

SUBSTITUTIE DOOR ELEKTRISCHE FIETSEN

(Electric bicycle use in the Netherlands)

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Samenvatting

Elektrisch fietsen is bezig aan een snelle opmars in Nederland. Verreweg de meeste e-bikes worden verkocht in China (90%) en overig Azië (5%). Van de in Europa verkochte fietsen gaat de helft naar Nederland en Duitsland. Het aandeel neemt in rap tempo toe: in 2011 was in Nederland 15% van de nieuw verkochte fietsen een e-bike. Het meeste onderzoek naar e-bikes komt uit China, dus dit paper over Nederland vult een lacune in Europa.

Er bestaan ruwweg twee soorten elektrische fietsen, namelijk fietsen met trapondersteuning tot een wettelijk maximum van 25 km/u, en volledig gemotoriseerde fietsen, die als motorfietsen gezien kunnen worden. Het onderzoek betreft de eerste categorie.

Een belangrijke vraag vanuit het perspectief van mobiliteitsstudies, is of elektrisch fietsen extra verplaatsingen genereert. Maar nog interessanter is of bestaande verplaatsingen per fiets, auto of openbaar vervoer vervangen worden door de e-bike, dus de vraag of de e-bike een meer of minder duurzaam profiel heeft.

Voor deze studie zijn elektrische fietsers uit het gehele land (n=217) gevraagd naar hun kenmerken, de kenmerken van hun elektrische fiets en hun gebruikspatronen. Bovendien is hen gevraagd om een dag lang een verplaatsingsdagboekje bij te houden.

De elektrische fietsers bleken gemiddeld 60 jaar oud, driekwart van hen zijn 55plus, iets meer vrouwen dan mannen. Per huishoudens zijn gemiddeld 1.38 e-bikes plus nog 2 andere fietsen en een auto. De e-bikes worden voornamelijk gebruikt voor recreatie, winkelen en in mindere mate voor woonwerkverkeer, veelal omdat deze gemakkelijker en comfortabeler is dan een traditionele fiets. Eenderde van de respondenten geeft aan moeilijk op een gewone fiets te rijden, dus zij zouden anders de auto of het OV nemen. De meeste verplaatsingen zijn ter vervanging van andere, dus extra ritten vinden relatief weinig plaats. Hoewel de respondenten aangeven dat 41% van de trips anders zou zijn gemaakt met een gewone fiets, wordt voor 40% aangegeven dat deze korte autoritten vervangen; de rest vervangt openbaar vervoer of lopen. Opvallend is het sterke verschil met China, waar jonge forenzen de grootste doelgroep vormen, die eerder met de bus gingen.

Samenvattend blijkt de elektrische fiets nog vooral populair onder ouderen, maar heeft potentie voor jongere leeftijdsgroepen, onder andere voor woonwerkverkeer omdat hogere snelheden en grotere afstanden mogelijk zijn. Het is onontkoombaar dat de elektrische fiets daarbij niet alleen de auto vervangt, maar ook de conventionele fiets.

1. Introduction

Electric bicycles are becoming a more popular mode of transportation all around the world and have experienced rapid growth over the last ten years with sales projected to be 24 million worldwide in 2010 (Rose, 2012). Of these, about 90% were sold in China, with an additional 5% sold to the rest of Asia. Together, the Netherlands and Germany accounted for about half of the electric bicycles sold in Europe (Rose, 2012). In 2011, electric bicycles had a 15% market share of new bicycles sold in the Netherlands, a significant increase from the 3% market share in 2006 (BOVAG RAI, 2012a). While new bicycle sales in the Netherlands dropped by 3.6% in 2011, electric bicycle sales increased by 7% to 178,000 units (BOVAG RAI, 2012b).

Because the electric bicycle makes up an increasing share of the bicycle market in the Netherlands, it will increasingly be used as a transportation option, either as a replacement for a previously used mode, or for trips that would not have been made otherwise. If electric bicycles are used as a substitute for car travel, then they could be targeted for policy measures aimed at reducing car use. This study attempts to analyze to what extent electric bicycles are being used as a replacement for other modes of transportation. The following questions will also be discussed. What are the demographics of electric bicycle users in the Netherlands, and how do they compare to other countries? What are the reasons that people choose to use electric bicycles? What are the purposes of trips made with electric bicycles? Which modes of transportation would electric bicycle users use if their electric bicycles were not available?

