Towards Zero Emission HGV Infrastructure in Scotland: Phase 2 Report

CENTRE FOR SUSTAINABLE ROAD FREIGHT
HERIOT-WATT UNIVERSITY
for
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About the Project

About

This project uses a high-quality sample of road haulage data within an advanced Agent-Based-Model (ABM), to understand exactly where en-route charging stations need to be built for Battery Electric Heavy Goods Vehicles (BEVs) across Scotland.

Aim

The aim is to a support government, energy, and transport stakeholders with an **evidence-based analysis of future BEV charging requirements.** The analysis can help in planning future infrastructure investment needs and contribute to ongoing debates on optimum decarbonisation pathways for the nation.

Objectives

The research will identify the following:

- Key road haulage routes along which charging infrastructure is required.
- The optimum location for individual charger facilities.
- Charger station usage.
- The demands placed on existing grid infrastructure, and where added substation capacity is needed.
- The total power demands placed on the energy system.
- The potential operational changes required by heavy goods vehicle (HGV) operators.

Authors

The work was undertaken by the **Centre for Sustainable Road Freight (CSRF) based at Heriot-Watt University**. This is a leading research centre in transport modelling and policy development for decarbonising freight transportation.

Funders

The work was **commissioned and funded by Transport Scotland;** the national agency responsible for delivering the Scottish Government's vision for transport. This commission is part of a commitment within the **HGV Decarbonisation Pathway for Scotland**.

Scope

This project focuses on en-route charging infrastructure in Scotland to service freight transportation by HGVs.

The project relies on a **high-quality representative sample of industry provided telematics data**, and where this was unavailable, synthetic data was generated.

Document Status

This is a **high-level summary report** delivered for wider stakeholder comment and feedback. An accompanying technical report will also be available on Heriot-Watt University’s website.

Key Messages

Based on an advanced Agent-Based Model fed with telematics data from approximately 2% of Scottish HGVs, plus additional synthetic data, **the en-route charging infrastructure needed for all HGVs in Scotland will:**

1. **Comprise** at least 63 en-route charger locations, of which 23 are already built or under development.
2. **Experience** heaviest usage on the M74/A9 corridors, with the two busiest charger sites needed within an approximate 5km radius of Annandale Water and Dalwhinnie.
3. **Require** at least 1.3TWh of electrical power.
4. **Enable** approximately 70% of routes to be completed without additional stops for charging.

1. Profiling HGV journeys in Scotland to assess the representativeness of the sample data.
2. Obtaining new telematics and scheduling data of existing diesel HGV routes.
3. Creating synthetic data for sectors where telematics data is missing.
4. Analysing fleet routes using Agent-Based Modelling (ABM).
5. Mapping impacts of charging on the electricity grid.
6. Reporting the findings.

Agent-Based Modelling (ABM)

Agent-Based Modelling (ABM) is a computer-based approach for simulating the behaviour of autonomous agents and their interactions. In this study, the agents are individual Battery Electric Vehicles (BEVs). Different rules can be applied to govern agent behaviour. For example, when a BEV agent requires charging, the rule is that it seeks locations that minimise both diversion time and distance from its original planned route. As these simulated agents interact according to these rules, collective phenomena such as charger usage, vehicle charge status, journey times, and other key information emerge. **This approach is state of the art in complex systems problems like transport decarbonisation.**

4A *Create a core network of BEV charging locations based on existing and potential infrastructure.*

4B *Map existing diesel truck routes onto the core network. A route "starts" when the truck leaves a depot and "finishes" upon arriving at a depot run by the same company.*

4C *Create a simulation to investigate how BEVs would complete each route. Each vehicle selects the optimal en-route location from the core charger network.*

4D *Primary truck routes are further analysed for other potentially high-value charge sites to begin creating an enhanced charger network.*

4E *Charging locations are analysed to determine utilisation and electricity delivered.*

1 Profiling HGV journeys in Scotland to assess the representativeness of the data.

The first step in the research was to use the Continuing Survey of Road Goods Transport (GB) to establish the main freight corridors in the country.

The total population of registered HGVs in Scotland is approximately 30,000[1]. The sample of telematics data harnessed for this study represents approximately 2% of this total, with synthetic data further contributing.

Cross checking this data sample with the Continuing Survey of Road Goods Transport (GB) establishes that the study sample accurately reflects the population in terms of routes travelled.

The analysis identified several key freight corridors experiencing high HGV traffic volumes (Figure 1). These corridors primarily connect major population centres, industrial zones, and ports across Scotland.

These routes rely on several key strategic roads in the country, including the A7, A75, A9, A90, M9, M8 and M74.

