Supporting the growth of clean transport

Decarbonising Heavy Goods Vehicles on the Strategic Road Network

May 2022

nationalgrid

36,000

There are around 36,000 premature deaths each year in the UK, due to high levels of air pollution. This is equivalent to over 98 preventable deaths every day.

Foreword:

The sale of all new petrol and diesel cars and vans is ending in 2030 and numbers of electric vehicles are at a record high. The direction of travel is clear and the conversation on zero-emission motoring has now firmly shifted from if, to when.

But what about HGVs? The road freight and logistics sectors underpin so many aspects of life we take for granted, moving most of our daily necessities such as fresh food, clothing, and electronics. But this crucial sector is also a disproportionate contributor to the UK's greenhouse gas emissions. Despite making up less than 6% of road traffic, HGVs account for 18% of the UK's road transport emissions.

Graeme Cooper
Head of Future Markets,
National Grid

Last year the UK government pledged to phase out sales of new non-zero-emissions HGVs weighing 26 tonnes and under by 2035 with all new HGVs sold in the UK to be zero-emission by 2040. It's the beginning of fundamental change for the sector, just as we're seeing in the switch to passenger electric vehicles.

The fleet and logistics industry is embracing this challenge and making significant progress. The zero-emission market is now taking off for even the heaviest HGVs and rapid progress and investments are expected in zero-emission options within the next decade. But action is still needed to reduce the impact of the freight sector on carbon emissions. Transport and energy networks need to work together to put a plan in place for the deployment of charging infrastructure that will support HGV decarbonisation.

The recently published EV infrastructure strategy is a strong start, setting the wheels in motion to move from planning to delivery. However, vital areas still that need to be fleshed out to turn all of this intent and ambition into a reality, such as investing in energy infrastructure ahead of need, planning the deployment of infrastructure in a way that ensures long distance trucks can charge or re-fuel en-route, and aligning investment with other transport sectors such as the EV rapid charging network.

This report builds on that, showing how energy networks are the critical enabler in decarbonising all road transport and outlines our recommendations for government to consider expanding the scope of the Rapid Charge Fund (RCF) to include en-route charging / refuelling provision for all modes of road transport. The bulk of HGV recharging or refuelling will take place at a depot or end location, but the market needs en-route provision too. There are a number of different zero-emission technologies (battery, hydrogen, or electric road system) but for each solution optimally located grid connections with adequate capacity are key. Regardless of technology there's a real opportunity to build before need, ensuring that sufficient provision is available ahead of demand. Digging once, in the right location, and planning future charging infrastructure around connections to energy networks can bring cost savings and reductions in the infrastructure required – at the same time as accelerating progress towards zero-emission transport.

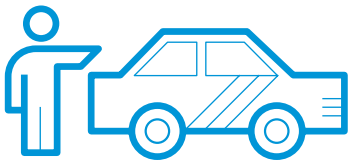
This report is made up of the following sections:

Background & Context

Since 2016, transport has been the largest contributor to the UKs carbon emissions. In 2019, this equated to 27% of all greenhouse gas emissions, the majority of this came from road transport vehicles.

This is leading to **36,000** premature deaths, and 6 million sick days each year, costing over **£6bn** to the NHS and **£22bn** to the UK economy.

The Government recognised this in their case for change and commitment to accelerating the shift to low carbon transport through the Industrial Strategy, Clean Growth Strategy and Clean Air Strategy.



A lack of infrastructure is the most serious deterrent to over half of UK drivers, 52% of whom say that they are worried about travelling long distances in an electric vehicle.

There will be 5 key locations required for electric vehicle charging…

Home: or on a residential street typically overnight.

Destination: While doing another activity e.g. work.

Local Fast: At petrol station equivalent visited for the recharge.

Fleet: At depot hub for fleets.

Motorway: At service stations, on driver routes enabling long journeys.

Following our engagement with Government on our **motorway proposal**, in March 2020 the Government announced the introduction of the Rapid Charge Fund. Today, this fund has **£950m** at its disposal to install a minimum of **6 rapid charge points for cars and vans**, at Motorway Service Areas (MSAs) along the Strategic Road Network (SRN) in England by 2023, and a total of **6,000 ultra-rapid charge points** at these MSAs by 2035.