1.1 The Electric Bicycle

The term electric bicycle can be used to describe a wide variety of electrically powered bicycle style vehicles. Electric bicycles are generally split into two categories: powered bicycles and power assist bicycles (Rose, 2012). On powered bicycles, the motor provides power without need for pedaling, while power is added only when the pedals are being operated on electric power assist models. Electric bicycles can also be categorized on a continuum between "scooter style" which look more like a motorbike, are fully powered and can achieve higher speeds and "bicycle style" which resemble a conventional bicycle and usually feature the power assist (Cherry & Cervero, 2007).

In Europe, electric bicycles are defined as having a maximum power of 250 watts with continually less power added as the bicycle reaches 16 km/h and power entirely cut off as the bicycle reaches the maximum speed of 25 km/h or if the cyclist stops pedaling (European Council, 2002). This paper concerns these bicycle style power assist models, which meet the European definition, and are common in the Netherlands.

1.2 Major Issues and Potential Uses of Electric Bicycles

In an overview of the emerging issues and unresolved questions surrounding electric bicycles, Rose (1) discusses that electric bicycles could appeal to women, the elderly, and those with deteriorating physical capacities. They could be used as an access-egress mode for public transit or as a part of a next generation bike sharing system (Sheehan et al., 2010). Electric bicycles have the potential to reduce the barriers placed on cycling due to lack of showers and parking at the work location (Rose & Marfurt, 2007), as well as natural barriers including hilly terrain and wind (McLoughlin et al., 2012).

1.3 Current Research Regarding Electric Bicycle Use

Rose (2012) describes a clear need for further research on the use patterns of electric bicycles, and calls for additional research in order to understand the roles that these vehicles currently play, or could play in the future. The majority of the literature regarding the use patterns of electric bicycles has been done in China, so this paper

contributes an example from a western country where different demographics and attitudes may lead to different use patterns.

In China, the electric bicycle is a stepping-stone between non-motorized and motorized transportation modes, and is mostly used for the purpose of commuting by people with an average age of 35 (Cherry & Cervero, 2007; Weinert et al., 2006). In comparing the ages of electric bicycle users in China and Japan, Parker (2004) noted that people over 50 years of age purchased two thirds of electric bicycles that were sold in Japan. Women under 40 and 40-50 year old men were the next largest age groups, each purchasing 10%. This is a strong departure from the age characteristics in China and suggests that in Japan, electric bicycles are used as a mobility option for the elderly and those with physical impairment while in China they are more of an everyday transportation option. This difference could possibly be attributed to different demographics, incomes or attitudes between the two countries.

In the Netherlands, a 2008 market research report showed that most electric bicycle users were aged 65 and older. The most common trip purposes were recreation, shopping and visiting friends and relatives. Electric bicycle users most frequently chose to use a normal bicycle or an automobile when their electric bicycle was not available (Hendriksen et al., 2008).

Besides the BOVAG market research report, little empirical research has been done about electric bicycles in the Netherlands, or in any other western country. While it can be assumed that electric bicycle use patterns in the Netherlands will not be the same as those documented in China, because of cultural and economic and land use differences, research into user travel behavior would add breadth to this important and growing transportation mode.

2. Methods

The survey targeted electric bicycle users in the Netherlands. It included a one-day travel diary and supplemental questions about general use patterns. This chapter includes information about the study area (2.1), the survey itself (2.2), the distribution of the survey (2.3) and a note about its representativeness (2.4).

2.1 Study Area

The Netherlands is a northern European country with 17 million people and a density of 489 persons per square km making it the 27th densest country in the world (CBS, 2012). The Netherlands is known for the popularity of cycling, with 27% of trips made by bicycle, its extensive cycling infrastructure network, and favorable bicycling culture (Pucher & Buehler, 2008). Compared to many other western countries, bicycles are used more often for non-recreational purposes including shopping and commuting (Heinen et al., 2012).

2.2 Survey Methods

A travel diary survey was conducted in April and May 2012. The survey targeted electric bicycle users in the Netherlands.