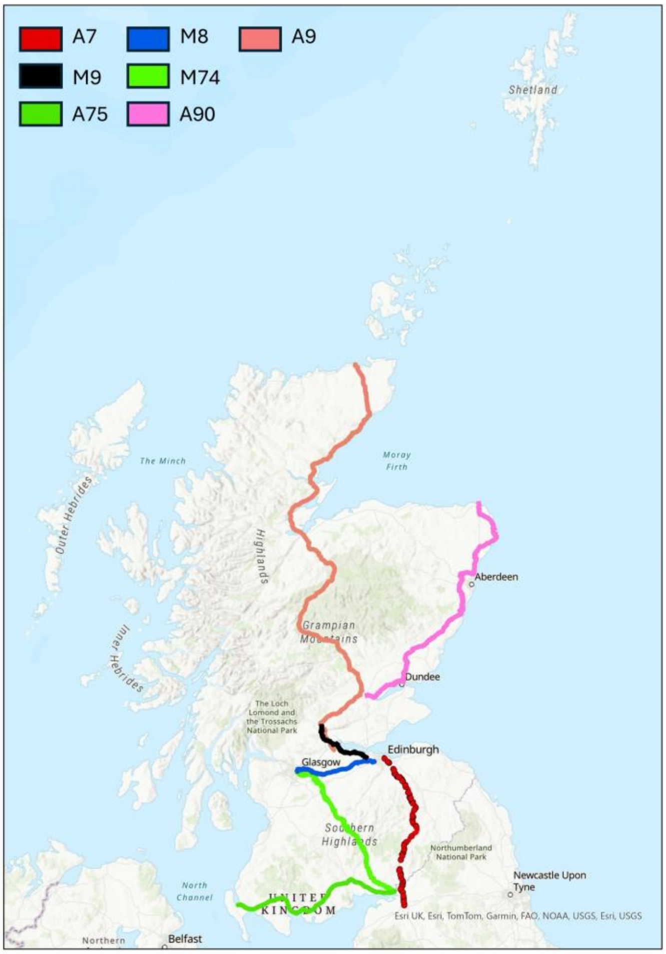


Figure 1 Primary freight corridors

1. https://www.transport.gov.scot/media/ritjw2te/industry-overview-and-swot-analysis.pdf

Data and Sampling

2 Obtaining new telematics and scheduling data of existing diesel HGV routes.

3 Creating synthetic data for instances where route data is missing.

Note on Data Quality

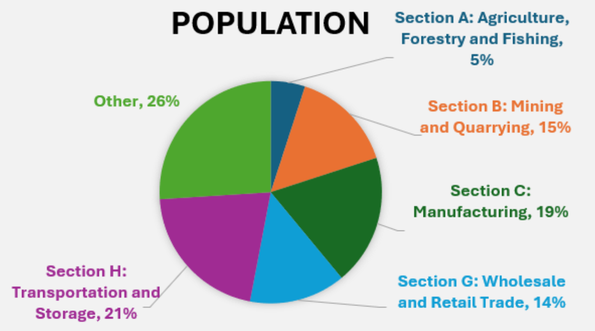
The project considered fleet operations covering a mix of freight including retail, food, and general logistics. It also considers synthetic data for the forestry sector.

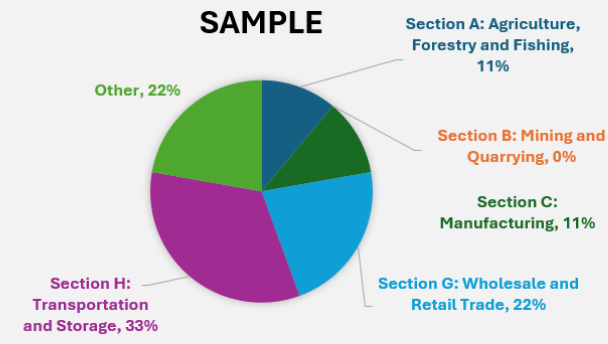
The data is high quality, being a mix of raw telematics data and scheduling data. It represents the movement and activities of individual HGVs over a one-year period, covering the majority of mainland Scotland.

Synthetic data is used for the forestry haulage sector. Synthetic data is designed to mirror the statistical properties of real-world data. In this case it was based on a network of routes identified in a report commissioned by the Timber Transport Forum covering the sector in Argyll and the Scottish Borders.

Note on Sampling

The data underlying this project covers a representative sample of HGV fleets in Scotland, equating to approx. 2% of the total. A broadly representative sample was achieved.





To provide greater confidence and nuance to drive investment decisions, there is an ongoing need to:

- Increase the quantity of data to reflect an even wider variety of HGV routes.
- Increase the quantity of data from specific sectors such as mining and quarrying.

Despite these caveats, the research is a significant step forward in our current understanding.

Core Charger Network

1

The charging infrastructure needed for all HGVs in Scotland will comprise at least 63 en-route charger locations, of which 23 are already built or under development.

The minimum-viable en-route BEV charger network is shown in Figure 2. The Agent-Based Modelling used in this research is based on this core network.

The core charger network locations are anchored to the 5km radius surrounding:

1. Truck stops, lorry parks, intermodal hubs, and ports (shown as circles and derived from Phase 1 of this research).
2. Findings from the Strathclyde University WattRoutes project[2] (shown as squares).
3. A range of other existing and planned HDV charging locations[3-5] (shown as triangles, pentagrams and stars).

