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5 First St,
Manchester
M15 4GU
T +44 0161 235 6000
www.jacobs.com

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Contents

Summary

The Welsh Government has set a target for all Welsh public sector bodies to be carbon neutral by 2030. The transport sector is challenging to decarbonise, particularly for heavy-duty vehicles that often require ranges that exceed those available from current battery electric vehicles. There are, however, increasing options for zero emission vehicles coming to market over the next few years. Monmouthshire County Council (MCC) is already taking an active role in sustainable transport and supporting a local hydrogen fuel cell car manufacturer, Riversimple, in trialling a small fleet of their vehicles (due to start in 2019) and the Council has provided a site for a hydrogen refuelling station (HRS) for these vehicles.

Welsh Government has commissioned an assessment on the opportunities for sustainable fuels and mobility in a rural context in partnership with neighbouring local authorities. This report is part of the assessment and provides an overview of the opportunities for hydrogen fuelled vehicles currently available, and those due to enter the market over the coming years. The study investigates options for hydrogen-fuelled vehicles within MCC's fleet and the opportunities to take advantage of the Riversimple trial to support the deployment of further hydrogen vehicles, including the expansion of hydrogen refuelling infrastructure within the region.

Three high-level feasibility studies for introducing additional hydrogen-fuelled vehicles into the MCC fleet and wider area have been undertaken. These include a fuel cell bus trial, expansion of the Riversimple Rasa deployment and a hydrogen van/minibus trial.

Fuel Cell Bus

This feasibility study investigated a potential deployment of c.40 fuel cell buses in the early 2020s. While fuel cell buses currently come with a significant price premium relative to diesel vehicles, a coordinated programme of pre-commercial demonstration projects is underway along with plans to increase production volumes to realise economies of scale that could reduce the price from >£500k to around £350k–£400k per bus by the early 2020s. The scale of the bus fleet at 40 buses would provide better value for money than smaller size fleets, as the cost of the hydrogen refuelling infrastructure would be spread over a larger number of vehicles. Even with the price reductions outlined above, fuel cell buses are expected to cost more to purchase and operate than equivalent diesel buses and such a project would therefore require public funding (estimated at c.£10m). The timescale for this type of project is between 3–4 years (including time to secure funding) before deployment.

Riversimple Commercial Development

The second feasibility project considers the potential scale-up of the Riversimple trial, and Riversimple's target to commence mass manufacturing of their hydrogen fuel cell vehicle, the Rasa, from the end of 2021. Small cars only make up c.6% of the MCC vehicle fleet, as such there is limited potential for large-scale deployment of the Rasa within MCC's fleet. However, Riversimple is also developing a van and larger car, both of which will be based on the Rasa vehicle platform. The establishment of a hydrogen transport hub in Monmouthshire based on the Riversimple fuel cell vehicle could also benefit other hydrogen fuelled vehicles, that could potentially use the same hydrogen refuelling infrastructure.

MCC Fleet Replacement

Approximately 30% of Monmouthshire County Council's fleet consists of vans or minibuses. The third feasibility study investigates the opportunities to replace some of these vehicles with hydrogen-fuelled alternatives. There is currently a relatively low number of suppliers of suitable vehicles, with the main options being offerings from companies such as Arcola Energy (the UK agent for the Kangoo ZE H2), Microcab, and ULEMCo. These companies can all offer 350 bar vehicles that could in principle be refuelled at the existing HRS in Abergavenny. The lowest cost route for MCC to trial a hydrogen-fuelled van is likely to be via a short-term lease agreement, whereas if a larger budget is available (tens of thousands of pounds or above) a longer term lease or outright purchase of vehicles could be considered.

In addition to the uptake of hydrogen vehicles, hydrogen refuelling infrastructure, including the production of hydrogen should be taken into consideration. The existing HRS installed for the Riversimple trial in Abergavenny has a limited quantity of surplus hydrogen but could support a few additional vehicles requiring 350 bar hydrogen. It should be noted the economics of smaller stations (including the one currently installed in Abergavenny) typically

result in a higher hydrogen price than larger stations. This is not a concern for the highly fuel efficient Riversimple Rasa, although more of an issue for dual-fuel vans and other fuel cell electric vehicles, which require lower cost hydrogen for fuel cost parity with petrol / diesel. The case for installing additional HRS in the area is likely to rely on significant increases in the demand for hydrogen for transport applications, implying fleets of tens of vehicles and an investment of several million pounds. A hydrogen refuelling station located in south Monmouthshire could be used by hydrogen vehicles in the MCC fleet, with many MCC fleet vehicles currently based around the Caldicot region and this location would also provide a link between the hydrogen refuelling stations in Port Talbot and Swindon. Alternatively, a focus on Riversimple vehicles would suit a network of smaller stations, sited to meet customer requirements. These lower capacity stations would require less investment to install (lower capex), however the lower quantity of hydrogen dispensed from these stations would likely result in a higher per-kilogram hydrogen price than stations with higher refuelling capacities.

Consideration of the hydrogen production route is also important, with electrolysis from renewable electricity currently the most common option for zero carbon hydrogen for transport uses in the UK. The cost of hydrogen produced in this way is largely dependent on the price of electricity used by the electrolyser and is also influenced by the load factor of the equipment, with greater demand for the fuel generally improving the economics.

Based on the analysis undertaken in this study, the following next steps are recommended for MCC to continue playing a role in facilitating wider uptake of hydrogen transport in the region:

1. Discuss the experiences of operating hydrogen fuelled vehicles with current hydrogen vehicle end users, including representatives of Aberdeen and Fife councils and Yorkshire Ambulance Services. This will help MCC learn from experiences of current hydrogen vehicle users.
2. Contribute to Riversimple's demonstration and commercialisation activities by providing feedback on the trial vehicle(s) and where possible supporting recruitment of additional vehicle users. This could include investigation of the feasibility of providing local incentives for zero emission vehicle users (e.g. dedicated / free parking).
3. Hold further discussions with hydrogen vehicle suppliers on the opportunities for initial trials of a small number of vehicles that can use the spare capacity of the existing Abergavenny hydrogen refuelling station – this implies 350 bar vehicles from companies such as Microcab, Arcola Energy, or ULEMCo (dual fuel diesel-hydrogen vehicle conversions).
4. Continue monitoring the market for zero emission vehicles, especially announcements on the availability of fuel cell electric vehicles in segments relevant to the Council's fleet (e.g. vans, minibuses and larger vehicles such as gritters, tippers, etc.), to ensure that fleet replacement decision makers are aware of the full range of low and zero emission options.
5. Participate in new forums that are emerging in South Wales, including the Decarbonised Industrial Group and Hydrogen Reference Group. Similar groups in the UK, such as the North-West Hydrogen Alliance and Swindon and Oxford Hydrogen Hubs bring together stakeholders in the region with an interest in hydrogen and act as a focal point to initiate hydrogen projects and can act as a platform to apply for funding. Such groups should include hydrogen vehicle manufacturers, end users, hydrogen suppliers and potentially hydrogen refuelling station operators with the aim to develop partnerships and hydrogen projects in the region.

1. Introduction

The Monmouthshire Sustainable Fuels project aims to provide an overview of the opportunities for sustainable mobility options in Monmouthshire and the surrounding Gwent region. This work will inform the local authorities of the options for low and zero carbon vehicles to consider deploying in their fleets and support the wider transition to low carbon transport in the region. This report comprises Work Package (WP) 3 and follows the State of Play Analysis in WP1 and a stakeholder workshop in WP2. It builds on the overview of low / zero emission vehicles that could be relevant to Monmouthshire's alternative fuels strategy in WP1 and WP2, with a focus on hydrogen-fuelled vehicles.

Section 2 of this report provides further context to the study, with a summary of the Riversimple Rasa trial and analysis of Monmouthshire County Council's (MCC) vehicle fleet.

Section 3 provides an overview of hydrogen fuelled vehicles that are currently available and those that are expected to be released within the next five years. Given that initiating and delivering a hydrogen transport project typically takes at least one to two years, there is value in considering this timeframe.

An analysis of hydrogen refuelling infrastructure in section 4 looks at the different options for hydrogen production and distribution in the region and the potential demand from hydrogen-fuelled vehicles. This includes the opportunities to expand the use of the recently opened hydrogen refuelling station in Abergavenny to support the trial of the Riversimple Rasa fuel cell cars.

Section 5 of the report presents a series of high-level feasibility studies for projects that could be taken forward to stimulate further hydrogen transport activity in the area. Three feasibility projects have been outlined including a fuel cell bus project, extension of the Riversimple Rasa trial, and introduction / testing of a hydrogen-fuelled van.

Section 7 details the engagement that has taken place within this work package under its expanded scope.

Section 8 provides a suggested structure (key themes and priorities) for a sustainable transport/low carbon vehicle strategy which could be developed further by the Council. This has also drawn upon the headlines from the electric vehicle study that has been co-ordinated by Caerphilly Council.

Finally, section 9 is a summary of the learnings from the study that will be useful to other local authorities looking at how they might take a similar study forward.

2. WP3 Task 1 - Hydrogen state of play for Monmouthshire

2.1 Introduction

The Welsh Government passed the Environment (Wales) Act in 2016, which places a duty on the Welsh Ministers to ensure that CO_2 emissions across all sectors in Wales are reduced by 80% in 2050 relative to a 1990 baseline. This sets interim targets and requires 5-yearly carbon budgets to achieve these carbon emission reductions. The Welsh Government has also stated an ambition for the public sector to be carbon neutral by 2030. In this context MCC has ambitions to lead the way in the transition to sustainable fuels and it is in this context that the use of hydrogen within Monmouthshire has been reviewed. The state of play analysis in WP1 identified several opportunities to develop sustainable mobility options and reduce carbon emissions from the transport sector. This includes capitalising on an existing trial of hydrogen fuel cell cars in Monmouthshire from local hydrogen-powered car manufacturer Riversimple.

2.2 Riversimple trial

Riversimple is a hydrogen fuel cell car manufacturer based in Llandrindod Wells in Powys, Wales. MCC is supporting Riversimple with the trial phase of their hydrogen fuel cell car, the Riversimple 'Rasa' (see picture below). The Council has provided a site for a hydrogen refuelling station for the trial, which will start in Q1 in 2019 and is taking delivery of the Rasa from the first production run which will be operated in a c.12 month trial. Riversimple also recently secured £1.25m in funding from the UK Government[1] to support the roll-out of 17 Fuel Cell Electric Vehicles (FCEV), in partnership with MCC.[2] Riversimple aims to deliver 20 demonstration vehicles to a range of trial customers throughout 2019, including Welsh Water, Natural Resource Wales, Brecon Beacons National Park Authority, and car clubs. The trial phase will allow Riversimple to gather data on the use of the vehicle and customer feedback before volume production of the vehicle, which is forecast to start at the end of 2021.

Rasa Hydrogen Fuel Cell Vehicle https://www.riversimple.com

The production of the Rasa for the trial phase will be in small batches of four vehicles, the small scale of production results in high costs per vehicle, however volume production would result in significant cost reductions. Riversimple is currently looking to secure investment for the construction of a larger manufacturing facility that would allow production of c.5,000 vehicles per year. Further scale-up would then be possible by developing further production plants in a modular fashion.

The Riversimple trial also involves the installation of a small hydrogen refuelling station (HRS) at Abergavenny (further details are provided in section 4.1). This station was installed in September 2018, is operating and ready to refuel the Rasa vehicles as part of the trial. This study considers options to increase the use of this station by introducing additional hydrogen-fuelled vehicles and thus to capitalise on the Riversimple trial in Monmouthshire.

1 Office for Low Emission Vehicles (OLEV)

2 Office for Low Emission Vehicles – Hydrogen Transport Programme Phase 2: https://ee.ricardo.com/htpgrants.

2.3 Overview of Monmouthshire County Council fleet

MCC operates c.320 vehicles of various types. Some of these vehicles are purchased outright by MCC and some are leased over several years or hired over shorter durations. There is a large spread in the type of vehicle across the range of MCC departments, including passenger transport to highways and refuse collection services. A summary of a breakdown of the vehicles operated by MCC along with the average annual distance travelled in 2018 is shown in Table 1.

Table 1: Overview of MCC vehicle fleet (as of January 2019) and average annual distance travelled for each vehicle category (for vehicles operated over the whole of 2018)

Vehicle type	Number of vehicles	Average annual distance travelled per vehicle (km)
Small cars	18	15,415
Large cars, 4x4, pickup	46	18,263
Van	40	16,046
Minibus	56	22,774
Sweeper, Gulley	8	17,975
Refuse collection vehicle	33	28,918
Gritter, gritter/multispread, gritter/tipper	21	13,623
Flat bed	12	23,423
Tipper/ QCB tipper, hotbox	68	23,695
Coach	20	31,169
Total	322	

These data are presented graphically below.

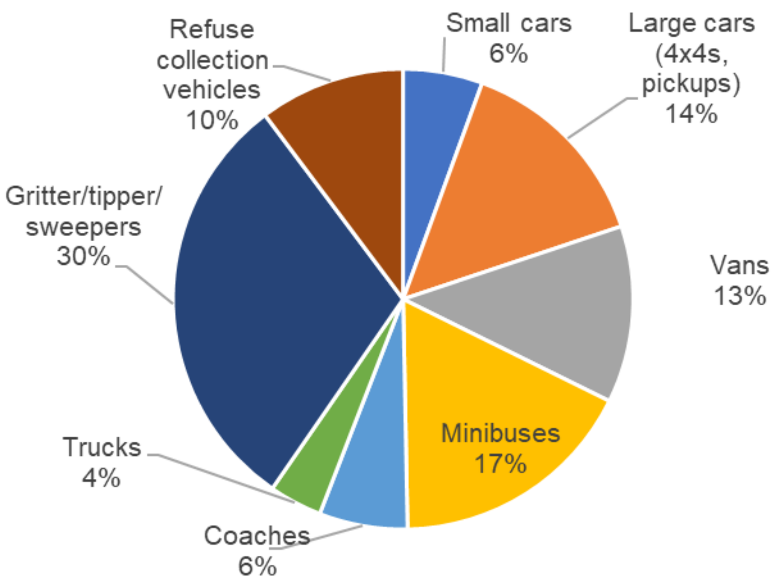


Figure 1: MCC vehicle fleet composition (January 2019)

The duty cycle and use of the vehicle are important factors to consider when replacing existing internal combustion engine (ICE) vehicles. The daily and annual mileage required from the vehicles within the MCC fleet should be compared with the vehicle range and refuelling times of alternative fuelled vehicles, as this will impact the operation of the vehicle and the refuelling/re-charging strategy. Figure 2 shows the annual distance travelled for vehicles operated by MCC and the average of the vehicle category within the fleet. There is a wide variation in the average annual distance travelled for each vehicle category within the MCC fleet. Refuse collection vehicles (RCV) and coaches cover the highest annual distance, c. 30,000 km/year, with the highest used coaches travelling c.40,000–50,000 km/year and several RCVs travelling >40,000 km/year. There are also a number of minibuses and tipper trucks that travel >40,000 km/year. The limited range of battery electric vehicles currently available would pose issues for the mileages of the vehicles covering further distances. Hydrogen fuelled vehicles would offer a zero-emission option for these vehicles travelling further distances.

In addition, the payload of the vehicle is an important consideration, for electric vehicles the additional mass and volume required by the powertrain can impact on the payload. These factors are considered in further detail in section 3.

