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BETT Quarterly Report

Trial Q6: July – September 2023

Cenex

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About BETT: the Battery Electric Truck Trial

In June 2021, DAF were awarded funding under the SBRI ZE Road Freight Competition to deploy and undertake research on the performance of 20 DAF LF Battery Electric Trucks.

Cenex, a non-profit research & consultancy organisation focused on low emission transport & associated energy infrastructure, partnered with DAF trucks to lead the study aspects of the research.

A key focus of the research and study aspect is to develop learning materials to promote and educate fleet owners about electric trucks to help remove barriers to adoption. This report informs on data insights from the sixth quarter of the trial (July to September 2023).

Contents

Best of BETT this Quarter

This quarter, one of the BETT trucks participated in the EV Rally, where it joined over 50 EVs on a 5 day rally, driving almost 2,000 kilometres through 5 capital cities. The stats on the left are from trucks doing their usual work, while the stats on the right are from EV Rally driving. More information on the rally can be found from slide 15.

Usual operations

442 km travelled in one day*
(Vehicle B-2, 13-07-2023, 164% battery used)

364 kWh used in one day*
(Vehicle B-1, 04-07-2023, 161% battery used)

09:58 hours worked in one day***
(Vehicle B-2, 13-07-2023, 164% battery used)

406 kWh charged in one day
(Vehicle B-2, 21-09-2023, using a rapid charger)

Including EV Rally driving

573 km travelled in one day*
(Vehicle H-2, 04-07-2023, 190% battery used)

421 kWh used in one day*
(Vehicle H-2, 04-07-2023, 190% battery used)

10:02 hours worked in one day***
(Vehicle H-2, 03-07-2023, 163% battery used)

424 kWh charged in one day
(Vehicle H-2, 04-07-2023, using a rapid charger)

* The vehicle charged during the day using a rapid charger
** Time worked includes time spent driving and idling (e.g. stopped at traffic lights), but not loading and unloading.

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Summary of the Quarter

Summary Stats	Q1 (Apr-Jun 2022)	Q2 (Jul-Sep 2022)	Q3 (Oct-Dec 2022)	Q4 (Jan-Mar 2023)	Q5 (Apr-Jun 2023)	Q6 (Jul-Sep 2023)	Total
Active Trucks	12	18	19	18	18	18	20
Total Distance	15,911 km	53,240 km	55,507 km	31,591 km	50,387 km	80,425 km	287,061 km
Total Energy	13,609 kWh	47,091 kWh	57,833 kWh	38,309 kWh	49,314 kWh	71,390 kWh	277,546 kWh
Total Number of Journeys	697	2,470	3,222	2,150	2,860	3,943	15,342
Total Emissions Savings*	11.5 tCO_2	38.7 tCO_2	40.7 tCO_2	23.4 tCO_2	37.3 tCO_2	58.5 tCO_2	210.1 tCO_2
Real World Range							
Average	296 km	288 km	253 km	241 km	277 km	294 km	276 km
Urban	253 km	239 km	214 km	206 km	235 km	241 km	231 km
Rural	342 km	315 km	284 km	274 km	303 km	318 km	303 km
Motorway	299 km	300 km	272 km	260 km	295 km	309 km	292 km

* WTW CO2e compared to a diesel equivalent truck.

Vehicle Activity Summary

This table summarises the distance travelled and number of days driven for each vehicle this quarter.

Due to vehicles **F-1** and **K-1** not having representative distances travelled during this quarter, they have been excluded from the rest of the reporting.

Due to a logger issue, three days of energy data is missing from **B-2**, and **B-1** is missing data from mid-August onwards**.**

The total distance is included in the table on the right, but analysis on the previous and following pages only include periods where we have full energy data.

This quarter has seen the vehicles drive the highest combined distance of any quarter in the trial by a significant margin.

