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# Future of Farm Fuels

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## What are the sustainable alternatives?

Farming will need a replacement for the diesel engine as the provider of power. The fuel chosen to power agricultural machinery must be available, sustainable and affordable, while still offering the familiar properties of diesel engines – performance, reliability and durability.

Retailers and food processors are increasingly expecting their suppliers to improve the sustainability of their businesses to help cut the carbon footprint of the final product. Government has similar expectations so its policies will encourage a transition too, for example by reforming the rebated fuels entitlement. The relative cost of diesel compared to its sustainable alternatives is also likely to increase, accelerating the case for investment.

Machinery is designed around a human operator. While robotics will play a role, autonomous machinery is often limited to specific, repetitive operations. It is not yet suited to the dispersed, rotational nature of UK land occupation, nor the intricate and varied operations within farmyards. Taking these needs into account, a replacement fuel for the versatile tractor seems the most readily adoptable solution. We look here at the emerging contenders for the farm fuel of the future and provide a matrix to help farmers evaluate which option to invest in.

### THE FUELS

■ **Diesel** The dominant fuel in agriculture. A fossil fuel able to deliver desirable characteristics, but with undesirable emissions and potentially volatile cost.
■ **Hydrogen** Gaseous alternative fuel that can be burned (like natural gas) or split within a fuel cell, converting chemical energy into electricity. Hydrogen can be more or less sustainable depending on how it's produced (*figure 1*).
■ **Biomethane** Chemically equivalent to methane, also known as natural gas. Produced via anaerobic digestion of organic material. It is burned to produce energy.
■ **Electric** Stored within a battery to be released when required. Sustainability is dependent on source; grid electricity originates with both renewable energy sources and burning fossil fuels.

### HYDROGEN

Several hybrid options for hydrogen are in development. Trials have retrofitted electrolysers to existing vehicles; this uses electricity from the vehicle's battery to split water and generate small volumes of hydrogen. That hydrogen is mixed with diesel in the engine, improving fuel efficiency and reducing emissions.

"Dual-fuel" engines also exist. These can be run on anything from 100% diesel to two-thirds hydrogen. This allows farms to continue with current fuelling arrangements and gradually transition to hydrogen as it becomes more accessible. The characteristics of this engine will be similar to conventional diesel engines, but the tractor and yard will require a specific hydrogen storage tank.

The biggest obstacle to hydrogen is the amount of investment required in on-farm and indeed national infrastructure. Hydrogen production and storage facilities will remain a novel and inaccessible technology to all but the very largest farming enterprises in the near future. Furthermore, the hydrogen used must be green (produced by the electrolysis of water using renewable energy) to confer environmental benefit, rather than grey (produced from fossil fuels without carbon capture).

Hydrogen fuel cells presently deliver the worst of all worlds for farming applications: the prohibitive costs of hydrogen and the regular refuelling events of electricity. Zero emissions and rapid refills are unlikely to be enough to compensate for these shortfalls.

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**0.2%**
relative carbon cost of biomethane to red diesel

**11,580**
tractor purchases (>50hp) registered in the UK in 2022

### BIOMETHANE

Biomethane, like hydrogen, will replicate many of the characteristics of a diesel engine, however it has advantages over hydrogen. Farms with existing anaerobic digesters could plan to be partly self-sufficient in biomethane production, though steps to upgrade biogas into biomethane will be required. There is also the near-term possibility of capturing and compressing methane emissions from covered slurry lagoons for processing into this fuel. Methane-powered agricultural machinery is already commercially available, however there are no options to retrofit existing machinery.

Biomethane's compatibility with net zero has been questioned. In ideal circumstances, biomethane can be a carbon-negative technology through reduced fossil fuel usage and avoided methane escapes from manure. However, methane leakages from anaerobic digesters remain a source of methane emissions (3.8% of all UK methane emissions according to Imperial College London). The burning of biomethane can also result in other undesirable emissions such as nitrous oxides and particulate matter. →

**Relative carbon cost of farm fuels**
Comparison of greenhouse gas emissions associated with the use of each fuel when used for cultivation, relative to diesel fuel (100%)