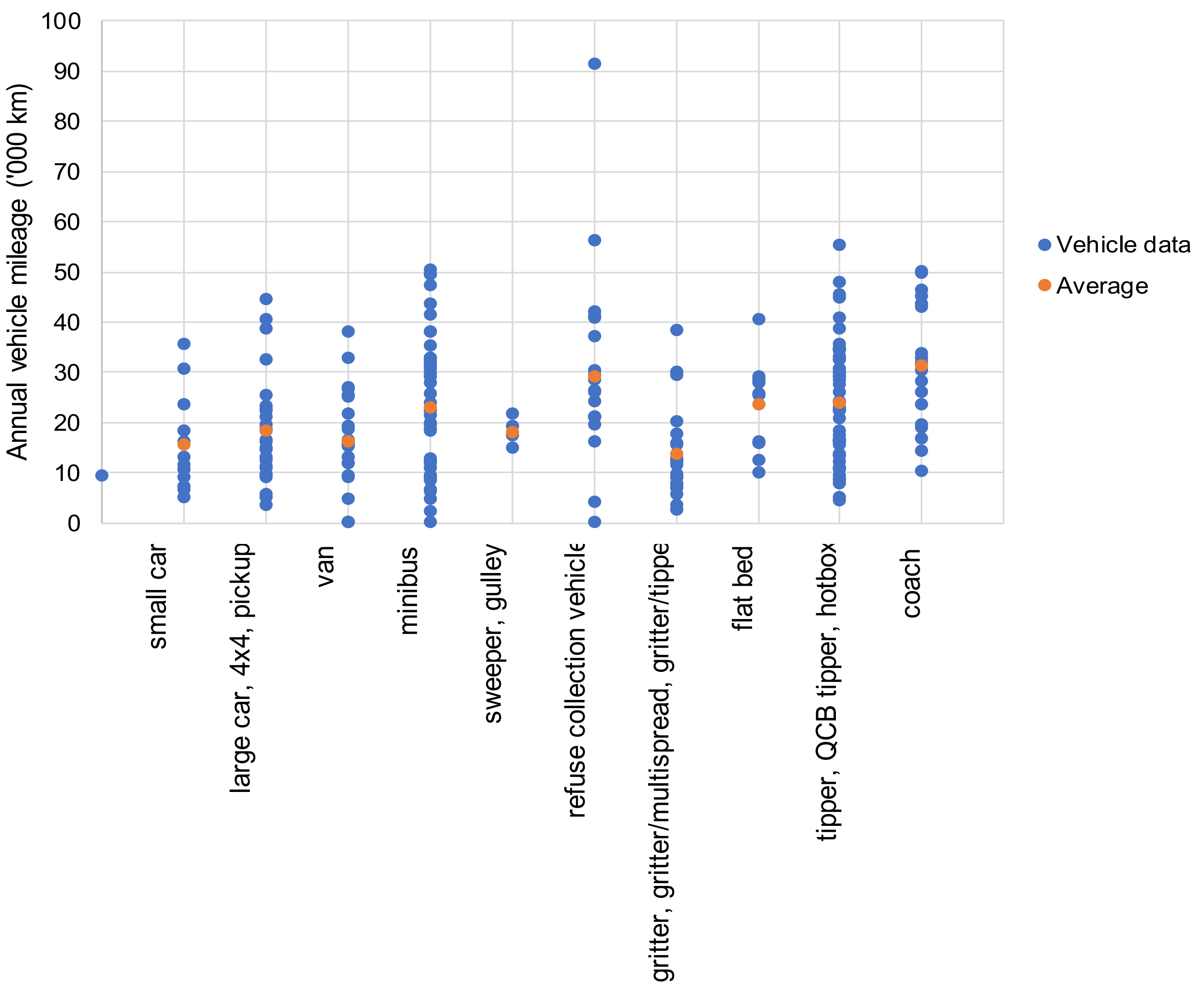


Figure 2: Overview of annual distance travelled (km) by vehicles operated by MCC

The 95% (307) of the vehicles operated by MCC are diesel vehicles, this is unsurprising given that 20% of the MCC fleet are cars, and 80% are vans or Heavy Goods Vehicles (HGV). Within their vehicle fleet MCC operate 10 petrol cars and five battery electric Nissan e-NV200 vans.

While the availability of commercial hydrogen-fuelled vehicles in the range of segments outlined above is currently limited, there is a significant level of research and development work underway in this area and new vehicles are coming to market in the coming years (see section 3).

3. WP3 Task 1 - Hydrogen Fleet Assessment

3.1 Introduction

A variety of different vehicle technologies and powertrains can deliver carbon emission reductions in the transport sector, including hydrogen and battery electric vehicles. Various configurations for hydrogen-fuelled vehicles are possible, including hydrogen fuel cell, range-extender and dual fuel vehicles:

- **Fuel cell electric vehicle (FCEV):** This is an electric vehicle driven by an electric motor that is powered by a fuel cell. A battery is typically used to capture energy in regenerative braking, however there are different hybridisation options available, some with larger batteries and smaller fuel cells. Examples include the Toyota Mirai and Hyundai NEXO.
- **Range-extender:** This is a FCEV with a smaller fuel cell that is used to charge up the battery that is used to power the electric motor. These vehicles are typically plug-in hybrid vehicles, that can charge the battery from an electric charging point, as well as being able to refuel with hydrogen. Examples include Daimler GLC F-Cell, and the Renault Kangoo ZE H2 (which uses a fuel cell system from Symbio FCell).
- **Dual fuel:** These vehicles are typically retro-fitted from existing compression ignition engine vehicles. This involves the installation of hydrogen tanks, control system and modification of the engine to allow hydrogen injection via the air intake. The vehicle can run on both hydrogen and diesel or just diesel.
- **H2 ICE:** There is on-going research and development on pure hydrogen ICE engines. ULEMCo is aiming to develop 100% H_2 ICE prototype vehicles using spark ignition engines to start customer trials in three years and commercial release in five to seven years, with quoted thermal efficiencies of 45%[3].

Hydrogen fuelled vehicles offer a range of advantages, including:

- **No harmful exhaust emissions (no NOx or Particulate Matter (PM)), with only water produced at the exhaust.** Dual fuel vehicles can also reduce NOx emissions, this is dependent on the vehicle, although the Ford Transit dual fuel is reported to reduce NOx by 40%[4]
- **Hydrogen-fuelled vehicles can offer zero carbon transport.** This depends on the source of hydrogen, the majority of HRS in the UK use renewable electricity, producing zero carbon hydrogen.
- **Similar vehicle range to ICE vehicles**. Hydrogen vehicles can offer ranges that are comparable to ICE equivalents (e.g. Hyundai NEXO 414 mile WLTP range).
- **Fast refuelling times.** Similar to ICE vehicles, hydrogen vehicles can be refuelled in <5 minutes. Refuelling times vary depending on the size of the tank and the detailed specification of the refuelling station.

There is an expanding range of different hydrogen vehicles in different vehicle categories. The Hydrogen Council has summarised the range of vehicle categories and estimated market share for hydrogen fuelled vehicles in 2050 (shown in Figure 3[5]). This includes passenger cars, trucks, buses, coaches and trains.

[3] ULEMCo, ULEMCo Announces Record Efficiency Results for 100% Hydrogen Zero Emission Engine, 2018, https://ulemco.com/?p=2706
[4] LowCVP, Low Emission Van Hub: Hydrogen, https://www.lowcvp.org.uk/Hubs/lev/technologies-and-fuels/Hydrogen.htm
[5] Hydrogen Council, Hydrogen Scaling Up, 2017, http://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf

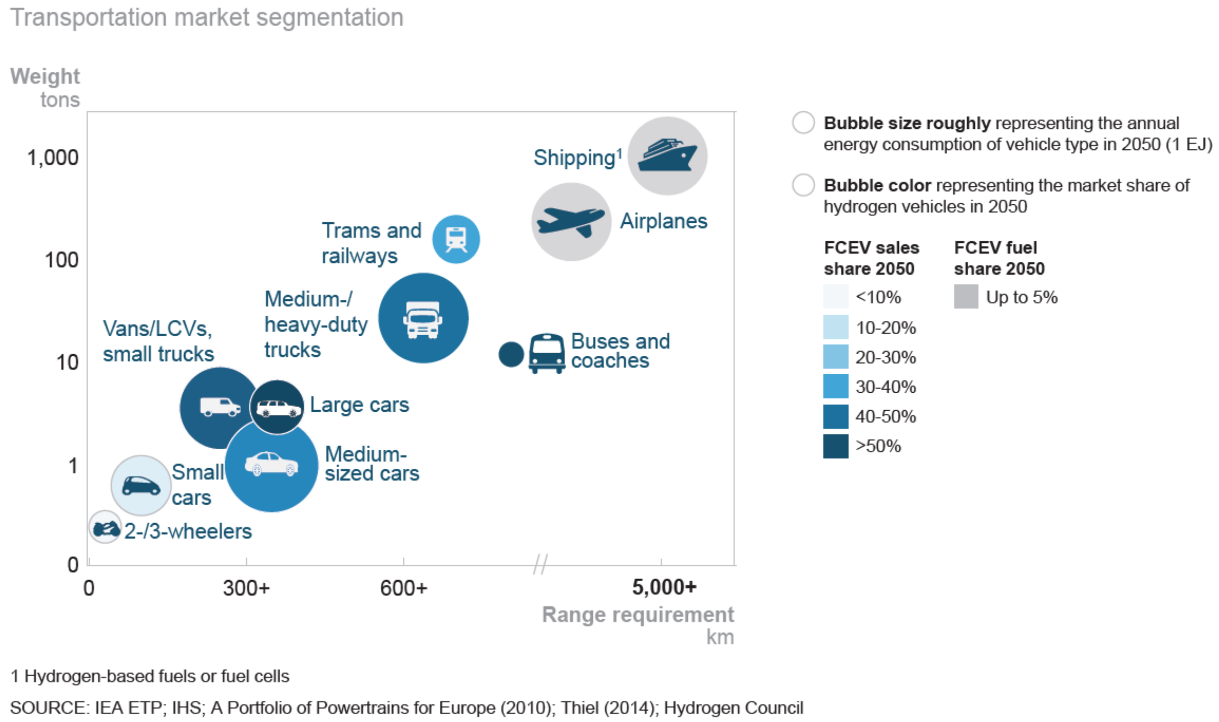


Figure 3: Overview of potential hydrogen-fuelled vehicle markets[6]

Where a battery electric vehicle can be used as a one-for-one replacement for the incumbent this is likely to be the most cost-effective zero emission solution. Current battery electric vehicles which are proven for light duty vehicles, including cars and vans are however less well suited to HGVs and similar heavy vehicles. Hydrogen-fuelled vehicles typically offer superior range and rapid refuelling which makes them potentially suitable across a wide range of vehicle types and duty cycles, including those that require long driving distances or where there are limited time windows for refuelling. This is represented in Figure 3, where hydrogen fuel cell vehicles are estimated to have a smaller proportion of the small car market, but higher market share across the vehicle categories for large cars, trucks, buses and coaches. The majority of MCC's fleet comprises HGVs, with heavy, challenging duty cycles that would suit hydrogen fuelled vehicles.

The options for hydrogen fuelled vehicles in these categories currently available and soon to be available are described in further detail in sections 3.2–3.6.

3.2 Light duty vehicles (cars and vans)

Several global automotive original equipment manufacturers (OEMs) have been developing FCEVs over the past two to three decades and the first commercially available cars were released in the early 2010s. For example, Hyundai began offering the ix35 Fuel Cell to customers in the UK in 2014, and Toyota followed with the Mirai in 2015. The Hyundai ix35 Fuel Cell has been replaced by the NEXO, which is available in the UK from 2019.

The uptake of FCEVs in the UK has been limited to date, with just 90 OEM FCEVs registered by the end of Q3 2018.[7] This reflects the immature state of the hydrogen transport sector: the number of publicly accessible HRS is also low and concentrated in south east England.

The number of FCEVs is increasing, with 150 new cars being deployed in 2019 through the Office for Low Emission Vehicles (OLEV) Hydrogen for Transport Programme. Most of these vehicles will be the Toyota Mirai, alongside the new Hyundai NEXO. These will be deployed to a variety of end users, including the Metropolitan

[6] Hydrogen Council, Hydrogen Scaling Up, 2017, http://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf

[7] Including 73 Mirai cars and 17 ix35 Fuel Cell cars. Source: DfT vehicle licensing statistics (veh0120), 2019. Note that a small number of Honda Clarity fuel cell cars are also on trial in the UK.

Police Service and taxi company Green Tomato Cars. This will be followed by another >60 vehicles through the second phase of the Hydrogen for Transport Programme from 2019–2020[8].

Various other FCEVs are available globally, however given the currently small global production capacity of FCEVs and the limited hydrogen refuelling infrastructure in the UK, they have yet to be commercially available in this country. Globally the largest markets for FCEVs are California, Germany and Japan. Expansion of hydrogen refuelling infrastructure and public sector support for hydrogen vehicles would see an increase in hydrogen vehicle options in the UK.

In addition to the FCEVs from international OEMs and Riversimple (see section 2.2), there is also a hydrogen fuel cell vehicle from Microcab and range-extender and dual-fuel combustion vehicles from ULEMCo and Symbio FCell:

- **Microcab** is a spin-out from Coventry University and has developed a fuel cell platform for small vehicles. The vehicles use fuel cells manufactured from Ballard, and Microcab aims to secure orders for at least 100 vehicles in 2019, which would be manufactured through contractors in the West Midlands, with the aluminium chassis produced by Lotus.
- **ULEMCo** converts diesel engines into dual fuel hydrogen-diesel and can offer this solution on a wide range of vehicle types, including vans. ULEMCo is also developing a fuel cell range-extender version of the Nissan e-NV200.
- **Symbio FCell** has collaborated with Renault to develop the HyKangoo range-extender version of the battery electric Kangoo.

A summary of these vehicle options is shown in Table 2. Prices shown in Table 2 exclude VAT and the plug-in car grant (PiCG).

Table 2: Overview of fuel cell cars and vans currently available / soon to be available

Vehicle	Price (excl. VAT & PiCG)	Availability	Description
Toyota Mirai and next generation FCEV 	£55,000[9] (£625/month contract hire, incl. fuel and maintenance)	Now	Toyota launched the Mirai in Japan in 2014 and has a production capacity of c.3,000 vehicles per year to 2020. The Mirai technical specification includes: 4 seats, real-world range of c.300 miles, top speed 111mph, power output: 113kW, 700bar fuelling. Toyota is currently constructing two new manufacturing facilities for the production of the next generation fuel cell vehicle, with estimated production capacity of c.30,000 FCEVs per year. This scale-up in FCEV manufacturing is estimated to reduce the cost of the next generation FCEV, expected to be released in the early 2020s.
Hyundai NEXO 	£54,170[9]	March 2019	Second commercially available FCEV from Hyundai. Specification: 5 seats, 414 mile range (WLTP), top speed 111 mph, power output 120kW, 700bar fuelling. Available from March 2019 in the UK in limited numbers.

[8] Hydrogen for Transport Programme, https://ee.ricardo.com/htpgrants
[9] Applicable for OLEV plug-in car grant (PiCG) up to £3,500 https://www.gov.uk/plug-in-car-van-grants

Honda Clarity FCEV 	c.£42,000 (estimated from US prices)	Currently as demonstrator vehicles in the UK and commercially available in the US and Japan	Four door sedan available in the US and Japan. A handful of Honda Clarity fuel cells have been trialled in the UK, Honda is not planning further release of this generation in the UK. Technical specs: 5 seats, range 240 miles, top speed 100mph, power output 100kW, 700 bar refuelling
Daimler GLC F-Cell 	-	Currently available in Germany and right-hand drive model available for Japan, as yet no plans to deliver to the UK	Daimler has produced several versions of fuel cell vehicles (including versions of the Mercedes A-Class and B-Class). The GLC F-Cell is the latest fuel cell vehicle and is a plug-in fuel cell vehicle planned for small-scale production. Technical specs: 4.4 kg H_2 on board, 155 kW output motors, 13.5 kWh battery, 478 km NEDC range.
Riversimple Rasa 	-	Trail phase on-going plans for volume production at the end of 2021	The Rasa is a lightweight two-seater car, with a carbon fibre chassis the total kerb mass of the vehicle is c.580 kg, containing 1.5 kg hydrogen on board. The Rasa includes an 8.5 kW fuel cell, motor with 55 kW peak and 16 kW continuous power output and estimated vehicle range of 300 miles.
Microcab Vianova 	-	Trial vehicles available and aiming to produce 100 vehicles in 2019	Microcab has developed the Vianova, a small hydrogen fuel cell car, with either 3.5 or 10 kW fuel cell and options for 350 or 700 bar hydrogen tank, with c.1.8 kg of on board hydrogen storage and 4 kWh battery. The vehicle has an estimated 180 mile range.
ULEMCo dual fuel van 	Est. £36,000 (order of 10+ vehicles)	Retrofits are performed on an ad hoc basis, but can be performed readily since no chassis needs be produced.	ULEMCo convert diesel ICE vehicles into dual fuel hydrogen and diesel vehicles. Examples include 3.5 tonne vans such as the Ford Transit van and Peugeot Boxer for Yorkshire Ambulance Service. The conversion adds c.160 kg to the van, reducing the payload. In the Peugeot Boxer the hydrogen tanks are installed in the space on the front passenger seat. Efficiency (approx.): 0.77 kgH_2 / 100km + 3.2 l (diesel) / 100km.

