Fleet and charging location archetype report

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Contents

1. Executive Summary

The Future Fleet project supports the UK freight sector's transition to electric heavy goods vehicles (eHGVs) by developing a detailed understanding of how HGV operations drive charging demand and where opportunities exist to manage this demand more efficiently. Led by Energy Systems Catapult, this report focuses on identifying how different fleet types, vehicle configurations and operational patterns influence when, where and how much electricity is required for eHGV charging.

The transition to eHGVs presents a significant challenge for electricity networks. High power demand from charging risks increasing costs and could trigger substantial infrastructure upgrades if unmanaged. This project addresses that challenge by building fleet and charging location archetypes that translate real-world logistics activity into model-ready energy demand profiles. The work enhances eFREIGHT 2030 data with the addition of more detailed insights and data from Future Fleet partners.

The project is delivered in collaboration with UK Power Networks (UKPN) and a consortium including Baringa, Voltempo, Maritime and Voltloader, bringing together expertise from networks, logistics operators, and chargepoint providers. This ensures that modelling reflects operational reality while aligning with network planning needs.

The work shows that fleet operations are a primary driver of energy flexibility requirements. The majority of HGVs operate as Day Drivers, returning to depot overnight, meaning a large share of charging demand could be met at depots overnight. In contrast, more intensive operations - such as Day + Night Drivers and Long-Haul Trampers - have limited dwell time and rely heavily on Destination and En-Route charging, reducing energy flexibility and increasing the need for high-power infrastructure.

Similarly, it is likely that fleet composition will strongly influence charging patterns. Smaller, rigid-dominated fleets may largely rely on depot charging, whereas larger, articulated and high-utilisation fleets require a more distributed charging network, including shared and public infrastructure.

This report highlights the need for the type of fleet operation to be a key consideration when investigating energy flexibility solutions and how both network providers and their customers (eHGV fleet operators) may be able to benefit from smart energy management.

1. Introduction

Future Fleet is a project designed to support the transition of the UK freight industry to electric heavy goods vehicles (eHGVs) by identifying the most efficient, cost-effective, and grid-friendly approaches to charging. As operators move towards Net Zero, the significant power demands of eHGV charging risk placing pressure on local electricity networks, potentially driving up costs and requiring major infrastructure upgrades. Building on insights from the eFREIGHT 2030 project, Future Fleet develops a detailed, evidence-based understanding of how logistics operators use vehicles, where and when charging demand arises, and how it can be managed more effectively.

The project brings together UKPN, Energy Systems Catapult, Baringa, Voltempo, Maritime and Voltloader to test and model practical solutions such as smart charging, shared infrastructure models and on-site energy generation and storage. By combining real-world fleet data with detailed geospatial network analysis, it aims to identify where demand will grow and how to minimise peak loads to avoid unnecessary upgrades.

Energy Systems Catapult has led the work developing fleet and charging location archetypes, with associated insight into operator needs. This work informs energy demand modelling, opportunities for smart energy schemes and business models for access to charging.

While the work focuses on the UKPN area, most of the insights are applicable to the rest of the UK.

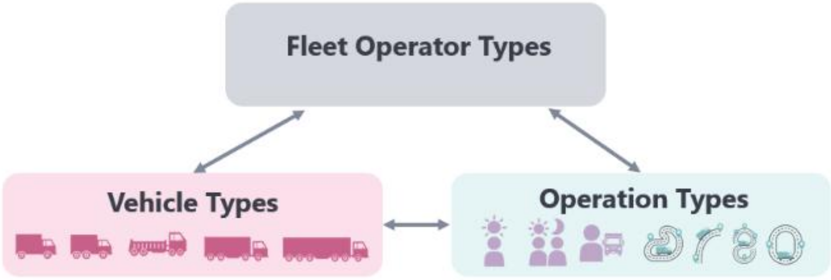
This report provides an overview of the fleet and charging location archetypes, focusing on:

- the types of fleet operator in the UKPN area, and the types of operations they do (Section 2);
- the potential level of electricity demand for these different fleet and operation types, with associated charging locations (Section 3);
- what could be done in the Beta SIF stage to build off this work (Section 4); and
- how to use our detailed output spreadsheet (Appendix);

2. Fleet operations

While fleet operator types vary widely across the UK, this section presents representative operators in the UKPN area. For these representative fleets, this section covers the types of vehicles they operate and the operations they undertake.

The types of fleet operator, vehicles and operations are all linked together. For example, types of HGV are linked to the type of operation. Then fleet operators will pick the right mix of vehicles and operations to meet their customer's needs.



In this section, types of fleet operator are discussed first. This is then built on with the types of vehicles they may own, then the likely types of operation those HGVs are generally used for. This builds a picture for how different fleet operators may run their fleets in the UKPN area, helping to build a picture of energy demands and opportunities for eHGV charging.

2.1 What types of fleet operator are there in the UKPN area?

Fleet operator types were identified using licence data from the Traffic Commissioner[1] and validated through engagement with Future Fleet operators. The operators in the consortium focus on larger vehicles and therefore, our assumptions around the fleets operating rigid vehicles may not be representative.

The dataset includes operator licence type and fleet size for each Depot in the UK. Operators were grouped by licence type, as licence type defines what operators are permitted to carry, and therefore the types of operations they undertake. The licences are:

- **Restricted**: operators can only carry their own goods within the UK.
- **Standard National**: operators can carry their own goods and other people's goods within the UK.
- **Standard International**: operators can carry their own goods and other people's goods within the UK and internationally.

Fleet size was also considered as a key classification. Fleet operators vary significantly in size, with smaller fleets facing different decarbonisation and charging challenges compared to larger fleets. The Traffic Commissioners data is by Depot location, so the number of vehicles shown below are also by Depot, rather than all the vehicles owned by a fleet operator in the country. The three categories for this study are:

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[1] https://www.data.gov.uk/dataset/2a67d1ee-8f1b-43a3-8bc6-e8772d162a3c/traffic-commissioners-goods-and-public-service-vehicle-operator-licence-records

- **One-Man Bands**: under 5 HGVs per Depot.
- **SMEs**: between 5 and 50 HGVs per Depot.
- **Large Fleets**: over 50 HGVs per Depot.

The dataset was cleaned by removing non-HGV fleets and duplicate rows, then filtered for the fleets inside the UKPN area. The distribution of fleet operators by licence type and size is shown in Table 1 below.

	Restricted	Standard National	Standard International
One-Man Bands	45.3%	22.7%	11.9%
SMEs	5.5%	8.8%	5.2%
Large Fleets	0.0%	0.4%	0.2%

Table 1 – UKPN operator split by licence and size

This indicates that the vast majority of Depots in the UKPN area have less than 5 HGVs, and most operators are on the very small end of the spectrum. Given the prevalence of small fleets, this should be considered for the transition to electric HGVs (eHGVs). These fleets may not have the capital for the upfront cost of chargers and may therefore chose charge outside of their Depots, or delay their transition to eHGVs.

Larger fleets have more vehicles, so it is important to also consider how the HGVs are distributed between types of fleet operator. The split of HGVs by operator licence and size is shown in Table 2 below.

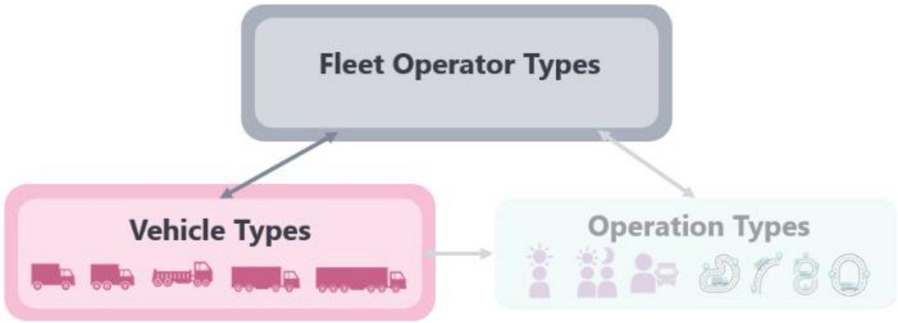
	Restricted	Standard National	Standard International
One-Man Bands	18%	10%	6%
SMEs	13%	26%	15%
Large Fleets	1%	7%	4%

Table 2 – UKPN HGV split by operator licence and size

This highlights that, although operators are dominated by the One-Man Bands, the distribution of HGVs in the UKPN area is more evenly split between different types of operator, with most being SMEs. This indicates that most fleet sizes and licence types should be considered when looking at the energy impacts.

2.2 What vehicles do these fleets operate?

This section covers the interaction between fleet operators and the vehicles they own.



HGVs are defined as vehicles over 3.5t and comprise a variety of types[2]. Rigid vehicles have a fixed cab and body, while articulated vehicles consist of a separate tractor unit and trailer. Within these categories, vehicles vary further by axle configuration and weight limits. The five types of wheel configuration for HGVs are:

- **2-axle rigid**
- **3-axle rigid**
- **4-axle rigid**
- **2-axle articulated**
- **3-axle articulated**

The HGVs have been categorised only by wheel plan to limit the number of vehicles investigated in this study, with the wheel plan being a big differentiator in energy demand and operation type. The split between these vehicles is shown below for the UK (and is assumed to be the same for the UKPN area).

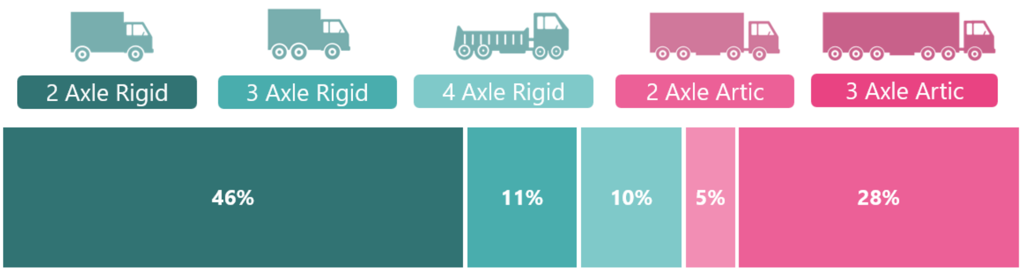


Figure 1 – Split of HGV types assumed for the UKPN area[3]

The Traffic Commissioners dataset does not include vehicle type, so assumptions needed to be made to arrive at vehicle types per fleet operator type.

The dataset includes information on the number of trailers authorised, so for each fleet this was analysed to estimate the split of rigid vs articulated HGVs in each fleet operator category. The standard UK split of vehicle types was then used to constrain this, meaning the overall figure across all operator types is the same as in Figure 1.

This results in the following estimated vehicle composition by operator type.

[2] https://www.gov.uk/government/statistics/road-traffic-estimates-in-great-britain-2024/notes-and-definitions

[3] Directly taken from The Road Ahead: National System Impacts of HGV Decarbonisation eFREIGHT 2030 report, but ultimately derived from DfT Vehicle licensing statistics data files (VEH0520).

Licence	Fleet Size	Total vehicles	2 axle rigids	3 axle rigids	4 axle rigids	2 axle artics	3 axle artics
Restricted	One-Man Bands	18%	70%	18%	12%	0%	0%
	SMEs	13%	62%	17%	12%	2%	7%
	Large Fleets	1%	67%	13%	13%	2%	5%
Standard National	One-Man Bands	10%	41%	10%	14%	9%	26%
	SMEs	26%	36%	9%	12%	10%	34%
	Large Fleets	7%	24%	6%	11%	8%	51%
Standard International	One-Man Bands	6%	0%	0%	0%	24%	76%
	SMEs	15%	0%	0%	0%	23%	77%
	Large Fleets	4%	0%	0%	0%	0%	100%

Table 3 – Vehicle split for each fleet type

The average number of vehicles per fleet type has been estimated, distributed to each type of vehicle. This provides a set of representative fleets with the vehicles they may operate. The main fleet archetypes that are a focus for this study are shown below, in Figure 2 and Figure 3.

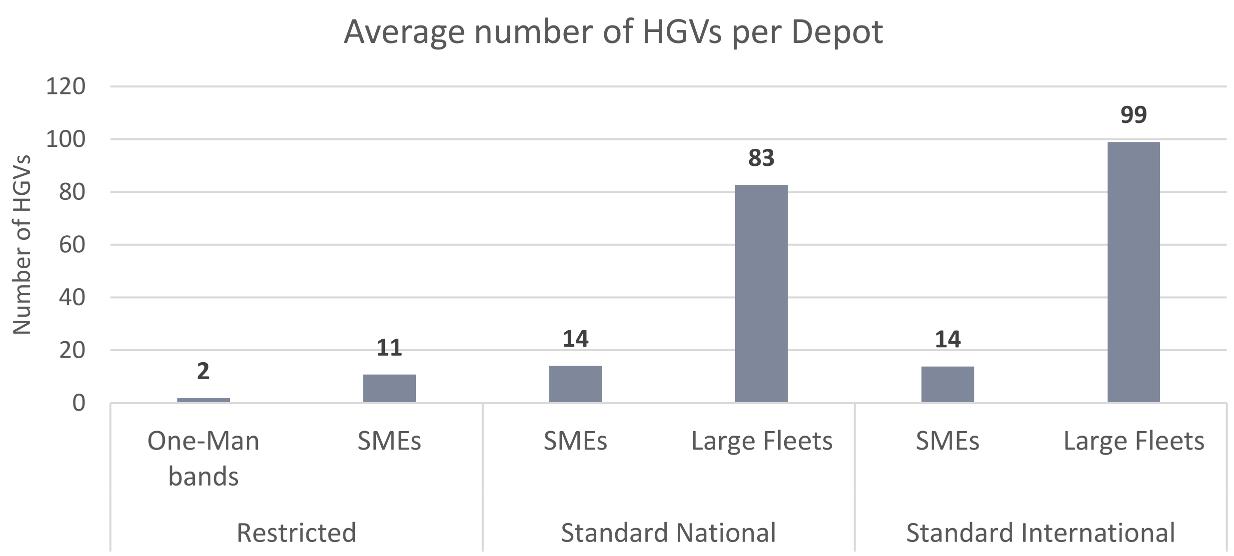


Figure 2 – Number of HGVs per Depot for each fleet type

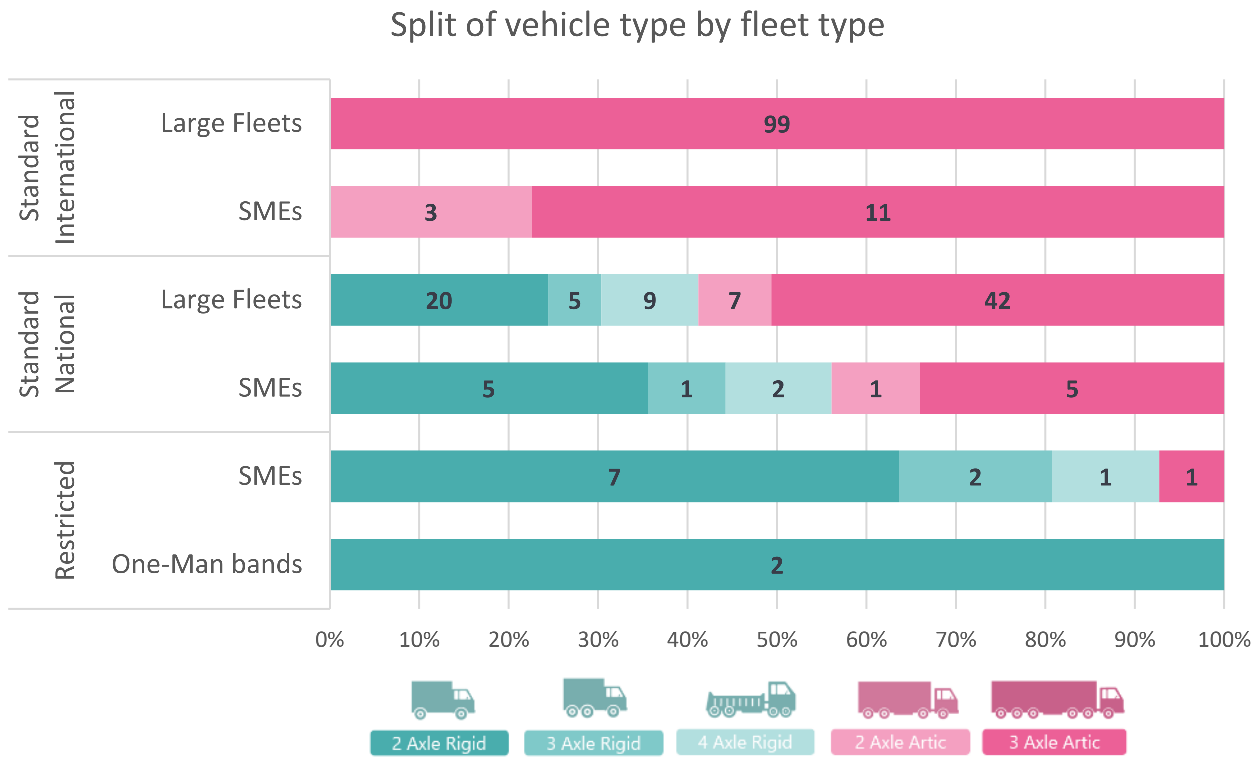


Figure 3 – Vehicle split for fleet archetypes

It is understood that HGVs with Restricted licences are more likely to be rigid vehicles. Standard National licenced HGVs may have a mix of articulated and rigid HGVs, with Standard International more likely to be dominated by articulated.

2.3 Where do these vehicles stop?

Based on workshops with the Future Fleet consortium, HGV stops have been grouped into three types, shown below.

Operators' Depot

Depot owned by a fleet operator where HGVs stop when not in use.

