Leak detection's role in the integration of CCUS with hydrogen production

The integration of CCUS with hydrogen production is being increasingly explored as an option for reducing large scale greenhouse emissions in the oil and gas industries[1], but it's important to consider the role pipeline leak detection will play and the challenges it will need to overcome as hydrogen is introduced. By Daniel Short, Senior VP Commercial, Atmos International.

Low carbon hydrogen can be produced from the process of capturing natural gas emissions during CCUS[2] and shows promise as a low-cost pathway for low-carbon production.[3]

As well as providing cost benefits, hydrogen production via CCUS is expected to decrease in cost over time and reduce emissions from existing hydrogen production, which currently averages more than 800 megatons of CO2 emissions annually.[3]

As hydrogen's integration with CCUS gains momentum, it's important to consider the role leak detection will play in hydrogen production, especially given that pipelines are key to CCUS fluid transportation.

However, it's first important to consider the challenges that will face leak detection in these pipeline scenarios.

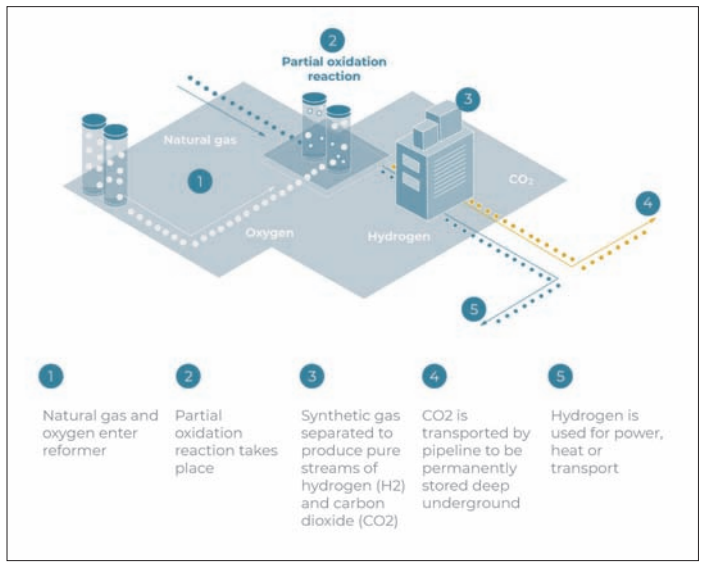

Figure 1: Example of hydrogen production via carbon capture, utilisation and storage

Considering existing pipeline infrastructure

Whether using existing pipelines that are repurposed or specially constructed networks, it's vital to have leak detection on pipelines integrating hydrogen with CCUS.

Hydrogen embrittlement can occur when it is introduced to pipelines, causing the interior wall of the pipeline to degrade and resulting in leaks.

On aging pipeline infrastructure, defects in the pipe wall are more common too. The small molecular make-up of hydrogen means leakage can occur more easily on aging gas pipelines, causing an increase in pipeline incidents, such as leaks and ruptures.

With CCUS becoming an important way for the global energy sector to help mitigate climate change, there will be a direct correlation with the number of existing pipelines being required for CCUS and hydrogen production, so examining existing infrastructure should be a core consideration.

Ambitions to build over 50 new carbon capture facilities by 2030 means that leak detection should also be factored into the planning of new CCUS pipeline projects as they emerge.[4] Installing leak detection on new infrastructure is more cost effective and sets a standard for efficient CCUS operations.

