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INTELLIGENT ENERGY EUROPE

Promotion & Dissemination Projects

Electric **C**ity **Tra**nsport – Ele.C.Tra

D 2.1 Report on current mobility and network

Project Co-funded by the Intelligent Energy Europe Programme of the European Union

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Work Package 2	ANTE-OPERAM ANALYSIS
Task:	2.1 Demand Mobility flows / 2.2 Infrastructural and service network
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Electric **C**ity **Tra**nsport – Ele.C.Tra.

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Abstract:

This document contains the main data to characterize Barcelona mobility in terms of public transport, private vehicles, pedestrians and bicycles, with data referred to the current Sustainable mobility plan. It also contains the result of Ele.C.Tra survey carried out in Barcelona.

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1. Introduction

This document resumes the main characteristics of Barcelona Mobility according existing data, and also describes the results of the Ele.C.Tra survey, carried out during the end of 2013.

In the first place there is a territorial and demographic description on Barcelona and its metropolitan area, key on mobility issues on the city, and also its vehicle fleet.

The document has two different parts. On the first part there is a description of the main aspects of urban mobility in Barcelona from a general view: number of trips, differences between internal and connection mobility (between Barcelona and its surroundings), pedestrian, bicycles, public transport and private vehicle, with special attention to bike mobility, and the electric vehicle, the focus of Ele.C.Tra project. The description of the whole mobility system gives the frame to contextualize the role of electric motorbikes on sustainable mobility.

This first part also gives a quick view of the main externalities of the mobility system in Barcelona like noise, air pollution, or accidents. Energy consumption has a preponderant role, as is one of the key aspects of Ele.C.Tra project.

There is also a summary of the main aspects of the current Sustainable Mobility Plan 2013 – 2018 (SUMP), in terms of scenarios and objectives.

All data of this first part, including charts, maps and tables, come from the Sustainable Urban Mobility Plan, unless other source is indicated.

The second part of the document describes the results of the Ele.C.Tra survey, performed to nearly 600 individuals, relating those results with the information of the first part. The main objective of this survey was to determine the level of acceptance of electric vehicles and particularly motorbikes, in a sharing system in the city.

A complete statistical analysis is provided with the main objective of linking social characteristics of the interviewed people to the interest in electric vehicles and willingness to use a bike sharing system.

Finally a main list of conclusions of these two parts is provided.

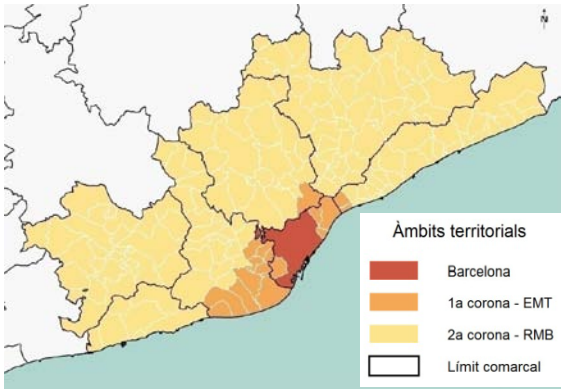
2. Territorial and demographic description

The city of Barcelona (Catalonia, Spain) has a population of 1.615.448, and it is characterized by a high density of population and economic activities, and a good accessibility both internal and external. But the city of Barcelona expands far beyond its municipality limits:

- AMB (Barcelona Metropolitan Area). It is the expansion of the compact city with a single labor market. It includes the first metropolitan ring with 34 more municipalities and a total population of 3.226.944 inhabitants.
- RMB (Barcelona Metropolitan Region). It includes the second ring which is formed by other cities with an own labor and commercial market, but with strong relations with Barcelona, and a total population of 4.777.042 inhabitants.

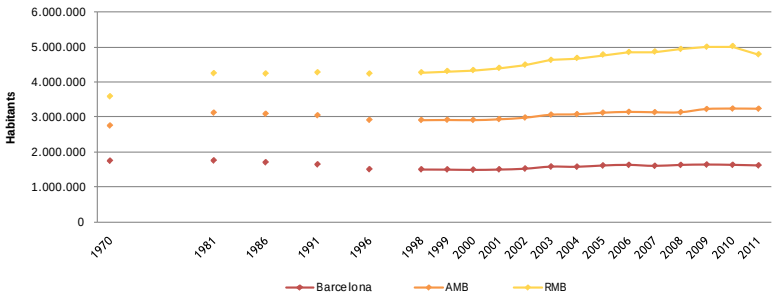
Metropolitan Barcelona 2011

	CITIES	AREA [km2]	POPULATION	DENSITY [Hab/km2]
Barcelona	1	101	1.615.448	15.995
AMB	36	628	3.226.944	5.138
RMB	164	3.241	4.777.042	1.474



After a population peak in the 70's due to Spanish migratory dynamics, the population of Barcelona has little decreased over the last decades (no real space available to grow within its city limits), with a decrease in the 80's and 90's and a recent recuperation. The big increases have taken place in the 1st and 2nd metropolitan rings (AMB and RMB), which have almost doubled their population since 1970. On the whole the Metropolitan Region has increased its population by 33,4% since 1970 (almost 1,2M people growth).

Population evolution in Metropolitan Barcelona



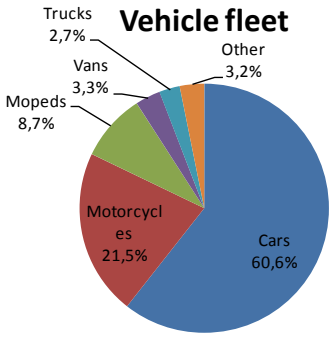
POPULATION			
Year	1970	2011	Increase
Barcelona	1.745.142	1.615.448	-7,4%
1st ring	996.983	1.611.496	61,6%
2nd ring	837.633	1.550.098	85,1%
AMB (Bcn + 1st ring)	2.742.125	3.226.944	17,7%
RMB (AMB+2nd ring)	3.579.758	4.777.042	33,4%

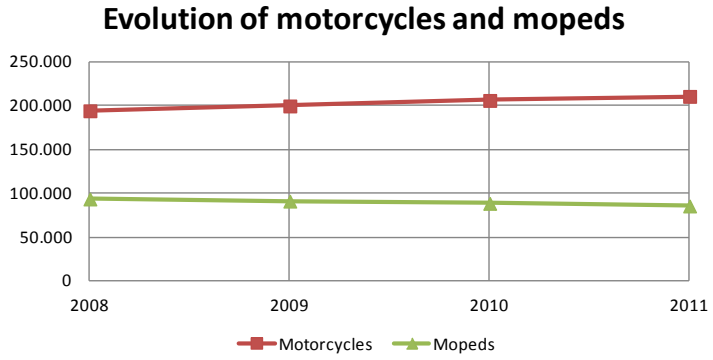
3. Vehicle fleet

Barcelona has a vehicle fleet of 976.345 units. Most of them are cars (60,6%), resulting in a motorization index (cars per 1.000 inhabitants) of 366. The fleet of motorcycles and mopeds is important and represents 30,3% of the total fleet (295.733 vehicles). Less than 10% are vans, trucks, and others. The evolution of the last years shows a decrease of cars, mopeds, vans, and trucks, and an increase of motorcycles. Globally, motorcycles and mopeds have increased from 287.284 units in 2008 to 295.733 in 2011.

Barcelona Vehicle fleet: evolution, composition and role of motorcycles

TYPE	2008	2009	2010	2011	%	% 2008-2011
Cars	608.830	599.534	597.618	591.733	60,6%	-2,8%
Motorcycles	193.902	199.407	205.705	210.328	21,5%	8,5%
Mopeds	93.382	90.934	88.391	85.405	8,7%	-8,5%
Vans	38.968	36.175	33.451	31.831	3,3%	-18,3%
Trucks	30.131	28.520	27.006	26.111	2,7%	-13,3%
Other	24.953	27.333	29.409	30.937	3,2%	24,0%
TOTAL	990.166	981.903	981.580	976.345	100,0%	-1,4%





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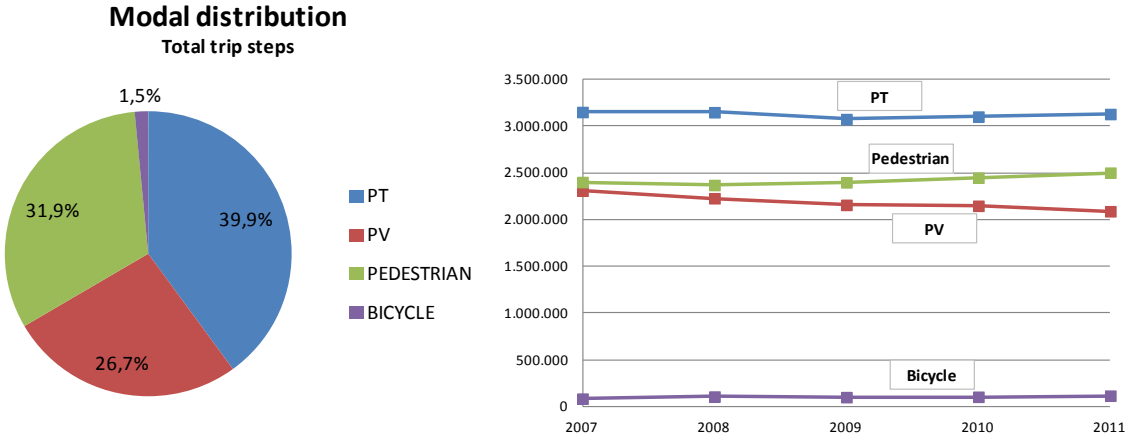
PART 1

4. Mobility in Barcelona

Every day in Barcelona (weekday) there is 7.833.495 trips. The modal distribution shows that public transport is the most used mode with 39,9% of all trips, followed by pedestrian trips (31,9%), and private vehicle (31,9%). Bicycle trips are in constant growth but this transport mode is still very little used with only 1,5% of the share.

Total trips in Barcelona. Evolution and distribution

TOTAL TRIP STEPS					
	2007	2008	2009	2010	2011
PT	3.148.519	3.146.085	3.072.831	3.099.286	3.126.796
PV	2.308.337	2.227.403	2.156.460	2.146.537	2.088.348
PEDESTRIAN	2.400.266	2.368.561	2.396.983	2.447.050	2.500.200
BICYCLE	86.406	108.924	102.824	106.521	118.151
TOTAL	7.943.528	7.850.973	7.729.098	7.799.394	7.833.495
TOTAL TRIP STEPS. MODAL DISTRIBUTION (%)					
	2007	2008	2009	2010	2011
PT	39,64%	40,07%	39,76%	39,74%	39,92%
PV	29,06%	28,37%	27,90%	27,52%	26,66%
PEDESTRIAN	30,22%	30,17%	31,01%	31,37%	31,92%
BICYCLE	1,09%	1,39%	1,33%	1,37%	1,51%
TOTAL	100,00%	100,00%	100,00%	100,00%	100,00%

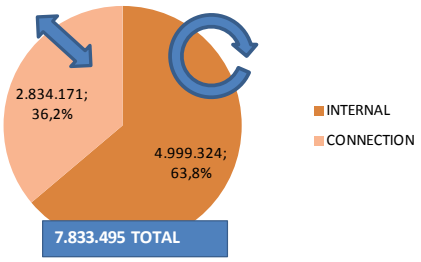


The trend in the last years shows an increase of bicycles and pedestrians, and a decrease of private vehicle. Public transport has a slight decrease. Decrease of private vehicle has had a very positive effect because it has diminished street congestion.

From the total 7,8M trips in Barcelona in 2011, 63,8% are internal trips (origin and destination in Barcelona) and 36,2% connection trips (origin or destination outside Barcelona).

Total trips in Barcelona. Internal and connection trips 2011

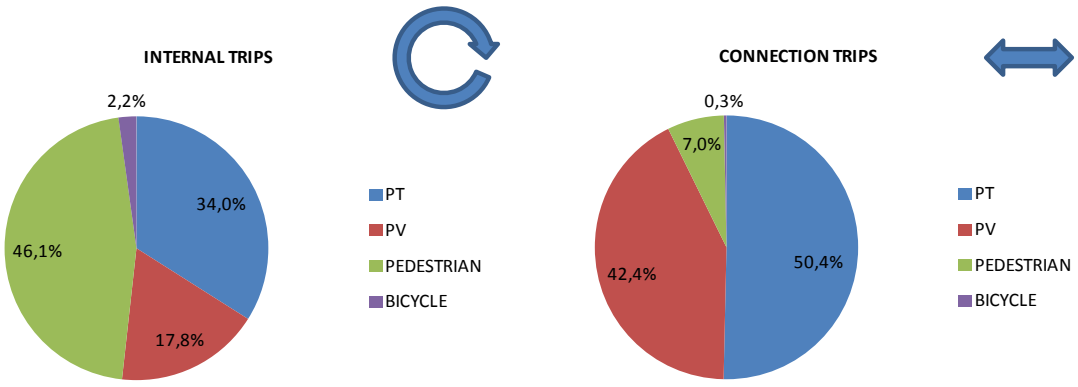
	INTERNAL	CONNECTION	TOTAL
PT	1.699.545	1.427.251	3.126.796
PV	887.928	1.200.419	2.088.347
PEDESTRIAN	2.302.569	197.631	2.500.200
BICYCLE	109.282	8.869	118.151
TOTAL	4.999.324	2.834.170	7.833.494



Within internal trips, pedestrian mobility is the most important and represents almost half the total internal mobility. Private vehicle represents only 17,8%. Bicycle mobility is a little bit more representative if we look only at internal trips with 2,2% of the share.

In connection trips, the more important mode is public transport with 50,4% of trips, followed by private vehicle trips with 42,4%. Pedestrians and bicycles are very low, but not so much as it could be expected since there are other neighboring cities which have a continuum urban area with Barcelona.

Modal distribution 2011



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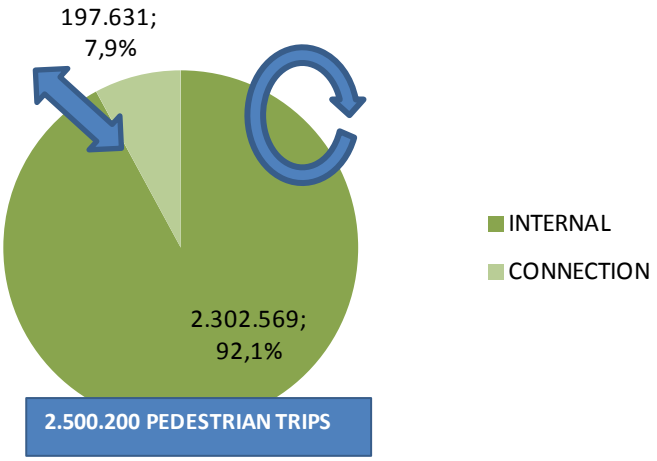
5. Pedestrian mobility

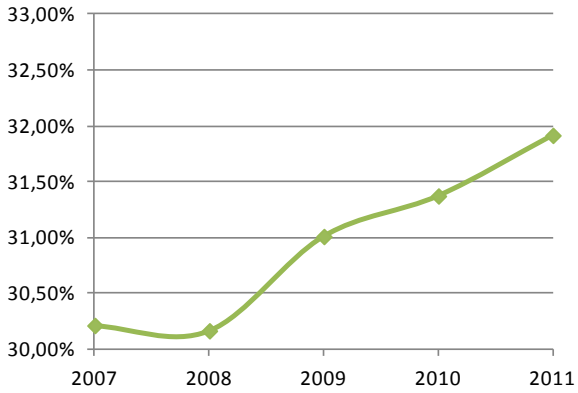
In the city of Barcelona, on a typical weekday there are 2.500.200 pedestrian trips, which represent 31,9% of the total mobility. Most of them are done within the city boundaries (internal trips), while 7,9% are connection trips done with neighboring cities with continuum urban tissue.

Pedestrian trips in Barcelona. Internal and connection trips 2011



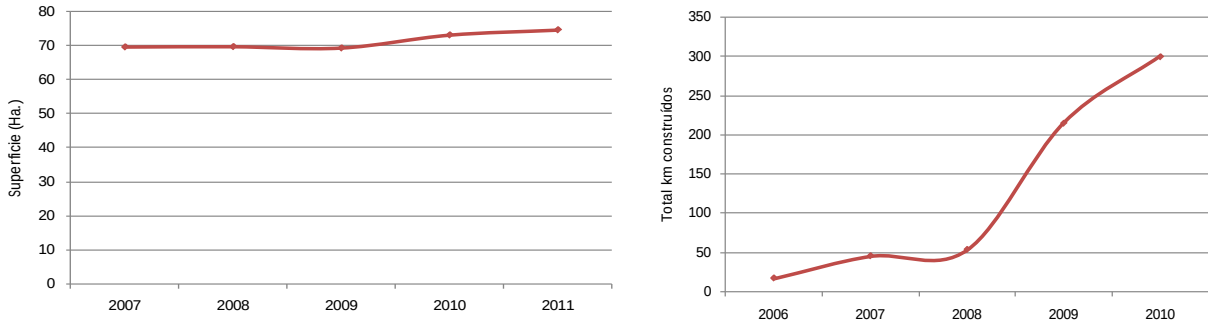
The evolution of the last years shows a steady increase on the modal distribution of pedestrian trips: in 2007 they represented 30,22% of total trips, and in 2011 31,92%.

% Pedestrian trips evolution in Barcelona



This can be explained both by the decrease of car trips caused by the economical crisis and by the improvement of conditions for pedestrian mobility. This improvement of conditions can be measured by the increase of "pedestrian friendly" areas. Pedestrian areas as such have not increased significantly over the last years. On the other hand, '30 areas' (areas where the speed of cars is limited to 30km/h) have increased dramatically.

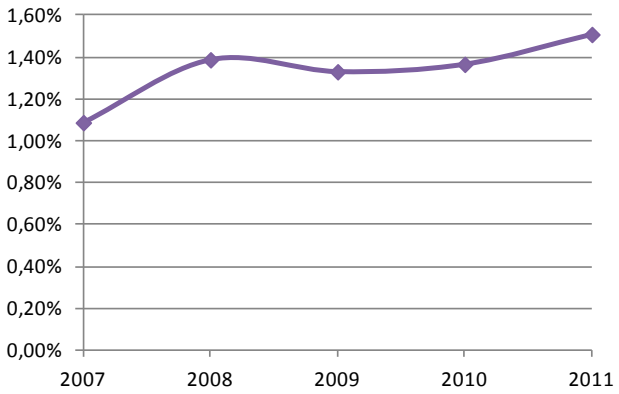
Evolution of pedestrian areas (left) and '30 areas' (right)



6. Bicycle mobility

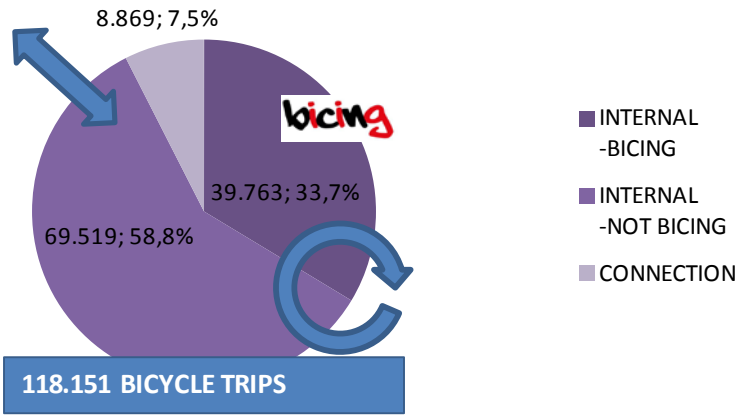
Bicycle mobility is still a small part of mobility in Barcelona, because it represents only 1,51% of total mobility. However, it is growing fast: in 2007 it represented 1,09% of total mobility (compared to 1,51% in 2011).

