Opportunities for provision of synthetic fuels in Northern Ireland from waste and re-use of carbon

Executive summary

Northern Ireland has substantial opportunities to develop a non-fossil synthetic and/or e-fuels industry which could complement existing biofuels production for regional use or potential export. Biogenic fuels such as biomethane, biomethanol, bio-DME, biodiesel and hydrotreated vegetable oil (HVO) could all be produced in Northern Ireland. Each of these can be derived from bio-feedstocks of varying origin. Biomethane, biomethanol and bio-DME can be derived from organic resources such as food and animal waste or crops fed into an AD process with subsequent conversion of CO_2 and/or biomethane as necessary, biodiesel and HVO can be produced from waste vegetable oils or tallow. The availability of these feedstocks is a limiting factor, and difficulties arise when energy competes with traditional markets, as exemplified by the debate on grass silage being used for supplementing AD production rather than for feeding livestock. Ultimately, the supply of bio-derived feedstocks is expected to constrain the bioenergy sector, and as a result, several future pathways envisage a technology mix which employs renewable electricity to produce green hydrogen, which is then combined with CO_2 to produce e-fuels – e-methane, e-methanol, and e-diesel or hydrogen and non-carbon carriers such as ammonia, or used to boost the energy value of biological or carbon-rich wastes which are generally hydrogen deficient.

This report, conducted in partnership with Cenex, looked at the options for bio and e-fuels production in Northern Ireland as well as an assessment of the opportunities for synthetic fuels from Agri-waste to support the Northern Ireland transport sector. The key outcomes of this work are reported below.

Fuel and Transport Pathways

Cenex reviewed fuel and vehicle technology roadmaps in the on-road, off-road, aviation, rail and marine sectors to understand potential opportunities for Agri-fuel waste. Initial findings on the opportunity within NI and fuel type are as follows:

Sector	Relative opportunity	Potential Agri-fuel type
Road transport	**Low**	**Renewable diesel, e-Diesel, Bio-methane**
Rail	**Low**	**Renewable diesel, e-Diesel**
Agriculture, Mining and Construction	**Moderate**	**Renewable diesel, e-Diesel**
Marine	**High**	**Renewable diesel, ammonia, bio-methanol, e-diesel**
Aviation	**High**	**Sustainable Aviation Fuel (SAF)**

- The Marine and Aviation sector are likely to have a high future demand for fuels derived from Agri-fuel waste, such as renewable diesel, e-diesel, ammonia, methanol and SAF.
- There is a moderate opportunity to provide fuels to Agriculture, Mining and Construction where the roadmaps indicate renewable and e-diesel fuels may play a strong role in the future fuel mix.

- There is relatively limited opportunity in the short term for road transport until zero emission (ZE) fuels begin to dominate the sector from 2035.
- It is unlikely that there is sufficient time to fully adopt multiple fuel supply infrastructure before 2050; therefore, in the short term, 'drop-in' fuels should be supported that use existing infrastructure whilst market capability, and infrastructure is being developed for key markets in Marine and Aviation industries.
- Any investment in new infrastructure for transition fuels should be compatible with final 2050 future fuels such as SAF, Ammonia, and Synthetic diesel.
- The sustainability criteria of fuels are expected to become increasingly more stringent. Carbon Capture, Use and Storage (CCUS) should be considered for all new fuel production plants.

Exploitation Potential

- Cenex attempted to estimate the number of vehicles in NI. Of the data available, most vehicles in NI are road vehicles, with 81% of the market being cars, 10% vans and 2% trucks. Agriculture, Mining and Quarrying vehicles account for a few percent of the vehicle stock. The number of Aviation and Marine vehicles are unknown.
- UK industry fuel supply data were adjusted to estimate NI fuel demand. This showed that the current annual potential total market for waste Agri-fuels in the NI transport sector is estimated at 15,500 GWh with a market value of around £1bln. Key transport market sectors are Aviation (46%), Road Transport (25%) and Maritime (10%).
- The total market size was estimated to be similar by 2050. However, with the shift to ZE drive-trains and improvements in transport efficiency, the key markets in 2050 are estimated to be Aviation (58%), Maritime (16%) and Construction (12%).

Supporting Policy and Legislation

- Cenex undertook a high-level review of policy and legislation that could impact the use of Agri-fuels in transport options.
- Policy and legislation were separated into those driving the **Supply Side** (fuel suppliers) for renewable fuels and those driving the **Demand Side** (transport operators).
- Key fuel **Supply Side** policies include the ban on the internal combustion engine (ICE) in road transport, which will reduce the demand for liquid and gaseous fuels. The Renewable Transport Fuel Obligation (RTFO), which sets a target for fuel supply to have an increasing amount of renewable content, and the expected SAF Mandate, which would legislate an increase in the renewable content of aviation fuel.
- Key **Demand Side** (transport operator) policies legislate the monitoring of energy and emissions by large organisations but do not require emission reduction actions to be taken by transport operators.
- No strong policy legislation is yet in place for the decarbonisation of Marine, Agriculture, Mining and Construction Sectors.
- It was noted that the Republic of Ireland had announced plans to increase the renewable content of motor fuels and develop a CNG refuelling network. These present a market opportunity for NI Agri-fuels.

