# Preferences for Alternative Fuel Vehicles of Lease Car Drivers in The Netherlands

Mark J. Koetse*, Anco Hoen

PBL Netherlands Environmental Assessment Agency, The Hague, The Netherlands

**Abstract**

In this paper we aim to get insight into preferences of Dutch lease car drivers for alternative fuel vehicles (AFVs) and their characteristics. Since AFVs are either not yet available on the market or have only very limited market shares, we have to rely on stated preference research. We perform a state-of-the-art conjoint analysis, based on data obtained through an online choice experiment among Dutch lease car drivers. Results show that under current tax regulations the average lease car driver is indifferent between the conventional technology, flexifuel and the hybrid car, while negative preferences exist for the plug-in hybrid, the electric and the fuel cell car. When current tax regulations would be abolished, strong negative preferences would result for all AFV's, and especially for the electric and fuel cell car. Increases in driving range, reductions in refuelling time, and reductions in additional detour time for reaching an appropriate fuel station, increase AFV preferences substantially. On average the gap between conventional technologies and AFVs remains large, however. We also find that there is considerable heterogeneity in preferences of lease car drivers, and that various market segments and potential early adopters can be identified. In this respect the most interesting finding is that preferences for electric and fuel cell cars decrease substantially, and willingness to pay for driving range increases substantially, when annual mileage increases. Annual mileage also has a substantial impact on sensitivity to monthly costs. We therefore use simulations to assess market shares of electric and fuel cell cars for different annual mileage categories. We find that people with a relatively low annual mileage are more likely to adopt than people with a relatively high annual mileage, regardless of driving range and monthly costs. For the fuel cell car we find similar results, although when driving range is high and cost differences are large, lease car drivers with a high annual mileage appear more likely to adopt a fuel cell car than those with a relatively low annual mileage.

*JEL-codes:* C25; C54; O33; Q54; R41
*Key words:* Car choice; Alternative fuel vehicles; Electric cars; Consumer preferences; Lease market; Choice experiment

* Corresponding author: E-mail: mark.koetse@gmail.com

## 1. Introduction

The Dutch government adopted the European goal to limit long term climate change to a maximum of 2 degrees compared to pre-industrial levels. To reach this goal $CO_2$ emission reductions of 80-95% are needed until 2050. The Dutch transport sector currently has a share of 20% in Dutch $CO_2$-emissions. Considering that approximately half of the transport $CO_2$-emissions can be attributed to passenger cars, this sector will have to contribute significantly to the long term climate goal. To that end alternative fuel vehicles (AFVs) such as battery electric vehicles, hydrogen cars and flexi-fuel cars are indispensable (Hoen et al., 2009).

In the Netherlands 40-50% of all new car sales each year is made up from company cars (Ecorys, 2011). These cars are generally used 3 to 4 years and then sold on the private second-hand car market. Company cars thus have a substantial impact on the composition of the Dutch car fleet and consequently on transport-related $CO_2$-emissions. Since the (structure of the) total cost of ownership for company car drivers is very different from that of drivers privately owned cars, car choice and preferences may differ largely between these two groups. Drivers of company cars are not confronted with high up-front investment and often do not directly pay for their fuel consumption. All costs are condensed in a single amount that the employer settles with the monthly salary of the employee. As a result the average company car in the Netherlands is larger (and heavier) than the average privately owned car and the share of diesel is higher. Company cars also drive around 50% more kilometres each year than privately owned cars (Ecorys, 2011). Policies aiming to mitigate $CO_2$-emissions from lease or company cars should therefore be specifically tailored towards this market segment, which requires specific information on AFV preferences of company car users.

In that light it is surprising to find that, where the literature on preferences of private car owners is extensive, studies on AFV preferences of lease car drivers are absent. Although in some papers lease car drivers might be included in the data sample, they are not identified and no separate analyses have been done in order to test whether private car owners and lease car drivers differ in terms of preferences. In this paper we aim to fill this gap. Since AFVs are either not yet available on the market or have only very limited market shares, we have to rely on stated preference research. Contingent valuation (CVM) has long been the most popular and widely used stated preference method. However, methodical advantages of conjoint analysis, accompanied by the development of specialised software and the use of the internet for obtaining questionnaire data, have made conjoint analysis the preferred method for doing stated preference research. We therefore perform a state-of-the-art conjoint analysis, based on data obtained through an online stated choice experiment among lease car drivers in The Netherlands. Our main goals are to obtain insight into the preferences of lease car drivers for AFVs and AFV characteristics, to uncover the background and car use characteristics that affect these preferences, and to identify potential early adopters.

The remainder of this paper is organised as follows. In Section 2 we give an overview of the relevant literature. Section 3 presents the design of the choice experiment, while Section 4 describes the process of data gathering and main data characteristics. Estimation results are presented in two separate sections. In Section 5 we present results from multinomial logit models, and compare results with those from a similar experiment for the private market in order to identify the main differences between these two markets. In Section 6 we estimate a mixed logit model to test robustness of the MNL results and to explore the heterogeneity in consumer preferences. In this section we also estimate a model with consumer background interactions in order to assess the main sources of preference heterogeneity, and to identify interesting market segmentations and potential early adopters. In Section 7 we look at interesting market segments more closely by performing market simulations. Section 8 concludes with a summary and discussion.

## 2. Overview of the literature

As mentioned in the introduction, studies on preferences for alternative fuel vehicles of lease car drivers are largely missing. Although in some papers lease car drivers might be included in the data sample, they are not identified and no separate analyses have been done in order to test whether private car owners and lease car drivers have different preferences for AFVs and AFV characteristics. A notable exception on the supply side is a study by Golob et al. (1997), who performed a choice experiment in 1994 among commercial fleet operators in California, USA. In the experiment each fleet operator was presented one choice task for each vehicle class present in their fleet. A distinction was made between 7 vehicle classes, i.e., cars, minivans, full size vans, compact pickups, full size pickups, small buses, medium duty trucks. For each vehicle class fleet operators were asked to imagine that they would have to replace their entire fleet and to allocate their budget over a set of three vehicle types (i.e., operators were asked to give proportions of each type). Each vehicle type was described by 8 characteristics/attributes, i.e., fuel type (gasoline, electric, compressed natural gas (CNG), methanol), vehicle capital cost, operating cost, range, refuelling time, fuel availability, cargo capacity, and emission levels. Given that there are four fuel types and operators had to allocate over three different vehicle types, three out of four fuel types were chosen randomly for each choice task. Ultimately responses from 2,023 different fleet sites representing 12 different sectors were obtained, giving 2,131 observations because in some fleets two vehicle classes were present. A multinomial logit model was used for estimations. The results show that gasoline is clearly the preferred fuel, *ceteris paribus*, implying that most fleet operators strongly prefer gasoline cars even when all other car characteristics are identical. Methanol is the most attractive alternative, most likely because it is a flexifuel vehicle, implying it also runs on gasoline. The CNG vehicle is not far off, while electric vehicles are clearly the least attractive alternative. However, sectoral variation in fuel type preferences of commercial fleet operators is large. For example, the agricultural sector has a stronger than average aversion against electric vehicles, while schools are almost indifferent between gasoline and electric cars. With respect to driving range the willingness-to-pay (WTP) of commercial fleet operators in terms of capital costs is approximately 83 US dollar per mile (52 US dollar per kilometre) for sectors that are not concerned with personnel transport. The coefficient for sectors concerned with transport of personnel is still statistically significant but substantially smaller, implying these sectors are less sensitive to (limited) driving range; the WTP is around 57 US dollar per mile (35 US dollar per kilometre). Off-site fuel availability was also found to be very important. The results suggest that, with gasoline station availability at 100%, for every 10 percentage point reduction in off-site fuel availability the WTP drops by approximately 8,000 US dollar, a rather extreme estimate in our opinion. Finally, $CO_2$ emissions appear to be of minor importance in commercial fleet composition choice.

Since insights into preferences of lease car drivers for AFVs are missing, an assessment of choice experiment studies among private car owners may give provide interesting information, e.g., on relevant AFV characteristics. For this we use and adapt the literature overview provided in Hoen and Koetse (2012). The choice experiment literature on AFV preferences of private car owners has been growing steadily since the beginning of the 1980s. Most studies use consumer samples from the USA, and within that subgroup most are from California, but many other countries are represented as well (see Table 1 in Hoen and Koetse, 2012). The fuel types included in each of the studies also varies widely (see Table 2 in Hoen and Koetse, 2012). All studies include a conventional vehicle and the full electric and hybrid electric vehicle were also included regularly. Interesting is that various studies include a general 'alternative fuel vehicle' category, i.e., without specifying which vehicle type is implied. In some studies the underlying reason is to focus on other attributes and to avoid vehicle-specific preferences from dominating the choices made by respondents. Finally, the sample of studies includes a wide variety of car characteristics, or car attributes (see Table 3 in Hoen and Koetse, 2012). With respect to the monetary attributes, purchase price and fuel costs are included in all but two studies, and operation and maintenance costs have been include frequently as well. Most studies include range, but fuel availability and refuelling/recharge time, which have also been recognized as potentially detrimental to AFV adoption, have been included in a relatively limited number of studies. In only one study all three attributes have been included (see Bunch et al., 1995). In almost half of the studies emissions or emission reduction have been included as an attribute, which makes sense since from a societal perspective it is one of the most beneficial features of alternative fuel vehicles. A final interesting attribute included in some studies is government incentives that aim to stimulate adoption of alternative fuel vehicles. Next to the obvious monetary tax incentives, interesting incentives are free parking, access to express lanes, and access to high-occupancy vehicle lanes.

Early studies already conclude that several characteristics of electric cars are very problematic, and more recent studies basically come to the same conclusion (e.g., Batley et al., 2004; Mau et al., 2008; Train, 2008; Hidrue et al., 2011). Especially the limited driving range of electric cars appears to be problematic. A related question is then to what extent increases in range would increase electric car preferences. In a meta-analysis on consumer willingness to pay for driving range, Dimitropoulos et al. (2011) show that estimates from the literature vary widely from 2 to 144 US Dollar per kilometre (2005 prices). They furthermore find that the willingness to pay per extra mile decreases when driving range increases, and that regional differences in WTP are large. The latter may reflect regional differences in taste, but more likely it is due to differences in spatial structure and car use. This observation suggests that it is difficult to compare WTP estimates between countries and regions without controlling for differences in car use, spatial structure and accessibility (of jobs, schools, etc).

Recharge time has not been included very often in choice experiments, but the available evidence suggests that long recharge time is an important barrier to consumer acceptance of electric cars (Beggs et al., 1981; Hidrue et al., 2011). Findings on the importance of fuel availability are somewhat mixed. Bunch et al. (1993) find that preferences are less sensitive to fuel availability when range and fuel costs of cars are comparable, although the drop in preferences is larger as fuel availability approaches lower levels. On the other hand, results by Horne et al. (2005) and Potoglou and Kanaroglou (2007) show that limited fuel availability has a strong negative effect on consumer preferences. Other recent studies show similar results (Batley et al., 2004; Mau et al., 2008). Train (2008) uses an alternative measure for fuel availability, i.e., extra one-way travel time to get to a station with the appropriate fuel. In the estimated models a dummy was included for an extra one-way travel time of 10 minutes (0 and 3 minutes being the reference category), which was found to have a negative effect. In conclusion, limited fuel availability likely has a strong negative effect on consumer preferences, but the evidence suggests that the effects are non-linear. The challenge is therefore to find the relevant ranges and cut-off points.

Results of several studies show that the emission level of an alternative fuel vehicle is an important attribute (see, e.g., Bunch et al., 1993; Ewing and Sarigöllü, 1998). However, most studies find very large estimates of willingness-to-pay for emission reduction (see, e.g., Potoglou and Kanaroglou, 2007; Batley et al., 2004; Hidrue et al., 2011). Since emission reduction predominantly affects social welfare and not individual welfare, these estimates are rather incredible. In our opinion these results are likely due to hypothetical bias, in this case probably due to respondents making socially desirable choices. Some supporting evidence is given in Caulfield et al. (2010), who find that $CO_2$ emission reductions are relevant but compared to fuel cost savings of relatively limited importance.

Finally, next to preferences for certain car characteristics, consumers may prefer specific cars just because of the car or the fuel type itself. The differences in study outcomes are large. For example, Ewing and Sarigöllü (1998) and Mabit and Fosgerau (2011) find (strong) preferences for electric vehicles over conventional cars, while Hidrue et al. (2011) and Hess et al. (2006) find the opposite. Differences between studies on this particular issue can be explained in various ways. For our purposes it is important to highlight the potential impact of differences in study design. For example, some studies include important fuel attributes, e.g., refuelling/recharge time and fuel availability, in their experiment, while in others these attributes are not included and their effects on preferences are therefore implicitly incorporated in the fuel type constants. In general, when important fuel or car type characteristics are not taken into account explicitly, the fuel-specific constants will pick up these effects.

To sum up we find that driving range, fuel availability and recharge times may have substantial effects on consumer preferences for AFVs. We have therefore included these attributes in our experiment (see next section). We also include various AFV types and not one 'general' AFV, because we are interested in AFV-specific preferences. Furthermore, willingness-to-pay estimates for emission reduction reported in the literature appear to be (substantially) biased, so caution is warranted when including an attribute on emission levels. Finally, substantial regional differences are found in stated preferences for AFVs and AFV characteristics, suggesting that transferring stated choice results from one country to another may lead to large over- or underestimation of preferences for AFVs and their characteristics.

## 3. Description of the choice experiment

In a choice experiment respondents are confronted with choices, often a number of them. Each choice, or choice task, consists of two or more options, and respondents are asked to indicate which of these options they prefer. The options are described by a number of characteristics, or attributes, and for each of these attributes various attribute levels are created so that people must make a trade-offs between the attribute values each time they are asked to make a choice. An efficient statistical design is generated such that sufficient variation in these trade-offs is available. Ultimately, assuming that a sufficient number of respondents is available, statistical models can be estimated, the results of which give insight into the relative impact of each attribute on consumer utility. By also including a monetary attribute, usually the price of good or a service, the relative value of each attribute can also be expressed in monetary terms.

