

Demand for standardization of public fast charger stations – user perspectives

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Summary

This paper presents results from an online survey with BEV owners and ICEV owners, and results from 15 in-depth interviews with BEV owners. The aim of the study was to 1) develop knowledge concerning end-user experiences of using public fast charging services in Norway and 2) map BEV owners and future BEV owner's usability needs in terms of charging services. Respondents report experiencing several usability issues when using public fast chargers. Many of the issues BEV-users experience can be traced back to the diversity of service providers in the fast charging market, which each have developed their own charging systems. Standardization of payment systems could solve many of the issues that BEV users are experiencing today. Another improvement would be to make payment with credit/debit card a standard option. Today, there are few service providers in Norway that allow payment with credit card.

Keywords: BEV, charging, user experience, standardization

1 Introduction

Norway has the one of the highest shares of new electric vehicles worldwide. In 2021 about 65 percent of new private cars registered in Norway were BEVs (Battery Electric Vehicle) [1], and the share is steadily increasing. BEV sales reached an all-time high in the first quarter of 2022 when the BEV share of new registered passenger cars reached 83 percent. The share of the total passenger vehicle fleet in Norway is now 16 percent [1]. This means that eight of ten new-car owners are potential users of public charging infrastructure.

Among BEV owners in Norway, home-charging is the most common form of charging, as most households can install an electric charger at home. Previous Norwegian user surveys indicate that the average non-Tesla BEV owner use public fast chargers about 19 times per year, while about 40 percent only use public fast chargers 1-3 times per year [2,3]. Although most BEV-users in Norway charge at home, many still depend on fast charging occasionally, for example for long distance driving. In a recent survey among BEV owners in three Norwegian Counties, about 75 percent report having used fast chargers when driving longer distances [4].

Figenbaum and Nordbakke [2] argue that long distance driving remains one of the final barriers to BEV adoption in Norway, particularly in households depending on one car. In many households, the BEV still functions as a secondary car, to a primary internal combustion engine vehicle (ICEV). Although BEV models with larger batteries and bigger range have made it more viable for many to use their BEV for driving longer distances, there are still many BEV owners who dread using their car for long distance driving [2, 4]. While expansion of the fast charging network has led to significant improvement, there are still several usability issues with fast chargers that need to be addressed.

In Norway, there are currently about 4000 public fast charging points, and the marked is steadily expanding. In a recent report by the Norwegian Environment Agency and the Public Roads Administration, it is estimated to be around 10 major operators in the marked with more than 280 charging stations, including Tesla [5]. In addition to these, there are about 20-25 additional charging operators with fewer charging stations and charging points. Unlike petrol stations, where the design of the pumps and the user-interface are more or less standardized, fast charging is characterized by many different charging systems, plugs, payment solutions and pricing models. Consequently, BEV users must navigate in a complex fast charge landscape and are forced to interact with a variety of different solutions and systems, which makes the user experience of fast charging less streamlined and more time consuming, compared to the user experience of filling petrol.

Compared to petrol stations, current fast charging services are not as user friendly, and may be difficult to operate, especially for BEV drivers who seldom use public fast chargers. Very few of the public fast charging providers offer payment by credit card. Consequently, customers must pay either by apps, operator specific payment card, SMS etc. To avoid having to pay extra for the charging (payment by SMS is more expensive) the customers must register personal information and bank information on the charging operator's internet pages before they use the public charger.

The Norwegian government's ambitious goal is that by 2025 all new passenger cars and vans sold in Norway are to be zero-emission [6]. As more and more vehicle owners change from ICEV to BEV it is important that public charging will not be considered a barrier for switching to BEV. Many of the early adaptor's changed to BEV due to environmental and/or technological interest (and the economic incentives). When "everyone" has BEVs the drivers are expected to demand more or less the same "seamlessness" at the public charging stations as on petrol stations. This will require an increased standardization of the public charging stations (both regarding charging and payment) and a better handling of queue situations. This will be even more important in the future, when more car owners without access to private charging facilities make the transition from ICEV to BEV.

