CATAPULT Energy Systems

Electric Heavy Goods Vehicles? Industry perspectives on the prospects for their adoption in the U.K.

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Executive Summary

Energy Systems Catapult was set up to accelerate the transformation of the UK's energy system and ensure UK businesses and consumers capture the opportunities of clean growth.

We are an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia and research.

We take a whole system view of the energy sector, helping us to identify and address innovation priorities and market barriers to decarbonise the energy system at least cost.

This report summarises the findings of qualitative research carried out by the Catapult, commissioned by Voltempo, to explore the potential for the U.K. road freight sector to transition to net zero carbon dioxide emissions in its Heavy Goods Vehicle operations.

The research consisted of semi-structured interviews with managers involved in sustainability strategy within organisations operating HGVs in the U.K., and one interview with a manager from a major HGV manufacturer.

The project objectives were:

1. To characterise HGV operators' sustainability strategies, their key features, and the roles of zero emission HGVs within them
2. To identify the key benefits and drawbacks that HGV operators see from zero emission vehicles (HGVs)
3. To identify HGV operators' perceptions of the barriers to acquiring and operating zero emission HGVs, now and in the future
4. To characterise HGV operators' requirements for charging infrastructure if they were to transition to electric HGVs

The conclusions of the study were:

- Operators accept there will be a need to transition their HGV fleets to net zero carbon emissions; some aim to achieve this by 2035, others will be later, some potentially getting there only by 2050
- Most operators believe they will achieve net zero largely through adoption of eHGVs, which will by 2030-2035 be able to replace all but the largest vehicles on all but the longest routes
- There may be a niche role for hydrogen FCV trucks in the largest size category on the longest routes
- Alternative fuels will only play an interim role in the transition
- Most operators will recharge their vehicles at home bases, but there will also be a role for recharging facilities on the strategic road network
- The cost and availability at the right locations of power for recharging is seen as potentially the biggest issue for a timely transition
- Major changes to operating patterns (including schedules, routes, break times, and number of vehicles being operated) will be necessary

- Government will need to support the sector in making this transition, both by changing regulations around allowed vehicle weights and dimensions for eHGVs, and in mitigating the high costs to operators of making the transition
- The cost and complexity of the transition will likely result in major restructuring of the road freight sector, with the distribution of fleet sizes becoming increasingly skewed towards larger fleets

1. Introduction

1.1 Energy Systems Catapult

Part of a world-leading network of innovation centres, Energy Systems Catapult was set up to accelerate the transformation of the UK's energy system and ensure UK businesses and consumers capture the opportunities of clean growth.

We are an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia and research – with around 200 staff based in Birmingham and Derby with a variety of technical, commercial and policy backgrounds.

We take a whole system view of the energy sector – from power, heat and transport to industry, infrastructure and consumers – helping us to identify and address innovation priorities and market barriers to decarbonise the energy system at the lowest cost.

To overcome the systemic barriers of the current energy market, we work to unleash the potential of innovative companies of all sizes. Helping them to develop, test and scale the products, services and value chains required to achieve the UK's clean growth ambitions as set out in the Industrial Strategy.

1.2 eFREIGHT 2030

Bringing together leading logistics providers, high street names and leading hauliers, the eFREIGHT 2030 consortium has been selected to join the UK Government's Zero emission HGV and infrastructure demonstrator programme, which aims to kickstart the uptake of zero emissions heavy goods vehicles.

One of four projects being funded by the Department of Transport in partnership with Innovate UK, the UK's national innovation agency, eFREIGHT 2030 will receive £49.2 million in government support, which will help unlock an expected £500 million of private investment from consortium members in electric vehicles and charging hubs across the UK by 2030.

Led by Voltempo, developers of the British designed and manufactured electric HGV megawatt charging system, the eFREIGHT 2030 consortium members are seeking to lead the way in decarbonising their operations and business sectors.

The aim of the Zero emission HGV and infrastructure demonstrator programme is to stimulate the deployment of long haul zero emission HGVs with a multi-year demonstration of 40 – 44t battery electric trucks, including the development of the required business models for scalable deployment and a network of dedicated infrastructure.

The eFREIGHT 2030 consortium will introduce 100 electric HGV 4×2 and 6×2 tractor units, and 32 new charging locations, all of which will have megawatt-charging capacity from day one.

As well as the nominated vehicle operators, the consortium includes a number of vehicles to be managed by the vehicle leasing company Vertellus as an extension of its EV Discovery Programme, which enables electric vehicle operation on a subscription basis. This will allow other fleet operators and SMEs to join the eFREIGHT 2030 programme as associate members of the consortium.

1.3 Context: Electric Heavy Goods Vehicles

Heavy Goods Vehicles (HGVs) include all road vehicles with a Gross Vehicle Weight of over 3.5 tonnes. Not many years ago the prospect of electric Heavy Goods Vehicles (HGVs) seemed remote, because of the weight of batteries and the relatively short operational ranges they could enable. Hydrogen fuel cells seemed the most likely low-emission powertrain option for HGVs. Now in 2023 the prospects for uptake and use of electric HGVs (eHGVs) seem to be growing. Electric HGV penetration is very small at present (313 out of 604,035 HGVs on U.K. roads in June 2022). However, the U.K. government announced in 2021 that all new HGVs of 26 tonnes and under will be zero emission by 2035, and all new HGVs over 26 tonnes will be zero emission by 2040. The Department of Transport, in partnership with Innovate UK, launched a £200 million Zero Emission Road Freight (ZERFT) trial and demonstration programme in 2022. This when it begins will be focussed on the heaviest categories of HGVs – 40-44 tonnes, and will include trials of eHGVs as well as hydrogen fuel cell HGVs.

In Great Britain (England, Wales, and Scotland) HGVs range in gross vehicle weight from 3.5 tonnes to 44 tonnes. There are two major types, rigid (generally the lower gross vehicle weights) and articulated (generally the larger). As Figure 1 shows, articulated HGVs carry the larger share of goods lifted in Great Britain.

