> *When producing hydrogen from coal, it'd be better to burn the coal for electricity in the first place.*

Seeing green

Hydrogen fuels – the future of hydrogen

Hydrogen is the most abundant substance in the universe and it could help to pave the way towards net zero within agriculture. However, this means generating it in a sustainable and affordable way which isn't as accessible as it might seem. *CPM* investigates.

By Melanie Jenkins

The potential for green hydrogen to change energy and fertiliser production as we know it is boundless, with one quick Google search resulting in a myriad of results – many likely to be from well-known firms as they seek to get ahead of the game. But what can it bring to agriculture?

Despite its apparently unlimited nature, accessing hydrogen in a usable form isn't that straightforward, but even so, it's widely used across different industries, explains Cenex's Nick McCarthy. "Hydrogen is essential to our civilisation; from its use in the manufacture of fertiliser to the de-sulphurisation of fuel for vehicles, it's used in food production, glass making and a range of other chemical applications."

However, there's an issue with this. Although hydrogen itself can provide a clean and green source of energy, in the majority of cases it's produced using natural gas or coal, he highlights. "How hydrogen is produced is often categorised using a colour code but green is the only one that's produced entirely using renewable energy. When producing hydrogen from coal, it'd be better to burn the coal for electricity in the first place."

Operator familiarity

One of the key advantages of adopting hydrogen as a fuel is that the experience of operating with it is similar to what currently exists in liquid fuelled vehicles, says Nick. "As far as its potential to replace diesel internal combustion engines in agriculture goes, there are two options available or in development, depending on the machine and manufacturer in question.

"Hydrogen can either be used in a fuel cell or in an adapted internal combustion engine. In a fuel cell, an electrochemical process similar to that of a battery takes place, where the discharging of electrons produces energy.

"Where the internal combustion engine is concerned, JCB has been at the forefront of developing this technology. Unlike in fuel cells, the hydrogen used in adapted internal combustion engines doesn't have to be as clean and because these are already the standard engines produced, it's a much easier adaption to make than creating a new engine because the infrastructure already exists."

But one of the biggest barriers to adopting this technology may be a lack of accessible locations for refuelling. "In the UK we have around 12 hydrogen refuelling stations, many of which are located on universities or behind security gates. And while there are firms producing mobile refuelling units, these are expensive and there are a number of legal and regulatory hurdles still to overcome.

"It's not yet clear whether it'd be possible to take a hydrogen bowser onto a farm because the farm will count as an industrial zone. Or it might be possible to have it on farm but not to drive with it on public roads

Hydrogen is lighter than air and even when it's compressed and contained it doesn't weigh much.

A LONG WAY TOGETHER

AGRIMAX FORCE

No matter how challenging your needs, AGRIMAX FORCE is your best ally when it comes to soil tillage and haulage applications with high-power tractors. Thanks to its IF Technology, this radial tyre can carry heavy loads with a lower inflation pressure than a standard tyre, thus reducing soil compaction and providing excellent traction. AGRIMAX FORCE also boasts reinforced tyre bead, which helps lengthen the life of the tyre, ensure great performance even at high speeds and reduce fuel consumption.

AGRIMAX FORCE is BKT's response in terms of both productivity and resistance for high-power tractors.

Discover the BKT Radial Range

IMPORTER FOR THE UK

R.H.CLAYDON Ltd

R H CLAYDON LTD
Saxham Industrial Estate
Saxham - Bury St Edmunds - Suffolk, IP28 6RZ
Tel: 01284 778509 - Fax: 01284 778560 - www.rhc.co.uk

BKT
GROWING TOGETHER

bkt-tires.com

to access the farm, based on current laws."

Nevertheless, the EU is working to overcome this with its Ten-T corridor policy which sets out road and other transport networks surrounding and adjacent to towns that are critical to the economics of the EU. "To allow for the integration of hydrogen as an accessible fuel across the EU, it's been agreed that a hydrogen refuelling station will be built at each node of this network as well as one every 200km (124m).

