optimat

Skills for low carbon Heavy Duty Vehicles

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1 Executive Summary

Transport accounts for 37% of total greenhouse gas emissions in Scotland, with Heavy Duty Vehicles (HDVs) accounting for 12.5% of these. The decarbonisation of HDVs will, therefore, play an important role in achieving the Scottish Government's objective for Scotland to be net-zero by 2045.

Unlike the situation for decarbonisation of cars and light vans (weighing 3.5 tonnes (T) or less), where electrification is widely accepted as the predominant solution, there are multiple potential low carbon technologies which could support HDV decarbonisation. The HDV fleet is also much more diverse than cars and light vans in terms of the driving range and payload capabilities required, meaning different low carbon technologies can be more, or less, suitable for different markets such as bus and coach, heavy goods vehicle (HGV) and off-highway construction and agricultural HDVs. Low carbon HDV technology options include battery electric, fuel cell electric, direct hydrogen combustion (both dual-fuel with diesel and pure hydrogen), biomethane and pantograph systems (the latter providing electrical power via fixed overhead cables similar to the operation of electric trams and trains).

1.1 The HDV fleet and low carbon technology options

There are 52,000 HGVs, buses and coaches (weighing over 3.5T) in Scotland with current adoption of low carbon vehicles being approximately 0.14%. In addition to this there is a significant (but unquantified) number of other HDVs used in the construction and agricultural sectors. From the current limited use of low carbon HDVs, a significant change in adoption rate will have to be achieved to contribute to the net-zero target. Uptake of low carbon HDVs is being driven by Government policy with a current consultation testing proposals for a ban on the sale of non-zero emission HGVs of 26T and under by 2035 and for those above this weight by 2040 (or earlier if a faster transition seems feasible). Supply chain pressure is also delivering adoption of low carbon HDVs, particularly from food and drink retailers. However, there are significant barriers for an HDV operator to shift from diesel to low carbon alternatives, including for example, capital cost of vehicles, availability of fuel and potential downtime whilst recharging, concerns regarding the ability of vehicles to match the distance and payload requirements of operators, availability of suitable low carbon HDVs on the market, etc.

All of these factors create uncertainty about how the level of adoption of low carbon HDVs will change in the short to medium term (2026) and medium to longer term (by 2032). In turn, this impacts on when, and at what scale, skills will be required to support the uptake of low carbon HDVs. The relationship between skills availability and levels of low carbon HDV adoption is interdependent as lack of skills in some areas can act as a barrier to adoption.

Based on a scenario of low carbon HDV adoption, validated by stakeholders, it is estimated that, by 2026, between 5% and 12% of the HGV, bus and coach fleet could be low carbon in Scotland. By 2032, this range could increase to between 17% and 39% of low carbon adoption in HGVs, buses and coaches.

There are over 87,000 employees across the HDV landscape that are likely to require some level of skills development as low carbon HDVs are adopted into the fleet. This estimate rises to 93,000 by

2032 due to a projected increase in road freight journeys. Of this total, between 34,400 and 38,200 people are likely to require some level of skills development relating to low carbon HDVs by 2026 and between 41,000 and 53,200 by 2032. Emergency service personnel, who need new skills to safely and competently attend road traffic incidents if they involve low carbon HDVs, account for most of the skills development need (in terms of number of people requiring training). All Driver and Vehicle Standards Agency (DVSA) personnel involved in HDV inspection, assessment and examination will also require new skills to safely and competently work with low carbon HDVs. The remaining employees across the HDV landscape require new skills in different areas, both technical and commercial, and the timing of developing these skills is linked to the rate of adoption of low carbon HDVs.

The figure below summarises the different segments of the low carbon HDV landscape in Scotland and the key stakeholder groups within each. Over 50 stakeholders were interviewed during the research for this study alongside a telephone survey of 44 HDV garages. This has provided a representative sample of opinions across the HDV landscape.

Manufacture of parts, components, systems & fuels	Vehicle Manufacture/ Systems Integration/ Conversion	Charging/ Refueling infrastructure developers/ operators	Vehicle Sales/Leasing	Vehicle owners/ operators	Vehicle inspection, service, repair, maintenance and recovery	End of life/ second life
Battery Electric Hydrogen Fuel Cell Biomethane ICE Hydrogen ICE EV Charging infrastructure Hydrogen Production & Refuelling Biofuel Production & Refuelling	Bus/ Coach Heavy Goods Vehicle Construction Heavy Vehicle Agriculture Heavy Vehicle Other, e.g. Emergency Services, RCVs, etc.	EV Battery Charging Hydrogen Refuelling Synthetic/ Biofuel Refuelling	Bus/Coach Sales/Leasing HGV Sales/Leasing Construction Vehicle Sales/Leasing Agriculture Vehicle Sales/Leasing Other Vehicle Sales/Leasing	Bus/ Coach Heavy Goods Vehicle (Third party and own fleet) Construction Agriculture Municipal Other Public sector e.g. Emergency Services Private Waste Management	HDV Garages (including private depots) HDV Roadside Recovery HDV Inspection (including DVSA and during remarketing) Emergency services attendance at Road Traffic Incidents	End of Life/ second life (e.g. EV batteries) Remanufacture

Supporting organisations							
Researchers/ Academics	Researcher and Technology Organisations	Finance providers	Policy makers/ Enterprise Agencies	Trade bodies	Skills/Competence Accreditation Bodies	Private training providers	Colleges and HEIs

1.2 Skills shortage and gaps in the low carbon HDV landscape

A number of skills shortages and gaps have been identified across different segments of the HDV landscape including:

- Potential future skill shortages for manufacturers/systems integrators at both engineer and technician level in areas such as electronics, electrical engineering, software, engineering

design and manufacture/integration of high-pressure gas systems. Note these are skills shortages rather than skills gaps as there is training provision available to develop these skills
- A lack of a focused Apprenticeship Framework for hydrogen refuelling infrastructure installation and maintenance to provide young people with a clear pathway into hydrogen infrastructure s a career
- A lack of a mandatory requirement for low carbon skills development in the Modern Apprenticeship Automotive Framework
- A lack of skills development content for safe and competent working on high pressure gas systems within HDVs (hydrogen and biomethane) beyond that available via manufacturers
- A lack of skills development options for safe and competent working on hydrogen fuel cell systems within HDVs beyond that available via manufacturers (although there are manufacturer independent options for the electrical drivetrain element of a hydrogen fuel cell vehicle)
- A lack of skills development options for people who sell/lease low carbon HDVs, and independent certification to demonstrate they have the necessary cross-technology technical and commercial skills
- A lack of skills development options for HDV operators (particularly smaller private sector HGV operators) to identify and assess (technically and commercially) low carbon HDVs
- A lack of skills in client consulting engineers impacting on their capability to develop the technical information required to support planning and consent processes for new hydrogen refuelling infrastructure
- A lack of data to support skills development relating to real-world performance data of different types and sizes of low carbon HDVs operating across a range of duty cycles
- A lack of skills development options for emergency services personnel concerning the constantly increasing range of low carbon HDVs they may encounter at a road traffic incident
- A lack of data to support skills development of emergency service personnel and DVSA inspection and assessment personnel, regarding the availability of current technical specification data covering the constantly changing diverse range of low carbon HDVs. This is necessary to allow them to work safely and competently at road traffic incidents, garage assessments and roadside examinations.

Action is required to address these skills gaps to support the uptake of low carbon HDVs in Scotland, together with clarification of the policy position regarding the role of biomethane and direct hydrogen combustion in the HDV decarbonisation roadmap for Scotland.

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2 Introduction

This report has been prepared by Optimat Ltd for Transport Scotland to present the results of a study into the skills required to support the uptake of low carbon heavy duty vehicles (HDVs). It is based on research carried out over the period March 2021 to August 2021 including 52 stakeholder interviews and a survey of 44 HDV garages. Optimat were supported by several partners in completing the study, including the Energy Technology Centre, CJM Research and Algiz Ltd.

2.1 Background

Transport accounts for 37% of total greenhouse gas emissions in Scotland and HDVs account for 12.5% of transport emissions. It is therefore important to better understand the skills required to support the adoption of low carbon HDVs to tackle this significant source of greenhouse gas emissions.

Low carbon HDVs are more complex to address than low carbon cars and light vans. For example, there are more drivetrain technology options to choose from and there is considerable diversity of vehicles within the HDV category (from 3.5 tonnes(T) to 44T) with a range of performance requirements, in terms of distance covered by vehicles and the payloads they must be capable of handling. The supply of low carbon HDVs varies across vehicle types with most options being at the lower end of the weight range. There is a need to understand how attractive different low carbon technologies are for different HDV markets, including the infrastructure necessary to support them. The type and timing of adoption of different low carbon HDVs has a direct relationship on the nature and scale of skills required at different parts of the HDV landscape.

Transport Scotland requires to develop a baseline of evidence around low carbon HDV skills so that they can work with partners to address skills gaps and barriers across the HDV landscape.

2.2 Study scope and objectives

This study investigates low carbon HDVs, classed as weighing above 3.5T and registered in Scotland.

The HDV landscape consists of a number of segments, including:

- System suppliers, fuel producers and refuelling/charging infrastructure suppliers
- HDV manufacturers / systems integrators and convertors
- Charging/ refuelling developers and operators
- Vehicle sales and leasing companies
- Main end use markets for HDVs
- HDV inspection, service, repair and maintenance garages, roadside recovery and emergency services
- Companies active in end-of-life treatment/second life opportunities (including remanufacture) for HDVs and/or component parts (e.g. electric vehicle (EV) batteries)

Low carbon HDV skills have been considered in the short to medium term (2026) and the medium to long term (2032).

The study brief identified three intended outcomes for the research:

- Identification of current levels of capacity and capability of the required skills to support the transition to low carbon HDVs.
- Identification of Scotland's skills requirements to support the transition to low carbon HDVs.
- Identification of specific areas which need greater support/specific interventions to support the skills requirements.

Several key research questions for this piece of work were specified in the tender invitation, as follows:

- What are the key skills required for people to work on low carbon HDVs, including those needed for:
    - repair and maintenance,
    - refuelling,
    - day-to-day upkeep/utilisation,
    - retrofitting, and
    - the supply chains, design, manufacture and production, of HDVs.
- What, and where are the skills gaps, for these requirements.
- Identifying where these transferable skills and talent might exist within other sectors of the economy.
- Does Scotland have, or is developing, the skills required to support the transition to low carbon HDVs?
- To what extent are garages and vehicle operators in Scotland equipped / preparing for the transition to low carbon HDVs.
- To what extent are colleges, universities, research and development organisations, and other training providers in Scotland, equipping people with the required skills for the transition to low carbon HDVs.
- What organisations provide skills training, where are they based, and what areas in Scotland do they cover/not cover.
- What are the barriers to developing the skills in the Scottish economy that are required to support the transition to low carbon HDVs?
- How are businesses currently involved in the sales and leasing of HDVs, planning to transition into low carbon HDVs, and how are they upskilling their staff to do so?
- How can transferable skills from other sectors such as engineering, design, and system integration, be utilised to support the growth and development of low carbon transport manufacturing capabilities.

To provide a basis upon which the nature and scale of different skills requirements could be analysed, it was agreed that scenarios of potential levels of low carbon HDV adoption were needed for the 2026 and 2032 periods. Following this it was also agreed to consider the relative importance of different low carbon HDV technologies in achieving these levels of adoption. Initially, the following technologies were identified as being in scope:

- Battery electric
- Hydrogen fuel cell electric
- Biomethane direct combustion in an internal combustion engine

During discussions with stakeholders, it became clear that consideration should also be given to:

- Direct hydrogen combustion in an internal combustion engine (both in hybrid dual fuel format, mixed with diesel and, in future, 100% hydrogen fuel)
- Pantograph systems to run electric HDVs

Section 3 describes the research method used to achieve the intended outcomes and answer the research questions.

3 Research method

The study commenced with a desk review of relevant policies, strategies, papers, articles and other data sources. This provided input into projections of the development of the low carbon HDV fleet in Scotland including an appropriate framework to segment the landscape and the main stakeholder types in each segment. Estimates of the number of HDVs in Scotland were made by combining data about different HDV applications (bus/coach and heavy goods vehicle (HGVs), Data for construction and agricultural HDVs lacked robustness and was therefore not included in the quantitative analysis. Estimates were also established for the number of employees in each HDV segment (e.g. vehicle manufacture, sales and leasing of HDVs, HDV garage technicians etc.).

Various reports were reviewed to create a draft understanding of the potential levels of low carbon HDVs over the two periods of interest, to 2026 and 2032. This also included developing an understanding of the relative attractiveness of different low carbon drivetrain technologies. This information was then initially tested on a small number of stakeholders (~10) before being revised to account for their feedback. Wider stakeholder engagement was then carried out to gather feedback via semi-structured qualitative discussions. Across these two activities, a total of 102 stakeholders were contacted and feedback was obtained from 52 stakeholder interviews. In parallel with this a structured telephone survey was carried out with HDV garages in Scotland. A total of 92 garages were contacted and 44 interviews carried out. Appendix A provides a list of organisations that kindly contributed to the study, either via the stakeholder interviews or the telephone survey of HDV garages, and consented to being named in this report.

The collated evidence base was then analysed to create draft scenarios of the potential adoption levels of low carbon HDVs across different applications. The potential relative importance of different low carbon drivetrain technologies in achieving these levels of adoption was also drafted. These draft findings were then tested at an expert workshop carried out in July 2021, attended by a group of six stakeholders (who had already participated in the stakeholder interviews). These six stakeholders provided technical expertise across a range of low carbon HDV technologies and included systems integrators and academic researchers. The purpose of this workshop was to test and improve the scenarios for low carbon HDV adoption in different applications and the relative importance of different low carbon technologies. The feedback received during this workshop was used to iteratively improve the low carbon HDV scenarios and our understanding of the types of low carbon technologies that would likely be utilised to achieve these adoption rates.

Finally, a validation workshop was held in August 2021 with eight attendees representing operators across different application areas. Our draft findings were presented and feedback received about the feasibility of the adoption rate scenarios, relative use of different technologies and the implications this would have for skills requirements and skills gaps. This feedback was used to further improve the study findings. The draft final report was then completed alongside a draft infographic, as required in the invitation to tender.

4 The HDV fleet and low carbon technology options

This section includes a description of how the Scottish HDV fleet has been segmented and quantified for the purposes of this study. It also identifies the drivers and barriers associated with different low carbon technology options and summarises the relative attractiveness of each technology for different vehicle applications in 2026 and 2032.

4.1 Segmenting and quantifying the HDV fleet

HDVs include a wide variety of different types and weights of vehicle ranging from 3.8T ambulances to 44T articulated lorries. Due to the wide variation in types of vehicles and the applications they are used for, different low carbon technologies can be more or less relevant. It is, therefore, useful to segment them into groups with some common characteristics.

For the purposes of this study, we have classified HDVs into four groups:

- Buses and coaches – including vehicles servicing Scotland's bus routes and other buses and coaches involved in activities such as tourism coach tours, private transportation, etc.

- HGVs (3.5T to 18T) – including lighter road freight vehicles (typically 2 axle), ambulances and most fire appliances

- HGVs (over 18T) – including heavier road freight vehicles (typically 3+ axles), some heavier fire appliances and much of the municipal fleet of refuse collection vehicles and road gritters

- Other HDVs – including off-highway vehicles used in construction (e.g. crawler excavators) and agriculture (e.g. tractors)

A further description of each group, including the number of vehicles in each group and indicative annual vehicle replacement rates, is provided below.

4.1.1 Buses and coaches

There were 12,515 buses and coaches licensed in Scotland at the end of 2020. In the previous four years (2016 to 2019) the average was 14,558. The fall in numbers of licensed buses and coaches in 2020 is likely to be due, in part, to the COVID pandemic where some vehicles will have been kept off the road during that period.

There were 403 buses and coaches registered for the first time in 2020 in Scotland. This is lower than the average of 748 in the previous four years (2016 to 2019). It is likely that the reduction in first registrations of buses and coaches was related to the COVID pandemic, with companies delaying decisions to purchase in 2020.

The Department of Transport provides a breakdown of licensed buses and coaches by body type for the UK but equivalent data specifically for Scotland could not be identified. It is reasonable to assume that the split in body types of buses and coaches in the UK is broadly representative of buses and coaches in Scotland. Figure 1, below, shows estimates of the breakdown of the Scottish bus and coach fleet by body type, based on the average UK segmentation.

Body Type	UK percentage of total licensed buses and coaches	Estimated number of Scottish buses and coaches (based on total of 14,558 – average over 2016 to 2019)
Minibus	55%	8,007
Single deck bus/coach	27.7%	4,033
Double deck bus/coach	16.7%	2,431
Other	0.6%	87

Figure 1 - Estimate of Scottish bus and coach fleet by body type

A recent report produced by EY for the Scottish Government states that there are c.4,200 buses currently servicing Scottish bus routes with only 23 being low carbon (including both electric vehicle and hydrogen fuel cell).

Department for Transport statistics state that of all the buses and coaches licensed in Scotland, 60 were classed as Ultra Low Emission Vehicles (ULEVs) as at quarter one of 2021. ULEVs are vehicles that are reported to emit less than 75g of carbon dioxide (CO_2) from the tailpipe for every kilometre travelled. In practice, the term typically refers to battery electric, plug-in hybrid electric and fuel cell electric vehicles.

Over the period 2017 to 2032, it is projected that annual passenger miles in urban buses will decrease by 6% and inter urban buses will decrease by 2%. It is reasonable to conclude that the total bus and coach fleet will reduce slightly in size over the same period to reflect this reduction in usage.

4.1.2 HGVs (3.5T to 18T)

At the end of 2020, there were 34,971 heavy goods vehicles licensed in Scotland. This is the lowest annual figure since 2003 and may have been impacted by vehicles being temporarily taken off the road during the COVID pandemic. Over the past four years (2016 to 2019) the average annual number of heavy goods vehicles licensed in Scotland was 37,473. It is assumed that this is a more accurate reflection of the number of licensed HGVs, adjusting for the impact of the COVID pandemic.

There were 2,804 newly registered HGVs in Scotland in 2020. This is lower than the average figure of 4,293 for the previous four years (2016 to 2019) and the 2020 total is likely to have been affected by the COVID pandemic. For all HGVs, new registrations of 4,293 represent 11.5% of the total average number of licensed HGVs of 37,473.

To identify the number of HGVs in the 3.5T to 18T segment in Scotland, it is assumed that the proportion of HGVs in different weight categories is the same as the UK. The figure below shows the estimated Scottish weight category breakdown based on this assumption and also derives the number of new registrations based on the assumption that replacement rates are consistent (at 11.5% of licensed vehicles) across all weight categories.

Weight range	% of total HGV (based on UK data)	Est. licensed HGVs by weight range	Est. new registrations per annum (based on 11.5% of licensed vehicles)
Up to 7t	13.8%	5,171	595
Over 7t to 8t	18.6%	6,970	802
Over 8t to 18t	19.8%	7,420	853
Over 18t to 31t	12.2%	4,572	526
Over 31t to 41t	11.3%	4,234	487
Over 41t	24.3%	9,106	1,047
Total	**100%**	**37,473**	**4,310**

Figure 2 - Breakdown of numbers of licensed HGVs in Scotland by weight range and estimate of new registrations per annum

Based on Figure 2, there are 19,561 licensed HGVs in the 3.5T to 18T weight category with an estimated 2,250 new registrations each year.

4.1.3 HGVs (over 18T)

Based on the analysis carried out in the previous section it can be seen from Figure 2 that there are 17,912 licensed HGVs in the 18T+ weight category with an estimated 2,060 new registrations each year.

It is likely that total numbers of vehicles in both categories of HGVs will increase over time as goods vehicle trips are projected to increase by 28.5% from 2017 to 2032.

4.1.4 Other HDVs

The bus and coach and HGV segments are a key part of the HDV fleet in Scotland and there is robust data reported for these vehicle classifications. There is another segment of HDVs not covered by this data, mainly relating to off-highway vehicles in construction and agriculture. For this segment the data is not as robust and therefore confidence in the numbers is lower than for the previously defined segments. This section provides a brief summary of the data available about other HDV numbers available, demonstrating the significantly different estimates derived using different data sources.

One method of estimating numbers of construction and agricultural HDVs is to consider annual sales then combine with assumptions on annual replacement rates.

At a UK level there were 32,000 units of construction equipment sold in 2019. Based on sales in the quarter Jan-Apr 2021, the breakdown of construction equipment sales, by equipment type can be applied to the annual sales of 32,000 units (for the UK) to estimate annual unit sales by type (percentages do not add to 100% due to rounding error). An estimate can be made for sales of construction equipment in Scotland based on the assumption that it represents 6% of UK construction equipment sales and that the segmentation of the construction equipment purchased in Scotland is the same as for the UK (based on 6% of UK construction firms being based in Scotland, Source: UK Business Counts Database (data for 2019)). The resulting estimates are shown in *percentages *do not add to 100% due to rounding error*

Figure 3, below.

Construction equipment type	Percentage of total unit sales	Estimated annual unit sales for UK	Estimated annual unit sales for Scotland
Road rollers	3%	960	57
Crawler excavators	19%	6,080	365
Mini/midi Excavators	57%	18,240	1,094
Wheeled loaders	3%	960	57
Others	7%	2,240	134
Telescopic handlers	12%	3,840	230
Total	**101%***	**32,320**	**1,937**

**percentages do not add to 100% due to rounding error*

Figure 3 - Indicative annual sales of construction equipment in Scotland

Note that a significant proportion of the above will be equipment weighing less than 3.5 tonnes, so would not be classed as heavy duty. If it is assumed that all of the mini/midi excavators are less than 3.5 tonnes and all the other categories are over 3.5 tonnes, then the annual Scottish sales of heavy duty construction equipment would be less than 1,000 units. It should be noted that this is a simplification as Mini/Midi excavators on offer by some leading manufacturers range from between 0.8 tonnes and 10 tonnes.

The average lifespan of construction equipment is difficult to state in years as it is typically a function of hours utilised rather than passage of time. However, if it is assumed that the new equipment sales (assuming 1,000 units for Scotland) are to replace end of life equipment then a 5 year average lifespan would indicate a total heavy duty construction equipment stock of around 5,000 units.

Total UK registrations of agricultural tractors (over 50hp) have varied between approximately 10,000 and 12,500 units over the period from 2017 to 2021. The average power of registered tractors (over 50 hp) is 170hp. An average 150hp tractor weighs six tonnes but there are also many examples of agricultural tractors of >50hp weighing less than 3.5T. Therefore, it is reasonable to assume that only a proportion of the registered tractors of >50hp can be classed as HDVs, but it is difficult to identify what that proportion would be. If it is assumed that 50% of tractors of >50hp weigh more than 3.5T then this would mean annual tractor registrations of 5,500 in the UK. Scotland contributes 14% of total UK income from farming, so the annual Scottish tractor registrations (over 50hp) would be approximately 770. This does not include other agricultural equipment such as telehandlers and combine harvesters. Like construction equipment, the longevity of an agricultural tractor is a function of hours utilised; so it is difficult to estimate the total fleet size based on annual new registrations. If it is assumed that the average lifespan is five years, then the total Scottish HDV tractor fleet size would be 3,850.

Combining the above estimates of both off-highway construction and agricultural HDVs gives a total ‘other HDV’ fleet size of 8,850. Clearly there are several assumptions made to reach this estimate and care should be taken with the interpretation of the resulting figures.

However, stakeholder feedback indicated that previous, unpublished, work to quantify numbers of construction and agricultural HDVs in Scotland, based on data sourced from the Driver and Vehicle Licensing Agency (DVLA), had estimated almost a factor of ten higher than produced from the above estimate (the data was provided in confidence and has not been published in the public domain. Therefore, no reference can be provided). Data on vehicles licensed in Scotland in Q1 of 2021, in Scotland, shows 86,000 ‘Other vehicles’ including rear diggers, lift trucks, rollers, ambulances, Hackney carriages, three wheelers and agricultural vehicles. It is not feasible to disaggregate this data based on publicly available sources but it is likely that a significant proportion are agricultural and construction HDVs.

In conclusion, it is assessed that there is a lack of robustness in data for this category of 'Other HDVs' so no point value is stated.

4.1.5 Summary of the HDV fleet in Scotland

Based on the above analysis of numbers of HDVs in the three identified segments, where robust data is available, the following overview can be presented. Note that the numbers are rounded to the nearest 10.

HDV segment	No. of vehicles	Annual new vehicle sales
Bus and coach	14,560	750
HGVs (3.5T to 18T)	19,560	2,250
HGVs (over 18T)	17,910	2,060

Figure 4 - Summary of licensed vehicle numbers and new registrations by HDV segment in Scotland

**Note that the data for the 'Other HDV' category is not included in the above table as estimates are subject to significant potential error due to lack of robust data and subsequent assumptions made.*

From the analysis of the scale of the HDV fleet in Scotland it can be observed that:

- Currently, there is a very low percentage adoption rate of low carbon HDVs (0.4% for bus and coach (there are 60 ultra-low emission vehicles registered as buses and coaches as of Q1, 2021) and 0.04% for HGVs (there are 15 ultra-low emission vehicles classed as HGVs as of Q1, 2021))
- If only low carbon technologies were to be adopted, at the point of natural vehicle replacement, then it is still likely to take a significant amount of time to decarbonise these fleets. For example, if all future new bus and coach purchases were low carbon then it would take nearly 20 years for the fleet to be decarbonised (assuming a consistent number of total vehicles and replacement rate over that period – 750 p.a.). Decarbonisation of the HGV fleet would take nearly nine years (again assuming a consistent number of total vehicles and replacement rates – 4,310 p.a.). However, this is an underestimate given that operators of buses, coaches and HGVs are likely to continue to procure a significant proportion of diesel vehicles in the short to medium term

4.2 Low carbon technology options – drivers and barriers

Within the HDV fleet, the range of duties and operational demands means that different segments of the market may adopt different technologies and at different rates. However, the primary driver for decarbonisation of the HDV fleet is consistent across the sector and the ultimate driver is the climate change emergency and need to cease the use of fossil fuels. Both the UK and Scottish Governments have committed to achieve net zero carbon emissions by mid-century, with ambitious interim targets for 2030 and 2040. In working towards these goals, both governments have utilised the powers available to them to support the decarbonisation of heavy-duty vehicles.

In an update to the Scottish Government Climate Change Plan, published in December 2020, the Scottish Government committed to work with the industry to understand the most efficient methods to remove the need for new petrol and diesel heavy vehicles by 2035. Specifically for buses, the commitment from the Scottish Government is more ambitious and it is intended to ensure that the majority of new buses purchased from 2024 are zero emission, with this date being brought forward if possible. There is also direct support for the procurement of ultra-low emissions buses in Scotland through the www.transport.gov.scot/public-transport/buses/scottish-ultra-low-emission-bus-scheme/. The UK Government has recently initiated a consultation on banning the sale of non-zero emission HGVS, with diesel powered HGVs up to 26 tonnes phased out by 2035 and those over 26 tonnes phased out by 2040 (Department for Transport, Consultation on when to phase out the sale of new, non-zero emission heavy goods vehicles (2021)). The consultation does not include off-highway vehicles or agricultural vehicles. A prior UK Government consultation was published looking specifically at the phase out of diesel buses in England (Department for Transport, Ending the sale of new diesel buses (2021)).

The legislative drivers then could hardly be any stronger for adoption of decarbonised HDVs but the timeframes for these changes are somewhat protracted compared to those seen in passenger vehicle markets. This protracted timeframe for the incentivisation of net zero vehicles or phase out of non-net zero drivetrains is necessary to reflect the state of technology development for heavier vehicles. The implication for skills is clear, as the relative adoption of each of these new technologies will affect the skills needed in the workforce to support the vehicles, as well as the skills needed in the supporting ecosystem for the vehicles (e.g. refuelling/ charging infrastructure). In the course of this study, we have identified five main technologies for decarbonisation which are among the most frequently cited in policy papers, articles and project reports in the field of decarbonised HDVs. Each of the five technologies is described below.

4.2.1 Types of Decarbonised Vehicle Drivetrains Considered

4.2.1.1 Battery electric vehicle

Battery electric drivetrains use electric motors with electrical energy stored in batteries. Lithium-ion batteries represent the current state of the art technology, and this is likely to be the case for the foreseeable future as these have the greatest energy density and power capabilities. However, compared with chemical storage of energy (i.e. in diesel, hydrogen or natural gas), batteries have a very low energy density, and a significant mass of batteries must be carried to support a viable vehicle range. Nevertheless, electrical systems have very high efficiency and so for lighter vehicles, battery electric drivetrains are becoming viable. The batteries can be directly charged from the electrical grid but there are likely to be additional infrastructure works to support high charging rate facilities, which allows large HDV batteries to charge in a reasonable time, without overwhelming the capacity of the local electrical grid.

4.2.1.2 Hydrogen fuel cell electric vehicles

Hydrogen fuel cell electric vehicles (HFCEVs) utilise electric motors with power coming from a fuel cell which harnesses electrical energy from the reaction of hydrogen and oxygen. By utilising the storage of energy in compressed hydrogen, the fuel cell system has a much higher energy density than battery systems, so is considered to have better potential to support heavy-haul, long distance vehicle duties.

The hydrogen is stored in pressurised tanks. The vehicle relies on available high-purity hydrogen, so a well-developed refuelling infrastructure must be in place for the vehicle to be useful.

