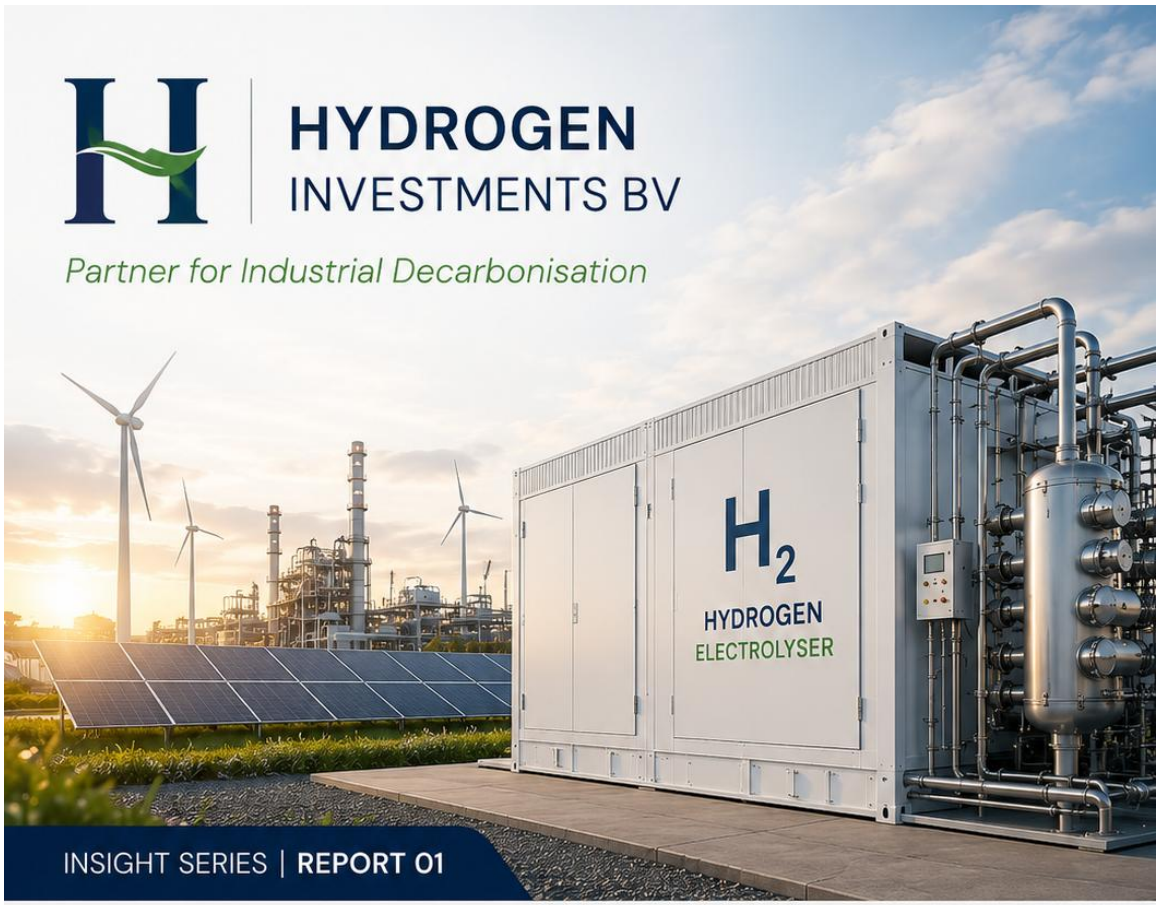
HYDROGEN
INVESTMENTS BV

Partner for Industrial Decarbonisation



INSIGHT SERIES | **REPORT 01**

Choosing the Right Electrolyser

What Industrial Buyers Should Really Evaluate Before Investing

SAFE.
RELIABLE.
PROVEN.

FULLY INTEGRATED.
AUTOMATED.
FLEXIBLE.

LOWER LIFETIME
COST.
HIGHER VALUE.

LONG-TERM
PARTNERSHIP.
LASTING IMPACT.

PREPARED BY
Hydrogen Investments BV
Amsterdam, The Netherlands

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About Hydrogen Investments BV

Hydrogen Investments BV is an independent advisory company supporting industrial decarbonisation through commercial representation, business development, investment advisory and legal & commercial structuring. The company works with carefully selected technology partners to help industrial users evaluate, develop and implement hydrogen and carbon management projects.

Publication

Hydrogen Investments BV Insight Series

Report 01

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Executive Summary

Hydrogen is rapidly becoming an important component of industrial decarbonisation strategies. Across industries including cement, steel, aluminium, refining, power generation and food processing, companies are increasingly evaluating hydrogen to reduce carbon emissions, improve energy resilience and prepare for a lower-carbon future.

As investment activity accelerates, selecting the right electrolyser becomes one of the most critical decisions within a hydrogen project. Yet procurement processes often focus on comparing purchase prices, hydrogen purity or headline efficiency figures presented in supplier brochures. While these parameters are important, they rarely determine the long-term success of an industrial hydrogen investment.

An electrolyser is not simply a hydrogen-producing device. It is often an integral industrial process plant expected to operate safely, efficiently and reliably for decades, and the most importantly in autonomous harmony with the changing requirements of factory. Its value depends not only on the stack, but also on the performance of power electronics, water treatment, cooling systems, automation, instrumentation, safety architecture and long-term service support. Ultimately, the success of an electrolyser is measured not by how it performs on the day it is commissioned, but by how it continues to perform throughout its operational life.

For industrial users, reliability is often more valuable than achieving the highest laboratory efficiency. Unexpected interruptions in hydrogen production may affect entire manufacturing processes, resulting in production losses that far exceed the cost of the electrolyser itself. Consequently, factors such as automation, integration with existing plant operations, availability of spare parts, supplier support and long-term service capability deserve the same level of attention as technical performance.

One of the most common misconceptions in electrolyser procurement is that capital expenditure represents the primary economic consideration. In reality, electricity consumption, maintenance, efficiency degradation and operational reliability generally account for a much larger share of the lifetime cost of producing hydrogen. A lower purchase price does not necessarily result in a lower cost of hydrogen over the life of the project. Successful investments are those that optimise **Total Cost of Ownership (TCO)** rather than simply minimising initial capital expenditure.

This report has been prepared to provide industrial decision-makers with a practical framework for evaluating electrolyser investments from an operational, technical and commercial perspective. Rather than comparing technologies or manufacturers, it focuses on the questions every industrial buyer should ask before making an investment decision.

At Hydrogen Investments BV, we believe that every industrial facility has unique operational requirements and that no single technology is universally the best solution. Successful projects begin with understanding the industrial process, defining performance requirements and objectively evaluating technologies against those requirements. Our role is to support industrial companies throughout this decision-making process by combining technical understanding, commercial insight and strategic advisory services.