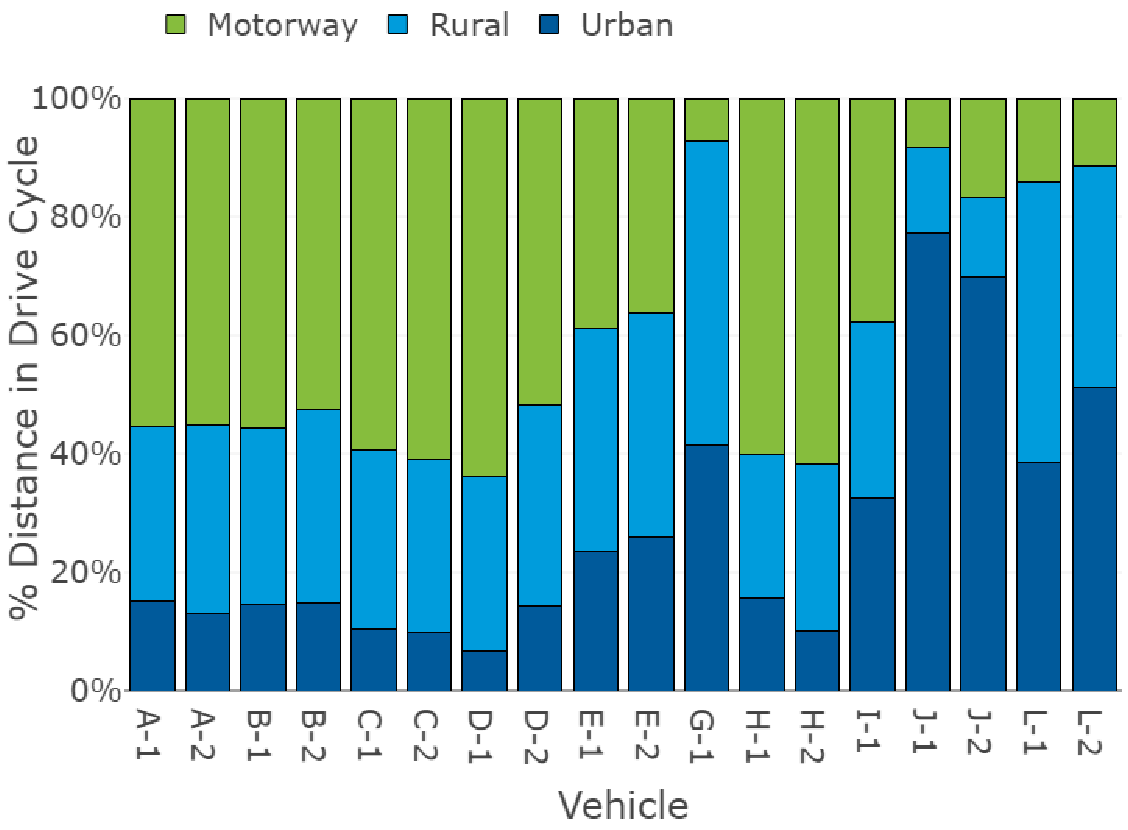
Fleet	Active/Expected	Vehicle	Distance Travelled (km)	Days Driven
A	2/2	A-1	3,232	41
		A-2	2,548	33
B	2/2	B-1	9,934	54
		B-2	10,642	63
C	2/2	C-1	12,094	62
		C-2	13,982	67
D	2/2	D-1	884	17
		D-2	3,911	39
E	2/2	E-1	6,527	58
		E-2	1,457	20
F	1/1	F-1	137	11
G	1/1	G-1	3,243	55
H	2/2	H-1	7,519	62
		H-2	3,401	42
I	1/1	I-1	962	33
J	2/2	J-1	703	63
		J-2	418	42
K	1/1	K-1	83	7
L	2/2	L-1	2,773	65
		L-2	2,343	66
Total	20/20	Total	86,790	900

Drive Cycle

The drive cycles shown on the right describe the type of driving the vehicles exhibit. It is not based on geo-location, but on speed and acceleration statistics. For example, motorway is fast and consistent, whereas urban has more stops and starts.

Compared to Q5 there has been **4%** less urban driving and **2%** less rural driving, while there has been a **6%** increase in motorway driving.

Vehicles **J-1** and **J-2** have a high proportion of urban driving due to them carrying out lots of short journeys this quarter.