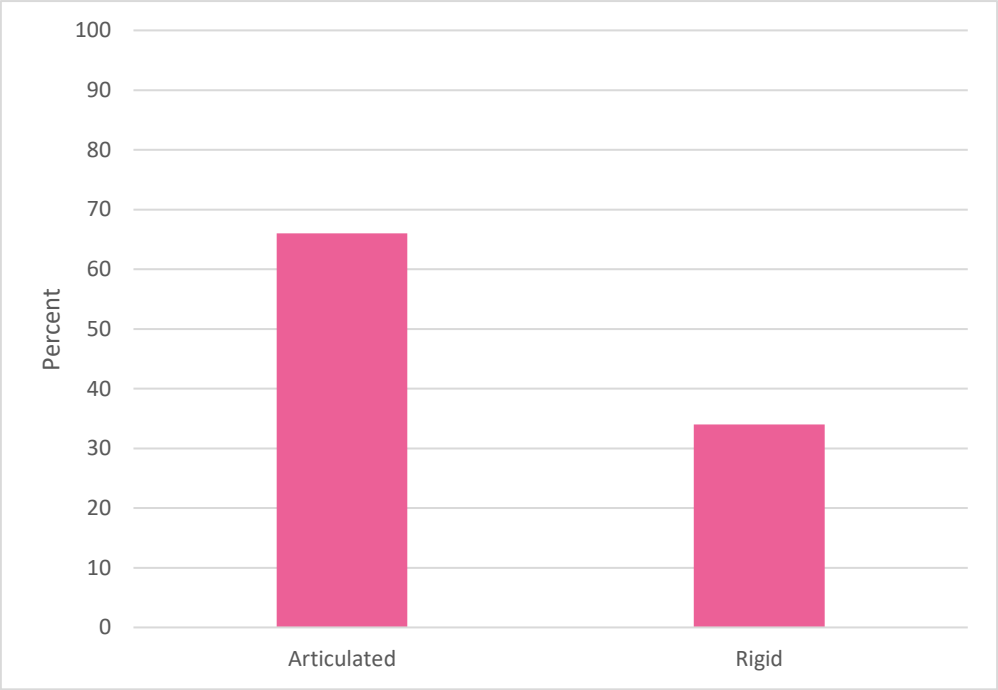

Figure 1. Percentage of goods lifted by Rigid vs. Articulated HGVs in Great Britain (source: Department for Transport Statistical Release, Domestic Road Freight Statistics, 29/7/21)

In 2020, 1.27 billion tonnes of goods were lifted by GB-registered HGVs. As Figure 2 shows, the majority of goods lifted in Great Britain are transported by public haulage operators, which carry goods for other organisations or individuals, but a large proportion is also carried by "own account" operators, which carry goods only for their own trade or business. Figure 3 shows that the largest category of freight is solid bulk, followed by palletised goods.

Figure 2. Percentage of goods lifted by Public haulage operators vs. Own account operators in Great Britain (source: Department for Transport Statistical Release, Domestic Road Freight Statistics, 29/7/21)

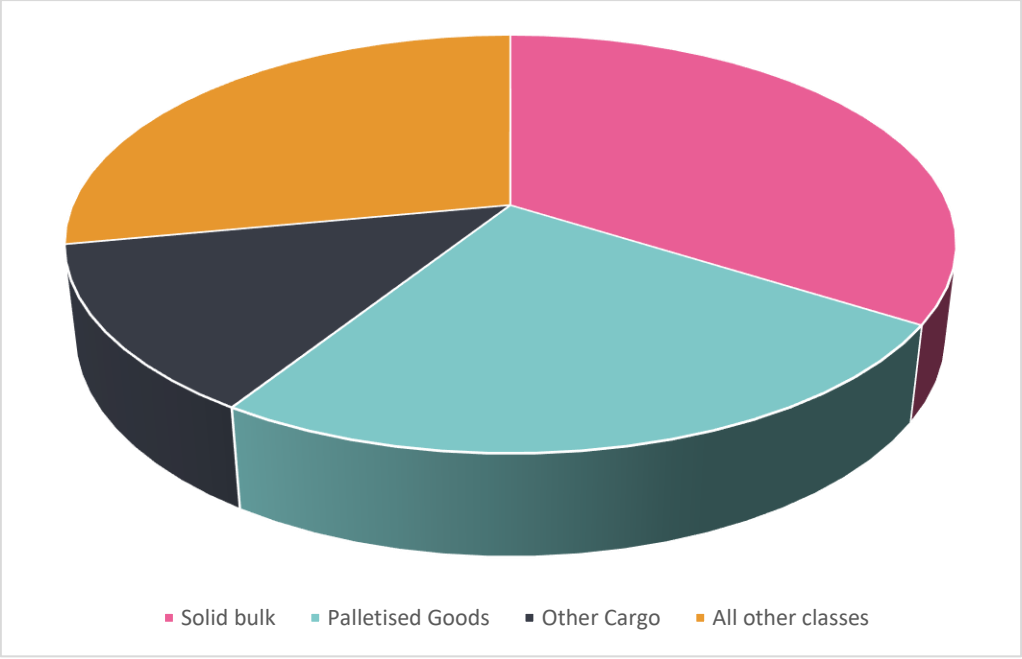

Figure 3. Proportion of goods lifted in Great Britain by method of transportation (source: Department for Transport Statistical Release, Domestic Road Freight Statistics, 29/7/21)

Examples of commercially available electric HGVs include the Volta Trucks 16 tonne Volta Zero, with battery capacities from 150kWh up to 225kWh, and range from 150-200km (described as "more than enough for most inner-city logistics") and the DAF XD/XF electric series, with ranges up to 500km (with a 525kWh battery pack). The latter can charge at up to 350kW using ultra-fast DC charging. Meanwhile charging point supplier Voltempo have told us that their HyperCharging system can deliver charge at a rate of 1MW to vehicles able to receive this – which would enable a full recharge of a 525kW DAF XF truck in a little over half an hour.

