

Fleet Conversion to EV – Summary Report

Undertaken for Northumbrian Water Limited

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www.ennovigasolar.com



Background

- NWL's carbon reduction commitment is challenging and will ultimately require emissions from mobility to be addressed. The most commercially mature technology at the moment is electric vehicles (EVs).
- NWL leases its vehicle fleet (1,100 vehicles) from VLS, a company it owns jointly with Northern Powergrid. Vehicles are generally driven home by the drivers, not back-to-base each night. Relatively complex analysis is required to work out the effect of converting to EV.
- The conversion to EV must not adversely affect each driver's routine or limit them from undertaking their work.
- ESL's work is heavily analytical and routinely addresses very complex issues; ESL has the capability and experience to undertake a complex EV conversion study.
- Conversion to EV should be economically rational and may not be right for some or all vehicles – the case needs to be made to do anything at all.

Background (2)

- NWL also concerned about the effect on their electricity bills if the vehicles are charging on-site, so the analysis must work out where and when the vehicles would charge.
- Furthermore, an EV fleet would need chargers to be installed at specific sites, and more expensive chargers can charge faster than cheaper slow chargers. So NWL wishes to know where to install how many of what capacity charger.
- In a subsequent phase, NWL may wish to undertake a discounted cash flow analysis for each vehicle to determine whether it is cost-effective to replace that vehicle with an electric version. Some vehicles may not be economic to replace with EV at present but may become economic in future.
- NWL may also choose to replace certain vehicle specifications with other specifications, for instance if the technician doesn’t need such a large carrying capacity, but a longer range might be better.

Data provided (1)

- NWL’s IVMS operator (Inseego) provided ESL with 2-years worth of vehicle trips as CSV files. These contained some data, but it was curious that other data (e.g. odometer readings) were not included.
- ESL cleaned and processed the data. Some inefficiencies were found, for instance Inseego data did not provide the seconds on the timestamps so in some cases there were multiple journeys recorded at the same time, whereas in reality they were likely sub-minute journeys.
- NWL provided a spreadsheet with their fleet data but some of this clashed with similar data provided by Inseego.
- ESL generated its own table of EV replacement and matched each actual vehicle to the top five EV replacements where the best replacement was the one that would have resulted in the most EV miles.
- The dataset is far too large to manipulate on Excel. ESL created a PostgreSQL database and has been coding queries using additional resources to process the data.
- Assume the 2018 NWL GIS layer showing ownership boundaries is still valid.

Data provided (2)

- In April 2024, NWL's IVMS operator (Inseego) provided ESL with a further 1-year worth of vehicle trips as CSV files (covering 2023) on an identical basis as before.
- ESL cleaned and processed the data in the same way as before.
- NWL provided a new spreadsheet with their fleet data and again some of this was inconsistent with data provided by Inseego.
- ESL created its own list of NWL vehicles from the Inseego journey data, purchased DVLA data for these vehicles and treated the DVLA data as the master set.
- NWL provided an updated GIS layer showing ownership boundaries. ESL originally understood that this layer matched the Land Registry shapes registered to NWL but some shapes were found not to match those in the Land Registry. ESL assumed NWL's shapes were correct and eliminated those where the ownership shape was set to 200m squares.

Analysis assumptions – vehicles

- Exclude "vehicles" that are not relevant (e.g. generators) from the analysis.
- Assume that the last 3-years of actual vehicle movements is representative of future vehicle movements.
- **Assume that the drivers will only charge on NWL sites, and will only charge when the vehicle was otherwise parked (as per historical dataset).**
- Assume that the drivers will always use a slow charger, unless they must use a (more expensive) fast charger to reach their next destination.
- For now, assume no on-board electrical loads drawing power from the battery.
- For now, assume a constant kWh/mi consumption rate. Later this can be set to a temperature-dependent rate.
- For now, assume a linear battery charge rate. Later this can be replaced with a curve as battery charging slows once the battery state of charge (SoC) reaches 80%.

Analysis assumptions – geometry

- Plot all ~5mln journey end points on the GIS and overlay the NWL property boundary polygons.
- Exclude all NWL shapes that represent reservoirs.
- Draw a 10m buffer around all NWL property polygons.
- Select all vehicle journey end points that land within the buffered polygons and add the name of the NWL property to each journey.

- **Future work**: some of the NWL property polygons are quite large. Based on the distribution of the actual journey end points, these large sites should be split into multiple separate destinations and the entire analysis rerun accordingly.

Method – choose replacement vehicles

To choose which model of EV is the ideal replacement for each existing vehicle:

- Created a table of every EV replacement candidate together with its payload volume, payload weight, towing capacity, battery size, energy consumption and cost.
  - OEM datasheets provide inconsistent consumption figures. ESL recorded two separate consumption figures: a conservative one using the official OEM range * 0.75 / OEM battery capacity * 0.9, and the official OEM consumption rate converted to miles / kWh.
  - This analysis uses the conservative version that is more representative of "real world conditions".
- For each vehicle, choose a shortlist of EV candidates where the EV payload weight <= 1.5 x current payload weight, and EV payload volume >= current payload volume, and EV vehicle length <= 1.2 x current vehicle length.
- Run the full hindcast analysis for each fleet vehicle against each shortlisted candidate EV model and create a table recording that replacement EV's suitability score where score = count of successful EV miles driven / total miles driven.
- Post-process the results table to create a ranking of which five replacement EV models are most suitable for each vehicle.

Method – vehicle journeys

- For each vehicle, look up the replacement vehicle's battery size, assume it starts full, and then calculate how much charge is consumed for each journey.
- When a journey ends at a site that has a NWL site name attributed to it, assume this is a charge point.
- Work out how long the vehicle is stopped at the charge point.
- If the vehicle can reach its next destination using the charge remaining in the battery plus charge added by a slow charger during the time it is stopped, then use a slow charger.
- If it cannot reach the destination with the slow charge, then use a fast charger. Assume that the fast charger can supply the maximum charge rate for that vehicle.
  - NB: This results in the maximum range but also the highest capacity charger. **Future work**: rerun this accounting for charger cost and consider whether a smaller capacity fast charger is better value.
- Then work out how many journeys can be completed without running out of charge.

- **Future work**: use battery charge curves rather than assume linear charge rates – this requires OEMs to share their charge curves (presently they don't).

Method – charging sites

- Based on the vehicle journey analysis, work out how many vehicles stop at each company site on a timeline.
- Group the results into half-hourly time slots that match the electricity market.
- Apportion the amount of electricity added to each vehicle to the appropriate time slot.
- Add up the amount of electricity used to charge EVs per site in HH time slots for the entire timeline.
- Simplify this to just 48 HH time slots to get an idea of when charging happens.
- A second iteration of this was done grouping the charge slots into 5-min rather than 30-min bins because using 30-min bins calculates a higher number of required chargers than is actually needed.

- **Future work**: check the maximum charging current needed and compare to each site's grid connection agreement.

EV charger types

AC

- 3.7kW (1-phase, 16A)
- 7.4kW (1-phase, 32A)
- 11kW (3-phase, 16A)
- 22kW (3-phase, 32A)

DC

- 22.5kW
- 50kW
- All the way to 1MW

Cables

Tethered (in-built cable)

Untethered (no cable)

Plugs

Type 1

CCS type 1

Type 2

CCS type 2

CHAdeMO

Virtually all new cars use CCS type 2 (that supplies both AC and DC)

Charger specification considerations

- ISO 15118
  - Standard allows car to talk to the charge point and vice-versa and to recognise the car (and allow charge) without RFID or other key fobs.
- Open Charge Point Protocol (OCPP 2.0)
  - A communication between an EV charging station and a central back-office system.
- Charge Point Management System
  - Software used to oversee all EV charging stations, collect usage statistics, allocate charges to vehicles / cost codes, track charger faults, etc.
- Dynamic Load Management
  - Functionality where the chargers dial back their current to not exceed DNO limits. Can be smart and use solar generation or battery when available.
- Charging hubs
  - Single large DC device distributes power to multiple dispensers meaning that capacity can be distributed as needed (e.g. 250kW to one vehicle and 20kW to another). For supply constrained sites may enable more charging.

Discussion on method

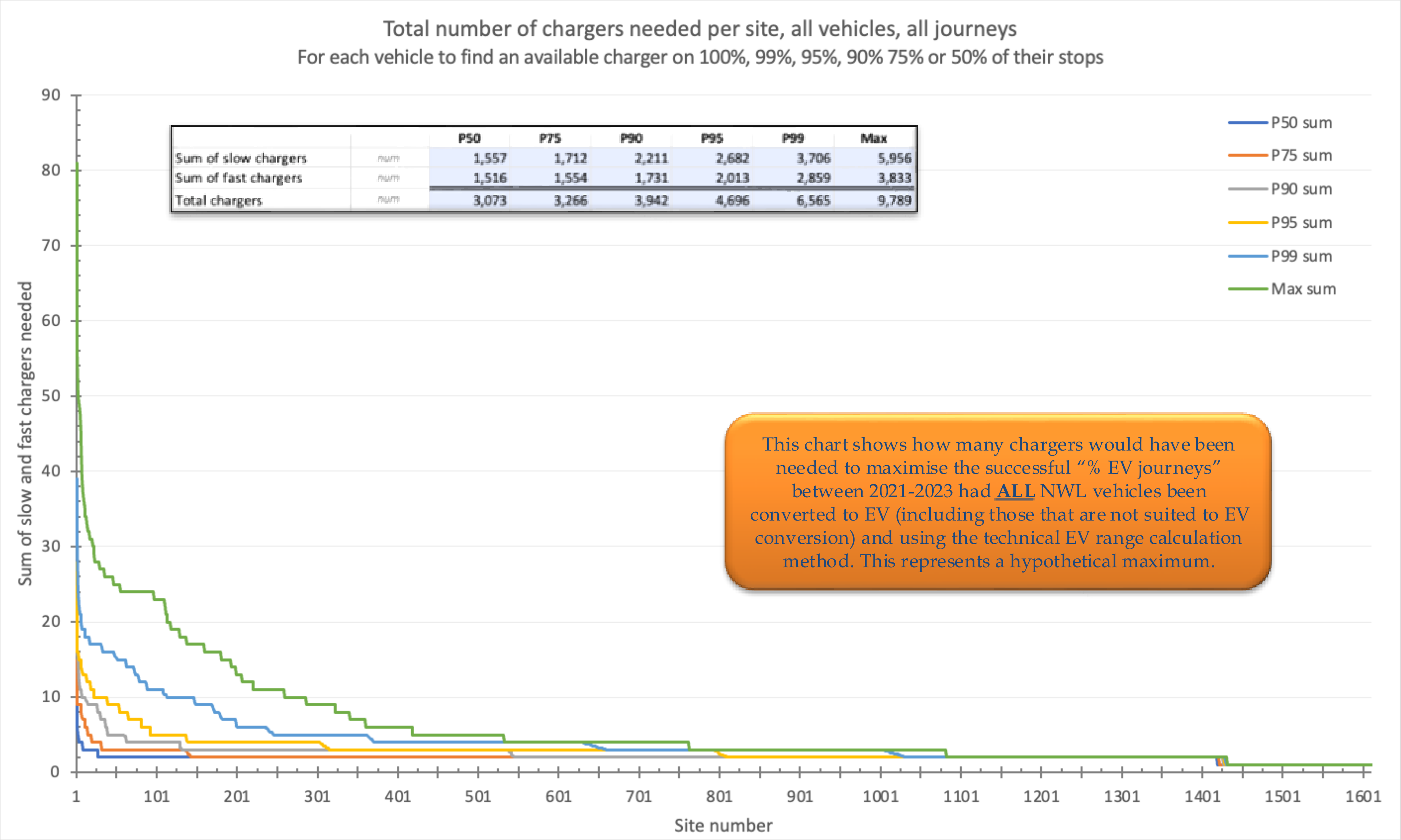
- This type of hindcast analysis is very rigorous because it is based on real vehicle journey data and it minimises the number of assumptions needed.
- The results are very strongly driven by two key boundary conditions:
  - Only charge on NWL sites (to not introduce price complexity);
  - Only allow charging during the time that the vehicle was anyway stopped (e.g. no dedicated charging time allowed).
- To explore the effect the second condition has on the results, this study was run twice:
  - The first time, "% EV miles" was calculated based on whether each vehicle is technically capable of undertaking each journey (e.g. is the vehicle's range > distance to next charge stop). This resulted in a high EV suitability fraction with some 321 vehicles 100% suitable for immediate conversion.
  - The second time, "% EV miles" was calculated using each vehicle's actual range based on the calculated battery state of charge. As charging time was restricted, much fewer vehicles (e.g. only 10) were found to be 100% suitable for immediate conversion.
- These contrasting results highlight that suitable EVs are available today, and that the key to maximising, "% EV miles" likely requires taking battery state of charge into account during journey scheduling, and maximising charging opportunities.

Discussion on method (2)

- This analysis calculated the number of chargers needed per NWL "site". However some NWL "sites" are huge and a future iteration ought to break large NWL sites into sub-sites and calculate the number of chargers needed on that basis. This could result in a higher number of chargers.
- Some uncertainty exists on how scheduling and human effects will affect actual journeys:
  - Can NWL connect real-time battery state of charge to its job dispatching software to increase the number of successful EV miles?
  - How close to the mathematical optimum will drivers actually behave? Will they loiter longer at NWL sites to charge more due to 'range anxiety', and will this result in congestion at charge points?
- Some concerns exists about EV drivers:
  - not plugging in (for instance during short stops and especially during foul weather), and
  - occupying and thus blocking fast chargers when they only need a slow charger, and
  - excessively using much more costly public chargers for convenience.
- These concerns likely require practical experience to both gauge their frequency and to identify effective mitigations.

