Methanol and synthetic fuels rely on CO2 utilisation

The challenge to substitute refined products that are derived from crude oil with suitably convenient and cost-effective alternatives that have a sustainable environmental impact is reliant on CO2 utilisation. By Stephen B. Harrison, Managing Director, sbh4 consulting.

Liquid fuels are incredibly useful energy vectors due to their high energy density and ease of handling. Gasoline, diesel, aviation kerosene and heavy fuel oil have become the fuels of choice for cars, trucks, planes, and shipping.

Liquid fuels of a non-fossil origin can be produced using renewable electrical power to generate hydrogen which can be combined with captured CO2 to build hydrocarbon molecules and so-called e-fuels through Power to Liquid (PtL) technology. Thousands of tonnes per year of CO2 could be utilised in this way.

The Stena Germanica is the world's first ferry powered by methanol

E-fuels are built on CO2 utilisation

Use of solid oxide electrolysis (SOE) can consume steam and CO2 to yield syngas which can be converted to liquid hydrocarbons through established chemical pathways such as Fischer-Tropsch conversion. Introduction of steam to the SOE means that water molecules are delivered to the electrolyser in a highly energised state and about 25% less electrical power is required to split them than when using low temperature electrolysis, such as a PEM or alkaline electrolyser.

On refineries and thermal power plants, there is often waste heat or excess steam that can be fed to a solid oxide electrolyser to reduce the electrical power consumption of the PtL process. If no waste heat is available, it may be preferable to use a PEM or alkaline electrolyser to generate hydrogen and react that with captured CO2 using the reverse water gas shift reaction to yield carbon monoxide which can be blended with more hydrogen to from syngas which can be converted to the required liquid hydrocarbons.

In both the SOE and low temperature electrolysis pathways, the required CO2 can be captured from point source emissions or direct air capture facilities. The use of captured CO2 reduces the overall CO2 impact of SAF and introduces an element of circularity into the value chain. Production of SAF through PtL is an emerging CO2 utilisation application that could consume thousands of tonnes per year of captured CO2.

e-Kerosene for aviation

Synthetic aviation fuel (SAF) is a broad term meaning that the jet fuel has been derived from non-fossil fuel origins. The largest source of SAF today is biofuel. Plant oils are refined to yield an aviation fuel that has been proven to be suitable for high altitude operation on jet aircraft.

More than 300,000 commercial flights have used SAF in the past 5 years. It has been used by more than 40 airlines with 13 major airports able to refuel aircraft with SAF. By the end of 2023, Neste plans to produce around 1,500,000 tonnes of SAF each year. BP also has growth aspirations for SAF and already incorporates used frying oils into their aviation fuel production at their refinery in Lingen, Germany.

SAF is made from waste frying oils through a process called hydrodeoxygenation. The resultant molecules are then isomerised to achieve the required property of the fuel. During this process, the hydrocarbon structure is branched. Distillation follows the isomerization to ensure the SAF meets international standards, such as ASTM D756609 which specifies the requirements of aviation turbine fuel.

Whilst biofuels dominate SAF production today, the next generation of SAF will be based on technology known as power to liq-

uids, or PtL. Hydrogen or syngas will be produced on electrolysers fed with renewable electrical power.

e-Methanol for shipping

Grey methanol is produced on about 100 plants worldwide with an annual capacity of around 140 million tonnes. About 100 ports worldwide have methanol storage. Despite the existence of some methanol bunkering facilities, extensive use of e-methanol as a maritime fuel in the future would require a significant ramp up in bunkering infrastructure.

E-methanol using captured CO2 will be produced in the HyNL project in Eemshaven, northeast NL. CO2 will be captured from the flue gas of the local waste to energy plant operated by EEW at Delfzijl. The CO2 will be utilised to make e-methanol by OCI BioMCN in combination with green hydrogen from electrolysers fed with renewable windpower. The resultant e-methanol will be used as a bunker fuel for shipping.

e-Methanol for trucks

Diesel has been the default fuel for trucks and buses for decades. Similarly, heavy fuel oil has been the maritime fuel of choice. Methanol, like diesel and heavy fuel oil, does produce CO2 emissions during combustion. However, since e-methanol is made from captured CO2 the emissions are carbon neutral: e-methanol is not a fossil fuel.

Diesel can begin to freeze at around -10 to -15 °C. Heavy fuel oil must be heated to ensure that it remains pourable. Methanol exhibits much better low temperature pour properties than diesel and heavy fuel oil and it remains usable in the harshest of winter conditions down -40 °C and below. It is therefore an ideal fuel for use on trucks operating all year round in northern Europe and Canada, or for emerging arctic shipping routes.

The wide temperature range over which methanol is a liquid makes it ideal for storage at ambient temperature and pressure since there is no need to use refrigerated storage to maintain methanol as a liquid. Neither must the storage vessel be capable of withstanding high pressure.

More information

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ExxonMobil signs 'biggest CCS contract'

CF Industries has entered into a commercial agreement with ExxonMobil to capture and permanently store up to 2 million metric tons of CO2 emissions annually from its Louisiana manufacturing complex.

Start-up for the project is scheduled for early 2025 and supports Louisiana's objective of net zero CO2 emissions by 2050.

As previously announced, CF Industries is investing $200 million to build a CO2 dehydration and compression unit at its Donaldsonville, Louisiana, facility to enable captured CO2 to be transported and stored. ExxonMobil will then transport and permanently store the captured CO2 in secure geologic storage it owns in Vermilion Parish.

As part of the project, ExxonMobil has signed an agreement with EnLink Midstream to use EnLink's transportation network to deliver CO2 to permanent geologic storage. The 2 million metric tons of emissions captured annually will be equivalent to replacing approximately 700,000 gasoline-powered cars with electric vehicles.

"This landmark project represents large-scale, real-world progress on the journey to decarbonize the global economy," said Dan Ammann, president of ExxonMobil Low Carbon Solutions. "ExxonMobil is providing a critical and scalable solution to reduce CO2 emissions, and we're ready to offer the same service to other large industrial customers in the state of Louisiana and around the world. We're encouraged by the momentum we see building for projects of this kind, thanks to supportive policies such as the Inflation Reduction Act."

CF Industries expects to market up to 1.7 million metric tons of blue ammonia annually. A chemical process is considered "blue" when CO2 emissions are captured before their release into the air, making the process more carbon-neutral. Demand for blue ammonia is expected to grow significantly as a decarbonized energy source for hard-to-abate industries, both for its hydrogen content and as a fuel itself, because ammonia's components – nitrogen and hydrogen – do not emit carbon when combusted.

CF Industries' Donaldsonville, Louisiana, facility (Image: CF Industries)

"EnLink has a system of over 4,000 miles of pipeline already in the ground in Louisiana," said Jesse Arenivas, Chief Executive Officer of EnLink. "Utilizing this extensive network enables us to provide the most timely and cost-effective solution to CO2 transportation, with a significantly lower environmental impact. Because of this, EnLink is uniquely positioned to be the CO2 transportation provider of choice in Louisiana's Mississippi River corridor, which is a hub of industrial activity that is important to our economy. We look forward to working with ExxonMobil to help CF Industries and the State of Louisiana reach their decarbonization goals."

More information

www.cfindustries.com