

From Early Adoption to Mainstream Acceptance: A Case Study on the Distribution of Electric Vehicles in Sweden (2016-2020)

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Executive Summary

In this study, we investigate the growth of EV ownership among Swedish households. Through detailed socio-economic data and the Swedish vehicle register, we are able to compare characteristics of households that had bought an EV in 2016 with those that became EV owners by 2020. We are thus able to describe and analyse the transition from the early EV owners to the early majority. The analysis is done in two steps: first, a descriptive analysis is done of the differences in the households between the two comparison years. Second, a regression model is used to find changes in explanatory factors. The results show that the demand for EVs has reached new consumer groups, e.g. both younger and older car buyers, and will be of use for further analyses of policy measures to support increased EV demand and vehicle fleet forecasting.

Keywords: EV, market development, passenger car, households, leasing

1 Introduction

In recent years, sales of rechargeable cars have increased rapidly in large parts of the world. However, we know little about the distribution of electric car (EV) ownership among different household groups. In this study, using data from Sweden to gain insight into the growing market for EVs, we examine who early EV buyers in 2016 were, and how the market has developed into 2020.

The private individuals who have opted for a rechargeable vehicle early on are often described as ‘early adopters’ in the literature; they are characterized as being interested in technology, climate/the environment, and as having the financial means to be able to be the first to try out new technologies. However, such people constitute a very limited customer group, and the question is which households will be next in line as the market for rechargeable vehicles broadens and an ever-greater share of the new cars sold are rechargeable. Our knowledge in terms of which households in Sweden were early adopters of rechargeable cars and which will come onboard in the next few years has been limited.

To gain a better understanding of which households have chosen a rechargeable car, in this report we have looked into which households opted to purchase or privately lease a rechargeable car, comparing the years 2016 and 2020. We have done so by proceeding based on Statistics Sweden’s household data, which we have cross-referenced against the vehicle register. This means that we have obtained a fairly comprehensive idea of the conditions and assumptions affecting households in terms of their choosing a rechargeable car, and which households have in fact done so. One of the main goals of our analysis is to identify and describe the conditions and factors that clarify which households have chosen a rechargeable car. The analysis thus contributes to the current state of our knowledge, which derives mainly from various types of questionnaire or interview studies based on forecasts rather than results, and with limited samples. Nor have we been able to find any other study that has taken different forms of ownership, such as private leasing, into account.

Sweden is currently far ahead of most other countries in EV sales. This makes Sweden a suitable case for increasing the understanding of how EV ownership spreads through different socio-economic household

groups. The study will, therefore, be useful for understanding how EV ownership might spread throughout other parts of the world.

By comparing EV-owning households in 2016 and 2020 we explore which households have become EV owners in those four years, and those which still have not chosen an EV. Previous studies, dominated by stated preference studies, have shown that individuals who live in houses, have more than one car in the household, and who are both highly educated and have an income above average, would be more likely to purchase an electric vehicle [3, 4, 7].

1.1 Aim of the study

The purpose of the report is to contribute to our understanding of which explanatory factors serve as the grounds for the purchasing or leasing of rechargeable cars by private individuals. This effort is expected to contribute to a greater knowledge of the distribution of rechargeable cars within various socio-economic groups, and to make it possible to roughly estimate the pace at which such vehicles are spreading to new socio-economic groups.

- A number of questions and hypotheses have been set forth to enable this analysis to achieve and accord with its purpose. The report will address the following questions:
- Are there any differences between those households that have chosen a rechargeable car and those that have chosen a non-rechargeable car?
- Did any such differences change from 2016 to 2020?
- Are there any differences between households that lease and those that buy a rechargeable car?
- Are there any differences between the households that have newly registered an electric hybrid versus a plug-in hybrid?
- Does access to public charging infrastructure affect the likelihood that one will choose a rechargeable car?