Using a choice experiment to elicit stated preferences has a number of advantages over the contingent valuation method. First, the choices made in a choice experiment resemble reality more closely, because trade-offs are made continuously in reality. Second, in a contingent valuation study people are asked directly for the amount of money they would be willing to pay for a certain change in an attribute, an approach that has been criticised because it is prone to bias and highly sensitive to framing and anchoring effects. In a choice experiment the monetary aspect is an integral part of the trade-off, and willingness to pay is measured in a more indirect way, thereby substantially reducing the before mentioned risks. Finally, in a choice experiment much more information can be obtained from a single respondent than in a contingent valuation set-up in the same amount of time.

In the remainder of this section we describe the set-up of our choice experiment, i.e., the attributes and attribute levels used, the way in which choices were presented to the respondents, the statistical design used, and the changes made due to insights from pilots.

### 3.1 Attributes and levels

The attributes selected and used in the choice experiment are based on consultations with stakeholders and an extensive literature review. An important criterion for selection was that there was a marked difference between current cars and some or all AFVs. Another criterion was that the attribute is considered to be crucial for car choice, both from an expert opinion point of view as well as from the literature. We first included car type as an attribute, simply because we also want to get insight into preferences for AFVs apart from their attributes. We included eight other attributes, i.e., purchase or catalogue price, monthly contribution, tax percentage charge, range, charging time/refuelling time, additional detour time, number of available brands/models, and policy measure. In the remainder of this section we discuss these attributes and the associated levels in some more detail.

In order to reduce the risk of hypothetical bias in a choice experiment, it is essential that the choices faced by respondents are as close to reality as possible. Vehicle purchase or catalogue prices were therefore made respondent specific. Prior to the choice tasks respondents were asked what the price range of their next car would presumably be, for which they could select from a drop-down menu with 17 price categories (ranging from less than € 9,000 to more than € 100,000). For the conventional technology we took the bottom price of the selected category and, in order to add variation to the dataset we multiplied this figure by a random number generated from a uniform distribution between 0.9 and 1.1. The purchase price of an AFV was equal to the price of the conventional technology plus a design-dependent mark-up, using three different mark-up levels for each AFV. In addition, the mark-up of the electric vehicle was also dependent on the vehicle range since higher range requires a larger battery pack with higher associated costs. More specifically, three mark-ups were selected for a range of 140 km because for this particular range we were able to obtain reliable price information. Mark-ups for ranges other than 140 km were assumed to be proportional to the range/140 ratio. Table 1 gives an overview of the purchase price mark-up levels for each AFV used in the design.

Table 1. Mark-up levels for alternative-fuel vehicles

| Car type | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Hybrid | € 0 | € 2,000 | € 6,000 |
| Plug-in hybrid | € 0 | € 2,000 | € 7,000 |
| Fuel cell | € 1,000 | € 3,000 | € 10,000 |
| Electric | € 1,000 * (Range/140) | € 3,000 * (Range/140) | € 10,000 * (Range/140) |
| Flexifuel | € 500 | € 1,200 | € 3,000 |

A tax percentage charge is relevant whenever the user of a company car in the Netherlands drives more than 500 non-business kilometres a year. The height of this annual charge depends on the $CO_2$ efficiency of the vehicle (see Table 2).

Table 2. Annual tax percentage charges for different levels of $CO_2$ emissions (in grams) per car kilometre in The Netherlands

| Annual tax % charge | $CO_2$/km |
|---|---|
| 0% | Zero emission (electric and fuel cell cars) |
| 14% | <95g (<110g) $CO_2$/km for diesel (non-diesel) cars |
| 20% | >95g (>110g) and <116g (<140g) $CO_2$/km for diesel cars (non-diesel cars) |
| 25% | >116g (>140g) $CO_2$/km for diesel cars (non-diesel cars) |

Basically the system works as follows. The catalogue price is multiplied by the tax charge and regular annual income taxes (in most cases 42%) have to be paid over the resulting amount. For example, a purchase price of € 20,000 combined with a tax charge of 20% leads to a 42% * € 4,000 = € 1,680 in additional taxes. Table 3 presents the tax percentage charges used for each of the vehicles. Although a tax percentage charge of 7% does not exist at the moment in The Netherlands, it is in our opinion a logical level between the 14% and 0% levels.

Table 3. Tax percentage charges for each vehicle in the experiment

| Car type | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Petrol/diesel | 14% | 20% | 25% |
| Hybrid | 7% | 14% | 20% |
| Plug-in hybrid | 7% | 14% | 20% |
| Fuel cell | 0% | 7% | 14% |
| Flexifuel | 0% | 7% | 14% |
| Electric | 0% | 7% | 14% |

Employers sometimes also require the employee to pay a monthly contribution for use of the lease car. Typically the personal contribution is higher for more expensive and larger cars and lies somewhere between € 0 and € 400. We decided to adopt four levels (€ 0, € 100, € 200 and € 400) for the monthly contribution and not to vary these levels for different car types.

The range of hybrids, plug-in hybrids and flexifuel vehicles does not differ from that of conventional cars. For these four car types the range was kept constant at 'same as current range'. The range levels for electric and fuel cell vehicles derived from a range of studies and consultations with experts. For electric cars the current real-world range amounts to approximately 75 km. Other ranges included were 150 km, 250 km and 350 km. For the fuel cell car the current range is claimed to be around 250 km. Ranges comparable with current petrol and diesel vehicles may be feasible in the long-run, which is why we also included 350 km, 450 km and 550 km as range levels for this car type.

Four levels of recharging/refuelling times were applied for plug-in hybrid, electric and fuel-cell vehicles, the value for the other car types was set constant at two minutes as a good proxy for the average refuelling time of conventional cars. See Table 4 for a detailed overview of the car type specific charging/refuelling times.

Table 4. Recharge/refuelling times for plug-in hybrid, fuel cell and electric vehicles

| **Car type** | **Level 1** | **Level 2** | **Level 3** | **Level 4** |
|---|---|---|---|---|
| Plug-in hybrid | 20 minutes | 35 minutes | 1 hour | 3 hours |
| Fuel cell | 2 minutes | 10 minutes | 15 minutes | 25 minutes |
| Electric | 30 minutes | 1 hour | 2.5 hours | 8 hours |

To test for differences in the availability of refuelling locations the attribute, additional detour time was used as an attribute. It was felt that additional travel time would be easier for respondents to understand than for example a percentage of the number of conventional fuel stations. An almost identical approach was used by Train (2008). Four levels were applied for fuel-cell, electric and flexifuel vehicles, i.e., 0, 5, 15 and 30 minutes. Additional detour time is equal to 0 for the other car types. For electric vehicles additional detour time only appeared when recharge time was equal to 30 minutes (fast charging), for recharge times larger than 30 minutes we assumed that recharging the vehicle occurs at home.

Preferences of car buyers are very heterogeneous (see, e.g., Hoen en Geurs, 2011; Carlsson et al., 2007). If the car supply would be (much) less diversified the chance that people would be driving the same car would become higher with increasing numbers sold. This might interfere with the desire to distinguish oneself with a particular car. To test this we include the number of available models as an attribute. Four attribute levels (1, 10, 50 and 200) were assigned to the all AFV car types, while number of models for the current technology was always “Same as current amount”.

The final attribute was added to test reactions of respondents for policy intervention. Three levels were included, i.e., current policy, free parking, and access to bus lanes within the built up area.

### 3.2 Presentation and statistical design

Information on the attributes and their levels was given to the respondent prior to the choice tasks. Each respondent was presented with eight choice tasks consisting of three options each, and was asked to indicate his or her 1$^{st}$ and 2$^{nd}$ choice. The order of the attributes remained the same throughout all choice tasks. Prior to the eight choice tasks an example choice card was shown. In this example we asked respondents to imagine that the moment had come when their current car (i.e., the car in which they drive most frequently) would have to be replaced. In the example we also pointed out that additional information on attributes could be accessed through ‘pop-up tooltips’ when moving the cursor over the question marks added to each of the attributes, except for purchase price. This information was identical to the information presented to the respondent earlier in the survey. The descriptive texts presented before the choice tasks and in the tooltips are given in Appendix A. Figure 1 gives an example of a choice card. Note that for the purpose of this paper we translated the originally Dutch wording in English.

Figure 1. Choice card example[a]

**Questionnaire car choice: Choice task 1**

| | OPTION 1 | OPTION 2 | OPTION 3 |
|---|---|---|---|
| **Car type** (?) | Petrol | Electric | Fuel cell |
| **Purchase price** (?) | € 21,800 | € 22,900 | € 31,800 |
| **Tax percentage charge** (?)<br>**Monthly contribution** (?) | 25%<br>€ 100 | 0%<br>€ 400 | 7%<br>€ 200 |
| **Driving range** (?) | Same as current range | 150 kilometres | 450 kilometres |
| **Charging/Refuelling time** (?) | 2 minutes | 8 hours | 25 minutes |
| **Additional detour time** (?) | No additional detour time | N.A., you need to charge at home | 30 minutes |
| **Number of brands/models** (?) | Same as current amount | 1 | 50 |
| **Policy measure for this car type** (?) | Current policy | Free parking | Access to bus lanes within built up area |

Indicate below which car would be your first choice, and which would be your second choice.

| | OPTION 1 | OPTION 2 | OPTION 3 |
|---|---|---|---|
| **1st choice** | ○ | ○ | ○ |
| **2nd choice** | ○ | ○ | ○ |

[Previous question] [Next question]

[a] Respondent values used in this example are:

- Fuel type next car: Petrol
- Purchase price next car: € 21,000 – € 24,000

We used the Sawtooth CBC software package to programme and field the online questionnaire. This software package is specifically suited for building an online choice experiment from start to finish. It generates efficient statistical designs with various options and it allows for respondent-specific adaptations of the design through HTML and PERL programming, which can also be used to adapt the online presentation of choice tasks and attribute levels to the respondents. The default method for generating a statistical design in Sawtooth is called Complete Enumeration, which provides the most efficient design (i.e., lowest standard errors) in terms of main effects. A variation on the Complete Enumeration method is the Balanced Overlap method, which allows for more effective and efficient estimation of attribute interactions by allowing for more overlap of attribute levels between options in a single choice set. For our purposes this option is interesting because some attribute levels (i.e., range, refuel/recharge time and detour time) differ per car type, but also other attribute interactions may prove to be interesting (e.g., interaction between refuel/recharge time and detour time). Sawtooth allows for testing both methods in terms of efficiency, assuming a specific number of respondents. These tests reveal that the loss in efficiency by using the Balanced Overlap method is relatively small. Still, even small losses in efficiency may have large consequences in small samples. However, because we could guarantee a relatively large sample size *a priori*, we chose to use the Balanced Overlap method for generating an alternative-specific efficient statistical design, which consisted of 30 survey versions of 8 choice tasks each.

### 3.3 Tests and pilots

Before fielding the questionnaire a number of consultations, tests and pilots were carried out. The purpose of this was two-fold, (1) to make sure questions were not too difficult to interpret and understand, and (2) to test the levels of the attributes in order to zoom in on the most interesting parts of the utility curves. Experts and policy makers from the Ministry of Infrastructure and Environment were invited to comment on the preliminary selection of attributes and attribute levels. This led to some changes in the questionnaire and the design of the stated choice questions. A test version was then prepared and sent to approximately 20 experts and colleagues who commented on wording and general quality of the questionnaire. This led to additional improvements.

Subsequently two consecutive pilots on small samples were fielded to finalise the testing phase; 52 respondents leading to 416 observations for pilot 1, and 51 respondents leading to 408 observations for pilot 2. The main objective of the pilots was to test the attribute levels, and some additional questions were added following the stated choice questions to determine at which level of a certain attribute respondents decided to reject a choice option. Ranges of levels for the attributes purchase price, monthly contribution and tax percentage charge were already fairly wide because we are interested in preferences under current circumstances as well as under possible future price, cost and tax scenarios. Levels for these attributes were basically not up for discussion or change. Also car fuel type and policy measures were not up for discussion, because their levels could not be changed at the margin, they could only be deleted. This was not an option since insights on car type preferences and policy measures are relevant and interesting no matter what the outcome. Results for pilot 1 showed expected signs on all attributes and attribute levels and were plausible in terms of magnitude. Still, changes were made on three aspects.

Initial range levels for electric vehicles were 75 km, 150 km, 250 km and 450 km. The results indicated that the difference in preference between the first three levels were minimal. We therefore decided to replace 250 km by 350 km. In a second pilot the distinction between 350 km and 450 km turned out to be minimal. In the main study we therefore included 75 km, 150 km, 250 km and 350 km, because 450 km is technologically possible but at the moment not very realistic, and because the first pilot indicated that the added value of 450 km compared to 350 km was limited.

Initial range levels for hydrogen vehicles were 250 km, 300 km, 400 km and 600 km. Results indicated that differences in preferences for the first three levels were minimal, so we changed the levels to 250 km, 350 km, 500 km and 600 km. Results from the second pilot indicated that the differences in preference between 500 km and 600 km was small, so we changed the levels to 250 km, 350 km, 450 km and 550 km in order to get a better grip on possible non-linearities in the 350 to 550 km range.

Initial detour times included were 2, 8 and 20 minutes. Results indicated that 2 minutes was not considered relevant by respondents, and that 8 minutes had only limited added value. We changed detour times to 5, 15 and 30 minutes in order to test a wider range of detour times and get a better grip on possible non-linearities. Results from the second pilot were again plausible and showed more interesting differences between the various detour times, so we made no further changes to these levels in our main study.