Future Economics of Renewable Fuels

- A study undertaken by E4Tech and Cenex in 2020 looked at the future economics of alternative fuel supplies for the off-road equipment sector.
- The study compared fuels on a total cost of ownership basis, which included fuel supply and use costs for an operator. The study considered fuels on a NOAK (nth of a kind) basis, which assumes costs of a mass market and mature fuel supply system.
- The study highlighted that bio-methanol, bio-LPG, e-methanol, ammonia, FAME, synthetic CNG and LNG could all potentially be cost competitive against the current cost of diesel fuel supply.

Comparison of Agri-fuel Demand

- A RAG matrix was used to summarise the potential performance in the 2035 and 2050 timeframe of the key renewable fuels.
- In the period to 2035, there is likely to be demand for drop-in diesel replacement fuels across Agriculture, Mining, Maritime, Construction and Road transport as these sectors look to decarbonise but awaiting maturity of 2050 net-zero fuel options. Demand for bio-methane would be limited by the availability of suitable ICE vehicles. There will be growing demand for SAF due to a mandate for increased use of the fuel, which is expected to be announced by the UK government over the next year.
- In the period of 2035 to 2050, there is likely to be a significant decline in demand from the Road transport sector, and also a decline from Agriculture, Mining and Construction sectors as these sectors are able to turn to ZE options. There is a strong demand from Maritime and the Aviation sector where long-distance transportation requires the energy density from liquid fuels. The RTFO legislation ceases in 2032 and is likely to refocus incentives for renewable fuels at hard to electrify areas such as heavy industry and long-haul shipping and aviation.

Key Recommendations

This study presents a high-level prefeasibility assessment of opportunities for biogenic based and other synthetic fuels with the focus on how best to meet Northern Ireland's requirements. Fundamental to the use of NI's resources is a determination of the short, medium and long-term allocations to many competing end uses with the goal of NI becoming as close to self-sufficiency as possible by 2050. This will require shifting policy support to encourage market choices as technology options and supply chains mature in the coming decades.

1. Green hydrogen is an enabler for many synthetic fuels and investment is needed in production, storage, and distribution even if battery technology overtakes hydrogen for most vehicles.
2. Biogenic sources of carbon in NI are not sufficient to replace current fossil fuel use so additional feedstocks beyond hydrogen need to be considered. A pilot scale investigation of circular economy approaches where CO_2 is captured and used as a synfuel feedstock is desirable to establish the economics and co-benefits of this method.
3. Replacement of kerosene for home heating in off-grid locations is possible via boiler replacement and use of renewable DME or LPG – this option warrants further investigation to establish the economic feasibility.

4. A clear roadmap is needed to displace liquid and gaseous fossil fuels for heating and transport as well as to provide the energy input into e-fuels. This includes building out renewable electricity generation capacity as well as constructing the facilities and infrastructure for synthetic fuel production and distribution. The lifetime of large capital plant coupled with planning and construction timescales will mean that synfuel investments starting development today may well be in operation in 2050 – potentially locking in fuel choices and tying up local resources.
5. A specific feasibility study should be undertaken to look at the short to medium term opportunity for drop-in fuel supply to assist in the decarbonisation of existing transport segments, and the longer-term opportunity for supply of future fuels focused on the aviation and marine industries. The study should include potential scenarios for NI, including fuel supply, infrastructure, demand, environmental and economic opportunity.
6. Establish plan to maximise collection and utilisation of biogenic feedstock. These should include undertaking studies to determine collection/processing efficiency based on location of resources and to optimise apportionment to different requirements: energy (fuels), maintaining soil carbon, peat substitute/other agricultural/horticultural uses etc.
7. Review opportunities to increase biogenic feedstock production by 2030 such as encouraging aquaculture in NI marine areas.
8. The authors identified several areas during the study where further research needs to be conducted to increase the accuracy of reported values before investment decisions, and policy decisions should be made.
    a. Estimates of fuel use in NI should be peer-reviewed and refined with other more specific NI data sources and factors, where available, incorporated into the assumptions.
    b. The average annual GDP change in NI of approximately 1.8% per year (based on figures from the twenty years covering 1999 to 2019) has been applied to the market data. Further work is required to determine a more specific value considering wider factors such as transport mode shift, long-term impacts of recent events such as the war in Ukraine, Covid-19, Brexit, and Net-Zero.
    c. There was little or no data available on the number and types of vehicles in the NI construction, mining, aviation and marine sectors. Further research and industry consultation should be undertaken to determine the make-up of these vehicle parts in NI.