Using data from 2016 and 2020, we have analysed any changes in the importance of the explanatory factors over time. Our choice of the years to study was determined largely by our access to data. Very few private individuals had purchased a rechargeable car prior to 2016, making it meaningless to try to go any further back in time. There is at the same time a limit on how current the data we can use are, as the household data published by Statistics Sweden is subject to a time lag of almost a year and a half. Data from 2020 were thus the most current data available at the start of this study.

1.2 Previous literature

The scientific literature regarding factors that influence rechargeable car ownership is, for obvious reasons, relatively recent. The majority of the studies have been published since 2010.¹ In particular, the older literature includes other types of ‘environmentally friendly’ cars, such as ethanol or compressed natural gas vehicles. The literature often divides influential factors into a number of larger categories, i.e. socio-economic, demographic and geographic, fuel type, offering and capacity, EV performance, interests and influence.

As a rule, the studies comprise from several hundred to a few thousand respondents, which is why the results are usually reported for a single country, or for the specific area being studied. There appear to be few studies that are based on rather more extensive data material, and most of those we found were based on questionnaires or interviews. One exception is the study by Trosvik and Egnér,[3] which is based on the number of EVs newly registered in Swedish municipalities from 2010 to 2016.

In our review we have found few studies [1, 5] with a particular focus on finding ‘early adopters’, i.e. those individuals who are interested in new technologies and willing to opt for an electric vehicle early on. Plötz et al. [5] studied early electric vehicle purchasers in Germany and found that they consist mainly of men aged

¹ The literature survey has been limited to published scientific articles. The search strings used are ‘socio economics electric vehicles’ and ‘determinants electric vehicles. In some cases, these articles have referenced other articles, which we have also chosen to subsequently obtain. Because a certain selection process has occurred, this compilation is not be viewed as a complete list for the entire research field.

40–50 who live in a house with multiple family members, enjoy a high financial standard of living, and are looking for a more environmentally friendly car.

In our review of the earlier research we found a number of factors of differing significance in different studies, as other studies have also noted. For example, Christidis and Focas[2] indicate that there is no proper consensus within the literature as to which factors are important.

In summary, it may be noted that much of the earlier research is based on different types of questionnaire or interview studies, with relatively few studies being based on any extensive data sets. The data to which we have had access has provided for different conditions and assumptions in terms of our study design. Combined with the difficulties in finding consensus in the literature, this means that our results may deviate from those in earlier studies. However, it is clear from the literature review that factors such as housing type, income, gender, education and family size are significant with regard to the likelihood that one will procure a rechargeable car.

2 Data and method

Sweden's official vehicle statistics is used to analyse how vehicle ownership varies across the country, in terms of both number and form of ownership. By matching vehicle data (4.5 million vehicles including 300,000 EVs) with data on Swedish households (4 million), we can link car ownership with several socio-economic factors. These were in turn linked to small geographical areas (DeSO)² making it possible for us to conduct regression analyses with a high level of geographical detail and to test which variables affect buying cars in Sweden in 2016 and 2020.

In 2016, sales of plug-in hybrids had quite recently accelerated, although relatively few electric cars were being sold. Rechargeable cars accounted for 5% of sales in 2016, and collectively there were ca. 7,500 EVs and almost 19,000 plug-in hybrids in use by the end of 2016. The households that chose to purchase a rechargeable car in 2016 are thus to be viewed as early EV purchasers who opted to invest in a relatively new and unproven technology. The number of EVs in use had risen to nearly 56,000 by 2020, with plug-in hybrids totalling 122,000. Collectively they accounted for 31% of the cars newly registered that year. Early studies have also shown that leasing a car privately became significantly more common in 2020 [6].

Comparing 2016 to 2020, we can thus capture the shift from when only a few people chose a rechargeable car to a point in time when doing so was about as common as choosing one powered by petrol or diesel. Our choice in terms of the years to study also enabled us to capture the transition from a year when leasing rechargeable cars was uncommon to a year in which it became a relatively common form of ownership. The range of available rechargeable car models broadened markedly between 2016 and 2020, and the difference in relative price between a rechargeable car and a non-rechargeable one in all likelihood changed. However, vehicle characteristics and changes to them during the studied period fall outside of the scope of this study, and we have not had the means of including this type of information in our analysis.