The delivery of the RCF will encourage the transition to electric vehicles, by providing access to a fast and reliable rapid charging network.

Since the RCF was announced, we've seen a lot of movement in the world of transport.

In July 2021:

The Government announced its Transport Decarbonisation Plan, which sets the framework for how the UK will achieve it's 2050 net-zero ambitions, across all modes of transport.

The Government also released a consultation to seek industry views on when to phase out the sale of new non zero-emission Heavy Goods Vehicles (HGVs) by 2035 for HGVs up to 26tonnes and 2040 for HGVs >26 tonnes, the outcome from this consultation is expected this year.

In November 2021:

COP26, the world's most important climate change summit of the decade, came to Glasgow for 2 weeks, where nations signed up to the "Glasgow Climate Pact" which outlines their commitment to work towards plans to limit climate change to 1.5C by phasing-down coal burning and re-submitting more ambitious Nationally Determined Contributions (NDCs) ahead of COP27 in 2022, rather than in five years as per the Paris agreement.

UN CLIMATE CHANGE CONFERENCE UK 2021
IN PARTNERSHIP WITH ITALY

Other commitments were made, ranging from:

Methane: More than 30 countries agreed to cut methane emissions by 30%.

Transport: A declaration on accelerating the transition to 100% zero-emission cars and vans, with all sales of new cars and vans being zero-emission globally by 2040, and no later than 2035 in leading markets.

Clean energy and a fair transition: The UK, South Africa, France, Germany, the US and the EU announced the Just Energy Transition Partnership to support South Africa's transition to clean energy away from coal.

Coal: Over 40 nations pledged to phase out coal use within the 2030s (within 2040s for poorer nations).

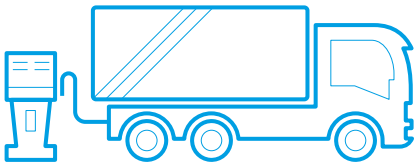
Trees: More than 100 nations signed up to a pledge to end world deforestation by 2030.

More recently in 2022:

National Highways published its 2030 – 2050 plan, which outlines their steps to decarbonising their own fleet and operations.

DfT launched a consultation to end the sale of new non-zero emission buses, alongside a call for evidence on the phasing out of new non zero-emission coaches and minibuses.

The **Government** also published its long-awaited Electric Vehicle Charging Infrastructure Strategy, which sets out the Government's vision and action plan for the rollout of electric vehicle charging infrastructure in the UK, ahead of the new petrol and diesel phase out date of 2030 for cars and vans.



National Grid Electricity Transmission (NGET) & HGV Decarbonisation:

It's clear from stakeholder insights we've gathered through our extensive industry engagement that there is a requirement for other modes of road transport to have access to rapid charging / refuelling facilities along the motorways and major A&B roads in England. National Grid sits at the heart of the net-zero transition and it's important to note that:

We are **technology neutral**, and ready and able to support the transition to zero-emission HGVs regardless of the technology of the vehicles themselves. This is particularly important for other modes of road transport where the winning technologies remain uncertain.

Zero-emission HGVs regardless of technology, will require similar connection capacity, in similar locations and therefore the **network infrastructure solutions are common** to each or a mixture.

All available technology options will require electricity infrastructure. By connecting MSAs to the electricity transmission system, we can provide significant capacity for zero-emission HGV infrastructure along the SRN. For other locations, similar connection solutions to those developed for MSAs would be appropriate.

The scope of our analysis supports the need case and demonstrates the feasibility for Government to expand the remit of the Rapid Charge Fund to provide sufficient levels of en-route charging provision for HGVs at key MSAs along the Strategic Road network in England. An expansion to the RCF will drive cost efficiencies, minimise disruption and accelerate the UKs transition to zero-emission transport, by building the right infrastructure, in the right place, ahead of need. Note: this analysis does not include all other charging / refuelling requirements needed to fully decarbonise the HGV sector, this will require collaboration across industry and Government to develop regional plans that include HGV depots and truck stops.