A single 1MW charger will draw the same current as twenty 50kW rapid chargers, so the potential impact on local networks, in terms both of operating within present capacity constraints and potential network reinforcement needs, could be substantial. Short-haul logistics fleets may well be able to recharge their vehicles at depots, while long-haul eHGVs will need to be recharged away from base. Knowledge of the utilisation patterns of existing HGVs, together with an understanding of eHGV ranges, would enable reasonably valid modelling of the necessary geographical distribution and network impacts of HGV charging stations. However, as the charging network develops there will necessarily be an interaction between the existing HGV charging point network distribution and the utilisation patterns of eHGVs. In addition, factors such as eHGVs making overnight stops at charging locations need to be taken into account.

At present there remain many questions about the prospects for eHGVs, in competition with other options such as hydrogen fuel cell vehicles (FCVs), vehicles using alternative fuels (such as liquified natural gas (LNG), compressed natural gas (CNG) and hydrotreated vegetable oil (HVO), and modal shift of freight to electric rail. These questions include, inter alia:

1. To what extent do HGV operators have sustainability strategies, what are their key features, and what are the roles they see for zero emission HGVs within their strategies?
2. What benefits do HGV operators see from zero emission vehicles? (cars & vans; HGVs)
3. What drawbacks do operators see from zero emissions vehicles? (cars & vans; HGVs)
4. What are HGV operators' perceptions of the barriers to acquiring and operating electric HGVs now? In the longer term? (5-10 years)
5. What charging infrastructure would HGV operators need if they were to transition to electric HGVs? (Geographical distribution, charging rate, cost, etc.). What would a charging CVP look like?

The Catapult was commissioned by Voltempo to conduct a small-scale qualitative research project, to explore these questions with UK HGV fleet operators, primarily through qualitative semi-structured interviews with those involved in corporate sustainability strategy. This report outlines the findings of that research.

1.4 Project objectives:

The project objectives were as follows:

1. To characterise HGV operators' sustainability strategies, their key features, and the roles of zero emission HGVs within them
2. To identify the key benefits and drawbacks that HGV operators see from zero emission vehicles (HGVs)
3. To identify HGV operators' perceptions of the barriers to acquiring and operating zero emission HGVs, now and in the future
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2. Method

2.1 Methodology

In exploratory research with people the most appropriate methodology is qualitative research through the medium of in-depth interviews with people connected with or immersed in the research topic. A key feature of this approach is that it enables participants to discuss the topics from their own perspectives, in contrast to quantitative surveys, where participants can only respond to the specific questions asked, which inevitably reflect researchers' framing of the topics. It also has the benefit of enabling in-depth exploration of the topic with each participant. This necessarily means that the research involves a much smaller set of participants than is typical for a quantitative survey. In qualitative research the aim is not to work with a statistically representative sample of a given population (say, sustainability managers of HGV operators) but rather to explore the diversity of different perspectives and views to be found within that population.

2.2 Research design

Nine semi-structured interviews were carried out, each lasting approximately 50 minutes. Interviews were carried out remotely using Microsoft Teams. To ensure accurate recording and to eliminate selective attention on the part of researchers, each interview was audio recorded and transcribed (with the interviewee's informed consent). The transcription facility within Microsoft Teams was used in the first instance, and the transcript was checked and corrected where necessary by the interviewer.

2.3 Participants

The majority of participants were managers involved in sustainability strategy within organisations operating HGVs in the U.K. In addition one participant was from a major HGV manufacturer with an awareness of eHGV development within that organisation. Participants were recruited to the study by the Catapult after initial contact by Voltempo.

2.4 Analysis

Data from the set of transcripts were analysed using thematic analysis. The analysis was approached inductively (Braun & Clarke, 2006), i.e. the structure of themes was allowed to emerge from the data itself, rather than being decided a priori by the researchers[1].

[1] The analysis was conducted at a semantic level (Braun & Clarke, 2006), from the explicit meanings contained in the data, without attempting to draw inferences about underlying meanings. It was approached from a critical realist ontological stance, assuming that the language used by participants reflected an objective reality in so far as they had experienced it, and a contextualist epistemological stance, assuming that participants' discourses reflected their social and temporal contexts, working in the U.K. road freight sector (or HGV manufacturing) in 2023.

3. Participating organisations - characteristics

Most participants' organisations had fleets of several thousand vehicles, mostly larger articulated HGVs though with around 15-50% smaller rigid HGVs. The smallest fleet operated around 450 HGVs and the largest around 5000. Several operators also had a fleet of vans.

Participants' organisations were operating vehicles over a wide range of journey lengths. Their vans and lighter trucks were typically engaged in shorter journeys, such as local distribution from a hub; larger vehicles, particularly articulated HGVs, were typically being used for longer journeys and "trunking[2]".

They served a wide range of customer sectors, including food & drink, clothing, furniture, books and other print, packaging, construction, automotive, bulk products (milk, beer, vinegar, oil/gases), hazardous chemicals, and defence.

[2] Transporting goods on trunk roads and motorways, typically longer journeys

4. Findings

4.1 Electric Heavy Goods Vehicles – development

Participants agreed that the pace of development of electric Heavy Goods Vehicles had been rapid in recent years, to the point where smaller rigid electric trucks for local operations are already or close to being available in the market.

