SPECIALTY GAS ZONE

# Gas analysis requirements for emerging decarbonisation technologies

## Hydrogen electrolysers and CCS

By **Stephen B. Harrison, sbh4 Consulting**

The world must decarbonise. The precise routes to the goal are unfolding, and each country will find its own path to 2050 and beyond. As a clean fuel, hydrogen will play a central role in securing the Paris Agreement mid-century target of 'net-zero' carbon dioxide emissions to which many nations aspire.

Green hydrogen produced from water electrolysis based on renewable electricity will be one part of the solution. Blue hydrogen produced from natural gas combined with carbon capture and storage (CCS) will also play a leading role. CCS can also enable decarbonisation of other fossil-fuel consuming industries.

### CCS can decarbonise the ammonia and beverage-grade $CO_2$ value chain

Carbon dioxide ($CO_2$) emissions from fossil fuels have resulted in global warming. The role of CCS is to recover $CO_2$ from industrial process gas emissions and inject that $CO_2$ deep into the ground for long-term storage. Atmospheric emissions of $CO_2$ from existing combustion processes, such as cement production or electrical power generation, can thereby be reduced to slow down climate change. $CO_2$ emissions from hydrogen steam methane reformers (SMRs) and auto thermal reformers (ATRs) are also ideal for CCS schemes.

The ammonia industry is one of the largest producers of hydrogen through steam reforming of natural gas. The growing use of ammonia in emerging energy applications as a marine bunker fuel or feedstock to gas-fired power turbines could increase ammonia demand, perhaps by an order of magnitude.

Ammonia production is mature, and many global technology providers have recently announced considerable up in ammonia plant designs. World-scale plants produce circa 3,300 tonnes of ammonia per day. New designs would be capable of around 6,000 tonnes per day.

Much of the $CO_2$ which is commercially recovered for use as an industrial gas in the food and beverage sectors comes from SMRs associated with ammonia and fertilisers. As ammonia production ramps up, natural gas will remain well placed as a feedstock and could support a decarbonised future if the hydrogen production is combined with CCS. In that case, $CO_2$ captured from the SMR which exceeds the demand for commercial $CO_2$ utilisation applications would need to be stored in underground CCS schemes.

> "ABB's experience in the oil and gas sectors gives us the right pedigree to offer process instrumentation and gas analysers for emerging CCS applications..."

### Gas analysers hold the key to CCS operations

The combination of CCS with steam methane reforming can reduce →

© ABB

$CO_2$ emissions by around 90%.
CCS can be specified for new SMR projects and can be retrofitted to existing plants. This will extend the operational life of existing hydrogen production assets in a decarbonised future.

CCS schemes require absorbers, strippers, high-pressure gas compression trains, and distribution pipelines. The process equipment bristles with temperature, level, flow, and pressure instrumentation. Stephen Gibbons, Head of Product Management for the Continuous Gas Analysers product range at ABBs Measurement & Analytics Division, confirms that, "Each CCS scheme also needs an array of gas analysers. Direct-read gas analysers are required for process control, emissions monitoring, and pipeline integrity confirmation."

High resolution process gas chromatographs ensure the $CO_2$ destined for permanent underground storage is compatible with the gas transmission pipeline and the underground storage location geology. Gibbons states that, "ABB's experience in the oil and gas sectors gives us the right pedigree to offer process instrumentation and gas analysers for emerging CCS applications because there are many similarities between these applications."

Many nations are likely to participate in CCS schemes. If their countries do not have the appropriate geological profile for

**"...our Caldos 27 thermal conductivity gas analyser is able to measure traces of hydrogen in the oxygen stream from the electrolyser"**


© NRG Energy Inc

underground storage, they must export their $CO_2$ for sequestration in a nearby geography. Gibbons believes that, "International trade of $CO_2$ for CCS will be likely. This would require extremely accurate $CO_2$ flow measurement and gas purity analysis. ABB process GCs, such as those in the NGC 8200 series, have been used for fiscal monitoring and custody transfer in natural gas pipelines for many years. They have all the right technology to be applied to CCS applications."

