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# Moving a taxi sector to become electric

An innovative incentive programme in Amsterdam

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**Summary**

The increased adoption of electric vehicles worldwide is largely caused by the uptake of private electric cars. In parallel other segments such as busses, city logistics and taxis, are increasingly becoming electrified. Amsterdam is an interesting case, as the municipality and the taxi sector have signed a voluntary agreement to realise a full electric taxi fleet by 2025. This paper investigates the results of a survey that was distributed amongst 3000 taxi drivers to examine perceptions and attitudes on the municipal charging incentives as well as taxi ride characteristics.

*Keywords: case study, fleet, policy, research, user behaviour*

## 1 Introduction

With electric vehicle (EV) adoption increasing among Dutch households, specific mobility sectors are targeted to contribute to this transition, with the taxi sector as a prime example. Taxis are compelling in this case, as they operate in inner city districts, contributing to the deterioration of local air quality. The municipality of Amsterdam signed a voluntary agreement with the majority of official taxi organizations at the end of 2015 with the aim of creating a full electric taxi fleet before 2025 [1]. Through this voluntary agreement, the official taxi organizations declared their commitment towards the transition to full electric passenger transport. The municipality facilitates this transition by a number of policy measures, including purchase subsidies, placement of (fast) chargers, a priority incentive at particular taxi stands and an environmental zone. The policy measures thus include incentives to stimulate the transition and persuade taxi drivers to purchase full electric vehicles (FEVs), but also include facilitation of FEV adopters through charging infrastructure and restrictions for non-adopters with designated environmental zones. The goal of this incentive programme is to encourage taxi drivers to switch to FEVs in the upcoming years.

The Amsterdam University of Applied Sciences (AUAS) has carried out research to track the adoption of FEVs amongst Amsterdam based taxi drivers. This research is part of the NOW sponsored project U-SMILE (Urban Smart Measures and Incentives for quality of Life Enhancement). One of the research topics entails consumer research, whereby perceptions, barriers and motivations regarding FEV adoption are mapped. In this paper we will discuss the results of a survey, centered around the respondents' perceptions on FEV range and the attitude towards incentives that increase charging opportunities. Range anxiety is likely to form a major barrier for large scale EV adoption among taxi drivers, as this functional attribute is often deemed as insufficient for the daily practice of driving a taxi. The innovative incentive programme as designed and implemented by the municipality of Amsterdam raises questions about effectiveness and experience from a user perspective: are the incentives effective in persuading taxi drivers with conventional vehicles to switch to FEV? This paper explores the attitude towards and role of the fast charging network and parking license within the Amsterdam based taxi fleet.

# 2 Literature review

We consider consumer research within other mobility branches as key to understanding how EV adoption is influenced in a different setting, where specific contextual factors are at play. Consumer research is furthermore of importance here as a complementary research component to other research methods, such as quantitative data analysis of charging behavior, as results from those methods do not always inform us of the lived reality of consumers [2]. This includes, for instance, attitudes towards the attributes of FEVs, as has been done in previous studies focused on consumers [3], [4]. Limited research is available concerning particular sectors, such as taxis, to move towards electric. Available taxi-related studies focus on socio-economic characteristics and preferences of hybrid electric vehicle drivers [5] or on analysis of operating and charging behavior [6]. Yet limited research is available on characteristics and preference of taxi drivers within the context of a governmental incentive programme that promote FEV use. Amsterdam based taxi drivers are also currently strongly influenced by different forces, such as competition from other taxi services. It is relevant to examine the perceptions and experiences of taxi drivers, so that motivations, barriers and considerations in FEV adoption can be further investigated and anticipated on.

# 3 Methodology

This research applies a large scale survey to test the acceptability and attractiveness of the different measures used by the municipality of Amsterdam. Furthermore the survey aims to establish other relevant consumer aspects information, such as attitude towards FEV attributes and FEV adoption. A survey was sent out to approximately 3000 taxi drivers in September 2017. Out of these 3000 taxi drivers, 307 taxi drivers filled out the survey (10%). A total of 6 responses were excluded from analysis as duplicate responses, resulting in 301 responses used in the analysis. Not all questions were mandatory and therefore some results shown here do not include al 301 responses.