Collaborating with industry:

we've worked with stakeholders across the HGV industry to develop and refine our analysis, by bringing together expertise from the energy, freight, and manufacturing sectors together.

SCANIA · Mercedes-Benz Trucks you can trust · DAF · VOLVO · RENAULT TRUCKS · RHA · LOGISTICS UK

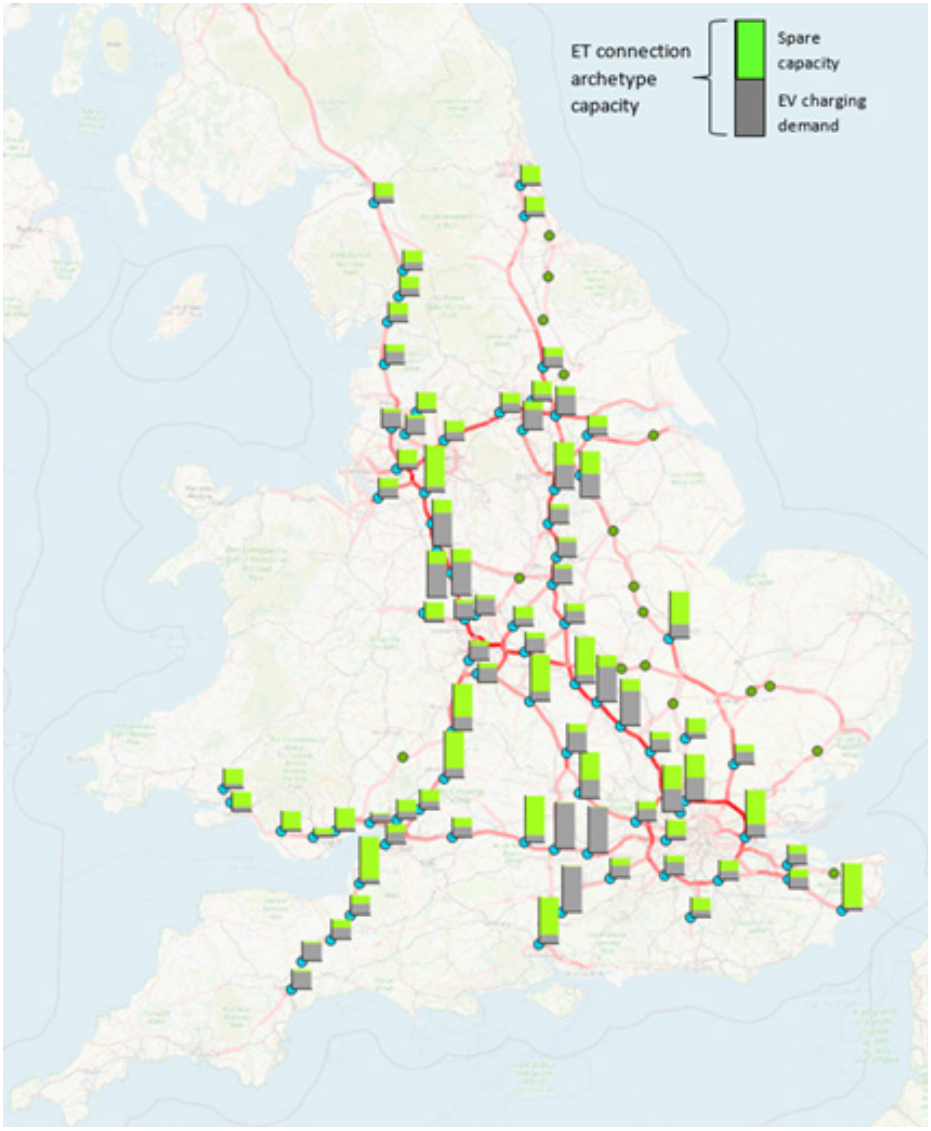
Executive Summary

The opportunity:

Our analysis shows that **there is a strong synergy** between EV and HGV en-route energy provision to MSAs in England and Wales, if Transmission connection solutions are used. Providing electricity capacity at MSAs for cars and vans through the roll-out of the Rapid Charge Fund creates an opportunity for other modes of road transport to utilise some of this provision.