Key Outcomes of the Report

- Start with your industrial process—not with the technology.
- Evaluate the complete electrolyser system, not only the stack.
- Focus on Total Cost of Ownership rather than purchase price.
- Assess long-term performance, not only Beginning-of-Life (BoL) figures.
- Reliability, automation and integration determine long-term project success.
- The right procurement questions lead to better investment decisions.

1. Why Electrolyser Selection Matters

The most important decision is not choosing a technology—it is defining what success looks like

Hydrogen is becoming an essential component of industrial decarbonisation strategies. Across industries such as cement, steel, aluminium, refining and power generation, hydrogen is increasingly viewed not only as an alternative energy source but also as a strategic raw material capable of reducing carbon emissions while supporting long-term sustainability objectives.

At the centre of every green hydrogen project is the electrolyser. It is the equipment responsible for converting electrical energy into hydrogen and oxygen through electrolysis of water. However, for industrial users, an electrolyser should not be viewed simply as another piece of process equipment. It is a critical production asset whose performance directly influences operating costs, production continuity and the overall feasibility of the investment.

Selecting the right electrolyser is therefore one of the most important decisions during the development of a hydrogen project. While many procurement processes focus primarily on purchase price, hydrogen purity or efficiency measured during commissioning, these parameters alone rarely determine the long-term success of an investment.

In practice, industrial facilities require much more than hydrogen production. They require a system capable of operating safely, continuously and reliably while integrating seamlessly with existing plant operations. The electrolyser must be able to respond to changing production requirements, communicate with plant automation systems, maintain stable operating conditions and minimise the need for operator intervention. Any unexpected shutdown may not only interrupt hydrogen production but can also affect upstream and downstream industrial processes, resulting in significant production losses.

For this reason, evaluating an electrolyser should be approached as an investment decision rather than a procurement exercise. The objective is not to identify the machine with the best specifications on the day of commissioning, but to select the solution that will continue delivering reliable, efficient and economical hydrogen production throughout its operational life.

There Is No Universally "Best" Electrolyser

One of the most common misconceptions in the hydrogen industry is the belief that a single technology or supplier represents the best solution for every project.

In reality, every commercially available electrolyser technology can successfully produce hydrogen when applied under the right operating conditions. The challenge for industrial users is not identifying the universally "best" technology, but selecting the solution that best matches the operational, commercial and integration requirements of their facility.

The optimum solution for a refinery producing ultra-high-purity hydrogen may differ significantly from that of a cement plant using hydrogen as a supplementary burner fuel. Similarly, a facility operating continuously twenty-four hours a day will have different priorities from one designed to follow intermittent renewable electricity generation.

Successful projects therefore begin by understanding the operational requirements of the industrial process before evaluating electrolyser technologies.

From Procurement Cost to Lifetime Value

A common procurement approach is to compare electrolysers based on their initial purchase price and Beginning-of-Life (BoL) performance values. While these figures are useful, they represent only a small part of the investment.

Industrial hydrogen projects generate operating costs throughout their entire lifetime. Electricity consumption, maintenance activities, stack degradation, spare parts, water treatment, planned maintenance and unexpected downtime often represent a much greater financial commitment than the initial purchase price.

In many projects, **CAPEX accounts for only approximately 25% of the Levelized Cost of Hydrogen (LCOH)**. Even during the first year of operation, electricity costs alone may exceed the initial investment. Consequently, relatively small improvements in long-term efficiency or plant availability can generate significantly greater financial value than modest reductions in purchase price.

For industrial investors, the relevant question is therefore not:

"Which electrolyser is the cheapest to buy?"

but rather:

"Which electrolyser will produce hydrogen at the lowest lifetime cost while operating safely and reliably for the next twenty years?"

An Electrolyser Is Not a Stack

Another common mistake is to evaluate an electrolyser almost exclusively by the performance of its stack.

An industrial electrolyser is a complete process plant comprising power electronics, transformers, rectifiers, cooling systems, water treatment units, instrumentation, control systems, safety equipment and numerous auxiliary components. The reliability of these systems often determines plant availability as much as the electrochemical performance of the stack itself.

For this reason, industrial buyers should evaluate the complete system rather than focusing solely on stack specifications. The quality of auxiliary equipment, the choice of component manufacturers, automation architecture, service capabilities and spare parts availability are equally important in ensuring long-term operational performance.

Objectives of This Report

This report has been prepared to support industrial companies evaluating investments in hydrogen production facilities. Rather than comparing electrolyser technologies or manufacturers, it focuses on the practical factors that determine long-term project success.

The following chapters examine how industrial users can evaluate electrolysers from an operational and investment perspective, with particular emphasis on lifetime efficiency, system integration, reliability, automation, maintenance strategy and total cost of ownership.

The objective is to provide decision-makers with a practical framework that supports informed procurement decisions and contributes to the successful implementation of industrial hydrogen projects.

Hydrogen Investments BV Perspective

The right electrolyser is not the one with the lowest purchase price or the best commissioning performance. It is the one that delivers the lowest lifetime cost of hydrogen while operating safely, reliably and seamlessly within the industrial process

THE INDUSTRIAL BUYER'S MINDSET

From procurement focus to lifecycle value

HYDROGEN INVESTMENTS BV
Partner for Industrial Decarbonisation

TRADITIONAL PROCUREMENT MINDSET

Focus on upfront purchase

Lowest CAPEX
Primary driver is purchase price

Hydrogen Purity
Often over-specified for the application

Beginning-of-Life (BoL) Efficiency
Values measured on the day of commissioning

Shortest Delivery Time
Focus on project schedule

Standard Warranty
Limited view of long-term performance

Looks at the first day.
Risks high operating costs and production disruptions.

VS.

LIFECYCLE INVESTMENT MINDSET

Focus on total value over lifetime

Total Cost of Ownership (TCO)
Considers energy, O&M, replacements, downtime and spare parts over 15–20+ years

Lifetime Efficiency & Degradation
Evaluates efficiency performance year after year

Reliability & Availability
Continuous, safe and robust operation with minimal unplanned stops

Integration & Automation
Seamless connection with plant systems, flexible operation, load following

Service, Support & Spare Parts
Local availability, long-term service agreements and proven support capability

Looks at every day of the next 20 years.
Delivers lower LCOH, higher reliability and sustained value.

The goal is not the cheapest electrolyser.
The goal is the lowest cost of hydrogen over its entire lifetime.

Right Choice → Reliable Supply → Industrial Value → Sustainable Future

2. Understanding Industrial Hydrogen Demand

Different industries use hydrogen differently. Your application defines your requirements.

Hydrogen is often presented as a universal solution for industrial decarbonisation. In reality, however, its role varies significantly depending on the industry, production process and operational objectives.