> *What I've seen in that 18-month period of time has been quite a rapid development… a rapid development on the truck side* (P5)
>
> *But it turns out for using it for local in Kettering and Corby, Northampton, it was actually perfect* (P1, discussing trialling a rigid eHGV)
>
> *So we know that electric is going to start with smaller vehicles* (P7)
>
> *If I think about the end of the decade… I think that the rigid market will have largely moved to battery electric by that point* (P8)

However, eHGVs are not yet seen as a credible option for heavier trucks making longer journeys, particularly in "trunking" operations (transport freight on trunk roads and motorways):

> *So at the heavy end… particularly the compromise is definitely gonna be around payload and range* (P1)
>
> *Obviously, the trailers and the tractors well happen within that later time frame* (P4)
>
> *With an electric vehicle to get 500 miles of charge with a 44 ton truck, you're gonna need a… massive battery*" (P7)

A particular problem is seen with electrifying the biggest UK trucks, the articulated 44 tonne, 6x2 category[3], typically used in long-range trunking operations. Fitting large enough batteries on the tractor unit is likely to increase its length, so that the overall tractor-trailer combination would exceed regulatory length limits and potentially be too long to negotiate some UK roads:

> *The OEMs are making the trucks and constantly tweaking and changing and they haven't released a 6 by 2 electric vehicle yet, so we can't see it. But what we understand is the six by two vehicle tractor unit and we'll have a much longer wheelbase so that you can put enough batteries onto it. The more batteries, the heavier the weight, the longer the wheelbase, the longer the total combination length. We believe that what they're suggesting means that you know a standard trailer and six by two unit will be too long for the UK roads.* (P4)

The pace of development of electric HGVs has been spurred on by "disruptors" who have to some extent redesigned the HGV without the limitations of starting from existing diesel HGV products:

[3] Six axles on the trailer, two on the tractor unit

> *The disruptors have come in… Volta have come up with a very innovative concept that is of if you want designed from the ground up and in theory brings a number of product innovations that that the traditional OEM cannot yet offer… the seven or eight mainstream OEMs have all adapted their diesel vehicles to accept an electric drive line… and so the product that is there is inevitably compromised in that sense* (P8)

However, there is an expectation that the mainstream OEMs will very soon also incorporate new electric technologies into their next generation of eHGV designs:

> *What we will see is in the next year or two, most of the OEM's bringing those products to market… we will see e-axles… we will see potentially in-Hub Motors and those achieve a further advantage for the vehicles* (P8)

The weight of batteries is one of the factors contributing to the limited range of the present generation of eHGVs:

> *The big challenge… which the industry is trying to grapple with… is to get the level of power output from a battery that's small enough to fit onto a onto a tractor unit…, but be sure that all of the OEM's are are working towards that goal as as we speak and and each of them will will have a solution to it* (P8)

But technological improvements are expected to offset this:

> *The current weight penalty, the weight-power sort of equation that is impacting the product offer at this point will be addressed by some of those developments* (P8)

> *Some of the OEMs … they feel pretty confident that they're going to make quite vast improvements on the range and the battery size* (P6)

4.2 Benefits of eHGVs

Decarbonisation – zero tailpipe emissions – is seen as the key benefit conferred by eHGVs:

> *Carbon reduction, that's very very obvious* (P3)

> *We believe the future is electric zero emission. So either it's electric or it's hydrogen or it's catenary*[4] *or it's a mixture of all three* (P7)

Reduced running costs, particularly of fuel and maintenance, are also recognised:

> *Theoretically, they're gonna be cheaper to fuel* (P3)

> *And in theory they should be cheaper to maintain* (P3)

[4] Electric vehicles powered from overhead cables

Electric HGVs are seen by some as saving on congestion charge costs, and potentially even road tolls:

> *Theoretically, they'll have cheaper access to some cities, and theoretically on the basis that we may not have to be charged congestion charge, or we may have a zero rate road tolling* (P3)

Another key benefit is a significantly better driving experience:

> *More usable controls, clearly quieter. And, you know, torque very low down, very* smooth (P1)

> *The drive is much preferred it to be honest because it's less vibrations, less engine noise... It's a more comfortable environment for the driver... it's just a it's a nicer place to be* (P2)

> *Preheating the cab for when they turned up was a big selling point* (P3)

Several participants indicated that the improved driving experience is seen as potentially helping to recruit more younger drivers and more women drivers:

> *I think they're more attractive to the younger generation and that's been a topic of discussion and driving for years and years and years about the age, average age of truck drivers* (P2)

> *I do think electric trucks will see more female drivers that join the industry, and I'm hoping that with the development of new charging hubs... to start again to put in nice facilities, nice showers, treat drivers with respect. You know these people are so crucial to what we're doing* (P4)

4.3 Barriers to eHGV adoption

Participants saw two major barriers to widespread adoption of eHGVs. First, range:

> *The range that, yeah, the range that you can do is definitely a factor* (P3)

> *The point is it won't be anywhere near as much in one charge as we can get with one tank of diesel. So that I think that's fair to say. So with a heavy truck, we can get 500 miles of diesel on it easily even with a full load* (P7)

Manufacturers tend to quote range at 30% payload, which operators find unhelpful because they generally seek to operate as near to full payload as they can:

> *Which is mad because we're spending all our time trying to absolutely maximise the* payload (P7)

> *If they put it at 100% payload, the range would be significantly lower and everybody, everybody would be spooked by how low the range was. So they're quoting it out that they are saying it very openly. It's 30% payload. But the obvious question is, well, what is it, 100% payload and they go well. It depends* (P7)

Range could also be reduced by other electrical loads on the vehicle:

> *So where you use the tail lift, you know significantly on multidrop operations it will be another draw on energy usage to run the tail lift… we run some food tankers, Usually [the cargo] it's hydraulically pumped off… there's gonna need to be some practical engineering solutions for some of the things that we do currently using the internal combustion engine* (P1)

Second, the high cost:

> *They cost. Currently they're circa three times more expensive than a diesel* (P1)

> *The cost of them was quite challenging… The upfront cost, even like the leasing prices…* (P2)
> *It was two to three times more expensive… although I say that there has been some movement on that recently with some discussions we're having with one of the OEM's that they have brought the price down…so that is a factor, but if that fact can be overcome, I don't see it being a problem* (P3)

Third, in any given vehicle weight category, the payload of an eHGV will be smaller than that of a diesel HGV because of the weight of the battery needed to confer adequate range:

