Understanding challenges and pathways to increasing diversity in EV adoption

Aim: The aim of this project is to create a better understanding of the social and demographic characteristics of EV adopters and how demand flexibility can be enabled to alleviate grid constraints. The project investigates gender biases in engaging with demand flexibility programmes and the challenges in adopting e-mobility solutions in the UK.

Outcomes in brief: The project investigated EV battery characteristics to create a better understanding of the affordability and maintenance efforts that pre-used EV adopters should expect. We investigated battery degradation in relation to charging and usage patterns to predict battery health beyond a standard 5-year lease, looking at how used EVs could offer an affordable but reliable solution to decarbonize transport encompassing varied demographics.

From the data analysis we found that EV uptake has been heterogenous within the UK. Based on the dataset "Battery Electric Vehicles or BEVs (subset of ULEVs) licensed at the end of quarter by postcode district, United Kingdom[1]" – Q4 2021, the top 10 postcodes for EV licenced were extracted and they are presented in Table 1. Table 2 contains a sample of postcodes with their population sizes and EVs licenced. It can be seen that Cardiff, for example, only had 2765 new EVs licenced in Q4 2021 for a population of 1,073,572, or a percentage of 0.26. This is very low compared to other postcodes such as SL (5.23%) or MK (3.97%).

Table 1: Top 10 (full first part of postcode)

	PO	No EVs
1	SK3	24246
2	SN5	17658
3	BS16	14820
4	SL1	14504
5	MK14	12028
6	BA14	7689
7	LS1	6396
8	PE1	6387
9	LS5	5807
10	CV34	5763

Table 2: Samples (postcode area)

PA	No EVs	Population	%
W	6907	577,968	1.20
UB	4890	385,080	1.27
CF	2765	1,073,572	0.26
EC	566	74,493	0.76
SW	6775	938,088	0.72
SE	3518	1,121,167	0.31
N	3959	915,947	0.43
E	3007	1,143,008	0.26
WC	242	62,340	0.39

Table 3: Postcode areas with higher adoption

LS	15653	835,145	1.87
MK	22171	558,291	3.97
SL	21130	403,980	5.23

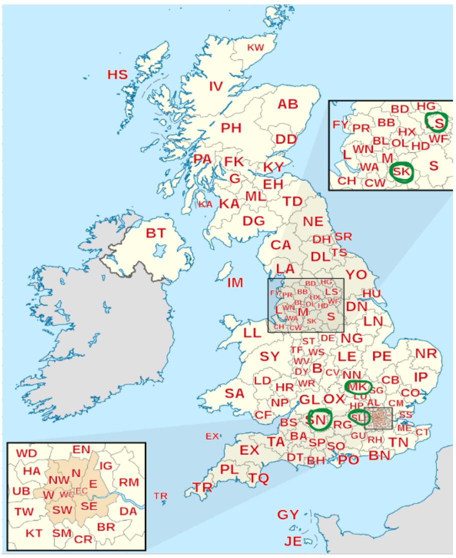

Figure 1

Using the National Travel Survey data[2], we found that there is difference in driving patterns for in two areas for males and females, with males using vehicles more than females for commuting, while females are driving more miles for school runs than males (Table 4). A detailed breakdown by gender and age is presented in Table 5.

The battery degradation model was implemented for chemistries used widely in the current EVs. We devised 9 scenarios of usage, presented in Table 6. The results in Table 7 show that using EVs for demand response does not degrade the battery excessively, neither for males nor female users. However, the financial benefits shown in Figure 2 are significant. The cost of purchase and use of EVs is compared to vehicles with internal combustion engines was

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[1] https://www.gov.uk/government/statistics/vehicle-licensing-statistics-2021/vehicle-licensing-statistics-2021

[2] https://www.gov.uk/government/collections/national-travel-survey-statistics

analysed and it was demonstrated that EVs become a more appealing proposition if owners participate in demand response programmes.

