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Transition from ICEV to BEV: How do personal usage patterns change?

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Executive Summary

Having the largest share of battery electric vehicles (BEV) worldwide, Norway is an ideal living laboratory for electric vehicle research. In our project, we are logging the vehicle usage patterns of households when they replace their internal combustion engine vehicle (ICEV) with a BEV. Preliminary results show that the usage pattern of ICEV and BEV in two-vehicle households is very distinct: The BEV covers most of the short distance trips, while the ICEV is used for some short trips and the longer trips. At the moment, logging of the ICEV in one-vehicle households is ongoing, while they wait for their BEV to be delivered. When the households get their BEV, logging will continue for 3 months, to make sure a habituation period to the BEV is completed and the users got used to driving a BEV. Analysis of this unique data set will provide in-depth insight into the change in driving pattern and possible rebound effects (e.g. increased driving since it is considered environmentally friendly).

0 Introduction

Having the largest share of BEVs worldwide, Norway is an ideal living laboratory for electric vehicle (BEV) research. In earlier studies, we leveraged this unique situation and sent out surveys to BEV users in order to investigate their car use [1]. In our current project, we install electronic travel diaries in the vehicles, to directly measure how usage patterns change when people replace their internal combustion engine vehicle (ICEV) with an electric vehicle. The assumption is that trips through the city toll boarder will increase, compared to the number of trips earlier conducted with the ICEV. Long range trips will have to be conducted with longer breaks to charge the BEV, or the trips might be conducted with a rental car.

In the further course of the project, we aim to investigate how the introduction of 2nd and 3rd generation of BEVs with longer range and wider model choice will change the usage pattern of the BEVs. They will have the potential to fully replace the ICEV, and we will start to see more households where the BEV is the only vehicle.

Since the broad availability of Global Navigation Satellite Systems (GNSS), such as the American Global Positioning System (GPS), the Russian GLObal NAvigation Satellite System (GLONASS) and European Galileo, researchers have been interested in tracking vehicles in order to measure driving patterns and learn more about car usage. This has resulted in several publicly available studies and data sets of vehicle movement patterns, that can be used by researchers to develop and test their models. Examples for these

datasets are [2] (commercially available), [3], [4]. Analysis methods range from GIS-analysis [2], to modelling approaches [5] However, in our approach, we will be able to directly compare changes in the driving patterns when an ICEV is replaced by a BEV.

1 Method

Originally, recruitment was planned to reach buyers of electric vehicles through the retailer when they sign their contract. While they wait for their BEV to be delivered, we log the usage pattern of their existing vehicle with an electronic travel diary provided by Autogear AS, Oslo. When the drivers switch to the BEV, they install the logger in the BEV. This group is expected to sell their ICEV when the BEV has arrived. However, this plan failed since the retailers proved unwilling to spend extra time on informing the consumer about the study. Additionally, they were concerned about overloading costumers with information when the purchase contract is signed.

The alternate recruitment strategy aimed for recruitment of neighbours, friends and colleagues, and a recruitment campaign through social media and web pages of the Norwegian EV association. In addition, 2-vehicle households participate in the tests.

The logger is set into the OBD (on-board diagnostics) port of the vehicle, but the port is only used to power the logger, no OBD data is accessed or logged. Once the electronic device has been plugged into the vehicle, the system runs autonomously with no follow up of the users. The logger contains a GPS receiver unit and a SIM card and sends location data to the server when the vehicle is in operation. On the server side, trips are split, map-matched and trip duration and trip length are calculated. Passing of toll stations is registered from map data, and can be used to calculate the exact value of the toll road exemption incentive that BEV owners enjoy [6].

A survey will be sent out to gain information on background data, such as size of the household, income, number of vehicles in the household, access and use of alternative transport.