4.2.1.3 Hydrogen internal combustion engine/ hydrogen-diesel dual fuel combustion engine

Internal combustion engines (ICEs) are the dominant current technology using diesel fuel. However, the ICE can be developed to utilise hydrogen which would result in no carbon emissions from the exhaust (although there are nitrous oxides produced). Currently, vehicles using a dual fuel system (mixing hydrogen and diesel) are in production as an interim means of reducing carbon emissions and this technology can be retrofitted to existing fleets. This dual fuel system can run purely on diesel when hydrogen is not available. The hydrogen ICE system utilises many of the same technologies as the HFCEV (e.g. refuelling systems, hydrogen storage tanks) so these are complementary technologies and dual fuel systems are seen as a way of transitioning to a hydrogen transport economy and supporting the development of hydrogen production and refuelling infrastructure. Drivetrain characteristics of the ICE engines can be similar to existing diesel engines, allowing a continuity of performance and minimal disruption to operation of the vehicles.

4.2.1.4 Biomethane internal combustion engine

Another use of ICE technology is an engine fuelled by biomethane (i.e. methane from a biogenic carbon source) most often from anaerobic digestion of waste products and refinement of the biogas into methane. The biomethane is compressed and used in a compressed natural gas (CNG) engine. These engines are more common in international markets outside of the UK. Whilst the engine has significant carbon emissions at the exhaust, the fuel is net zero as it is derived from a biogenic source, not a fossil fuel source. Commonly, the biomethane is injected into the gas network and natural gas is extracted from the network at the refuelling point. The net zero credentials of the biomethane are maintained by selling guarantees of origin as the biomethane is not segregated from fossil natural gas in the gas network.

4.2.1.5 Pantograph electric road systems

Electric road systems are based on the electrification of sections of trunk road using similar technology to electrified rail and with some similarity to trolley buses. Overhead wires carry electrical power which HDVs connect to with pantographs, in order to power electrical motors. The overall effect is the same as a battery electric vehicle, but in the case of the pantograph system the energy source does not need to be carried with the vehicle, reducing the weight and bulk of the decarbonised vehicle. The most obvious limitation of this system is the establishment of a system of catenary wires over large sections of the trunk road network. These electrified vehicles would also likely require a secondary power source (e.g. battery or fuel cell) to provide power for the vehicle to access the “electric road” and then to leave it at the end of the journey.

4.2.2 Recent Technology Developments and Deployments

In response to recent policy drivers and the range of potential technologies, there have been a large number of developments in testing and deployment of decarbonised HDVs across all sectors of the fleet. Across Scotland and the UK these projects are beginning to set the direction of travel for these technologies and are instructive in establishing a picture of which technology may be most suitable for which type of application and relative levels of adoption. In the following sections we have highlighted a number of key recent developments which we have synthesised into a technology landscape, in order to understand what skills will be needed to service Scotland's decarbonised HDV fleet.

4.2.2.1 Battery electric vehicles

Battery electrification has seen widespread and increasing adoption in the passenger car market but is often portrayed as unsuitable for most HDV applications. The primary limitation is the inherent low energy density of batteries and operational challenge presented by the large battery weight required for normal HDV operation. However, we have seen significant progress in operators adopting battery electric vehicles, particularly in bus and coach markets. For example, First Bus recently announced that the Glasgow Caledonia bus depot will be developed as the UK's largest electric vehicle charging hub with space to charge up to 300 buses. In the coach market, Ember operates the UK's first all-electric intercity bus service between Edinburgh and Dundee using battery electric vehicles. Outside bus and coach markets, North Lanarkshire council has deployed an electric refuse collection vehicle (RCV) as part of its vehicle fleet. In the HGV market there are a number of operators with a pipeline of battery electric vehicles under development, including Volvo and Leyland Trucks, with the lighter HGVs being closer to market than heavier vehicles. The battery electric HDV pipeline, therefore, appears well developed.

In keeping with the state-of-the-art technology, we see that current deployments of battery powered vehicles most often focus on vehicles with the lowest average mileage and those which perform back-to-base daily usage. Adoption of the electric vehicles is also highest in the bus markets where we see financial support for adoption of ultra-low emissions vehicles and a de-risking of technology due to previous electrification of city-wide bus fleets in other geographic markets (notably in China).

4.2.2.2 Hydrogen fuel cell electric vehicles

In contrast to the perception of battery electric technology being suitable only for the lightest duties, HFCEVs are often seen as a future option for the heavier vehicles which need the longest operational range, but there is evidence of potential adoption of fuel cell technology across all HDV sectors. In buses and coaches, First Bus in Aberdeen has deployed HFCEV buses on specific routes within the Aberdeen City Council area. For municipal vehicles, Glasgow City Council has approved the purchase of 19 HFCEV RCVs with operation beginning in 2022. Across other classes of vehicles, many HGV OEMs have stated an intention to have HFCEVs on the market by the end of the decade. A recent UKRI funded project in Scotland has been announced to demonstrate the feasibility of an HFCEV in the 44 tonne HGV segment. The secondary evidence indicates that HFCEV drivetrains are at a lower state of technology readiness compared to battery electric vehicles, with prototype and trial vehicles still being used for development. As the HFCEV is so reliant on the hydrogen production and distribution infrastructure, this is also a key element of the uptake of this technology. While the evidence from the trials above is that the hydrogen fuel infrastructure will be primarily supported by public sector activity in the initial stages, there is some evidence that the private sector is poised to develop support for the necessary hydrogen infrastructure in Scotland (Peel L&P waste plastics to hydrogen facility, The Acorn Project, Port of Cromarty Firth) This private sector involvement could mean that hydrogen deployment in Scotland could become more widespread as the availability of fuel supply is de-risked and cost effective in the medium to long term. There are also companies that are developing mobile hydrogen refuelling solutions at far lower costs than fixed infrastructure (e.g. NanoSUN and Octopus Energy).

4.2.2.3 Hydrogen internal combustion engine/ hydrogen-diesel dual fuel combustion engine

Hydrogen or dual fuel ICE drivetrains are less frequently mentioned in policy papers and technology reports for HDV decarbonisation when compared to electrified drivetrains. However, in the research underpinning this study, we have seen evidence that this drivetrain may make up a significant part of the technology mix for certain HDVs. Glasgow City Council has procured 20 hydrogen/ diesel dual fuel gritters with around half of the vehicles being converted from a diesel ICE drivetrain. Aberdeen City Council has also procured a number of dual fuel municipal vehicles. In off-highway vehicles, there has been some recent development in prototype hydrogen ICE vehicles. There is also evidence of prototype development from a number of established ICE market players (e.g. MAN). The Advanced Propulsion Centre has recently announced funding of £14.6m to support the development of a zero-emissions hydrogen combustion engine to address the HGV market, with Cummins being the lead partner. Overall, the level of development in the hydrogen ICE is relatively low but it draws on existing supply chains and benefits from developments in refuelling infrastructure supporting HFCEVs, so it can be seen as complementary to HFCEV technology. Dual fuel ICE helps build this infrastructure and establish stable demand whilst providing interim carbon emission reduction in the medium term so it may become an important interim step in markets which are hard to electrify using current technology. However, in follow up discussion conducted as part of the primary research in this study, it was noted by some stakeholders that sustained R&D spend on both fuel cell and hydrogen combustion is unlikely to be tenable and only one technology is likely to reach full maturity. This is in contrast with some secondary evidence and so the development pathway for this ICE technology is unclear.

4.2.2.4 Biomethane internal combustion engine

In the most recent biomethane fuel developments, almost all of the activity has been focused on the heaviest end of the HGV market and driven by private sector operators. A large number of operators have announced plans to convert some, or all, of their HGV fleets to biomethane, including Glenfiddich, Waitrose, Royal Mail and Hermes, with the primary focus being HGVs over 40 tonnes. In terms of the supporting infrastructure, there is evidence of significant private sector investment in Scotland to support the refuelling of these vehicles. This private sector led movement is due to the fact that operators are driven by stakeholder demand to show action on reducing carbon emissions but there are limited viable decarbonisation options for the heaviest vehicles. For the heaviest HGVs, commercial zero emission vehicle availability is likely to be limited in the medium term until there are significant technology developments in other zero emission options. Therefore, operators using heavier HGVs may determine that it is very unlikely there will be a better drivetrain option for a number of years and adopt biomethane HGVs to take action in the short term to reduce their carbon emissions. The longer commercialisation timescales for zero emissions heavy HGVs (7-10 years) would mean that there is no advantage to a “wait and see” approach as biomethane is likely to be the only option for decarbonisation for this investment cycle. This is in contrast to the lighter end of the HDV market where biomethane is not likely to be a key technology as there is a high probability that more attractive zero emission options will reach the market in the short to medium term. Some stakeholders reported that the lack of clear government policy (at UK and Scottish level) about biomethane as a ‘stepping-stone’ low carbon technology was acting as a barrier to investment in HDVs using this fuel.

4.2.2.5 Pantograph electric road system

The Pantograph electric road system is only viable for the heaviest HDVs or those which spend the vast majority of their operational time on main trunk roads which could be electrified with overhead catenary wires. This type of electric road system is under trial deployment in Germany and a UK demonstrator project was recently funded by UKRI. However, this technology is at a very early stage of deployment and its feasibility is still being established for road transport (the underpinning technology appears to share significant commonality with rail electrification). More so than for other technologies, deployment of the electric road system will be region specific as it will depend heavily on how concentrated HDV travel is on certain trunk routes and how far from these roads HDVs need to travel in their use cycles. Therefore, it would need to be established if this is a viable solution for HDV transport in Scotland, given the road network, the profile of HDV use, and the local geography. There has been recent coverage of a pantograph system in use for Stagecoach electric buses in the Irvine Valley. However, this is more accurately described as an opportunity charging development, rather than an electric road system and so is more relevant to extending the range of electric battery vehicles.

The above represents only a cross section of the recent activity in the development and deployment of HDVs and this is a very active area given the pressures from policy developments and stakeholder demands for action on carbon emission reduction.

4.2.3 Analysis of Decarbonised Drivetrains for Different HDV Market Segments

We have used available secondary information to construct a comparison of how attractive each technology will be to specific markets, in line with the HDV market segmentation above. The methodology used is based on scoring each technology across ten different factors (carried out for both 2026 and 2032):

- Emissions
  - CO_2 emissions
  - Air quality
- Vehicle operation
  - Capex
  - Fuel cost
  - Size and weight constraints
  - Energy density (range)
  - Refuelling (uptime)
  - Vehicle availability
- Infrastructure
  - Infrastructure costs
  - Infrastructure state of readiness

Further details on how this analysis was derived is given in Appendix C. Summary information is provided in the remainder of this section.

For each combination of technology and HDV segment, a combined score was calculated by multiplying the scores for each factor. For example, against the criteria “CO_2 emissions”, diesel ICE was scored 1 (poor performance). For buses and coaches CO_2 emissions were rated a 5 for importance (very important) due to imminent policy moves towards phase out of fossil fuelled buses. Combining these gives a factor score of 5 for diesel bus and coaches. Completing this for all factors gives a total score which can be compared with other drivetrains in the same HDV segment. Completing this process for every HDV segment results in the analysis shown in Figure 5.

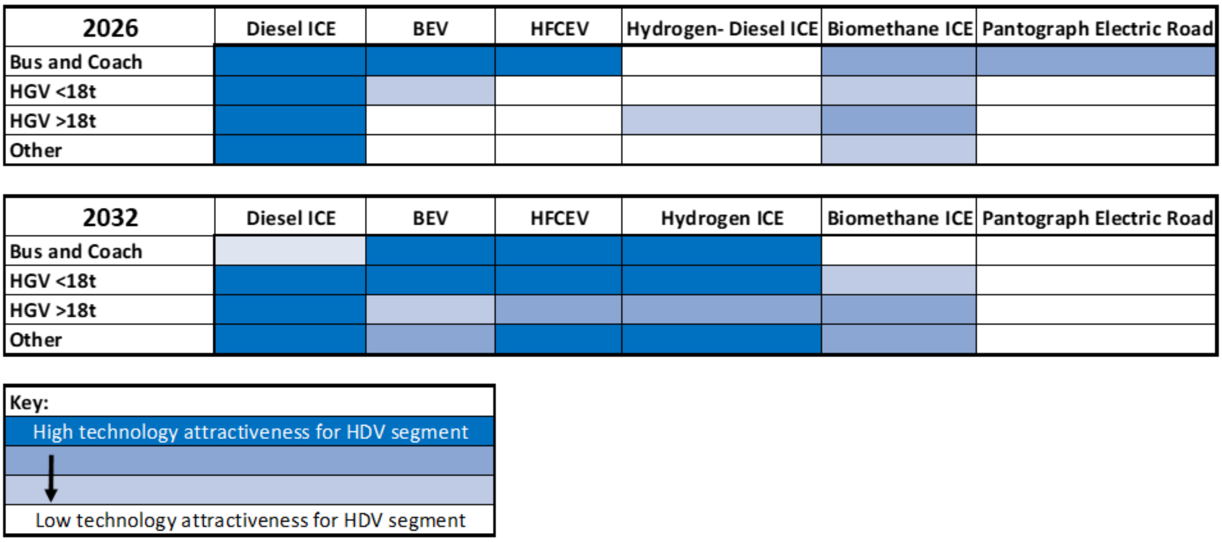

Figure 5 - Attractiveness of Decarbonised Drivetrains for HDV Segments

The dark blue colouring indicates that a technology is relatively attractive to an HDV segment at a particular point in time (i.e. either 2026 or 2032). As the colour lightens this reflects relatively lower levels of attractiveness for the relevant HDV segment. The analysis is also somewhat subjective as there are very few comparable sources of quantitative data which allow direct comparison of the different drivetrains against the factors considered, and within each sector there will be a range of HDV duty cycles. Therefore, the scores represent the best approximation of relative performance, based on a consensus from a range of sources. However, the general trends are instructive and form the basis for further development of our analysis of which technologies and skills would be important to support the adoption of low carbon HDVs in Scotland.

4.2.4 Summary of the key findings for different drivetrain technologies

4.2.4.1 Diesel internal combustion engine

Firstly, in both the analysis for 2026 and 2032, we note that is it likely that diesel will continue to be an important part of the technology mix, particularly for heavier HGVs or off-highway vehicles performing heavy duty.

4.2.4.2 Battery Electric Vehicles

Based on this analysis, we anticipate that battery electric drivetrains will be as attractive as diesel for buses and coaches by 2026. By 2032, battery electrification may be the most viable option for buses, coaches, lighter HGVs and is likely to form a part of the technology mix for other off-highway HDVs.

4.2.4.3 Hydrogen fuel cell electric vehicles

In 2026, we anticipate that HFCEVs will play a relatively minor part in the technology mix, due to the timescales to bring this drivetrain to market and lack of vehicle and infrastructure availability. However, there may be significant deployment in some bus categories, in keeping with recent developments by First Group in Aberdeen. By 2032, it may be expected that HFCEVs play a more significant role in the HDV market as vehicles are commercialised and refuelling infrastructure becomes more available. A combination of the potential energy density and high efficiency, alongside the focused attention from vehicle OEMs makes this a potentially viable solution for heavier duties in virtually all HDV segments.

4.2.4.4 Hydrogen internal combustion engine/ hydrogen-diesel dual fuel combustion engine

We have anticipated that while dual fuel combustion engines are a viable technology considered in the 2026 analysis, by 2032 they will have been superseded by hydrogen combustion engines. In the short-term, hydrogen-diesel dual fuel may play a modest part of the technology mix for heavier HGVs but is likely to be a transitional measure as it has limited CO_2 reduction potential compared to some other drivetrains. By 2032, hydrogen ICE drivetrains may be a relatively important part in the decarbonisation of vehicles in all segments of the HDV market due to the relative affordability of the combustion engine and increasing hydrogen infrastructure availability. However, the exact course of this technology development is less certain as there has been only limited publicised vehicle development activity from the major OEMs, particularly when compared to battery and fuel cell electrified systems.

4.2.4.5 Biomethane internal combustion engine

By 2026, we anticipate that biomethane will be modestly attractive to a number of market segments but predominantly in heavy HGVs where it fills a gap in available decarbonising technologies for the heaviest vehicles. The technology is a somewhat good fit for buses and there has been some prior activity in this area but it is anticipated that zero emissions options will supersede biomethane in this segment. The attractiveness of this technology changes relatively little by 2032 as it is already mature. By 2032, it is expected that biomethane will only be of significant relevance to the heavy HDV market, with the attractiveness for other HDV segments being minimal compared with zero emissions options.

4.2.4.6 Pantograph electric road system

In all of our analysis, pantograph electric road systems scored relatively low. This is primarily due to the extensive infrastructure required and unclear development pathway. The necessary catenary cable infrastructure would need to be developed for specific parts of the Scottish road network based on viable use cases (e.g. the most heavily used HGV corridor routes). We note that it is anticipated in some reports that the development of catenary electric HGVs is predicted to commence around 2035, beyond the timeframe of this study and supporting the case that it will play a minimal role in decarbonisation in the early 2030s.

4.2.5 Summary of the key findings for the different HDV market segments

4.2.5.1 Buses and Coaches

In considering the HDV market segments, we see that by 2026 for buses and coaches, decarbonised electrified drivetrains are expected to already be at least as attractive as diesel engines. By 2032 this trend continues, and battery electrification and hydrogen power (through fuel cell or ICE) are expected to be more attractive than diesel engines.

4.2.5.2 HGVs less than 18 tonnes

For lighter HGVs, less than 18 tonnes, we expect that diesel will still be the dominant technology in 2026 but with biomethane and battery electric drivetrains being relevant to some specific vehicle uses. By 2032, a wide range of technologies are likely to be viable for these lighter HGVs with diesel, battery electric, HFCEVs and hydrogen ICE all being potentially viable considerations for operators.

4.2.5.3 HGVs more than 18 tonnes

For the heaviest HGVs, by 2026 we expect that diesel will continue to be the primary drivetrain technology, with biomethane ICE being one of the few viable alternatives given the demanding heavy-haul and long-distance applications of these HGVs. By 2032, it is expected that the heaviest HGVs will still strongly depend on diesel engines but biomethane, hydrogen ICE and HFCEVs will begin to become competitive drivetrain technologies in some use cases.

4.2.5.4 Other HDVs

For other, off-highway HDVs, diesel will also be a main drivetrain fuel by 2026, with biomethane, dual fuel ICE and battery electric vehicles potentially being a viable technology, depending on the specific use. By 2032 hydrogen ICE, diesel and hydrogen fuel cell vehicles may make up the most attractive technologies for off-highway applications. Battery vehicles will make up a modest part of the off-highway segment for vehicles with lighter duty (e.g. small excavators etc).

This method of analysis, based on combining and synthesising a variety of secondary sources is instructive in determining which technologies may be attractive and relevant to the market at certain points in time. However, it has inherent limitations in that it omits some qualitative drivers and nuanced market understanding that is held by small number of subject matter experts. Given the limitations of this analysis, we have used this as a starting point and built on it with the qualitative information gained through engagement with a large number of stakeholders in this study. Our approach to further developing this analysis, based on expert input, which underpins a robust understanding of the skills needs in Scotland, is given in the following section.

4.3 Potential adoption levels of low carbon vehicles

Having identified the nature and scale of the current HDV fleet in Scotland in section 4.1 and the drivers and barriers of the potential low carbon technologies in section 4.2, it is necessary to estimate the levels of low carbon vehicles adoption that the different HDV segments are likely to achieve over the short and medium term. As defined earlier, short term is defined as 2026 and medium term as 2032. This step is required as it will have a direct influence on the scale and nature of future skills requirements to support the uptake of low carbon HDVs.

Based on a combination of literature review, consultation with stakeholders (including an expert workshop involving representatives from academia and industry) and interpretation of the analysis in the preceding sections, the following indicative range of scenarios about adoption rates was developed.

HDV Segment	Fleet size	Annual sales	2026 (% of total fleet low carbon)	2026 (number low carbon)	2032 (% of total fleet low carbon)	2032 (number low carbon)
Bus and Coach	14,560	750	10% to 25%	1,456 to 3,640	30% to 50%	4,368 to 7,280
HGV (3.5T to 18T)	19,560	2,250	5% to 10%	978 to 1,956	15% to 40%	2,934 to 7,824
HGV (18T+)	17,910	2,060	1% to 5%	179 to 895	10% to 30%	1,791 to 5,373
Total	**52,030**	**5,060**	**5% to 12%**	**2,613 to 6,491**	**17% to 39%**	**9,093 to 20,477**

Figure 6 – Indicative range scenarios for adoption rates of low carbon HDVs, by vehicle segment

It should be noted that the above analysis involves a high level of qualitative judgement and can only be regarded as a potential scenario for the future adoption of low carbon HDVs.

As previously described, there are a number of different low carbon technologies that could be adopted in each of the HDV segments. Combining the analysis of the relative attractiveness of different technologies, presented earlier in Figure 5, with data on annual unit sales, enables a realistic scenario to be created of the relative composition of the Scottish low carbon HDV fleet in 2026 and in 2032. It is important to have some indicative understanding of the nature and scale of the technologies adopted as this will impact on the nature and scale of the skills required to support them.

Figure 7, below, shows the potential relative adoption of different technologies based on combining the analysis described in section 3.2 with feedback from stakeholders regarding the relative use of different technologies in the four segments of the HDV fleet. Note that the 'Other HDV' category, including construction and agricultural HDVs, has been included in this qualitative analysis as it is less dependent on being able to estimate actual numbers of these vehicles in the overall HDV fleet.

	2026	2032
Bus and coach	Diesel	Diesel
	Battery Electric	Battery Electric
	Hydrogen Fuel Cell	Hydrogen Fuel Cell
	Hydrogen (direct combustion)	Hydrogen (direct combustion)
	Biomethane	Biomethane
HGV (3.5T to 18T)	Diesel	Diesel
	Battery Electric	Battery Electric
	Hydrogen Fuel Cell	Hydrogen Fuel Cell
	Hydrogen (direct combustion)	Hydrogen (direct combustion)
	Biomethane	Biomethane
HGV (18T+)	Diesel	Diesel
	Battery Electric	Battery Electric
	Hydrogen Fuel Cell	Hydrogen Fuel Cell
	Hydrogen (direct combustion)	Hydrogen (direct combustion)
	Biomethane	Biomethane
Other (e.g. construction, agriculture, etc.)	Diesel	Diesel
	Battery Electric	Battery Electric
	Hydrogen Fuel Cell	Hydrogen Fuel Cell
	Hydrogen (direct combustion)	Hydrogen (direct combustion)
	Biomethane	Biomethane

Key:
Leading use
Significant use
Lower scale use
Very limited/ no use

Figure 7 – Possible relative use of technologies by different HDV segments in 2026 and 2032

Note that Figure 7 differs from Figure 5 in a number of important ways. Firstly, Figure 7 includes input and analysis of qualitative information from key stakeholders that is not captured in Figure 5. A key example of this is for the use of biomethane where key stakeholders informed us that it would primarily be used in the market for HGVs weighing 40 tonnes or over. Therefore, while Figure 5 indicates that biomethane may be technically viable for a number of HDV segments, we have revised our assessment of the relative use to reflect the expert market knowledge gleaned from our primary research. Secondly, while Figure 5 shows the attractiveness of a technology at a point in time, Figure 7 shows the relative use of the technology in the Scottish HDV fleet at that time. Therefore, it includes consideration of the fleet replacement rate, lifespan of the HDVs and how long new technologies have been on the market. An example of this is seen in the use of hydrogen fuel cell vehicles. While Figure 5 indicates that the technology will be very attractive by 2032, it is only expected to be commercialised by the late 2020s. Hence, the actual use among the Scottish HDV fleet by 2032 is limited and this is reflected in Figure 7. Similarly, the current dominance of diesel vehicles means that it will take a significant time for the current diesel vehicles to reach the end of their useful life and be removed from the HDV fleet. Thirdly, Figure 7 does not include pantograph electric road systems. Whilst we note some development work in this technology field, in our consultations with subject matter experts, this technology was not cited as a key part of the decarbonisation mix for the Scottish HDV fleet. Due to the anticipated long timescales for this to be realised and uncertainty over its applicability to the Scottish road network, electric road systems were not included in any further analysis.

In this scenario, low carbon vehicles are estimated to make up between 5% and 12% of the total HDV fleet by 2026. As such, diesel will continue be the dominant fuel across all four segments. In the bus and coach and lighter HGV segment there is likely to be significant use of battery electric vehicles. There is also likely to be lower scale use of hydrogen fuel cells, direct combustion hydrogen (blended with diesel) and biomethane (particularly in the heavier HGV segment).

By 2032, low carbon vehicles are estimated to make up between 17% and 39% of the total HDV fleet. The uncertainty of future adoption levels of low carbon HDVs increases when time periods further into the future are considered and this leads to wider percentage adoption ranges being used in the scenario. Again, diesel will remain the dominant fuel for HGVs, construction and agricultural vehicles. For buses and coaches the use of battery electric vehicles will be similar to that of diesel. Battery electric will continue to form a significant proportion of the HGV fleet (3.5T to 18T and 18T+). Biomethane is likely to also play a significant role in the large HGV fleet (18T+). Direct combustion of hydrogen (potentially without blending) will play a significant role in heavier construction and agricultural vehicles.

A key finding based on this scenario is that new skills across a range of technologies will be required by HDV operators (around driver safety, refuelling, etc) and those involved in inspection, repair, maintenance and recovery. This will be discussed further in the next section.

5 Skills needs and gaps in the low carbon HDV landscape

The following diagram represents an overview of the landscape for which new skills could be expected to be required for the adoption of low carbon HDVs.

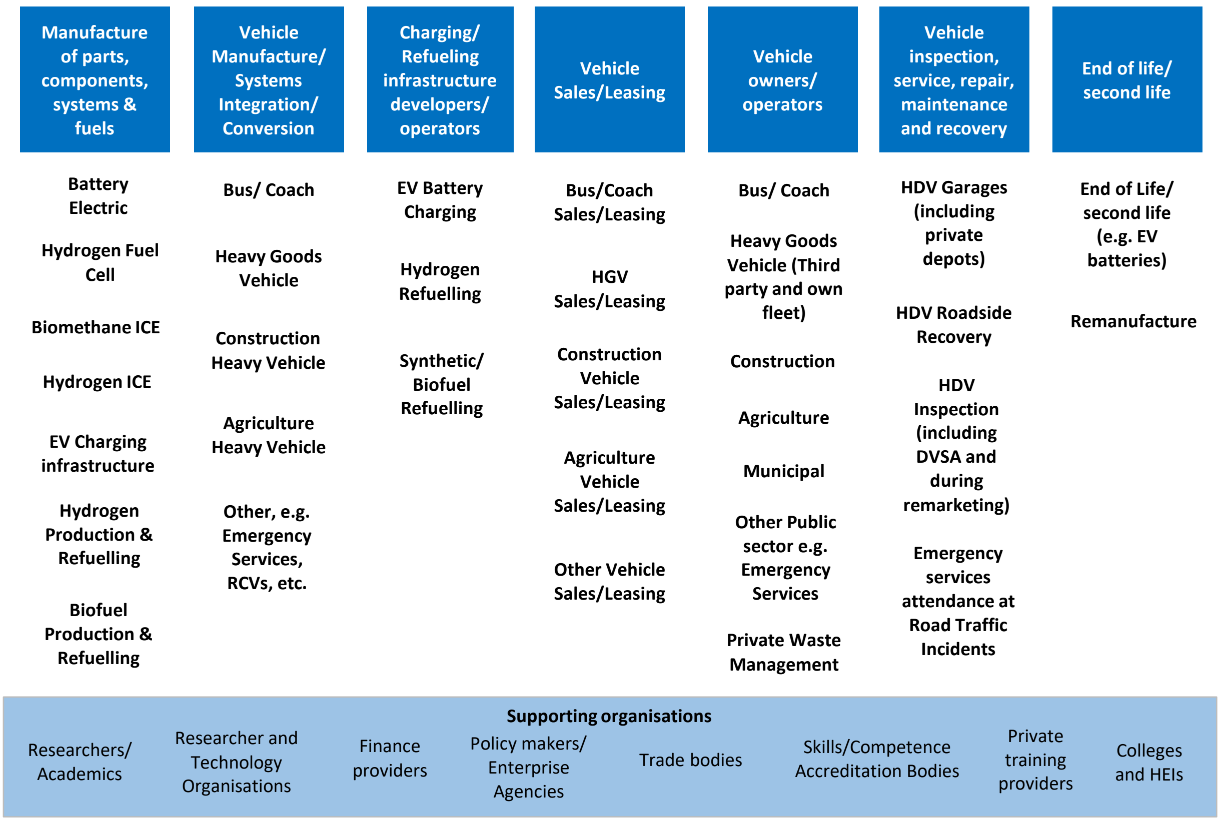

Figure 8 - Landscape impacted by low-carbon HDV adoption

The top line represents the sectors where skills would be required, the middle part of the diagram the range of different applications, and the bottom line of the diagram, organisations supporting research and development, finance, policy and skills.

It is important to establish an understanding of the current scale of each part of the supply chain and end markets based in Scotland, as it is organisations operating in these different parts that need skills relevant to HDV production and operation. This provides a baseline, upon which scenarios for future growth can be built and the potential nature and scale of skills required can be identified.

