H_2O and O_2 measurements for green hydrogen production

Benefits at a glance

- Reliable H_2O and O_2 measurement in green hydrogen production using TDLAS and QF optical analysis technologies
- Improved safety, process control, and hydrogen quality validation during purification stages
- Accurate, real-time measurements without interferences
- Very fast response times for instant protection of downstream equipment
- No moving parts, no electrolytes, and long-lasting optics to enable extremely low maintenance
- Very reliable construction using solid state sensing elements means extremely high uptime
- Easy to install and commission with health monitoring that provides hands-off operation for years
- Simple in-field component servicing for minimal downtime
- NIST-traceable calibration
- ASTM standard test method compliance and global hazardous area certifications

Overview PEM electrolyzer (PEMEC: Proton exchange membrane electrolysis cell

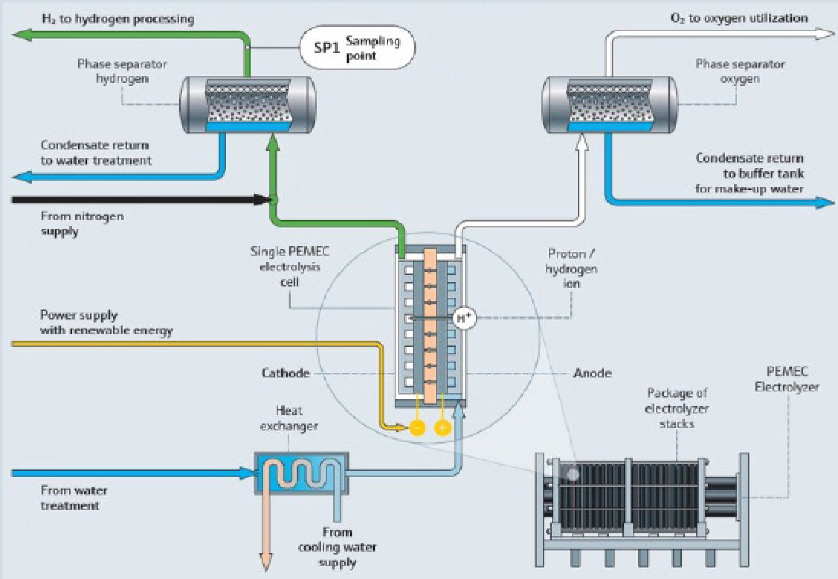

Figure 1: The electrolyzer converts water into hydrogen and oxygen. Trace moisture and oxygen are considered contaminants and must be measured prior to hydrogen processing.

Green hydrogen is becoming a viable clean energy source to support global efforts to reduce carbon emissions to net zero by 2050. To meet this ambitious target, rapid, reliable measurement of moisture (H_2O) and oxygen (O_2) in hydrogen (H_2) streams is critical to ensure product quality and process safety.

Hydrogen measurement challenges

Hydrogen can be produced from a variety of processes including fossil fuels, nuclear energy, biomass and renewable energy sources. Because it is derived from clean renewable energy sources like solar or wind, green hydrogen will play a key role in the transitioning energy ecosystem. Green hydrogen is produced through a process called electrolysis which divides water into two hydrogen atoms and one oxygen atom. The resulting “pure” hydrogen is then compressed for efficient storage and distribution.

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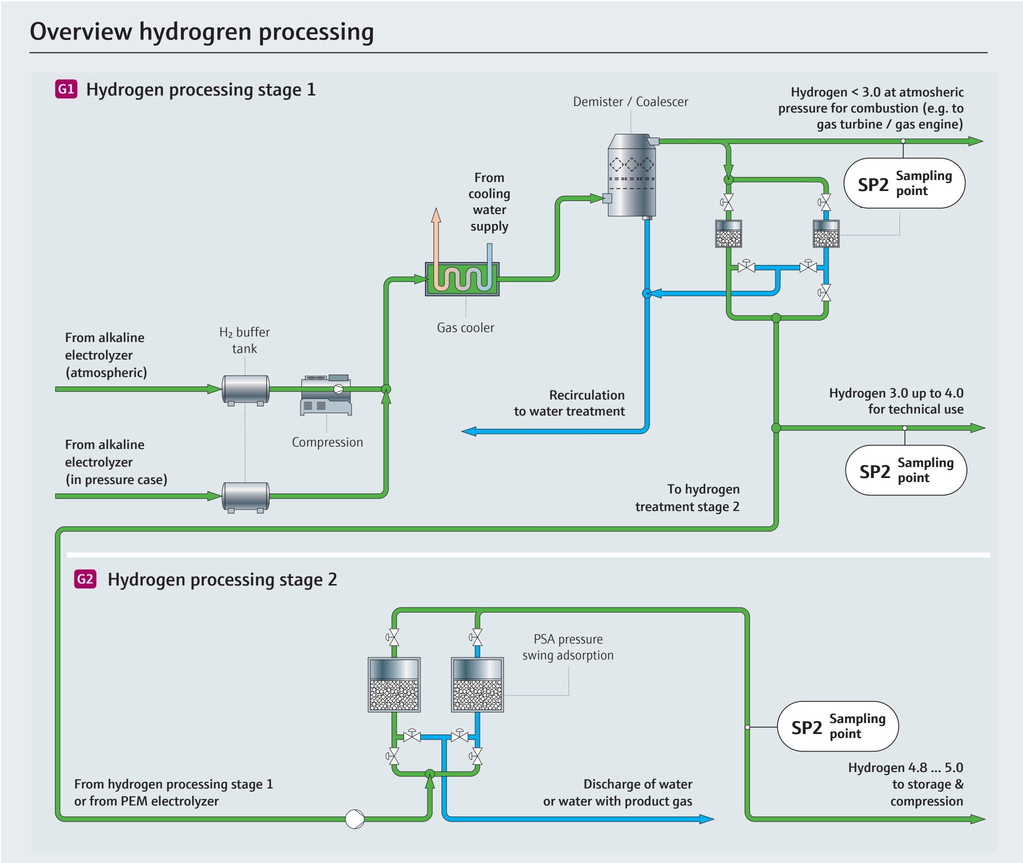