## 4. Data

### 4.1 Data panel, segmentation and sampling

Respondents for the choice experiment were selected from a Dutch internet panel owned by TNS-NIPO. More specifically, respondents were selected from a separate automotive panel containing more than 40,000 households with one or more car. The panel is established through random sampling, meaning that each member of society has an equal chance to be added to the panel as long as he or she has conveyed the willingness to cooperate. The automotive panel has several advantages above and beyond more general panels, i.e., regular screenings of respondents reveal additional information on current car type and use, it allows for a priori segmentations on fuel type and type of ownership, panel members are familiar with automotive related questions which improves reliability of results, and those who fully complete the questionnaire are paid for their efforts. Our experiment focused on the company car market, so we exclude private ownership. We made a segmentation between petrol and diesel car drivers. Too few LPG drivers were present in the panel to obtain reliable results, so we excluded them altogether.[1] We aimed for a net response of 450 respondents for both petrol and diesel drivers, and used representative sampling on age, gender, education, and place of residence. We added a selection question in the questionnaire in order to obtain those respondents in the household that were most likely to make the decisions on replacement of the company car. For example, in a two-person household with one car where person A would be the main user of that car, we wanted to be sure it would be person A filling in the questionnaire and not person B. Person A is more likely to know the specifics of the car, the way in which it is used, and most likely to be the person that makes decisions regarding replacement. Ultimately, if the respondent was not the person that drove the company car most frequently, he or she was excluded from the sample in the beginning of the questionnaire.

### 4.2 Data characteristics

The final version of the questionnaire was fielded in two stages, the first in June/July 2011 and the second in October 2011. Total response rate, including the respondents who were disqualified, is high at 78%. This is the result of the specific panel that we used for our data collection. After excluding respondents who indicated to have made random choices (around 4%) from our sample, we have a total of 940 complete questionnaires, 458 for petrol and 482 for diesel, for a total 7,519 usable observations (1 observation was missing). In Appendix B we present background characteristics for these 940 respondents. There is an overrepresentation of male respondents in the sample, at least in comparison with total population. This is probably not very problematic, since males are likely overrepresented in the population of car buyers as well. The age distribution is fairly even between the age group 35 to 55, while age groups 18 to 35 and 55 to 75 are somewhat underrepresented. The average household size (not shown) is equal to 3.0,

[1] The share of LPG cars in the total lease car fleet was around 3% in 2007 and around 2% in 2010. Shares of LPG in lease car sales in 2007 and 2010 were even lower than that (Ecorys, 2011).

which is quite high compared to the national average of 2.2. The distribution of respondents living in urban and rural areas is fairly even.

In Appendix C we present some car use and travel characteristics for the full sample. Approximately 9% indicate that their next car will not be a lease car, and most respondents think that the purchase price of their next car will not exceed 30,000 Euro.[2] Most respondents drive more than 25,000 kilometre per year and over a quarter of respondents indicate that they drive over 45,000 kilometres per year. Most cars weigh between 1,000 and 1,500 kilograms. By far the majority of respondents use their lease car five day or more per weak for commuting purposes, and one-way commuting distance is more than 70 kilometres for a quarter of the respondents. Other relevant characteristics not shown in the table are: 21% of respondents do not use their car for holidays abroad, 8% of respondents use their car for towing a caravan, 10% of respondents need a parking permit for parking at (or close to) home, and 63% of the respondents indicate they have the possibility to charge an electric vehicle at home.

We added two questions following the choice tasks that aimed to reveal respondents' perceptions on environmental and safety performance of AFVs. We asked respondents to score each AFV on environmental and safety performance compared to the conventional technology a 7-point scale (1=Less safe / Worse environmental performance; 4=equally safe / equal environmental performance; 7=Safer / Better environmental performance). Table 5 shows the mean scores and the standard deviations for each AFV.

Table 5. Means and standard deviations of perceived environmental and safety performance of AFVs compared to the conventional technology (full sample)

| | **Perceived environmental performance** | | **Perceived safety performance** | |
|---|---|---|---|---|
| **Car type** | Mean | Standard deviation | Mean | Standard deviation |
| Conventional technology | 4 | -- | 4 | -- |
| Hybrid | 4.10 | 0.69 | 4.20 | 0.77 |
| Electric | 4.03 | 0.88 | 4.09 | 0.91 |
| Plug-in | 4.01 | 0.64 | 4.09 | 0.69 |
| Flexifuel | 4.06 | 0.61 | 4.14 | 0.68 |
| Fuel cell | 3.63 | 0.86 | 3.62 | 0.94 |

The table shows that the average perception on environmental and safety performance of most AFVs is very close to that of the conventional technology. Both the perceived environmental and safety performance of fuel cell cars is lower on average than that of the conventional technology. The standard deviations, however, also show that there is substantial heterogeneity in people's perceptions. In Section 4 we therefore analyse whether individual respondent perceptions on environmental and safety performance of AFVs affect their car choice behaviour.

### 4.3 Choice characteristics

Table 6 shows the car type choices made by the respondents in the eight choice tasks that each of them faced. In the statistical design used for our experiment approximately 40% of the choice tasks contained the conventional technology (CT), and approximately 60% of the choice tasks contained only AFVs. The main reason why we did not include

[2] Lease car drivers obviously don't purchase their car themselves but do have a general idea of the retail price of their next car.

the conventional technology in each choice task was that it might be used as an 'opt out' by many respondents, potentially leaving us with a limited set of information leading to difficulties in obtaining reliable estimates. The conventional technology was chosen 60% of the times when it was among the choice options. This percentage is of course lower in the full sample. The figures shown in Table 6 tell us nothing about AFV preferences, because the frequency of occurrence is different for each AFV because of efficiency reasons. More specifically, car types that have many different levels (electric car, fuel cell car) appear more often in the choice tasks. The most relevant insight from the table is that there appears to be sufficient variation in car choice for reliably estimating choice models.

Table 6. Counts and percentages of car type choices made by respondents

| | **Full sample** | | **Sample with CT in choice set** | |
|---|---|---|---|---|
| **Car type** | **Count** | **Percentage** | **Count** | **Percentage** |
| CT | 1,788 | 24% | 1,788 | 60% |
| Hybrid | 700 | 9% | 77 | 3% |
| Electric | 715 | 10% | 166 | 6% |
| Plug-in hybrid | 960 | 13% | 163 | 5% |
| Flexifuel | 1,497 | 20% | 358 | 12% |
| Fuel cell | 1,859 | 25% | 429 | 14% |
| Total | 7,519 | 100% | 2,981 | 100% |

In this light it is also interesting to explore the characteristics of the AFV's that are chosen by respondents. Table 7 presents range, refuelling time and detour time characteristics of the chosen electric and fuel cell cars.

Table 7. Range, refuelling time and detour time characteristics of electric and fuel cell cars chosen by respondents

| **Electric car** | **Full sample** | **CT sample** | **Fuel cell car** | **Full sample** | **CT sample** |
|---|---|---|---|---|---|
| **Range** | | | **Range** | | |
| 75 km | 20% | 14% | 250 km | 21% | 16% |
| 150 km | 19% | 28% | 350 km | 22% | 23% |
| 250 km | 25% | 19% | 450 km | 28% | 17% |
| 350 km | 35% | 38% | 550 km | 30% | 44% |
| **Recharge time** | | | **Refuelling time** | | |
| 30 minutes | 26% | 25% | 2 minutes | 28% | 23% |
| 1 hour | 27% | 25% | 10 minutes | 28% | 34% |
| 2.5 hours | 25% | 41% | 15 minutes | 23% | 25% |
| 8 hours | 22% | 10% | 25 minutes | 21% | 18% |
| **Detour time** | | | **Detour time** | | |
| 0 minutes | 79% | 84% | 0 minutes | 31% | 34% |
| 5 minutes | 7% | 12% | 5 minutes | 24% | 30% |
| 15 minutes | 9% | 2% | 15 minutes | 24% | 15% |
| 30 minutes | 5% | 2% | 30 minutes | 21% | 22% |

The table clearly shows that that the chosen electric and fuel cell cars display a wide range of characteristics, both for the full and the CT sample. This is a strong indication of preference heterogeneity among respondents. It also clearly indicates that for many respondents a maximum range and short refuelling and detour times are not necessary conditions for the electric or fuel cell car to be chosen. Stated differently, we have a good indication that respondents have made clear trade-offs between choice options and that our data contain sufficient variation to reliably estimate our choice models.

## 5. Estimation results

As was discussed in the introduction of this paper, estimation results are presented in two separate sections. In this section we present results from a multinomial logit (MNL) model. This model is still the starting point for any choice modelling analysis (Louviere et al., 2000). We first discuss results from a linear specification in Section 4.1, and in Section 4.2 use a dummy specification to test for potential non-linear attribute effects. We furthermore compare dummy specification results with results from a similar experiment for the private market in order to identify the main differences between these two markets in Section 4.3. In Section 5 we estimate a mixed logit model to test robustness of the MNL results and to explore the heterogeneity in consumer preferences. In that section we also estimate a model with consumer background interactions in order to uncover the main sources of preference heterogeneity, and to identify interesting market segmentations and potential early adopters.

### 5.1 Main attribute effects and WTP's

In this section we analyse main effects and willingness to pay estimates using a multinomial logit model and linear model specifications. Estimation results for three different models are presented in Table 8.[3] Model 1 is based on the full sample with all choice tasks, i.e., including those that did not have the conventional technology among the three choice options. Model 2 is based on the sample of choice tasks in which the conventional technology was one of the choice options. It might be argued that this sample contains more reliable information on preferences for AFVs and AFV characteristics because the conventional technology could always be used as a status quo choice. The third set of estimates (Model 3) is based on the full sample again, but here individual respondent perceptions on the environmental and safety performance of AFVs are included in the model estimation as additional attributes.[4]

In all three models the estimation results for the AFV type constants represent a reference situation in which driving ranges of the electric and fuel cell car are 75 kilometres and 250 kilometres, respectively, refuelling/recharge times for the electric, plug-in and fuel cell car are 480, 180 and 25 minutes, respectively, and additional detour time is 30 minutes for electric, flexifuel and fuel cell cars.

All estimates for Model 1 have the expected sign and model fit is reasonable with an adjusted pseudo R2 of 0.239. Under the above mentioned conditions all AFV constants are negative, and the electric car constant is by far the most negative one. The latter can be explained by the fact that in the reference situation range is the most limiting factor for electric cars. We may conclude that lease car drivers value range highly which is likely a result of their relatively high annual mileage. Fuel cell cars are the 2$^{nd}$ least preferred car type followed by plug-in hybrids, flexifuel and hybrid cars. The difference between car

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[3] All estimations in this paper were done in NLogit 4.0.

[4] We also estimated a nested logit model, with conventional technology in a first tree, and all AFV's in a second tree. Estimates and derived elasticities were very similar, both for the full sample and for the CT sample, and the two nesting coefficients were very similar and both close to one. Other nesting structures, e.g., with conventional technology, hybrid and flexifuel in a first nest and all other AFV's in a second nest, gave comparable results. In conclusion, nested models do not appear to add much to our analyses.

type constants becomes much smaller if we would assume performances on range, fuel time and additional detour time comparable to the conventional technology. However, even with these improvements, constants for all AFVs remain negative indicating an intrinsic negative utility for AFVs compared to the conventional technology. The coefficient for the number of available models is relatively large, indicating that an increase in the diversity of the supply of AFVs may have a substantial effect on AFV adoption. Implementing free parking as a policy incentive has a slight positive effect on preferences, while the effect of access to bus lanes is close to zero.

The signs of coefficients in Model 2 are identical to those in Model 1, but car type constants in Model 2 are larger in absolute value, especially for the hybrid and flexifuel car. Most likely these two car types are chosen relatively often in those choice tasks that did not include the conventional technology, producing substantially lower negative preference estimates in Model 1. Also the model fit of Model 2 is slightly better (adjusted pseudo R2 of 0.259), which may be an indication that there were more random choices in the choice tasks in which the conventional technology was not among the choice options.

Table 8. MNL estimation results for three models using a simple model specification (monthly costs in Euro, purchase price in 1,000 Euro)

| | **Model 1 (full sample)** | | | **Model 2 (CT sample)** | | | **Model 3 (full sample)** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **b** | **se** | **p** | **b** | **se** | **p** | **b** | **se** | **p** |
| Environmental performance | -- | -- | -- | -- | -- | -- | 0.1289 | 0.0499 | 0.010 |
| Safety performance | -- | -- | -- | -- | -- | -- | 0.0848 | 0.0459 | 0.065 |
| Hybrid | −0.5575 | 0.0733 | 0.000 | −0.9954 | 0.1473 | 0.000 | −0.5944 | 0.0737 | 0.000 |
| Electric | −4.0163 | 0.1387 | 0.000 | −4.2537 | 0.3073 | 0.000 | −4.0540 | 0.1392 | 0.000 |
| Plug−in hybrid | −1.5424 | 0.1040 | 0.000 | −1.6772 | 0.2354 | 0.000 | −1.5626 | 0.1043 | 0.000 |
| Flexifuel | −1.0277 | 0.0775 | 0.000 | −1.4307 | 0.1440 | 0.000 | −1.0528 | 0.0778 | 0.000 |
| Fuel cell | −2.6210 | 0.1066 | 0.000 | −2.9313 | 0.2094 | 0.000 | −2.5534 | 0.1070 | 0.000 |
| Range electric | 0.0033 | 0.0004 | 0.000 | 0.0026 | 0.0008 | 0.002 | 0.0033 | 0.0004 | 0.000 |
| Range fuel cell | 0.0028 | 0.0003 | 0.000 | 0.0028 | 0.0005 | 0.000 | 0.0028 | 0.0003 | 0.000 |
| Fuel time electric | −0.0012 | 0.0002 | 0.000 | −0.0013 | 0.0007 | 0.049 | −0.0012 | 0.0002 | 0.000 |
| Fuel time plug-in | −0.0020 | 0.0007 | 0.005 | −0.0020 | 0.0017 | 0.243 | −0.0021 | 0.0007 | 0.004 |
| Fuel time fuel cell | −0.0197 | 0.0036 | 0.000 | −0.0228 | 0.0082 | 0.005 | −0.0201 | 0.0036 | 0.000 |
| Detour time | −0.0174 | 0.0020 | 0.000 | −0.0284 | 0.0038 | 0.000 | −0.0174 | 0.0020 | 0.000 |
| Models | 0.0011 | 0.0002 | 0.000 | 0.0012 | 0.0005 | 0.007 | 0.0011 | 0.0002 | 0.000 |
| Free parking | 0.1021 | 0.0425 | 0.016 | 0.1192 | 0.0908 | 0.189 | 0.1080 | 0.0426 | 0.011 |
| Access bus lanes | 0.0135 | 0.0440 | 0.758 | −0.0160 | 0.0910 | 0.860 | 0.0177 | 0.0441 | 0.688 |
| Percentage | −0.0385 | 0.0026 | 0.000 | −0.0455 | 0.0047 | 0.000 | −0.0388 | 0.0026 | 0.000 |
| Monthly cost | −0.0026 | 0.0001 | 0.000 | −0.0028 | 0.0002 | 0.000 | −0.0026 | 0.0001 | 0.000 |
| Purchase price | −0.0334 | 0.0044 | 0.000 | −0.0256 | 0.0000 | 0.007 | −0.0337 | 0.0044 | 0.000 |
| NOBS | 7,519 | | | 2,981 | | | 7,519 | | |
| Log-L | −6,273 | | | −2,406 | | | −6,249 | | |
| Log-L restricted | −8,251 | | | −3,255 | | | −8,251 | | |
| Pseudo R2 (adjusted) | 0.239 | | | 0.259 | | | 0.242 | | |

As discussed in the previous section we asked respondents for their perceptions on environmental and safety performance of AFVs compared to the conventional technology. Interesting is that these perceptions can be included as attributes in our model, even though they were not included as explicit attributes in our choice experiment. One might argue that including these attributes is not possible, since the scores on environmental and safety performance for a specific AFV are constant for a single respondent, and as such cannot be distinguished from the AFV-specific constant for that respondent. However, note that an AFV-specific constant is equal for *all* respondents, while the scores on environmental and safety performance for that AFV display variation across respondents, which is why the effects of environmental and safety perceptions on stated choice are identified in our model.

