

A University survey with a Comparative study of an E-Bikes Sharing System

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Short Abstract

Transport sector is responsible for more than 30% of European final energy consumption and carbon emissions. An increasing interest and concerns to the transportation sector has been observed to deal with the challenge of reducing the ecological footprint and the promotion of different transportation alternatives. The purpose here is twofold: first to record the everyday practices and preferences of the students at the University (Mons) regarding the use of electric bikes instead of conventional means of transport and second to explore the key factors that can influence its increasing use in the future under an electric bike sharing scheme.

Keywords: Bicycle, Electric Vehicles, Survey, Transport

1 Introduction

The widespread deployment of electric vehicles is typically viewed as an approach to decarbonize the transportation sector, which is increasingly linked to environmental problems and social issues that contribute to the degradation of the quality of life of modern cities. Alternative modes of transport with the aim to increase the occupancy of private vehicles are emerging as a means of alleviating contemporary urban problems. The academic community is considered more receptive to alternative services. Considering that Universities offer fertile ground for innovative solutions, the paper presents a preliminary survey conducted at the University of Mons (Belgium) along with the electric bike selection process on a comparative study with the final aim to explore the tendencies towards the kind of electric bike and that of the use of sharing systems, their characteristics and the key indicators that will influence their final use as integrated part of the smart cities. The results prove the users' willingness and electric bike preferences and indicate the weaknesses for the adoption of bike sharing system in the city/region of Mons.

Over the last century, a growing concern concerning the increasing energy consumption related to transportation sector has been remarked, leading to challenges for the decrease of energy consumption in regional but also in global scale. In 2011, transport sector was responsible for more than 30% of the European final energy consumption [1]. In addition, the sector faces challenges regarding the carbon emissions. In a European level, urban traffic is responsible for more than 40% of emissions of CO₂ and it is directly depended on fossil fuels with inherent and destructive consequences for the environment and public health. As a result, in recent decades, alternative vehicle technologies are proposed to overturn this trend. Electro-mobility seems to be an efficient and secure direction towards a broad use of renewable and

low carbon energy sources [2], while non-motorized models of transport has been increased as part of the sustainable urbanism and the vision of eco-mobility [3].

From different alternatives, the use of bicycles seems one of the most advantageous allowing users to move at significant spends for short distances with no carbon or fuel emissions [4]. Generally, the alternative mode of transport is related to the use of more efficient vehicle technologies and with a shift to public transportation system encouraging users to adopt vehicle sharing schemes (bikes or cars) [4]. Particularly, this mode of transport that has been mostly influenced is cycling due to its low-cost, zero carbon emissions and its health benefits [3]. Therefore, a broad literature has been recently focused on the determinants of the bike sharing systems as part of the emerging smart city of tomorrow. The interest in bike-sharing has come at a time when issues such as environment conservation, cultural continuity and social and health return on investment all challenge policy-makers to rethink ways of creating shared value [5]. Bike sharing scheme is a transportation alternative system that has been rapidly growing in popularity across the world with an increasing concern about the energy consumption derived from the transportation sector, leading to challenges on how to decrease the ecological footprint and the local carbon emissions [4]. However, despite the high expectations for electric bikes, few studies have tried to manage their benefits in urban transportation systems and their perspectives towards the achievement of the ‘smart’ grid and the cities of tomorrow.

From the authors’ point of view, the combined use of Electric Vehicles (EVs) sharing with public transportation systems (‘green mobility’) multiplies the benefits in terms of environmental protection and less car dependency. This paper presents an exploratory survey conducted during the period of 17/06/2015 to 30/07/2015 on a sample of 74 students at the University of Mons (UMONS), Belgium. The principal goal of the survey is to examine the interest of the students towards the transition to the electro-mobility and the use of electric bikes – following a similar approach as in [6]. In this framework, the paper explores the key factors that influence the use and the development of the e-bike sharing system in the city of Mons. The paper is structured accordingly: the first part includes introductive components of the e-bike sharing system (historical background and technical characteristics), the second consists the core of the study with the extrapolation of the particular (but preliminary) results of the survey and the last one the main conclusions of the study.