A cement plant, for example, evaluates hydrogen primarily as an alternative fuel capable of reducing carbon emissions while maintaining kiln performance. A refinery may require hydrogen as a high-purity process gas, whereas a power plant may use hydrogen both as a cooling medium for generators and, increasingly, as a supplementary fuel. Similarly, food processing facilities use hydrogen for applications such as hydrogenation and modified atmosphere packaging.

These differences have a direct impact on electrolyser selection. Parameters such as hydrogen purity, operating pressure, production flexibility, system availability and integration requirements vary considerably from one application to another. Consequently, the first step in any hydrogen investment should not be selecting an electrolyser technology, but understanding how hydrogen will be used within the industrial process.

This chapter provides an overview of the principal industrial applications of hydrogen and highlights the operational considerations that influence investment decisions.

Hydrogen Across Industrial Sectors

Hydrogen serves different purposes in different industries. Consequently, the definition of a "successful" hydrogen project is not the same for every industrial user.

Cement Industry

Among heavy industries, the cement sector presents one of the strongest business cases for green hydrogen. Cement production is responsible for substantial carbon emissions, both from fuel combustion and the calcination process. While carbon capture technologies offer the greatest potential for emission reduction, they require significant capital investment and introduce additional operating costs.

Hydrogen provides an alternative pathway by partially replacing conventional fuels within the kiln. Beyond reducing carbon emissions, hydrogen combustion offers higher flame temperatures and faster combustion characteristics, which can improve kiln performance and increase the utilisation of alternative fuels. As a result, hydrogen investments may contribute not only to sustainability objectives but also to operational improvements.

For cement producers, the primary evaluation criteria extend well beyond hydrogen production itself. Continuous operation, system reliability and seamless integration with existing burner control systems are critical. Any interruption in hydrogen supply can disrupt the combustion process, resulting in production losses and

significant operational costs. Consequently, plant availability and operational reliability often outweigh small differences in initial purchase price.

Steel Industry

Hydrogen has long been used within the steel industry for applications such as annealing, heat treatment and protective atmospheres. Looking ahead, its role is expected to expand significantly with the development of Direct Reduced Iron (DRI) processes, where hydrogen has the potential to replace carbon-intensive reducing agents.

Unlike fuel applications, steel production often requires strict control of hydrogen purity and process stability. The quality of hydrogen can directly influence metallurgical properties and product quality, making consistency of supply an important operational requirement.

As hydrogen-based steelmaking technologies continue to mature, producers will increasingly evaluate electrolysers based on long-term operational efficiency, scalability and integration with renewable electricity generation.

Aluminium Industry

The aluminium industry is under increasing pressure to reduce its carbon footprint while maintaining international competitiveness. Hydrogen can contribute to this transition by replacing fossil fuels in high-temperature heating applications.

Unlike the cement industry, hydrogen does not necessarily reduce operating costs for aluminium producers. Green hydrogen is generally more expensive than natural gas, increasing energy costs in the short term. Nevertheless, investments are increasingly justified by sustainability objectives, energy security and the growing market premium associated with low-carbon or "green" aluminium products.

Over time, integrating electrolysers with dedicated renewable energy generation may significantly improve project economics while reducing dependence on external energy markets.

Oil & Refineries

Hydrogen is already an essential feedstock within refinery operations, supporting processes such as hydrocracking and hydrotreating. Rather than introducing a completely new application, electrolysers provide an opportunity to replace conventionally produced hydrogen with low-carbon alternatives while supporting future capacity expansion.

Because refinery operations often require high hydrogen purity and uninterrupted supply, system reliability, redundancy and operational flexibility become particularly important during project evaluation.

Power Generation

Hydrogen has been used in the power generation sector for decades as an efficient cooling medium for large electrical generators due to its excellent thermal conductivity and low density. Compared with traditional cooling methods, hydrogen significantly improves generator efficiency while reducing cooling water requirements.

Looking forward, hydrogen is also expected to play an increasing role as a supplementary fuel. In coal-fired power plants, hydrogen blending can improve combustion characteristics and reduce carbon emissions. Gas-fired plants are also exploring hydrogen-natural gas mixtures as part of broader decarbonisation strategies, although economic viability will depend on future hydrogen production costs and renewable electricity availability.

Food Processing

Although less visible than heavy industry, the food sector also relies on hydrogen for several specialised applications. Hydrogen is widely used in hydrogenation processes, including the production of margarine and edible oils, and increasingly supports packaging technologies designed to extend product shelf life.

For these applications, consistent product quality and reliable hydrogen purity are generally more important than large production capacity.

Key Takeaways

- Hydrogen applications vary significantly between industries.
- The definition of project success depends on the operational objectives of each facility.
- Hydrogen purity is critical in some industries but of secondary importance in others.
- Reliability, automation and integration remain essential across all industrial sectors.
- Understanding the application should always precede technology selection.

Hydrogen Investments BV Perspective

The first question in any hydrogen investment should not be "Which electrolyser should we buy?" It should be "How will hydrogen be used within our process?" Once the application is clearly defined, the appropriate technology, system configuration and investment strategy become significantly easier to determine.

3. Define Your Requirements Before Selecting an Electrolyser

The best technology is the one that fits your process—not the one with the best brochure.

One of the most common mistakes in hydrogen projects is to begin evaluating technologies before clearly defining the operational requirements of the industrial facility.

Manufacturers naturally promote the strengths of their own products, often emphasising stack efficiency, hydrogen purity, operating pressure or capital cost. While these parameters are important, they only have meaning when evaluated against the specific needs of the intended application.

A cement plant, refinery, aluminium producer and food processing facility may all require hydrogen, but they do not require the same hydrogen system. Differences in production philosophy, operating conditions, process integration and commercial objectives mean that no single electrolyser configuration is optimal for every project.

Consequently, the first stage of every hydrogen investment should be a structured assessment of operational requirements. Once these requirements have been defined, selecting the most suitable technology becomes a far more objective engineering exercise.

Begin With Your Process, Not the Electrolyser

Rather than asking:

"Which electrolyser should we buy?"

Industrial buyers should first answer a series of fundamental questions about their own process.

These questions determine not only the size of the electrolyser but also the required level of automation, flexibility, redundancy, integration and long-term operational performance.

Understanding Your Hydrogen Demand

Hydrogen demand is the starting point of every project.

The required production capacity determines not only electrolyser size but also the architecture of the complete hydrogen production plant.

Important considerations include:

• Average hydrogen consumption

• Peak hydrogen demand

• Future production expansion

• Daily operating hours

• Seasonal variations

• Continuous or batch production

Many facilities initially install smaller systems with the intention of future expansion. In such cases, modularity and scalability become important selection criteria.

Continuous Production or Flexible Operation?

Not every industrial facility consumes hydrogen in the same way.

