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Norwegian user and usage profiles for BEVs and PHEVs - Results from a Norwegian survey of vehicle owners

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Abstract

Norway had at the end of March 2017 105800 BEVs and more than 37000 PHEVs on the road. Combined they make up over 5% of the total passenger vehicle fleet. About 85% of the BEVs were owned by consumers. In the beginning of 2016 consumers owned 2/3rds of the PHEVs on the road at that time.

A survey of 3111 Norwegian BEV owners, 2065 PHEV owners and 3080 ICEV owners was carried out in March 2016. The survey was designed to provide insights into user experiences among BEV and PHEV owners in Norway, and the attitudes to these vehicle types among the three user groups. Further on the vehicle usage patterns and sociodemographics of the three user groups was investigated to compare differences and similarities.

The survey shows that BEV, PHEV and ICEV owners have different characteristics. BEV owners are younger have larger families and larger transportation needs than owners in the other groups. The Norwegian BEV policies, levelling out the price difference towards ICEVs through the tax policy and offering user incentives, have put BEVs in the hands of multi-vehicle households, the group that can best take them into use with minimal impact on their behaviour, and maximum impact on replaced ICEV kilometres. Users, mostly multi-vehicle households, experience modest challenges with their BEVs in everyday travel. Most owners charge their vehicles effortlessly at home and use their BEV for all possible local driving. About half of the challenges related to driving range of BEVs could be solved with a wider built out and more reliable public normal and fast charge infrastructure. The purchase motivations of BEV and PHEV owners are rather alike, low cost of ownership ranks highest.

Keywords: Consumers, BEV, PHEV, User behaviour, Incentive

1 Introduction

Norway had at the end of March 2017 105800 BEVs and more than 37000 PHEVs on the road [5]. Combined they make up over 5% of the total passenger vehicle fleet and have from initial zones in and around cities expanded to the entire country [4]. The market share of BEVs has been above 10% since the end of 2013 and

since the start of 2016 for PHEVs as seen in figure 1. Both vehicle types sold in volumes of about 15% each month in the first 5 months of 2017 [6].

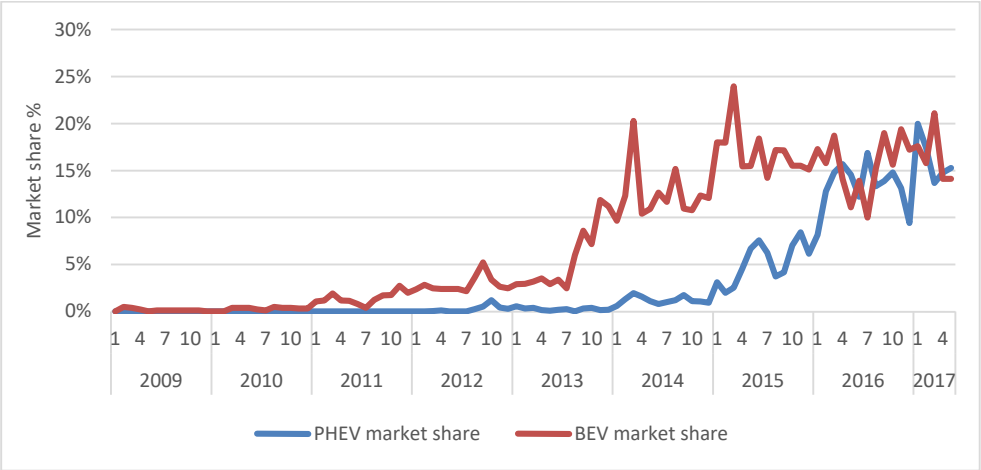


Figure 1: Market shares of BEVs and PHEVs in new vehicle market in Norway 2009-05/2017. Source: [6].

About 80% of the BEVs are owned by consumers [7]. In the beginning of 2016 consumers owned 2/3rds of the PHEVs on the road at that time [1]. The large share of the fleet and number of users means that researchers can establish a large database of user and non-user experiences not seen anywhere else in the world. In Oslo and Bergen BEVs for instance made up over 10% of the vehicles flowing through the toll road rings in the beginning of 2017 [8]. BEVs are therefore starting to make a large and visible impact on the transport systems and are a very real alternative in the minds of consumers planning to buy a new vehicle.

These developments have been powered by huge incentives that eliminate the sales price disadvantage (tax exemptions) of BEVs and PHEVs compared to ICEVs, and provide BEV owner with very attractive local incentives such as free access to bus lanes and free toll roads. Some of these incentives have been in force over a period of up to 25 years [4]. Due to lack of attractive and available models the market did not take off until Mitsubishi and Nissan started selling BEVs in the Norwegian market from 2011.

The rapid increase in the market shares raises the question as to how these vehicles are used, the motivations for buying them and the type of transportation they replace. Surveys have therefore been carried out in 2014 and 2016. This paper will mainly present results from the 2016 survey with some comparisons with the 2014 survey [3] to track development over time. Developments are now so fast in Electromobility that it does not make much sense to compare results with older research. Some comparisons will however be done with a Swedish survey that was also carried out in 2016 [2].

The paper starts off in section 2 with a brief presentation of the Norwegian BEV and PHEV policies and incentives as they form the basis to make it possible to understand the remarkable Norwegian developments. Section 3 presents the method and material used in the analysis followed by the results in section 4. Section 5 contains a brief discussion of the implication of the results leading up to the conclusion in Section 6.

2 Norwegian BEV and PHEV policies and incentives

The battery electric vehicle market in Norway is heavily incentivized [4,7], and some of the most important incentives have been in place over a period of 20-25 years as seen in table 1. In the 1990s incentives were introduced to allow experimentation with electric vehicles, and in a period around 2000 to nurture a growing EV industry in Norway. From 2010 the focus shifted towards supporting climate policy goals [4,7]. These incentives are therefore now anchored in policies that support the ambitious Norwegian climate policy targets [4]. The primary target is to become a carbon neutral society by 2050. In 2016 the transportation authorities suggested in the planning document for the National Transportation Plan for 2018-20 [9], that only zero emission passenger vehicles, light duty vans and distribution trucks shall be sold from 2025, essentially targeting a phase out of diesel and gasoline passenger vehicles and diesel vans, from the sales mix [9]. The

proposal was confirmed to be the Governments policy when the National Transportation Plan was sent for approval to the parliament in 2017 [10]. The parliament approved the target in a decision in May 2017 [11]. The plan and the decision in the Parliament also contained some suggestions for revision of incentives for battery electric vehicles, as seen in table 1. A ban on ICEV vehicles would violate the conditions set in the trade agreement between the EEA countries and the EU, but Norway can use the tax system to make ICEVs very unattractive.

The large market shares for BEVs achieved has thus been the result of policies that, in spite of shifting basis along the way, provided long term stable national incentive framework supporting the marketability of BEVs. Actors could thus take advantage of windows of opportunities that arose over the years [4]. The political stability has been one of the most important factors in the BEV development. The most important incentives have been the exemptions from VAT, registration tax and toll road charges, as well as the free access to bus lanes [4,7].

It is important to understand that these incentives make BEVs cheaper to buy than ICEVs in all but the smallest vehicle classes [4], and they provide owners with very attractive privileges in daily traffic. PHEVs do not enjoy these daily privileges but fares well enough in the tax system to be competitive with diesel vehicles of the same type.

Table 1 BEV incentives in Norway, adapted from [7].

Incentives	Introduced	BEV buyers - relative advantage	Future of incentive (NTP 2017, Stortinget 2017)
Fiscal incentives: Reduction of purchase price/yearly cost gives competitive prices			
Exemption from registration tax	1990/1996	The tax is based on ICEV emissions and weight. Example taxes: VW Up 3000 €. VW Golf: 6000-9000 €,	To be continued until 2020.
VAT exemption	2001	Vehicles competing with BEVs are levied a VAT of 25% on sales price minus registration tax.	To be continued until 2020.
Reduced annual vehicle license fee	1996/2004	BEVs and hydrogen vehicles 52 € (2014-figures). Diesel rate: 360-420 € with/without particulate filter.	To be continued indefinitely
Reduced company car tax	2000	The company-car tax is lower but BEVs are seldom company cars.	This incentive may be revised from 2018
Free toll roads	1997	In Oslo-area saved costs are 600-1 000 € per year. Some places exceed 2 500 €	Law revised so that fees for battery electric vehicles in toll roads and ferries will be decided by local governments, up to a maximum rate of 50% of the ICEV rate.
Reduced fares on ferries	2009	Similar to toll roads saving money for those using car ferries.	
Financial support for normal charging stations	2009	Reduce investors risk, reduce users range anxiety, expand vehicle usage.	A national plan for charging infrastructure shall be developed.
Financial support for fast charge stations	2011	More fast-charging stations influences BEV km driven & market shares.	ENOVA support programme to establish fast charging along major transport corridors. City fast charging is left to commercial actors.
Access to bus lanes	2003/2005	BEV users save time driving to work in the bus lane during rush hours.	Local authorities given the authority to introduce restrictions if BEVs delay buses.
Free parking	1999	Users get a parking space where these are scarce or expensive and save time looking for a space.	Local authorities will be given the authority to introduce rates up to maximum rate of 50% of the ICEV rate.
Free charging		Not regulated by national law, but often bundled with free parking	Local authorities and parking operators decides whether this incentive will continue.