1.1 E-bikes: a historical background

Bike sharing systems exist for nearly half a century, however only few studies have systematically examined the demand or other operational parameters of these systems [7]. Historically, the first generation of e-bikes began in Amsterdam in 1965, where station-less bicycles were borrowed and left anywhere in the city with disadvantages and lack of security. Afterwards, in 1991 the second generation was born in Denmark allowed bicycles to be picked up and returned to central locations. These programs were limited with 26 bikes at four stations, however, same problems – mainly vandalism – are registered [8]. Bike sharing systems have become more popular since the introduction of their 3rd generation, born in Portsmouth University of England (1996) and involved several technological improvements (i.e. automatic bike racks, on-board electronics, telecommunication capabilities, etc.) and identified users [9]. These systems have become relatively successful around the world. In 2005 and 2007 respectively, Lyon and Paris launched successfully third generation bike sharing systems. Vélib’ in Paris, with about 7,000 bikes has been expanded to 20,600 bikes changing the bike-sharing history and created a growing interest in this alternative mode of transport (Fig.1) [8].

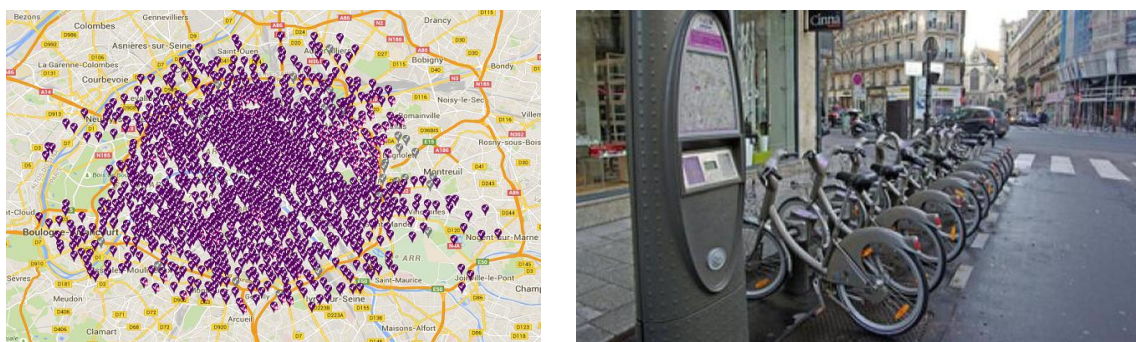


Figure 1 (from left to right): A map of the Vélib stations located throughout Paris [10]/typical example [11]

Beginning in 2008, cities outside of Europe began to launch third generation programs. Rio de Janeiro launched a pilot bike sharing program in 2009. Afterwards, numerous countries followed: South America, Asia, Chile, New Zealand, South Korea and Taiwan. Some of the largest bike sharing networks exist, today, in China: Hangzhou (40,000 bicycles and 1700 stations) and Wuhan, China (13,000 bicycles and 516 stations) [8]. A growing number of cities worldwide, nowadays, integrate bicycles in their daily transportation systems and mobility plans. More than 400 cities worldwide have car-sharing systems [4]. Currently, there are about 120 programs, as shown in Fig. 1, with existing 3rd generation programs around the world (Fig. 2).



Figure 2: Bike-sharing European [12]

Bike-sharing (and electric bike-sharing as well) have profound effects on the creation of an increasing cycling population improving the public health, decreasing the greenhouse effects and protect the environment but also to promote a new lifestyle of bike mode with undoubtable benefits ([12];[13]):

- Reduction of single occupancy journeys with cars, and thus ease of traffic congestion
- Reduction of CO₂ emissions from motorized traffic, and thus improvement of air quality
- Increase in physical activity levels and improvement of public health
- Improvement of accessibility and flexibility of mobility
- Improvement of road safety (particularly for cyclists)
- Enhancement of the profile and conditions of living in modern cities, supporting also local economies and tourism.

1.2 E-Bike sharing system: description

In September 2011, the University of Tennessee-Knoxville (UTK) installed North America's first e-bike sharing station as a technical and operational research pilot project. The e-bike sharing system consists of e-bikes (powered by lithium batteries) and a vending/charging station [8]. The energy use by electric vehicles is evaluated using the balance or driving cycle approach, while the capacity of the battery to determine its range. The system of driving cycle meets both the energy and the power requirement of an electric vehicle [15].