Some plants require stable hydrogen production twenty-four hours a day.

Others require rapid changes in output depending on production schedules or renewable electricity availability.

Therefore buyers should determine:

• Is hydrogen consumed continuously?

• Does production need to ramp up and down?

• Is renewable electricity the primary energy source?

• Will hydrogen production follow electricity prices?

The answers directly influence control philosophy and equipment selection.

Integration With Existing Plant Operations

An electrolyser should never operate as an isolated machine.

It should become part of the existing industrial process.

Industrial buyers should therefore evaluate how the electrolyser will communicate with:

- Plant DCS
- PLC systems
- SCADA
- Burner management systems
- Energy Management Systems (EMS)
- Utility systems
- Safety systems

The ability to automatically adjust hydrogen production according to real-time plant demand is often considerably more valuable than marginal improvements in laboratory efficiency.

Automation and Operational Philosophy

Large industrial facilities are designed for continuous operation with minimal operator intervention.

Hydrogen production should follow the same philosophy.

A modern electrolyser should provide:

- Fully automatic operation
- Automatic start-up and shutdown
- Remote monitoring

• Alarm management

• Predictive maintenance

• Historical data recording

• Cybersecure communication

The objective is not simply producing hydrogen but producing hydrogen reliably without disrupting existing plant operations.

Reliability Is More Valuable Than Peak Performance

Industrial production cannot tolerate unexpected shutdowns.

If hydrogen becomes an integral component of the production process, interruption of hydrogen supply may stop the entire facility.

For example, in a cement plant where hydrogen is used as burner fuel, loss of hydrogen supply may interrupt combustion stability, resulting in production losses, increased fuel consumption and lengthy restart procedures.

For this reason, reliability often creates greater economic value than small improvements in efficiency.

Industrial users should therefore evaluate:

• Proven operating hours

• Availability guarantees

• Component reliability

• Redundancy philosophy

• Service response time

• Spare parts availability

Water Availability and Water Quality

Although electricity represents the largest operating cost, water quality has a significant influence on both electrolyser efficiency and stack lifetime.

Poor water quality may result in:

• Reduced electrical efficiency

• Increased maintenance

• Higher degradation rates

• Shorter stack lifetime

• Reduced hydrogen purity

Industrial buyers should therefore evaluate not only water consumption but also the complete water treatment system, including reverse osmosis, electrodeionisation and continuous monitoring of water conductivity.

Water treatment should be considered an integral part of the electrolyser rather than an optional auxiliary system.

Hydrogen Pressure and Purity

Hydrogen pressure and purity are among the most frequently advertised performance indicators.

However, their importance depends entirely on the intended application.

For example:

High hydrogen purity is essential for many refinery and chemical applications.

By contrast, hydrogen used as burner fuel in cement production generally places greater emphasis on availability and production flexibility.

Similarly, higher outlet pressure may reduce downstream compression requirements in some facilities but offer little benefit in others.

Consequently, pressure and purity should be evaluated only after the process requirements have been clearly defined.

Planning for Future Expansion

Industrial hydrogen projects rarely remain unchanged throughout their operational life.

Increasing production capacity, expanding renewable electricity generation or introducing additional hydrogen applications may require future plant expansion.

Questions to consider include:

• Can additional stacks be installed?

• Can power electronics be expanded?

• Is the control system prepared for larger capacities?

• Can hydrogen storage be increased?

Planning for future expansion during the initial design stage often reduces future investment costs considerably.

Key Takeaways

- Define operational requirements before comparing suppliers.
- The industrial process determines the required electrolyser characteristics.
- Automation and integration are as important as electrochemical performance.
- Reliability, maintainability and service support directly influence project economics.
- Pressure and hydrogen purity are important—but only when required by the application.
- Planning for future expansion reduces long-term investment costs.

- The objective is not purchasing an electrolyser; it is implementing a hydrogen production system that supports reliable industrial operation.

Hydrogen Investments BV Perspective

Industrial buyers often spend significant time comparing brochures before fully understanding their own operational requirements. In our experience, successful projects begin with a detailed assessment of the industrial process—not with supplier presentations. Once the operational philosophy is clearly defined, identifying the appropriate electrolyser becomes a structured engineering exercise rather than a commercial comparison.

4. Looking Beyond the Stack

An electrolyser is not a stack. It is an industrial process plant.

When evaluating electrolysers, many industrial buyers naturally focus on the stack. After all, the stack is where electrolysis takes place and where hydrogen is produced. Manufacturers frequently highlight stack efficiency, current density, operating pressure and other electrochemical performance indicators, making the stack appear to be the defining element of the entire system.

While the stack is undoubtedly the heart of an electrolyser, it is not the entire plant.

A modern industrial electrolyser consists of dozens of interconnected systems working together to produce hydrogen safely, efficiently and continuously. The overall performance of the plant depends not only on the electrochemical characteristics of the stack, but also on the quality of power electronics, cooling systems, water treatment, automation architecture, safety systems and auxiliary equipment.

The Electrolyser Is an Integrated Process Plant

An industrial electrolyser is comparable to any other critical process unit within a factory.

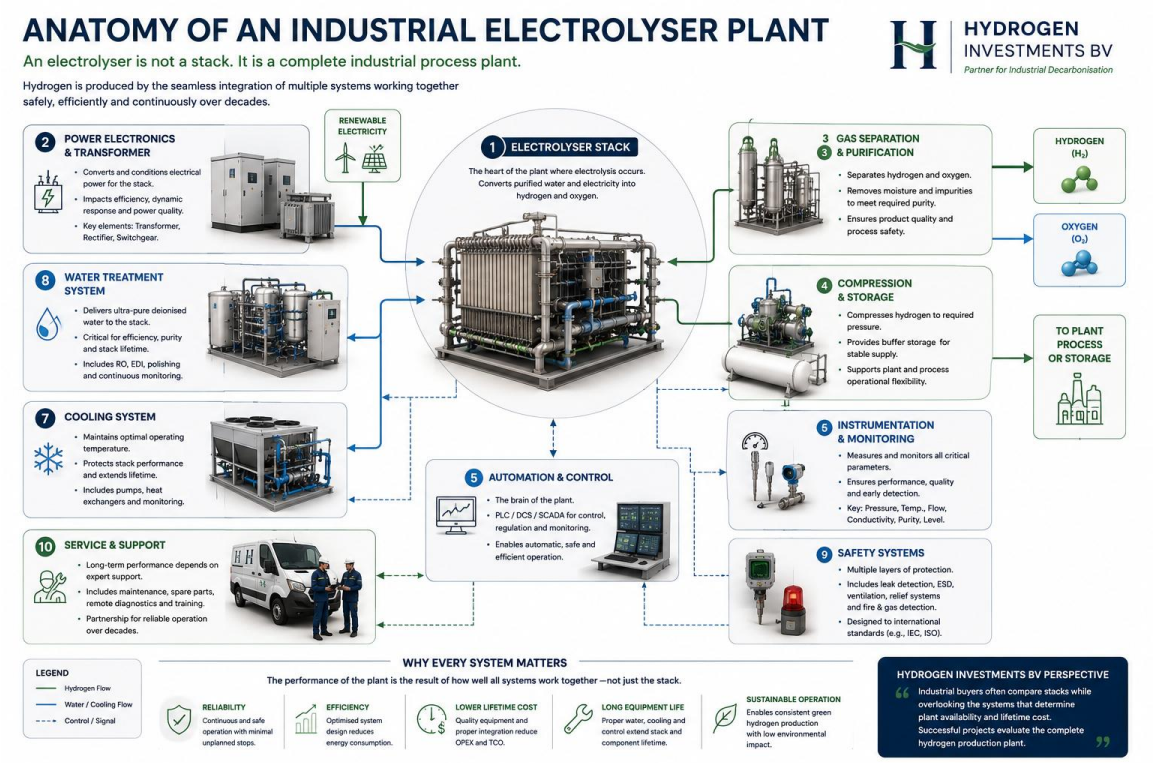
It receives electrical power and ultra-purified water as inputs, converts these into hydrogen and oxygen, continuously monitors many operating parameters and communicates with the plant automation system while maintaining strict safety standards.