The average for all vehicles is:

Urban 18% | Rural 32% | Motorway 50%

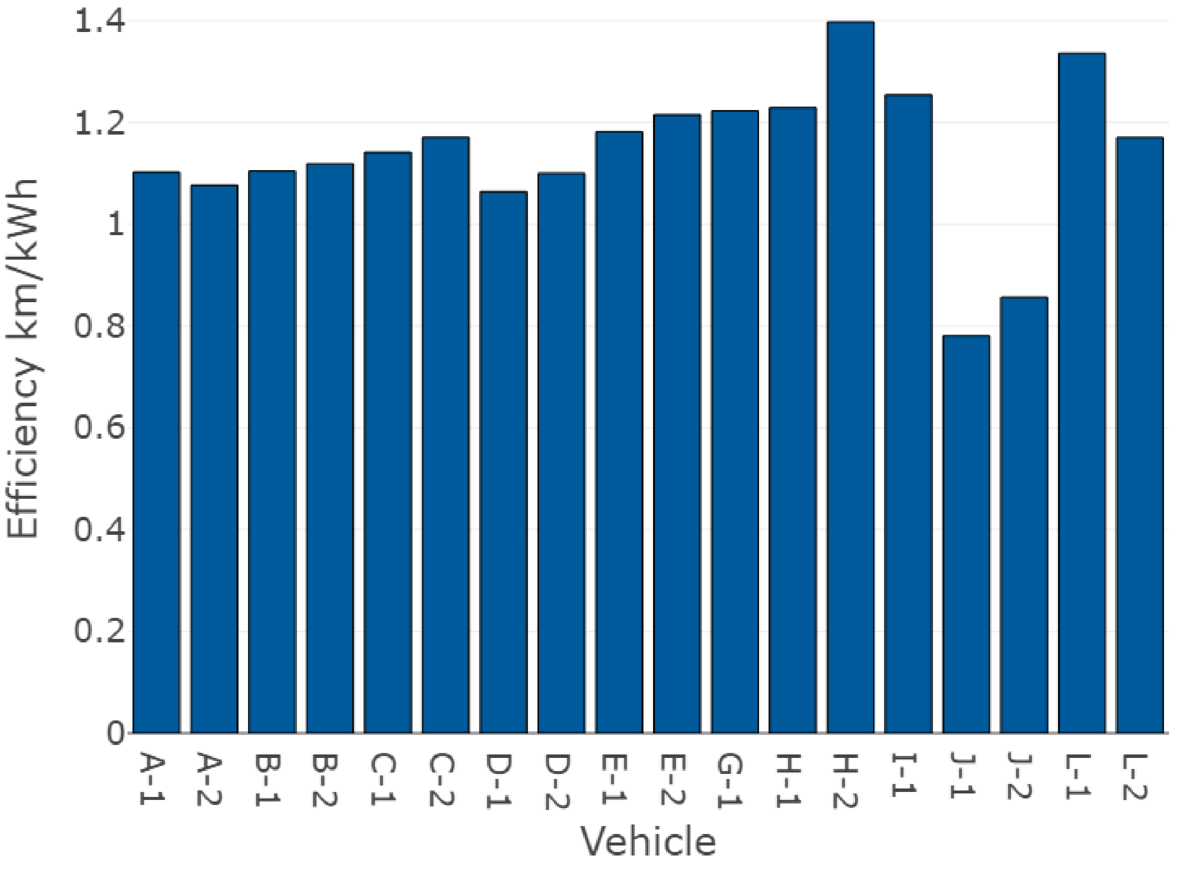
Energy Efficiency

The energy efficiency of the trucks across all drive cycles ranges between **0.78** and **1.40 km/kWh**. The efficiencies are slightly higher than last quarter. **H-2** was the vehicle that took part in the EV Rally, and had the highest efficiency.

With a 250 kWh battery, that translates to a real-world range of between **195 km** and **350 km**. The average real-world range observed during the trial this quarter is **276 km**.

Both **J-1** and **J-2** have a particularly low efficiency due to these vehicles being used for very short journeys with significant amounts of start-stop operation.

The overall energy efficiency is relatively high this quarter due to the warmer weather. All vehicles, battery electric or combustion engine, tend to have higher efficiencies in warmer weather. Less cab heater usage with warmer temperatures will also help to increase efficiency.

