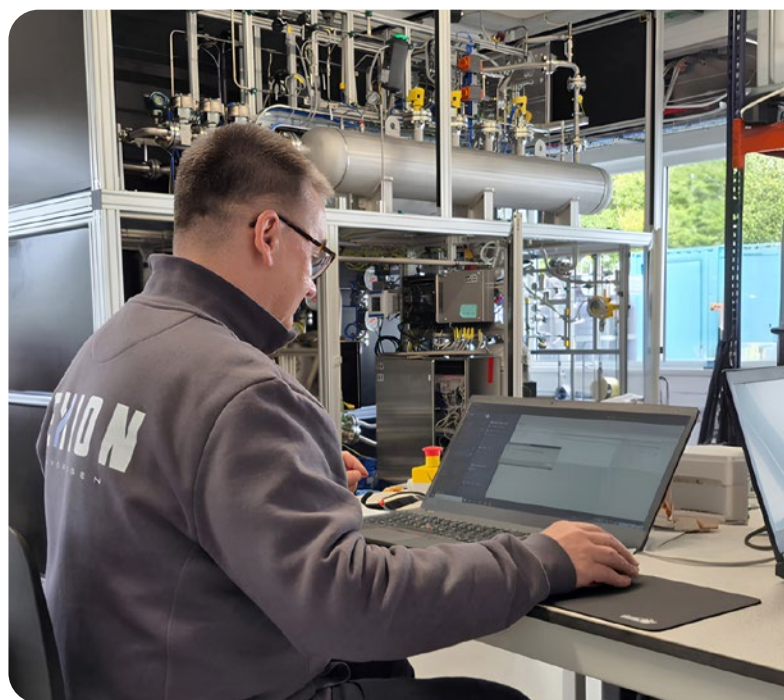
LOPA, SIF and SIL

A LOPA uncovers safety gaps, and it triggers the definition and implementation of Safety Instrumented Functions (SIFs), each with a required Safety Integrity Level (SIL). We adhere to IEC 61508 standards to design, implement and maintain safety systems to minimize operational risks for people, property and the environment. We run sequential Functional Safety Assessments to document and reconfirm all safety objectives.

EUROPEAN DIRECTIVES AND INTERNATIONAL STANDARDS

Understanding and adhering to safety directives and standards is crucial for the safe and efficient operation of electrolyzers. Our engineers vigorously interpret, cross-check and implement all relevant norms and standards, including:

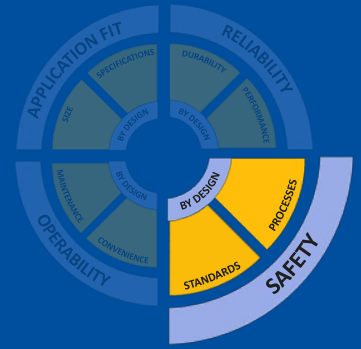
- **European Directives** such as the ATEX Directive, Pressure Equipment Directive (PED), Machine Directive, Low Voltage Directive and Electromagnetic Compatibility Directive.
- **International Standards** such as ISO (International Organization for Standardization), IEC (International Electrotechnical Commission), EN (European Norm) and ASME (American Society of Mechanical Engineers). These provide codes and standards for mechanical devices, promoting safety and reliability.



*At Exion Hydrogen, **our commitment goes beyond mere compliance.** Our meticulous design approach ensures not only safety but also enhanced performance and environmental sustainability. Independent verification and certification by third parties confirm that our electrolyzers meet all stringent regulatory safety and performance standards, facilitating a secure transition to green hydrogen production.*

SMART PROCESSES AND DOCUMENTATION

Smart design, processes and documentation are all essential to achieve consistent, reliable, and safe hydrogen production. We design, test, and evaluate every component of our electrolyzers against new hypotheses, documenting each design decision along the way. We release up-to-date documentation and guidelines at every stage of our customer projects. This makes the use, maintenance, and support of our units safer and easier.



A STRICT DESIGN PROCESS

Our R&D team bases all design decisions on **simulations and laboratory experiments**. For instance, we use 2D drawings and 3D models to visualize and refine our product designs, and extensive Piping and Instrumentation Diagrams (P&IDs) to describe the **layout and operational process flows of our systems**. This disciplined approach aids our manufacturing team in correctly assembling all components, and it provides a valuable resource for addressing any issues that may arise at a later stage.



COMPREHENSIVE PROJECT DOCUMENTATION

At Exion Hydrogen, we have established a **standardized project timeline**, from the signing of the commercial agreement to commissioning, with clear, time-bound project milestones and all the necessary document deliverables.