# 4 Results

## 4.1 Respondents

296 of the 301 respondents specified their current vehicle type, leading to the following distribution per type of vehicle.[1] As can be seen the majority of vehicles are internal combustion engine vehicles (ICEV, 77%), followed by FEVs (11,8%) and Plug-in Hybrid Vehicles (PHEV) and Natural Gas Vehicles (NGV) (both 3,9%). Based on information provided by the municipality at the time of the survey, around 400 electric taxis were registered, between 10-12% of the expected total taxi fleet in Amsterdam).

[1] Due to (i) the municipal focus on zero emission vehicles, (ii) the low response rate from PHEV and NGV drivers and (iii) our focus on FEVs, most results will only include data from ICEV and FEV respondents.

Table 1: response per type of vehicle

| Vehicle Type | ICEV | PHEV | NGV | FEV |
|---|---|---|---|---|
| N | 236 | 12 | 12 | 36 |
| % | 77,1% | 3,9% | 3,9% | 11,8% |

As shown in table 2, at the time of the survey distribution, the FEVs have been used the longest of the different type of vehicles. At the time of the survey distribution FEVs were, on average, older than four years. Hence, these vehicles have a more limited range than the FEVs currently on the market. Note that the taxi drivers were asked since when they started using the taxi vehicle, which does not automatically indicate the vehicle's age, as second hand vehicles are not uncommon within the taxi sector.

Table 2: year of vehicle purchase

| Vehicle Type | N | Average year of commissioning |
|---|---|---|
| ICEV | 236 | 2014 |
| NGV | 12 | 2016 |
| PHEV | 12 | 2014 |
| FEV | 36 | 2013[2] |

## 4.2 Interest in FEV

We measured the self-reported degree of *interest* in purchasing a FEV in the future and the self-reported degree of *likelihood* of purchasing a FEV in the future. Both interest and likelihood were measured on a 7 point scale (1 = not interested at all … 7 = very interested, 1 = not likely … 7 = very likely). Out of the 236 ICEV drivers 139 (58,9%) of the ICEV drivers reported a moderate to strong disinterest in purchasing a FEV, 33 (14%) remained neutral in their interest and 64 (27,1%) showed a moderate to strong interest in purchasing a FEV in the future. Concerning likelihood, 124 (52,5%) ICEV drivers considered it somewhat to very unlikely that they would purchase a FEV in the future, with 45 (19,1%) neutral and 66 (28%) considering it somewhat to very likely.

A strong positive significant correlation ($\rho = 0,719$, sig = 0,000) was found between interest in a FEV and self-reported likelihood of purchasing a FEV among ICEV drives, with 110 (46,6%) ICEV drivers displaying a disinterest and unlikelihood in purchasing a FEV versus 47 (19,9%) ICEV drivers showing interest in purchasing a FEV and considered it likely to purchase a FEV in the future. The remaining ICEV drivers were either interested but did not consider the purchase likely (6 – 2,5%), were not interested but did consider the purchase likely (11 – 4,7%) or gave a neutral response on either interest or likelihood (61 – 25,8%). Note that self-reported likelihood of driving a FEV in the future might not be accurate for predicting FEV adoption: in the context of the voluntary agreement and the incentives implemented by the municipality, ICEV drivers might feel forced to switch to a FEV and thus consider FEV adoption likely, despite being not interested in the electric vehicle itself.

Since it is the aim of the municipality to facilitate current FEV drivers in driving electric and simultaneously incentive current ICEV drivers to adopt FEV, the following result section will make a

[2] A large share of this FEV fleet consists of Tesla Model S vehicles which were commissioned in a taxi pilot of 170 vehicles for Schiphol Airport. These vehicles have recently been replaced by a selection of other vehicles, including the Tesla model X.

distinction between (i) the complete sample of ICEV drivers, (ii) ICEV drivers interested in a FEV, (iii) ICEV drivers not interested in a FEV and (iv) FEV drivers. ICEV drivers who showed neither an interest nor disinterest in purchasing a FEV are only displayed in the total ICEV results.