The analysis is done in two steps. First, a descriptive analysis of the actual changes in which households became EV owners between the years 2016 and 2020 is carried out. In the second step, a regression analysis is carried out to determine changes in explanatory factors between the two comparison years. Five logistic regression models were estimated over a two-year period (2016–2020). The first model aimed to identify factors that determine the registration of new vehicles, without taking into consideration the type of fuel used. The sample consisted of all Swedish households. The subsequent four models used only the subset of households that had registered a vehicle in the first model, in order to distinguish between factors that are important for the purchasing and leasing of electric cars and plug-in hybrids in comparison to other vehicles.

Model 1: Which factors explain that a household has registered (purchase and lease) a car during the year, regardless of fuel type?

Model 2: Given that a household has bought a vehicle during the year (i.e., a subset of the vehicles that were registered in Model 1), what factors explain the household buying an electric car?

Model 3: Given that a household has bought a vehicle during the year (i.e., a subset of the vehicles that were registered in Model 1), what factors explain the household buying a plug-in hybrid?

² DeSO is a demographic breakdown that divides Sweden into 5,984 areas with between 700 and 2,700 inhabitants.

Model 4: Given that a household has leased a vehicle during the year (i.e., a subset of the vehicles that were registered in Model 1), what factors explain the household leasing an electric car?

Model 5: Given that a household has leased a vehicle during the year (i.e., a subset of the vehicles that were registered in Model 1), what factors explain the household leasing a plug-in-hybrid?

Based on data from the Swedish Energy Agency regarding public charging stations (>11 kW), we have also performed a simple analysis to determine whether any correlation exists between new registrations of rechargeable cars and local access to public charging infrastructure for various housing types.

3 Results

The results from the descriptive analysis are presented based on the six variables for which we have data at the household level, i.e. gender, age, income, housing type, household type, and household location.

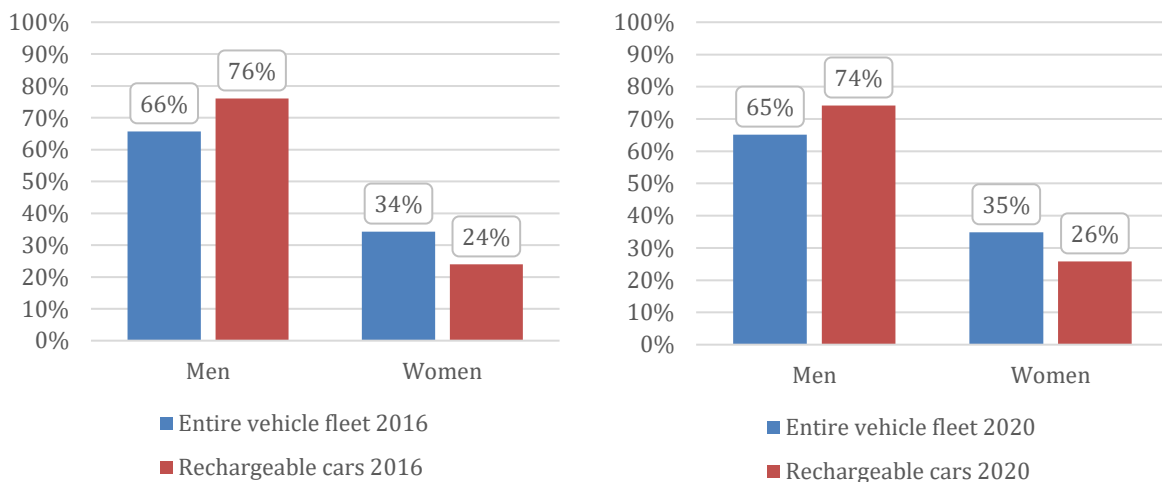


Figure 1 Privately owned passenger cars in use broken down by owner's gender, the entire fleet and rechargeable cars, 2016 and 2020.

