

HYDROGEN

DEVELOPING THE VALUE CHAIN FOR
SUSTAINABLY PRODUCED ENERGY



**BUREAU
VERITAS**



THE ROAD TO DECARBONIZATION

Hydrogen offers multiple advantages as a sustainable energy source. It produces no greenhouse gases or sulfur oxides when burned, and when used in fuel cells, emits only water. In addition, hydrogen can be produced locally at usage sites and generated from a number of clean energy sources and processes.

As the energy transition moves full steam ahead, industry players worldwide continue to invest in cleaner energy sources, with hydrogen among the front-runners. Demand for this carbon-free energy source for numerous industrial uses has increased threefold since 1975¹, and is set to grow further as the energy transition accelerates. The European Commission recently announced that by 2050, hydrogen should represent 12-14% of the EU's overall energy mix², powering industries from mobility to energy to heavy industry.

However, for hydrogen to fulfill its potential as a sustainable energy source, work must be done to secure a carbon-free value chain for hydrogen generation, storage, distribution and use. Players throughout that chain, including producers, distributors and technology providers, are working to design, build and operate the technology, facilities and infrastructure to make blue and green hydrogen successful energy sources.



70 MILLION METRIC TONS
Global demand for pure hydrogen



€140 BILLION
European Commission investment in hydrogen by 2030



60%
Efficiency offered by hydrogen fuel cells³

Contents

- PAGE 3 The road to decarbonization
- PAGE 4 Transforming three key industries
- PAGE 5 Taking hydrogen production to the next level
- PAGE 6 Project assessment: the first step of every hydrogen project
- PAGE 7 Risk management: prioritizing prevention improving safety
- PAGE 8 Regulatory compliance: front of mind at all times
- PAGE 9 Measuring performance: achieving a lifetime of safe operations
- PAGE 10 The future of hydrogen
- PAGE 11 What BV brings to your hydrogen project

Alternative options for renewable hydrogen



Currently, most hydrogen is produced via a process that releases carbon emissions. One way to decarbonize this process is to produce blue hydrogen, which uses carbon capture, utilization and storage (CCUS) methods to remove carbon from production and store it underground, offsetting emissions.



Alternatively, hydrogen can be produced from electricity via electrolysis: this is known as green hydrogen, where electricity is generated from renewable energy sources like wind, solar or hydraulics. Hydrogen can also be generated from other alternative energy sources, including nuclear power and biomass.



Thinking long term



Companies, governments and organizations the world over have begun to invest massively in the production of hydrogen, particularly in Europe and Asia with the goal of making renewable hydrogen cost competitive in the long-term.

¹<https://www.iea.org/fuels-and-technologies/hydrogen> ²https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf
³Compared to 20% for a gasoline-fueled internal combustion engine

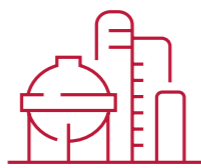
TRANSFORMING THREE KEY INDUSTRIES

Hydrogen's huge potential as a zero-carbon source of energy will make it a game-changer for three sectors in particular: mobility, heavy industry and energy. For these sectors, our planet's lightest element has great sustainability potential.



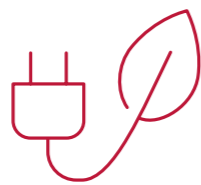
MOVING MOBILITY FORWARD

Together, the rail, automotive, marine and aerospace industries account for about 25% of the world's carbon emissions⁴, and every year regulations are tightening. As a zero-carbon fuel source, hydrogen is ideal for limiting greenhouse gas emissions onboard ships and planes. Hydrogen also offers major advantages for heavy mobility like trains, providing three times the energy of gasoline per unit of mass.



HELPING HEAVY INDUSTRY LIGHTEN ITS LOAD

The petrochemical, manufacturing and construction industries combined represent another quarter of the world's CO₂ emissions⁵. These heavy industries are under increasing scrutiny and pressure to decarbonize their products, and make significant changes in line with the new regulations defining the energy transition.



GREENING THE ENERGY SECTOR

Energy providers are looking to switch to renewable, clean sources like hydrogen to meet public demand and emissions reduction targets. Hydrogen makes an effective carrier and storage solution for surplus or seasonal energy, as it can be stocked and transported in a more stable manner than electricity. By enabling the safe storage of energy, hydrogen can also help avoid disruptions to supply, and provide power to regions that are not connected to national grids. For companies pursuing a clean energy agenda, green hydrogen can be a key pillar of their strategy.

TAKING HYDROGEN PRODUCTION TO THE NEXT LEVEL

Hydrogen has long been used as an energy source. The challenge of the 21st century is the development of decarbonized blue and green hydrogen to support the energy transition. Over the next decade, a lot of work will be done to build out the hydrogen value chain, with each stage facing its own challenges.

How do we get there?

FIRST, the industry requires massive investment from governments, banks and energy providers. It is estimated that an investment of €430 billion is needed for Europe to scale up its hydrogen sector enough to meet its 2030 target⁶.