Figure 2 provides an example of how the purchase prices and total cost of ownership costs are affected by the Norwegian incentives, and for reference an estimation for Germany. Zero taxes on BEVs makes the E-Golf the cheapest version of the VW Golf. The situation becomes even more positive for the battery version when taking into account annual ownership cost differences (insurance, tyres and maintenance not

included). The plug in hybrid GTE version is more expensive to buy than the gasoline version but the cost of ownership is lower. The results are very different on Germany where BEVs are the most expensive to buy and electricity is so expensive that the cost of ownership is the highest and the gasoline version will have the lowest cost.

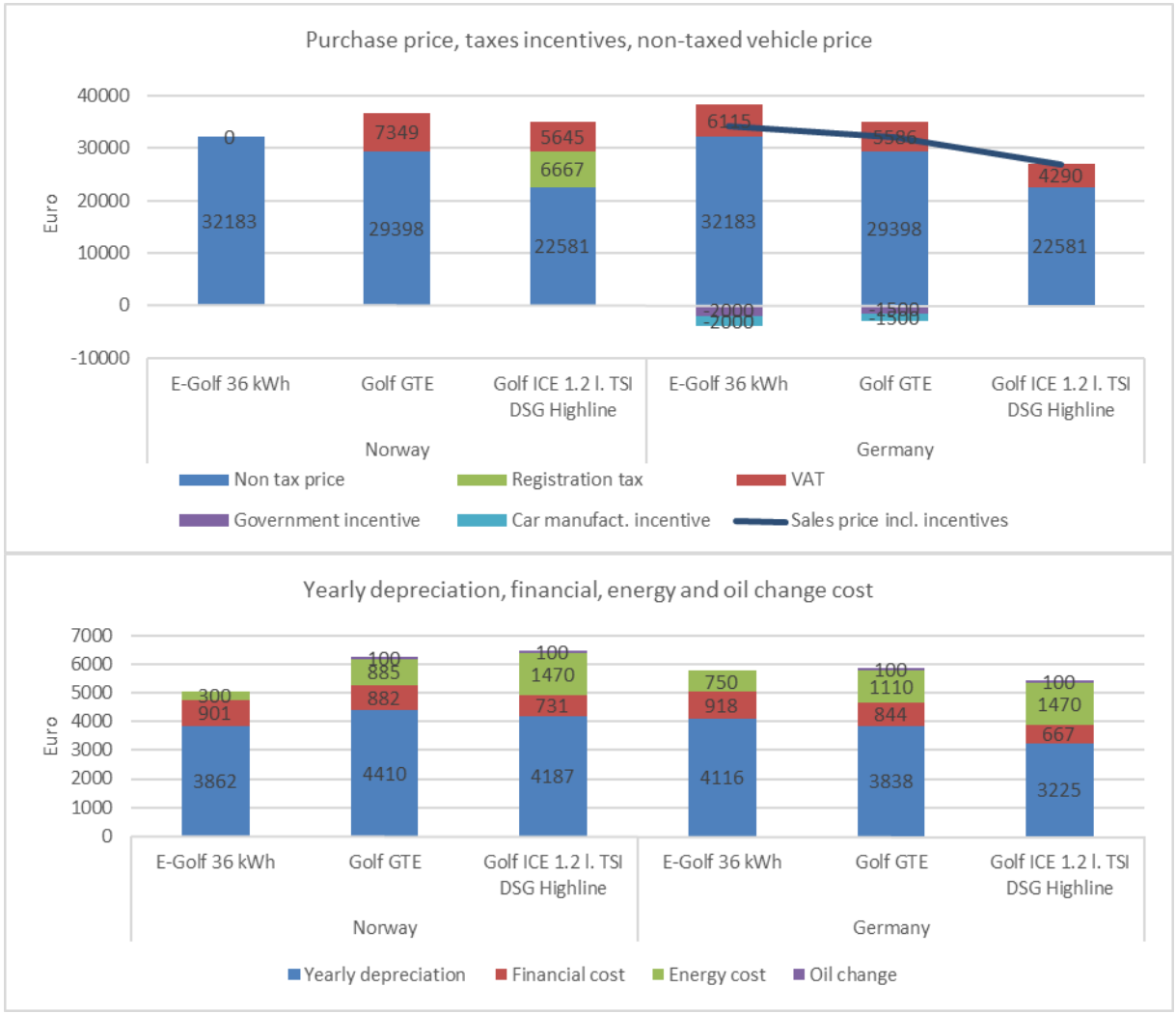


Figure 2: Purchase cost and differences in Total Cost of Ownership for variants of the VW Golf, Norway and Germany. Service, insurance and tyre cost are equal (Servicing of BEVs may be lower but is non-transparent)

3 Method and material used

A survey of 3111 Norwegian BEV owners, 2065 PHEV owners and 3080 ICEV owners was carried out in March 2016 [1]. The details are shown in table 2.

Table 2: Overview of sample. Norwegian PEV consumer survey. Source: [1].

Sample	Survey recipients	Respondents	Response rate	Share of total fleet
PHEV owners	7870 letters with address to online survey, was sent to private owners based on data from the Norwegian vehicle register.	2065	26%	17%
EV owners	16321 members of the EV association sent to their membership e-mail address	3111	19%	4%
ICEV owners	20000 national average randomly selected members of Norwegian Automobile Federation (e-mail addresses)	3080	15%	0.12%
Total	44191	8256	19%	0.3%

BEV owners were recruited from the members of the Norwegian electric vehicle association. All buyers of new BEVs gets a one-year free membership in the EV association, so a selection of arbitrary new vehicle buyers are reached when using their membership register. PHEV owners were recruited among private owners (2/3 of the PHEV fleet) via regular mail sent to the home address of the registered owner. ICEV owners were recruited from a national representative sample of the member registry of the Norwegian Automobile Federation (NAF).

The survey was designed to provide insights into the user experiences and behavior adaptations among BEV and PHEV owners in Norway, and attitudes to these vehicle types among the three user groups. The survey was partly common for all three groups and programmed as one online survey. The questions could be grouped into the following categories: Socio demographics, incentives usage, usage patterns, attitudes and perception of BEVs and PHEVs, rational for buying and disadvantages and advantages of BEVs and PHEVs. Some questions were only given to one of the groups, or the wording was rephrased to make the question relevant for other groups. For instance, BEV owners where asked how much they save on free access to toll roads, and ICEV and PHEV owners how much they spend.

The survey built on a survey carried out in 2014 [3] which was part of the EU FP7 funded Electromobility+ project COMPETT. The 2014 survey contained responses from 1721 BEV owners (EV Association members) and 2241 ICEV owners (Oslo-Kongsberg region members of the Norwegian Automobile Federation). Some comparisons will be done with this survey to track attitudes and usage patterns over time. A Swedish survey also carried out in 2016 [2], will be used for some comparisons between Norway and Sweden.

4 Results

4.1 Socio-demographics

There are distinctive differences between the three vehicle types owners as seen in table 3. BEV owners are well educated and substantially younger than PHEV and ICEV owners as seen in figure 3, The differences are particularly large in the 25-34, 3-44 and 67-74 age groups. The same tendency of younger BEV buyers and older PHEV buyers was found in the Swedish survey [2] but the differences were much smaller.

BEV owners have larger families than the two other groups and they own more vehicles and have longer driving distances to work. PHEV owners are in many ways in between BEV and ICEV owners, for instance older than BEV owners, but younger than ICEV owners. 79% of BEV owners also owns another vehicle, whereas 54% of PHEV owners do the same. This difference is mainly related to the socio-demographics. BEV owners are in an age group and social setting with children where it is more common to own more than one vehicle.

Table 3: Work status, education, gender, age, in the different samples. n_{BEV} = 3111, n_{PHEV} = 2065, n_{ICEV} =3080. Norwegian PEV consumer. Source: [1].