If all the HGVs in England and Wales were:

- **Battery Electric Vehicles** (BEVs) - their annual energy demand would be around **29TWh/yr**, equivalent to a continuous energy demand of **3.3GW** which equates to approx. **10%** of the total amount of electricity generated in 2019
- **Hydrogen Fuel Cell** (FCEVs) with hydrogen production by electrolysis – their annual energy demand would be around **98TWh/yr**, equivalent to a continuous energy demand of **11.2GW** which equates to approximately **30%** of the total amount of electricity generated in 2019.



RCF capacity illustration, when using transmission connection solutions

The **peak demand in the Rapid Charge Fund with full EV rollout** is just over **2GW**, for which the **Transmission connection solutions** have around **3GW of additional capacity**, spread across the SRN, as shown in the map. Using industry insights, we modelled that **70-90%** of HGV energy provision is done overnight at depot or destination, then the remaining **10-30%** could be provided **en-route** at **MSAs**.

Our analysis also shows that within the current £950m budget of the Rapid Charge Fund there would be **no additional cost** to add substantial en-route eHGV rapid charging, at a large share of MSAs, across a range of scenarios.

Scenario	% of MSAs with **no additional cost** for HGV capacity if connected to the transmission network	**Number of 700kW HGV chargers operating at peak across all MSAs**
10% of HGVs charging en-route	**78%**	**900**
20% of HGVs charging en-route	**63%**	**1,800**
30% of HGVs charging en-route	**53%**	**2,700**

A small marginal cost increase to the Rapid Charge Fund would be needed, to provide the required capacity at the remainder of MSAs, across a range of scenarios.

Scenario	**Marginal % cost*** for the remainder of MSAs to add HGV capacity through Transmission connections	**Approximate marginal £ cost increase** to Rapid Charge Fund (£m)
10% of HGVs charging en-route	**+3%**	**£28.5m**
20% of HGVs charging en-route	**+7%**	**£66.5m**
30% of HGVs charging en-route	**+16%**	**£152m**

*as a percentage of total cost of connecting all England and Wales MSAs via Transmission connections for the Rapid Charge Fund

Around **85%** of **en-route charging** could be provided at MSAs, a further **17 Trunk Road Service Areas (TRSAs) / Truck-Stops** outside of the Rapid Charge Funds remit would need an equivalent charging capability to give full HGV coverage.

The synergy exists (to a lesser extent) for an equivalent amount of hydrogen fuel cell HGVs, through green hydrogen electrolysis provision at MSAs, meaning that both electric and **hydrogen** HGV pathways can benefit from this solution.

This would:

provide between **8-25% of all future eHGV energy demand** in 2050 through en-route network

enable **long-distance** coaches that use the SRN, **to benefit** from these charging facilities

provision for **900-2700 HGV rapid chargers at 700kW** each operating at peak

include provision for **daytime trickle charging of 4,500 HGVs** at MSAs, at peak

add between **0.5-1.4GW** of eHGV rapid charging capacity, on average, at peak across all MSAs.

Recommendations

We ask that Government…

1. **Expand the scope of the Rapid Charge Fund to include en-route provision for HGVs**, in order to accelerate the decarbonisation of the freight sector by maximising economies of scale, driving cost efficiencies, and minimising disruption for MSA operators and the public. Having access to a fast and reliable en-route charging network or hydrogen refuelling, will remove a key barrier to the adoption of zero-emission HGVs.

   Long distance coaches that use the SRN would also benefit from this expansion, which would also accelerate their decarbonisation plans.

2. **Accelerate the Zero-Emission Road Freight Trials** to better inform industry investment decisions, while aligning to the Rapid Charge Fund and accelerate the transition to zero-emission HGVs

3. **Act as a convener and work collaboratively with industry**, to develop effective solutions for all **other aspects** of **HGV operations** not addressed by charging or refuelling provisions at MSAs on the SRN..

Industry Support

This analysis was developed in collaboration with stakeholders from across the HGV industry.