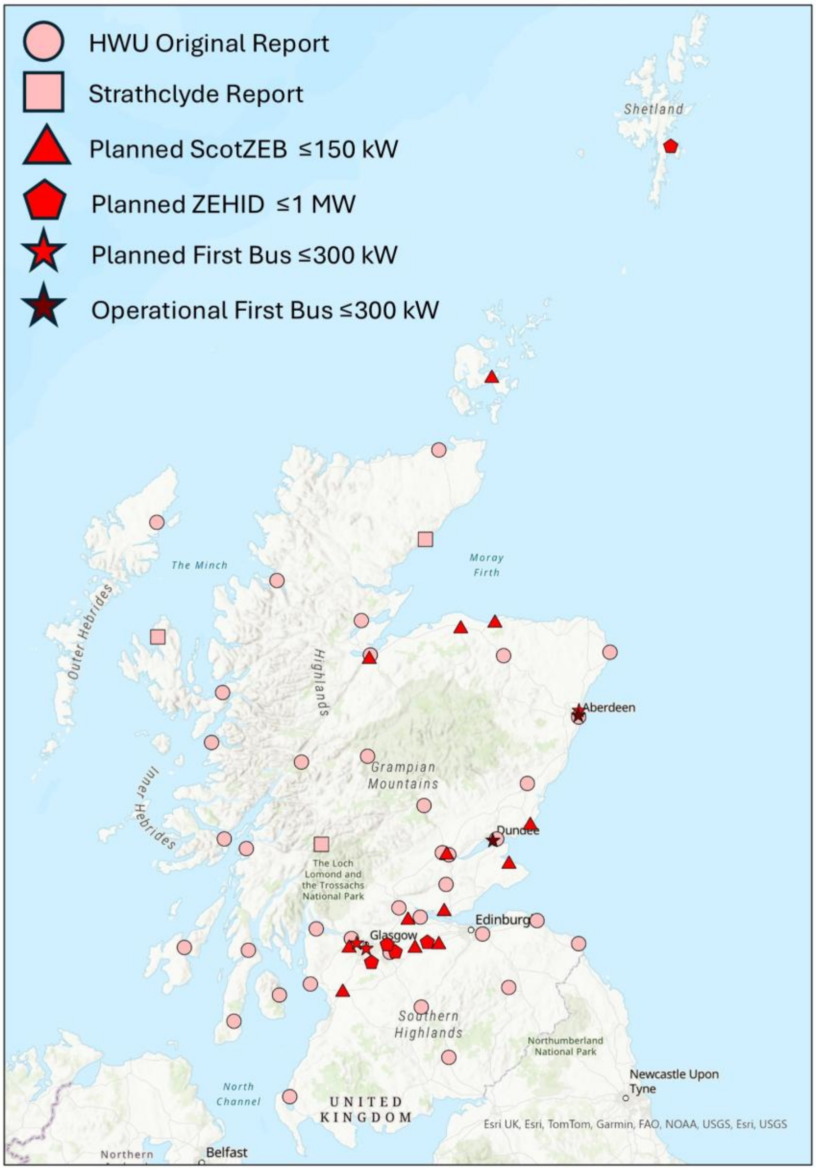


Figure 2. Core BEV charger network map.

2. L. C. Hunter, J. Scobie, C. McGarry, & S. Galloway, (2024). WattRoutes: smart planning for electric HGV charging infrastructure. In *IET Conference Proceedings CP890*
3. https://iuk-business-connect.org.uk/wp-content/uploads/2025/03/ZEHID-Slides.pdf
4. https://www.firstbus.co.uk/about-us/electric-vehicle-charging-partnerships
5. https://www.ember.to/charging/

1 **The charging infrastructure needed for all HGVs in Scotland will comprise** at least 63 en-route charger locations, of which 23 are already built or under development.

Route Testing the Charger Network

The core BEV charger network can be explored further to identify additional high-value charger locations.

Primary HGV routes from the sample data were identified and put to the test with 'best' and 'worst case' BEVs. The ability of these vehicles to complete the routes reveals additional charger locations which could enhance the core, minimum viable network. **These additional locations would add value in further reducing journey time and distance penalties, boosting redundancy in cases where charge distances are marginal, and increasing user choice and convenience.**

Note

Route Testing is a process by which the core network can be 'analytically prototyped' and further, potentially high value charger locations identified. Further work is required to systematically explore other HGV routes in Scotland. It is expected several additional charger sites will be required to deliver an enhanced/optimised BEV charger network beyond the minimum viable core network which forms the basis of this analysis.

Route specifics

Six routes are considered. Five reflect real-world supermarket logistics routes, while the sixth approximates an (anonymised) route drawn directly from the telematics dataset. The routes are as follows:

Table 1. Selected Logistics Routes

Origin	Destination	Route
Eurocentral	Inverness	M8-M90-A9
Eurocentral	Aberdeen	M8-M90-A90
Bathgate	Newcastle	A720-A1
Livingston	Carlisle	M8-M74
Livingston	Cairnryan	M8-M77-A77
Carlisle	Cairnryan	M6-A75

Vehicle Specifications

The vehicles to be tested on these routes within the Agent-Based Model represent best and worst case BEVs. The best-case vehicle is based on the median range of commercially available BEVs. The worst-case BEV takes the lowest performing commercially available vehicle and reduces the normal and winter ranges by approximately 20% (Table 2).