		BEV	PHEV	ICEV
Work status	Employed or self-employed	91 %	77 %	67 %
	Retired/Benefit recipient	8 %	23 %	33 %
	Student	1 %	0 %	1 %
Education	Primary and lower secondary school (1-10th grade)	2 %	3 %	5 %
	Upper secondary/High school (11-13th grade)	20 %	22 %	28 %
	Higher education up to 4 years	38 %	38 %	37 %
	Higher education in excess of 4 years	40 %	37 %	29 %
Gender	Female	20 %	17 %	22 %
	Male	80 %	83 %	78 %
Average age		47 y	55 y	56 y
Household size	Average number of persons in household	3,2	2,6	2,5
	Share of households with children	56%	32%	27%
	Share of households with more than 1 child	38%	20%	16%
	Average number of Children below 18y	1,1	0,6	0,5
	Number of persons with driving licence	2,03	1,96	1,87
Housing conditions	Small family houses	69%	66%	63%
	Other small houses	12%	15%	14%
	Flats/others	19%	19%	23%
Multivehicle household %		79%	54%	52%
Average distance to work		24 km	17 km	17 km
Prior transportation to work	Other vehicle either, either as driver or passenger	87%	85%	74%
Household gross income	<200 000 NOK	0 %	0 %	1 %
	200 001-400 000 NOK	3 %	3 %	8 %
	400 001-600 000 NOK	9 %	13 %	21 %
	600 001-800 000 NOK	14 %	19 %	22 %
	800 001-1000 000 NOK	23 %	22 %	22 %
	>1 000 000 NOK	51 %	44 %	26 %
	Estimated average NOK	920 171	884 289	774 025

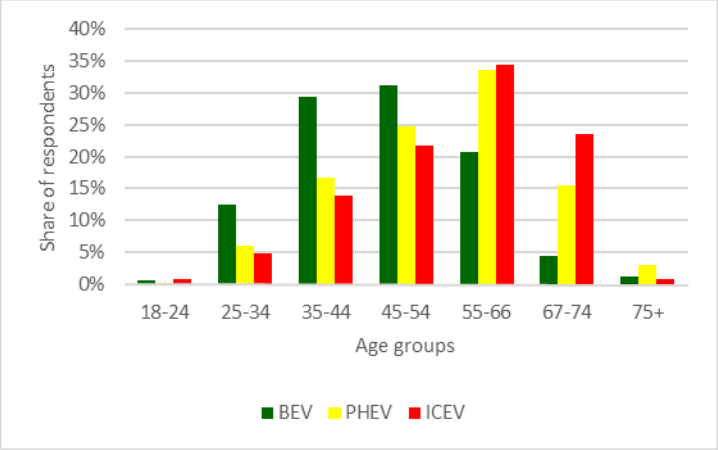


Figure 3: Age cohorts for vehicle ownership.

BEV owners in Norway tends to be families with children and owners are much younger than PHEV and ICEV owners, whereas PHEV owners consists of a higher share of retired people. Also in the Swedish survey it was found that BEV owners are younger (3 years) than PHEV owners and there is a higher share of retired people (2.9%) among PHEV owners. As in Norway, the differences in education level among the two owner groups is small. Income is not possible to compare between countries as the cost of living are much higher in Norway than Sweden and the taxes and incentives on vehicle purchase is very different.

BEV and PHEV owners mainly live in small single family houses both in Norway (66-69%) and in Sweden (about 73-75%). The share of households living in such houses is higher than in the population at large in both countries. The reason is probably the need for charging facilities, and the higher likelihood of owning more than one vehicle in general for single family house households.

The share of multi-vehicle households among BEV and PHEV owners is higher in Sweden than in Norway, at 85% and 70% respectively. In Norway BEV owners have longer distance to work than PHEV owners but this was not the case in Sweden.

Tesla is much more common in single vehicle households in Norway than in multi-vehicle households also owning ICEVs (30% of single vehicle households own a Tesla vs 15% of multivehicle households).

These results, depicting BEV owners as younger working, well-educated men with families with children, living in-and around cities, are as expected, based on the review of the literature and reports from Norway and internationally, in Figenbaum and Kolbenstvedt [3,4,7] The results fits well with the early adopter groups in Roger's theory of diffusion of innovations [12].

4.2 Driving and charging

A rather big surprise is that BEVs are driven slightly more per year than ICEVs and PHEVs of the same age. The average driving distance is respectively 15800, 15200 and 15000 km based on users insured distance data. The odometer readings of BEVs and PHEVs suggests the same with an average of 16500 km for BEVs and 16000 km for PHEVs (no data for ICEVs), as seen in figure 4, but the spread is very large and there was some noise in the data due to the possibility to type wrong data or wrong km, that introduces uncertainty.

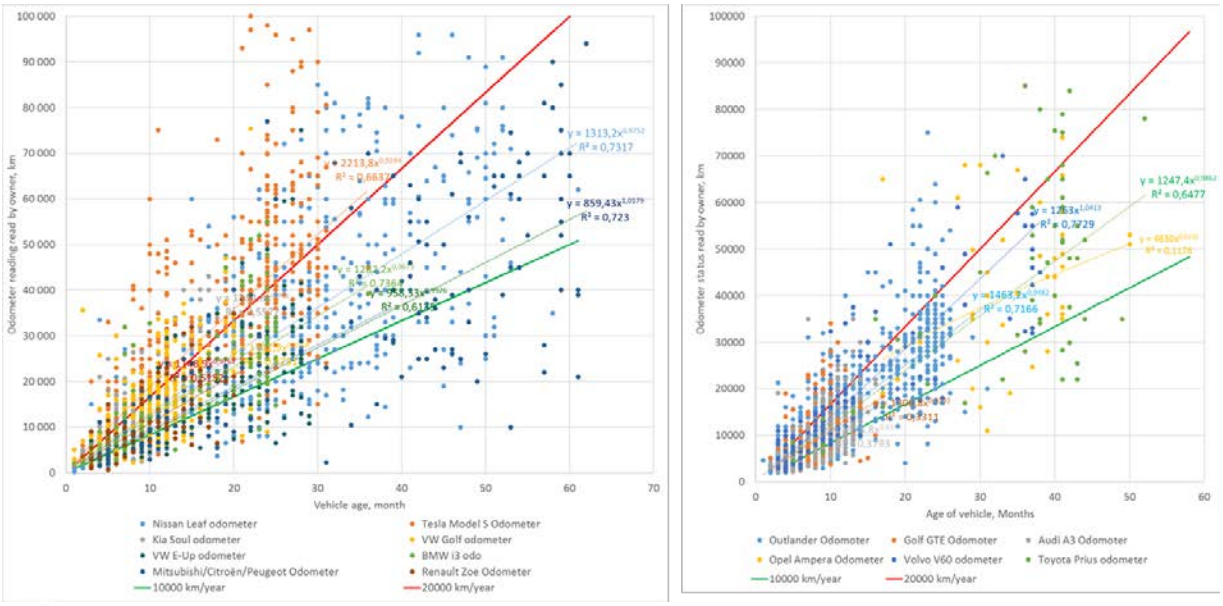


Figure 4: Odometer readings BEVs (left) and PHEVs (right). Green line = 10000 km/year, red line 20000 km/year.

The higher yearly mileage of BEVs is also reflected in user's estimate of their trip frequencies. BEVs are used more often than ICEVs and PHEVs in all local trip purposes, such as for commuting, shopping and escorting children, but less for vacation trips. Figure 5 shows the usage frequency data for visit, leisure and escort of children trips. PHEVs is in a middle position between the two other technologies.

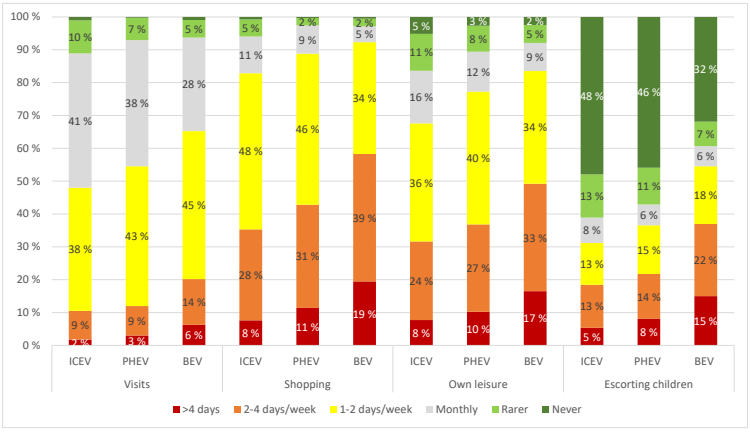


Figure 5: Trip type frequencies for visits, shopping, own leisure and escorting children trips for employed or self-employed BEV, PHEV and ICEV owners. n_{BEV} = 2812, n_{PHEV} = 1569, n_{ICEV} =2008. Norwegian PEV consumer. Source: [1].