% Bicycle trips evolution in Barcelona



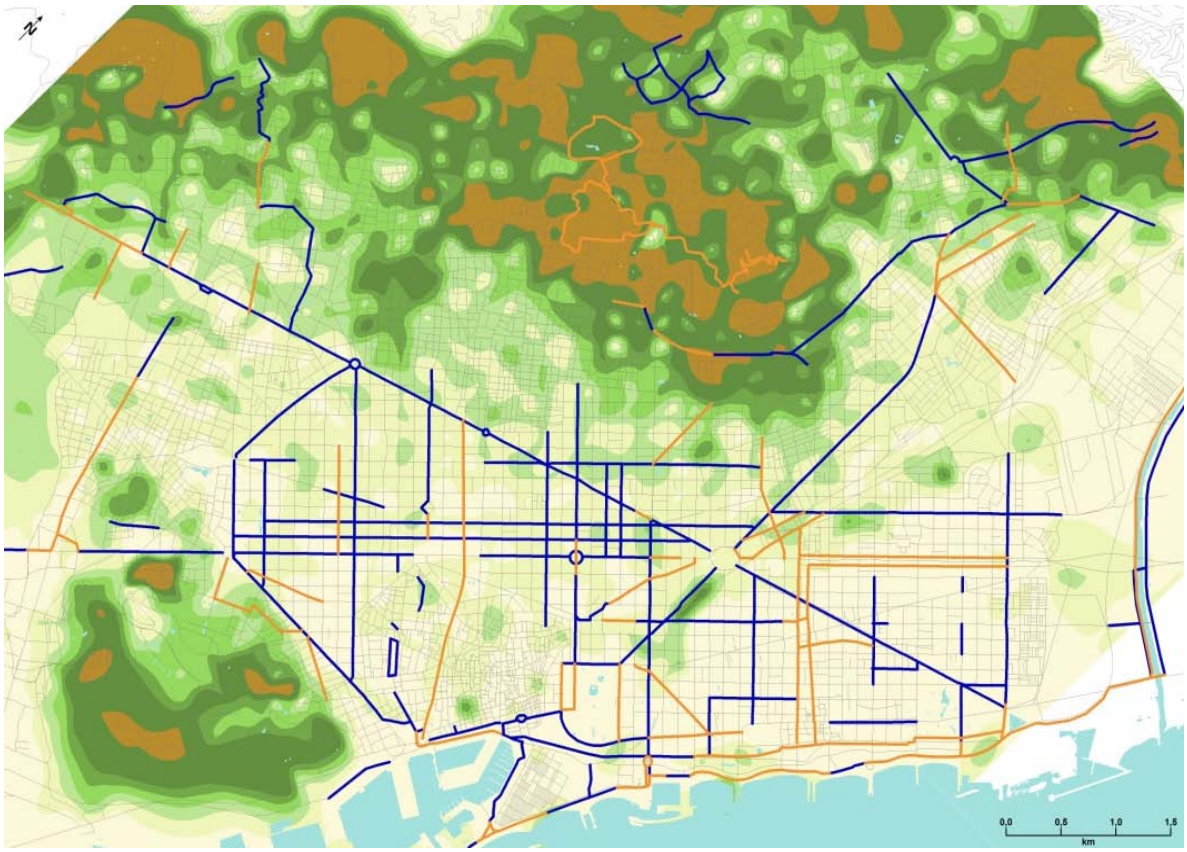
92,5% of the trips are internal (origin and destiny in Barcelona), a percentage very similar to pedestrian (92,1%), despite the bicycle allows for longer distance trips. Connection trips are only 7,5%. It is remarkable also the use of 'Bicing', the Barcelona public bicycle sharing service, which represents 33,7% of total bicycle mobility.

Bicycle trips in Barcelona. Distribution 2011

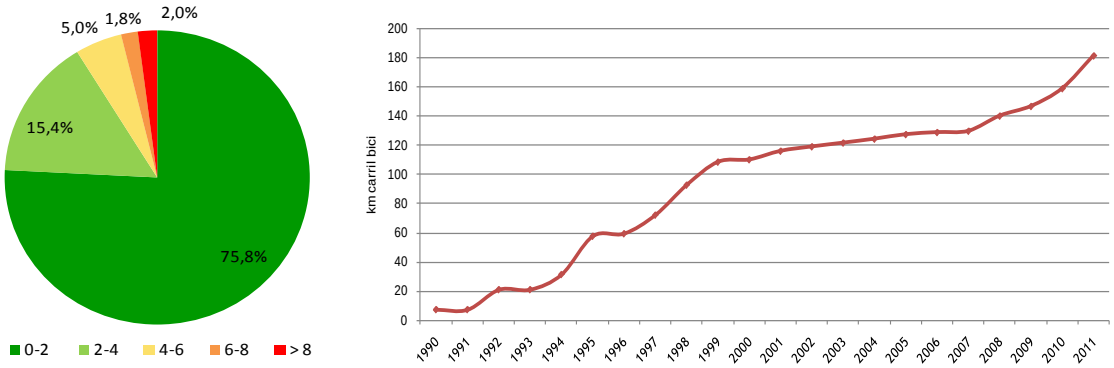


Bicycle mobility is very much conditioned by Barcelona topography which in some parts of the city is certainly an obstacle to the use of the bicycle as a regular transport mode. The figure below shows at the same time the distribution of the bike network and the slope of the terrain: most of the bike network extends over the flattest area of the city. To overcome the 'slope problem', the electrical bicycle looks as having a promising future.

Topography and bike lane network in Barcelona



Bike lane network in Barcelona: section slope (left) and length evolution in km (right)

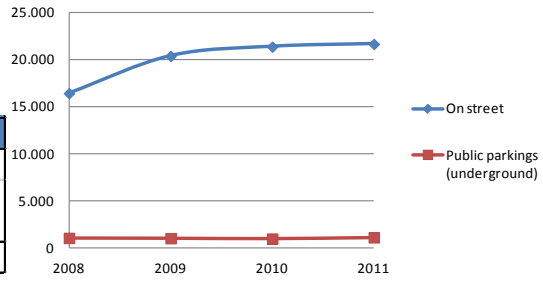


The bike lane network has a length of 182 km, and most of it develops over the flat area of Barcelona, with slopes below 2%. Besides that slope factor, the bike lane network shows lack of connection in several places and also shows some uncovered areas. However, the bike lane network has had a continuous increase of km over the last years, and will continue over the following years since one of the purposes of Barcelona's SUMP (Sustainable Urban Mobility Plan) is to solve these connection and coverage problems.

At present, Barcelona has almost 22.000 bicycle parking places on street ("U" shape where the user needs his own locking system), and 1.142 places on public underground car parkings which has a reservation of space for bicycles. On street parking has increased by 31,8% in the period 2008-2011, while increase in underground public parkings has been much more moderate.

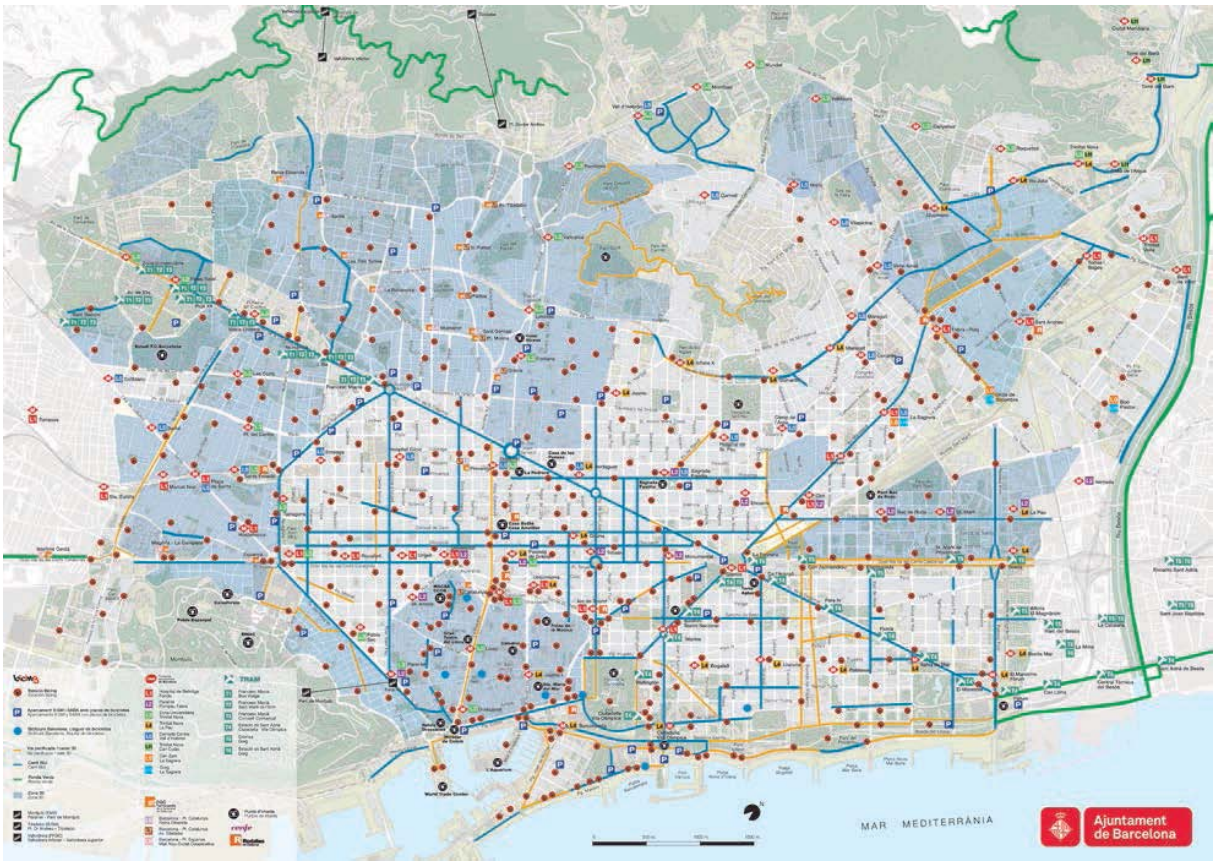
Bicycle parking facilities in Barcelona. Evolution and distribution

	2008	2009	2010	2011	% 2008-2011
On street	16.450	20.402	21.387	21.673	31,8%
Public parkings (underground)	1.079	1.052	1.005	1.142	5,8%
Total	**17.529**	**21.454**	**22.392**	**22.815**	**30,2%**



6.1. Bicing: Public bicycle sharing service

As shown in the trips description, Barcelona has a public bicycle sharing service called Bicing which was implemented in 2007. Bicing works as a mobility transportation mode in its own, and it can be also used as a complement of the city public system (bus, subway, tram, etc.). At present, Bicing has 6.000 bicycles and 420 bicycle stations, and 99.881 registered users. Registration cost is 46,4 €/year. Every bicycle is used on average 6,9 times a day, and runs 559 km per month. The average time trip is 13,9 minutes.

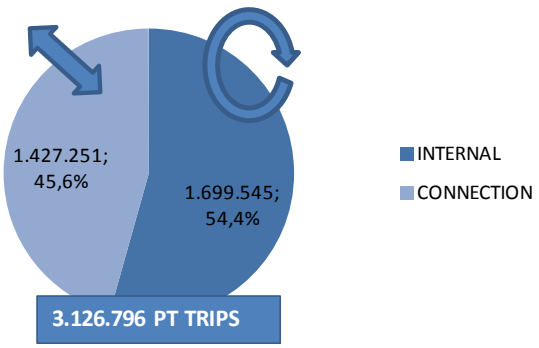


Location of Bicing stations

7. Public transport mobility

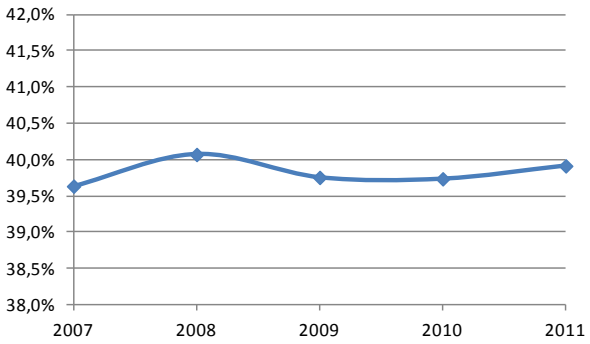
In the city of Barcelona, on a typical weekday there are 3.126.796 public transport trips, which represent 39,92% of the total mobility. Approximately half the trips in public transport are done within the city (internal trips 54,4%) and the other half with neighboring cities (connection trips 45,6%).

Public transport trips in Barcelona. Internal and connection trips 2011



The evolution of the last years shows no significant trend, and it has kept around 40% of modal distribution.

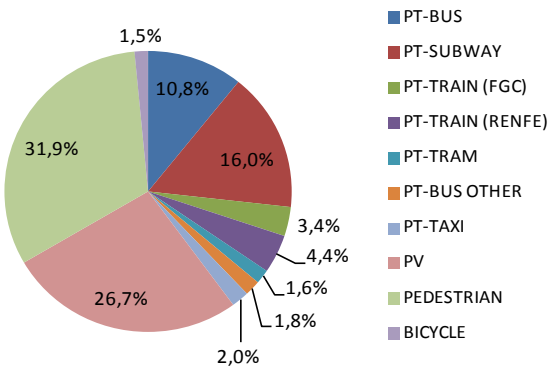
% of Public transport trips evolution in Barcelona



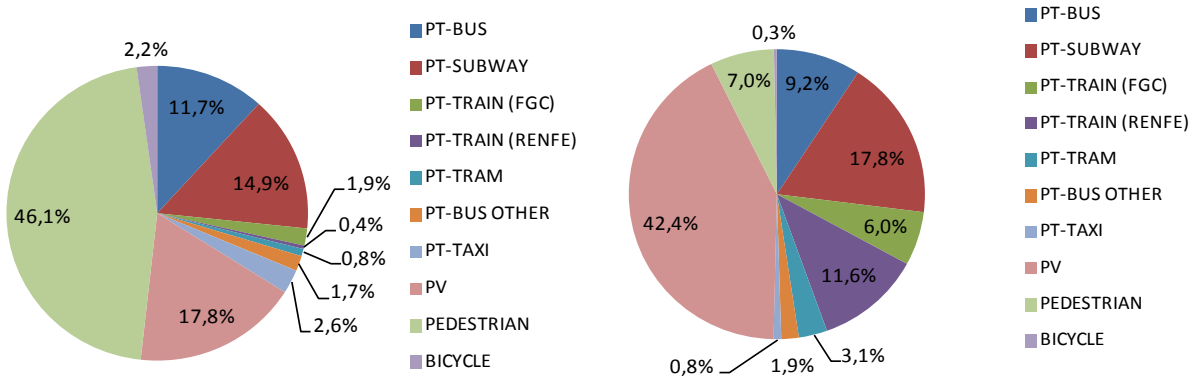
Public transport in Barcelona is formed by the following sub-modes: bus (regular), subway, train (FGC network), train (RENFE network), tram, bus (other buses or discretional), and taxi. The following tables and figures show the mobility for these sub-modes. The most important PT sub-mode is the subway, with 16,0% of total trips. The second most important sub-mode is regular bus, with 10,8% of total trips. The other sub-modes represent less than 5% each. If we look only at internal trips, the picture is approximately the same. For connection trips there is a difference since train appears as a significant mode. Subway keeps the first position with 17,8%, but train gets the second place (RENFE network 11,6% , FGC network 6,0%, total 17,6%. Regular bus is also important and takes 9,2% of connection trips.

Public transport trips in Barcelona. Modal distribution 2011

	INTERNAL	CONNECTION	TOTAL
PT-BUS	585.989	260.583	846.572
PT-SUBWAY	746.402	503.981	1.250.383
PT-TRAIN (FGC)	93.809	169.601	263.410
PT-TRAIN (RENFE)	18.822	327.416	346.238
PT-TRAM	39.766	87.661	127.428
PT-BUS OTHER	83.643	54.442	138.085
PT-TAXI	131.113	23.568	154.681
PV	887.928	1.200.419	2.088.347
PEDESTRIAN	2.302.569	197.631	2.500.200
BICYCLE	109.282	8.869	118.151
TOTAL	4.999.324	2.834.170	7.833.495

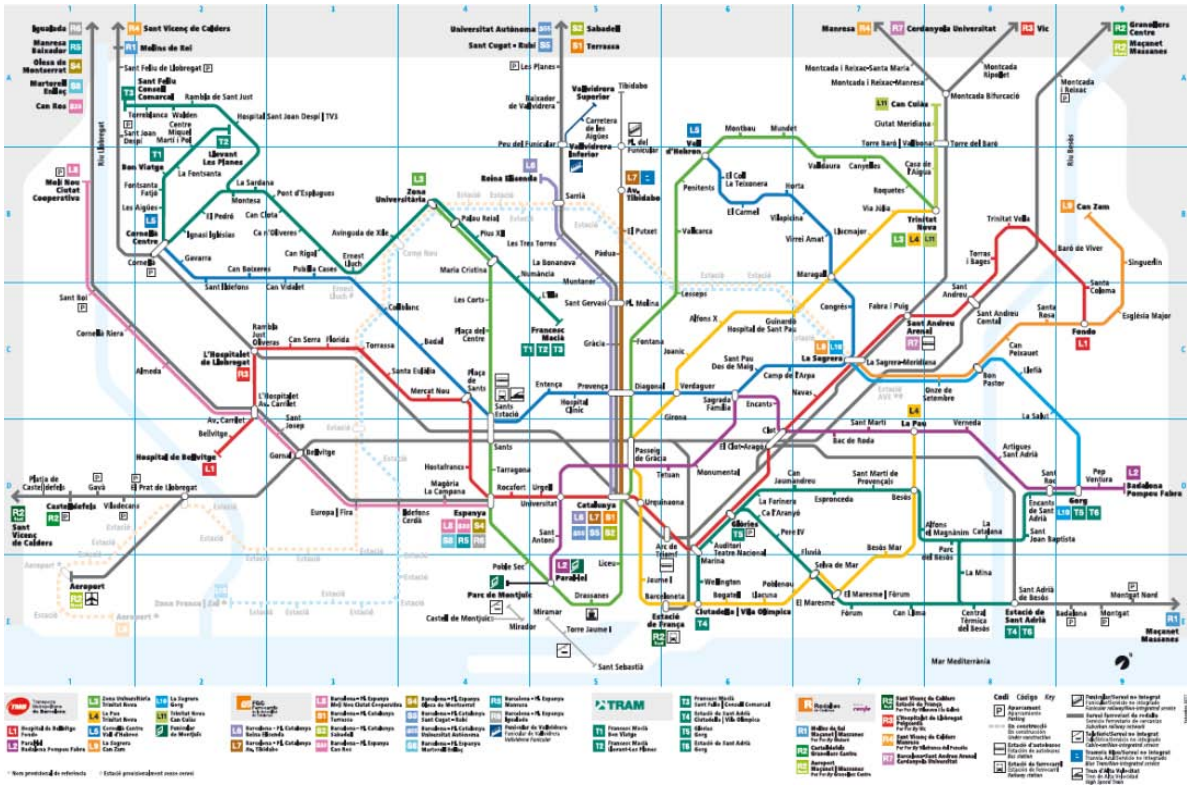


Public transport trips in Barcelona. Internal (left) and connection (right) distribution 2011



The figures and tables below show the public transport networks and their main characteristics.

