Increasing the Viability of Blue Hydrogen

EMERSON™

Clean Hydrogen Helps to Enable Global Decarbonization

Hydrogen has an important role to play in efforts to reach the target of net-zero emissions by 2050. Hydrogen is expected to provide cleaner energy for hard-to-decarbonize industrial processes, parts of the transport sector and long-term energy storage. However, for it to be considered a truly clean fuel, it is essential to reduce CO_2 during production.

Today, about 95% of hydrogen produced globally is 'grey' hydrogen. To make 'blue' hydrogen, producers must remove the carbon dioxide during the production process. While green hydrogen is the ideal aspiration for a low-carbon energy future, it will be a number of years before it is price competitive. In the interim, blue hydrogen can help create the demand and distribution networks for hydrogen, helping to accelerate the transition from traditional fossil fuels.

Increasing Demand For Blue Hydrogen

Remaining on track with net-zero targets requires an increase in demand for cleaner fuels such as blue hydrogen, particularly from new applications. The majority of hydrogen is used by refineries and petrochemical plants for hydrotreating, hydrocracking and isomerization. As new markets emerge for cleaner hydrogen, such as domestic heating, power generation and transport fuel, the demand for blue hydrogen is expected to grow significantly. Current production of hydrogen is approximately 94 million tons a year, but this is expected to grow to 500-680 million tons by 2050.

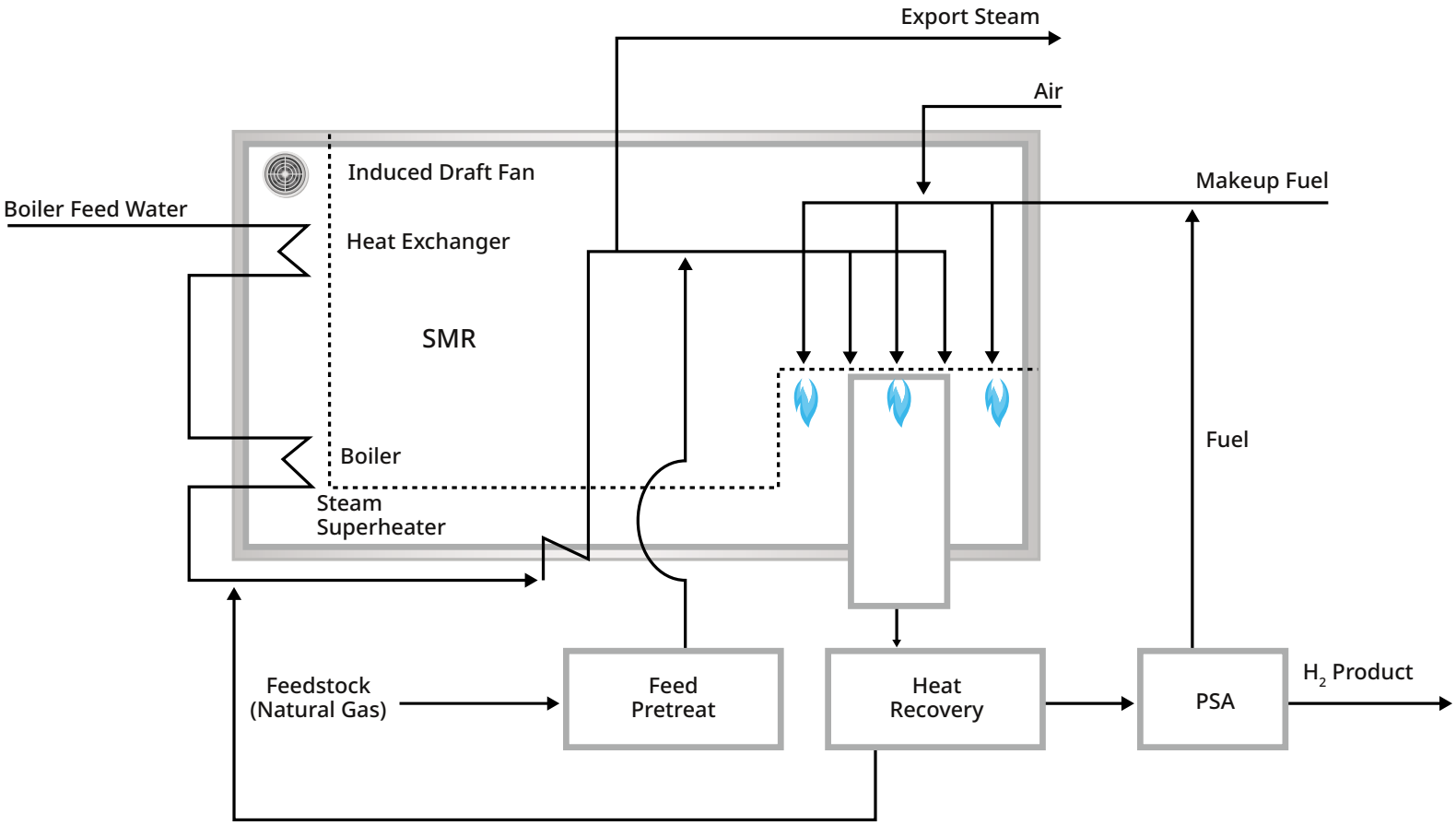
Although there is significant investment in 'green' hydrogen, produced using electrolysis powered by sustainable energy, the processes used to produce blue hydrogen are more easily scaled and well tested. Blue hydrogen will be essential in meeting future demand, but an abundance of hydrocarbon feedstock could also provide a cost advantage in the market.