Where possible, the scale of each of the segments is quantified in terms of number of enterprises operating in Scotland and employment within these segments. This quantification is based on the following methods:

- Search of several databases accessible via the Office for National Statistics, [Nomis website for official labour market statistics](). This includes the Business Register and Employment Survey (employment levels) and UK Business Counts (number of enterprises). Both sources enable searching for Scottish level data within industries defined at the 5-digit Standard Industrial Classification (SIC) Code level. Whilst this is the most disaggregated level of SIC Code data available, there are still limitations with using this approach due to potential lack of alignment between the supply chain/market segments defined in Figure 8 and the activities included in the closest available 5-digit SIC Codes. Notwithstanding these limitations, this approach can provide a reasonable indication of scale of activity present in Scotland. It should be noted that when data from Nomis is presented in figures later in this section, all figures are rounded to avoid disclosure. In some cases, the values may be rounded down to zero. However, all zeros are not necessarily true zeros.
- Due to the potential limitations with the SIC Code approach, described above, it is also useful to use other sources of data such as Government vehicle licensing statistics, research reports, general internet searching, etc.
- Where SIC Code data does not have a good fit with the types of organisations, defined for HDV end users and the supply chain, it can be useful to reference Standard Occupational Classification (SOC) data for Scotland (also accessed via the Nomis website) This analysis has focused on those working in industry sectors that would operate or be involved in servicing and repairing HDVs. It is far more difficult to identify with any degree of certainty the proportion of individual employees in other sectors that would require skills for low-carbon HDVs. For example, mechanical engineers (2122), electrical engineers (2123), electronics engineers (2124) and design and development engineers (2126) will each be required by the manufacturing sector, but the vast majority of such skilled employees will be working on application areas other than low-carbon HDVs
- Where none of the above sources can provide a robust point value for number of organisations or employees present in Scotland then a range estimate is made which will, necessarily, include an element of subjectivity

A detailed analysis of scale of employment across the different HDV segments can be found in Appendix D. The figure below shows the summary findings of this analysis.

HDV Segment	Employment sub-total	Indicative total employment by segment
Manufacture of parts, components, systems and fuels	N/A	965
Vehicle manufacture/ systems integration	N/A	1,000
Charging/refuelling infrastructure developers/operators	N/A	No data
Vehicle sales and leasing	N/A	2,225
Vehicle owners/operators	N/A	48,750
HDV inspection, service, repair, maintenance and recovery	N/A	2,680
HDV Technicians	2,500	N/A
DVSA Inspection/examination	180	N/A
HDV Recovery	No data	N/A
Emergency Services	N/A	31,400
Fire	5,700	N/A
Police	19,000	N/A
Ambulance (incl. paramedics)	6,700	N/A
End of Life/Second Life	N/A	No data
Total employment potentially requiring low carbon HDV skills	**N/A**	**87,020**

Figure 9 - Indicative number of employees potentially requiring development of skills to support the uptake of HDVs in Scotland

This analysis shows that over 87,000 people potentially need to develop new skills to support the uptake of HDVs. For some categories of employment listed above (e.g. emergency services, DVSA, roadside recovery, etc.), all of the people employed in these roles should develop these skills as soon as possible as there is currently a possibility of these skills being required when attending a road traffic incident. In other roles (e.g. vehicle sales, operators, HDV Technicians) then the skills do not need to be adopted by the whole workforce at the moment, instead the need will arise as more low carbon HDVs are adopted into the overall fleet.

Most of the stakeholders consulted, who offered an opinion, asserted that, overall, the workforce associated with operating, maintaining, servicing and repairing HDVs would remain a similar size. There was evidence identified from the desk research that the number of road freight trips is projected to increase by 28.5% from 2017 to 2032, so, it is reasonable to assume that the HGV operator employment will increase over this period.

5.1 Scale and nature of key skills required

5.1.1 Scale of employees likely to require low carbon HDV skills in future

The indicative scale of the numbers of employees likely to require new skills can be derived by combining the previously identified data on employee numbers within each HDV segment, from Figure 9, with the potential ranges of low carbon HDV adoption connected to the scenario described earlier in Figure 6.

For some segments, the need for skills development can be assumed to track the adoption rate (e.g. HDV technicians) whilst in other segments (e.g. Emergency services) these skills are required as soon as possible due to the possibility, for example, of having to attend a road traffic incident involving a low carbon HDV. Figure 10, below, shows the indicative range of employees potentially requiring skills development by 2026 and 2032. To account for the likely increase in HGV employment due to the projected growth in road freight trips (previously highlighted as increasing by 28.5% from 2017 to 2032) the current estimate of large goods vehicle drivers (of 25,200) should also be increased. It is assumed that growth in road freight transport is constant over the period and the rate of growth for 2020 (the year for which the figure of 25,200 is sourced) to 2032 is 25% (slightly lower than the 2017 to 2032 growth). A 25% growth rate applied to 25,200 results in additional employment of 6,300. It is assumed that employment of large goods vehicle drivers will increase by 3,150 by 2026 and a further 3,150 by 2032. This takes the new total of vehicle owners/operator employment from 48,750 now to 51,900 in 2026 and 55,050 in 2032. This revised employment data is used in Figure 10, below.

HDV Segment	Employment sub-total	Indicative total employment by segment	Scale of skills development in 2026 (number of employees requiring skills development)	Scale of skills development in 2032 (number of employees requiring skills development)
Manufacture of parts, components, systems and fuels	N/A	965	48 to 116	164 to 376
Vehicle manufacture/ systems integration	N/A	1,000	50 to 120	170 to 390
Charging/refuelling infrastructure developers/ operators	N/A	No data	N/A	N/A
Vehicle sales and leasing	N/A	2,225	111 to 267	378 to 868
Vehicle owners/operators	N/A	48,750	2,437 to 5,850	8,287 to 19,012
HDV inspection, service, repair, maintenance and recovery	N/A	2,680	N/A	N/A
HDV Technicians	2,500	N/A	125 to 300	425 to 975
DVSA Inspection/examination	180	N/A	180	180
HDV Recovery	No data	N/A	N/A	N/A
Emergency Services	N/A	31,400	N/A	N/A
Fire	5,700	N/A	5,700	5,700
Police	19,000	N/A	19,000	19,000
Ambulance (incl. paramedics)	6,700	N/A	6,700	6,700
End of Life/Second Life	N/A	No data	N/A	N/A
Total employment potentially requiring low carbon HDV skills	**N/A**	**87,020**	**34,351 to 38,233**	**41,004 to 53,201**

Figure 10 - Indicative scale of skills development needs by 2026 and 2032, by HDV segment

Note that where the scale of skills needs to track the adoption of low carbon HDVs then the earlier scenario of HDV adoption rates can be used:

2026: between 5% and 12% of the HDV fleet use low carbon technologies

2032: between 17% and 39% of the HDV fleet use low carbon technologies

The above figure highlights that, by 2026, between 34,400 and 38,200 (rounded to nearest 100) employees are likely to need new skills and by 2032 this increases to between 41,000 and 53,200 employees. A significant number of these employees requiring new skills are emergency service workers (31,400) who need to develop new skills to enable safe working at road traffic incidents involving low carbon HDVs at the earliest practical opportunity.

Due to the high levels of uncertainty about which low carbon HDV drivetrain technologies will be adopted by 2026 and 2032, it is not possible to provide quantitative estimates of the number of people requiring skills training in each of the different technologies. However, it is clear that a large number of emergency service workers (31,400) and DVSA staff (180) will require some level of skills development covering both high voltage systems and high-pressure flammable gas systems to enable safe working at road traffic incidents. For most emergency service workers this is likely to involve training via self-paced online content, developed by each service, and delivered during induction of new employees and ongoing CPD for existing staff. For some (e.g. fire service personnel) there is also a requirement to develop skills in identifying key elements of continuously emerging low carbon HDVs such as location of isolator switches for high voltage systems, locations of batteries and gas storage tanks and how high voltage cables are routed through the bodywork of vehicles (to facilitate safe cutting in the event of having to access casualties in the vehicles). For DVSA staff a more in-depth level of skills will be necessary and this is likely to require a mix of manufacturer and other training.

Other segments of the HDV landscape will likely develop skills aligned with the types of low carbon HDVs adopted. As such they will require to develop most skills in electric/hybrid HDVs, as the most common low carbon technologies used over the periods to 2026 and 2032. Over the period to 2032 there is likely to be a growing need for skills in working with high pressure gas systems, particularly hydrogen (either in combination with fuel cell technology or direct combustion). Skills for biomethane are likely to remain limited and focused on larger weight HGVs.

5.1.2 Nature of low carbon HDV skills required

The nature of the skills required to support the uptake of low carbon HDVs varies across the different segments. These requirements are described below for each different segment of the HDV landscape.

5.1.2.1 Manufacture of parts, components, systems and fuels

Stakeholder feedback is that many of the component parts in decarbonised HDVs (glider chassis, batteries, fuel cells, etc) will be sourced from suppliers based outside of Scotland. As part of the integration of these separate systems and sub-systems into a vehicle, some stakeholders noted a need for skills to support quality inspection and quality control for specific drivetrain components (e.g. high pressure tanks or batteries) in the Scottish supply chain.

There is perhaps more scope in future for skills to support the development of hydrogen production systems and of the fuel itself but current demand is limited and there are only a small number of regionally based hydrogen production facilities (e.g. Aberdeen). Some stakeholders anticipated that there may be an increasing demand for mid-sized electrolysers to produce hydrogen for large commercial operators or a cluster of smaller operators. In developing and deploying these systems, the skills required centred on the safe handling of hazardous flammable gases, high pressure gas systems as well as specialist plumbing and specialised welding skills.

Biomethane fuel production is currently carried out using anaerobic digestion (AD), and two food and drink production companies were identified where their waste was being used to produce biomethane in parallel with the adoption of biomethane HDVs for product deliveries. The skills required for this include repair and maintenance of local compressor equipment that takes methane from the natural gas network and compresses it to a high pressure. At the same time the biomethane produced via the AD facility is fed into the natural gas network and certificate produced to mass balance the demand from the vehicle fleet.

5.1.2.2 Vehicle manufacture/ systems integration

Several stakeholders highlighted that production of low carbon HDVs required very similar skills to traditional fossil fuel ICE vehicle production. A number of stakeholders noted that, with the exception of a few specialist specific drivetrain areas, the skills for vehicle manufacture and systems integration would change very little. The main difference being additional safety skills required when working with high voltage and high-pressure gas components. The sector skills body with responsibility for automotive manufacture, Enginuity, is working with Skills Development Scotland on revision of the Automotive Apprenticeship - Engineering pathway. This process is looking at what skills are required by automotive manufacturers including digitalisation, electrification and motors/drives. This could result in changes to National Occupational Standards and associated changes to the Modern Apprenticeship Framework for Automotive Engineering.

HDV production activities in Scotland can best be described as systems integration of off-the-shelf components and the skills required include design engineering (designing a vehicle superstructure that integrates all of these components to produce an HDV that meets specific use needs) and production line technical skills, with the aforementioned focus on working safely with high voltage and high pressure gas components. Systems integration skills were noted as a strong need for manufacturers with a need to integrate a variety of mechanical, electronic and software systems into a working vehicle. However, this was not unique to decarbonised HDVs. Some manufacturers noted a current high demand for electrical skills at a craft level and that this demand was likely to grow as decarbonised vehicle demand grew.

5.1.2.3 Charging/refuelling infrastructure development and operation

The skills required to develop and operate charging/ refuelling include traditional civil engineering and construction skills which are well developed. There is also a requirement for skills to specify electrical power infrastructure and work with Distribution Network Operators (DNOs). Stakeholders report skills issues on both the DNO side and the potential operator side (in the latter case skills issues are more likely to occur relating to operators' depots rather than larger scale public charging infrastructure). There was also a noted need for skills in analysing electrical demand and designing options to manage peak load at the design and build stage of electrical recharging infrastructure. In terms of the practical deployment of the electrical recharging infrastructure, electrical engineering skills were generally present in Scottish supply chains, but some providers needed opportunities to expand into electric vehicle charging work from other industrial high-voltage electrical work. For hydrogen and biomethane refuelling operations there is a need for skills in working with high pressure gases and stakeholders report a lack of training options for this in Scotland. For hydrogen refuelling, deployment of the infrastructure would likely need the same specific skills as deployment of electrolysers (specialist welding and specialist plumbing). Stakeholder feedback highlights that current Modern Apprenticeship

Frameworks do not adequately cover all the skills necessary to install and maintain hydrogen refuelling infrastructure. Companies involved in this activity which take on Apprentices need to select from existing framework including: Domestic plumbing and heating; Heating, ventilation and refrigeration; Electrical installation or; Upstream oil & gas production. Whilst elements of the training provided via these Frameworks are relevant, other elements are not focused on the skills needed for hydrogen refuelling infrastructure (e.g. plumbing focuses on skills around copper pipework and methane gas whereas hydrogen infrastructure development companies need people with skills in steel pipework and hydrogen gas). Feedback from this segment of the HVM landscape is that it would be beneficial to give young people a clear and focused pathway into a career in hydrogen. Obviously, this would involve changes to National Occupational Standards.

5.1.2.4 Vehicle sales and leasing

In discussions with professionals involved in the sales of decarbonised HDVs, it was noted that the approach to sales had become much more technical and long-term, with the sales professionals requiring a level of technical understanding in a number of areas (e.g. vehicles capabilities, charging/ fuelling options). It was noted that the sales of decarbonised HDVs was, to a certain extent, following the same path as passenger cars and light vehicles, where a clear discussion of vehicle capability and vehicle use was required. This was in contrast to diesel vehicles where customers were confident that the vehicle would meet almost all duty cycles and use cases. Senior sales professionals which were consulted during this work informed us that formalised continuous professional development was likely to be required to ensure that sales teams had the relevant skills to be effective. This was due to the rapid rates of technology development and the variety of technologies customers may be considering (battery electric, hydrogen fuel cell etc). It was noted that the investment in decarbonised HDVs and the associated infrastructure was very significant so customers would expect sales advisors or account managers to be suitably qualified to make appropriate recommendations. Vehicle sales professionals will also need to understand how the whole eco-system works from the grid connection all the way through to installation and the final operation and fuelling or charging of the vehicle. The sales-person of the future will need to understand the total cost of ownership from charger maintenance to efficiency from grid to wheel and how this may be effected throughout the life of the vehicle, i.e. a fuel tank never changes in size but the state of health of a battery (and therefore performance) does. Stakeholders also anticipated that some kind of certification or approval scheme would mark out qualified professionals in the longer term. We note the existence of the Electric Vehicle Approved scheme for passenger vehicles and believe this is the type of scheme that is envisioned by some sales professionals. However, an equivalent HDV scheme would need to cover a wider range of technologies and be targeted appropriately at the HDV market. The increasing range of decarbonising technologies also makes this training more critical as the commercialised vehicle options develop. For example, the skills sales professionals will need to support hydrogen fuel cell vehicles may be quite different from the technical demands for selling battery electric vehicles.

We note that demand for these skills is expected to grow as demand for decarbonised HDVs grows. Some organisations are utilising additional technical sales personnel to help communicate technical details with customers in a sales environment and bridge the gap between commercial and technical roles. In-house, on-the-job learning and training is filling current demand for technical skills in the sales workforce.

In terms of skills to engage with customers, a range of approaches was required which closely links with our findings on the need for operators to have the technical/financial skills to procure and operate decarbonised HDVs. Some customers expected vehicle operators to act as turn-key solution providers identifying suitable vehicle technologies, as well as corresponding aspects of the charging/refuelling and supporting infrastructure. Other operators had well developed decarbonisation plans and expected vehicle manufacturers to be involved in the supply of vehicles only, as they used a variety of manufacturers and already had charging/ fuelling infrastructure in place. We believe this observation is in keeping with our findings that there is a need for operators to be supported in developing these skills, reflecting the widely varying levels of competency and skills in operators that are adopting decarbonised HDVs.

One barrier to the development of these skills is the difference between manufacturer performance data and actual operational performance (e.g. the distance a truck is capable of achieving, time to charge, etc.). There is a lack of actual performance data for different low carbon vehicle types that affects the confidence of those involved in sales and leasing, and their customers. Skills are also required in responding to customer queries about the development of depot refuelling/recharging infrastructure and/or availability of public charging/refuelling infrastructure. High level knowledge of how the different drivetrains work is also required as the level of customer queries about this is much higher than for the relatively well understood diesel fleet. Provision of skills training is currently through vehicle manufacturers and also their component suppliers (e.g. battery and electric drive manufacturers).

Several stakeholders also highlighted that new innovative financing options were starting to emerge (particularly in the bus and coach market). For example, single payments that cover the capital cost, infrastructure development and repair and maintenance (vehicle as a service). In this case there is a need for those involved in sales and leasing to develop skills in understanding and articulating these novel finance mechanisms. One stakeholder noted a need to upskill personnel in the business domain to help them understand the risks in investing in decarbonised technologies (this applied to investors rather than operators as a significant amount of finance would be needed in the conversion of the HDV fleet to decarbonised drivetrains). It was noted that investment in decarbonisation technologies could not be easily captured on a balance sheet, and investors would need the skills to understand how to effectively evaluate the risks associated with decarbonised HDVs, so that sufficient finance was available for the transition. Similarly, insurance industry professionals who may deal with battery or fuel cell vehicles needed to be able to assess risks in order to offer suitable cover so that the industry was not stifled by a lack of sufficient cover. One stakeholder noted that professional indemnity and business insurance for those working specifically with hydrogen fuel cells was often only available through specialist insurers from the oil & gas industry.

5.1.2.5 Vehicle operation

The skills required by those responsible for fleet operation include the ability to identify and assess new vehicles for their fleet. Several stakeholders highlighted a skills gap in being able to identify the operational performance data necessary to calculate the total cost of ownership of low carbon HDVs. Provision of training in this area is likely to vary, depending on the type of operator. For Local Authorities (LA) and NHS Health Boards, the Energy Saving Trust (EST) provides fleet review support. This has mainly focused on cars and light vans in terms of replacement strategies, but the overall transport carbon dioxide emissions include the heavy-duty fleet vehicles. Peer learning also takes place between LA fleet managers through attendance at the Association of Public Sector Excellence (Scotland) Transport and Mechanical Advisory Group. Fleet Managers in NHS Health Boards can also access support via the NHS National Services Scotland fleet specialist team. For private HGV operators in Scotland, support from the EST is not available in the same way as from the EST in England which offers HGV Fleet Reviews to all operators, funded by the Department of Transport. There is also some guidance and case studies available on The Freight Portal which can be used by operators to increase skills and knowledge about low carbon HDVs.

Stakeholder feedback also highlighted a specific skills gap in organisations considering commissioning low carbon systems and the consulting engineers who support this process. There is a need to provide practical guidance on how to develop the technical information required to support the planning and consent processes for refuelling infrastructure.

New skills are required for fleet and depot managers to allocate vehicles to delivery routes and payloads to ensure mixed fleets can achieve close-to-theoretical efficiencies.

Several of the companies consulted noted that driver training was an important part in maximising the benefits of the decarbonised HDVs. As electrified drivetrains often rely on high efficiency to maximise the useful work from the energy source, it was noted that driver performance could alter the effective range by tens of percent. Currently this is provided by the manufacturers. Operating organisations which had adopted decarbonised HDVs stated that the new skills required for efficient driving of the vehicles could be imparted through a few days of professional development by building on the existing skillset of competent HDV drivers.

5.1.2.6 Vehicle service, repair, maintenance, recovery and emergency services

HDV technicians require skills to safely work on different types of low carbon HDVs. At a high level this covers safe working with high voltage batteries, electric drivetrains and high-pressure gases such as hydrogen (in the context of both fuel cells and direct hydrogen combustion, currently dual fuel engines that also use diesel) and biomethane. Compared to diesel engines, stakeholders highlighted that additional skills are likely to be required to work with different engine management systems. Compared to cars and light vans, there is the potential for low carbon HDVs to exhibit greater levels of non-standardisation in the technical functioning of the vehicle and the location of parts and components between different vehicle manufacturers. Developing skills to work on low carbon HDVs is therefore likely to involve training on specific manufacturers' vehicles as well as more generic qualifications/awards (such as the heavy duty electric hybrid awards offered by IMI approved training centres). For safe operation of decarbonised vehicles, there was a recognition that there would be demand for skills to inspect and evaluate pressurised gas tank safety and integrity, and battery safety in the servicing market. In our discussions, manufacturers noted that they manufacture/ assemble vehicles that meet the required safety and performance standards (e.g. ISO 26262 covering functional safety). These manufacturing standards ensure that vehicles are safe to operate, maintain and decommission when they leave the production line but, to ensure the vehicles remain safe in real-world operation, this has to be supported by skilled personnel in the aftermarket supply chain who can maintain and inspect the vehicles appropriately. Service and maintenance skills are of vital importance in maintaining the safety of decarbonised vehicles as these often utilise high-pressure tanks or high voltage electrical systems. Capability in inspection of fuel tank safety/ integrity or isolation of high voltage systems is needed in the aftermarket supply chain to support these decarbonised vehicles.

Stakeholders highlighted that repair and maintenance of low carbon HDVs required, in some cases, new skills in safe working at height due to, for example, the location of batteries in some double decker buses being on the roof of the vehicle. These skills are now being taught alongside existing IMI qualifications in heavy duty hybrid and electric vehicles. It was also noted by some stakeholders that the weight of components could also be an issue (e.g. batteries and electric motors), requiring training in safe lifting practices.

Several stakeholders highlighted that more IT skills will be required for low carbon HDVs compared to diesel HDVs due to more sophisticated engine management and diagnostic systems. It was anticipated that software diagnostic skills would continue to become an increasingly important part of the maintenance and repair skillset, particularly for electrified vehicles. It was expected that repair services would transition to identification of faulty components through software diagnostics and replacement of components or sub-systems, rather than repair.

A survey of 44 HDV garages in Scotland was carried out as part of this study. With combined employment of over 800 HDV Technicians, this sample is estimated to represent one-third of the total number of HDV Technicians in Scotland. The full results of this survey can be found in Appendix B. Key insights are summarised below:

- 34% of garages reported that they currently provide services for battery electric/hybrid HDVs
- 15% (118) of the 803 HDV Technicians covered in the survey were reported to have recognised qualifications for working on electric/hybrid HDVs. Excluding one large franchise garage that has 45 HDV Technicians with recognised qualifications in working on electric/hybrid HDVs, 10% of the remaining sample of HDV Technicians are qualified to work on electric/hybrid HDVs
- The most common qualification was the IMI Level 3 Award in heavy electric/hybrid vehicle system repair and replacement (including bus and coach) with vehicle manufacturers also providing some qualifications/accreditations in EV/hybrid HDVs
- 32% of garages did not currently offer services for electric/hybrid HDVs but planned to do so in the next 1 to 3 years. Only 5% of garages said they did not intend to offer services for electric/hybrid HDVs in future
- The main barrier to developing skills in electric/hybrid repair for HDVs was lack of demand to justify investment (reported by 83% of garages not currently offering these services)
- Only 5% of garages report that they currently offer services for dedicated biogas/hybrid HDVs with 89% stating they do not intend to offer these services in future. Lack of customer demand was identified by 98% of garages as the reason for not investing in skills for biogas HDVs
- Only 2% of garages report that they currently offer services for hydrogen fuel cell HDVs with 59% stating they did not intend to offer them in future. Lack of customer demand was identified by 93% of garages as the reason for not investing in skills for hydrogen fuel cell HDVs
- Almost all (95%) garages agreed that they have a good understanding of the qualifications/ accreditations required to work on electric/hybrid HDVs and that they knew which providers offered the relevant training
- 27% of garages agreed that they had a good understanding of the qualifications/accreditations required to work on biogas/hybrid HDVs and 32% knew which providers offered the relevant training

- 30% of garages agreed that they had a good understanding of the qualifications/accreditations required to work on hydrogen fuel cell HDVs and 34% knew which providers offered the relevant training

There is an increasing need for technicians capable of repairing and maintaining advanced electronic systems that are becoming more prevalent in vehicles and in undertaking diagnostic testing of these. This includes advanced driver assistance systems (ADAS) for which we understand there is a severe lack of skilled people to undertake testing and diagnostics in the aftercare market. This demand for diagnostic and software skills extends beyond those involved in maintenance and repair of vehicles and is required across charging/fuelling infrastructure providers and operators (albeit to a limited degree). In particular, electrical charging systems have much more integration with the vehicle system and the local grid (especially where vehicle-to-grid technology may be deployed in the future) and servicing and maintenance of these systems involves diagnostic testing skills.

To date the focus has been on developing accredited training for hybrid and electric drivetrains, with IMI, in particular, developing a number of awards for electric/hybrid HDVs:

Qualification	Description
L2 Award in Preparing Heavy Electric/Hybrid Vehicles for Repair	Level 2 vocational qualification which provides individuals with an introduction to the knowledge, understanding and practical skills required to work on heavy electric and hybrid vehicles including bus and coach.
L3 Award in Heavy Electric/Hybrid Vehicle System Repair and Replacement	Level 3 vocational qualification which provides individuals with the knowledge, understanding and practical skills required to work on heavy electric/hybrid vehicles including bus and coach.
Intl L4 Fault Diagnosis, Testing and Repair of Heavy Electric/Hybrid Vehicles and Components	The purpose / aim of this qualification is to provide technicians who maintain and repair heavy electric / hybrid vehicles with the knowledge and skills required to work on live high voltage vehicle electrical components and associated systems.
Large Electric Vehicle: High Voltage Isolation, Reinstatement and Safety	Aimed at technicians who are responsible for the safe isolation and reinstatement of a `Large Electric Vehicles` high voltage electric drivetrain system. This can be part of an irtec licence (validates the competence of HDV technicians and in this instance is valid for 3 years).

Figure 11 - IMI accredited qualifications for electric/hybrid HDVs

There are, however, few skills providers that are accredited to provide such qualifications for HDVs in the UK, and at the moment only one, GTG, in Scotland. Colleges are considering these needs but are at present focused on delivery of hybrid/electric skills for cars and light goods vehicles. There is also the issue of infrastructure and equipment investment to run such courses. This would require access to a hybrid/electric HDV and a facility to work on it.

Skills are also required to safely inspect MOT facilities for electric/hybrid HDVs, technical knowledge of different low carbon HDVs as part of MOTs, roadside checks and post collision examination. The DVSA is working with a variety of manufacturers to create relevant training courses. These are used in addition to Awards offered by IMI as the level of non-standardisation in HDVs is much higher than for cars and light vans. The different placement of components and parts (e.g. isolator switches, batteries, fuel storage tanks) means that manufacturer specific training is required and there is an ongoing issue with keeping skills up to date as new vehicles come onto the market. Accessing the level of technical information about these vehicles creates a barrier to continual skills development.

Emergency services personnel also have a current skills requirement to enable them to work safely at the site of potential road traffic incidents involving low carbon HDVs. Similar to the DVSA, emergency service personnel need to know what they can and cannot do at the scene of an incident involving low carbon HDVs. The situation is more complex than for an incident involving diesel HDVs due to the potential for high voltages and/or high pressure flammable gases. Having the skills to identify risks and, for example, safely isolate an electric battery are skills needs that require development now. Ongoing access to data regarding technical specifications of existing and new low carbon HDVs coming onto the roads in Scotland is also an issue for emergency service personnel due to the non-standardisation of vehicle systems.

5.1.2.7 End of life/second life

The nature of skills required for end of life treatment for low carbon HDVs is focused on safe working with high voltage systems and high pressure gas systems. Otherwise, the skills utilised identification of how to depollute vehicles, recover parts and components with an aftermarket value and recover any valuable metals. It is likely that the non-standard design of low carbon HDVs could make ongoing skills development difficult as new vehicles are placed on the market. No specific training has been identified for the safety risks associated with end of life treatment of low carbon HDVs.

No significant activity in remanufacturing/refurbishing end of life HDVs or their parts/components was identified. In common with electric cars there could be future interest in utilising end of life batteries in stationery storage solutions and this would require diagnostic skills to assess the battery's state of health then technical skills to combine batteries into a storage system (requiring design engineering and electrical engineering and technician skills). There is no evidence of any activity planned in this area.

5.2 Key skills gaps

While there is not widespread adoption of low-carbon HDVs there are several examples of local authorities, bus companies and others doing so, as described in Section 3. For hybrid and electric vehicles, the main issue appears to be that the EV modules are not yet mandatory for modern apprenticeships and that there are few training providers for hybrid/electric HDVs. Feedback from the interviews is that in some cases employers are coming to training providers to ask them to include such modules in their employee training. A number of stakeholders consulted as part of the primary research for this study noted that the content of apprenticeships would need to be revised to reflect the increasing electrical knowledge that was necessary to work on many of the decarbonised drivetrains. However, there was still a noted need for mechanical skills; so the apprenticeship content had to balance the demand for electrical and mechanical skills. Stakeholder feedback has also highlighted that current apprenticeship frameworks are only partially relevant to the skills needs for installation and maintenance of hydrogen refuelling infrastructure. Currently companies in this segment of the HDV landscape have to select the best fit option (e.g. electrical installation) which only develops some of the skills required. A more focused apprenticeship offering a clear pathway for young people into a career in hydrogen was highlighted as being a beneficial development.

There is also an increasing number of companies using compressed biomethane to power their HGVs, particularly those operating large delivery fleets or which have access to biomethane from their manufacturing processes. However, they report difficulties identifying courses (accredited or not) that provide training for employees to service and maintain such vehicles. Instead, companies purchasing such HDVs also contract the manufacturer to provide servicing, repair and maintenance packages. One interviewee in the study stated that they had put their mechanics through a high-pressure gas safety course that was primarily aimed at the oil and gas sector, because there was nothing more suitable available. This was confirmed by speaking with a training provider who indicated that there are no accredited courses for working on high-pressure gas systems in vehicles and he is currently developing material to address this, as there is increasing demand from industry. It is our understanding that IMI is considering whether to develop an accredited course in this area.