Subway, tram, train (RENFE), and train (FGC) network in Barcelona



Bus network in Barcelona

Characteristics of the public transport network in Barcelona

	2008	2009	2010	2011
BUS TMB				
Network length (km)	915,16	923,92	932,37	935,95
Number of lines	108	108	106	106
Bus stops	2.545	2.573	2.610	2.632
Bus lane	113,5	122	125,97	131,95
Commercial speed	11,1	11,14	11,79	11,93
Number of buses	1.079	1.080	1.090	1.064
SUBWAY				
Network length (km)	88,43	93,29	102,59	102,59
Number of lines	6	7	8	8
Subway stops	125	130	140	141
Vehicles · km (milion)	80,37	79,04	87,63	90,59
TRAIN (RENFE)				
Network length (km)	529,6	522	522	552
Number of lines	6	5	5	6
RENFE stops	121	121	121	122
Vehicles · km (milion)	17,02	17,27	17,2	17,64
TRAIN (FGC)				
Network length (km)	143,3	143,3	143,3	143,3
Number of lines	4	4	4	4
FGC stops	74	74	75	75
Vehicles · km (milion)	32,74	33,01	32,61	33,27
TRAM				
Network length (km)	58,4	58,4	58,4	58,4
Number of lines	6	6	6	6
Tram stops	55	55	55	55
TAXI				
Users (million)	107	107	107	107
Number of taxis	10.483	10.480	10.480	10.480
Taxi stops	174	183	183	183
Drivers	12.353	12.852	13.167	13.249

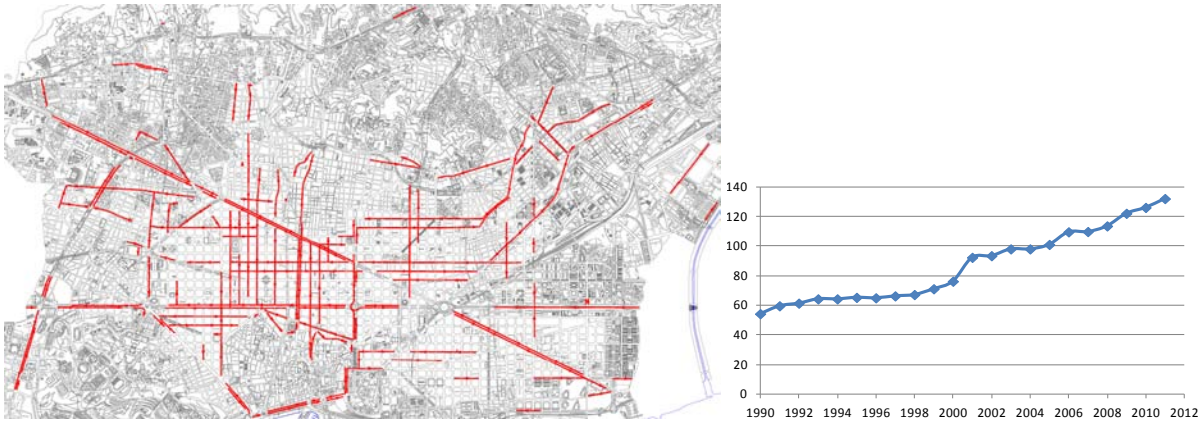
All vehicles on railway infrastructure are electric powered (subway, RENFE train and FGC tram). The bus fleet was all non electric until 2009. In 2010 the first hybrid buses were introduced, and in 2011 there were 12 units (1,2% of a total fleet of 1.064 buses).

Type of bus per fuel in Barcelona

	2008	2009	2010	2011
Diesel	715	664	623	554
Natural gas	248	295	341	353
Biodiesel	116	121	122	145
Hybrid	0	0	4	12
TOTAL	**1.079**	**1.080**	**1.090**	**1.064**

The city of Barcelona is willing to improve public transport mobility, and a proof of that is the constant growth of the bus lane network (reserved lane only for buses and taxis).

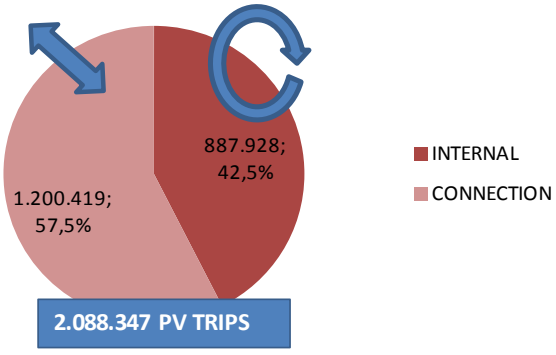
Bus network in Barcelona (left) and length evolution in km (right)



8. Private vehicle mobility

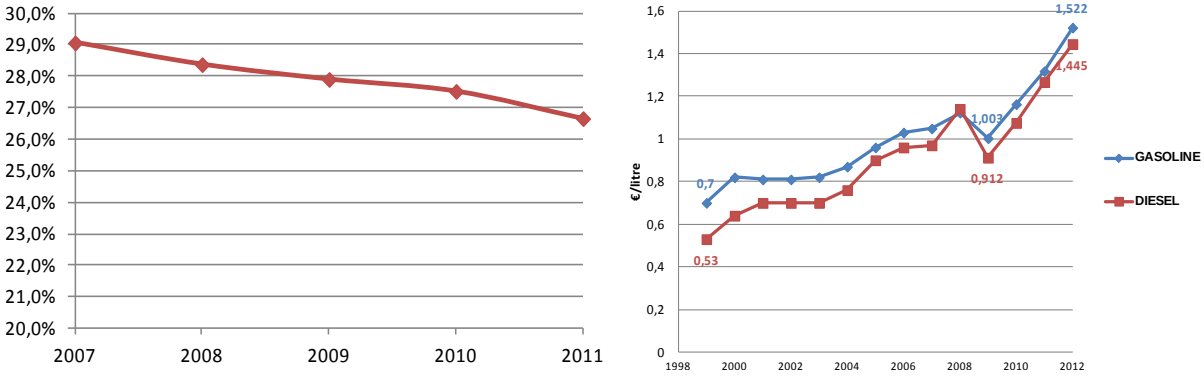
The private vehicle (car, motorcycle, van/truck) has a notorious presence in Barcelona's streets. However, it is the third mobility mode in order of importance, behind public transport and pedestrian mobility. On a typical weekday, there are 2.088.348 private vehicle trips, which represent 26,66% of total mobility. 42,5% of trips in private vehicle are internal trips and 57,5% are connection trips.

Private vehicle trips in Barcelona. Internal and connection trips 2011



The evolution of the last years shows a clear downwards tendency in private vehicle mobility (29,06% in 2007 and 26,66% in 2011), due to the economical crisis and up to some point to the increase of fuel price. Between 1999 and 2012, fuel price has more than doubled (almost tripled in the case of diesel), and between 2009 and 2012 the increase has been 50%.

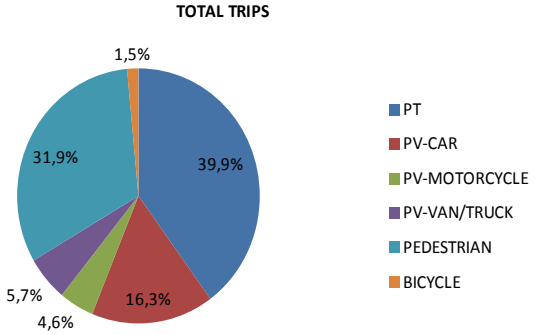
Evolution of % Private vehicle trips in Barcelona (left) vs. Fuel price evolution, €/l (right)

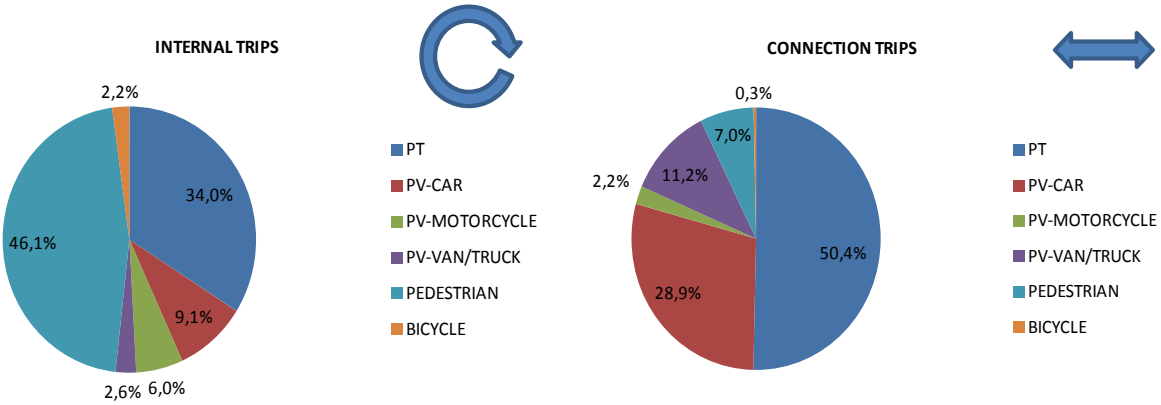


Private vehicle is composed of cars, motorcycles, and vans/trucks. The following tables and figures show mobility trends for these sub-modes. The 26,66% of private vehicle mobility is distributed in the following way: 16,3% car, 4,6% motorcycle, and 5,7% van/truck. If we look at internal mobility, private vehicle represents 17,8% of mobility and it is distributed: 9,1% car, 6,0% motorcycle, and 2,6% van/truck. In connection mobility, private vehicle represents 42,4% distributed in 28,9% car, 2,2% motorcycle, and 11,2% van/truck.

Private trip distribution in Barcelona. Total, internal and connection trips 2011

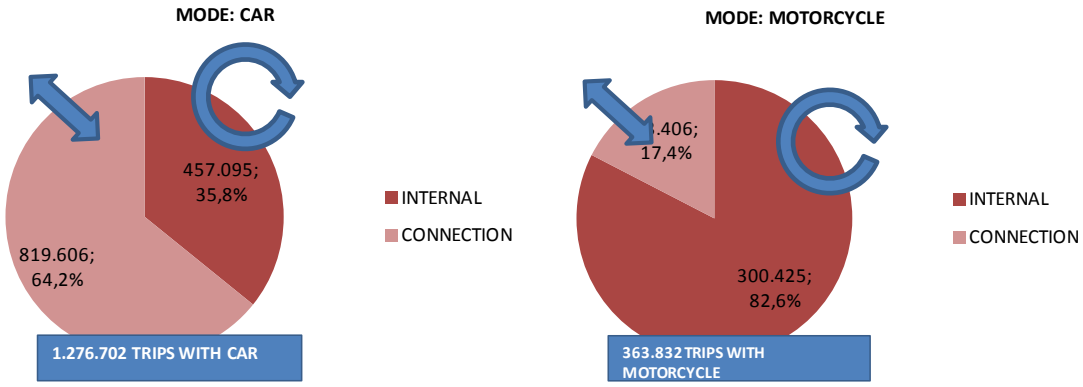
	INTERNAL	CONNECTION	TOTAL
PT	1.699.545	1.427.251	3.126.796
PV-CAR	457.095	819.606	1.276.702
PV-MOTORCYCLE	300.425	63.406	363.832
PV-VAN/TRUCK	130.408	317.407	447.814
PEDESTRIAN	2.302.569	197.631	2.500.200
BICYCLE	109.282	8.869	118.151
TOTAL	4.999.324	2.834.171	7.833.495





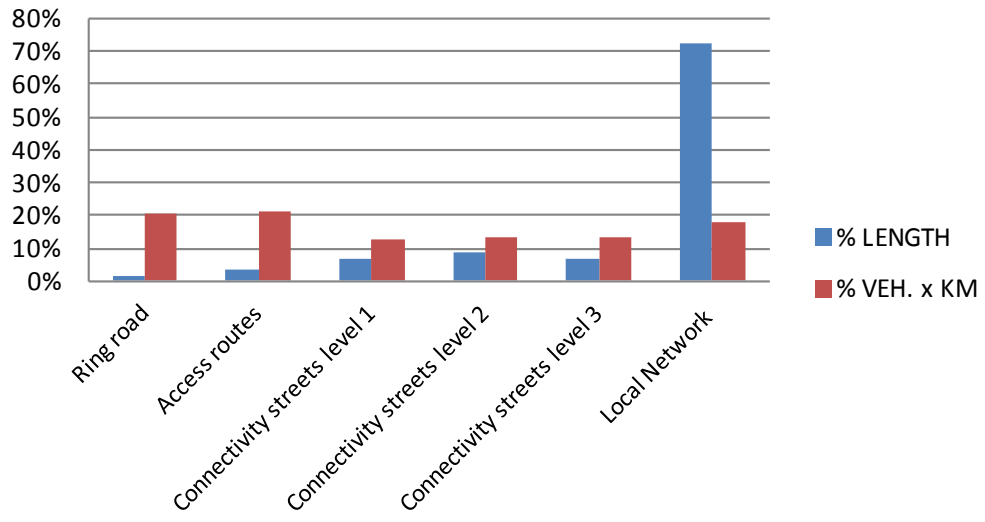
It is very interesting to notice the different mobility behavior of cars and motorcycles: cars are more used in connection trips than in internal trips, while for motorcycles is the other way around. Some reasons that explain this are: difficulty of car trips inside the city (parking, congestion, etc.), advantage of car in connection trips where there is a significant gain in time with respect to public transport, available and free parking for motorcycles almost everywhere, motorcycles not so much congestion dependent, connection trips are less attractive to motorcycles because of having to take high speed infrastructure.

Car and motorcycle trips in Barcelona. Internal and connection trips 2011

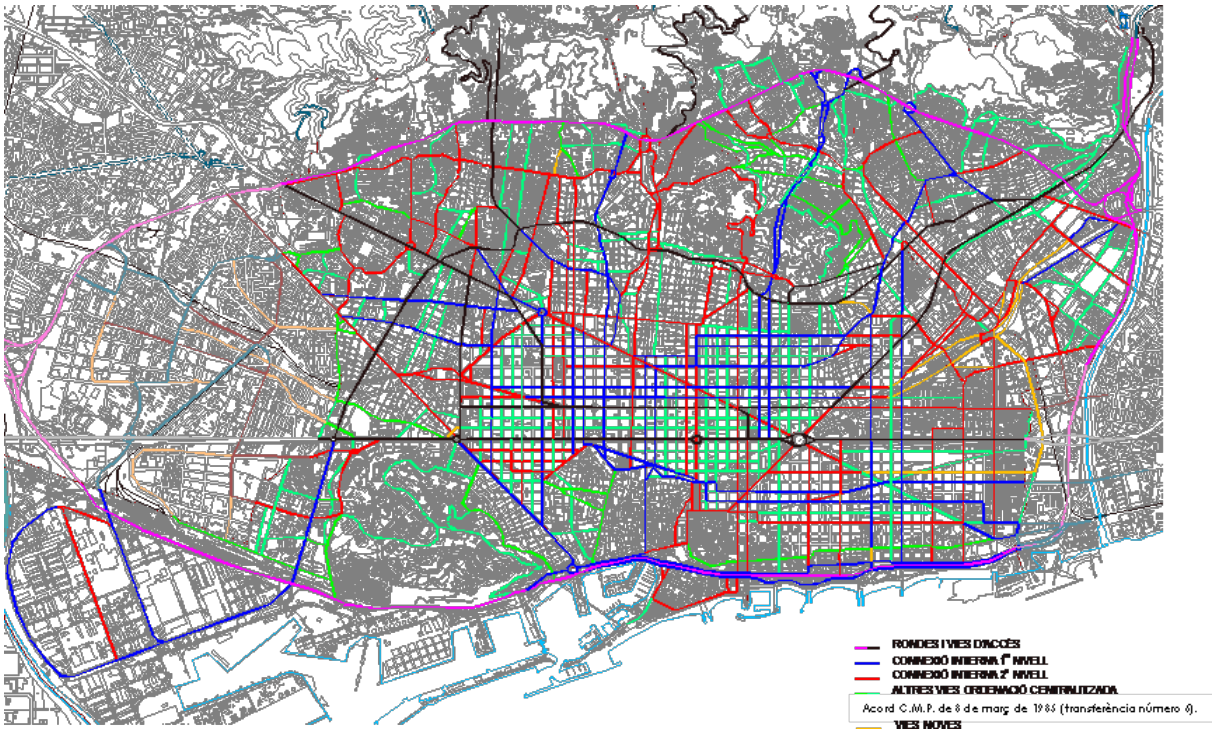


The city of Barcelona has a total of 1.275 km of streets, which are classified into 6 categories: ring roads, access routes, connectivity streets level 1, 2 and 3, and local network. The first 5 determine the city basic network, which represents 27,55% (351km) of total length street, but absorbs 81,76% of total traffic (measured as vehicles per km).

Street characteristics per category in Barcelona. 2011

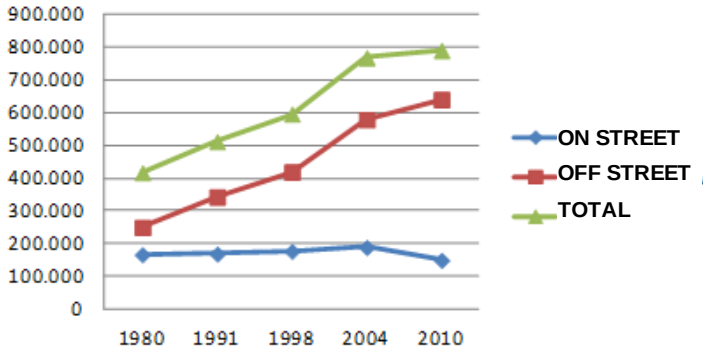


Barcelona basic traffic network



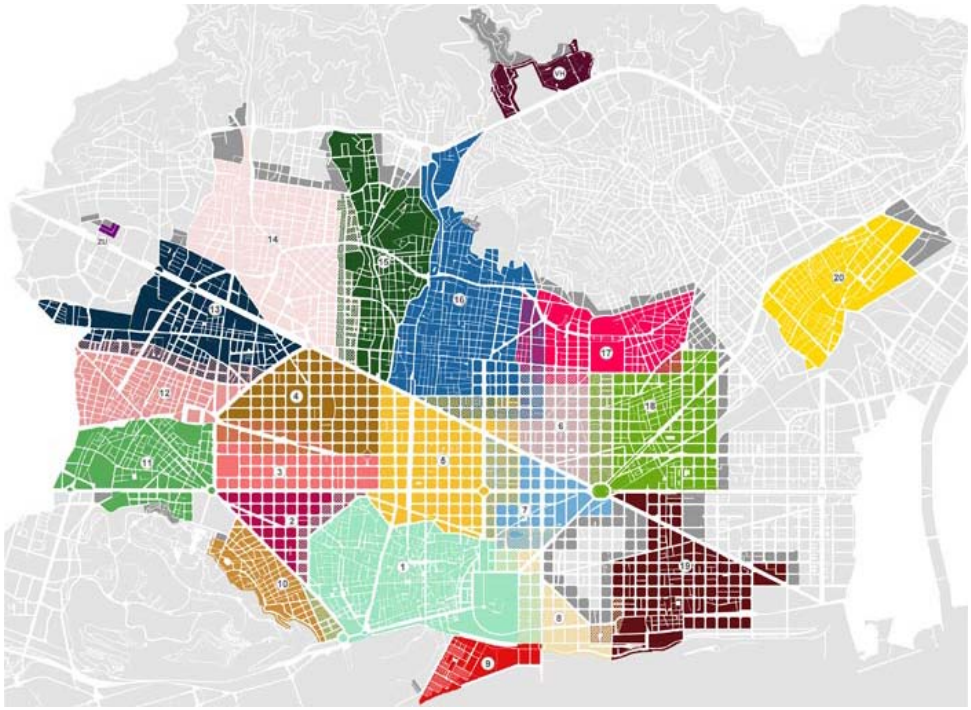
Parking places on street have decreased from 167.000 in 1980 to 150.000 in 2010. Parking off street has increased from 250.000 in 1980 (579.000 in 2004) to 640.000 in 2010. The ratio on street / off street has changed from 40-60% in 1980 to 19-81% in 2010.