> *The payload on this electric vehicle is 6 tonnes whereas a typical diesel vehicle payload will be 10 tonnes, the gross is 16 because the weight of the vehicle itself is 10 tonnes in terms of battery vehicle* (P2)

This is particularly the case for the largest articulated trucks, in the 44 tonne category:

> *The engine and the and the diesel tank is on the tractor unit. If you want to put [EV battery with] the same capacity on it, the weight of that is so high that it changes the balance of the vehicle because you can only put so much load on each axle… it's gonna be evenly distributed because there's so much weight on that front end. You can't evenly distribute, therefore you have to have a bit more length to change the seesaw to allow it to operate legally* (P2)

> *So there's a weight issue. A gross weight issue and a dimensional issue that is ensuing with EV at the upper end of the weight band* (P2)

> *You can't have a 44 ton truck on the road, electric one. And it's too heavy. And if you do have the batteries, it's gonna be too long for UK legislation. So that means that it's going to be four by twos that are the common truck on the road when it comes to battery electric, and we'll have to assess how that affects payloads and customer requirements* (P4)

Fourth, there was a perception that the availability of eHGVs from manufacturers could become an issue:

> *Maybe the supply [of eHGVs] because… there's not a lot of them at the minute I know… Depends on how the manufacturer ramp up… I think they're planning to ramp up… how successful that is* (P3)

4.4 Hydrogen Fuel Cell Vehicles as an alternative to eHGVs

Most participants had considered hydrogen fuel cell vehicles (FCVs) as an alternative to eHGVs. They have the potential advantage of longer range:

> *The distance that you can cover with a hydrogen truck compared to an electric is much greater. So if you're looking for a type of operation that will be most similar to the diesel vehicle, hydrogen (P4)*

> *We were thinking that hydrogen would become relevant if we were doing really long, long journeys and that's not really what we do* (P6)

They also have the potential advantage of solving the difficulty with eHGVs of providing sufficient power to recharging locations:

> *Not having the restrictions around energy into the sites that you needed for recharging* (P1)

However, they are seen as being an even more expensive option than eHGVs:

> *But then, anecdotally, I'm told hydrogen is circa £600,000 to £700,000 per truck* (P4)

> *The knowledge gained that I've had from manufacturers is it will probably still be 20% more expensive on a TCO basis than electric… the TCO is looking, though it's gonna be more expensive because it's a battery electric vehicle with a fuel cell on* (P2)

> *If an electric truck is 3 times the price [of a diesel truck] the hydrogen truck is 6 times the price* (P4)

Perhaps the biggest issue with hydrogen FCVs is seen as being the potential difficulties of producing and supplying sufficient "green" hydrogen:

> *Green hydrogen will be an essential and I'm not so sure there'll be enough green hydrogen to go around… So again, macroeconomics making green hydrogen is a bit futile really because it's not efficient to make hydrogen… You're better off sending electron into the battery instead of into hydrogen… So you'd only really in a real world situation want to use hydrogen as a last resort* (P2)

> *You've got all the infrastructure that's required for that and the production of hydrogen, which needs to be green as well* (P4)

There will also need to be a new hydrogen distribution and fuelling infrastructure:

> *On the face of it, it seems like a very good solution for the heavy end of the market… But clearly it's gonna be around about how the infrastructure develops, whether that gets government support in terms of how, how it starts to move forward* (P1)

One participant pointed out the potential issues associated with leakage of hydrogen from storage facilities, including onboard storage:

The particles [molecules] are very, very small. So there's, there's this idea of slippage. You know if you deliver, if you're transporting hydrogen, you're gonna lose a lot of it in the transportation unless it's stored properly (P4)

Availability of hydrogen FCVs is a problem at the moment – they are seen as being behind eHGVs in this respect:

We understand the vehicle, but they're simply not out there at the minute in the volumes that we need… you can't go to our traditional supply line OEMs and say I want a hydrogen (P2)

4.5 Alternative fuels as an alternative to eHGVs

Several participants had trialled or considered biodiesel and/or HVO, typically as an interim step towards decarbonisation:

We're looking at how we can roll it out in our own fleet is use of biodiesel … because it works almost as a complete drop in alternative … The beauty of it is that if you require to use diesel because it's not readily available in forecourts, we have a bulk fuel tank available, you can just have regular diesel in it and there's no engine modifications or issues with mixing fuel or anything like that (P3)

We've done some, some, some work with customers where we've transitioned vehicles to HVO, very, very simple drop in solution, no changes needed to vehicles, but it's significantly more expensive than diesel (P1)

Likewise, some participants had explored the possibility of using CNG[5] or LNG[6] as an interim step:

Done some trials on bio-gas CNG and LNG and I think that's a a useful transition fuel, the infrastructure for refueling for CNG and LNG, these slowly still expanding. So it is becoming a little bit more viable… Ultimately, it's still a fossil fuel, so it is a it's a stepping stone and a transition fuel (P1)

4.6 Trialling of eHGVs and HFCV trucks

Participants have gained some experience of operating electric HGVs and vans. Trials with eHGVs have usually involved one or a few smaller rigid vehicles and been on a limited scale, in operations that matched the range and payload capabilities of the vehicles:

I've 16 tonne full electrics coming through the door… We're putting on a 16 tonne EV to carry a six ton load… we can only put them into some operations where that is suitable and hence that's why the one that we're putting on are very, very best, not

[5] Compressed Natural Gas
[6] Liquified Natural Gas

bespoke, but we're picking the operation that is bespoke to the the ability of the vehicle (P2)

In terms of big HGV, we have only had one on trial and that was a Renault 19 tonne with the dispensation for the batteries… we had it for four weeks, two days we essentially just trialled it to see how it would get on… in terms of cost per mile, it was significantly cheaper… it turns out using it for local in [locations] it was actually perfect (P2)

Several participants mentioned involvement in proposals for the government-funded ZERFT trials, which aim to test both eHGVs and hydrogen FCVs on a larger scale and for longer duration. Results from the ZERFT trial are eagerly awaited:

We're part of the consortium bid for ZERFT funding, which we're still awaiting with baited breath whether we our successful or not (P1)

4.7 Recharging of EHGVs

The ability to recharge eHGVs is seen as critical:

My mantra is it's not about the truck, it's about the infrastructure around it. So the truck will be here, but the issues with it is how could we charge it? (P2)

What I've seen in that 18 month period of time has been quite a rapid development but a rapid development on the truck side of it I think has been less so on the charging (P5)

Participants used terms like "charging infrastructure" with two meanings: (1) recharging eHGVs en route at public locations (sometimes referred to as "opportunity charging"), for instance on the strategic road network, and (2) charging equipment at their own premises.

