

# Usage patterns of BEVs in two-car households

Sten Karlsson  
Space, Earth and Environment  
Chalmers Univ of Technology

**Project title:** Usage patterns of BEVs in two-car households

**Project manager:** Sten Karlsson

**Researchers:** Sten Karlsson, Chalmers University of Technology

**Partners:**

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## Sammanfattning

Flerbilshushåll har identifierats som viktiga “early adopters” av elbilar (BEV). Tvåbilshushåll kan ge mer elbilskörning och samtidigt undvika räckviddsbegränsningar med ett mindre och billigare batteri. Detta projekt har undersökt i vilken utsträckning hushållen i en försöksgrupp utnyttjar dessa möjligheter. Projektet har utnyttjat två unika GPS-dataset för båda bilarnas rörelser i 20 tvåbilshushåll, för tiden både före och efter en elbil ersatte en av de konventionella bilarna.

Projektet har exempelvis undersökt olika faktorer som påverkar rörelsemönstret lämplighet för elbilsanvändningen utvecklat index för och analyserat det faktiska utnyttjandet av elbilspotentialen. Projektresultatet kommer att bidra till en bättre förståelse för beteendet hos en viktig del av den framtida elbilsmarknaden.

Projektet har genomförts under perioden september 2018 - juni 2019. Projektkostnaden har varit 494 kSEK med 100% finansiering från Swedish Electromobility Centre.

## Summary

Many-car households have been identified as important early adopters of battery electric vehicles (BEVs). Two-car households make possible more of the cheaper BEV driving and avoidance of range limitations while still having a small and less expensive battery. This project has investigated to what extent households in a BEV trial group utilize these options. The project has utilized two unique GPS dataset for both cars' movements in 20 two-car households; before and after, respectively, the introduction of a BEV replacing one of the conventional cars.

The project has for instance investigated various factor influencing the movement pattern appropriateness for BEV driving and developed indices for and analysed the actual utilization of the BEV potential.

The project results will contribute to a better understanding of the behaviour of an important component of the current and near-term BEV market.

The project has been performed during the period Sept 2018 – June 2019. The project cost has been 494 kSEK with 100% finance from The Swedish Electromobility Centre.

## Background

Many-car households have been identified as important early adopters of battery electric vehicles (BEVs). Two-car households make possible more of the cheaper BEV driving and avoidance of range limitations while still having a small and less expensive battery<sup>1</sup>. The aim of the project was to investigate to what extent households in a BEV trial group utilize these options.

Our two databases on car movements in two-car households, ex ante and ex post BEV introduction, respectively, are unique in an international setting which gives opportunities for specific analyses of the behaviour when households adopt a BEV.

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<sup>1</sup> Karlsson S, 2017. What are the value and implications of two-car households for the electric car? *Transportation Research Part C* 81, 1-17.

Many-car household are seen as an important group for the near-term BEV market development why analyses of the BEV adoption in these households are of great value for various stakeholders, as vehicle manufacturers, policy makers, and for early adopters and thus help the diffusion process of BEV in Sweden, which are essential for reaching climate and fossil independence goals.

## General project description

The detailed actual use of the BEV in the form of home-to-home trips has been evaluated in comparison to the possible “optimal” use the BEV and the conventional vehicle for back-up. To what extent is the potential actually utilized in the different households? How will this depend on the replaced car, the car use patterns, or other factors?

We have applied and adapted the car movement pattern optimization programmes developed in earlier projects. We have developed utilization indices for the two principle choice situations for the BEV driving, single trips and simultaneous overlap trips. In the analysis of the revealed behavior, we have also compared to the pre-trial period data.

## Results

The households determined themselves which of their conventional cars to replace with a BEV and which to keep. We analysed how well different car and driving pattern properties as well as charging options correlated with the car choice. Our analyses show that the households focused the car properties with the size as the most important factor; they preferred to replace their smallest car with a BEV.

We have seen large differences in movement pattern appropriateness for BEV utilization; the possible BEV share of the driving varied a factor two (38 to 76%), There are two main factors affecting this: the overlap of trips limits the possible driving of any car and then the range further limits the use of the BEV. The range limitation was identified as the most important one for the variation between the households.

When it comes to the households’ actual utilization of the potential for electric driving we have developed in indices for the utilization of Single and Overlap trips, respectively, which vary between -1 and +1 for minimum and maximum utilization of the potential, respectively. Fig 1 shows the resulting indices in the 20 households.