Evolution of parking places in Barcelona



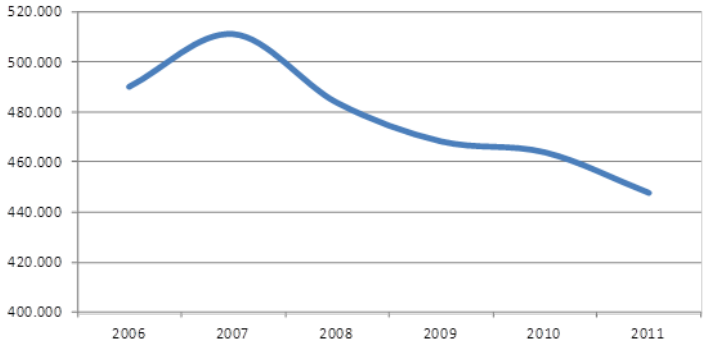
In 2005, Barcelona established the "Green Area" parking policy. On these areas, there are no on-street free parking places for people coming from outside their zone. This policy has decreased parasite traffic looking for free parking and is a deterrent for the use of car. It has improved traffic fluidity, environmental quality (air pollution and noise), and has allowed for a better management of public space.

Barcelona "Green Area" and zones



Urban freight distribution represents approximately 21,4 % of city traffic (447.815 trip steps over 2.088.347 trip steps in private vehicle). Most of the traffic generated by urban freight distribution comes from connection trips (70,9%), compared to internal trips in Barcelona (29,1%). The crisis has significantly affected the number of operations (reduction of 12,4% between 2007 and 2011).

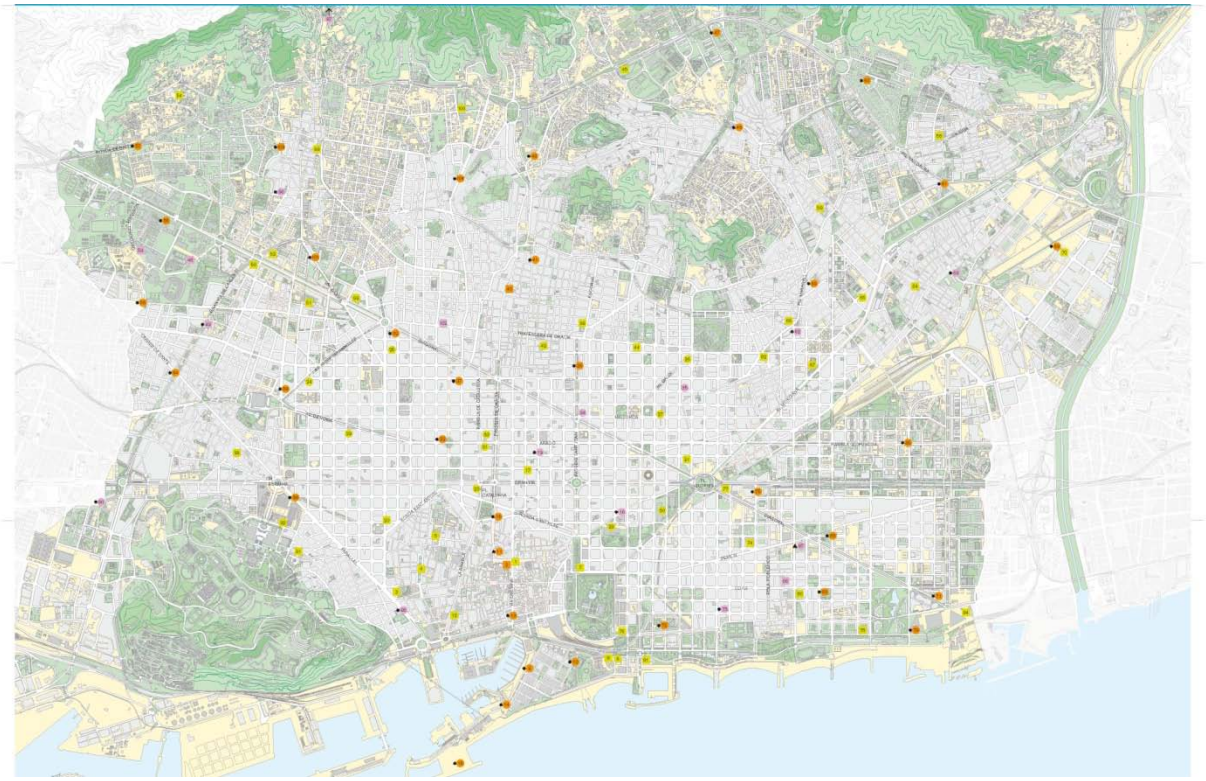
Evolution of freight vehicle trips in Barcelona



6.2. State of the electric vehicle in Barcelona

The electric vehicle has not achieved a significant penetration in Barcelona; therefore its energy consumption is still very low. However on recent years there has been some initiatives (both at local, national and European level) to increase the integration of electric mobility: subsides for the acquisition of an electric vehicle, installation of charge points in the public space, organizations of conventions to promote this technology or free public parking. As a result Barcelona currently has more than 249 electric charge points distributed for whole the city (they were 104 in 2011) and there has been a significant increase of electric vehicles use during recent years.

Charging points for electrical vehicles in Barcelona



Live Project is the platform developed by Barcelona Council, the Catalan regional government with the collaboration of other private entities, which is promoting the electric vehicle in the city as an opportunity to situate Barcelona as a centre of innovation in electric mobility on a world-wide scale.

The **MOVELE Plan** it's a national plan promoted by Spanish Government and its part of the strategy to promote the electric vehicle in Spain from 2010 to 2014. This plan consists on a series of measures to be implemented to encourage decisively the introduction of electric vehicles. These measures fall within four basic areas: promoting the demand for these vehicles, support industrialization and R&D of this technology, facilitate the adaptation of the electrical infrastructure for the correct charge and demand management and promote a series of cross-cutting programs related to information,

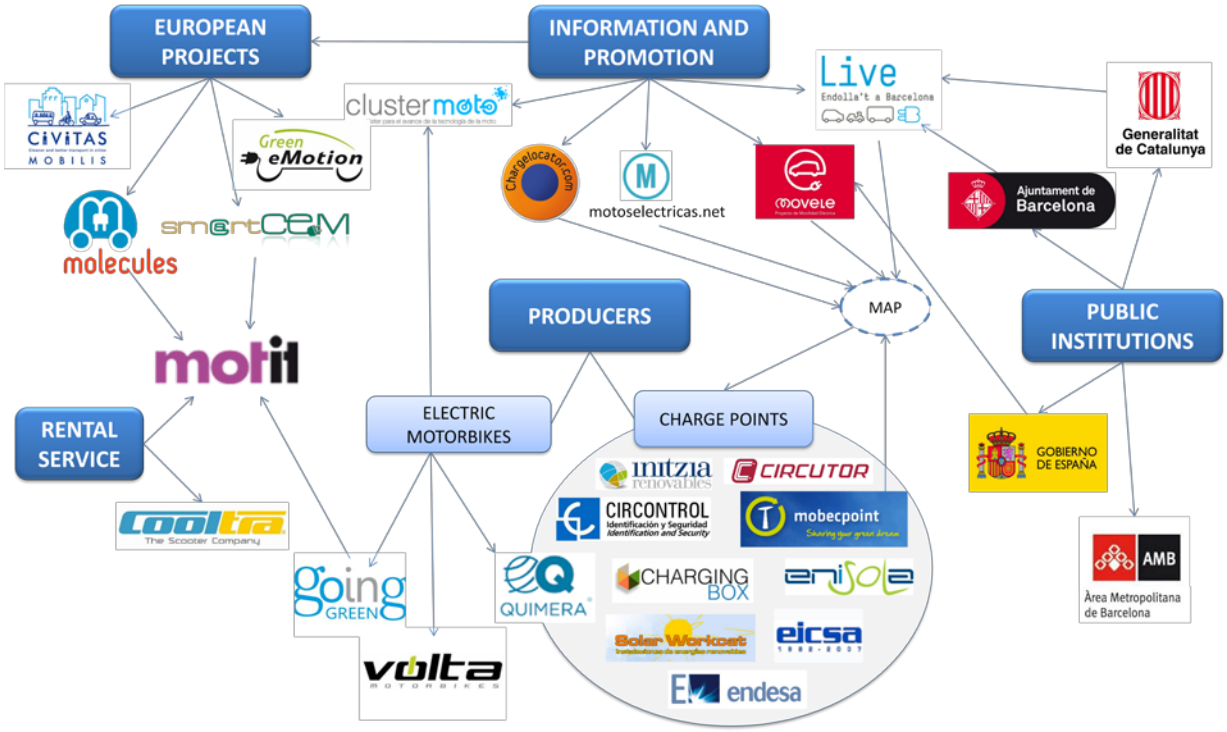
communication, training and standardization of these technologies. The aim of that strategy is to reach 250,000 electric vehicles by the end of 2014 circulating through our streets and highways.

Referring to electric scooter, there are some actuations and initiatives which are being developed nowadays; European projects to promote its use, web platforms including information of scooters models or charge points maps... Also is creating a network of local manufacturers, which are producing charge points and electric scooter. Finally there are some private initiatives of electric scooters renting; however by the moment these companies are mainly focused to tourism.

Next diagram represents the state of art of the different projects and initiatives related to the use of electric scooter in Barcelona:

Diagram of relevant electromobility actors in Barcelona

Source: BCNecologia



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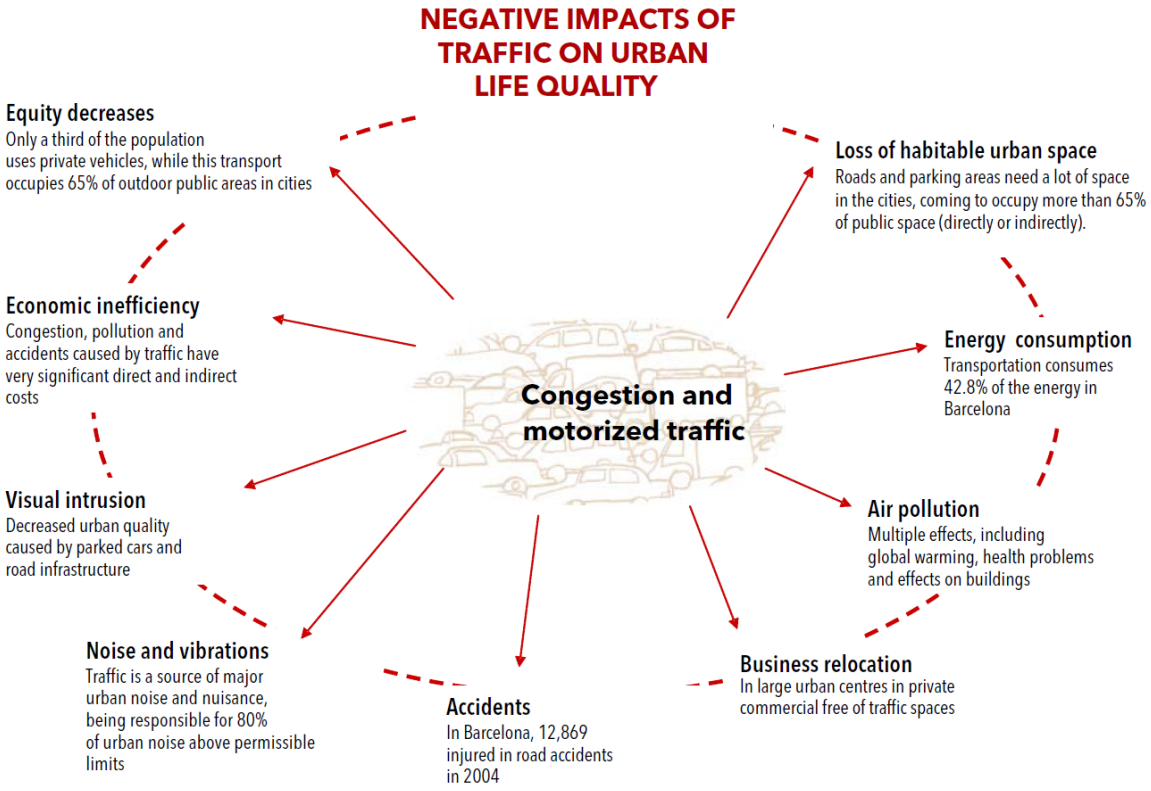
9. Externalities of the mobility system

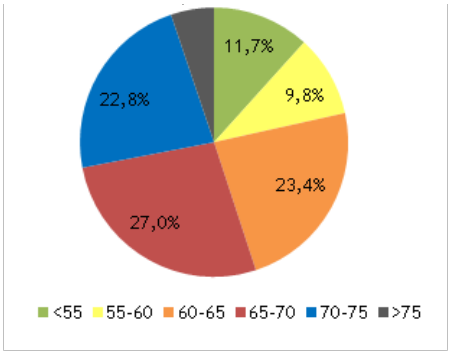
The mobility system, especially motorized traffic and congestion, has some negative effects on urban life quality which are represented in the figure below.



9.1. Noise

Noise is one of the major problems. 55% of Barcelona's population is exposed to unhealthy noise levels (65dBA), which are marked by legal thresholds according European, Spanish and municipal law.

Noise (Lden) affected population in Barcelona. 2011



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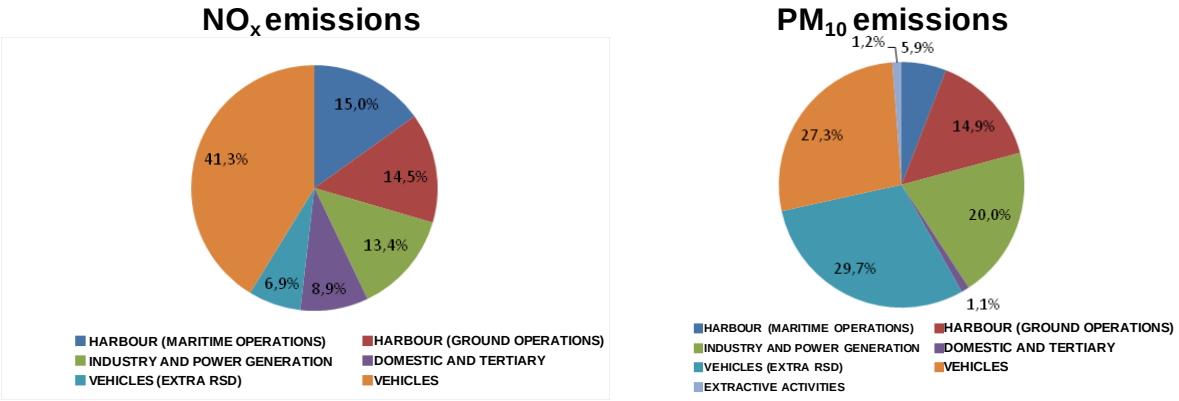
9.2. Air pollution

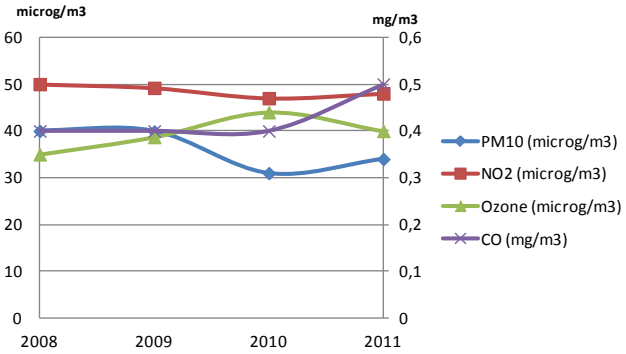
Air pollution and its negative effects (global warming, health problems, effects on buildings) are produced on a great measure by traffic. NOx emissions are caused by traffic on a 48,1%, and PM_{10} emissions by a 57,0%. In the figures below traffic emissions are classified as "vehicles" and "vehicles extra RSD"[1]. The other sectors (domestic, industrial, etc.) contribution to air pollution is much less significant.

Air pollutants emissions in Barcelona. Distribution per source 2011



The evolution of air pollution over the last years doesn't show a clear downwards tendency despite traffic decrease.

Evolution of air pollutants emissions in Barcelona

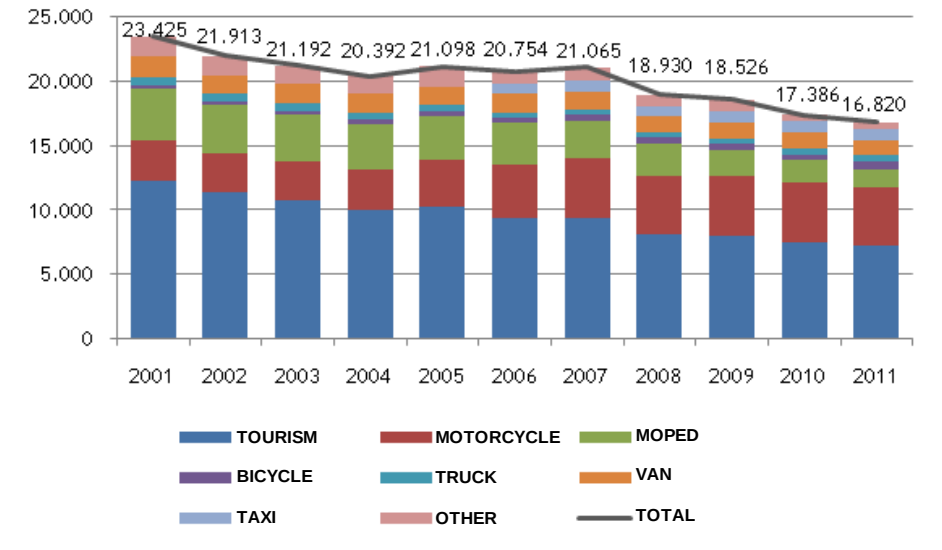


[1] "Extra RSD" are additional emissions detected with the RSD measuring system.

9.3. Accidents

Traffic accidents are another problem caused by mobility. In 2011 in Barcelona traffic accidents injured 10.229 people and killed 31. The tendency over the last years is decreasing.

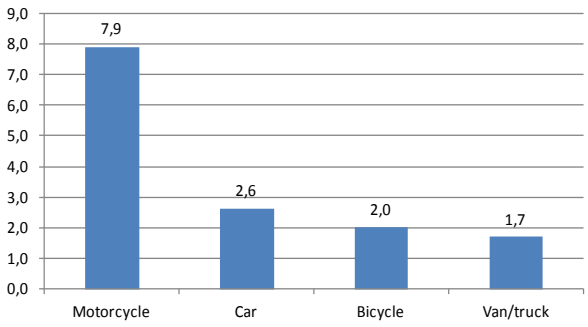
Evolution of number of accidents by type of vehicle involved in Barcelona



Not all vehicles have the same "risk factor". If we divide the vehicles involved in an accident by their mobility (per vehicle type), we obtain a risk factor by vehicle type. This calculation shows that a trip by motorcycle has almost 4 times more probabilities of having an accident than a trip by car or bicycle.

Accident risk factor per vehicle type in Barcelona. 2011

	% TOTAL MOBILITY	% VEHICLE INVOLVED IN ACCIDENT	ACCIDENT RISK FACTOR
Motorcycle	4,5%	35,6%	7,9
Car	16,3%	42,7%	2,6
Bicycle	1,5%	3,0%	2,0
Van/truck	5,7%	9,7%	1,7



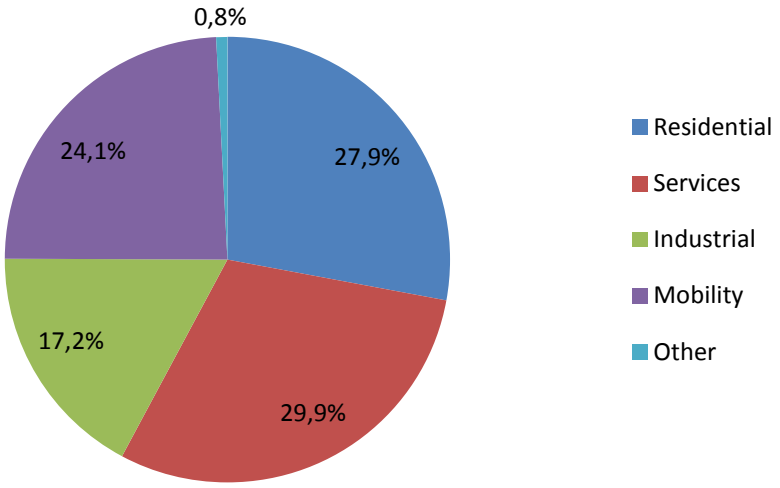
9.4. Energy consumption

Mobility is a high intensive energetic sector. Nowadays it represents 42% of the Spanish energy consumption and 41% of the Catalan. Mobility is the energetic sector with a lower efficiency and the only one that has not reduced its consumption in the period between 1990 and 2000, despite the increase of the combustion engines efficiency.