Destination

A drop-off or pick-up location. This could be a fleet's own depot, a customer's depot or a location such as a port.

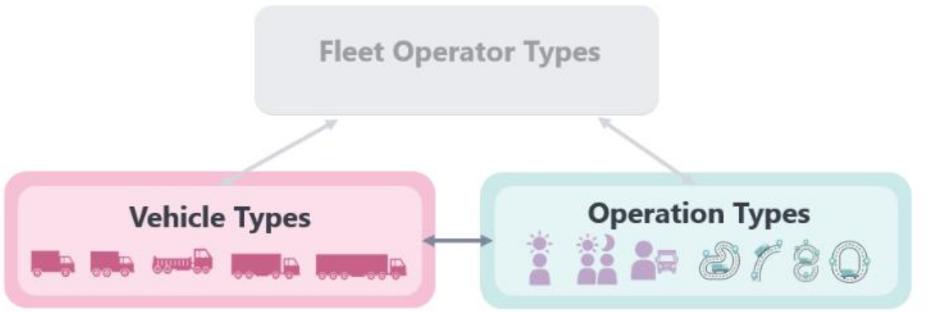
Dedicated En-Route

Anywhere outside of a depot or destination location (for example motorway services).

These locations will have distinct eHGV charging requirements, discussed later in this Section 3.2.

2.4 What types of operations do these vehicles do?

This section covers the interaction between vehicles and the types of operation they are likely to do.



The type of operation is going to be a significant factor in when and where an eHGV is likely to charge. This also affects the level of energy flexibility available.

2.4.1 Operations

Workshops with the Future Fleet consortium were used to characterise HGV operations. This identified two main factors for how HGVs are used, the driver type and journey type.

Different driver types use HGVs at different times of day and for different types of work. This will therefore impact when eHGVs being used in these ways have an opportunity to charge. The three types of driver are shown below.

Day Driver

These drivers start early in the morning and finish in the afternoon, starting and stopping at the same location.

Day + Night Driver

HGV is double shifted, so once the day driver has finished another driver takes over for the night shift. The day and night drivers start and stop at the same location.

Long-Haul Tramper

These drivers have the same driving time limitations as the day driver but sleep in their vehicles so can end their journey anywhere.

As Day Drivers operate only during daytime hours, it is likely eHGVs with these drivers will have a long charging opportunity overnight. However, eHGVs with Day + Night Drivers are unlikely to have much downtime and may find it harder to find a window to charge. The Long-Haul Trampers are away from base for a large portion of the week, meaning they are likely to rely on Destination or En-Route locations to charge.

The other main factor in HGV operations is the journey type, with the main four shown below.

Shunting

Low mileage, high frequency, regular movements between a depot and a destination.

Round Trip

HGV starts at a depot with cargo, travels to a destination where it drops it off, then picks up cargo at the same location and travels back to the original depot.

One-Way Trip

HGV goes one-way (from a depot to a destination). If returning to a depot it could do this empty, or it can go to another destination to pick up cargo, then travel back to the original depot.

Multi-Drop

HGV has multiple customers' cargo, so the truck stops in multiple destinations along its route.

The journey will impact the opportunities to charge at different locations. For example, an eHGV doing Shunting is likely to have multiple opportunities for top-up charging at Depot and Destination locations while dropping off and picking up cargo. Whereas a One-Way Trip will have limited stops at Depot and Destination locations but may stop more frequently at En-Route sites.

These operations are discussed further in Section 3.3, where consortium data has been used to add detail to operational patterns for these driver and journey types.

2.4.2 Operations by vehicle type

Different vehicle types are associated with different operating patterns. This directly affects the charging requirements for these vehicles and the fleets that use them.

For each HGV type, the distribution between driver type and journey type has been estimated based on fleet operator feedback and DfT data. Additional evidence was drawn from eFREIGHT 2030 outputs where available.

DfT *Domestic road freight activity (RFS01)*[4] data on the quantity and length of goods moved by HGV type was used as a starting point. For each commodity group and vehicle type, an estimate was made about how it may relate to each journey type. This was then built upon with fleet operator feedback.

The estimated split of operation by vehicle type is shown in the following sections.

[4] https://www.gov.uk/government/statistical-data-sets/rfs01-goods-lifted-and-distance-hauled

2.4.2.1 2-Axle Rigid & 3-Axle Rigids

For 2-axle rigids and 3-axle-rigids the split is expected to be the same. It has been assumed (based on fleet operator feedback) that all of these HGVs would have Day Drivers. The journey split has mostly been derived from the DfT analysis, but with an adjustment to make Shunting 10% and One-Way Trips 15%, based on fleet operator insights. The split of 2- and 3-axle rigids is assumed to be as follows.

		Shunting	Short to Medium Round Trip	One-Way Trips	Multi-Drops
Operation	Total	10%	28%	15%	46%
Day Driver	100%	10%	28%	15%	46%
Day + Night Driver	0%	0%	0%	0%	0%
Long-Haul Tramper	0%	0%	0%	0%	0%

Table 4 – 2-Axle Rigid and 3-Axle Rigid Operation Split

2.4.2.2 4-Axle Rigid

For 4-axle rigids, it has been assumed that 95% of HGVs would have Day Drivers and 5% would have Day + Night Drivers. This is based on fleet operator feedback. The journey split has been derived from the DfT analysis. The split of 4-axle rigids is assumed to be as follows.

		Shunting	Short to Medium Round Trip	One-Way Trips	Multi-Drops
Operation	Total	9%	53%	15%	24%
Day Driver	95%	8%	50%	14%	22%
Day + Night Driver	5%	0%	3%	1%	1%
Long-Haul Tramper	0%	0%	0%	0%	0%

Table 5– 4-Axle Rigid Operation Split

2.4.2.3 2-Axle Articulated

For 2-axle artics, it has been assumed that 60% of HGVs would have Day Drivers, 20% would have Day + Night Drivers, and 20% would have Long-Haul Trampers. This is based on fleet operator feedback. The journey split has mostly been derived from the DfT analysis, but with input from fleet operators (to have around 5% Multi-Drop).

It was also noted by fleet operators that:

- Day + Night Drivers are unlikely to do Multi-Drops;
- Day + Night Drivers are likely to do Shunting or Round Trips (with around 5% looking reasonable for One-Way Trips);
- Long-Haul Trampers are unlikely to do Shunting; and
- Long-Haul Trampers are likely to do One-Way Trips, with some Round Trips.

The percentage splits were then redistributed in the matrix to account for these changes. The assumed split of 2-axle artics is then assumed to be as follows.

		Shunting	Short to Medium Round Trip	One-Way Trips	Multi-Drops
Operation	Total	8%	41%	45%	5%
Day Driver	60%	3%	27%	25%	5%
Day + Night Driver	20%	6%	9%	5%	0%
Long-Haul Tramper	20%	0%	5%	15%	0%

Table 6- 2-Axle Artic Operation Split

2.4.2.4 3-Axle Articulated

For the 3-axle artics, it has been assumed that 60% of HGVs would have Day Drivers, 15% would have Day + Night Drivers, and 25% would have Long-Haul Trampers. This is based on fleet operator feedback. The journey split has mostly been derived from the DfT analysis, but with input from fleet operators.

The percentage splits were redistributed in the matrix to account for the same insights noted for the 2-axle articulated HGVs. The split of 3-axle artics is then assumed to be as follows.

		Shunting	Short to Medium Round Trip	One-Way Trips	Multi-Drops
Operation	Total	8%	41%	45%	5%
Day Driver	60%	6%	22%	27%	5%
Day + Night Driver	15%	3%	9%	3%	0%
Long-Haul Tramper	25%	0%	10%	15%	0%

Table 7- 2-Axle Artic Operation Split

2.4.2.5 All HGVs

The individual tables above have then been combined, based on a weighted average (with the weighting based on the split of vehicles in each class, shown in Figure 1). This results in the following overall distribution of vehicles.

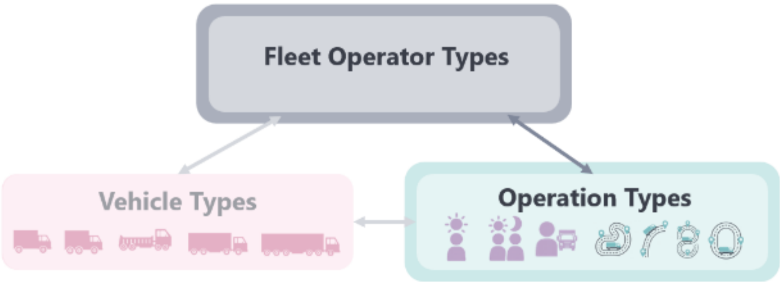
		Shunting	Short to Medium Round Trip	One-Way Trips	Multi-Drops
Operation	Total	10%	35%	25%	30%
Day Driver	86%	8%	29%	19%	30%
Day + Night Driver	6%	1%	3%	1%	0%
Long-Haul Tramper	8%	0%	3%	5%	0%

Table 8 - Operation Split by Number of HGVs

This shows that the majority of HGVs are likely to have Day Drivers, meaning these HGVs will be stopped at a Depot overnight.

2.4.3 Operations by fleet types

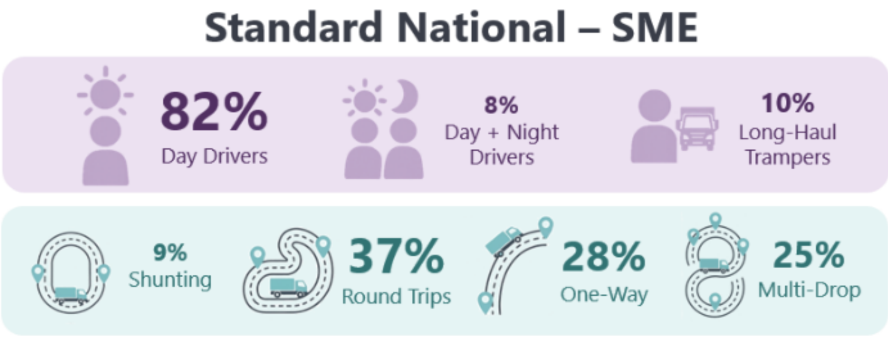
This section covers the interaction between fleet operators and the types of operation they are likely to do.



The above assumptions have been combined to estimate the operations for each fleet archetype. This gives an indication of the level of energy flexibility that may be possible for each type of fleet. This is discussed in more detail in Section 3.4.

In the Restricted licence category, it is expected that nearly all drivers will be Day Drivers. This means there is likely a long charging window overnight for these eHGVs. A significant portion of their journeys may be Multi-Drops. For Multi-Drop, top-up charging may be needed at Destination locations if Depot charging isn't available.

The Standard National category is still expected to be dominated by Day Drivers, but with some Day + Night Drivers and some Long-Haul Trampers. While Multi-Drop is still expected to be a reasonable proportion of the journeys, these HGVs are more likely to be doing round-trips and One-Way Trips. These involve less stops at Depot and Destination sites, meaning there may be more reliance on En-Route charging.



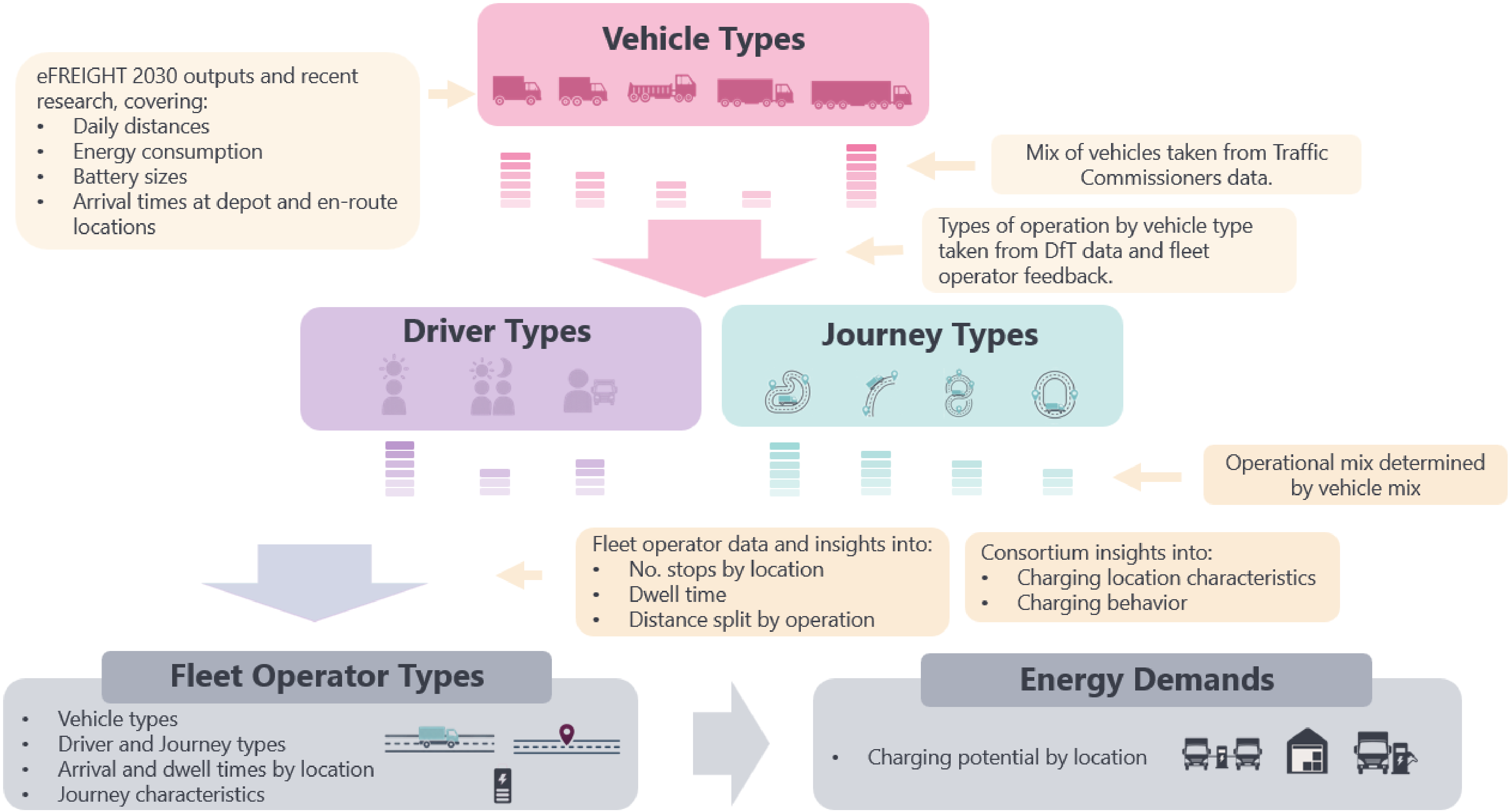
In the Standard International category there is expected to be a greater mix of driver types, with the journeys focussed more on round and One-Way Trips. While over half may still be Day Drivers, there would likely be a significant portion of Day + Night Drivers and Long-Haul Trampers. These are likely to be less flexible with when they can charge.

3. Future eHGV Demand

To determine the electricity demands for different fleet operators and operations, data was pulled from a range of sources and a number of assumptions were made. This section covers these core inputs alongside potential levels of energy demand for eHGVs in different fleets and doing different types of operations.

While fleet operator types have been looked at for the UKPN area, HGVs are not constrained to this geography. Therefore, any demand outside of the Depot location could be outside of the UKPN region.

A summary of how vehicle types, operation types and fleet types fit together to determine energy demands is shown below.


Vehicle Types
eFREIGHT 2030 outputs and recent research, covering:
• Daily distances
• Energy consumption
• Battery sizes
• Arrival times at depot and en-route locations
Mix of vehicles taken from Traffic Commissioners data.
Types of operation by vehicle type taken from DfT data and fleet operator feedback.
Driver Types
Journey Types
Operational mix determined by vehicle mix
Fleet operator data and insights into:
• No. stops by location
• Dwell time
• Distance split by operation
Consortium insights into:
• Charging location characteristics
• Charging behavior
Fleet Operator Types
• Vehicle types
• Driver and Journey types
• Arrival and dwell times by location
• Journey characteristics
Energy Demands
• Charging potential by location

3.1 Core Inputs

Insights derived as part of eFREIGHT 2030 have been used as a starting point, then built upon by data provided by fleet operators.

3.1.1 HGVs in the UKPN area

A list of local authorities was provided by UKPN for their area, then DfT vehicle licensing statistics[5] were used to estimate the proportion of HGVs in UKPN compared to the UK. This showed that 39% of the UK's HGVs could be based in the UKPN area. This leads to the following breakdown of vehicles for UKPN.

	Total Vehicles
2-Axle Rigid	86,000
3-Axle Rigid	21,000
4-Axle Rigid	18,000
2-Axle Artic	11,000
3-Axle Artic	53,000

Table 9 – HGV breakdown for UKPN area

3.1.2 eFREIGHT 2030

In eFREIGHT 2030, 13 different HGV segments were modelled across a range of vehicle classes and weights. These have been aggregated into the five vehicle types in this study. This provides the following assumptions per HGV type.

	Average Daily Distance (km)	Average eHGV Battery Size (kWh)
2-Axle Rigid	86	220
3-Axle Rigid	120	340
4-Axle Rigid	124	420
2-Axle Artic	181	540-630*
3-Axle Artic	389	540-630*

*Table 10 – HGV type eFREIGHT 2030 assumptions (*some vehicles have a range of battery sizes, as it is expected different operations may need different battery sizes in a small number of cases)*

These vehicles are expected to have different uptakes rates for eHGVs out to 2050. The uptake rates from the eFREIGHT 2030 Core Scenario were used to estimate the uptake rate per HGV type in the UKPN area. The estimated eHGV uptake for those in the UKPN area is shown in Figure 4.