Results

Charger count, all journeys, technical range (5-min bin)



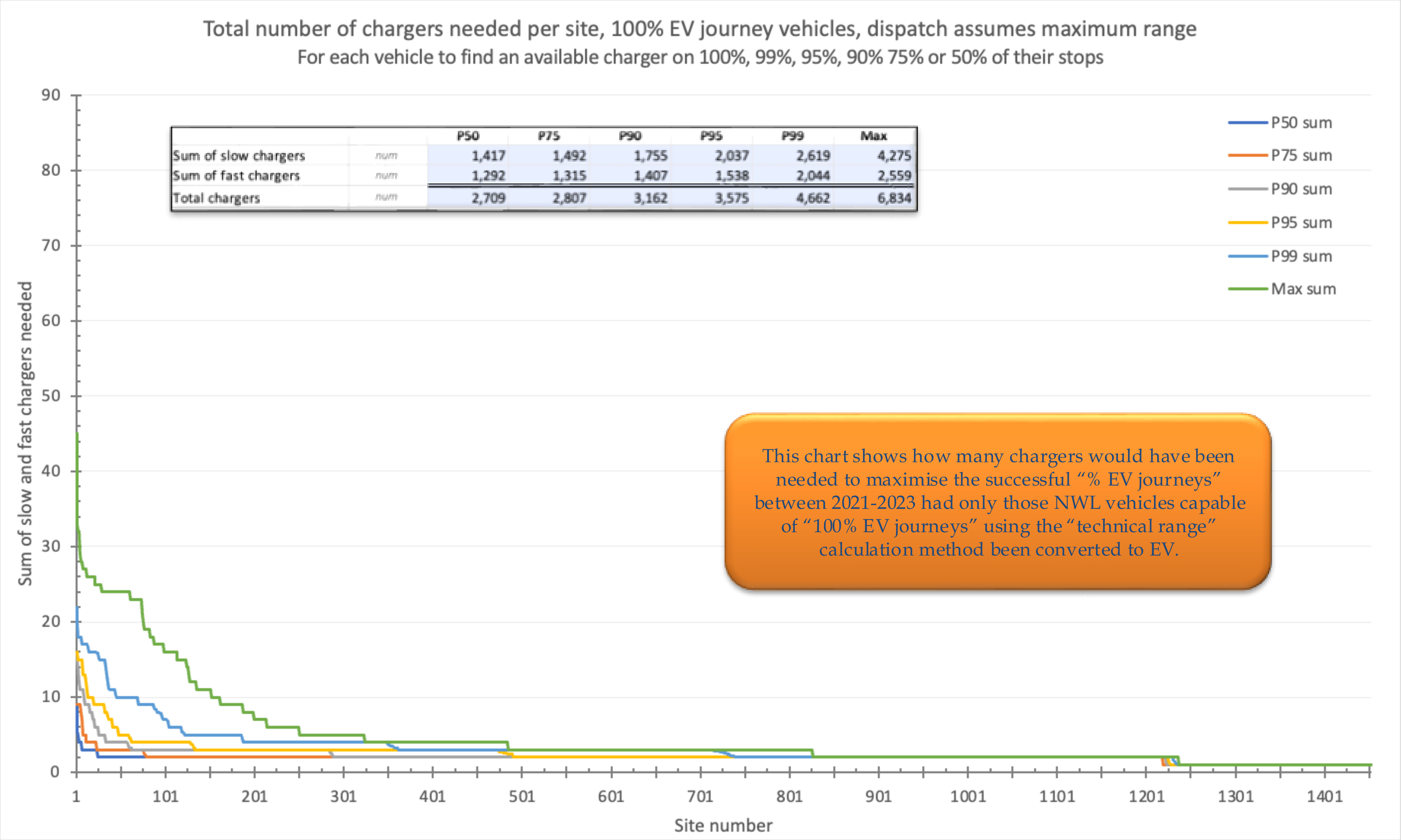
Total number of chargers needed per site, all vehicles, all journeys

For each vehicle to find an available charger on 100%, 99%, 95%, 90% 75% or 50% of their stops

		P50	P75	P90	P95	P99	Max
Sum of slow chargers	num	1,557	1,712	2,211	2,682	3,706	5,956
Sum of fast chargers	num	1,516	1,554	1,731	2,013	2,859	3,833
Total chargers	num	3,073	3,266	3,942	4,696	6,565	9,789

This chart shows how many chargers would have been needed to maximise the successful "% EV journeys" between 2021-2023 had **ALL** NWL vehicles been converted to EV (including those that are not suited to EV conversion) and using the technical EV range calculation method. This represents a hypothetical maximum.

Charger count, 100% EV vehicles, technical EV range (5-min bin)

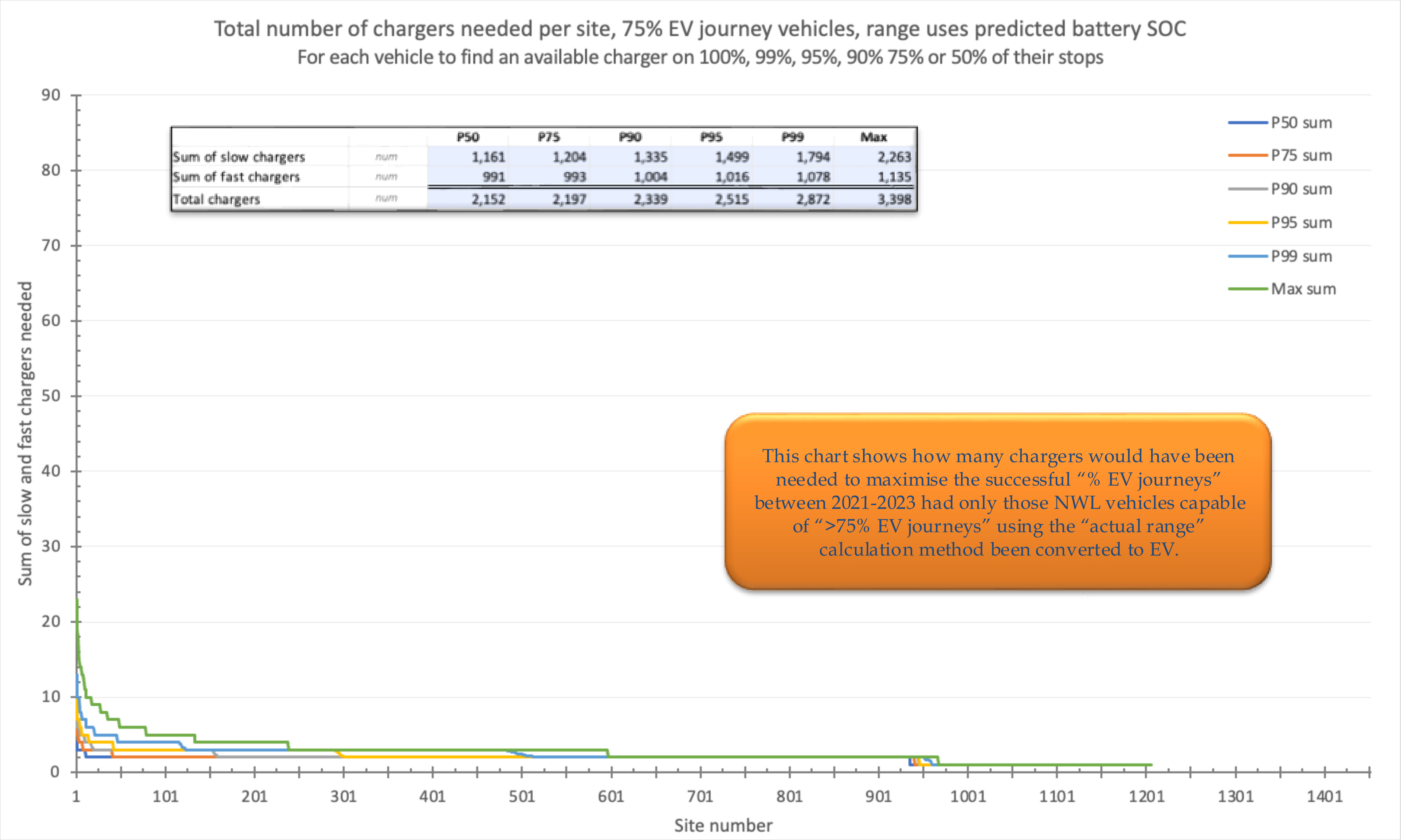


Total number of chargers needed per site, 100% EV journey vehicles, dispatch assumes maximum range
For each vehicle to find an available charger on 100%, 99%, 95%, 90% 75% or 50% of their stops

		P50	P75	P90	P95	P99	Max
Sum of slow chargers	num	1,417	1,492	1,755	2,037	2,619	4,275
Sum of fast chargers	num	1,292	1,315	1,407	1,538	2,044	2,559
Total chargers	num	2,709	2,807	3,162	3,575	4,662	6,834

This chart shows how many chargers would have been needed to maximise the successful “% EV journeys” between 2021-2023 had only those NWL vehicles capable of “100% EV journeys” using the “technical range” calculation method been converted to EV.

Charger count, 75% EV vehicles (actual EV range) (5-min bin)



Total number of chargers needed per site, 75% EV journey vehicles, range uses predicted battery SOC

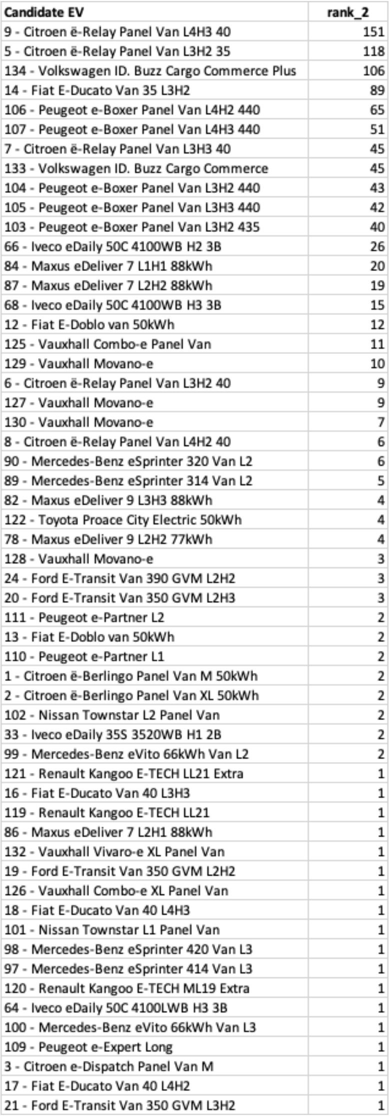
For each vehicle to find an available charger on 100%, 99%, 95%, 90% 75% or 50% of their stops

		P50	P75	P90	P95	P99	Max
Sum of slow chargers	num	1,161	1,204	1,335	1,499	1,794	2,263
Sum of fast chargers	num	991	993	1,004	1,016	1,078	1,135
Total chargers	num	2,152	2,197	2,339	2,515	2,872	3,398

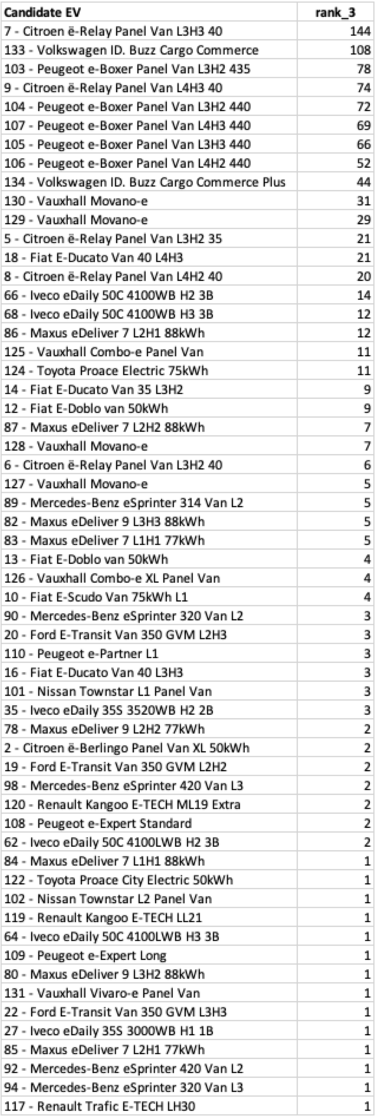
This chart shows how many chargers would have been needed to maximise the successful "% EV journeys" between 2021-2023 had only those NWL vehicles capable of ">75% EV journeys" using the "actual range" calculation method been converted to EV.