ULEMCo Range-extender 	Est. £60,000[10] (based on £35,000 premium)	ULEMCo is delivering a range extender Nissan-e-NV200 to customers in 2019.	ULEMCo has fitted a fuel cell and hydrogen tanks on to a battery electric Nissan e-NV200. The hydrogen tanks are fixed in a rooftop box, with a 12 kW fuel cell and 1.6 kg H_2 of hydrogen tanks doubling the range of the vehicle >150 miles when fully laden[11]. The range-extender conversion can be applied to other battery electric vehicles, with an estimated 6 month lead time for vehicle conversions.
Symbio FCell/Arcola Energy 	-		Symbio FCell has modified a range of electric vehicles, including the Renault Kangoo and Nissan e-NV200 and fitted hydrogen fuel tanks and a fuel cell on board to recharge the batteries. The Symbio HyKangoo has c. 1.7 kg H_2 on board, providing an estimated hydrogen range of 200 miles[12]
Streetscooter Work L 	-	Plans to deploy 300 vehicles to Westnetz by 2022	Streetscooter is owned by Deutsche Post DHL and develops battery electric vehicles. They are developing a fuel cell model that will extend the range from 167 km to 540 km, with a fuel cell range extender. Streetscooter has plans to deploy 500 vehicles in the fleet of Deutsche Post and 300 vehicles by Westnetz[13]

3.3 Buses

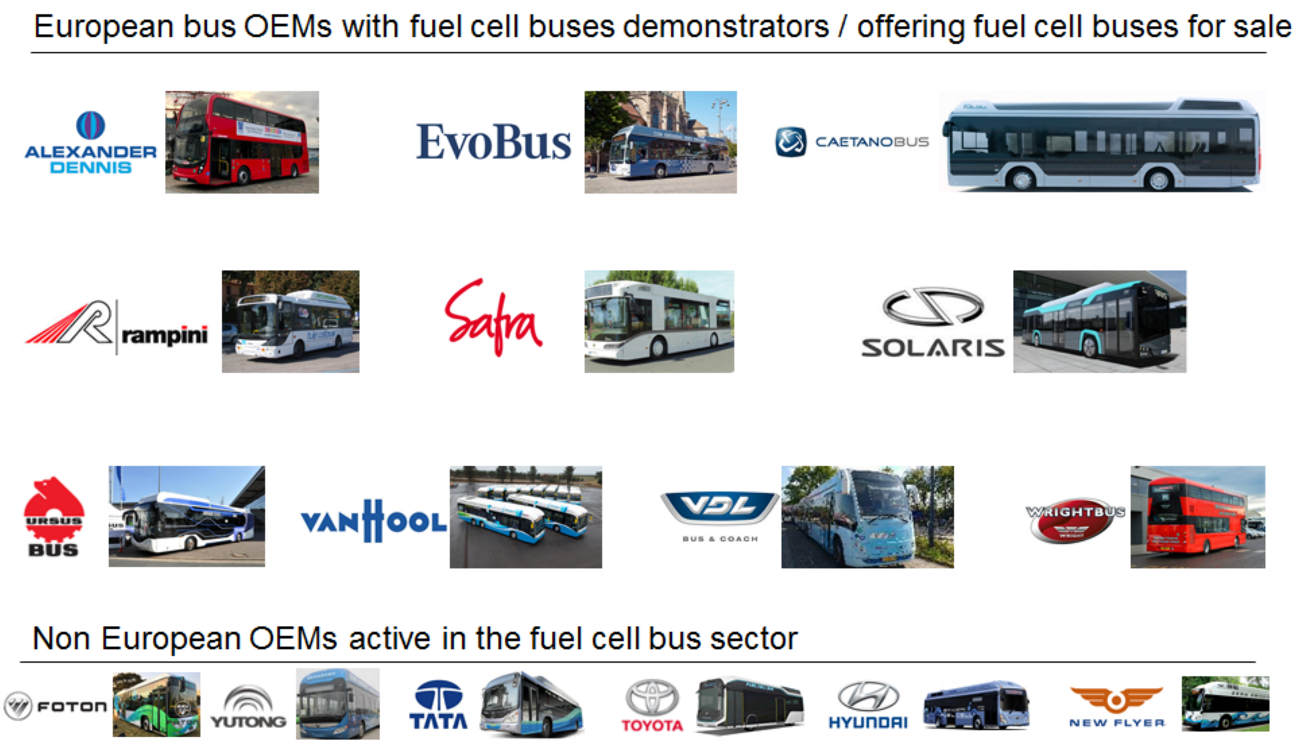
Fuel cell buses have been operating in London since 2011 and a wide range of bus manufacturers have developed a range of fuel cell models. This includes UK bus manufacturers Wrightbus and Alexander Dennis. Wrightbus has deployed 8 fuel cell single deck buses through the CHIC[14] project operating in London and is developing next generation single and double deck fuel cell buses. Alexander Dennis has developed a fuel cell version of the double deck Enviro 400 in collaboration with Arcola Energy and is looking to deploy this in the UK (e.g. plans for an initial trial of 30 of these vehicles were recently announced[15]). The Belgium-based bus and coach manufacturer Van Hool is the market leader in fuel cell buses in Europe in terms of number of vehicles deployed to date and is involved in several of the on-going pre-commercial demonstration projects. Aberdeen's fleet of ten Van Hool fuel cell buses recently passed the milestone of one million miles of operation[16]. The A330 fuel cell bus is now in its third generation and the Ballard fuel cells operating the London RV1 route in the bus have demonstrated >28,000 hours of operation. A summary of these fuel cell buses is provided below in Table 3.

[10] Applicable for OLEV plug-in car grant, up to £8,000 for commercial vehicles
[11] Van Fleet World https://vanfleetworld.co.uk/ulemco-introduces-hydrogen-powered-roof-box-range-extender-for-nissan-e-nv200/
[12] Symbio FCell, HyKangoo by Symbio FCell, http://www.symbiofcell.com/symbiov3/wp-content/uploads/2015/05/kangooZEH2_en2015-05.pdf
[13] IEA Fuel Cell, https://www.ieafuelcell.com/newsletter.php?view=december2018#National%20updateGermany
[14] Clean Hydrogen in European Cities https://www.fch.europa.eu/project/clean-hydrogen-european-cities
[15] https://ee.ricardo.com/htpgrants.
[16] https://news.aberdeencity.gov.uk/aberdeens-pioneering-hydrogen-bus-project-arrives-at-major-milestone/.

Table 3: Selection of fuel cell bus models currently available or soon to be available

	**Alexander Dennis** Alexander Dennis has been investigating fuel cell drivetrains for double deck buses in collaboration with Arcola Energy and Warwick Manufacturing Group. Route trials of a prototype bus were completed in London in 2018 and plans are in place to deploy a fleet of at least 30 vehicles in selected locations.
	**Van Hool** Van Hool has over 40 FC buses operating in Europe and the US. Van Hool is producing 40x12 metre fuel cell buses (the largest order of FC buses in Europe) for Cologne and Wuppertal, Germany ("JIVE" project). As well as 8x18 metre articulated buses for Pau, France ("3EMotion" project). Both sets of buses use Ballard fuel cells and are planned for delivery in 2019.
	**Wrightbus** Wrightbus has proven hydrogen fuel cell buses can work reliably (running 19 hour routes/day since 2011). Wrightbus is now offering single or double deck fuel cell bus models based on their Streetdeck chassis.

Beyond these three bus OEMs with fuel cell buses operational / planned in the UK, various other bus suppliers are developing vehicles in this sector as summarised in the figure below.



Source: Element Energy (based on public announcements. Note: lists are not exhaustive.

Figure 4: Overview of bus suppliers offering / developing fuel cell buses

3.4 Refuse Collection Vehicles

There has been interest in converting RCVs into either battery electric, fuel cell or dual-fuel hydrogen-diesel vehicles. European funded projects are supporting the development of fuel cell vehicles, and recently Scania has shown interest in developing a prototype fuel cell RCV in Sweden. A summary of hydrogen-fuelled RCVs is shown below in Table 4.

Table 4: Summary of hydrogen fuelled refuse collection vehicles

	**ULEMCo** As with ULEMCo's other dual fuel (diesel and hydrogen) internal combustion engines they have fitted hydrogen tanks to refuse trucks, that are currently in use by councils in the UK, including Fife and operated by commercial waste contractor Grundons in London. This includes conversion of the DAF refuse truck, as well as Mercedes Econic.
	**E-Trucks** E-Trucks has developed a prototype fuel cell refuse truck in the EU FCH JU funded LIFE 'N' GRAB HY project. The company is now developing 15 fuel cell refuse collection vehicles in the REVIVE FCH-JU project.
	**Scania** Scania has announced they are developing a fuel cell refuse truck with Swedish waste handling company Renova. The truck will include an electrified powertrain and compactor. Further details on the truck have yet to be released.[17]

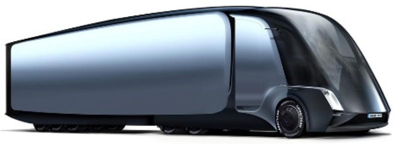
3.5 Heavy Goods Vehicles

Hydrogen-fuelled HGVs offer the promise of zero emissions, with quick refuelling times and adequate vehicle range. There are several prototype HGVs currently being tested by existing vehicle OEMs and new companies. These are still in the early stage of development, however potential opportunities to trial vehicles through projects may be available in the short term.

Table 5: Summary of hydrogen-fuelled heavy goods vehicles

	**Nikola** US-based Nikola motor company has announced a hydrogen fuel cell semi-truck for European markets. The vehicle is a concept, however Nikola is aiming to begin construction of the vehicle in 2022–2023. Testing of the European truck is estimated to begin in Norway in 2020.[18]

[17] Scania, https://www.scania.com/group/en/scania-delivers-fuel-cell-refuse-truck/
[18] Nikola Motor Company, https://nikolamotor.com/press_releases/nikola-launches-stunning-truck-for-european-market-53

	**Hyundai** Hyundai has announced ambitious plans to deploy 1,000 hydrogen fuel cell trucks in Switzerland from 2019 – 2023. The truck will have a 250 mile range and will be supported by a refueling infrastructure developed by H2 Energy[19].
	**Scania** In 2016, Scania announced its intention to produce a 27t fuel cell truck for use by the Norwegian grocery store chain ASKO. An initial fleet of four trucks, each with a range of up to 500 km will be built and used to distribute goods in Norway, fuelled by green hydrogen generated from solar energy. The vehicles will use fuel cells from Hydrogenics and Scania aims to deploy 30 hydrogen-powered vehicles in Norway by the end of 2023.
	**Renault/ Symbio** In 2015, Symbio collaborated with GreenGT to fit a fuel cell range extender to a 4.5t Renault Maxity electric truck, which doubles the vehicles' range to approximately 200 km. In addition to the extended range, the truck used residual heat from the fuel cell unit for heating of the cabin. The vehicle has been trialled by La Poste in France since 2015.
	**ESORO** In 2016, the engineering and prototyping company ESORO announced the development of the world's first fuel cell truck in the 34t weight category. The vehicle is based on MAN truck and uses a fuel cell from Swiss Hydrogen. It is being tested as part of Coop's logistics operations in Switzerland and received approval for use on public roads in 2017.
	**HV Systems** HV Systems is developing three HGV trucks, from 7.5 tonnes up to 44 tonnes. The trucks will have a range estimated up to 800 miles. The first truck will be the smaller 8 tonne van, HV Systems is planning to test the prototype in summer 2019 with a 388 mile trip from Glasgow to London without refuelling.
	**VDL** As part of the EU funded H2 Share project VDL is developing a 27 tonne rigid fuel cell truck, which will be a fuel cell range extender configuration. The truck will contain a 72 kWh battery and 88 kW fuel cell. The truck will have c. 30 kg H_2 storage on board, providing an expected range of c. 350 km. VDL is planning to test the vehicle in 2019.

3.6 Trains

In 2018 the UK Government announced an ambition to phase out all diesel-only trains by 2040. Other European countries are also seeking to increase the use of zero-emission trains (notably Germany), and this has led to several suppliers developing fuel cell trains. Hydrogen fuel cells offer a solution for self-propelled trains that operate on non-electrified routes. Although trains are not operated by Monmouthshire County Council, hydrogen trains will create a demand for hydrogen for transport applications. This could have a significant impact on the availability of hydrogen in the region and facilitate the uptake of hydrogen fuelled road vehicles. A summary of hydrogen trains under development that could be relevant to South Wales is shown in Table 6 below.

[19] Transport Engineer: http://www.transportengineer.org.uk/transport-engineer-news/hyundais-fuel-cell-truck-coming-to-europe-next-year/189837

Table 6: Summary of key players in the rail sector that could develop a hydrogen transport demand in Monmouthshire

	**Alstom & Eversholt** Train manufacturer Alstom and rolling stock company Eversholt are working to convert the class 321 electric multiple units into hydrogen fuel cell trains. The 'breeze' fuel cell trains will be demonstrated in the UK in 2019 with a target to be in operation by 2022[20].
	**Porterbrook & University of Birmingham** Rolling stock company Porterbrook and the University of Birmingham are developing the HydroFlex, a fuel cell train from converted Class 319. The HydroFlex is planned to be demonstrated in 2019[21].
	**Vivarail** The train manufacturer Vivarail is converting Class 230 with modular traction equipment, including diesel engines, batteries and fuel cells. Vivarail has released details of the hydrogen fuel cell train concept and has also suggested that the diesel-electric hybrid trains they are developing for Transport for Wales Rail Services could be converted into a hydrogen fuel cell train. These trains would have a self propelled range of c. 650 miles, with two battery driving motor cars powered by the hydrogen fuel cell[22].

3.7 Opportunities for hydrogen fuelled-vehicles in MCC fleet

There are several potential options for light duty cars and vans in the MCC fleet, such as the Hyundai NEXO and range extender fuel cell vans from ULEMCo and Symbio FCell. These vehicles currently have a significant price premium over similar specification ICE vehicles which could be a barrier to widescale adoption into the MCC fleet. The next generation of FCEVs from Toyota, expected in the early 2020s, could potentially see a reduction in the price of the FCEVs and may provide a more competitive option for the council fleet.

There have been successful demonstrators of FCEVs, including the Toyota Mirai in vehicle fleets operated by taxi companies and car clubs, including HYPE taxis in Paris and Green Tomato Cars in London (noted above). The HYPE taxis in Paris are incentivised by the local authority who allow the zero emission taxis to operate throughout the whole day, whereas petrol and diesel taxis are limited by the daily number of hours they can operate to reduce air pollution within Paris. HYPE taxis currently have a fleet of 100 FCEVs, with plans to expand this to 600 FCEVs by the end of 2020[23]. Green Tomato Cars operate in London and advertise themselves as a green and ethical car service, where they have developed a customer base that value a zero emission taxi service. They currently have a fleet of 25 Toyota Mirai cars with plans to expand this to 50 by the end of 2019. Within these fleets the vehicles drive long daily mileages, and benefit from the range of hydrogen vehicles and quick refuelling times in comparison to battery electric vehicles. The appeal of Green Tomato Cars to customers is heightened from the awareness of the impact of diesel vehicles in London in contributing to local air pollution. Although this is not a direct incentive, this helps Green Tomato Cars promote their brand and the requirement for zero emission vehicles in London.

MCC could incentivise the adoption of zero emission vehicles in taxi or other private vehicles fleets through a variety of policy measures, such as changes to taxi licensing rules, the introduction of low emission zones, or

[20] Alstom, 2019, Alstom and Eversholt Rail unveil a new hydrogen train design for the UK, https://www.alstom.com/press-releases-news/2019/1/alstom-and-eversholt-rail-unveil-new-hydrogen-train-design-uk

[21] Porterbrook, 2018, Porterbrook and University of Birmingham sign partnership to develop HydroFlex – the UK's first hydrogen train, https://www.porterbrook.co.uk/news/post.php?s=2018-09-19-porterbrook-and-university-of-birmingham-sign-partnership-to-develop-hydroflex-the-uks-first-hydrogen-train

[22] Vivarail, 2019, Vivarail spearheads development of green fuel technologies, http://vivarail.co.uk/vivarail-spearheads-development-of-green-fuel-technologies/

[23] New Mobility News, 2019, Hype to roll out fleet of 600 hydrogen taxis in Paris; https://newmobility.news/2019/02/22/hype-to-roll-out-fleet-of-600-hydrogen-taxis-in-paris/

incentives such as free parking or use of bus lanes for zero emission vehicles. Naturally, the potential impacts of any such measure would need to be considered as part of a detailed feasibility study before introducing these types of incentives / regulations and this should also be considered in light of the outcome of the Improving public transport consultation.[24]

Smaller fuel cell vehicles, such as the Riversimple Rasa and Microcab Vianova could be considered for deployment within the MCC fleet. Both these vehicles are produced by small, UK-based vehicle manufacturers. These vehicles are being developed with flexibility to use the vehicle platform for small vans for commercial use, this could fit in with the cars and smaller vans operated by MCC.

In addition to purely hydrogen-fuelled vehicles, solutions exist to either use fuel cells as a range extender (with the option of plugging in the vehicle to charge the battery), or to use hydrogen combined with diesel in ULEMCo's dual fuel vehicles. One advantage of these vehicles is that they have a lower dependence on dedicated hydrogen refuelling infrastructure, so if hydrogen is not available for any reason (e.g. unplanned downtime of the HRS), the vehicles can still be operated. The addition of the hydrogen tanks can reduce a vehicle's available payload and / or volume-capacity, depending on the packaging arrangements. ULEMCo is minimising the impact of this in their more recent vehicle modifications, including the Peugeot Boxer patient transport vehicle, which maintained the payload in the back of the vehicle by removing a front passenger seat for the hydrogen tanks, and the hydrogen fuel cell range-extender Nissan e-NV200 that houses the hydrogen tanks and fuel cell in a box on the roof of the vehicle.

It is clear from the summary above that there is a relatively limited selection of hydrogen fuelled vehicles as of early 2019. If specific vehicle configurations are required (such as lifting arms on a flatbed transit), these vehicles are unlikely to be available in a hydrogen-fuelled vehicle. ULEMCo can convert existing diesel ICE vehicles into hydrogen-diesel dual fuel vehicles and this would allow specific vehicle configurations to be available as hydrogen-fuelled options. These vehicles would then have the same benefits as other dual fuel vehicles, with extended vehicle range, reduced NOx emissions and reduced CO_2 emissions (when renewable hydrogen is used). There are additional costs to convert new vehicle models to those ULEMCo already offer, this is from the additional design and development required for different vehicles. This cost would be dependent on the volume of the order and would reduce on a per vehicle basis with larger volume orders.

MCC has already engaged with several vehicle OEMs and technology integrators, including initial discussions with ULEMCo on hydrogen dual fuel RCVs. MCC use RCVs that are designed with space for three different waste streams per vehicle. These vehicles are optimised to serve the routes within Monmouthshire and the Council's waste collection strategy, however this reduces the space available on the vehicle to house additional hydrogen tanks, with space only available for one tank. This limit on the on-board hydrogen storage that is able to fit onto the current fleet of diesel RCVs reduces the effectiveness of the hydrogen conversion for these routes, as such these vehicles are not currently considered suitable for MCC. The development of fuel cell RCVs in the coming years from Scania and E-trucks may provide a more suitable hydrogen fuelled RCV for Monmouthshire.