[5] Vehicle licensing statistics data tables - GOV.UK

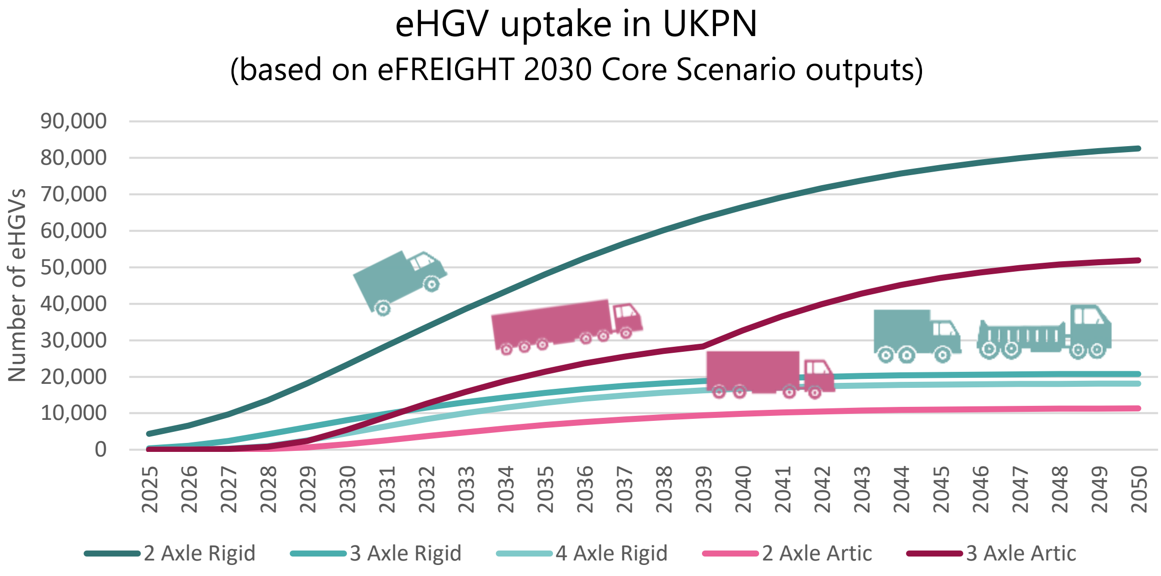


Figure 4 – eHGV uptake rate for UKPN

In the eFREIGHT 2030 project, telematics data was used to look at arrival times at Depots and En-Route locations. If an HGV is ending its shift at a Depot, Figure 5 shows the percentage chance it will arrive for this stop at any given hour in the day (based on eFREIGHT 2030 outputs).

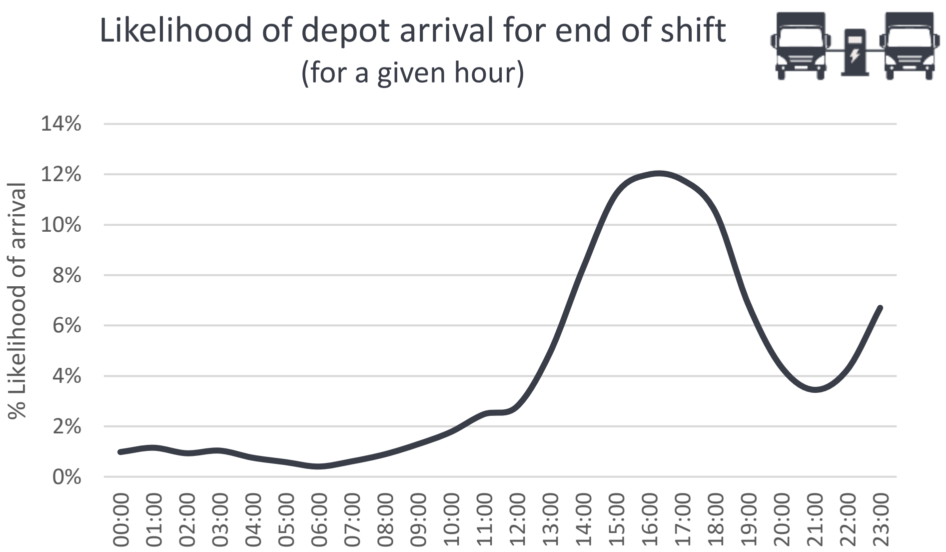


Figure 5 – Arrival time distribution for a Depot location

If an HGV is stopping during its journey, Figure 6 shows the percentage chance it will arrive for this stop at any given hour in the day (based on eFREIGHT 2030 outputs).

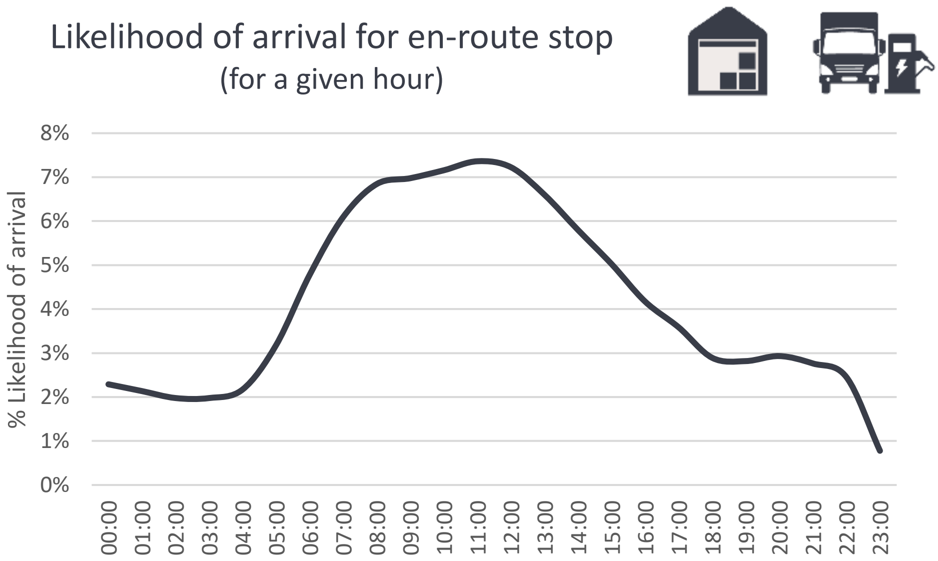


Figure 6 - Arrival time distribution for En-Route locations

The data gathered for eFREIGHT 2030 only included articulated HGVs. Therefore, there is a gap in the understanding of rigid HGVs, which make up a significant portion of the fleet.

3.1.3 Future Fleet developments

eFREIGHT 2030 data has been consolidated and further analysed during Future Fleet, with the addition of more detailed insights and data from Future Fleet partners. This has enabled a more detailed understanding of the operational characteristics of fleets, specifically within the UKPN network area.

3.1.3.1 Stop and dwell time by operation

To understand operational behaviours, duty cycle data was requested from the consortium fleet operators and categorised according to driver type and journey type. Stop locations were also classified to distinguish whether vehicles were at an operator Depot, customer Destination, or Dedicated En-Route stopping location.

The operational datasets used in this study provided useful insight into different freight activity and helped inform the assumptions applied in the analysis. However, both datasets had limitations in terms of coverage, structure and representation of the UK fleet. Therefore, the data could not be relied upon to give representative arrival time data per location. This could be built upon in Beta stage, which is discussed further in Section 4.

For this reason, the derived profiles from the eFREIGHT 2030 study were used to inform the likelihood of vehicles arriving at different locations during a journey and at the end of shift. As the eFREIGHT 2030 dataset covered a larger sample of freight activity, the occupancy curves provide a more reliable indication of these stopping patterns.

These profiles were then adjusted to reflect the expected characteristics of each driver type. For example, day + night operations were assumed to include two Depot stops in order to capture driver handover during the day. Long-Haul Trampers were assumed to stop at the same time as Day Drivers (though at an En-Route location rather than a Depot).

The distribution of arrival times for Day Drivers and Long-Haul Trampers at the end of their shifts are shown in Figure 5. The distribution of in-journey stops is assumed to be the same as in Figure 6. For Day + Night Drivers, the Depot handover distribution is shown in Figure 7 (where the total % over the day adds up to 200% as the HGV will arrive twice over the day).

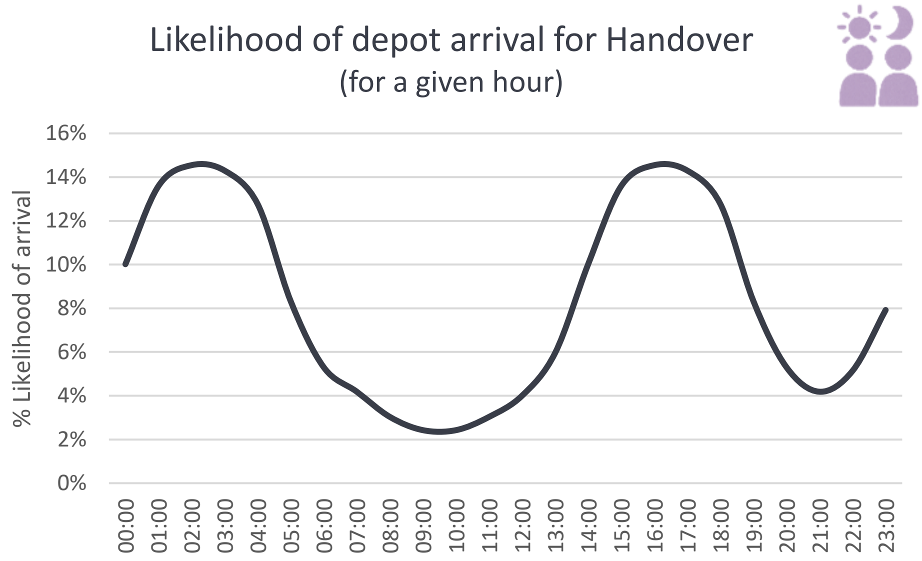


Figure 7 - Arrival Times for Depot Handover (Day + Night Driver)

The data from the Future Fleet operators played a key role in understanding how often different operations stopped at different locations, and for how long.

At the end of shift, Day Drivers were assumed to stop for 12 hours and Day + Night Drivers were expected to stop for 1 hour for the handover. This is based on the fleet data and feedback from the operators. For Long-Haul Trampers they are likely stopped for a long period overnight, but it is unlikely they will have access to a slow charger or wake up in the middle of the night to go and charge. Therefore, based on fleet operator feedback, it is assumed that charging must occur within three hours of arrival at the final stop.

During the journey, at Destination locations, the dwell time may differ by operation. For this study, there was not enough data to break this down over the course of the day or by every operation type. However, some averages were estimated based on journey type. For Shunting the average stop is assumed to be 25 minutes, for round and One-Way Trips the assumption is 45 minutes and for Multi-Drop it is 30 minutes.

There was limited data on the length of stop at En-Route locations, so an average was taken over all operations. This resulted in an average stop time of 45 minutes.

The following table shows the average number of in-journey stops per day for each type of operation, per location (excluding end of shift stops).

		Depot	Destination	Dedicated En-Route
Day Driver	Shunting	2.3	2.3	0
	Short to Medium Round Trip	0.4	1.1	1.6
	One-Way Trips	0.3	1	1.6
	Multi-Drops	0.1	2.4	1.6
Day + Night Driver	Shunting	4.6	4.6	0
	Short to Medium Round Trip	0.8	2.1	3.1
	One-Way Trips	0.7	2	3.1
	Multi-Drops	0.3	4.7	3.1
Long-Haul Tramper	Shunting	2.7	2.7	0
	Short to Medium Round Trip	1.1	2.9	1.6
	One-Way Trips	0.3	2	1.6
	Multi-Drops	0.6	3.9	1.6

Figure 8 – Number of in-journey stops by operation and location

Again, the level of data did not allow for detailed breakdowns by operation and location. Therefore, some assumptions had to be made. For example, limited En-Route stop data was available, so the number of stops has been assumed to be the same across most operations, with double the number of stops for Day + Night Drivers.

3.1.3.2 Distance split by operation

The fleet data also provided an insight into the different lengths of journey by operation. The data was a limited sample, so may not accurately reflect all types of operations. However, for this study it should provide a suitable indication. This resulted in the following average daily distances per vehicle type and operation. Blank values in the tables below are for journeys not assumed to be completed by that type of driver and vehicle combination.

Day Driver

Average Daily Distance (km)	Shunting	Short to Medium Round Trip	One-Way	Multi-Drops
2-Axle Rigid	80	88	89	86
3-Axle Rigid	112	122	124	120
4-Axle Rigid	109	119	121	117
2-Axle Artic	130	142	144	140
3-Axle Artic	286	313	316	307

Day + Night Driver

Average Daily Distance (km)	Shunting	Short to Medium Round Trip	One-Way	Multi-Drops
4-Axle Rigid	218	239	241	234
2-Axle Artic	260	284	288	-
3-Axle Artic	572	625	633	-

Long-Haul Tramper

Average Daily Distance (km)	Shunting	Short to Medium Round Trip	One-Way	Multi-Drops
2-Axle Artic	-	199	201	-
3-Axle Artic	-	437	442	-

Table 11 – Average daily distance by operation and vehicle

3.1.3.3 Energy consumption

Since the eFREIGHT 2030 *'The Road Ahead: National System Impacts of HGV Decarbonisation'* report[6], new research has been done on energy consumption for eHGVs. Therefore, the electricity consumption values per km have been updated for Future Fleet.

[6] https://esc-production-2021.s3.eu-west-2.amazonaws.com/wp-content/uploads/2026/03/17084953/WP5-eFreight-The-Road-Ahead.pdf

This has been done based on eFREIGHT 2030 analysis, the Battery Electric Truck Trial[7], Transport Scotland[8], DfT consumption analysis[9] and data from eHGVs in Germany[10].

This has resulted in the following energy consumption per km values for this study.

	kWh/km
2-Axle Rigid	1.09
3-Axle Rigid	1.22
4-Axle Rigid	1.66
2-Axle Artic	1.73
3-Axle Artic	1.86

Table 12 – kWh/km per vehicle type

3.2 Base Case assumptions

The Base Case has been used to show where energy may be delivered to eHGVs based on a set of assumptions agreed with the Future Fleet partners. It is not intended to represent a fully realistic scenario. Instead, it is designed to illustrate the scale of potential unmanaged demand on the electricity network and to provide a clear view of the possible value of energy flexibility for both the network and fleet operators. This will be built upon in future work packages to produce cost benefit analysis for a range of energy flexibility scenarios.

In this scenario, fleet operators are assumed to face no grid connection constraints, allowing them to charge when required and at any power level. Charging is optimised around operational needs rather than energy price signals.

Operators' Depot

50kW charger.
The preferred time and place to charge.
For day + night doing handover this may need to be 200kW.

Destination

200kW charger.
eHGVs would only charge at destinations if they needed to complete their journey. However, a destination would be preferable to en-route.

Dedicated En-Route

400kW charger.
eHGVs would only charge en-route if it is required to complete their journey.
Long-haul trampers staying overnight would still use a 400kW charger.

[7] https://www.fleetnews.co.uk/features/four-key-takeaways-from-the-battery-electric-truck-trial
[8] https://www.transport.gov.scot/publication/towards-zero-emission-hgv-infrastructure-in-scotland-phase-2-report/grid-demand/
[9] https://assets.publishing.service.gov.uk/media/6899f224e7be62b4f0643229/speed-emission-energy-consumption-curves-operating-costs.pdf
[10] https://www.oeko.de/fileadmin/oekodoc/Real-world-data-analysis-of-battery-electric-trucks.pdf

The charger efficiency is rated at 95%, which is taken directly from the eFREIGHT 2030 modelling assumptions. This was based on chargepoint operator's feedback.

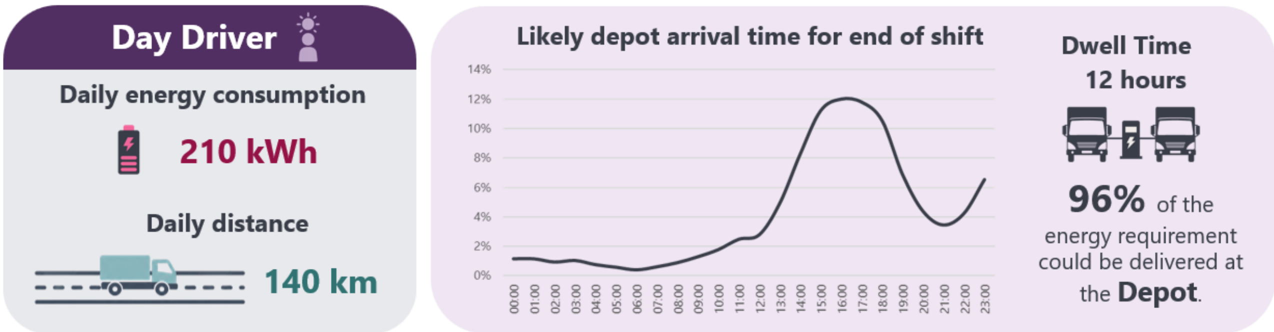
3.3 Energy demand for different operations

The type of operation an eHGV is doing is going to be a significant factor in the level of energy demand for that vehicle, as well as when and where this energy can be delivered. This therefore also impacts the level of flexibility it can have with its charging.

3.3.1 By driver type

This section focuses on how charging demand may vary by operating pattern. Across all HGVs in the UKPN area, the analysis examines how different driver types shape stop patterns and dwell times, and how this influences where charging is most likely to occur. The figures therefore help to show not only the scale of daily energy demand associated with each operation, but also the extent of energy flexibility available within current operating practices, without requiring material changes to schedules or routes.

