

To what extent do electric car drivers utilize the flexibility options in two-car households?

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Aim

Background and Relevance

In two-car households, potentially a BEV can 1) drive longer, 2) avoid range limitations, 3) with a small battery [Karlsson 2017]. Two-car households are an important near-term market, as most private cars in industrialized countries are in multi-car households. Karlsson S, 2017. What are the value and implications of two-car households for the electric car? *Transportation Research Part C* 81, 1-17.

Question

Do actual households utilize this potential?



Method

BEV trial

- 25 two-car households replaced by a BEV one of the cars of own choice
- VW e-Golf: 24 kWh, ≈120 km range, (Fig 1)
- Home-charging equipment installed (3kW)
- 3.5 months, at different seasons
- Paid for own electricity, congestion charging, insurance deductibles

Modeling

- maximum possible BEV driving in each HH
- changing cars at home only
- home charging only
- no charging rate restrictions (always full SoC when leaving home)
- maximum possible driving compared to actual driving and driving before trial
- distinguish single and overlap home-to-home trips, (Fig 2)

Data

- Both cars simultaneously logged by GPS both *before and during* the trial
- SoC and odometer reading
- Home charging point of time and energy

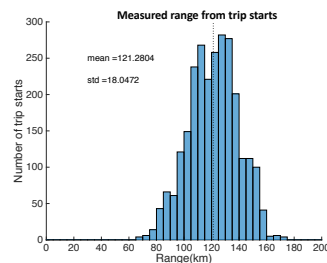


Fig 1 Measured ranges from every trip start.

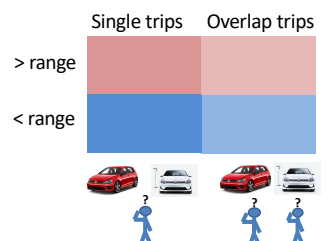


Fig 2 Two choice situations, and two ranges.

Results

Which car was kept?

Car properties rather than driving pattern characteristics or charging options were important for which car to replace, (Fig 3). Especially, the household preferred to keep the largest car.

KEEP Property	SCORE	Rank	KEEP Property	SCORE	Rank
Car properties			Movement pattern properties		
KEEP the Largest	19 - 2 (90%)	1	KEEP with Shortest commuter distance	11 - 10 (53%)	8
KEEP the Newest	15 - 8 (65%)	6	KEEP with Longest annual driving	12 - 6 (67%)	5
KEEP the Diesel/EBS	10 - 3 (77%)	2	KEEP with Most DRA	14 - 6 (70%)	4
KEEP with a Towbar	12 - 4 (75%)	3	KEEP with Highest Gini-coeff for hth distances	16 - 9 (64%)	7
Infrastructure					
KEEP with No charging at work	2 - 3 (40%)	9			

Fig 3 Ranking of properties along correlation with choice of kept car in the households.

How did driving pattern limit potential BEV use?

Overlap trips are on average 2/3 of all driving and even more below range, (Fig 4). Overlap trips limit driving by any car to on average 79 %. The further limitation due to range differs more between the households: ≈ 2-50%, (Fig 5).

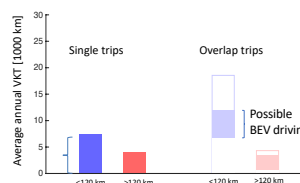


Fig 4 Average single and overlap trips.

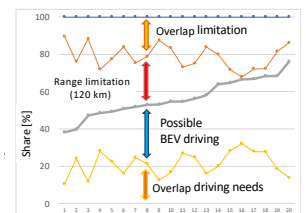


Fig 5 Overlap and range limitations.

How much of the potential was utilized?

An index [-1,1] for the utilization of possible BEV driving with a range D was formulated:

$$\text{INDEX (hth distance } D) = \frac{BEV_{actual}(D) - BEV_{min}(D)}{BEV_{max}(D) - BEV_{min}(D)} \cdot 2 - 1$$

For single trips, the index is above zero for 19 of 20 hhs and results in an average utilization of 68% of the potential below 120 km, (Fig 6). For overlap trips, the index is more diverse, varies between -0.8 and 0.8, and the average utilization of the possibilities is 56%, (Fig 7).

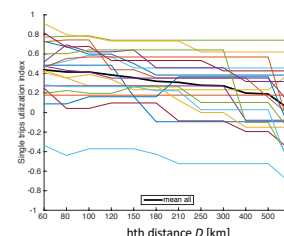


Fig 6 Index for single trips utilization.

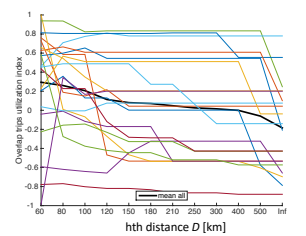


Fig 7 Index for overlap trips utilization.

Heritage or environment?

For single trips, the BEV considerably increased the utilization compared to the average utilization of the replaced car, (Fig 8). Also the big difference in use before the trial between 1st and 2nd car, especially for overlap trips, (Fig 9) was almost eliminated with the BEV.

Conclusions

Two-car households utilize to a large extent the potential BEV driving also with a short-range BEV, especially for single trips. Multi-car households are therefore an important near-term market. Current trend towards large batteries counteracts the favorable economics, though. Also, the large up-front cost is an extra financial burden on most of these households. They need considering both cars then.

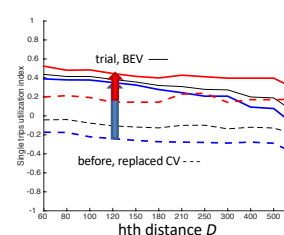


Fig 8 Index for replaced car, single trips.

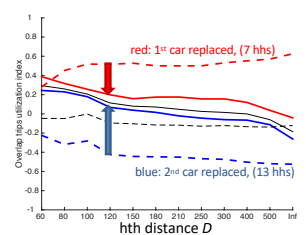


Fig 9 Index for replaced car, overlap trips.