Some of their thoughts are summarised below…

Mercedes-Benz
Trucks you can trust

"We are delighted to have provided our input into this excellent National Grid analysis. We're bringing trucks like the battery-electric Mercedes-Benz eActros Long Haul to market, but the provision of **suitable HGV charging infrastructure** on the UK's Strategic Road Network is essential to the success of Daimler Truck's decarbonisation strategy. Collaboration is key for our **customers to meet their zero-emission goals**".

RENAULT TRUCKS

"The work of National Grid indicates that such a charging infrastructure could be facilitated through **a modest extension of the Rapid Charge Fund**. We believe this would be a very strategic and worthwhile investment which would **significantly increase confidence** in and take-up of decarbonised commercial vehicle solutions".

RHA

"We **strongly support** the aim of decarbonising the HGV sector and welcomes the National Grid's commitment to **expand the Rapid Charge Fund**. It marks **an important step** in the investment needed to support a viable transition towards zero tailpipe emission commercial vehicles".

LOGISTICS UK

"We strongly welcome the analysis work by National Grid to map en-route energy demand for zero tailpipe emission HGVs. In order for our members to confidently switch to these vehicles, there must be the **right infrastructure**, in the **right places, at the right time**. Early planning and **futureproofing** the delivery of additional energy capacity along the strategic road network will help this infrastructure be delivered in the most **cost-effective way**".

Analysis Explained

Inputs, Considerations and Scenarios:

We started off by considering all the location-based pieces of the HGV Puzzle…

HGV traffic and operating centres

+

Transmission network

+

Long haul stops (ACEA data)

+

Strategic Road Network and Service Areas + EV en-route charging

We then calculated the amount of en-route HGV energy demand for each MSA / TRSA by combining **3 elements** (the When, the What and the Where)…

When		What		Where		
1. HGV Charging Profile	×	**2. HGV Fleet Energy Demand**	×	**3. HGV Traffic share per site**	=	**Energy Demand Profile per site**
Assumed to follow the hourly HGV traffic profile for the UK		Total amount of energy to be provided in each HGV scenario		A geographic share of HGV miles and therefore energy provision for each MSA / TRSA		

Our research suggests that a majority of HGVs return to their operating centre overnight, and as such most HGVs will be recharged by overnight 'trickle' charging (35 - 100kW), plus some destination charging in a similar manner to the ongoing electrification of buses with depot charging. We assumed that a minority of HGVs, which are likely to be the furthest travelling HGVs, will be the main users of en-route charging and may use, for example, double the amount of energy of an average HGV.

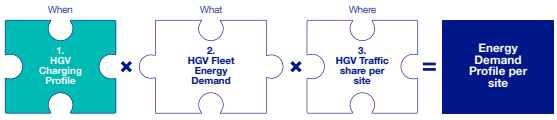
Further details on how we calculated each of these component parts, can be found on pages 8 –11.

We repeated this process for 5 realistic scenarios, which were identified through research and industry engagement.

	Scenario	Peak Demand (MW)
Battery Electric Vehicles (BEV)	**10% en-route energy provision** at MSA / TRSAs for 100% HGV uptake in 2050	**559**
	20% en-route energy provision at MSA / TRSAs for 100% HGV uptake in 2050	**1,118**
	30% en-route energy provision at MSA / TRSAs for 100% HGV uptake in 2050	**1,676**
Hydrogen Fuel Cell Vehicles (FCEV)	***10% en-route energy provision** at MSA / TRSAs for 100% HGV uptake in 2050	**1,119**
	20% en-route energy provision at MSA / TRSAs for 100% HGV uptake in 2050	**2,239**

TRSAs were used instead of Truck-Stops because of the potential for further synergies at these locations with EV rapid charging, but the results would apply equally to Truck Stops chosen in similar areas. These demand figures also include an estimate of daytime rest break trickle charging, across all scenarios.

*The 10% FCEV scenario was found to have almost identical peak demand to scenario 2, so was therefore not analysed separately.