In Barcelona energy consumption has been estimated from the vehicle fleet and the flow traffic map for the city, calculating energy consumption and emissions associated to mobility. It represents 24.1% of the total energy consumption in Barcelona.

Energy consumption per sector in Barcelona.

Source: ICAEN and Repsol 2008

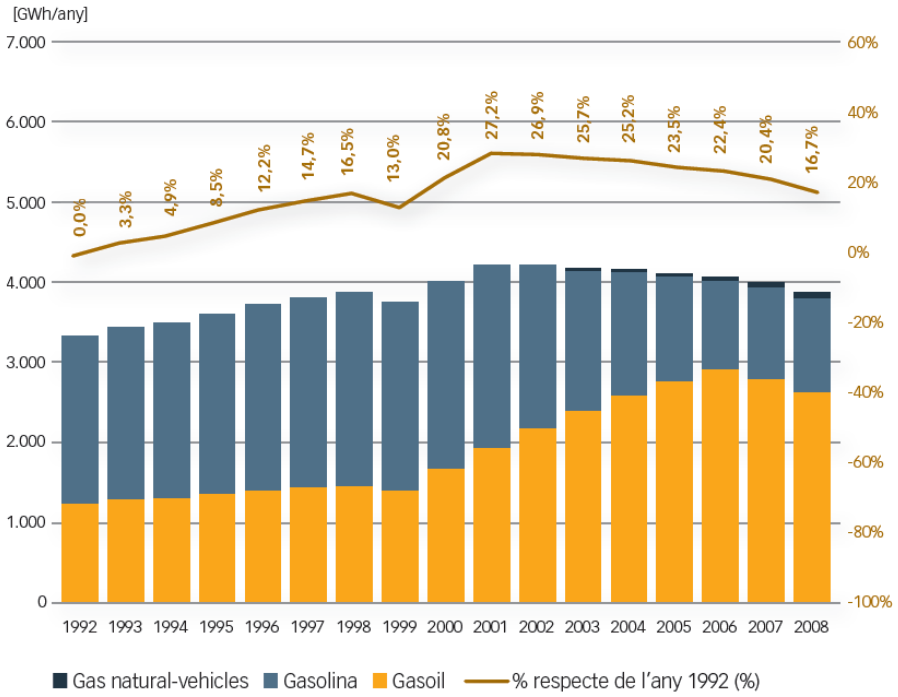


Energy consumption related to mobility has remained mainly constant during the last years. In 2008 the consumption was 3.850,17 GWh, with an average of 0.87 kWh for each km. The annual increase rate between 1999 and 2008 was about 0,37%; however since 2001 has been a reduction of 1.22% for year. This reduction is due to various actuations taken by the municipality, which has supposed an increase of collective and not motorized mobility (mainly bike and foot). There has also been an improvement of energy efficiency thanks to the increase of electric public mobility (metro, train and railway) and natural gas powered buses.

Referring to private mobility there are two factors which have supposed a reduction of its energy consumption: a reduction of the number of circulating vehicles and an increase of its efficiency. On the other hand, the increase of trucks, buses and two-wheeled vehicles has compensated this energy reduction. In more recent years there has been an additional decrease of car trips caused by the economical crisis which will have had a higher influence reducing energy consumption.

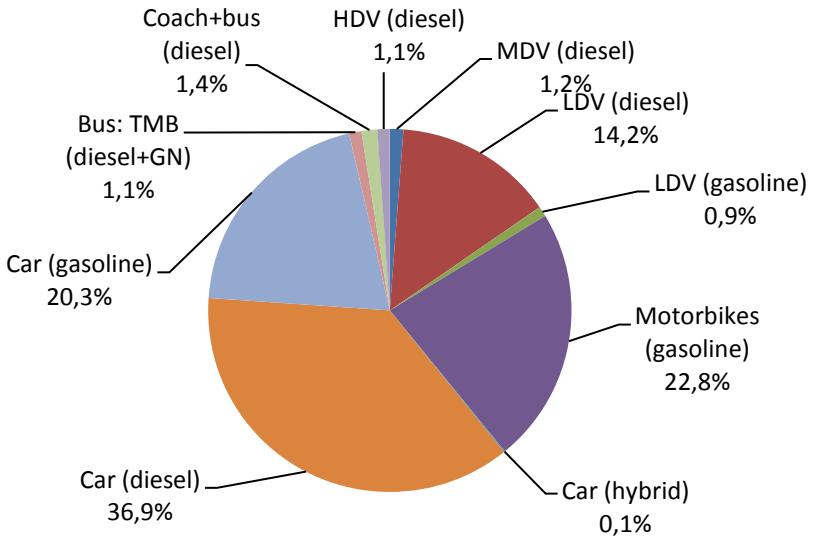
Energy mobility consumption by fuel between 1992 and 2008.

Source: Agencia de l'Energia de Barcelona.



The most common vehicle in Barcelona is diesel car, which represents 36,9% of the motorized circulation. This value is complemented by the 20,3% of the trips realized by gasoline cars. Both add up to 57,2% of motorized trips. Motorbikes represent 22.8% of motorized trips.

Mobility displacements by transport mode and vehicle typology
Source: Agencia de l'Energia de Barcelona 2008.



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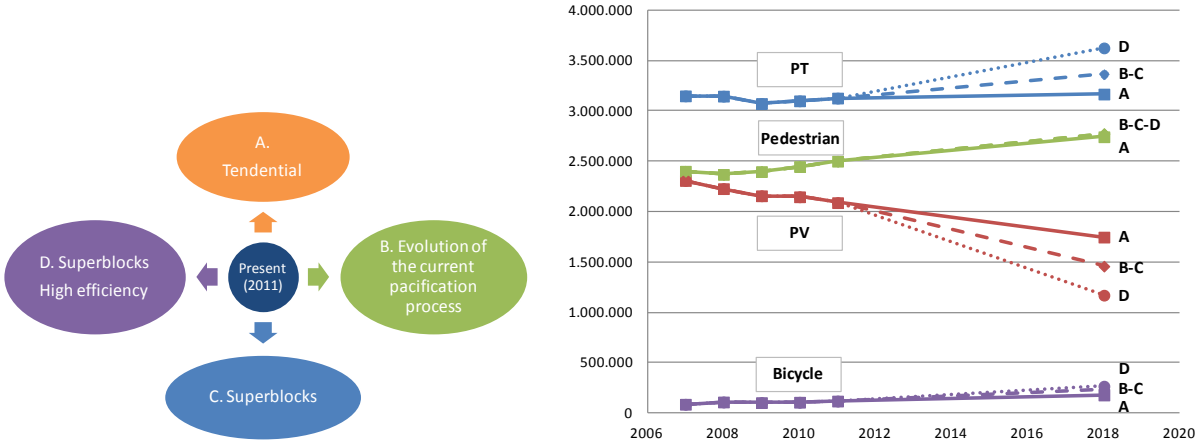
10. Mobility objectives: SUMP (Sustainable Urban Mobility Plan) 2013-2018

Barcelona's SUMP (Sustainable Urban Mobility Plan) 2013-2018 analyses 4 different future scenarios. Scenario A is tendential: what would happen if no specific additional actions were taken. Scenarios B, C, D are Scenarios with a bigger restriction of car use and a greater use of more sustainable modes. The figure below shows the mobility objectives for each scenario. In all scenarios, private vehicle decreases, and bicycle, public transport and pedestrians increase.

SUMP future scenarios of the and estimated evolution of current modal distribution



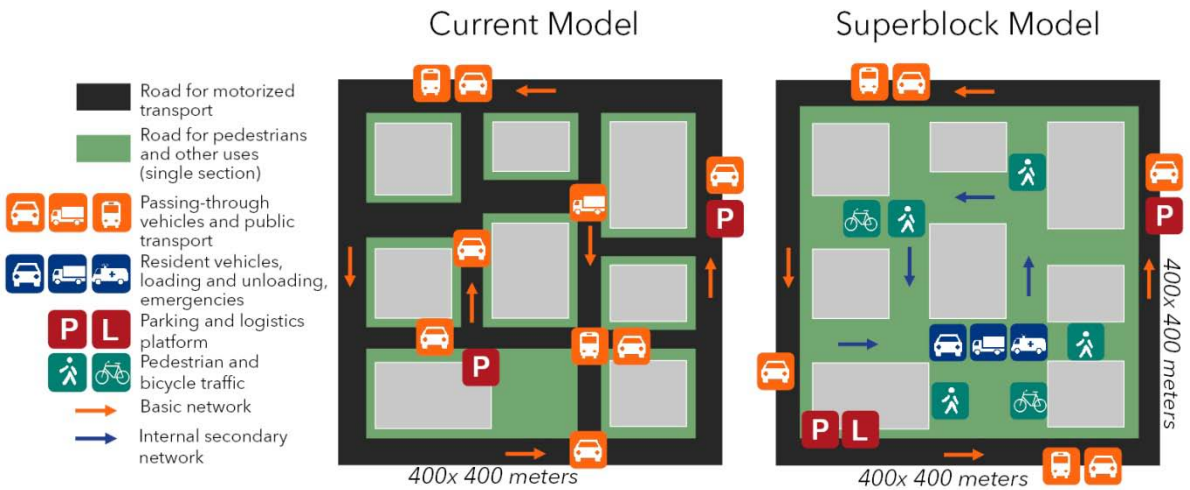
The objective scenario is C, with the following goals:

- Achieve a figure of 43% for trips by public transport (currently it stands at 40%).
- Achieve a greater pacification than in scenario B with a traffic level of service similar to present.
- Compliance with policy environmental quality parameters: EU directive, Kyoto, etc. (annual average limit values: NO2: 40µg/m3, PM10: 40µg/m3, PM2,5: 25µg/m3).
- Reduce noise from traffic in 60% of public space.
- Reduce traffic victims.
- Increase to 58% street space for pedestrians.
- Reduction of the number of private vehicle trip steps from 26.7% to 18,6% of the modal distribution.

Three of the key aspects of the SUMP are:

- Implementation of Superblocks: areas inside which no passing traffic is allowed
- Implementation of a new bus network: New network based on orthogonal lines which allow for a more efficient network.
- Enhance the use of the electrical bicycle.

Current mobility scenario vs. Superblock mobility scenario



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PART 2

11. Introduction

The second part of the document describes the results of the Ele.C.Tra survey and also relates those results with the official information of the first part. The surveys were performed to 586 individuals in the city of Barcelona during the end of 2013.

The main objectives of the Ele.C.Tra survey were:

- To describe mobility practices and characteristics of people moving across Barcelona municipality.
- To determine the interest of Barcelona citizens and visitors regarding electric vehicles and their relation with sustainable mobility.
- To know the disposition of the inhabitants and visitors of Barcelona to use an electric bike sharing system in the city.
- Relate the characteristics of the population with electromobility, in order to know which population groups have a higher level of acceptance.
- Provide a common analysis framework for all Ele.C.Tra partners to the development of the project.

486 surveys were performed to residents and 101 to visitors, with different questions for each group according the Ele.C.Tra questionnaire. This document has a descriptive part of both surveys, starting from the tourists analysis. Additionally, in the residents survey results, a complete statistical analysis has been performed, with the main objective of linking social characteristics of the interviewed people to the interest in electric vehicles and willingness to use a bike sharing system.

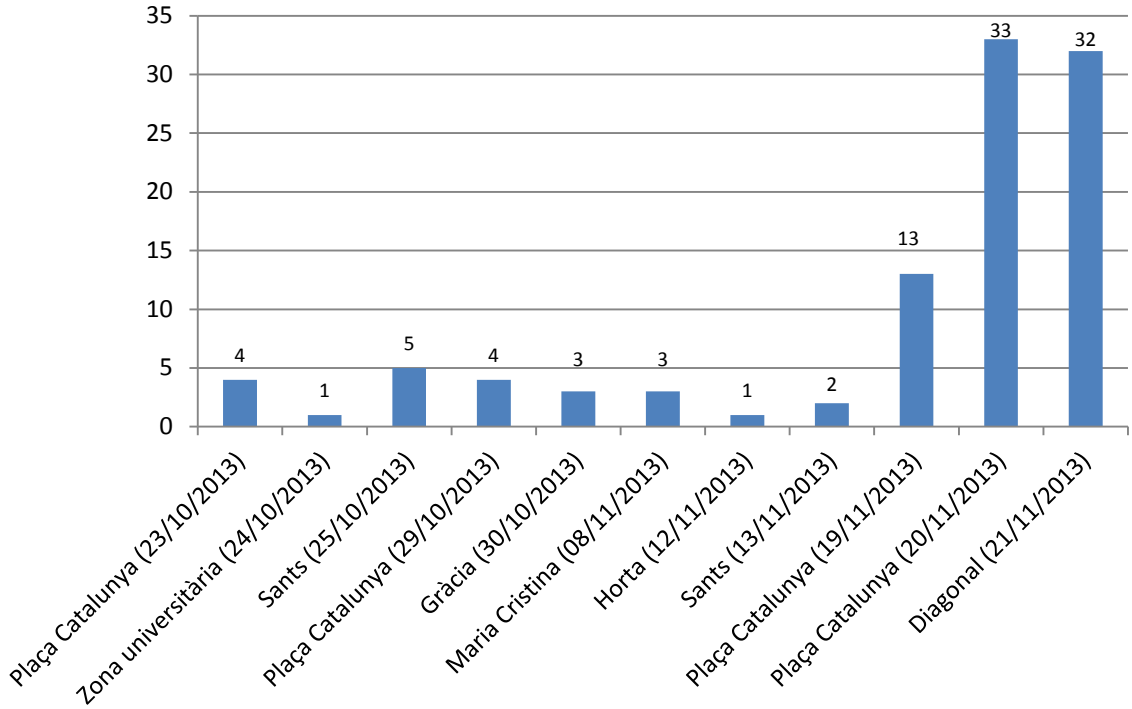
12. Results from tourists surveys

12.1. Introduction

This report is the result from the fieldwork developed between 23rd of October and 21th of November of 2013. Most of the surveys to tourists were performed during the 19th and 21th of November in *Plaça Catalunya* and its surroundings (*Portal de l'Àngel* and *Plaça de la Catedral*), near the metro station of *Diagonal*, at *Rambla de Catalunya* and in *Passeig de Gràcia*; being all of them typical places with a high tourist affluence..

On the whole 101 tourists were surveyed, which gives an error margin of ±9,97% (confidence level of 95,5% or two sigma and maxim uncertainty situation where p=q=0,5). The next information should be taken as an estimation or tendency due to its high error margin.

Survey collection: surveys per day and place



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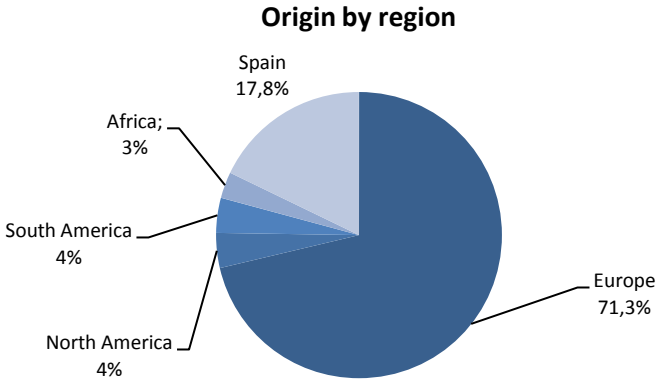
12.2. Interviewed profile

There were no defined characteristics samples according to origin, age, income or other variables for touristic survey. The profile obtained from the surveyed group was as follows.

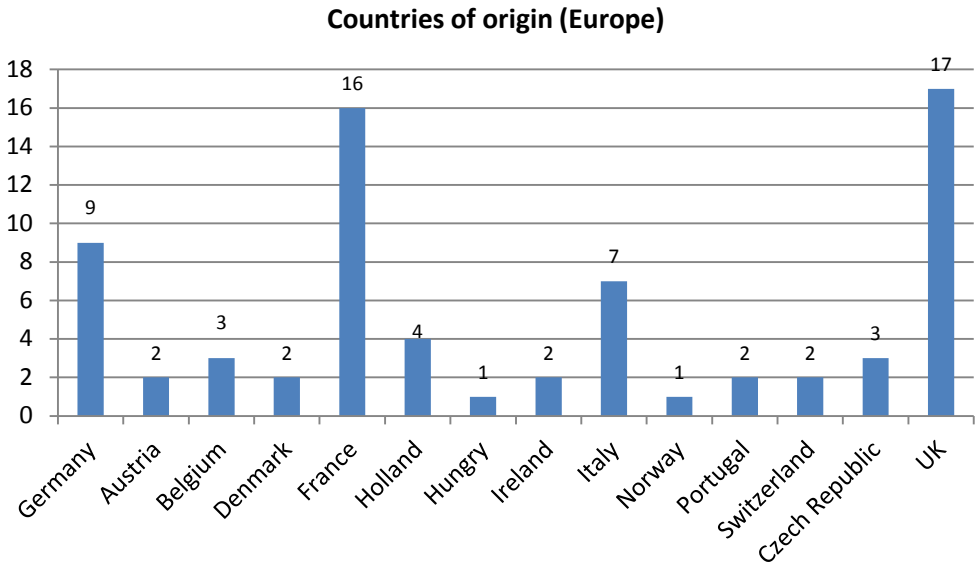
Origin

Most of the interviewed people were Spanish and European tourists. Apart from this group there were also eleven cases from South America, North America and Africa.



n=101

Referring to the European countries, the most surveyed tourists were from UK, France and Germany:



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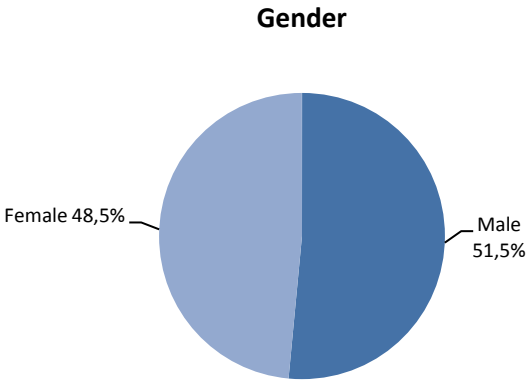
Despite the large amount of Russian and Japanese tourists that visit in Barcelona it was impossible to survey them, mainly due to language problems or because they were not predisposed to be interviewed.