Count of replacement EV models, entire fleet

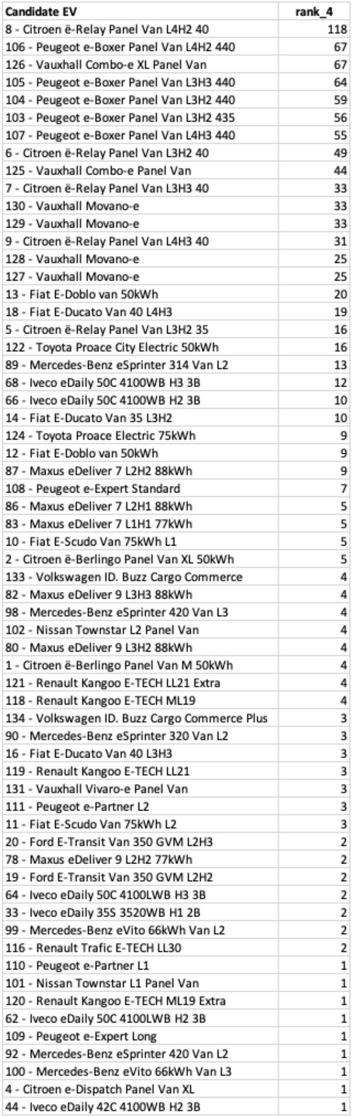
Candidate EV	rank_1
5 - Citroen ē-Relay Panel Van L3H2 35	523
14 - Fiat E-Ducato Van 35 L3H2	116
107 - Peugeot e-Boxer Panel Van L4H3 440	63
106 - Peugeot e-Boxer Panel Van L4H2 440	51
104 - Peugeot e-Boxer Panel Van L3H2 440	41
105 - Peugeot e-Boxer Panel Van L3H3 440	38
103 - Peugeot e-Boxer Panel Van L3H2 435	38
68 - Iveco eDaily 50C 4100WB H3 3B	21
66 - Iveco eDaily 50C 4100WB H2 3B	15
128 - Vauxhall Movano-e	9
129 - Vauxhall Movano-e	9
130 - Vauxhall Movano-e	9
87 - Maxus eDeliver 7 L2H2 88kWh	9
7 - Citroen ē-Relay Panel Van L3H3 40	7
9 - Citroen ē-Relay Panel Van L4H3 40	6
134 - Volkswagen ID. Buzz Cargo Commerce Plus	6
6 - Citroen ē-Relay Panel Van L3H2 40	4
89 - Mercedes-Benz eSprinter 314 Van L2	4
82 - Maxus eDeliver 9 L3H3 88kWh	4
118 - Renault Kangoo E-TECH ML19	3
121 - Renault Kangoo E-TECH LL21 Extra	3
8 - Citroen ē-Relay Panel Van L4H2 40	2
127 - Vauxhall Movano-e	2
16 - Fiat E-Ducato Van 40 L3H3	2
90 - Mercedes-Benz eSprinter 320 Van L2	2
119 - Renault Kangoo E-TECH LL21	2
24 - Ford E-Transit Van 390 GVM L2H2	2
125 - Vauxhall Combo-e Panel Van	1
84 - Maxus eDeliver 7 L1H1 88kWh	1
12 - Fiat E-Doblo van 50kWh	1
122 - Toyota Proace City Electric 50kWh	1
86 - Maxus eDeliver 7 L2H1 88kWh	1
124 - Toyota Proace Electric 75kWh	1
10 - Fiat E-Scudo Van 75kWh L1	1
80 - Maxus eDeliver 9 L3H2 88kWh	1
132 - Vauxhall Vivaro-e XL Panel Van	1
11 - Fiat E-Scudo Van 75kWh L2	1
19 - Ford E-Transit Van 350 GVM L2H2	1
111 - Peugeot e-Partner L2	1
15 - Fiat E-Ducato Van 40 L3H2	1
26 - Ford E-Transit Van 425 GVM L3H2	1



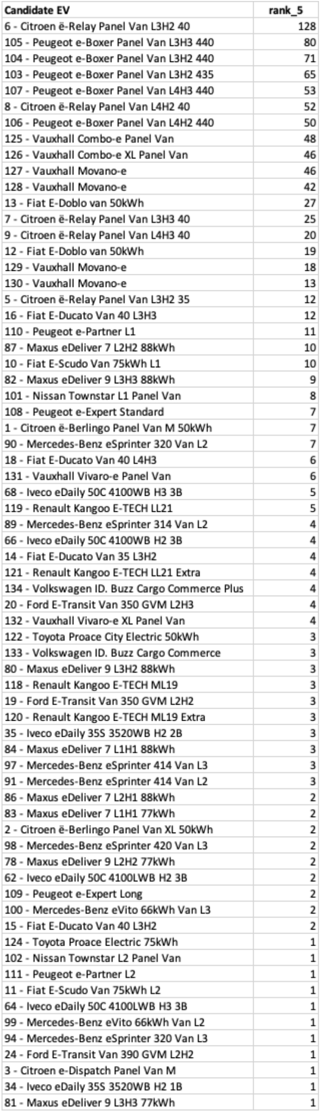
Candidate EV	rank_2
9 - Citroen ē-Relay Panel Van L4H3 40	151
5 - Citroen ē-Relay Panel Van L3H2 35	118
134 - Volkswagen ID. Buzz Cargo Commerce Plus	106
14 - Fiat E-Ducato Van 35 L3H2	89
106 - Peugeot e-Boxer Panel Van L4H2 440	65
107 - Peugeot e-Boxer Panel Van L4H3 440	51
7 - Citroen ē-Relay Panel Van L3H3 40	45
133 - Volkswagen ID. Buzz Cargo Commerce	45
104 - Peugeot e-Boxer Panel Van L3H2 440	43
105 - Peugeot e-Boxer Panel Van L3H3 440	42
103 - Peugeot e-Boxer Panel Van L3H2 435	40
66 - Iveco eDaily 50C 4100WB H2 3B	26
84 - Maxus eDeliver 7 L1H1 88kWh	20
87 - Maxus eDeliver 7 L2H2 88kWh	19
68 - Iveco eDaily 50C 4100WB H3 3B	15
12 - Fiat E-Doblo van 50kWh	12
125 - Vauxhall Combo-e Panel Van	11
129 - Vauxhall Movano-e	10
6 - Citroen ē-Relay Panel Van L3H2 40	9
127 - Vauxhall Movano-e	9
130 - Vauxhall Movano-e	7
8 - Citroen ē-Relay Panel Van L4H2 40	6
90 - Mercedes-Benz eSprinter 320 Van L2	6
89 - Mercedes-Benz eSprinter 314 Van L2	5
82 - Maxus eDeliver 9 L3H3 88kWh	4
122 - Toyota Proace City Electric 50kWh	4
78 - Maxus eDeliver 9 L2H2 77kWh	4
128 - Vauxhall Movano-e	3
24 - Ford E-Transit Van 390 GVM L2H2	3
20 - Ford E-Transit Van 350 GVM L2H3	3
111 - Peugeot e-Partner L2	2
13 - Fiat E-Doblo van 50kWh	2
110 - Peugeot e-Partner L1	2
1 - Citroen ē-Berlingo Panel Van M 50kWh	2
2 - Citroen ē-Berlingo Panel Van XL 50kWh	2
102 - Nissan Townstar L2 Panel Van	2
33 - Iveco eDaily 35S 3520WB H1 2B	2
99 - Mercedes-Benz eVito 66kWh Van L2	2
121 - Renault Kangoo E-TECH LL21 Extra	1
16 - Fiat E-Ducato Van 40 L3H3	1
119 - Renault Kangoo E-TECH LL21	1
86 - Maxus eDeliver 7 L2H1 88kWh	1
132 - Vauxhall Vivaro-e XL Panel Van	1
19 - Ford E-Transit Van 350 GVM L2H2	1
126 - Vauxhall Combo-e XL Panel Van	1
18 - Fiat E-Ducato Van 40 L4H3	1
101 - Nissan Townstar L1 Panel Van	1
98 - Mercedes-Benz eSprinter 420 Van L3	1
97 - Mercedes-Benz eSprinter 414 Van L3	1
120 - Renault Kangoo E-TECH ML19 Extra	1
64 - Iveco eDaily 50C 4100LWB H3 3B	1
100 - Mercedes-Benz eVito 66kWh Van L3	1
109 - Peugeot e-Expert Long	1
3 - Citroen e-Dispatch Panel Van M	1
17 - Fiat E-Ducato Van 40 L4H2	1
21 - Ford E-Transit Van 350 GVM L3H2	1



Candidate EV	rank_3
7 - Citroen ē-Relay Panel Van L3H3 40	144
133 - Volkswagen ID. Buzz Cargo Commerce	108
103 - Peugeot e-Boxer Panel Van L3H2 435	78
9 - Citroen ē-Relay Panel Van L4H3 40	74
104 - Peugeot e-Boxer Panel Van L3H2 440	72
107 - Peugeot e-Boxer Panel Van L4H3 440	69
105 - Peugeot e-Boxer Panel Van L3H3 440	66
106 - Peugeot e-Boxer Panel Van L4H2 440	52
134 - Volkswagen ID. Buzz Cargo Commerce Plus	44
130 - Vauxhall Movano-e	31
129 - Vauxhall Movano-e	29
5 - Citroen ē-Relay Panel Van L3H2 35	21
18 - Fiat E-Ducato Van 40 L4H3	21
8 - Citroen ē-Relay Panel Van L4H2 40	20
66 - Iveco eDaily 50C 4100WB H2 3B	14
68 - Iveco eDaily 50C 4100WB H3 3B	12
86 - Maxus eDeliver 7 L2H1 88kWh	12
125 - Vauxhall Combo-e Panel Van	11
124 - Toyota Proace Electric 75kWh	11
14 - Fiat E-Ducato Van 35 L3H2	9
12 - Fiat E-Doblo van 50kWh	9
87 - Maxus eDeliver 7 L2H2 88kWh	7
128 - Vauxhall Movano-e	7
6 - Citroen ē-Relay Panel Van L3H2 40	6
127 - Vauxhall Movano-e	5
89 - Mercedes-Benz eSprinter 314 Van L2	5
82 - Maxus eDeliver 9 L3H3 88kWh	5
83 - Maxus eDeliver 7 L1H1 77kWh	5
13 - Fiat E-Doblo van 50kWh	4
126 - Vauxhall Combo-e XL Panel Van	4
10 - Fiat E-Scudo Van 75kWh L1	4
90 - Mercedes-Benz eSprinter 320 Van L2	3
20 - Ford E-Transit Van 350 GVM L2H3	3
110 - Peugeot e-Partner L1	3
16 - Fiat E-Ducato Van 40 L3H3	3
101 - Nissan Townstar L1 Panel Van	3
35 - Iveco eDaily 35S 3520WB H2 2B	3
78 - Maxus eDeliver 9 L2H2 77kWh	2
2 - Citroen ē-Berlingo Panel Van XL 50kWh	2
19 - Ford E-Transit Van 350 GVM L2H2	2
98 - Mercedes-Benz eSprinter 420 Van L3	2
120 - Renault Kangoo E-TECH ML19 Extra	2
108 - Peugeot e-Expert Standard	2
62 - Iveco eDaily 50C 4100LWB H2 3B	2
84 - Maxus eDeliver 7 L1H1 88kWh	1
122 - Toyota Proace City Electric 50kWh	1
102 - Nissan Townstar L2 Panel Van	1
119 - Renault Kangoo E-TECH LL21	1
64 - Iveco eDaily 50C 4100LWB H3 3B	1
109 - Peugeot e-Expert Long	1
80 - Maxus eDeliver 9 L3H2 88kWh	1
131 - Vauxhall Vivaro-e Panel Van	1
22 - Ford E-Transit Van 350 GVM L3H3	1
27 - Iveco eDaily 35S 3000WB H1 1B	1
85 - Maxus eDeliver 7 L2H1 77kWh	1
92 - Mercedes-Benz eSprinter 420 Van L2	1
94 - Mercedes-Benz eSprinter 320 Van L3	1
117 - Renault Trafic E-TECH LH30	1