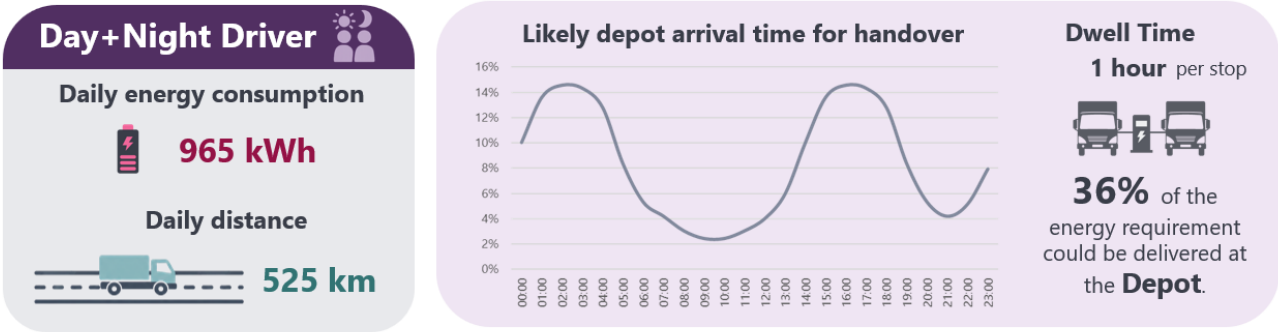
3.3.1.1 Day Drivers



Day Driver operations are the most compatible with Depot-based charging. These vehicles typically complete a single daytime duty and return to base for a long overnight dwell of around 12 hours. This creates a clear operational pattern in which most charging can be concentrated at the operator Depot using lower power infrastructure, with limited need to rely on Destination or En-Route charging during the working day. It is estimated that 96% of daily energy demand can be met at the Depot, reflecting both the length of the overnight stops and the relatively moderate daily energy requirement of this duty cycle.

Destination and En-Route locations may provide supplementary charging where needed but are not required to complete the operation under the Base Case assumptions. In practical terms, this makes Day Driver work the most inherently flexible of the driver types considered, because a large share of energy demand can be shifted into an extended off-shift window without changing the underlying operation.

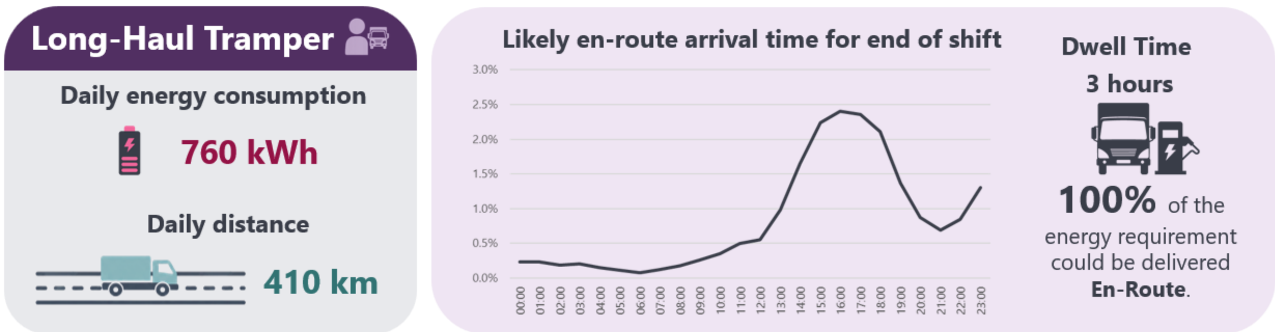
3.3.1.2 Day + Night Drivers



Day + Night Driver operations present a different charging profile. These vehicles are used more intensively across the day, with shorter and more fragmented dwell periods and limited idle time between duties. The vehicles are assumed to return to the Depot twice per day to support driver handover, but these stops are relatively brief, around one hour on average, and therefore provide only constrained opportunities for charging. This is reflected in the much lower Depot share, with only around 36% of daily energy demand delivered at the Depot despite the use of higher power charging at handover points.

At the same time, this operating pattern is associated with the highest daily energy requirement, at approximately 965 kWh/day (over all HGV types), driven by long daily distances and near-continuous utilisation. As a result, charging demand may become more distributed across Destination and En-Route locations, where short top-up events are more likely to be required to sustain the duty cycle. Compared to Day Driver operations, this duty cycle offers significantly less energy flexibility, as charging windows are shorter, tightly constrained, and closely tied to fixed handover and service schedules.

3.3.1.3 Long-Haul Trampers



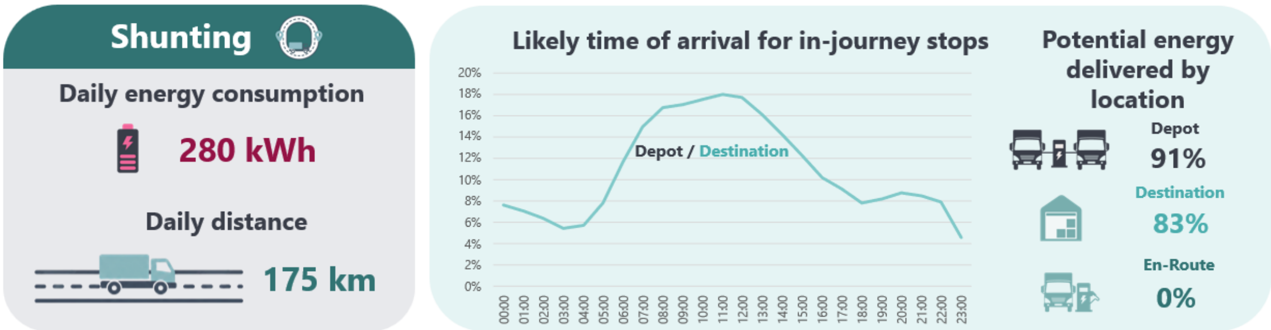
Long-haul tramper operations are the least compatible with Depot-based charging and the most dependent on charging away from base. In this duty cycle, the vehicle is assumed to remain away from the Depot for several days at a time, returning only at the end of a shift cycle, which significantly reduces the role that overnight Depot charging can play in meeting routine energy demand. It is estimated around 3% of daily energy demand can be delivered at the Depot when this pattern is averaged over time, with the majority instead needing to be met at Destination sites and Dedicated En-Route locations.

This aligns with the broader operational pattern of long-distance, one-way or extended round-trip work, where stop opportunities are governed less by Depot return and more by mandated driver rest periods, customer dwell times and strategic pauses during the journey. With daily energy demand of around 760 kWh (across all HGV types), these vehicles are likely to require regular high-power charging away from base in to remain feasible within current operations. Consequently, long-haul tramper work offers the least energy flexibility of the three driver types, charging must be integrated into tightly constrained long-distance operations rather than shifted into flexible Depot dwell periods.

3.3.2 By journey type

Again, looking across all HGVs in the UKPN area, this section considers how different journey types shape stop patterns, dwell times and, in turn, where charging is most likely to occur.

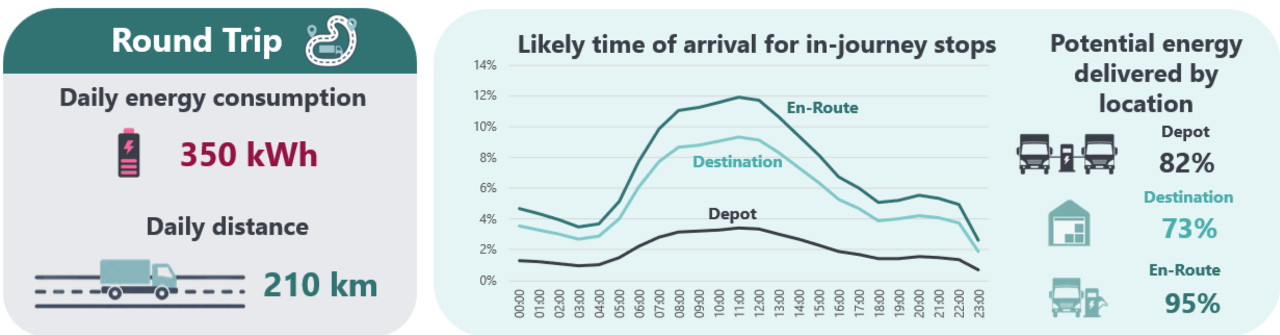
3.3.2.1 Shunting operations



Shunting operations involve short, frequent movements between Depots and nearby customer or terminal locations. They have little or no true En-Route stopping. In the example shown, this duty cycle has an average daily distance of around 240 km and daily energy demand of approximately 280 kWh. As vehicles return repeatedly to known operational sites, charging opportunities are concentrated at Depot and Destination locations rather than across the wider road network.

The analysis indicates that around 91% of daily energy demand could be met at the Depot and 83% at Destinations, while En-Route charging makes no contribution. This means that Shunting retains a useful degree of energy flexibility within current operations. However, that flexibility is confined to controlled sites where vehicles stop regularly, rather than to public or Dedicated En-Route infrastructure.

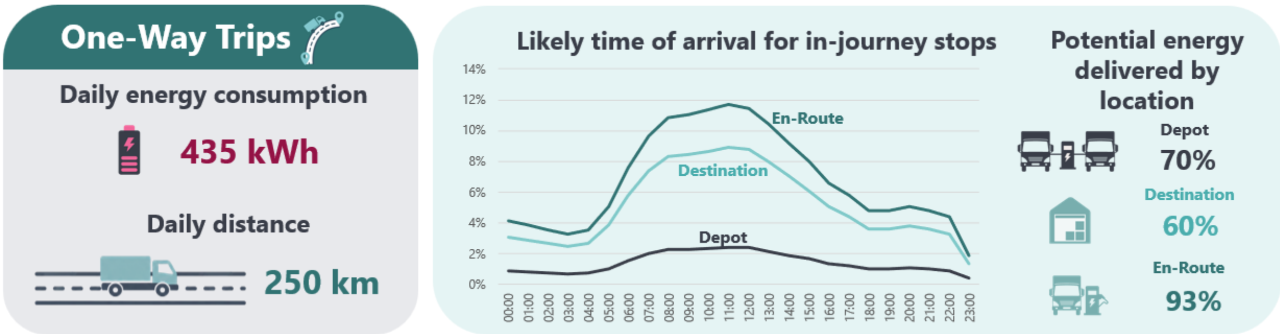
3.3.2.2 Round-trip operations



Round-trip operations present a more distributed charging profile. These journeys are defined by a return movement between Depot and Destination, but with distances and duty lengths that can require additional stops away from base during the day. Over all HGVs in the UKPN area, the operation is associated with an average daily distance of around 210 km, which increases the likelihood that charging may be needed not only at Depot and Destination sites, but also at Dedicated En-Route locations.

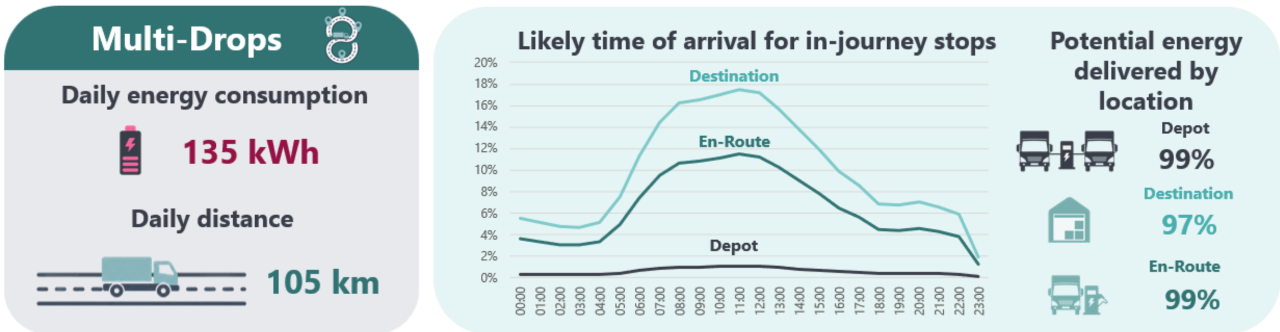
Around 82% of daily energy demand could be met at the Depot, 73% at Destinations and as up to 95% at En-Route locations, where suitable infrastructure is available. This suggests that round-trip operations retain meaningful Depot energy flexibility but also have strong potential for non-Depot charging because the route structure naturally creates opportunities for short top-up events during the working day.

3.3.2.3 One-Way Trip operations



One-Way Trip operations have a similar overall charging pattern to Round Trips. In this operating model, the vehicle is more likely to continue from one Destination to another, or to reposition before eventually returning to base, which reduces both the frequency and duration of returns to the Depot. This is reflected in the graphic, which shows that around 70% of daily energy demand could be met at the Depot, compared with 60% at Destination locations and 93% en route.

3.3.2.4 Multi-Drop operations



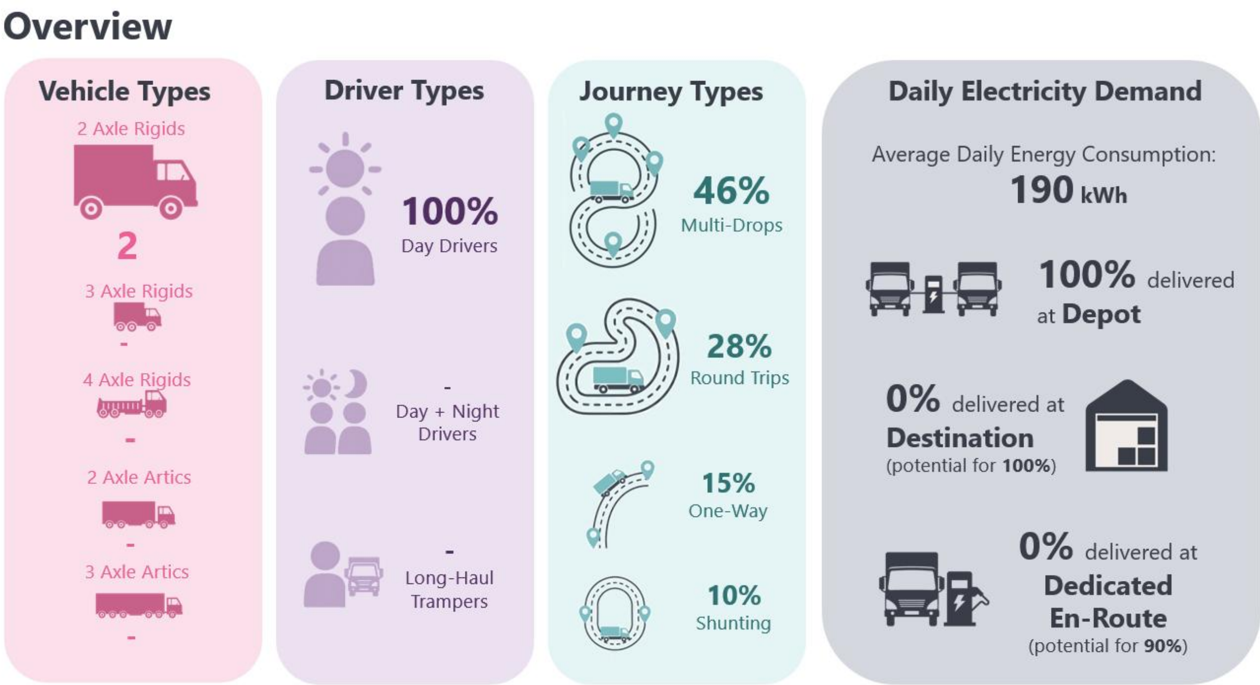
Multi-Drop operations show the highest overall charging flexibility of the journey types considered. These trips are typically associated with smaller rigid vehicles undertaking shorter daily distances, but with frequent stopping throughout the route as goods are delivered to multiple customers. Over all HGVs in the UKPN area, the operation is associated with an average daily distance of around 105 km and daily energy demand of approximately 135 kWh.

Although the total energy requirement is lower than for the other journey types, the stop pattern creates numerous opportunities to charge across all three location types. The chart indicates that around 99% of daily energy demand could be met at the Depot, 97% at Destinations and 99% en route. This reflects the fact that Multi-Drop vehicles combine a return-to-base pattern with repeated intermediate stops, creating multiple charging opportunities without requiring changes to the underlying operation. As a result, Multi-Drop work appears to offer the greatest level of charging location choice within current duty cycles.