Regardless of whether a car is rechargeable or not, it is most common for a man to be registered as its owner (Figure 1). The share of rechargeable cars registered to women increased somewhat from 2016 to 2020, primarily with respect to plug-in hybrids, where the difference between men and women approached the distribution pattern for the entire fleet, regardless of fuel type.

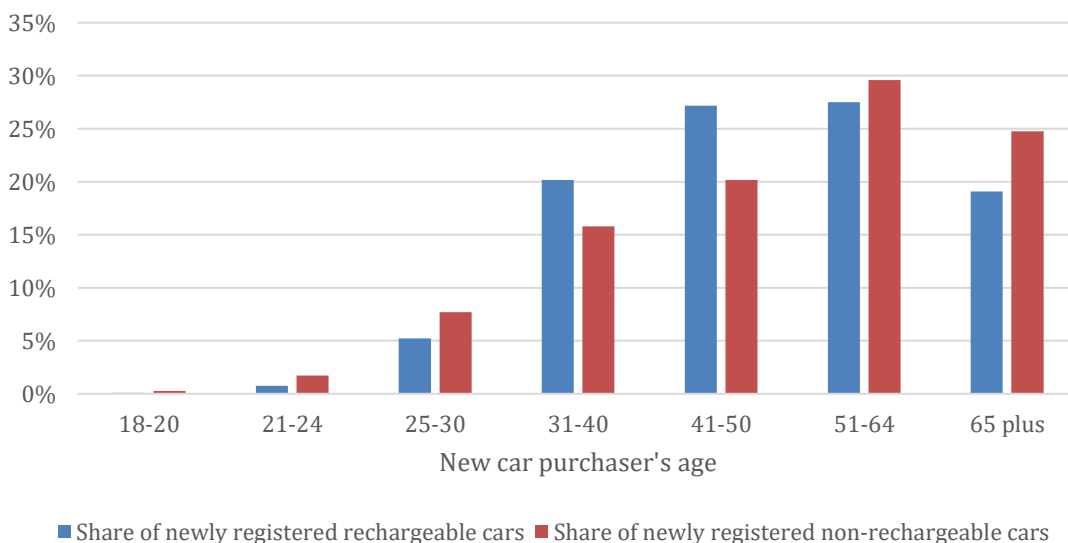


Figure 2 Share of newly registered cars broken down by purchaser's age, rechargeable cars and non-rechargeable cars, 2020.

Car purchases correlate strongly with age (Figure 2). Younger people generally own a relatively small share of the Swedish vehicle fleet, and account for a low share of newly registered cars. Purchasing a car becomes increasingly common with increasing age, at least up until retirement age. Peak car ownership is found in the 50–64 age group, after which car ownership declines among those over 65.

There are a number of differences if we consider those who newly register rechargeable versus non-rechargeable cars. People between the ages of 31–40 and 41–50 account for a significantly greater share of newly registered rechargeable cars than non-rechargeable cars. We can thus state that rechargeable cars have a younger customer group than non-rechargeable cars. People under the age of 30 register new cars to only a limited extent, but in those cases where they do there is somewhat of a preponderance of non-rechargeable cars.

