DUAL FUEL PROJECT

DUAL-FUEL VEHICLE MODELLING PROJECT

PROJECT DETAILS

Cluster: Bio-Energy
Knowledge provider: Queen's University Belfast – School of Mechanical and Aerospace Engineering (PI Professor Roy Douglas)
Industrial Partners: AgriAD, Northern Ireland Water and TG Haulage.
Total project costs: £262,288 over 24 months from 1st June 2015 to 30th June 2017.

PROJECT BACKGROUND

In 2014, Northern Ireland produced an estimated 20.3 million tonnes of CO2 equivalent, and accounted for 4% of the total greenhouse gas (GHG) emissions in the UK, while only accounting for around 2.8% of the population of the UK. The second largest contributor to GHG emissions in Northern Ireland is the transport sector, which accounted for 21% of the emissions in 2014. The Renewable Energy Directive was devised in order to promote the production of energy from renewable sources, and requires all EU member states to fulfil at least 20% of their energy needs with renewables by 2020, with at least 10% of transport fuels coming from renewable sources.

Over the past months, reports have emerged that the UK government will ban the sale of new petrol and diesel only cars and vans from the year 2040, encouraging the uptake of electric vehicles. However, electrification is not a realistic option for heavy duty vehicles, due to limited range and battery weight, restricting available payload. Therefore, an alternative renewable fuel, such as biomethane must be considered. As a fuel, biomethane offers the same benefits as natural gas (lower carbon intensity, reduction in emissions of particulate matter) but has a lower carbon footprint than natural gas (and other fossil fuels) if it is sustainably derived from organic materials.

In order to reduce the dependence in Northern Ireland on imported fossil fuel (which accounts for around 90% of total energy demand), incentives and targets have been put in place to increase the proportion of locally sourced renewable energy, including biogas from AD. The anaerobic digestion industry is a growing industry in Northern Ireland, with around 40 AD plants either in operation or under construction. As of 2013, 91 planning applications had been granted for AD plants in Northern Ireland. In order to make natural gas transport fuels feasible in Northern Ireland, it is important to have biomethane infrastructure available. On the island of Ireland as a whole, the natural gas network is extensive, but the current grid does not supply many of the key towns in the west and north west of Northern Ireland. There is, however, a "Gas to the West" project currently well under way, with an overall investment of £250 million, which will bring a natural gas supply to these towns. In the Republic of Ireland, Gas Networks Ireland plan to produce a network of 70 compressed natural gas (CNG) stations servicing public transport, haulage and private CNG vehicle operators.

This project helps to promote natural gas use by producing tools, based on real on-road vehicle trials, that allow fleet managers to see the potential cost and emissions savings that result from the switch to dual fuel/dedicated natural gas. Models can be used by the project industrial partners to present to wider industry the benefits of natural gas for transport, but also to governing bodies to encourage the development of natural gas refuelling infrastructure.

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PROJECT OUTPUTS

During this project two vehicle trials were conducted in order to obtain the data required for vehicle modelling. The first trial was conducted using a Volvo FM13 6x2 vehicle, fitted with a Clean Air Power dual fuel system, running on a combination of diesel and compressed natural gas (CNG). The vehicle was operated by TG Haulage, and used to perform a daily milk collection and delivery run on local roads in Northern Ireland. The opportunity arose during this project to perform a second one week long vehicle trial on a dedicated natural gas vehicle. The demonstrator vehicle was an Iveco Stralis NP. As in the dual fuel trial the vehicle was operated by TG Haulage, and used to perform a number of different tasks on local roads in Northern Ireland, including for the transport of milk, timber, and heavy mechanical equipment.