Possible biases

Our participants know that their driving behavior will be tracked. This might potentially introduce some bias, they might consciously or unconsciously change their driving behavior, just because of their knowledge of being part of a scientific study (“observer effect” [7]). However, we have two reasons to believe that this effect has a minor influence on our results: The logging device itself is very discreet, most participants forget about it soon after installation. They have been offered to access their data online, but no participant did so. Furthermore, when changing to the EV, we expect other effects such as “newness” of the new car and the habitation period to the new vehicle to have stronger influence on the driving pattern than a possible observer effect.

Of course, buying a new BEV is expensive, so the participant sample might be skewed to higher than average income. However, in Norway new BEVs are in general as cheap to buy as ICEVs and have lower TCO (Total Cost of Ownership) [6].

2 Preliminary results

Most of the users that signed up for participation in the data logging period are still waiting for their BEV to be delivered. Therefore, only ICEV data exists for these households. A survey to gather additional information on the household size, vehicle registration number and demographic information will be sent out to the participants. We also recruited 2-vehicle households, which allow to compare the usage pattern of the BEV and ICEV, and how the total vehicle usage of the household is split between the two vehicle types. This will be presented in the following section.

At the date of data extraction, one of the 2-vehicle households conducted 1214 trips in total in a 9-month period. With a share of 78.5 %, most household vehicle-based trips were conducted with the BEV. For the total distance of about 19500 km driven in total, the share is somewhat more balanced, with the BEV standing for 56.9 % of the distance driven.

Figure 1 shows the number of trips conducted in this household with the BEV and ICEV, respectively, on a semilogarithmic scale. Obviously, most short trips below 25 km are conducted with the BEV, whereas long distance trips above 100 km are conducted exclusively with the ICEV. One note of caution here: Trips below 100 km might still be part of a longer journey over the day or several days, so this representation might underestimate longer trips where the vehicle was stopped to fill up energy. Deeper analysis of the distinct trips is necessary.

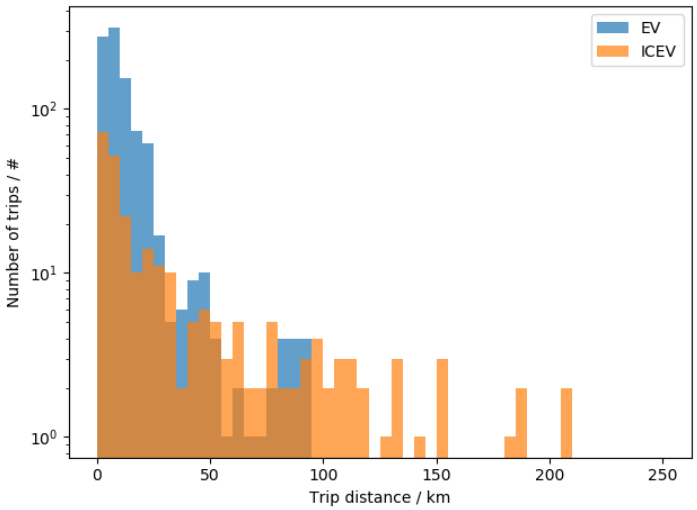

Figure 1: Number of trips conducted (logarithmic scale) with BEV and ICEV for at 2-vehicle household, categorized into trip distance bins of 5 km.

3 Conclusion

The first results hint for distinctly different usage patterns found for ICEV and BEV for 2-vehicle households. Data acquisition and recruiting is still ongoing. At the date of writing this paper, BEV deliveries have been delayed and none of our respondents have moved their logger to the BEV yet. This is expected to happen in the April/May timeframe. By the 3rd quarter of 2019, we expect to have collected enough data in the single-vehicle households to be able to analyse potential changes in the driving behaviour. Special attention will be given to investigate the habituation period, where the drivers learn to drive the BEVs.

From the data available then, we can calculate monetary savings, like fuel costs and city toll savings. Furthermore, savings in CO2eqv. and local pollutants (particular mass, nitrogen oxides) can be estimated.

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