Figure 3: Components of e-bike sharing system station [8]

1.3 Technical characteristics of proposed e-Bikes

The e-bikes have a battery augmenting the pedal-power of its rider. The e-bike is considerably heavier than a conventional bike (principally because of its battery) and environmentally superior to other motorized transportation modes and quicker consisting an alternative means for daily commuting with the potential to replace car and with the all environmental benefits [18].

Technical evaluation of six designed, developed, manufactured and commercially available electrical bicycles in Belgium's region of Walloon are here in subject.

For better understanding of the used framework, the following categories are made. Not only examples discussed in this paper but all electric bicycle can be precisely described with the four main categories and it's sub-categories according to **Error! Reference source not found.**

Table 1 Generic description of electric bicycle

1) Purpose	city, cargo, general use, foldable, off-terrain, street /race
2) Motor: placement & type	a) Motor / electric engine placement: Front hub, rear hub, mid drive, on wheel – friction drive, seat post or main tube. b) Engine type: Brushed, brushless, with/without regenerative breaking,
3) Battery: placement & type	a) Placement i. Integrated: in frame, in hub ii. External: rear cargo rack, between rear wheel and seat post tube, bottle place, cargo bag or basket b) Type: Li-ion, Pb, NiMH, NiCd (discontinued) c) Voltage: 12V, 24V, 36V, 48V, 72V
4) Modes / motor control / power delivery mode	Pedal assist only (usual 3 levels), conditional pedal assist, on/off, power on demand (pure throttle), multiple/mixed

In Europe, electric bikes are classified as regular only in case of an auxiliary electric motor with a maximum speed of 25km/h [16]. For that reason, the absolute majority of bicycles like this sold in Europe meets this specification, as well all six of examples discussed in this study. That is why in the above table one cannot find category where speed would be taken under consideration.

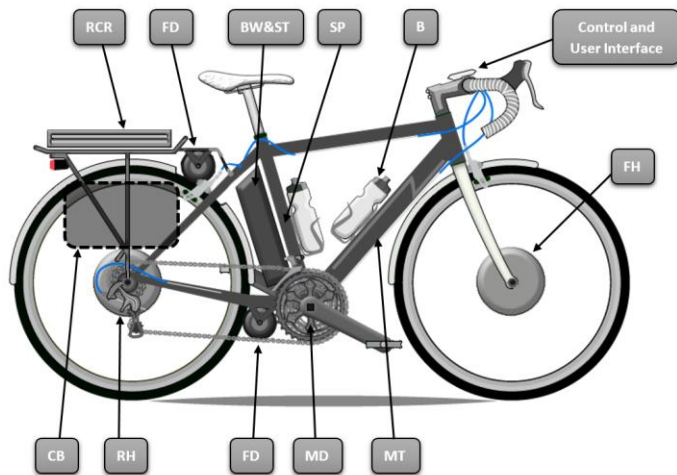
All data here presented is the official data provided by manufacturer or official purchase point and it was not verified by the authors of this work. Said that there are no data on what were the conditions in which this data was obtained nor if it meets any international standardization.

Table 2 Technical data of analysed electrical bicycles

	Unit	Bike 1	Bike 2	Bike 3	Bike 4	Bike 5	Bike 6
General							
Range	[km]	40 - 100	45 - 60	45 - 60	65 - 120	40 - 80	45 - 85
Max Speed	[km/h]	-	25	25	25	25	25
Total weight	[kg]	22,6	20	24	24	25	23,7
Type of assistance			3 levels	Multiple	Multiple	3 levels	Multiple
Engine							
Power	[W]	250	250	250	250	250	250
Type		Brushless	Brushless	Brushless	Brushless	Brushless	Brushless
Location		RH	RH	RH	FH	MD	FH
Battery							
Power	[Wh]	324	360	360	396	468	324
Voltage	[V]	36	36	36	36	36	36
Capacity	[Ah]	8,6	10	10	15	13	9
Type		Li-Ion	Li-Ion	Li-Ion	Li-Mn	Li-Ion	Li-Ion
Weight	[kg]	-	2,4	3,9	-	3,2	-
Cycles		-	800	800	-	500	-
Loaction		RCR	B	RCR	BW&ST	BW&ST	RCR
Charge time	[h]	-	5	5	4-6	-	-
Factors							
Weight ratio (Bicycle to battery)	[%]	-	12	16,25	-	12,8	-
Min Range per € (bicycle value)	[€/km]	~37,5	~33,1	~30,8	~23	~27	~35,5
Retail price	[€]	1499	1490	1390	1499	1079	1599