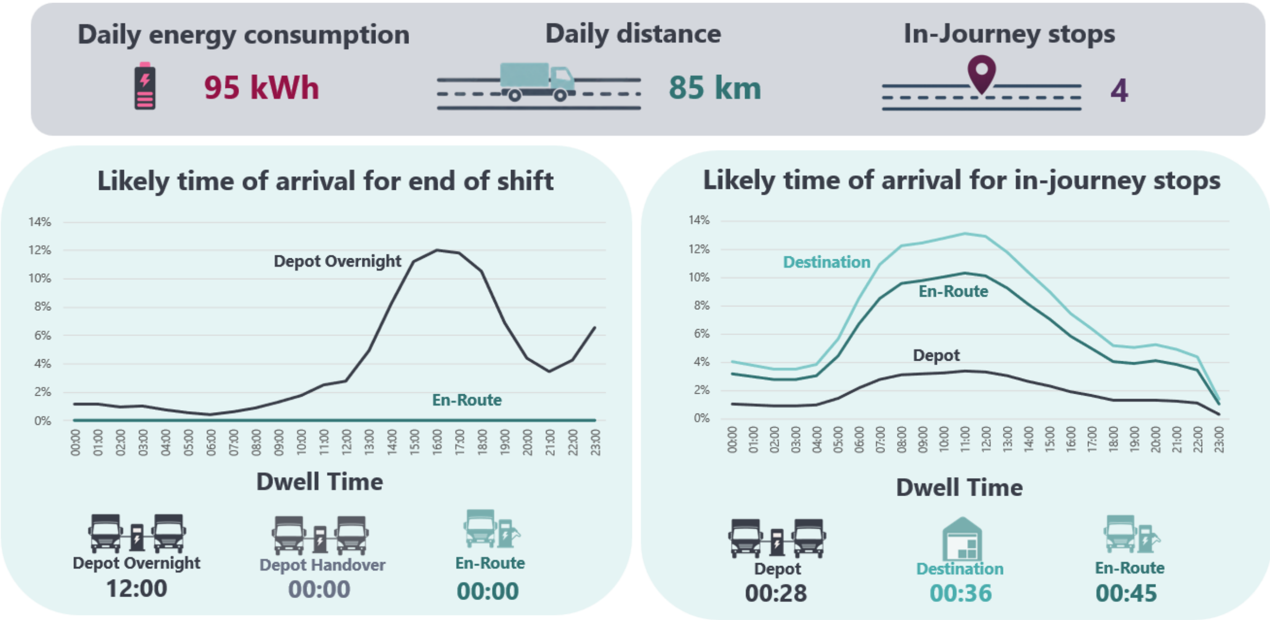
3.4 Energy demand for fleet types

The following fleet archetypes combine the assumptions on vehicle mix, operational pattern and charging behaviour set out earlier in this report. For each archetype, this section summarises the estimated daily energy requirement and likely arrival times and dwell durations for both end-of-shift and in-journey stops. Together, these results indicate where charging demand is most likely to arise and where there may be energy flexibility within existing fleet activity.

3.4.1 Restricted – One Man Bands



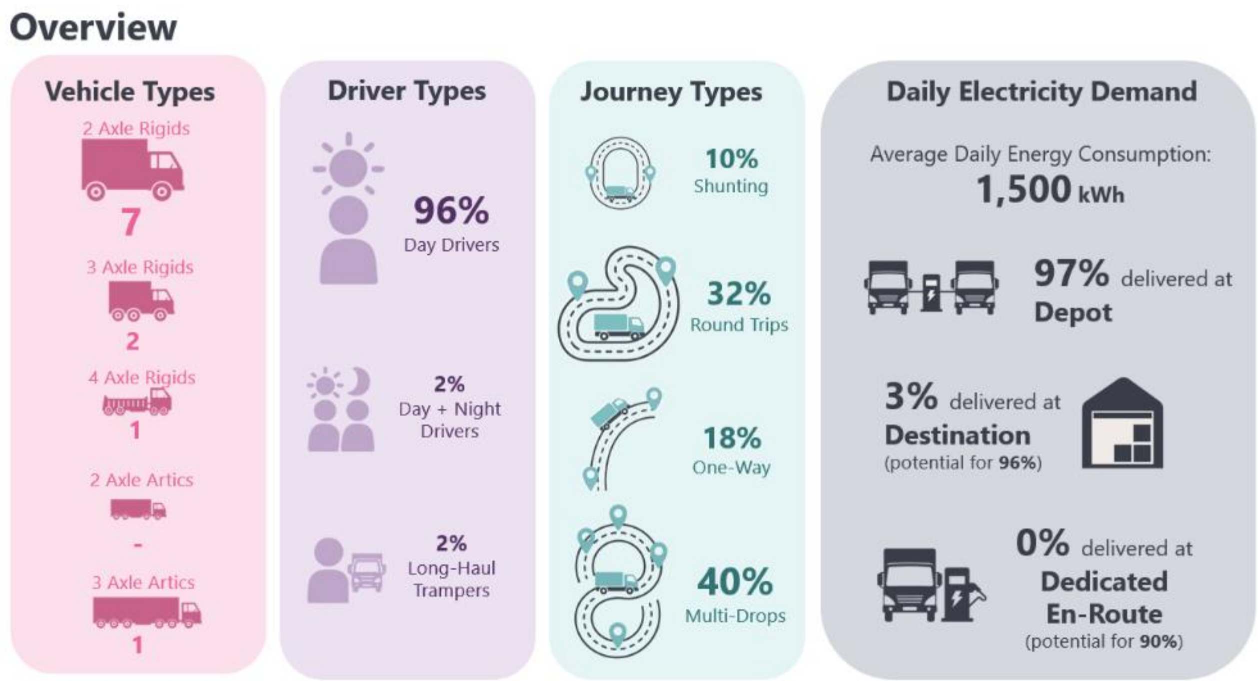
Average Vehicle

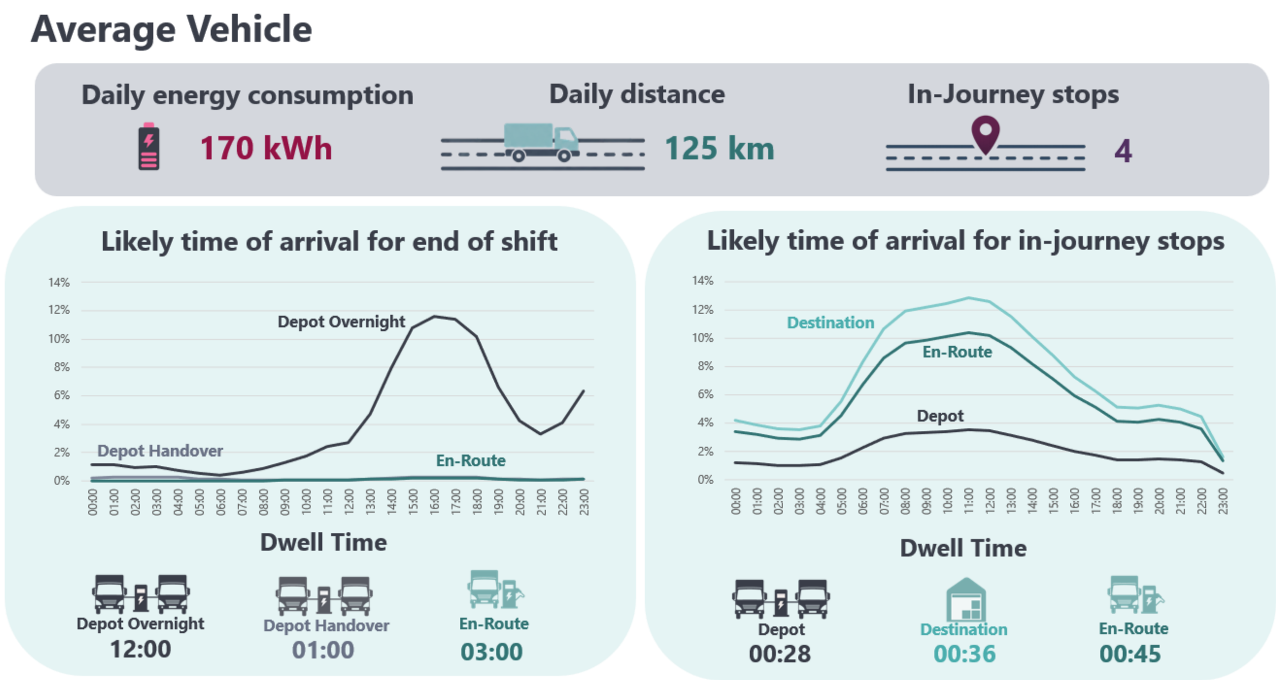


The Restricted One-Man-Band archetype broadly represents Depots with fewer than five HGVs, typically centred on smaller 2-axle rigid vehicles. These vehicles are assumed to operate almost exclusively as Day Drivers, with an average daily distance of around 85 km and daily energy demand of approximately 95 kWh. As shown in the graphic above, this operating pattern is highly compatible with Depot-led charging because vehicles return to base each day and benefit from a long overnight dwell window. Under the Base Case assumptions, the full daily energy requirement can therefore be met at the Depot, without routine reliance on Destination or En-Route charging.

The figures also indicate that Destination and En-Route charging could still be feasible if required, but in practice these would be supplementary rather than essential. Given that this archetype represents a substantial share (18%) of the overall HGV fleet, it suggests that a large proportion of smaller operators may have comparatively straightforward charging requirements, provided Depot charging is available.

3.4.2 Restricted – SMEs

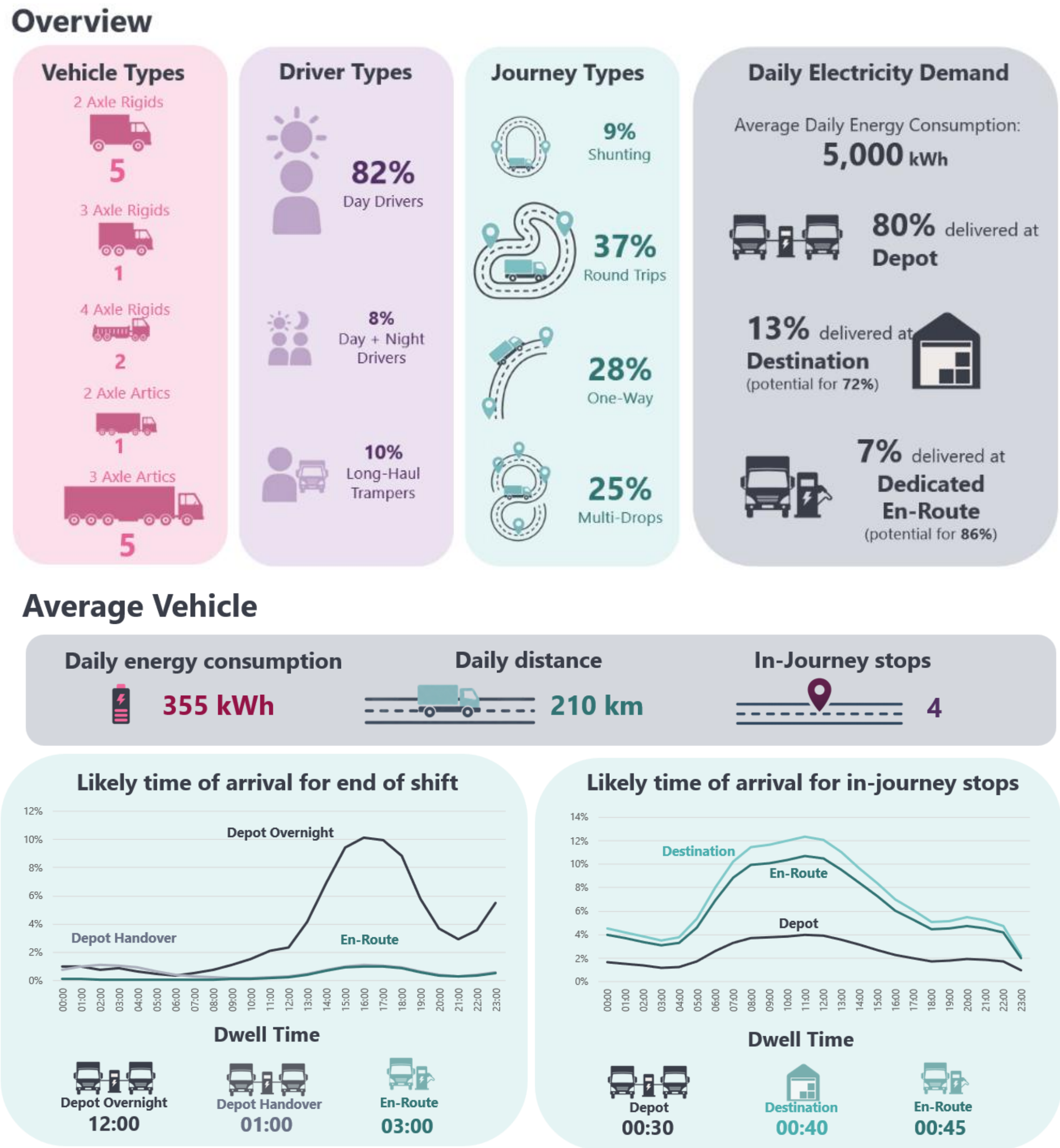




The Restricted SME archetype represents Depots with around 5 to 50 HGVs, with an average of approximately 11 vehicles per Depot. The fleet remains dominated by smaller rigid vehicles and, as a result, is still largely characterised by Day Driver operation, with only a limited proportion of day-and-night use. Around 96% of vehicles are expected to be stationary at the Depot overnight, and approximately 95% of total daily energy demand can be met at the Depot under the Base Case assumptions.

Only a small share of demand is expected to fall to Destination or En-Route charging. At the same time, the figure suggests that these fleets retain large energy flexibility beyond the Depot, particularly because Restricted SME operations are still strongly associated with Round Trips and Multi-Drop journeys. Where required, a high proportion of energy could also be delivered during Destination and En-Route stops, but the dominant pattern remains Depot-led charging supported by long overnight dwell periods.

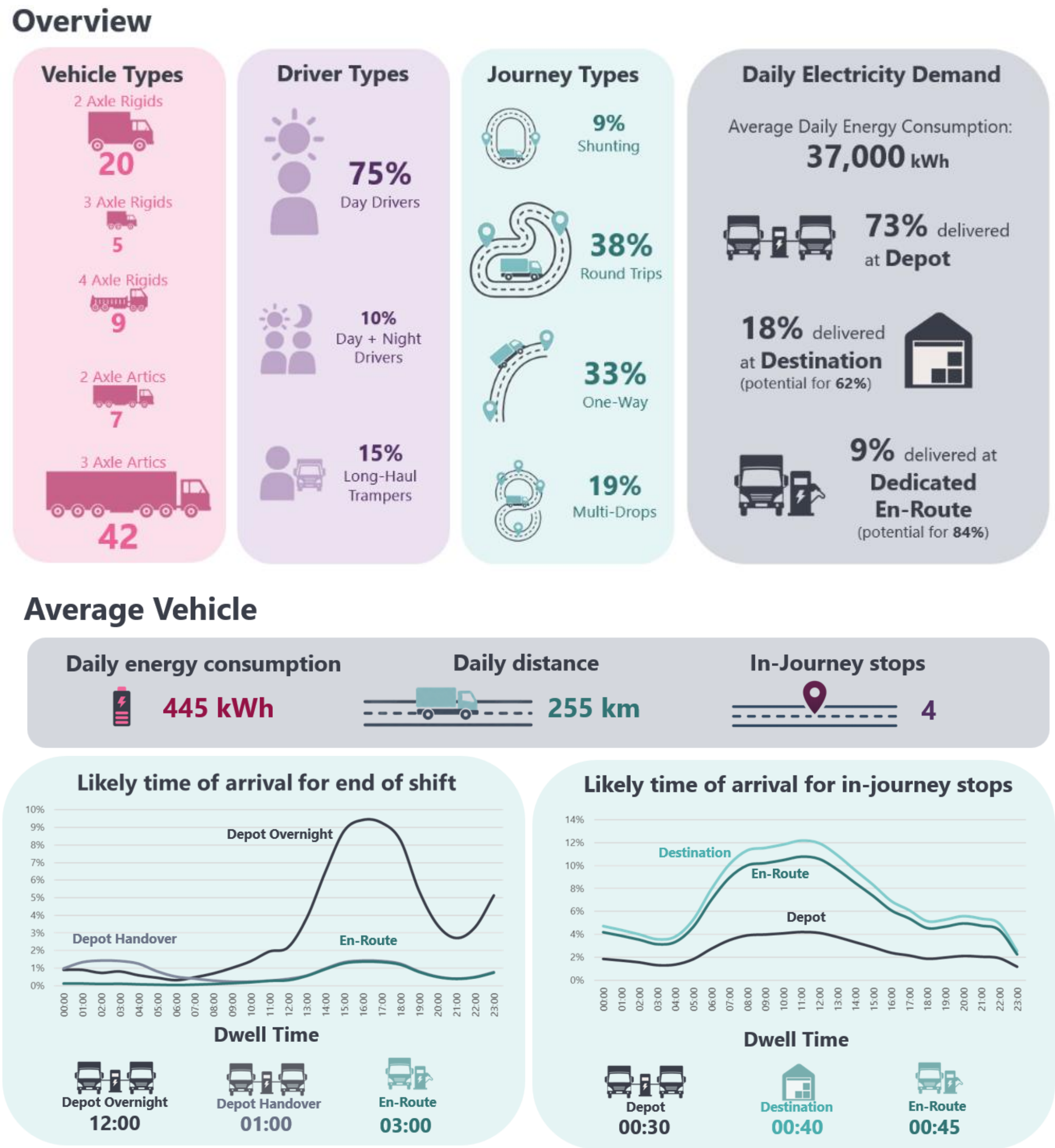
3.4.3 Standard National - SMEs



The Standard National SME archetype consists of Depots with 5 to 50 HGVs and an average of around 14 vehicles per Depot. In contrast to the Restricted archetypes, this fleet is made up of more articulated vehicles undertaking longer-distance work. The graphic indicates a more mixed operating model, with Day Drivers still forming the majority of drivers, but with a meaningful contribution from Day + Night Drivers and Long-Haul Trampers. This reduces the proportion of charging that can be concentrated at the Depot to around 80%.

The figure therefore highlights a transition point between largely Depot-based charging and more distributed charging demand. These fleets still have a choice of where to charge but are more constrained by operational intensity and longer vehicle utilisation compared to smaller rigid-based fleets.