It is likely that such a course would have significant cross-over with skills needed to service, repair and maintain hydrogen fuelled vehicles, particularly if these were powered by combustion engines. For fuel cell electric vehicles, as the presence in fleets is still very low (mainly local authorities running RCVs and some bus companies) there is, as yet, little demand, and as stated earlier the routine service and maintenance is being delivered by manufacturers or suppliers. However, with more widespread adoption it can be envisaged that the skills required would be a combination of understanding of working safely with high pressure gas systems and with high voltage electrical systems (which would be derived from the hybrid/electric courses described above). One subject matter expert noted that they anticipated that many of these skills would be combined in a new role of fuel cell systems engineer. This role would be required throughout the FCEV supply chain and would holistically cover all of the sub-systems in a fuel cell electric vehicle using the skills identified above. Many of the individuals carrying out this role would be educated to HND level, with a smaller number of graduate level fuel cell systems engineers required. However, the fuel cell itself is generally non-serviceable and any faults would require it to be sent back to the manufacturer for repair or to be replaced for a new one. This is a common theme with many of the electrified drivetrains where interviewees informed us that it was expected that vehicle technicians would be more likely to diagnose faulty parts using digital diagnostics and replace parts or sub-systems, rather than undertake any repairs on damaged/ faulty components.

For those involved in sales and leasing of low carbon HDVs there is a gap in the provision of the skills development training needed. As described in section 4.1, the technical and commercial knowledge requirements are much higher when compared to diesel HDV sales/leasing. Training provision is limited to that provided by manufacturers and will be focused on specific technologies and vehicle types. This limits the transferability of skills between different employers. In addition to the lack of training provision in this area there is a lack of independent certification of competency which stakeholder feedback suggests would be valued by customers.

In organisations operating low-carbon HDVs, there will also be a need to develop new skills and understanding amongst those responsible for procuring vehicles, managing their daily operations, driving the vehicles and developing the necessary recharging/refuelling infrastructure. A key skills gap commonly occurs in smaller private sector HGV operators without a dedicated fleet manager resource. Some are unaware of the skills they need to identify and technically/financially assess low carbon HDV options. When low carbon HDVs are purchased, there is also a skills gap around matching vehicle ranges and refuelling/recharging times and locations with duty cycles. Several interviewees mentioned examples where low-carbon HDVs were not being used effectively as a result of a lack of understanding on the operator's part. Many manufacturers of low-carbon HDVs have recognised this need and provide planned duty cycle use as part of their customer service, however this is still a range of skillsets that the operator will need to have in-house to ensure smooth running of its fleet. It was also noted that operators tended to participate in peer-to-peer learning, with fleet operators, which had undertaken decarbonisation, guiding those which were procuring decarbonised vehicles. This appears to be achieved through informal means as no formal structure for this was identified. The demands for smart scheduling and efficient charging/fuelling plans increased as HDV operators moved from single route decarbonisation to more complex whole depot decarbonisation. In addition, some stakeholders reflected that there are specialist services they subcontract in, rather than having staff trained in these, for example, to repair lifter mechanisms on RCVs. This is likely to continue being the case for some requirements of low-carbon HDVs, until numbers justify bringing such skills in-house. A specific skills gap was identified within operators and their consulting engineer advisers about the capability to develop the technical information necessary to support planning and consent processes for new hydrogen fuelling infrastructure.

Our understanding is that most Scottish and UK manufacturers of low-carbon HDVs, are essentially systems integrators – putting together components sourced from other manufacturers. Gliders (vehicle chassis without the engine, fuel tank or exhaust systems) are purchased from manufacturers such as Volvo, Scania or Iveco, while the fuel cell and battery systems are purchased from other manufacturers, such as Ballard (fuel cells) and A123Systems (batteries). The manufacturer of the low-carbon HDV designs a vehicle superstructure that accommodates these components while fulfilling the end-user needs (e.g. bus, RCV, etc). What this means in effect is that the skills required from engineering and assembly operatives in such companies are largely the same that are being delivered through existing university and college engineering courses. However, there is a skills shortage, with several stakeholders reporting that it is currently difficult to source employees with particular skillsets, mainly around electronics, digital technologies, diagnostics and software systems. In one case, there was increasing demand from the company's customers to analyse data for specific routes to accurately meet the client's tender briefs for new vehicles. This placed a requirement on the company to analyse GPS, route planning and system energy demand data, something which in the future they have stated that they may consider hiring a data scientist to do. This is of particular importance for decarbonised HDVs as, unlike diesel powered vehicles, overdesign of the vehicle would be a disadvantage for both the manufacturer and operator. For example, in a battery electric vehicle poor analysis of the proposed vehicle use could result in a bigger than required battery incurring significant extra expense. Conversely, failure to account for key factors in the use case (such as temperature, loaded vehicle weight, etc.) could result in a vehicle which cannot perform in real world use. Therefore, data analysis skills were much more important for decarbonised vehicles than for fossil fuelled vehicles.

Several stakeholders have also highlighted the current gap in skills for emergency service personnel attending road traffic incidents. The primary responsibility for making vehicles safe at the scene lies with the fire service but other services also need to develop the skills of their workforce as any one of the services could attend an incident first and needs to be aware of what to do and not do. Given that there are already low carbon HDVs driving on Scottish roads (in low numbers) covering battery electric, hydrogen fuel cell, direct hydrogen combustion (hybrid with diesel) and biomethane there is potential for these vehicles to be involved in an incident. The emergency services are aware of the risks involved and stakeholders have identified examples of training content being developed and parts of the workforce starting to be trained (initially focused on regions where there is a greater presence of low carbon HDVs). There is also a gap in skills for DVSA inspectors and examiners carrying out post collision investigations, assessments of vehicles in garages and at the roadside. Work is also underway to develop training content for this part of the HDV landscape. In both cases (Emergency services and DVSA) there is a need for the ongoing provision of access to vehicle specific technical data as there is a much higher level of non-standardisation in low carbon HDV design compared to cars and vans. This impacts on the ability to identify vehicle faults and ensure safe rescue and recovery.

5.3 Skills provision for low carbon HDVs

In terms of the specific skills and training provision in the current HDV market, much of the specific training is delivered by vehicle manufacturers. One manufacturer informed us that their organisation offered diagnostic training, unlimited support to qualify vehicle technicians and driver training to customers. At least one operator noted that their preferred vehicle distributor provided training to qualify a local maintenance partner in working on their electric vehicles. This arrangement currently benefits the early adopters, as the garages receive some vehicle specific training in decarbonised vehicles and the manufacturers develop a support network across Scotland and the UK. However, this manufacturer driven model is not likely to meet demand as the market penetration of decarbonised vehicles increases and as vehicles age and move onto second owners. Several stakeholders noted a risk if the skills to support the decarbonised vehicles are not present in the aftermarket as the vehicles aged and passed to subsequent owners/operators. These older vehicles would not receive manufacturer support from highly trained personnel. The availability of service and maintenance skills in the garages serving HDVs is expected to be critical as after a number of years of use, very specific skills would be needed to inspect, assess and service electrified drivetrains to ensure safe operation. We therefore anticipate that the current model of training new entrants to the industry and upskilling existing workers will be maintained, with increasing demand for training as the number of decarbonised HDVs grows. The manufacturer-led training approach that has been observed to date will support the early adopters but is not likely to be viable for a whole market conversion to decarbonised HDVs.

More of the training required by organisations using low-carbon HDVs will be delivered by further education colleges and private training providers through existing courses, if they can be satisfied that there is sufficient demand to justify investment. Qualifications will likely be updated as different low-carbon drivetrains become more prevalent. University graduates will be important for leading teams in manufacturing companies and providing specific expertise, but as development is largely around systems integration rather than RTD, the demand for graduates with skills related specifically to low-carbon drivetrains will be lower (in some areas a ratio of one graduate level specialist to 20 technicians was proposed as an approximate split). Specific graduate level skill demands cited by stakeholders were in power electronics, electrochemistry and hydrogen fuel cell fundamentals. It was noted that a large number of graduates that could fill these electrical skills currently pursued careers in microcontrollers or software and would need to be diverted to power controls engineering specialisation to ensure there was not a shortage of these specialists. Electrochemists were also noted to be in short supply, even for the limited number that would be required in the Scottish supply chain. Specialisation modules for other types of engineers or focused graduate level specialisation for chemistry graduates could address this gap.

In terms of Modern Apprenticeships, the following frameworks are relevant:

- Automotive (on average 1,088 starts each year since 2014/15), apprentices can choose light or heavy vehicle maintenance and repair routes (majority will train in light vehicles)
- Bus and Coach Engineering and Maintenance (on average 32 starts each year since 2014/15), includes mechanical, electrical and electrical-mechanical aspects
- Freight Logistics (on average 1,173 new starts each year since 2014/15), apprentices can choose either a ‘driving goods vehicles’ or a ‘warehousing, storage and distribution’ route

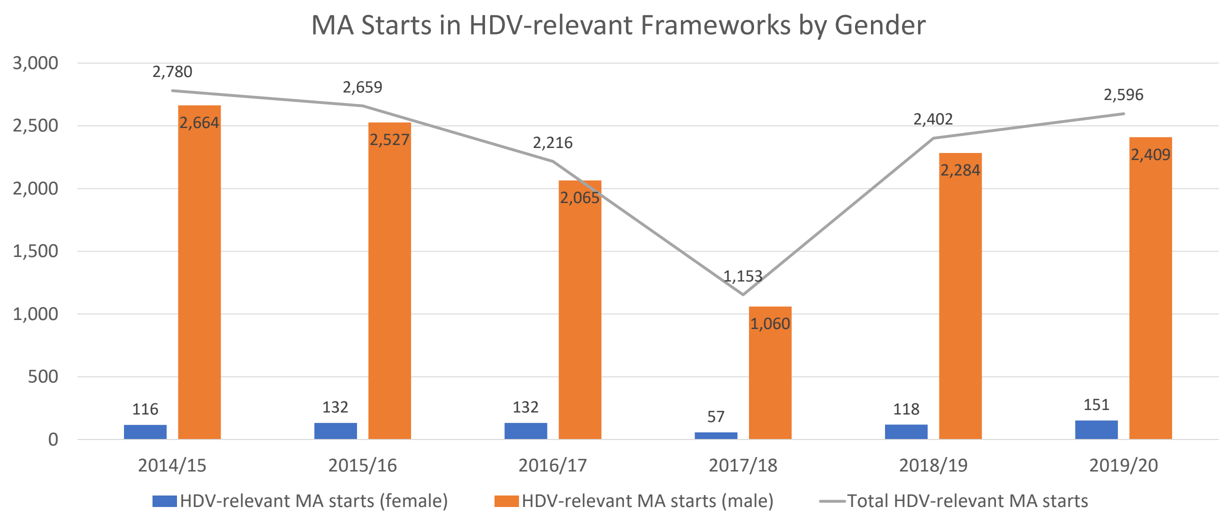

Figure 12 - MA starts in HDV-relevant frameworks per year by gender (SDS)

It is noted that 94% of these starts are male.

The figure below provides an indication of the numbers qualifying each year from further education courses that could have relevance to low carbon HDVs across manufacturing, operations, servicing and maintenance and end-of-life. The majority of these qualifications are from completing non-advanced or short courses.

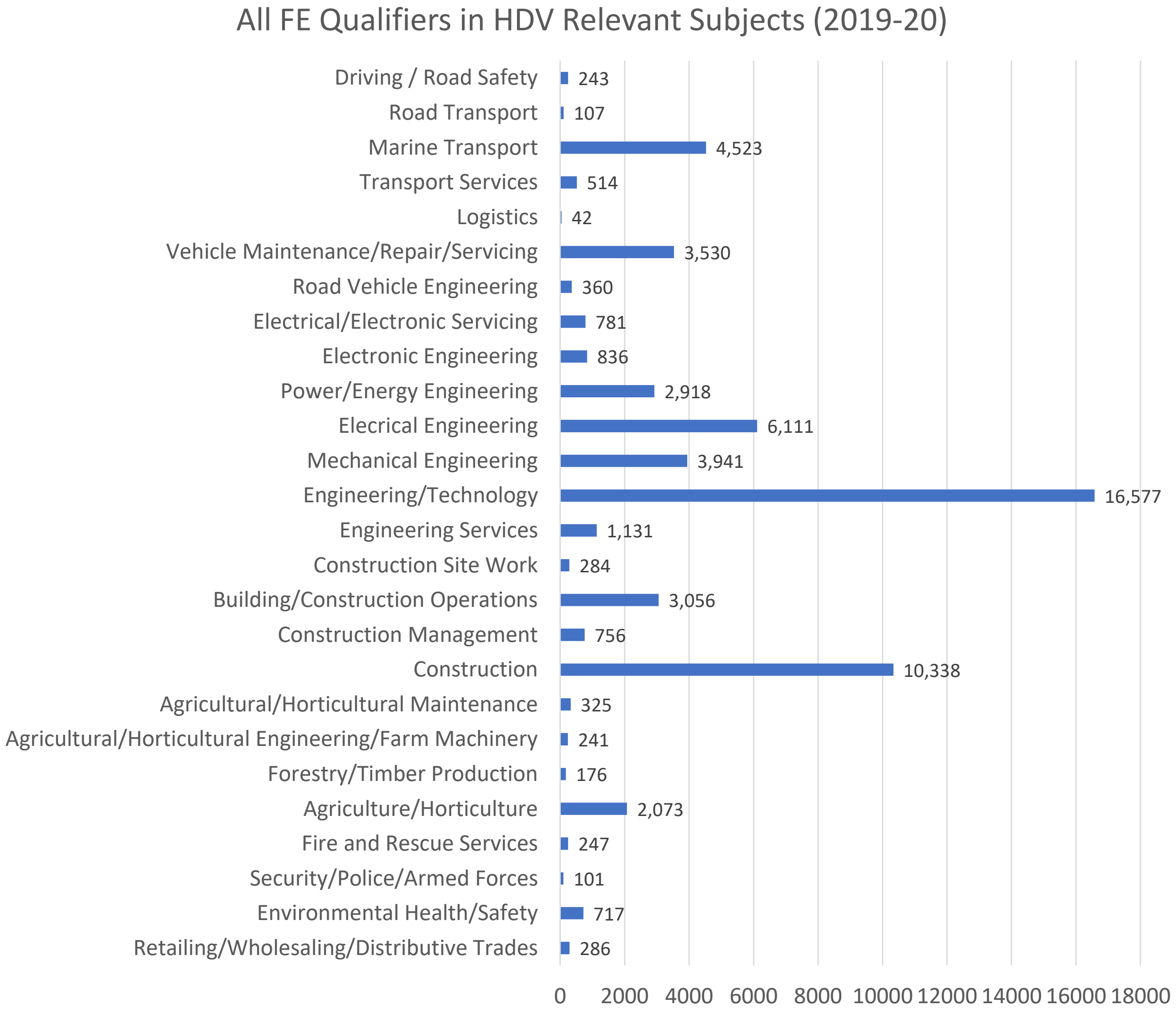

Figure 13 - Qualifiers from courses that have relevance to HDV manufacturing, operations, servicing & maintenance and end-of-life (Infact)

On the vocational side this will also include training from private companies, most notably GTG, which is the only organisation in Scotland that is accredited to run the IMI electric/hybrid HDV courses (although Alexander Dennis (ADL) also run IMI accredited courses for work on their hybrid/electric buses). Figure 14, below, provides an overview of organisations that provide training for low-carbon HDVs or related activities.

Organisation	Location	Type of Training	Examples
GTG	Glasgow, Edinburgh	Various HDV driver courses, MAs in transport & logistics, health & safety courses. Also, HDV technical courses including hybrid/ electric	IMI Level 2 Award in Preparing Heavy Electric/Hybrid Vehicles for Repair

Organisation	Location	Type of Training	Examples
ADL	Guildford and at customers' premises	IMI approved training to work on ADLs buses (including hybrid and electric) for maintenance and repair	IMI Level 1 award Hybrid overview & high voltage awareness
EINTAC	Various	IMI and C&G accredited courses for hybrid/electric vehicles, including for vehicle dismantlers and recovery	Tailored courses for businesses working with high voltage battery systems
Ebusco	Unclear, customers' premises?	Manufacturer of electric buses, providing training for technicians and for drivers – both on safety aspects and servicing/maintenance	N/A
Wright Bus	Ballymena, customers' premises	Provide training to customers on HFCE buses in partnership with Ballard (manufacturer of the fuel cell)	N/A
MTC	Bradford	Hybrid bus and HGV training courses	N/A
Renewable Energy Institute	Online, Edinburgh	Delivers a range of renewable energy courses directly or via partner educational institutes, including hydrogen technologies and electric vehicles	Hydrogen energy course Electric vehicles course
MIRA Technology Institute	Online, Nuneaton	Provides a range of courses on hydrogen fuel cells and their applications from short/CPD through to degree level	Hydrogen Fuel Cells & their Applications
Pure Energy Centre	Unst (Shetland)	Training courses on fuel cell technologies and introduction to hydrogen technologies	N/A

Figure 14 - Providers of training to support low-carbon HDV uptake

Note that a range of manufacturers (e.g. Scania, Volvo, Iveco, MAN, etc.) will also work with customers to provide training to customers on their low carbon HGVs, outside of the formalised IMI qualification/accreditation structure.

The Institution of Road Transport Engineers provides a Large Electric Vehicle – LEV Isolation and Reinstatement IRTEC licence for HDV Technicians to demonstrate their competence in this area. The assessments are carried out by approved centres although there does not appear to be any IRTEC approved centres in Scotland offering assessment of this licence.

Stakeholder feedback has also highlighted proposed projects being developed by researchers at several Scottish Universities (including University of Strathclyde, University of Edinburgh and Edinburgh Napier University – although it is unclear whether these are operating independently or in collaboration). The focus would be to carry out research into the real-world performance of different types of low carbon HDVs for different applications and under different conditions. This would help address the identified gap in this data which is acting as a barrier to skills development for those involved in sales and leasing of vehicles and operators seeking robust real-world performance data to help assess opportunities for low carbon HDVs in their fleet. There would also be access to low carbon HDVs that could be used for apprentice training and upskilling/reskilling of the existing workforce. It should be noted that this area of research is still at an early stage of development and, in some cases, still needs to go through internal processes at both universities.

Specific skills related to the adoption of low-carbon HDVs that will be required by different segments of the low-carbon HDV landscape can be summarised as follows:

HDV Landscape Segment	Skills Required	Training Provision	Skills Gaps	Skills Shortages
Manufacture of parts, components, systems & fuels	Not necessarily specific to low-carbon drivetrains, but include: • Engineers and technicians for electrical, electronic, power, high-pressure gas and software • Materials scientists, chemists and biochemists • Quality inspection and control of component parts	Further and higher education	None reported at moment, but few specialist manufacturers of these products in Scotland, and these are all small companies	Shortages noted for all of these skillsets, due to demand for these skills across a range of different sectors
Vehicle manufacture/ systems integration	• High-voltage electrical systems • High-pressure gas systems • Design engineering for the above • Systems integration	In-house, further & higher education, and private training providers	None reported at the moment – manufacturers in Scotland generally integrate parts from other manufacturers with vehicle chassis	Shortages noted more broadly for design, electrical, electronic and software engineers and technicians
Charging/ refuelling infrastructure developers/ operators	• High-voltage electrical systems • High-pressure gas systems • Civil engineering and construction	Further & higher education, and private training providers	Lack of an apprenticeship framework focused on hydrogen infrastructure installation and maintenance	Shortages noted due to demand for these skills across a range of different sectors
Vehicle sales/ leasing	• Mapping different HDV capabilities & infrastructure requirements to customer duty cycle requirements • Understanding and articulating novel financing options (e.g. vehicle as a service)	Manufacturer, component suppliers, finance suppliers, supplemented with in-house and other sources	Lack of capability to map different types of low-carbon HDVs to different duty cycles based on understanding the operator's requirements and infrastructure available to them – linked to lack of performance data	Shortages around data analytics combined with some understanding of drivetrain technologies in terms of capabilities and requirements
Vehicle owners/ operators	• Procurement & operation of HDVs that match duty cycle requirements and available infrastructure • Basics of high-voltage & high-pressure gas systems in event of breakdown or accident	Manufacturer, vehicle sales/leaser, further & higher education, and private training providers	Lack of capability to map different types of low-carbon HDVs to different duty cycles that will be undertaken during normal operations, and also considering wider infrastructure	Shortages around data analytics combined with some understanding of drivetrain technologies in terms of capabilities and requirements

HDV Landscape Segment	Skills Required	Training Provision	Skills Gaps	Skills Shortages
	• Efficient driving of low-carbon HDVs		(charging/refuelling) requirements and TCO associated with each Lack of client consulting engineering skills to develop technical information to support planning and consent processes for new hydrogen refuelling stations	
Vehicle inspection, service, repair & maintenance, recovery and emergency services	• High-voltage electrical systems • High-pressure gas systems • Safe working at road traffic incidents • Safe working at height • IT skills relating to diagnostics	Further education, and private training providers Vehicle manufacturers	Lack of relevant courses for working on high-pressure gas systems an increasing concern Technical data and skills to safely deal with Road Traffic Incidents Safe working at height	General shortage of HDV Technicians Shortages of individuals with suitable skills to inspect and work on high-pressure gas systems in HDVs Limited EV qualified recovery personnel
End or life/ second life	• Safe isolation and removal of high-voltage electrical and high-pressure gas systems • Hazardous material salvage and sorting from such systems • Remanufacture/refurbishment	Further education, and private training providers	Understanding health and environmental safety issues with respect to different materials and systems	Shortages of individuals that understand the range of materials and systems that are used in low-carbon HDVs No significant shortages in reman/refurb due to lack of industry base

Figure 15 - Summary of skills requirements, provision, gaps and shortages by low-carbon HDV landscape segment

5.4 Barriers to skills development

The key current barriers to skills development include:

1. Lack of adoption of low-carbon drivetrain HDVs – the vast majority of HDVs are still conventional ICE vehicles. There is limited need to develop skills in some parts of the workforce as there is little current demand
2. Most manufacturers/suppliers of low-carbon HDVs include extended service, maintenance and repair packages with their vehicles; so for the most part customers do not require such skills within their own workforce (although as noted, there is a need for basic skills to understand what to do when a vehicle breaks down or is in an accident)
3. Lack of availability of robust and independent real-world performance data for low carbon HDVs to help assess what low-carbon drivetrain is best suited to the users' needs. This is a combination of understanding:
    a. different drivetrain capabilities versus duty cycles
    b. requirements of the supporting infrastructure (e.g. charging and refuelling stations for H_2 or CNG)
    c. the total cost of ownership (TCO) for different drivetrains over different timeframes (dependent on the duty cycles)
4. The policy environment and lack of clarity as to whether government support will focus on one system over another, e.g. will CNG lose its tax relief at some point, will a hydrogen refuelling network for HDVs get government backing and would this be for combustion or fuel cells?
5. The lack of ongoing access to technical information about the constantly evolving low carbon HDV fleet is acting as a barrier to developing the skills necessary for both emergency service personnel attending road traffic incidents and DVSA inspection and assessment staff

5.5 Transferable skills and talent

There are a number of skills that will be required in increasing numbers by those manufacturing, integrating, operating, maintaining and servicing, inspecting, and finally recycling or disposing of low-carbon HDVs. However, three 'sets' stand out as broadly transferrable between a number of different sectors:

1. Operating safely on high-voltage systems has crossover into the rail sector, while the charging infrastructure will build on the existing light vehicle charging network and be informed by the Distribution Network Operators.
2. Operating safely on high-pressure gas systems for CNG combustion and for hydrogen combustion and fuel cells, which will have crossover with gas engineering, while the refuelling infrastructure will take its lead from the gas network. There will also be opportunities for oil and gas (O&G) operatives to reskill in this sector based on their knowledge of high-pressure natural gas systems and the specific skills used in the O&G industry (specialist welding, specialist piping). It was noted that the skills from the O&G industry would be applicable to many areas in deploying hydrogen for transport. More general skills like hazard evaluation for large numbers of potentially flammable batteries or potentially explosive hydrogen tanks at refuelling sites would also be present in the oil & gas workforce (e.g. Control of Major Accident Hazards for sites handling over 5 tonnes of hydrogen).

3. Data analysis to model and understand the different aspects that need to be considered when operating a low-carbon HDV fleet compared with a conventional diesel fleet. Such individuals are highly sought after across a wide range of sectors as a result of access to ever increasing datasets that can be analysed to improve operational performance

In addition to these 'sets' there are broader skills requirements related to software engineering, electronics and diagnostics which are relevant across a number of different industrial sectors and applications.

6 Conclusions and recommendations

This section highlights key conclusions relating to identified skills gaps, transferrable skills and talent, current preparation of HDV garages and operators, extent of existing skills supply and the key barriers to developing skills.

A number of recommendations are also proposed for consideration.

6.1 Conclusions

6.1.1 Overall conclusions

By 2032, diesel HDVs are likely to remain as the most common type used on Scottish roads. As such there will be a continued need for individuals with existing skillsets related to diesel technology. Even where low carbon HDVs are adopted there will be common skills requirements across all vehicle types, e.g. for testing, maintenance and repair of mechanical, pneumatic and hydraulic systems.

By 2032, battery electric is likely to constitute a significant proportion of the HDV fleet across all market sectors, particularly bus and coach where it could begin to challenge diesel as the leading technology type. Hydrogen fuel cell HDVs will be emerging as a significant part of the bus and coach fleet and also be present in all other market sectors. There is likely to be significant adoption of biomethane as 'stepping-stone' technology in the heavier end (41T+) of the HGV market. Direct combustion of hydrogen (in both dual-fuel and pure formats) is likely to be utilised in both HGV and off-highway construction and agricultural markets.

The indicative number of employees in Scotland with potential to require skills development associated with low carbon HDVs is 87,000. This is likely to grow to over 93,000 by 2032 due to a projected increase in road freight trips.

It is estimated that between 34,400 and 38,200 people will require some level of skills development by 2026 and between 41,000 and 53,200 by 2032. The majority of these will be emergency service personnel who require the skills to work safely and competently at road traffic incidents, which have the potential to involve HDV across the range of low carbon technologies. DVSA personnel responsible for post collision investigation, vehicle assessment and roadside examination will also all have to develop skills in safely and competently working with low carbon HDVs.

It is assumed that employees in other HDV segments will need to develop skills at the same pace as the adoption of low carbon HDVs (e.g. HDV garage technicians).

6.1.2 Areas where skills gaps exist

A range of skills are required across the HDV landscape, from in-depth design engineering skills to support manufacturing and systems integration to relatively light touch driver safety and efficiency training. In many cases the required skills training is already in place but there may be shortages of people with those skills, especially in future when adoption of low carbon HDVs increases. To address these skills shortages there is a need to produce skilled engineers and technicians, particularly in disciplines such as electronics, electrical engineering, software engineering design and high-pressure gas. In other cases, there are gaps in skills provision for the requirements. The identified skills gaps are listed below.

There are skills gaps in the development and maintenance of hydrogen refuelling infrastructure. This relates specifically to the lack of an apprenticeship framework focused on the skills requirements for this growing area. Currently companies involved in this area have to choose a 'best-fit' apprenticeship framework, such as electrical installation, but this does not fully meet their skills requirements.

There are skills gaps in low carbon HDV sales and leasing. These relate to the more complex discussions with vehicle operators when considering low carbon HDVs relative to the diesel HDV sales process. The relevant skills requirements include the ability to develop a high-level technical knowledge about how the technologies used in new low carbon HDVs work, the real-life performance (e.g. distance capabilities, payload capabilities, etc.) that can be achieved for different duty cycles, the ability to match operator requirements with appropriate low carbon HDVs, supporting customers to answer questions about the recharging/refuelling infrastructure (or know who to signpost to and what to ask), understand the differences in operation for drivers and requirements for repair, maintenance and recovery in the event of a breakdown. One vehicle manufacturing stakeholder identified that there was a need for an independently certified CPD course to enable sales staff to demonstrate to customers that they were skilled in this area. This is deemed necessary due to the high unit cost of the vehicles and the desire from customers to know they are getting robust information from the salesperson. There are similarities with this request and an existing scheme for salespeople active in the low carbon cars and light vans market (the EVA Approved scheme endorsed by the National Franchised Dealers Association, Office for Zero Emission Vehicles and Energy Saving Trust). Skills are also required to support the customer with information and data they need to assess the financial feasibility of investing in a low carbon HDV. This means having skills and knowledge about real-world performance of the different types of low carbon HDV coming onto the market and not purely relying on manufacturer data which, often does not reflect the range of different operating conditions of the vehicle, driver behaviour, etc. The lack of real-world performance data is a barrier to developing the skills necessary to sell/lease low carbon HDVs. HDV sales/leasing relies on developing long term relationships with customers and it is crucial that the customer is given reliable performance data. If not, this could impact on whether the customer buys/leases from the salesperson again.

HDV operators also face skills gaps relating to how to assess the technical and financial suitability of low carbon HDVs. With diesel HDVs there are well established cost and technical performance data available to support assessment between different vehicles. This information either does not exist in the public domain (e.g. real-world performance data for different low carbon HDVs operating across a range of duty cycles, payloads, route types and driver behaviour, etc.) or is hard to identify (e.g. capital cost data, depot infrastructure development costs, repair and maintenance costs, etc.). For smaller operators there may also be skills requirements around the actual process of assessing the vehicles.