Hydrogen Investments BV Perspective

A reliable electrolyzer has more than 50 instruments to monitor the sensible data for efficient and stable operation.

Like any industrial process plant, its long-term success depends on the reliability of every subsystem—not just one.

The illustration below demonstrates the major building blocks of a complete electrolyser plant.



Supporting every stage are:

- Water Treatment
- Cooling System
- PLC / DCS / SCADA
- Safety Systems
- Instrumentation
- Remote Monitoring
- Utilities

Power Electronics: The Hidden Performance Driver

The quality of the power supply has a direct influence on electrolyser performance.

Transformers and rectifiers determine how efficiently electrical energy is delivered to the stack and how precisely operating conditions can be controlled.

Modern industrial facilities increasingly require electrolysers capable of adjusting production output dynamically while maintaining stable operating conditions. This places significant importance on the design of the power electronics and the sophistication of the control algorithms.

Industrial buyers should therefore evaluate:

- Rectifier efficiency
- Dynamic load response
- Current stability
- Harmonic performance
- Redundancy philosophy
- Supplier reputation
- Availability of spare parts

Water Treatment: Protecting Efficiency and Stack Lifetime

Electricity may represent the largest operating cost of an electrolyser, but water quality has a profound influence on both efficiency and equipment lifetime.

Electrolysers require ultra-pure deionised water with extremely low conductivity. Even small deviations in water quality can accelerate stack degradation, reduce electrical efficiency and increase maintenance requirements.

A properly designed water treatment system therefore contributes directly to:

- Higher electrical efficiency
- Longer stack life
- Reduced maintenance
- Stable hydrogen purity
- Lower operating costs

Industrial buyers should evaluate the complete water treatment philosophy, including reverse osmosis, electrodeionisation, polishing systems and continuous water quality monitoring.

Hydrogen Investments BV Perspective

Water treatment should never be viewed as an auxiliary package. It is one of the most important factors influencing long-term electrolyser performance.

Cooling Systems: Maintaining Stable Operation

Electrolysis generates heat continuously.

Without effective cooling, stack temperatures increase, accelerating degradation and reducing system efficiency.

Cooling systems therefore perform a critical function by maintaining stable operating temperatures across varying production conditions.

Industrial buyers should consider:

- Cooling philosophy
- Redundancy
- Pump reliability
- Heat exchanger quality
- Cooling water requirements
- Maintenance accessibility

A well-designed cooling system not only protects the stack but also contributes significantly to operational reliability.

Automation: The Brain of the Plant

Large industrial facilities operate through sophisticated automation systems designed to maximise productivity while minimising operator intervention.

The electrolyser should follow the same philosophy.

Modern hydrogen plants should provide:

- Fully automatic operation
- Automatic start-up and shutdown
- Remote diagnostics
- Predictive maintenance
- Data logging
- Alarm management
- Cybersecure communication
- Integration with plant DCS and SCADA systems

In many industrial facilities, automation quality has a greater influence on day-to-day operation than marginal differences in electrochemical efficiency.

Instrumentation and Control

Reliable measurement is fundamental to reliable operation.

Pressure, temperature, flow, water conductivity, hydrogen purity and electrical parameters must all be monitored continuously to ensure safe and efficient hydrogen production.

Industrial buyers should pay close attention to:

- Instrument quality
- Sensor redundancy
- Calibration philosophy
- Control algorithms
- ATEX Classification

Accurate instrumentation enables predictive maintenance and supports long-term operational optimisation.

Safety Is Designed Into the Plant

Hydrogen is a highly valuable industrial gas, but it requires rigorous engineering and safety management.

A modern electrolyser plant incorporates multiple layers of protection designed to minimise operational risk.

These include:

- Hydrogen leak detection
- Ventilation systems
- Emergency shutdown systems
- Pressure relief devices
- Electrical protection
- Functional safety logic
- Hazardous area classification
- Compliance with applicable standards

Industrial buyers should evaluate the overall safety philosophy rather than focusing solely on individual safety components.

The Importance of Component Selection

Not all industrial components offer the same level of reliability or global service support.

Many experienced industrial operators request detailed equipment lists during procurement in order to understand which manufacturers supply critical components such as:

- Rectifiers
- Pumps
- Heat exchangers
- PLC hardware
- Instrumentation

- Valves
- Sensors

Well-established component manufacturers often provide stronger technical support, shorter spare parts lead times and longer product life cycles.

Consequently, understanding the equipment philosophy can be as important as evaluating stack specifications.

Service Is Part of the Product

An electrolyser is expected to operate for decades.

Throughout this period, maintenance support, spare parts availability and technical assistance become essential elements of project success.

Industrial buyers should therefore evaluate:

- Local service capability
- Spare parts inventory
- Long-Term Service Agreements (LTSA)
- Remote technical support
- Response times
- Preventive maintenance programmes
- Performance guarantees

The relationship with the supplier should be viewed as a long-term operational partnership rather than a one-time equipment purchase.

Key Takeaways

- The stack is only one component of a complete industrial process plant.
- Auxiliary systems often determine reliability, availability and maintenance requirements.

- Power electronics, automation and cooling systems directly influence long-term performance.
- Ultra Pure DI Water is critical for efficiency, stack life and hydrogen quality.
- High-quality instrumentation improves operational reliability and predictive maintenance.
- Service capability and spare parts availability are fundamental investment criteria.
- Successful projects evaluate the complete plant rather than focusing solely on stack specifications.