In Model 3 both aspects are therefore included as additional attributes. We can see that the model fit is slightly better than for Model 1 (adjusted pseudo R2 of 0.242 versus 0.239), and that on average the perceptions on environmental and safety performance of an AFV have a small but positive effect on car choice. Stated differently, respondents are willing to pay for cars that they perceive as being safer and cleaner.

Table 9 presents willingness-to-pay (WTP) estimates for the three models. Attribute coefficients were divided by the monthly cost coefficient, which was used as the monetary attribute, so WTP values are in Euro per month. For reasons of clarity, note that the WTP values for AFV type represent a reference situation in which driving ranges of the electric and fuel cell car are 75 kilometres and 250 kilometres, respectively, refuelling/recharge times for the electric, plug-in and fuel cell car are 480, 180 and 25 minutes, respectively, and additional detour time is 30 minutes for flexifuel and fuel cell cars.

Differences between estimates from the three models are limited, with the exception of the differences in WTP for driving range and additional detour time between Model 1 and Model 2. The full sample produces a higher WTP for driving range and a lower WTP for additional detour time. Below we further discuss the results from Model 1.

Negative WTP values associated with the car type constants range from approximately 200 Euro per month for the hybrid to roughly 1,500 Euro per month for the electric car. Since these figures represent average compensations needed to make people indifferent between AFVs and the conventional technology, they should be interpreted as statistical constructs and indications of barriers to adoption rather than actual compensation figures.

For the electric car each additional kilometre driving range is valued at around 1.26 Euro. This means that the WTP for a doubling of the current range of electric cars from 75 kilometres to 150 kilometres is almost 95 Euro per month. The WTP for an increase in range of the fuel cell car is somewhat lower at 1.08 Euro per kilometre. Since for fuel cell cars driving range is a less restrictive attribute compared to electric cars, it is plausible that in this case we are on a somewhat flatter part of the utility curve (see also Section 4.2).

Each additional minute of recharge time for the electric car is valued negatively at 0.45 Euro. Interestingly, the WTP for recharge time of the plug-in hybrid is even more negative at -0.79 Euro per minute. This is somewhat counterintuitive since the plug-in car has an alternative fuelling option besides electric charging. Due to this greater flexibility of the plug-in hybrid it would seem logical that the WTP for an increase in fuel time would be lower for the plug-in than for the electric car. A possible explanation could be that people with a severe dislike of large recharge times will more often choose a plug-in hybrid than an electric car, implying their large willingness to pay for recharge time reductions shows up in the recharge time coefficient for plug-in hybrid cars. The WTP for fuel time for fuel cell cars is much more negative than for electric and plug-in cars. This is plausible since the time necessary for recharging an electric or plug-in vehicle at home can be used for other activities, whereas the time spent to drive to and refuel at a fuel cell station will generally be considered as lost time. The same argument applies when comparing VOT values for recharge time with the VOT estimate for additional detour time, which is much higher. A minute of additional detour time is valued negatively at 6.70 Euro per month and is comparable to the VOT for refuelling time of fuel cell vehicles.

An increase in the number of models has a limited effect on WTP. Increasing the number from 1 to 50 models is valued at almost 21 Euro per month. Free parking definitely has an effect on choice with an average willingness to pay of around 40 Euro per month. The WTP for access to bus lanes within the built-up area is much smaller and not statistically significant.

Table 9. WTP estimates (in Euro per month) for the three MNL models

| **Attributes** | **Model 1 (full sample)** | **Model 2 (CT sample)** | **Model 3 (full sample)** |
|---|---|---|---|
| Environmental performance | -- | -- | € 49 |
| Safety performance | -- | -- | € 33 |
| Hybrid | –€ 215 | –€ 354 | –€ 228 |
| Electric | –€ 1,549 | –€ 1,515 | –€ 1,554 |
| Plug-in hybrid | –€ 595 | –€ 597 | –€ 599 |
| Flexifuel | –€ 396 | –€ 509 | –€ 404 |
| Fuel cell | –€ 1,011 | –€ 1,044 | –€ 979 |
| Range electric | € 1.26 | € 0.91 | € 1.26 |
| Range fuel cell | € 1.08 | € 1.00 | € 1.06 |
| Fuel time electric | –€ 0.45 | –€ 0.46 | –€ 0.46 |
| Fuel time plug-in | –€ 0.79 | –€ 0.72 | –€ 0.80 |
| Fuel time fuel cell | –€ 7.6 | –€ 8.13 | –€ 7.70 |
| Detour time | –€ 6.7 | –€ 10.1 | –€ 6.66 |
| Models | € 0.42 | € 0.44 | € 0.42 |
| Free parking | € 39.4 | € 42.5 | € 41.4 |
| Access bus lanes | € 5.22 | –€ 5.70 | € 6.79 |

It is difficult to compare our WTP estimates with estimates from the literature, for two reasons. First, literature for lease car drivers is absent. Although there is a study from Golob et al. (1997), they studied the supply side (fleet car operators), their data are from 1994 and from California, USA. Moreover, their estimates are based on the purchase price coefficient, which for lease car drivers is a fundamentally different entity than for fleet car operators, because lease car drivers do not have to pay for the car themselves. Second, although we could compare our results with those from studies for private car owners, WTP estimates from these studies are based on purchase price coefficients. Again, purchase price is fundamentally different for lease car drivers than for private car owners, because lease car drivers do not pay for the car themselves. Still, in Section 5.3 we compare WTP estimates with those from a similar choice experiment we conducted among private car owners.

### 5.2 Non-linear attribute effects

In this section we estimate a MNL model with dummy variables for the attribute levels to allow for potential non-linear attribute effects. In Table 10 we present estimation results and associated WTP values (in Euro per month) for the full sample. The non-linear effects discussed below are by and large similar for the CT sample. The AFV constants represent cars with, when applicable, lowest range, highest fuel and detour times, and lowest number of models.

Table 10. MNL estimation results for a dummy coded model specification and associated WTP values (in Euro per month) for the full sample

| **Attributes** | **b** | **se** | **p** | **WTP** |
|---|---|---|---|---|
| Hybrid | −0.6818 | 0.0785 | 0.000 | −€ 261 |
| Electric | −3.6527 | 0.1436 | 0.000 | −€ 1,397 |
| Plug-in hybrid | −1.6189 | 0.1088 | 0.000 | −€ 619 |
| Flexifuel | −0.5886 | 0.0821 | 0.000 | −€ 225 |
| Fuel cell | −2.1786 | 0.1190 | 0.000 | −€ 833 |
| Range electric | | | | |
| 75 → 150 km | 0.2438 | 0.1300 | 0.061 | € 93 |
| 75 → 250 km | 0.6196 | 0.1249 | 0.000 | € 237 |
| 75 → 350 km | 0.9332 | 0.1211 | 0.000 | € 357 |
| Range fuel cell | | | | |
| 250 → 350 km | 0.2929 | 0.0888 | 0.001 | € 112 |
| 250 → 450 km | 0.5754 | 0.0832 | 0.000 | € 220 |
| 250 → 550 km | 0.8123 | 0.0879 | 0.000 | € 311 |
| Fuel time electric | | | | |
| 8 hours → 2.5 hours | 0.4013 | 0.1233 | 0.001 | € 154 |
| 8 hours → 1 hour | 0.5044 | 0.1228 | 0.000 | € 193 |
| 8 hours → 30 minutes | 0.5952 | 0.1266 | 0.000 | € 228 |
| Fuel time plug-in | | | | |
| 3 hours → 1 hour | 0.1718 | 0.1263 | 0.174 | € 66 |
| 3 hours → 35 minutes | 0.1448 | 0.1287 | 0.261 | € 55 |
| 3 hours → 20 minutes | 0.4147 | 0.1261 | 0.001 | € 159 |
| Fuel time fuel cell | | | | |
| 25 minutes → 15 minutes | 0.1521 | 0.0868 | 0.078 | € 58 |
| 25 minutes → 10 minutes | 0.4154 | 0.0847 | 0.000 | € 159 |
| 25 minutes → 2 minutes | 0.4049 | 0.0867 | 0.000 | € 155 |
| Additional detour time | | | | |
| 30 minutes → 15 minutes | 0.2680 | 0.0657 | 0.000 | € 103 |
| 30 minutes → 5 minutes | 0.4221 | 0.0666 | 0.000 | € 161 |
| 30 minutes → No detour time | 0.5716 | 0.0663 | 0.000 | € 219 |
| Models | | | | |
| 1 → 10 | 0.1864 | 0.0478 | 0.000 | € 71 |
| 1 → 50 | 0.2387 | 0.0475 | 0.000 | € 91 |
| 1 → 200 | 0.3207 | 0.0474 | 0.000 | € 123 |
| Free parking | 0.1043 | 0.0430 | 0.015 | € 40 |
| Access bus lanes | 0.0163 | 0.0444 | 0.713 | € 6.25 |
| Percentage | −0.0390 | 0.0026 | 0.000 | |
| Monthly cost (in Euro) | −0.0026 | 0.0001 | 0.000 | |
| Purchase price ( in 1,000 Euro) | −0.0333 | 0.0044 | 0.000 | |
| NOBS | | 7,519 | | |
| Log-L | | −6,259 | | |
| Log-L restricted | | −8,251 | | |
| Pseudo R2 (adjusted) | | 0.240 | | |

The results show that on average respondents are willing to pay substantial amounts for increases in range, both for the electric and the fuel cell car. The range utility curves for electric and fuel cell cars are shown in Figure 2. Since we only know relative preferences for range, we have assumed in this figure that the WTP for range of a fuel cell car of 250 kilometres is identical to the WTP for a range of 250 kilometres for the electric car. For both electric and fuel cell cars the figure shows that the WTP curve is practically linear, i.e., marginal WTP for an extra kilometre of driving range is constant. Interesting here is the difference with results for private car owners, for which a decreasing marginal WTP was found (see Hoen and Koetse, 2012).

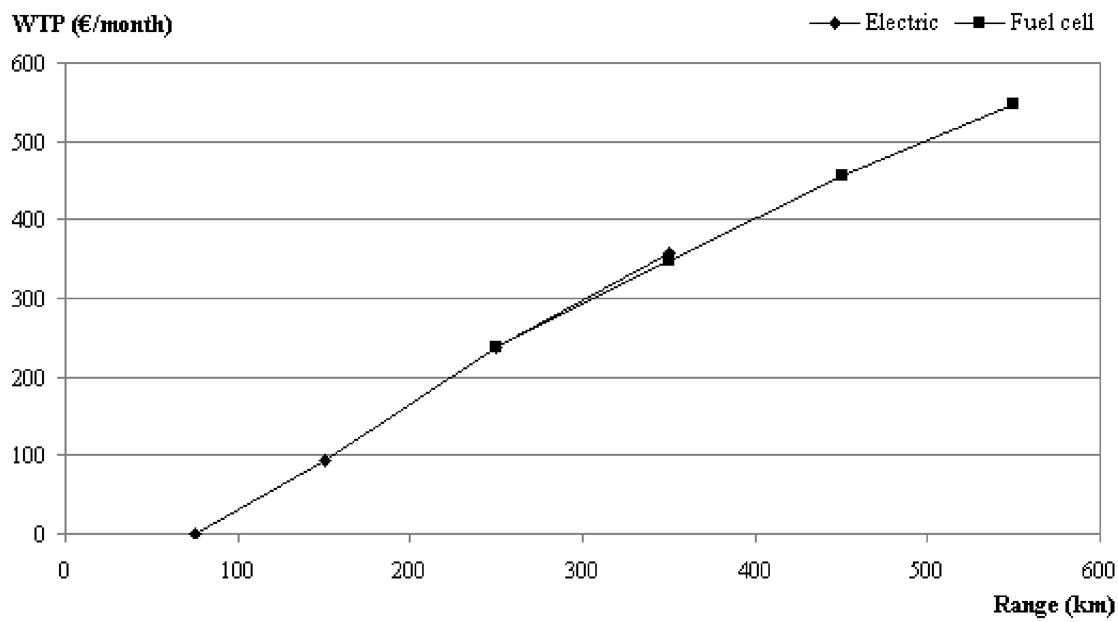


Figure 2. WTP for range for the electric and fuel cell car

The willingness to pay estimates for recharge/refuelling time of the electric, the plug-in hybrid and the fuel cell car are shown in Figure 3. When parameter estimates are close and do not differ statistically we give them identical WTP values, purely for the sake of clarity and presentation. From the figure it is clear that WTP for reductions in refuelling/recharge time are high, although in absolute value increases in driving range have a much larger effect on preferences for the electric and fuel cell car. Striking is that marginal willingness to pay for a unit reduction in refuelling/recharge time increases substantially when refuelling/recharge times decrease. This is shown by the convexity of the utility curves but even more so by comparing the three utility curves, which become steeper when refuelling/recharge times decrease. Marginal benefits from decreasing refuelling/recharge time are especially high when refuelling time is below approximately 60 minutes. Since marginal *costs* likely also increase, economically optimal reductions in refuelling/recharge times are not clear a priori and depend on (marginal) cost and benefit curves for the different car types.

