Hydrogen and Improving Fuel Efficiency

Nether Aden
Climate Change Focus Farm

Notes from the meeting on
17th January 2018

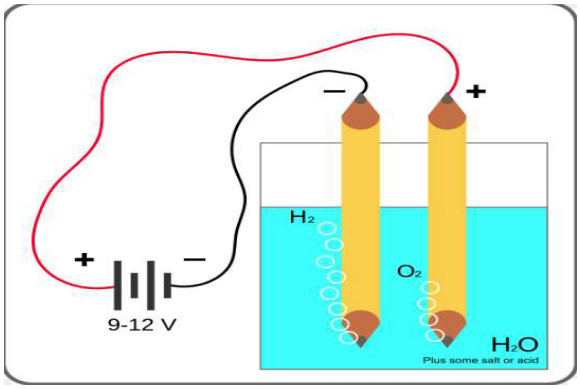
The latest meeting of the Climate Change Focus Farm at Nether Aden looked at fuel use on the farm and some of the opportunities to improve fuel efficiency. The meeting looked closely at the performance of a hydrogen electrolyser recently fitted to a loader on farm.

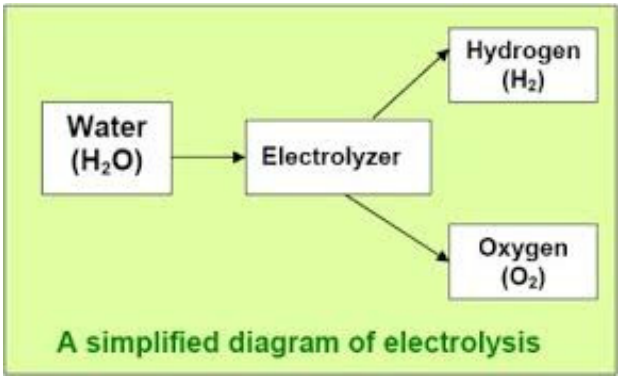
Opportunities in Hydrogen use

Phil Davies from the company Water Fuel Engineering attended the meeting, together with some engineers from the company, to help explain an ongoing trial on Nether Aden. This company has recently been involved in fitting hydrogen electrolysers to various council vehicles such as road sweepers, bin lorries etc in many parts of England. In late summer 2017, this company also fitted a hydrogen electrolyser to the JCB loadall on Nether Aden as part of a trial funded by the Scottish Office

Mr. Davies looked at the possibilities of using hydrogen as a fuel. Currently there is a good example of hydrogen being used as a fuel for a fleet of busses in Aberdeen. However, there are some issues that have become apparent eg the hydrogen busses cost in the region of £700,000 each, the hydrogen fuel is costing approximately £10 per litre, the hydrogen fuel tanks are very heavy, while careful storage of the hydrogen is also needed.

Having seen these issues, Water Fuel Engineering have produced a hydrogen electrolyser to be fitted on to vehicles which allows them to run on both diesel and hydrogen. The electrolyser is fitted to existing vehicles with the stated aim being to work alongside conventional fossil fuels to reduce emissions and improve efficiency. This allows vehicles to run on both diesel and hydrogen. The machine itself consists of an electrolyser, a control unit and a water reservoir. The electrolyser is retro fitted to existing engines and works by splitting water into its component parts of hydrogen and oxygen.





Rather than trying to collect these gases separately, the system collects oxyhydrogen. This gas is then injected into the conventional engine and supplements the supply of existing fuel, such as diesel. It is claimed that this process accelerates the combustion process leading to the cleaner and faster burning of the fuel mixture. This results in more efficient combustion of the fuel, giving a reduction in the fuel used plus also lower emissions. Details from the manufacturer suggest that the hydrogen is introduced to the fuel mix at a rate of approximately 6%, meaning that there is no damage to conventional engines.