## 4.3 Attitude towards voluntary agreement and FEV

Regarding the attitude towards the voluntary agreement, both FEV drivers and ICEV drivers with an interest in purchasing a FEV acknowledged the importance of the voluntary agreement signed between the municipality and the taxi drivers. Acceptability of the voluntary agreement is low among the total group of ICEV drivers yet high among the current FEV drivers. A strong positive significant correlation ($\rho = 0{,}677$ Sig = 0,000) was found between overall interest in purchasing an electric vehicle (including NGV, PHEV and current FEV drivers) and acceptability of the voluntary agreement.

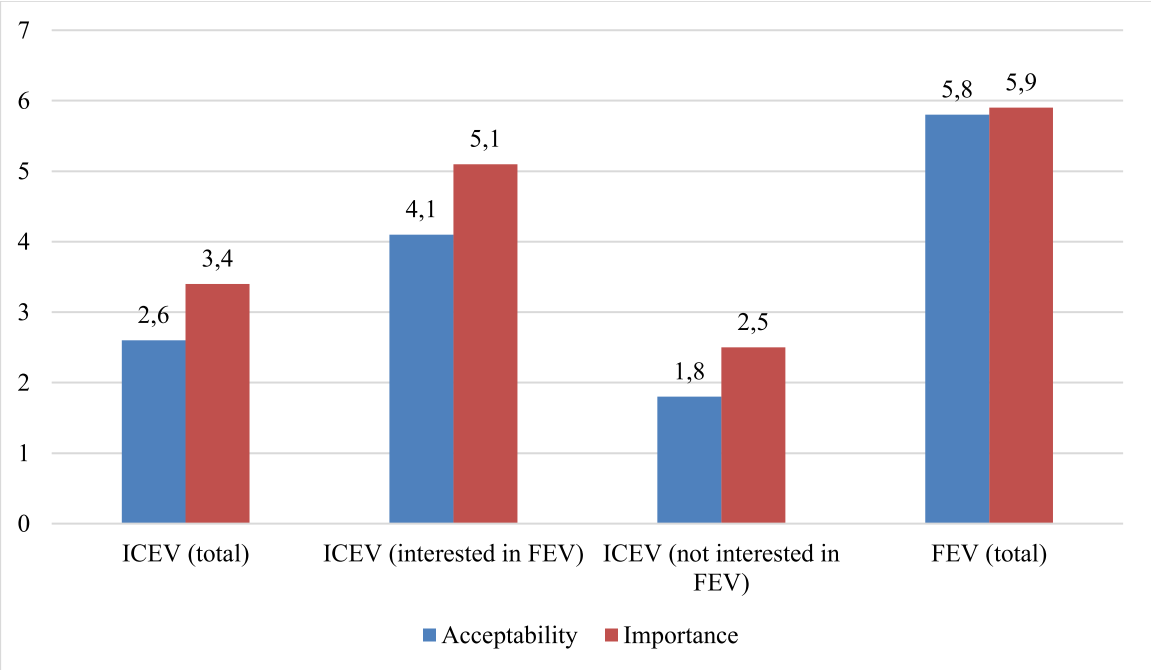


Figure 1: rated acceptability and importance of the voluntary agreement

Results on the attitude towards the instrumental and financial attributes of the vehicle show no considerable distinction between ICEV and FEV drivers concerning purchase price and range (figure 1). Interestingly, FEV drivers do not have a considerable different perception from ICEV drivers when it comes to purchase price and range, although ICEV drivers with an interest in purchasing a FEV evaluate the purchase slightly better than current FEV drivers.