The survey contained a section that gathered demographic data, a section with information about the person's electric bicycle, a section that asked questions about general characteristics of use patterns, and a detailed travel diary of all the trips made on the most recent day the person used their electric bicycle.

Demographic data included age, household composition, income, and number of different types of vehicles in the household. Information gathered about the electric bicycle included make, model, approximate cost and year purchased.

The questions about general characteristics of use patterns were posed in the form of statements to which survey-takers were requested to respond on an likert scale of 1-5: 1 meaning "does not apply to me at all", 2 meaning "does not apply to me", 3 being neutral, 4 meaning "applies to me" and 5 meaning "applies to me very much". The question "My electric bicycle replaces my old bicycle" is a typical example of a question from this section. Questions were grouped into three categories, in order to gain some general and broad insight into the three remaining sub-questions: reasons for use, trip purpose, and alternate modes of transportation that electric bicycle trips may be replacing.

The travel diary section asked for purpose of trip, length in minutes, distance in kilometers and which mode would be used if an electric bicycle were not available. Answers from this section provide a second, and more specific, way of answering the sub-questions regarding trip purpose and replacement mode.

2.3 Distribution of survey

Surveys were distributed in April and May 2012 in both an online and paper form. The majority of respondents were referred to the online survey by a link that was featured in the Fietsersbond's (Dutch cycling union) monthly email newsletter. A link to the survey was posted on the electric bicycle section of the website of elektrischefiets.org and on the Fietsersbond website. Invitations to participate in the survey were placed on parked electric bicycles around the Delft city center in two ways: a paper version of the survey with an addressed, stamped envelope, and a short introduction followed by a link to the online survey. Finally, an online version of the survey was distributed to known electric bicycle users that were found through a snowball method, where electric bicycle users referred other electric bicycle users to the survey. The frequency of valid responses for each collection means can be found in Table 1.

In total, 217 valid responses were collected, after filtering out surveys that were mostly incomplete or were completed by somebody who was not an electric bicycle user. These surveys were identified by those who entered '0' in the field for number of electric bicycles or those who wrote something similar to "no e-bike" in the field for make and model of electric bicycle.

Responses were collected from all over the Netherlands and were evenly distributed around the country.

TABLE 1 Source of Valid Survey Responses Used in the Study

Source of Data	Frequency	Valid Percent
Link on fietsersbond and elektrischefiets.org	47	21.7
Online link, electric bicycle users in Delft	2	.9
From snowball method	5	2.3
From fietsersbond email newsletter	153	70.5
By post, electric bicycle users in Delft	10	4.6
Total	217	100.0

2.4 Representativeness of the Sample

70% of the sample found the survey through the Fietsersbond e-newsletter and are therefore members of the Fietsersbond. The Fietsersbond has 35,000 members and its main mission is to campaign for better cycling conditions in the Netherlands. It is fairly simple to become a member, and costs a minimum of € 26 Euros per year. There is no

way of knowing if the amount of Fietsersbond members in this sample creates a bias, but it is possible that members of the Fietsersbond are more active and engaged cyclists and may use their electric bicycles differently than non members. A comparison of means of the general characteristics questions, using independent samples t-tests showed only two means that differed significantly between the group of Fietsersbond members and the group of non-members. Non-members had more automobiles per household (1.34 to 0.90) and agreed more with the statement "my electric bicycle replaces my old bicycle" (4.25 to 3.79). There was no significant difference in means of the 20 other variables that were tested. The sample size of members is 153, while the sample size of non-members is 64.

3. Survey Results

This section presents information about the demographics of electric bicycle users in the Netherlands (3.1), the main reasons for using an electric bicycle (3.2), the trip purpose (3.3) and the replacement mode (3.4). Finally some analysis is done comparing trip purposes and replacement modes (3.5) and the characteristics of users who would have otherwise made a trip by automobile (3.6).

This paper presents the results of the survey in a straightforward way, generally frequencies and percents. The responses on the general questions (discussed in sections 3.2-3.4) were collapsed in order to present the information more clearly. After comparing the presentation of data in both 3 and 5 columns, it was found that presenting the data in 5 columns did not add additional insight. Responses of a 1 or 2 are added together for a "does not apply to me" column and 4 and 5 are added together for an "applies to me" column. In addition a mean and standard deviation value, based on the 5-point scale, are presented to give an idea of the spread of the data.