Some of the benefits seen from the electrolyser include:

- Fuel savings of between 11 and 29%
- Overall emissions claimed to be reduced by 80%
- No limitations on range as oxyhydrogen is produced on board and on demand
- Less frequent diesel particulate filter replacement

Why we need to reduce emissions

Global warming and climate change is an ongoing issue for everyone. Industries in many parts of the world are now looking at changes to practices to try to reduce emissions, with legislation being introduced in many cases. Agriculture is no different. Agriculture has numerous sources of greenhouse gas emissions e.g. nitrous oxide from soil management and fertiliser applications, enteric fermentation producing methane from farm animals, methane from manure management, carbon dioxide from fossil fuel consumption. Many of these sources of emissions are natural, biological processes and it can be difficult to reduce these emissions. Water Fuel Engineering claim that the use of their hydrogen electrolyser can reduce fuel consumption by up to 25% and reduce emissions to virtually zero.

Mr Davies proceeded to set the scene as to why air quality was also important in terms of public health, in addition to its importance in relation to climate change. Recently the "Committee on the Medical Effects of Air Pollution" (COMEAP) had stated that

- About 29,000 deaths in the UK each year are associated with exposure to fine particles (PM2.5), ca. 5-6% of total deaths
- In cities, PM2.5 primarily comes from cars, lorries and buses
- In Europe, the WHO estimates about 500,000 people die prematurely as a result of air pollution each year.

The estimates above do not take any account of any contribution from Nitrous Oxide. Mr Davies then gave some facts from another COMEAP report on the effects of Nitrous Oxide on public health

- The estimated effect of NO_2 on the mortality rate in the UK is 23,500 annually
- Many of the sources of nitrous oxide are also sources of particulate matter
- The combined effect of nitrous oxide and particulate matter is 52,000 deaths per year and represents a significant public health challenge

Diesel engines produce a variety of particles during combustion of the fuel/air mix due to incomplete combustion. The composition of the particles varies widely dependent upon engine type, age, and the emissions specification that the engine was designed to meet. Diesel particulate matter resulting from the incomplete combustion of diesel fuel produces soot or carbon particles. These particles include tiny nano particles—smaller than a thousandth of a millimetre. Soot and other particles from diesel engines worsen the particulate matter pollution in the air and are harmful to health. Over the years, a number of different measures have been put in place to try to reduce these harmful emissions.

Diesel engines will be fitted with a diesel particulate filter which will usually remove 85% or more of the soot, and under certain conditions can attain soot removal efficiencies approaching 100%. Some filters are single-use, intended for disposal and replacement once full of accumulated ash. Others are designed to burn off the accumulated particulate either passively through the use of a catalyst or by active means such as a fuel burner which heats the filter to soot combustion temperatures. This is known as "filter regeneration". Cleaning is also required as part of periodic maintenance, and it must be done carefully to avoid damaging the filter. Failure of fuel injectors or turbochargers resulting in contamination of the filter with raw diesel or engine oil can also necessitate cleaning. The regeneration process occurs at road speeds higher than can generally be attained on city streets; vehicles driven exclusively at low speeds in urban traffic can require periodic trips at higher speeds to clean out the DPF. If the driver ignores the warning light and waits too long to operate the vehicle above 40 miles per hour (64 km/h), the DPF may not regenerate properly, and continued operation past that point may spoil the DPF completely so it must be replaced. Some newer diesel engines, namely those installed in combination vehicles, can also perform what is called a Parked Regeneration, where the engine increases RPM to around 1400 while parked, to increase the temperature of the exhaust.

Is Hydrogen the Answer?

Following on from the presentation by Phil Davies, John Farquhar, a senior renewables consultant with SAC Consulting, gave a presentation of his experiences of hydrogen as a potential fuel. John was previously involved in a project for the Scottish Government looking at the viability of the production of Green Hydrogen on farms.

John started by posing a number of questions about this technology that still required answers. John's primary concern was that the electrolyser required more energy in the form of electricity to run it, than was produced in the form of oxyhydrogen. The electrolyser produces 0.15 Nm3 litres of oxyhydrogen per hour, which is equivalent to 290 watt-hours of energy. The electrolyser itself is powered by the battery at up to 21 amps which equates to 250 – 300 watt hours per hour. However, alternators are generally about 50 – 60% efficient, therefore approximately 500 watt-hours need to be supplied. Engines themselves tend to be approximately 50% efficient therefore 1000 watt-hours of fuel need to be burned to supply the alternator.