Models that are taken under the analysis conclude in general, entry model from the manufactures offer. It was found that in this price range one can expect certain set of same technical specifications. The difference in overall usefulness (having maximal range without recharge, maintaining low weight) makes the absolute capacity of the battery, which makes this component, the most important in the setup. In our study batteries range in-between 8,6 and 15 Ah of capacity. On example of bicycle number 4, it can be seen that there is no direct relation between capacity and price. In this case this model is rated with second biggest unit, still maintaining the lowest price from the six. It is important to notice, that on the price and weight of a bicycle, or any other similar vehicle, influence not only the electrical power train with its components, but also the rest of essential parts. This percentage can range from as little as one hundred euros to couple thousands euros and from couple hundreds of grams to couple of kilograms in weight. In this study nevertheless we have tried to select stock models of bicycles that offer, if not identical, similar or comparable standard of parts and components – others than electric. For this reason, our focus is only on the electrical drivetrain and general performance.

Figure 4 and presented list, explains the general nature of components placement of electrical bike and used abbreviation. Same abbreviations are use in **Error! Reference source not found..**



- 1.1.1.1 RH - Rear Hub
- 1.1.1.2 FH - Front Hub
- MD - Mid Drive
- FD - Friction Drive
- SP - Seat Post
- MT - Main tube
- RCR - Rear Cargo Rack
- B - Bottle place
- CB - Cargo bag or basket
- BW&ST - Between rear Wheel and Seat post Tube

Figure 4: Generic electrical bicycle

None of the 6 selected models had friction drive nor electrical components located inside the main frame, nor “all in one” solution (battery + engine + driver in one non separable package) making an illustration of classical electric bicycle design in the range under €1,5k.

The selection of technology used and their physical position in the frame on particular model makes no influence on a range, but in a day to day usability and handling which is subjective to many riders.

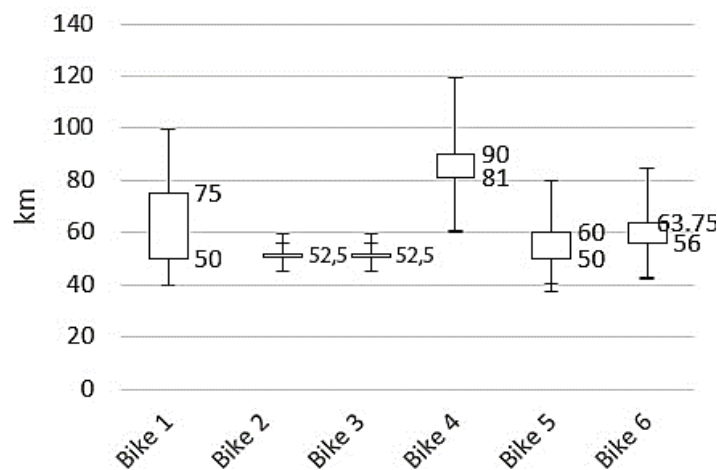


Figure 5 - Bicycle average estimation

Since driving range can suffer from multiple factors like: rider weight, quantity of stops, ambient temperature, level of assist, terrain characteristics (mainly the nature of slopes), average speed and energy provided by the rider itself, it is difficult to predict. Nevertheless, manufactures provide maximum and minimum range. Those numbers might not be comparable, since there is no data or indication that they were obtained in the same way using the same procedure. For purpose of this study it was assumed that those numbers might not be 100% true in real life application having in mind the above causes of range decrease. For that reason, we have established a safe 25% of deviation on maximum and minimum numbers. In this way we estimate real life bias range for average rider (Figure 5). Nevertheless, it is worth to point out that even assuming the minimal average range of 46 km bicycles here studied it is still enough to make excellent alternative for any other mode of transport. We also assume that up to 1h in total time commuting each day is an acceptable range for average person. That said, it is important of visualization of how reasonable those numbers are.