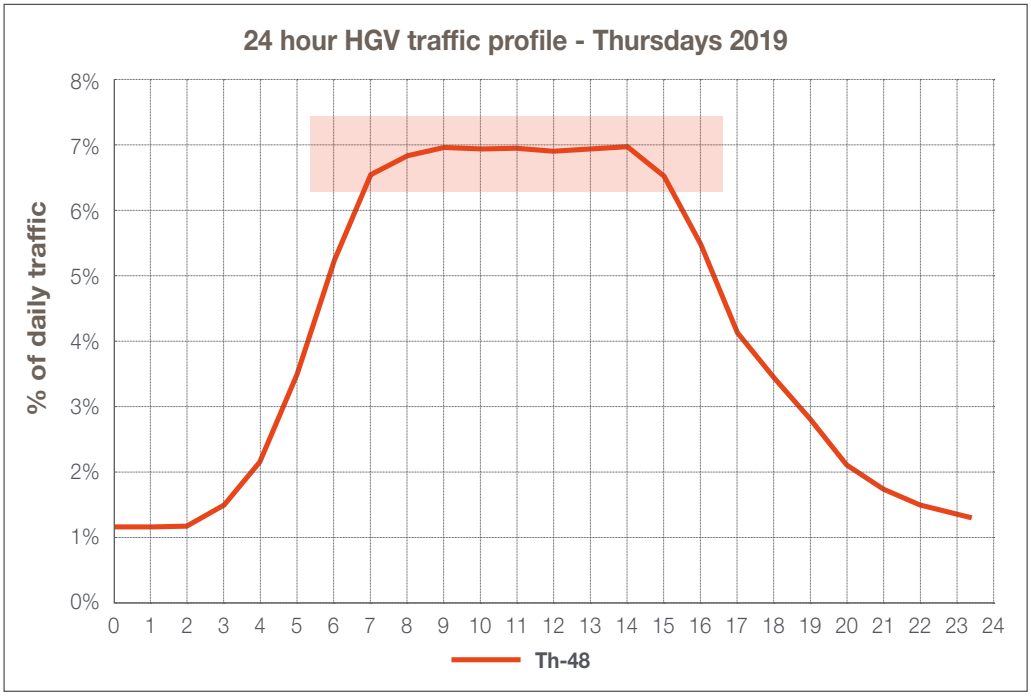
1. Defining the HGV Charging Profile:

We developed an en-route energy demand profile for the UK truck fleet using the Department for Transport (DfT) traffic data for 2019, which showed that:

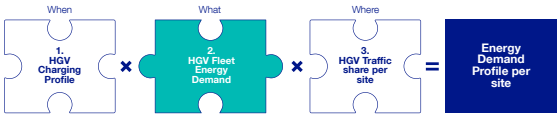
- Thursdays see the most HGV traffic, with Tuesday and Wednesday having very similar profiles, and
- A flat peak in HGV traffic persists for around 8 hours from 7am-3pm.

This profile was then scaled into an en-route charging demand profile, using the assumption that en-route charging will happen during existing mandatory **45-minute rest breaks**. By law, HGVs can drive **up to 4.5 hours** before the first mandatory rest stop, and it is likely the actual en-route charging demand could be offset some hours later in the day.

In this analysis, we assumed that the HGV peak en-route charging demand overlaps the EV peak en-route charging demand, such that the peak demand seen by the network connection is the sum of the two elements.



Department for Transport statistics, Table TRA0308, Traffic distribution on all roads by time of day and day of the week, for selected vehicle types, Great Britain: 2019, Source: DfT Automatic Traffic Counters



2. Calculating the Energy Demand for HGVs:

To calculate the energy demand needed to power HGVs along the SRN we used the DfTs data table (TRA0206) which shows that in 2019 HGVs travelled **24.2 billion vehicle km** in England and **1.2 billion vehicle km** in Wales.