Transition to Blue Hydrogen

Hydrogen is predominantly produced from fossil fuels, usually natural gas, using the process of steam methane reforming (SMR). SMR is the lowest-cost method of production, which involves reacting natural gas or other light hydrocarbons with steam at high temperature and pressure to produce hydrogen, with CO_2 formed as a by-product. When carbon capture and storage (CCS) solutions are applied to production, this creates 'blue' hydrogen, which helps to minimize emissions and supports decarbonization.

Carbon Capture Solutions

Post-combustion amine-based absorption is the most mature and deployed carbon capture process. After a chemical solvent captures the CO_2 from the flue gas, the chemical solvent is regenerated while the CO_2 is extracted. Vacuum swing adsorption (VSA) and pressure swing adsorption (PSA) processes are also used to purify a hydrogen stream, by extracting impurities and CO_2. Using these carbon capture solutions, CO_2 sequestration rates above 90% can be achieved. Auto-thermal reforming, where oxygen is introduced to burn part of the feedstock as opposed to separately burning natural gas, creates the possibility of over 95% capture of CO_2 emissions.



Blue Hydrogen Industry Challenges

Blue hydrogen production is already operating at scale at a number of plants around the world as feedstock or energy in many industrial applications, but use of hydrogen, blended with natural gas, in residential areas is being piloted and may soon be available.

Key production challenges:

- Improve equipment reliability, to reduce process downtime and maintenance costs
- Achieve the highest possible CO_2 capture rates
- Increase and maintain peak production efficiency
- Lower energy consumption and costs
- Minimize upstream leaks and emissions
- Enhance the safety of plant and workers

The Role of Automation

With its power to improve efficiency, reliability and safety, advanced automation technology is playing a central role in solving many of these problems. Automation can aid engineering, optimize the production and carbon capture processes, save energy and improve the reliability of essential equipment like compressors, heat exchangers, fans, valves and pumps. Along pipelines and at any point where hydrogen changes hands, automation helps to keep contaminant-free, pressurized, at the ideal density, and fully accounted for in fiscal transactions.

SMR Performance Challenges

The throughput and efficiency of the SMR process depends on maintaining an optimal ratio of steam to carbon entering the reformer reactor, protecting the catalyst from coking and managing energy usage. However, controlling the steam-to-carbon ratio in the reformer reactor is challenging when the fuel changes composition, potentially reducing the output or thermal efficiency of the plant and increasing energy use and operational costs.

Advanced Automation Maximizes SMR Performance

Advanced automation solutions can improve the efficiency and profitability of SMR units by controlling the steam-to-carbon ratio with greater precision, using advanced process control systems, online asset monitoring and mass flow meters. The life of the catalyst can be extended by continuous chemical composition analysis, which is essential for improving the performance of carbon capture methods.