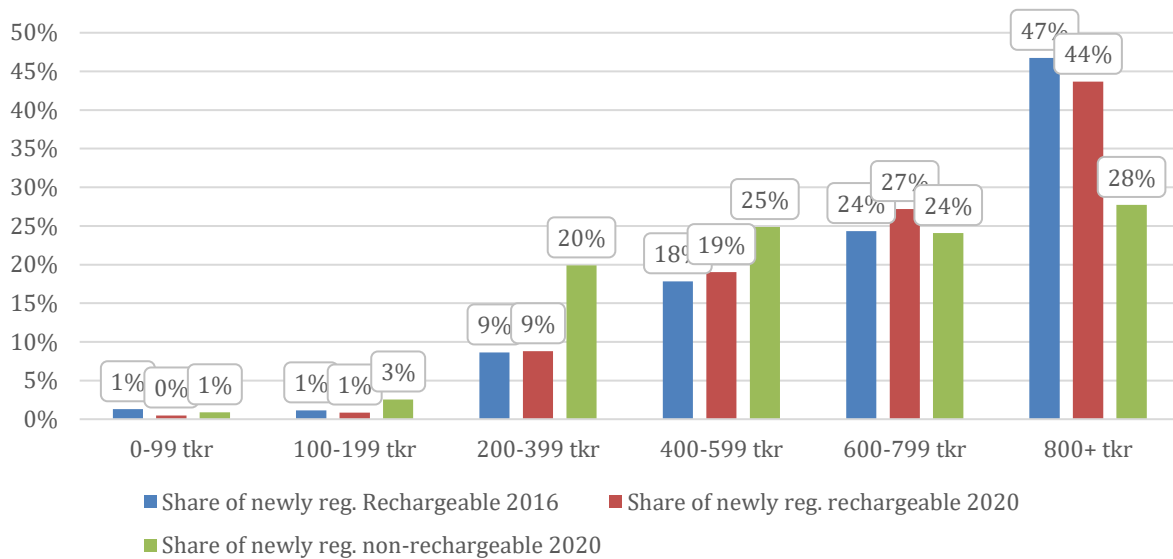


Figure 3 Breakdown of newly registered passenger cars, rechargeable and non-rechargeable, 2016 and 2020³.

Low-income households very seldom purchase a new car, and this pattern is even clearer for rechargeable cars (Figure 3). We have been able to determine that households in the highest income group accounted for nearly half of all newly registered rechargeable cars in 2020. These results are not particularly surprising. A car is often a household's second-largest expense after housing and given a low income it is difficult to finance a new car. Rechargeable cars have still not achieved price parity with non-rechargeable cars, with the result that they are more expensive and thus more difficult for a low-income household to finance.

³ Tkr=thousand kronor, 1 Euro~11 kronor

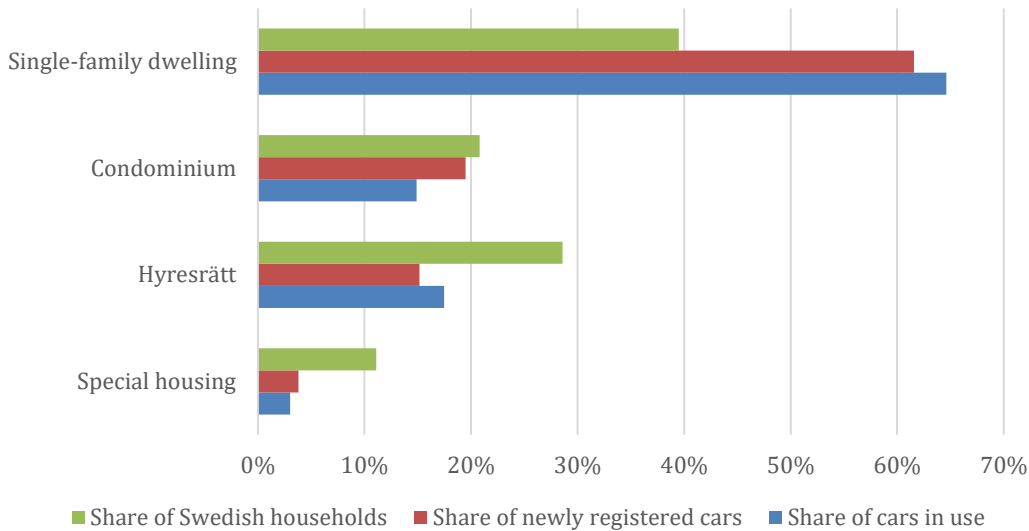


Figure 4 Breakdown of Swedish households by housing type and shares of newly registered cars and cars in use, 2020.

Just over 40% of Swedish households live in a single-family dwelling, but they accounted for 65% of all newly registered passenger cars in 2020 (Figure 4). A single-family dwelling is thus the most common housing type for households that registered a new car. Households living in special housing⁴ had the lowest share of newly registered cars in relation to how many have this type of housing.