At the assumed range of 120 km, for single trips, the index is larger than zero for 19 out of 20 households with an average of 0.38. For overlap trips the index shows an on average lower utilization of the potential. The utilized the BEV potential below range is 69% and 56% for *Single* and *Overlap trips*, respectively. Also, the potential utilization was on average relatively independent of whether 1<sup>st</sup> or 2<sup>nd</sup> car was replaced, indicating a low heritage from before the trial.

While overlap trips is regular in the weekdays, the single trips dominate the weekends. Combined with the higher utilization for single trips this leads to a tendency for BEVs driving in the weekends.

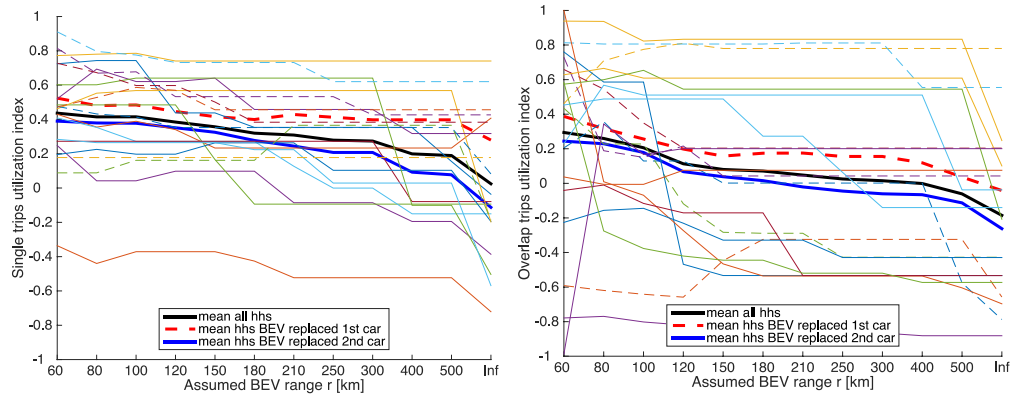


Figure 1. The actual utilization of the BEV in trial period in the different two-car households depicted with a utilization index for different BEV ranges for a) single trips, and b) overlap trips. Dotted lines: indices for households, which replaced the 1<sup>st</sup> car; solid lines: indices for households, which replaced the 2<sup>nd</sup> car.

## Utilization of results

The research results have been presented at four conferences, one international (EVS32, Lyon May 19-22, 2019) and three Swedish (National conference in transport research, Oct 15-16, 2018; Energirelaterad fordonsforskning, Gothenburg April 1-2, 2019; Swedish Electromobility Centre days, Linköping April 23-24, 2019).

Further, the results have been presented at a meeting with the International PEV Policy Group, led by UC Davis, California, and in which the research group participates.

To EVS32 a scientific article was written [Karlsson 2019a] and the result were also conveyed by a poster presentation in a dialogue session [Karlsson 2019b].

We plan to develop the conference paper [Karlsson 2019a] into a paper for a peer-reviewed scientific journal.

## Targets

The project has contributed to increased knowledge of BEV adaptation and utilization in two-car households. Many-car households are identified as important early adopters in the market for BEV due to the ability to circumvent range limitation and reap the cheap operational costs. Together with the technical development, knowledge of the market prerequisite for different electric vehicles are of great benefit for various stakeholders, as vehicle manufacturers and policy makers.

A better understanding of both the potential and the usage of BEV in two-car households will contribute to better knowledge for early adopters and thus help the diffusion process of BEV in Sweden, which are essential for reaching goals for climate mitigation and fossil fuel independency.

## Collaboration

The project has interacted with other ongoing projects at the division related to electromobility, for instance, another SEC project collaborating with UC Davis and Volvo Cars on PEV charging and use, and a larger Mistra project, Carbon Exit. The

project has been used within the International PEV Policy Group, led by UC Davis, California, and in which the research group participates.

## **Dissemination of knowledge**

The project has been presented at several conferences and in the form of a conference paper and a poster.

## **Papers and publications**

Karlsson S, 2019a. *To what extent do electric car drivers utilize the flexibility options in two-car households?* In proceeding of 32<sup>nd</sup> Electric Vehicle Symposium (EVS32), Lyon, France, May 19-22, 2019.

Karlsson S, 2019b. *To what extent do electric car drivers utilize the flexibility options in two-car households?* Poster presented at 32<sup>nd</sup> Electric Vehicle Symposium (EVS32), Lyon, France, May 19-22, 2019.