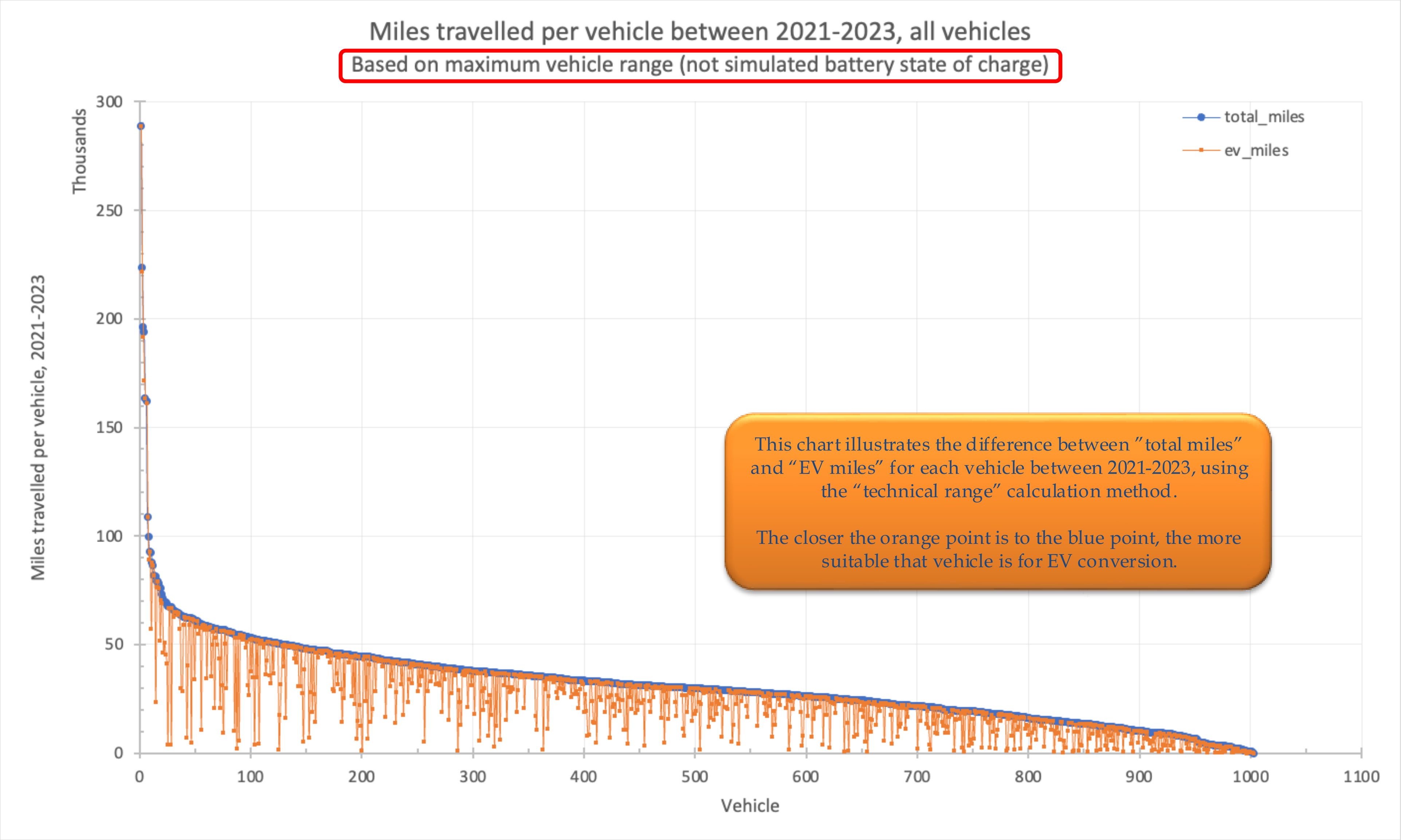


Candidate EV	rank_4
8 - Citroen ē-Relay Panel Van L4H2 40	118
106 - Peugeot e-Boxer Panel Van L4H2 440	67
126 - Vauxhall Combo-e XL Panel Van	67
105 - Peugeot e-Boxer Panel Van L3H3 440	64
104 - Peugeot e-Boxer Panel Van L3H2 440	59
103 - Peugeot e-Boxer Panel Van L3H2 435	56
107 - Peugeot e-Boxer Panel Van L4H3 440	55
6 - Citroen ē-Relay Panel Van L3H2 40	49
125 - Vauxhall Combo-e Panel Van	44
7 - Citroen ē-Relay Panel Van L3H3 40	33
130 - Vauxhall Movano-e	33
129 - Vauxhall Movano-e	33
9 - Citroen ē-Relay Panel Van L4H3 40	31
128 - Vauxhall Movano-e	25
127 - Vauxhall Movano-e	25
13 - Fiat E-Doblo van 50kWh	20
18 - Fiat E-Ducato Van 40 L4H3	19
5 - Citroen ē-Relay Panel Van L3H2 35	16
122 - Toyota Proace City Electric 50kWh	16
89 - Mercedes-Benz eSprinter 314 Van L2	13
68 - Iveco eDaily 50C 4100WB H3 3B	12
66 - Iveco eDaily 50C 4100WB H2 3B	10
14 - Fiat E-Ducato Van 35 L3H2	10
124 - Toyota Proace Electric 75kWh	9
12 - Fiat E-Doblo van 50kWh	9
87 - Maxus eDeliver 7 L2H2 88kWh	9
108 - Peugeot e-Expert Standard	7
86 - Maxus eDeliver 7 L2H1 88kWh	5
83 - Maxus eDeliver 7 L1H1 77kWh	5
10 - Fiat E-Scudo Van 75kWh L1	5
2 - Citroen ē-Berlingo Panel Van XL 50kWh	5
133 - Volkswagen ID. Buzz Cargo Commerce	4
82 - Maxus eDeliver 9 L3H3 88kWh	4
98 - Mercedes-Benz eSprinter 420 Van L3	4
102 - Nissan Townstar L2 Panel Van	4
80 - Maxus eDeliver 9 L3H2 88kWh	4
1 - Citroen ē-Berlingo Panel Van M 50kWh	4
121 - Renault Kangoo E-TECH LL21 Extra	4
118 - Renault Kangoo E-TECH ML19	4
134 - Volkswagen ID. Buzz Cargo Commerce Plus	3
90 - Mercedes-Benz eSprinter 320 Van L2	3
16 - Fiat E-Ducato Van 40 L3H3	3
119 - Renault Kangoo E-TECH LL21	3
131 - Vauxhall Vivaro-e Panel Van	3
111 - Peugeot e-Partner L2	3
11 - Fiat E-Scudo Van 75kWh L2	3
20 - Ford E-Transit Van 350 GVM L2H3	2
78 - Maxus eDeliver 9 L2H2 77kWh	2
19 - Ford E-Transit Van 350 GVM L2H2	2
64 - Iveco eDaily 50C 4100LWB H3 3B	2
33 - Iveco eDaily 35S 3520WB H1 2B	2
99 - Mercedes-Benz eVito 66kWh Van L2	2
116 - Renault Trafic E-TECH LL30	2
110 - Peugeot e-Partner L1	1
101 - Nissan Townstar L1 Panel Van	1
120 - Renault Kangoo E-TECH ML19 Extra	1
62 - Iveco eDaily 50C 4100LWB H2 3B	1
109 - Peugeot e-Expert Long	1
92 - Mercedes-Benz eSprinter 420 Van L2	1
100 - Mercedes-Benz eVito 66kWh Van L3	1
4 - Citroen e-Dispatch Panel Van XL	1
44 - Iveco eDaily 42C 4100WB H2 3B	1



Candidate EV	rank_5
6 - Citroen ē-Relay Panel Van L3H2 40	128
105 - Peugeot e-Boxer Panel Van L3H3 440	80
104 - Peugeot e-Boxer Panel Van L3H2 440	71
103 - Peugeot e-Boxer Panel Van L3H2 435	65
107 - Peugeot e-Boxer Panel Van L4H3 440	53
8 - Citroen ē-Relay Panel Van L4H2 40	52
106 - Peugeot e-Boxer Panel Van L4H2 440	50
125 - Vauxhall Combo-e Panel Van	48
126 - Vauxhall Combo-e XL Panel Van	46
127 - Vauxhall Movano-e	46
128 - Vauxhall Movano-e	42
13 - Fiat E-Doblo van 50kWh	27
7 - Citroen ē-Relay Panel Van L3H3 40	25
9 - Citroen ē-Relay Panel Van L4H3 40	20
12 - Fiat E-Doblo van 50kWh	19
129 - Vauxhall Movano-e	18
130 - Vauxhall Movano-e	13
5 - Citroen ē-Relay Panel Van L3H2 35	12
16 - Fiat E-Ducato Van 40 L3H3	12
110 - Peugeot e-Partner L1	11
87 - Maxus eDeliver 7 L2H2 88kWh	10
10 - Fiat E-Scudo Van 75kWh L1	10
82 - Maxus eDeliver 9 L3H3 88kWh	9
101 - Nissan Townstar L1 Panel Van	8
108 - Peugeot e-Expert Standard	7
1 - Citroen ē-Berlingo Panel Van M 50kWh	7
90 - Mercedes-Benz eSprinter 320 Van L2	7
18 - Fiat E-Ducato Van 40 L4H3	6
131 - Vauxhall Vivaro-e Panel Van	6
68 - Iveco eDaily 50C 4100WB H3 3B	5
119 - Renault Kangoo E-TECH LL21	5
89 - Mercedes-Benz eSprinter 314 Van L2	4
66 - Iveco eDaily 50C 4100WB H2 3B	4
14 - Fiat E-Ducato Van 35 L3H2	4
121 - Renault Kangoo E-TECH LL21 Extra	4
134 - Volkswagen ID. Buzz Cargo Commerce Plus	4
20 - Ford E-Transit Van 350 GVM L2H3	4
132 - Vauxhall Vivaro-e XL Panel Van	4
122 - Toyota Proace City Electric 50kWh	3
133 - Volkswagen ID. Buzz Cargo Commerce	3
80 - Maxus eDeliver 9 L3H2 88kWh	3
118 - Renault Kangoo E-TECH ML19	3
19 - Ford E-Transit Van 350 GVM L2H2	3
120 - Renault Kangoo E-TECH ML19 Extra	3
35 - Iveco eDaily 35S 3520WB H2 2B	3
84 - Maxus eDeliver 7 L1H1 88kWh	3
97 - Mercedes-Benz eSprinter 414 Van L3	3
91 - Mercedes-Benz eSprinter 414 Van L2	3
86 - Maxus eDeliver 7 L2H1 88kWh	2
83 - Maxus eDeliver 7 L1H1 77kWh	2
2 - Citroen ē-Berlingo Panel Van XL 50kWh	2
98 - Mercedes-Benz eSprinter 420 Van L3	2
78 - Maxus eDeliver 9 L2H2 77kWh	2
62 - Iveco eDaily 50C 4100LWB H2 3B	2
109 - Peugeot e-Expert Long	2
100 - Mercedes-Benz eVito 66kWh Van L3	2
15 - Fiat E-Ducato Van 40 L3H2	2
124 - Toyota Proace Electric 75kWh	1
102 - Nissan Townstar L2 Panel Van	1
111 - Peugeot e-Partner L2	1
11 - Fiat E-Scudo Van 75kWh L2	1
64 - Iveco eDaily 50C 4100LWB H3 3B	1
99 - Mercedes-Benz eVito 66kWh Van L2	1
94 - Mercedes-Benz eSprinter 320 Van L3	1
24 - Ford E-Transit Van 390 GVM L2H2	1
3 - Citroen e-Dispatch Panel Van M	1
34 - Iveco eDaily 35S 3520WB H2 1B	1
81 - Maxus eDeliver 9 L3H3 77kWh	1

Vehicles ranked by total mileage



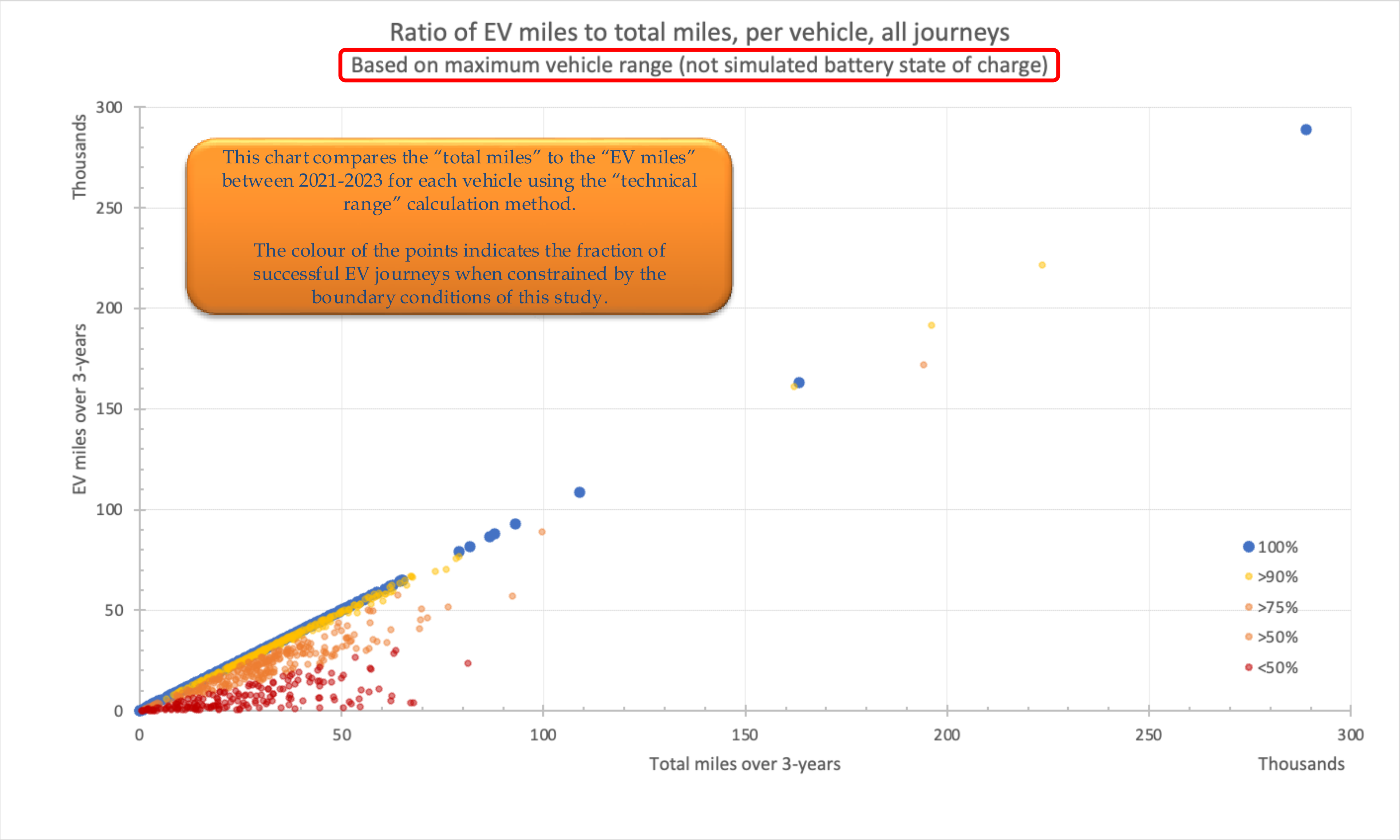
Miles travelled per vehicle between 2021-2023, all vehicles

Based on maximum vehicle range (not simulated battery state of charge)

This chart illustrates the difference between "total miles" and "EV miles" for each vehicle between 2021-2023, using the "technical range" calculation method.

The closer the orange point is to the blue point, the more suitable that vehicle is for EV conversion.