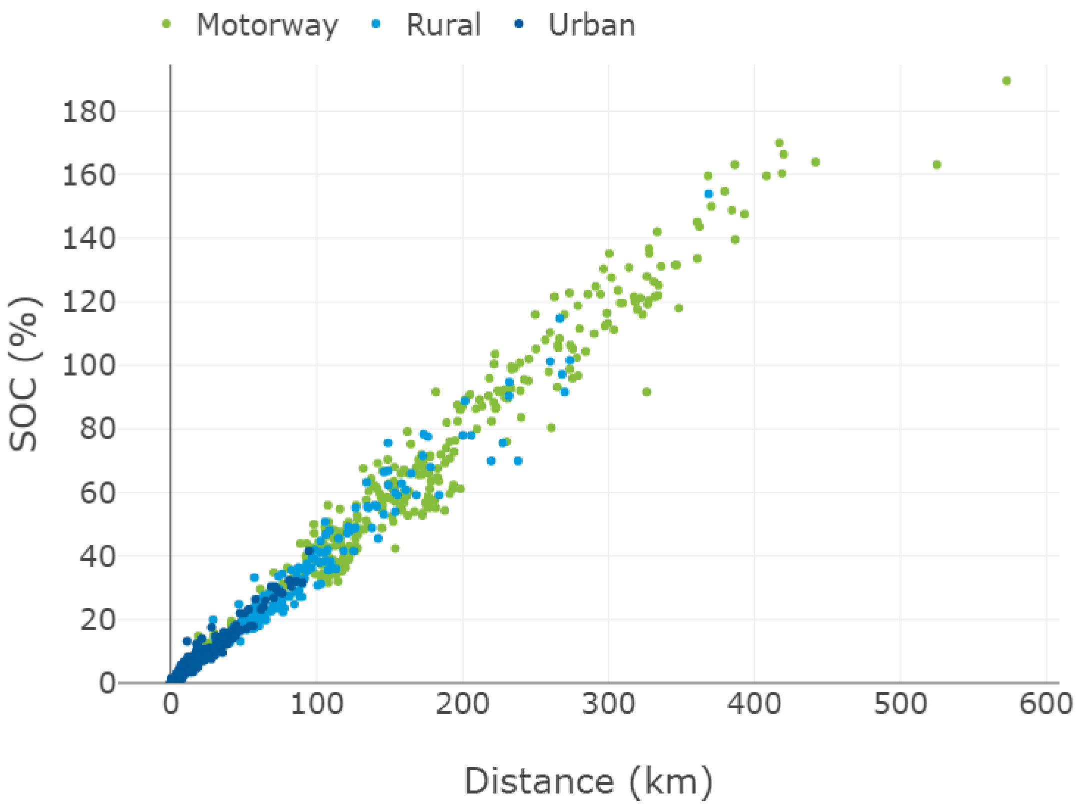


Daily Distance vs Battery State of Charge (SOC)

This graph shows how far vehicles travelled in a day, and how much battery state of charge (SOC) was used*.

Days are colour coded by which drive cycle they mostly drove.

Many vehicles have continued to travel well beyond their range thanks to top up charges with rapid charging during the day, with a peak distance of **442 km** reached this quarter in normal operations, and **573 km** achieved during the EV Rally.



- Only takes into account the energy used while driving or idling.