The development of fuel cell HGVs is still at an early stage and although several vehicle OEMs are developing prototypes there are yet to be any commercial vehicles. There are ambitious plans for long haul HGVs, from Nikola Motors and Hyundai, however there is uncertainty around the availability and timescales of fuel cell trucks that would be suitable for replacing diesel trucks in MCC's fleet. The cost of these vehicles is still unknown; however they look to provide a zero emission option for HGVs, with the same benefits as fuel cell buses with longer range and faster refuelling times than alternative battery electric vehicles.

The potential to deploy additional fleets of hydrogen-fuelled vehicles in Monmouthshire and / or the surrounding area is considered in further detail in the feasibility studies presented in section 5.

[24] Welsh Government consultation document (closed 27th March 2019) https://gov.wales/sites/default/files/consultations/2018-12/improving-public-transport_0.pdf

JACOBS elementenergy

4. WP3 Task 2 – Hydrogen infrastructure assessment

4.1 Hydrogen Refuelling Stations (HRS) in the UK

As of early 2019, there are over 100 publicly accessible HRS operating across Europe, many of which have been installed via grant-funded demonstration projects. Table 7 summarises the current HRS in the UK (including those under construction and where planning permission has been granted and construction is due to shortly begin). In addition to the 17 sites listed in Table 7, there are also seven other sites in planning, including two further sites in London, and sites in Belfast, Crawley, St. Helens, Middlesbrough and Stockton on Tees[25].

Table 7: Summary of current UK hydrogen refuelling stations (including those under construction and where planning permission has been granted and construction is due to shortly begin)

#	Location	Operator	Capacity	Pressure	Source	Launch[26]
1	Lea Interchange, London	Air Products	320 kg/day	Bus only 350 bar	Delivered SMR[27]	2011
2	Swindon, Honda	BOC	200 kg/day	350 & 700 bar	On-site WE[28]	2011, 2014
3	Hatton Cross, London	Air Products	80 kg/day	350 & 700 bar	Delivered SMR	2012
4	Kittybrewster, Aberdeen	BOC	360 kg/day	350 & 700 bar	On-site WE	2015, 2018
5	Birmingham, bus and car	ITM Power	1,500 kg/day	350 & 700 bar	On-site WE	[2019]
6	AMP, Sheffield	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2015, 2016
7	Baglan, South Wales	Uni of S. Wales	35 kg/day	350 bar [& 700 bar]	On-site WE	2011 [2019]
8	NPL, Teddington	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2016
9	CEME, Rainham	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2016
10	Shell, Cobham, London	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2017
11	Tullos, Aberdeen	Aberdeen City Council	80 kg/day	350 & 700 bar	On-site WE	2017
12	Shell, Gatwick, London	ITM Power	80 kg/day	350 & 700 bar	On-site WE	[2019]
13	Shell, Beaconsfield	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2018
15	Swindon, J Matthey	ITM Power	80kg/day	350 & 700 bar	On-site WE	2018
16	Abergavenny	Riversimple	20 kg/day	350 bar	Delivered H_2	2018
17	Derby, Shell	ITM Power	80kg/day	350 & 700 bar	On-site WE	[2019]

Figure 5 illustrates the distribution of hydrogen refuelling stations across the UK. There is a focus of stations in the south east, around London, and Swindon and Aberdeen are both establishing hydrogen clusters, each with two stations, which provide back up to each other. These hydrogen clusters provide redundancy and additional confidence to early adopters of hydrogen-fuelled vehicles. The provision of at least two stations within a local area has been identified as an important target in the early stages of the development of the hydrogen transport

25 Hydrogen for Transport Programme: https://ee.ricardo.com/htpgrants
26 Years in brackets indicate estimated opening year
27 SMR: Steam methane reforming
28 On-site WE: On-site water electrolysis

sector[29]. There is also a variety of stations that provide dispensed hydrogen at 350 and 700 bar. The higher pressure hydrogen allows for greater quantities of on-board hydrogen storage and thus an extended vehicle range. Certain vehicles, including the Toyota Mirai require hydrogen at 700 bar, while fuel cell buses, range-extender fuel cell vehicles, dual fuel vehicles and the Riversimple Rasa use 350 bar hydrogen tanks. For potential hydrogen fuelled vehicles operated by Monmouthshire County Council the refuelling stations in Baglan and the Abergavenny station (number 7 and 16 in Table 7) could be utilised.

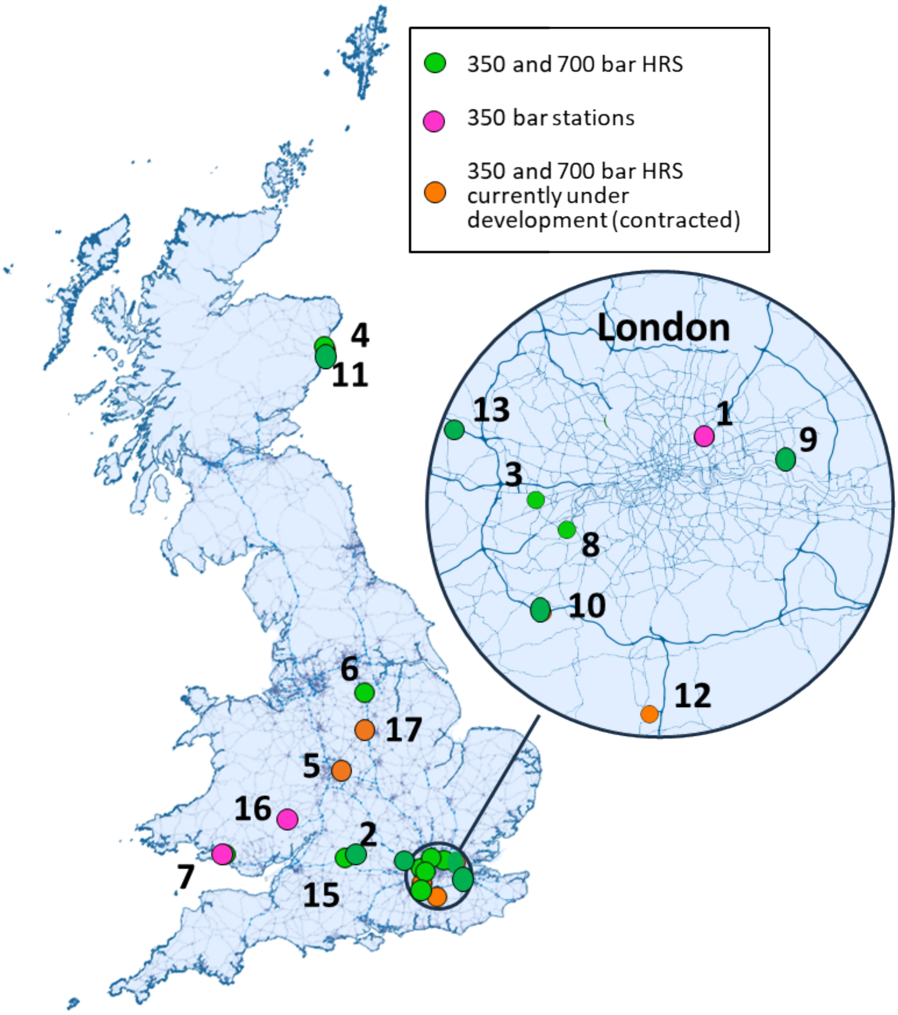


Figure 5: Overview of UK hydrogen refuelling stations, numbers link to stations shown in Table 7

4.2 Abergavenny HRS

As part of the Riversimple Rasa trial that will run from 2019 – 2021 a temporary HRS has been installed at the bus station car park in Abergavenny (shown as HRS 16 in the map in Figure 5). The HRS was installed by McPhy and provides hydrogen at 350 bar, with a capacity to provide 20 kg H_2/day. This station has been designed for the Riversimple Rasa, with each vehicle estimated to require a weekly refuel the trial is expected to consume 30 kg H_2/week. There is therefore spare capacity at the refuelling station to supply other vehicles at up to 350 bar. The pressure level would not be suitable for some vehicles, such as the Toyota Mirai that require 700 bar refuelling. The station could, however, provide hydrogen for the Hyundai ix35 fuel cell vehicles, including the two vehicles operated by Mid and West Wales Fire Service that currently refuel at the Port Talbot station (although the ix35 Fuel Cell car has 700 bar tanks, Hyundai allows the cars to be refuelled at 350 bar or 700 bar). The

[29] UK H2Mobility, 2017, UK H2Mobility Communication pack, http://www.ukh2mobility.co.uk/wp-content/uploads/2017/09/Communication_pack_January_2017.pdf

station would also be able to serve a small fleet of range-extender fuel cell vans, or dual fuel hydrogen-diesel vehicles.

The hydrogen is currently delivered to the station by BOC (the hydrogen is produced from an SMR plant and delivered in manifold cylinder packs). The current cost of the hydrogen for the trial phase is high in comparison to other HRS, the small capacity and planned short duration of the refuelling station results in a high price per kilogram to cover the operating costs, including the delivery charge and cylinder rental. While this may not be an issue for a small scale, limited duration trial, the hydrogen price is an important component of the total cost of ownership for hydrogen-fuelled vehicles operated for many months / years. Future expansion of the station could be considered after the trial of the Riversimple Rasa, or alongside the development of the feasibility studies in section 5. The station currently provides hydrogen at 350 bar, and is unable to refuel certain fuel cell vehicles, such as the Toyota Mirai. Given the short-term duration of the HRS and the focus on the Riversimple vehicles, in the short term it is unlikely there will be a case to upgrade the station to 700 bar. MCC should instead focus on 350 bar vehicles that could make use of some of the spare capacity identified.

Figure 6: Abergavenny hydrogen refuelling station[30]

4.3 HRS siting criteria

If sufficient users for fleets of hydrogen-fuelled vehicles could be identified in the local area, there may be a case for installing a new HRS. The business case for installing an HRS will depend on a range of factors including refuelling pressure needed (700 bar stations are more expensive than 350 bar stations), source of hydrogen, certainty over demand for fuel, etc. It is therefore difficult to give precise figures for the number of vehicles or hydrogen demand level required to justify a new HRS. However, the HRS network development in Germany provides a useful proxy – the company set up to install and operate HRS will consider building a new station in a location where a fleet of 50+fuel cell cars will operate. The following factors should be considered when selecting or evaluating potential sites for hydrogen refuelling stations:

- **Space** – is there sufficient space to accommodate a hydrogen refuelling station of the capacity required, including space for vehicles to refuel? Is there scope for expansion?
- **Utilities** – are there existing utilities / services such as three phase power supply, water, drainage, phone / internet connection, etc.? If not, how much work and expense is likely to be involved in providing the necessary utilities?
- **Location** – is the site well located for the expected users of the station? To what extent does the proposed site fit with the UK's wider network of HRS?

[30] Image credit Riversimple

- **Access** – is there sufficient space for vehicles to access the station? Can articulated trucks (tube trailers) access the site to deliver fuel?[31]
- **Site preparation** – how much work is needed to prepare the site and what are the likely costs?
- **Planning permission** – are there likely to be any issues with securing planning permission for a hydrogen refuelling station at the site? Will there be any restrictions in terms of visual appearance of the station, or other impacts such as noise impact, traffic movements, etc.?
- **Commercial arrangements** – who owns the site and what type of commercial arrangement will be needed between the landlord and the HRS owner / operator (length of lease, rent, conditions such as the need to reinstate the site to its original condition at the end of the agreement period, etc.)?

4.4 HRS siting criteria - MCC

Table 8 shows a summary of where the MCC fleets are based within Monmouthshire, this is represented in Figure 7 that maps the hotspots where the MCC vehicle fleets are based and the locations of HRS in the region. The MCC vehicle fleet is focused around hubs in Abergavenny, Raglan and Caldicot. Based on the MCC vehicle fleet and the stations in Baglan and Swindon, a potential HRS site around Caldicot could prove useful to a variety of vehicles. This would be near the M4, about half way between the Baglan HRS and Swindon HRS cluster, 80km from each and c.40 km from the station in Abergavenny. This could also serve hydrogen demands in the Newport area and provide a hydrogen refuelling site between the urban areas of Cardiff and Bristol for private hydrogen vehicles. The vehicle fleet based in the Caldicot region includes a range of cars, vans, minibuses, coaches, trucks and refuse collection vehicles.

Table 8: Summary of MCC vehicle fleet location

Location	Postcode	Percentage of MCC fleet
Abergavenny	NP7	20%
Raglan	NP15	32%
Chepstow	NP16	6%
Newport	NP20	7%
Monmouth	NP25	7%
Caldicot	NP26	28%

[31] Note: even if the station has on-site production, it is worth considering access for hydrogen deliveries as this can be used as a back-up solution.

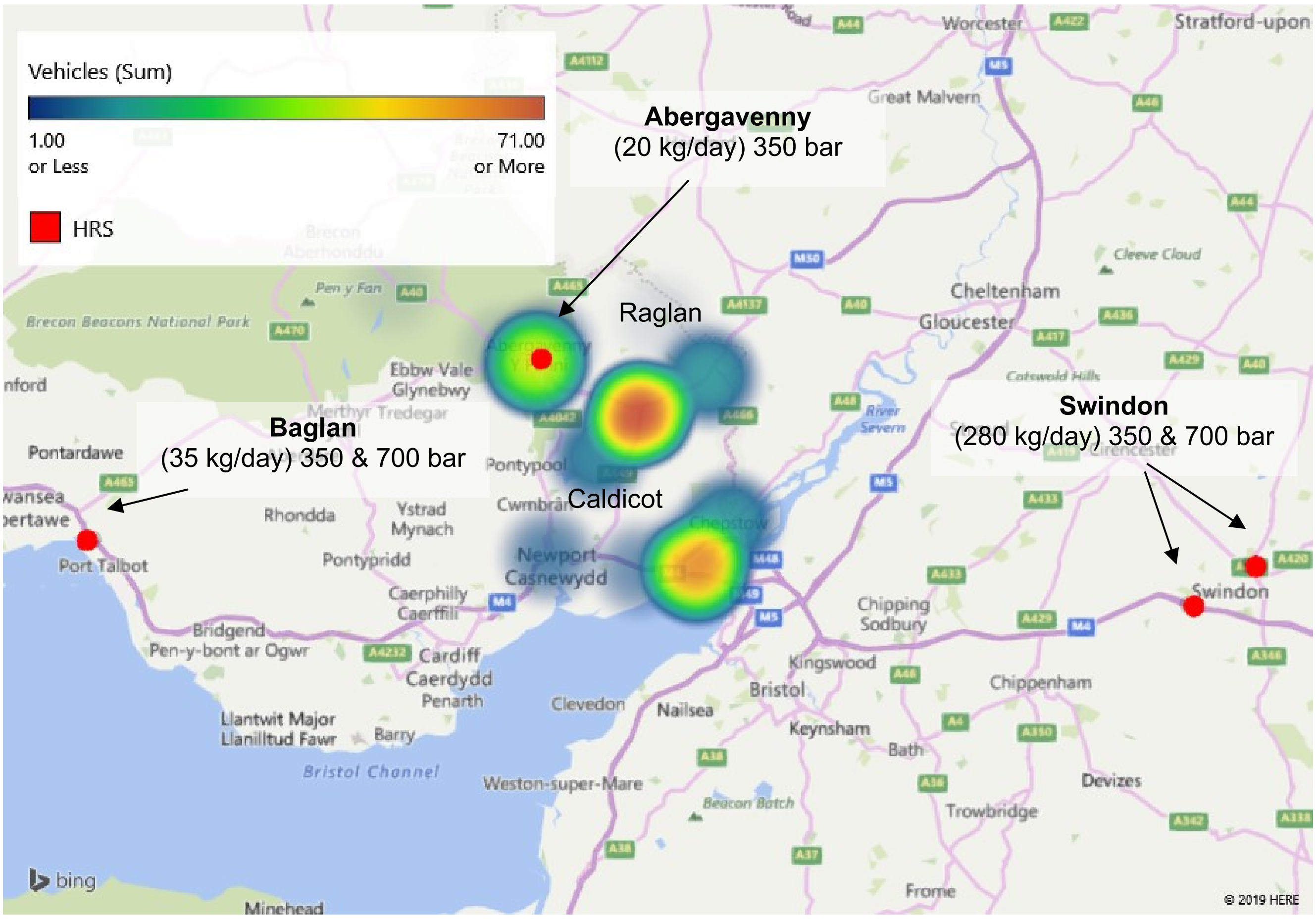


Figure 7: Overview of base locations of the MCC vehicle fleet

4.5 Hydrogen production/delivery options

There is a mix of hydrogen production routes supplying hydrogen refuelling stations in the UK, the majority of these contain on-site electrolysers that produce hydrogen on-site. These sites require an electricity connection and water supply to produce and store hydrogen on-site for when it is required by vehicles. There are also several, larger-scale hydrogen production facilities across the UK that produce hydrogen at larger quantities for industrial uses. These sites typically produce hydrogen from natural gas through steam methane reforming (SMR) and can deliver hydrogen in compressed tube trailers to hydrogen refuelling stations. Compressed tube trailers have a capacity up to 1,000 kg H_2 at a pressure of 500 bar. These tube trailers can then either discharge the hydrogen into on-site compressed hydrogen storage tanks, or the trailer can be swapped at the hydrogen refuelling site and act as the on-site hydrogen storage. For hydrogen refuelling stations that refuel at 350 bar, no further compression is required from a 500 bar tube trailer, however additional compression from a 'booster' and pre-cooling is required for refuelling at 700 bar. Figure 8 illustrates the different steps required for on-site hydrogen production and off-site production with delivery to the hydrogen refuelling station.