This paper presents results from an online survey with BEV owners and ICEV owners, and results from 15 in-depth interviews with BEV owners. The aim of the study was 1) to develop knowledge concerning end-user experiences of using public fast charging services in Norway 2) to map BEV owners and future BEV owner's usability needs in terms of charging services. In this paper, we focus on experiences related to public fast charging (not Tesla's superchargers) and BEV owners' experiences and views concerning these.

2 Method

The results are based on an online survey and in-depth interviews. Both the survey and the interviews were carried out in June 2021.

2.1 Survey

Survey participants were recruited from NAFs (Norwegian Car Association) member base through a special invitation sent out to 10 000 of NAF members (As of 2020, there were almost 500 000 NAF members). The invitation contained a link to the survey. The target population of the survey was BEV owners and owners of

passenger cars with combustion engines, the latter representing potential future BEV owners that have not yet made the transition.

The survey contained questions about car ownership, car use and driving behaviour. BEV owners were asked about charging behaviour and views on public charging infrastructure in Norway, more specifically about payment methods, pricing, experiences pertaining to charging queues, usability and preferred facilities on charging stations ICEV-owners were asked about their views on BEVs and asked to state their imagined preferences regarding number of charging stops and acceptable charging time if they were BEV-owners.

A total of 1237 respondents answered the survey. Of these 76 percent, were BEV owners, 18 percent were owners of passenger cars with combustion engines (diesel, petrol, non-chargeable hybrid cars), five percent were owners of chargeable hybrid cars, and finally one percent of the respondents use car sharing services. The mean age of the respondents was 54 year, and 85 percent were men.

The survey also contained an open-ended question, where respondents could write comments. Many shared their views and experiences with fast chargers.

2.2. Interviews

In addition to the survey, 15 in-depth interviews were conducted with BEV owners. In order to gain insight into different user groups experiences and views regarding use of charging infrastructure, a strategic sampling strategy was utilized. The sample was put together to reflect variations in BEV user groups, and represent different types of BEV-users, with different housing situations, car usage patterns and charging behaviour.

Participants were recruited from NAFs member base, from members of the national car sharing service “Bilkollektivet” and from contacts within our existing professional network. Nine of the participants were male and six were female. The respondents age ranged from 20-70 years.

Interviews were carried out digitally via Microsoft teams or over telephone and was conducted by a team of three researchers. Interviews lasted between 30 minutes to 80 minutes. Upon completion, each interview was transcribed, and a thematic analysis was performed to identify salient themes in the data reflecting BEV-users experiences.

3 Results

3.1 User-friendliness

Respondents from the survey and participants in the interviews report experiencing several usability issues when using public fast chargers. Many of the issues BEV-users experience can be traced back to the diversity of service providers in the fast charging market, which each have developed their own charging systems. The charging stations greatly vary and offer different type of plugs, the cable have different length and locations, the different charging points offers different effect, and the method of activating the charging and paying also differs. Consequently, several of the respondents were dissatisfied with public fast charging services and emphasized the need for standardization of all public charging stations.

«There are many different systems in terms of physical plugs. What kind of plug is this? What effect can I get out of this one? What is most up to date? Is it the same standard on a Tesla? After a while, you start to understand”.
Informant 6

«Often I see people that are not accustomed to driving an electric vehicle, trying to use the charger that I’m already using, thinking they are using the other cable (there are two options, one that I can’t remember the name of and CSS). Visible information on the charger should have been available where it says that you can only use one cable at a time» Informant 8

Quote from survey participant” *To charge a BEV should be just as simple as filling petrol at a petrol station. Drive to the station, insert the cable, and pay with credit card. I have never experienced that this succession differs between different petrol stations. It should be alike to use all public charging stations; it should be simple”.*

To avoid having to learn the operating and payment system of another charging operator, 55 percent of the respondents in our survey stated that they deliberately used the same charging operator each time they use public chargers. Almost half of the respondent also stated that they bought a BEV with large batteries to avoid having to use public chargers.

3.2 Pricing

The operators of the fast charging stations in Norway have different prices and pricing models. Some charge for kWh, some per minutes, and some use a combination of these solutions. Many find paying by the minute unfair, because the important part is how much kWh you receive.