Table 2. Truck Specifications and Ranges

BEV Model	Normal Range (km)	Winter Range[6] (km)
MAN	600	480
DAF	570	456
Renault	560	448
Scania	520	416
Mercedes-Benz	500	400
Volvo	450	360
16t Electric Truck	241	193
Best Case BEV	**360 (Median)**	**288 (Median)**
Worst Case BEV	**200**	**160**

6. CALSTART (2024): Drive to Zero's Zero-Emission Technology Inventory Data Explorer, version 1.5 https://globaldrivetozero.org/tools/zeti-data-explorer/version

1 **The charging infrastructure needed for all HGVs in Scotland will comprise** at least 63 en-route charger locations, of which 23 are already built or under development.

Route 1:
Glasgow-Inverness

This route covers approximately 290 km, connecting the Eurocentral industrial estate on the edge of Glasgow, to Inverness, via the M90 and A9. Three chargers on the core network are located along the route at Kinross, Ballinluig, and Dalwhinnie. Ballinluig is in the middle of this route, 140km from Glasgow and 150km from Inverness.

An alternative route would follow the M73 and M80, joining the A9 near Stirling. This is another location on the core charger network.

Table 3 shows how the simulated (worst case) and median (best case) BEVs perform over this route in summer and winter.

Recommendation

The charging location at Ballinluig is essential. The Dalwhinnie, Stirling, and Kinross locations will all be required to ensure full all-season viability of the route, and for vehicles running with sub-optimal efficiency.

Figure 3. Essential and additional charging on the Glasgow-Inverness HGV route

Table 3. Vehicle performance on the Glasgow-Inverness HGV route

	Simulated Truck (Worst Case)	Median Truck (Best Case)
Can complete without charger, summer	No	Yes
Can complete without charger, winter	No	No (marginal)
Can complete with 1 charge (Ballinluig), summer	Yes	Yes
Can complete with 1 charger (Ballinluig), winter	Yes (marginal)	Yes

1

The charging infrastructure needed for all HGVs in Scotland will comprise at least 63 en-route charger locations, of which 23 are already built or under development.

Route 2:

Glasgow-Aberdeen

This route covers approximately 250 km, connecting Eurocentral to Aberdeen via the M90 and A90. Three chargers are located along the route at Kinross, Dundee and Stracathro. Dundee is in the middle of this route, 137 km from Glasgow and 116 km from Aberdeen.

Table 4 shows how the simulated (worst case) and median (best case) trucks perform over this route in summer and winter.

Recommendation

The charging location at Dundee is essential.

Additional charging at Kinross would be beneficial to ensure full all-season viability of the route. It also supports BEV usage of the Edinburgh-Inverness route.

The Stracathro location is not essential for the viability of this route, as 116 km is within the range of all vehicles in all foreseen circumstances.

Figure 4. Essential and additional charging on the Glasgow-Aberdeen HGV route

Table 4. Vehicle performance on the Glasgow-Aberdeen HGV route

	Simulated Truck (Worst Case)	Median Truck (Best Case)
Can complete without charger, summer	No	Yes
Can complete without charger, winter	No	Yes
Can complete with 1 charge (Dundee), summer	Yes	Yes
Feasibility with 1 charger (Dundee), winter	Yes (marginal)	Yes

1 **The charging infrastructure needed for all HGVs in Scotland will comprise** at least 63 en-route charger locations, of which 23 are already built or under development.

Route 3:
Livingston-Newcastle

This route covers approximately 230 km, connecting Bathgate to Newcastle via the M8 and A1. Two chargers are located along the A1 at Dunbar and Eyemouth. Eyemouth is in the middle of this route, just under 115 km from both Livingston and Newcastle.

Recommendation

The charging location at Eyemouth is essential, ensuring logistics operations can run smoothly between Scotland and the North East of England. The Dunbar location is not essential for the viability of this route, and nor is a charger between Eyemouth and Newcastle, as 115 km is within the range of all vehicles in best and worst case scenarios.

Figure 5. Essential and additional charging on the Livingston-Newcastle HGV route

Table 5. Vehicle performance on the Livingston-Newcastle HGV route

	Simulated Truck (Worst Case)	Median Truck (Best Case)
Can complete without charger, summer	No	Yes
Can complete without charger, winter	No	Yes
Can complete with 1 charge (Eyemouth), summer	Yes	Yes
Feasibility with 1 charger (Eyemouth), winter	Yes	Yes

1 **The charging infrastructure needed for all HGVs in Scotland will comprise** at least 63 en-route charger locations, of which 23 are already built or under development.

Route 4:

Livingston-Cairnryan

This route covers approximately 170 km, connecting Bathgate to Cairnryan Port via the M8, M77 and A77. One charger is located along the route at Hamilton (Mossend). Alternatively, a diversion can also be made to the charging location at Ardrossan. This breaks the journey into two very feasible chunks of just under 110 km each but adds approximately 45 km to the route.

Recommendation

One charging location is essential to ensure full feasibility of the route, including in harsh weather conditions and for vehicles running with sub-optimal efficiency. The illustrated route via Mossend is viable in most situations.

Additional charging could be made available on the A77 around Ayr to avoid the diversion to Ardrossan, which is otherwise necessary for many vehicles in winter weather conditions.

