

## Summary

# Battery electric vehicle user experiences in Norway's maturing market

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*According to Rogers' theory on the diffusion of innovations, users can be split on a timeline of successive adopters into innovators, early adopters, early and late majority and laggards. Under this perspective, a 2016 user survey showed that battery electric vehicle (BEV) owners in Norway could be classified as early adopters. A recent survey - performed in June 2018 – now shows that owners are moving into the early majority user group, and have now approached the average socio-demographics of vehicle owners in general. This development has been facilitated by the availability of new BEV models with longer range, improvements to the fast charger networks to allow for long distance driving and less stress in daily traffic, and the increased familiarity with BEVs in the population. Large incentives and the low marginal cost of use, have additionally made BEVs very attractive in the market. Although there is potentially a risk that the total volume of traffic increases more than anticipated, due to the low marginal cost of use, so far this effect seems to be fairly limited. Survey results also show that compared to the situation in 2016, fewer users have experienced trouble with their BEV and the willingness to buy a BEV again is higher.*

## Introduction

This report presents the results from an online survey of Battery Electric Vehicle (BEVs) and Internal Combustion Engine Vehicle (ICEVs) owners. The survey was conducted in May/June 2018 within the Electromobility LAB Norway (ELAN) project. This research project is led by the Institute of Transport Economics (TOI) and sponsored by the Research Council of Norway. The main purpose of the ELAN project is to develop enhanced and accurate knowledge on the diffusion of electric vehicles and on the innovations and strategies required to reach Norway's goals for the low emission society.

## Battery Electric Vehicles in Norway

The results of the BEV and ICEV owner survey must be seen in a broader context, whereby Norwegian policies and characteristics plays an important role. Whereas BEVs are expensive and little known among consumers in most European countries, they have become very popular among Norwegians. The main reason for the appeal in Norway is the long term BEV policy involving extensive national and local incentives.

The BEV share of the total fleet passed 7% at the end of 2018, when 200 000 BEVs were on the roads of Norway. The BEV share of new vehicles sold in 2018 reached 31%, which is unprecedented anywhere in the world. Although hugely positive, these results are still not enough to reach Norway's ambitious environmental goals to follow up the Paris agreement. According to the goals set in national vehicle policy, from 2025 all new passenger vehicles will be zero emission vehicles. In addition, the growth in person transport in larger cities

should be taken by public transport, bicycles or walking, as defined by the targets stated in the National Transportation Plan from 2018-2029.

Norwegian political incentives for BEVs range from purchase incentives, such as exemption from Value Added Tax (VAT) and registration tax (which are substantial in Norway) to local incentives such as exemptions from road tolls, parking charges and access to bus lanes. These incentives have eliminated the BEV disadvantage with respect to the purchase price compared to ICEVs, and local incentives have provided the initial BEV owners with advantages not available to others. At the same time a network of fast chargers covering cities and main roads between cities have been put in place since 2011, making life with BEVs gradually easier.

Norway is also especially suited for vehicle electrification; 98% of the electricity production is produced from renewables (mainly hydro-electric based), the electricity grid is robust from power plant to homes, and most Norwegians can park on own land and electricity is often already available. Home charging is thus feasible for most vehicle owners. The population is affluent and up to half of the vehicle owning households own more than one vehicle. These households can easily accommodate one BEV into the household without sacrificing much flexibility.

## **Methods, Materials and Analysis**

The net based user survey which is analysed in this report was conducted in May/June 2018. Participants were 3650 BEV owners who were drawn from a sample of members of the Norwegian Electric Vehicle Association, and 2033 ICEV owners drawn from a sample of members of the Norwegian Automobile Federation. The response rates were 18 percent and 9.4 percent respectively for the two groups.

The BEV sample was found to be representative of BEV owners in general, whereas the ICEV sample seemed to deviate somewhat from ICEV owners when comparing with vehicle owning households in the National Travel Survey 2013/14. To solve this issue, most of the analysis was conducted for subsamples of vehicle owners that were workers (either full, part-time or self-employed). In some cases the ICEV sample was further limited to persons that owned vehicles with a model year of 2011 or more recent (the year BEVs came fully on the market) to make it as equal as possible to the BEV sample.