Most of the respondents found it difficult to understand how much the charging would cost. This was evident in the survey as well as in the interviews. About 70 percent of the BEV owners in the survey either partly or fully agreed to the statement “it is difficult to understand what the price of using public fast chargers will be”. Both the group using public fast chargers 1-3 times a year and the persons using public chargers more than 20 times each year agree on the difficulty of understanding the price.

Price information is often lacking or difficult to understand. In the interviews, several of the participants drew parallels to fuelling on petrol stations, where pricing information tends to be clear and easy to understand. In the case of public fast chargers, BEV users are often not provided with price information until the charging is finished.

“What annoys me is the price. The taximeter starts before the charging has begun and it ends a couple of seconds after the charging is finished. The Norwegian Metrology Service should conduct controls on fast charger stations, like they do on gas stations, so we are not taken advantage of. It boils down to seconds”. Informant 4

“The problem is lacking information about how fast I’m charging; how much I’m charging and how much it costs. These three things tend to be hidden for most operators. It’s normally when you’re finished charging that you know how much you’ve spent, unless you’ve brought a calculator and do the math yourself”. Informant 9

“It’s like going to a petrol station where they’ve covered all the prices with white tags. You can’t see the price before after you’ve charged. That really sucks” Informant 5

Quote from survey participants” *Hopeless that precise pricing is not available, like at petrol stations. Would prefer information about actual costs and received kWh during the charging session. Ideally, I could indicate the wanted charging percentage at the beginning, and the charging session would automatically stop when this percentage is achieved”.*

“Want to be able to pay by credit/debit card, get information on the price before I start the charging, and receive information about the actual costs after the charging session is ended”.

3.3 Payment method

More than 50 percent of the BEV owners find the payment method at the public fast charging stations inconvenient (Fig.1). Figure 1 show the level of dissatisfaction/inconvenience with the payment system, depending on how often they use public fast chargers (Tesla’s superchargers not included) during a year. Many state that they wished paying with credit/debit card was an option (this is currently only available at a small

percentage of the fast charging stations in Norway). BEV owners who seldom use public fast chargers find the payment method slightly more cumbersome than the ones that use public chargers more often. Even among BEV owners who use the chargers more than 30 times a year, the level of dissatisfaction is high.

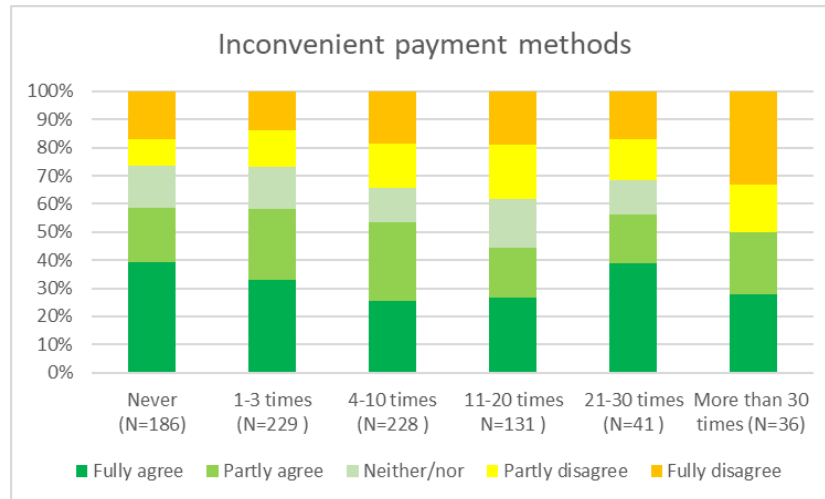


Figure 1: BEV owners finding the payment methods at public fast charging stations inconvenient/cumbersome, depending on the number of times the respondents have used public fast chargers (not Supercharger) the last 12 months.

The average BEV driver in our survey has downloaded 3 different charging apps. About 75 percent state that it is inconvenient that all the charging operators have different apps. The perceived inconvenience is shared more or less independent of the number of times the BEV owners are using public fast chargers (Fig. 2) and between different age groups (Fig. 3). But it is a tendency that the ones who seldom (3 or less) or often (30 or more) use public chargers are somewhat more annoyed.

