HYDROGEN SOLUTIONS THAT OPTIMIZE APPLICATIONS

Decarbonizing the future

As a clean-burning renewable fuel, hydrogen will play a key role in securing the target of achieving “net-zero” carbon dioxide emissions by 2050. Emerging applications such as near-grid energy storage, fuel-cell-powered mobility, heating, and direct reduction of iron (DRI), will become common as hydrogen progressively substitutes traditional fossil fuels in these processes. ABB offers measurement and analytics solutions that help to optimize all of these areas.

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Today, ammonia production accounts for approximately 50 percent of all global hydrogen use, while methanol production accounts for an additional 25 percent. Other major uses include refining, heat treatment processes to produce metals and glass, the hydrogenation of oils to fats in the food sector, and, increasingly, transportation and mobility applications; the latter, however, amount to less than five percent of total global hydrogen use.

In order to establish hydrogen as a cost-competitive energy solution, the capital cost of electrolyzer units must be reduced. Clearly, cost reductions will be achievable as the power of electrolyzers increases from the current 10 MW range to the 100 MW and 1 GW scale. For instance, plans call for a 50 MW electrolyzer powered by wind energy at the BP Lingen refinery at Emsland, Germany to be scaled up to 500 MW, which will be sufficient to supply the refinery's existing hydrogen demand while also enabling synthetic e-fuels production.

Hydrogen for refinery and petrochemical applications accounts for approximately 20 percent of global hydrogen consumption today. Although this application is likely to decline over the coming decades, hydrogen's application in liquid biofuels processing is likely to grow. In both cases, the combination of carbon capture and sequestration (CCS) with hydrogen production by means of steam methane reforming methods (SMRs) will be essential to reduce the environmental impact of hydrogen production.

Here, the ability to precisely determine the composition of the incoming natural gas feedstock in order to quantify its energy value is essential. The BTU value of the natural gas coming into an SMR process is best measured using a rapid response gas chromatography system such as ABB's PGC1000, which is optimized for natural gas BTU analysis. Direct read infrared gas analyzers are ideal for measurement of final hydrogen purity. It is generally taken for granted that the gas coming off the SMR will be hydrogen but what really matters is the absence of CO and CO_2. These are poisons to the hydro-treating catalysts in the subsequent processes where the hydrogen is used in a refinery. Typically, the final hydrogen product specification will have a maximum total combined CO and CO_2 content of 10 parts per million by volume. Simultaneous measurement of these two components can be achieved using ABB's Uras26 infrared gas analyzer module mounted in an Advance Optima AO2000 system.

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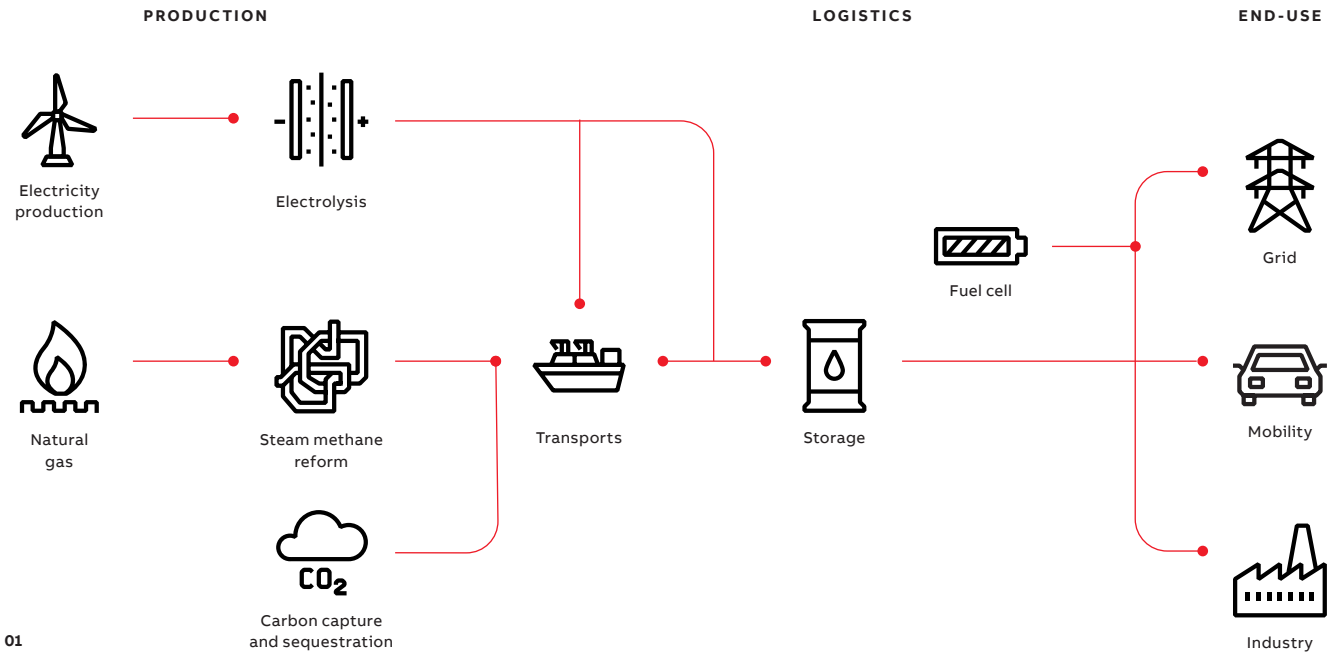
Ammonia and methanol production
As mentioned above, hydrogen's primary current application is in ammonia and methanol production. Ammonia is the number one petrochemical in terms of volume of production, and in fact is the second most common chemical of any kind