A user survey was also conducted in 2016, drawn from members of the same organizations as in 2018. Results from the 2016 survey are used here as a benchmark to assess the direction the BEV market is moving, when it comes to adopter groups.

According to the diffusion theory as described by Rogers, diffusion of innovations normally follows an s-shaped curve with five adopter groups successively adopting the innovation: the innovators (2 %), the early adopters (14 %), the early majority (34 %), the late majority (34 %), and laggards (16 %). The “early adopters” are described by Rogers as the ones that triggers the critical mass by making judicious decisions on what to adopt and conveying it to peers. The “early majority adopters” are characterized by the motto: “not to be the first, nor be the last to adopt”. The majority are the mainstream adopters whereas laggards are prone to sticking to the status quo. The relative advantage of the innovation compared to existing solutions is the most important criteria that adopters evaluate new technology against. Therefore, understanding the user motivations for buying a BEV, how they are used, and the advantages and disadvantages that users experience, is vital to understanding the diffusion process of BEVs in Norway. The survey therefore contained questions related to the Socio-demography of users and households, their daily travel and charging behaviour, their long distance travel and charging behaviour, travel changes

undertaken after buying a BEV, buying motivation, value of and use of incentives, and the importance of various incentives and attributes of vehicles when deciding on the purchase, as well as opinions about the vehicles, and the use of and the quality of the charging infrastructure.

Data about the BEV fleet composition and the geographical spread complement the analysis. It was used, for instance, to investigate the BEV samples representativeness geographically and for the split between different BEV models and size segments.

## Results

### BEV and ICEV owners socio-demographic characteristics

In 2016, Figenbaum and Kolbenstvedt found that BEV owners had typical characteristics of being “early adopters”, such as being younger male workers with high education and higher incomes. Being younger they also tended to be part of larger households.

While BEV owners retain some of these characteristics in 2018, there are several indications that BEV-owners are becoming more similar to the population of car owners in general in terms of socio-economic characteristics: Compared to 2016, the BEV owners are older, more females own a BEV, fewer BEV owners are within the workforce and the households associated with BEV owners are smaller in 2018. The adoption of BEVs is thus moving up the s-curve to the “early majority” of adopters.

### Daily driving and home charging

The battery electric car continues to be an everyday workhorse of families in Norway, as they were also in the 2016 survey. BEVs were in 2018, as in 2016, used more often for all local trip types (commuting, shopping, escorting children to activities etc) than ICEVs were. This is likely to be associated with the much lower marginal cost of operating a BEV than an ICEV, so that those owning more than one vehicle tend to use the BEV locally whenever possible. Another reason can be that families, the dominant owner group, tend to have larger needs for local transport than other vehicle owning groups, for instance to escort children to activities.

BEV owners in the survey had on average 35 percent longer distance between home and work locations than ICEV owners, further supporting the assumption that low marginal cost of driving is important when choosing a BEV over an ICEV, and that commuting is an important reason for buying a BEV.

The frequency of home charging was the same in 2018 as in 2016, with 80 percent of users charging 3 times or more per week at home. On average, users said they charged about 4.4 times/week at home and about 1.1 times/week at work. The home charging process had become safer with 43 percent using home chargers (Wallbox) in 2018, up from 24 percent in 2016. Only 7 percent of users said they never charged their vehicles at home, whereas another 2 percent said they did it rarer than monthly. For these two groups of BEV owners, 53 percent said they charged at work, 29 percent at public chargers and the rest on-street close to home. BEV owners living in apartments charged less often at home (65% weekly or more often) than owners living in detached houses (96% weekly or more often).

## Long distance driving

Long distance driving is one of the last hurdles towards mass adoption of BEVs, particularly for single vehicle households. For single vehicle households to take BEVs into use, they must be able to use them for long distance trips. The greatest disadvantages of BEVs, as perceived by ICEV owners, were in order of importance: driving range, vehicle size and practical characteristics (trunk size, tow bar availability etc.). These are all features that are often necessary for long trips. Besides the vehicle characteristics, a large challenge for full diffusion of BEVs in Norway will be to put in place efficient charging solutions for long distance driving. The challenge will be particularly important during peak long distance travel times, such as vacations.