"Before Brexit the UK was included in this policy, and although we aren't now, the overall economic gravity it has hasn't changed. So it's essential that the UK aims to provide a similar frequency of refuelling stations to allow for the rollout of the technology and continued economic cohesion."

The refuelling process itself is simple and would be very similar to adding a

Refuelling hydrogen vehicles would be very similar to adding a liquid fuel to a vehicle.

Green fuel

Refuelling hydrogen powered tractors is something Fendt is exploring in Lower Saxony, Germany, with its H2Agrar project. This project has involved building infrastructure to produce and supply hydrogen locally using wind turbines, to two Fendt Helios tractors, explains the firm's Ed Dennett.

"Hydrogen fuelled machines are still a long-term project for us and from a manufacturer's perspective, there's a lot of hedging going on in regard to where the industry will be in terms of fuel sources in the future. As Fendt sees it, hydrogen machines could fit the market above 130hp, however, making hydrogen power commercially available and successful is a challenge."

While Fendt began trialling its hydrogen fuel cell tractors in 2023, the H2Agrar project commenced in 2021 with the installation of a hydrogen production station in Haren. The energy sourced for the hydrogen comes from 16 community wind turbines.

Two specially installed electrolysers, each with an output of 1MW, produce up to 900kg of hydrogen per day. At the same time, there are two battery storage units on site with a total capacity of 4MWh for buffering electrical energy. The hydrogen produced is fed into the local natural gas grid and supplied to the hydrogen filling station; there's also a Green Charging Park for trucks and cars with a charging capacity of 480kW per charging station.

Each Helios tractor used in the project has a hydrogen tank on the roof holding 4.2kg at 700bar (10,153psi) which totals 21kg of hydrogen. This is reduced to around 10bar (145psi) to be added to the fuel cell where it's converted to approximately 350kWh of electricity. The tractor has another 25kWh battery giving it a total of 105kw, which allows it to undertake 4-7 hours of work.

Refuelling hydrogen powered tractors is something Fendt is exploring in Lower Saxony, Germany, with its H2Agrar project.

"The whole idea behind the project is local generation of hydrogen," explains Ed. "We see it as similar to a biodigester that can be located anywhere but with hydrogen. Farms are already producing their own renewable energy and making money from it, so this project explores how feasible it is to produce and use hydrogen on a localised scale."

Although the firm still very much sees itself as a machinery manufacturer, the project helps to determine the possibility of widespread adoption of hydrogen machines in the future. "There's a lot of investment going into green hydrogen across different industries and we feel it's important to be a part of this so we can help shape its future and determine how it could be commercially viable," says Ed. "It also demonstrates to our customers that when purchasing a Fendt machine, they're investing in the future."

But in order for this technology to progress, there has to be interest from investors and demand from customers, he says. "We can't bring a product to market that no one wants, or one that's too expensive. But by exploring the feasibility and economics of the localised production of green hydrogen it demonstrates there's potential for farmers to be in control of their own fuel supply in future – it's all about being open to what's possible."

liquid fuel to a vehicle, says Nick. "The connectors would lock into place and would likely be cooled to ensure there's no overheating and the process is quick – all-in-all it's about a five-minute task for a passenger car sized fuel tank."

Work performance

But how does hydrogen's work performance compare with diesel? In terms of energy density comparative to mass, hydrogen is fantastic, says Nick. "Hydrogen is lighter than air and even when it's compressed and contained it doesn't weigh much, however, it has a very low volumetric energy density meaning it's the storage of the fuel which takes up space."

According to the University of Michigan's Center for Sustainable Systems, its volumetric energy density is 8MJ/L for liquid hydrogen, 5.6MJ/L for compressed hydrogen gas at 700bar (10,152psi) pressure, compared with 32MJ/L for gasoline at ambient conditions.