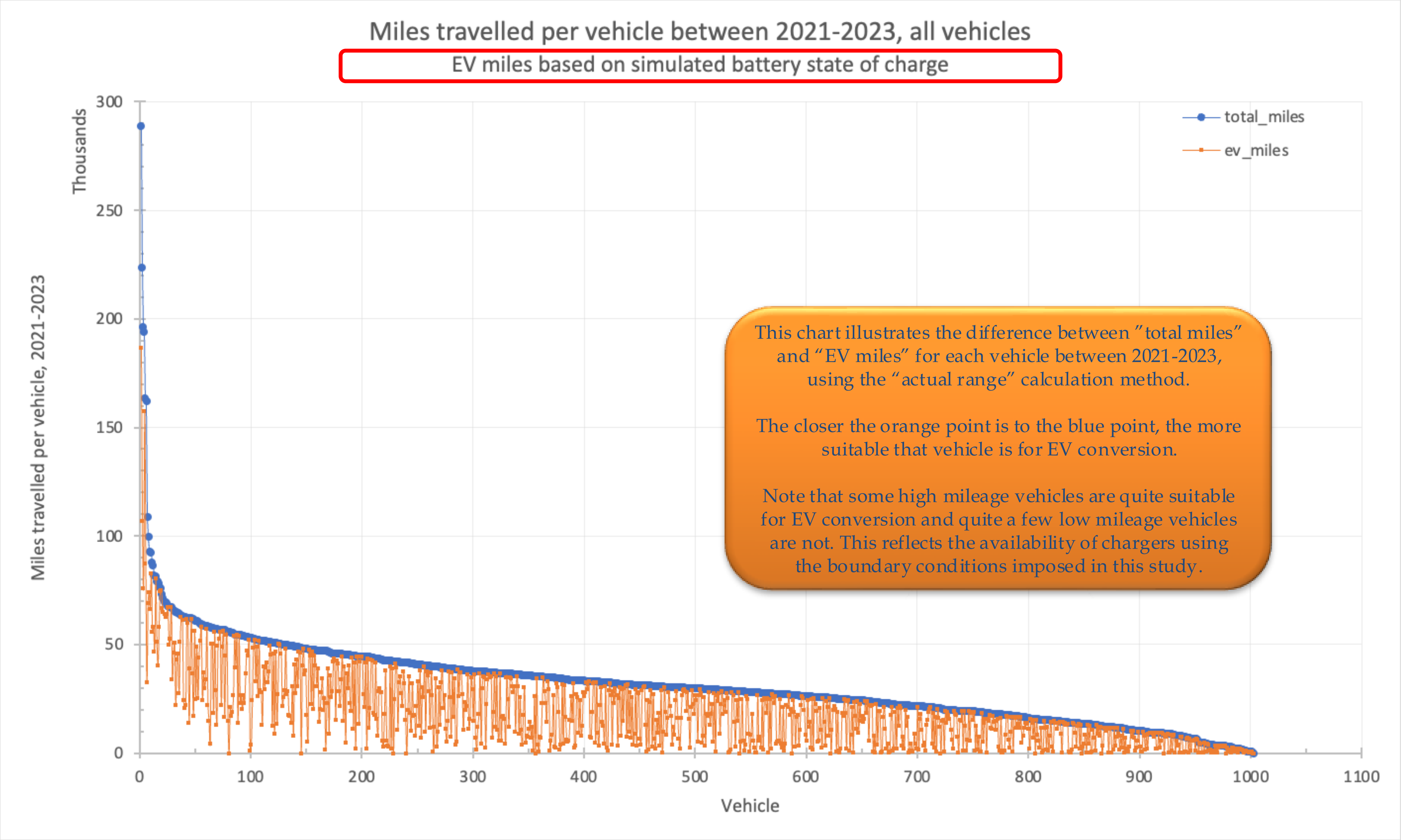
Potential EV mileage as % of each vehicle journeys



This chart compares the "total miles" to the "EV miles" between 2021-2023 for each vehicle using the "technical range" calculation method.

The colour of the points indicates the fraction of successful EV journeys when constrained by the boundary conditions of this study.

Vehicles ranked by total mileage



Miles travelled per vehicle between 2021-2023, all vehicles

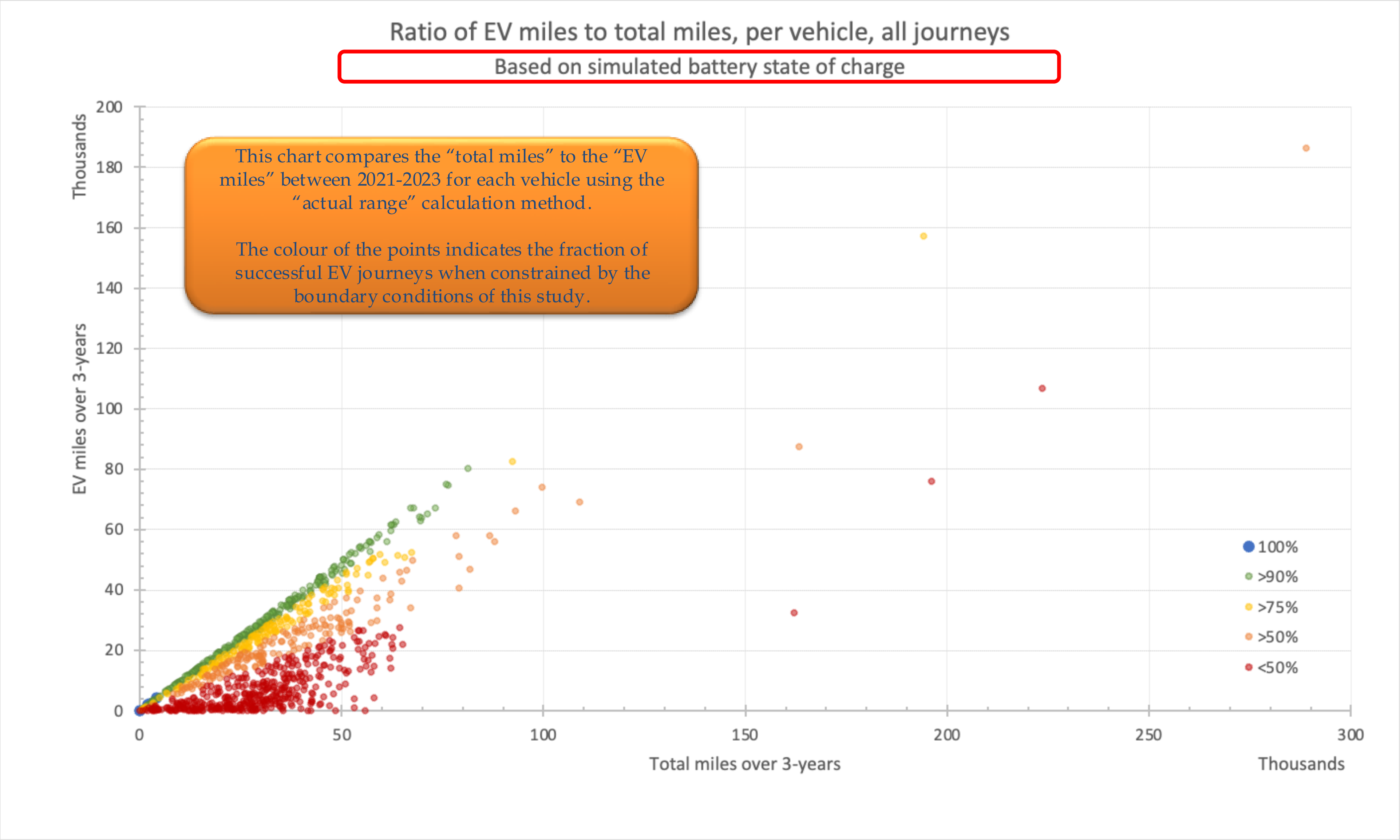
EV miles based on simulated battery state of charge

This chart illustrates the difference between "total miles" and "EV miles" for each vehicle between 2021-2023, using the "actual range" calculation method.

The closer the orange point is to the blue point, the more suitable that vehicle is for EV conversion.

Note that some high mileage vehicles are quite suitable for EV conversion and quite a few low mileage vehicles are not. This reflects the availability of chargers using the boundary conditions imposed in this study.

Potential EV mileage as % of each vehicle journeys



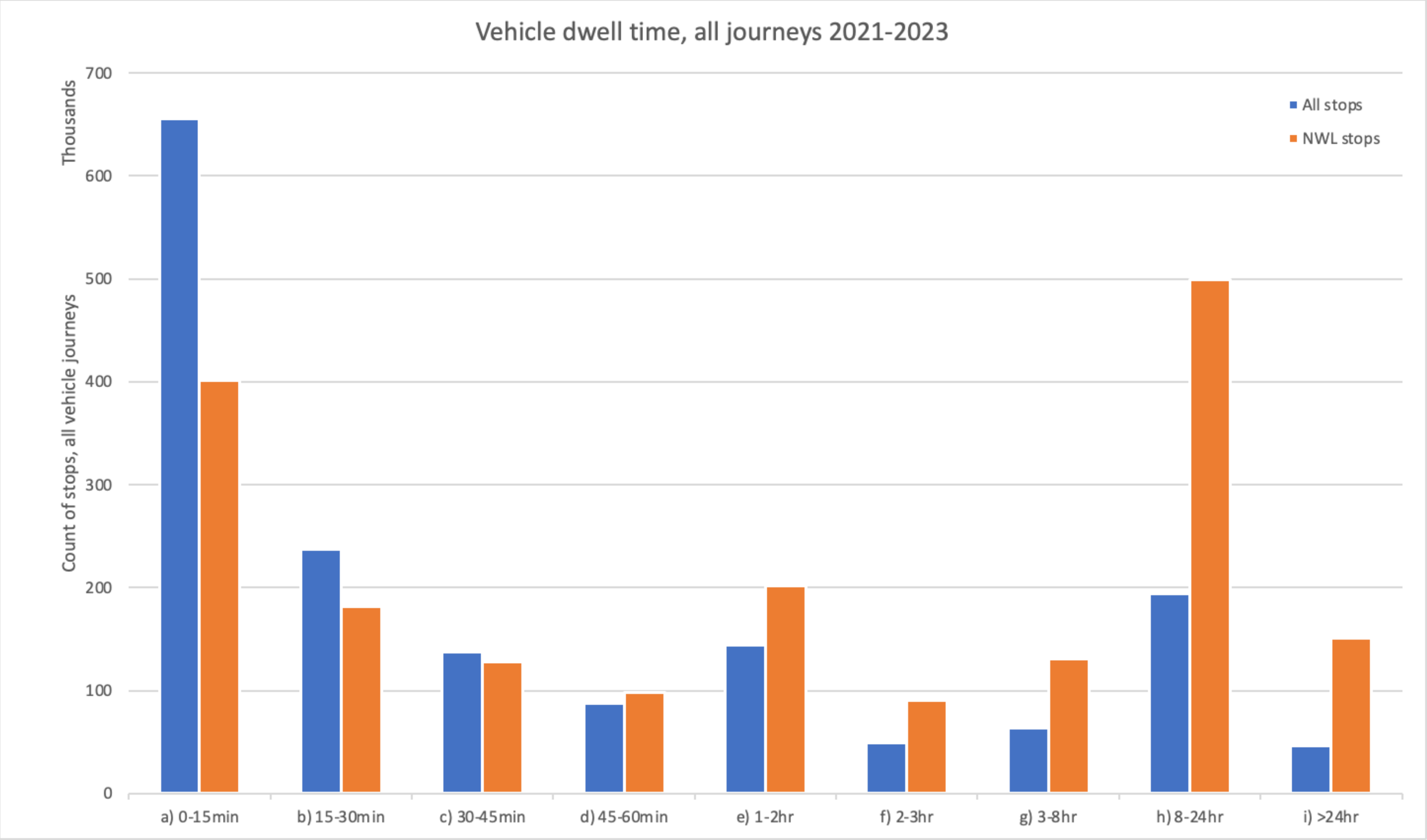
Ratio of EV miles to total miles, per vehicle, all journeys

Based on simulated battery state of charge

This chart compares the "total miles" to the "EV miles" between 2021-2023 for each vehicle using the "actual range" calculation method.

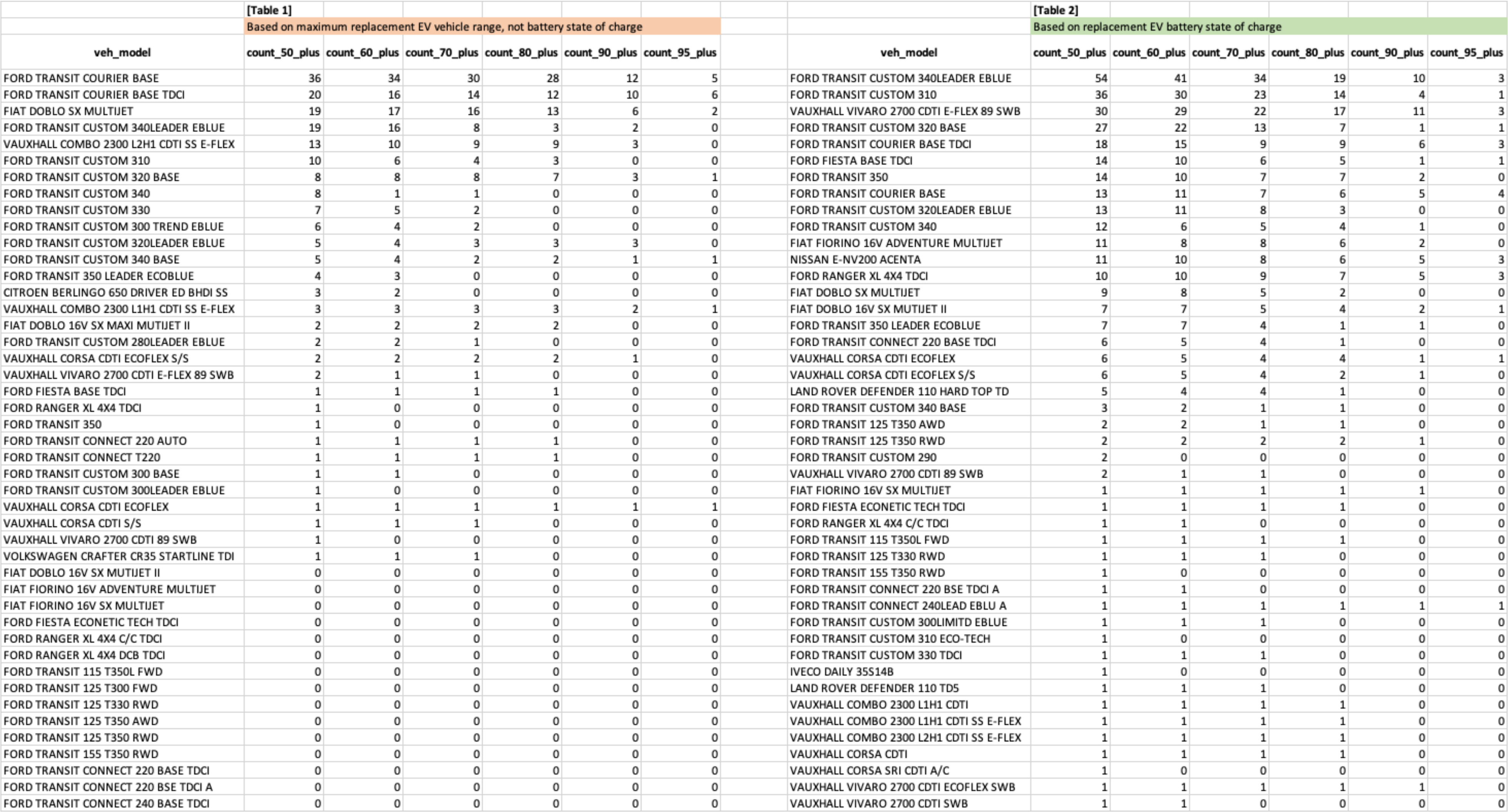
The colour of the points indicates the fraction of successful EV journeys when constrained by the boundary conditions of this study.