BEVs were more often used for longer distance trips and vacation in 2018 than they were in 2016, with a much higher share of the surveyed ICEV owners (52 percent) than BEV owners (31 percent) going on long vacation trips (above 300 km). The average BEV and ICEV owner, however, do as few as 4 and 6 of these trips respectively per year. Of the four main vacation periods (summer, Easter, fall and winter), summer was the period when the difference in the stated long distance driving behavior between BEV and ICEV owners was the largest. More ICEV owners than BEV owners said they do long distance trips in this time period. The reason for this is not clear. For the other vacation periods, the long distance driving pattern was fairly equal. The differences between BEV and ICEV owners were about the same when looking separately at households with and without children, workers and non-workers, and single and multi-vehicle households.

The summer vacation long distance driving is less problematic for charging infrastructure deployment than the other periods, even when taking into consideration the fact that more people go on the longest distance trips in this period. Reasons are that the vehicles' range will be at the maximum, it will be easier for users to drive economically (no need to heat the vehicle), and the summer vacation period is more stretched out in time and geography than the other vacation periods.

A specific but common type of long distance trip in Norway is to the family owned cabins/huts and vacation homes (hereafter, described as 'cabin'). There are 464 000 of these in total (one per five households). Of the 58 percent of BEV owners that said they have access to vacation homes/cabins, 65 percent said they can charge there, whereas of the 51 percent of ICEV owners with access to cabins, only 35 percent said that electricity is or can be made available for charging where the vehicle is parked. The average number of annual trips to these cabins is about the same for both groups.

In theory, range needs on peak travel days could be solved to a large extent if vehicle owners driving the longest stretches on peak travel days buy the vehicles that have the longest range. An analysis of the market by sub segments and vehicle prices, and the availability of long range BEVs, indicate that such vehicles will become available in most vehicle segments. Users will thus be able to select a more expensive vehicle or battery option that allow them to avoid charge queues on peak travel days.

## Fast charging

Fast charging supports long distance trips in addition to extraordinary local and regional travels, as well as those that forgot to charge their vehicle overnight. The surveyed BEV users said they did about 19 fast charges per year on average. Charge queues were experienced both locally and regionally to a similar extent, and a bit more often on long

distance trips. 12-18 percent experienced queues often or always depending on location and on the county they lived and charged. Another 41%-54% experienced queues sometimes. There was however some acceptance for fast charge stops and standing in queues among BEV owners. Owners seemed to accept between 1-3 stops and 5-20 minutes of charge queues on days when many people are travelling. Nonetheless, these results could be due to a sense of realism for what was possible. About half of users were willing to change travel time on peak travel days to avoid charge queues, but mainly within the same day. The charge time and queue time is not fully wasted. BEV owners reported a variety of activities while charging, such as checking/sending e-mails, looking at social media, taking a stroll or using the facilities at the charge station (kiosks, cafés, toilets etc.).

The user perception of the fast charger network improved substantially between 2016 and 2018. Fast chargers supporting long distance trips were by most (non-Tesla) BEV owners deemed acceptable or good when it came to availability, position, quality and reliability. Only about 10 percent rated those attributes as poor. Payment systems were even more favorably rated, with only about 5 percent rating them as poor. The satisfaction with these attributes was even higher among Tesla owners, which indicate that the Tesla Supercharger network was performing well.

## **Total travel and travel changes**

Incentives for BEVs can lead to unintended side effects. A key question is if the use of the vehicle is higher when people buy a BEV instead of another vehicle type. This result could be expected based on economic theory. The much lower marginal cost per km of BEVs compared to ICEVs should lead to increased usage when a vehicle owner replaces an ICEV with a BEV. The reasons for the low marginal cost of use is both the efficient utilization of electricity and the low cost of electricity compared to the inefficient use of expensive diesel or gasoline in ICEVs.

There are some indications of a rebound effect. One third of the BEV owning households (within the workforce) reported that the acquisition of the car had led to changes in the households total travel behaviour, and about half of these reported to be driving more often than before. This indicates that buying a BEV does not imply a huge increase in average car use. The overall effect appeared to be small also when looking at other indicators. The increase in the households average total vehicle km insured (insurance cost varies with annual km), as reported by the users themselves, was only 2.4 percent.