For instance, when a commercial agreement is signed, we issue a Product Reference Guide, all permitting documents, an Explosion Protection Concept, an Installation Manual, and a Data Policy document. And after a successful Factory Acceptance Test (FAT), we provide additional documents (e.g. Site Acceptance Test (SAT) documents) to ensure the flawless installation and commissioning of our systems. Our extensive list of deliverables, from spare parts lists to the Declaration of Conformity, includes technical documentation, certificates, and actionable Operator and Service Manuals.

FUNCTIONAL PRODUCT FEATURE DESIGN

Developing robust control and automation capabilities for our electrolyzers requires a **targeted process design** and a deep understanding of each operational phase. Clear and consistent documentation plays a vital role in achieving this goal.

For instance, creating a **process control narrative** that outlines automatic states such as 'ambient,' 'inerting,' and 'preparing' to ensure smooth transitions between all operational phases of our systems requires a clear understanding of each phase. The same applies to the integration of PLCs and a Safety Instrumented System (SIS) to allow for real-time system monitoring, remote control to support faster troubleshooting, and outlining a Safety Requirements Specification (SRS) to always ensure a safe state.



*While documentation is often considered an afterthought, **we see documentation as an essential part of our design process**. By consistently recording all our design decisions and workflows, and providing comprehensive, up-to-date documentation at each phase of our customer project timelines, we significantly enhance the safety and user-friendliness of our water electrolyzers.*

OPERATIONAL CONVENIENCE

We design our water electrolyzers with operational convenience in mind. Our user-friendly design allows for easy access and on-site as well as remote monitoring by authorized personnel.

A COMPREHENSIVE DESIGN PROCESS

Our HyGGe™ water electrolyzers are housed in **robust, containerized and modular units**. Operators and service technicians can access the systems at various points according to their duties. Additionally, each section and skid within our units is optimized for easy and functional access.

SOFTWARE ACCESS LEVELS

The HMI (Human Machine Interface) in the General Purpose room enables **clear monitoring of all relevant operating parameters**. Operators can easily check and interpret operating conditions and safely start or stop operations. Restarting the units after a safety trip requires the physical presence of an operator or designated deputy to ensure all safety conditions are met. Other system notifications can be reset remotely.

Access levels to the electrolyzer software vary based on the training and seniority of the individual working with the unit. For instance, operators can start and stop the unit and access all essential parameters. Customer service teams have additional screens for **advanced troubleshooting**, and Exion Hydrogen engineers can also modify parameters remotely when this level of support is included in the service agreement.

REMOTE ACCESS TO OUR WATER ELECTROLYZERS

When agreed upon and provided, a **secured connection** allows for remote interventions and the exchange of operational data feedback from the electrolyzers. This enables us to build a comprehensive knowledge database for each unit and monitor parameter trends for proactive maintenance.

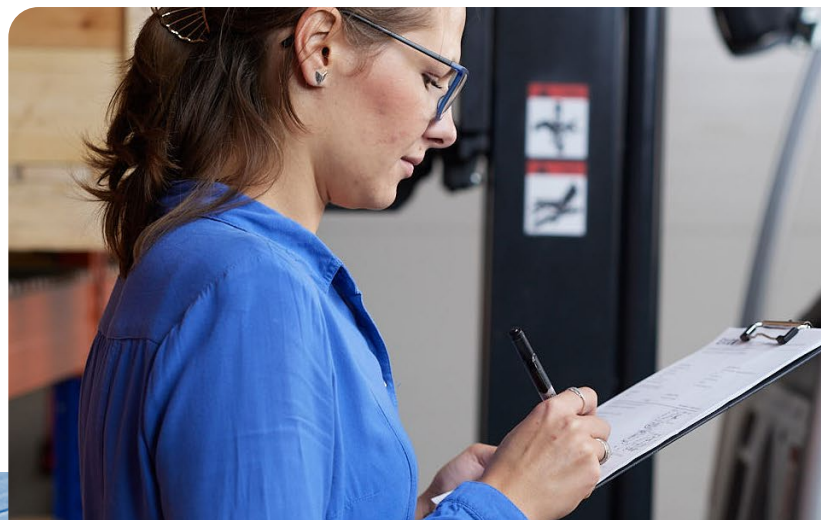
INTEGRATION WITH YOUR DISTRIBUTED CONTROL SYSTEM

Our water electrolyzers can also be connected to your existing Distributed Control System (DCS/SCADA, etc.). Various connectivity protocols are supported to facilitate this integration. This connectivity allows for **proactive action**, and it streamlines service interventions by Exion Hydrogen engineers and service teams.