Capacity constraints

With discussions around existing pipeline in-

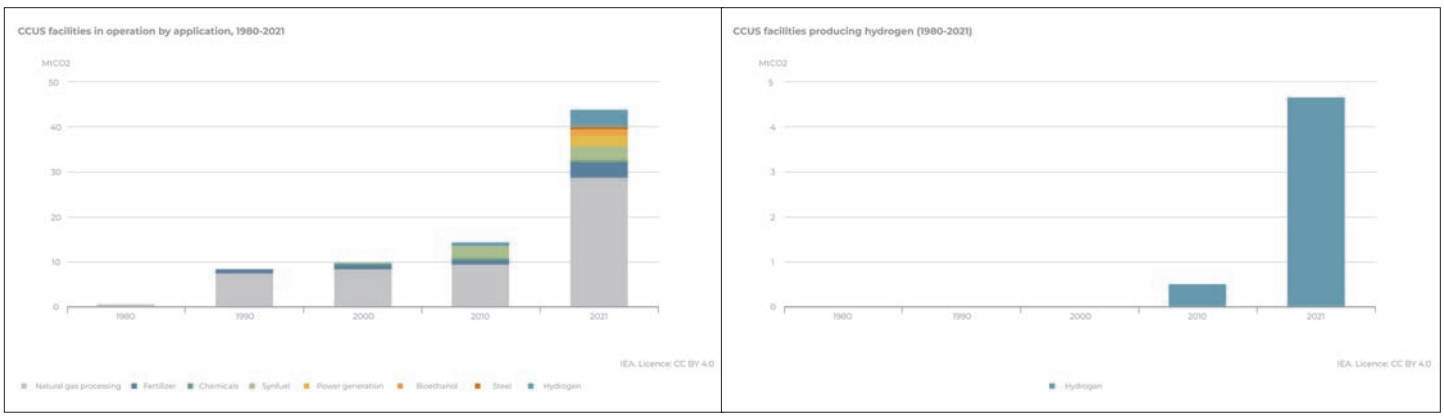

Figure 2: Operational CCUS sites (1980-2021), with a focus on the increase in hydrogen production via CCUS in the second graph

frastructure being used to facilitate the introduction of hydrogen to CCUS,[3] pipeline operators need to fully understand their network's capacity constraints.

Demand pressure requirements is one of the key areas operators should consider as hydrogen is introduced to pipelines because every pipeline has a maximum daily quantity as well as minimum and maximum pressure constraints. Exceeding these limits can threaten the integrity of the pipeline and lead to leakage, pipeline simulators such as Atmos SIM can be used to model hydrogen blends. When used offline, simulation can help pipeline companies understand whether network reinforcement is required.

When hydrogen is introduced to a pipeline, the maximum capacity is reduced as the concentration of hydrogen increases. Figure 3 shows an example of capacity reduction as 10%, 25% and 50% hydrogen is introduced in a natural gas network.

Atmos SIM makes this task easier by separating by demand groups. Once the minimum pressure constraint is violated, the demand is reduced to maintain pressure. The point this happens is deemed as maximum capacity.

Consequences of a hydrogen leak

While pipelines remain the safest means of transporting any fluid, there are still concerns that hydrogen can permeate metal and leak through the pipeline. Paired with the high possibility of hydrogen production taking place in existing pipeline infrastructure, leakage should be a core consideration of pipeline operators integrating hydrogen production with CCUS.

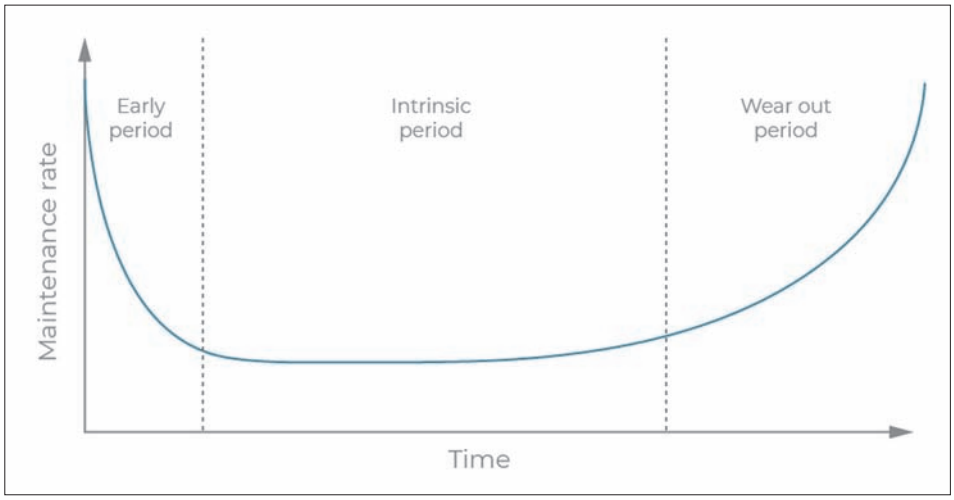

Figure 3: A visualization of the bathtub curve, as used to define the reliability of a product