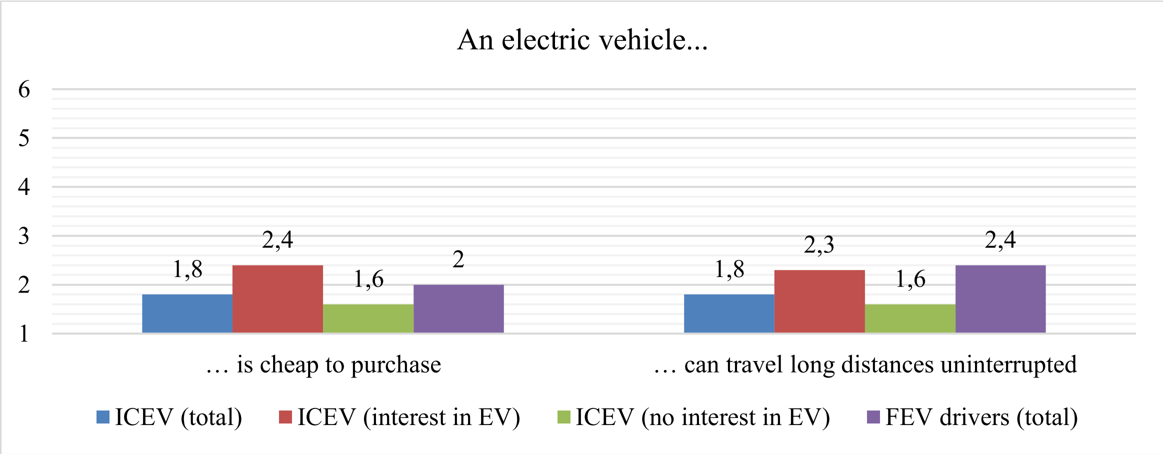


Figure 2: attitude towards FEV range and purchase price ranked on a 6 point scale (1 = ‘’totally disagree’’ … 6 = ‘’totally agree’’)

While this could indicate that an increase in range would also increase FEV uptake, we hypothesize that misperceptions may also play a role, wherein the range of the FEV is deemed as insufficient while actually meeting the needs of the driver.

## 4.4 Charging facilities to counter range anxiety

In order to counter possible range anxiety, the municipality of Amsterdam is developing a dense public charging infrastructure, where fast charging hubs accommodate the taxi sector’s most urgent needs for rapid charging in between local rides. Even on certain taxi stands fast chargers allow taxi drivers to charge right before picking up passengers. Complementary to the fast charging infrastructure, taxi drivers can apply for a charging permit that allows them to park at any public parking spot with a public charging point in the inner city for 30 minutes for free, provided that they are using the charger to charge their car.

Results show the call for more fast chargers (figures 3 and 4), whereby parking exemptions at regular public charging stations prove less attractive (figure 5).

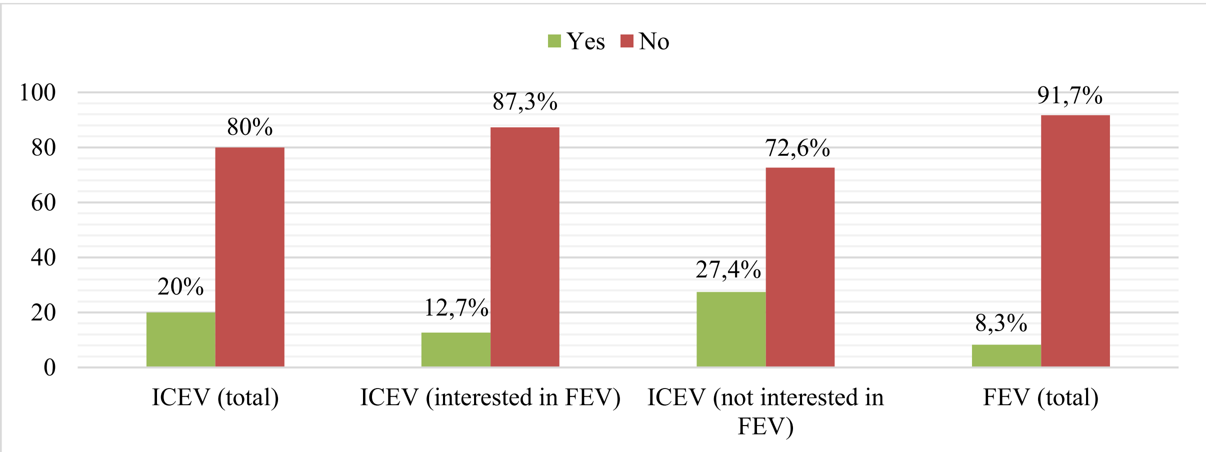


Figure 3: response to the question: ‘’are there enough fast chargers?’’ (answers displayed in percentages).