For Battery Electric Vehicles (BEV) HGV scenarios:

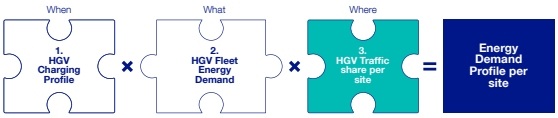
- A BEV HGV efficiency of 1.15kWh/km was derived from published electric truck capabilities of various Original Equipment Manufacturers (OEMs) and first principles research by the European Federation for Transport and Environment (T&E) suggesting 1.1-1.4kWh/km is credible
- **In a 100% BEV HGV uptake scenario**, this gives an annual England and Wales HGV energy demand of **29TWh/yr**
- The annual energy demand was converted into a daily energy demand, and an en-route/rapid charging share (10-20%) and then apportioned to the MSAs and selected TRSAs, and the demand curve above applied to calculate the peak HGV charging demand at each site
- For long stay HGV energy demand, based on data from the 2017 and 2009 **AECOM HGV parking surveys**, we estimate there could be up to **4500** eHGVs on trickle charge during the day at English MSAs. Assuming a **9-hour** rest break and a **35kW charger** for each eHGV (although 50kW chargers are also plausible), this is an extra demand of on average around **2.2MW** per MSA and expected to be coincident with the en-route charging peak demand (which lasts multiple hours and so hard to avoid). Similar analysis for Wales suggests an extra demand of **~0.8MW** per MSA).

For Hydrogen Fuel Cell Electric Vehicle (FCEV) HGV scenarios:

- The site-by-site energy demand was taken by rescaling the BEV HGV demand for fuel cell efficiencies and for a flat load hydrogen electrolysis plant sized to run continuously to meet the peak H2 refuelling demand
- We used **Centre for Sustainable Road Freight** assumptions of a **56% fuel cell efficiency** and a **53% efficiency for on-site electrolysis**, H2 compression losses were assumed negligible
- These efficiencies lead to a **3.4x larger energy requirement to power the same HGV mileage with FCEV HGVs compared to BEV HGVs**, but the increased demand in a hydrogen scenario can be partially offset by the flat loading of the electrolyser with H2 storage.

For Overhead catenary systems:

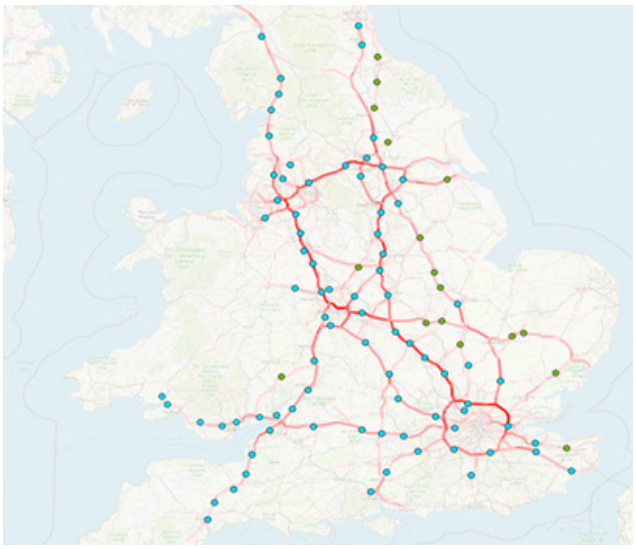
Catenary systems have the potential to be connected to the electricity transmission system, given the high synergy between transmission assets and the SRN, which means that network connection costs can be kept to a minimum. We therefore ask Government to continue to consider **all technology solutions** as part of the ongoing **Zero Emission Road Freight Trials (ZERFT)**, to allow for further research to be undertaken as to these benefits.



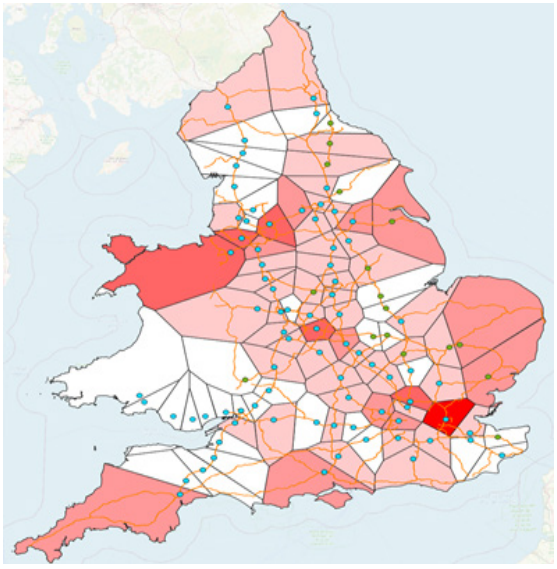
3. HGV Traffic and demand allocation (per MSA):

The sites selected for energy provision were all **80 MSAs** in England and Wales, plus **17 Trunk Road Service Areas** in England.

