WHITEPAPER

Empowering the hydrogen economy

How gas analysis can drive the **clean industrial revolution**

Analysis that **empowers**

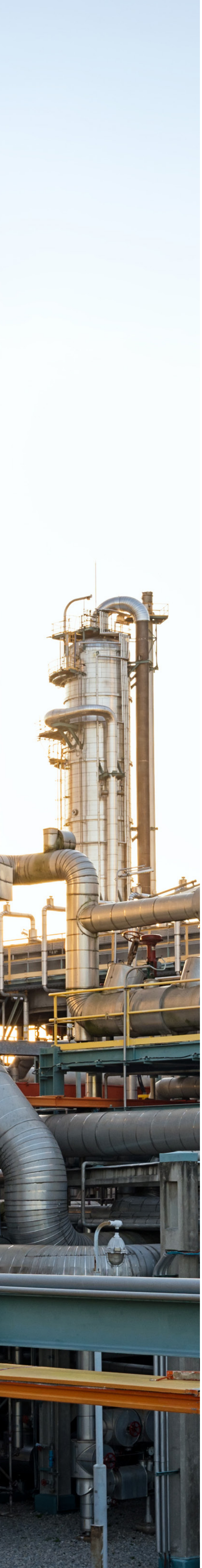
SERVOMEX
a spectris company

Executive summary

Hydrogen (H_2) is vital energy source for the low-carbon future because it only produces water when burned. However, current production methods still produce greenhouse gases. Over 90% is “grey” hydrogen produced using steam methane reforming (SMR) or “blue” with carbon capture utilization and storage (CCUS). Only a small fraction is “green” hydrogen, produced renewably via electrolysis.

Integrating hydrogen also faces challenges like high production costs, storage limitations, and flammability risks. Significant investment is also needed to develop production and distribution.

As a leader in gas analysis, Servomex provides advanced solutions to empower hydrogen adoption, including for air separation unit (ASU) applications. This can ensure regulatory compliance, operational efficiency, and safety, helping make it viable for all industrial applications.



Introduction

The world uses 97 million tonnes (Mt) of hydrogen (H_2) a year.[1] Refineries consume half the global supply, using it to convert crude oil into products like petrol and diesel.[2] But now the gas could become a possible replacement for the very fossil fuels it has long helped make. As a result, production demand for H_2 is projected to surge six-fold in the next 25 years – reaching 125-585 Mt per annum, (Mtpa).[3] This represents a huge business opportunity, but also comes with technical challenges.

Reaching net-zero by 2050 will require a multi-faceted strategy. Energy efficiency, electrification and renewable power can mitigate 70% of emissions.[4] But decarbonizing heavy industry needs a different approach. The world relies on the essential materials this sector produces like steel, cement, and aluminium. Just using less is not an option. In fact, demand for these materials is also soaring – rising up to 80% by 2050 – in part to build renewable energy infrastructure.[56] Production often requires temperatures exceeding 1000°C, which would be difficult to power from renewable sources alone. While carbon dioxide (CO_2) is a natural byproduct of many chemical processes, such as making plastics, cement, and steel.[7]

As a highly reactive element and established energy carrier, H_2 offers a solution. Industry can burn the gas to achieve intense heat, producing only water vapour as a byproduct. It can also replace fossil fuels in reduction and reactions processes.[8] For instance, switching out coal for H_2 in iron ore processing can reduce steel-making emissions by 80%.[9] Crucially, industrial processes and infrastructure that currently use natural gas can be adapted to use H_2.[10] This allows companies to utilize their existing equipment with minimal modifications, reducing the need for entirely new systems. Consequently, one UK report indicated that the gas could replace 40% of fossil fuel used in manufacturing by 2040.[11]

The need for accurate gas analysis

Don't mistake H_2 for a magic bullet. The way we currently produce it is very carbon intensive, so ramping up our use of the gas risks offsetting the benefits of switching. The same qualities that make H_2 an ideal fuel for heavy industry also makes it very dangerous. The gas has a very low flashpoint, much lower than petrol, at -43°C, so extra safety precautions need to be taken.[12] Furthermore, it is also the lightest element with low volumetric energy density. This creates challenges for storing and transporting H_2 unless its compressed or liquefied.[13] But these challenges can be overcome.