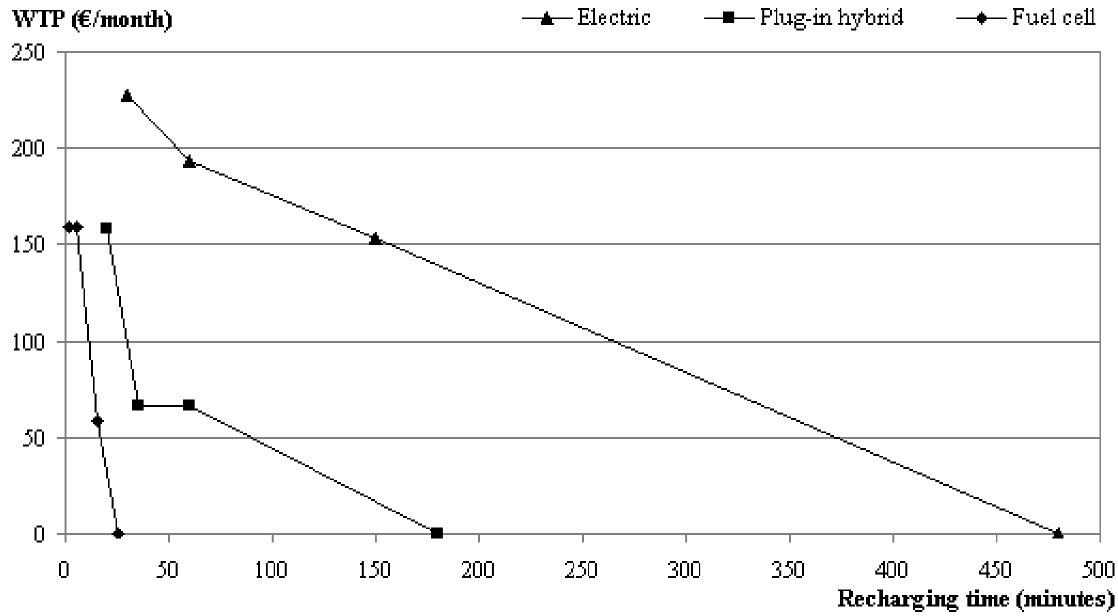


Figure 3. WTP for recharging time of the electric, the plug-in hybrid and the fuel cell car

In Figure 4 we show the willingness to pay for additional detour time for the electric, the fuel cell and the flexifuel car, which shows that the marginal WTP is practically constant. In this case we run into a situation where marginal benefits from decreasing additional detour time are constant while marginal costs are likely increasing, implying that the economically optimal network density is not clear a priori and depends on the (marginal) cost and benefit curves.

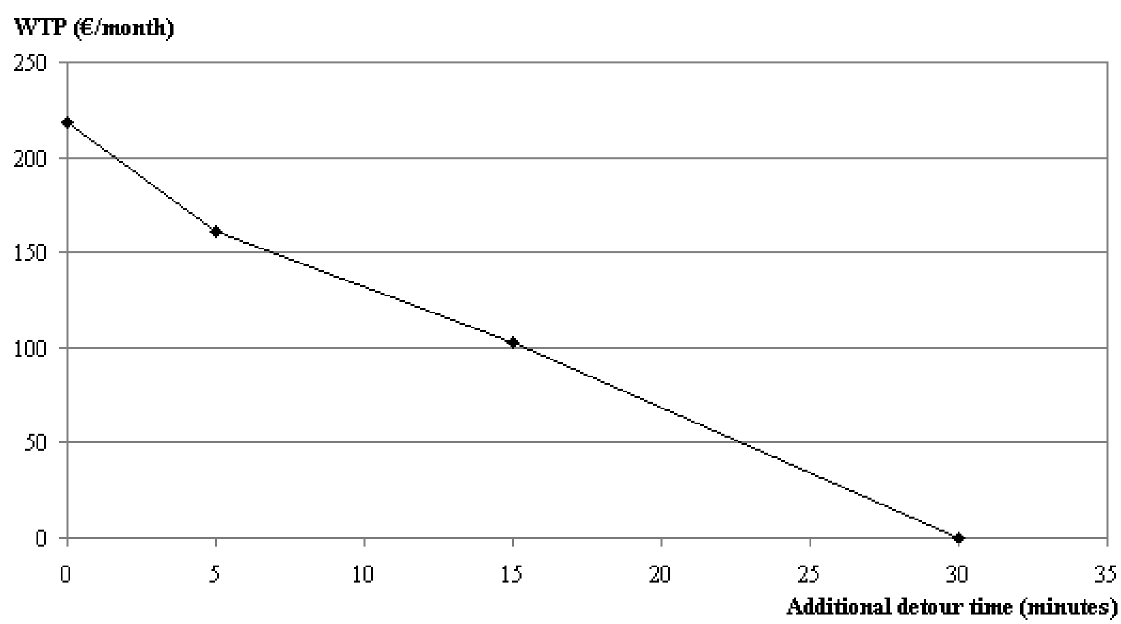


Figure 4. WTP for additional detour time for the electric, fuel cell and flexifuel car

Finally, we present WTP estimates for the number of available car models in Figure 5. The overall willingness to pay for model availability is modest, and marginal WTP is by far the highest when the number of models increases from 1 to 10. Apparently some choice has substantial added value above and beyond no choice, but having even more choice matters much less.

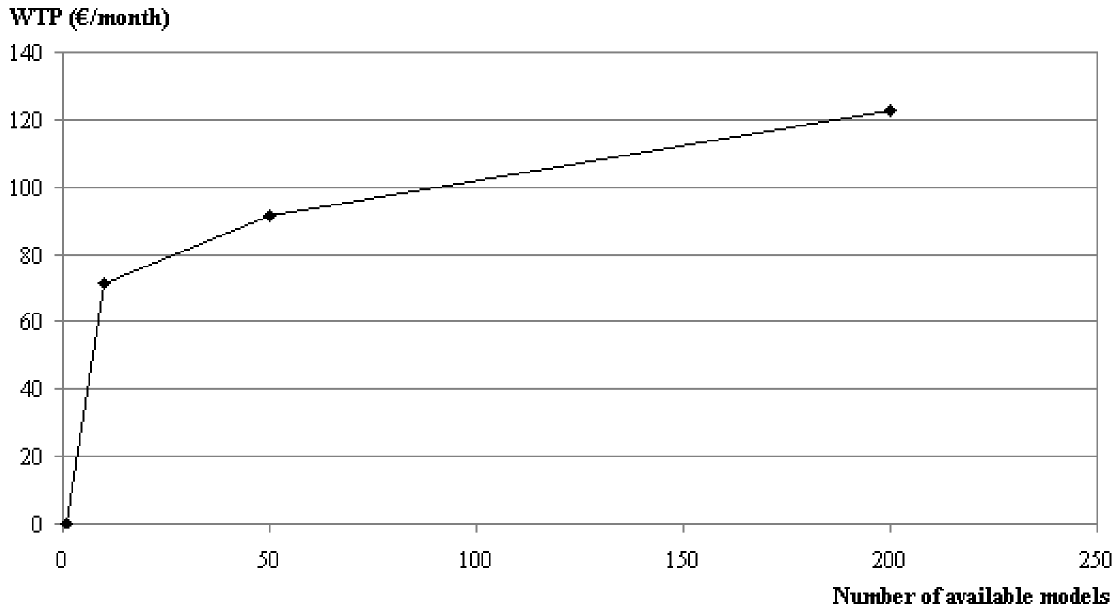


Figure 5. WTP for the number of available car models for all AFVs

### 5.3 Comparison with private ownership

To our knowledge this is the first study that explicitly addresses AFV preferences of lease car drivers. It is difficult to compare our WTP estimates with those reported in earlier studies, because of reasons set out in Section 5.1. We can, however, compare our WTP estimates with those from a similar choice experiment we conducted among private car owners (see Hoen and Koetse, 2012). This study was done for the same country, in the same period, and using roughly the same attributes and attribute levels. In the Netherlands, private car owners and lease car drivers are treated differently in terms of fiscal policy, and the structures of total costs of ownership are very different. Private car owners have high up-front (purchase) costs and relatively low monthly costs, whereas lease car drivers are confronted with monthly costs only (consisting of a centralised tax payment and sometimes a contribution to the employer). Purchase price is therefore difficult to use as a common denominator. However, an extra Euro of monthly costs is the same for private car owners and lease car drivers, even though the structure of monthly costs is different for the two groups. We can therefore use the monthly cost coefficients from the two experiments as a common denominator.

In Table 11 we present WTP values for a dummy coded model specification for lease car drivers and private car owners. Fiscal advantages for AFVs are excluded from the WTP estimates in order to make the estimates as comparable as possible. In general, although point estimates can be quite different, very few of the differences are statistically significant at 5 or 10%.[5] Exceptions are negative preferences on the hybrid and the flexifuel car, so lease car drivers are, on average, substantially less negative on

[5] A possible underlying reason is that preferences may display large heterogeneity, an issue we will discuss in detail in the next section.

these two car types than private car owners. Also significant is the difference in willingness to pay for a reduction in fuel time for the fuel cell car from 25 to 10 minutes. Apparently lease car drivers derive added value from this reduction, whereas it takes an even further reduction in fuel time for private car owners to be affected. Finally, the differences in willingness to pay for the number of available models choice are also significant at 90% or 95%, indicating that lease car drivers are much more sensitive to choice than private car owners.

Table 11. WTP estimates in Euro per month for lease car drivers and private car owners (excluding the effect of fiscal advantages for AFVs)

| **Attributes** | **WTP Lease** | **WTP Private** |
|---|---|---|
| Hybrid * | –€ 261 | –€ 386 |
| Electric | –€ 1,397 | –€ 1,202 |
| Plug-in hybrid | –€ 619 | –€ 766 |
| Flexifuel ** | –€ 225 | –€ 404 |
| Fuel cell | –€ 833 | –€ 708 |
| Range electric | | |
| 75 → 150 km | € 93 | € 205 |
| 75 → 250 km | € 237 | € 328 |
| 75 → 350 km | € 357 | € 438 |
| Range fuel cell | | |
| 250 → 350 km | € 112 | € 20 |
| 250 → 450 km | € 220 | € 168 |
| 250 → 550 km | € 311 | € 233 |
| Fuel time electric | | |
| 8 hours → 2.5 hours | € 154 | € 123 |
| 8 hours → 1 hour | € 193 | € 174 |
| 8 hours → 30 minutes | € 228 | € 226 |
| Fuel time plug-in | | |
| 3 hours → 1 hour | € 66 | € 119 |
| 3 hours → 35 minutes | € 55 | € 68 |
| 3 hours → 20 minutes | € 159 | € 230 |
| Fuel time fuel cell | | |
| 25 minutes → 15 minutes | € 58 | € 16 |
| 25 minutes → 10 minutes ** | € 159 | € 33 |
| 25 minutes → 2 minutes | € 155 | € 123 |
| Additional detour time | | |
| 30 minutes → 15 minutes | € 103 | € 158 |
| 30 minutes → 5 minutes | € 161 | € 200 |
| 30 minutes → No detour time | € 219 | € 198 |
| Models | | |
| 1 → 10 * | € 71 | € 12 |
| 1 → 50 ** | € 91 | € 25 |
| 1 → 200 ** | € 123 | € 49 |
| Free parking | € 40 | € 53 |
| Access bus lanes | € 6 | € 19 |

*, ** = Difference is statistically significant at 10% and 5%, respectively (based on confidence intervals)

Other WTP differences between lease car drivers and private car owners are not significant in a statistical sense. Still, the point estimates may be quite different. For example, negative WTP estimates for electric cars and fuel cell cars are higher for lease car drivers than for private car owners. A plausible explanation is that, on average, lease car drivers dislike driving range limitations more than private car owners. Evidence for this explanation is provided by looking at the WTP estimates for driving range. The average WTP for an increase in driving range of the electric car is lower for lease car drivers, especially the WTP for an increase from 75 to 150 kilometres. Average WTP for an increase in driving range of the fuel cell car is much higher for lease car drivers. This pattern suggests that, compared to private car owners, preferences of lease car drivers are more affected by driving range increases at higher driving ranges.

Lease car drivers furthermore appear to have a higher value of time than private car owners; WTPs for decreases in recharging/refuelling times are higher for lease car drivers with respect to the electric and fuel cell car. The patterns for fuel time of the plug-in hybrid car are somewhat strange, especially for the private sample where a decrease from 3 hours to 1 hour is significant at 5%, while a decrease from 3 hours to 35 minutes is not. On the whole, private car owners appear to be somewhat more sensitive to fuel time decreases for the plug-in hybrid than lease car drivers. The pattern for additional detour time is also interesting. Whereas private car owners don't see much added value in a further decrease in additional detour time below 15 minutes, lease car drivers appear only interested when additional detour times below 15 minutes are achieved, and are even willing to pay substantial amounts of money for a reduction from 5 to 0 minutes. Finally, lease car drivers appear to be slightly less affected by policy measures, although differences are not significant in a statistical sense.