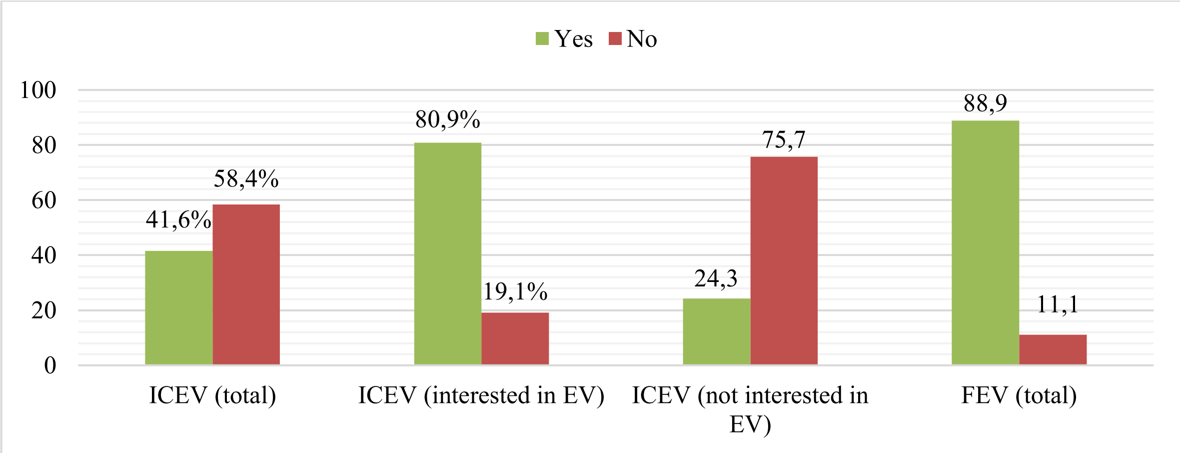


Figure 4: response to the question: ''would you purchase an electric taxi faster if there were more fast chargers?'' (answers displayed in percentages).

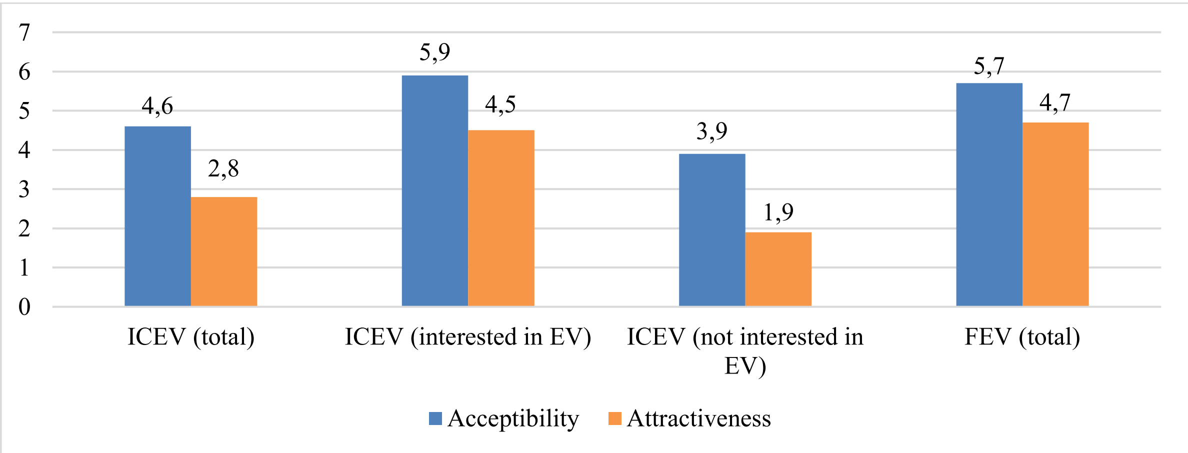


Figure 5: acceptability and attractiveness ratings of the parking license incentive on a 7 point scale (1 very unacceptable/very unattractive … 7 very acceptable/very attractive)