3.1 Demographics of Electric Bicycle Users in the Netherlands

Demographic information of the sample is shown in Table 2. The survey respondents demonstrate that electric bicycle users come from a variety of groups of people in the Netherlands. The average age was 59.9 and 73% of the respondents were 55 years old or older. The most common household composition was *Couple without children*. 56% of respondents were female, showing a slight trend towards female users.

Survey respondents had a mean of 1.38 electric bicycles per household, meaning that several households owned 2 or more electric bicycles. This was more prevalent among couples without children, for whom 50% had two electric bicycles compared to 23% for other respondents. Age and number of electric bicycles had a positive correlation meaning that older respondents tended to have more electric bicycles in their household. Respondents had an average of 1 car per household and averaged more than 2 city and/or racing bicycles.

The average net household income was € 2,681 per month. The mean and distribution of this data largely mirrors the general Dutch population.

TABLE 2 Demographic Information of Survey Respondents

Age and Household Income			
	Mean	Std. Dev.	N
Age	59.9	10.6	190
Household income	€2681	1195	163
Average Number of Vehicles			
	Mean	Std. Dev.	N
Number of Automobiles	1.03	0.648	217
Number of Motorbikes	0.07	0.365	217
Number of Electric Bicycles	1.38	0.541	217
Number of City Bicycles	1.21	1.229	217
Number of Racing Bicycles	0.94	1.244	217
Household Composition			
	Frequency	Percent	
Single	36	17%	
Single with children	5	2%	
Couple with children living at home	39	18%	
Couple without children	125	58%	

3.2 Reasons For Use

Respondents chose to use an electric bicycle mostly because it is easier (applied to 71%) and more comfortable (67%) than an ordinary bicycle. The ability to ride faster was less important (45%) than the ability to travel for longer distances (60%). The results of the survey questions dealing with reasons for use can be found in Table 3.

The 30% of respondents that had difficulty riding a normal bicycle made up an important group of electric bicycle users. In the Netherlands, the electric bicycle allows them to continue to be a part of the bicycle culture even when normal bicycling becomes physically too difficult. While a sizeable portion of respondents had difficulties with an ordinary bicycle, it is important to remember that the remaining 70% of respondents made a choice to use an electric bicycle for a variety of reasons, including comfort, ease of use, travelling longer distances and increased speed.

In addition to the likert scale questions, an open question was asked: "What is the most important reason why you use an electric bicycle?" This resulted in a plethora of more specific responses, including combating windy conditions, riding a bicycle without sweating, health problems that prevent the use of a normal bicycle, exercise, recreation and countless others.

TABLE 3 Reasons for Electric Bicycle Use

I use my electric bicycle...	Does not apply to me	Neutr al	Applies to Me	Mean	Std. Dev.
Because it is more comfortable	12%	17%	71%	3.9	1.2
Because it is easier	15%	18%	67%	3.8	1.3
For longer trips	22%	18%	60%	3.7	1.4
Because it is faster	35%	20%	45%	3.1	1.5
I have difficulty riding a normal bike	53%	17%	30%	2.5	1.5

Respondents were asked to respond on a scale of 1 to 5 from "does not apply to me" to "applies to me very much"

3.3 Trip Purpose

Information about trip purpose is presented in two ways: general likert scale questions and a specific travel diary survey. The scale questions are used to identify the general purpose of owning or using an electric bicycle and the travel diary section is used to determine the purpose for specific trips.

The most commonly stated general uses were: recreation, visiting friends and family and shopping (See Table 4). Over 50% of respondents said that they used their electric bicycle for each of those reasons. From the travel diaries, recreation was again the most common trip purpose (37% of all trips), followed by work (27%) and then shopping (25%). Visiting was lower on this list perhaps because it was conducted less frequently. Almost nobody stated that they used an electric bicycle to travel to school or to access public transportation.

Commuting is an important category when discussing mode choice. 42% of respondents identified that they sometimes use their electric bicycle for commuting (Table 4), and indeed 42% of respondents reported at least one work related trip, while 27% of all reported trips had a purpose of commuting, the second most popular trip purpose (Table 5).