Gender

The interviewed number of males and females was almost the same:



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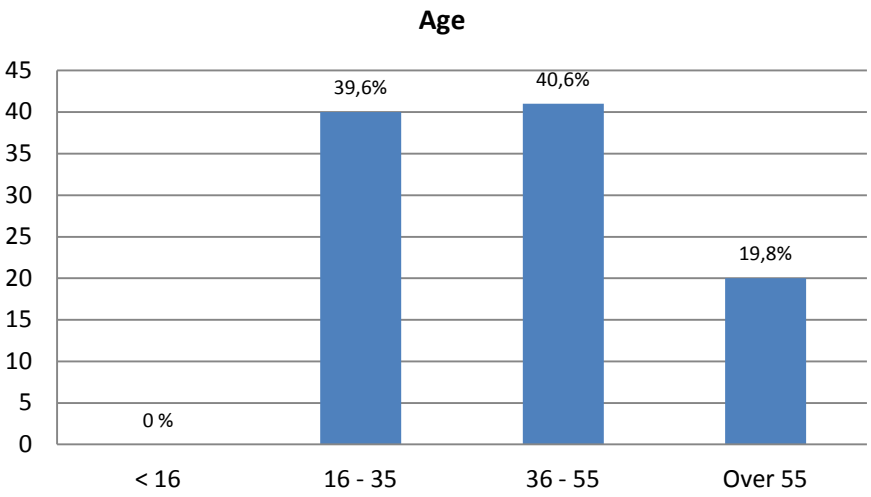
Age

All the interviewed torists were over 16. It was not possible to interview people younger than this age mainly due to the reticence of this collective and in some occasions because the familiars did not allow it.



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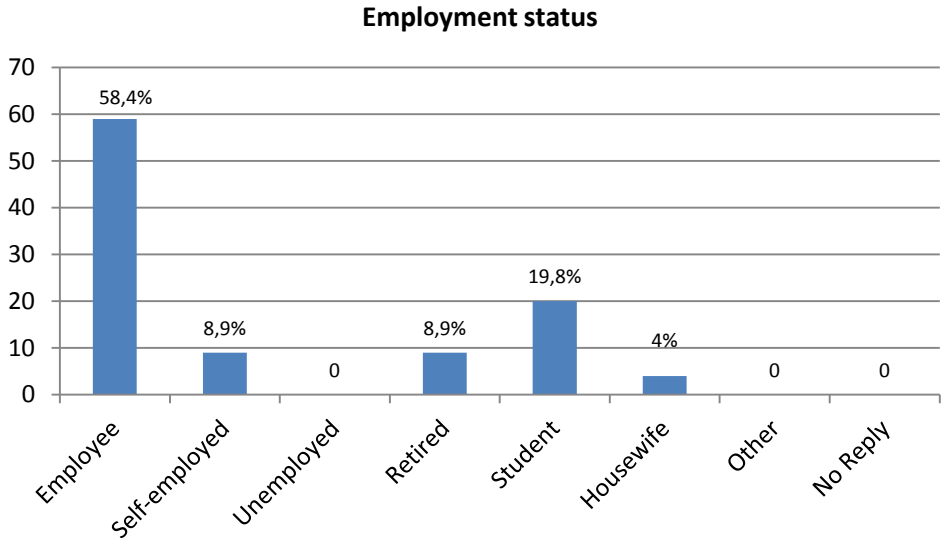
Job relation

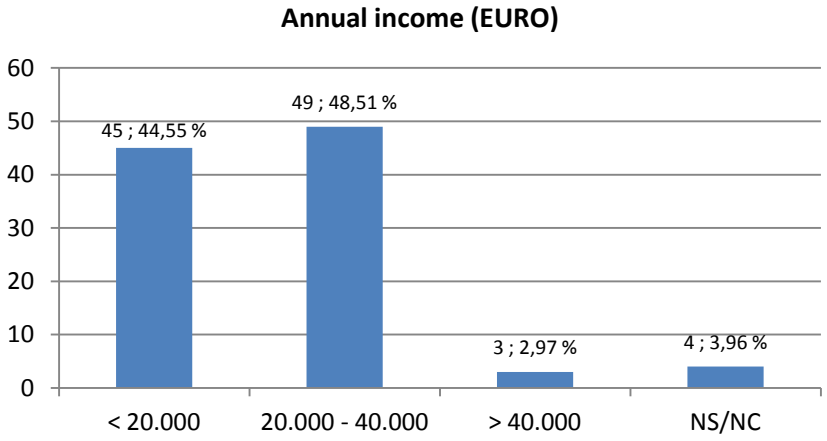
Most of the interviewed tourists (58,4%) were employed. Students were the second predominant group (19,8%).



n=101

Income

Almost all the interviewed people earn less than 40.000 €/year and the half part of them earn less than 20.000 €/year (this last group include the 20 students). Despite being a question that could be unpleasant, only 4 people did not answer it. That fact can be explained for the wide range of the income categories given.



n=101

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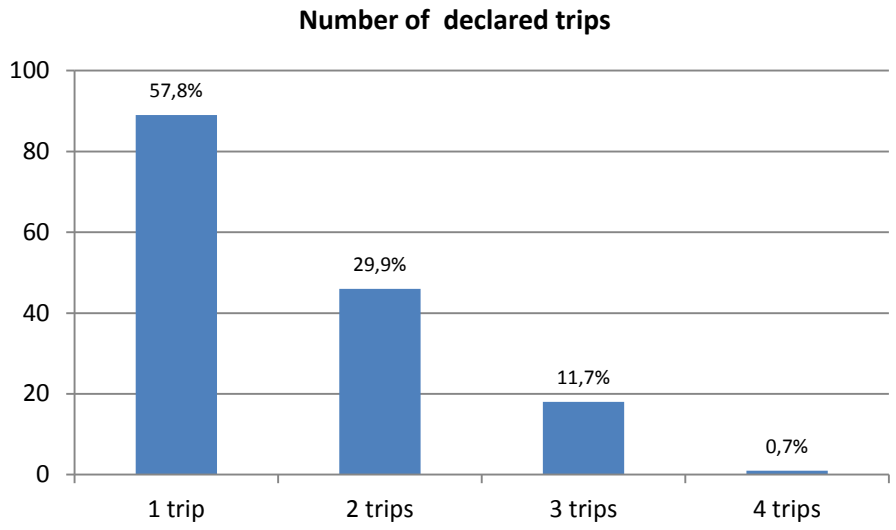
12.3. Descriptive analysis

Question 6. Choose the most common trips that took longer than 5 minutes (which you did today or yesterday in Barcelona). If no trip in Barcelona today or yesterday, skip question 7.

This question was only addressed to the people who had done a more than 5 minutes trip inside Barcelona during the current or the previous day. From all the interviewed people, 12 of them did not satisfy this condition because they had just arrived to Barcelona.

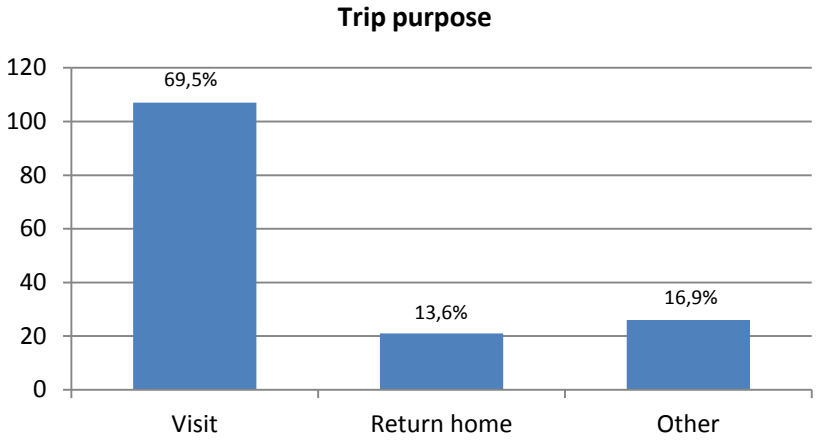
It was possible to declare 4 trips for each survey as a maximum, then, the total number of trips that could be recorded was 404 (101*4). However only in one case were recorded the four trips, 18 people declared 3 trips and 46 people 2 trips. In total there were recorded 154 trips from the possible 404 (38,1% of total).



n=154

Trip purpose

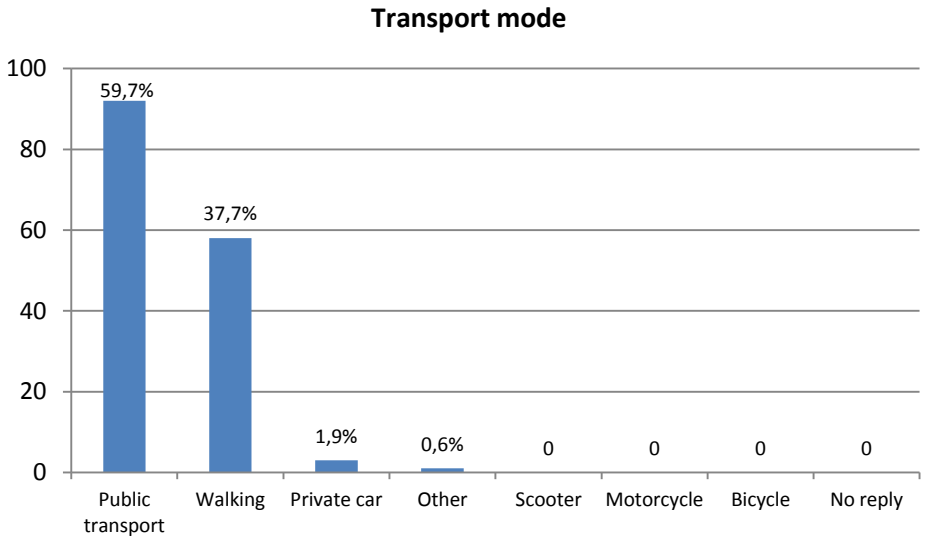
Logically, the main purpose of the trips was to visit some touristic place (69,5% of the trips) and return to their staying place (13,6%). The category others (16,9%) included working purposes, shopping, congresses, etc.



n=154

Transport mode

Public transport and walking reach 97,4% of the trips. Only 3 people use a car or another non specified option.



n=154

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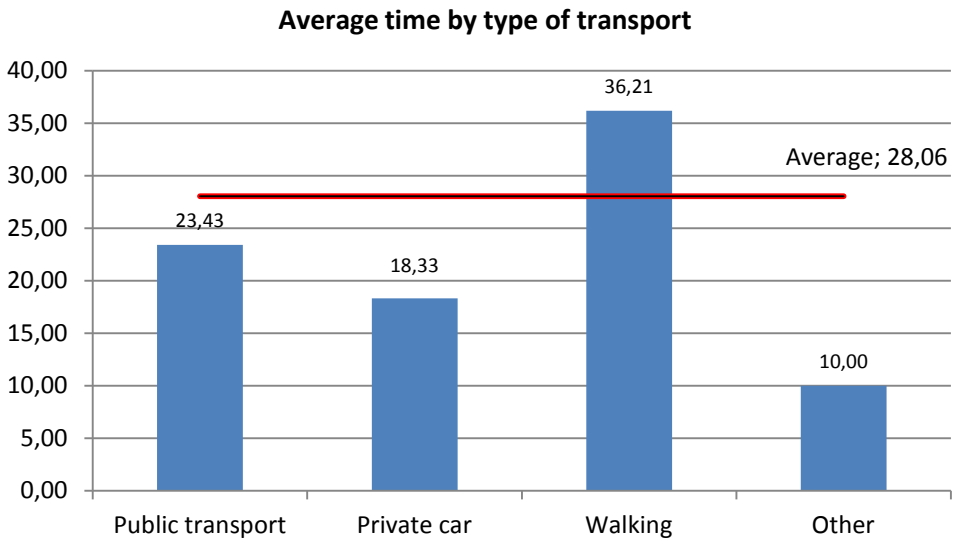
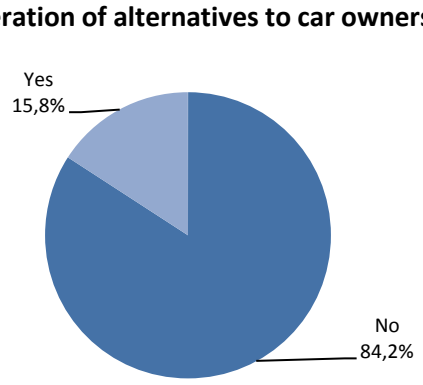
Trip timing

The average travel time is 28,1 minutes for trip, with a standard deviation of 19,7 minutes (the minimum value is 10 minutes and maximum is 180 min). The walking trips correspond to the longest ones (36,2 min).



Question 7. Have you ever thought of alternative solutions to the possession of the car?

Only sixteen of the interviewed people (corresponding to the 15,8% of the sample) have considered alternative options to car ownership; most people had not considered this option.



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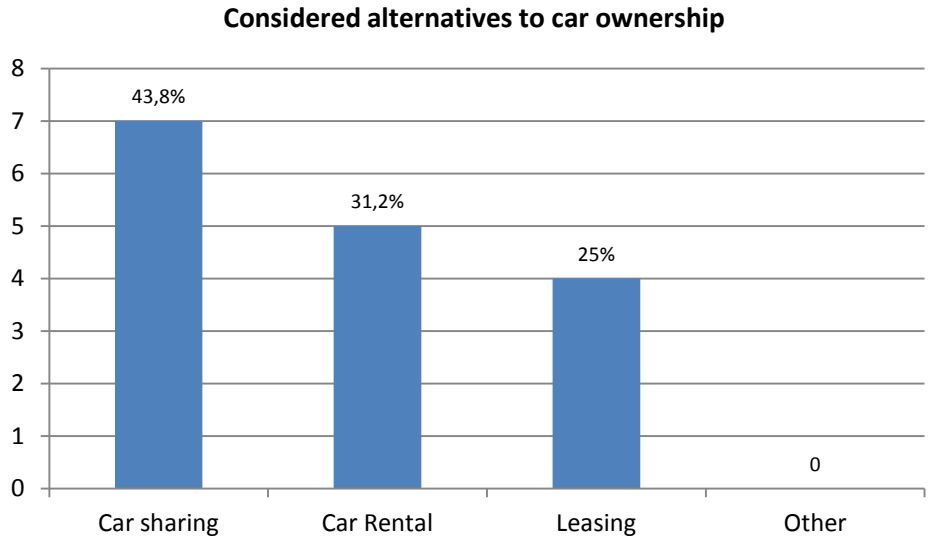
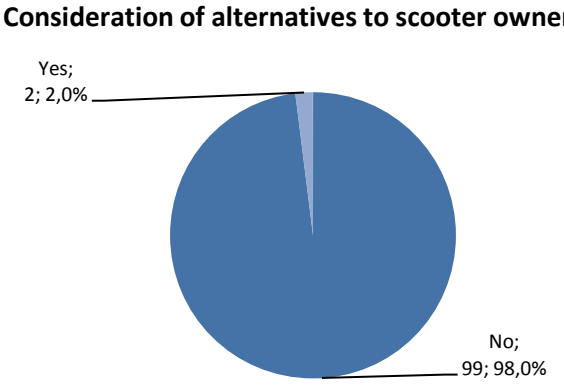
For those who considered other options (sixteen people), the most common alternative was car sharing, followed by car rental and leasing.



n=16

Question 8. Have you ever thought alternative solutions to the scooter use?

Almost all the surveyed people (98,0%) has never thought about alternative options to scooter ownership. The two people who answered affirmatively to this question preferred the renting option than sharing or leasing ones.



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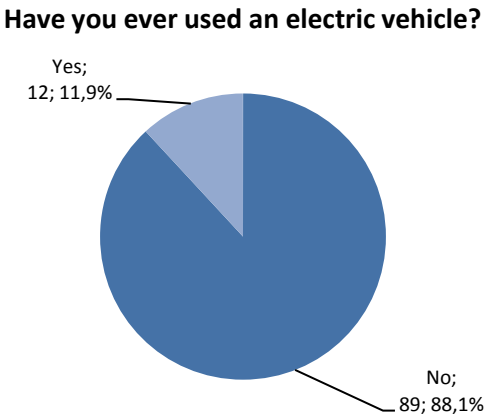
Question 9. Have you ever used an electric vehicle?

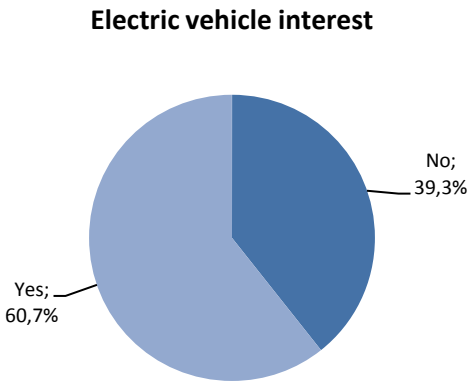
A 11,9% of interviewed (12 cases) stated that they had used an electric vehicle at least one time.



n=101

Question 9.1. If NO, would you be interested in testing/buying and electric vehicle taking into account the following advantages: speed, comfort, safety, environmental friendly, consumption reduction?

54 of the 89 cases that have never used an electric vehicle would consider to test it or to buy one. The conclusion from the last two questions is that 66 out of 101 interviewed people (65,4%), has used or would consider using an electric vehicle in the future.



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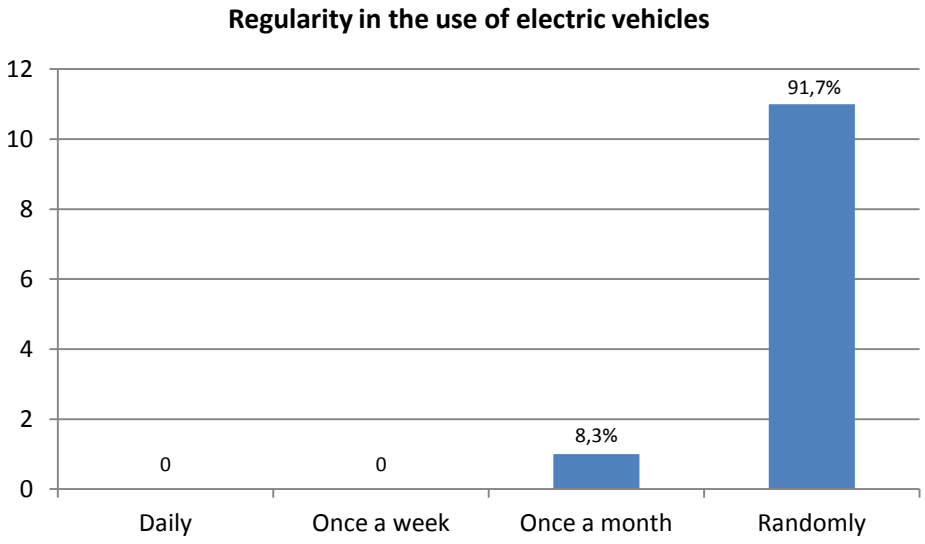
Question 9.2. If yes, how often?

From the 12 people who have used an electric vehicle, 11 did it very occasionally.



n=12

Question 9.3. If yes, what type of vehicle?

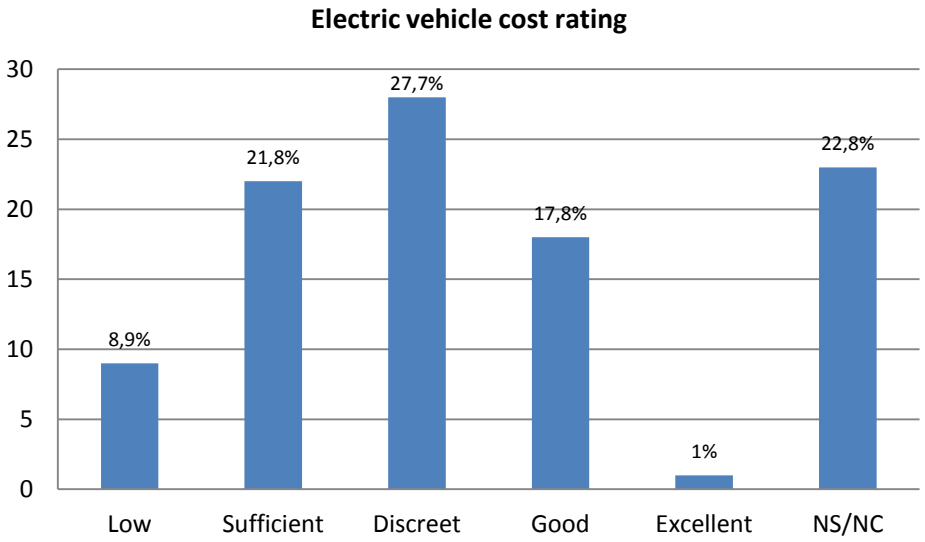
Seven out the twelve people who answered affirmatively about having used an electric vehicle, had used a car, while the other five cases had used an electric motorbike.