Parts of the market such as Local Authorities and NHS Health Boards can access support for Fleet Reviews from organisations such as the Energy Saving Trust and peer to peer learning via fleet manager forums. Bus and coach operators can access peer learning opportunities via the Zemo Partnership. However, availability of skills development in this area can be limited for private HGV operators. There are examples of independent expert support for private HGV operators in England via the Energy Saving Trust, but the same/similar service is not currently available to Scottish HGV operators. It should be noted that operator member organisations such as the Scottish Wholesale Association are actively trying to address this skills gap by developing guidance material aimed at members with limited fleet manager resource. In addition to this, a specific skills gap exists within consulting engineers involved in developing the technical information necessary for the planning and consent processes for new hydrogen refuelling stations. This could be addressed through a combination of content developed by infrastructure developers and professional bodies, such as IMechE.

Those involved in vehicle inspection also face skills gaps relating to low carbon HDVs. DVSA post collision examiners, vehicle standards assessors and roadside vehicle examiners all require skills to enable them to safely and competently assess vehicles post collision, in garage assessments and at roadside checks. There is relevant training available based on IMI awards/qualifications covering electric/hybrid HDVs but skills are also required beyond this to reflect different technology types (e.g. hydrogen fuel cell and biomethane) and the different ways in which these new HDVs are constructed across different manufacturers. The degree of non-standardisation of vehicle design across manufacturers means that specific manufacturer training is required in addition to IMI qualifications/awards. There is a lack of accredited/recognized manufacturer training in low carbon HDVs that could be combined with the broader IMI heavy duty electric hybrid awards/qualifications that would provide a comprehensive skills training package. There is also a skills gap in being able to remain up-to-date with new low carbon HDVs emerging onto the market that have different vehicle designs and specifications.

HDV technicians and recovery personnel also face skills gaps when servicing, repairing, maintaining and recovering low carbon HDVs. Although the IMI provide awards/qualifications in heavy electric/hybrid vehicles there is no equivalent accredited/recognised training in safely working with high pressure gas systems (beyond those provided by individual vehicle manufactures). Whilst HDV technicians and recovery personnel working for franchised dealers or manufacturer approved repair centres have ready access to this training, those in the independent sector face barriers in accessing this training.

The lack of mandatory training content on low carbon HDVs in MA Apprenticeship Frameworks was highlighted by several stakeholders as a skills gap. This is viewed by many as a missed opportunity to develop skills in this area within new entrants to the sector.

Emergency service personnel face a gap in developing the skills to safely work at road traffic incidents involving low carbon HDVs. The approach being developed by some emergency services is to produce online content highlighting the possible risks to be aware of and processes to follow to ensure safety. This content will be delivered to new recruits and also via annual CPD for the existing workforce. Material is being developed in conjunction with manufacturers. However, there is a skills gap in remaining aware of the different vehicle designs produced by different manufacturers as new vehicles are placed on the market. There is a higher potential for non-standardisation in vehicle design for

HDVs than for cars. Not only are different technologies used but safety critical features can also be different in different vehicle types. For example, the location of isolation switches to cut off high voltage supply, the colour coding of high voltage cables, the location of batteries, the path that high voltage cables run through the vehicle (and therefore the risks of cutting through them when using specialist vehicle access tools).

6.1.3 Transferrable skills and talent

Transferrable skills and talent exist in the manufacture of high-pressure gas parts, components and systems and the development of gas refuelling stations. Employees in oil and gas supply chain companies have transferrable skills for producing high pressure gas equipment in safety critical environments. This source also offers skills in fitting and operating this type of equipment (e.g. storage tanks, compressors, etc.). The oil and gas sector also contains transferrable skills in risk assessment and hazard management processes likely to be of relevance to handling of high voltage batteries and storage of high-pressure gases.

Skills from the rail sector, in dealing with high voltage systems, are likely to be relevant to the development of charging infrastructure as are the skills present in Distribution Network Operators.

Skills in gas engineering and gas network companies have relevance to the development of high pressure gas refuelling infrastructure (hydrogen and biomethane).

Data analysis skills from the IT sector are likely to be relevant to analysing telemetry and other data gathered about HDV performance.

6.1.4 Current preparation of HDV garages and operators

HDV garages are well prepared for the transition to electric/hybrid HDVs. Just over one third of garages surveyed reported that they currently offer services to repair and maintain hybrid/electric HDVs with IMI qualifications being the most common route to skills development, followed by manufacturer training. They are aware of what qualifications/accreditations are required and what training providers offer this type of skills development. Almost all garages intend to offer services for electric/hybrid HDVs in future (95%). The main barrier to further skills development in this area is the current lack of customer demand.

However, HDV garages are much less likely to have technicians with the skills required to work on hydrogen fuel cell and biomethane HDVs (2% and 5% of garages, respectively). The majority of garages do not have a good understanding of what qualifications/accreditations are required to enable technicians to safely work on hydrogen fuel cell and biomethane HDVs and, also, most are unaware of which providers offer this type of skills development training. Most (59%) of garages stated they did not intend to offer services for hydrogen fuel cell HDVs in future and a significant majority (89%) also stated they did not intend to offer services for biomethane HDVs in future.

Different types of operators are at different stages of preparedness. Bus and coach operators (particularly those running public service bus routes) are probably the most advanced operator types in preparing for the low carbon HDV transition. This is mainly due to a combination of factors including public sector grant support for buses, availability of low carbon vehicles and public sector targets for adoption of low carbon fleet. Public sector operators (including local authorities, NHS Health Boards and the emergency services) are also relatively well prepared in terms of having a good understanding of the carbon emissions associated with their HDV and other fleets. This understanding has and is being developed through fleet review support from the Energy Saving Trust. Some private sector HGV operators are also preparing well for the transition of their HDV fleet to low carbon. The most advanced segment of this group is those involved in food and drink production as they are being driven by supply chain pressure from supermarkets to demonstrate actions on carbon reduction. Due to the resulting requirement to act quickly the adoption of biomethane is emerging as a key technology in the larger end of the private HGV fleet. At the lighter end (3.5T to 7.5T) there is increasing preparedness in the adoption of electric/hybrid vehicles. Some other private HGV operators are taking a 'wait and see' approach, especially at the heavier end of the HGV fleet. This is due to a combination of several factors including, for some smaller operators, a lack of skills in identifying and assessing low carbon HDVs, higher capital costs of vehicles, additional infrastructure costs, concerns about fuel availability cost (particularly relating to hydrogen), concerns about the availability of low carbon HDVs, concerns about the ability of vehicles to meet distance and payload requirements and reluctance to pick a particular technology type in case the rest of the market chooses and alternative technology.

6.1.5 Extent of skills supply activity

There are examples of existing centres of expertise in Scottish universities carrying out research into electric/hybrid (University of Strathclyde) and hydrogen fuel cell vehicles (University of St Andrews). Stakeholder feedback also identified an emerging project, being developed by researchers at the University of Edinburgh, Edinburgh Napier University and several industry partners, to address the issue of lack of data on real-world performance of a range of low carbon HDVs and also provide training for in a real-world environment (an operational consolidation centre using a range of low carbon HDVs). It is noted that this is at an early stage of project development and needs to go through internal approval processes at both universities.

There is limited existing low carbon HDV technician training offered in Scotland with only GTG Glasgow delivering training to IMI Level 3 in heavy electric/hybrid vehicles. Colleges do not yet appear to offer low carbon HDV technician training due to lack of demand. The main providing of training for low carbon HDV technician is vehicle manufacturers. Manufacturers will typically provide some training to operator staff regarding safe day-to-day operation and driving at customer premises. There is a general lack of skills supply for high pressure gas systems beyond that offered by manufacturers.

The Institution of Road Transport Engineers offers a Large Electric Vehicle – LEV Isolation and Reinstatement licence to allow HDV Technicians to demonstrate competence in this area, with assessment carried out at approved IRTE Centres. The licensing scheme is administered by IMI.

6.1.6 Key barriers to skills development

There are several key barriers to skills development that impact on different segments of the low carbon HDV landscape. These include:

- Limited current uptake of low carbon HDVs using hydrogen or biomethane acts as a barrier for the development of recognised qualifications/accreditations in skills to work with these high-pressure systems. There is a lack of market demand pull from HDV garages for qualification development organisations and their approved training centres. Many stakeholders highlighted that the lack of low carbon HDV repair and maintenance options for high pressure gas systems has a dampening effect on customer demand for these types of vehicles.

- Low carbon skills development of HDV technicians in independent garages is also limited by the barrier presented by operators wrapping up repair and maintenance in vehicle procurement contracts.
- The lack of real-world low carbon HDV performance data is acting as a barrier to skills development in both vehicle sales/leasing staff and HDV operators as there is a reluctance to develop these skills when this data is not available.
- The lack of clear government policy is acting as a barrier to investment in some low carbon HDV types and also the associated skills development required to support them. This means understanding whether a range of drivetrains will continue to be supported or if support will be phased out after a certain period (e.g. biomethane, hydrogen combustion), plans for public support of charging and hydrogen refuelling infrastructure, constraints and unknowns associated with the decarbonisation roadmap, etc.
- The lack of up to date, easily accessible, technical details about new low carbon HDVs launched onto the market is a barrier to continual skills development of DVSA inspection/examination staff and emergency services personnel.

6.2 Recommendations

The recommendations arising from this study are provided below and cover several areas including addressing skills gaps across the HDV landscape, availability and access to data to support skills development and policy clarification to reduce uncertainty for investment in skills.

6.2.1 Addressing skills gaps across the HDV landscape

We would recommend investigation of:

- whether there is any work underway to update National Occupational Standards to reflect the increasing need for apprentices with skills to install and maintain hydrogen infrastructure. If no such activity exists then conduct further research to demonstrate scale of demand for this change with key industry and other partners, e.g. Skills Development Scotland.
- how skills development content can be developed and delivered for those involved in sales/leasing of low carbon HDVs but do not have easy access to manufacturer training. There are relevant examples of short training courses for independent car sales garages covering electric vehicle and charging knowledge and skills, delivered by EST. Obviously, the variety of technology options applicable to low carbon HDVs increases the scope of skills and knowledge required.
- the potential for a third-party certified competency scheme to enable those involved in low carbon HDV sales/leasing to demonstrate to customers they are credible to do so. An existing independent competency scheme for people selling/leasing electric/hybrid vehicles (EVA Approved) is likely to provide a useful starting point for this investigation.
- how operator skills in identifying and assessing low carbon HDVs and associated infrastructure can be developed. This could involve working with member organisations, such as the Road Haulage Association and the Scottish Wholesale Association, to develop guidance on the process of identifying and evaluating options. It is understood that the Institute of Road Transport Engineers has a working group developing guidance about working on electric HDVs,

which may also be useful to engage with. This could also involve investigating the feasibility of offering one-to-one independent technical advice to operators which would be part consultancy and part skills development. For example, the EST, in England, offer HGV operators access to an independent fleet support person to carry out a free HGV Fleet Review (funded by the Department of Transport).

- how the skills of consulting engineers can be developed to increase capabilities around the production of technical information required for hydrogen refuelling infrastructure development and planning. This could be developed in conjunction with industry and delivered in partnership with professional bodies such as IMechE, for example.
- the feasibility of an awarding/qualification body independently accrediting manufacturer training to formalise modules that can be delivered alongside existing non-manufacturer specific awards/accreditations. This is viewed as necessary due to the lack of standardisation in technical design of different manufacturer's low carbon HDVs.
- the feasibility of incorporating mandatory elements covering low carbon HDVs within the heavy duty vehicle MA Framework.
- the feasibility of the preparation of skills development content covering safe and competent working with high pressure gas systems (hydrogen and biomethane) and also safe and competent working with fuel cells. There is only manufacturer training currently available with a lack of cross manufacturer training equivalent to the IMI awards in heavy electric/hybrid vehicles.
- the availability of skills development opportunities in electric/hybrid HDVs (as a starting point with high pressure gas systems and fuel cells fallowing later when relevant awards become available). This could include supporting the skills and competencies of trainers and reducing the barriers to accessing appropriate low carbon HDVs and training equipment. This investigation could include delivery by colleges already active in HDV technician training and also the early-stage proposal being developed within the Scottish universities (which would involve provision of training in a live operational environment).

6.2.2 Availability and access to data to support skills development

We would recommend Investigation of:

- how access to real-world vehicle performance data can be improved to support skills development in those involved in sales/leasing of low carbon HDVs and operators. This could include discussions with the researchers at various Scottish universities, about the early-stage research proposals they are working on which focus on identifying such real-world performance data across a range of low carbon HDVs and applications
- the feasibility of enabling stakeholders, such as emergency service personnel and DVSA inspection and assessment staff, to access up-to-date technical details about different types of low carbon HDVs to support the skills development necessary to safely and competently work at road traffic incidents and when inspecting and assessing low carbon HDVs.

6.2.3 Policy clarification to reduce uncertainty for investment in skills

We consider that steps should be taken to clarify the position of Government about the role of biomethane and direct hydrogen combustion (dual fuel and pure hydrogen) in the roadmap to decarbonising HDVs.

Appendix A – Contributors to the study

Stakeholders from the following organisations kindly provided input to the study. This list includes only those who consented to their organisations being named. Opinions provided reflect individual's views and are not necessarily the views of their organisations.

A.and J.Nelson (Haulage Contractors) Limited

Aberdeen City Council

AJ Spence Ltd

Alex Aiken & Son Ltd

Alexander Dennis

Almar Garage

AM Phillip Trucktech Ltd

Arcola Energy

Armstrong Vehicle Centre

Association for Public Sector Excellence

ATT Commercials

CBB Commercials Ltd

Cenex

Ciceley Commercials Ltd

CMC Maintenance Ltd

CMS Glasgow Ltd

CMS Scotland

CNG Services

Coach Tech Assist

College Mill Garage

Connected Places Catapult

David Philp Commercials

DM Commercials

Driver and Vehicle Standards Agency

Drummond Motor Co Ltd

Dundee & Angus College

Edinburgh College

Elgin Truck and Van Centre Limited

Ember Core

Energy Saving Trust

Enginuity

ESP

Ferguson Transport and Shipping

G. Bannerman (Tain) Ltd

Gary Buist Commercials Limited

Graham's Family Dairy

GTG Training - Glasgow

GWC Commercials Ltd

HHH Ltd

Highlands and Islands Enterprise

Houston's Coaches

Hydrogen Vehicle Systems

I A and C Maciver Limited

Institute of Road Transport Engineers

J Borthwick Vehicle Repairs

JD Engineering

John Mitchell Transport

Leslie Commercials Ltd

Logan Energy

Lothian DAF

M8 Recovery

Mackenzies (Cambuslang) Ltd

McDougall Commercials

NHS National Services Scotland

NMIS Manufacturing Skills Academy

North East Scotland College

Optare (Now known as Switch Mobility)

Police Scotland

RA Commercials Ltd

Remit Training

Ristol Consulting

Road Haulage Association

Roadside Vehicle Services Ltd

Scotland Excel

Scottish Ambulance Service

Scottish Enterprise

Scottish Fire and Rescue Service

Scottish Hydrogen Fuel Cell Association

Scottish Research Partnership in Engineering

Scottish Wholesale Association

Society of Operations Engineers

Solway DAF

SWARCO

The Institute of the Motor Industry

Transport Scotland

ULEMCo

University of Edinburgh

University of St Andrews

University of Strathclyde

Urban Foresight

Volvo Trucks

Western Automobile Company Ltd- Govan

WH Malcolm Ltd

William McArthur

Wrightbus

Appendix B – HDV garage survey – full results

A total of 92 HDV garages were contacted and 44 HDV garages were surveyed (48% response rate). The results are presented below.

What type of business do you represent? ***Tick one only***

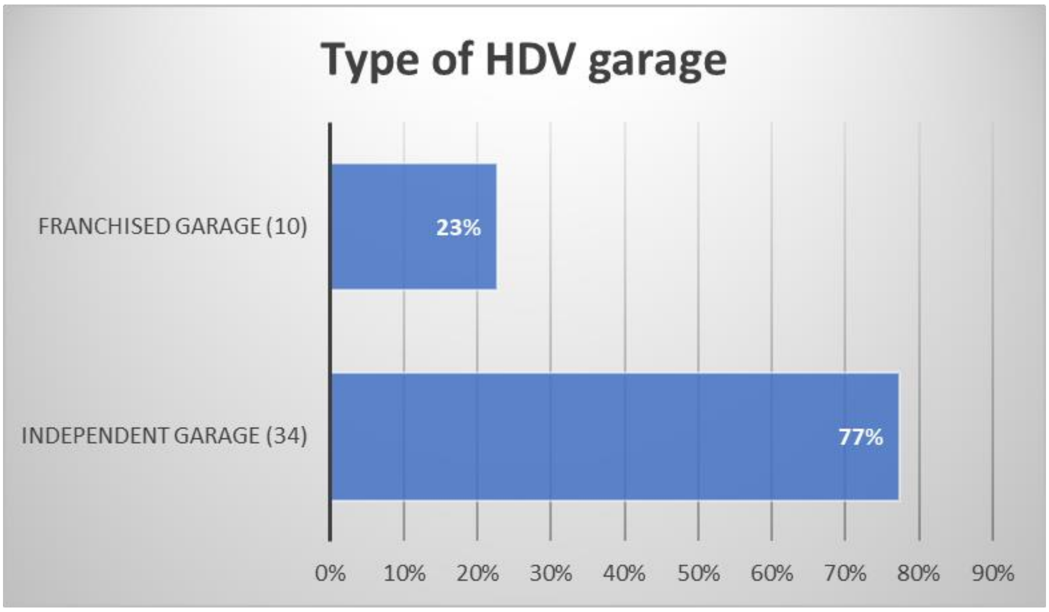

Figure 16 - Split of survey respondents by garage ownership

Do you operate at a single site or multiple sites? ***Tick one only***

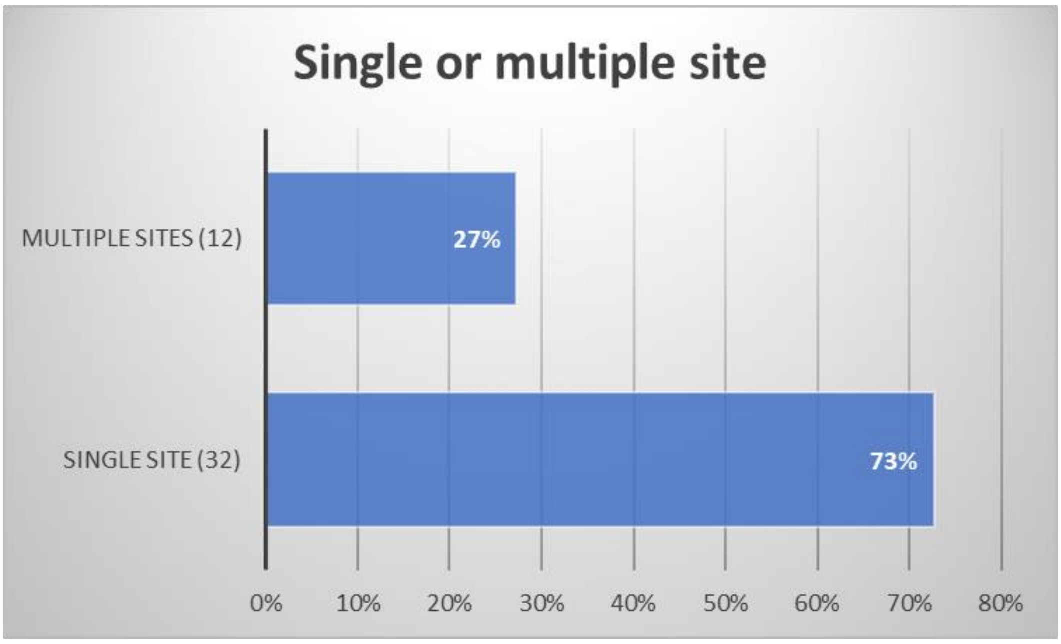

Figure 17 - Survey respondents by number of garage sites

How many staff do you have in total based in Scotland? ***Tick one only***

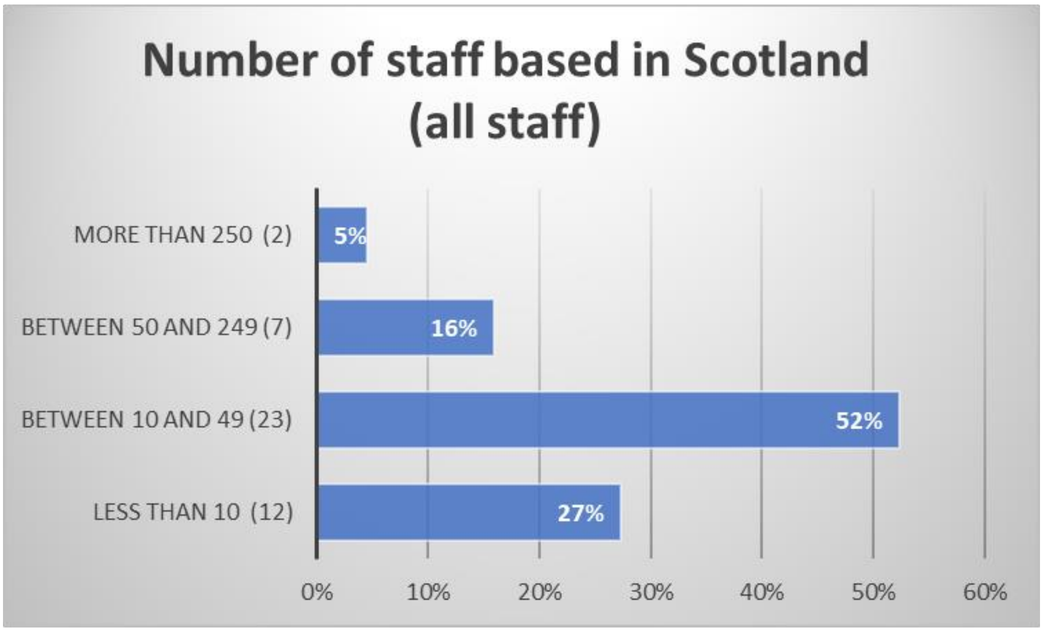

Figure 18 - Survey respondents by number of employees (all staff)

In total, how many staff carry out general heavy duty vehicle inspection, repair, maintenance or recovery as part of their day-to-day duties?

In total, the 44 respondents employed 803 HDV Technicians. It is useful to compare this with the estimated total number of HDV Technicians in Scotland of 2,500, meaning the survey responses covered 32% of all HDV Technicians.

The average number of HDV Technicians employed by respondent garages was 18 (min 1, max 200). The standard deviation was 38, meaning the garage with 200 HDV Technicians was an outlier in the sample.

Which of the following heavy duty vehicle types do you inspect, repair, maintain or recover? *Tick all that apply*

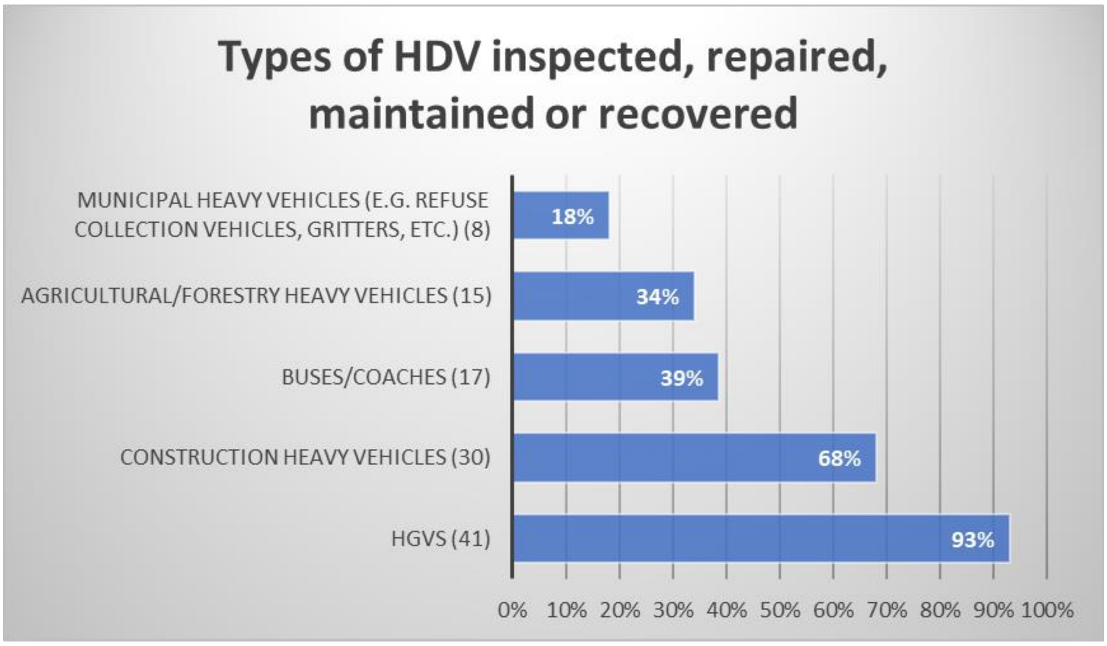

Figure 19 - Types of HDV inspected, repaired, maintained or recovered

Do you currently provide services to inspect, repair, maintain or recover hybrid battery electric/ full battery electric heavy duty vehicles? ***Tick one only***

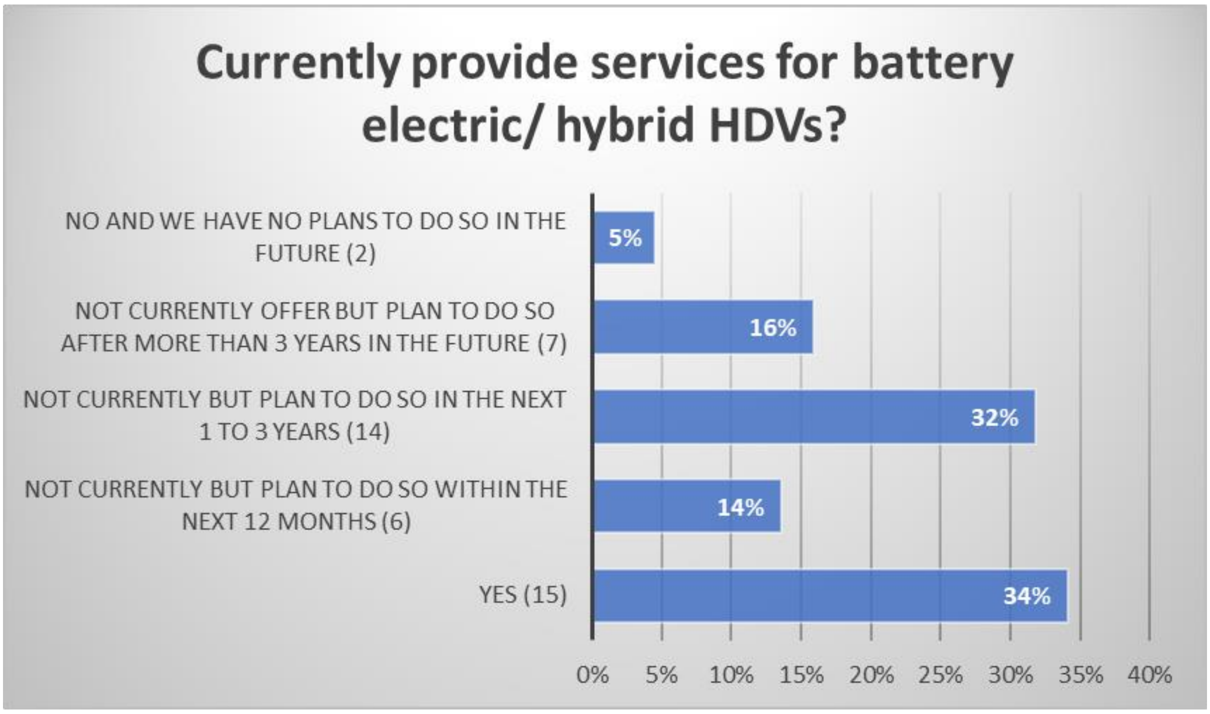

Figure 20 - Current provision of services for battery electric/hybrid HDVs and future intentions, by timescale

Just over one-third of garages report that they are able to provide services for battery electric/hybrid HDVs. A further 62% intend to do so in future, with 1 to 3 years being the most common time period predicted for this to occur. Only 5% said they do not intend to introduce such services in future.

