INDICATING AND MANAGING BEV RANGE ISSUES IN TWO-CAR HHS

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Aim

To assess how vehicles with limited electric range (BEV/PHEV) can fit and utilize vehicle use patterns in two-car households (HH). Most private cars in industrialized countries are in multi-car HHs.

Results

1. *What is the value of flexibility for a BEV?*

A flexible use of the cars in a 2-car HH with one BEV enables **more e-kms** due to more trips available, **avoidance of unfulfilled trips** by back-up from the conventional car, even with **less range**, see **Fig 1**. This flexibility has on average **a value of $6700.** At mass production costs this makes the BEV **economically viable in all 2-car HHs, Fig 2**.

Lessons learned: • The viability makes 2-car HHs an important **near-term BEV market**.
• A **cheaper small battery** is enough.

2. *Is the PHEV a challenge to the BEV?*

In 2-car HHs, the **PHEV TCO *gain* is halved** compared to a BEV. If optimally used then **a BEV has lower TCO** in most HHs, **Fig 3**. The electric driving is about the **same**, though, **Fig 4**. But there are also **other factors** favoring a PHEV or BEV, such as no range limitations in a PHEV, work place charging or fast charging along major roads.

Lessons learned: • The competition between PHEV and BEV is **not yet settled**.
• For e-kms driven, PHEVs or BEVs are about **equally good**.

3. *What do commonly used range indicators tell us?*

Days requiring adaptation (DRA) is often used as an indicator of the inconvenience of the BEV range. Another option is the number of *unfulfilled trips* (UFT). These two capture and ignore various situations differently, but roughly give the same average result. They apply to a single car's driving only and **ignore the flexibility** in multi-car HH, see **Fig 5**.

Lessons learned: • DRA and UFT have different pros and cons but give **similar results**.
• They are both **not appropriate** for multi-car households.

4. *Do households currently utilize the BEV flexibility?*

In the BEV trial, compared to the replaced car, some HHs increased the BEV use, while some decreased it, **Fig 6**. In interviews people claimed to increase the BEV use out of economical, environmental, and driving comfort concerns, and to limit it due to, for example, range anxiety, size and towing needs, and company car availability.

Lessons learned: • There is a need for HHs to **learn to utilize** the flexibility. But also:
• **Hindrances exist** for the full use of the flexibility given by the driving.

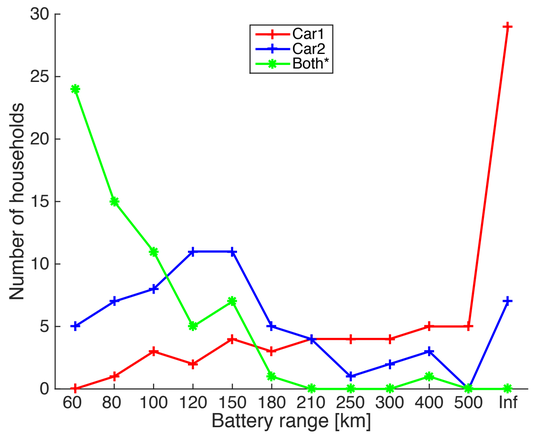

Fig 1 For BEV use strategies, ranges needed to fulfil each HH's driving.

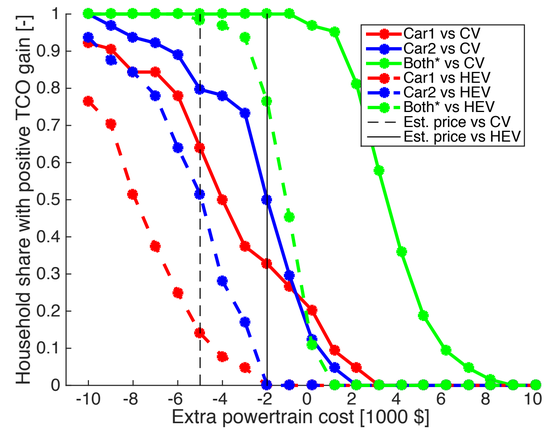

Fig 2 HH share with a positive TCO gain for a BEV as function relative BEV cost w/o battery.