TABLE 4 Responses about electric bicycle use

I use my electric bicycle...	Does not apply to me	Neutral	Applies to Me	Mean	Std. Dev.
For pleasure rides	12%	11%	77%	4.2	1.2
To visit friends and family	26%	20%	54%	3.5	1.4
For shopping	35%	12%	53%	3.3	1.6
For exercise	34%	24%	42%	3.1	1.4
For commuting	55%	4%	42%	2.7	1.9
To access public transport	80%	6%	14%	1.7	1.3
To go to school	95%	1%	4%	1.2	0.8

*Respondents were asked to respond on a scale of 1 to 5 from "does not apply to me" to "applies to me very much"

TABLE 5 Trip purpose as stated in the travel diary survey

Trip Purpose	Frequency	Percent
Recreation	126	37.3
Work	92	27.2
Shopping	85	25.1
Other	17	5.0
Visit Friends or Family	16	4.7
Access to Public Transportation	2	0.6

3.4 Replacement Mode

Information about replacement mode is also presented in two ways. The likert scale questions give an idea of the respondent's general attitude towards certain behaviors, and the travel diary data represents their stated replacement mode for each electric bicycle trip over the course of a day.

The results of the travel diary as presented in Table 7 show that only 2.1% of trips would not have taken place if an electric bicycle were not available. This means that the electric bicycle is likely being used as a replacement for another mode of transportation. The most common replacement modes, as stated in both the general questions and in the travel diaries, were the automobile and the bicycle.

In response to the general questions, 68% of respondents said that their electric bicycle replaces their old bicycle, while 62% said that it replaces short automobile trips (see Table 6). This indicates that some respondents view their electric bicycle as a replacement for both the car and the ordinary bicycle.

From the travel diary, the bicycle would have been the replacement mode for 41% of trips, while the automobile would have been the replacement mode for 40% of trips (see Table 7). Electric bicycles replaced few trips that would have been made using public transportation, motorbikes or walking.

TABLE 6 Responses about the replacement mode

My electric bicycle...	Does not apply to me	Neutral	Applies to Me	Mean	Std. Dev.
Replaces my old bike	20%	13%	68%	3.9	1.4
Replaces a short auto trips	27%	11%	62%	3.6	1.6
Replaces short public transit trips	49%	6%	45%	2.9	1.8
Replaces walking	63%	12%	25%	2.3	1.5

*Respondents were asked to respond on a scale of 1 to 5 from "does not apply to me" to "applies to me very much"

TABLE 7 Replacement mode as stated in the travel diary survey

	Frequency	Percent
Bicycle	137	40.7
Automobile	134	39.8
Public Transportation	25	7.4
Motorbike/Scooter	21	6.2
Walk	12	3.6
I would not have gone	7	2.1
Other	1	0.3

3.5 Trip Purpose and Replacement Mode Choice

A cross tabulation of trip purpose and replacement mode was used to determine the relationship between these two variables. This analysis was done on data gathered from the trip diaries.

Table 8 shows that electric bicycles are more likely to replace automobiles for work related trips than for other purposes. In the case that electric bicycles were to be increasingly used by commuters, this indicates that it may have an impact with regards to the amount of automobile trips.

TABLE 8 Cross Tabulation of Trip Purpose and Mode Choice

Replacement Mode	Trip Purpose (in Column Percentages)				
	Recreation	Work	Shopping	Other	Total
Automobile	37.3%	51.6%	34.9%	37.1%	40.7%
Bicycle	44.4%	35.2%	39.8%	34.3%	39.6%
Public Transportation	4.8%	7.7%	7.2%	17.1%	7.4%
Motorbike/Scooter	9.5%	1.1%	7.2%	5.7%	6.2%
Other	4.0%	4.4%	10.8%	5.7%	6.0%
Total	37.6%	27.2%	24.8%	10.4%	

3.6 Characteristics of Automobile Replacers

The characteristics of respondents who reported at least one trip that would have replaced an automobile trip were analyzed separately in order to identify differences from the other respondents. The means of the demographic and general questions of this data were compared with those of the whole sample, using t-tests, in order to identify differences. The characteristics that had significantly different means, using 95% confidence intervals are shown in Table 9.