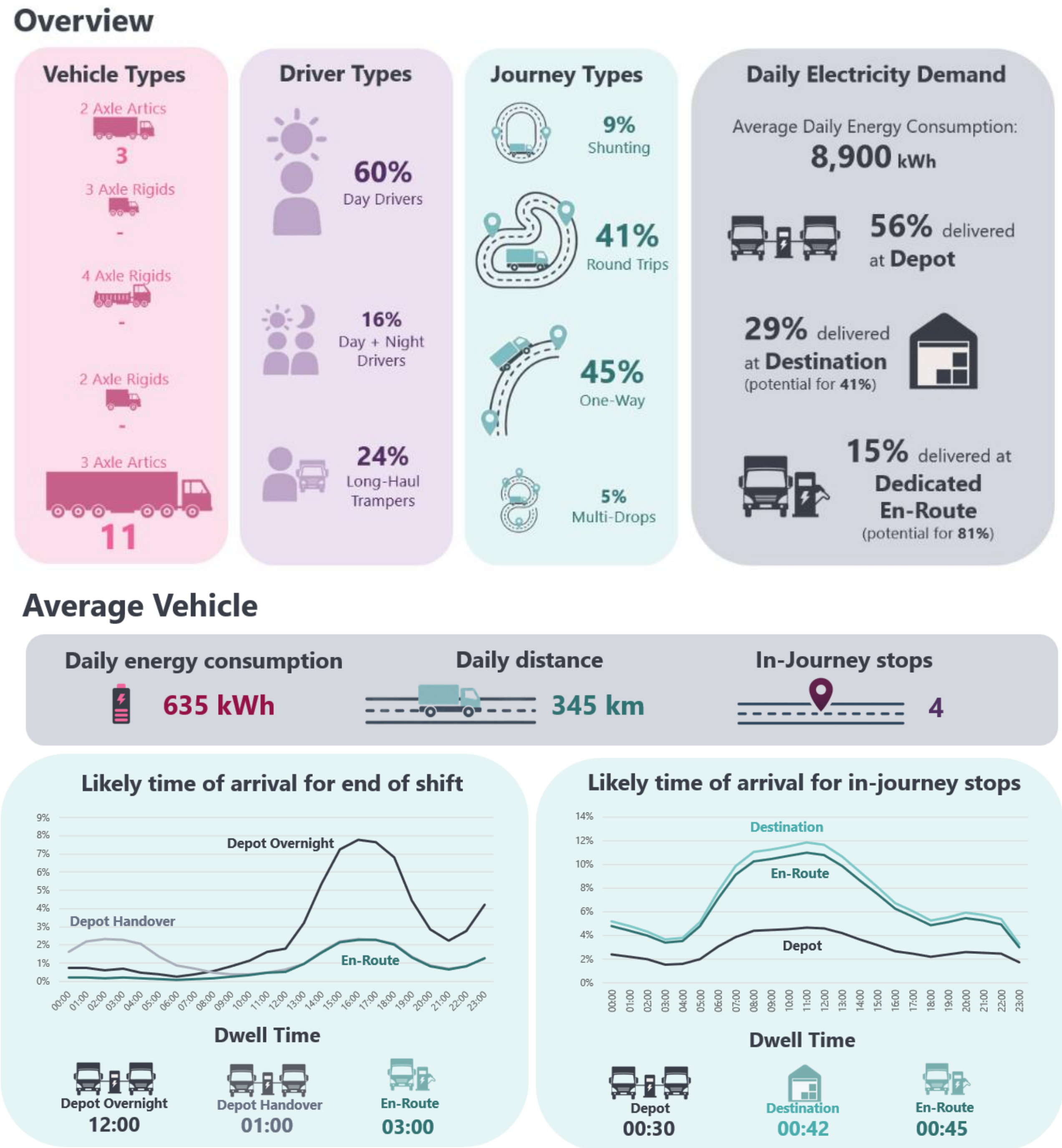
3.4.4 Standard National – Large Fleets



The Standard National Large Fleet operator has more than 50 HGVs per Depot, with the Depot likely remaining as the single most important charging location. However, the charging profile is materially more complex than for smaller fleets. Around 79% of vehicles are expected to be stationary at the Depot overnight, resulting in an estimated 73% of total daily energy demand being met at the Depot, with the remainder split across Destination and En-Route charging.

The presence of Day + Night Driver operations is particularly important here, because these vehicles have less time available for charging and therefore require more active management of charging opportunities during the day. The chart also indicates that substantial energy flexibility exists outside the Depot if infrastructure is available, especially at En-Route locations. In practice, this means that large Standard National fleets are still likely to be primarily Depot-led for charging, but with a growing dependency on complementary non-Depot charging to support higher-utilisation operations.

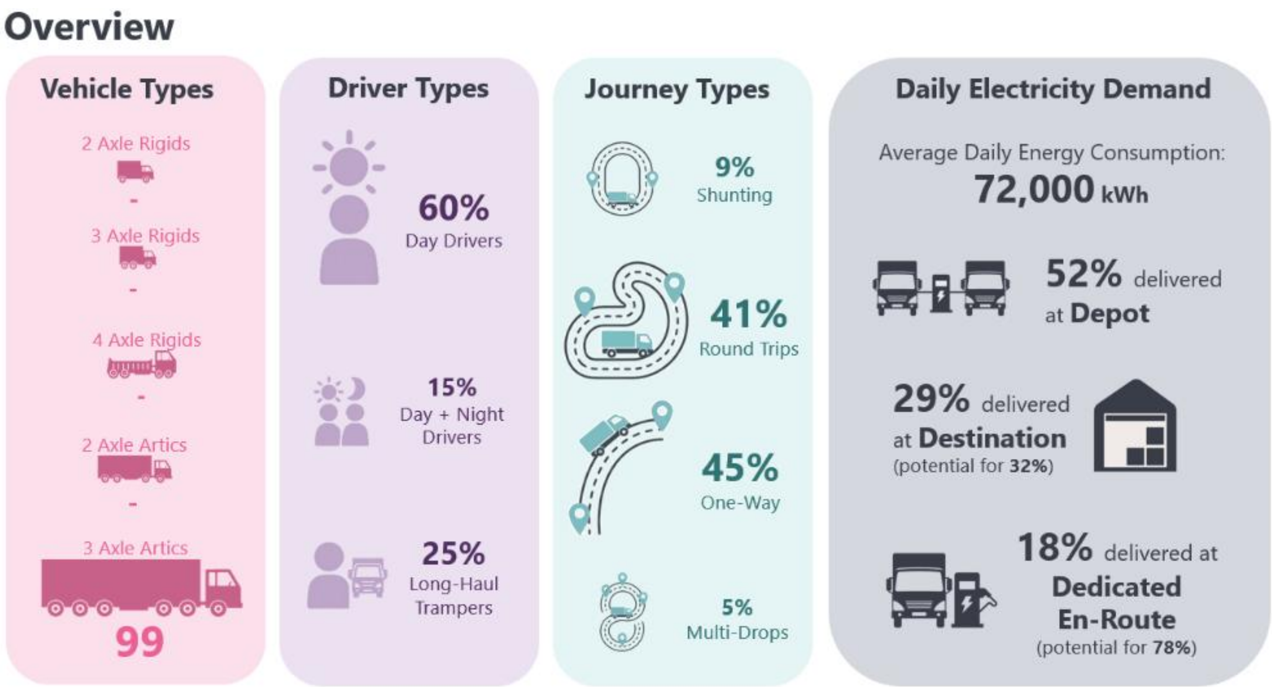
3.4.5 Standard International – SMEs

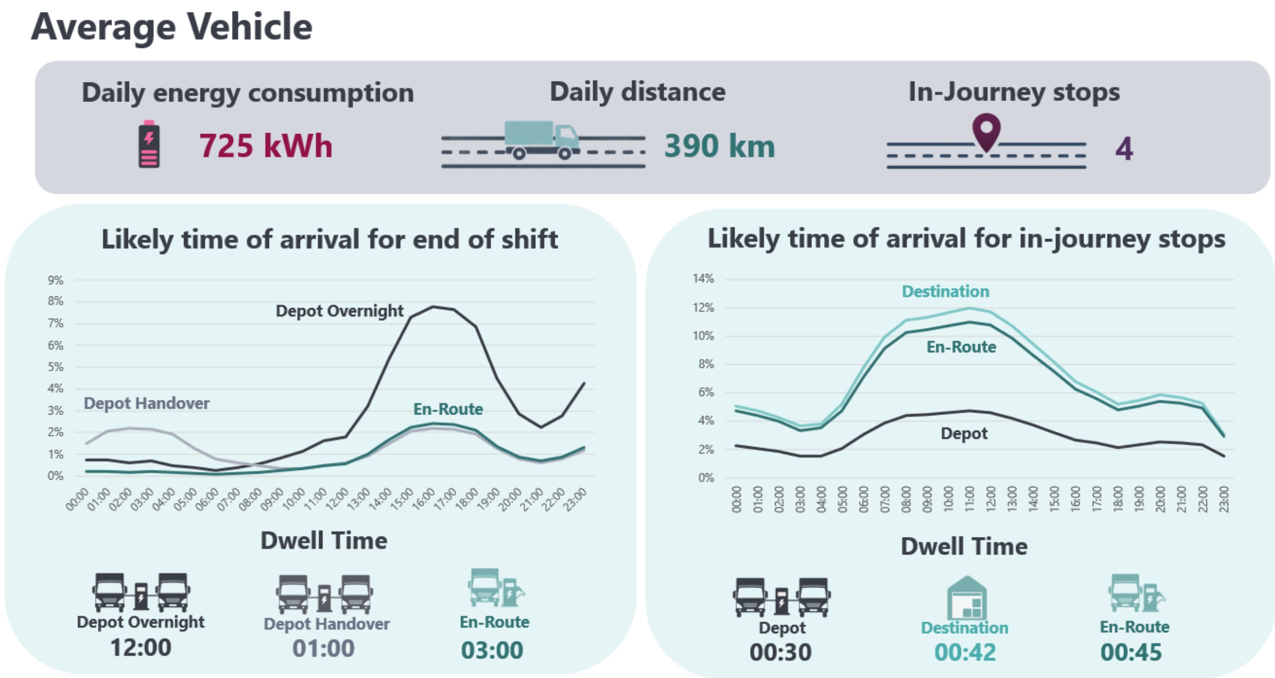


The Standard International SME fleet archetype represents Depots with around 14 HGVs on average, typically made up of larger 2- and 3-axle articulated vehicles. These vehicles are associated with longer daily distances and higher daily energy consumption than the rigid-dominated fleets discussed above. The corresponding graphic shows a broader mix of driver types, with Day Drivers still the largest group but with a significant share of Day + Night Drivers and Long-Haul Trampers.

This has a direct effect on charging behaviour: only a little over half of total daily energy demand is expected to be met at the Depot, while Destination and En-Route charging play a much larger role. The reduced Depot share reflects shorter or less frequent returns to base, as well as the operational constraints of higher-utilisation vehicles. As a result, this archetype has less energy flexibility than the Restricted or Standard National categories and is more dependent on strategically located non-Depot infrastructure to support routine operation.

3.4.6 Standard International – Large Fleets





The Standard International Large Fleet archetype represents the most operationally demanding of the fleet types considered, with Depots of more than 50 HGVs and an average of 99 vehicles per Depot. These fleets are expected to be dominated by 3-axle articulated vehicles and to include a relatively high share of Day + Night Drivers and Long-Haul Trampers. As shown in the graphic above, this combination results in the lowest Depot charging contribution of the archetypes presented, with only around half of daily energy demand expected to be delivered at base. The remainder must be met through Destination and, En-Route charging.

This reflects the fact that many vehicles in this category either do not return to Depot daily or only do so for limited periods, reducing the scope for lower-power overnight charging. Consequently, while Depot charging remains important, these fleets are much more reliant on high-power charging away from base and offer less flexibility to shift charging without affecting operations. From a system-planning perspective, this archetype is therefore likely to be one of the strongest drivers of demand for strategically located public or shared charging infrastructure.

3.5 Operational flexibility

When planning eHGV demand and charging infrastructure, it is important to understand the degree of operational flexibility that can be introduced without disrupting the day-to-day logistics requirements of fleet operators. This includes understanding where charging can be shifted or optimised around depot operations, delivery schedules and driver breaks. The degree of operational flexibility directly influences the potential for energy flexibility.

Currently, fleet operators need to fit within customer timings, with meeting customer needs being the priority. The operational flexibility discussed in this section reflects this constraint, rather than thinking of new operational patterns that may better suit eHGVs.

To understand the operational flexibility, a workshop was organised with the fleet representation in Future Fleet. From the workshop, insights around the flexibility within their standard operations was understood, with a summary by operation type shown below.

Day Driver

✗ Tight start-time constraints

Start time variation usually less than one hour day-to-day for fatigue management.

✗ Tight drop-off constraints

Drivers cannot delay departure or delivery just to optimise energy use.

✓ Return-time flexibility

More flexibility on when trucks return to depot than when they leave. However, this depends on how the day progresses (traffic) and remaining driver hours.

Day + Night Driver

✗ Handover constraints

A vehicle is continuously utilised across two shifts, so the driver must return in time for the next shift. Typical handover is 45 minutes to an hour.

✗ High utilisation

Most intensively used assets and planners aim to keep trucks working across both shifts

✓ Some handover flexibility

Some shifts are variable and there could be a longer handover time, but this depends on workload and scheduling.

Long-Haul Tramper

✗ Often hardest workers

Often end up doing the longest working days and journeys, meaning less flexibility during this time.

✓ Seasonal variation

Peaks and troughs in workload means there will sometimes be more flexibility, but is uncertain

✓ High route flexibility

These journeys are often the last to be planned as they can be very flexible with where they start and stop. This could allow for some flexibility throughout the journey.

Shunting

✗ Limited control over stop timing

Drivers cannot choose when loading/unloading happens or speed up site processes.

✗ No time for extra stops

No opportunity for additional or longer en-route stops

✓ Some shunting types may be flexible

There are different types of shunting and in some cases stops could be extended to allow for longer charging windows.

Round Trip / One-Way / Multi-Drop

✗ Limited control over stop timing

Drivers cannot choose when loading/unloading happens or speed up site processes.

✓ Planning enables flexibility

If jobs are planned well there is likely some flexibility that can be found. This could be arriving early at the destination or including en-route stops

All operations

Customer-led scheduling dominates

Operations are fundamentally driven by customer requirements (delivery slots, contracts). Drivers cannot delay departure or delivery just to optimise energy use.

Driver hour regulations

10-hour day is typical. There is a maximum of 15 hours a day, but using extra hours reduces flexibility later in the week.

Operations already highly optimised

Industry is described as low-margin and highly optimised already. Limited "slack" to extract further efficiency without trade-offs

Increasing electrification reduces flexibility

When eHGVs are a small share there can be flexible assignment. As the eHGV share grows, the fleet must meet overall fixed demand, reducing flexibility.

Both operators emphasised that existing fleets are already utilised intensively, meaning there is limited "unused" operational capacity available within the system. As such, any operational constraints introduced by electrification must be carefully managed within already tightly optimised logistics networks.

However, the discussions also demonstrated that operators are willing to adapt operational practices where flexibility can be introduced without creating additional driver hour, mileage, or service penalties. This operational flexibility is most viable during periods when vehicles are returning to the Depot after dropping off cargo. Operators noted that charging opportunities could be opportunistically integrated into the working day, particularly when vehicles return to Depot between jobs or arrive earlier than required for customer deliveries. Fleet operators are already beginning to respond dynamically to electricity pricing signals and are willing to modify operational behaviours where practical benefits exist.

Importantly, operators distinguished between operational flexibility and commercial flexibility. Although some schedule adjustments may technically be possible, the feasibility is heavily dependent on customer operating windows and distribution centre opening hours. The ability to shift charging or delivery activity into evenings or weekends is therefore constrained not only by fleet operations, but also by wider supply chain practices and customer requirements. This suggests that future eHGV charging strategies will need to account for interactions across the broader logistics ecosystem rather than focusing solely on fleet Depot operations.

Overall, the operator feedback indicates that while there is some flexibility within logistics operations to support smart and managed charging approaches, this flexibility is limited and highly conditional. Opportunities are most likely to arise through short-duration daytime charging, utilisation of natural Depot dwell periods, and dynamic response to electricity pricing signals, rather than through large-scale rescheduling of logistics operations. Consequently, eHGV infrastructure planning should seek to enable flexible and opportunistic charging solutions that align with existing operational patterns, while minimising disruption to highly optimised freight movements.

4. Future Enhancements for Beta

The Future Fleets project is currently in Alpha stage of the Strategic Innovation Fund, with the aim of progressing to a Beta demonstration project. There are many enhancements and further areas to explore in the Beta stage based on this work. This section provides an overview of these opportunities.

4.1 Fleet engagement

During the next stage Energy Systems Catapult would recommend engaging with a more operationally diverse set of fleet operators and ensuring sufficient time to distinguish different use types in greater depth and detail. It will also be essential to articulate the potential benefits of energy flexibility to fleet operators to secure their time. Networks will only benefit from eHGV charging flexibility if fleets, as the consumers, recognise the benefits and are willing to engage and adopt smart or flexible charging.

Work should be carried out to consider the fleet-facing proposition and how to demonstrate the value of energy flexibility to consumers.

4.2 Site flexibility tool

The spreadsheet developed and made available for use in this work package could be further developed into a tool that provides rapid insights for fleet operators (see Appendix for user instructions). The spreadsheet already has the capability to dynamically change the number of vehicles by type, the driver types and journey types. These inputs dynamically update summary outputs, including:

- average battery size;
- average daily distance;
- average daily energy consumption;
- number of stops by location;
- % of HGV stopped overnight (by Depot and En-Route) / don't stop overnight;
- energy that could be delivered at each location;
- arrival times at different location; and
- dwell times by location.

This could be enhanced to include energy flexibility options, allowing fleets to quickly assess how different solutions could benefit their specific operations.