Figure 2: Key measurement points in green hydrogen processing

Accurate, rapid H_2O and O_2 measurement is vital at several key measurement points in this process chain to meet quality compliance regulations and safeguard process equipment and personnel.

Many traditional measurement technologies have sensors that come in direct contact with H_2 streams and are adversely affected by large changes in concentration, pressure, and temperature. Ultimately, these analyzers often deliver unreliable measurements, cause lengthy downtime, and are costly to operate.

After exiting the electrolyzer, hydrogen can contain water vapor and oxygen. Accurate, reliable measurement of these contaminants in real time is essential to maximize process efficiency, safety, and quality compliance. There are several key measurement points in green hydrogen production (Figure 2):

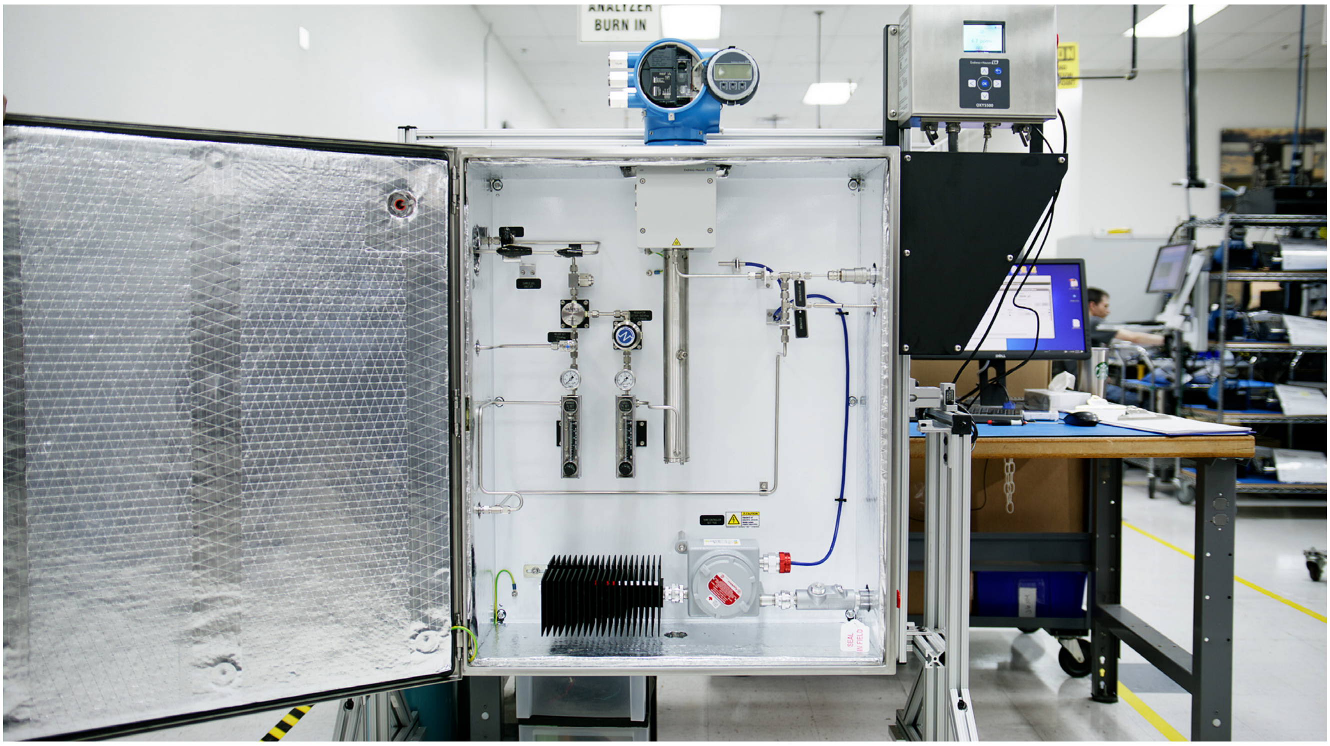
- O_2 and H_2O measurements at the outlet of the electrolyzer
- Trace O_2 and H_2O measurements through the hydrogen processing stages

Hydrogen quality compliance at the outlet of the electrolyzer

Hydrogen is produced by electrolysis plants powered by solar or wind farms, and it is an efficient way to store significant amounts of renewable energy. Hydrogen must meet strict purity requirements to ensure the proper function of hydrogen fuel cells. Optical technologies for H_2O and O_2 measurements offer maintenance-free operation due to their inherent robustness and reliability. Sample point 1 (SP1 in Figure 1) is found directly after the phase separator. This is the first step in removing any moisture carry-over from the electrolysis cell. Excess moisture in the hydrogen stream could indicate issues with the separation process. Meanwhile, excess oxygen in the hydrogen stream is a predictor of membrane degradation within the cell.