Which of the following reasons are relevant to your decision not to provide hybrid battery electric/full battery electric heavy duty vehicle services? *Tick all that apply*

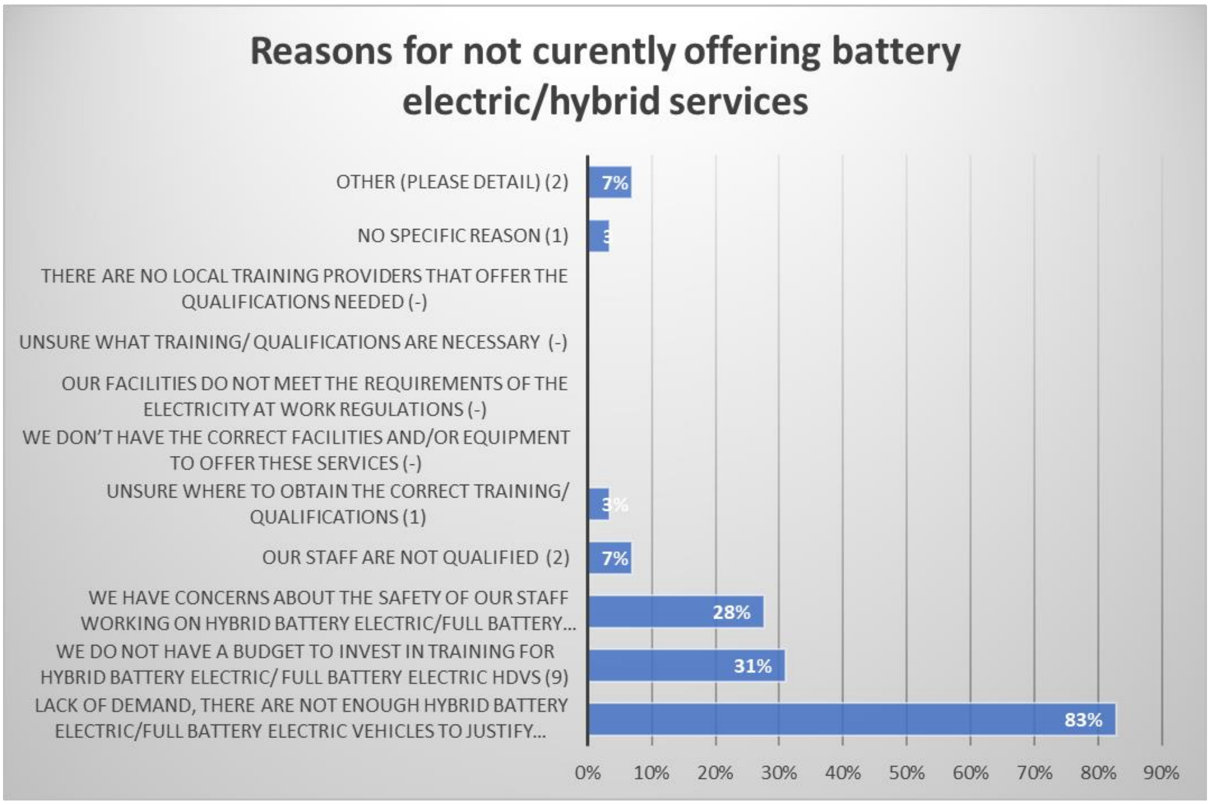

Figure 21 - Reasons for garages not currently offering battery electric/hybrid services for HDVs

The most common reason (cited by 83% of those who do not currently offer battery electric/hybrid services for HDVs) for not offering these services is lack of demand in the market to justify investment in skills development and additional equipment/workshop modifications necessary.

Lack of budget for skills development and concerns about staff safety were also cited by a significant number of respondents (31% and 28% respectively).

Do you have any staff with a recognised qualification(s)/ accreditation(s) which allows them to work on Hybrid battery electric/ full battery electric heavy duty vehicles? *Tick one only*

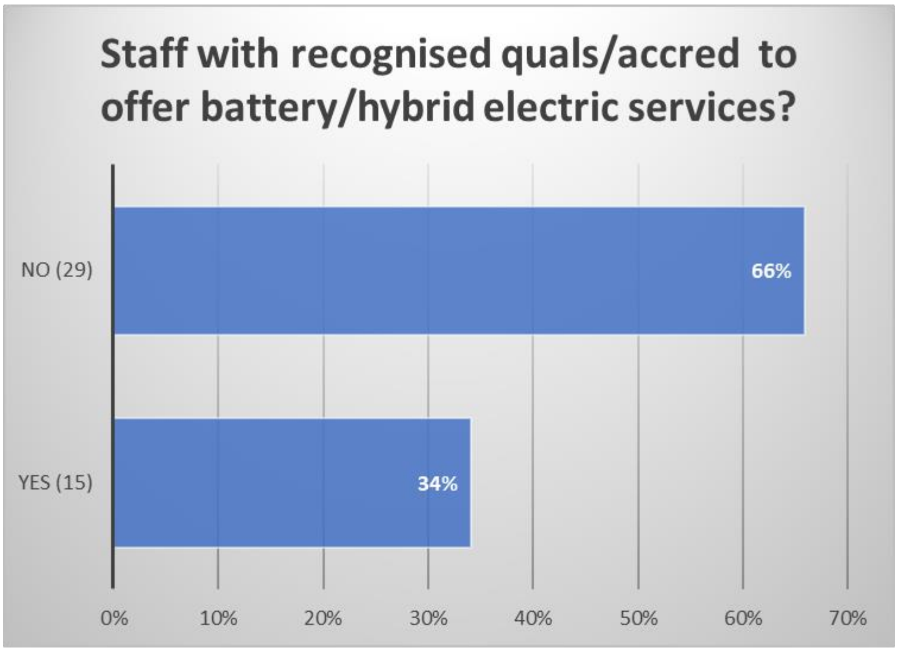

Figure 22 – Garages with HDV Technicians that have recognised qualifications/accreditations to enable them to work safely and competently on battery electric/hybrid HDVs

One-third of HDV garages had HDV Technicians with recognised qualifications/accreditations to enable them to work on battery electric HDVs. This aligns with the proportion of garages offering these services.

How many staff do you have with recognised qualification(s)/ accreditation(s) which allows them to work on Hybrid battery electric/ full battery electric heavy duty vehicles *Write in the number*

A total of 118 HDV Technicians were identified as having recognised qualifications/accreditations enabling them to work on battery electric/hybrid HDVs. Compared to the total sample of 803 HDV Technicians, this means 15% have the necessary qualifications/accreditations. However the results are skewed by the presence of a large, multi-site franchise garage. Excluding this outlier, the figure reduces to 10% of HDV Technicians having the necessary qualifications/accreditations to work on battery electric/hybrid HDVs.

Do you have any plans for your staff to gain recognised qualification(s)/ accreditations(s) to inspect, repair, maintain or recover Hybrid battery electric/ full battery electric heavy duty vehicles? *Tick one only*

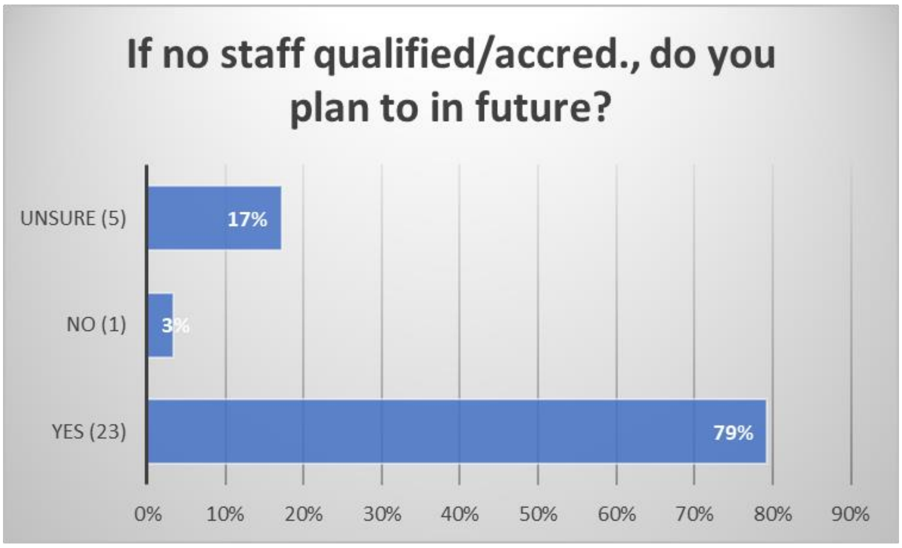

Figure 23 - Future plans of garages with no current HDV Technicians with recognised qualifications/accreditations to work on battery electric/hybrid HDVs

A significant majority of those garages intend to develop the skills of some of their HDV Technicians in future, to enable the to work on battery electric/hybrid HDVs.

When do you plan for your staff to gain recognised qualification(s)/ accreditations(s) to inspect, repair, maintain or recover Hybrid battery electric/ full battery electric heavy duty vehicles? ***Tick one only***

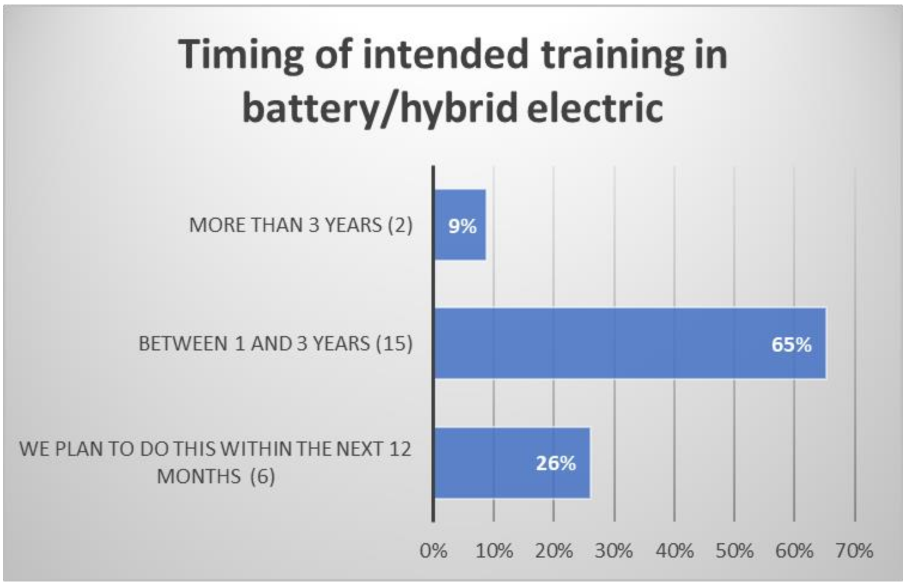

Figure 24 - Intended timing of skills development of HDV Technicians to work on battery electric/hybrid HDVs (based on responses from garages without HDV Technicians with current qualifications/accreditations in this area)

The majority (65%) of garages intending to develop the skills of their HDV Technicians in battery electric/hybrid HDVs state they plan to do so in the next 1 to 3 years. A significant minority (26%) intend to do so in the next 12 months.

Which training providers delivered the training in inspecting, repairing, maintaining or recovering hybrid battery electric/ full battery electric heavy duty vehicles? ***Tick all that apply***

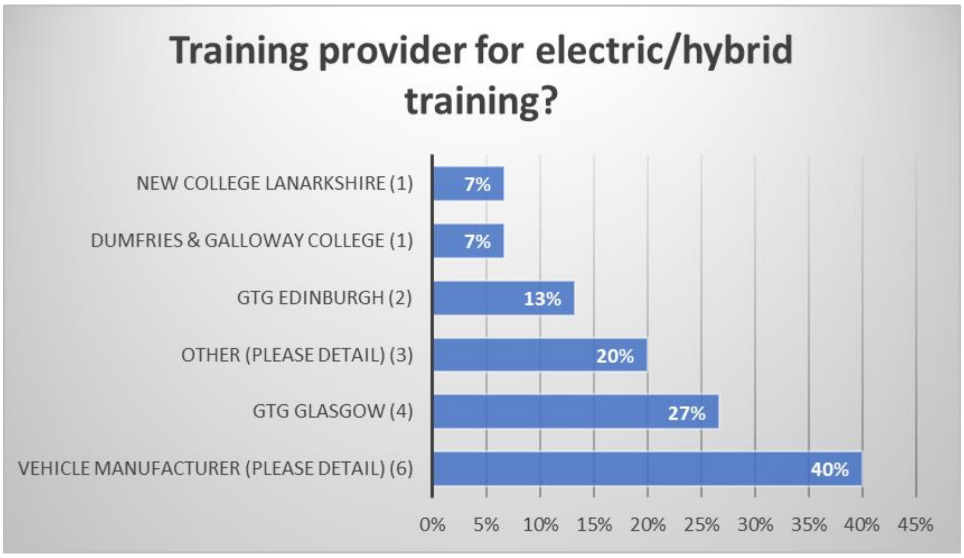

Figure 25 - Training providers used by garages already having HDV Technicians with recognised qualifications/ accreditations to work on battery electric/hybrid HDVs

The joint leading training provider category is vehicle manufacturers with providers named including DAF, Scania, Volvo, Ford and Hyundai (with 40%). GTG (both Glasgow and Edinburgh combined) also represented 40% of training provision. Other private provision identified includes Alexander Dennis, City Link and Dingbro Virtual Academy. New College Lanarkshire and Dumfries & Galloway College are also identified although it is likely this relates to the IMI Level 1 Awareness in Electric/Hybrid vehicles Award rather than the more in-depth Level 2 and Level 3 Heavy Electric/Hybrid vehicle Awards.

Which of these qualification(s)/ accreditation(s) in inspecting, repairing, maintaining or recovering hybrid battery electric/ full battery electric heavy duty vehicles are held by your staff? *Tick all that apply*

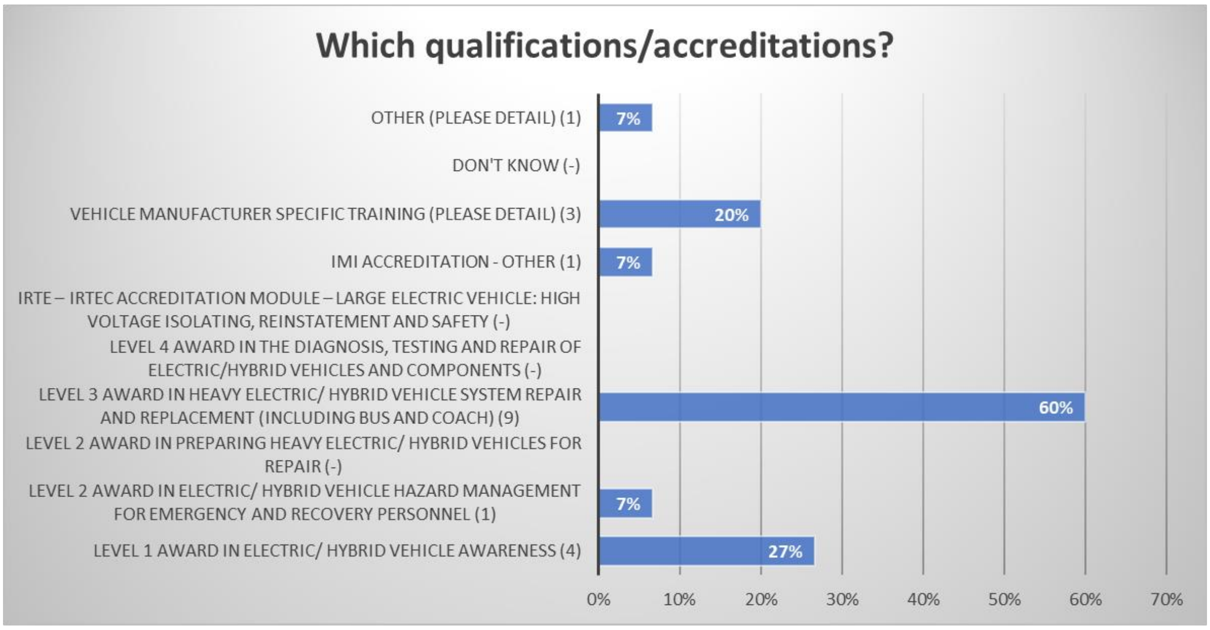

Figure 26 - Qualifications/accreditations held by HDV Technicians relevant to working on battery electric/hybrid HDVs

The most common qualification/accreditation is the IMI Level 3 Award in heavy electric/hybrid vehicle system repair and replacement (including bus and coach). The IMI Level 1 Award in electric/hybrid vehicle awareness qualification is also highlighted but it is assumed this HDV Technicians with this award also have a Level 3 award and/or manufacture specific training as the Level 1 award, in isolation, would not be sufficient to enable HDV Technicians to work safely and competently on electric/hybrid HDVs.

Who is the certifying body for the recognised qualification(s)/ accreditation(s), held by your staff, to work on hybrid battery electric/ full battery electric heavy duty vehicles? ***Tick all that apply***

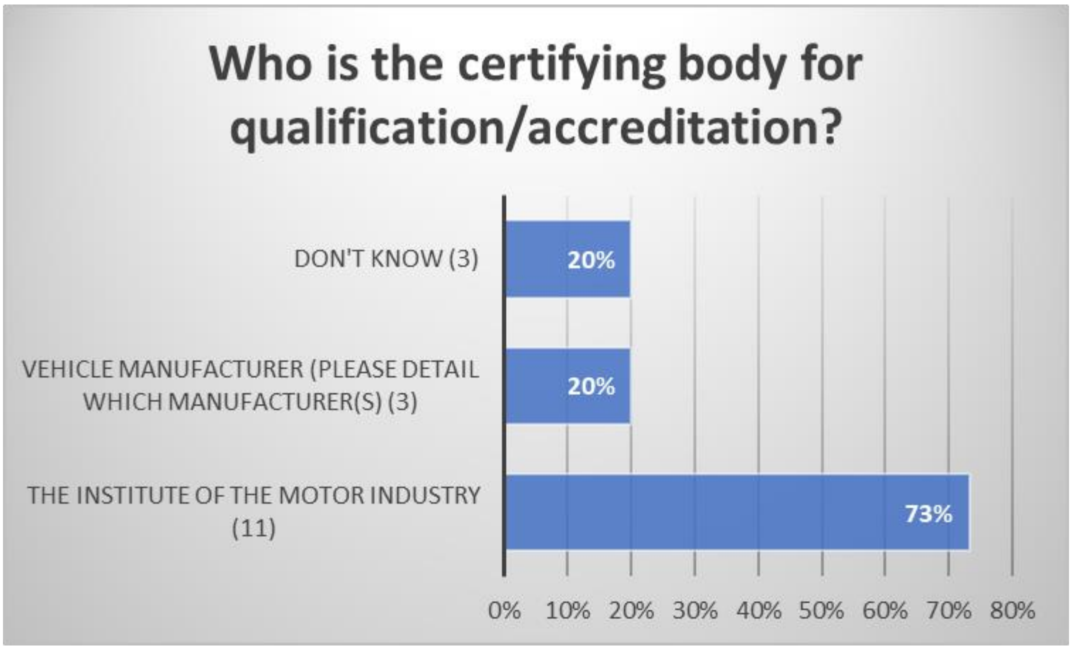

Figure 27 - Certifying body for the qualifications/accreditations gained by HDV Technicians in working with electric/hybrid vehicles

The certifying bodies for the qualifications/accreditations achieved by HDV Technicians are the IMI (73%) and vehicle manufacturers (20%). Vehicle manufacturers identified include Mercedes, DAF and Hyundai.

Do you currently provide services to inspect, repair, maintain or recover dedicated biogas/ hybrid biogas heavy duty vehicles? ***Tick one only***

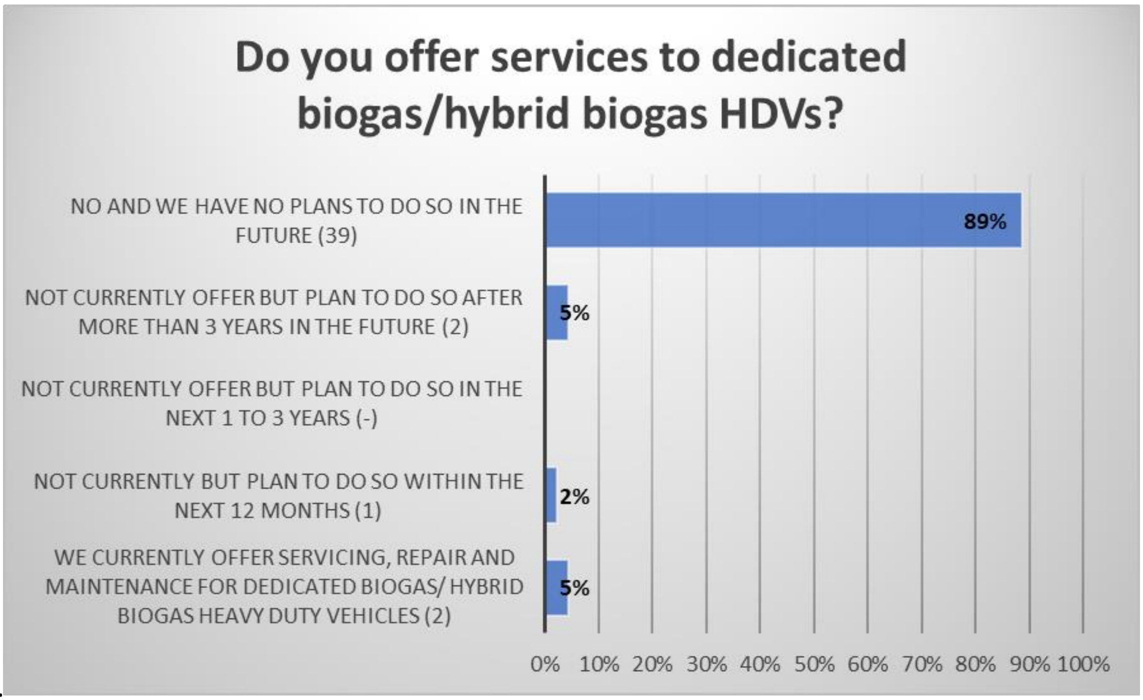

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Figure 28 - Current status and future plans of HDV garages about offering services for biogas/hybrid biogas HDVs

Only a very small proportion (5%) of garages currently offer services for this type of HDV and a significant majority (89%) do not intend to do so in future.

Of those that do offer services the HDV Technicians received training from vehicle manufactures, with Volvo and Iveco named as providers.

Which of the following reasons are relevant to your decision not to provide dedicated biogas/hybrid biogas heavy duty vehicle services? ***Tick all that apply***

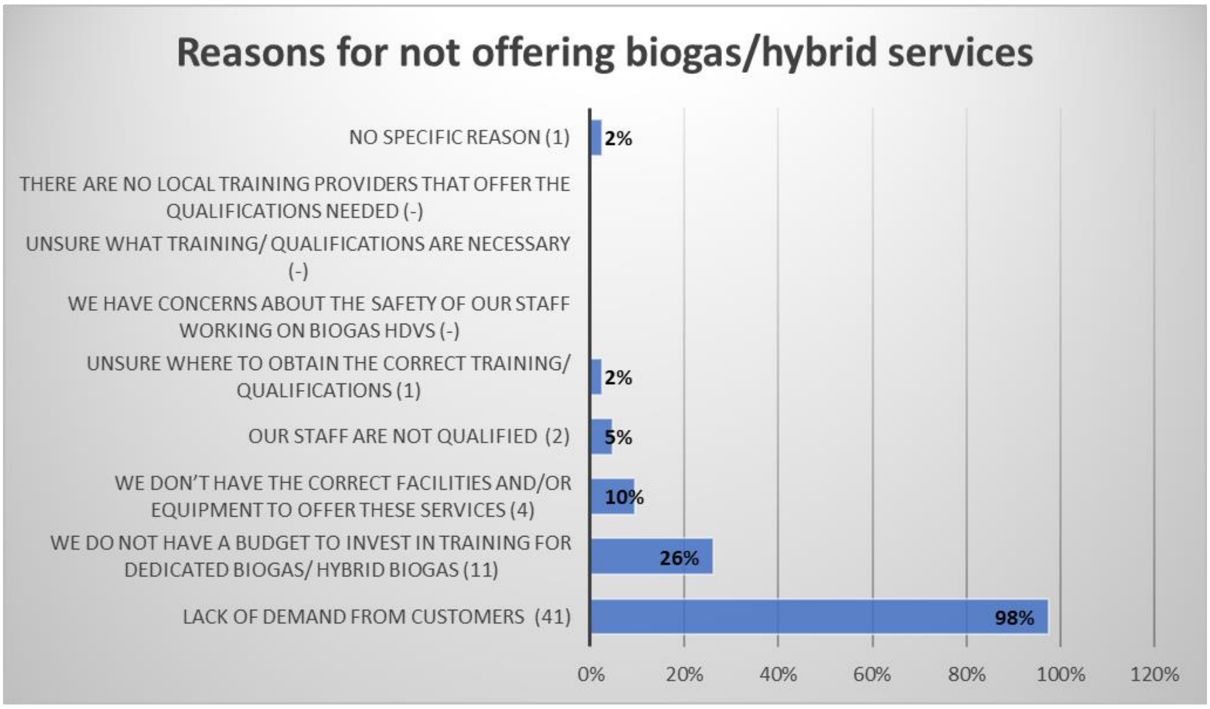


Figure 29 - Reasons for garages not offering services for biogas/hybrid HDVs

Almost all (98%) of the garages not currently offering services for biogas/hybrid HDVs stated lack of demand from customers was the main reason for this. Just over one quarter also identified the lack of a training budget as being a reason for not investing in the necessary skills.

Do you currently provide services to inspect, repair, maintain or recover Hydrogen fuel cell electric heavy duty vehicles?

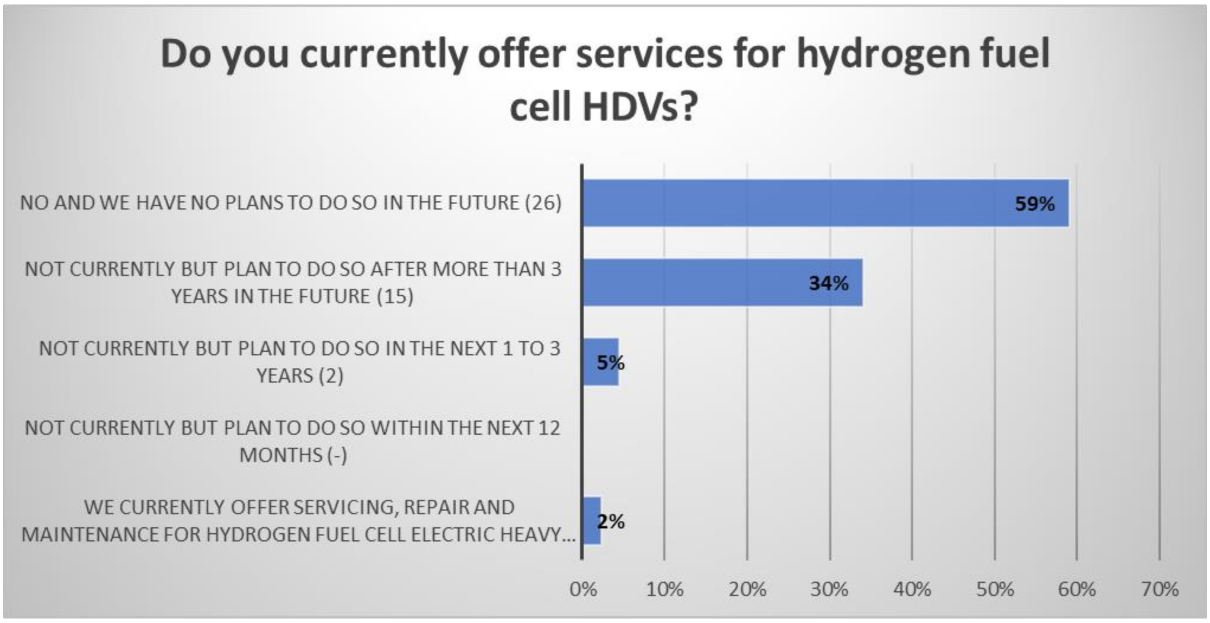


Figure 30 - Current status and future plans of HDV garages aboutoffering services for hydrogen fuel cell HDVs

A very small minority (2%) of garages currently offer services for hydrogen fuel cell HDVs. However, there is greater interest in providing these services in future compared to biogas/hybrid HDVs. 39% said they planned to develop these services in future, with most of this activity planned for more than three years into the future. A majority (59%) have no plans to develop these services in future.

The one garage that does currently offer these services received training from the manufacturer, Wrightbus.