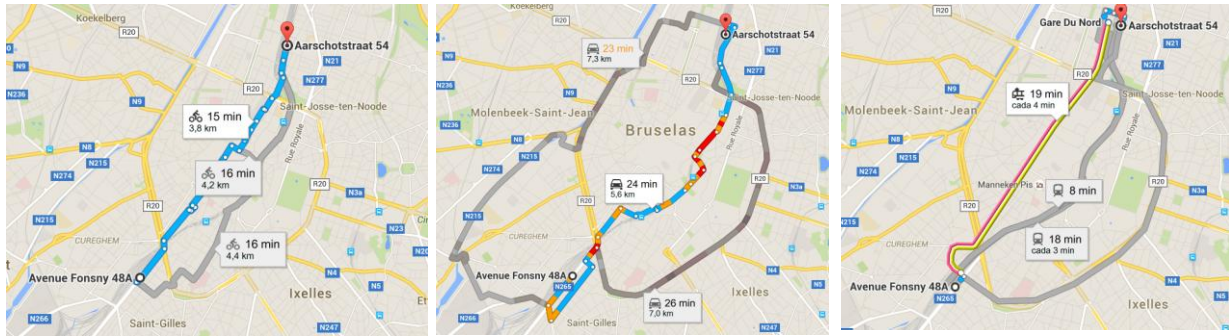


Figure 6 Distance and time in Brussels (Google Maps)

As an example we take the case of crossing the city of Brussels from south to north train station in three different means of transport on week day afternoon. There are three important aspects of this comparison. First is the distance, which is the most favourable for bicycle route and it is just 3,8 km, taking a cyclist just a quarter of an hour to cover this distance. Making the trip there-and-back, the minimal capability of our average minimum range will permit of 40 km more, or doing the same route 12 times in a row.

2 Population Study and Survey

2.1 Location

This section includes the data analysis of the survey conducted at the University of Mons, Belgium (abbreviated as 'UMONS'). UMONS is a French-speaking University in the Province of Hainaut, near the French-Belgian borders, 50km far from the Belgian capital (Fig.5):

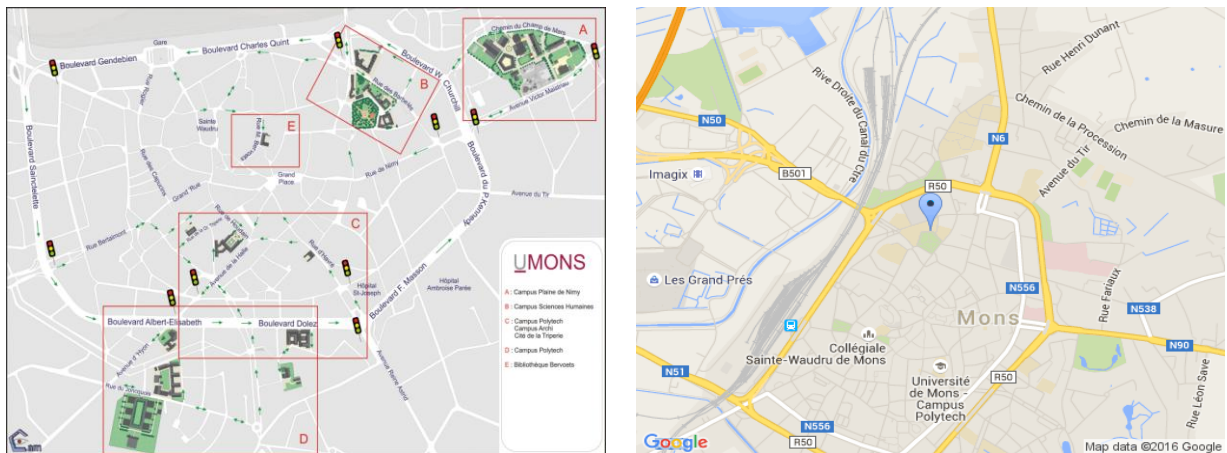


Figure 7: Location of the UMONS ([15];[16])

2.2 Survey characteristics

The survey is conducted in the UMONS during the period of 17/06 to 30/07/2015 on a sample of 74 students. The purpose of this work is to collect information on the preferences and analyse the attitude of the respondents towards the use of e-bikes in the form of a vehicle sharing system. The results are presented on three parts:

- ❖ Part I: analysis of users' identity, profile and main characteristics
- ❖ Part II: identification of key factors that influence the user decision for renting an e-bike
- ❖ Part III: outline of the recommendations or other issues registered

2.2.1 Part I: Users' profile

Among a sample of 74 students of UMONS included at the survey, more than 80% are women (Fig. 6). The majority of the respondents are students of 1st (29.7%), of 4th (23.0%) and of 5th (27.0%) year (Fig.7).