Multi-vehicle BEV owners apparently use their BEV for as much local transport as possible, thus replacing not only the km of the ICEV they replaced with the BEV, but also transportation activities that previously was done by the other "primary vehicle" in the household. In a sense the BEV becomes the everyday primary vehicle in multi-vehicle households.

When asked about long distance recurring trip patterns all groups in Norway had rather similar behavior as seen in figure 6.

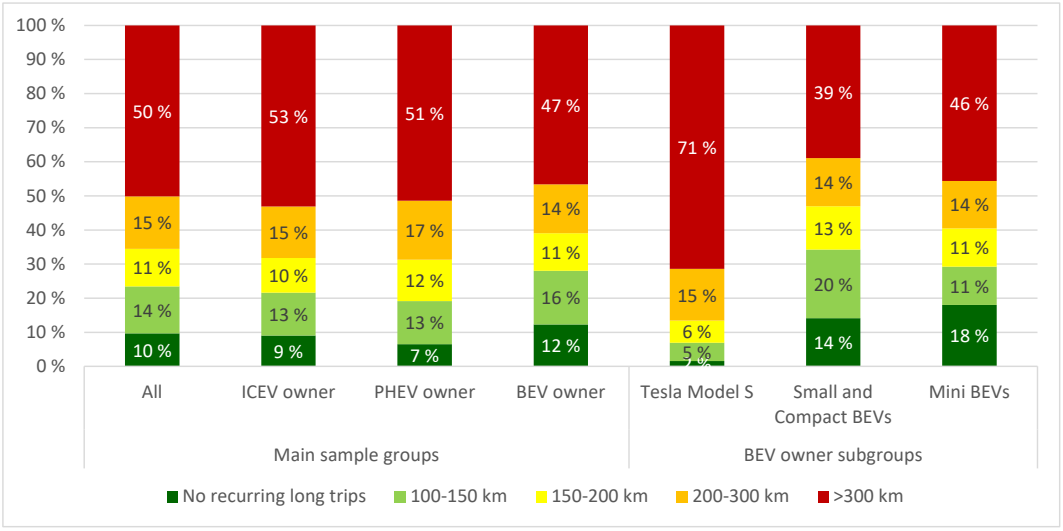


Figure 6: Share of owners recurring long distance trips by distance intervals. n_{BEV} = 2775, n_{PHEV} = 1800, n_{ICEV} =2623. «Don't know» category not included. Norwegian PEV consumer. Source: [1].

The general picture is that there is little difference between the main groups, although BEV owners goes less seldom on long recurring trips. When splitting the BEV owner group in sub samples it becomes apparent however, that Tesla owners have the most extreme long distance recurring trip pattern, i.e. the longest of these recurring trips. The trips typically go to a holiday home, friends, family or similar destinations. The expectation before the survey was that these types of vehicle owners rather would have bought a PHEV. The logical explanation likely lies in the free Tesla Supercharger network, effectively enabling long distance travels at almost zero cost.

Owners of mini-BEVs goes more seldom on long distance trips, but when they do they travel longer distances than the others, either with another household vehicle or with another mode of transport. 44% of BEV owners used their BEV on all of these trips. Reasons that were mentioned for not going on long distance trips with BEVs in Norway were, as expected range (mentioned by 94%), the vehicle being to small (48%) and various

charging issues (53%). Some 20% missed a tow hook and 20% had other reasons. BEV owners going on long distance trips charge on the go, at fast charge stations (74%) or at the destination (60%), and a few at friends or family (22%) or other places (8%). PHEV owners charge mainly at destination (52%) but 45% see no need to charge versus 17% for BEV owners.

The typical place to charge in Norway is at home. 95% of all BEV and PHEV owners have charging possibility at their home, 79% of BEV owners and 89% of PHEV owners charges at home 3-5 times per week or every day. Only 5-6% never charge at home and likely can charge at work, thus saving electricity costs.

The typical user plugs into a regular household outdoor Schuko socket when coming home from work, so that the peak charge period is between the hours of 14-20. Wallboxes hardwired to a fuse in the buildings electrical installation, the safest and fastest home charging solution, has been taken into use by 24% of BEV and 9% of PHEV owners. Some 28% BEV owners and 16% PHEV owners charge 3-5 times per week or daily at work. Public normal chargers are rarely used, 24-30% of BEV owners and 72% of PHEV owners never use them.

Fast charging is on the average done 26 times/year for Tesla owners and 13-16 times/year for other BEV owners with little difference between summer and winter, as seen in figure 7. Most BEV owners (68-74%) say that the use of fast chargers was planned before the trip started as seen in figure 8.

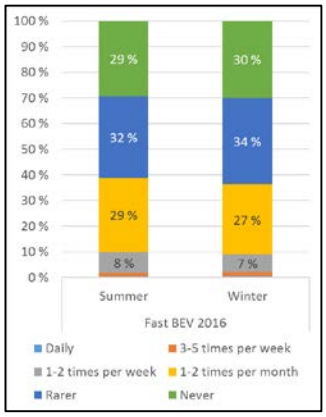


Figure 7: Frequency of use of fast chargers. Norwegian PEV consumer. Source: [1].

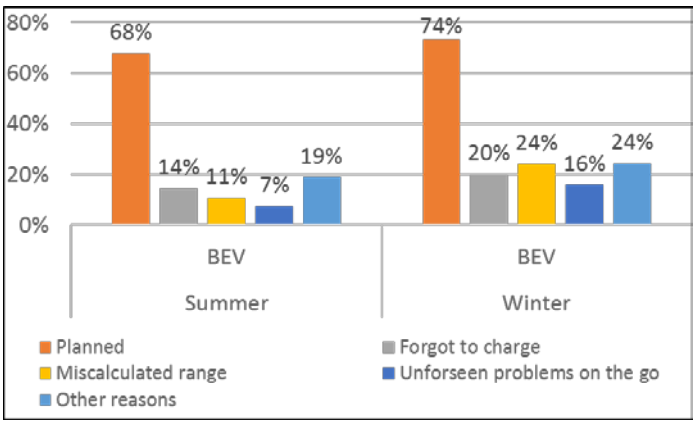


Figure 8: Reasons to use fast chargers summer and winter, percentage, more than one answer was possible. Norwegian PEV consumer. Source: [1].

4.3 User challenges and solutions

BEV owners in general report few problems with not being able to cover their transport needs with their BEVs, 17% report that they have at least once avoided travel due to range being too short. BEV owners report a variety of adaptation possibilities ranging from borrowing another vehicle from family or friends to taking public transport, using energy efficient driving and fast charging on the go. Running out of power on the go has only been experienced by 6% of BEV users, but among those it happens on the average once per month.

The positive user experience has been achieved in spite of BEV and PHEV owners experience their range to be much shorter than the official type approval value, especially in winter as seen for BEVs in figure 9. The 20-80 percentile range estimate for Tesla (not presented in the figure) was 345-399 km in the summer and 291-343 km in the winter with medians of 397 km and 300 km.

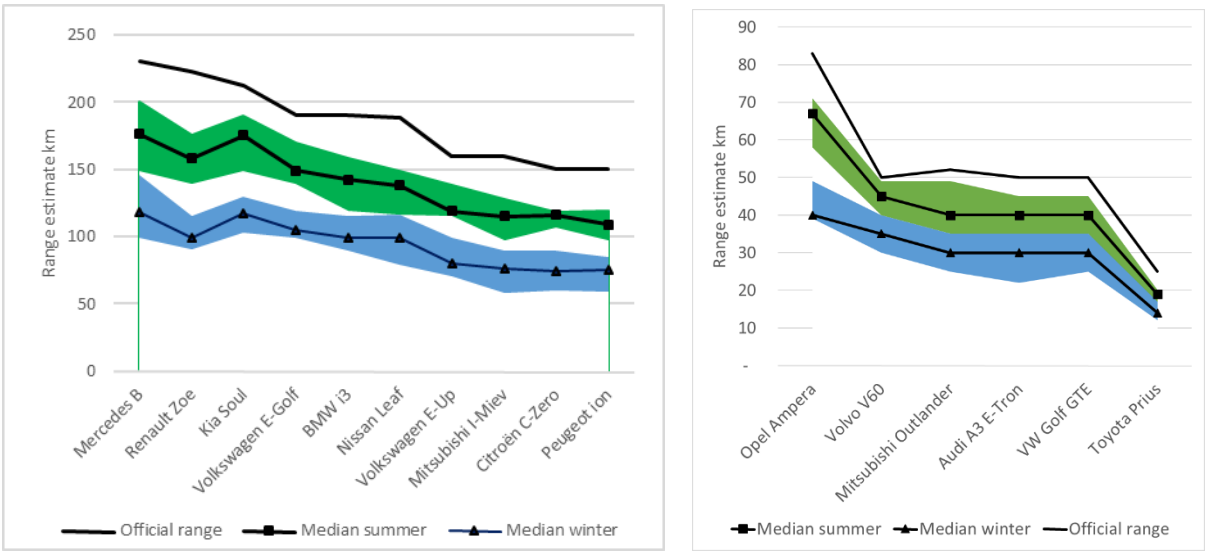


Figure 9: Users estimate of real available range summer and winter for BEVs and PHEVs. Coloured areas cover 20-80 percentile respondents. Norwegian PEV consumer. Source: [1].