### The importance of carbon dioxide purity in CCS applications

Before $CO_2$ is stored deep underground, important purity criteria must be met. Inert and incondensable gases such as argon, nitrogen, or methane reduce the efficiency of the gas compression process by increasing the required energy input.

Furthermore, these gases do not behave in the same way as $CO_2$ when injected underground and take up valuable storage space. CCS can draw on Enhanced Oil Recovery (EOR) experience to define a suitable operating envelope for pipeline integrity, safety, and operational considerations.

In both EOR and CCS schemes, for cost-effective transportation in long-distance pipeline, the $CO_2$ distribution process compresses the gas to a very high pressure. It is then injected into suitable geological structures deep underground. These compressor stations and pipelines are highly valuable assets that must be protected. Corrosive contaminants in the $CO_2$, such as moisture or hydrogen sulphide, may cause irreversible damage to the infrastructure.

One of the most important criteria is the maximum amount of water permitted in the pipeline. An excess of water would produce carbonic acid that would corrode standard carbon steel. It is generally cheaper to take the water out of the $CO_2$ than to build a corrosion-resistant pipeline. Corrosion could also pose a safety risk if it went unnoticed and caused a gas leak or pipeline rupture.

Process performance and gas distribution asset integrity are not the only reasons for careful analysis and control of CCS $CO_2$ purity. The safety of operators and the public are also of paramount importance. $CO_2$ intended for CCS may contain traces of toxic chemicals such as CO, NOx, or SOx. Whilst operators cannot always prevent these molecules from being present at tiny amounts, they can monitor their concentrations. The idea is to ensure they exist at concentrations low enough that any potential $CO_2$ leak from the pipeline or storage site does not pose a health risk.







© ABB

### Safe operation of electrolysers

Emerging hydrogen applications such as near-grid energy storage, fuel-cell powered mobility, heating, and direct reduction of iron will become common as hydrogen progressively substitutes traditional fossil-fuels in these applications. Large-volume hydrogen consuming industries such as ammonia and methanol production can also decarbonise using 'green' hydrogen.

The increasing importance of hydrogen in our future means that a variety of production methods, including modern electrolysis of water using renewable electricity will be required. The gas-related safety issues on electrolysers call for reliable gas analysis techniques.

At the anode of the electrolyser oxygen gas is produced. At the cathode hydrogen gas is generated. If there is no leakage of gas from one side of the electrolyser to the other, the mixing of a fuel with an oxidising agent is avoided. However, some mechanisms can potentially cause an oxygen-hydrogen fuel mix. Electrochemistry is complex. Many reactions take place in the electrolyser which can cause small concentrations of oxygen to build up in the hydrogen stream and vice-versa. Furthermore, the electrolyser membrane can leak gas from one side of the electrolyser cell to the other.

Section 4.5.1 of ISO 22734-1 (Hydrogen generators using water electrolysis process– Industrial, commercial, and residential applications) states, "The hydrogen generator shall be equipped with a control system that provides required safe and reliable hydrogen generator performance and limits hazardous conditions from occurring."

It goes on to identify measurement of oxygen in the hydrogen stream and measurement of hydrogen in the oxygen stream as fault conditions to be considered as part of the monitoring and control system.

"Electrolysers need sensitive gas analysers for safe operation", says Gibbons. Automated safety control systems invoke the appropriate actions in the event of an oxy-fuel gas mixing alarm being activated. For example, a severe alarm would trigger an emergency shutdown of the electrolyser. In that event, electrical power is isolated, nitrogen, an inert gas, is introduced to purge the internal space of the electrolyser, and all the gases are vented to a safe location.

Gibbons concludes that, "Our Caldos 27 thermal conductivity gas analyser is able to measure traces of hydrogen in the oxygen stream from the electrolyser. It can be mounted in an explosion proof housing. That is important for electronic devices that are used around electrolysers because hydrogen could be present."

If the Caldos 27 gas analyser is configured appropriately, this thermal conductivity technology can also be used to confirm the quality of the hydrogen product stream. gw

## About the author

Stephen B. Harrison is Managing Director of sbh4 Consulting. Harrison has over 30 years' experience of the industrial and specialty gases business, and is also a member of gasworld's Editorial Advisory Board.