DOCUMENTATION AND PROJECT MANAGEMENT

A solid system monitoring interface and comprehensive documentation are crucial for operational convenience. That's why we make all manuals accessible via the HMI. This ensures **seamless communication** with our support personnel at any time.

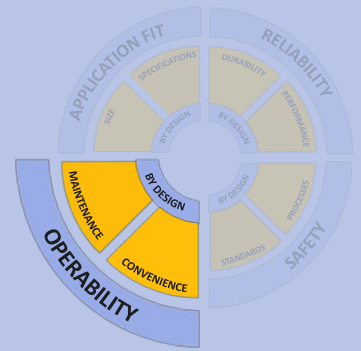
Providing adequate support and guidance begins with the pre-installation and commissioning process, overseen by a dedicated Customer Success Manager. This key function streamlines all communications between your team and ours.



*When it comes to water electrolyzers, convenience goes beyond having a safe, robust, and reliable unit. **Functional operability for all designated technical personnel is essential.** Additionally, clear status monitoring and reporting, along with comprehensive manuals and documentation, are critically important.*

MAINTENANCE BY DESIGN

The main objective of our electrolyzers is to ensure safe, smooth, and reliable hydrogen production throughout their lifespan. To maintain optimal performance and minimize production interruptions, we provide premium maintenance services, including remote support, proactive preventive maintenance planning, rapid response times, and cost-effective emergency solutions.



OPERATIONAL MAINTENANCE INTERFACE

Our electrolyzers are **designed for low maintenance**, featuring easily accessible logs, test modes, and maintenance schedules via the Human Machine Interface (HMI). **Separate logins and tools** for operators and service technicians ensure appropriate access levels based on their roles and duties. For instance, operators will only have access to limited service functionality tasks such as temperature and pressure checks.

The HMI assistant

The HMI of our electrolyzers features a **dedicated maintenance tab** where service technicians can easily access maintenance logs, schedule overviews, calibration records, loop tests, and step-by-step instructions. In 'safe mode,' a maintenance assistant helps with troubleshooting, serial tracking, and calibration tasks.

Safety front and center

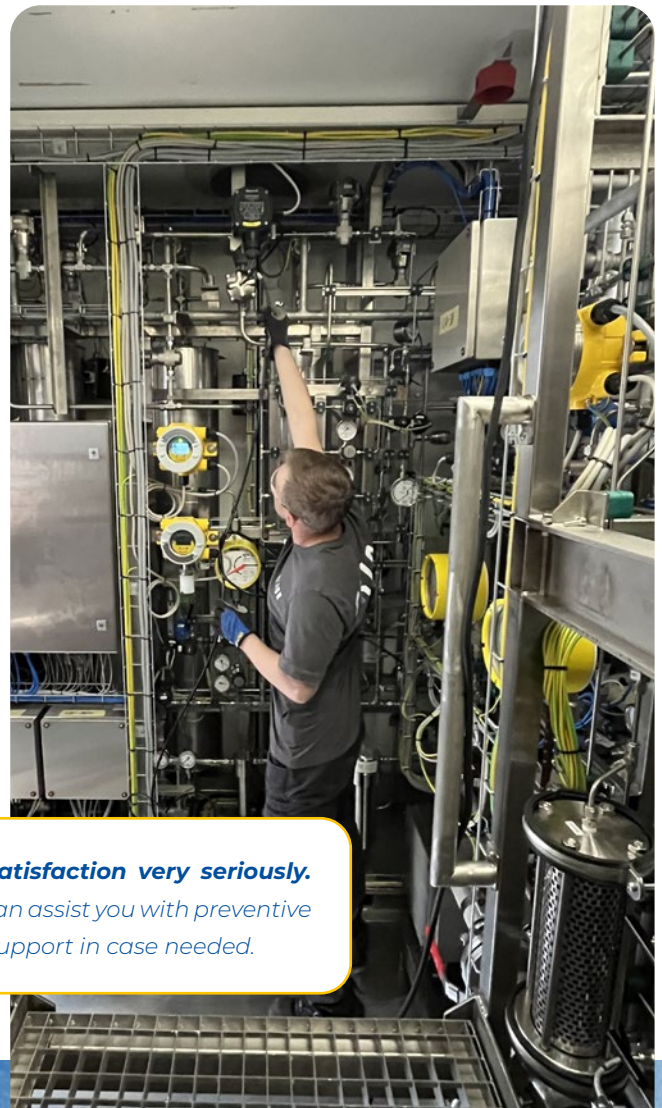
Safety precautions are integral to our maintenance procedures and include multiple safeguards, such as safe states, inerting processes, and dedicated alarms designed to notify technicians of any safety concerns during maintenance.