Figure 6. Essential and additional charging on the Livingston-Cairnryan HGV route

Table 6. Vehicle performance on the Livingston-Cairnryan HGV route

	Simulated Truck (Worst Case)	Median Truck (Best Case)
Can complete without charger, summer	Yes	Yes
Can complete without charger, winter	No (marginal)	Yes
Can complete with 1 charge (Hamilton), summer	Yes	Yes
Feasibility with 1 charger (Hamilton), winter	Yes	Yes

1

The charging infrastructure needed for all HGVs in Scotland will comprise at least 63 en-route charger locations, of which 23 are already built or under development.

Route 5:
Carlisle-Cairnryan

This route covers approximately 175 km, connecting Carlisle to Cairnryan via the A75. No chargers are located along this route, although Cairnryan (Loch Ryan Port) is part of the suggested charger network, which means that vehicles can charge at the end of the route.

A diversionary charge is available towards the start of the route, in the vicinity of Annandale Water. This increases the route length to around 205 km, composed of two shorter routes of 148 km and 55 km.

Recommendation

Additional charging could be made available between Dumfries and Cairnryan (Castle Douglas) to ensure full viability of the route, including in harsh weather conditions and for vehicles running with sub-optimal efficiency.

Figure 7. Essential and additional charging on the Carlisle-Cairnryan HGV route

Table 7. Vehicle performance on the Carlisle-Cairnryan HGV route

	Simulated Truck (Worst Case)	Median Truck (Best Case)
Can complete without charger, summer	Yes (marginal)	Yes
Can complete without charger, winter	No (marginal)	Yes
Can complete with 1 charge (Annandale), summer	Yes	Yes
Feasibility with 1 charger (Annandale), winter	Yes (marginal)	Yes

1 **The charging infrastructure needed for all HGVs in Scotland will comprise** at least 63 en-route charger locations, of which 23 are already built or under development.

Route 6: Livingston-Carlisle

This route covers approximately 175 km, connecting Bathgate to Carlisle via the M8 and M74. Three chargers are located along the route in the vicinity of Hamilton (Mossend), Abingdon and Annandale Water.

Annandale Water was highlighted above as being essential for the Carlisle-Cairnryan route. It can play a similar role on this route, being only 120 km from Livingston and 55 km from Carlisle, which are viable distances for all vehicles in all foreseen circumstances.

Recommendation

The charging location in the vicinity of Annandale Water is not essential for this route but would ensure BEVs can travel between Livingston/Edinburgh and the North-West of England in winter weather conditions.

The Annandale Water location is essential for routes to Northern Ireland via Cairnryan and would ensure logistics operations can run smoothly between Scotland, the North-West of England, and Northern Ireland.

Figure 8. Essential and additional charging on the Livingston-Carlisle HGV route

Table 8. Vehicle performance on the Livingston-Carlisle HGV route

	Simulated Truck (Worst Case)	Median Truck (Best Case)
Can complete without charger, summer	Yes (marginal)	Yes
Can complete without charger, winter	No (marginal)	Yes
Can complete with 1 charge (Annandale), summer	Yes	Yes
Feasibility with 1 charger (Annandale), winter	Yes	Yes

Charger List

1

The charging infrastructure needed for all HGVs in Scotland will comprise at least 63 en-route charger locations, of which 23 are already built or under development.

Table 9. New en-route charger locations within a 5km radius of:

No	Place Name
1	Abington
2	Annandale Water
3	Ardrossan
4	Huntly
5	Ballinluig
6	Brodick
7	Broxden
8	Campbeltown
9	Clydebank
10	Craignure Mull
11	Dalwhinnie
12	Dunbar
13	Dundee
14	Edinburgh East
15	Eyemouth
16	Friarton
17	Galashiels
18	Grangemouth
19	Greenock
20	Inverness Seafield
21	Kennacraig
22	Kinross
23	Kyle of Lochalsh
24	Loch Ryan
25	Mallaig
26	Mossend
27	Oban
28	Peterhead
29	Port Askaig
30	Aberdeen
31	Skiach
32	Spean Bridge
33	Stirling
34	Stornoway
35	Stracathro
36	Sutherland and Caithness
37	Thurso
38	Tyndrum
39	Uig
40	Ullapool

Note

The specific locations listed Table 9 lie at the centre of a 5km radius. Future charging infrastructure can be developed anywhere within this radius and the model findings remain valid.

Charger List

1 **The charging infrastructure needed for all HGVs in Scotland will comprise** at least 63 en-route charger locations, of which 23 are already built or under development.

Table 10. Existing and planned charger locations

No	Place Name
1	Aberdeen
2	Bridge of Don
3	Dundee
4	Glasgow
5	Glasgow (Scotstoun)
6	Arbroath
7	Dunfermline
8	Kilmarnock
9	St Andrews
10	Buckie
11	Elgin
12	Orkney
13	Glasgow Airport
14	Perth
15	Larbert
16	Livingston
17	Inverness
18	Harthill
19	East Kilbride
20	Bellshill
21	Coatbridge
22	Bathgate
23	Lerwick

Table 11. Potential high-value locations within a (5km radius) of:

No	Place Name
1	Ayr
2	Castle Douglas

Note

The specific locations listed Table 11 lie at the centre of a 5km radius. These additional locations extend the core charger network and help to further reduce time and distance penalties.