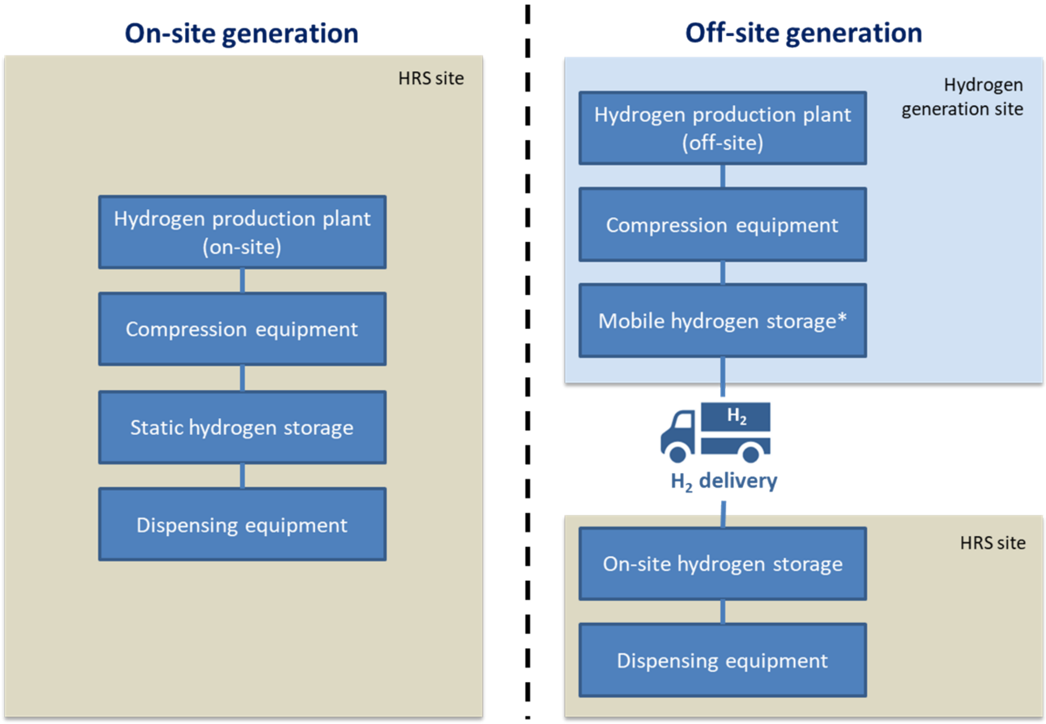


Figure 8: Schematic of hydrogen refuelling stations (HRS) comparing on-site hydrogen production with off-site generation and delivered hydrogen

The option for a refuelling station to produce hydrogen from on-site generation (typically by electrolysis) or delivery from off-site generation will depend on a range of factors, including the distance (and cost) of the off-site hydrogen generation, the daily hydrogen demand and the space available at the hydrogen refuelling site. The average price of hydrogen offered from HRS in the UK is £10–15 kg/H_2, with stations that have been installed with grant funding support producing hydrogen from on-site electrolysis offering hydrogen for £10kg/H_2 (excl. VAT)[32]. Hydrogen produced from SMR is recognised as the lowest cost hydrogen production route[33], if the cost of hydrogen delivery is low enough this could provide significant cost savings to the current dispensed price of hydrogen. Similarly large-sale electrolysis plants that are installed near locations with low cost electricity, such as direct connection to renewable electricity sources or at constrained regions of the electricity grid, can also produce low cost hydrogen, with estimates from hydrogen refuelling station operators within the Euro zone of €5/kg H_2 (£4.3kg/H_2)[34].

Using published cost and performance data / targets, the cost of dispensing hydrogen from various sources can be calculated. The graphs below show the results of generic cost analysis for typical HRS. Note that the purpose of this analysis is to illustrate the impact of factors such as scale of demand and production route on the relative costs of dispensed hydrogen. The analysis is non-exhaustive in terms of the costs included (i.e. various elements are excluded, such as one-off engineering, site-specific costs, fixed opex, risk premium, profit margin, etc.) and the figures should be taken as illustrative. Figure 9 shows cost estimates for hydrogen produced through off-site electrolysis, SMR and delivered to the HRS, as well as on-site hydrogen production for a 30 kg H_2/day demand (enough daily capacity to fully refuel 20 Riversimple Rasas, 15 Symbio HyKangoo range-extender vans or 5 Hyundai NEXOs). This station could illustrate a publicly accessible light duty HRS, which has a design capacity of 200 kg H_2/day and low utilisation of 15%. The cost of on-site electrolysis is slightly lower than the SMR delivered hydrogen in this scenario, although the costs of delivery to the site will vary depending on a range of factors, including the distance between the refuelling station and hydrogen production site.

[32] ITM Power, 2018, Fuel contract with the Metropolitan Police, http://www.itm-power.com/news-item/fuel-contract-with-the-metropolitan-police
[33] H2FCSupergen, 2017, The role of hydrogen and fuel cells in delivering energy security in the UK; http://www.h2fcsupergen.com/wp-content/uploads/2015/08/IMPJ5213-H2FC-Supergen-Energy-Security-Extended-Summary-032017-WEB.pdf
[34] NEL Hydrogen, 2018, https://www.altenergy.info/wp-content/uploads/2018/10/4-Jacob-Krogsgaard-Nel.pdf

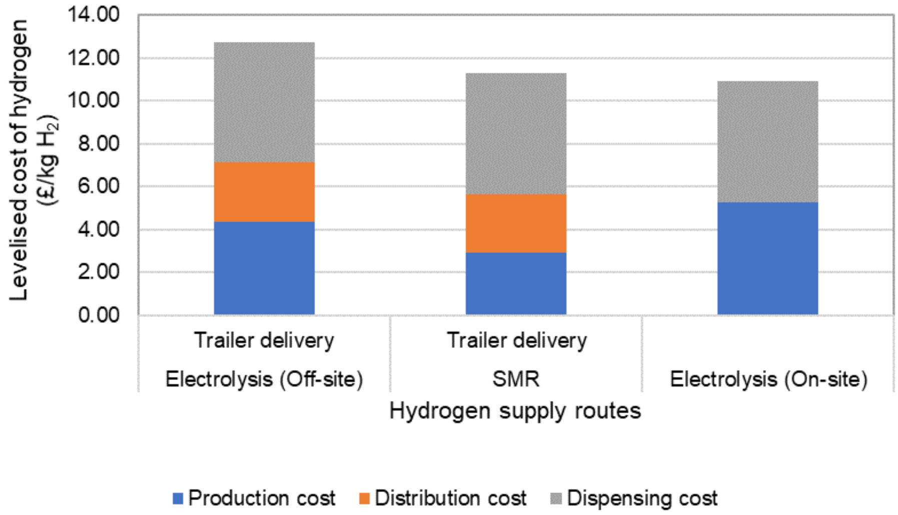


Figure 9: Illustrative cost of dispensed hydrogen comparing centralised production of electrolysis, SMR and on-site electrolysis for 30 kg H_2/day demand

Figure 10 illustrates the cost of hydrogen from a hydrogen refuelling station with a higher demand of 500 kg H_2/day. This could illustrate the hydrogen demand from a fleet of c.25 fuel cell buses with a daily hydrogen demand of 20 kg H_2. The increase in scale of the hydrogen refuelling station results in significant cost reduction of the dispensing and delivery of hydrogen. In this scenario on-site electrolysis is the most expensive hydrogen supply option and delivery from off-site production, where the electrolyser is also assumed to be able to access lower cost electricity is a lower cost option. In both options the production of hydrogen from SMR is shown as the lowest cost option. The costs shown here do not assume any carbon capture and storage, which would increase the cost of hydrogen from SMR.

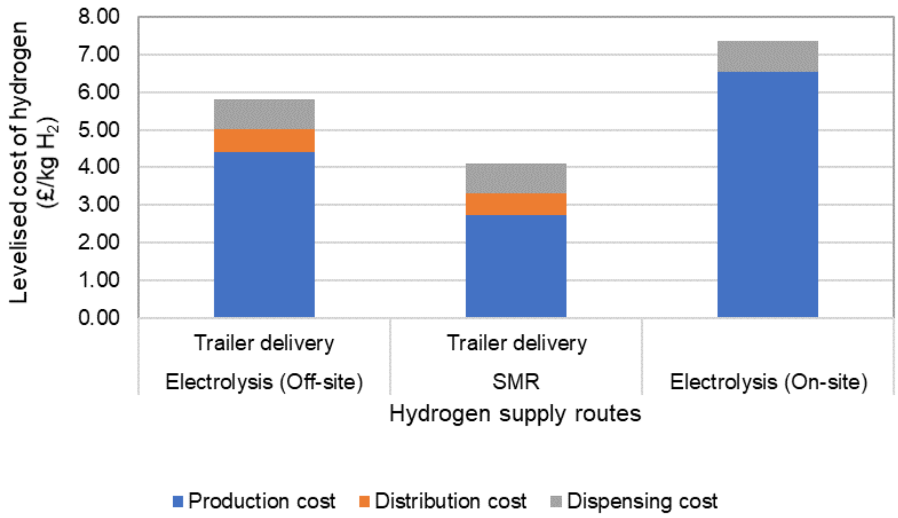


Figure 10: Hydrogen supply cost based on hydrogen demand of 500 kg H_2/day

Table 9: Assumptions used for the hydrogen cost analysis in Figure 9 and Figure 10

Parameter	Value	References
Electrolyser capital cost	£750/kW	Taken from Hydrogen supply chain evidence base[35]
SMR capital cost	£2,000/tonne H_2	Taken from IEAGHG[36]
Electricity cost	£0.09/kWh (on-site) £0.05/kWh (off-site)	Assumed
Gas cost	£0.03/kWh	Assumed
HRS cost	£2,600/(kg H_2/day)	Taken from UK Hydrogen and fuel cell roadmap[37]
Tube trailer capital cost	£320,000	Taken from FCH JU MAWP[38]
Tube trailer OPEX	£2/km	Based on discussions with gas suppliers
Distance from H_2 production site to HRS	200 km	Assumed

The analysis of the cost of hydrogen supply illustrate the importance of the scale of hydrogen demand, higher numbers of hydrogen fuelled vehicles operating from a refuelling station will allow for cost savings in the production, delivery and dispensing of hydrogen. Hydrogen fuelled vehicles with a high hydrogen demand, such as fuel cell buses, can therefore provide an opportunity to reduce the cost of hydrogen for other vehicles.

[35] Element Energy and Jacobs, 2018, Hydrogen supply chain evidence base. Prepared by Element Energy for the Department for Business, Energy & Industrial Strategy
[36] IEAGHG, 2017, Techno-economic evaluation of SMR based standalone (merchant) hydrogen plant with CCS
[37] E4tech and Element Energy, 2016, Hydrogen and Fuel Cells: Opportunities for Growth, Mini roadmaps (appendix to roadmap report)
[38] FCH JU, 2018, Multi-annual work plan

5. WP3 Task 3 - Trial project feasibility assessment

5.1 Introduction

The options and current availability of hydrogen fuelled vehicles were reviewed in Section 3 of this report, including those currently on the market (as of early 2019), and models expected to become available over the coming years. In this section we present the results, timeframes and actions required for three potential high-level studies to introduce additional hydrogen vehicles into the Monmouthshire region. Conducting detailed feasibility studies was not within the scope of the current project, rather the aim is to provide a foundation of potential projects for further development.

5.2 Fuel cell bus fleet

5.2.1 Project overview

Introduction of a fleet of hydrogen fuel cell buses to replace diesel vehicles in day-to-day public transport service provision.

Key features:

- Fleet of 40+ fuel cell buses, ideally based in one depot.
- New depot-based hydrogen refuelling station.

This feasibility study considers the case for deploying a fleet of 40+ buses, rather than a smaller fleet of five to ten vehicles for example. A fleet of many tens of buses is likely to be a more attractive proposition than a less ambitious project for several reasons. For example, if operated in regular service (>100 miles per day per bus), a fleet of this size would create a demand for hydrogen of many hundreds of kilograms per day, which is expected to be sufficient for the operator to access cost-effective hydrogen supplies. The fixed costs associated with installing new refuelling infrastructure / establishing a hydrogen supply system mean that the economics of fuel cell bus projects improve with increasing scale. Similarly, there are other costs associated with introducing a new technology into a bus depot (e.g. upgrades to the maintenance facilities, tooling, retraining maintenance staff, etc.) that do not scale linearly with fleet size, which can make the per-bus costs of small fleets of fuel cell buses very high.

The deployment of a fleet of hydrogen fuel cell buses would require training of staff to operate and maintain the vehicles. Current fuel cell bus deployments in the UK, such as the Aberdeen and London fleets involved training for technicians, drivers, fuellers / shunters, sub-contractors and the local emergency services[39]. This training along with the installation of safety features at the maintenance facilities, such as ventilation and alarm systems for hydrogen, allows routine maintenance of the fuel cell buses to be carried out at the bus depot/maintenance facility. The specialist training of bus operator employees is typically conducted by the vehicle supplier (and / or component supplier), and refuelling infrastructure supplier. Similarly, expert advice on modifying depots for safe indoor maintenance of hydrogen vehicles is typically sourced from international specialists. In the medium terms, there could be opportunities to offer education / training / expert advice through local educational institutions, particularly if hydrogen and fuel cell technologies begin to be adopted in other applications and become more of a mainstream solution. This would help ensure greater local benefits from the transition to increased use of clean energy technologies.

[39] Beyer, P., TfL, 2015, 3Emotion, Maintenance of fuel cell buses: the challenge?, https://3emotion.eu/sites/default/files/documents/Keynote%20talk.pdf

5.2.2 Partners required

The following organisations would be required for a project of this type:

- Fuel cell bus supplier, for example:
    - Alexander Dennis – now offering a fuel cell double deck bus.
    - Wrightbus – can supply fuel cell buses in single deck or double deck configurations.
- Bus operator – e.g. First Group, Stagecoach (both these organisations have experience operating hydrogen buses in Aberdeen and run bus services in South Wales).
- Hydrogen refuelling station / fuel supplier – e.g. Air Products, BOC, ITM Power, Nel.
- Others – for example safety experts to carry out surveys of the bus depot and advise on any modifications needed for the safe maintenance of the vehicles in enclosed spaces, contractors to undertake site preparation work for installation of the refuelling station.

5.2.3 Pre-requisites

Developing and implementing a fuel cell bus project in Monmouthshire or the wider area is contingent upon the following[40]:

- Further demonstration of the technical performance of the latest generation of fuel cell buses (e.g. via the JIVE project[41] and related activities).
- Further reductions in the costs (and hence prices) of fuel cell buses – this depends on increasing scale of demand for these vehicles more broadly. For example, the "H2 Bus Europe" initiative is seeking to secure sufficient scale and certainty of demand for fuel cell buses to provide economies of scale in the supply chain and thus reduce the costs of these vehicles significantly relative to current levels.
- A commitment from at least one bus operator to integrate the vehicles into their fleet and run them in day-to-day operations. This in turn will rely on the business case for fuel cell buses being sufficiently attractive, which largely depends on attractive lifetime costs. Like any zero emission vehicle, fuel cell buses come with a price premium relative to incumbent technologies and the bus operator is unlikely to be able to pay a high premium relative to operating diesel vehicles. Therefore, a strategy is required for filling any gap between the costs of delivering the project and the maximum contribution the operator is willing to pay.

5.2.4 Indicative budget and potential funding sources

The case for proceeding with a fuel cell bus project in Monmouthshire will be largely dictated by the overall costs and securing sufficient commitments to fund the activities from all stakeholders. This section considers budgetary costs for deploying, operating, and maintaining a fleet of fuel cell buses to gain a sense of the level of investment required. The key assumptions are summarised in Table 10: Key assumptions for budget calculations Table 10.

[40] Note that this is not an exhaustive list.
[41] www.fuelcellbuses.eu/projects/jive.