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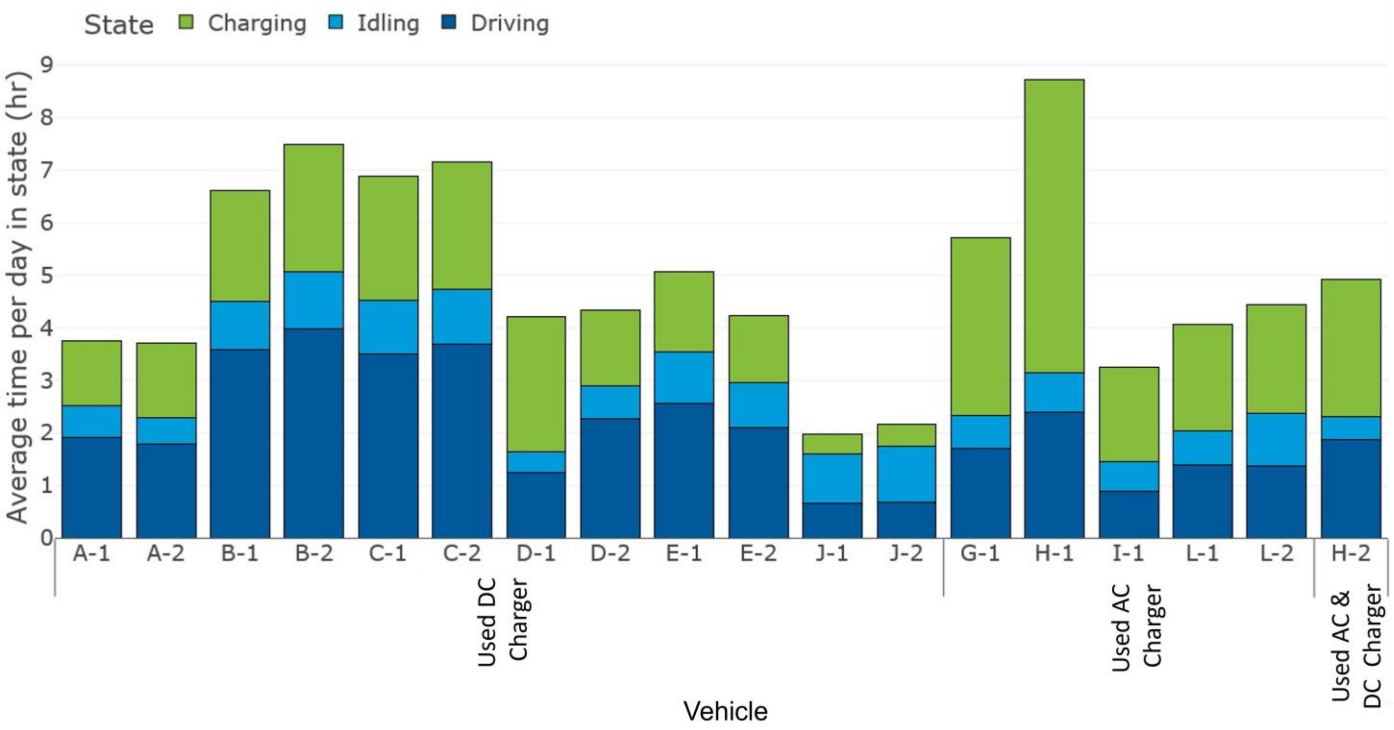
State Duration

A vehicle is in one of four states: driving, charging, idling (e.g. at traffic lights) and parked.

The graph to the right shows how long vehicles are in each state*, except for parked, which is the remainder. Note that 'parked' can also include loading and unloading cargo. Vehicle **H-2** would ordinarily use an AC charger, but used DC charging throughout the EV Rally.

In Q6, the time spent charging compared to time spent driving has decreased compared to Q5. This is due to the higher vehicle efficiencies in this quarter.



Quarter	Charging time as percentage of driving time	
	AC (fast)	DC (rapid)
Q2	178%	76%
Q3	233%	92%
Q4	266%	117%
Q5	161%	83%
Q6	**191%**	**65%**

Compared to Q2 (the equivalent quarter in 2022), slightly more time was spent charging using AC chargers than driving, whereas less time was spent charging with DC chargers than driving.