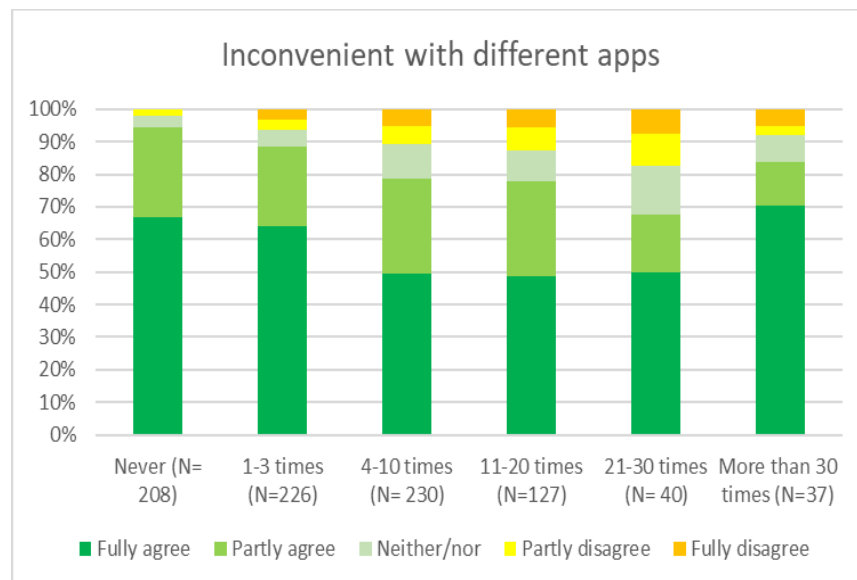


Figure 2: BEV owners finding it inconvenient that the different charging operators all have different apps, depending on the number of times the respondents have used public fast chargers (not Supercharger) the last 12 months.

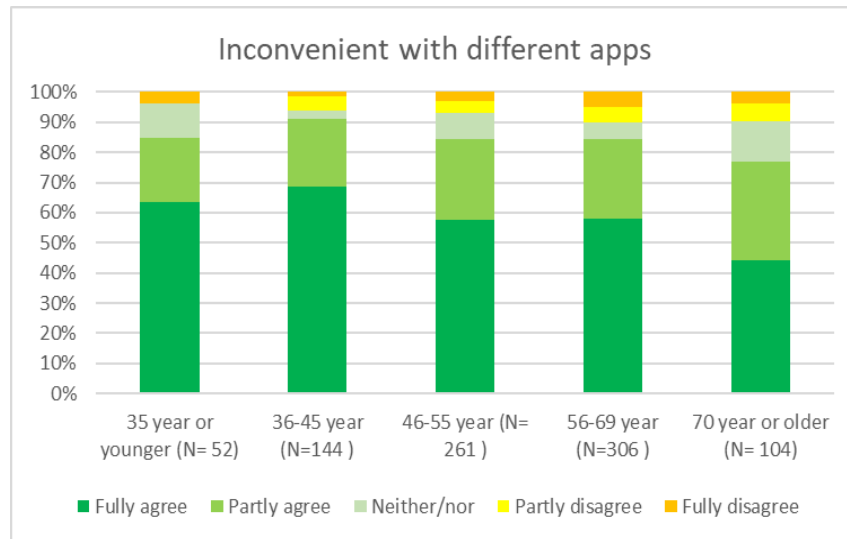


Figure 3: BEV owners finding it inconvenient that the different charging operators all have different apps, depending on the respondents age-group.