Enhanced Charger Network

1 **The charging infrastructure needed for all HGVs in Scotland will comprise** at least 63 en-route charger locations, of which 23 are already built or under development.

Summary

The minimum viable en-route charger network for all Scottish HGVs is based on 23 currently installed (or being developed) sites. These combine with 40 new sites defined by the WattRoutes project[2] (Strathclyde University), and areas identified from previous analysis which lie within a 5km radius of existing truck facilities. **This is the core network upon which the remainder of the analysis will be based.**

An analysis of six primary HGV routes revealed a further two potentially high value locations. While not needed for routes to be completed, they would meaningfully reduce time and journey penalties from en-route charging, boosting convenience and redundancy. These additional sites have been added to the core network in Figure 9. This represents early insight into a future enhanced/optimised charger network for Scotland. **Further analysis is required to develop the enhanced network fully.**

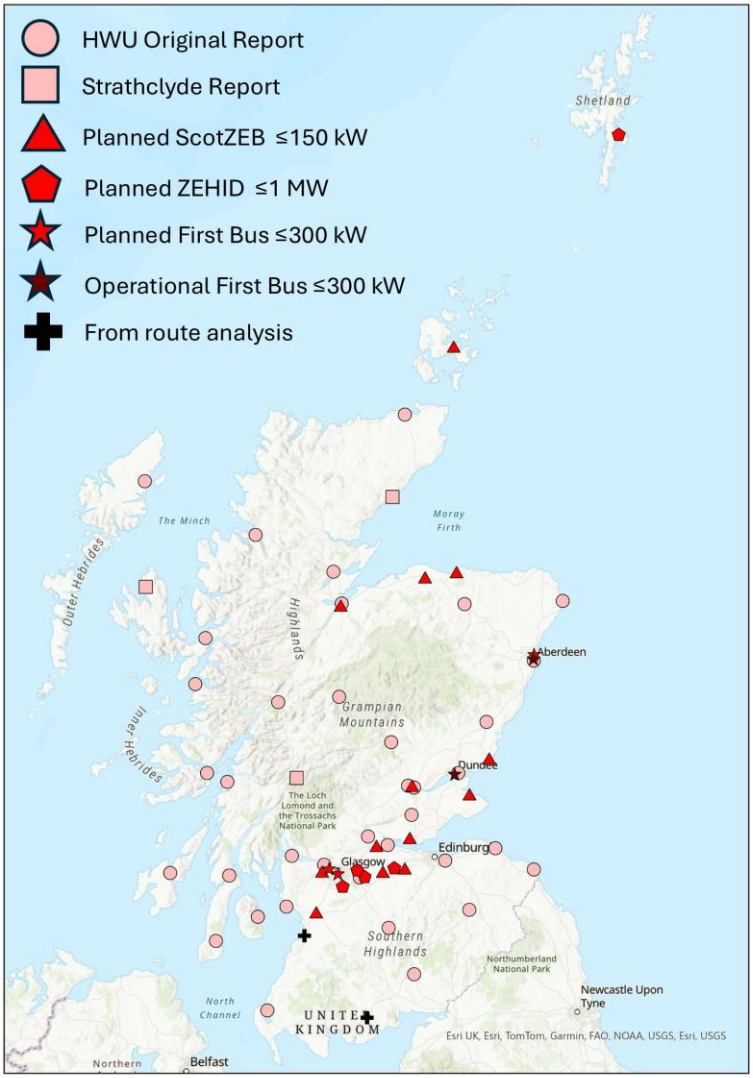


Figure 9 Enhanced BEV charger network map.

Charger usage

2

The charging infrastructure needed for all HGVs in Scotland will experience heaviest usage on the A9/M74 corridors, with the two busiest charger sites needed within an approximate 5km radius of Annandale Water and Dalwhinnie.

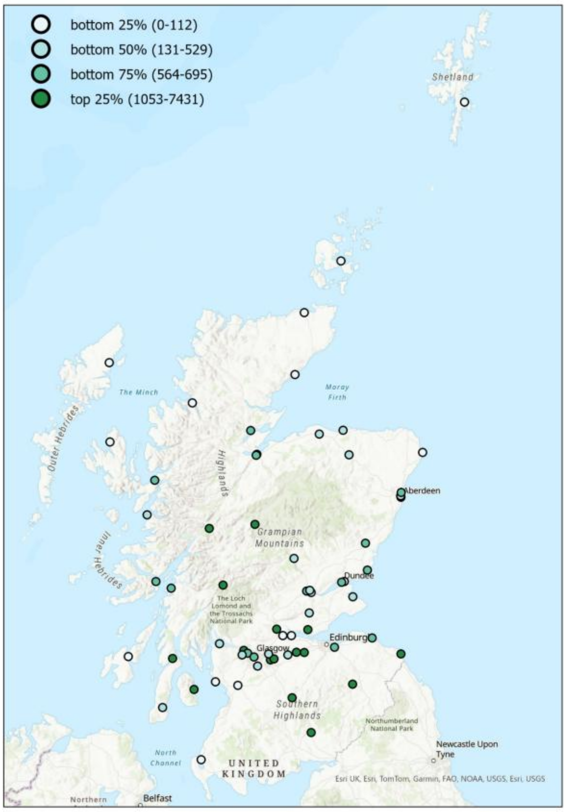


Figure 10. Utilisation of en-route charging locations by the sample vehicles in the Agent-Based Model.