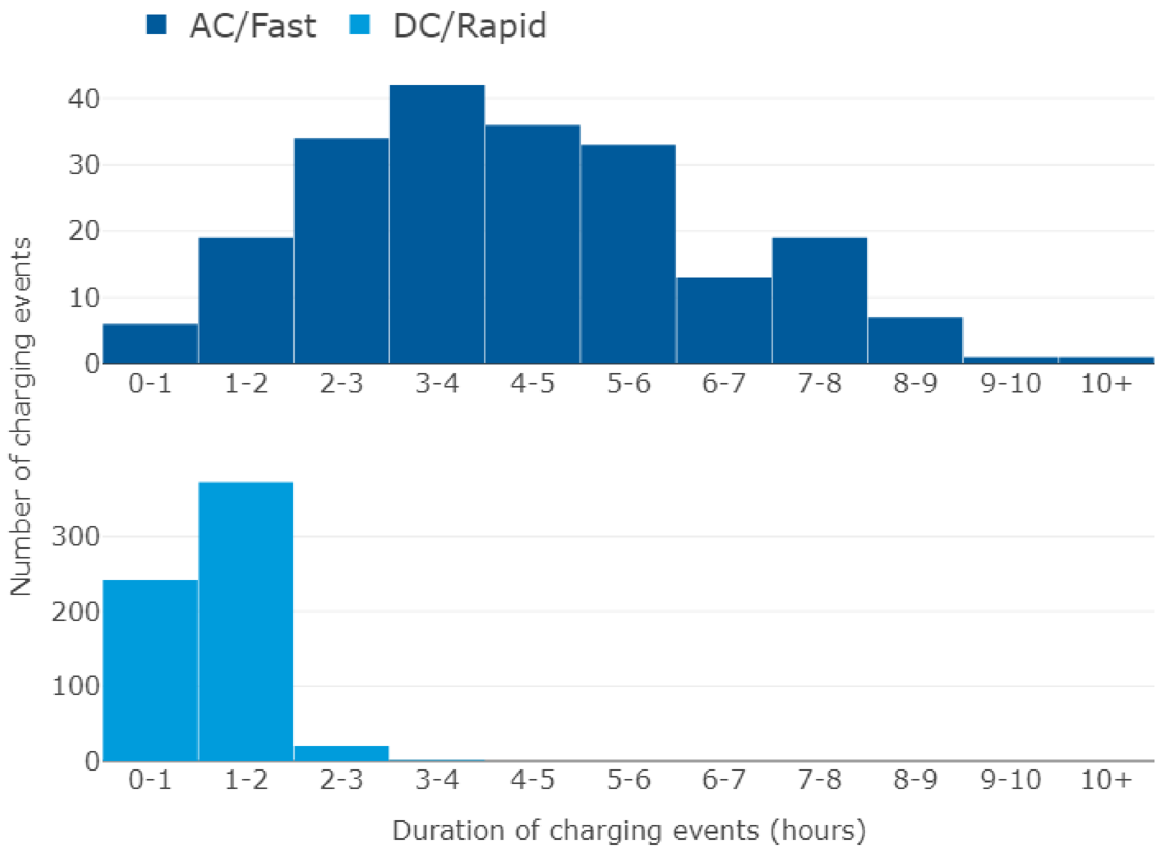
* Only includes days when vehicle is in use (driving or charging) for more than 20 minutes.

Charging Duration

This graph shows how long vehicles spend charging using AC fast (22 kW) or DC rapid (150 kW) chargepoints*.

AC charging is used both for top up charging and overnight charging. The majority of charging events were longer sessions used for full charges, lasting between **2-6 hours**. Compared to last quarter, there was a higher proportion of charges which lasted between **7-8 hours**.

The majority of DC rapid charging sessions tend to take less than **2 hours**.



* Only charging sessions which last longer than 5 minutes are included.