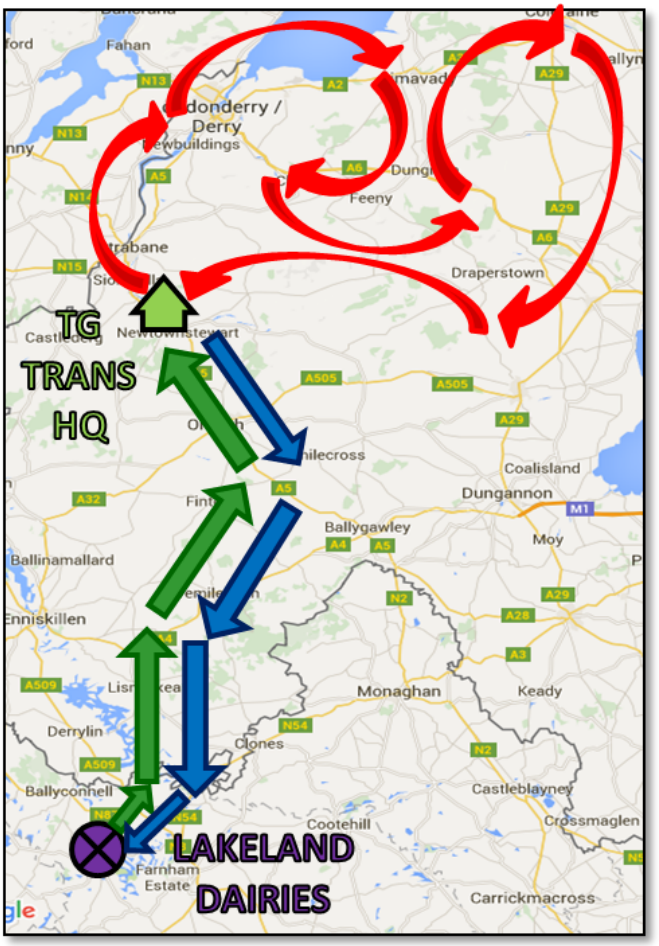

Figure 1 – TG Haulage local milk run for vehicle trial

Figure 2 (above)– Iveco Stralis NP demonstrator vehicle, b) (below) Volvo FM13 vehicle fitted with CAP dual fuel system.

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PROJECT OUTPUTS CONT.

Data from the dual fuel trial was then used in order to develop a Microsoft Excel VBA based dual fuel drive cycle model. This model is capable of predicting the cost and emissions savings of a dual fuel vehicle over an inputted drive cycle compared to a diesel vehicle. Inputs to this model include data such as vehicle dimensions, payloads at specified points along the vehicle journey, and trip information such as vehicle speed, distance travelled instantaneous fuel substitution rate and road type. The model can therefore predict how varying payload and driving conditions can affect the dual fuel vehicle performance, as well as comparing the fuel costs to those of a diesel vehicle performing the same journey.

For the Volvo dual fuel truck hauling a milk tanker (50 tonnes total weight) around a 350 km route, the vehicle achieved 6.75 mpg and a saving of £40 per day per truck compared to the equivalent diesel vehicle. For TG Haulage who perform this route twice per day this is a saving of 27% compared to diesel only operation.

Data from both the Volvo and Iveco vehicle trials was used to develop a Microsoft Excel spreadsheet based model that allows vehicle fleet managers to assess the financial soundness of converting their fleets to run on CNG/LNG/biomethane fuel. The model requires the fleet manager to input data such as average yearly mileage, diesel vehicle fuel economy and number of vehicles in the fleet. The life cycle analysis tool Sima Pro was used in order to provide inputs for emissions during diesel and natural gas/biomethane combustion. Outputs of the model include a presentation of payback period, investment cash flow, annual diesel displacement and greenhouse gas savings. This model shows that, conversion of a diesel fleet to 100% natural gas, will provide payback in less than 2 years.