When hydrogen is released into the atmosphere, it automatically becomes flammable at a range of between 4% and 75% in the air which is a wider range than in other fuels.5 As previously mentioned, the molecular makeup of hydrogen means it can disperse quickly into an open environment. It's almost invisible to the naked eye in daylight and partially visible at night, so external methods of leak detection such as line walks, drones and helicopter patrols will not be a suitable method of leak detection.

Leak detection is vital in the integration of CCUS with hydrogen production

Software solutions like Atmos SIM use a hydraulic model and statistical analysis algorithm to detect leaks reliably and accurately.

Similarly, Atmos Pipe can be finely tuned to meet the sensitivity requirements to detect a hydrogen leak on large complex pipelines. This is important, since many larger scale CCUS projects complete the storage step of the CCUS process at an offshore subsea location. When used offshore, Atmos Pipe is configured to take account of both the hydraulic profile of the pipeline and the seawater outside the pipeline.

Alternatively, the multi method Atmos Wave Flow may be used which includes both a volume balance and a negative pressure wave (NPW) algorithm.

To learn more about how Atmos is equipped to provide vital leak detection support during the integration of CCUS with hydrogen production, visit our website.

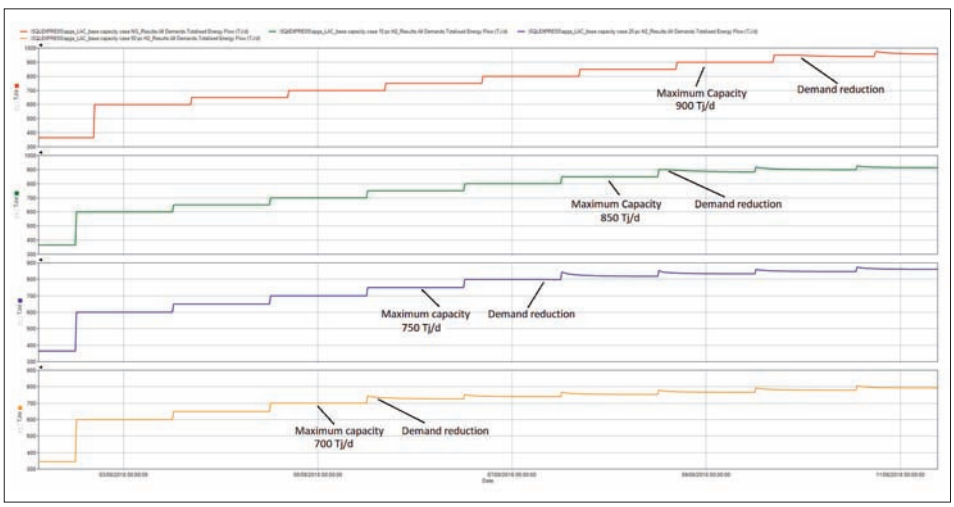

Figure 4: Hydrogen blend maximum capacity calculated by Atmos SIM (red 0%, green 10%, blue 25% and orange 50%)

References

1 https://doi.org/10.1073/pnas.2202397120

2 https://www.bp.com/en_us/united-states/home/who-we-are/advocating-for-net-zero-in-the-us/ccs-and-hydrogen.html

3 https://www.iea.org/reports/ccus-in-clean-energy-transitions/a-new-era-for-ccus

4 https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage

5 https://h2tools.org/bestpractices/hydrogen-compared-other-fuels

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