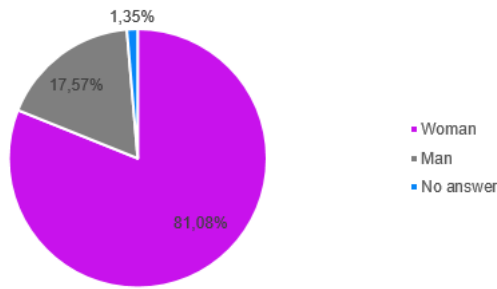


Figure 8: Gender of respondents

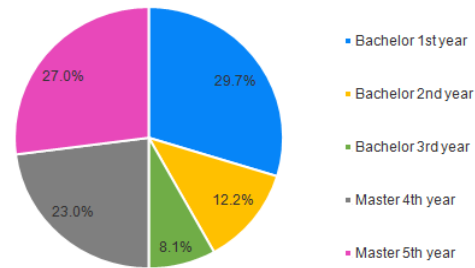


Figure 9: Education level of respondents

Generally speaking, in the users' perspective, the e-bike use as an alternative type of vehicle (typical example of electro-mobility) remains a challenge and still is not clear how users will adapt their behaviour to these innovative technologies and charging routines [2].

2.2.2 Part II: Key Factors for E-bike Rent

This part of the survey includes the factors, the initiatives and the reasons associated with the e-bike renting according to the survey's results. This framework distinguishes between individual factors (intention for e-bike renting related to the age, gender, preferences, etc.), socio-economic factors (i.e. environmentally friendly, reduction of traffic congestion, etc.) or physical-environmental factors (i.e. infrastructure, safety, etc.) including land use patterns. However, individual factors contribute in a great extent for the e-bike renting and determine the quality of the systems conditions as well as the encouragement (or not) of the e-bike sharing systems. Table 1 and presents the most important factors associated with the e-bike sharing systems as proposed by Handy et al. [3].

Table 3: Key factors associated with e-bike sharing systems [3]

Key factor	Criterion	Sub-criterion
Individual factors	Age Household income	Gender
		Education level
		Vehicles per person
		Ecological-economic awareness
Physical environmental factors	Bicycle district Traffic conditions	Land-use mix
		Distances to bike facilities
		Bicycle lanes
		Weather
		Traffic conditions
		Driving behaviour
Socio-environmental factors	Safety	Reduction of traffic congestion

According to the results of the UMONS survey regarding the potential reasons for the e-bike renting (and not renting), the majority of the respondents recognises the ecological benefits (26%) and its contribution to reduce the ecological footprint (traffic congestion, carbon and fuel emissions, etc.), while a share of 20% of them consider the e-bikes as a practical and comfortable means of transportation. However, other individual reasons are also taken into account (trends, facility, price, preference on e-bike, etc.) (Fig. 8). Other interesting responses from the sample of students regarding the reasons of e-bike renting are presenting on Fig. 9 and include mainly physical and socio-environmental factors (i.e. comfort, easiness, physical assistance, etc.).

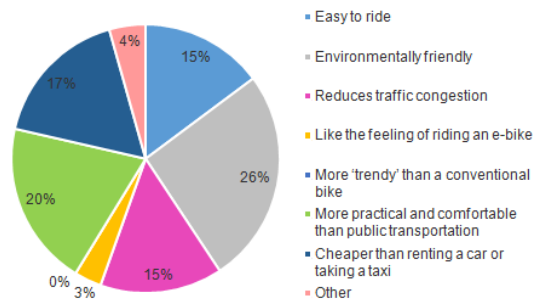


Figure 10: Reasons for e-bike renting

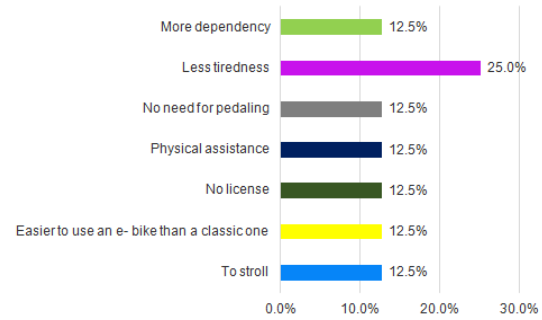


Figure 11: Other reasons for e-bike renting

However, despite the interesting intention of the respondents to use an e-bike (47%) for the workplace but also for other initiatives (i.e. sightseeing -18%, strolling to streets -14%, entertainment -4%, etc.), the survey registers a series of disadvantages that prevent users (or potential users) to the e-bike use. The principle obstacle of not using an e-bike in the region of Mons is the problem of weather conditions (48%) but also problems related to the safety road rules (no adapted bike lanes or driving behaviour) or problems of utility or price or even no preference for public transport and more for bike (and e-bike as well).