In this whitepaper, we'll unpack how air separation units (ASUs) and precise gas analysis can ensure H_2 production is safe, efficient, and ultimately, sustainable. We'll show you how these technologies are crucial for making H_2 a viable part of our energy future.

The role of **SMR** in H_2 production

The majority of H_2 production is made with unabated fossil fuels, primarily natural gas. Steam methane reforming (SMR) brings together natural gas and heated water in the form of steam. The output is H_2, but for every ton produced, nearly 12 tons of CO_2 are released into the atmosphere.[14] This process is so dirty it equates to almost 2% of global greenhouse emissions each year.[15]

But it doesn't have to be that way. Electrolysis – the process of using electrical charge to split water into oxygen (O_2) and H_2 – can produce clean "green hydrogen" using just solar or wind power. This is still an emerging industry, and it will take time to build electrolyser capacity worldwide. In the race to meet emissions targets, so-called "blue hydrogen" offers a practical solution we can act on now.

Challenges in H_2 integration

Integrating H_2 production presents several challenges, with purity and safety being paramount. Fuel cell applications, for example, demand extremely high purity levels (often exceeding 99.97%), as even trace contaminants can significantly impact performance.[17] Precise gas analysis is crucial to detect and quantify impurities like O_2, N_2, carbon monoxide (CO), and sulphides. The flammability of H_2 also means you need robust safety measures, including reliable leak detection and inerting systems to prevent combustion risks.

Environmental and safety regulations also continue to evolve. Industries must adhere to stringent standards, requiring continuous monitoring and analysis of gas purity, emissions, and other key parameters. You also need to ensure product quality, optimize energy use, and demonstrate compliance throughout the process.

Advanced gas analysis solutions are vital for overcoming these challenges. High-accuracy analyzers can detect trace impurities, ensuring H_2 meets stringent purity requirements.

Continuous monitoring systems provide real-time data for process optimization, quality control, and regulatory compliance. By implementing these solutions, industries can effectively integrate H_2 production, achieving high purity, safe and efficient operation, and adherence to all applicable standards.

New technologies, new opportunities

Blue hydrogen also produces the gas from fossil fuels – but carbon capture utilization and storage (CCUS) limit emissions. This can work with conventional SMR, making it easier to adapting existing production plants. But new technologies are also being explored, including autothermal reforming (ATR). This works similar to SMR, but energy is provided by introducing O_2 to burn part of the feedstock. When combined with CCUS, this can achieve higher energy efficiency with lower investments and a simplified production process. While still not quite net-zero, this process can capture 99% of carbon emissions.[16]

The addition of O_2 as a feedstock opens new avenues for ASUs. This technology divides atmospheric air into its primary components – O_2, nitrogen (N_2), and argon (Ar). The predominant method for this is the cryogenic distillation process, which results in high-quality, high-volume liquid and gaseous products.