Table 10: Key assumptions for budget calculations

Metric	Value	Notes
Fuel cell bus price (single deck)	£350k per bus	While this figure is well below the historical price of fuel cell buses, some suppliers are working to achieve significant cost reductions that could lead to prices around this level from the early 2020s.
Fuel cell bus maintenance cost	£0.35 per km	Indicative average maintenance cost including maintenance of conventional parts, powertrain components, the fuel cell system, and fuel cell stack replacement. This is based on figures published in the "fuel cell bus commercialisation study".[42] In practice maintenance costs will depend on the maintenance strategy and the operator's attitude to risk, e.g. over future costs of replacement parts.
Hydrogen price	£5 per kg	This is a relatively aggressive all-inclusive price for dispensed hydrogen (including the costs of infrastructure). Such prices are only likely to be available given sufficient scale and long-term certainty of demand (e.g. take-or-pay type contract over ten years).
Fuel cell bus average fuel efficiency	7 kgH_2/100km	Total consumption including heating / cooling.
Other costs	£250k	Allowance for costs of any depot modifications required (e.g. installation of hydrogen sensors, additional ventilation, etc.).
Equivalent diesel bus price	£175k per bus	Indicative price of a new single deck, low floor urban bus.
Equivalent diesel bus maintenance cost	£0.23 per km	Indicative cost of maintaining a diesel bus (averaged over lifetime).
Equivalent diesel bus fuel efficiency	37 litres/100km 7.6 mpg	Representative figure.
Average diesel price	£1.1 per litre	Represents the average price of diesel over the full period of the economic analysis (15 years). Clearly, future fuel prices are uncertain and the option of fixing hydrogen prices via a long-term contract may be attractive to some operators (most of whom typically perform some level of hedging of diesel costs).
Average annual km per bus	65,000 km/yr	Representative figure.
Bus lifetime	15 years	Typical lifetime of an urban bus. The budgetary costs presented below correspond to 15 years of operation.

All prices exclude VAT.

Note that the following costs are excluded from this analysis:

- Costs of finance
- Ad Blue costs
- All costs assumed to be common between fuel cell buses and diesel buses: driver costs, overhead costs, insurance, etc
- The Bus Services Operators Grant (BSOG). BSOG is under review and for the purposes of this analysis the assumption is that from the early 2020s, BSOG will offer at least equal treatment for zero emission buses

[42] www.fch.europa.eu/publications/fuel-cell-electric-buses-%E2%80%93-potential-sustainable-public-transport-europe.

relative to diesel vehicles (as of early 2019 the structure of the scheme means that operators receive a rebate based on litres of diesel consumed, which makes the case for adopting zero emission alternatives more challenging).

The graph below summarises the costs and potential sources of funding for a project to deploy and operate a fleet of 40 fuel cell buses over 15 years.

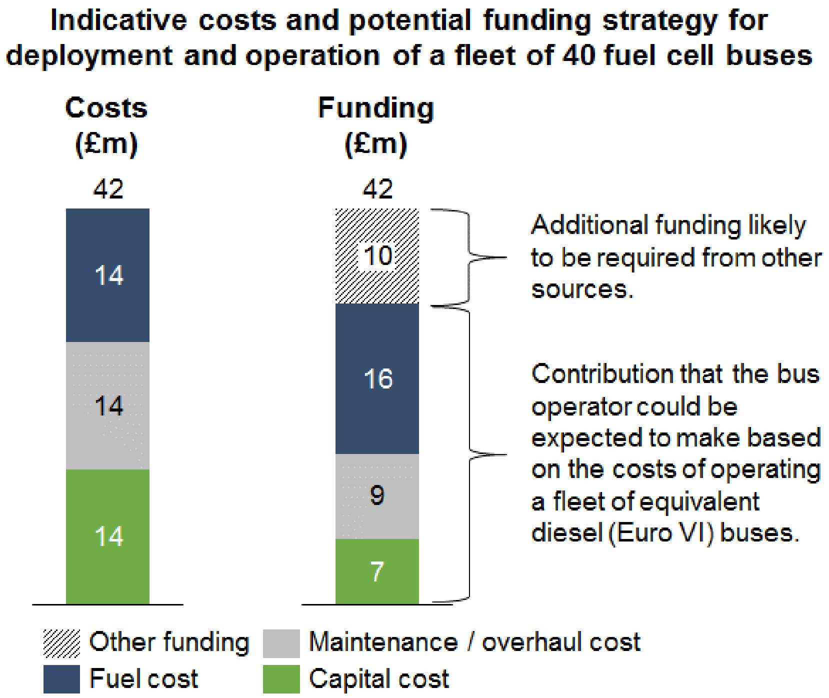


Figure 11: Fuel cell bus project – costs and potential funding sources

This analysis suggests that assuming the bus operator would be willing to make a financial contribution equivalent to the costs of acquiring and operating equivalent diesel buses, the project could be delivered with the operator covering most of the costs (c. 75% under the assumptions set out above). This would leave around £10m of funding to be sourced from others. Practically all the fuel cell bus projects running / planned in Europe to date rely on public funding to cover the cost gap and unless regulations are introduced to disincentivise / ban diesel buses this situation is likely to continue in the 2020s.

It is important to highlight that the costs presented above are indicative figures only and are subject to a relatively high degree of uncertainty and changes to future policy (e.g. Ultra Low Emission Zones ULEZ, e.g. diesel ban). We recommend that if MCC is interested in supporting the development of a fuel cell bus project, validation of the budget figures should be undertaken as part of more detailed feasibility work.

A hydrogen bus project could also be developed based on a smaller (initial) fleet of vehicles. While this may reduce the costs and funding required, for the reasons explained above the per bus budget and funding levels would likely be higher which may negatively impact the viability of the project.

5.2.5 Timescales and next steps

It is recognised that delivering a fuel cell bus project in Monmouthshire in the near term is likely to rely on securing a significant level of public funding to bridge the cost gap between zero emission vehicles and conventional buses. Developers of any zero emission bus project need to be aware of the broader context of bus services in the region, where many routes are not commercially viable without public subsidy and maintaining services (particularly in rural areas) is often challenging. There is therefore a tension between realising emission reduction ambitions by delivering bus services with zero emission technologies and maintaining / expanding services in areas where the commercial case is marginal at best. Most zero emission buses are being introduced into cities where the urgent need to act to address air quality is a key argument used to justify the higher costs, and where the financial viability of regular bus services is higher due to higher population densities and greater bus use. Nonetheless, if a case for investing in fuel cell buses in Monmouthshire can be made, such a project could result in wider benefits, such as providing a relatively high level of anchor demand for hydrogen as a transport fuel which could lead to low cost, renewable hydrogen being available for other application in the region.

The figure below summarises the main tasks that would need to be undertaken to develop and implement a fuel cell bus project. Note that the timescales (which are based on experience of developing similar projects) are indicative and relatively conservative, i.e. there could be scope to accelerate this process depending on the details of the activities and the partners involved.

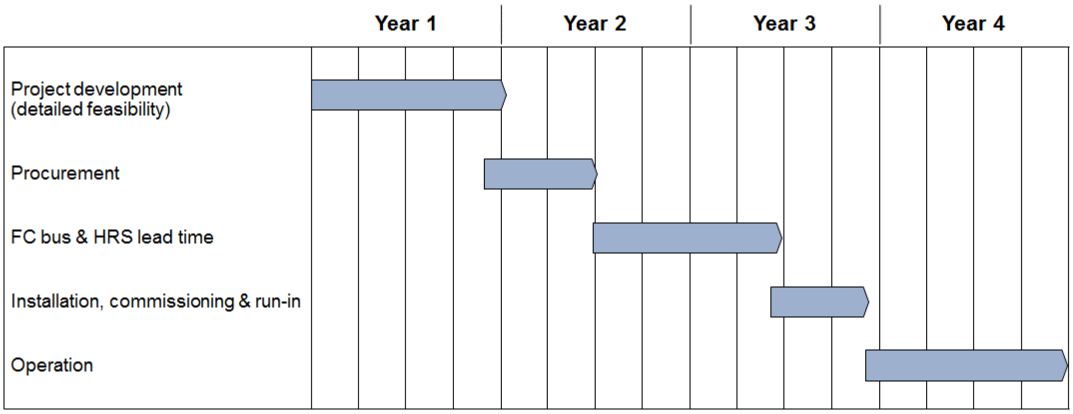


Figure 12: Fuel cell bus project development – indicative timescale

The principal tasks to take forward a project of this type include:

- **Detailed feasibility** – for example, discussions with potential operators, understanding the conditions under which they could invest, identifying routes, selecting a depot, developing a refuelling strategy and procurement strategy, etc.
- **Procurement** – tender exercises are likely to be needed to select suppliers of the fuel cell buses and the hydrogen refuelling station / hydrogen supply.
- **Deployment** – this phase includes off-site construction of the buses and refuelling infrastructure, preparation of the depot (e.g. any civil engineering works needed for the HRS and adaptations to the maintenance facilities), installation and commissioning of the infrastructure, and delivery of the buses. As with any new technology, it is advisable to include a "run-in" period during which the bus operator can become familiar with the vehicles and any teething issues are resolved before full operation.

Note that there is a significant amount of knowledge and experience relating to developing fuel cell bus projects, and many useful resources are available from past / on-going demonstration projects in this area.[43]

As shown by the indicative timescale and budget of £10 million, a hydrogen fuel cell bus project is a significant undertaking and would require the co-operation of several partners, including bus operators, hydrogen suppliers and infrastructure operators. The next steps needed to develop a fuel cell bus project include:

1. Review of the bus routes that would most benefit zero emission and hydrogen fuelled buses, i.e. those where air quality factors are a concern and where the length of the bus routes/operational hours of the buses are more suited to hydrogen fuel cell buses, than battery electric buses.
2. Consideration of the infrastructure requirements and where the hydrogen refuelling infrastructure could be sited, including whether there is space at existing bus depots and whether this would be suitable for on-site hydrogen production, or delivered hydrogen.

[43] See https://www.fuelcellbuses.eu/.

3. Initial discussions with bus operators and approach bus manufacturers, hydrogen suppliers and HRS infrastructure providers/ operators for budgetary quotes to develop a project budget and identify the funding that would be required to implement a zero-emission bus project.
4. Identify and apply for funding from appropriate sources, this could include UK Government schemes, such as the Ultra-low emission bus scheme or Hydrogen for Transport Programme (and the subsequent support schemes from Government).

5.3 Expansion of Riversimple Rasa roll-out

5.3.1 Project overview

Riversimple is aiming to deliver 20 Rasa vehicles to customers in 2019 through a trial phase and then plans for the series production of the Rasa commencing from the end of 2021. This feasibility project looks at the options for and role of MCC to support the development of the Rasa and for the deployment of the vehicle in the MCC fleet in the future. This includes the steps for the Rasa to be produced at scale, rather than the current prototypes used in the trial that are not commercially competitive at small production scales.

The current prototypes of the Rasa are produced in batches of <5 vehicles, this leads to very high manufacturing costs per vehicle and the scale-up of the manufacturing process is required before the Rasa can become a competitive vehicle with other series production vehicles (e.g. Renault Zoe has a production capacity c.60,000 vehicles per year[44]). Riversimple is aiming to develop a manufacturing plant that can produce 5,000 vehicles per year, which will achieve economies of scale and reduce the vehicle production costs.

Figure 13: The Riversimple Rasa, small hydrogen fuel cell car with a 300 mile range

Table 11: Specification summary of the Riversimple Rasa

Parameter	Value
Power source	8.5 kW fuel cell
Power output	16 kW continuous (55 kW peak)
Chassis	Carbon composite
Fuel tank capacity	1.5 kg hydrogen
Additional energy storage	1.9 MJ lithium-ion hybrid capacitors
Estimated range	300 miles (485 km)
Vehicle mass	580 kg

The specifications of the Rasa are summarised in Table 11. The MCC vehicle fleet includes c. 40 cars, many of which are small cars and could be replaced by the Rasa, including the Ford Fiesta (8 cars), Hyundai i10 (4 cars) and Toyota Yaris (3 cars). While the 300-mile range of the Rasa and quick refuelling time (c. 3 minutes) would make it suitable in terms of vehicle range and refuelling, further consideration of the payload and passenger carrying capacity should be reviewed by MCC and the suitability of the Rasa from a practicality perspective will be tested as part of the current trial. If the payload of the Rasa limited its functionality within the MCC fleet, the planned small van and five-seater sedan (currently developed as concepts, but aiming for production shortly after the Rasa) should be considered. These vehicles will be based on the same drivetrain as the Rasa and expand the vehicle options that could be replaced within the MCC fleet.

[44] Automotive News Europe, 2018, Renault prepares to double output of Zoe EV, https://europe.autonews.com/article/20180711/ANE/180709760/renault-prepares-to-double-output-of-zoe-ev

The project to expand the Rasa fleet in Monmouthshire may have the following objectives:

- Support the local manufacturing facility of the Riversimple Rasa and subsequent small van and five-seater sedan in the region.
- Expand the vehicle fleet of the Rasa within MCC fleet after the trial and encourage deployment of the Rasa by local businesses and private individuals.
- Support the installation of a hydrogen refuelling cluster within Monmouthshire, providing hydrogen vehicle users with several locations across the region to refuel. Explore options in the future to site publicly accessible hydrogen refuelling stations, alongside hydrogen bus refuelling stations (similar to the hydrogen refuelling station in Kittybrewster, Aberdeen and the Birmingham hydrogen refuelling station).

5.3.2 Partners required

As an SME based in Llandrindod, Riversimple already works closely with Monmouthshire County Council and they would be the main partner involved within this project. Riversimple aims to "*pursue systematically, the elimination of the environmental impact of personal transport*"[45] and is focused on the environmental sustainability throughout the design and use of the Rasa. This is emphasised in the company's business model, which involves leasing vehicles with fuel, maintenance and insurance included (rather than outright sale). This incentivises Riversimple to extend the lifespan of the vehicle.

In early 2019 Riversimple was awarded £1.25 million through the OLEV Hydrogen for Transport Programme to support the production of 20 Rasa cars[46]. As a small company Riversimple is seeking investment to enable the scale-up of production of the Rasa and is preparing a crowd-funding campaign to support this activity.

Maximising the environmental benefits offered by growing fleets of Rasa cars in the area will require a supplier of green hydrogen (or electrolysers for on-site production using renewable electricity), a HRS operator and partners who are willing to provide or lease land for the siting of hydrogen refuelling stations. MCC could continue to support Riversimple and the HRS operators through the planning application process, and potentially help with identifying sites within the region that could be suitable for HRS. One of the advantages of the Rasa is its low fuel consumption; with such low fuel consumption the ownership costs of the Rasa are less sensitive to hydrogen price than heavier, less efficient hydrogen fuelled vehicles.

A deployment scenario for the Riversimple Rasa could involve HRS that are exclusive to Riversimple vehicles. These stations could be relatively small and located in areas that are convenient to Riversimple customers. The smaller scale of the stations will result in a higher dispensed cost of hydrogen than larger HRS, however this is not the primary concern, due to the low per-km demands from these ultra-lightweight, efficient cars. An alternative HRS infrastructure deployment scenario would share refuelling infrastructure with other FCEVs, in which these stations could benefit from higher demand and provide hydrogen at a lower cost to Riversimple vehicles.

MCC only has a limited number (6%) of small cars in their fleet, therefore these vehicles will only have a small role in decarbonising the existing vehicle fleet. The Council could provide support for the uptake of vehicles by private customers, using incentives such as free-parking and use of bus lanes, which have been successful in promoting electric vehicles in Norway[47]. Any subsidies would need to be carefully designed to ensure they promote the uptake and commercialisation of hydrogen fuelled vehicles and allow a transitional phase where the subsidies or incentives could be phased out with minimum disruption to the vehicle uptake.

5.3.3 Pre-requisites

A series of key steps need to be achieved for the development of the Rasa and feasibility trial. This includes the successful demonstration of the Riversimple Rasa in the customer trials throughout 2019, 2020 and 2021. The

[45] Riversimple, https://www.riversimple.com/mobility-at-zero-cost-to-the-planet/
[46] Riversimple, 2019, Ultra-efficient, hydrogen electric car maker, Riversimple win £1.25m government funding; https://www.riversimple.com/wp-content/uploads/2019/02/Press-release-Riversimple-win-%C2%A31.25m-funding-award-190208-1.pdf
[47] Transport Environment, 2018, https://www.transportenvironment.org/news/evidence-norway-poor-supply-cars-holding-back-e-vehicle-revolution

customer feedback and the usability of the vehicle and the refuelling station will be important to demonstrate the Rasa to potential investors, attract customers and provide vindication to scale-up the manufacturing capacity or the Rasa.

The manufacturing capacity of the Rasa needs to be scaled up to reduce the costs per vehicle. Riversimple is aiming to develop manufacturing facilities with a production capacity of c.5,000 vehicles per year. This will require significant investment, backed by the demand from customers. Alongside the requirement for investment, a site for the manufacturing facility will need to be identified.

Provided the investment can be secured for the manufacturing scale-up of the vehicles, a zero carbon and readily available supply of hydrogen will be required in the regions for deployment. To support the Rasa local clusters of hydrogen refuelling stations will need to be established. As a smaller vehicle the Rasa is less suited to longer drives than other hydrogen fuelled cars, such as the Toyota Mirai or Hyundai NEXO, and hydrogen refuelling stations at motorway service stations will be of less use than local refuelling stations in and around urban areas. This might require collaboration with hydrogen suppliers, refuelling station operators and landowners who are willing to provide sites for hydrogen refuelling stations.

As a new company entering a very competitive consumer vehicle market, Riversimple will need to quickly develop a customer base. This is in addition to convincing customers to a nonstandard business model that is based on sign up to a monthly contract that includes fuel, vehicle maintenance and insurance, rather than purchasing vehicles outright. The trial demonstration of the Rasa in Monmouthshire will help to raise the profile of Riversimple in the local area. They also have an active online presence and crowd funding activities will help to attract new customers, however they will still need to provide a compelling customer offer. It is also likely that they will initially be constrained geographically to find customers based on the available hydrogen refuelling infrastructure. HRS will need to be installed to support the Rasa fleets, an orderbook with pre-orders from customers would help to strengthen Riversimple's case to secure siting partners for refuelling stations. This would help to show the potential demand from customers at the HRS, where potential siting partners could benefit from increased footfall at the refuelling station increasing opportunities for revenue at associated shops/supermarkets etc.