BEV owners rely on charging infrastructure to supply energy to their vehicles and 29% have experienced charging problems, compared with only 10% of owners of PHEVs, as seen in figure 10. The biggest charging problems are "no power available" and damaged cable or charge socket. It can be estimated that infrastructure issues are at the heart of about half of the incidents of avoided or aborted travel. Typically avoided travel is routed in a lack of infrastructure along the way, whereas aborted travel often is linked with faults in the charging infrastructure, for instance that public charging stations are out of order. These are likely teething problems and a higher quality charging infrastructure gradually emerging will be able to drastically reduce the share of avoided and aborted trips. Tesla owners already enjoys such a network of high quality chargers as most Tesla owners reports no infrastructure issues.

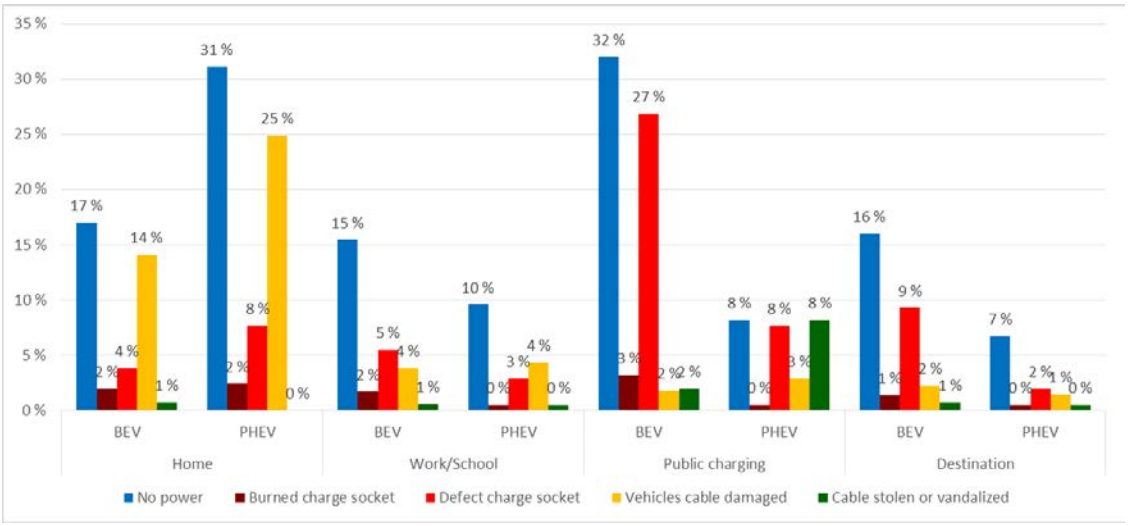


Figure 10: Occurrence of charging problems. n_{BEV}=894 n_{PHEV}=209. Norwegian PEV consumer. Source: [1].

Users take numerous actions, when they discover that the range is too short to fulfil the trip, such as finding other means of transport or take actions before travelling or while on the go, as seen in figure 11. There is a tendency of wanting to solve the problem on the go, using the BEV at hand rather than finding other means of transport in 2016 than in 2014. The fast charger infrastructure between cities was much better built out in 2016 than in 2014 [8], explaining some of the differences. It is also expected from theories on diffusion of innovations that consumers adapt to the new technology as it becomes more familiar over time.

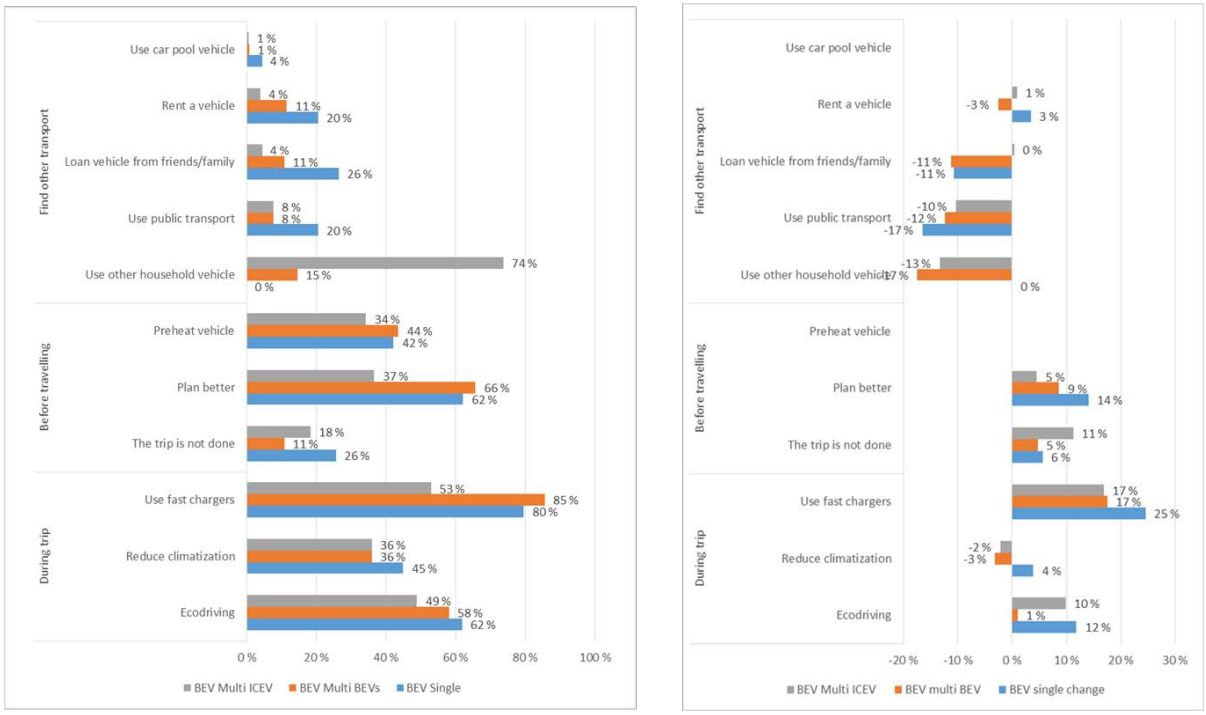


Figure 11: Solving range issues before and during transport or by finding other transport. Norwegian PEV consumer. Source: [1].

4.4 Utilization of and benefit of user privilege incentives

The average BEV user reaps local benefits such as free toll roads, access to bus lanes, free parking and cheaper ferries, worth on the average 14000 NOK/year (1500 €/year), with a median value of 1100 €/year. The exemption from toll roads accounts for 49% of the value, the time saving using bus lanes for 31% with the rest shared between free parking (16%) and cheaper ferries (4%). BEV owners report saving more on these benefits than PHEV and ICEV owners say they spend, thus indicating that consumers saving the most on incentives are the first to adopt BEVs. Variation between users and between regions of Norway is however huge as seen in figure 12.