LOCAL SUPPORT

We always provide in-house testing (FAT), start-up and commissioning (SAT), and **comprehensive operator training**. This way, your operators are well-prepared to handle daily maintenance tasks as outlined in our Service Manuals. Furthermore, our rigorous monitoring and follow-up of maintenance activities enable us to continuously improve our predictive maintenance capabilities, as per our Service Level Agreements.

Our most convenient agreement empowers your team to **manage first- and second-line support independently**. In this model, your operators serve as the first line of support, escalating any unresolved issues to their technical team. Additionally, we provide a comprehensive spare and wear parts package that covers 85% of service and maintenance needs, ensuring your electrolyzers remain up to date and operational.

For more complex issues, **Exion Hydrogen Service Engineers can assist your technical team**. This will resolve up to 95% of all questions and issues. In the rare case of unresolved issues, an on-site visit by an Exion Hydrogen engineer can be easily scheduled.



We take the uptime of your electrolyzers and your satisfaction very seriously.
Depending on the Service Level Agreement you prefer, we can assist you with preventive maintenance, remote monitoring and support, or on-site support in case needed.

APPLICATION FIT BY DESIGN

Since hydrogen production capacity and performance are crucial factors when selecting the most suitable water electrolyzer for your project, our alkaline and PEM platforms are designed with application fit and scalability at their core. They deliver up to 100 Nm³/h and 500 Nm³/h respectively in single-unit configurations, while enabling multi-unit setups to further scale production across a wide range of industrial applications.

RIGHTSIZING FOR CURRENT AND FUTURE PROJECT NEEDS

There is a wide range of water electrolyzers targeting large-scale hydrogen projects. However, many clients still benefit from efficient and reliable solutions tailored to their specific needs. To provide systems that meet (but do not exceed) hydrogen production requirements, we developed **flexible and scalable platform solutions** that can operate in any location, both on and off the grid.

A flexible and scalable solution

Our HyGGe™ 100A alkaline and HyGGe™ 500P PEM electrolyzers are designed to serve a wide range of markets, **from applications requiring a modest and steady hydrogen supply to those demanding higher production capacities**. The HyGGe™ 100A features two proprietary cell stacks of 50 Nm³/h each, delivering up to 100 Nm³/h, while the HyGGe™ 500P is based on a single proprietary cell stack with an output of up to 500 Nm³/h, both ensuring continuous production of high-quality hydrogen.

The systems are designed to be 'load-following,' meaning their **production rate automatically adjusts** to meet actual hydrogen demand. Higher production capacity can be achieved by adding additional units, while lower production levels are possible by reducing input power or, in the case of the HyGGe™ 100A, operating a single cell stack.

The importance of redundancy

Our HyGGe™ 100A alkaline and HyGGe™ 500P PEM electrolyzers are **designed with redundancy in mind** to ensure continuous hydrogen production. For the HyGGe™ 100A, a first layer of redundancy is implemented at the cell stack level. In the unlikely event of a failure in one of the two cell stacks, the system can continue operating with the remaining stack at reduced capacity.

A second layer of redundancy is implemented at the unit level. Multiple electrolyzer units can be easily combined to increase hydrogen production volumes. In such **multi-unit setups**, production output can be balanced to a predetermined setpoint using a leader-follower configuration.



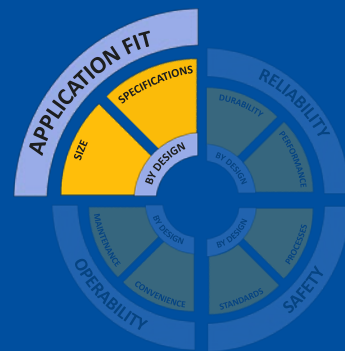
MODULARITY AS A KEY ENABLER

Cost-effective scaling and operational flexibility are essential considerations in every hydrogen generation project and electrolyzer purchasing cycle. Modularity offers clear benefits by supporting both expansion and redundancy, thereby enhancing reliability and incrementally increasing capacity.

*The design of both our HyGGe™ 100A and HyGGe™ 500P units allows for **seamless integration into existing systems, infrastructures, or hydrogen supply chains**. This feature is particularly beneficial for industries transitioning to hydrogen, as it minimizes the need for extensive modifications to their current setups.*

SPECIFICATIONS BY DESIGN

Our HyGGe™ 100A as well as our HyGGe™ 500P electrolyzer are scalable solutions for hydrogen production in industrial and emerging markets. Its ability to serve diverse sectors and applications sets it apart as a unique and flexible solution for high-purity hydrogen production.