Public access charging infrastructure for heavy goods vehicles is gonna be fundamental that as the catalyst to be able to then start to utilize them more (P1)

We're going to have to have more opportunity charging… the infrastructure is not there, you know… So until that infrastructure is more readily available, that's gonna be a problem to get opportunity charging (P2)

You could only hope that as as the infrastructure starts to emerge, we'll get to a position where you're potentially going to have some kind of opportunity charging and top up charging on route that you can start to tap into. But at the moment that doesn't exist so our starting point will be through trying to engage with other operators that may have charging infrastructure that we could tap into and develop on our own (P6)

Participants saw risks in vehicles arriving ad-hoc at public chargers, particularly loss of efficiency if their vehicles had to queue for access to chargers, as experienced by electric car users at motorway services:

> *Now when I want it not queuing and you know and be able to book it ahead, you know the commercial vehicle world is going to be more, more demands on the system… simply ensure that we keep our productivity* (P2)

Even if a driver gets immediate access to a 1MW charging point, there will still be an issue of driver/vehicle downtime:

> *We'll absolutely need to, but we see we see huge issues with that. You know the amount of land required… to have a electric fuelling station is significant because it's not a 10 minute refuel… best case with MW charging is 45 minutes… the reality is a few hours and so… how many trucks can be serviced at one time if they're all waiting for one to two to three hours and also if you are waiting for a long time to charge, what does the driver do?* (P4)

One participant suggested that recharging could usefully be made available at customers' premises too:

> *We're having to approach our customers and say, look you as customers need to start putting charging stations in your store in your distribution centres… so that we can grab some energy while we're tipping or loading* (P2)

Other participants suggested that shared facilities might emerge, close to their bases:

> *It might mean that it's much more cost effective for us to just go and use a infrastructure up the road or shared infrastructure with other operators then buying all of that infrastructure and upgrade for our own depots* (P7)

4.8 Recharging – availability and cost of power

Whether charging takes place at an operator's own premises or at public locations, two major issues were seen by most participants: the costs involved in providing the charging infrastructure (particularly at their own premises) and the potential difficulties involved in getting sufficient power to the charging point locations (i.e. the Distribution Network Operator providing a sufficiently high-power connection to the distribution network):

> *The biggest issue is power and how much power is required to charge these vehicles* (P6)

> *The power requirements that we're going to need. It's gonna be significant investment… that actually goes very much hand in hand in terms of the vehicles becoming operationally viable and being able to work within the operations that we run* (P1)

> *In order to minimize the stand or dwell time, we need MW chargers… So… a MW charger probably cost the best part of £150,000 each… Now, if you've got 100 vehicles at your site and you needed 20 chargers, that's a lot of money…* (P2)

> *Our biggest our biggest concern is power… getting access to power through the grid… And it's significant. Well, it's very, very expensive. We don't know what is available in certain areas. Ww don't know if logistics will be given any priority* (P4)

You know there are difficult times of day in the daytime when power is much less available because the demand is much higher (P4)

You know, we've been quoted obscene amounts to get power into sites (P4)

What's the cost for putting it into the actual depots? What's the upgrade costs, which can be all over the place? You know, what's the relationship with the DNOs? Can somebody offer a full turnkey solution to make it happen, which would be ideal for the likes of us because we're not experts in energy management (P5)

It seems like it's a dark art to uncover where the power is and how accessible it is (P4)

Trying to find land with power or trying to find land in general in this country is difficult, trying to find it with power when everyone else is also trying to transition means that actually it is gonna be very, very difficult and and unless you own the land, you're not gonna invest millions of pounds into it for somebody else's benefit (P4)

Some participants questioned whether the electricity system could deliver the amount of charging supply that the road freight sector will need, particularly at times of peak electricity demand:

That's a massive amount of electricity just to look after [our] vehicles… If we were to go to electric vehicles, well, how's the grid gonna cope with that? You know, we we the industry will need so much… fundamentally, is there enough energy gonna be in the grid to power the trucks? (P2)

In addition, participants foresaw problems with the timescales on which DNOs could make high-power connections available:

If we have a massive growth spurt in electric vehicles demand, the DNO's will say ohh we can't connect to the grid, you'll just turn the lights off at the minute… OK, right, when can we then?… Well, five years time (P2)

DNO can we have 10 megawatts of energy a year? … Yeah, you can… in about 5 years time (P2)

4.9 Changing the operating model to accommodate eHGVs

All participants expressed the view that their organisation would need to change substantially the way it carried out its operations to adapt to having eHGVs in its fleet, or to transitioning to an entirely electric truck fleet. For instance, payload and range constraints would be important factors they would need to adapt to:

Trying to work through how we change our operations to be able to accommodate electric HGV's in terms of payload and range constraints… and but it's about making it work operationally that doesn't compromise the operations… so at at the heavy end at the heavy end, particularly the the compromise is definitely gonna be around payload and range that's ultimately where we're gonna get (P1)

The need for charging, and the time it would take, would also lead to a reduction of utilization rates per vehicle (and hence more vehicles to deliver the same total payload) and a need to change operating patterns:

> *We've got very well established kind of supply chains and efficient ways of doing things. You know, we've tried to work on utilization. We work on load fill reducing the number of journeys, everything systemized and we've refined that over lots and lots of years and there's been no fundamental changes but… the recharging infrastructure and the recharging times will have a significant impact in the efficiency of the operation* (P1)

A necessary consequence of these constraints will be new approaches to routing and the scheduling of breaks:

> *Work out different ways of routing vehicles and drivers clearly have to take breaks and that's built into the routes that we do* (P1)

Changes to operating patterns are likely to be easier to implement for regular routes, but potentially more of a problem when routes and payloads vary from day to day:

> *You need to know exactly how many miles you're doing, where to charge, which then makes it more simple to use on standard routes that you do every day, whereas it's maybe slightly more difficult to do it on different routes, so your distribution networks that will go to different areas, different days and might be more challenging* (P3)

As well as needing to adapt to vehicle downtime for charging, operating patterns will also need to change because of the reduced payload of eHGVs within a size class (because of the weight of the battery):

> *Now the productivity will be so much worse, because today we carry 29 tonnes of payload on a typical 44 tonner… Tomorrow, we're likely only be a carry 22 tonnes, so immediately we're 20% worse off in productivity* (P2)

> *You would have a reduction in efficiency compared to a diesel, but it's almost like an extra thing that the planners have to think about and extra complication in the system, which I personally I think can be managed, but it has to be managed carefully* (P3)

One participant described working with a vehicle manufacturer to review their operations and identify where existing 44 tonne 6x2 vehicles could be replaced by smaller ones:

They're doing an assessment of our operations as well… So we're looking at where is an actual need for a 6 by two and where where could you have a four by two in that in that place (P5)

One participant pointed out that an issue in considering changes to operating patterns is conservatism within their organisation, and how many staff aren't used to the alternative language needed to discuss eHGVs and/or FCVs:

> *I'm starting to talk a lot of electric language and hydrogen language, and if you go to our guys in the transport operations, they are they are talking, they're still talking obviously*

because we're 100% diesel pretty much they're still talking the language of diesel. So it's all about horsepower… there's so few people who know how many miles per kWh or how many kilowatt hours per mile their truck would do (P7)

4.10 Sustainability strategies of HGV operators

Broadly speaking, participants were all oriented towards decarbonising their road freight operations. However, there were different perspectives on how rapidly their organisations would make this transition. Some were committed to moving quickly:

> *Our journey is such that we want to progress down the zero emissions route as fast as commercially possible* (P2)

> *Our overall strategy is to reach net zero by 2035… we're looking to replace our rigids… by kind of 2030ish* (P6)

Some are a little more conservative about the timescale to transition:

> *We've actually gone out and said we're gonna do it by 2040. Reason we chose 2040 is because… in theory, we won't be able to buy a diesel vehicle after 2040, so we've said, well, you know, we might as well start that transition because we're not gonna just wait until 2039 and then…* (P7)

Most have considered a staircase of measures to reach net zero, typically starting with small changes that can implemented quickly, and electrifying smaller vehicles first:

> *We've started to put plug points in at some of our depots so that when the rigids are there unloading, they can be plugged in and not using diesel they can be there for kind of three to four, maybe five hours sometimes… So it means that we're making that saving already in diesel* (P6)

> *So then you have to look at what you can do better with diesel. So we focus heavily on driver training… I'm making sure that we're operating the vehicle to the maximum in the first place… then making sure that we're planning efficiently… So we're starting to bring in optimization technology which we didn't have before… I think in the road haulage sector it's a little bit underused and it's been quite an old school industry, so it's kind of trying to route optimisation* (P3)

> *We're looking at how we can roll it out in our own fleet is use of biodiesel* (P3)

> *If we could work with somebody who I know we're talking to different companies about second life in the batteries and using those in our depots, that would be a really great way* (P6)

Some organisations see themselves considering hydrogen FCVs, if the vehicles and refuelling infrastructure develops sufficiently, particularly for larger trucks and longer journeys:

> *My view is we'll probably have 20 or 30% of our fleet will be hydrogen and the rest will be electric… Hydrogen probably longer haul* (P2)

For some participants, their strategy is dependent on customer demand for them to decarbonise, and for customers to be willing to bear the costs involved (or for those costs to reduce to parity with the costs associated with diesel vehicles):

> *Some customers are happy to pay the difference between a traditional diesel vehicle and an environmentally friendly vehicle… because we're a collection of contracts, some of the contracts are really up for having some zero emission vehicles and it and they'll pay for that other contract that say, well, no, we're bottom line orientated, we're only interested in diesel until there's price parity… or TCO[7] parity rather so total cost of ownership is where the break point would be a lot, lot more people interested in it* (P2)

For one participant, modal shift away from long road journeys towards rail is likely to be an important part of their strategy:

> *Because we identified that actually to reduce congestion and to reduce emissions, rail is a service… that is here today. It can move cargo on mass. The price point is not… something that our customers can't accept and so that for us is the first way to transition. Our aim is to let the trains do the majority of the journey and then run short distances on a highly utilized fleet from the central hub. Let the train do 200 miles and let the truck do 20… using trains to do 90% of the journey also means that 90% of the cost can remain* (P4)

All participants recognised that the transition to net zero in road freight would be expensive. One observed that the costs involved would be beyond the capacity of smaller logistics companies, which would lead to a restructuring of the sector:

> *For those that can't, I think you'll see a mass exodus from the logistics space… you'll see people who own one truck or five trucks or even 15-20 trucks that have small little operations, very niche businesses… And I don't think they will have the time or the money to completely transition their business… the distribution of fleet sizes is going to shrink and there's going to be more likely a few big operators and a lot less of the of the long tail of smaller operators* (P4)

One participant expressed a rather pessimistic view of the challenges involved in making a transition to a decarbonised fleet using eHGVs:

> *Because of the mileage restrictions that you have, it doesn't work for a lot of I say would say most of our applications and currently which is challenging* (P3)

4.11 Role of government

Most participants saw a need for government to adapt weight and length restrictions on HGVs to accommodate the weight and size of eHGV batteries:

[7] Total Cost of Ownership

> *And EVs as they emerge, get different weight limits than that allow for either a higher weight capacity or different loads and then dimensions in terms of whether we can go longer quickly… potentially whether there's any opportunities for going either longer or or heavier weights could help offset some of that efficiency loss that we're gonna see* (P1)

> *There's a massive issue there that the UK has got to accept that we need to have heavier vehicles basically… We need to change the weight allowances for EVs* (P2)

> *In terms of the weight restrictions, it would be more challenging if we weren't allowed at dispensation because of the batteries* (P3)

Also, the high costs involved in the transition will need to be mitigated by government intervention:

> *There's a need to pump prime and open doors for us as a as an industry to be able to pass through without adding cost to the UK economy… So we need to ensure that we for investing for the future our business and get tax benefits or something or some grant or something to pay for that infrastructure* (P2)

5. Discussion

Multiple key points have been identified in this research.

Major operators within the U.K. road freight sector appear to accept the need to transition their operations towards zero carbon dioxide (tailpipe) emissions or net zero. The timeframes discussed reflect the present (2023) U.K. government deadlines for ending the sales of diesel trucks under 26 tonnes by 2035 and diesel trucks in larger size categories by 2040. Some operators are committed to achieving net zero by 2035, whilst others are less specific and more likely to see the timetable for achieving net zero as being influenced by customer demand and customer willingness to contribute to the transition costs, which were perceived to be high by all participants.

These major operators appear now to see eHGVs as the most credible option for achieving most or all of this transition, despite the existence of several barriers, discussed below. Electric rigid HGVs are expected to be available with sufficient payload and range for short and medium range distribution operations by the end of the 2020s. Electrification of larger articulated HGVs for longer routes is expected to take longer but these are expected to be available by the late 2030s, in all but the largest weight categories, which are seen as being more challenging.

The main other option, hydrogen FCVs, has faded from contention in recent years, partly because of perceived even higher total cost of ownership (TCO) (and substantially higher vehicle purchase/lease costs), partly because of the lower overall energy efficiency of the FCV option, and particularly because this option depends on the availability of sufficient "green hydrogen" (produced by electrolysis of water using electricity from renewable sources) the supply of which may be limited (and the limited supply may be in demand from other sectors).

The availability of sufficient high-power connections to electricity distribution networks, to enable recharging of eHGVs in large numbers, is seen as the most important hurdle to overcome if mass deployment of eHGVs is to be achieved. The operators see a need for multiple MegaWatt charging stations at their own depots and (for longer journeys) on the strategic road network. Long lead times are anticipated for such connections, and they may be beyond present local network capacities.

Some operators are suggesting that shared use of charging facilities by several operators may help to mitigate the high costs involved in installing sufficient charging capacity at their own depots.

High costs are anticipated in any transition to eHGVs, both in terms of TCO and up-front purchase costs for vehicles (both seen as being higher than for diesel vehicles), and in terms of the capital cost and connection costs of high-powered (MW) charging stations. There is a view across the sector that contributions towards these costs will need to met either by their customers, or government, or both.

Electrification of the bigger weight categories of articulated trucks is seen as being particularly difficult due to the sizes and weights of batteries required. Even if it were possible to produce a 44 tonne eHGV with sufficient range to meet operators' needs, the

weight of its batteries would impose a substantial reduction in payload compared to a 44 tonne diesel truck, meaning that more vehicles would be required. This might be addressed by changes to the weight and length requirements applicable to larger eHGVs. Some operators believe that decarbonisation of these largest weight category trucks might be better achieved using hydrogen FCVs.

Operators expect that they will need to make substantial changes to their operating patterns in order to accommodate a transition of their fleets from diesel to eHGVs. This may include:

- Changes to schedules, routes, and break times to accommodate vehicle recharging (charging durations and charging locations)
- Changes to schedules and routes to accommodate reduced payloads per vehicle
- Changes to the number of vehicles needed for a given weight/volume of freight, because of the relatively smaller payloads (by weight) that could be carried by an eHGV compared to a diesel truck within the same weight category

Operators anticipate only an interim, short-term role for alternative fuels such as LNG, CNG, HVO, etc.

Operators anticipate two main roles that government will need to play to facilitate a transition to net zero in the road freight sector:

- Adjustments to regulations governing weight and length of HGVs to take into account the impact of battery weights on payloads of eHGVs
- Mitigation of the high cost to operators of this transition, both in terms of higher costs of vehicles compared to diesel trucks, and in terms of the very high costs of acquisition of chargers and connection to distribution networks (effectively a whole new category of operating costs for these organisations)

6. Conclusions

- Operators accept there will be a need to transition their HGV fleets to net zero carbon emissions; some aim to achieve this by 2035, others will be later, some potentially getting there only by 2050
- Most operators believe they will achieve net zero largely through adoption of eHGVs, which will by 2030-2035 be able to replace all but the largest vehicles on all but the longest routes
- There may be a niche role for hydrogen FCV trucks in the largest size category on the longest routes
- Alternative fuels will only play an interim role in the transition
- Most operators will recharge their vehicles at home bases, but there will also be a role for recharging facilities on the strategic road network
- The cost and availability at the right locations of power for recharging is seen as potentially the biggest issue for a timely transition
- Major changes to operating patterns (including schedules, routes, break times, and number of vehicles being operated) will be necessary
- Government will need to support the sector in making this transition, both by changing regulations around allowed vehicle weights and dimensions for eHGVs, and in mitigating the high costs to operators of making the transition
- The cost and complexity of the transition will likely result in major restructuring of the road freight sector, with the distribution of fleet sizes becoming increasingly skewed towards larger fleets

7. References

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