## 6. Robustness and preference heterogeneity

In this section we assess the robustness of our results and explore heterogeneity in preferences for car types and car attributes. In the first subsection we discuss mixed logit model estimations, basically to test robustness of the results presented in the previous section (see Hensher and Greene, 2003, for an extensive discussion of the mixed logit model). An advantage of the mixed logit model is that it also gives insight into the magnitude of preference heterogeneity for the various attributes. Since the model does not reveal the underlying sources of heterogeneity, we estimate a MNL model including background and car use interactions in the second subsection. From this we aim at identifying relevant market segments and potential early adopters of alternative fuel vehicles within the lease market.

### 6.1 Insights from mixed logit models

In this section we discuss the results from a mixed logit model with parameter distributions for all attributes. For the simulations we use a maximum of 100 iterations and 2,000 Halton draws from a triangular distribution. Results for the full sample and the sample with choice sets that contain the conventional technology (CT sample) are presented in Table 12.

Table 12. Mixed logit estimation results for the full and the CT sample (monthly costs in Euro, purchase price in 1,000 Euro)

| | Full sample | | | CT sample | | |
|---|---|---|---|---|---|---|
| | **b** | **se** | **p** | **b** | **se** | **p** |
| **Means of parameter distributions** | | | | | | |
| Perceived environmental performance | 0.2158 | 0.0922 | 0.019 | 0.0866 | 0.0843 | 0.304 |
| Perceived safety performance | 0.1349 | 0.0821 | 0.100 | 0.1055 | 0.0780 | 0.176 |
| Hybrid | −0.0424 | 0.1556 | 0.785 | −0.3259 | 0.2582 | 0.207 |
| Electric | −5.3624 | 0.2606 | 0.000 | −3.5980 | 0.3869 | 0.000 |
| Plug-in hybrid | −1.3615 | 0.1831 | 0.000 | −1.0204 | 0.2988 | 0.001 |
| Flexifuel | −0.6691 | 0.1556 | 0.000 | −0.7486 | 0.2454 | 0.002 |
| Fuel cell | −2.8311 | 0.1873 | 0.000 | −2.1679 | 0.3036 | 0.000 |
| Range electric | 0.0042 | 0.0006 | 0.000 | 0.0027 | 0.0009 | 0.002 |
| Range fuel cell | 0.0042 | 0.0004 | 0.000 | 0.0027 | 0.0005 | 0.000 |
| Fuel time electric | −0.0018 | 0.0003 | 0.000 | −0.0011 | 0.0007 | 0.094 |
| Fuel time plug-in hybrid | −0.0024 | 0.0010 | 0.013 | −0.0021 | 0.0017 | 0.221 |
| Fuel time fuel cell | −0.0273 | 0.0048 | 0.000 | −0.0225 | 0.0083 | 0.007 |
| Detour time | −0.0230 | 0.0027 | 0.000 | −0.0282 | 0.0038 | 0.000 |
| Models | 0.0016 | 0.0003 | 0.000 | 0.0014 | 0.0005 | 0.002 |
| Free parking | 0.1314 | 0.0591 | 0.026 | 0.1151 | 0.0919 | 0.210 |
| Access to bus and taxi lanes | 0.0355 | 0.0588 | 0.547 | −0.0374 | 0.0923 | 0.686 |
| Tax percentage charge | −0.0536 | 0.0041 | 0.000 | −0.0468 | 0.0048 | 0.000 |
| Monthly costs | −0.0041 | 0.0002 | 0.000 | −0.0029 | 0.0002 | 0.000 |
| Purchase price | −0.0537 | 0.0072 | 0.000 | −0.0272 | 0.0097 | 0.005 |
| **Standard deviations of parameter distributions** | | | | | | |
| Perceived environmental performance | 0.8916 | 0.3244 | 0.006 | 0.0361 | 0.1667 | 0.828 |
| Perceived safety performance | 0.5592 | 0.4446 | 0.209 | 0.1577 | 0.1313 | 0.230 |
| Hybrid | 0.0469 | 1.1573 | 0.968 | 0.0606 | 0.4700 | 0.897 |
| Electric | 4.6396 | 0.3099 | 0.000 | 0.5505 | 0.2818 | 0.051 |
| Plug-in hybrid | 1.9990 | 0.3435 | 0.000 | 0.3358 | 0.3939 | 0.394 |
| Flexifuel | 2.0220 | 0.3098 | 0.000 | 0.0430 | 0.2198 | 0.845 |
| Fuel cell | 2.3624 | 0.2468 | 0.000 | 0.1679 | 0.2212 | 0.448 |
| Range electric | 0.0083 | 0.0029 | 0.004 | 0.0002 | 0.0017 | 0.930 |
| Range fuel cell | 0.0032 | 0.0036 | 0.380 | 0.0005 | 0.0010 | 0.602 |
| Fuel time electric | 0.0002 | 0.0022 | 0.941 | 0.0016 | 0.0008 | 0.035 |
| Fuel time plug-in hybrid | 0.0005 | 0.0065 | 0.944 | 0.0009 | 0.0035 | 0.802 |
| Fuel time fuel cell | 0.0164 | 0.0331 | 0.620 | 0.0303 | 0.0136 | 0.025 |
| Detour time | 0.0200 | 0.0164 | 0.223 | 0.0023 | 0.0060 | 0.705 |
| Models | 0.0062 | 0.0005 | 0.000 | 0.0003 | 0.0004 | 0.439 |
| Free parking | 0.6657 | 0.3839 | 0.083 | 0.3560 | 0.2176 | 0.102 |
| Access to bus and taxi lanes | 0.0031 | 0.7012 | 0.996 | 0.3991 | 0.2122 | 0.060 |
| Tax percentage charge | 0.1283 | 0.0125 | 0.000 | 0.0025 | 0.0088 | 0.779 |
| Monthly costs | 0.0083 | 0.0006 | 0.000 | 0.0015 | 0.0005 | 0.005 |
| Purchase price | 0.1595 | 0.0283 | 0.000 | 0.0475 | 0.0252 | 0.060 |
| NOBS | | 7,519 | | | 2,981 | |
| Iterations completed | | 89 | | | 43 | |
| Log-L | | −5,881 | | | −2,381 | |
| Restricted Log-L | | −8,260 | | | −3,275 | |
| Pseudo R2 (adjusted) | | 0.286 | | | 0.268 | |

Comparing ML coefficients with MNL coefficients reveals that signs are identical. In order to make comparisons in terms of magnitude we calculate average willingness-to-pay estimates from the 'means of parameter distributions' and compare these with the MNL WTP estimates; results are reported in Table 13.

Table 13. Comparison of WTP estimates (in Euro per month) from MNL and ML models for the full and the CT sample

| | **Full sample** | | **CT sample** | |
|---|---|---|---|---|
| **Attributes** | **MNL** | **ML** | **MNL** | **ML** |
| Environmental performance | € 49 | € 53 | € 31 | € 30 |
| Safety performance | € 33 | € 33 | € 40 | € 36 |
| Hybrid | –€ 228 | –€ 10 | –€ 366 | –€ 112 |
| Electric | –€ 1,554 | –€ 1,308 | –€ 1,509 | –€ 1,241 |
| Plug-in hybrid | –€ 599 | –€ 332 | –€ 604 | –€ 352 |
| Flexifuel | –€ 404 | –€ 163 | –€ 513 | –€ 258 |
| Fuel cell | –€ 979 | –€ 691 | –€ 1,014 | –€ 748 |
| Range electric | € 1.26 | € 1.02 | € 0.92 | € 0.93 |
| Range fuel cell | € 1.06 | € 1.02 | € 0.99 | € 0.93 |
| Fuel time electric | –€ 0.46 | –€ 0.44 | –€ 0.45 | –€ 0.38 |
| Fuel time plug-in | –€ 0.80 | –€ 0.59 | –€ 0.75 | –€ 0.72 |
| Fuel time fuel cell | –€ 7.70 | –€ 6.66 | –€ 8.36 | –€ 7.76 |
| Detour time | –€ 6.66 | –€ 5.61 | –€ 9.95 | –€ 9.72 |
| Models | € 0.42 | € 0.39 | € 0.45 | € 0.48 |
| Free parking | € 41.4 | € 32.0 | € 40.7 | € 39.7 |
| Access bus lanes | € 6.79 | € 8.66 | –€ 8.30 | –€ 12.9 |

Although mixed logit WTP estimates are generally somewhat lower than their MNL counterparts, results of the two models are very comparable, with the exception of the WTPs associated with car type constants. In both samples these are substantially lower for the mixed logit than for the MNL model, although the preference ranking of car types is identical in all cases. Ultimately, using the insight from both models as upper and lower bounds seems to be a sensible strategy in dealing with the uncertainty on which parameters to use for addressing policy related questions and model simulations.

Something that the MNL model does not provide, but the mixed logit model does, is insight into preference heterogeneity, represented in Table 12 by the 'standard deviations of parameter distributions'. With respect to the full sample the heterogeneity in preferences for many attributes is large and statistically significant at the usual critical significance levels. There appears to be little to no heterogeneity on preferences on the hybrid car, on fuel time and additional detour time, on range of the fuel cell car and on access to bus lanes. The results for the CT sample are quite different. In general the estimated standard deviations of parameter distributions are much smaller than for the full sample and many of them are now statistically insignificant. Interesting is that the heterogeneity for the electric car, with a range of 75 km and an 8 hour recharge time, remains large and statistically significant. Furthermore robust are the estimated heterogeneity for purchase price and monthly costs and for free parking as a government incentive. Results furthermore show that, in contrast with the full sample, heterogeneity on fuel time of the electric and fuel cell car and heterogeneity on access to bus lanes as a government incentive, appear to be substantial.[6]

It is difficult to assess the underlying reasons for the differences between the two samples. It is possible that choices in choice sets that do not contain the conventional technology are random more often, but that people more often choose the conventional technology when it is included in a choice set without looking at and weighing the attributes of the other options. Both issues likely hold to a certain extent, and although it is unclear in what way they affect the estimates of heterogeneity, it is clear that the effects could be substantial.

Whatever the underlying reasons of the differences found between the two samples, in all cases the standard deviation estimates are substantially lower for the CT sample than for the full sample. Some results are robust, at least in terms of statistical significance: estimates on preference heterogeneity for the electric car, driving range of the electric car, free parking and purchase price and monthly costs, are large and statistically significant. For these attributes or attribute levels we can be fairly sure that preferences are indeed heterogeneous to a large extent. As discussed earlier, the mixed logit model is well suited to assess the magnitude of possible heterogeneity in consumer preferences, but it does not reveal its sources. In the next subsection we treat this particular issue in more detail.

### 6.2 Market segmentations

We obtained respondent background characteristics, car and car use characteristics both from our choice experiment survey and from TNS-NIPO. In this section we analyse to what extent these characteristics matter for AFV preferences in the lease market. We estimate a MNL model with interaction effects, i.e., interactions between background characteristics and the choice experiment attributes. The estimation strategy is as follows. For the full sample we estimate a model with an interaction effect for every background characteristic separately. Those interactions that appear to matter, or are interesting because they do not appear to matter, were included in a model with multiple interaction effects. From this model we subsequently excluded some of the interaction effects that turned out not to matter, while some of these were still included in the final model because their irrelevance is interesting in itself, or because they matter for one attribute but not for the other. This strategy prevents that not only those characteristics are selected that we expect to be relevant a priori, but at the same time ensures that we still end up with a fairly parsimonious model. The results are presented in Table 14.

[6] The common assumption in a mixed logit model is that the random parameters are normally or triangularly distributed, which generally forces the resulting parameter distribution to include positive/negative values even when such values are theoretically unlikely. For example, full sample results for electric car driving range suggest that a substantial part of respondents values range negatively, i.e., should be compensated when driving range increases, *ceteris paribus*. This is of course not the case, and solely the result of the before mentioned distributional assumption. The estimates from the mixed logit model must therefore be treated with caution and be interpreted purely as indications of the magnitude of preference heterogeneity, and not as credible or accurate indicators of the actual preference distribution. A possible improvement in this respect could be the use of a restricted triangular distribution, with which we can restrict the lower or upper bound to zero. Also the estimation of a latent class mixed logit model would be a possible solution, because it is more flexible in its assumptions by allowing for bi- or multi-modal preference distributions. Although this would be an interesting extension of our estimations, it is beyond the scope of this paper.