Hydrogen Investments BV Perspective

Industrial buyers often compare stacks while overlooking the systems that determine plant availability. In practice, transformers, rectifiers, cooling systems, automation architecture and service capability frequently have a greater impact on operational success than small differences in stack efficiency. The objective should always be to evaluate the complete hydrogen production plant—not just its electrochemical core.

5. Total Cost of Ownership vs Purchase Price

The cheapest electrolyser is rarely the lowest-cost investment.

Never compare electrolysers solely on their purchase prices.

While capital investment is undoubtedly an important consideration, it represents only a fraction of the total cost associated with producing hydrogen over the lifetime of the plant. For most industrial users, the largest financial commitment begins after commissioning, when electricity consumption, maintenance, stack degradation and operational reliability start influencing the economics of hydrogen production every day.

Selecting an electrolyser should therefore be viewed as a long-term operational investment rather than a one-time equipment purchase.

The objective is not to minimise the purchase price.

The objective is to minimise the **lifetime cost of producing hydrogen**.

Looking Beyond CAPEX

Capital expenditure is often the easiest figure to compare because it is visible, fixed and available before procurement.

Operating expenditure is far more difficult to estimate.

Unfortunately, it is also far more important.

Electricity, water treatment, maintenance, spare parts, stack replacement and production losses continue throughout the entire life of the plant.

Small differences in efficiency or plant availability therefore accumulate into substantial financial differences over twenty years of operation.

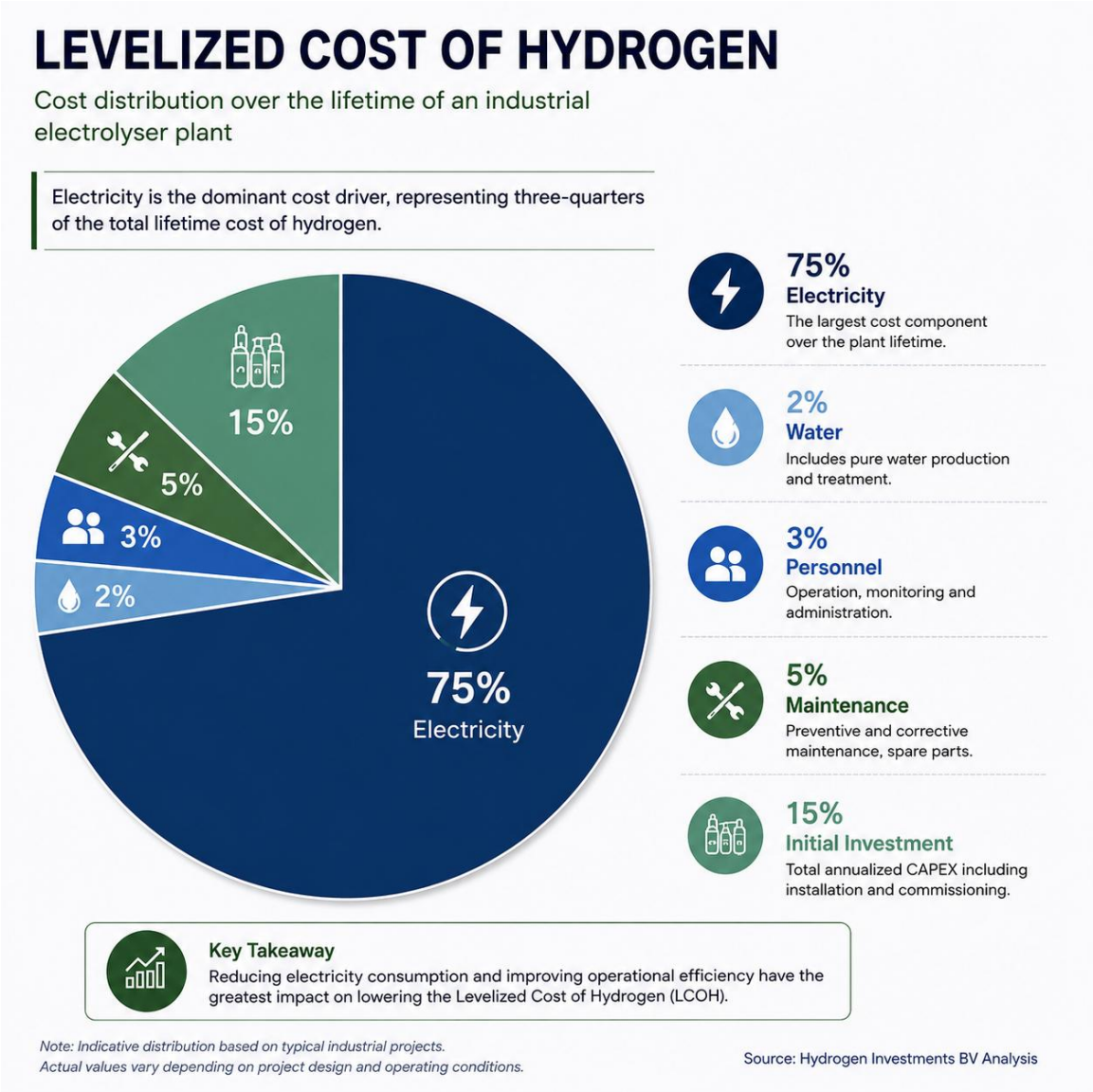
For this reason, two electrolysers with similar purchase prices may produce hydrogen at significantly different lifetime costs.

Industry experience shows that **capital expenditure typically represents only around one quarter of the Levelized Cost of Hydrogen (LCOH)**.

The remaining costs arise during operation.

Even during the first year of operation, electricity costs alone may exceed the initial investment value.

Consequently, a five percent improvement in long-term efficiency often creates greater economic value than a ten percent reduction in purchase price.



Beginning-of-Life Is Not End-of-Life

Most supplier proposals highlight performance values measured during factory acceptance testing or commissioning.

These figures represent **Beginning-of-Life (BoL)** performance.

They do not necessarily describe how the electrolyser will perform after one year, five years or ten years of industrial operation.

This distinction is particularly important because operating costs dominate project economics.

If efficiency deteriorates faster than anticipated, electricity consumption increases and hydrogen production becomes progressively more expensive.

For industrial investors, understanding the degradation profile of the complete system is therefore more valuable than achieving the highest initial efficiency.

Hydrogen Investments BV Perspective

Always ask for third party inspection reports before making a purchase decision.

Reliability Has Financial Value

An electrolyser that operates continuously for years without major intervention creates value that extends far beyond maintenance savings.

For many industrial applications, hydrogen becomes integrated into the production process. An unexpected shutdown may therefore interrupt clinker production, refinery throughput or other critical industrial operations.

The resulting production losses often exceed the cost of the maintenance event itself.