Question 10. How would you rate an electric vehicle on the following aspects?

That question is divided in five categories (cost, velocity, comfort, safety and parking availability) that according the 101 interviewed tourists give a total number of answers of 505. All the categories coincide for having a lot of unanswered questions (22,8% of the total possible answers), that reveals a lack of knowledge of the electric vehicle.

Cost

Economic cost is one of the worst rated aspects. The most common answer is discreet (27,7%).



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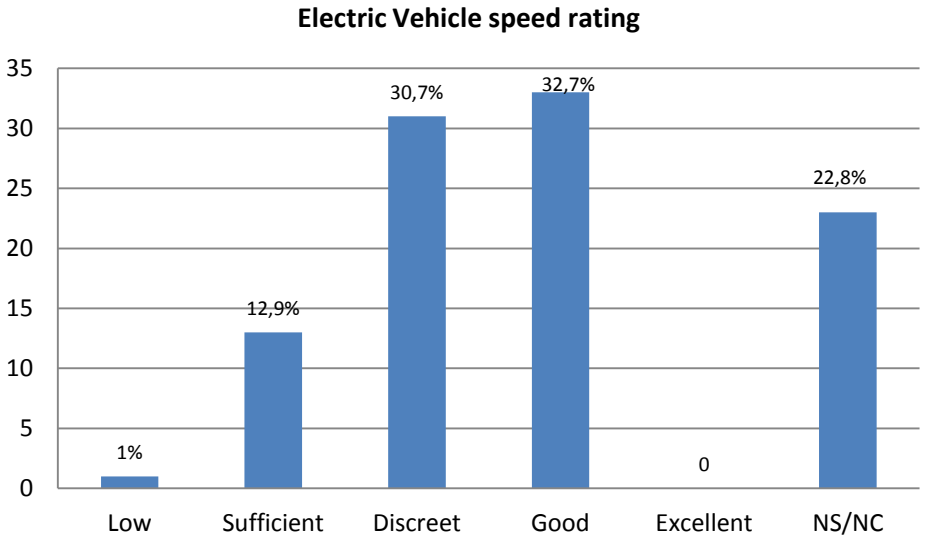
Speed

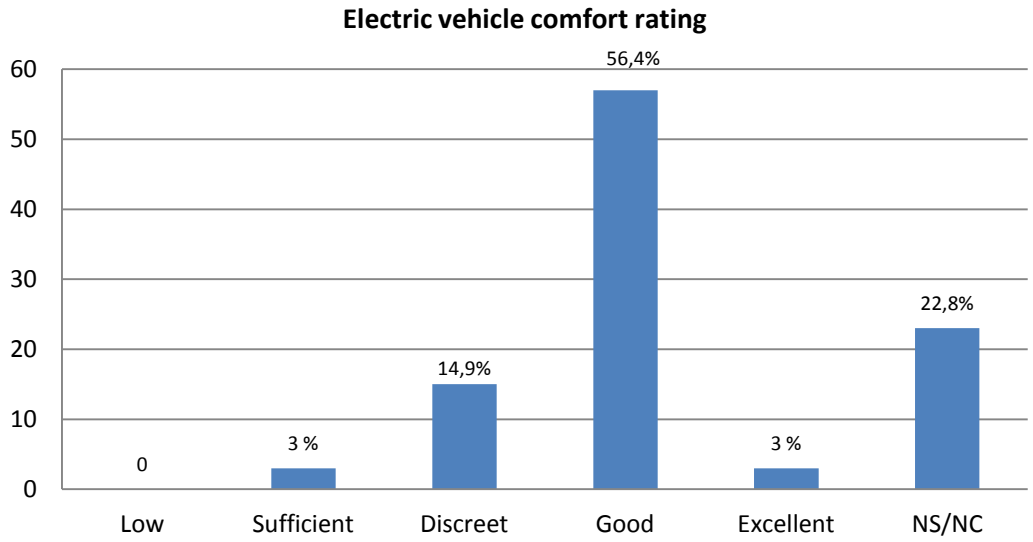
Velocity has a better ratting than cost, being good the most common answer. Only 1% of people rated electric vehicles as slow.



n=101

Comfort

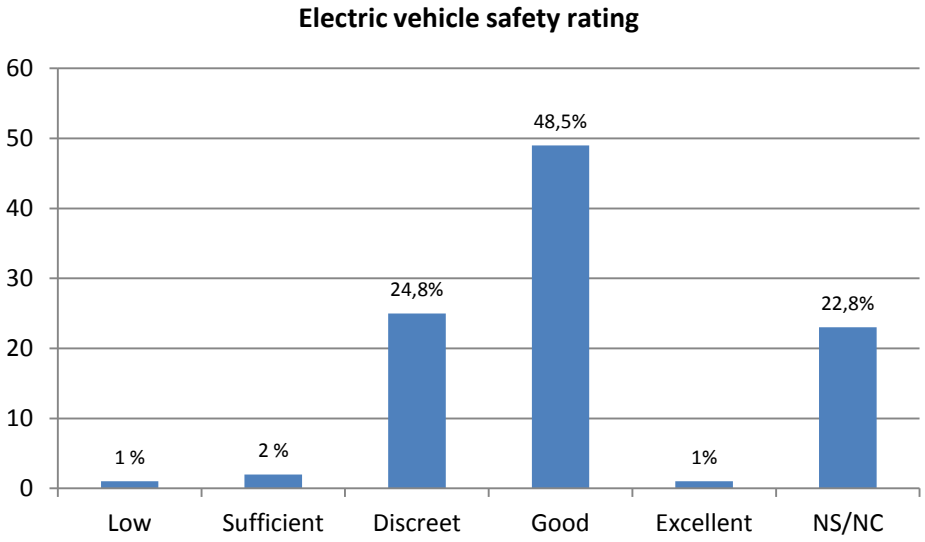
Most people (56,4% of valid cases) rate as good the comfort of electric vehicles.



n=101

Safety

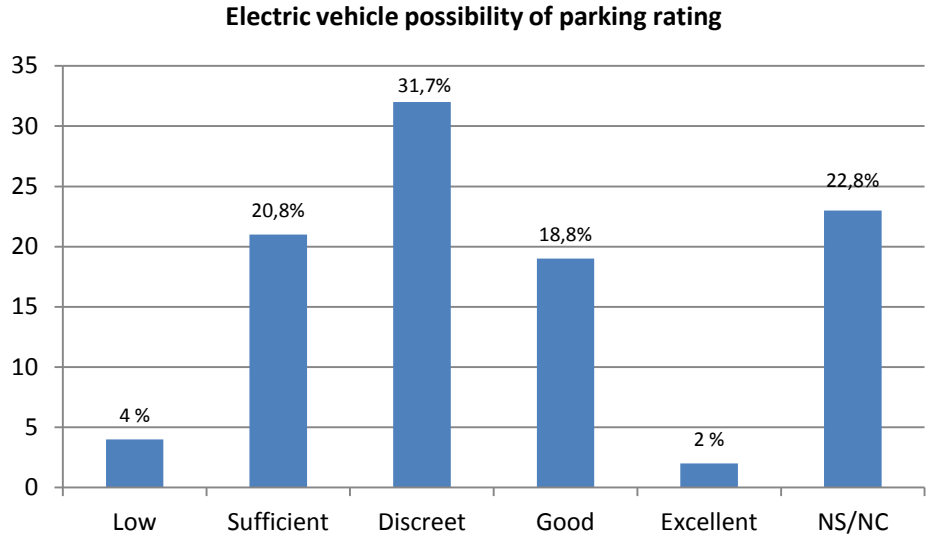
Safety is well rated, being good and discreet the most chosen options (both add up to 94,9% of valid answers).



n=101

Parking availability

Intermediate options are the most answered ones. A bad rating (low and sufficient) is a more common answer than good and excellent.

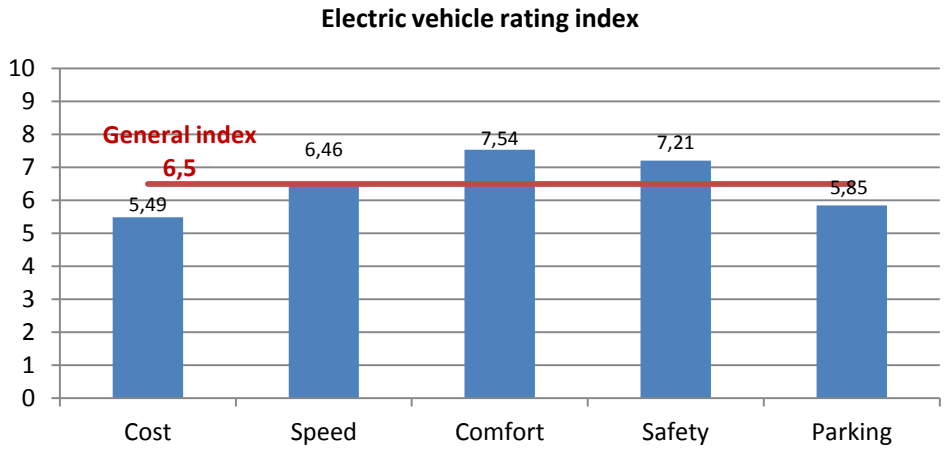


n=101

Index

To have a general rate for this question an index has been created assigning a value for each answer (low = 2, sufficient = 4, discreet = 6, good = 8 and excellent = 10) and calculating the average value. To calculate this index only valid answers have been considered (excluding NS/NC).

Thanks to this index it is possible to see that comfort is the most rated characteristic, followed by safety and speed. On the other side, parking availability and cost are the less rated aspects. The general index for the electric vehicle is 6,5 over 10.



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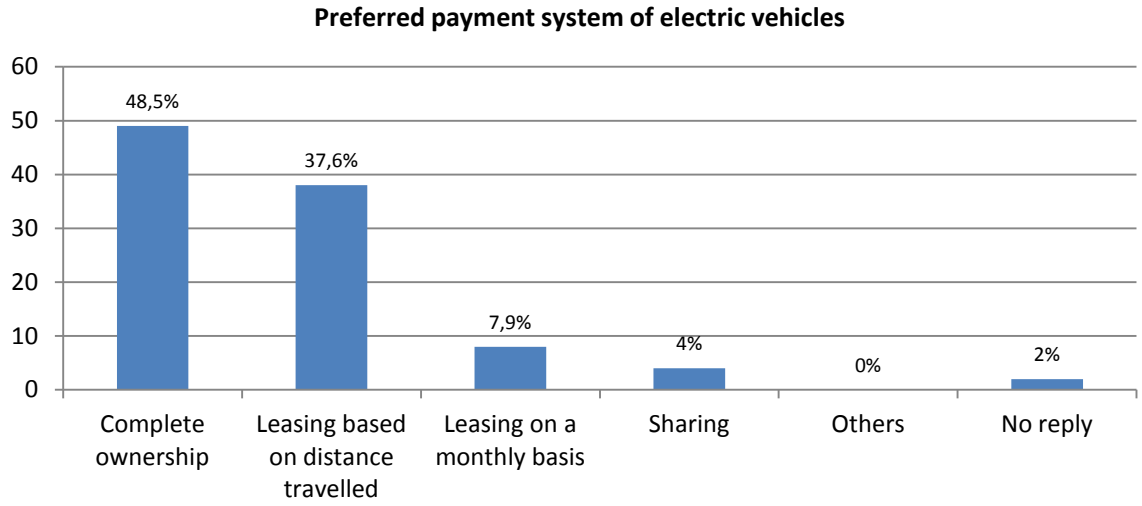
Question 11. Which cost of the service would you find suitable about the use of electric scooters/cars/bicycles?

Almost half of the interviewed people prefer ownership as an option to use an electric vehicle. This answer is coherent with the results from question 7, where 84,2% of people did not consider alternatives to car ownership, or question 8, where 98,0% did not consider any alternative to scooter ownership. However a significantly high number of tourists (37,6%) consider the leasing based on distance travelled as the best option for electric vehicles.



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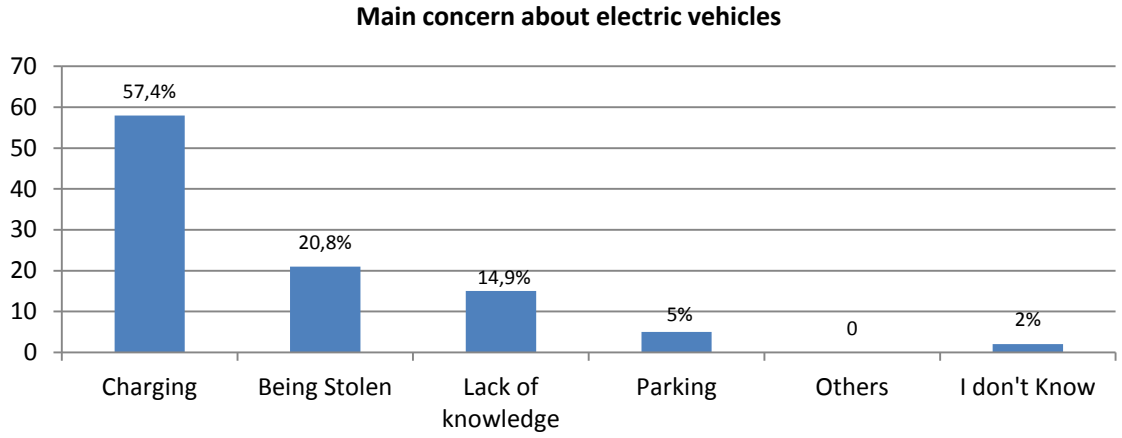
Question 12. What would bother you about the use of electric scooters/cars/bicycles?

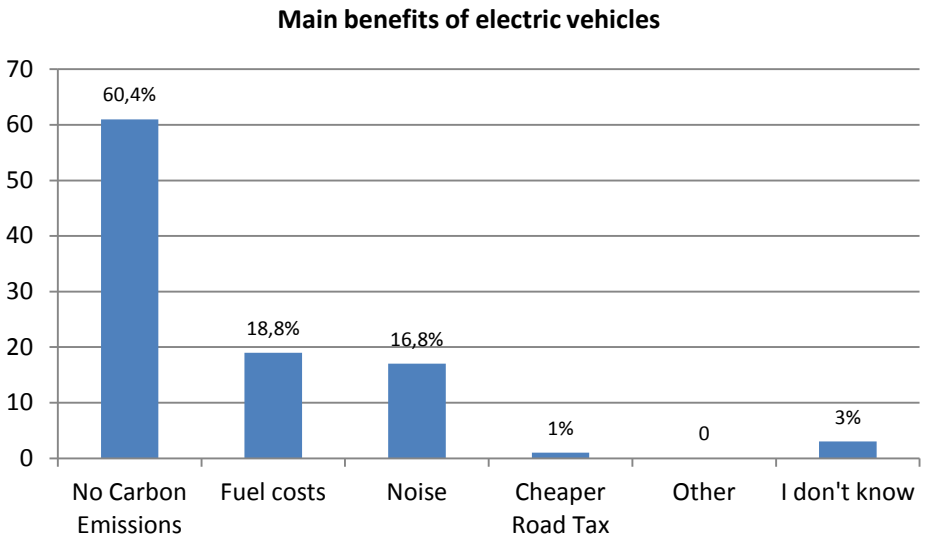
Battery charging was one of the main concerns of the electric vehicles use, while theft and lack of knowledge were less common answers.



n=101

Question 13. What are/would be the benefits from an electric scooters/car/bicycle system?

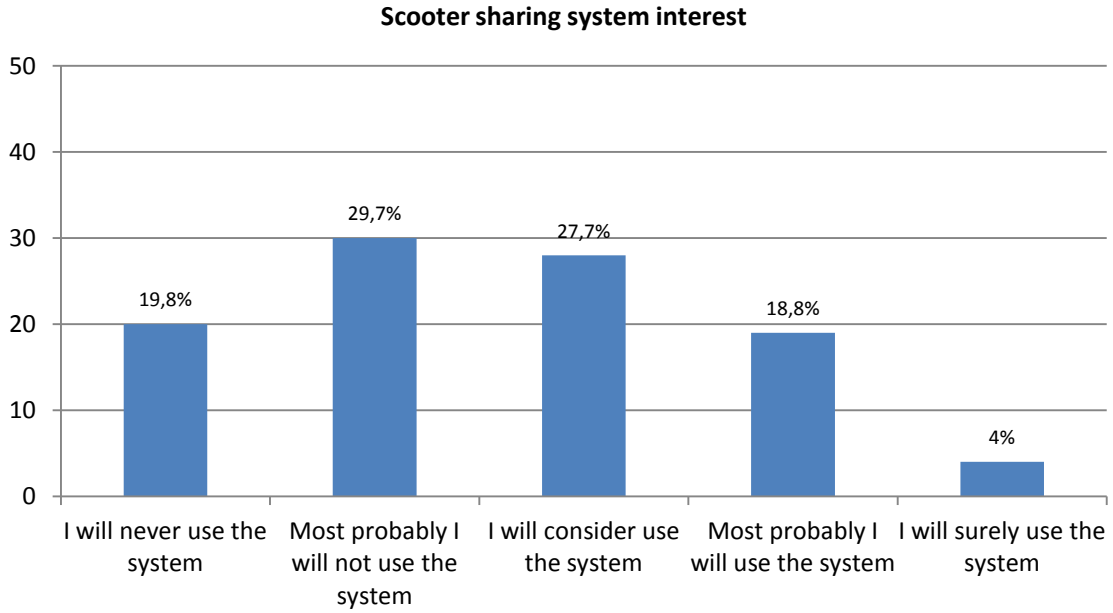
Most of the interviewed tourists (60,4%) consider the reduction of pollutant emissions as the main advantage of electric vehicles, followed by fuel costs and noise reduction. Cheaper road taxes and reduced parking costs were marginal answers.



n=101

Question 14. If a scooter sharing system is provided in your city, would you be interested in using it? Please rate your willingness to use the system.