Historical vehicle dwell times



NWL models that can be converted to EV

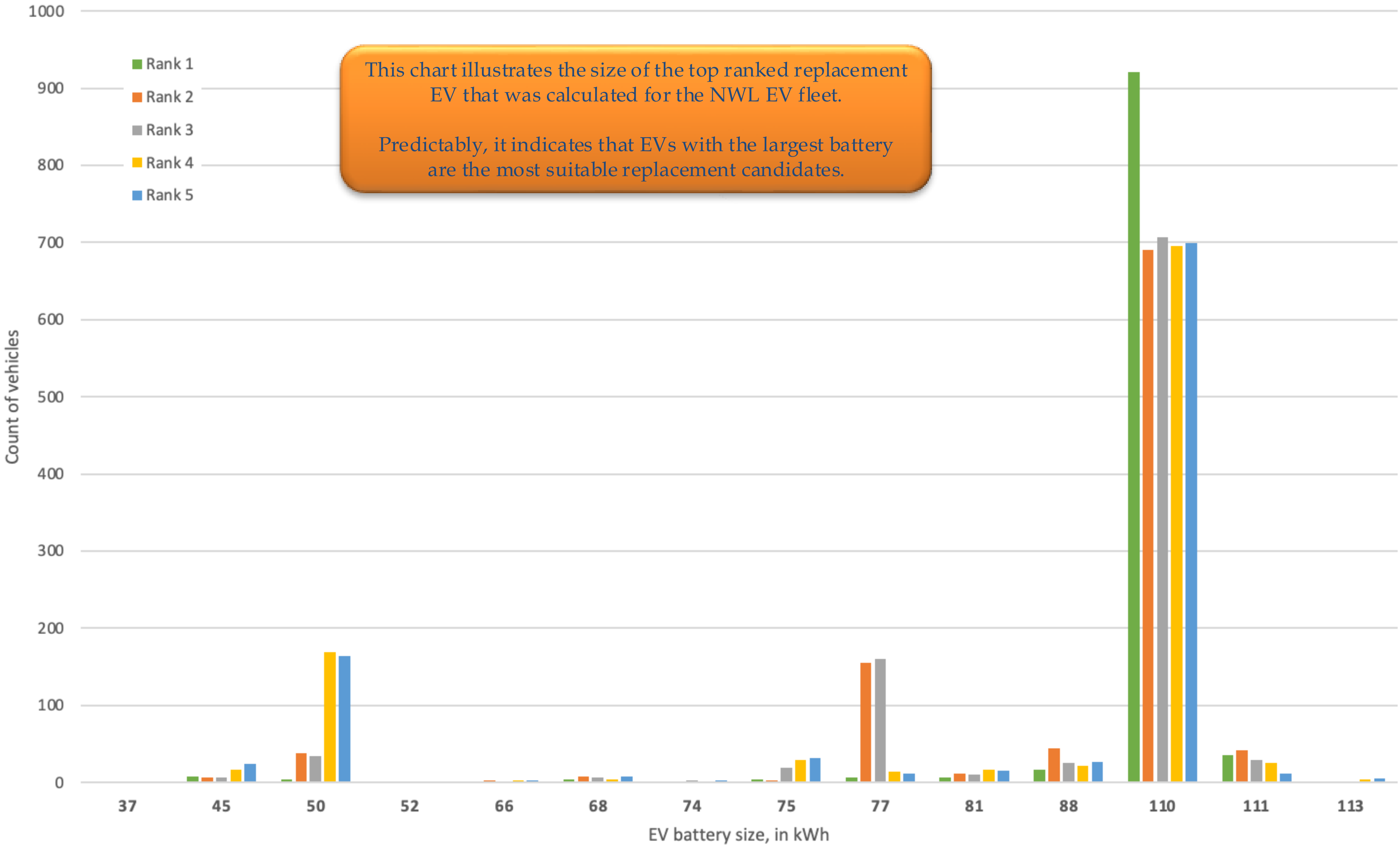
The columns in these tables show how many of each current NWL fleet model vehicles can achieve various "% EV miles", where [Table 1] is calculated using the "technical range" method, and [Table 2] is calculated using the "actual range" method.



	[Table 1]					
	Based on maximum replacement EV vehicle range, not battery state of charge					
veh_model	**count_50_plus**	**count_60_plus**	**count_70_plus**	**count_80_plus**	**count_90_plus**	**count_95_plus**
FORD TRANSIT COURIER BASE	36	34	30	28	12	5
FORD TRANSIT COURIER BASE TDCI	20	16	14	12	10	6
FIAT DOBLO SX MULTIJET	19	17	16	13	6	2
FORD TRANSIT CUSTOM 340LEADER EBLUE	19	16	8	3	2	0
VAUXHALL COMBO 2300 L2H1 CDTI SS E-FLEX	13	10	9	9	3	0
FORD TRANSIT CUSTOM 310	10	6	4	3	0	0
FORD TRANSIT CUSTOM 320 BASE	8	8	8	7	3	1
FORD TRANSIT CUSTOM 340	8	1	1	0	0	0
FORD TRANSIT CUSTOM 330	7	5	2	0	0	0
FORD TRANSIT CUSTOM 300 TREND EBLUE	6	4	2	0	0	0
FORD TRANSIT CUSTOM 320LEADER EBLUE	5	4	3	3	3	0
FORD TRANSIT CUSTOM 340 BASE	5	4	2	2	1	1
FORD TRANSIT 350 LEADER ECOBLUE	4	3	0	0	0	0
CITROEN BERLINGO 650 DRIVER ED BHDI SS	3	2	0	0	0	0
VAUXHALL COMBO 2300 L1H1 CDTI SS E-FLEX	3	3	3	3	2	1
FIAT DOBLO 16V SX MAXI MUTIJET II	2	2	2	2	0	0
FORD TRANSIT CUSTOM 280LEADER EBLUE	2	2	1	0	0	0
VAUXHALL CORSA CDTI ECOFLEX S/S	2	2	2	2	1	0
VAUXHALL VIVARO 2700 CDTI E-FLEX 89 SWB	2	1	1	0	0	0
FORD FIESTA BASE TDCI	1	1	1	1	0	0
FORD RANGER XL 4X4 TDCI	1	0	0	0	0	0
FORD TRANSIT 350	1	0	0	0	0	0
FORD TRANSIT CONNECT 220 AUTO	1	1	1	1	0	0
FORD TRANSIT CONNECT T220	1	1	1	1	0	0
FORD TRANSIT CUSTOM 300 BASE	1	1	0	0	0	0
FORD TRANSIT CUSTOM 300LEADER EBLUE	1	0	0	0	0	0
VAUXHALL CORSA CDTI ECOFLEX	1	1	1	1	1	1
VAUXHALL CORSA CDTI S/S	1	1	1	0	0	0
VAUXHALL VIVARO 2700 CDTI 89 SWB	1	0	0	0	0	0
VOLKSWAGEN CRAFTER CR35 STARTLINE TDI	1	1	1	0	0	0
FIAT DOBLO 16V SX MUTIJET II	0	0	0	0	0	0
FIAT FIORINO 16V ADVENTURE MULTIJET	0	0	0	0	0	0
FIAT FIORINO 16V SX MULTIJET	0	0	0	0	0	0
FORD FIESTA ECONETIC TECH TDCI	0	0	0	0	0	0
FORD RANGER XL 4X4 C/C TDCI	0	0	0	0	0	0
FORD RANGER XL 4X4 DCB TDCI	0	0	0	0	0	0
FORD TRANSIT 115 T350L FWD	0	0	0	0	0	0
FORD TRANSIT 125 T300 FWD	0	0	0	0	0	0
FORD TRANSIT 125 T330 RWD	0	0	0	0	0	0
FORD TRANSIT 125 T350 AWD	0	0	0	0	0	0
FORD TRANSIT 125 T350 RWD	0	0	0	0	0	0
FORD TRANSIT 155 T350 RWD	0	0	0	0	0	0
FORD TRANSIT CONNECT 220 BASE TDCI	0	0	0	0	0	0
FORD TRANSIT CONNECT 220 BSE TDCI A	0	0	0	0	0	0
FORD TRANSIT CONNECT 240 BASE TDCI	0	0	0	0	0	0

	[Table 2]					
	Based on replacement EV battery state of charge					
veh_model	**count_50_plus**	**count_60_plus**	**count_70_plus**	**count_80_plus**	**count_90_plus**	**count_95_plus**
FORD TRANSIT CUSTOM 340LEADER EBLUE	54	41	34	19	10	3
FORD TRANSIT CUSTOM 310	36	30	23	14	4	1
VAUXHALL VIVARO 2700 CDTI E-FLEX 89 SWB	30	29	22	17	11	3
FORD TRANSIT CUSTOM 320 BASE	27	22	13	7	1	1
FORD TRANSIT COURIER BASE TDCI	18	15	9	9	6	3
FORD FIESTA BASE TDCI	14	10	6	5	1	1
FORD TRANSIT 350	14	10	7	7	2	0
FORD TRANSIT COURIER BASE	13	11	7	6	5	4
FORD TRANSIT CUSTOM 320LEADER EBLUE	13	11	8	3	0	0
FORD TRANSIT CUSTOM 340	12	6	5	4	1	0
FIAT FIORINO 16V ADVENTURE MULTIJET	11	8	8	6	2	0
NISSAN E-NV200 ACENTA	11	10	8	6	5	3
FORD RANGER XL 4X4 TDCI	10	10	9	7	5	3
FIAT DOBLO SX MULTIJET	9	8	5	2	0	0
FIAT DOBLO 16V SX MUTIJET II	7	7	5	4	2	1
FORD TRANSIT 350 LEADER ECOBLUE	7	7	4	1	1	0
FORD TRANSIT CONNECT 220 BASE TDCI	6	5	4	1	0	0
VAUXHALL CORSA CDTI ECOFLEX	6	5	4	4	1	1
VAUXHALL CORSA CDTI ECOFLEX S/S	6	5	4	2	1	0
LAND ROVER DEFENDER 110 HARD TOP TD	5	4	4	1	0	0
FORD TRANSIT CUSTOM 340 BASE	3	2	1	1	0	0
FORD TRANSIT 125 T350 AWD	2	2	1	1	0	0
FORD TRANSIT 125 T350 RWD	2	2	2	2	1	0
FORD TRANSIT CUSTOM 290	2	0	0	0	0	0
VAUXHALL VIVARO 2700 CDTI 89 SWB	2	1	1	0	0	0
FIAT FIORINO 16V SX MULTIJET	1	1	1	1	1	0
FORD FIESTA ECONETIC TECH TDCI	1	1	1	1	0	0
FORD RANGER XL 4X4 C/C TDCI	1	1	0	0	0	0
FORD TRANSIT 115 T350L FWD	1	1	1	1	0	0
FORD TRANSIT 125 T330 RWD	1	1	1	0	0	0
FORD TRANSIT 155 T350 RWD	1	0	0	0	0	0
FORD TRANSIT CONNECT 220 BSE TDCI A	1	1	0	0	0	0
FORD TRANSIT CONNECT 240LEAD EBLU A	1	1	1	1	1	1
FORD TRANSIT CUSTOM 300LIMITD EBLUE	1	1	1	0	0	0
FORD TRANSIT CUSTOM 310 ECO-TECH	1	0	0	0	0	0
FORD TRANSIT CUSTOM 330 TDCI	1	1	1	0	0	0
IVECO DAILY 35S14B	1	0	0	0	0	0
LAND ROVER DEFENDER 110 TD5	1	1	1	0	0	0
VAUXHALL COMBO 2300 L1H1 CDTI	1	1	1	1	0	0
VAUXHALL COMBO 2300 L1H1 CDTI SS E-FLEX	1	1	1	1	0	0
VAUXHALL COMBO 2300 L2H1 CDTI SS E-FLEX	1	1	1	1	0	0
VAUXHALL CORSA CDTI	1	1	1	1	0	0
VAUXHALL CORSA SRI CDTI A/C	1	0	0	0	0	0
VAUXHALL VIVARO 2700 CDTI ECOFLEX SWB	1	1	1	1	1	0
VAUXHALL VIVARO 2700 CDTI SWB	1	1	0	0	0	0