The pattern is even clearer for rechargeable cars (Figure 5). Three out of four rechargeable cars newly registered by a private individual in 2020 were registered to a household living in a single-family dwelling. It was significantly more common for residents in condominiums to choose a rechargeable car compared to those living in a rented flat.

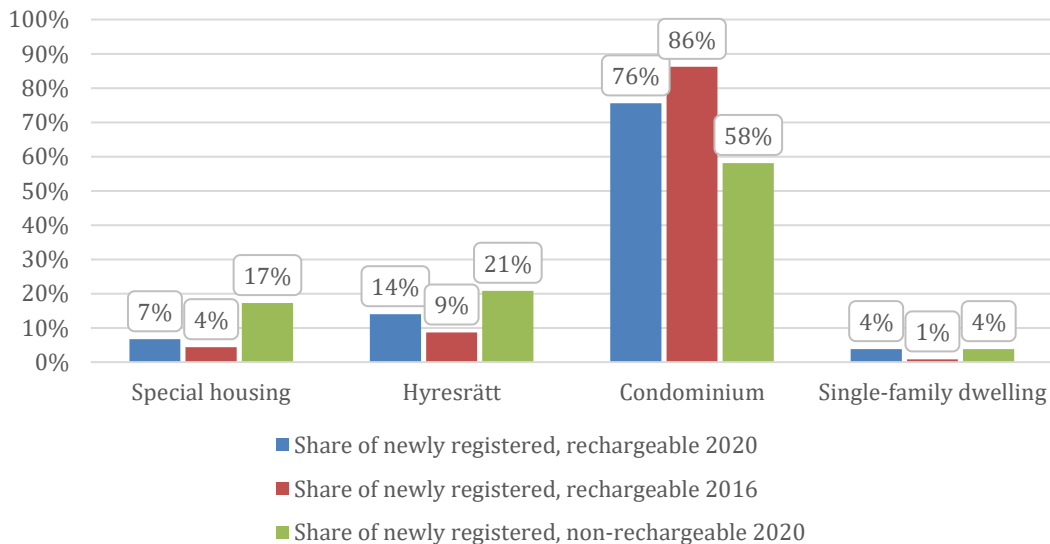


Figure 5 Share of newly registered rechargeable and non-rechargeable passenger cars broken down by housing type, 2016 and 2020.

Households comprising cohabitants, with or without children, are the most common new car purchasers (Figure 6). Single people without children also accounted for a significant share of the cars newly registered in 2020. Nearly half of all rechargeable cars registered in 2020 were owned by cohabitants with children under the age of 24.

⁴ Special housing consists of housing adapted for a specific group, such as student housing or a retirement home.

The majority of rechargeable cars registered to cohabitants with children under the age of 24 were leased privately. The highest share of private leasing, regardless of whether or not the car was rechargeable, was found among single people with children under the age of 24.

