In focus...

CCS in the APAC region

Stephen B. Harrison explores carbon capture and storage (CCS) and why Australia is the 'torchbearer' for CCS in the Asia-Pacific region

It is becoming clear that carbon capture and storage will have a central role to play in securing the mid-century target of 'net-zero' carbon dioxide emissions which is the aspiration of many nations. To underline this point, on the 24th September 2020, Dr. Fatih Birol, Executive Director of the International Energy Agency (IEA) said, "Carbon capture is critical for ensuring our transitions to clean energy are secure and sustainable."

Hydrogen has recently received worldwide recognition that it will be essential for the decarbonisation required to combat climate change that has resulted from greenhouse gas emissions. We will soon see a similarly high level of recognition for the complimentary role that carbon capture and storage (CCS) can play. There are 26 operating CCS schemes worldwide. Many are related to enhanced oil recovery in the US and Canada. Several more exist in Europe and the Asia-Pacific (APAC) region. In the next decade, this number is likely to increase ten-fold to become 300 schemes, or more.

As the torchbearer for CCS in the APAC region, Australia has long been a pioneer of the technology and is home to the Global CCS Institute. Operating from Barrow Island off the western coast of Australia, the Gorgon CCS scheme is one of the world's largest and has a nameplate capacity to capture and store four million tonnes of carbon dioxide (CO_2) each year. It is linked to production of liquefied natural gas (LNG) from the Gorgon and Jansz-Io gas fields. The distribution of LNG via ocean-going tankers to export markets in Asia must take place in the absence of CO_2. The CCS project fulfils the role of separating the CO_2 from the methane and injecting the CO_2 underground for permanent storage. The methane is liquefied and loaded onto ships as LNG.

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Challenges and opportunities

CCS presents challenges and opportunities to industrial gases companies. Process equipment required to operate CCS schemes, such as gas separation systems, high pressure gas compression trains and distribution pipelines will need to be constructed and operated as new projects are confirmed. These technologies are in the sweet spot of industrial gases expertise and are potential business opportunities.

On the other hand, through the operation of steam methane reformers (SMRs) and gasification plants to produce syngas and hydrogen, industrial gases companies face a challenge to decarbonise. As they look upstream in the value chain, they will also see that much of the power consumed by their ASUs to perform the cryogenic separation of air into oxygen, nitrogen and argon is derived from fossil fuel combustion with significant CO_2 emissions. That power generation will also need to decarbonise, perhaps though the application of CCS or with a transition to renewable power from hydro-electric, wind and solar sources.

CCS will decarbonise Australia's hydrogen exports

The Hydrogen Energy Supply Chain (HESC) project will demonstrate the viability of ocean shipments of liquid hydrogen from Australia to Japan. It will open the door to full scale energy exports of low-carbon hydrogen.

At this early stage of the project, hydrogen gas is produced from the gasification of brown-coal at a pilot plant in the Latrobe Valley in the Australian state of Victoria. Gasification involves reacting coal with oxygen at a high temperature to produce Syngas which contains carbon dioxide, carbon monoxide, and hydrogen. This gas mixture is further purified to yield the desired hydrogen. The result is a high purity, low-cost hydrogen gas which can be cryogenically cooled to form liquid hydrogen for efficient long distance transportation.

The 'brown' hydrogen produced in this gasification process is generated from coal and for every tonne of hydrogen produced on this pilot reactor 12 tonnes of CO_2 are produced. When the HESC pilot project is complete, a full-scale gasification plant incorporating CCS will be used to make the hydrogen production process more sustainable. Hydrogen produced from coal combined with CCS is sometimes referred to as 'purple' hydrogen, a close relative of 'blue' hydrogen which is the colour generally used to describe hydrogen produced on a steam methane reformer (SMR) fitted with CCS.

CCS on SMRs for ammonia, methanol, and refinery hydrogen production

The production of ammonia as part of the urea fertiliser value chain is the largest consumer of hydrogen globally, accounting for approximately 50% of the world's hydrogen demand. These plants use Steam Methane Reformers (SMR) for hydrogen production. SMRs are also used on crude oil refineries and methanol plants to produce hydrogen.