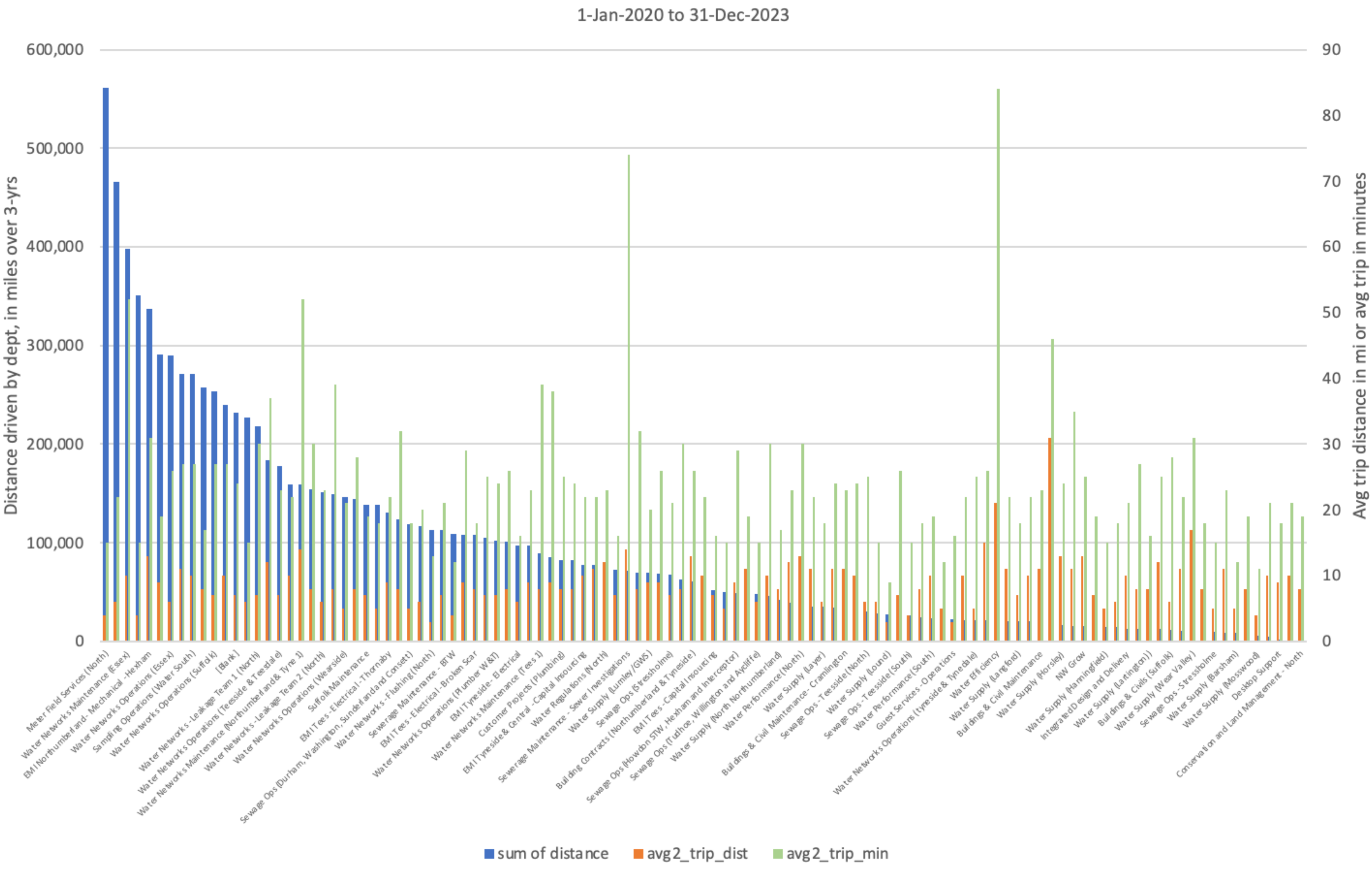
Count of replacement EVs by battery size, entire fleet



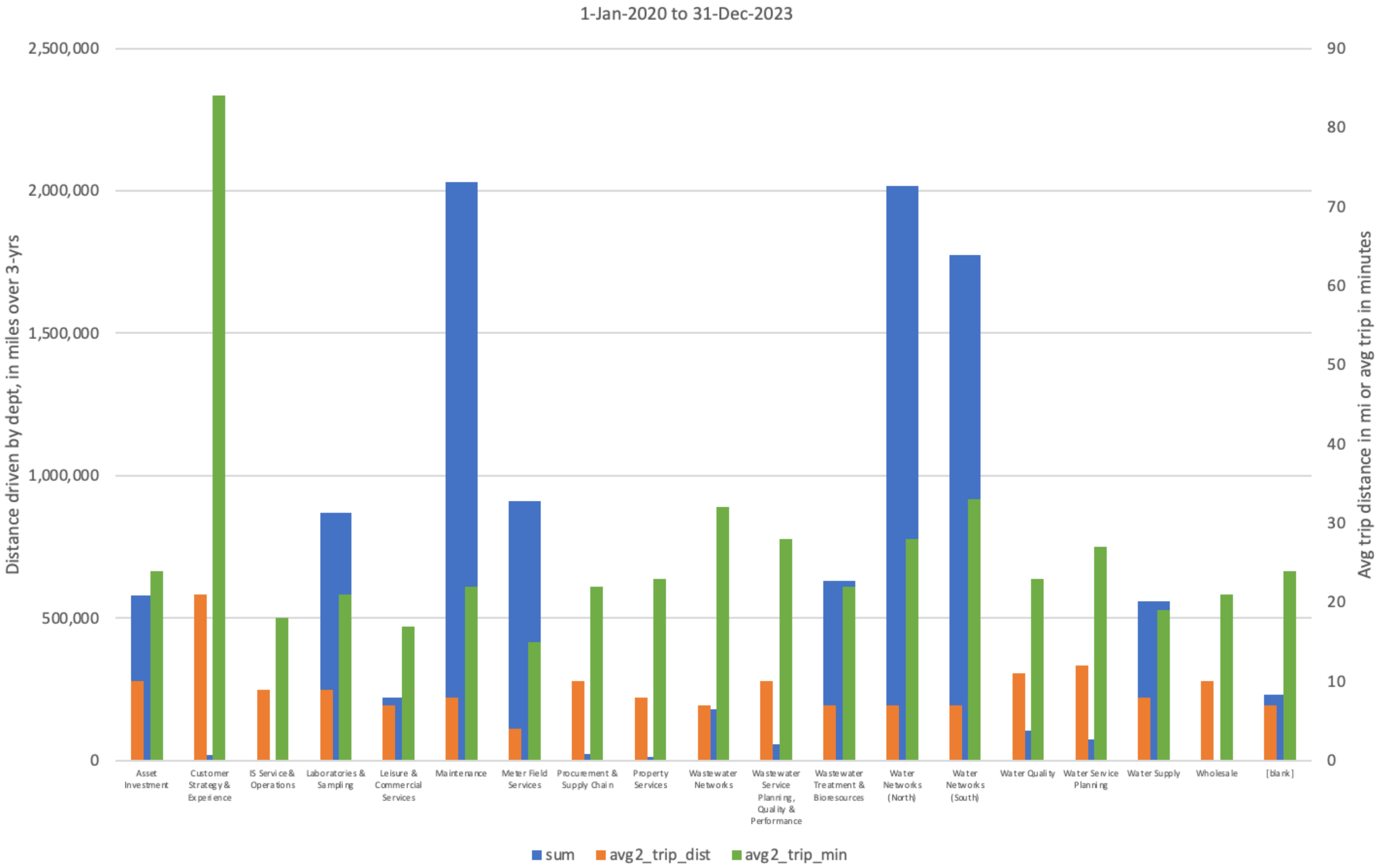
This chart illustrates the size of the top ranked replacement EV that was calculated for the NWL EV fleet.

Predictably, it indicates that EVs with the largest battery are the most suitable replacement candidates.

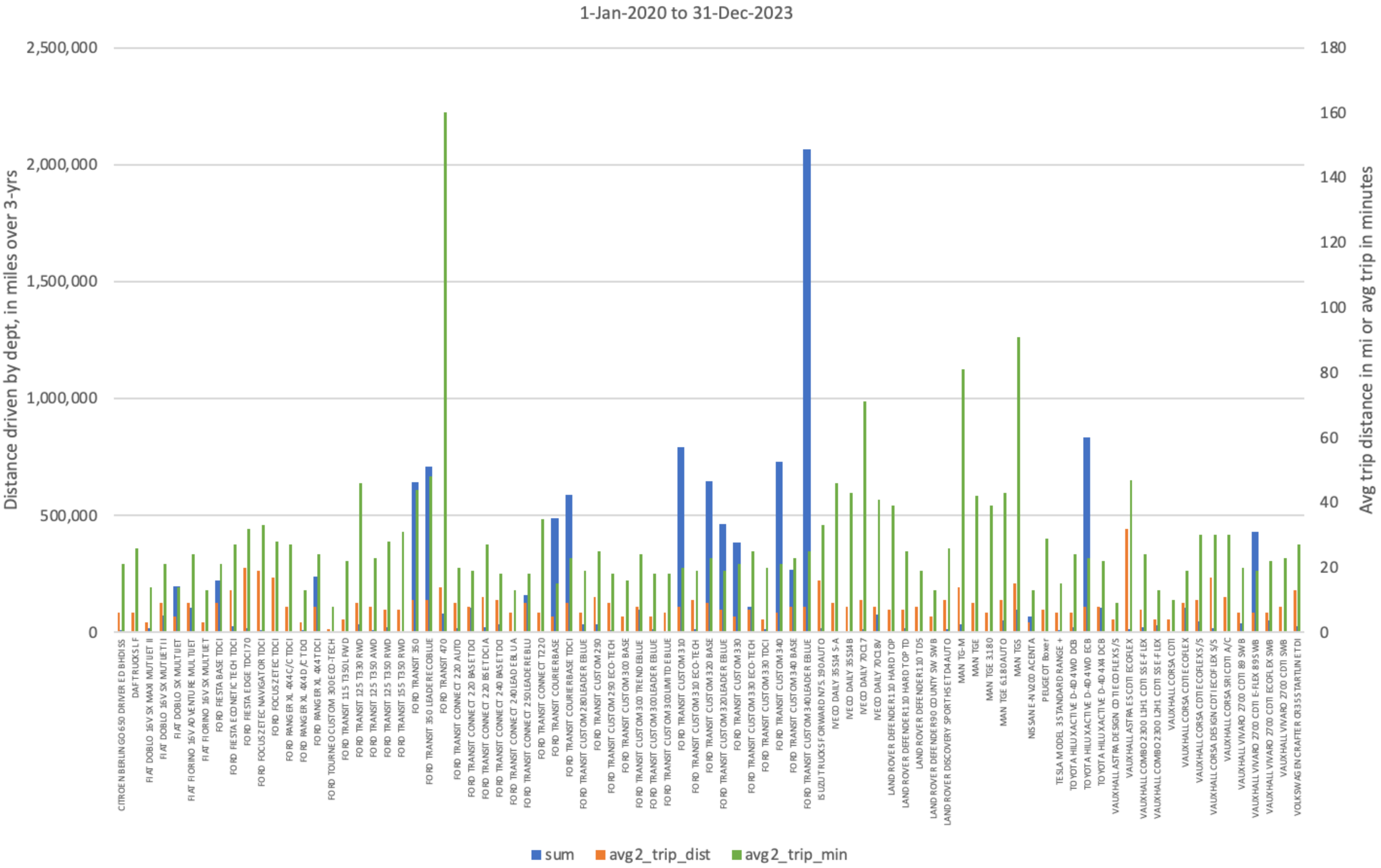
Historical mileage and trip length by dept, all journeys