SECOND, and closely related, it is crucial that production costs be reduced to make the solution more competitive. On this point, governments have a key role to play, offering incentives and using public funds to support R&D and attract private capital for innovation⁷.

THIRD, by drawing on innovation, and with the support of industry and institutions, industry players will need to shift to larger-scale hydrogen production plants. Between scaling up hydrogen production and the declining price of renewable energy, the cost of green hydrogen production could be reduced by 30% by 2030.

LASTLY, it is vital that the industry implement excellent project and risk management. Limiting risk and ensuring safety must be a non-negotiable element of hydrogen production and use from end to end⁸.



Achieving compliance for the Marine industry



⁶<https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/060220-eu-needs-eur430-billion-to-scale-up-hydrogen-by-2030-trade-body>
⁷<https://www.iea.org/reports/the-future-of-hydrogen> | ⁸<https://www.iea.org/reports/the-future-of-hydrogen>

PROJECT ASSESSMENT

THE FIRST STEP OF EVERY HYDROGEN PROJECT

Excellent project management begins with a good project assessment, the indispensable first step for any hydrogen project. From the earliest stages of conception and design, hydrogen projects must be evaluated and their feasibility confirmed. Assessments like this ensure that a project can be delivered safely and on time, while conforming to industry standards. This is an essential baseline for investors, who must be confident in a project's safety and operability from end-to-end.



Check, check and check again

To ensure the safety and effectiveness of projects, specifications must be reviewed at every phase of development, including pre-project, design, conception, construction and operation. This offers stakeholders a clear and comprehensive picture of the risks of their hydrogen project, and detailed information on how those risks can be managed and mitigated.

In strictly regulated sectors like mobility, energy and heavy industry, project owners often require expert guidance to ensure project feasibility and compliance. They will also need support to measure and improve the performance of infrastructure, facilities and technology once they become operational – in both the short- and long-term.

Having a hydrogen project evaluated by a trusted source before giving it the green light builds stakeholder confidence. Knowing that a project stands up to scrutiny in terms of performance, environmental impact, conformity, safety and effectiveness of its contribution to the energy transition allows all parties to move forward on solid footing.

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RISK MANAGEMENT

PRIORITIZING PREVENTION, IMPROVING SAFETY

In its natural gaseous form, hydrogen is both volatile and flammable. Great care and precautions must be taken throughout hydrogen production, storage, transportation, distribution and use to minimize associated risks. Risk management is thus crucial to developing safe and successful hydrogen projects, infrastructure and technologies.

Rising to the challenge

While hydrogen offers significant advantages as a sustainable energy source, it is not without its challenges. As well as being flammable and potentially explosive, it can also seriously damage infrastructure over time by causing metal to become brittle, reducing both its ductility and strength. For asset owners, this means undergoing regular inspections and taking on increased maintenance costs.

Hydrogen gas also has very low energy density per unit of volume, which means it takes up significant space and must be stored at high pressure. In addition, due to the small size of hydrogen molecules, special equipment and procedures are needed to ensure it is stored and transported in airtight containers to prevent leaks and keep handling crews safe.

Another concern is ensuring that new hydrogen projects work with existing infrastructures and can be integrated safely and cost-effectively. All projects should undergo extensive risk analyses such as hazard and operability studies (HAZOP) and failure mode effects and criticality analysis (FMECA). These assessments identify potential risks and offer insights into how to improve safety.



FLAMMABLE
Hydrogen has high flame velocity and ignition range



EMBRITTLING
Diffusible hydrogen ions make metal brittle over time



PRESSURIZED
Hydrogen's small molecules must be stored in high-pressure tanks

REGULATORY COMPLIANCE FRONT OF MIND AT ALL TIMES

When designing new hydrogen technologies or facilities, or building hydrogen infrastructure, asset owners must achieve compliance with existing regulations. Taking this into account at the earliest stages of a project can help avoid potentially costly problems later down the line. The same is true when refurbishing existing facilities and infrastructure to use hydrogen, and throughout the entire lifecycle of hydrogen projects.

Greater regulation for a growing industry

Conformity with national and international regulations is often a license to operate and must be taken seriously for longstanding and new players alike. It is crucial to respect the relevant key guidelines for health, safety and environmental protection, and to ensure technical conformity with industry-specific standards.

Today, regulations for hydrogen production, distribution and use vary greatly from country to country and industry to industry. The industrial sector, for example, has well-developed, standardized regulations in place; the transportation sector, by contrast, largely relies on individual local and regional regulations.

Looking forward, a major priority will be the development and consolidation of a uniform regulatory framework for hydrogen projects across the value chain. This will enable actors worldwide to take an approved approach to technical and safety challenges for hydrogen production, distribution, transportation and use.

As the sector grows in the coming decades, regulatory conformity will become imperative at local, national and international levels. Guidance from a trusted source will be essential for companies looking to avoid sanctions for breach of compliance, gain stakeholder trust, and secure financing for forward-thinking projects.