“Having all these apps is confusing, because if I’m planning a trip, I can’t just use Google maps and find all the different charger services there. My experience is that I’m unable to get a full overview, and that I’m forced to use each app individually to locate charging stations, and get information about the terms and so forth, and then I’m not even sure if I have the right app”. Informant 10

“An opportunity for simpler payment would be nice. To be able to pay with credit card (...). An elderly person who uses fast chargers on rare occasions would want to do it as simple as possible. If this was better, I think the development in terms of number of electric vehicles would go much faster”. Informant 5

Quote from survey participant” *It should have been a common method for payment at all public charging stations, without having to download an app to the phone. Should be possible to pay with debit or credit card. Not everybody is comfortable with apps, especially the elderly”.*

3.4 Information and on-site service options

Finding from the survey and the interviews suggest that BEV owners also desire better information about the status of chargers, such as information about chargers that are out of order, and information about the availability of charging points at charging stations. Moreover, road signs indicating the location of charging stations along main roads. For fast chargers used typically by long distance drivers (driving 100 km+) different on-site service options are also highly valued. Toilet facilities are in especial demand, but also the possibility to buy food is important. Enough lighting to both read the information on the charging station and to be able to insert the cable and cover for when it is raining/snowing is also important. Many of the BEV owners also want a system for handling the que at the charging station. Problems with que have been an increasing problem especially during the seasonal vacation times, public holidays and on weekends. BEV owners want the same amenities at the fast charging stations, that are today available at petrol stations.

Figure 4 show some important factors when choosing a charging station. Location and payment method are most important, but price and amenities are also important. About 75 percent of the BEV owners state that additional amenities at fast charging stations is important (the question did not differ between the charging stations located in the cities or along the main arterial roads connecting the cities). The availability of amenities is more important at the fast charging stations typically used by long distance travelers.

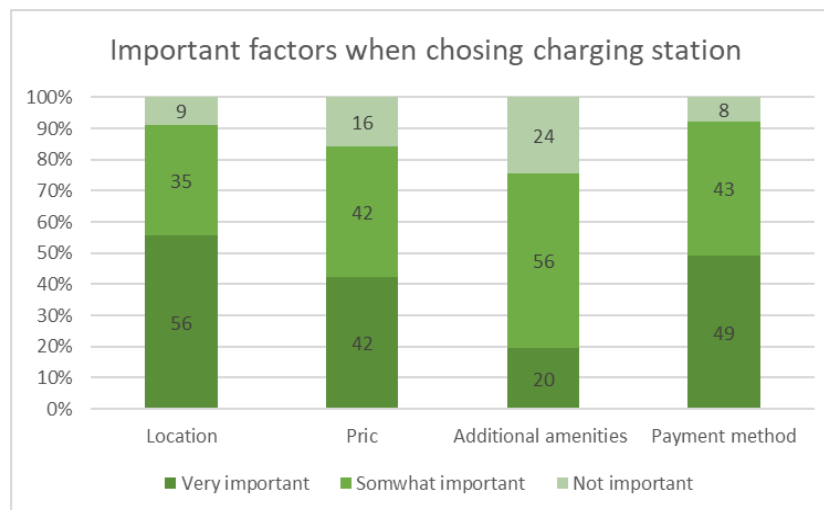


Figure 4: Important factors when choosing public charging station. BEV owners; NO= 675.

"I normally charge where I can use toilets, buy ice cream, coffee etc. That is much more OK than (charging stations) where there are just two chargers in the middle of no man's land. It's nice to be able to do something other than just sit in the car. I would not let it determine my path, but along the route I am going, I would choose charging stations with extra service options. This is more important than if I save 15 kroner on charging." Informant 7

"I'm not very fond of chargers that are in the middle of nowhere. It must be facilities that allows you to do something there while charging. Gas station, toilet, etc." Informant 8

"I have experienced that there are no available charging points when arriving at a charging station. It's difficult to know how long others plan to charge and where to park in the meantime. How does the queuing system work? Are you supposed to drive to the next charging point? (...) I get that all charging points are busy sometimes, but the fact that you're not provided with any information regarding when it will be available, creates a sense of uncertainty. There should be a function on the charger where you could plot in "I need to have 50 km left so I get home, how long does it take". Informant 5

Quote from survey participants" *When it comes to amenities, the type of amenities is not so important, if it is a grocery store, a kiosk or a café. The important thing is that **there is something**. The best option would be if the chargers were placed at petrol station because they are usually open 24/7 and have toilet facilities"*

"A form for booking systems/queue handling system should be available, to avoid arguments and "pointed elbows" on popular weekends".