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in these terms. Ammonia consumption is tied directly to agriculture, where, in one form or another (liquid ammonia, "nitrogen" solutions, ammonia nitrate, or urea) it is used as fertilizer. However, although approximately 75 percent of the world's hydrogen production capacity is locked into the methanol and ammonia value chains, there is an increasing shift toward "clean" hydrogen, either through capturing carbon dioxide emissions from SMR or autothermal reforming (ATR) operations, or by moving toward electrolysis powered by renewable energy. Below are examples from several key industries that illustrate this point →01.

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Decarbonizing iron, steel and cement production

Current decarbonization trends make it clear that the steel sector is set to become a major consumer of hydrogen in coming years. For instance, as an alternative to the CO_2-intensive production and use of coke, hydrogen can be used in a process referred to as "direct reduction of iron" or DRI →02. Here, the hydrogen reacts with ore to produce iron and water vapor. An ArcelorMittal facility in Hamburg, Germany is one of several plants worldwide that is conducting tests to establish the viability of this process.

As a number of pilot studies indicate, hydrogen is also expected to play a major role in decarbonizing cement production. Here, analyzers and instrumentation will continue to play an important role in ensuring safe, efficient, and compliant operations. The gas composition at different points in a cement production process can vary, which requires adapted or new solutions from equipment vendors such as ABB.

Decarbonizing aviation

With regard to hydrogen's mobility applications, attention has largely focused on trucks, buses, cars, rail, and shipping. However, although aviation is one of the most challenging areas to decarbonize, a few hydrogen-powered drones and small-scale transporters have been proposed and piloted. Government programs and a handful of corporations are exploring possible renewable fuels for the aviation sector, including green hydrogen and synthetic e-fuels produced using a solid oxide electrolyzer (SOE), combined with a Fischer-Tropsch reactor.

Hydrogen admixing into the natural gas grid

Hydrogen gas is, of course, also entering the lives of individual consumers. For instance, in a project at Levenmouth, Fife, UK, green hydrogen will soon be used to heat 300 homes. The idea is to use renewable electrical power from a nearby wind farm to drive an electrolyzer that produces hydrogen. The hydrogen will then be mixed with

natural gas and distributed through the existing gas distribution network. This makes good sense for countries that have embraced natural gas as a heating medium and have invested heavily in gas pipeline distribution infrastructures.

But hydrogen is not a panacea – at least not yet. Although admixing of hydrogen into existing natural gas grids is technically possible, several countries have set an upper limit of two percent hydrogen in existing natural gas pipeline grids.

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Eventually, much of the natural gas infrastructure will be converted to transport 100 percent hydrogen.

In Australia, gas pipeline operator Jemena has considered mixing up to ten percent hydrogen in the existing grid. And over time, much of the established natural gas infrastructure worldwide will be converted or replaced to transport 100 percent hydrogen. But this will call for major investments in new or refurbished pipelines since, depending on the type of steel involved, hydrogen can cause embrittlement that may lead to cracking and rupture.