Reliability should therefore be considered a direct economic parameter rather than merely a technical characteristic.

Service Is an Investment

Many procurement evaluations treat after-sales service as an optional consideration.

In practice, service quality becomes increasingly important as the plant ages.

Industrial buyers should evaluate:

- Long-Term Service Agreements (LTSA)
- Local technical support
- Spare parts availability
- Remote diagnostics
- Preventive maintenance programmes
- Response time commitments

A supplier's ability to maintain performance over twenty years may ultimately prove more valuable than a lower purchase price.

A Practical Example

Consider two proposals for the same industrial hydrogen project.

Option A

- Lower purchase price
- Slightly higher beginning-of-life efficiency
- Limited service support
- No guaranteed degradation profile
- Spare parts supplied on demand

Option B

- Higher purchase price
- Proven long-term efficiency
- Comprehensive Long-Term Service Agreement

- Local spare parts availability
- Strong automation and remote diagnostics

At first glance, Option A appears more attractive.

However, for an industrial facility where uninterrupted hydrogen supply is essential, Option B often represents the lower-risk and lower-cost investment over the plant's lifetime.

The additional investment purchases confidence in operational continuity, predictable performance and long-term accountability.

As discussed in earlier chapters, the economic consequences of an unexpected production interruption frequently exceed the initial difference in purchase price.

Key Takeaways

- CAPEX is only one component of hydrogen production cost.
- Electricity is typically the largest contributor to lifetime hydrogen cost.
- Beginning-of-Life performance should never be evaluated without understanding long-term degradation.
- Reliability and plant availability directly influence project economics.
- Long-Term Service Agreements reduce operational risk.
- Procurement decisions should focus on lifetime value rather than purchase price alone.

Hydrogen Investments BV Perspective

Industrial buyers often compare purchase prices while underestimating the financial impact of efficiency degradation, downtime and operational reliability. In our experience, successful projects are those that minimise the lifetime cost of hydrogen rather than the initial cost of equipment. Procurement decisions should therefore be based on total economic value over the operating life of the plant, not solely on capital expenditure.

6. Ten Questions Every Industrial Buyer Should Ask

Selecting an electrolyser is a long-term investment decision that will influence operational performance, production costs and plant reliability for many years.

While supplier presentations often focus on strengths and technical specifications, industrial buyers should ensure they ask questions that reveal how the system will actually perform under real operating conditions.

The following ten questions provide a practical framework for evaluating suppliers and comparing proposals on a consistent basis. They are not intended to replace detailed engineering studies, but they can help buyers move beyond brochures and marketing claims to focus on the factors that truly determine long-term project success.

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1. How will the electrolyser perform after five years—not just on the day it is commissioned?

Most suppliers present Beginning-of-Life (BoL) performance figures. However, electricity consumption and operating costs are determined by how the system performs throughout its operational life.

Questions on this subject:

- Availability of degradation curve
- Expected efficiency after one, five and ten years
- Performance guarantees under normal operating conditions

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2. Can the system automatically adjust hydrogen production according to our process requirements?

Demand for hydrogen during operation rarely remains constant.

The electrolyser should integrate seamlessly with the plant's control philosophy and automatically respond to changing production requirements.

Questions on this subject:

- Cold start and hot start times
- Ramp-up and ramp-down capability
- Integration with PLC, DCS and SCADA systems

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3. What happens if a critical component fails?

Downtime is expensive.

Understanding the supplier's maintenance philosophy is often more important than understanding maximum efficiency.

Questions on this subject:

- Mean repair time
- Spare parts availability
- Local service capability
- Recommended critical spare parts inventory

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4. Which equipment manufacturers are used inside the electrolyser?

Balance of Plant of every electrolyser consist of important equipment groups.

The reliability of pumps, rectifiers, heat exchangers, valves, instrumentation and PLC hardware directly influences long-term performance.

Questions on this subject:

- Major component brands
- Availability of global service support

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5. What level of automation does the system provide?

Industrial facilities require continuous operation with minimal operator intervention.

Automation should not be treated as a luxury feature—it is a fundamental requirement.

Questions on this subject:

- Automation parameters
- Automatic start-up and shutdown
- Remote monitoring & control
- Predictive maintenance

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6. How is water quality managed throughout the life of the plant?

Water quality directly influences stack efficiency, hydrogen purity and equipment lifetime.

Questions on this subject:

- Water quality specifications
- Water treatment philosophy
- Conductivity monitoring

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7. What service support will be available ten years from now?

Industrial electrolysers are expected to operate for decades.

Service capability should therefore be evaluated over the entire life of the plant.

Questions on this subject:

- Long-Term Service Agreement (LTSA) availability

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8. How easily can the system be expanded in the future?

Hydrogen demand is likely to increase.

A system designed for future expansion reduces the cost and complexity of later investments.

Questions on this subject:

- Modular expansion capability
- Additional stack integration availability
- Automation expansion capacity

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9. What is the total lifetime cost of producing hydrogen?

Purchase price alone provides only a partial picture.

The supplier should demonstrate the expected lifetime economics of the project.

Questions on this subject:

- Lifetime electrical efficiency
- Maintenance costs
- Stack and membrane replacement assumptions
- Expected Levelized Cost of Hydrogen (LCOH)

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10. Are there any available third party inspection reports?

Perhaps the most important question of all.

It will increase the reliability of figures on data sheet. Because, the electrolysis technology is still developing, different suppliers use different materials. It is important to be able to compare third party test results of different suppliers.

Questions on this subject:

- Third party inspection & test reports availability

7. Hydrogen Investments BV Perspective

Independent advice. Industrial perspective. Long-term value

Industrial decarbonisation is not achieved by selecting the newest technology. It is achieved by selecting the right technology, integrating it effectively and operating it reliably over decades. Our role is to help industrial companies make those decisions with confidence.

Every facility has different production objectives, operational constraints and commercial priorities. Consequently, successful projects require more than selecting a reputable manufacturer or comparing technical specifications.

At Hydrogen Investments BV, we believe the most successful hydrogen projects begin with understanding the industrial process before evaluating technology. Our role is to bridge the gap between industrial users, technology providers and project stakeholders by providing independent commercial and technical guidance throughout the investment process.

Because we work with both industrial end users and selected technology partners, we understand the expectations of each side. This allows us to facilitate projects that are technically robust, commercially viable and designed for long-term success.

Our Philosophy

Our advisory philosophy is based on five fundamental principles.

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1. Start with the Process, Not the Technology

Every hydrogen project should begin by understanding the industrial process.

Hydrogen demand, operating philosophy, production flexibility, integration requirements and future expansion plans should all be defined before evaluating technologies.

Technology should support the process—not determine it.

2. Evaluate the Complete System

An electrolyser is an industrial process plant.