MEETING THE DEMANDS OF SPECIALIZED INDUSTRIES

Many specialized sectors require a daily hydrogen supply ranging from 50 kg to 1,000 kg, often with **strict purity and flow requirements**. The HyGGe™ 100A alkaline and HyGGe™ 500P PEM electrolyzers deliver up to 100 Nm³/h and 500 Nm³/h of 4.8-grade hydrogen at 30 barg respectively, making them well suited to meet these demands.

For higher hydrogen output, multiple units can be deployed in a **modular configuration to scale production**. This approach increases capacity while adding redundancy, ensuring a reliable hydrogen supply for critical applications.

Whether for industrial production or sensitive processes like hydrogenation in the food industry, our electrolyzers ensure that hydrogen is delivered at **the right flow rate, purity, and pressure**, effectively meeting the requirements of these industries.



*The HyGGe™ 100A alkaline and HyGGe™ 500P PEM electrolyzers are **robust, scalable, and versatile solutions** designed to meet the diverse needs of various industries and applications. Their ability to handle varying hydrogen demands, while maintaining exceptional purity and reliability, positions them as key enablers in the transition to cleaner and more sustainable energy solutions across multiple sectors.*

A FEW EXAMPLES

The **food industry**, particularly in the hydrogenation of edible oils, demands extremely pure hydrogen with minimal contaminants. Both our technology platforms produce electrolytic hydrogen of sufficiently high purity, free from harmful impurities.

In **flat glass production**, hydrogen is critical for maintaining a reducing environment to prevent oxidation. Hydrogen produced by our HyGGe™ units, containing virtually no oxygen, is an ideal solution for this demanding application.

In **metallurgy**, hydrogen plays a crucial role in ensuring that oxygen does not interfere with heat treatments such as annealing and sintering. Typically, a setup with one to five units is sufficient to meet the high-purity hydrogen demands for these processes.

The **electronics industry** requires hydrogen of exceptional purity, up to 7.0-grade, for applications such as wafer production, integrated circuits (ICs), and solar panels. While our HyGGe™ systems provide 4.8-grade hydrogen, it serves as an excellent foundation for further purification up to the required purity.

Whether for catalytic reactions or chemical processing, the HyGGe™ electrolyzers deliver hydrogen that adheres to the high standards of the **chemical, petrochemical, and pharmaceutical industries**.

While grid-scale hydrogen production requires larger electrolyzers, the HyGGe™ systems are well-suited **for distributed energy projects**, such as smaller solar or wind farms. The unit efficiently meets the hydrogen production needs and operational flexibility of such localized projects.

Hydrogen fuel cell vehicles (FCEVs) require high-purity hydrogen that meets the SAE J2719 standard. The HyGGe™ 100A and HyGGe™ 500P electrolyzers deliver hydrogen with a purity exceeding these requirements, producing over 200 kg/day and 1,000 kg/day respectively when **operating continuously**.

The HyGGe™ 100A and HyGGe™ 500P are the epitome of versatility.

LEADING THE FUTURE OF SAFE HYDROGEN PRODUCTION

At Exion Hydrogen, we understand that the future of hydrogen lies in decarbonizing at the source, and we are committed to leading this transition with the HyGGe™ 100A alkaline and HyGGe™ 500P PEM pressurized electrolyzers, as well as future models set to enter the market. By integrating **advanced engineering, durable materials, and innovative design**, we have developed electrolyzer solutions that not only meet today's industrial demands but are also primed for the challenges of tomorrow. Whether you are optimizing hydrogen production for energy storage, industrial processes or mobility applications, both HyGGe™ platforms deliver high-purity hydrogen with high reliability and durability.

Our approach prioritizes not just performance but also **ease of operation and maintenance**. With features such as modular expansion, autonomous power modulation, and real-time demand management, our electrolyzers are designed to seamlessly integrate into existing systems while offering the flexibility to scale as hydrogen needs grow. This future-proof approach ensures that production stays ahead of the curve, no matter how demands evolve.

We know that safe and reliable hydrogen production hinges on more than just equipment; it also requires dedicated support. That is why we offer **comprehensive service options**, from preventive maintenance and remote support to flexible maintenance scheduling. Our team of experts is ready to ensure systems operate at peak performance, minimizing disruptions and maximizing efficiency.

In a world striving for decarbonization and energy independence, the HyGGe™ 100A and HyGGe™ 500P are more than products. They are cornerstones of the sustainable hydrogen economy. With a **focus on quality, performance, and adaptability**, Exion Hydrogen is here to support the transition toward cleaner, more sustainable energy solutions.

Together, we are building better electrolyzers for a sustainable future.

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