Table 14. MNL estimation results for a model with interaction effects for the full sample (monthly costs in Euro, purchase price in 1,000 Euro)

| | b | se | p |
|---|---|---|---|
| **Main effects (reference for interaction effects)** | | | |
| Environmental performance | 0.1300 | 0.0502 | 0.010 |
| Safety performance | 0.0902 | 0.0463 | 0.052 |
| Hybrid | 0.2275 | 0.1420 | 0.109 |
| Electric | −1.7997 | 0.5989 | 0.003 |
| Plug-in hybrid | −0.3374 | 0.1374 | 0.014 |
| Flexifuel | 0.3670 | 0.1403 | 0.009 |
| Fuel cell | −0.3436 | 0.7577 | 0.650 |
| Range electric | 0.0033 | 0.0026 | 0.198 |
| Range fuel cell | 0.0006 | 0.0017 | 0.711 |
| Fuel time electric | −0.0009 | 0.0003 | 0.001 |
| Fuel time plug-in | −0.0022 | 0.0007 | 0.003 |
| Fuel time fuel cell | −0.0183 | 0.0037 | 0.000 |
| Detour time electric | −0.0042 | 0.0087 | 0.630 |
| Detour time flexifuel | −0.0322 | 0.0054 | 0.000 |
| Detour time fuel cell | −0.0209 | 0.0038 | 0.000 |
| Models | 0.0011 | 0.0002 | 0.000 |
| Free parking | 0.0766 | 0.0444 | 0.084 |
| Access to bus lanes | 0.0176 | 0.0475 | 0.711 |
| Monthly costs | −0.0014 | 0.0007 | 0.049 |
| Purchase price | −0.0301 | 0.0045 | 0.000 |
| Tax percentage charge | −0.0407 | 0.0027 | 0.000 |
| **Interactions annual mileage** | | | |
| Electric × (7,500 < Annual mileage < 15,000) | −0.6467 | 0.6285 | 0.304 |
| Electric × (15,000 < Annual mileage < 25,000) | −0.6387 | 0.5984 | 0.286 |
| Electric × (25,000 < Annual mileage < 35,000) | −0.8796 | 0.5965 | 0.140 |
| Electric × (35,000 < Annual mileage < 45,000) | −0.9299 | 0.6005 | 0.122 |
| Electric × (Annual mileage > 45,000) | −1.0940 | 0.6040 | 0.070 |
| Fuel cell × (7,500 < Annual mileage < 15,000) | −0.7228 | 0.8766 | 0.410 |
| Fuel cell × (15,000 < Annual mileage < 25,000) | −0.9658 | 0.7936 | 0.224 |
| Fuel cell × (25,000 < Annual mileage < 35,000) | −1.0112 | 0.7848 | 0.198 |
| Fuel cell × (35,000 < Annual mileage < 45,000) | −1.0713 | 0.7883 | 0.174 |
| Fuel cell × (Annual mileage > 45,000) | −1.4875 | 0.7853 | 0.058 |
| Range electric × (7,500 < Annual mileage < 15,000) | −0.0000 | 0.0028 | 0.998 |
| Range electric × (15,000 < Annual mileage < 25,000) | 0.0004 | 0.0026 | 0.875 |
| Range electric × (25,000 < Annual mileage < 35,000) | 0.0002 | 0.0026 | 0.945 |
| Range electric × (35,000 < Annual mileage < 45,000) | 0.0004 | 0.0026 | 0.891 |
| Range electric × (Annual mileage > 45,000) | −0.0001 | 0.0026 | 0.968 |
| Range fuel cell × (7,500 < Annual mileage < 15,000) | 0.0012 | 0.0020 | 0.559 |
| Range fuel cell × (15,000 < Annual mileage < 25,000) | 0.0022 | 0.0018 | 0.227 |
| Range fuel cell × (25,000 < Annual mileage < 35,000) | 0.0019 | 0.0018 | 0.281 |
| Range fuel cell × (35,000 < Annual mileage < 45,000) | 0.0021 | 0.0018 | 0.249 |
| Range fuel cell × (Annual mileage > 45,000) | 0.0028 | 0.0018 | 0.113 |

Table 14. *Continued*

| | b | se | p |
|---|---|---|---|
| **Interactions 1st versus 2nd car and fuel type** | | | |
| Electric × Car is 2nd car in household | 0.9475 | 0.3023 | 0.002 |
| Range electric × Car is 2nd car in household | −0.0030 | 0.0017 | 0.081 |
| Hybrid × Current fuel diesel | −0.2542 | 0.1398 | 0.069 |
| Electric × Current fuel diesel | −0.1373 | 0.1231 | 0.265 |
| Plug-in hybrid × Current fuel diesel | −0.3026 | 0.1131 | 0.008 |
| Flexifuel × Current fuel diesel | −0.4240 | 0.1382 | 0.002 |
| Fuel cell × Current fuel diesel | −0.3409 | 0.1173 | 0.004 |
| Detour time electric × Current fuel diesel | 0.0041 | 0.0113 | 0.718 |
| Detour time flexifuel × Current fuel diesel | 0.0225 | 0.0074 | 0.002 |
| Detour time fuel cell × Current fuel diesel | 0.0037 | 0.0053 | 0.481 |
| **Interactions weight current car** | | | |
| Hybrid × Weight car > 1,400 kg | −0.4576 | 0.1477 | 0.002 |
| Electric × Weight car > 1,400 kg | −0.2509 | 0.1228 | 0.041 |
| Plug-in hybrid × Weight car > 1,400 kg | −0.3304 | 0.1203 | 0.006 |
| Flexifuel × Weight car > 1,400 kg | −0.3069 | 0.1118 | 0.006 |
| Fuel cell × Weight car > 1,400 kg | −0.3340 | 0.1010 | 0.001 |
| **Interactions holidays** | | | |
| Electric × Caravan | −0.8028 | 0.4277 | 0.061 |
| Plug-in hybrid × Caravan | −0.5842 | 0.1904 | 0.002 |
| Fuel time electric × Caravan | −0.0014 | 0.0011 | 0.216 |
| Fuel time fuel cell × Caravan | −0.0278 | 0.0079 | 0.001 |
| **Interactions on recharging potential and policy measures** | | | |
| Free parking × Paid parking in very urbanised area | 0.4227 | 0.1462 | 0.004 |
| Access to bus lanes × Very urbanised area | −0.0160 | 0.1003 | 0.873 |
| Electric × recharging potential at home | −0.0380 | 0.1545 | 0.806 |
| Range electric × recharging potential at home | 0.0002 | 0.0008 | 0.785 |
| **Interactions on costs, price and tax** | | | |
| Monthly costs × (7,500 < Annual mileage < 15,000) | −0.0004 | 0.0008 | 0.585 |
| Monthly costs × (15,000 < Annual mileage < 25,000) | −0.0013 | 0.0007 | 0.088 |
| Monthly costs × (25,000 < Annual mileage < 35,000) | −0.0013 | 0.0007 | 0.079 |
| Monthly costs × (35,000 < Annual mileage < 45,000) | −0.0014 | 0.0007 | 0.065 |
| Monthly costs × (Annual mileage > 45,000) | −0.0015 | 0.0007 | 0.042 |
| Purchase price × Price next car < 15,000 Euro | −0.0521 | 0.0157 | 0.001 |
| Tax charge × Price next car < 15,000 Euro | 0.0145 | 0.0072 | 0.043 |
| NOBS | | 7,519 | |
| Log-L | | −6,162 | |
| Restricted Log-L | | −8,251 | |
| Pseudo R2 (adjusted) | | 0.250 | |

The main effects in the table primarily serve as reference categories for the interaction effects. These main effects estimates represent preferences for specific groups within our sample. For example, when we estimate preferences for driving range for those respondents with an annual mileage larger than 7,500 kilometres, the main effect on range represents the preferences of respondents with an annual mileage lower than

7,500 kilometres. In terms of magnitude the main effects presented in Table 14 therefore differ somewhat from the average estimates presented in Section 4.

An essential variable in explaining heterogeneity of preferences for the electric and fuel cell car is annual mileage. Preferences for the electric car with a driving range of 75 kilometres decrease substantially when annual mileage increases, but preferences for increases in driving range do not increase with annual mileage. Preferences for the fuel cell car with a driving range of 250 kilometres decrease even more with annual mileage, but here we do find that the preferences for increases in driving range are higher for those with a high annual mileage. Although the coefficients are statistically insignificant, the pattern clearly shows increasing WTP's and the differences are substantial. A similar analysis for private car owners also shows the importance of annual mileage for electric and fuel cell car preferences (see Hoen and Koetse, 2012), but the patterns are quite different. Where private car owners display larger heterogeneity for the electric car than for the fuel cell car, for lease car drivers it is the other way around. Moreover, the WTP of lease car drivers for fuel cell driving range increases with annual mileage but the WTP of private car owners does not, while exactly the opposite is true for driving range of the electric car. This result is in line with the fact that lease car drivers generally have higher annual mileages than private car owners, and that for many lease car drivers the electric car is a less attractive option due to its much smaller driving range. The fuel cell car appears to be a more serious alternative, probably because maximum driving range of the fuel cell car is substantially higher than for the electric car. Evidence for this conclusion is also provided by the electric and fuel cell constants for those with an annual mileage below 7,500 kilometres (the reference category), which is substantially more negative for the electric car than for the fuel cell car, in contrast to the pattern found for private car owners (Hoen and Koetse, 2012).

Also interesting is the finding that when the lease car is the second car in the household, which does not occur very often (circa 5% in our sample), preferences for the electric car with a 75 kilometre driving range are substantially less negative and WTP for driving range increases is close to zero.[7] When checking statistics for this group we observe that it consists of people with a relatively limited annual mileage, who live at relatively short distances from their work, and of which more than 15% does not or very rarely commute to work by car.[8] Apparently, these circumstances and the existence of substitution possibilities make that driving range limitations are not much of a limitation at all. Although this finding applies to only a small part of all lease car drivers, the effect is large and may reveal an interesting niche market for cars with limited driving range.

Weight of the car appears to matter, i.e., those with heavier cars are more negative about alternative fuel vehicles in general. Since the finding holds for all AFV types this result is likely not related to a specific AFV characteristic, such as limited driving range or longer refuelling times, but actually reflects intrinsic AFV preferences. Those who use the car to go on holidays abroad with a caravan are substantially more negative on the electric and plug-in hybrid car. For the electric car this result may of course be related to limited driving range, but it is also quite likely that uncertainty and perceptions on motor power are important factors. Having the opportunity to charge an electric vehicle at home appears not to matter for electric car and electric driving range preferences.

[7] In order to be check whether the 2nd car variable does not pick up some sort of residual annual mileage effect we also estimated a model in which we interact the 2nd car dummy with the electric car constants for each mileage category. The results are similar, although the pattern is somewhat erratic since the number of observations for some of the 2nd car interaction variables are very limited. Note furthermore that the effect is absent for fuel cell cars.

[8] Detailed descriptive statistics for the 1st and 2nd car are available upon request from the authors.

Although having access to bus lanes is potentially more attractive in very urbanised areas than in other areas, our results show no effect, i.e., access to bus lanes remains a policy measure that, at least in our choice context, does not stimulate lease car drivers to buy an alternative fuel vehicle. Free parking, on the other hand, does have a substantial effect on choices made by people who live in very urbanised areas and have paid parking in their neighbourhood.

With respect to cost sensitivity, respondents who indicate that their next lease car will have a relatively low catalogue price are more sensitive to catalogue price, but less sensitive to the tax percentage charge. An interpretation of this finding could be that there is a group with very strict budget restrictions implemented by their employers, but with otherwise similar household budget restrictions, leading to a reduced sensitivity for the height of the tax percentage charge. Finally, annual mileage not only affects fuel type and range preferences, but also appears to be relevant for cost sensitivity, i.e., those who drive more are more sensitive to monthly costs. This makes it difficult to make a priori inferences about which annual mileage group is more likely to adopt an electric or fuel cell car in the future, since it strongly depends on developments on both driving range and financial lease structures. Since annual mileage is by far the most important factor in explaining preference heterogeneity for electric and fuel cell cars, insight into which mileage group is most likely to adopt under specific circumstances is important for effective policy making. We therefore do market simulations in the next section to shed more light on this issue.

## 7. Effects of mileage, costs and driving range on market shares of the electric and fuel cell car

In this section we aim to get insight into which annual mileage category is more likely to adopt an electric or fuel cell car under various circumstances. For this we simulate market shares of the electric and the fuel cell car for six different annual mileage categories. From the previous section it is clear that driving range and monthly costs are two crucial factors in this respect, so in order to cover a wide range of possible scenarios we use five cost structure scenarios and four driving range scenarios. For the simulations we systematically vary the monthly costs and driving range for the electric and fuel cell car. Monthly costs takes on values of 0, 100, 200, 300 and 400, driving range of the electric car takes on values of 75, 150, 250 and 350, and driving range of the fuel cell car takes on values of 250, 350, 450 and 550. All other attribute values were kept constant according to the information provided in Table 15, leading to a total of 20 sets of market share simulations (five cost structure scenarios times four driving range scenarios).

For this simulation exercise we estimate a separate model, which includes no interactions other than the interactions of annual mileage with monthly costs, with the electric and fuel cell car constants, and with driving range of the electric and fuel cell car.[9] After estimating the model, the attributes take on the values provided in Table 15, and we derive market shares for each of the six car types distinguished in our experiment. Relevant for our purposes in this section is that we obtain electric and fuel cell car market shares for each of the six annual mileage categories, for the 20 different monthly cost-driving range scenarios.

[9] Estimation results are available upon request from the authors.

Table 15. Attribute values used for the simulations

| | Conventional technology | Hybrid | Plug-in hybrid | Flexifuel | Electric | Fuel cell |
|---|---|---|---|---|---|---|
| Price | € 20,000 | € 25,000 | € 25,000 | € 25,000 | € 35,000 | € 35,000 |
| Monthly costs | € 200 | € 200 | € 200 | € 200 | **€ 0 - € 400** | **€ 0 - € 400** |
| Tax charge | 25% | 14% | 14% | 14% | 0% | 0% |
| Range | -- | -- | -- | -- | **75 – 350 km** | **250 - 550 km** |
| Refuel time | -- | -- | 3 hours | -- | 8 hours | 25 minutes |
| Detour time | -- | -- | -- | 30 minutes | 0 minutes | 30 minutes |
| Models | -- | 10 | 10 | 10 | 10 | 10 |
| Policy | -- | Current policy | Current policy | Current policy | Current policy | Current policy |

Although the predicted electric and fuel cell car market shares are interesting in themselves, we are primarily interested in the market share differences between the six annual mileage groups. We therefore focus on these differences and not on the actual predicted market shares. It is furthermore not very insightful to compare all annual mileage groups, so we present only the differences in market shares between the highest (more than 45,000 kilometres per year) and the lowest (less than 7,500 kilometres per year) annual mileage group. In Table 16 we present the ratio of the market shares for these two mileage groups, for each of the 20 scenarios. From the table various interesting patterns emerge. Most relevant for our purposes is that, for an electric car driving range of 75 km and a fuel cell car driving range of 250 km, the differences in market shares between the two annual mileage categories are large, both for electric and fuel cell cars. More specifically, those with a relatively low annual mileage have substantially larger predicted market shares than those with a relatively high annual mileage. Moreover, these differences increase when monthly costs of electric and fuel cell cars increase compared to monthly costs of other cars. This is because people that drive more are more sensitive to monthly costs than those who drive less.