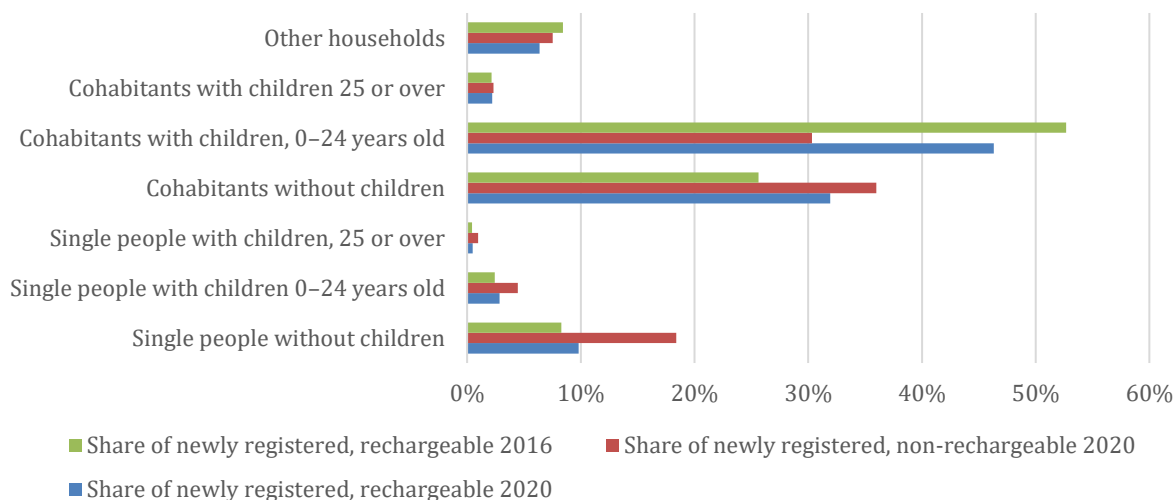


Figure 6 Shares of the total number of newly registered cars, broken down by rechargeable and non-rechargeable passenger cars and household type, 2020.

In brief, the results from the regression analyses show that the market for both EVs and plug-in hybrids grew between 2016 and 2020. Our focus is on finding the explanatory factors that increase or decrease the likelihood of purchasing or leasing an EV or a plug-in hybrid as opposed to a car that runs on a conventional fuel.

Signs appeared in 2020 indicating that the market for rechargeable passenger cars is starting to resemble the passenger car market in general. The market for plug-in hybrids is most similar, while the typical EV buyer has a more distinctly different profile. Factors such as higher income, living in a detached house or condominium, and households with a preponderance of men correlate positively with the purchasing and leasing of both EVs and plug-in hybrids. One factor specific to EV households is that they are located in areas with a relatively highly educated population, among whom Swedish backgrounds are commonly present. These households are largely confined to metropolitan municipalities, although not to the administrative centres. Both those households that purchase and those that buy an EV often have another car from before. There is also a tendency for the household car owners to be somewhat younger compared to car owners in households that buy or lease plug-in hybrids, and for EVs to be more popular than plug-in hybrids among the households of single people.

The analysis of charging infrastructure and the inclination to choose a rechargeable car indicates that, as access to public recharging stations increased, there was a somewhat greater likelihood of procuring a rechargeable vehicle in 2020 among residents of condominiums compared to other types of housing. The results thus indicate that access to public charging infrastructure is important in terms of introducing rechargeable vehicles in urban areas. Public charging infrastructure is not as important to households living in single-family dwellings, as they can recharge their cars at home. The negative correlation for rented flats may be explained in that such households generally tend to newly register rechargeable vehicles to a lesser extent. There was no significant correlation for 2016. Nor were any major changes in the results observed when only households with an income in excess of SEK 600,000 were included.

4 Discussion

It is clear that the market for rechargeable vehicles grew between the two studied years. In 2016, rechargeable cars were being procured by those individuals and households characterized in other studies as ‘early adopters’, i.e. knowledgeable and interested individuals and households with the financial means to make such a purchase. As the offering of available rechargeable vehicles grew, private leasing had, by 2020, become an option that many motorists could consider. However, there still appears to be some degree of

resistance to making the move to an EV. In such cases a plug-in hybrid can serve as an intermediate step as, for example, their driving characteristics are reminiscent of those of a fuel-powered car. Plug-in hybrids are also the very vehicles that are being newly registered in large numbers by households with similar characteristics (explanatory factors) that normally choose to register a petrol- or diesel-powered car. In other words, the differences between households that choose a plug-in hybrid and those that opt for a fuel-powered car are no longer as great.

Both the descriptive account regarding who is opting for rechargeable cars and the regression analysis in which explanatory factors are analysed offer clear indications that there are a number of significant factors that can shed light on new registrations of rechargeable vehicles. These factors also accord, to some extent, with those that have featured in earlier studies. The major deviation in relation to much of the earlier literature can be attributed to socio-economic factors having an impact on new registrations. Such factors have often played a less prominent role in earlier research, which rather gave precedence to attitudes and preferences, factors on which we have not focused in this report.