4.3 Hardest to electrify operations

The modelling indicates that Day + Night Drivers undertaking Shunting operations may be among the most challenging to electrify. This is due to these vehicles typically operating at high daily utilisation with limited downtime. Although these vehicles stop frequently, these stops are short and generally limited to Depot and Destination locations. Under the Base Case assumptions, Depot and Destination locations are assumed to have lower-power chargers than Dedicated En-Route sites. This means the lower powered chargers may not be able to deliver the energy required.

While this may indicate a need for higher-power chargers at Depot or Destination sites, it warrants further investigation, alongside other hard-to-electrify operations. For example, it could be trialled to see how these difficult to electrify trips could be charged within current operation patterns. Alternatively, the level of operational flexibility for these use cases could be tested in practice.

This could then feed into analysis on how this would impact the energy system, given the constraints on the times of charging for these eHGVs.

4.4 Operational flexibility

A workshop was conducted with Future Fleet operators to explore operational flexibility. This indicated that, while eHGV deployment remains low, operational flexibility has not yet been widely tested with these vehicles. This is because eHGVs are currently deployed only on routes that align with their existing capabilities. While eHGVs represent a small proportion of fleets, they are typically assigned to the most suitable operations. As a result, there has been limited need to introduce operational flexibility specifically to accommodate eHGVs.

Workshop feedback suggested that flexibility could be introduced across many operations; however, this should be tested in the Beta stage, particularly for more challenging routes and less flexible customer environments.

Feedback was gathered from a limited number of fleet operators. The level of operational flexibility is likely to vary by operator. A wider set of fleets could be interviewed in the Beta stage to fully understand the level of operation flexibility in the HGV market and how it may differ by type of fleet operator and customer type.

4.5 Data gaps

Data was gathered from only two fleets and represents a limited subset of their full datasets. This reflects both time constraints (as data extraction and formatting can be resource-intensive) and concerns around commercial sensitivity, given the limited number of participating fleets.

This means eFREIGHT 2030 outputs were relied on heavily for this project, which were also limited to the largest HGVs, with new fleet data used to inform assumptions on how to repurpose for use in this study. As such, the analysis provides an indicative view of operational patterns; however, a more robust dataset would strengthen the findings. Including additional fleet operators with a wider range of operations would improve both the scale and representativeness of the dataset.

To use this data for network planning, a more robust set of data will be required to properly understand potential times of high demand on the network.

4.6 Rigid HGV gap

Both the eFREIGHT 2030 and Future Fleet projects have primarily focused on articulated HGV fleets. In eFREIGHT 2030, only the data from articulated HGVs was provided. For Future Fleet, the fleet operators only ran articulated HGVs.

This creates a significant gap in understanding of rigid HGVs, which account for approximately 67% of the fleet. These vehicles and their operational characteristics should be investigated further during the Beta stage. Addressing this gap would strengthen network planning and ensure rigid HGV operations are fully incorporated into energy flexibility analysis.

5. Summary

Future Fleet is a project designed to support the transition of the UK freight industry to electric heavy goods vehicles (eHGVs) by identifying the most efficient, cost-effective and grid-friendly approaches to charging. As operators move towards Net Zero, the significant power demands of eHGV charging risk placing pressure on local electricity networks, potentially driving up costs and requiring major infrastructure upgrades. Building on insights from the eFREIGHT 2030 project, Future Fleet develops a detailed, evidence-based understanding of how logistics operators use vehicles, where and when charging demand could arise, and how this demand could be managed more intelligently.

The project brings together UKPN, Energy Systems Catapult, Baringa, Voltempo, Maritime and Voltloader to test and model practical solutions such as smart charging, shared infrastructure models and on-site energy generation and storage. Energy Systems Catapult has led the development of fleet and charging-location archetypes, with associated insight into operator needs. This work informs energy demand modelling, identifies opportunities for smart energy schemes, and supports the development of business models for charging access. This report provides an overview of the fleet and charging location archetype study. This includes:

- the types of fleet operators and operations in the UKPN area;
- the potential electricity demand associated with a range of fleets and operation types;
- an overview of what could be taken forward in the Beta SIF stage; and
- a run-through of the archetype output spreadsheet.

5.1 Data and methodology

Data was primarily sourced from the eFREIGHT 2030 project and open government datasets, supplemented by insights and data from consortium fleet and chargepoint operators.

Workshops with consortium fleet operators were used to characterise real-world operating patterns. These were structured into representative driver and journey types to reflect how vehicles are used across the freight sector. As the consortium represents a limited sample of operators, some operation types may not be captured.

Charging locations were categorised through consortium-wide workshops, then specific charger characteristics were determined based on feedback from the chargepoint and fleet operators in Future Fleet.

Traffic Commissioners data was analysed to identify fleet operator types within the UKPN area and the likely HGV types they operate.

The operation types, vehicle types and location types were combined to characterise typical fleets, including their:

- average daily energy consumption and distance travelled;
- number of in-journey stops by location, with likely time of arrival and dwell time;

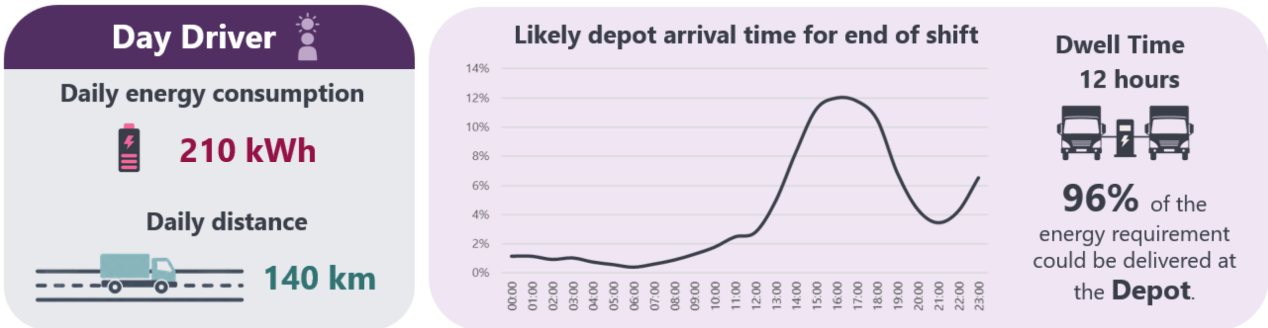
- number of shift handovers by location, with likely time of arrival and dwell time;
- typical eHGV battery sizes within the fleet;
- energy that could be delivered to eHGVs at each location; and
- likely locations for charging.

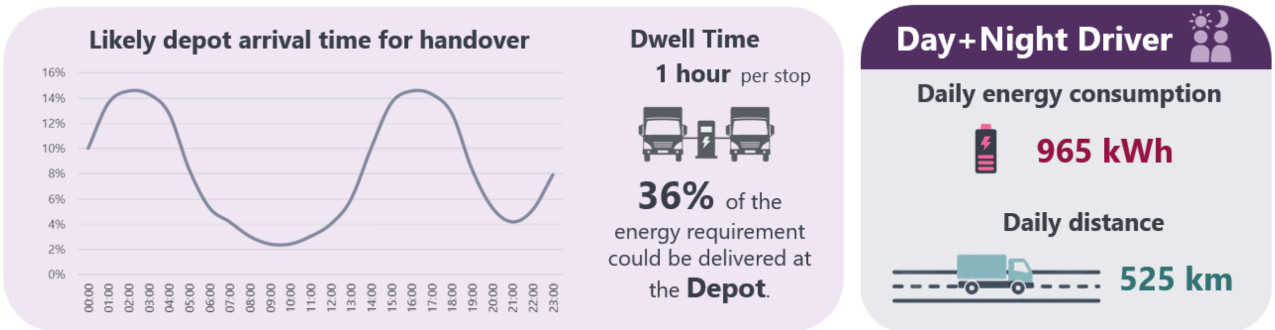
5.2 Operation Overview

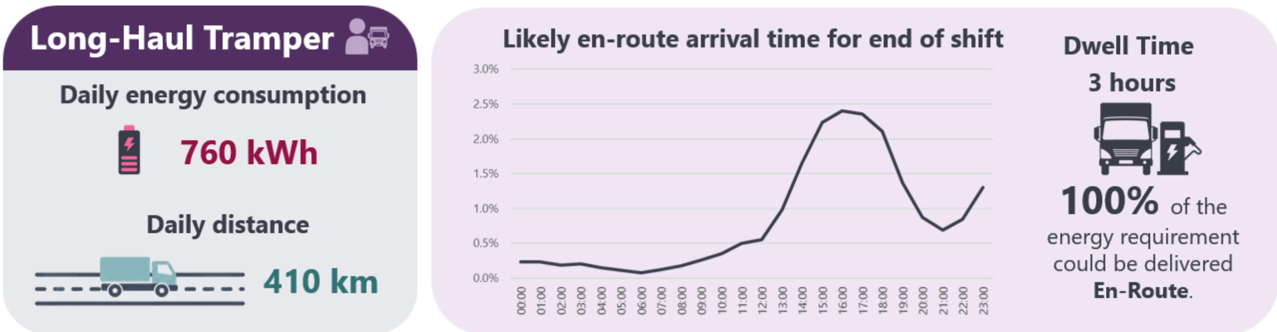
The different types of HGV fleet operation have been investigated as they will likely have different levels of energy flexibility potential. The operations are split into driver type and journey type, with the driver types including:

- **Day Driver**: only drives in the day and the HGV is stopped overnight.
- **Day + Night Driver**: double shifted, with handovers in the morning and evening.
- **Long-Haul Tramper**: driver sleeps in cab and can go anywhere.

An overview of average energy consumption, daily distance, end-of-shift time and dwell times is shown below for each driver type. The graphs show the percentage likelihood of an HGV arriving at a given time in the day. For example, for the Day Driver we estimate a 12% likelihood an HGV would arrive at 16:00. If there were 100 HGVs doing this operation in a fleet, we would expect 12 to arrive around this time.







Charging requirements are likely to be strongly shaped by operating patterns. The analysis suggests that Day Driver operations are generally the most compatible with Depot charging. This is because these vehicles benefit from long overnight dwell periods at Depots, allowing most daily energy demand to be met at the Depot. By contrast, the Day + Night Driver presents a different challenge, associated with higher daily energy demand coupled with short charging windows. This means a greater share of energy is likely to be delivered away from base locations. Long-haul tramper operations are the most constrained, as vehicles may remain away from Depot for several days and are therefore much more reliant on Destination and Dedicated En-Route charging. Broadly, as vehicle utilisation increases and Depot dwell time decreases, charging demand becomes more distributed and the opportunity for the energy flexibility offer by longer overnight charging at Depots falls substantially.

Another key factor in energy flexibility is the type of journey. The main journey types in this study are:

- **Shunting:** An HGV undertaking low-mileage, high-frequency movements between fixed locations.
- **Round Trip:** An HGV starts at a Depot with cargo, travels to a Destination where it drops it off, then picks up cargo at the same location and travels back to the original Depot.
- **One-Way Trip:** An HGV goes one-way (from a Depot to a Destination). If returning to a Depot it could do this empty, or it can go to another Destination to pick up cargo, then travel back to the original Depot.
- **Multi-Drops:** An HGV has multiple customers' cargo, so the truck stops in multiple Destinations along its route.

An overview of average energy consumption, daily distance, in-journey stop times and dwell times is shown below for each journey type. Again, the graphs show the percentage likelihood of an HGV arriving at a given location at a given time in the day. For example, for the Round Trip we estimate a 12% likelihood an HGV would arrive at an En-Route stop at 11:00. We also assumed a 9% likelihood an HGV will arrive at a Destination and a 3% likelihood of arrival at a Depot in the same hour. We would not expect a single HGV to be stopping at all these locations at once. Instead, if there were 100 HGVs doing this operation in a fleet, we would expect 12 to arrive at an En-Route stop, 9 to arrive at a Destination and 3 to arrive at a Depot within this hour.

One-Way Trips

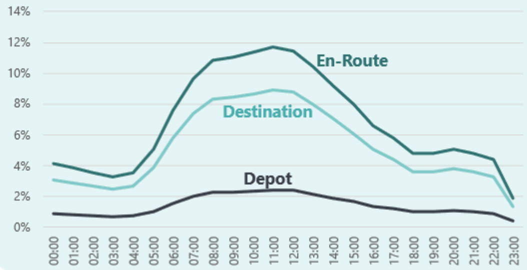
Daily energy consumption

435 kWh

Daily distance

250 km

Likely time of arrival for in-journey stops



Potential energy delivered by location

Depot **70%**

Destination **60%**

En-Route **93%**

Multi-Drops

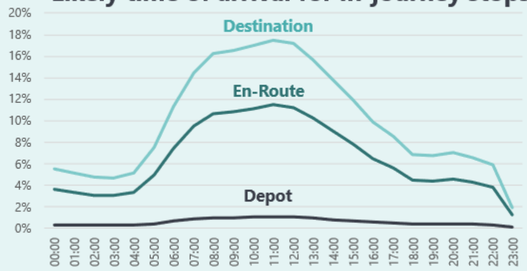
Daily energy consumption

135 kWh

Daily distance

105 km

Likely time of arrival for in-journey stops



Potential energy delivered by location

Depot **99%**

Destination **97%**

En-Route **99%**

Shunting

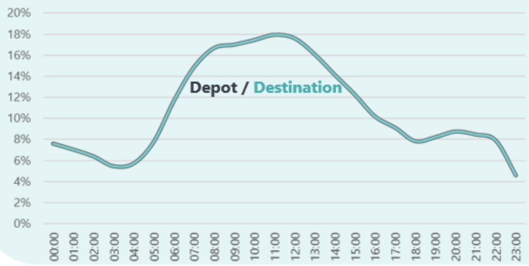
Daily energy consumption

280 kWh

Daily distance

170 km

Likely time of arrival for in-journey stops



Potential energy delivered by location

Depot **91%**

Destination **83%**

En-Route **0%**

Round Trip

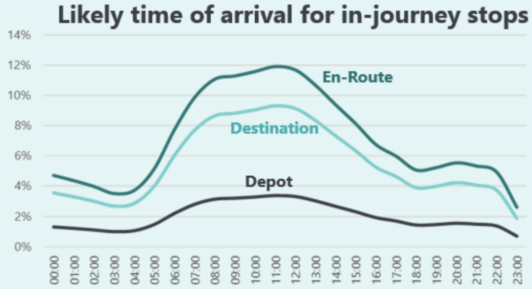
Daily energy consumption

350 kWh

Daily distance

210 km

Likely time of arrival for in-journey stops



Potential energy delivered by location

Depot **82%**

Destination **73%**

En-Route **95%**

Overall, Multi-Drop and Shunting operations may retain comparatively high energy flexibility because they combine lower daily energy demand with multiple stopping opportunities across Depot, Destination and, where needed, En-Route locations. Round and One-Way Trips, which are usually run by the larger articulated trucks, are less flexible because they have a lower number of Depot and Destination stops.

These findings show that both driver type and journey type should be considered when designing energy flexibility solutions, as many solutions may not be compatible with certain operations.

5.3 Fleet overview

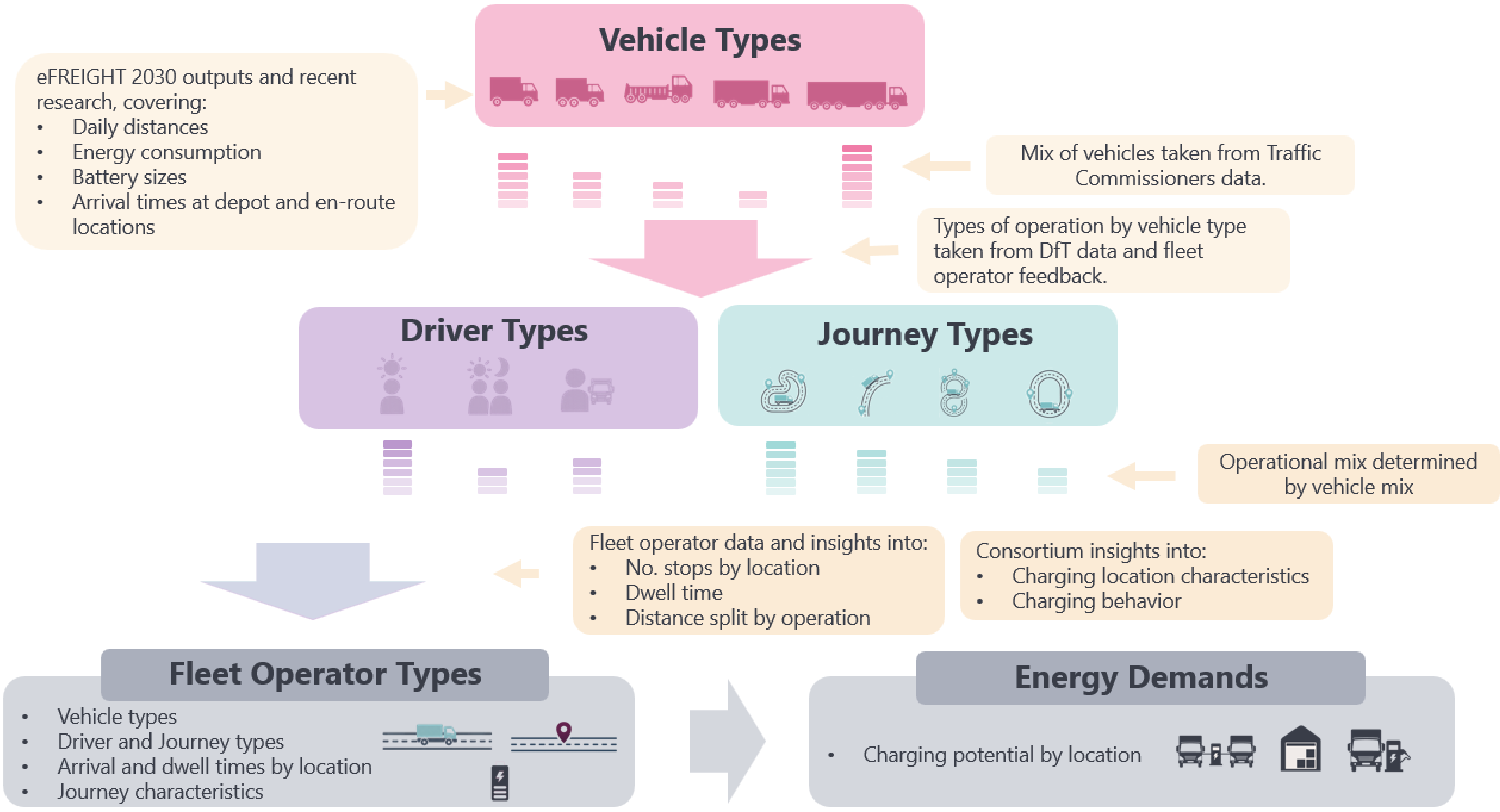
Fleet operators have been categorised based on licence type and size, with the licence categories being:

- **Restricted**: operators can only carry their own goods within the UK.
- **Standard National**: operators can carry their own goods and other people's goods within the UK.
- **Standard International**: operators can carry their own goods and other people's goods within the UK and internationally.