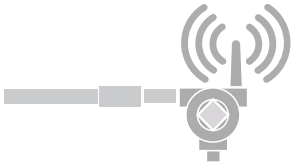
Automation solutions:

Advanced measurement and control technology ensures precise control and reduced process variability, optimizing SMR performance and throughput

Process gas analyzers and gas chromatographs provide highly accurate continuous gas composition analysis, enabling reforming and shift converter efficiency to be monitored

Assured measurement accuracy, provided by Coriolis mass flow meters, enables optimized steam-to-carbon ratio, extending catalyst life, decreasing energy costs and increasing safety

Online monitoring solutions for heat exchangers help to maintain efficiency and reduce energy consumption



High-accuracy temperature transmitters ensure critical temperature control and safety loops are optimized, supporting enhanced process control

Wireless sensors support continuous monitoring of equipment and pipework to prevent corrosion and containment issues

Energy management information systems support the evaluation of energy-related KPIs and help achieve optimal steam and electricity usage targets

Carbon Capture Challenges

Amine-based absorption involves a trade-off between the energy needed to regenerate the chemical solvent used in the carbon capture process and the rate of efficiency of the process itself. The main challenges for the operation of PSA and VSA processes are ensuring safety, purity and reliability, despite very high cycle rates. It is also essential to prevent leaks that cause lower capture efficiency.

Key challenges:

- Maximize carbon capture efficiency
- Decrease energy consumption and costs
- Ensure hydrogen purity
- Minimize safety risks, leaks and fugitive emissions
- Increase availability and reduce maintenance costs

Enhancing Amine Treatment Process

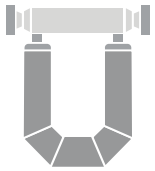
When using amine treatment to capture CO_2 there is a trade-off between capture efficiency and energy cost to regenerate solvent. Meeting the target CO_2 capture rate in the most efficient manner is the key challenge. Because corrosion and erosion are prevalent within amine treating units, there is a need for predictive maintenance to maximize uptime, safety and throughput. Implementing automation solutions helps increase visibility to process equipment health, which ensures greater operational efficiency, process uptime and safety.

Automation solutions:

Online analysis allows process optimization through multivariable control and analytics

Advanced controls and alarm management software help optimize operational performance, while digital twin technology improves operator performance

Energy management information systems that detect poor performance can reduce site energy usage by up to 15%



Coriolis density meters automate lean amine concentration measurement to determine solvent circulation rate to achieve desired capture efficiency at lowest cost

Pressure safety valves offer greater stability and tightness, helping to reduce leakages and discharges

Wireless corrosion monitoring systems eliminate manual inspections and provide real-time asset integrity data to improve planned maintenance timing and scope

Vacuum Swing Adsorption (VSA) and Pressure Swing Adsorption (PSA)

The PSA and VSA cyclical processes require high levels of hydrogen purity to remove CO_2 from continuous gas streams. Improved process control supported by greater measurement accuracy and reliability helps to optimize the process, which can provide an immediate impact on the unit cost of production.

Automation solutions:

High-performance gas analyzers continuously monitor hydrogen purity to ensure hydrogen meets appropriate specification

Dedicated control and rotary valves suitable for critical high-cycle operations and stringent leak requirements minimize safety risks and emissions

Precise control of rotating equipment can reduce energy consumption, while online machinery health monitoring reduces downtime

Prioritized maintenance based on asset integrity analysis helps to avoid loss of containment, increase unit uptime and reduce maintenance costs

Selecting The Right Automation Partner

Partnering with a supplier able to provide a complete portfolio of automation solutions together with extensive project expertise can help to reduce project complexity, drive operational efficiency and maximize plant safety and reliability.

Emerson offers an extensive range of measurement, control and electrical equipment for hazardous areas, and has deep experience in setting industry standards. This makes it the perfect partner to support companies in the fast-growing hydrogen market by providing solutions to meet their most demanding applications. Emerson's advanced automation technologies are designed to optimize the SMR, anime treatment, VSA and PSA processes, by delivering advanced control, increased process visibility and actionable information for improved decision-making.

Emerson's project engineering services, combined with extensive industry expertise available globally, reduces project risk and helps to ensure delivery of large-scale capital projects, on time and within budget.

Transition to Low Carbon Future

Emerson delivers environmentally sustainable solutions for customers across the hydrogen value chain, from production to transmission and storage, to distribution and consumption. Our advanced automation technologies are helping to improve productivity, reduce variability, decrease energy usage, lower emissions and validate the sustainability of operations.

As the demand for blue hydrogen fuel grows, we continue to develop innovative solutions to meet the challenges of expanding production, safe and lower cost distribution and reliable fuel cell operation.

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