Another potential rebound effect of the BEV policies is an increase in the total number of vehicles, due to the total ownership cost of BEVs being lower than that of ICEVs in Norway. An effect was also visible in the data here, with up to 10 percent of the BEVs consisting of potentially additional vehicles that might not have been bought as ICEVs. BEV owners tended however to have more reasons for buying an additional vehicle and larger transportation needs in general than ICEV owner, so the 10% seems to be an upper limit for this potential rebound effect.

Based on the insurance interval of annual km driven it can be estimated that both BEVs and ICEVs that were 2011 and newer year models in 2018, were driven about the same number of km per year. The estimates, based on the survey respondents in 2018, are 16 500 and 16 200 km respectively. These results are about the same as in 2016.

## Value of local incentives

The users own assessment of the average value of local incentives was reduced by 10 percent between 2016 and 2018, but the average value was still rated as high as 14 000 NOK/year per user. The value of access to the bus lanes had gone down substantially between 2016 and 2018, while the value of the toll road exemption had gone up. Both changes are related to policy changes that occurred during this period. BEV owners had in 2016 free access to bus lanes, but were in 2018 required to have a passenger in the car when driving in the most busy bus lanes in the rush hours. Toll road prices have gone up around cities between 2016 and 2018, in particular around Oslo, and new toll roads were introduced along some major roads, leading to an increased value of that incentive in many counties. The toll road exemption was therefore the most important local incentive in 2018, accounting for 65% of the average annual value of local incentives. This incentive has increased in importance since 2016.

The availability of local incentives is gradually changing. Bus lanes access will increasingly be restricted during rush hours, to keep bus travel times down. The local monetary incentives can be cut in half as local authorities now can choose to introduce half of the ICEV owners' rate for BEV owners on toll roads, parking facilities and ferries according to the latest revisions in BEV policies.

## Current and future buying behaviour

While there are many reasons to buy a particular type of vehicle, 56 percent of BEV owners said economy was the most important, when forced to provide the single most important factor. In contrast, only 8 percent of ICEV owners said this was the most important factor. The second most important reason for BEV owners was the environment (18 percent) which was not important at all to ICEV owners. Reliability and buying a practical vehicle were most important reasons among ICEV owners but much less important among BEV owners. The same situation applied when looking at how they rated the various attributes of vehicles, but here both groups put the highest emphasis on reliability and driving abilities. ICEV owners said that comfort, safety and size also are very important vehicle characteristics in the buying process, whereas BEV owners rated range, energy cost and purchase price higher.

The importance of economy of use is not surprising. BEV owners can (in Norway) save 2000-3500 Euros per year owning a BEV rather than an ICEV, due to the much lower energy cost, the competitive sales price resulting from the tax exemptions, and the high monetary value of local incentives.

The challenges of owning a BEV were in general reduced between 2016 and 2018. Fewer BEV owners had in 2018 avoided doing trips with their BEVs compared to 2016, at 21 percent and 28 percent, respectively. The share that had aborted a trip was unchanged (5-6 percent for both years).

A higher share of BEV owners said in 2018 that they would repurchase a BEV compared with 2016 (94 percent vs 88 percent). The share of 'don't know' responders had gone down from 11 percent to 6 percent. A positive development was also seen among ICEV owners. Fewer said they would repurchase an ICEV (63 percent vs 55 percent) and those that said they would not (9 percent vs 7 percent), were much more inclined to say they would rather buy a BEV in 2018 than in 2016 (55 percent vs 23 percent), while the opposite was the case for PHEVs (27 percent vs 60 percent).

## **Conclusion**

The Norwegian BEV market has taken another step towards the normalization of BEVs as a regular vehicle option for consumers. The socio-demographic differences of BEV owners between 2018 and 2016 points at BEVs moving up the adoption curve towards the majority buyer groups. This development has been facilitated by new models coming on the market, an increased driving range of new and existing models, improvements to the network of fast chargers, and the increasing familiarity with BEVs in the population.

The risk that the overall number of vehicles in the fleet can increase and each vehicle be driven more, due to the low marginal cost of owning and operating a BEV in Norway, seems so far limited. This can, however, still change as and when new groups take BEVs into use.