Seven (7) key factors associated with the intention of users to use an e-bike in the region of Mons are registered in the survey and influence their decision (the importance given to each factor ranges from 1: not at all important to 5: very important), namely price, conditions, brand, colour, quality, size and electric range. As expected, the issues of price and rent conditions are between the highest priorities of the users to intend using (or not) an e-bike. Other important reasons that influence users' decisions for e-bike use are: (1) the quality, (2) the bike's size and (3) the electric range. For the majority of the respondents 'quality' is very (or slightly) important (35.1%), the parameter of 'size' (20.3%) and the 'electric range' (32.4%) as well (Fig.10,11 and 12 respectively).

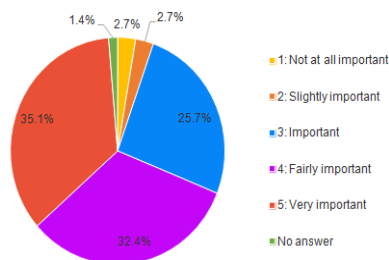


Figure 12: 'Quality' as a key factor for an e-bike rent

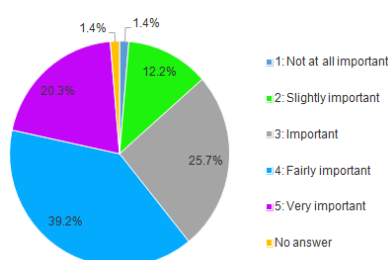


Figure 13: 'Size' as a key factor for an e-bike rent.

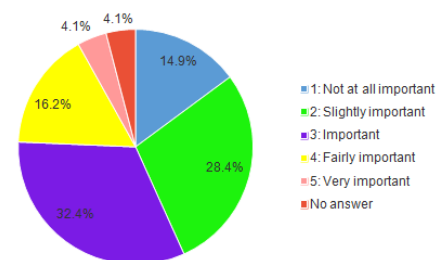


Figure 14: 'Electric range' as a key factor for an e-bike rent.

2.2.3 Part III: Recommendations and Other Issues

In the last part of the survey, the participants were asked to express their recommendations about alternative itineraries that could be useful during their daily commuting apart from the University (or their workplace). Approximately 80% of the participants would like to receive route suggestions for other interesting destinations (apart from the route to the University) during the rent period of the e-bikes.

3 Conclusions

This paper presents the results of an exploratory survey on a representative sample of students at UMONS, aiming at identifying the characteristics of the potential users of an e-bike sharing system, in support of the indicative mobility plan in the city of Mons, Belgium. This research work demonstrates and quantifies that e-bicycles provide an interesting solution for urban trips, with comparable trip times to other transportation modes and are included among the most particular solutions for the electro-mobility for the future cities.

The results obtained are case-specific on the city/region of Mons but indicative in a quantitative basis presenting interesting results of the intentions of a sample of the academic community to encourage the electro-mobility (and precisely the e-bikes) as well as the impacts of shifting to other transport modes or

using alternative and innovative technologies (e-bikes) for their daily commuting or other activities (i.e. sightseeing, entertainment, etc.). At the same time, the survey reveals the obstacles and the problematic points related to the e-bike renting system in the region of Mons (i.e. safety or no adaptation of bike lanes, lack of infrastructure, etc.) confirming also that electro-mobility is applied with difficulties in regions with harsh weather conditions.

Further work is required to generalise the results of the survey (i.e. a larger sample of respondents including also staff members, etc.) and considering its socio-demographic characteristics focusing also in other aspects that might have an impact on users' decision for e-bike use in the future.

Acknowledgments

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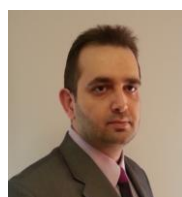
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