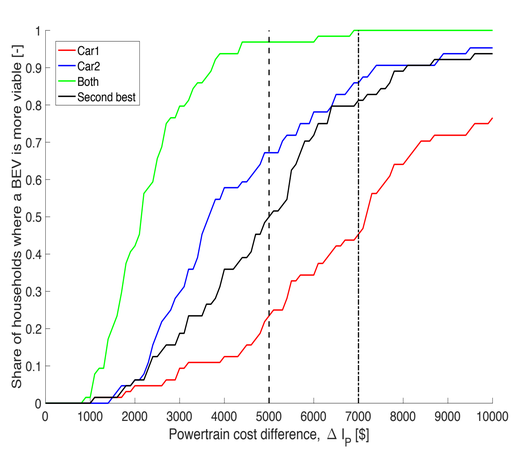

Fig 3 HH share with $TCO_{BEV} < TCO_{PHEV}$.

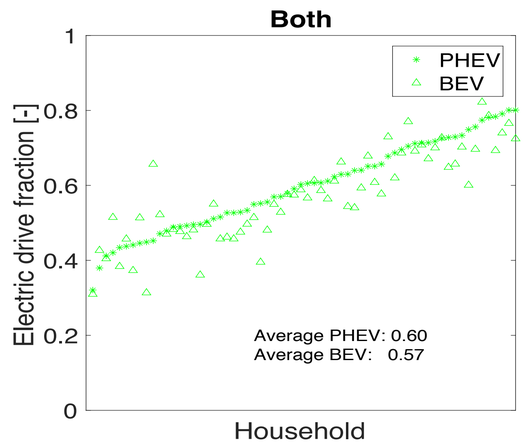

Fig 4 HH electric drive fraction for BEVs and PHEVs, respectively.

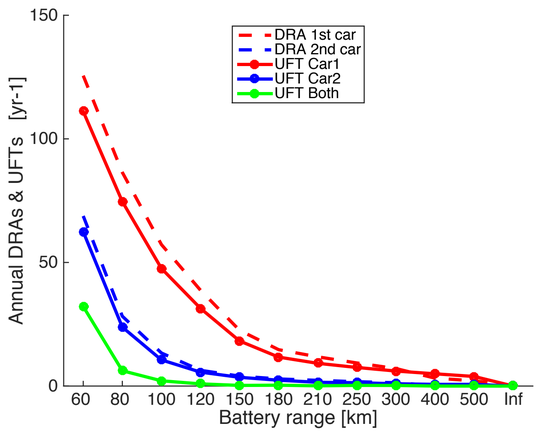

Fig 5 For BEV use strategies, average annual DRAs and UFTs.

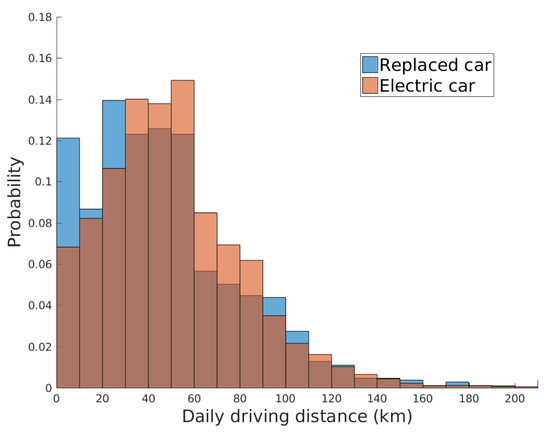

Fig 6 Average BEV daily use in comparison to the replaced car.

Data and Methods

We use 1-3 months of simultaneous GPS logs of both conventional cars in 64 commuting 2-car HHs. These were randomly drawn from the car registry in the Gothenburg region in Sweden.

We model for different battery ranges the possible driving of a PHEV/BEV in each HH for different car usage "strategies": a PHEV/BEV substitutes a single car only, 1st ("**Car1"**) or 2nd ("**Car2"**) car, or both as much as possible ("**Both"**), see **Fig 5**. We assume home charging only (3 kW).

Table 1 Assumed cost parameters

Specific energy use: fuel car and PHEV in CS mode [kWh/km]	0.6	Battery capacity utilization [–]	0.7 – 0.9
Specific energy use: BEV and PHEV in CD mode [kWh/km]	0.2	Extra fixed cost for unfulfilled trips [$/trip]	50
Fuel price [$/kWh]	0.2	Annuity [yr^{-1}]	0.15
Electricity price [$/kWh]	0.2	Charging power [kW]	3
Specific battery cost [$/kWh]	300		

Economic optimization of costs, Table 1 (for propulsion energy, battery, and unfulfilled driving (BEV only)) gives an optimal battery range. Addition of mass production costs as of year 2020 (based on ANL 2016) gives TCO comparisons between PHEV, BEV and a conventional car.

During a BEV trial period of 3.5 months 25 of the earlier logged 64 households had a BEV replacing one of their conventional cars. Both cars were logged again. Interviews with HH members were performed before and after the trial period.

References

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