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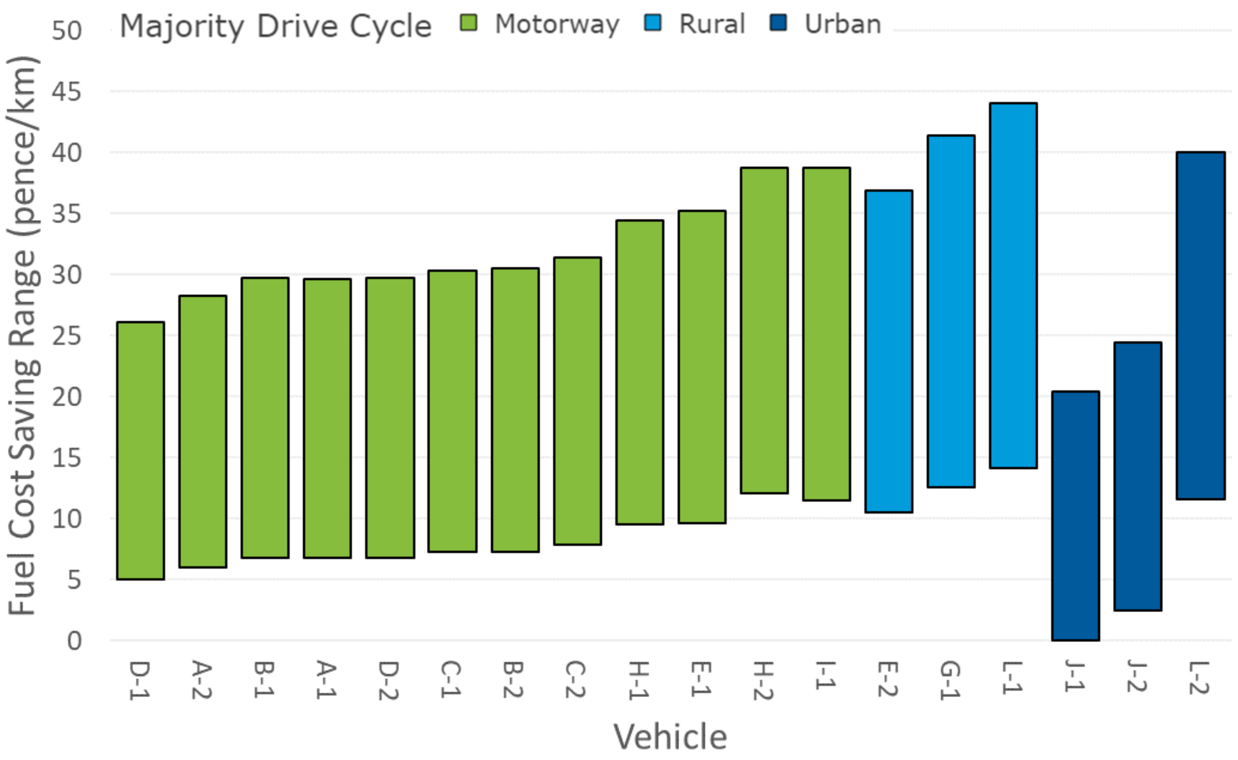
Fuel Savings

This graph shows average fuel savings per km for each vehicle. The bar represents the range of savings possible using different diesel and electricity prices seen throughout the trial. The upper end uses the prices at the start of the trial and used in previous reports (£1.90/l for diesel, £0.23/kWh for electricity) while the lower end uses typical prices during this quarter (£1.48/l for diesel, £0.30/kWh for electricity).

Most vehicles have a saving of **5p to 14p per km** using Q6 prices, which equates to an annual saving of between **£2,500** and **£7,000 per year** based on an annual distance of 50,000 km*. With more favorable prices, savings range from **26p to 44p per km**, or **£13,000 to £22,000 per year.**



J-1 and **J-2** appear to have much lower savings, however this is an artifact of the way we estimate diesel fuel costs which does not work well with the way these vehicles are currently operated. They are used for very short journeys with lots of short acceleration and braking events which causes low efficiency, however it would also cause low MPG in a diesel vehicle. Unfortunately, as this operating pattern differed significantly from the information the end user originally provided, our analysis does not properly account for this, and it makes the savings look lower than they really would be.

*Average annual distance in UK for 17-25t rigid trucks (source: DfT)