As shown in figures 3 and 4, more than half of the total group of ICEV drivers indicated that additional fast charging infrastructure would not make FEV purchase more attractive, even though 80% of all ICEV respondents claim that the current amount of fast chargers is insufficient. 80,9% of ICEV drivers interested in a FEV reported that the placement of more fast charging would make the purchase a FEV faster. Although this is not a direct guarantee, it does provide a powerful signal of the importance of charging infrastructure availability as an important condition for purchasing EVs.

Almost all of the FEV respondents acknowledge that additional fast chargers make FEV purchase more attractive, which could mean that additional fast chargers might be a way to secure the current group of FEV drivers to continue driving FEVs when they require a new vehicle. Figure 5 shows the acceptability and attractiveness of the parking license, which indicates that ICEV drivers find the parking incentive considerably less attractive than FEV drivers, with the exception of the ICEV drivers interested in purchasing a FEV.

The desire for more fast charging opportunities can stem from the dissatisfaction with current fast charging availability. The desire for more fast chargers by FEV drivers could indicate that current fast charging hubs specifically designed for taxis are easily crowded during certain peak hours of the day. More range could equal less frequent charging and thus less competition for a time slot at a fast charging hub. Likewise, ICEV drivers might be unfamiliar with charging practices or perceive charging at charging hubs placed outside the regular pathways to taxi stands as an unnecessary detour, even though the need for (fast) charging might arise only once a day and can be strategically planned to avoid peak hours at the hubs.

## 4.5 FEV in the lead

Even though the dissatisfaction with the range of FEVs is present amongst both ICEV and FEV drivers, ride frequency and ride length reveal both an interesting difference as well as a similarity. If we analyze the average amount of rides per week and the average length per ride however, we see that FEV drivers have just as many rides per week as ICEV drivers, but exceed ICEV drivers in ride length by almost 50% on average (16,77km/ride versus 11,14 km/ride). Table 3 shows the absolute numbers.[3]

Table 3: average rides per week and length per ride

| Vehicle Type | N | Average rides per week | Average km per ride |
|---|---|---|---|
| **ICEV (total)** | 198 | 39,33 (SD = 18,32) | 11,14 (SD = 6,32) |
| **ICEV (interested in FEV)** | 52 | 41,11 (SD = 17,57) | 12,65 (SD = 6,71) |
| **ICEV (not interested in FEV)** | 117 | 38,68 (SD = 19,01) | 10,56 (SD = 6,34) |
| **FEV (total)** | 31 | 39,42 (SD = 16,06) | 16,77 (SD = 3,77) |

The similarity in average rides per week but the difference in average kilometers per ride counters the notion often voiced in interviews by ICEV drivers that FEV drivers have to decline rides from passengers asking for a trip that exceeds the vehicles battery range. The data also shows that ICEV drivers interested in a FEV have slightly more and longer rides than their ICEV colleagues not interested in a FEV. Results from the survey do not provide an explanation for this difference between the two groups.

Using these averages, the results tell us that a FEV taxi drives, on average, about 95 kilometers with passengers a day. Assuming that FEV taxi drivers return to their preferred taxi stand after dropping off their passengers, they drive approximately 190 kilometers per day. This is a range that will most likely be covered by both the latest and future FEV models without the need to charge in between rides, even by vehicles that arrive on the cheaper spectrum of the market.