"In essence, this means that the number of hectares you can plough in a day is good, but the volume of hydrogen you can take with you to that field is limited," explains Nick. "I estimate 20kg of hydrogen would be required to achieves a day's work from a tractor. It's likely this would be stored on the roof of the cab but there's then the challenge of maintaining balance."

In addition to this, hydrogen has to be held at high pressures, with most non-road hydrogen prototypes storing the gas at 350bar, while on road this is 700bar to be able to store enough to operate. "That's a lot of pressure to contain which means the thickness of the walls of the cylinders has to be considerable to store it safely."

But safety is of utmost importance to manufacturers, with cylinders undergoing incredibly stringent testing, says Nick. "Tests include placing a cylinder in a bonfire for eight hours to see if it explodes, dragging them behind a truck on a 20ft chain, and firing rifles at them. Hydrogen cylinders are built to pass these tests and there are UK firms installing them which expect their cylinders to outlast the vehicles they're designed to go in."

Access to green hydrogen is a further obstacle but in theory, the UK is one of the places in the world where there's potential to produce cheap hydrogen, suggests Nick. "The UK has an incredible wind resource available and if this was pursued – privately or via government incentivisation – the UK could potentially produce hydrogen cheaply and be able to transport it domestically in a cost-effective manner." ■

Green fertiliser

June 2024 saw Yara open a new renewable hydrogen plant in Herøya, Norway, the biggest hydrogen production facility of its kind in Europe.

Hydrogen is already fundamental for UK agriculture due to its use in the manufacturing of any nitrogen fertiliser product, be that liquid, urea, ammonium nitrate or NPK, reminds Yara's Mark Tucker.

Up until recently, the industry has been producing hydrogen from fossil fuels but it's now working to shift this to another source to decarbonise the supply chain. In Yara's case, it's through the use of electrolysis. "This is both a challenging and expensive transition but we can produce ammonia without the unwanted consequence of climate change, then we have to use renewable sources to drive processes such as electrolysis, at scale," he says.

June 2024 saw Yara open a new renewable hydrogen plant in Herøya, Norway, the largest hydrogen production facility of its kind in Europe. "It's involved a huge investment and technological challenge, but is now able to help cut up to 41,000t of CO_2 emissions annually."

The 24MW plant will produce fertiliser products for Yara's Climate Choice portfolio to help decarbonise the food chain and reduce the climate impact from fertilisers. Although there's limited supply at the moment, Yara aims to produce 40% of its fertiliser from its Climate Change portfolio by 2030 – not solely from its Norwegian plant, but from other sites and renewable sources elsewhere around the world.

But Mark highlights that the adoption of fertiliser produced from renewable sources isn't an excuse to be blasé. "It's important that we're still combining this with a reduction in the amount of fertiliser being used, because if we apply it in wrong ways at the wrong times, then this undoes all the efforts of producing it using a low or no carbon method."

Yara's Dale Turner points out that it's essential to coordinate green fertiliser with optimised field applications. "It's equally important that yields aren't sacrificed to lower your carbon footprint, because that'll undo what you're trying to achieve overall."

But due to the unknown position of hydrogen in the future of fertiliser production and fuels, securing investment for further research and development is a sizeable challenge, says Mark. "We're talking about billions of pounds that's gone into this so far to allow for a green product to become available for farmers. So far this has been funded by ourselves, the Norwegian government and our market partners such as PepsiCo and Simpsons Malt."

Unless these partnerships can develop across the supply chain it could lead to limitations in investment, says Dale. "We want to ensure there's a meaningful, collaborative approach across the board, which should include partners from farm level to food companies and processors."

To this end, he advises exploring how the adoption of green fertilisers could add value to food produced from it. "It's important that its use can be measured and verified accurately through carbon auditing. However, without standardised methodologies the impact can be difficult to accurately verify."

Although Yara has already reduced its emissions by 45% since 2005, it's still going to be some time before the agricultural industry can transition to a point where most, if not all, fertiliser is produced using green hydrogen, says Mark. "We're talking about decades before there's millions of tonnes of fertiliser produced from green hydrogen across the world."