4 Discussion

An increased standardization would help the overall user friendliness of the public fast charging station, this includes:

- Standardization of the payment method. The same type(s) of payment methods should be available at all stations. Preferable one common app for all charging stations, and easy options for drop-in clients (debit/credit card option).
- Standardization of the pricing system. The price should be clearly marked, and the pricing system should be easily comparable between different charging stations (without having to download an app).
- Standardization of use. Available user information, placing of charging cables to fit all vehicle models, method for starting the charging etc. Universal design at all fast charging station (easy use independent of nationality, technological knowledge or disabilities).
- Standardization of a certain level of amenities at fast charger along the major highway network. Including toilets, food options, light, garbage bins, road signs etc.

Survey and interview results suggest many BEV users experience several usability issues when using public fast chargers. Lacking user-friendliness and variations in pricing and payment systems across operators are important disadvantages among BEV users when using public fast chargers in Norway. According to a survey performed by the Norwegian EV Association, 88 percent of current BEV owners want a simpler fast charging system that is universal and independent of which company may be operating the charging station, and more than 70 percent state that they want to be able to pay for the charging with a credit/debit card [7]. Findings from the current study are consistent with these results.

Recent years have shown consistent improvements to the network of fast chargers in Norway, particularly in terms of availability [2]. However, findings from the present study suggest that there is still a long way to go in terms of usability. As BEV shares are steadily increasing and BEV users are on the rise of becoming the majority buying group among car owners in Norway, the need for a more user-friendly and seamless charging experience is pressing.

Standardization of payment systems could solve many of the issues that BEV users are experiencing today. This could be done for example by unifying all available charging services into one smart phone application. A universal app would greatly reduce the number of apps and payment system that BEV users need to acquire, and thus simplify payment, particularly for BEV users that only use public charging services occasionally. Moreover, a universal app could also house accurate pricing information feature, and provide users with simpler price information, regardless of service provider.

Another improvement would be to make payment with credit/debit card a standard option. Today, there are very few service providers in Norway that allow payment with credit/debit at public fast charging stations. Findings from the current study and other studies [e.g. 5,7,8] imply that most EV-users would like to have this option. It has been suggested that elderly may be less comfortable with app-based payment solutions. In the present study however, elderly participants (+70 years) did not report being more sceptical to using apps than the other age groups, however, this could partly be because the elderly respondents in our sample have been early BEV users, and generally are more technologically interested than the average elderly population. EU [9] are considering standardizing the payment method at public charging stations. For charging stations offering charging at 50 kW or more, the preliminary plan is to require the facilitation of payment card readers at all charging stations by 2027 (or a contactless solution). Other methods to simplify the existing payment methods discussed in Norway [5] are etc.: include charging in the existing toll road system (AutoPass chip) or implement a type of ANPR (Automatic Number Plate Recognition) system to start the charging (plug-and charge system).

It is also difficult for the BEV owners to get an overview of the price of charging. Different operators have different pricing system (paying for minutes, paying for kWh, or a combination of both). The price of charging also varies depending if you are a drop-in customer or if you are a register customer of the charging operator. Drop-in customers in Norway who pay for the charging with SMS, typically pay 2-3 times more than the operators registered customers who pay by app or by using RFID card/tag [5]. Most of our respondents prefer a solution where you pay for the kWh you receive, but with a possible incentive to avoid some occupying the charger longer than necessary. Compared to petrol station it is difficult both to know the price before you start the charging, and to know what the charging costed after you have finished the charging session. A standardization of information available to all customers (including drop-ins) are necessary.

In Norway many of the BEV owners only use public chargers 0-3 times a year [2,3], it is there for important that the user information at the charging stations are easy to understand (and in both Norwegian and English). That all charging stations have a universal design are also important. The chargers need to be easily accessible to different vehicle models, and to people with different disabilities and to drop-in customers. EU [9] are planning to include regulation for accessible user information, traffic signs and information on prices in the updated version of Directive 2014/94/EU.

Customers generally want the same amenities at the charging stations as the petrol stations. Access to toilets, lights, cover are important. Especially for long distance travelers the following amenities are important [4,5,7,8]: toilets, cover for rain/snow, access to food, resting areas, garbage bins, 24/7 service and access to water (window washing).

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