5.3.4 Budget considerations and fuel cost comparison

The pricing details for the Rasa are yet to be released, although Riversimple estimates that production scale-up will reduce the bill of materials costs by >80% from the current cost of the Rasa prototype. Riversimple is planning to lease the vehicle to customers, including the cost of maintenance, fuel and insurance, so all these costs would need to be considered when comparing the cost of the Rasa with other vehicles. The lightweight design of the Rasa reduces fuel consumption, and the 1.5 kg H_2 on board is estimated to provide a 300-mile range[48]. The fuel efficiency and range of the Riversimple Rasa is compared with a similar battery electric and diesel car in Table 12. It should be noted the Riversimple Rasa range is based on the estimates from Riversimple and further data from the customer trial can validate this.

Table 12: Summary of fuel efficiencies of different fuel cell, battery electric and diesel cars

	Vehicle mass	Estimated range[49]	On-board fuel/ energy storage	Fuel efficiency
Riversimple Rasa	580 kg	485 km	1.5 kg H_2	0.3 kg/100 km
Battery electric car	1,480 kg	233 km	40 kWh battery	17.6 kWh/100 km
Diesel car	1,200 kg	950 km	43 L diesel	4.5 L/100 km

The fuel/energy consumption of the three vehicles shown in Table 12 are compared to each other in Figure 14 (the red crosses indicate fuel/energy consumption and correspond to the axis on the right). The fuel consumption of the diesel car (based on the Ford Fiesta 1.5 TDCi currently used in the MCC fleet) equates to 45 kWh/100 km[50],

[48] Riversimple, https://www.riversimple.com/technology-behind-rasa-hydrogen-car/
[49] Based on range of Renault Zoe (https://www.whatcar.com/news/renault-zoe-long-term-test-review/n16067) Ford Fiesta 1.5 TDCi (https://www.honestjohn.co.uk/realmpg/ford/fiesta-2017/15-tdci-85) and Riversimple Rasa (https://www.riversimple.com/the-technology-behind-the-hydrogen-car/)
[50] Based on diesel density of 1.19 kg/L and lower heating value of 11.93 kWh/kg

this is higher than the electricity consumption of the battery electric car of c.18 kWh/100 km (based on the Renault Zoe).

The lightweight design and aerodynamic efficiency of the Riversimple Rasa results in a lower energy consumption (c. 10 kWh/100 km) than even battery electric cars. The fuel costs are then calculated based on hydrogen at £10/kg excl. VAT (the price advertised by ITM Power at its publicly accessible UK hydrogen refuelling stations) an electricity price of £0.13/kWh for overnight charging[51] and £0.3kWh for fast charging[52] and diesel £1/L (excl. VAT).

The fuel costs are shown in Figure 14 on the axis on the left; at a hydrogen price of £10/kg the Rasa fuel costs are just over £3/100 km. A reduction in the hydrogen price to £7.5/kg H_2 would bring the fuel running costs of the Rasa down to £2.3/100 km, in line with the electric vehicle charging on the average overnight electricity tariff. At the higher end, a hydrogen price of £14.5/kg H_2 would bring the fuel running cost of the Rasa to £4.5/100 km, in line with the diesel car.

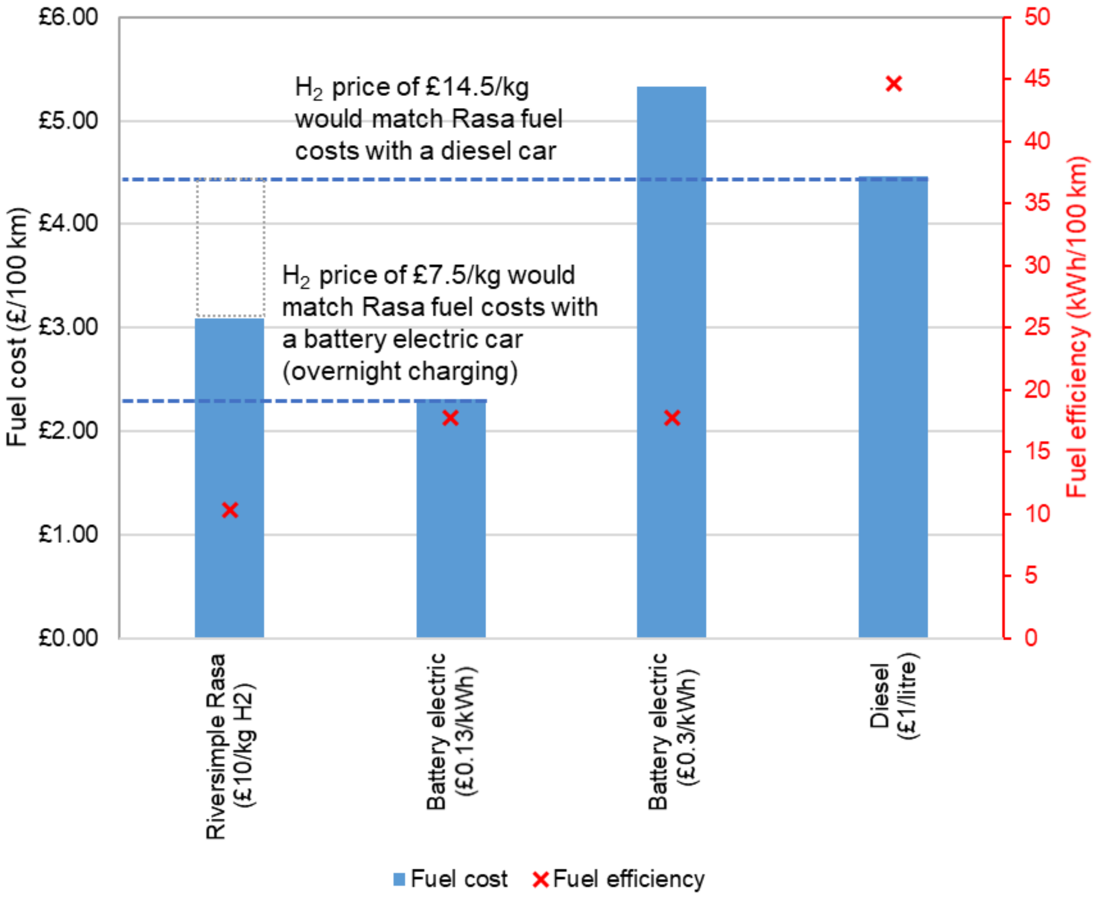


Figure 14: Overview of fuel running costs and fuel efficiency of fuel cell and battery electric cars (H_2 at £10/kg and electricity at £0.13/kWh for overnight charging and £0.3/kWh for fast charging and diesel cost at £1/L)

The highest fuel running cost is from the battery electric vehicle that is recharged from fast chargers at 30p/kWh. This shows the importance of selecting a vehicle based on the vehicle range and mileage requirement, and the cost impact for using a fast charger, where even occasional use would increase the overall running costs of battery electric vehicles.

[51] Pod Point, Cost of charging an electric car; https://pod-point.com/landing-pages/cost-of-charging-electric-car
[52] Ecotricity, Electric car charging stations; https://www.ecotricity.co.uk/for-the-road/our-electric-highway

The fuel costs discussed here should be considered alongside the capital cost of the vehicles, and the maintenance and insurance costs. This comparison illustrates the potential competitiveness of the Rasa, which offers a range of >450 km, fast refuelling times and is competitive with the fuel running costs of electric vehicles, even at the costs of hydrogen today, which are expected to reduce in the near future.

5.3.5 Timescales and next steps

The Riversimple Rasa is still in the prototype stage and as such the timelines for this feasibility project are further behind other feasibility projects (such as buses and vans) that are already able to offer commercial vehicles, albeit at a premium to conventional petrol and diesel vehicles. Riversimple aims to provide the Rasa at the same cost as a conventional car, and continued support of the Rasa is required to scale-up production and deliver these cost savings. Figure 15 shows an indicative timeline for the commercial production of the Rasa, based on Riversimple estimates, with volume production commencing at the end of 2021. Along with supporting the Rasa trial, further development of the hydrogen refuelling infrastructure, perhaps through fuel cell bus, or hydrogen fuelled van deployments would help to establish a hydrogen cluster in Monmouthshire that could improve the case for the Riversimple Rasa deployment.

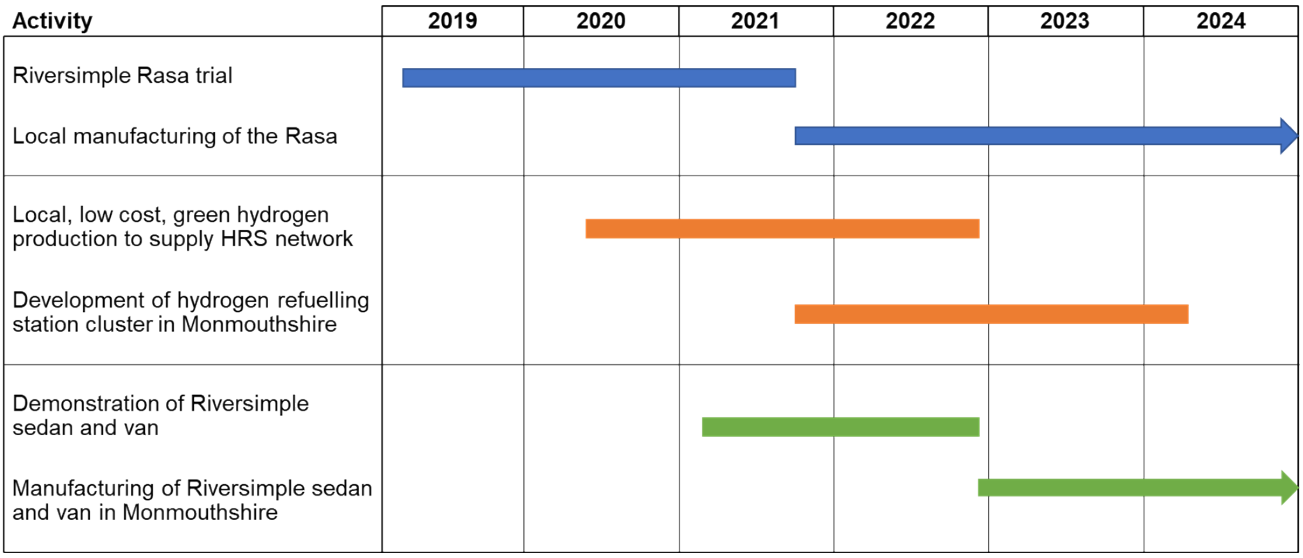


Figure 15: Indicative timeline of Riversimple hydrogen vehicle deployments and manufacturing scale-up

The next steps required to support the development of the Rasa within the Gwent region are outlined below:

1. Facilitate the trial of the Riversimple Rasa by encouraging a varied user base within different Government bodies and private organisations and individuals.
2. Consider wider initiatives to support the uptake of zero emission vehicles across the region, such as free-parking or the use of bus lanes for zero emission vehicles in Abergavenny and Monmouth.
3. Support the siting of hydrogen refuelling stations across the region, potentially assisting in providing sites (or extension of the HRS in Abergavenny) or by supporting suitable sites through the planning application process.
4. Support and develop platforms for hydrogen stakeholders to meet and develop new projects, such as the Decarbonised Industrial Group and Hydrogen Reference Group. These platforms could be developed to follow similar formats as the Hydrogen Hub in Swindon and Oxford[53] or the North-West Hydrogen Alliance[54].

[53] Hydrogen Hub, https://www.hydrogenhub.org/
[54] North-West Hydrogen Alliance, http://www.nwhydrogenalliance.co.uk/

5.4 Hydrogen van trial

5.4.1 Project context and overview

MCC has around 40 vans and over 50 minibuses in its fleet, which equates to 30% of the entire vehicle fleet. Many of the vans cover relatively low annual mileage (see graph), which suggests that battery electric solutions could be a good fit, subject to availability of suitable models. As of early 2019, the choice of battery electric vans is relatively limited and most zero emission vans in the UK are either Nissan e-NV200 or Renault Kangoo ZE vehicles (both small vehicles). However, several manufacturers (e.g. Mercedes, Renault, Volkswagen) have announced plans to bring to market electric versions of larger vans in the coming months / years (see Table 13 below).

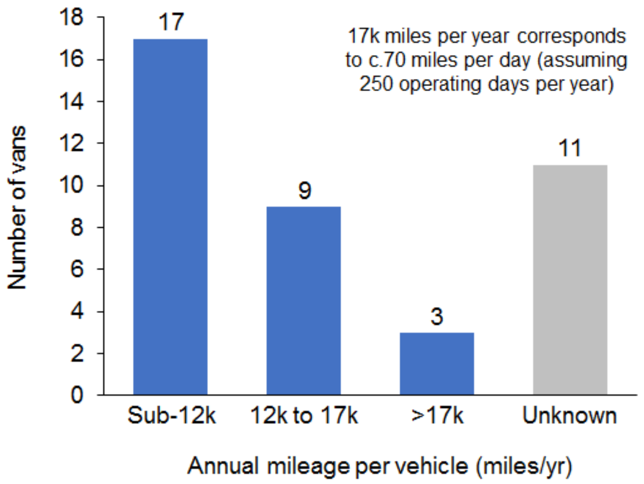


Figure 16: Number of vans in MCC's fleet by annual mileage

A hydrogen-fuelled van could be a suitable option for any vehicles that have daily mileages that regularly exceed the range of pure battery electric vehicles (c. 100 miles/160 km), accounting for variations in real-world range with temperature, driving conditions, etc.

Table 13: Overview of battery electric vans available / coming to market in the UK[55]

Van name	Van type / size	Official driving range*
Renault Kangoo ZE 33	Small van	170 miles
Nissan e-NV200 40kWh	Small van	174 miles
Citroen Berlingo Electric	Small van	106 miles
Peugeot Partner Electric	Small van	106 miles
VW e-Caddy **(on sale mid-2019)**	Small van	160 miles
Mercedes eVito **(on sale 2019)**	Medium van	93 miles
VW e-Transporter **(on sale early 2020)**	Medium van	134 miles (single-battery) / 250 miles (twin-battery)
Renault Master ZE	Large van	120 miles
LDV EV80	Large van	127 miles
Mercedes eSprinter **(on sale 2020)**	Large van	71-93 miles (depending on battery packs)
Volkswagen e-Crafter **(on sale 2021)**	Large van	107 miles
Iveco Daily Electric	Large van	Varies with battery packs

**The official driving range is that given by manufacturer, based on a mandated testing procedure known as NEDC; real-world range is the estimated distance you should be able to do in actual driving. NEDC is due to be replaced by WLTP very soon, and the new testing method is designed to better reflect real-world driving.*

[55] Source: https://www.parkers.co.uk/vans-pickups/advice/2018/electric-van-guide/.

The availability of battery electric vans is relevant for this study as one option for creating a hydrogen-fuelled van is based on adding a fuel cell "range extender" to a base electric, a solution that has been offered by Symbio FCell and which the UK-based company ULEMCo is also developing (see below).

The objectives of a hydrogen-fuelled van in Monmouthshire trial could include:

- Test the real-world performance of innovative zero-emission van technology.
- Provide feedback on the performance of the vans, and the extent to which they meet the Council's needs to vehicle suppliers to inform future product development.
- Increase the demand for hydrogen from the Abergavenny HRS, thus supporting the case for on-going operation of the station.
- Increase awareness of hydrogen and fuel cell technologies amongst MCC staff.

5.4.2 Partners required

Initiating a hydrogen van trial would be contingent upon identifying a suitable organisation to supply the vehicle(s). An overview of the main options is provided below.

Arcola Energy

Arcola Energy is a London-based specialist in hydrogen and fuel cell technologies that is currently offering the Kangoo ZE H2 (see Figure 17) – a battery electric van with a fuel cell range extender, giving a range of up to 250 miles and the ability to recharge (by plugging in) / refuel with hydrogen. Arcola Energy is the "*sales and deployment agent for Symbio FCell in the UK*".

Arcola Energy is also developing a zero-emission powertrain for a 3.5t Transit van via a publicly-funded project. This is a demonstration project for which partners are being sought to deploy trial vehicles in real-world operations.

Figure 17: Symbio HyKangoo hydrogen fuel cell range-extender van

For further information see www.arcolaenergy.com/kangoo-ze-h2/

Microcab

Microcab is a spin-out from Coventry University and has been developing small, lightweight fuel cell vehicles for many years.

Having tested its vehicles in several demonstration projects (including the FCH EU-funded SWARM[56] project), Microcab is now seeking to commercialise its products. The new "Vianova" vehicle is central to this aim, and although originally built as a small car, a van version is also being planned. Specifications of the Microcab Vianova are shown below in Figure 17.