Two plausible explanations can shed light on this difference in ride length in favor of FEVs. First, data shows that FEV drivers are much more likely to share their vehicle with another taxi driver (63,9%) than ICEV drivers (15,7%). [4] This means these full electric taxi vehicles are most likely used more hours of the day, as drivers change shifts to accommodate the passenger peaks on different taxi stands throughout the day. This cooperation between different drivers driving the same vehicle can also be an effective measure to counter the relative high purchase or lease costs associated with FEVS.

Second, all of the FEV respondents indicated to be active at the Schiphol Airport taxi stand. Schiphol Airport is one of (greater) Amsterdam's largest local taxi stands and has recently become a FEV-only market. The so-called *Schiphol Concession* provides a privilege to FEVs by excluding any other type of vehicle from the regular local taxi stands. This means that airport passengers looking for a taxi ride will receive a ride in a FEV, resulting in possible benefits for the FEV drivers depending on the passengers destination. While other taxi stands, such as the taxi stand at Amsterdam Central Train Station, offer similar priority advantages to FEVs, it is likely that rides from the airport are often longer than inner city rides, with a destination outside of the greater Amsterdam area. The taxi stand market is currently the biggest market where taxi drivers operate, with appointment based requests, hotel transport and airport transport coming in as second, third and fourth largest markets respectively.

[3] To improve reliability, reported outliers for either rides per week or kilometers per ride have been excluded from all results shown in table 3.
[4] Although FEV drivers consist of only a small group of respondents, we believe it is important to highlight the high percentage of shared FEV taxis as an indication of a new taxi ownership construction to counter purchase/lease costs as a barrier.

Average rides and kilometers per week thus is caused by amongst others specific travel behavior, pick up spots but also ownership and vehicle sharing constructions. The taxi sector is fragmented in particular segments, which is likely to influence the frequency of rides and kilometers driven. FEV taxi drivers thus make use of the markets that demand FEV taxis created by the municipality. Whether or not an exclusive FEV market would make the purchase of a FEV more attractive was tested among all respondents. Respondents were asked whether they would find an increase in FEV taxi demand (source of the demand not specified) acceptable and whether an increase in FEV taxi demand would make the purchase of a FEV more attractive.