High Utilisation Hot Spots

The dataset highlights heavy freight use on the A9 (Stirling-Inverness) and M74 (Glasgow-Carlisle). Strategically placed en-route chargers on these corridors would have the greatest impact on facilitating BEV journeys. High utilisation hot spots are marked in Figure 10, and the top 10 most utilised sites are listed in Table 3.

Limitations

Charger locations have been introduced in Orkney, Shetland, and the Isle of Lewis, but their utilisation is low. This reflects limited representation of island-based journeys in the current dataset. This will need to be addressed in future work.

Table 12. Top 10 en-route charger locations, ranked by total annual visits and energy delivered (MWh) by the sample vehicles in the Agent-Based Model.

Location	Number of uses (annual)	Total charge delivered (MWh)
Annandale Water	7,431	2,039
Dalwhinnie	6,832	1,978
Dunfermline	6,529	902
Bathgate	2,338	493
Galashiels	2,371	421
Tyndrum	2,243	392
Abington	1,256	370
Spean Bridge	1,269	369
Eyemouth	1,296	289
Aberdeen	695	275

3

The charging infrastructure needed for all HGVs in Scotland will require at least 1.3TWh of electrical power.

Power Requirements

The electrical power requirements for a fully electric HGV fleet in Scotland are considerable. The Agent-Based Model reveals the following:

Total number of charge events = 143,319 (both at the depot and en-route)

Total charge delivered = 26GWh

Scaling the current sample size (approx. 2% of the total Scottish HGV fleet) to the size of the full Scottish HGV fleet results in a:

Total power requirement = 1.3TWh.

Note

There have been several previous estimates of electrical energy demand should the HGV fleet move to battery-electric.

Based on Road Traffic Statistics for the Scotland region[9], HGVs accumulated 1.5 billion vehicle miles in Scotland in 2024, which translates to 2.4 billion kilometres. If these vehicles operated with an efficiency of 1.7 kWh/km, as used in the Agent-Based Model, the total power consumption would be approximately 4 TWh (1.7 kWh/km * 2.4 billion km). Even if efficiency were doubled, halving this figure, it would still represent a substantial 2 TWh.

Further modelling work is required but the scale of investment needed is clear.

9. https://roadtraffic.dft.gov.uk/regions/3

Grid Infrastructure

3

The charging infrastructure needed for all HGVs in Scotland will require at least 1.3TWh of electrical power.

Substation Strengthening

The research has innovated a methodology for exploring where the energy system will need strengthening to support a switch to BEVs.

The primary substation closest to each proposed charging location was identified. Its ability to support the charging demands resulting from 2% of journeys switching to BEV was assessed using data from Distribution Network Operators (DNOs) unutilised grid capacity[7-8].

The highest electrical draw scenario for the sample dataset —mixed depot and en-route charging using 500kW equipment—was selected for analysis. Two further scenarios were considered: a high-intensity scenario with trucks arriving for charging in two concentrated peak periods, and a low-intensity scenario with arrivals spread across four periods. **The expected total power draw at each primary substation was calculated and compared to its forecasted headroom.** Substations are colour-coded in Figure 11:

- **Green:** Sufficient headroom even in the high-intensity scenario (80% of substations).
- **Amber:** Sufficient headroom only in the low-intensity scenario, potentially requiring strengthening (2% of substations).
- **Red:** Insufficient headroom even in the low-intensity scenario. Strengthening required (18% of substations).

Even with a single digit sample of HGV journeys running with BEV technology, 11 substations require upgrade: Gartsherrie, Glendinning Terrace (Galashiels), Larbert, St. Ninians, Bridge of Don, Burghmuir, Dalwhinnie, Lochdonhead, Milnathort, and Mount Pleasant.

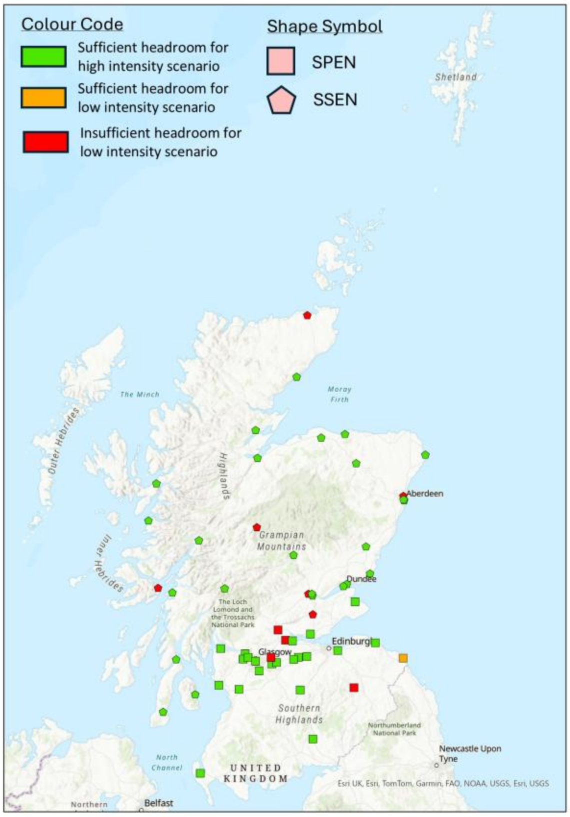


Figure 11. Substation capacity to support the core charger network and 2% of the HGV fleet switching to BEV.