Table 16. Electric and fuel cell car market shares for the highest annual mileage group divided by market shares for the lowest annual mileage group, for five cost structure and four driving range scenarios [a]

| | | Monthly costs electric and fuel cell cars in Euro per month | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 100 | 200 | 300 | 400 |
| Driving range electric car | 75 km | 33% | 29% | 25% | 21% | 18% |
| Driving range fuel cell car | 250 km | 68% | 59% | 50% | 43% | 37% |
| Driving range electric car | 150 km | 38% | 33% | 28% | 24% | 21% |
| Driving range fuel cell car | 350 km | 87% | 76% | 65% | 56% | 48% |
| Driving range electric car | 250 km | 45% | 39% | 34% | 29% | 25% |
| Driving range fuel cell car | 450 km | 111% | 97% | 84% | 72% | 62% |
| Driving range electric car | 350 km | 53% | 46% | 40% | 35% | 30% |
| Driving range fuel cell car | 550 km | 139% | 122% | 107% | 93% | 80% |

[a] Highest annual mileage group has mileage of more than 45,000 kilometres per year, while lowest annual mileage group has a mileage of less than 7,500 kilometres per year

In general, the patterns found for larger driving ranges of electric and fuel cell cars are comparable; market shares for those who drive few kilometres are higher and the differences between the two annual mileage categories increase when monthly costs increase relative to other cars. Also interesting to observe is that differences between the two annual mileage categories decrease when driving range increases, which is the result of the higher willingness to pay for increases in driving range of people who drive more. For the electric car this reduction in market share differences does not lead to a reversal of the general pattern found, i.e., people with a relatively low annual mileage are more likely to adopt than people with a relatively high annual mileage, regardless of driving range and monthly costs. For the fuel cell car this pattern is reversed in some cases. However, these cases are rather extreme, i.e., when monthly costs are relatively low and for fuel cell car driving ranges of 450 and 550 kilometres, those who drive more are more likely to adopt a fuel cell car than those who drive less.

In conclusion, an assessment of which market segments are most likely to adopt electric an fuel cell vehicles is to a certain extent dependent on monthly cost structure and future driving range developments. However, our findings show that in the current situation, with relatively low driving ranges for both the electric and the fuel cell car, those with a relatively low annual mileage are more likely to adopt an electric or fuel cell car than those with a relatively high annual mileage.

## 8. Summary and discussion

In this paper we aim to obtain insight into the preferences of lease car drivers for AFVs and AFV characteristics, to uncover the background and car use characteristics that affect these preferences, and to identify possible early adopters. For this we conduct a choice experiment among Dutch lease car drivers using the automotive panel from TNS-NIPO. Although choice experiments represent the state-of-the-art in stated preference research, caution is required in using the results, e.g., for modelling future AFV demand. First, choices made by respondents in choice experiments are hypothetical and may, for various reasons, be different from choices made in reality. Second, preferences may change substantially over time because of, for example, technological developments and reductions in uncertainty on AFV performance and costs. Repeating this experiment in due time is therefore essential.

In the experiment we presented each respondent with eight choice tasks, of which each consists of three car choice options. Next to the conventional technology we distinguish five different alternative technologies, i.e., hybrid, plug-in hybrid, flexifuel, electric and fuel cell cars. In the experiment all car types have eight attributes. Purchase price was made respondent specific by using information on the presumed purchase price of the next car, as indicated by respondents in the beginning of the online survey. Other attributes were monthly costs to be paid to the employer, tax percentage charge (car-specific tax charge used to calculate the figure that is added to taxable income), driving range, refuelling time, additional detour time to reach a fuel station, number of available models, and a policy measure. Not all attributes vary for each car type, so we generated an alternative-specific design; attribute levels for purchase price, driving range, refuelling time and additional detour time were car type specific. Ultimately we obtained 940 complete and useable choice experiment surveys and a total of 7,519 observations.

Results from multinomial logit models show that, on average and assuming current AFV characteristics, preferences for AFVs are substantially lower than those for the conventional technology. Limited driving range, long refuelling times and limited availability of refuelling opportunities are to a large extent responsible for this. These barriers are most substantial for the electric car, and to a lesser extent for the fuel cell car, and it is therefore not surprising that, ignoring differences in purchase price and monthly costs, negative preferences for these two car types are largest. However, under current circumstances these negative preferences for AFVs are substantially mitigated by the prevailing tax regime that favours cleaner technologies. Moreover, average preferences for AFVs increase considerably when improvements in driving range, refuelling time and additional detour time are made. An increase in the number of available models from which a consumer can chose has a substantial positive effect as well. The results also show that, when substantial improvements on these issues occur, average negative preferences remain, and remain substantial. Likely most AFV technologies are relatively unknown, and their performance and comfort levels are uncertain for most people, which may be contributing factors in this respect.

In assessing possible non-linearities we find that the effect of driving range on preferences only shows a slightly non-linear pattern, in contrast to results for private car owners, where marginal WTP for driving range decreases substantially at higher driving ranges (see Hoen and Koetse, 2012). The effect of reductions in refuelling/recharge time are highly non-linear; marginal WTP for time reductions increases when refuelling/recharge time decreases. We find a similar pattern for reductions in additional detour time. In sharp contrast to results for private car owners, especially reductions below 15 minutes of additional detour time have a large impact, the most substantial WTP being for a reduction from 5 to 0 minutes. Finally, increasing the number of models has relatively much added value compared to results for the private market, and marginal WTP per model is highest when the number of models is low.

To test robustness of the MNL results we estimate a mixed logit model in which each of the attribute parameters is assumed to be triangularly distributed. Mixed logit WTP estimates are generally somewhat lower than their MNL counterparts, but otherwise results of the two models are similar, with the exception of the WTPs associated with car type constants. In both samples these are substantially lower for the mixed logit than for the MNL model, although the preference ranking of car types is identical in all cases. Ultimately, using the insight from both models as upper and lower bounds seems to be a sensible strategy in dealing with the uncertainty on which parameters to use for addressing policy related questions and model simulations. The mixed logit results furthermore indicate that there is substantial heterogeneity in consumer preferences for AFVs and AFV characteristics. They do not, however, reveal the underlying sources of heterogeneity. We therefore we estimate a model with interactions between the car attributes and respondent background and car (use) characteristics. Several variables, such as using the car for holidays abroad and fuel type, appear to be relevant for car choice. With respect to heterogeneity in preferences for the electric and fuel cell car by far the most important factor is annual mileage, i.e., preferences of those with low annual mileage are far less negative than preferences of those with high annual mileage. The main explanation for this pattern is that those who drive more run into problems of limited driving range more often. Because kilometres driven during a single day will also often exceed the maximum electric driving range for this group, recharging would have to take place not only at night but also somewhere in between trips. Recharging potential and recharge time are limiting factors in that respect as well. Furthermore interesting is that annual mileage has a large impact on willingness to pay for driving range as well, implying that the heterogeneity in preferences for electric and fuel cell cars decreases substantially when driving range increases. Because annual mileage also has a substantial impact on cost sensitivity, the differences in predicted market shares of electric and fuel cell cars for different annual mileage categories depend on both driving range of the electric and fuel cell car and differences in monthly costs of the different car categories. Market simulations show that differences between annual mileage groups are substantial in most cases, but decrease when driving range increases and when monthly costs of electric and fuel cell cars increase relative to monthly costs of other cars. In the end, people with a relatively low annual mileage are more likely to adopt an electric car than others, regardless of driving range and differences in monthly costs. The findings for the fuel cell car are similar, although when driving range is high and cost differences are large the pattern is reversed, i.e., respondents with high annual mileage are more likely to adopt a fuel cell car than those with a relatively low annual mileage.

Finally, there are many interesting lines of further research. For example, it is well-known that attitudes may have strong effects on consumer preferences, implying that research on the influence of attitudes on AFV preferences is important. Also revealed preference studies will be possible in the near and somewhat farther future, now that different types of AFVs are being sold on the market. These are fairly general and well-known research directions, but several interesting lines of further research follow directly from our results. First, annual mileage has a large effect in preferences for range, indicating that the way in which someone uses his or her car may greatly affect the attractiveness of AFVs, and the electric and fuel cell car in particular. More detailed information on car use may therefore give more insight into differences in preferences between different categories of car users. For example, information on average daily kilometres would be very useful, or more generally a metric that takes into account to what extent a person can make his or her daily trips given a certain range. An interesting extension of our study would be to analyse whether preferences for the electric car, but also the fuel cell car, are affected by such differences in car use and car use patterns. Second, although preferences of lease car drivers are important for assessing future AFV adoption, probably equally important are preferences of lease car companies. Although there is an early study that uses Californian data from 1994, no studies have been done since then. Clearly, further work is necessary on this particular issue in order to more reliably assess the market potential of alternative fuel vehicles within the lease car market.

**Acknowledgements**

We gratefully acknowledge comments and suggestions by Rogier Kuin of BOVAG on a first draft of the choice experiment set-up and the questionnaire. Also the comments and suggestions by Jordy van Meerkerk, Kees Vringer and Bert van Wee on a first draft of this working paper are greatly appreciated.

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## Appendix A: Descriptive texts on attributes as presented to respondents

**Car type**
*Full electric*: a car that is set in motion by an electric motor. Batteries provide the electric motor with energy. The car must be charged to be able to drive it and electricity from a socket is suitable.

*Fuel-cell*: also called hydrogen car. A car that requires to be fuelled with hydrogen in order to be able to drive it. In the car the hydrogen is converted into electricity with fuel cells. An electric motor sets the car in motion.

*Plug-in hybrid*: a car with both a petrol or diesel engine and batteries. The batteries can be charged with a plug and the car drive several tens of kilometres solely on electricity. When the batteries are empty the car will switch to using petrol/diesel. It is thus also possible to drive solely on petrol/diesel.

*Flexifuel*: a car that, besides petrol or diesel, can drive completely on biofuels (fuels manufactured from biological materials). It could be biodiesel, bioethanol (comparable to petrol) or biogas (comparable to natural gas).

*Hybrid*: a car with batteries but without a plug. The engine in the car charges the batteries during driving and braking energy is recovered as well to charge the batteries. A hybrid can drive several kilometres solely on electricity.

**Tax percentage charge**
The tax addition for the private use of your company car. Higher percentages result in higher additions to your monthly salary over which you pay income tax.

**Personal monthly contribution**
The amount you pay to your employer for using your company car. This amount is subtracted from your monthly gross income, so a part of this contribution can be retrieved through lower income taxes.

**Range**
The number of kilometres you can drive at most on a full tank or fully charged batteries (in case of an electric car).

**Charging/refuelling time**
The time it takes to fully charge the car (electric or plug-in hybrid) or to fill your tank. NB. the time shown at the plug-in hybrid applies to charging time of the batteries.

**Additional detour time**
In the case that not every fuelling station offers the fuel your car drives on it may be that you have to drive further to be able to refuel. As the availability of the fuel for the concerning car gets lower, the additional detour time is greater.

**Number of available brands/models**
The larger the number of models, the more alternatives there are for this car type. This concerns different brands and models, and different versions regarding engine size, acceleration and size of the car.

**Policy measure**

Concerns policies with which the government aims to influence the sales of this car type. We distinguish (1) current policy, (2) free parking, which applies to both parking permits and parking zones, and (3) permission to drive on bus and taxi lanes within the built-up area. The policy only applies to the car type for which it is shown. When for example the electric car option shows 'Free parking', this policy measure only applies to electric cars and not to the other AFVs. When 'Current policy' is shown all government policies are those that hold in the current situation.

## Appendix B: Background characteristics

Table B1. Background characteristics of respondents used for model estimations

| Variable | Percentage share |
|---|---|
| **Gender** | |
| Male | 87% |
| Female | 13% |
| **Age category** | |
| 18 to 25 | 0% |
| 25 to 35 | 16% |
| 35 to 45 | 35% |
| 45 to 55 | 33% |
| 55 to 65 | 16% |
| 65 to 75 | 0% |
| **Household size** | |
| 1 person | 15% |
| 2 persons | 25% |
| 3 persons | 18% |
| 4 persons or more | 42% |
| **Highest finished education** | |
| Primary school | 0% |
| Secondary school (level 1; lowest) | 6% |
| Secondary school (level 2) | 5% |
| Secondary school (level 3) | 25% |
| Secondary school (level 4; highest) | 11% |
| Bachelor | 36% |
| Master/PhD | 16% |
| Don't know/no response | 0% |
| **Degree of urbanization** | |
| Non urbanised (less than 500 inhabitants/km2) | 13% |
| Little urbanised (500 to 1000 inhabitants/km2) | 18% |
| Moderately urbanised (1000 to 1500 inhabitants/km2) | 27% |
| Urbanised (1500 to 2500 inhabitants/km2) | 27% |
| Very urbanised (2500 or more inhabitants/km2) | 15% |

## Appendix C: Car use and travel characteristics

Table C1. Car use and travel characteristics of respondents used for model estimations

| | **Percentage share** |
|---|---|
| **New/used** | |
| Next car will be lease | 91% |
| Next car will be privately owned | 9% |
| **Purchase price next car** | |
| Less than 6,000 Euro | 6% |
| 6,000 to 12,000 Euro | 7% |
| 12,000 to 18,000 Euro | 15% |
| 18,000 to 24,000 Euro | 28% |
| 24,000 to 30,000 Euro | 33% |
| 30,000 to 40,000 Euro | 10% |
| more than 40,000 Euro | 1% |
| **Annual mileage current car** | |
| < 7,500 km | 2% |
| 7,500-15,000 km | 6% |
| 15,000-25,000 km | 18% |
| 25,000-35,000 km | 24% |
| 35,000-45,000 km | 23% |
| > 45,000 km | 26% |
| **Weight current car** | |
| < 750 kg | 1% |
| 750 – 1,000 kg | 7% |
| 1,000 – 1,250 kg | 24% |
| 1,250 – 1,500 kg | 49% |
| 1,500 – 1,750 kg | 14% |
| 1,750 – 2,000 kg | 4% |
| > 2,000 kg | 1% |
| **Frequency of car commute** | |
| Almost never | 5% |
| Once a week | 1% |
| Twice a week | 2% |
| Three times a week | 4% |
| Four times a week | 17% |
| Five or more times a week | 71% |
| **Distance to work (kilometres)** | |
| <10 km | 16% |
| 10-20 km | 13% |
| 21-30 km | 11% |
| 31-40 km | 13% |
| 41-50 km | 9% |
| 51-60 km | 7% |
| 61-70 km | 5% |
| >70 km | 25% |