Another concern is that the thermal heating energy value of hydrogen per unit of volume is less than that of natural gas. That means that existing metering systems would deliver less energy for the same invoiced monetary value. In other words, as the concentration of admixed hydrogen increases, gas composition measurement and gas metering systems will need to be transformed to ensure a fair supply of energy and accurate invoicing.

With this in mind, ABB's PGC1000, a rapid-response process gas chromatograph with a thermal conductivity detector that is ideal for monitoring the gas mixture composition in natural gas distribution and transmission systems, is an ideal solution. Established applications for this type of gas analyzer include monitoring the thermal value of natural gas in burner control systems to ensure the correct combustion stoichiometry.

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02 Hydrogen can be used as an alternative to the CO_2-intensive production and use of coke in a process referred to as "direct reduction of iron" or DRI.

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Photo fig. 02: ©betoon/istockphoto.com

Other ABB process gas chromatographs, such as those in the high-precision NGC8200 range, can be used for monitoring natural gas pipelines containing admixed hydrogen.

Why hydrogen purity is essential

Among its many potentially game-changing applications, hydrogen could be used to smooth out the seasonal imbalance between renewable electricity generation and energy demand. Production and long-term storage of green hydrogen produced on electrolyzers is a potential solution. However, a precondition for this scenario is the application of the international standard known as "ISO14687:2019 hydrogen fuel quality – product specification," which includes a range of application-specific purity specifications. For example, with regard to hydrogen destined for use in fuel cell electric vehicles and other fuel cells, impurities such as CO and H_2S are capped at levels that will guarantee the hydrogen is compatible with standard modern fuel cells and does not poison sensitive catalysts. Nitrogen too must be managed because this inert gas would otherwise accumulate in fuel cells, resulting in a less active area for power production, which would lead to a gradual deterioration of fuel cell performance. Many of the standard's specifications are easy to achieve with hydrogen produced in an electrolyzer, but they become more challenging when hydrogen is produced on an SMR or ATR – processes that demand careful gas analysis with sensitive equipment.

> Hydrogen could smooth the seasonal imbalance between renewable electricity generation and energy demand.

Having supplied instrumentation and analyzer solutions for hydrogen applications for decades, ABB's portfolio offers a range of solutions for this increasingly important market →03. Examples include "H-shield" for pressure, level, and flow products, which ensures extremely high resistance against hydrogen permeation. In the area of gas analyzers, ABB products ensure the safety, efficiency and reliability of hydrogen production and downstream processes in hundreds of installations around the world. Furthermore, in line with the evolving hydrogen environment, ABB offers associated software solutions that harness the power of measurement and diagnostic data to monitor and inform regarding the health of devices.

Conclusion

Hydrogen will clearly play a major role in a decarbonized future. Green hydrogen produced from renewable power and water will be one part of the solution. Blue hydrogen produced from natural gas, combined with CCS will also play a significant role. The precise routes to the goal are still unknown and each region is likely to follow its own path to 2050 and beyond. In each route to decarbonization, gas analyzers and instrumentation will be required to ensure safe, successful, and environmentally compliant operations. Products and services from ABB Measurement and Analytics will be at the heart of the action, as will a myriad of power management solutions and process control systems from the wider ABB Group.

Moving forward, ABB is not standing still on sensor technology development to meet evolving measurement needs and is leading the way on digital software solutions to harness the power of data with a view to improving the energy efficiency of customers. •

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03 ABB's portfolio offers a wide range of solutions for the hydrogen market.

ABB'S "HYDROGEN-READY" SOLUTIONS

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ANALYZERS

- Continuous gas analyzers
- Continuous emission monitoring systems (CEMS)
- ICOS laser technology
- Process gas chromatographs
- Standardized, system solutions – Containerized "Analyzer-houses"

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INSTRUMENTATION

- Thermal mass flowmeters
- Variable area flow
- Pressure & temperature measurement
- Level transmitters and switches
- Digital products with latest communication standards
- Platform concept: Same look & feel across portfolio

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SERVICE & DIGITAL

- Measurement Care Service Agreements
- My Measurement Assistant
- ABB Ability™ Remote Insights for service
- ABB Ability™ Condition Monitoring for measurement devices
- ABB Ability™ Verification for measurement devices

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MAIN ELECTRICAL AND AUTOMATION CONTRACTORS (MEC, MAC)

- Plant control (DCS solutions)
- Containerized modular electrical and automation infrastructure
- Compressors/pumping station control
- Telecom, security and monitoring for pipelines
- Full project execution
- Life cycle service

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