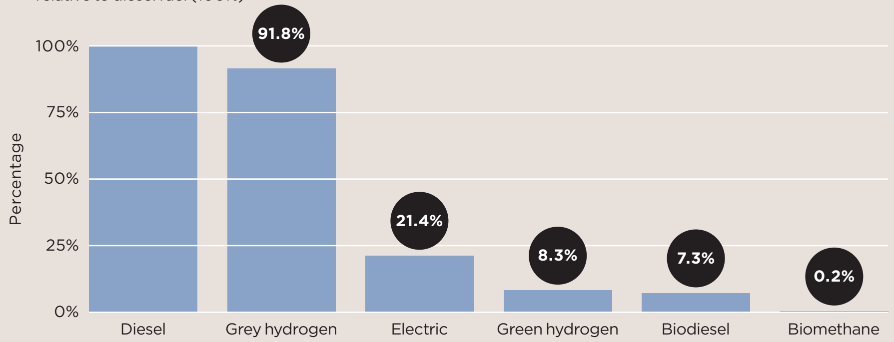


*figure 1*

**Source** BEIS

> The fuel chosen to power agricultural machinery must be available, sustainable and affordable, while still offering the familiar properties of diesel engines – performance, reliability and durability

## ELECTRIC AND BATTERIES

While battery-based electric machinery would be a more easily adopted form of alternative power, it is unlikely to provide the performance required by many farming activities such as cultivating or drilling. Reducing or avoiding the movement of soil, such as in minimum tillage systems, may make this technology more feasible.

If a farm business is already electrifying other activities, for example the heating of buildings, it may wish to consider a partial electrification of machinery for lighter applications such as telehandlers and on-farm transport, which could deliver instantaneous torque and high reliability. For larger scale activities, the trade-off between power, range and battery size has not yet been optimised. On-farm production of electricity through renewables, together with battery storage, is likely to improve the financial viability of this option.

## OTHER

Diesel could be substituted with more sustainable alternatives such as hydrogenated vegetable oil (HVO) or fatty acid methyl ester (FAME, also known as biodiesel). These will reduce emissions in the short term, but are unlikely to be sufficiently scalable or tolerated by policymakers and users in the long term. For example, FAME is not a net zero fuel and biodiesel systems require more frequent maintenance than conventional diesel.

Synthetic efuels are formed by capturing carbon dioxide and combining it with hydrogen to create a compound chemically identical to fossil fuels, but without the carbon cost. While posing an ideal solution, they come at a significant cost so are not currently viable for agricultural use. They could, however, eventually be produced and distributed like their fossil fuel equivalents, with no need for a change in engines.

## CONCLUSION

Batteries are fundamentally unable to deliver the power and range required for agricultural operations. Hydrogen can deliver much that farmers have become accustomed to with diesel. However, the infrastructure for hydrogen remains underdeveloped and expensive, which is unlikely to change before 2050. Sustainable and synthetic fuels require significant investment to meet net zero and cost expectations.

Biomethane is currently the choice for sustainably-fuelled machinery. There are some concerns over its long-term sustainability, however these can be resolved with effective regulation and conscientious practice. It provides similar traits to diesel, such as fast refuelling and high-power potential. It also holds similar benefits to hydrogen, including reduced emissions, but is far easier and cheaper to adopt as the required infrastructure and machinery already exists.

## Evaluating the best future fuel options

| | Diesel | Hydrogen | Biomethane | Electric battery |
|---|---|---|---|---|
| **Range** | High | Low | Low | Very low |
| **Refill speed** | Fast | Fast | Fast | Slow |
| **Fuel accessibility** | High | Low | Medium | High |
| **Power potential** | High | High | High | Low |
| **Torque** | Flat curve; Progressive delivery with slight peak. High torque | Potentially higher torque than diesel | Equivalent or better than diesel | Instant peak torque. Increased power gives greater weight or less range |
| **Reliability** | Medium | Medium | Medium | High |
| **Weight** | Low | Medium | Medium | High |
| **Nature of transition** | Not applicable | Hybridisation and retrofit possible. Not commercially available | Full transition required. Commercially available | Full transition required |
| **Long term solution?** | No | Yes | Uncertain | Yes |
| **Tailpipe pollution** | Very high | Medium | High | Zero |
| **Cost rank** | 1 | 4 | 3 | 2 |
| **Accessibilty rank** | 1 (implemented) | 4 | 2 | 3 |
| **Timescale rank** | 1 (implemented) | 4 | 2 | 3 |

*figure 2*

**Source** Savills Research

“Biomethane provides similar traits to diesel, such as fast refuelling and high-power potential, and is far easier and cheaper to adopt than hydrogen”

# Savills team

Please contact us for further information

**Andrew Teanby**
Associate Director
Rural Research
+44 (0) 7835 445 458
ateanby@savills.com

**Joe Lloyd**
Associate
Rural Research
+44 (0) 7790 824 970
joe.lloyd@savills.com

**Thomas Brunt**
Director
Food and Farming
+44 (0) 1962 857 407
tbrunt@savills.com

**Duncan Winspear**
Director
Food and Farming
+44 (0) 1904 756 310
dwinspear@savills.com