[56] https://www.swarm-project.eu/

Microcab VIANOVA
Vehicle Specification

Technical Specification	
Length	3.5 meters
Height	1.7 meters
Width	1.6 meters
Gross Vehicle Weight	Approx. 750kg
Chassis	Lotus bonded aluminium
Crash Protection	Front offset impact; side impact; roof crush
Emissions	Zero at point of use

FCEV Powertrain	
Drive	Single AC motor, 40kw peak
Main Drive Voltage	72V
Transmission	Single Speed gearbox, front wheel drive
Lithium Battery Pack	Up to 4kWh capacity
Max Speed	55mph / 88kph
Range on full tank	180miles
Fuel Cell	Low temperature (PEM)
Fuel Cell Power	3.0kW - 10.0kW
Hydrogen Tank Capacity	1.8kg
Hydrogen Tank Pressure	350bar & 700bar

Figure 18: Microcab VIANOVA specification

Note: Microcab has up to six of its "H2EV" vehicles from previous demonstration projects available. New FCEVs from any small-volume manufacturer are likely to come at a relatively high cost due to the fixed costs associated with setting up a production run and leasing an existing vehicle could be a more cost-effective way of trialling the technology. The lead time associated with this route to obtaining a trial vehicle is also likely to be considerably lower than ordering a new FCEV.

For further information see www.microcab.co.uk/the-new-h2ev/.

ULEMCo

ULEMCo is a UK-based company that converts commercial vehicles to run on hydrogen. Two technology options are available:

1) **Hydrogen internal combustion engines** – ULEMCo offers retrofit conversions to compression ignition (diesel) engines, allowing vehicles to run on a blend of hydrogen and diesel. The company has experience converting a range of different vehicle types using this technology, including Transit vans and refuse collection vehicles. Conversion costs depend on the number of vehicles (as prices of components such as hydrogen tanks are volume-dependent) but are in the range of £20k to £40k per vehicle.

2) **Fuel cell range extender** – ULEMCo also offers a fuel cell range extender power module for the Nissan eNV200 van. The 8.5kW fuel cell power module with a single tank of hydrogen gives a claimed increase in NEDC range from 106 miles to 192 miles.

For further information see https://ulemco.com/?page_id=2572.

5.4.3 Indicative budget and potential funding sources

The required budget for a hydrogen-fuelled van demonstration project will clearly depend on the details of the activities: type of vehicle(s), number of vehicle(s), ownership model (purchase / lease), trial period, expected use (which affects fuel demands and maintenance requirements), etc.

It may be possible to complete a short-term trial (weeks / small number of months) using a vehicle from an existing demonstration project (e.g. one of the Microcab vehicles supported via the SWARM project) for a relatively modest budget (e.g. sub-£10k). However, procuring a "new" hydrogen-fuelled van from any of the suppliers outlined above would require a budget of many tens of thousands as a minimum.

Depending on the details of the project, it may be possible to access public funding to support a trial. For example, UK Government funding for these types of projects is often made available via Innovate UK.

5.4.4 Timescales and next steps

Based on a review of MCC's current vehicle fleet, it appears that most of the vans have annual mileages that equate to average daily distances that are consistent with the expected ranges of battery electric vans that are now entering the market. Provided that a battery electric vehicle can meet the operational requirements, this is likely to be the most cost-effective zero emission option.

In terms of potential for hydrogen-fuelled vans, the most promising option appears to be the Ford Transit van currently used by the "Grounds" department, which has a relatively high annual mileage and which could be converted to become a dual-fuel vehicle (or replaced with a new dual-fuel van from ULEMCo).

The minibuses operated by MCC have on average a higher annual mileage than the vans, and therefore could offer a more suitable fit for hydrogen vehicles. Although ULEMCo has yet to convert a minibus, they have converted both the Ford Transit and Peugeot Boxer, which are available in minibus configurations. ULEMCo converted the Peugeot Boxer which is used as a passenger transport vehicle by the Yorkshire Ambulance Service[57]. This conversion involved removing the front passenger seat to allow space for the fuel cell and hydrogen storage tanks. MCC currently operates over 50 minibuses on services such as the Grass Routes community transport service, some of the higher mileage minibuses operate >30,000 km/year and battery electric configurations are not yet available and would struggle to meet the vehicle range required (particularly in winter when heating requirements would increase the vehicle fuel consumption).

ULEMCo has a demonstration dual-fuel van that can be loaned to potential customers for short periods, and ULEMCo has also indicated a willingness to undertake a wider review of MCC's fleet to understand the opportunities for dual-fuel conversions across several different vehicle types (gritters, minibuses, sweepers, tipper trucks, etc.). The lead time for vehicle conversions from ULEMCo is approximately six months (from order (including payment) to delivery), which includes the lead time for the hydrogen tanks.

The next steps that should be considered in deploying a small of fleet of vans within the MCC are outlined below:

1. Discussions with current hydrogen van operators to learn from the experiences of other end users. This would include local authorities in Aberdeen and Fife, as well as the Yorkshire Ambulance Service and Westminster Council who have trialled hydrogen vans from ULEMCo and Symbio.
2. Discussions with hydrogen vehicle manufacturers/providers, including Microcab, ULEMCo and Arcola Energy to discuss in further detail the vehicle options they are able to offer. This could also include opportunities to trial vehicles such as the Microcab H2EV, developed as part of the EU funded SWARM project.
3. The deployment of a small fleet (<5 vehicles) of hydrogen vans could be supported by the existing HRS at Abergavenny, however for additional vehicles either an extension to the Abergavenny HRS, or a new HRS would be needed. The commercial case for a new HRS serving fuel cell and hydrogen dual fuel vans would be strengthened by increased number of hydrogen fuelled vehicles in the region. Therefore discussions with

[57] Yorkshire Ambulance Service, 2018, Pioneering patient transport vehicle joins Yorkshire Ambulance Service, https://www.yas.nhs.uk/news/media-releases/2018/pioneering-patient-transport-vehicle-joins-yorkshire-ambulance-service/

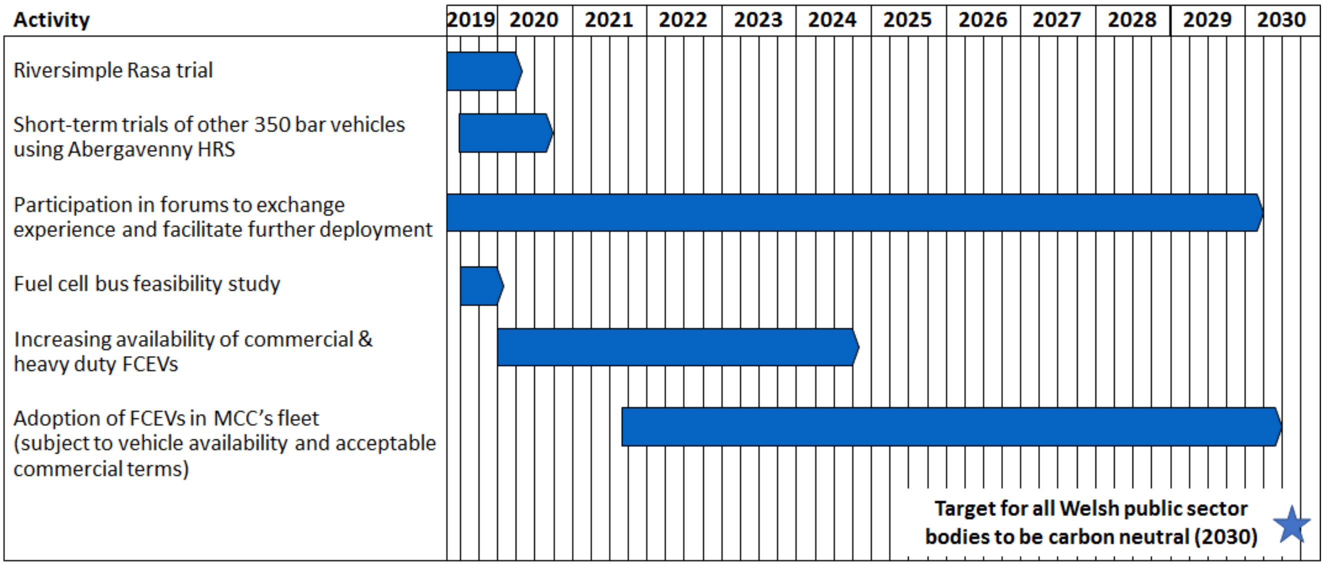
private vehicle fleet operators, as well as potential HRS operators would help to form a case for an additional HRS. These discussions could be part of a wider platform to generate interest in hydrogen transport options, such as the Hydrogen Hub concept in Swindon and Oxford.

6. WP3 Task 1-3 Conclusions

Based on the review of Monmouthshire County Council's fleet, availability and characteristics of hydrogen-fuelled vehicles in this study the following conclusions can be drawn:

- The current range of hydrogen fuelled vehicles available includes light vehicles, such as cars and range-extender or dual-fuel vans to fuel cell buses and dual-fuel refuse collection vehicles and road sweepers. There are plans from various vehicle manufacturers to release increasing numbers of hydrogen fuelled vehicles in the near future (within the next five years), particularly in the heavy duty vehicle sectors.
- Hydrogen-fuelled vehicles are particularly well suited to heavy duty applications, and in some cases may be the only viable zero emission option. While the cost of hydrogen-fuelled vehicles is currently high as the technology is in a pre-commercial phase of deployment, costs and hence prices of these vehicles could reduce significantly with increasing scale of manufacturing expected from the growing demand for zero emission mobility solutions.
- MCC is supporting the Riversimple fuel cell car trial by integrating a small number of Rasa cars into the fleet. The composition of MCC's fleet means that until more hydrogen vehicles in the van / minibus / truck segments are available, the opportunities for the Council to use more hydrogen-fuelled vehicles in its day-to-day operations are relatively limited. However, the hydrogen transport sector continues to develop, several major strategic studies have identified heavy duty vehicles as a key application area for hydrogen, and vehicle manufacturers are responding to this opportunity. MCC should therefore follow developments in this sector and monitor the availability of zero emission vehicles across a wide range of classes.
- To build on the momentum created around hydrogen transport locally, MCC should continue to work with Riversimple, trial the cars, provide feedback, and support the on-going efforts to identify additional early adopters of the technology that will be required for Riversimple to realise its plans to increase the scale of production and commercialise the technology (the target date for the start of series production is currently late 2021).
- There is spare capacity at the Abergavenny hydrogen refuelling station (HRS) installed as part of the Riversimple trial and therefore an opportunity to refuel and trial other 350 bar vehicles in the short term. Given the relatively high cost of hydrogen from the station, it is unlikely to provide an economically sustainable source of fuel on an on-going basis for vehicles other than the most fuel efficient (such as the Rasa). The most feasible route for MCC to obtain hydrogen-fuelled vehicles in the near term would be short-term tests of existing demonstration vehicles from companies such as Microcab or ULEMCo, both of which have vehicles that could be made available for trials. Further discussions with these suppliers would be needed to determine the details of any such demonstration.
- The case for installing additional HRS in the area is likely to rely on significant increases in the demand for hydrogen for transport applications, implying fleets of tens of vehicles and an investment of several million pounds. If vehicle numbers increase, the preferred location for new refuelling infrastructure will depend on the types of vehicles, users of the vehicles, and other factors. For example, Riversimple cars are designed as small, ultra-efficient vehicles mainly for local use and HRS for Riversimple customers are expected to be sited in and around towns. On the other hand, drivers of larger vehicles that might be used for inter-city driving on a more regular basis may be better served by HRS in slightly different sites. An initial assessment of the base locations of MCC's fleet vehicles suggests Caldicot (near the M4 / M48) and Raglan (on the A40 / A449) could be good strategic sites for HRS mainly used by Council employees while providing links to stations in Swindon and Port Talbot.
- Hydrogen transport projects require a range of stakeholders including vehicle providers, end users and hydrogen fuel suppliers. MCC could help to facilitate hydrogen projects in the region, potentially partnering with other local authorities to establish a platform where these stakeholders can meet and develop projects. This would also help to raise awareness amongst and increase the profile of hydrogen as a transport fuel across Wales.

- Discussions with current users of hydrogen vehicles, such as the local authorities in Aberdeen, Fife, as well as the Yorkshire Ambulance Service would provide an insight into the day-to-day operations of hydrogen vehicles within a fleet and the potential challenges and issues that need to be considered when planning any deployment project.
- A proposed pathway for further development of the hydrogen fuelled vehicle fleet is illustrated below. Initial discussions with existing hydrogen customers, hydrogen vehicle providers and potential hydrogen stakeholders in the region would be the first steps to develop a hydrogen transport project in the region. The detail of the project and timelines would be dependent on the scale and scope of the project, with a potential hydrogen bus project deploying 40 fuel cell buses estimated to require approximately £10 million of additional funding.



7. WP3 Task 4 - Engagement Meeting/Facilitation

Jacobs and Element Energy have been involved in discussions with MCC around hydrogen, mainly focused around the engagement with Riversimple. This has taken the form of calls with relevant stakeholders; a summary of the key ones is given below:

- Meeting in August 2018 between Jacobs and MCC to discuss provision of Riversimple Hydrogen Vehicle Trial checklist. This checklist lists the actions to be taken to explore this opportunity and is included in full in Appendix A.
- Kick off call with MCC in December 2018 to ensure that the expected outcomes of the reporting for the hydrogen fleet assessment, infrastructure and trail projects were discussed. This call also served as a scoping call to assess the current data available and how this compared to the data that Element Energy required to undertake the hydrogen assessment.
    - Update call in January 2019, progress update on the work and the ongoing engagement with Riversimple and how MCC wanted this to be shaped. MCC informed that they were happy to continue with the Riversimple engagement based on previously provided checklist and take the lead on this.
- Call with colleagues at Caerphilly and Torfaen in January 2019 to discuss scope and data being collected for the parallel EV infrastructure project for Gwent being conducted by Urban Foresight and the Carbon Trust EV review for Gwent. This was to assist with wider work to integrate fleet and sustainable fuel assessment across both EV and hydrogen for Gwent to increase efficiency of this process and give a full picture of options.
    - This data will be used for a project, expected to start in April 2019, that will expand the hydrogen review that has been carried out for MCC (excluding the trail project feasibility) to the other four fleets in the Gwent region.

8. Sustainable transport/low carbon strategy recommendation

Placeholder for recommendations based on a review the outputs form the Urban Foresight and Carbon Trust work to combine the conclusions to make suggestions for a future for a sustainable transport/low carbon vehicle strategy which could be developed further by the Council.

9. Case Study – Learnings Infrastructure and Fleets

Rachael from Torfaen has already collected her learnings about EV infrastructure and fleets

Tracy similarly has some thoughts on this

Energy savings trust already have theirs ready from their perspective and their views on local authorities issues

- Data collection process – found there was no one person responsible for transport/energy in the authorities so not on people's agenda. Fragmented so need co-ordination and strategy which can be kept up to date.

- Fleets – authorities struggling to respect timeframes decarbonisation and air quality - they have old fleets compared to emergency services and health authorities. In particular it's the heavier vehicles which are the oldest and more expensive but they do not carry out the mileage which huge investment could support i.e. 9,000 miles a year

- Lack of high mileage to justify low carbon investments as EVs need certain mileage before they become economical is my understanding?

- People using their own cars and how to influence their moving to low carbon vehicles and maintenance was found to be suspect

- GDPR obtaining detail for grey fleet use was hard and complicated and needs to be an improved way of doing this for future fleet reviews.

- Insurance need check on type of insurance if want to introduce car clubs as covering under 25 can prove difficult when this group may be the ones that are most used to not owning their vehicles and so more likely to access this type of new service for the future.

Urban foresight already have insights which they can share on this too.

Plus yours and Element Energy

Placeholder - This section pulls together the learning from this work (and the EV review work) to inform future similar pieces of work that may be undertaken by other local authorities. This includes a list of key elements together with a case study to help inform Welsh Government and other Local Authorities of how to achieve added value activities.

Appendix A. Riversimple Hydrogen Vehicle Trial checklist

Action	Information Required	Outcome	Timescale
1. Arrange a meeting with Riversimple to explore the potential of having a Rasa car as part of the trial	Fiona Spowers Riversimple Movement Ltd T. 01597 821060 M.07768 351005	Meeting booked with person responsible for agreeing to hire out Rasa trial to individuals?	August 2018
2. Meeting with Riversimple	- When is the trial taking place? - What sort of journeys could the car be used for? - Who is able to drive the vehicle? - How long can the council have the vehicle? - What training is required to fuel/drive the car? - What insurances are needed? - What costs will there be to the council? - Would Riversimple be supportive of MCC having a Rasa car for the trial?	Understand timescales/cost and feasibility - Make a decision around whether the Rasa trial is suitable for MCC	September 2018
3. Review telematics in cars to understand which car has suitable journeys which the Rasa could replace.	- Which journeys are only transporting the driver and one passenger with no luggage? - Which location is best for the Rasa to be based?	Car chosen to be substituted for Rasa	October 2018
4. Present the case to MCC Cabinet	Prepare paper on the costs and benefits of having a Rasa vehicle for a trial and confirm budget	Approval to process with Rasa trial	November / December 2018
5. Engage with staff to clarify which car will be replaced and provide training if needed for staff drivers	List of staff who would be able to/interested in driving – provide to Riversimple		January 2019

6. Plan and Produce Marketing Campaign to raise awareness of the Rasa being used by MCC	Gather as much detail as possible about the vehicle, user experience of the Rasa and show how it fits with MCC' goal to support sustainable mobility		January 2019
7. Riversimple RASA trial takes place in Monmouthshire			TBC
8. Contact the press to run marketing campaign		Raise awareness of MCC leading the way in sustainable fuels	TBC