

Farm of the Future - Decarbonising Farm Vehicles and Future Fuels

N. McCarthy⁽¹⁾, J. Wheeler⁽²⁾, K. Budden⁽¹⁾, R. Gueterbock^{(3)*}, A. Bywater⁽⁴⁾, M. Woollacott⁽⁵⁾

(1) Cenex, Holywell Building, Holywell Park, Ashby Road, Loughborough, Leics, LE11 3UZ United Kingdom

(2) Wheeler Woodhouse, 21 Elmfield Avenue, Birstall, Leics LE4 3DG, United Kingdom

(3) Foodchains, Trevena, Winton Hill, Stockbridge, Hants SO20 6HL, United Kingdom

(4) University of Southampton, B178/Room 5019 Boldrewood Campus, Burgess Road, SO16 7QF, United Kingdom

(5) Greenwatt Technology, Roseleigh House, Oversley Green, Alcester, Warwickshire, B49 6PG United Kingdom

*Corresponding author: richard@foodchains.co.uk

On behalf of the Royal Agriculture Society of England (RASE): The Arthur Rank Centre, Stoneleigh Park, Warwickshire, CV8 2LZ, UK. and its sister charity 'Innovation for Agriculture' (IfA – at same address).

Keywords: Decarbonisation, Net Zero, Future Fuels, Diesel Replacement and Transition

Farmers and land managers need to decarbonise food production systems to contribute to the delivery of Net Zero. Mechanisms to sequester carbon and enhance the environment include improved soils management, agro-forestry, low carbon livestock husbandry, initiatives to protect rural land and water resources and adoption of renewable energy sources. The priority for farm vehicles, as energy and fuel prices soar, is reduced fossil fuel reliance (and removal of outdated subsidies). Emissions in the agri-food supply chain must be reduced, alongside efforts to boost energy and food security. While food production is their primary role, only profitable farmers can afford to deliver 'systems change' investment required to reduce the sector's carbon footprint. The food supply chain requires novel fuels, production technologies and powertrains, suited to specific needs of farm vehicles. This study examines options for vehicles and fuels in the agri-food sector, particularly on-farm, within the Royal Agricultural Society of England's "Farm of the Future" project¹. The paper identifies practical solutions and emerging technologies to reduce overall carbon emissions from agriculture. It focuses primarily on the UK but is more widely applicable. A number of fuels, powertrains and vehicle types were investigated. Businesses operating in this sector were identified, with a subset selected as case studies. A 'traffic light' evaluation helped assess liquid biofuels, biomethane, electricity and hydrogen (inc. fuel cell and internal combustion (ICE) technologies) across multiple emissions, technology maturity, infrastructure, operational and cost parameters, with technology roadmaps for different vehicle types. Key findings include:

- Diesel replacement for rural non-road and farm vehicles is a priority requiring access to on-farm renewable energy and clean fuels.
- Future farm fuels include electricity and biofuels (liquid/gas) and in time, other gas fuels including hydrogen.
- Biomethane does not need to be grid injected and can be produced at off-grid biogas sites and distributed in virtual pipelines.
- Low ground pressure or controlled traffic systems, robotic and gantry solutions will be used alongside minimum/zero tillage.
- Robotic machinery can use electricity generated on-farm and hybrid tractors will utilise multiple fuels (e.g. gas and electric).
- Gas powertrains already exist - suppliers have developed low-emission ICEs and need increased output of gas fuels for these vehicles.

¹ The paper 'Decarbonising Farm Vehicles and Future Fuels' (55 pages) published March 2022 by RASE, UK - www.rase.org.uk/reports.

The study concluded that the transition to future farm fuels requires policymakers to:

- Set timetables for fossil fuel replacement, while developing alternatives such as biomethane (on and off-grid), other gas fuels and hybrid options.
- Encourage use of smaller robotic, controlled traffic or gantry systems alongside minimum/zero tillage as part of efforts to boost soil health.
- Enable improved farmer access to research, knowledge transfer, demonstration sites, field trials and independent advice.
- Facilitate improved rural connectivity and communications to help farms embrace digital technologies, field robotics and artificial intelligence.

Future farm vehicle design should include a mix of hybrid fuel technologies, battery-powered compact and robotic systems, plus for heavier vehicles, ICE powertrains running on gaseous fuels. For farmers to make significant operational changes, they require government, research and supply-chain support, including with replacement of fossil fuels.