Its long-term performance depends not only on the stack but also on power electronics, water treatment, cooling systems, automation, safety architecture and after-sales support.

We therefore evaluate the complete system rather than individual components.

3. Focus on Lifetime Value

Purchase price represents only a small proportion of the lifetime cost of producing hydrogen.

Operational efficiency, degradation behaviour, reliability, maintenance strategy and electricity consumption have a far greater influence on project economics.

Our evaluations therefore focus on Total Cost of Ownership rather than initial investment alone.

4. Build Long-Term Partnerships

Industrial hydrogen projects are expected to operate for decades.

Successful implementation requires more than equipment delivery.

It requires trusted relationships between technology providers, EPC contractors, industrial users and long-term service organisations.

We believe successful projects are built on long-term partnerships rather than one-time transactions.

5. Remain Technology Independent

Every electrolyser technology has strengths and limitations.

Similarly, every industrial facility has different operational priorities.

Rather than promoting a single solution, we believe the most appropriate technology is the one that best satisfies the technical, operational and commercial requirements of each individual project.

Independent evaluation leads to better investment decisions.

Where We Add Value

Hydrogen Investments BV supports industrial projects throughout the investment lifecycle.

Commercial Representation

Representing selected technology providers and connecting innovative solutions with industrial customers.

Business Development

Supporting market entry, customer acquisition, strategic partnerships and commercial negotiations.

Investment Advisory

Providing technical and financial guidance from project concept through investment decision.

Legal & Commercial Structuring

Supporting contract strategy, supplier negotiations and commercial risk allocation through robust legal and commercial frameworks.

Why Clients Work With Us

Our clients choose Hydrogen Investments BV because they value independent advice grounded in industrial experience.

Rather than acting as an equipment supplier, we work alongside project developers, industrial companies and technology providers to ensure investment decisions are based on technical merit, commercial feasibility and long-term operational success.

Our multidisciplinary approach combines engineering insight, commercial strategy, investment analysis and legal expertise to help clients navigate the complexity of industrial decarbonisation projects with confidence.

Our Core Principles

Instead of measuring success by equipment sales, we measure success by project performance.

Our recommendations are guided by four simple questions:

- Will this solution improve the client's industrial process?
- Will it remain reliable over its operational life?
- Will it reduce the lifetime cost of hydrogen?
- Will it create long-term value for the investor?

If the answer to any of these questions is uncertain, further evaluation is required before proceeding.

8. Conclusions

Successful hydrogen projects begin long before the electrolyser is purchased

As with the developments in electrolysis technologies and exploring variety of different industrial benefits of hydrogen; it is becoming an increasingly important component of industrial decarbonisation strategies. Across sectors such as cement, steel, aluminium, refining, power generation and food processing, industrial companies are exploring hydrogen not only to reduce carbon emissions but also to improve operational resilience and prepare for a lower-carbon future.

As investment activity accelerates, selecting the right electrolyser becomes one of the most important technical and commercial decisions within a hydrogen project.

However, as this report has demonstrated, selecting an electrolyser is not simply a matter of comparing technologies or identifying the lowest purchase price.

The success of a hydrogen investment depends on understanding the industrial process, defining operational requirements, evaluating the complete hydrogen production system and considering the total cost of ownership over the lifetime of the plant.

The Right Questions Lead to the Right Decisions

Look beyond what is provided in technical brochures. Start by asking the right questions.

How should the electrolyser integrate with existing production systems?

What is the level of automation?

How will efficiency change over time?

How will maintenance and service be managed throughout the operational life of the plant?

Answering these questions before selecting technology significantly improves the quality of investment decisions and reduces long-term project risk.

Think Beyond the Stack

The stack is the heart of the electrolyser—but it is not the entire system.

Power electronics, water treatment, cooling, automation, instrumentation, safety systems and after-sales support all contribute to long-term performance, reliability and operating cost.

Industrial users should therefore evaluate the hydrogen production plant as a complete integrated system rather than focusing exclusively on electrochemical performance.

Think Beyond CAPEX

Purchase price is only one element of project economics.

Over the operating life of an electrolyser, electricity consumption, efficiency degradation, maintenance, reliability and plant availability generally have a much greater influence on the true cost of producing hydrogen.

The objective should therefore be to minimise the **lifetime cost of hydrogen**, not simply the initial investment.

Hydrogen Investments BV Perspective

At Hydrogen Investments BV, we believe that successful hydrogen projects are built on informed decision-making rather than assumptions.

We help industrial companies to understand their operational requirements, evaluate technology objectively and structure projects that are technically sound, commercially robust and aligned with long-term business objectives.

As an independent advisor working across technology providers, industrial companies and investment stakeholders, we believe the most successful projects share one common characteristic:

Technology serves the industrial process—not the other way around.

About Hydrogen Investments BV

Hydrogen Investments BV supports industrial companies throughout the hydrogen investment journey by combining commercial representation, business development, investment advisory and legal & commercial structuring. Working

alongside carefully selected technology partners and industrial users, we help transform hydrogen opportunities into practical, bankable and operationally successful projects.

Partner for Industrial Decarbonisation

Appendix A – Electrolyser Procurement Checklist

This checklist has been developed by Hydrogen Investments BV to help industrial buyers conduct a structured evaluation of electrolyser proposals. It is intended as a practical reference during supplier discussions and should be used alongside detailed technical and commercial assessments.

1. Technical Performance	✓
Beginning-of-Life (BoL) efficiency provided (kWh/kg H_2)	☐
Efficiency guarantee included	☐
Stack degradation profile provided	☐
Expected stack and membrane lifetimes defined	☐
Operating pressure confirmed	☐
Hydrogen purity specified	☐
Dynamic operating range explained	☐
2. Process Integration	✓
Integration with DCS/PLC confirmed	☐
SCADA compatibility verified	☐
Automatic load following available	☐
Automatic start-up/shutdown	☐
Alarm management included	☐
3. Balance of Plant	✓
Ultra Pure DI Water Preparation package included	☐
Conductivity measurement included	☐
Cooling system brand approval	☐
Rectifier brand approval	☐
Hydrogen purification system included	☐
Hydrogen leakage and fire protection included	☐

4. Reliability & Maintenance	✓
Preventive remote monitoring available	☐
Recommended spare parts list included	☐
Local service capability confirmed	☐
Long Term Service Agreement available	☐
Response time guaranteed	☐
Major component suppliers identified	☐

5. Commercial Evaluation	✓
CAPEX clearly defined	☐
Estimated electricity consumption evaluated	☐
Annual maintenance costs estimated	☐
Water consumption estimated	☐
Lifetime operating cost evaluated	☐
LCOH assessment completed	☐

6. Future Expansion	✓
Modular expansion possible	☐
Additional stacks can be integrated	☐
Future power expansion possible	☐
Automation scalable	☐

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