Even though there has been a trend towards smaller differences between households that choose a rechargeable car and those that choose a fuel-powered one, regional differences still persist, with larger urban areas, their neighbouring municipalities and major population centres clearly predominating. The big breakthrough has not yet occurred in other parts of Sweden. The fact that the introduction of rechargeable vehicles is proceeding somewhat more slowly in rural areas may seem counterintuitive, as the means available for recharging the vehicle at home are likely greater than in the cities. One possible explanation could be that a sufficiently built-out public charging infrastructure is still needed in these areas, so that a rechargeable car is not exclusively one that is limited to trips in the immediate vicinity. Moreover, fewer new cars are sold in rural areas than in urban areas in general. Given that per capita vehicle ownership is also somewhat higher in rural areas and the populations there are somewhat older, it will likely take longer to transition the vehicle fleet in the areas outside of the bigger cities. One possible explanation for why the use of rechargeable cars is increasing more rapidly in and around cities than in rural areas is that the influence exerted by other people in one's surroundings based on their experiences with rechargeable car use is greater in more urban areas.

There has thus occurred a significant normalization and proliferation of rechargeable cars, and primarily plug-in hybrids, which are to an ever-greater extent being chosen by similar households that would normally opt for a non-rechargeable vehicle. However, the situation is different for EVs, which appear to have a more niche market and are often used as a household's second car. However, our data extend only to 2020, and the market changed in 2021 and 2022, with the result that more EVs than plug-in hybrids are being sold. Given that households are adapting to EVs at the same pace as they did to plug-in hybrids, EVs should be exhibiting roughly the same consumption patterns as cars using the other means of propulsion by 2025.

5 Conclusions

In this study we have found that the market for rechargeable cars grew significantly between 2016 and 2020, with plug-in hybrids becoming more similar to non-rechargeable cars. One notable change was the broader distribution of rechargeable car ownership among various socio-economic groups. In 2016, over 50% of all newly registered rechargeable cars were owned by households with an income over SEK 800,000/year, but this share had dropped to 44% by 2020. The share of rechargeable cars newly registered in the SEK 400,000 to 800,000/year income groups had increased. In terms of housing, the majority of all passenger cars, whether rechargeable or not, were registered by households living in single-family dwellings. However, this share had fallen from 86% in 2016 to 76% in 2020, with an increasing number of rechargeable cars being registered by residents of multi-family dwellings.

The report also highlighted differences in purchasing behavior between private leasing and purchasing. Private leasing is more common for rechargeable cars than for non-rechargeable ones, and it is more prevalent among younger people and households with children. The share of private leasing is highest between the ages of 25 and 30 and lowest for those 65 and over. Residents of multi-family dwellings are also more likely to choose private leasing.

Regarding charging infrastructure, the report found a positive correlation between the number of public charging stations and the likelihood of choosing a rechargeable car, particularly for those living in multi-family dwellings. This suggests that access to public charging infrastructure is important for those households

that do not have the same ability to arrange their own means of recharging their cars as those who reside in single-family dwellings. However, further research is needed to fully understand the importance of charging infrastructure.

With respect to countries which currently have rechargeable car sales on a par with Sweden's level in 2016, the results of our study may offer some guidance in terms of spreading such vehicles out into new customer groups. It is clear that the initial purchasers of rechargeable cars are prosperous, high-income consumers who live in single-family dwellings. However, we have been able to show that, in just four years, the market for rechargeable cars came, by and large, to resemble the new car market in general. It is still prosperous households that are opting for new cars, which means that the customer group for new rechargeable cars will also be limited, assuming that such vehicles do not become significantly less expensive than current non-rechargeable cars. This should also mean that private leasing will play an important role in the introduction of EVs to younger households with more modest incomes.

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Presenter Biographies



Mikael Levin works as a Senior Adviser at the governmental agency Transport Analysis in Sweden. Levin works mainly on evaluating Swedish transport policy and the vehicle market in Sweden and has been working on forecasting the Swedish road vehicle fleet since 2016. Levin has a PhD in Social Science from Umeå University.



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Björn Tano works as a Statistician at Transport Analysis. Tano works with data mining, statistical analyses, data processing, data extractions, and data visualization of transport statistics. Tano has a BSc in Statistics from Örebro University.