The argument for fuel saving using this technology involves the fact that the oxyhydrogen mixed with the diesel results in an earlier and more mechanically efficient explosion at the piston. Because of the more efficient burning of the fuel mix, there is also an argument that engines will no longer need the additive AdBlue, but this is not proven at the current time.

At Nether Aden, the hydrogen electrolyser was fitted to the JCB Loadall on 21/9/2017. The following fuel consumption results have been recorded to date

Date	Fuel Use per work Hour
23/6/17 – 21/9/17	6.84 litres
21/9/2017 – 10/1/2018	5.92 litres

This equates to a fuel saving of 13.5%
It should be noted at this time that at the time of the meeting it was discovered that the electrical current being used to produce the hydrogen was had been working at a lower electrical charge than recommended. Adjustments were made, with the manufacturers expecting improved results going forward. Fuel consumption figures will be recorded and the results provided in due course.

At Nether Aden, the JCB telehandler operates for approximately 1,000 hours per year. This gives a 920 litre fuel saving, which for red diesel equates to approximately £500 per year. With white diesel, the saving would be approximately £1,100 per year. If the use of AdBlue could be saved, this would be a saving of an additional £500 per year.

Looking at the potential to convert existing cars, vans etc. to run exclusively on hydrogen, it can be seen that due to the high conversion cost(£30,000 - £40,000) an annual mileage of approximately 20,000 miles would be required and the car would need to last at least 10 years to make this viable. This assumes that it is possible to claim the FITs. Without the FITS, the car would need to be travelling approximately 50,000 miles per year and still last for 10 years.

Other points to note with the production of hydrogen is the difficulty in transporting the fuel. The biggest transport lorry currently available will only be able to transport 100 kg of hydrogen. The transport costs for hydrogen are generally in the region of 20 – 50 times more expensive than fossil fuels.

Hydrogen production on farm

John then went on to report on work done previously looking at some of the key factors that would influence the potential for hydrogen to be produced on farms and used as a fuel, either on farm for vehicles and heating, or sold off the farm. A number of different scenarios were examined and modelled including the use of existing renewables to supply the electricity to produce the hydrogen, using existing renewables but installing additional capacity, or using new renewables. In all situations, diverting electricity away from the grid reduced income where the export tariff could be claimed. All scenarios improved when the grid connection was given priority. The reason for this is that the transport fuel being produced is worth less than the export tariff once the efficiency of converting electricity into fuel is considered. However, based on the assumption that hydrogen is approximately 85% of the price of fossil fuel, it would only require a price increase to £1.40 - £1.70 to reverse this finding.

The models also found that in terms of the market for hydrogen, only 5 – 15 high mileage cars would be sufficient to make a system viable. Only a small uptake in the sector would be required for the market to develop. In terms of a power source for the electricity, a constant generator is most viable eg AD, hydro, biomass CHP. Because of intermittent supply, wind generation would require 4 – 5 times the generation capacity as these other technologies. The current tax regime, makes supplying the transport market more viable than targeting the heating market.

Key Points

- Hydrogen electrolyser fitted to the farm telehandler
- Electrolyser passes an electrical current through water to produce oxyhydrogen
- Oxyhydrogen added to fuel mix in engine at a rate of approx. 6%
- The system works with conventional diesel engines
- Manufacturers claim a more efficient combustion
- To date, the Nether Aden trial suggests a fuel saving of 13.5%
- Manufacturers claim at least an 80% reduction in emissions
- The trial is still ongoing

There are nine climate change focus farms in Scotland. Keep up to date with their activities at

www.farmingforabetterclimate.org

Meetings are free to attend and all farmers are welcome.
Contact farm facilitator alan.bruce@sac.co.uk or telephone 01888 563 333 for more information on the Nether Aden discussion group.

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