- The MSAs (**blue dots**) show excellent coverage of much of the HGV traffic flow
- To ensure robust coverage across the full SRN, a further **17 TRSAs** (**green dots**) were added, e.g. for routes such as the A14 to Felixstowe, and A1 North-South route
- These additions were by visual inspection of HGV traffic flows and limited to TRSAs because of the further potential for synergy with EV rapid charging energy infrastructure
- Truck-Stops and new sites could also be considered.



HGV traffic density overlaid with MSAs (**blue**) and selected TRSAs (**green**) for en-route HGV energy provision.



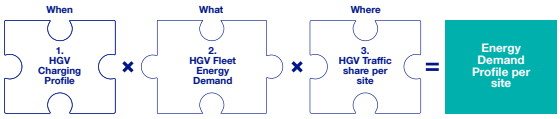
HGV en-route demand share by MSA/TRSAs' allocated areas, overlaid with SRN in England

The total en-route energy demand was then allocated to the MSAs and selected TRSAs by dividing up the major road network (not just the SRN) geospatially between sites. Each polygon is the sum of HGV traffic (2019 AADF) and road segment length.

The road segment length was included to reflect the fact that the further a HGV drives, the more likely it will need to stop and charge/refuel, and so traffic density alone is not a good measure of en-route demand for any particular road segment.

The headline results from this demand allocation exercise are summarised in the table on the next page.

The Energy Demand Required – per MSA



		Scenario			
		Battery Electric			Hydrogen Fuel Cell
		10% HGV en-route charging*	20% HGV en-route charging*	30% HGV en-route charging*	20% HGV onsite electrolysis
Minimum no. of 700kW HGV chargers per site**	Minimum	**2**	**4**	**6**	**-**
	Average	**14**	**25**	**36**	**-**
	Maximum	**51**	**93**	**135**	**-**
HGV Peak Energy Demand per site /MW	Minimum	**1.3**	**2.1**	**33.0**	**3.6**
	Average	**7.5**	**13.2**	**19.0**	**23.1**
	Maximum	**27.0**	**49.0**	**70.9**	**88.0**

* includes 166MW of additional daytime trickle charging across all MSAs
** 700kW charger numbers assumes a HGV charges for 45mins of a 1 hour charging slot

These numbers are across all 97 sites (**80 MSAs** plus **17 TRSAs**) in the 100% coverage solution of England and Wales

There is **significant variation** in HGV demand across sites, which is driven by **HGV traffic density** and **proximity to neighbouring sites**, and **kilometres** of major road network covered by each site.

What type of HGV chargers are needed at MSAs?

A HGV travelling at 56mph for 4.5 hours between mandatory breaks, at a 1.15kWh/km efficiency, would require a 465kWh recharge, which over a 45-minute break is a 620kW flat recharge rate. This suggests that a **700-800kW charger** would be required, which allows for secondary loads e.g. powered tail lift or refrigeration.

Our analysis includes a provision for daytime trickle charging of **4,500 HGVs**. We expect that **35 – 50kW chargers** can be used at MSAs (during 9 hour rest periods).

If you require any further information, please contact

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References:

1. Department for Transport (DfT) - (Road traffic estimates - 2019)
2. DfT - National Road Traffic Survey (Table TRA0206 - 2019)
3. Centre For Sustainable Road Freight (report on long haul lorries powered by hydrogen or electricity - 2020)
4. Transport and Environment (Analysis of long-haul battery electric trucks in EU - 2018)
5. Climate Change Committee (research on Zero-emission HGV infrastructure requirements - 2019)
6. Clean Air Strategy - 2019
7. Clean Growth Strategy - 2017
8. The UK's Industrial Strategy - 2021

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