Case study
Analysis that empowers zero-carbon steel

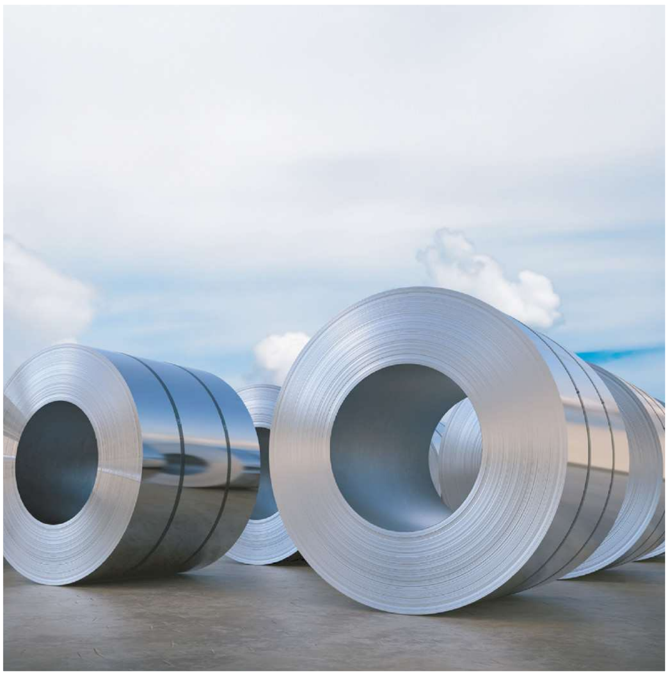
Steel-making is a key industry that hydrogen can help decarbonize. Coke – high-carbon coal, purged of volatile compounds – is fundamental to the traditional blast furnace–basic oxygen furnace (BF-BOF) process.[18] As well as providing heat to melt the iron ore, the coke produces CO, which reacts with the ore to produce crude iron (Fe). This is then transferred to another furnace, where O_2 combines with some of the carbon in the Fe. This results in low-carbon steel, but high emissions – 1.73 tons of CO_2 per ton of steel, including both process and combustion.[19]

However, as we touched in our introduction, hydrogen can replace coke as both an energy source and reducing gas. The key to revolutionising this process is reliable gas measurement. At Servomex, we know this because we've helped achieve it.

A groundbreaking project wanted to utilize a giga-scale H_2 plant powered entirely by renewable energy sources, including wind and hydropower. Rather than use the traditional BF-BOF process to create steel, this facility wanted to utilize the green hydrogen produced at the site, fundamentally transforming the reduction reaction:

- **Traditional process:** Coke + iron ore = Fe + CO_2
- **New green process:** H_2 + iron ore = Fe + H_2O

This innovation process, known as direct reduction of iron (DRI), successfully produces iron that can be turned into steel, which eliminates CO_2 emissions.



Working together to optimize production

With more than forty years of successful partnership with the steel and iron company behind the project, we were asked to provide the high-performance gas analysis technologies required to ensure the safety, efficiency, and reliability of the H_2 systems used in the DIR process.

Designed for analyzing corrosive, toxic and flammable gas streams, the **SERVOTOUGH 2500** analyzers measure H_2 concentrations to ensure optimized performance of the reduction process. **SERVOTOUGH Oxy 1900** analyzers utilize our Paramagnetic sensing technology to provide the stable, reliable percentage O_2 measurements required to maintain process safety and efficiency.

Integrated with complementary sampling systems into a single analyzer house, this solution seamlessly combined with the company's proprietary and third-party technologies to achieve a comprehensive gas monitoring and analysis capability.

The power of partnership

The deployment of Servomex's gas analysis technologies delivered multiple benefits to the project:

- **Enhanced process efficiency:** Accurate monitoring of gas compositions ensures that the H_2 reduction process operates at peak efficiency, minimizing resource use and maximizing output.
- **Safety assurance:** As H_2 is highly flammable, our precise O_2 measurements are critical for maintaining safe operating conditions.
- **Sustainability gains:** By facilitating the use of green hydrogen in place of coke, our solutions contribute directly to the elimination of CO_2 emissions from the iron reduction process.
- **A reliable solution:** Our decades-long partnership underscored the commitment to providing robust solutions backed by unparalleled expertise in gas analysis technologies. This history of collaboration ensured a seamless integration of Servomex technologies into the facility.

This green steelmaking plant is now up and running. It's projected to reduce 300 million tonnes of CO_2 emissions by 2040, setting a benchmark for decarbonization in heavy industry.[20] The steel produced will meet the growing demand for sustainable materials, with customers including leading European car manufacturers.