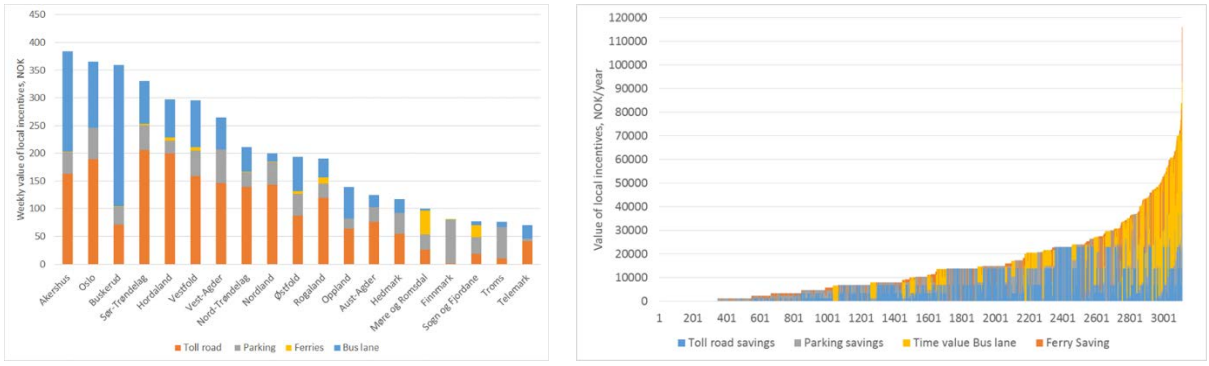


Figure 12: Variation in user incentive benefits received by province (left, NOK/week) and individual owners (right, NOK/year). Norwegian PEV consumer. Source: [1].

4.5 Buyers sources of inspiration and motivation

BEV buyers tends to be mostly influences by friends and family when deciding to buy a BEV as seen in figure 13. This situation is typical of diffusion among early adopters [12] but also a result of the deep diffusion of BEVs all over Norway. PHEV buyers on the other hand have less likelihood of knowing someone with a

PHEV and are more influenced by advertising and dealers. Exposure at work was not a big factor in Norway but may be so in countries were the technology diffusion typically starts in fleets.

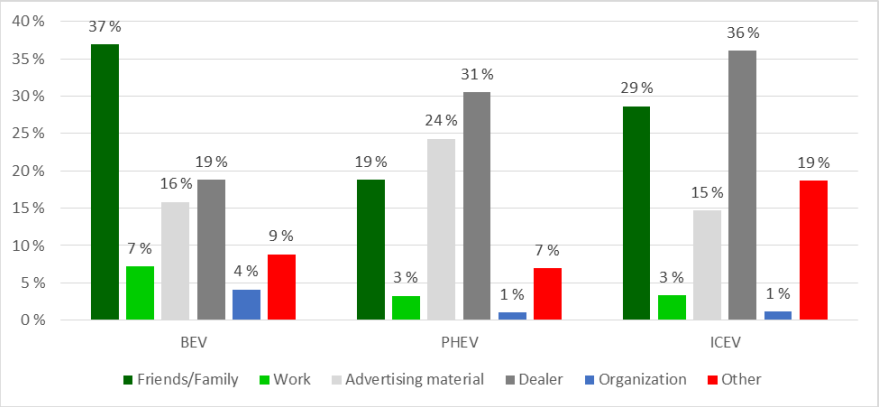


Figure 13: Information sources essential in the process leading to the vehicle purchase. Multiple answers were possible. n_{BEV} *= 3111,* n_{PHEV} *= 2065,* n_{ICEV} *=3080. Norwegian PEV consumer. Source: [1].*

Low energy cost was very important to BEV owners and also PHEV owners when buying a vehicle as seen in figure 14. BEV owners also valuate low maintenance cost as an important purchase factor. Environment was more than twice as important for BEV and PHEV owners as for ICEV owners. The importance of performance, the vehicle being the best for their need and value for money as purchase motivations, did not differentiate much between the groups.

Both BEV and PHEV owner say the vehicle was the best for their need. Most of BEV and PHEV purchase decisions were motivated by reductions in the cost of vehicle ownership and usage, whereas low operating cost, less environmental impact and home charging are perceived as BEVs main advantages among all survey respondents. In addition, the free toll road incentive is highly appreciated by a large share of users. Free parking and access to bus lanes is on the average much less important but could have been the incentive that triggered the purchase for those that can utilize this advantage. Range and charge time are as expected rated as the biggest disadvantages, especially among ICEV owners, whereas BEV owners are much less negative to these issues.

4.6 Opinions about BEVs among BEV owners and ICEV owners

BEV owner and ICEV owner opinions about BEVs differs widely as seen in figure 15, and provides insights into how BEVs might diffuse among ICEV owners in a later time. Range is seen as a big disadvantage by over 70% of ICEV owners but only 30% of BEV owners and 40% of ICEV owners sees charge time as a barrier. Longer range and faster charging vehicles will therefore likely build down the barriers to EV adoption in this group.

The vast majority of BEV owners see home charging and low user costs as big advantages of BEVs and almost 42-46% of ICEV owners agrees. BEV owners are more positive to BEV safety and environmental characteristics than ICEV owners are.

Comparing with the 2014 survey it is apparent that the attitudes to BEVs are becoming more positive in both groups when it comes to second hand value and charge time (Figenbaum and Kolbenstvedt 2016). Range and size is viewed a bit more negative by BEV owners, likely because they would like to drive electric on longer trips (with luggage).

For BEVs, people also value incentives, in particular the toll road exemption and reduced annual tax. PHEV owners value highly the ability to drive on electricity locally.

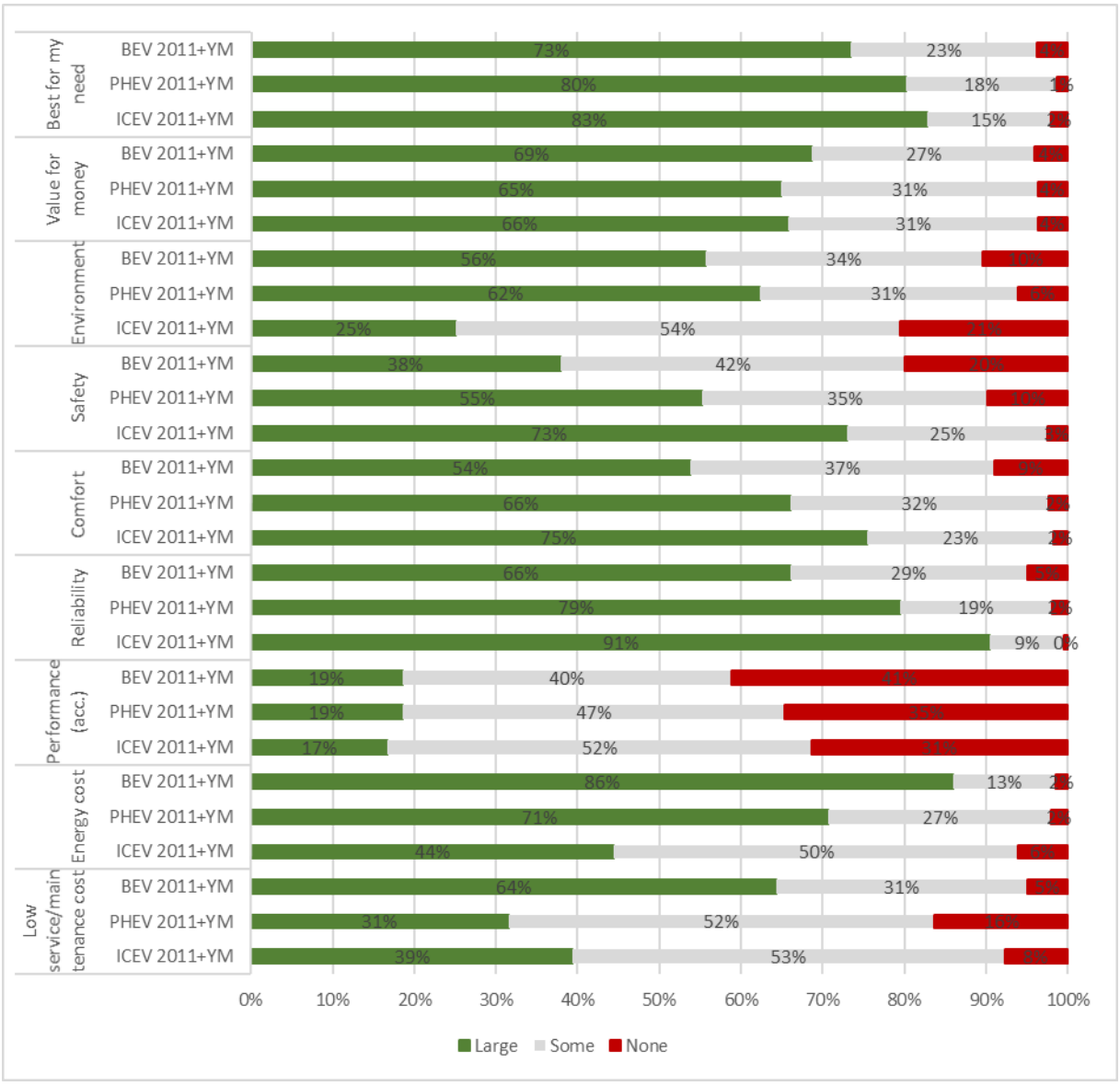


Figure 14: Importance of different factors when purchasing a vehicle. ICEV owner group is those owning 2011 and newer year models. Norwegian PEV consumer. Source: [1].