The vehicle trials also provided TG Haulage with the opportunity to assess the drivability of the alternative fuel vehicles, on local roads, and compare directly to diesel. For the Volvo dual fuel vehicle TG Haulage found no difference in the performance of the vehicle compared to a diesel vehicle and was of no hindrance to their milk run over local roads. For the Iveco Stralis NP, although they enjoyed driving the vehicle TG Haulage found that they could not conduct their usual milk runs across many small country roads and farmyards. They found that although the vehicle had the horse power required, it could not provide sufficient torque. It was their opinion that the Iveco vehicle would be more suitable for the needs of a supermarket chain for example, transporting goods on motorway and A-roads, where volume rather than payload weight is the limiting factor.

By using data from literature and from the anaerobic digestion plant on the site of AgriAD, the potential of biomethane as a transport fuel was analysed. In Northern Ireland in 2012 freight used 383 million litres of imported diesel, at a total cost of £383-550 million, all of which exited the Northern Ireland economy. For every one hectare of grassland, anaerobic digestion can produce 2400 m3 of biomethane, equivalent to 4500 litres of diesel. Therefore, 50% diesel displacement could be achieved using only around 5% of the total grassland in Northern Ireland. There are 500,000 tonnes of food waste generated annually in Northern Ireland, which is enough biomethane to displace 10% of diesel. Anaerobic digestion is a growing industry in Northern Ireland, with 60 plants planned to be in operation by 2018, and therefore has a huge potential as an alternative to diesel fuel.

Within this project a study was performed which investigates the application of a circular economy in a rural agricultural setting in Northern Ireland. The study was centred around a typical anaerobic digestion plant, showing its potential to provide renewable energy for the electricity and transport fuel needs of an average dairy farm and associated milk processing facilities. The study used the dual fuel data from the Volvo vehicle trial in order to calculate the required diesel fuel energy that could be fulfilled by biomethane. It was calculated that an average anaerobic digestion plant, such as that operated by AgriAD, has the potential to fuel 22 avaerage sized dairy farms in Northern Ireland, equating to the production, transport, and processing of around 52,000 litres of milk per day.

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IMPACT OF CASE FUNDING

The immediate impact of the project is that it allows the project consortium member companies to make informed decisions about their business. TG Haulage and Northern Ireland Water are now in a position to make informed decisions about their future fleet management, while AgriAD are better positioned to evaluate potential diversification to the provision of renewable natural gas as a transport fuel. On a wider scale, this research could lead to increased uptake of natural gas powered vehicles and more rapid development of natural gas refuelling infrastructure in Northern Ireland. This will result in reduced fuel bills and carbon emissions for industry, along with decreased greenhouse gas emissions and improved air quality in Northern Ireland as a whole. Utilisation of biomethane as a transport fuel would also reduce the amount of money exiting the Northern Ireland economy as diesel imports would be decreased.

BENEFITS FOR CASE MEMBERS

The industrial partners of this project have had the benefit of financial and emissions saving models, based on vehicle trials conducted for tasks on routes on which the companies perform their daily business. These models were then applied to their fleets to analyse the cost and emissions savings that would result based on a conversion from diesel to natural gas. This task illustrated to Northern Ireland Water that for their fleet, mainly made up of light-duty vehicles with a short daily range, conversion to natural gas is not financially viable. On the other hand, the results for TG Haulage fleet conversion were very positive, showing clear financial and emission savings benefits. TG Haulage are interested in being involved in any future research that may result from this project.

TG Haulage had the benefit of performing two vehicle trials, with their drivers using the trucks to perform the company's daily tasks. This allowed them to directly compare the driveability of the natural gas vehicles to their diesel trucks.

AgriAD now have tools which they can use to evaluate the fuel needs of industry if the diversification to biomethane as a transport fuel was to be widespread. They can then decide if the biogas produced by their anaerobic digestion plant is upgraded to biomethane and utilised as a transport fuel, rather than the current use for electrical energy production.

CASE
Centre For Advanced Sustainable Energy

CASE is an Invest Northern Ireland funded competence centre with grant funding of £5 million. The centre has successfully funded 18 research projects in renewable energy across biogas, marine renewables and energy systems sectors.

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