The average number of automobiles per household was higher among the sub sample of automobile replacers, while the average number of city bicycles per household was lower. Respondents in the sub sample were much more likely to agree with the statements "My electric bicycle replaces my old bicycle" and "My electric bicycle replaces short auto trips." The result for the second statement is expected, as those who are actually using their electric bicycle as a replacement for their car should all be in agreement with this statement. The result for the first statement suggests that while the electric bicycle is often initially a replacement for a traditional bicycle, it allows a shift in mode choice from traditional bicycle to electric bicycle to take the place of a shift from traditional bicycle to automobile.

TABLE 9 Characteristics of Respondents Who Reported at Least One Electric Bicycle Trip Replaced an Automobile Trip

	Responses with no trips that replaced an automobile trip		Responses with at least one trip that replaced an automobile trip		Mean Difference
	Mean	Std. Dev.	Mean	Std. Dev.	
Number of Autos	0.78	0.562	1.37	0.606	0.59
Number of city bikes	1.40	1.276	0.96	1.118	-0.44
Replaces my old bike	3.67	1.528	4.27	1.202	0.60
Replaces Short Auto Trips	3.19	1.768	4.14	1.121	0.95
For Exercise	2.90	1.478	3.40	1.343	0.50

*Independent samples t-tests were performed to confirm differences between means

4. Discussion And Conclusions

This paper has presented the results of a survey concerning of electric bicycle users in the Netherlands. The main purpose of this research was to determine the extent to which electric bicycle trips are replacing trips that would have previously been made by other modes. The paper also shows that the demographics of Dutch electric bicycle users and the reasons for use and trip purposes differ from similar research done in China.

It was shown that the electric bicycle in the Netherlands is most commonly used by people with an average age of 60 for recreation, shopping and other errands, generally because it is easier to use and more comfortable than a traditional bicycle. The electric bicycle was also used for commuting, although to a lesser extent. These results differ greatly from the use characteristics in China, which show that commuting is the most common trip purpose and users had a much lower average age of 35 (4).

Electric bicycles are likely being used as a replacement for other modes and were used for very few trips that would not have otherwise taken place. While a large majority of survey respondents stated that their electric bicycle was a replacement for their old bicycle, they also agreed that their electric bicycle trips replace short automobile, public transit and walking trips. 41% of electric bicycle trips would have otherwise been made with an ordinary bicycle and 40% would have been made by automobile, showing that the electric bicycle is predominately being used in the place of those two modes. Electric bicycles are more likely to replace automobiles for work related trips. Again, these results differ greatly from China, where the most common replacement mode is the bus.

The electric bicycle is particularly well suited for individuals that have physical difficulty riding a traditional bicycle. This paper presents evidence that the electric bicycle provide an option that keep the elderly on the bike paths, rather than switching to automobiles as riding a traditional bicycle becomes more challenging.

This research shows that electric bicycles can be a legitimate mobility alternative to both the traditional bicycle and the car in the Netherlands. For now, electric bicycle use is concentrated among the elderly, and it should continue to be popular with that age group. However, it has been shown that the electric bicycle is a viable option for daily travel, including commuting and shopping, and should it gain more acceptance among a younger population, it could be used more and more frequently for commuting, as it allows cycling for longer distances at higher speeds.

4.1 Further Research

This research represents a broad overview, and raises many additional questions about electric bicycle use in the Netherlands. Possibilities for future research include: a closer look into reasons for use, change in time of user characteristics and safety and policy implications.

This survey did not present detailed options to explain different reasons for using an electric bicycle. The main conclusion of this survey, in regard to reason for use, shows that people tend to use electric bicycles because they are easier and more comfortable. A more specific research, focusing on reasons for use, could result in a richer, more detailed picture of specific reasons for use, rather than the more general comfort and ease of use as presented here.

It will be important to monitor the key characteristics of electric bicycle users including: the average age, gender, trip purpose (specifically commuting), trip length and reason for purchase, as they change through time and the amount of electric bicycles sold in the Netherlands continues to increase. Further travel diary studies will be needed in order to incorporate and refine an electric bicycle mode in national and regional models. Incorporating an electric bicycle mode into the national travel survey is recommended and will allow the Netherlands to better predict future travel patterns as this relatively new mode becomes more common.

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