Which of the following reasons are relevant to your decision not to provide hydrogen fuel cell electric HDVs vehicle services? *Tick all that apply*

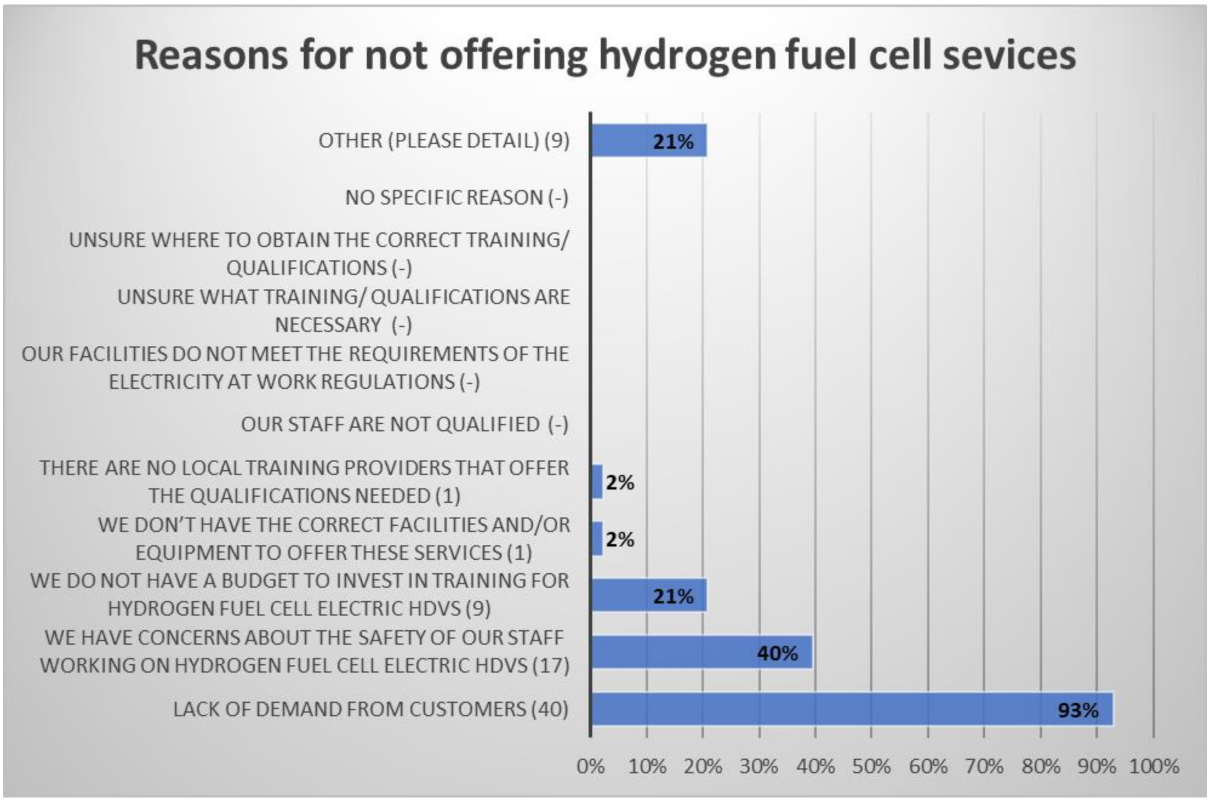


Figure 31 - Reasons for garages not offering services for hydrogen fuel cell HDVs

Again, lack of demand was given as the reason by a significant majority (93%) of garages for not offering services for hydrogen fuel cell HDVs. Concerns about the safety staff also featured highly for a number of garages (40%) together with lack of available training budget (21%).

Of the 21% responding 'Other' the main reasons related to it not being cost effective, which can be regarded as similar to lack of demand. Two of the respondents reported having trialled hydrogen fuel cell HDVs in their own fleet (as it is common for fleet owners to also offer third party garage services) but state it was not cost effective.

How important do you believe it is for skills and competencies to be developed in Scotland for inspection, repair, maintenance and recovery of the following types of low carbon heavy duty vehicles in the next 5 years? *(Tick one on each row)*

Attitudes about low carbon heavy duty vehicle inspection, repair, maintenance and recovery

Analysis % Respondents	Total	Not at all important	Not important	Unsure	Important	Very important	NA	% Combined important	% Unimportant
Base	132	-	1%	39%	44%	16%	-	60%	1%
Hybrid battery electric/full battery electric heavy duty vehicles	44	-	-	2%	66%	32%	-	98%	0%
Hydrogen fuel cell electric heavy duty vehicles	44	-	-	50%	39%	11%	-	50%	0%
Dedicated biogas/hybrid biogas heavy duty vehicles	44	-	2%	66%	27%	5%	-	32%	2%

Figure 32 - Views on importance of developing HDV Technician skills for different technology types, by 2026

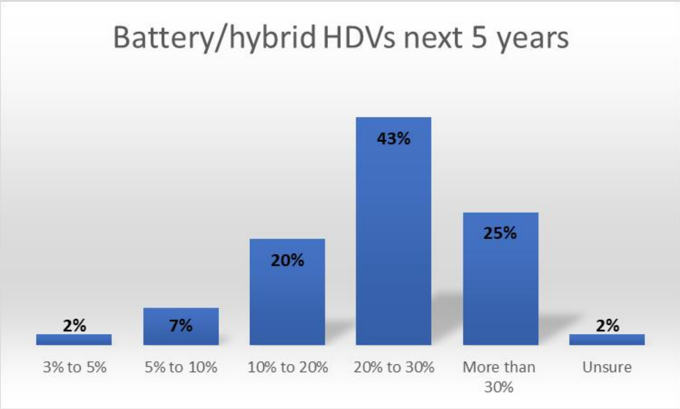
Almost all (98%) agreed that it was important to develop skills to work on battery electric/hybrid HDVs by 2026. Of this, one third thought it would be very important.

Half of garages agreed that it is important to develop skills to work on hydrogen fuel cell HDVs by 2026. This is slightly more than the 41% of HDV garages who responded in an earlier question that they currently or plan to offer these services in future.

One third of garages agreed that it is important to develop skills to work on biogas/hybrid HDVs by 2026. However, earlier responses that indicate only 12% of HDV garages currently, or plan to, offer these services in future.

Respondents were asked to estimate what proportion of all heavy duty vehicles (over 3.5 tonnes), in Scotland, will use different technology types by 2026 and 2032

<u>Battery electric/hybrid</u>



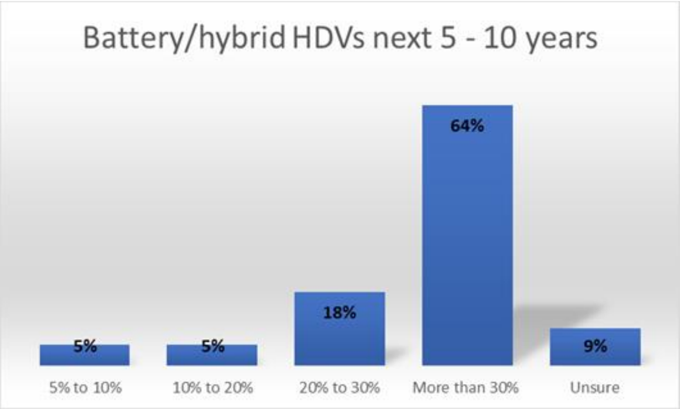
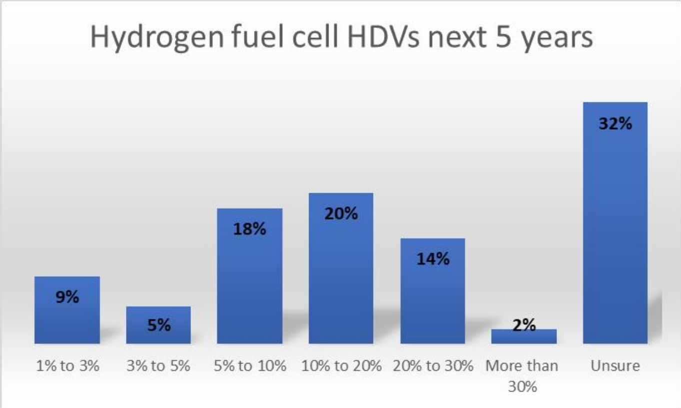


Figure 33 - Expectation about the proportion of the total Scottish HDV fleet that will use battery electric/hybrid technology by 2026 and 2032

Garages estimated a much higher proportion of fleet to use battery/hybrid HDVs by 2026 than the study literature review or stakeholder consultations suggested. It may be that some interpreted the question as referring to percentage of annual HDV sales rather than percentage of the total vehicle fleet on the road. There is a relatively low level of uncertainty for estimates about this technology type compared to the estimates for hydrogen fuel cell and biogas/hybrid HDVs (see below).



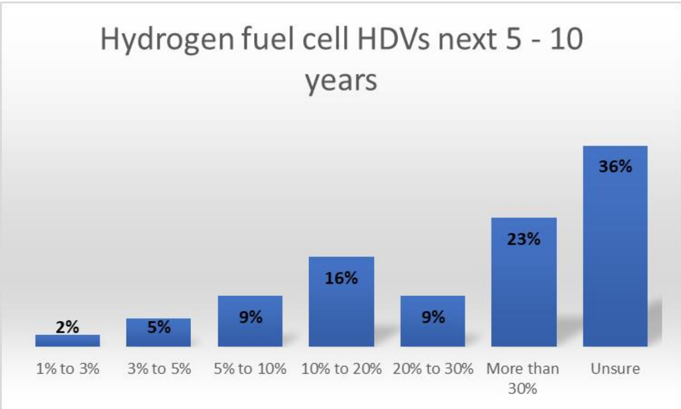
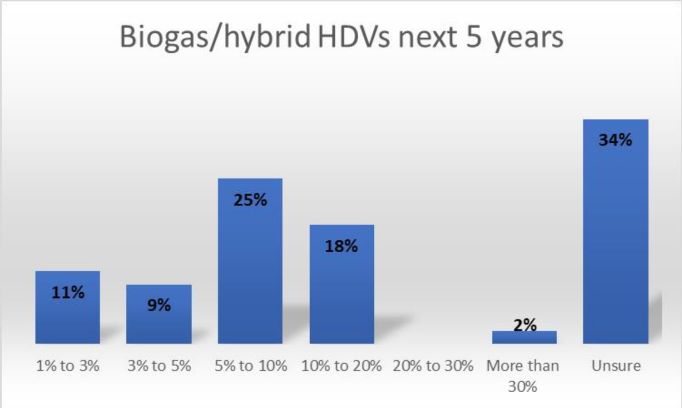


Figure 34 - Expectation about the proportion of the total Scottish HDV fleet that will use hydrogen fuel cell technology by 2026 and 2032

The estimated future proportion of the HDV fleet using hydrogen fuel cell technology is lower than battery electric/hybrid. This is the same relative position as suggested by the literature review and stakeholder interviews but the absolute level of penetration is much higher (as was the case for estimates for electric/hybrid technology), particularly for the period to 2026. Again, it may be that some of the garage respondents perceived the question to be about proportion of annual HDV sales rather than the proportion of the overall HDV fleet. The level of uncertainty is high across both time periods, with over one-third of respondents unsure what level of fleet penetration hydrogen fuel cell HDVs would achieve.



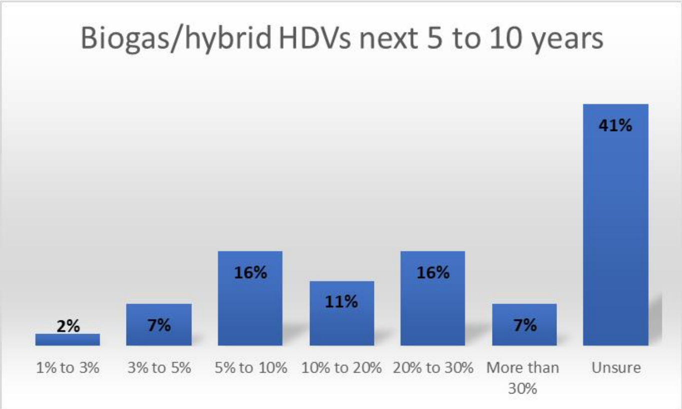


Figure 35 - Expectation about the proportion of the total Scottish HDV fleet that will use biogas/hybrid HDVs by 2026 and 2032

Respondents estimated a lower proportion of the fleet would use biogas/hybrid technology compared to both battery electric and hydrogen fuel cell technology by 2032 but in the period to 2026 the proportion of biogas/hybrid HDVs is estimated to be higher than hydrogen fuel cell. This relative positioning of technologies is consistent with the findings of the literature review and stakeholder interviews. Again, the absolute proportions of the fleet estimated to be biogas/hybrid are high compared to the findings of the literature review and stakeholder interviews. As with the estimates for the other technologies it may be that respondents are interpreting the question to be about the proportion of annual sales rather than of the total HDV fleet. As is the case with hydrogen fuel cells, there is a high level of uncertainty about future estimates for biogas/hybrid HDVs.

To what extent do you agree or disagree with the following statements: ***(Tick one on each row)***

	Analysis % Respondents	Total	Strongly disagree	Disagree	Unsure	Agree	Strongly agree	NA	% Combined Agreement	% Combined Disagreement
	Base	528	-	16%	29%	40%	15%	-	55%	16%
	Working on hybrid battery electric/full battery electric heavy duty vehicles requires additional/different skills and competencies compared with the skills and competencies required to work on traditional heavy duty vehicles	44	-	-	2%	70%	27%	-	98%	0%
Different skills/competences required	Working on dedicated biogas/hybrid biogas heavy duty vehicles requires additional/different skills and competencies compared with the skills and competencies required to work on traditional heavy duty vehicles	44	-	11%	30%	57%	2%	-	59%	11%
	Working on hydrogen fuel cell electric heavy duty vehicles requires additional/different skills and competencies compared with the skills and competencies required to work on traditional heavy duty vehicles	44	-	7%	30%	61%	2%	-	64%	7%
	Being able to provide hybrid battery electric/full battery electric heavy duty vehicle services will be a necessary part of our business in the future	44	-	-	5%	45%	50%	-	95%	0%
Necessary part of business in future	Being able to provide dedicated biogas/hybrid biogas heavy duty vehicle services will be a necessary part of our business in the future	44		23%	70%	5%	2%	-	7%	23%
	Being able to provide hydrogen fuel cell electric heavy duty vehicle services will be a necessary part of our business in the future	44	-	14%	64%	20%	2%	-	23%	14%
	We have a good understanding of what qualifications/accreditations our technician staff should hold to enable our business to offer hybrid battery electric/ full battery electric heavy duty vehicle inspection, repair, maintenance or recovery services	44	-	2%	2%	59%	36%	-	95%	2%
Good understanding of required qualifications/ accreditations	We have a good understanding of what qualifications/accreditations our technician staff should hold to enable our business to offer dedicated biogas/hybrid biogas heavy duty vehicle inspection, repair, maintenance or recovery services'	44		34%	39%	23%	5%	-	27%	34%
	We have a good understanding of what qualifications/accreditations our technician staff should hold to enable our business to offer hydrogen fuel cell electric heavy duty vehicle inspection, repair, maintenance or recovery services'	44	-	32%	39%	25%	5%	-	30%	32%
	We have a good understanding of who the providers are that offer training in inspection, repair, maintenance or recovery of hybrid battery electric/ full battery electric heavy duty vehicles	44	-	2%	2%	59%	36%	-	95%	2%
Good understanding of who provides training	We have a good understanding of who the providers are that offer training in inspection, repair, maintenance or recovery of dedicated biogas/ hybrid biogas heavy duty vehicle repair and maintenance training'	44	-	34%	34%	25%	7%	-	32%	34%
	We have a good understanding of who the providers are that offer training in inspection, repair, maintenance or recovery of hydrogen fuel cell electric heavy duty vehicles	44	-	34%	32%	27%	7%	-	34%	34%

Figure 36 - Extent of agreement with various statements relating to low carbon HDV technologies

A number of observations can be made from the responses in the above figure.

<u>Difference in skills and competencies required</u>

- There is almost unanimous agreement (98%) that different skills and competencies are required to work on electric/hybrid HDVs
- Around one-third are unsure whether working on biogas/hybrid or hydrogen fuel cell HDVs requires different skills and competencies
- 11% of garages disagree that different skills and competencies are required to work on biogas/hybrid HDVs
- 7% of garages disagree that different skills and competencies are required to work on hydrogen fuel cell HDVs

<u>Importance of low carbon HDVs to the future of your business</u>

- 95% of garages agree that being able to provide services for electric/hybrid HDVs will be a necessary part of their business in future
- 7% of garages agree that being able to provide services for biogas/hybrid HDVs will be a necessary part of their business in future
- 23% of garages agree that being able to provide services for hydrogen fuel cell HDVs will be a necessary part of their business in future

<u>Levels of understanding about what qualifications/accreditations are required for HDV Technicians</u>

- 95% of garages have a good understanding of the qualifications/ accreditations HDV Technicians should hold to enable them to work on electric/hybrid HDVs
- 27% of garages have a good understanding of the qualifications/ accreditations HDV Technicians should hold to enable them to work on biogas/hybrid HDVs
- 30% of garages have a good understanding of the qualifications/ accreditations HDV Technicians should hold to enable them to work on hydrogen fuel cell HDVs

<u>Levels of understanding of who the providers are that offer relevant training</u>

- 95% of garages have a good understanding of which training providers offer relevant training for HDV Technicians to work with electric/hybrid HDVs
- 32% of garages have a good understanding of which training providers offer relevant training for HDV Technicians to work with biogas/hybrid HDVs
- 34% of garages have a good understanding of which training providers offer relevant training for HDV Technicians to work with hydrogen fuel cell HDVs

Can you describe any specific skills and/or competencies where additional qualification(s)/ accreditation(s) and/ or training provision needs to be developed to help your business take advantage of the opportunities to inspect, repair, maintain or recovery low carbon heavy duty vehicles?

A number of comments were made in response to this question. These responses highlighted that HDV garages would be more likely to General comment from a number of garages that they are likely to need more skills in IT, electrical and electronic and diagnostics.

Appendix C: Evaluating Decarbonisation Options for HDV Market Segments

As an initial step in the preliminary process, each of the decarbonised drivetrain types were evaluated against 10 criteria in three broad categories which are summarised below. In each category a higher score means that a drivetrain performs better against that criterion, with the drivetrain rated 5 being the best performer. The scoring was carried out twice, once to reflect the state of the technology in 2026 and again to reflect the technology in 2032.

Emissions- Drivetrain profiles

Each drivetrain, including diesel ICE was evaluated on how effectively it reduced CO_2 emissions and on how effectively it reduced local air pollution (i.e. the impact on air quality). In general, diesel scored the lowest due to significant carbon emissions as well as levels of other pollutants. Electrified drivetrains scored the highest as they are zero emissions and combustion engines scored an intermediate based on our understanding of the likely emissions. By the 2030s it is assumed that the dual fuel engines will be developed to run on pure hydrogen; so these drivetrains score higher for carbon emissions.

2026

Factor	Drivetrain technology					
	Diesel ICE	BEV	HFCEV	Hydrogen- Diesel ICE	Biomethane ICE	Pantograph Electric Road
CO2 Emissions	1	5	5	2	3	5
Air Quality	1	5	5	3	2	5

2032

Factor	Drivetrain technology					
	Diesel ICE	BEV	HFCEV	Hydrogen- Diesel ICE	Biomethane ICE	Pantograph Electric Road
CO2 Emissions	1	5	5	5	3	5
Air Quality	1	5	5	3	2	5

Vehicle Operation – Drivetrain profiles

Six categories were considered to reflect the operational capabilities of the decarbonised vehicles and how well each drivetrain performed. In general diesel ICE performed the highest, reflecting the long range and operational flexibility of the engine that has been developed over many years of use. Other combustion engines and HFCEV were given a moderate score to reflect the range, availability and capability of these engines, which was noted as key reason for their development or deployment. Battery and pantograph systems scored lowest, reflecting the limited energy density of the batteries, the size and weight penalties associated with battery systems, and the constrained used of pantograph systems to trunk roads only. Capital costs (CAPEX) was based on predicted costs of the vehicles based on a number of reports (e.g. from Cadent, Element Energy and Transport and Environment). Similarly, fuel costs were based on an estimate of the cost, with electricity incurring the lowest cost and an underlying assumption that blue or green hydrogen would become more widely available by 2032. Size and weight constraints and range were scored based on relative gravimetric energy density, volumetric energy density, and the vehicle systems required (e.g. compressed gas tanks). Refuelling and uptime were scored based on estimated recharge times and methods (i.e. electrical charging versus compressed gas tank filling). Vehicle availability was scored to reflect the relative commercial availability of vehicles on the market, based on announcements to date (e.g. as identified in a recent report from Cadent).

2026

Factor	Drivetrain technology					
	Diesel ICE	BEV	HFCEV	Hydrogen- Diesel ICE	Biomethane ICE	Pantograph Electric Road
CAPEX	5	2	3	4	4	3
Fuel Cost	3	5	3	3	4	5
Size and Weight Contraints	5	2	4	3	4	2
Energy Density (Range)	5	3	4	5	4	2
Refuelling (Uptime)	5	2	3	4	5	4
Vehicle Avalaibility	5	3	2	4	3	2

2032

Factor	Drivetrain technology					
	Diesel ICE	BEV	HFCEV	Hydrogen- Diesel ICE	Biomethane ICE	Pantograph Electric Road
CAPEX	5	3	4	5	4	3
Fuel Cost	2	5	4	4	3	5
Size and Weight Contraints	5	3	4	4	4	3
Energy Density (Range)	5	3	4	4	4	2
Refuelling (Uptime)	5	2	4	4	5	4
Vehicle Avalaibility	5	4	3	4	4	2

Infrastructure – Drivetrain profiles

In order to reflect the level of supporting infrastructure required, each drive train was assessed for the estimated cost of the infrastructure and the state of readiness. Again, diesel ICE scores highly given the extensive refuelling infrastructure that is available. Battery electric and biomethane infrastructure scored moderately as the underpinning structure for transport of the fuel/ energy already exists (the electrical grid and the gas grid) but will require development. For battery electrification, it was considered that there would be considerable synergy with the development of chargers for passenger cars and light vehicles. Drivetrains using hydrogen or requiring specific dedicated infrastructure (e.g. electric road systems) and, therefore, requiring development of a new infrastructure system scored lowest to reflect the lower state of development.

2026

Factor	Drivetrain technology					
	Diesel ICE	BEV	HFCEV	Hydrogen- Diesel ICE	Biomethane ICE	Pantograph Electric Road
Infrastructure Costs	5	3	2	2	3	2
Infrastructure State of Readiness	5	4	2	3	4	1

2032

Factor	Drivetrain technology					
	Diesel ICE	BEV	HFCEV	Hydrogen- Diesel ICE	Biomethane ICE	Pantograph Electric Road
Infrastructure Costs	5	3	2	2	3	2
Infrastructure State of Readiness	5	4	3	3	4	2

Relative importance of categories to HDV segments

In order to complete the assessment, it was necessary to rate how important each category was to the individual sub-segments of the HDV market to go alongside the high-level assessment of the drivetrains. This is somewhat coarse as each segment will cover a range of use cases which will have different sensitivities. For example, in the HGV less than 18 tonne category, vehicles which routinely perform inner city duties may be very strongly driven to reduce emissions other than carbon (NOx etc) as demands for urban air quality improvements become more of a driver for stakeholders. Conversely, a vehicle used primarily for distribution centre transport using primarily trunk roads may not be heavily influenced by exhaust emissions, as long as the vehicle can meet minimum requirements. This single example exemplifies the difficulties in analysing a broad market such as HDVs in a limited number of categories. However, a representative score has been applied based on the secondary research. In the analysis below, a high score indicates that the criterion is important to the HDV sub sector.

Emissions – HDV Sector profiles

In analysing carbon emissions, the relative importance was scored based on the timing of legislation and incentives to support the phase out of non-net zero HDVs in law. Therefore, buses scored the highest with the heaviest HGVs scoring the lowest. For air quality, the segments were scored on how frequently vehicles may be expected to perform urban driving and relative rates of use in environments where air quality was a concern. Again, buses (most likely to see extensive urban use) scored the highest and the heaviest HGVs (most likely to see primary use on major trunk roads) the lowest.

Factor	HDV Type			
	Bus and Coach	HGV <18t	HGV >18t	Other
CO2 Emissions	5	4	3	4
Air Quality	5	4	2	3

Vehicle Operation - HDV Sector Profiles

For the criteria ranking how important operational parameters were, each HDV segment was assigned a score based on what was assumed to be an average use case for the segment. The capital expenditure sensitivity and sensitivity to fuel cost was allocated based on the relative usage intensity of the vehicle class and average mileages. This approach was an attempt to reflect how important these two components would be in the relatively complex total cost of ownership. For other, off-highway HDVs it was assumed usage intensity would be relatively lower and mileage (and hence fuel use) would also be lower. For heavier HGVs, usage would be intense and vehicles would be in operation more of the time and use more fuel. The other HDVs and heavy HGVs, therefore, give the two extreme cases for sensitivity to capital costs and fuel costs with buses, coaches and lighter HGVs scored in between these two extremes. For the constraints on size and weight, the effective range and uptime, this was seen as being most important for heavy HGVs which operate close to weight limits, travel the longest distance and are most likely to be in use for extended periods and require refuelling during the duty cycle. For buses and coaches, which are typically used for less distance and return to depot at set intervals, the relative importance of these factors was lower. Lighter HGVs and other HDVs were scored in between these two cases. While vehicle availability is important for all sectors of the HDV market, it was assumed that the bus and coach market may have slightly lower sensitivity to this factor, due to the evidence of buses and coaches being early technology adopters and the availability of funding to support demonstrators and trial projects in public service buses.

Factor	HDV Type			
	Bus and Coach	HGV <18t	HGV >18t	Other
CAPEX	4	4	3	5
Fuel Cost	3	4	5	3
Size and Weight Contraints	3	3	5	3
Energy Density (Range)	2	3	5	3
Refuelling (Uptime)	2	3	5	3
Vehicle Avalaibility	3	5	5	5

Infrastructure -HDV Sector Profiles

For infrastructure, it was assumed that the heaviest HGVs would be most sensitive to infrastructure availability given the range of duties and routes the vehicles may be called on to perform, necessitating operational flexibility in a variety of locations. Lighter HGVs were only slightly less sensitive to these infrastructure factors. Buses and coaches were scored as the least sensitive to infrastructure concerns as some of the sub-sectors of the market (e.g. urban buses) more frequently used predefined routes and established depots, limiting their exposure to external infrastructure and curtailing the extent to which this infrastructure needs to be rolled out for viable use. In the off-highway "other" category, sensitivity to infrastructure was assumed to modest as these operations already utilise decentralised infrastructure for on-site refuelling (e.g. bowsers or intermediate bulk containers) so will likely require dedicated solutions for each site in any case.

Factor	HDV Type			
	Bus and Coach	HGV <18t	HGV >18t	Other
Infrastructure Costs	2	4	5	3
Infrastructure State of Readiness	3	4	5	3

Analysis of Decarbonised Drivetrains for Different HDV Market Segments

For each combination of technology and HDV segment a combined score was calculated by multiplying the scores for each factor. For example, against the criteria "CO_2 emissions", diesel ICE was scored 1 (poor performance). For buses and coaches CO_2 emissions were rated a 5 for importance (very important) due to imminent policy moves towards phase out of fossil fuelled buses. Combining these gives a factor score of 5 for diesel bus and coaches. Completing this for all factors gives a total score for that drivetrain in a specific market segment (e.g. the total score for diesel bus and coaches is 114). Completing this process for every combination of drivetrain and HDV type gives a range of scores that can be compared within each vehicle segment. The results of this analysis are shown below.

HDV Type	Drivetrain technology scoring - 2026					
	Diesel ICE	BEV	HFCEV	Hydrogen- Diesel ICE	Biomethane ICE	Pantograph Electric Road
Bus and Coach	114	116	113	102	110	111
HGV <18t	150	132	123	124	134	121
HGV >18t	185	141	134	144	160	129
Other	141	117	114	117	125	111

HDV Type	Drivetrain technology scoring - 2032					
	Diesel ICE	BEV	HFCEV	Hydrogen- Diesel ICE	Biomethane ICE	Pantograph Electric Road
Bus and Coach	111	126	128	125	110	114
HGV <18t	146	144	143	144	135	125
HGV >18t	180	154	157	161	160	134
Other	140	135	137	141	130	119

Key:
High technology attractiveness for HDV segment
↓
Low technology attractiveness for HDV segment

The total values are shown only so that the calculation process is transparent, but the absolute values are not instructive for a number of reasons detailed below. Only the relative value of the scores within each HDV segment are comparable. For example, we can compare the values for different drivetrains within the bus and coach segment in each table, but we cannot compare the values for bus and coach with the values for HGVs >18t. This is because the numerical evaluation used is designed to allow for comparison of the drivetrains within each segment as this is the most relevant way to evaluate the HDV decarbonisation.

The absolute values are not consistent as we have evaluated each HDV segment to have different sensitivities to the specific factors. For example, the heaviest HGVs were assessed as having high sensitivity to the available range, high sensitivity to size and weight constraints and high sensitivity to infrastructure due to the variable routes used. Therefore, these factors were weighted higher for heavy HGVs than for any other HDV segment. While this approach means that these factors are given higher importance in the final evaluation of different drivetrains, it also means that HGVs over 18t have higher absolute scores than other HDV segments, making comparison across different segments impossible using this method.

In evaluating the relative scores, the range of scores within each HDV segment was calculated by subtracting the highest scoring drivetrain from the lowest scoring and dividing this range into four to give the relevant colour banding. As identified above only the relative scores are important but by comparing with the diesel ICE drivetrain (which we know to be functionally suitable for all of these HDV segments based on the current market) we can see if the decarbonised drivetrains are likely to address the needs of the vehicle operators. Where we have a number of scores close to the maximum, it implies that a range of drivetrains could address that market. Where we have one clear outlying maximum score, it implies that there is one technology which is likely to address the HDV segment better than any other.

Appendix D – Characterising the HDV landscape in Scotland

To set the context for research and analysis into ‘skills for low carbon HDVs’, the scope of the different parts of the relevant supply chain and markets needs to be defined. Figure 37, below, summarises the overall scope of this study.