Swedish vehicle owners value the environmental advantages of Plug-in Electric Vehicles (PEVs=BEVs+PHEVS) much higher than Norwegian buyers, as 88% of BEV and 77% of PHEV owners see that as a big advantage of PEVs. Also performance is valued much higher by Swedes. Operating costs and second hand value are valued fairly similar. Purchase price is valued much more negatively in Sweden which is expected given the smaller incentives in Sweden. Norwegians rate BEV safety higher than what Swedes rates PEVs.

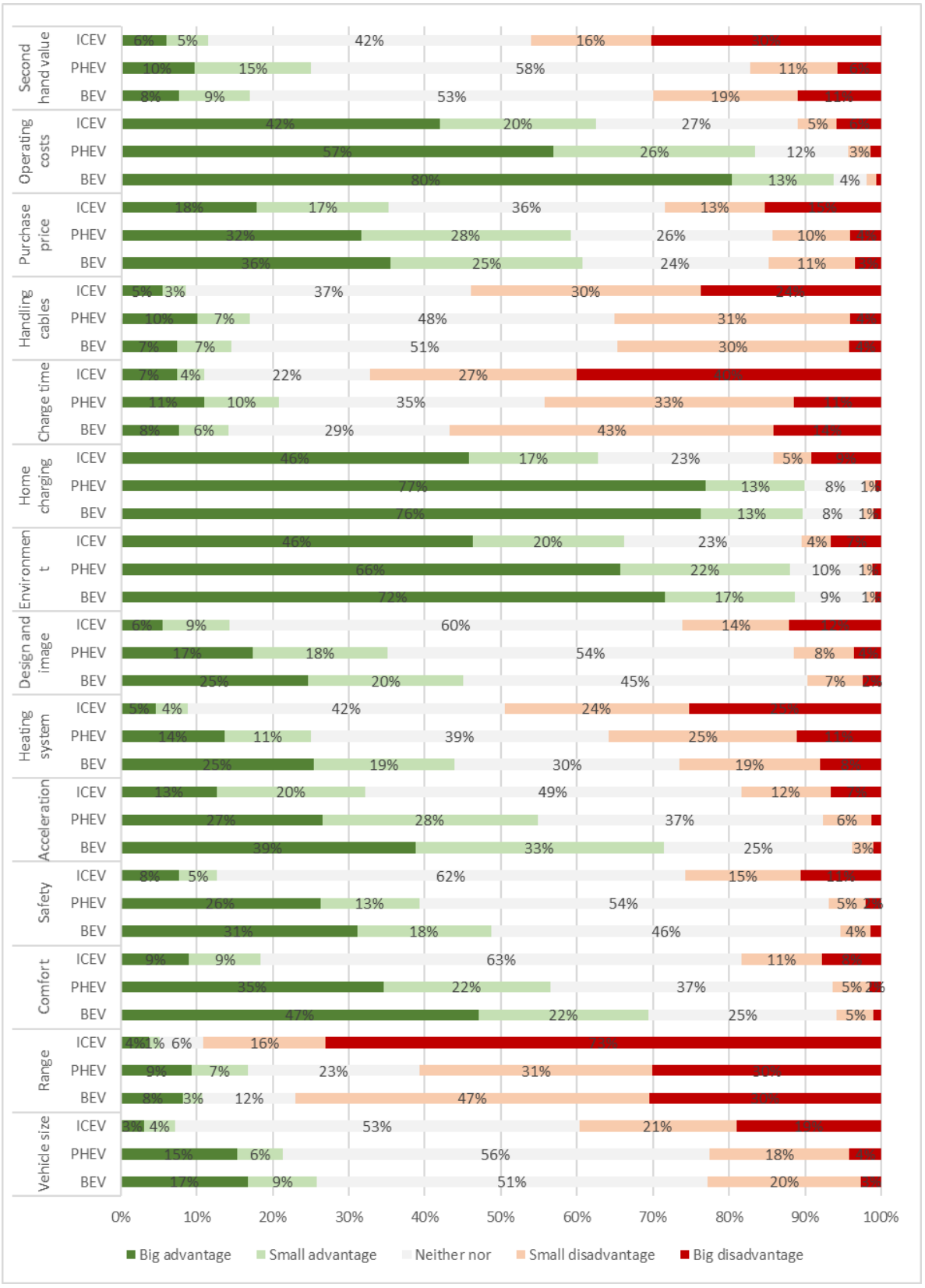
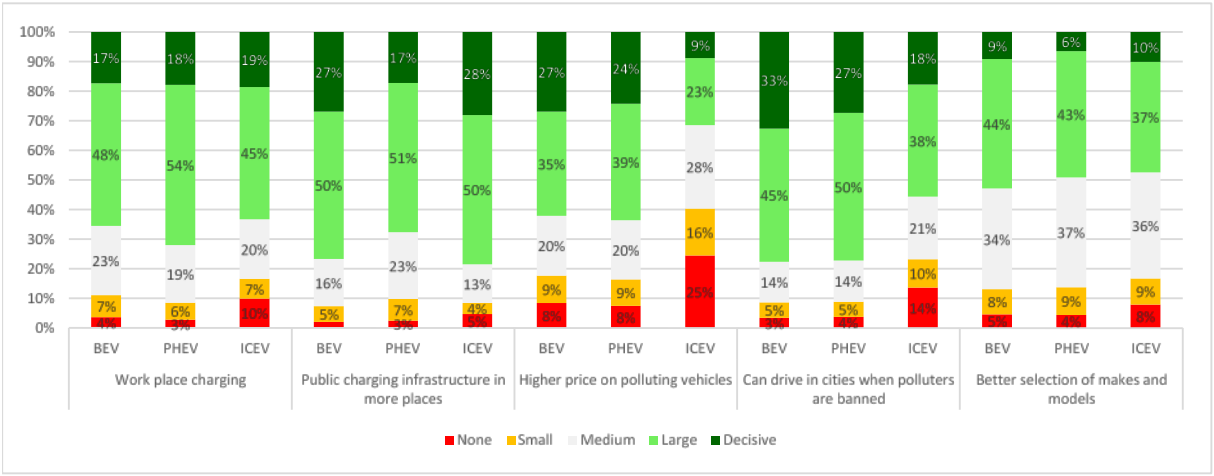
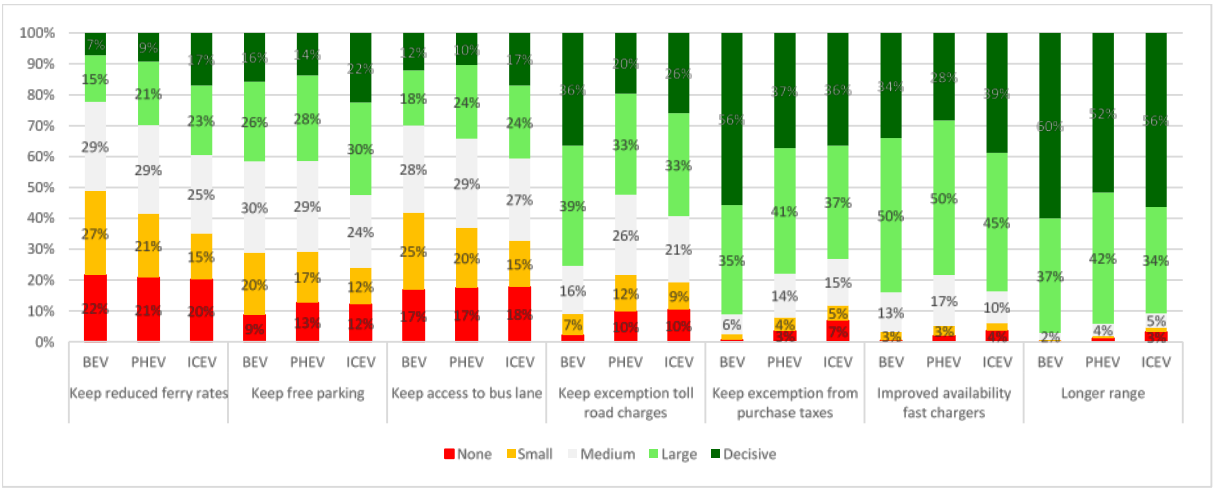


Figure 15: Advantages and disadvantages of BEVs as seen by different user groups. Norwegian PEV consumer. Source: [1].