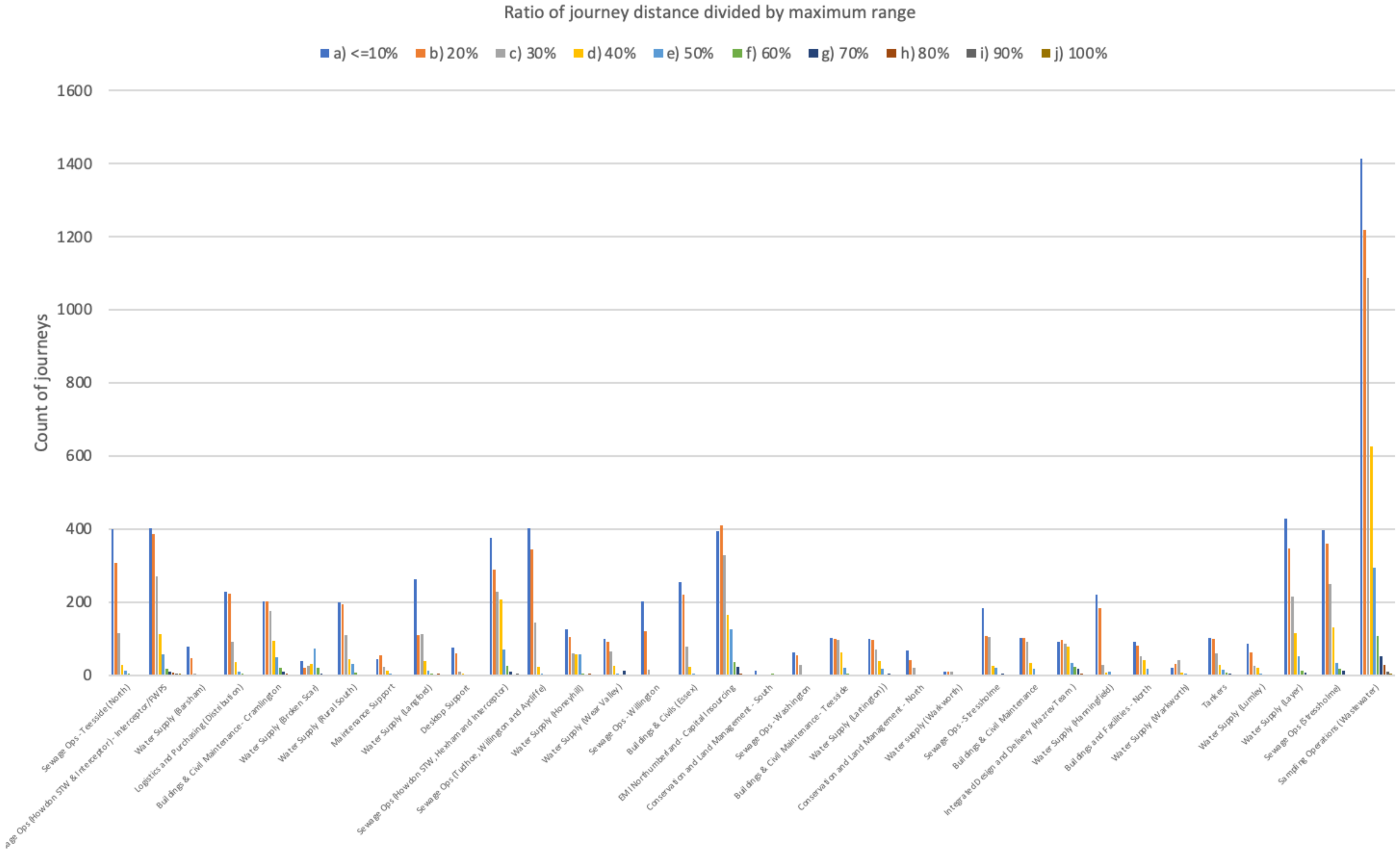
Historical mileage and trip length by level, all journeys



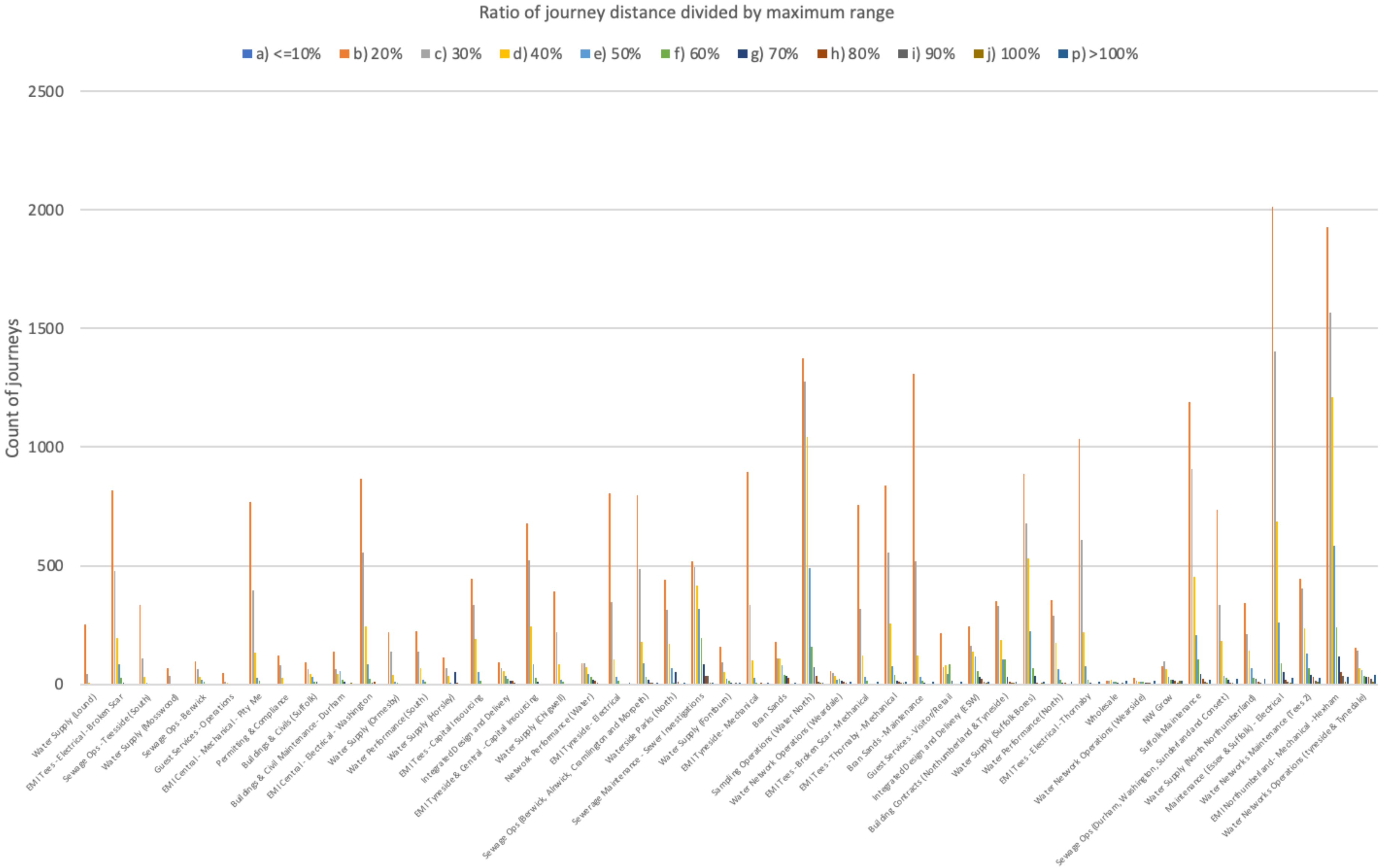
Historical mileage by vehicle model, all journeys



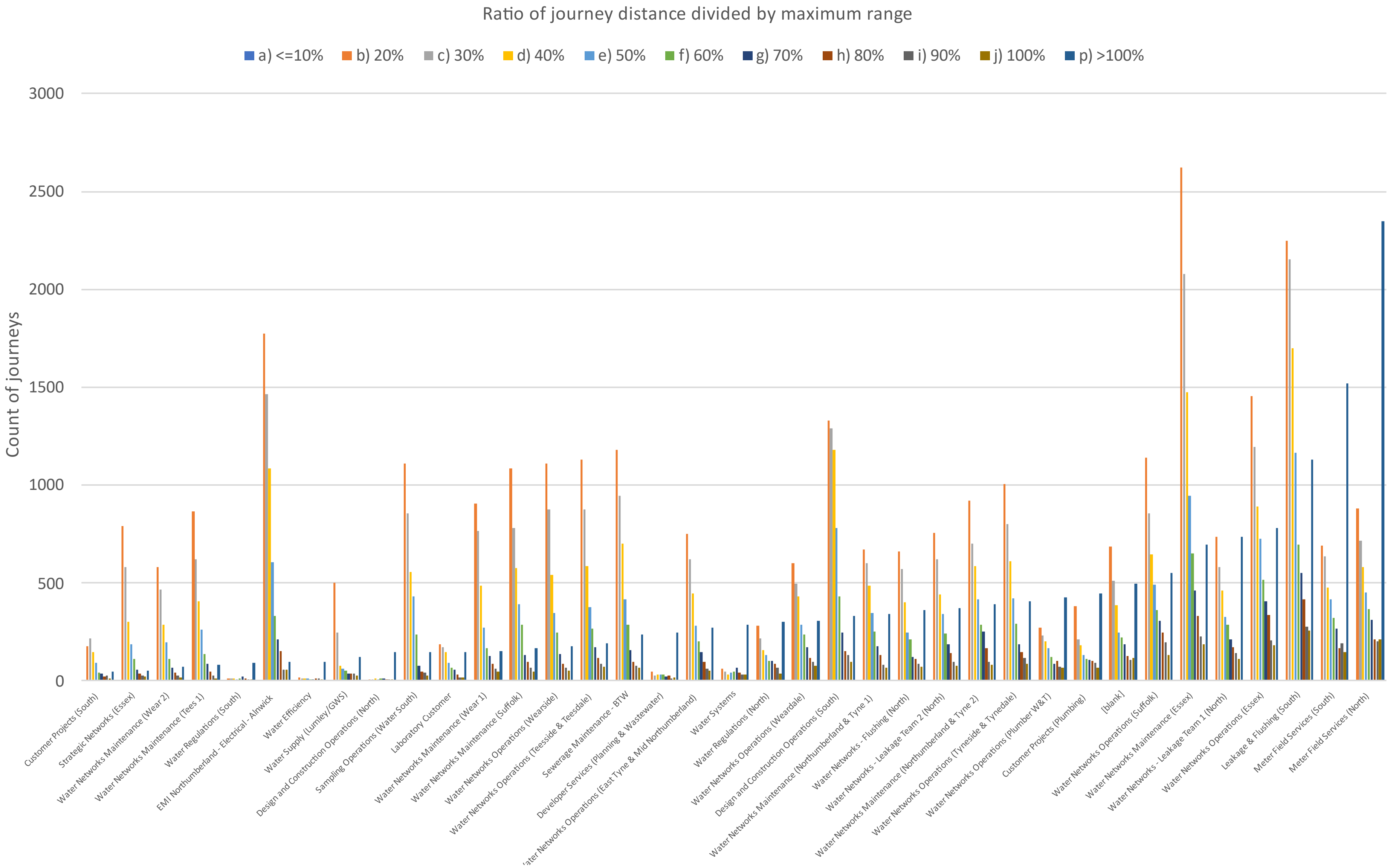
Journeys as % of vehicle range by dept, all journeys



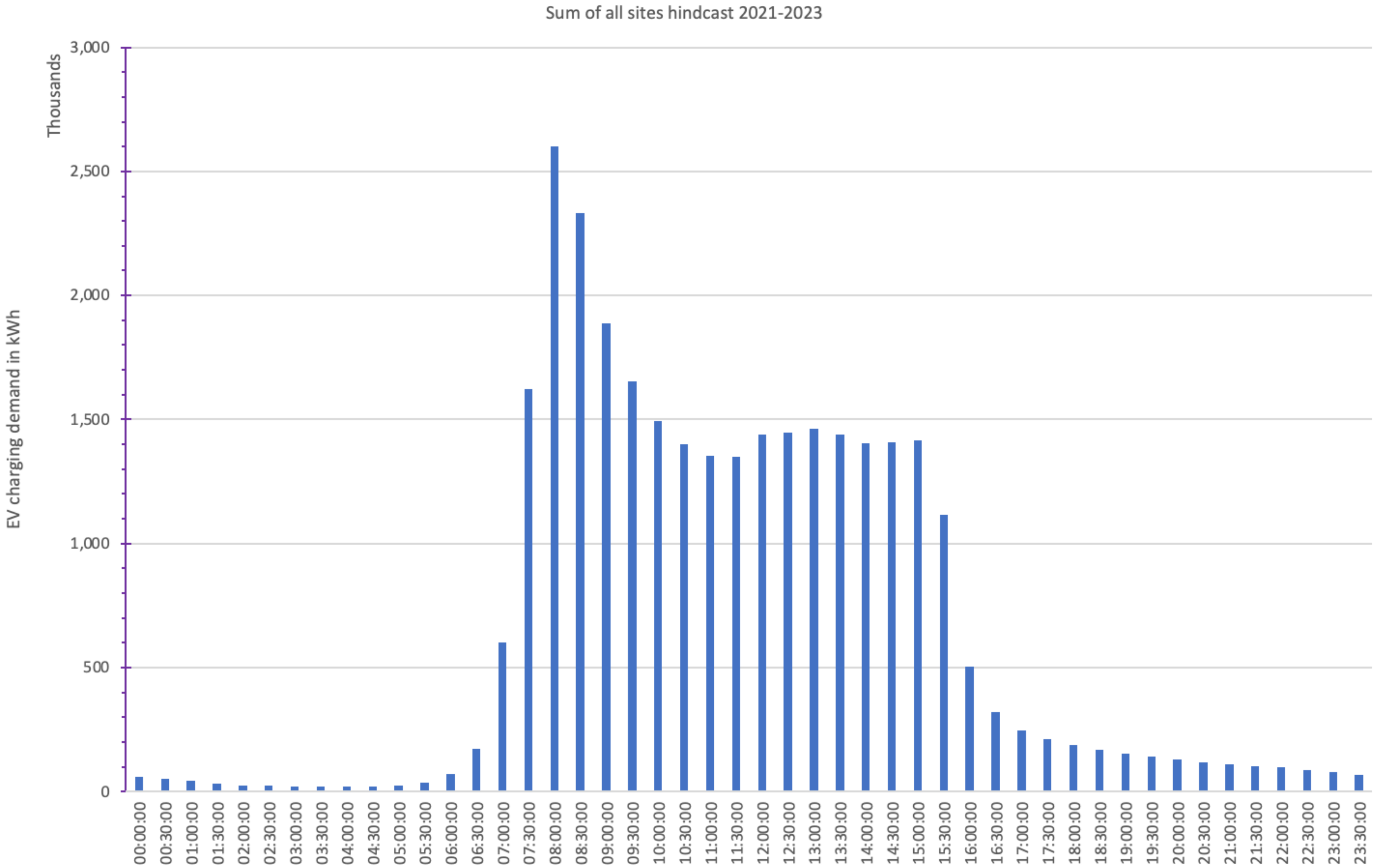
Journeys as % of vehicle range by dept, all journeys (2)



Journeys as % of vehicle range by dept, all journeys (3)



Phasing of charging demand, all journeys



Thank you

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