Emissions Savings

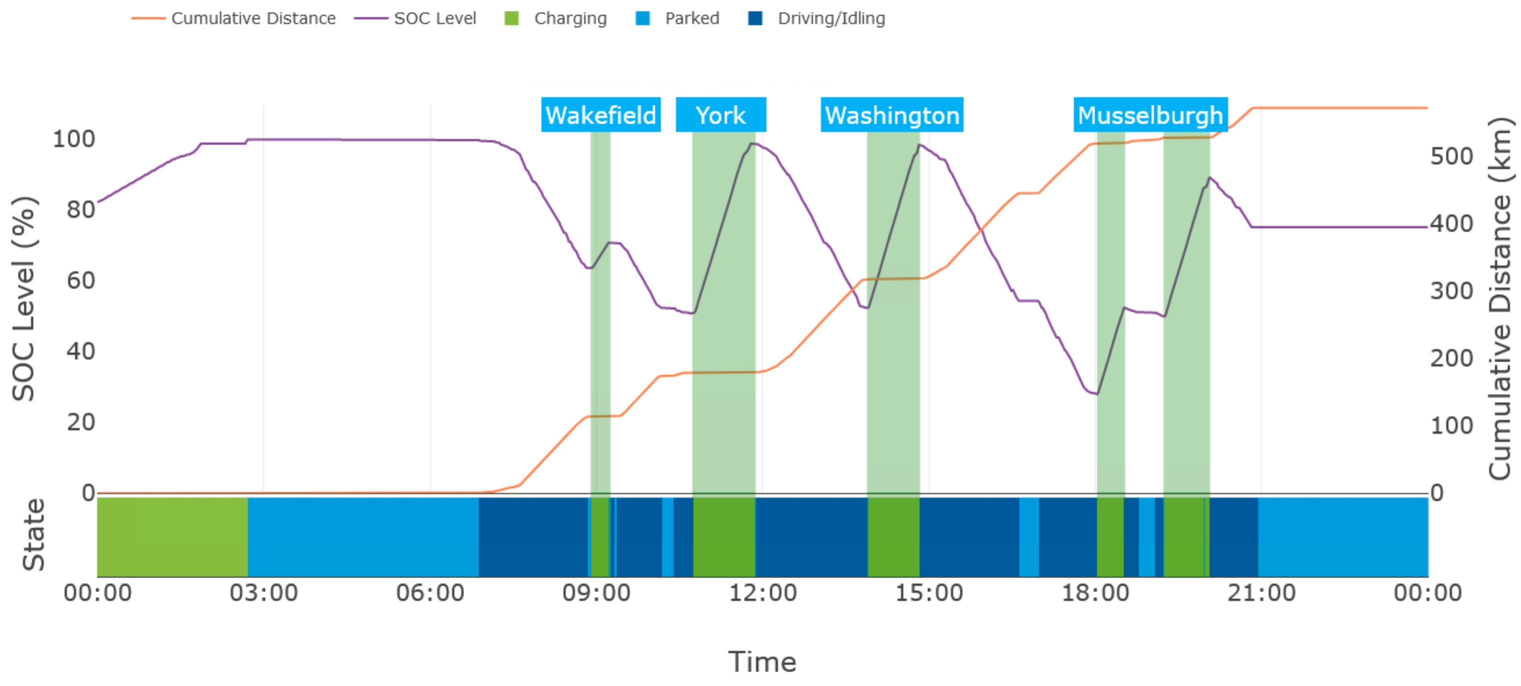
Emissions savings are calculated as the reduction in CO_2 emitted from ‘Well to Wheel’ (WTW), which includes the whole life cycle of the fuel/electricity from extraction/production/generation through to use in the vehicle.

Emissions saved range from **705 to 836 gCO_2/km**. The total WTW CO_2 saved in the sixth quarter of the trial was **58.5 tCO_2**.

EV Rally 2023

One of the BETT trucks (**H-2**) took part in the Greenfleet EV Rally in July. The full report covering its journey and insights can be found on the BETT Portal here: https://bett.cenex.co.uk/bett-learnings/ev-rally-report

On day 2 of the rally the truck recorded the highest daily distance of any BETT vehicle during the trial, at **573 km**. This distance was dictated by the route of the rally, and to achieve it the vehicle had to use public chargers. In comparison, while some of the BETT vehicles have achieved more than 450 km in one day in normal operation, the average daily distance across the trial is less than 100km.



The truck also achieved the highest efficiency out of all the trucks this quarter, at **1.40 km/kWh.** This was helped in part due to the vehicle being unladen during the rally to avoid customs paperwork when travelling to Ireland. While this may not be representative of most operations, the next most efficient truck was only slightly behind at 1.33 km/kWh.

The figure on the left shows the distance and charging patterns of the truck on day 2 of the rally between Nottingham and Edinburgh.

Despite the long distance and scarcity of public chargers suitable for HGVs, the battery state of charge rarely dropped below 50% before a quick top-up brought it back to 100%.

Glossary of Terms

Acronym/Term	Definition
SOC	State of Charge
WTW	Well to Wheel
Urban	Many stops and starts
Rural	Steady continuous speed
Motorway	Higher continuous speed
BETT	Battery Electric Truck Trial
ZE	Zero Emission

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To keep up to date with the trial, visit bett.cenex.co.uk

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