Future trends
Green hydrogen and decarbonization

Green hydrogen is a nascent industry, with low-emission sources producing under 1% of the gas in 2023.[21] However, this could change rapidly. There have been a seven-fold increase in clean H_2 investments in the past four years, totalling $75 billion.[22] Electrolyser manufacturing doubled in 2023, while nine times as many have been installed since 2021.[23] At the same time, the price of renewable energy to power production continues to drop.[24]

As electrolysis becomes increasingly competitive it's expected to replace traditional H_2 production. At the start of this white paper, we talked about global production demand for the gas reaching 125-585 Mtpa by 2050. The same projections expect green and blue hydrogen will account for 73-100% of that demand, with less than 1-50% being grey.[25]

The precise monitoring and control of gas composition is also key to making green hydrogen economically viable. A UK-based company offers an innovative approach, manufacturing membrane-free electrolysers (MFE). This takes a totally different approach to splitting water into its constituent gases.[26] Water is mixed with electrolyte and travels to the stack, where the mixed gas is generated. The mixed gas is dried and cryogenically separated in a patented system.

To achieve this, the company selected the **SERVOTOUGH OxyExact 2220**.[27] This is approved for the measurement of O_2, including enriched O_2 (>21%), in H_2 in hazardous areas. It helps ensure the MFE produces H_2 purity of up to 99.999% and O_2 up to 99.8%. The advantage of this solution over traditional proton exchange membrane (PEM) or alkaline electrolysers is that the input water doesn't need to be as pure, lowering operational costs and reducing water waste. No membranes to degrade or fail also makes MFE a more robust, cost-effective solution.

The growing importance of ASUs

Air separation will play a vital role as green hydrogen plants expand. High-purity N_2 will be needed for purging electrolyser systems. Nitrogen is also crucial for cooling H_2 to cryogenic temperatures for safer liquid storage and transport. Gigawatt-scale plant may even opt for on-site production – either using an ASU or a simplified N_2 generator.[28]

Servomex is well known for comprehensive multi-gas analysis on the ASU plant. The **SERVOPRO MultiExact 4100** provides simultaneous measurement of up to four gas streams, including O_2, CO_2, and moisture. Utilising a wide range of sensing technologies, this high-performance analyzer offers operational flexibility and high reliability, meeting the stringent demands of industrial gas manufacturers.

In industrial gas applications, where accurate O_2 and moisture measurements are vital, the **SERVOPRO MonoExact DF310E** stands out. Designed for precision trace-level measurement, it combines a digital Coulometric O_2 sensor with a non-depleting Paramagnetic sensor option. This ensures reliable performance in various applications, from N_2 and Ar production to specialty gas blending.

SERVOPRO
MultiExact 4100

SERVOPRO
MonoExact DF310E

Conclusion: Preparing for the H_2 future

Hydrogen offers a real opportunity to fuel the energy transition and limit global warming. The industry demand is there, and the technology is viable. But that doesn't mean the H_2 future is guaranteed. As this whitepaper has demonstrated, ASUs are pivotal in both short-term and long-term production pathways, enabling blue hydrogen through CCUS and supporting green hydrogen infrastructure with vital gases. However, the integration of H_2 presents significant challenges, notably in ensuring purity, safety, and operational efficiency.

Advanced gas analysis is emerging as the linchpin in overcoming these challenges. From trace impurity detection to robust safety monitoring, precise analytical solutions are indispensable for optimizing processes and meeting stringent regulatory standards. This will only intensify as the hydrogen sector continues to evolve.

At Servomex, we analyze change, so you can make it happen. We're helping customers make their processes cleaner and healthier, as well as develop technologies that will power a greener future. This includes a comprehensive portfolio of cutting-edge gas analyzers that can help address the specific demands of ASU applications, ensuring accurate, reliable, and sustainable operations. Plus, we continue to empower all businesses to navigate the energy transition and drive a clean industrial revolution.

Want to know how Servomex can support your hydrogen initiatives?
Contact us at servomex.com/contact

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