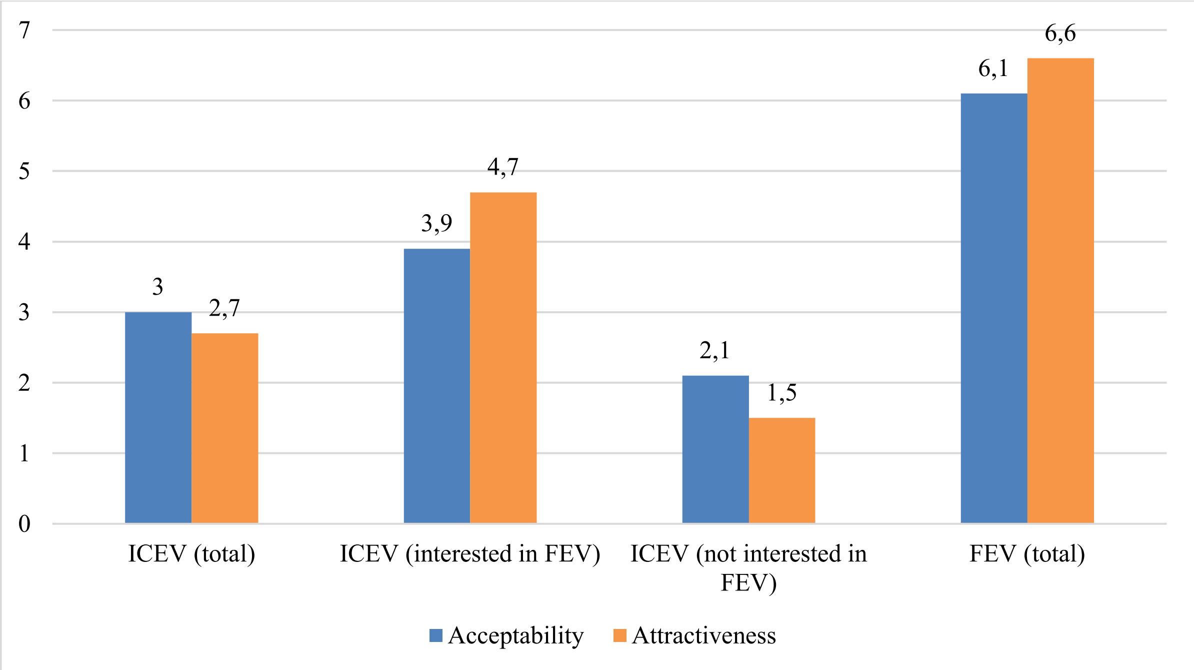


Figure 6: acceptability and attractiveness ratings of increasing FEV taxi demand on a 7 point scale (1 = very unacceptable/very unattractive … 7 = very acceptable/very attractive)

Results show that increasing FEV taxi demand in Amsterdam would only prove mildly attractive to ICEV drivers interested in a FEV and would not be an attractive measure for ICEV drivers currently not interested in a FEV. Only current FEV drivers rate an increase in FEV taxi demand as an acceptable incentive.

# 5 Conclusion

This paper shows results of a survey amongst taxi drivers in the city of Amsterdam that are confronted with incentive measures to stimulate the sector to switch to electric.

Results show that ICEV drivers interested in purchasing a FEV were (compared to ICEV drivers not interested in purchasing a FEV), more positive about the voluntary agreement, although not as positive as current FEV drivers. These FEV-interested ICEV drivers were also slightly more optimistic on the purchase price and range of current FEV vehicles, although both attributes still had low average scores. The need for expanding fast charging infrastructure could provide a powerful incentive to further incentivize this particular group of ICEV drivers. Additionally, ICEV drivers interested in purchasing a FEV taxi found increasing electric taxi demand only mildly attractive.

Similarly, the results signal that FEV drivers are content with the voluntary agreement but dissatisfied with the current amount of fast chargers provided by the municipality. Expanding the fast charging infrastructure would thus not only incentivize drivers interested in purchasing a FEV but also facilitate the current early adopter group. A positive evaluation of availability of charging infrastructure by FEV taxi drivers may also spread to ICEV-taxi drivers, where word of mouth is likely to play an important role in convincing ICEV drivers to make the switch to electric.

These results are interesting as a specific mobility sector is targeted with certain incentives, and this case shows how policy makers can create a broad set of measures that aim at technological change among a group that is difficult to reach. Charging infrastructure can simultaneously facilitate current FEV drivers while also incentivizing the ‘early majority’ currently still driving ICEVs. While dissatisfaction in relation to purchase price and battery range exist amongst those driving FEVs and those not driving FEVs, data shows that despite this dissatisfaction and the wish for a denser (fast) charging infrastructure, a significant group of taxi drivers (10-15%) has already made the switch to FEVs, leading to new ownership constructions and market opportunities. Despite the presence of two traditional operational barriers (e.g. price and range), a small group of taxi drivers has thus switched to FEVs within the regulative context, resulting in access to FEV-exclusive markets, such as Schiphol Airport.

This paper shows the important enabling role of technological developments to make electric-taxis a legitimate alternative, and that incentive programmes should not be viewed and assessed in isolation, but placed in context together with user experiences and perceptions, as well as technological developments. While further research is necessary to determine the role of misperceptions in FEV taxi purchase, results suggest that information on current FEV models and their functional attributes, such as price and range, is not always up to date. Furthermore, it can be difficult for ICEV drivers to assess their satisfaction and knowledge of unfamiliar topics, such as the density of the public charging network. Misperceptions can thus be easily created by skewed knowledge. It is expected that the upcoming FEV models with lower purchase costs and larger range will remove the two main barriers for FEV adoption amongst Amsterdam based taxi drivers. Further research will be conducted to assess if the attitude towards functional attributes will change over time as the EV market develops.

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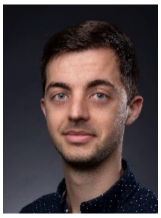


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