Table 4: Trips by gender

	miles/year	
Trip purpose	Males	Females
Commuting	1086	554
Business	294	115
Education	137	148
Escort education	60	117
Shopping	407	523
Other escort	319	317
Personal business	288	291
Visiting friends at private home	646	743
Visiting friends elsewhere	185	207
Entertainment / public activity	255	214
Sport: participate	126	30
Holiday: base	310	314
Day trip	390	368
Other including just walk	106	115
Total	4609	4055

Table 5: Trips by gender and age

Gender	Males					Females				
Age range	Avg	21-29	30-39	40-49	50-59	Avg	21-29	30-39	40-49	50-59
Commuting	191	182	197	196	187	144	169	111	150	145
Business	25	21	19	25	34	19	10	19	21	27
Escort education	47	3	44	111	29	105	31	179	182	28
Shopping	125	94	123	145	139	166	153	160	172	178
Visiting friends at private home	57	61	48	42	77	73	74	73	58	86
Visiting friends elsewhere	27	34	22	24	27	29	32	25	35	24
Day trip	31	20	27	36	42	36	28	44	28	44

Table 6: Simulated scenarios

Sc	Characteristics	Purpose	No of trips	Assumed annual mileage	Charging conditions
0	Combined short and long trips	Escorting (school drop) Shopping Day trip	2 every weekday 1 every weekday 1 every weekend	28,600	At home whatever the SoC; On motorway until SoC = 80%
1	The same as Scenario 0 but charge the EV only when the SoC <= 5%				
2	Only short trips	Escorting (school drop) Shopping	Any pattern to satisify the annual mileage	28,600	At home and only when the SoC <=5%
3	Medium range work trip	Commuting	1 every weekday	10400	Charge only at work after every work trip
4	Long range work trip	Commuting	1 every weekday	26000	Charge only at work after every work trip
5	Leisure	Shopping Visiting Friends Entertainment	2 every week 2 weekends 3 other short trips	3640	Charge at home at weekend
6 Males and Females	Based on national statistics data				
7 Males and Females	Same as Sc6 but distances multiplied by 4 to get nearer 10k miles per year				

Table 7: Battery degradation results

	%Capacity loss Cycle&Caldendar	Sc0	Sc2	Sc3	Sc4	Sc5	Sc6 Males	Sc6 Females	Sc7 Males	Sc7 Females
Only Drive	1 year	4.82	4.46	4.51	4.58	3.92	3.98	4.05	4.13	4.21
	5 years	9.6	8.45	8.59	8.78	7.16	7.28	7.42	7.6	7.78
Drive + Grid Event	1 year	4.87	4.55	4.61	4.7	4.05	4.08	4.15	4.25	4.32
	5 years	9.77	8.69	8.87	9.16	7.43	7.5	7.64	7.88	8.06

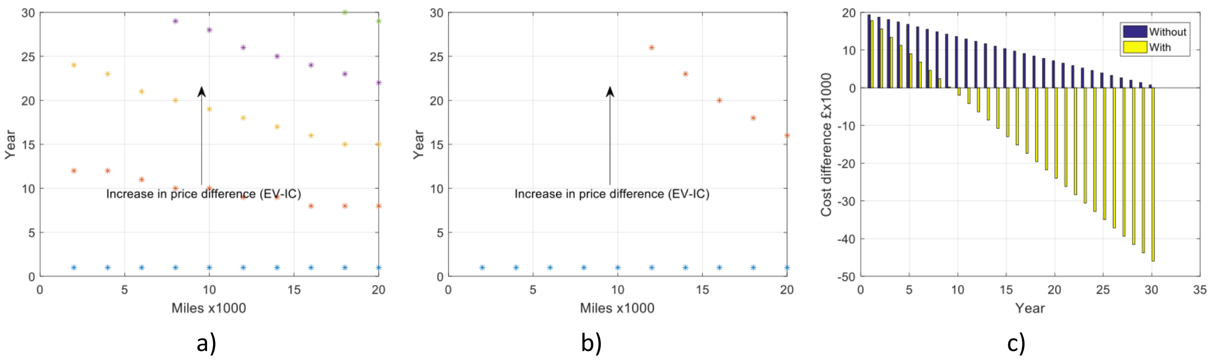

Figure 2: Economic analysis – a)EV-IC comparison with grid services;b) EV-IC comparison without grid services; c) Payback comparison with and without grid services

Outlook: An extension until May 2023 has been requested so that the following planned work could be completed: 1) Assess the correlation between demographics and EV charging patterns, understanding how under-represented adopters could be engaged in transport decarbonization; 2) Inform education pathways for community members in overcoming barriers in e-mobility adoption.