Manufacture of parts, components, systems & fuels	Vehicle Manufacture/ Systems Integration/ Conversion	Charging/ Refueling infrastructure developers/ operators	Vehicle Sales/Leasing	Vehicle owners/ operators	Vehicle inspection, service, repair, maintenance and recovery	End of life/ second life
Battery Electric	Bus/ Coach	EV Battery Charging	Bus/Coach Sales/Leasing	Bus/ Coach	HDV Garages (including private depots)	End of Life/ second life (e.g. EV batteries)
Hydrogen Fuel Cell	Heavy Goods Vehicle	Hydrogen Refuelling	HGV Sales/Leasing	Heavy Goods Vehicle (Third party and own fleet)	HDV Roadside Recovery	Remanufacture
Biomethane ICE	Construction Heavy Vehicle	Synthetic/ Biofuel Refuelling	Construction Vehicle Sales/Leasing	Construction	HDV Inspection (including DVSA and during remarketing)	
Hydrogen ICE	Agriculture Heavy Vehicle		Agriculture Vehicle Sales/Leasing	Agriculture	Emergency services attendance at Road Traffic Incidents	
EV Charging infrastructure	Other, e.g. Emergency Services, RCVs, etc.		Other Vehicle Sales/Leasing	Municipal		
Hydrogen Production & Refuelling				Other Public sector e.g. Emergency Services		
Biofuel Production & Refuelling				Private Waste Management		

Supporting organisations

Researchers/ Academics	Researcher and Technology Organisations	Finance providers	Policy makers/ Enterprise Agencies	Trade bodies	Skills/Competence Accreditation Bodies	Private training providers	Colleges and HEIs

Figure 37 - Low carbon Heavy Duty Vehicle supply chain and markets

Figure 37 illustrates the different drivetrain options that can be used to develop a range of different HDV types for the key markets that use HDVs. It includes:

- Different system suppliers, fuel producers and refuelling/charging infrastructure suppliers
- HDV manufacturers/ convertors/ systems integrators
- Charging/ refuelling developers and operators
- Vehicle sales and leasing companies
- Main end use markets for HDVs
- HDV inspection, service, repair and maintenance garages and roadside recovery
- Companies active in end of life treatment/second life opportunities (including remanufacture) for HDVs and/or component parts (e.g. EV batteries)

In addition to the above segments, there are a range of supporting organisations covering innovation, finance, skills development, competence accreditation and assessment etc.

It is important to establish an understanding of the current scale of each part of the supply chain and end markets based in Scotland, as it is organisations operating in these different parts that need skills relevant to HDV production and operation. This provides a baseline, upon which, scenarios for future growth can be built and the potential nature and scale of skills required can be identified.

Where possible, the scale of each of the segments is quantified in terms of number of enterprises operating in Scotland and employment within these segments. The quantification is based on the following methods:

- Search of several databases accessible via the Office for National Statistics, Nomis website for official labour market statistics. This includes the Business Register and Employment Survey (employment levels) and UK Business Counts (number of enterprises). Both sources enable searching for Scottish level data within industries defined at the 5-digit Standard Industrial Classification (SIC) Code level. Whilst this is the most disaggregated level of SIC Code data available, there are still limitations with using this approach due to potential lack of alignment between the supply chain/market segments defined in Figure 37 and the activities included in the closest available 5-digit SIC Codes. Notwithstanding these limitations, this approach can provide a reasonable indication of scale of activity present in Scotland. It should be noted that when data from nomis is presented in figures later in this section, all figures are rounded to avoid disclosure. In some cases the values may be rounded down to zero. However, all zeros are not necessarily true zeros.
- Due to the potential limitations with the SIC Code approach, described above, it is also useful to use other sources of data such as company databases (e.g. FAME), trade body directories, Government vehicle licensing statistics research reports, general internet searching, etc.
- Where SIC Code data does not have a good fit with the types of organisations, defined for HDV end users and the supply chain, it can be useful to reference Standard Occupational Classification (SOC) data for Scotland (also accessed via the Nomis website)
- Where none of the above sources can provide a robust point value for number of organisations or employees present in Scotland then a range estimate is made which will, necessarily, include an element of subjectivity

Each of the main segments is described and quantified below.

Manufacturers of parts, components, systems and fuels

This segment focuses on suppliers of parts, components, systems and fuels relating to the different drivetrain options: battery electric, hydrogen fuel cell, direct hydrogen combustion (initially blended with diesel but aiming for 100% hydrogen combustion) and biomethane.

Activities included in the scope of this segment are:

- Production of hydrogen, hydrogen fuel cells, hydrogen storage tanks, other key elements of a hydrogen fuel cell HDV, hydrogen combustion ICE and hydrogen refuelling infrastructure
- Production of electric HDV drivetrain parts, components and systems and electric vehicle charging infrastructure
- Production of parts/ components for biomethane or hydrogen refuelling production and infrastructure

The above description of activities was compared with 5-digit SIC Code activities. This highlighted that the following 5-digit SIC Codes are cover some relevant activities:

- 20110 – Manufacture of industrial gases (which includes manufacture of liquefied or compressed inorganic industrial or medical gases, including elemental gases such as hydrogen). However, this SIC Code also includes non-relevant activities such as manufacture of other industrial gases such as liquid/compressed air, refrigerant gases etc.

- 27200 – Manufacture of batteries and accumulators (which includes manufacture of primary cells and batteries containing lithium). However, this SIC Code also includes non-relevant activities such as the manufacture of non-rechargeable batteries and lead acid batteries.
- 27900 – Manufacture of other electrical equipment (which includes manufacture of battery chargers and manufacture of fuel cells). However, this SIC Code also includes a significant number of non-relevant activities such as electrical signs, electrical welding/soldering equipment, etc.
- 29310 – Manufacture of electrical and electronic equipment for motor vehicles (which includes a broad range of parts and components such as ignition wiring harnesses, power window and door systems, etc, most of which are unlikely to be specific to low carbon vehicle manufacture).
- 29320 – Manufacture of other parts and accessories for motor vehicles (which covers a broad range of parts and components such as brakes, gearboxes, axles etc, much of which are unlikely to be specific to low carbon vehicle manufacture).
- 35210 – Manufacture of gases (which includes the manufacture of gaseous fuels and production of gas from by-products of agriculture or from waste). However, this SIC Code also includes non-relevant activities such as production of different types of gaseous fuels (i.e. which may not be hydrogen or biomethane)
- 38210 – Treatment and disposal of non-hazardous waste (which includes treatment of non-hazardous waste to produce biogas). However, this SIC Code also includes non-relevant activities such as operation of landfills and energy from waste facilities.

The number of enterprises and level of employment in each of the above SIC Codes, in Scotland, is summarised in Figure 38, below.

SIC Code	SIC Description	No. of Enterprises	Employment	Fit of SIC definition to HDV activities
20110	Manuf. of industrial gases	0	150	Med
27200	Manuf. of batteries and accumulators	5	100	Med
27900	Manuf. of other electrical equipment	25	350	Low
29310	Manuf. of electrical and electronic equipment for motor vehicles	10	15	Med
29320	Manuf. of other parts and accessories for motor vehicles	30	400	Med
35210	Manuf. of gases	0	300	Med
38210	Treatment of disposal of non-hazardous waste	65	3,500	Low

Figure 38 - Number of enterprises and employment data by relevant SIC Code and degree of fit between SIC definition and HDV activities covering manufacture of parts, components, systems and fuels (Scottish data)

Based on SIC data there are 135 companies employing 4,815 people in the defined categories. However, the alignment of these SIC categories with the types of companies involved is low in some cases and, at best, medium in others. Based on those SIC categories with medium alignment there are 45 companies employing 965 people relevant to the manufacture of parts, components, systems and fuels. This data is subject to some error due to the limited level of alignment with the actual economic activities sought.

Feedback from stakeholders is that there is limited manufacture/systems integration/ conversion of HDVs or manufacture of refuelling/recharging infrastructure equipment carried out in Scotland. Production of biomethane via anaerobic digestion does take place at several sites in Scotland and is injected into the gas grid. This includes companies, such as Glenfiddich, which is producing biomethane alongside conversion of some of its own fleet to run on the same fuel. There are also some hydrogen production facilities emerging in Scotland such as the plastics to hydrogen plant being built in Glasgow to support the new fleet of hydrogen fuel cell refuse collection vehicles.

There will be Scottish based suppliers of the limited number of existing vehicle manufacturers (such as ADL) but the scale of this is not easily identifiable in a study of this nature.

Vehicle manufacturers/systems integrators

This segment focuses on organisations that manufacture HDVs across several applications including freight transport, bus/coaches, construction, agriculture and municipal) and/or integrate systems purchased from OEMs. The SIC Codes likely to be relevant/partially relevant to this segment include:

- 28301 – Manufacture of agricultural tractors (including for use on forestry)
- 28922 – Manufacture of earthmoving equipment (which includes manufacture of bulldozers, levellers, mechanical shovels, off-road dumping trucks, etc.). However, this SIC Code also

includes non-relevant activities such as the manufacture of grading machining, bulldozer blades, etc.

- 29100 – Manufacture of motor vehicles (which includes vans, lorries, buses, coaches, fire appliances, concrete mixer lorries). However, this SIC Code also includes non-relevant activities such as the manufacture of passenger cars, golf carts, go-karts, etc.)

The number of enterprises and level of employment in each of the above SIC Codes, in Scotland, is summarised in Figure 39, below.

SIC Code	SIC Description	No. of Enterprises	Employment	Fit of SIC definition to HDV activities
28301	Manuf. of agricultural tractors	0	0	High
28922	Manuf. of earth moving equipment	5	300	Med
29100	Manuf. of motor vehicles	45	1,750	Med

Figure 39 - Number of enterprises and employment data by relevant SIC Code and degree of fit between SIC definition and HDV activities covering vehicle manufacturers/convertors (Scottish data)

Based on SIC code data, there are 50 companies with 2,050 employees active across the three categories that best align with the types of heavy duty vehicle manufacturers. However, this is likely to be an overestimate due to companies being included that produce motorised vehicles weighing less than 3.5T (e.g. SIC code 29100 includes rebuilding of motor engines).

Desk research and stakeholder feedback suggests that there are far fewer companies involved in the manufacture of heavy-duty vehicles than suggested by the SIC code data. For example, only a small number of manufacturers/systems integrators have been identified:

- Alexander Dennis (bus and coach)
- Arcola (RCVs, trains)
- Farad Hillend (RCVs)
- Emergency One (fire appliances)
- Cuthbertson (snow ploughs/gritters)
- Terex Trucks (Off-highway articulated dumper trucks)
- HV Systems (HGVs)

Overall, it is assessed that there is a maximum of ten companies involved in HDV manufacture/systems integration in Scotland. Employment levels are harder to assess but there is significant employment in Alexander Dennis, Emergency One and Terex, for example. For the purposes of this study, it is estimated that employment in HDV manufacture/ systems integration in Scotland is a maximum of 1,000.

Charging/ refuelling infrastructure developers/operators

This segment includes companies involved in activities such as:

- Developing/operating electric vehicle charging points for hybrid electric and fully electric HDVs
- Developing/operating hydrogen refuelling stations

- Sale of hydrogen to refuelling stations
- Developing/operating biofuel/synthetic fuel refuelling stations
- Sale of biofuel/ synthetic fuel to refuelling stations

This segment presents a significant challenge in defining the scale using SIC Codes. The SIC Codes where there is potential to have some alignment with the above activities include:

- 43210 – Electrical installation (including electrical wiring and fittings). However, many other activities are listed under this SIC Code that are not relevant to installation of EV charging infrastructure (e.g. installation of fire alarms, burglar alarms, etc)
- 43220 – Plumbing, heat and air conditioning installation (including gas fittings). However, this SIC Code also includes non-relevant activities such as installation of heating systems, fire sprinklers, etc.
- 46719 – Wholesale of fuels and related products (other than petroleum and petroleum products). However, this includes wholesale of greases, lubricants, oils, etc. and likely to include a high proportion of non-relevant companies
- 47300 – Retail sale of automotive fuel in specialised stores. However, it is likely that most of the companies in this category will be petrol/diesel fuel garages

The broad nature of some of the above SIC Codes is likely to lead to a significant over-statement of number of enterprises and employment relevant to low carbon HDV charging/refuelling infrastructure.

The number of enterprises and level of employment in each of the above SIC Codes, in Scotland, is summarised in Figure 40, below.

SIC Code	SIC Description	No. of Enterprises	Employment	Fit of SIC definition to HDV activities
43210	Electrical installation	2,875	16,000	Low
43220	Plumbing, heat and air conditioning installation	2,630	19,000	Low
46719	Wholesale of fuels and related products (other than petroleum and petroleum products)	100	800	Low
47300	Retail of automotive fuel in specialised stores	215	1,750	Low

Figure 40 - Number of enterprises and employment data by relevant SIC Code and degree of fit between SIC definition and HDV activities covering charging/refuelling infrastructure developers/operators (Scottish data)

Based on SIC data, there are a maximum of 5,820 companies and 37,550 employees within the categories relevant to the operation of charging/refuelling infrastructure. However, the level of alignment of the SIC categories and the relevant activities is low.

Qualitatively, desk research and stakeholder feedback has suggested that there are a number of companies providing installation, service, repair and maintenance of electrical charging infrastructure in Scotland. There is also some regional presence of hydrogen refuelling infrastructure (e.g. in Aberdeen). CNG Fuels are developing a biomethane refuelling station near Eurocentral on the M8 and plan two further stations along the central belt. Examples of companies developing their own in-house CNG refuelling infrastructure were also provided (to support merging biomethane truck fleets).

It is therefore unknown how many employees in Scotland are involved in this segment. Subjectively, it is likely to be in the low hundreds with most of these being active in electrical charging infrastructure.

Vehicle sales/ leasing

This segment includes activities relating to the sale or lease of low carbon HDVs across several applications including buses/coaches, HGVs, construction, agriculture, municipal etc.

The SIC Codes that have some alignment with these activities include:

- 45190 – Sale of other motor vehicles (including wholesale and retail of new and used vehicles such as lorries and off-road motor vehicles of weight exceeding 3.5T). However, this SIC Code also includes non-relevant activities such as sales of trailers, semi-trailers, caravans and motor homes
- 77120 – Renting and leasing of trucks (including trucks and heavy motor vehicles of weight exceeding 3.5T). However, this SIC Code also includes non-relevant activities such as renting and leasing of utility trailers and recreational vehicles
- 77310 - Renting and leasing of agricultural machinery and equipment (including agricultural tractors, etc.) without operator. However, this SIC Code includes significant non-relevant renting and leasing activities including ploughs, lawnmowers, harvesting, grading fruit, etc)
- 77320 – Renting and leasing of construction and civil engineering machinery and equipment (including crane lorries). However, this SIC Code includes non-relevant activities such as scaffolds and work platforms

The number of enterprises and level of employment in each of the above SIC Codes, in Scotland, is summarised in Figure 41, below.

SIC Code	SIC Description	No. of Enterprises	Employment	Fit of SIC definition to HDV activities
45190	Sale of other motor vehicles	75	1500	Med
77120	Renting and leasing of trucks	55	500	High
77310	Renting and leasing of agricultural machinery and equipment	65	225	Med
77320	Renting and leasing of construction and civil engineering machinery and equipment	355	5,000	Low

Figure 41 - Number of enterprises and employment data by relevant SIC Code and degree of fit between SIC definition and HDV activities covering vehicle sales/leasing (Scottish data)

Based on the SIC category data there are 550 companies and 7,225 employees. However, SIC code 77320 includes renting and leasing of scaffolding and work platforms as well as crane lorries so much of the activity in this SIC category will be out of scope. Including only the SIC categories assessed as having a medium or high alignment with the defined activities leads to an estimate of 195 companies and 2,225 employees involved in HDV sales, renting and leasing.

The relevant SOC Code for 'Vehicle and parts sales persons and advisors' (7115) can be used to provide an alternative estimate of employee numbers. Using the nomis database identifies 1,900 employees in this category in 2020. This compares with an average of 5,750 over the previous two years. It is clear that the 2020 is low compared to previous years, likely due to the Covid pandemic. It should also be noted that this data includes employees involved in the sales of cars and light vans as well as HDVs. The SIC categories are a better fit for the required data compared to SOC categories in this instance.

Vehicle owners/ operators

This segment includes activities relating to the operation of different types of HDVs in different markets. The operators may, or may not, own the vehicles used (i.e. they could be leased). The activities included in this segment include:

- Provision of passenger transport services using buses and coaches covering both urban and inter urban travel
- Provision of third-party road freight and post/courier services using HGVs and large vans over 3.5T in weight
- Own fleet logistics operations
- Provision of construction services using specialist HDVs such as bulldozers and off-road dumping trucks
- Use of HDVs to perform agricultural and forestry activities
- Provision of municipal services using HDVs such as refuse collection vehicles and gritters
- Provision of private waste collection services
- Provision of removal services
- Other activities such as the use of fire appliances to provide fire-fighting services

The SIC Codes that have some alignment with these activities include:

- 01610 – Support activities for crop protection (including agricultural activities provided on a fee or contract basis such as field preparation, establishing crops, harvesting crops, etc, maintenance of agricultural land and provision of agricultural machinery with operators and crew). However, this SIC Code includes non-relevant activities such as pest control and operation of irrigation equipment
- 02200 – Logging (including production of roundwood for manufacturing, gathering and producing wood/forest residues for energy)
- 02400 – Support services in forestry (including carrying out part of the forestry operation on a fee or sub-contract basis, such as transport of logs within the forest). However, this SIC Code includes non-relevant activities such as forest management consultancy, forestry pest control, etc.)
- 38110 – Collection of non-hazardous waste (including general waste and recyclable materials from households, commercial, industrial and construction and demolition customers). However, this SIC Code also includes non-relevant activities such as the operation of waste transfer stations for non-hazardous waste
- 38120 – Collection of hazardous waste (including used oil from garages, bio-hazardous waste, nuclear waste, used batteries etc.) However, this SIC Code also includes non-relevant activities such as the operation of waste transfer stations for hazardous waste

- 43120 – Construction site preparation (including earth moving, excavating and rock/overburden removal, etc.)
- 49319 – Urban, suburban or metropolitan are passenger land transport other than railway transportation by underground, metro or similar system (includes bus passenger land transport which may be carried out on scheduled routes following a fixed time schedule, using fixed stopping points to pick up and set down passengers). However, this SIC Code also includes other, non-relevant, urban, sub-urban, metropolitan passenger land transport modes such as trams.
- 49390 – Other passenger land transport not elsewhere classified (including scheduled long distance bus services, charters, excursions and other occasional coach service es, school buses and buses to transport employees)
- 49410 – Freight transport by road (including logging haulage, stock haulage, refrigerated haulage, heavy haulage, bulk haulage including haulage in tanker trucks including milk collection at farms, haulage of automobiles, transport of waste and waste materials without collection or disposal and renting of trucks with driver)
- 49420 – Removal services (including removal/relocation services to businesses and households by road transport)
- 53100 – Postal activities under universal service obligation (pickup, sorting, transport and delivery (domestic or international) of letter-post and (mail-type) parcels and packages by postal services operating under a universal service obligation. One or more modes of transport may be involved and the activity may be carried out with either self-owned (private) transport or via public transport)
- 53201 – Other postal and courier services – licensed carriers (including letter-post)
- 53202 – Other postal and courier services – unlicensed carriers (excluding letter-post)

Own fleet HDV operations are difficult to associate to a particular SIC Code(s) as a large number of different business activities require the use of freight transport and/or courier services particularly those involved in production and/or wholesale activities. If third party providers are used then these activities can be allocated under SIC Codes 49410, 53100 and 532012. However, if businesses operate their own fleet, then it is not possible to accurately use SIC Code related statistics on number of enterprises and employment involved in this, as the inhouse fleet operations may only represent a small proportion of overall company activity.

The number of enterprises and level of employment in each of the above SIC Codes, in Scotland, is summarised in Figure 42, below.

SIC Code	SIC Description	No. of Enterprises	Employment	Fit of SIC definition to HDV activities
01610	Support activities for crop protection	515	2,500	Med
02200	Logging	135	450	High
02400	Support services in forestry	220	700	Low
38110	Collection of non-hazardous waste	130	5,000	Low

SIC Code	SIC Description	No. of Enterprises	Employment	Fit of SIC definition to HDV activities
38120	Collection of hazardous waste	5	50	Low
43120	Construction site preparation	245	4,000	Med
49319	Urban, suburban & metropolitan passenger land transport other than railways, etc. (including urban bus services)	160	9,000	High
49390	Other passenger land transport (including long distance buses/coaches)	320	8,000	High
49410	Freight transport by road	2,130	17,000	High
49420	Removal services	165	1,000	High
53100	Postal services under Universal Service Obligation	150	13,000	Low
53201	Other postal & courier services – licensed couriers	260	300	Med
53202	Other postal & courier services – unlicensed couriers	835	4,500	Med

Figure 42 - Number of enterprises and employment data by relevant SIC Code and degree of fit between SIC definition and HDV activities covering vehicle owners/operators (Scottish data)

Based on the above SIC categories there are 5,270 companies and 65,500 employees active as vehicle operators/owners. Counting only those with a medium or high alignment of the SIC categories with the defined activities gives an estimate of 4,765 companies and 46,300 employees.

For comparison, employment data for the SOC categories relevant to this segment of the HDV landscape has been sourced (Annual population survey – regional – employment by occupation 2020):

- 8223 Agricultural machinery drivers – 900 employees
- 8213 Bus and coach drivers – 8,200 employees
- 8211 Large goods vehicle drivers – 25,200 employees
- 8221 Crane drivers – 1,400 employees
- 8229 Mobile machine drivers and operatives not elsewhere classified – 9,500
- 1161 Managers and directors in transport and distribution – 6,000

The SOC code data provides a figure of 51,200 for employment in owners and operators. This is higher than the SIC code based estimate and this may be due, in part, to a number of employees included in the ‘mobile machine drivers and operatives’ category not driving HDVs. Taking both sources into account a reasonable indicative figure for the number of employees would be the mid-point of the two estimates, 48,750.

In addition to using SIC and SOC Codes to understand the nature and scope of the vehicle owners and operators market, a wider search was carried out into each of the different market segments. The findings of this analysis are presented below.

Bus & Coach operators

There are 744 public service vehicle licence holders in Scotland. Operators with a restricted licence are only able to utilise it for internal operations, i.e. not driving third parties for commercial gain. This group could include companies using hired, or owned, minibuses to transport their own staff. Commercial bus and coach operators require standard licences (either national or international) to provide transport services for commercial gain. The total number of PSV licensed operators in Scotland, as of December 2020, was 511. This is broadly consistent with the data in Figure 42, which identifies 480 enterprises across the two five digit SIC Codes relevant to buses and coach passenger transport services (SIC codes 49319 and 49390).

There were 12,515 buses and coaches licensed in Scotland at the end of 2020. In the previous four years (2016 to 2019) the average was 14,558. The fall in numbers of licensed buses and coaches in 2020 is likely to be due, in part, to the COVID pandemic where some vehicles will have been kept off the road during that period.

There were 403 buses and coaches registered for the first time in 2020 in Scotland. This lower than the average of the previous four years (2016 to 2019) of 748. It is likely that the reduction in first registrations of buses and coaches was related to the COVID pandemic, with companies delaying decisions to purchase in 2020.

Transport Scotland Statistics report that there were 14,400 staff employed by local bus operators (2019-20), of which, 2,000 were classed as maintenance staff (Transport Scotland, Scottish Transport Statistics No. 39 2020, Table 2.4 – Note: 'Local bus operators' covers all operators who run local bus services, including those who also do non-local work (e.g. private hire, school contracts). This estimate of 14,400 staff is less than the estimate of employment in the two five-digit SIC codes covering bus and coach passenger transport services of 17,000 shown in earlier Figure 42 (SIC codes 49319 and 49390). This could be due to differences in the definition by the Department of Transport of 'local bus operators' and the wider definition of urban and long-distance buses and coaches included in the SIC data.

Heavy Goods Vehicle freight operators

There are 5,606 licensed operators of heavy goods vehicles in Scotland. Of these operators, 2,640 had a 'restricted licence' meaning that the licence only covers the movement of the operator's own goods and does not allow them to offer to carry the goods of others for commercial gain. The remaining 2,966 HGV operators have standard licences, allowing either national (UK) or international transportation of goods for third parties on a commercial basis. This figure is higher than the estimate of 'freight transport by road' enterprises in Scotland (2,130) as noted in Figure 42. The higher number of HGV licensed operators, with standard licences, compared to the number of 'freight transport by road' enterprises may be due to some businesses offering goods transport by HGV that are registered with Companies House as having a different primary activity than 'freight transport by road' (e.g. removals companies). The 2,966 licensed HGV operators is a more accurate estimate of the number of companies offering third party transportation of goods in Scotland.

HDV inspection, service, repair, maintenance and recovery

This segment includes activities relating to the service, repair and maintenance of HDVs, including:

- Service, repair and maintenance by internal depot staff employed by the organisation utilising the HDVs
- Third party garages that carry out service, repair, maintenance of HDVs for a fee or on a contract basis
- Inspection by DVSA staff in garages and at the roadside
- Recovery of HDVs

The SIC Code that has some alignment with these activities is:

- 45200 – Maintenance and repair of motor vehicles. However, this SIC Code does not differentiate between service, repair and maintenance of different vehicle types. Experience from a previous study suggests that almost all of the car and light van repair garages tend not to also service HDVs. Therefore, the SIC Code data will include a significant number of enterprises and employment that is not relevant to HDVs

The number of enterprises and level of employment in each of the above SIC Codes, in Scotland, is summarised in Figure 43, below.

SIC Code	SIC Description	No. of Enterprises	Employment	Fit of SIC definition to HDV activities
45200	Maintenance and repair of motor vehicles	3,220	21,000	Low

Figure 43 - Number of enterprises and employment data by relevant SIC Code and degree of fit between SIC definition and HDV activities covering HDV service, repair and maintenance garages (Scottish data)

A number of SOC categories are also relevant to defining this segment, including:

- 1252 Garage managers and proprietors – 2,700 employees
- 5231 Vehicle technicians, mechanics and electricians – 9,800 employees
- 5232 Vehicle bodybuilders and repairers – 2,600 employees

This provides a total of 15,100 employees, based on SOC code data. However, this will include employees working on cars and light vans.

Discussions with stakeholders suggested that there are approximately 2,500 HDV technicians based in Scotland and this is a more accurate figure to use as an estimate for the target population. A total of 92 HDV garages were identified during the research for this study.

In addition to this there are approximately 180 DVSA employees involved in inspection in Scotland, covering post collision incident investigators, vehicle standards assessors (carrying out MOTs on HDVs) and vehicle examiners (inspecting HDVs at the roadside).

It is also useful to consider the Emergency Services staff that are likely to require varying levels of skills development related to safely working at the site of road traffic incidents involving low carbon transport. Examination of SOC code data covering the operational emergency services identifies the following scale of employment:

- 6142 Ambulance staff (excluding paramedics) – 3,300 employees
- 3213 Paramedics – 3,400

- 3313 Fire service officers (watch manager and below) – 5,700 employees
- 3312 Police service officers (sergeant and below) – 19,000 employees

In total there are 31,400 emergency service staff with the potential to be attending road traffic incidents involving low carbon HDVs.

End of life, second life and remanufacturing

This segment includes activities relating to:

- End of life treatment of HDVs, including legally required depollution processes and commercially driven parts recovery and material recycling
- Development of second life opportunities for parts recovered from HDVs. This may include refurbishment/remanufacture of parts for supply into the replacement parts market. In the case of HDVs using an electric battery this is also likely to involve repurposing of working cells/packs in other applications, e.g. power storage

The SIC Code that has some alignment with these activities is:

- 38320 – Recovery of sorted materials (including mechanical crushing, size reduction and or/shredding of end of life vehicles). However, this SIC Code includes a significant number of non-relevant activities involving a sorting wide range of material and product types beyond HDVs. Even in the end-of-life vehicle category only a small proportion of this is likely to relate to HDVs

There is no SIC Code that aligns with the recovery and reuse of electric vehicle batteries for second life uses. There are an increasing number of examples of HDV (predominantly bus) batteries being reconditioned for second life use including the provision of second life bus batteries for power storage at a bus garage to charge the electric fleet.

The number of enterprises and level of employment in each of the above SIC Codes, in Scotland, is summarised in Figure 44, below.

SIC Code	SIC Description	No. of Enterprises	Employment	Fit of SIC definition to HDV activities
38320	Recovery of sorted materials	100	2,000	Low

Figure 44 - Number of enterprises and employment data by relevant SIC Code and degree of fit between SIC definition and HDV activities covering end of life/second life (Scottish data)

The alignment between this SIC code and the define activities of this segment is low. There are no suitable SOC categories to estimate the number of employees involved in end of life HDV treatment or second life opportunities.

Summary of employment in the Scottish HDV landscape

Figure 45, below provides a summary of the indicative levels of employment in the different HDV segments in that are likely to require some additional skills when transitioning to low carbon HDVs.

HDV Segment	Employment sub-total	Indicative total employment by segment
Manufacture of parts, components, systems and fuels	N/A	965
Vehicle manufacture/ systems integration	N/A	1,000
Charging/refuelling infrastructure developers/operators	N/A	No data
Vehicle sales and leasing	N/A	2,225
Vehicle owners/operators	N/A	48,750
HDV inspection, service, repair, maintenance and recovery	N/A	2,680
HDV Technicians	2,500	N/A
DVSA Inspection/examination	180	N/A
HDV Recovery	No data	N/A
Emergency Services	N/A	31,400
Fire	5,700	N/A
Police	19,000	N/A
Ambulance (incl. paramedics)	6,700	N/A
End of Life/Second Life	N/A	No data
Total employment potentially requiring low carbon HDV skills	**N/A**	**87,020**

Figure 45 - Indicative number of employees potentially requiring development of skills to support the uptake of HDVs in Scotland

In some cases the fit between the HDV definition and SIC/SOC code data was poor. In some circumstances stakeholders were able to provide indicative estimates of employment levels in Scotland. In other circumstances no indicative estimates were able to be identified and therefore 'No data' was registered.

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