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MEASURING PERFORMANCE ACHIEVING A LIFETIME OF SAFE OPERATIONS

Once a sector's technologies, facilities and infrastructure have had risks mitigated and been positively assessed for regulatory compliance, performance becomes the biggest factor for a hydrogen project's success. To manage this, asset owners and operators need to monitor and measure performance throughout an asset's operational lifetime, evaluating project highs and lows.

What are the key performance indicators (KPI)?

Being able to reliably and consistently measure the performance of assets is of particular importance for industry players with hydrogen projects. Since the goal of developing hydrogen is to have a clean, alternative energy source, hydrogen producers, distributors and users can come under heavy scrutiny. This means that operators must be prepared to show the environmental impact of each asset across its in-service lifetime, and have the data to back up their claims.

To do this, asset owners must accurately measure the carbon reduction associated with their projects, proving its benefits and effectiveness. They must be able to maintain and attest to the quality of the hydrogen produced; regularly and actively monitor their operations; and perform essential maintenance in a timely fashion.

Ideally, industry players will also go beyond their own sustainability performance, assessing the environmental credentials of their entire hydrogen supply chain. For green hydrogen in particular, a fully green value chain is essential for operators and energy providers to meet the expectations of environmentally conscious consumers.

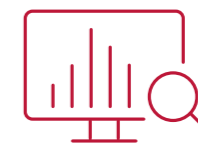
By working with external experts, companies can evaluate their performance constantly and objectively, being always on the lookout for potential improvements and upgrades.



**TESTING
HYDROGEN
QUALITY**



**REDUCING
CARBON
EMISSIONS**



**MONITORING
OPERATIONS
REGULARLY**



**DEVELOPING
A GREEN
VALUE CHAIN**

THE FUTURE OF HYDROGEN

Hydrogen has a major role to play in helping industry players decarbonize their activities, bringing a strong alternative energy solution to the carbon-heavy mobility, heavy industry and energy sectors. From powering ships and trains, to decarbonizing manufacturing and construction, to feeding electrical grids, hydrogen – a small molecule with huge energy storage capacity – can greatly reduce environmental impact.

As a result, industry stakeholders throughout the value chain are investing heavily in hydrogen R&D projects, pushing for more and faster innovation. There is great latitude for the development of new ideas, technologies and products in this dynamic, growing market with high demand and even higher potential.

To accompany developments in hydrogen technology, specialized training will become essential for workers across sectors – whether they are involved in project conception, design, operations, monitoring or maintenance. Handling hydrogen and working with hydrogen-powered technologies is not without its safety risks, so it is crucial that training be thorough, up-to-date, and delivered by experts.

As a long-term supplier of inspections and certification for the energy sector, and with a strong portfolio of sustainability services and solutions, Bureau Veritas is perfectly positioned to support clients across the hydrogen value chain. By helping clients assess and approve projects for risk, safety, compliance and performance, we are playing our part in growing hydrogen's role in the energy transition.



WHAT BUREAU VERITAS BRINGS TO YOUR HYDROGEN PROJECT

Bureau Veritas draws on nearly 200 years of experience and a network of more than 75,000 employees worldwide. This includes a team of more than 70 people specifically dedicated to the burgeoning hydrogen industry. As a member of both national and international organizations, we are mobilizing our resources to provide a trusted partner for companies working towards the development of greener hydrogen.



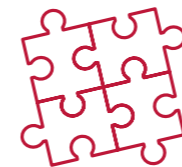
EXPERTISE

Our experts have extensive experience and an in-depth understanding of all different types of hydrogen along with their various risks and quality levels. We can support you in navigating the expanding hydrogen market with expertise in carbon neutrality, environmental responsibility and sustainability.



EXPERIENCE

Bureau Veritas has been involved in the hydrogen industry for over 20 years, working with clients of all sizes across the globe. We offer all the benefits of our testing, inspection and certification expertise and network for every aspect of your projects.



COLLABORATION

Developments in hydrogen technology impact many sectors, and Bureau Veritas is leveraging best practices from all our centers of expertise and activity. Teams from across our business, including Certification, Commodities, Industry and Facilities, Onshore and Offshore Gas, Marine, Automotive and Aerospace, are working together to bring hydrogen solutions to market quickly and safely.



Our Green Line of services and solutions enables clients to meet sustainability challenges, protecting the environment and improving the quality of products and services across the value chain. We are a key player in the energy transition, present at all stages of the renewable and alternative energy production chain. The BV Green Line helps organizations implement, measure and achieve sustainability objectives, and enables us to support our clients in sustainably designing, building and operating their assets.

SHAPING A WORLD OF TRUST

Bureau Veritas is a Business to Business to Society company, contributing to transforming the world we live in. A world leader in testing, inspection and certification, we help clients across all industries address challenges in quality, health & safety, environmental protection and social responsibility.

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