The most compatible CO_2 capture technology for the SMR off-gases is a system that involves absorbing CO_2 in an amine-based chemical and then heating the amine in the second stripping tower to yield a high purity CO_2 gas stream. The gases emitted to atmosphere from the absorber contain only circa 10% of the CO_2 that would be emitted without CCS.

Stephen Gibbons, Head of Product Management for the Continuous Gas Analysers product range at ABBs Measurement & Analytics Division, says that "online gas analysers are used to control the SMRs and the carbon capture process. They are also essential to monitor emissions to air." In many countries, emissions of the three main greenhouse gases (CO_2, methane, and nitrous oxide) are reported to environmental authorities to ensure that the integrated SMR and CCS facility is operating within its consent levels. Gibbons states that, "These IR- and UV-active gases can be measured on Uras26 and Limas11 continuous gas analyser modules which can be incorporated into our Advance Optima system."

Gibbons adds that, "As a robust and cost-effective solution, the CCS operator may choose to combine the greenhouse gas and pollutant gas measurements in a single FTIR gas analyser such as ABB's ACF5000. With an installed base of more than 2000 units worldwide and an uptime of better than 98% we are confident that end-users will find this a highly reliable and trouble-free option for regulatory emissions monitoring."

The importance of carbon dioxide purity in CCS

In CCS schemes, the distribution process compresses CO_2 ▸

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so that it can be transported in long distance pipelines before being injected into suitable geological structures deep underground. These are highly valuable assets which must be protected. One of the most important criteria is the amount of moisture permitted in the pipeline, because water can combine with CO_2 to produce carbolic acid that would corrode the grades of steel which are used to construct gas pipelines.

Inert and incondensable gases such as argon, nitrogen or methane increase the power demand of the gas compression process. Furthermore, these gases do not shrink in the same way as CO_2 when compressed and they take up disproportionately large amounts of valuable storage space.

The safety of the public is also of paramount importance. CO_2 intended for CCS may contain trace levels of toxic chemicals such as CO (carbon monoxide), NOx or SOx. Operators can monitor the concentrations of these impurities to ensure that any potential CO_2 leak from the CCS processing equipment or storage site does not pose a health and safety risk.

ABB's Gibbons points out that, "Many of the chemicals that must be monitored in CCS pipelines are the same ones that are present in the environmental emissions monitoring application and our UV or IR based gas analyser technologies or the broad-spectrum ACF5000 FTIR can play vital roles in gas purity analysis during CO_2 distribution."

Emerging CCS clusters will require custody-transfer

Most existing CCS schemes are point-to-point, meaning that one carbon capture location such as an ammonia plant SMR is connected to one underground geological CO_2 storage location. This simple model will transition to more complex 'hub and cluster' schemes where CO_2 will be captured from several plants and fed into a feeder network connected to a long-distance transmission pipeline. This will mirror the existing natural gas pipeline grids.

A leading example of this concept is CarbonNet. It aims to establish a commercial-scale CCS network in Victoria, Australia. The network will deliver CO_2 captured from a range of industries based in Victoria's Latrobe Valley such as the future commercial phase of the HESC project and existing fertiliser plants. The main CO_2 transmission pipeline will be more than 100km long with a 10km offshore leg extending into the Bass Strait. CarbonNet has the potential to capture five million tonnes of CO_2 per year, giving it a similar scale to the Gorgon CCS project off the coast of Western Australia.

One of the implications of this network concept is that there is likely to be a change of ownership of the CO_2 as it flows from the feeder pipelines to the main transmission pipeline. There is also likely to be invoicing based on accurate metering of the CO_2 flow. Furthermore, the CO_2 gas purity will need to be confirmed before it can enter the highly valuable transmission infrastructure. These concepts replicate current natural gas distribution grid operations where regular gas analysis and flow metering also take place. gw

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