4.7 Opinions on measures to promote BEVs and PHEVs

A battery of question was used to find out the opinions these owner groups have about measures that can promote BEVs and PHEVs and expand their market shares, as seen in figure 16.





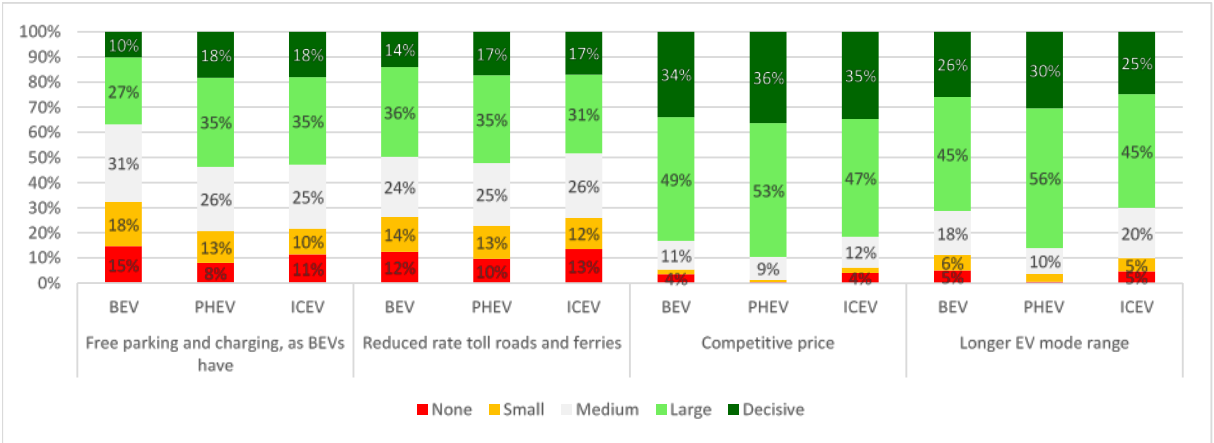


Figure 16 Measures to increase sales of BEVs and PHEVs (top), BEVs (Middle) and PHEVs (bottom). Norwegian PEV consumer. Source: [1].

Looking at the factors having most decisive and largest impact, there is a unison agreement that a competitive price is important for PHEV proliferation and that improved infrastructure is important for both BEVs and PHEVs. BEVs already have a competitive price, and the importance of keeping that advantage is reflected in the importance of keeping the purchase tax exemptions. Longer range is viewed as the most important parameter to increase sales of BEVs and very important for PHEVs. The owner groups differ in how much range they believe is needed to make them more attractive, but all want a lot more than BEV and PHEV owners (apart from Tesla) stated that they currently have (ref figure 9), as seen in figure 17.

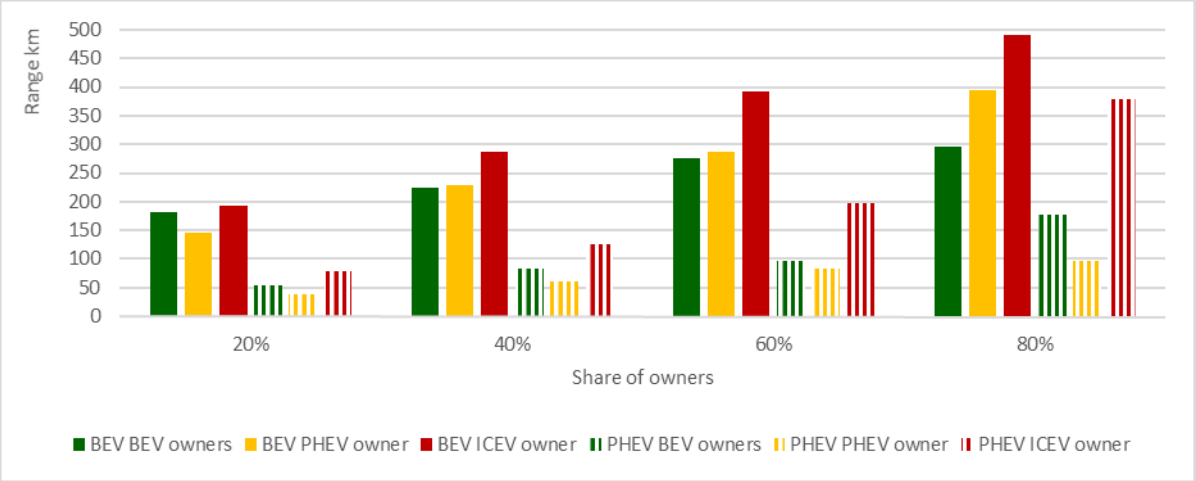


Figure 17. Vehicle owner groups suggested minimum winter range in km (i.e. minimum all year range) that is required to make more people want to buy BEVs and PHEVs. Norwegian PEV consumer. Source: [1].

To reach 50% acceptance, BEV and PHEV owners essentially wants BEVs with 225 km winter range, whereas ICEV owners thinks 300 km is required. For PHEVs, BEV owners wants 75 km, PHEV owners slightly more, whereas 50% of ICEV owners are not convinced until the range reaches 175 km in E-mode. To reach 20% acceptance in all groups, the respondents suggests that PHEVs will need 75 km range and BEVs 200 km. The former is only feasible with one model, the BMW i3 REX, the latter will be possible with several BEVs coming on the market the coming years or already on the market.

The user groups disagree when it comes to restrictive measures on ICEVs which BEV owners and PHEV owners thinks will make these technologies proliferate, whereas ICEV owner are not too keen on the idea. Of the local incentives, the user groups agree that the toll road exemption is the most important to keep. A better selection of makes and model will help but was not regarded as a very important factor in building out the market.

5 Discussion

BEV owners in Norway represents a unique source of information about BEV usage, advantages and drawbacks, as seen by mainstream consumers due to the deep diffusion into the Norwegian market. The Norwegian incentives however distorts the market compared to other countries making a transfer of knowledge difficult. The Norwegian incentives have pushed BEV diffusion forward to a point of becoming institutionalized [4], and spreading into the early majority of vehicle buyers. While Norway thus has proven that powerful incentives can have powerful effect when attractive vehicles are available, the user experiences also provides some general learnings that are transferable and important to other countries.

There is for instance no apparent contraction between BEVs and regular long distance driving needs, once the range reaches the level of Tesla Model S, and an efficient fast charger infrastructure is available. Even short range BEVs pose very few challenges for their main users, i.e. multi-vehicle households, as seen by the long annual driving distances the vehicles have, and the low share of users reporting aborted or avoided travel. Yet users estimate a much lower range in real traffic than the type approval indicates. Part of the explanation for this contradiction is the gradual build out of a network of public normal and fast chargers, providing a safety net and an opportunity to stretch range. Further improvements in infrastructure with a focus on quality, reliability and availability, could reduce the share of aborted and avoided travel by 50%,

and speed up sales. But all vehicle buyers agree that substantially longer range will also be required to reach larger market shares. BEV buyers should keep purchases incentives for these vehicles continued competitiveness, whereas PHEVs seems to need a reduction in purchase price, which was actually introduced in 2016, leading to increases in sales.

BEV owners spread the word and influence others to buy, whereas PHEV buyer finds their information from advertising material and information from dealers. The main reasons for purchasing BEVs and PHEVs seems to be reduced user costs, comfort, reliability, and a vehicle matching needs and good value for money. These are also important factors for ICEV buyers, apart from user costs. BEV owners also value the local incentives, in particular the toll road exemption and reduced annual tax while PHEV owners value highly the ability to drive on electricity locally. Environment is also important and considered by all to be a big advantage of BEVs and PHEVs. In the purchase decision environment however weighs less than user costs and value for money. For ICEV buyers, environment comes further down on the list. Home charging is seen as a very big advantage by all groups.

6 Conclusion

Norwegian BEV policies, levelling out the price difference towards ICEVs through the tax policy and offering user incentives, have put BEVs in the hands of multi-vehicle households, the group that can best take them into use. The impact on their behaviour has been minimal while maximizing the replaced ICEV kilometres. Users, mostly multi-vehicle households, experience modest challenges with their BEVs in everyday travel. Most owners charge their vehicles effortlessly at home and use their BEV for all possible local driving. About half of the challenges related to driving range of BEVs could be solved with a wider built out and more reliable public normal and fast charge infrastructure. Longer range vehicles will further expand the market as long as incentives remain in place.

Acknowledgments

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