The fleet sizes per Depot are:

- **One-Man Bands**: under 5 HGVs per Depot.
- **SMEs**: between 5 and 50 HGVs per Depot.
- **Large Fleets**: over 50 HGVs per Depot.

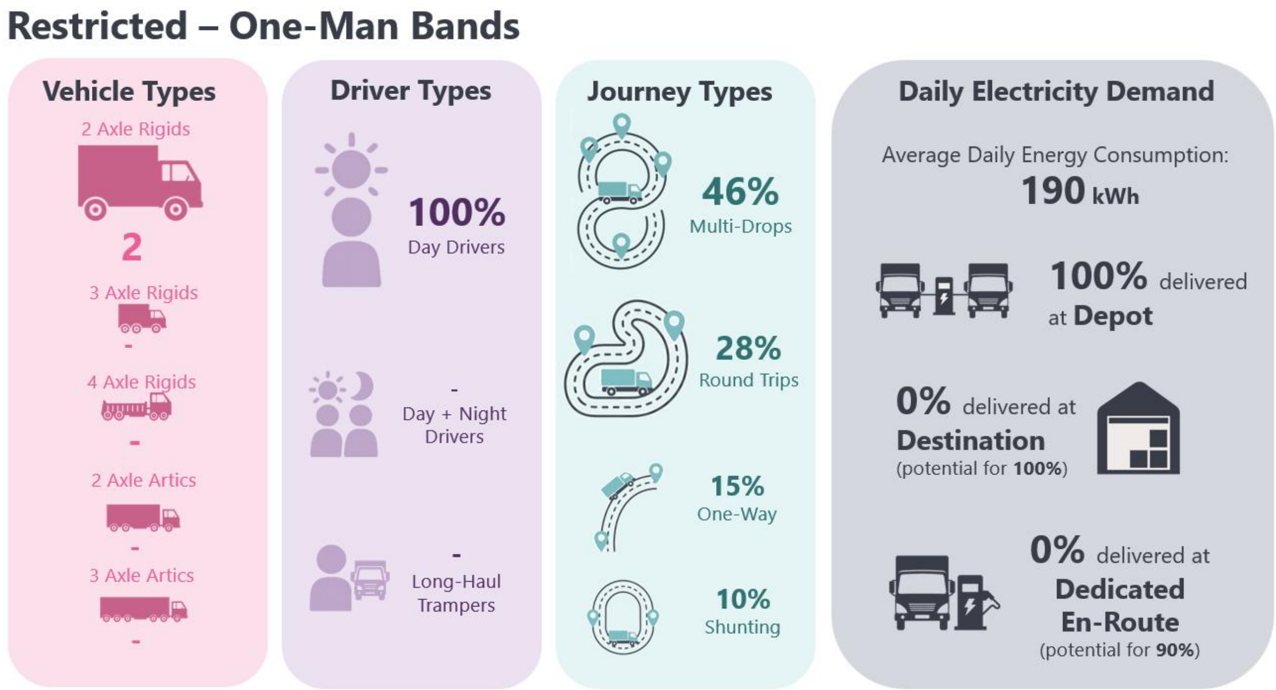
A summary of how the different types of HGV and operations combine to create fleet operator overviews, with the associated inputs and assumptions, is shown below.



Vehicle Types
eFREIGHT 2030 outputs and recent research, covering:
• Daily distances
• Energy consumption
• Battery sizes
• Arrival times at depot and en-route locations
Mix of vehicles taken from Traffic Commissioners data.
Types of operation by vehicle type taken from DfT data and fleet operator feedback.
Driver Types
Journey Types
Operational mix determined by vehicle mix
Fleet operator data and insights into:
• No. stops by location
• Dwell time
• Distance split by operation
Consortium insights into:
• Charging location characteristics
• Charging behavior
Fleet Operator Types
• Vehicle types
• Driver and Journey types
• Arrival and dwell times by location
• Journey characteristics
Energy Demands
• Charging potential by location

Selected fleets are shown below to give a sense of the range in fleet types in the UKPN area. Further fleet types are also explored in the main report.

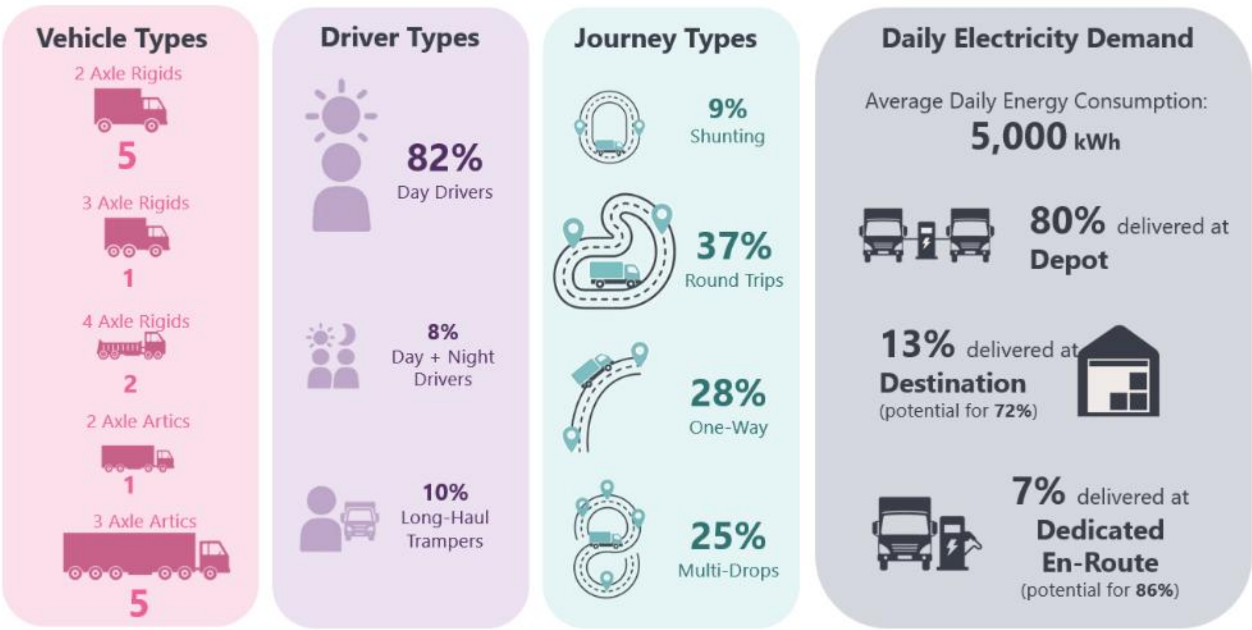
At the smaller end of the spectrum, we have the Restricted - One-Man Bands fleet.



These operators typically own between one and two HGVs which they use to carry their own goods. These fleets may be well aligned with Depot-based charging, given they are likely dominated by Day Drivers, with the HGV stopped at the Depot overnight. This suggests that, where Depot access is available, these fleets may have substantial energy flexibility in scheduling overnight charging. Although Destination charging may not be required to complete journeys, there remains substantial theoretical flexibility to use Destination or Dedicated En-Route charging if needed, without fundamentally changing the nature of their operations.

As fleets become more diverse in vehicle composition and operating patterns, daily eHGV energy demands are likely to rise and charging requirements may become less concentrated at Depots. An example of this is the Standard National – SME fleet.

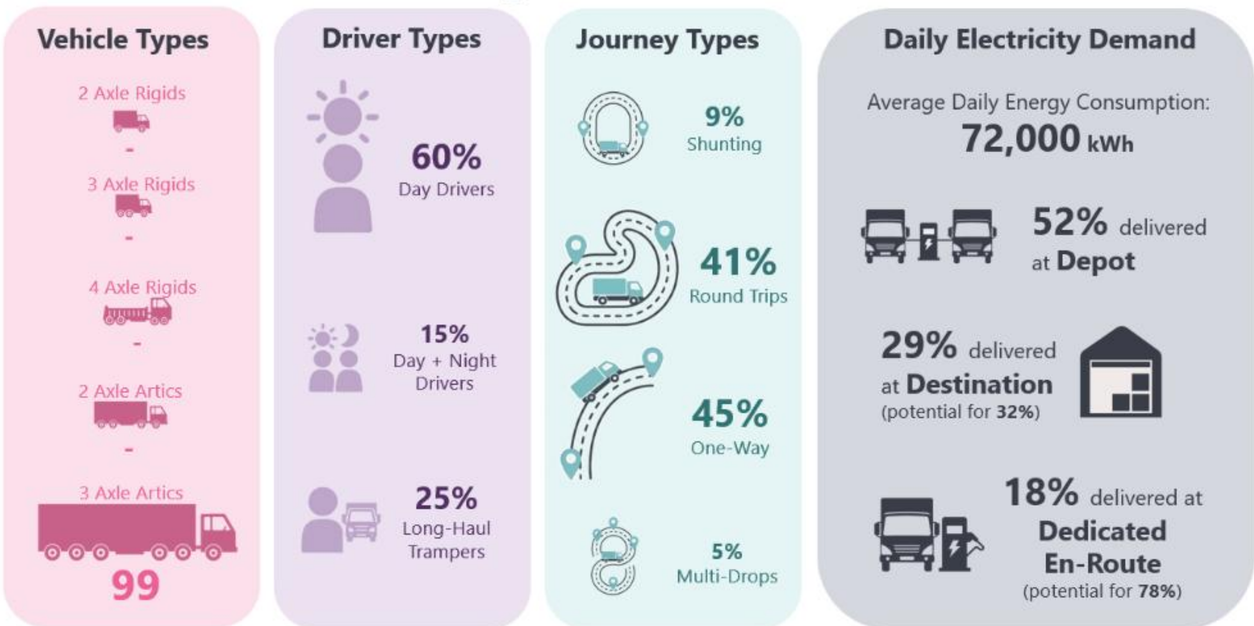
Standard National - SMEs



The Standard National – SME fleet is still dominated by Day Driver operations, although day + night and long-haul tramper operations begin to emerge. Given 80% of the fleet's electricity requirement may be met at a Depot, this could allow for a high level of energy flexibility overnight. While only 20% of the remaining energy is required outside of the Depot, these fleets may be able to benefit from substantial flexibility with their location of charging. There may be potential to charge up to 72% of their daily requirement at Destination locations and 86% at Dedicated En-Route, without changing their current operations.

At the most operationally intensive end of the fleet spectrum, charging demand is both highest in scale and likely the least concentrated at Depot. An example of this is the Standard International - Large Fleet.

Standard International – Large Fleets



The Standard International - Large Fleets are reliant mostly on the bigger articulated vehicles, longer-distance activity and higher utilisation operating patterns. This reduces the opportunities to charge, especially at Depots. As a result, they are likely to be more dependent on Destination and Dedicated En-Route charging. They are likely to be among the strongest drivers of demand for strategically located high-power infrastructure, especially at Dedicated En-Route. This location may have the highest potential for energy delivery due to the likely high power ratings of the chargers at this location.

5.4 Summary

Given the high proportion of Day Drivers in the UKPN region**, Depot charging is likely dominate for many fleets**, especially smaller, rigid operations. This may allow for a **high level of energy flexibility overnight**.

Non-Depot charging is likely to become increasingly important for larger, articulated, high-utilisation and long-haul fleets. These locations **may offer less energy flexibility**.

6. Appendix (How to use our output spreadsheet)

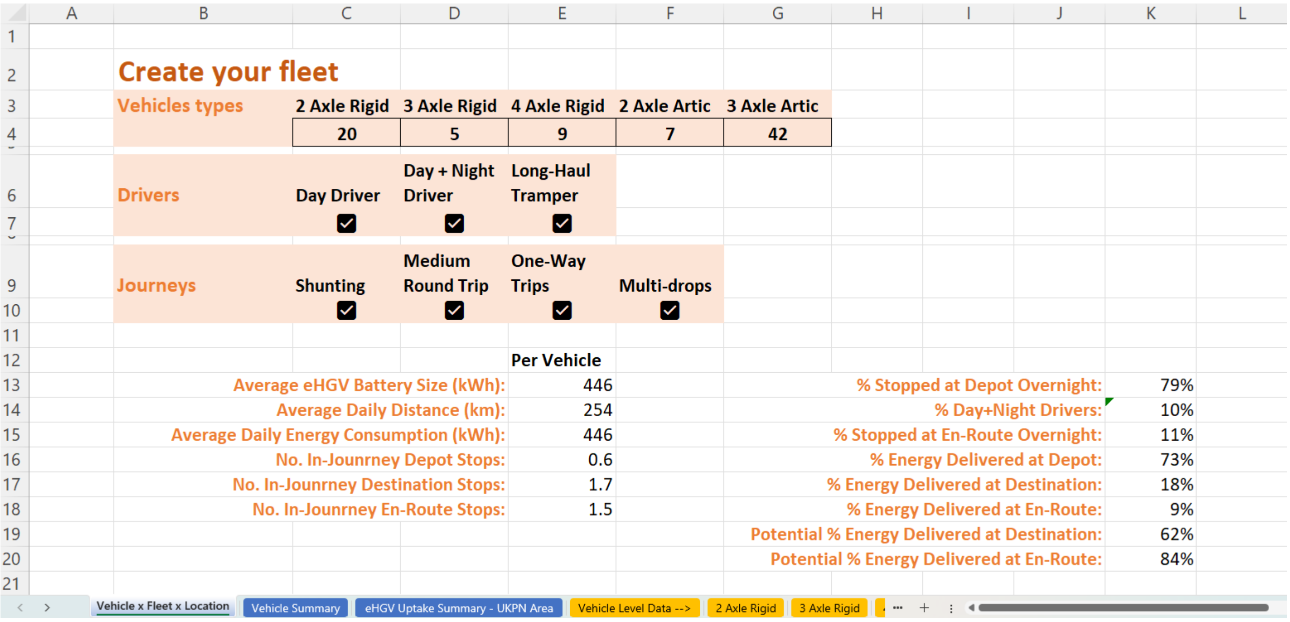
The *WP2 Fleet archetype outputs* spreadsheet translates the data and assumptions in this report into model-ready outputs for subsequent Future Fleet work packages. The main outputs cover energy demand, arrival profiles, and dwell times across different fleet, operation, and location types, and are split between in-journey and end-of-shift periods.

At a high level, the spreadsheet is organised into three layers.

- The green tabs contain the core assumptions, including fleet composition, charging behaviour, operational splits, and utilisation assumptions (e.g. weekday vs weekend usage). These can be adjusted to test sensitivities.
- The orange tabs perform processing and calculations, translating those assumptions into detailed vehicle-level and operational profiles.
- The blue tabs are the main outputs, where all of this is brought together into a simplified interface for defining scenarios and extracting results.

The *Fleet Types* tab (green) can be used to define realistic Depot archetypes and cover the outputs in Section 2.2.

The blue tabs are designed to contain all the information required for subsequent work packages. The remaining tabs allow for more detailed analysis and sensitivity testing. The primary blue tab is *Vehicle x Fleet x Location*. In this tab, users define a Depot or scenario by selecting the number and types of vehicles, with the option to refine assumptions by driver and journey type. The model then automatically calculates key outputs, including average battery size, daily energy demand, number of stops by location, arrival distributions throughout the day, and associated dwell times.



The outputs in this tab retain the predefined assumptions on operational mix by vehicle type. For example, 2-axle rigid vehicles are assumed to operate exclusively as Day Drivers; therefore, selecting Long-Haul Trampers will result in zero outputs. The driver and journey type selection buttons allow users to explore results in more detail for the specified fleet. This enables different energy flexibility options to be assessed against specific operational constraints.

Two additional summary tabs (blue) are provided: *Vehicle Summary* and *eHGV Uptake Summary - UKPN Area*. These provide outputs by vehicle and operation type, showing estimated battery capacity, average daily distance, average daily consumption and electrification rates.

Overall, the spreadsheet should be seen as a scenario-building and data extraction tool, where the main task is to define a credible fleet configuration and then use the outputs to inform downstream modelling, rather than relying on every intermediate tab.

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We use that 'whole energy' system capability to support innovative companies -- small and large – to test, trial and scale their new products and services. Our impact comes when those innovators attract new customers, new investment, and new grants so they can thrive in the future energy system.

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