Final measurements during hydrogen processing

After phase separation, hydrogen must go through additional processing to achieve high purity. The processing stages may vary depending on the type of electrolyzer and size of the facility. Each stage normally involves additional steps to further remove moisture and oxygen from the stream. Final analytical measurements (shown as SP2) are done after each processing step to ensure that these contaminants are removed to a point where the gas can be compressed for sales. Green hydrogen may be classed based on its purity. Hydrogen 3.0 equates to 99.9% pure, while hydrogen 5.0 is 99.999% pure. The additional processing ensures that oxygen and moisture levels are < 10 ppmv.



A look inside a combined J22 / OXY5500 analyzer system

Endress+Hauser’s solution

Endress+Hauser tunable diode laser absorption spectroscopy (TDLAS) and quenched fluorescence (QF) analyzers provide the reassurance that your electrolyzer process has removed H_2O and O_2 contaminants sufficiently to allow you to deliver a quality product to end users. Our analyzers have proven reliability in H_2 green production applications at installations worldwide. Laser-based TDLAS technology provides real-time, non-contact measurements using a near infrared solid-state laser to isolate the distinct peaks in the wavelength absorption spectrum, indicating H_2O with high accuracy.

TDLAS analyzers are able to perform continuously analysis in real-time, while Endress+Hauser’s QF analyzers help to further avoid O_2 carry over into pure O_2. Endress+Hauser TDLAS and QF analyzers are demonstrably faster, more accurate, and more stable than other H_2 green production process measurement alternatives, with no contaminant interferences and nearly zero maintenance.

TDLAS and QF analyzers help to future-proof power and energy systems by providing reliable, real-time concentration analysis of hydrogen streams at critical points of transfer. Moisture and oxygen can be detected at the outset of the electrolyzer down to trace ppm levels. TDLAS analyzers are easy to install and commission, have no moving parts or consumables, and feature 24/7 online health monitoring. These capabilities provide hands-off operation for years with nearly no required maintenance.

Conclusion

As energy sources and gas mixtures continue to shift, the infrastructure to produce green hydrogen on an industrial scale will be critically important. TDLAS and QF-based measurement systems should play prominent roles in the processes involved to support this new emerging energy ecosystem. A changing mix of molecules and pipeline infrastructure, coupled with advancements in process automation, will further drive the need for on-line gas analysis in hydrogen processes for enhanced safety, asset integrity, and quality control for decades to come.

Technical specifications

Application data		
Target analyte	H_2O in hydrogen (J22)	O_2 in hydrogen (OXY5500)
Principle of measurement	Tunable diode laser absorption spectroscopy (TDLAS)	Quenched fluorescence (QF)
Analyzer	J22 & OXY5500 (sold individually or with combined sample conditioning system)	
Typical measurement ranges	0 - 10 ppmv (H_2 specific build) 0 - 50 ppmv (minimum) 0 - 6000 ppmv (maximum)	0 - 10 ppmv (minimum) 0 - 1000 ppmv (maximum)
Repeatability	± 100 ppbv (H_2 specific build) ±1 ppmv or 1% of reading (whichever greater)	±1% of reading
Measurement update time	1 second	User selectable 30 seconds standard 3 seconds fastest
Sample flow rate	0.5 - 1.0 slpm (1 - 2 scfh)	
Operating pressure range	800-1200 mbar (standard) 800-1700 mbar (optional)	
Validation & calibration	No calibration required Validation through chilled mirror, Portable TDLAS, or binary cal gas	Calibration with zero gas (N_2) and span gas (O_2 in N_2)
Electrical and communication		
Controller power supply	24 VDC, 10W 100 to 240 VAC, 10W	24 VDC, 4.7W 108 to 253 VAC, 6.6W
Heater power supply	100 to 240 VAC, 200W (common heater for sample conditioning system)	
Analog and relay outputs	I/O2 and 3: software configurable, set as relay output, analog output (4-20 mA) or digital/status output	Analog: (2) 4-20 mA Output relays: (2) relay outputs
Modbus output	Modbus RS485 Modbus TCP	Modbus RS485
Ingress protection (analyzers)	IP66, Type 4X	
Ordering information		
H_2O and O_2 measurements can be supplied as complete system with a single sample conditioning system or as dedicated analyzers. Sample stream conditions must be reviewed through Endress+Hauser's Application Engineering team for final quote.		

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AI01381C/66/EN/01.23

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