Further Work

Further work using the methodology is required alongside deeper engagement with energy stakeholders. The Agent-Based Model approach enables the findings from the sample to be scaled to the entire HGV fleet while ensuring a wide range of interacting factors are considered. The result will be a robust approach to guiding investment decisions.

7. https://spenergynetworks.opendatasoft.com/pages/home/
8. https://opennetzero.org/ssen

Changes to HGV Operations

4 The charging infrastructure needed for all HGVs in Scotland will enable approximately 70% of routes to be completed without additional stops for charging.

This section explores some headline operational implications of a switch to BEVs. Under consideration is whether existing journeys can be completed with or without recharging, and any additional penalties in journey time and/or distance may be incurred.

Assumptions

The Agent-Based Model assumes a full transition (100%) of the HGV fleet to electric vehicles. Further research is required into how the transition will occur and the resulting mix (if any) of fuel/energy types.

The model also assumes a 44-tonne HGV with a 350 kWh usable battery capacity and a conservative 1.7 kWh/km energy consumption rate based on previous published research[10]. Actual performance could be better.

Three primary scenarios are analysed:

- Home Depot Charging Only: Vehicles start each day 100% charged and can only recharge at their own company depots. Forestry vehicles are an exception. They have no depot and only charge en-route, reflecting real-world individual operations.
- En-Route Charging Only: Vehicles recharge solely at designated en-route chargers, leaving their depot with their previous day's charge state.
- Mixed Charging: Vehicles can charge at both their home depot and en-route.

For proposed new locations, two analyses were run: one with 500 kW and another with 350 kW chargers.

No charging at delivery destinations is assumed due to current infrastructure limitations. En-route charging is capped at 80% battery capacity.

These assumptions are conservative in nature.

Key Findings

For 70% of trucks in the Agent-Based Model, charging at the depot where they are based is enough to cover their routes. They do not need to make any extra charging stops.

A mixed charging strategy allows over 90% of current journeys to be carried out, albeit 30% of the total experience some level of route or journey penalty.

Across all charging scenarios the percent of journeys which require one charging stop is between 4 and 6%.

The percent of journeys which require 2 to 3 stops is between 7 and 13%.

The percent of journeys which require more than 4 stops is between 1 and 4%.

Relying just on en-route charging results in 34% of current journeys not able to be completed.

The average route time increase with 350kW chargers is within the range of 37 to 46% across depot, en-route, and mixed charging strategies.

The use of 500kW chargers – on average – makes relatively little difference. The route time increase in this case being in the range 30 to 40%.

10. de Saxe, C., Ainalis, D., Miles, J., Greening, P., Gripton, A., Thorne, C., & Cebon, D. (2023). An electric road system or big batteries: Implications for UK road freight. Transportation Engineering, 14, 100210.

Next Steps

Summary

This research used a representative sample of high-quality HGV telematics data to inform a sophisticated Agent-Based Model (ABM). The model has delivered insights into charger utilisation, energy infrastructure demands, and operational implications of transitioning to BEVs.

What the research can tell us:

There is a minimum-viable 'core' charger network solution. To create a minimum viable charging network approximately **40 additional sites** are required.

Even with just 2% of the current HGV transitioning to BEV, eleven substations do not have sufficient capacity to support the core charging network. This is an indication of the scale of additional investment in the energy system which may be required.

Using the model outputs to conduct a simple calculation of total energy demand reveals **substantial extra capacity is going to be required or released**. While lower than some previous estimates, power consumption in the TWh range will require significant investment.

The minimum viable core charging network will enable the majority of HGV journeys to be completed without having to stop for an en-route charge.

Where further work is needed:

A larger sample size and greater quantities of journey data will enable more robust investment decisions to be made.

Continuing expansion of the sectors and locations (e.g. non-mainland) will ensure greater utility and equity in the carbon transition / freight electrification.

The enhanced charger network, with additional high-value locations identified, will reduce the proportion of journeys incurring some form of time or route penalty. Further route analysis and a larger sample will enable these shortcomings to be mitigated.

Get Involved

This analysis is ongoing and will be updated as new datasets become available. Additional journey data from HGV fleets is invited to further enhance the analysis.

For more information on the telematics data required, as well as details on how the data will be stored and anonymised, please contact cls-info@hw.ac.uk.

Transport Scotland is developing a forum for fleet operators, charge point operators, financiers and others interested in developing energy infrastructure projects for HGVs. If you are interested in joining this forum, please email FleetsandInfrastructure@transport.gov.scot

The forum will enable hauliers to express interest in specific locations and understand the potential commitment asked of them. It may build sufficient interest for specific locations to move to development stage.

Those considering installing charging infrastructure at some point in the future should contact their DNO at an early stage to understand what information is helpful in securing the power required.

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