It was quite a heterogeneous answer, where the two firsts categories ("I will never use it" and "Most probably I will not use it") include almost half of the answers (49,5%). The other half corresponds to the next two categories ("I will consider using it" and "Most probable I will use it"). Only 4% of the interviewed subjects answered that "They will surely use it". On the whole negative answers are more common than the positive ones.



n=101

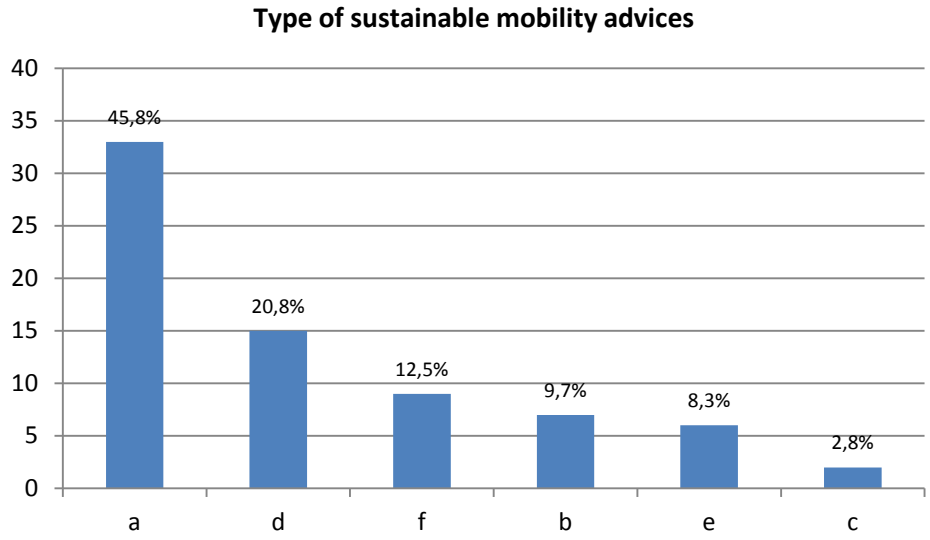
Question 15. Advice on the development of sustainable mobility

This last question was an open one. Surveyed people were asked to suggest ideas to improve mobility sustainability. Each interviewed had a maximum of four suggestions, that give a total possible answer of 404 (101*4), but only 72 answers were collected (17.8%). Although the answer was open they were also provided with the next options if they had not clear suggestions:

a) *A model of sustainable mobility would be one in whose means of transport consume the least energy and produce less pollution per km travelled and passengers have greater recognition (travel on foot, by bicycle, collective transport and shared car);*
b) *Other alternative fuels and other technologies (natural gas, Liquefied Petroleum Gas (LPG), Bioethanol (alcohol, biodiesel) that allow different motorization (electric and hybrid vehicles;*
c) *Sustainable (green) transport infrastructure: greenways and foreshoreways, bikeways, busways, railways;*
d) *Access restrictions: Access management / Enforcement, Car Restricted Zones / Living Streets, Multifunctional areas, Parking management, Pedestrian zone, Traffic calming / Speed reduction;*
e) *Integrated pricing strategies: Congestion pricing, Integrated ticketing, Parking Management;*
f) *Collective passenger transport: Public transport, Bus services, Rail transport, Intermodal transfers, Integrated ticketing, Park & Ride, Accessible transport systems, Paratransit, Bus rapid transit, Quality of service, Security, including Transit police.*

To facilitate data treatment all answers have been assimilated to one of the provided options. For example lower public transport prices is included in option “e”, reducing the amount of vehicles circulation in option “d”, etc.

Almost half of the people (45,8%) choose “a” option (promotion of sustainable transport modes, mainly in relation with an improvement of bicycle use, walking and public transport, but not related to car sharing). The second most common answer is “d” (mainly related to car restrictions) that accounts for 20,8% of cases.



n=72

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13. Results from residents surveys

13.1. Introduction

The fieldwork to collect resident's survey started on 23rd of October and finished on 29th of November. The surveys were done in representative mobility attraction points in Barcelona (*Plaça Catalunya, Estació de Sants, Zona Universitaria*…). The surveys addressed to younger people than 16 years were realized in the Institute *Joan Salvat-Papasseit*, basically because during working period (in which surveys were done) that collective uses to be in the school.

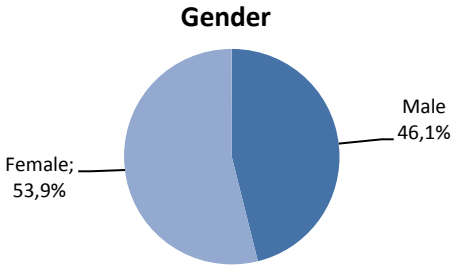
Places of survey collection	Date	n
Plaça Catalunya	23/10/2013	18
Zona universitària	24/10/2013	36
Sants	25/10/2013	17
Plaça Catalunya	29/10/2013	10
Gràcia	30/10/2013	38
Maria Cristina	31/10/2013	37
Nou Barris	05/11/2013	35
Sant Andreu	06/11/2013	39
Sarrià	07/11/2013	36
Maria Cristina	08/11/2013	27
Horta	12/11/2013	35
Sants	13/11/2013	34
Guinardó	14/11/2013	33
Gràcia	15/11/2013	23
Plaça Catalunya	19/11/2013	18
Plaça Catalunya	20/11/2013	7
IES Joan Salvat-Papasseit	25/11/2013	10
IES Joan Salvat-Papasseit	26/11/2013	12
IES Joan Salvat-Papasseit	28/11/2013	21

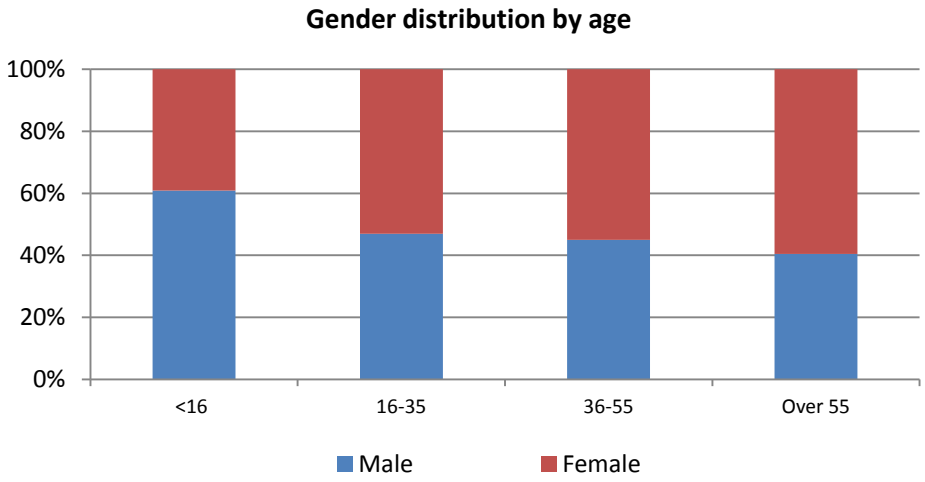
The final sample survey is about 486 residential people, which supposes ±4,85% margin error (confidence degree of 95,5% or two sigma; maximum uncertainty situation where p=q=0,5), which can be considered as a significant sample. The profiles were chosen in a consistent way with Barcelona socio-demographic characteristics, in order to make the surveyed population sample as representative as possible of Barcelona Inhabitants. However the sample it's not totally representative so although general quotes are fulfilled (gender, incomes, age…) the sample is not stratified by each group. For example it occurs that most of the surveys over 55 year's people correspond to women, therefore the results and conclusions should be seen as significant statistical trends but they are not totally representative.

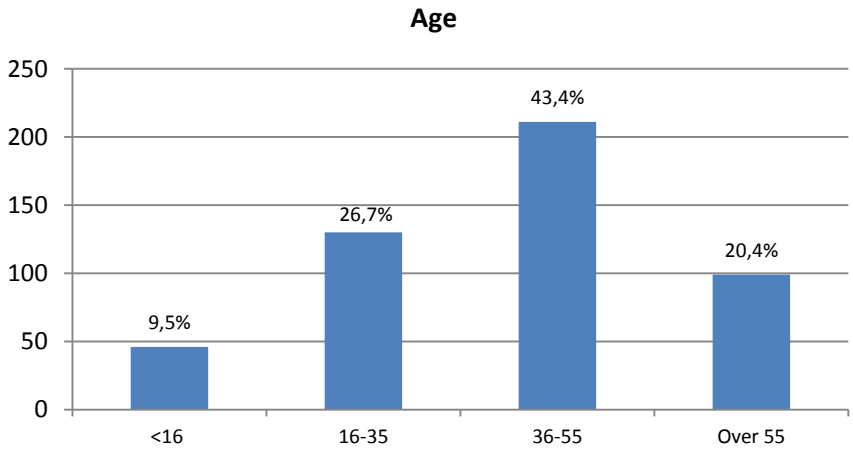
13.2. Interviewed profiles

Age and gender

There are more interviewed females (53,9%) than males (46,1%), especially for some age ranges like over 55 years. This fact can be explained because women have a higher predisposition to be interviewed.

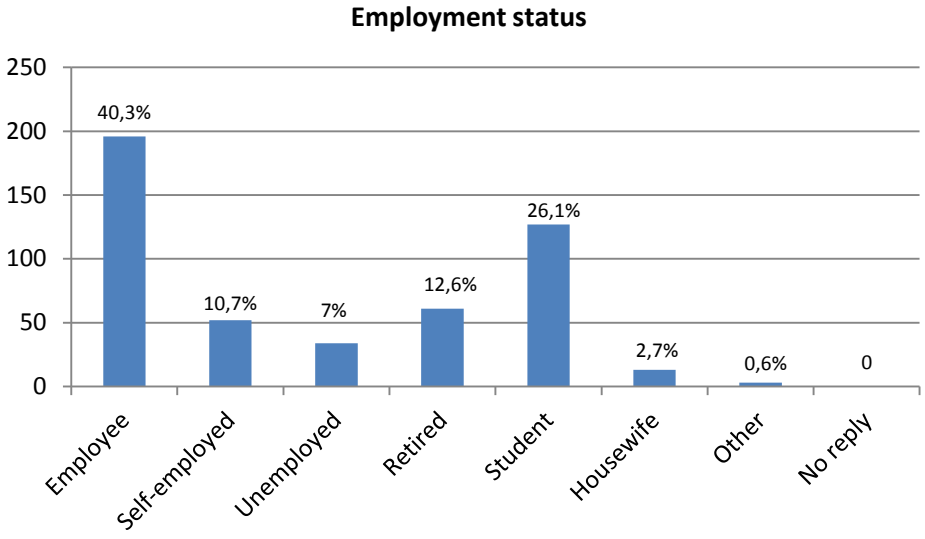


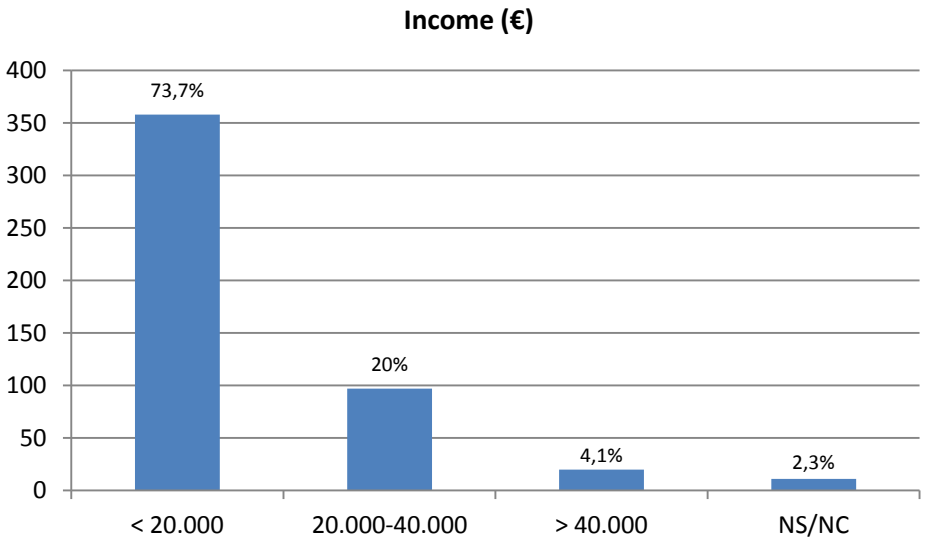




Employment status

According with Barcelona characteristics, most of the interviewed people were employees or students (40.3% and 26.1%), with an income level lower than 20.000€ (73,7%)





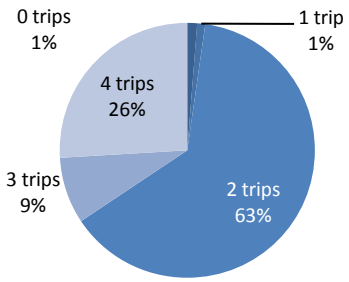
13.3. Descriptive analysis

Main trips

Main trips are referred to those that last more than 5 minutes. In that question was possible to include 4 trips for each survey which means a maximum of 1.944 displacements (486*4). The total of trips declared in the whole sample is 1.248 (64,2% of the maximum possible).

Most of the people declared just 2 trips. Only 6 people have not declared any trip, while 126 people declared 4 trips.

Declared trips

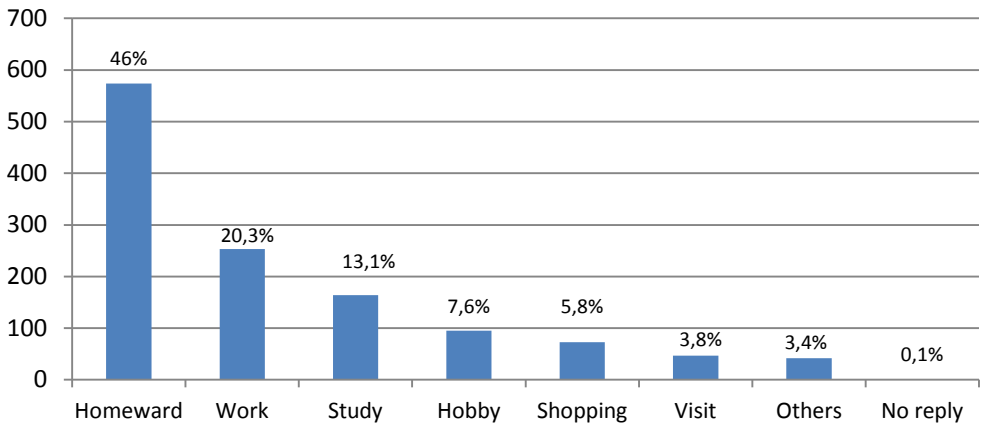


n=486

Trip purpose

Most trips have the purpose of returning home, which represents almost 50% of trips. That makes some logics so after most of the trips people use to come back home. Go to work and to study are the 2nd and 3rd main reasons.

Trip purpose distribution



n= 1248

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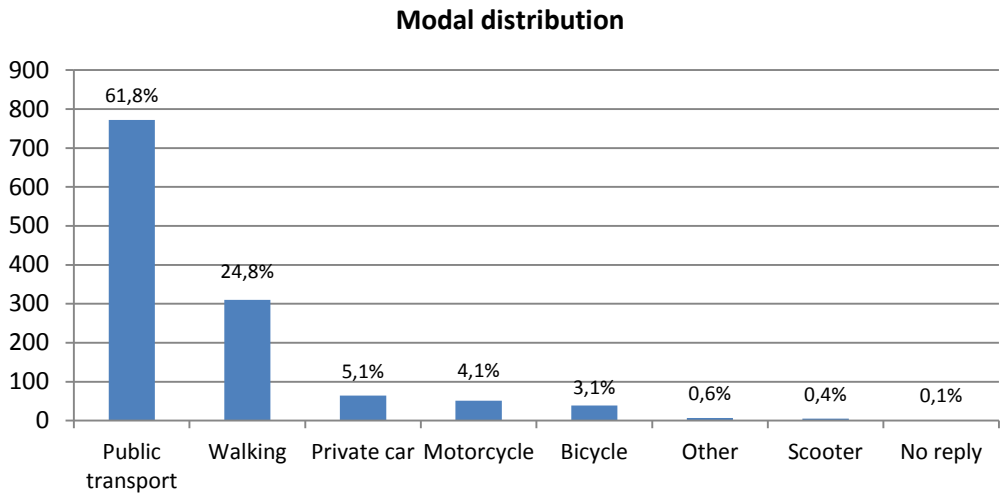
Transport mode

Main mobility system used is public transport. Walking is the second method (around 35 answers) while cars only supposes a 5,1% and motorcycle represents a 4,1%. Results are not numerically consistent with the official mobility survey but follow the same trends: high proportion of public transport use as the main transport mode (61,8% vs 31,9%), relevant proportion of walking as the second transport mode (24,8% vs 31,9%) and low proportions of car, motorcycle and bicycle.

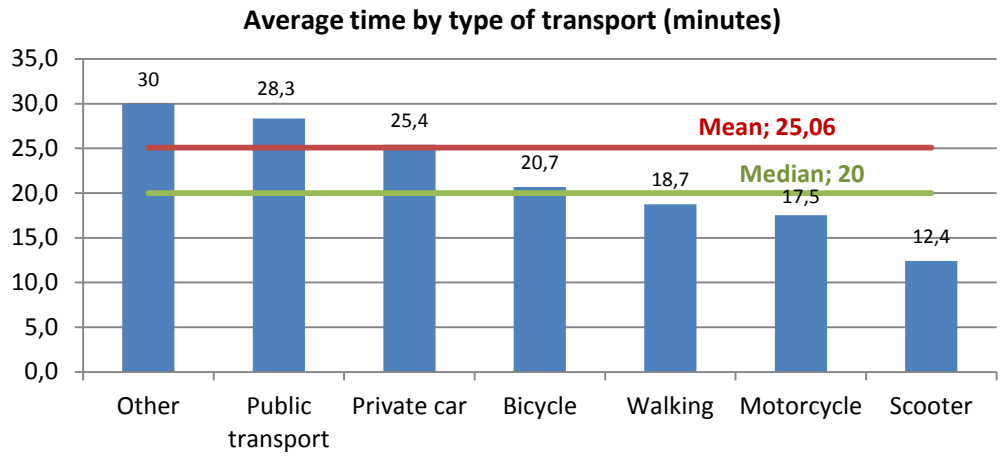


n= 1248

Time

Average trip time is about 25,1 minutes. However, due to the elevated standard deviation caused by the extreme cases, is more precise to use the median, which is about 20 minutes.

Public transport gets the longest times. That is partly caused because in this category includes most of the trips performed by people from outside the metropolitan area of Barcelona.



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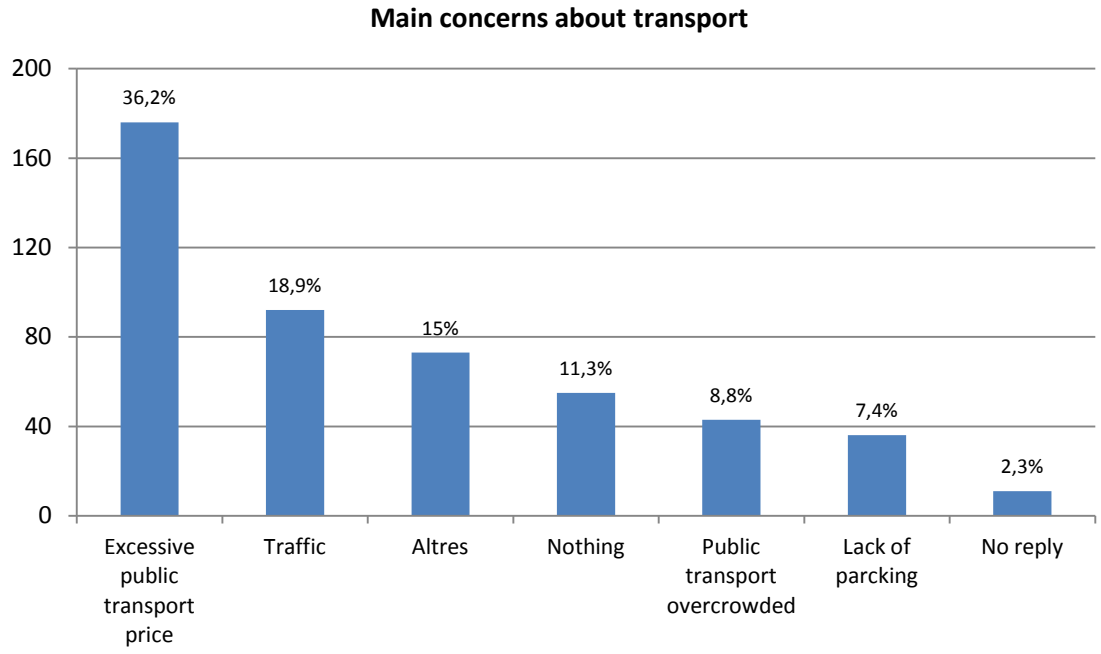
Question 7. What bothers you about transport in your city?

The main concern is the elevated cost of public transport. Students and unemployed people represent a big share of the sample, economic crisis is a major concern in most Barcelona households so economic issues are a social priority and besides this is consistent with the price raisings that public transport has suffered, significantly higher than life cost: a 34%[2] in the last five years. Traffic congestion is the second concern, while the other issues have a similar percentage. Most of the respondents that have not any complaints tend to coincide with the ones that walk more usually (mainly older and younger respondents).

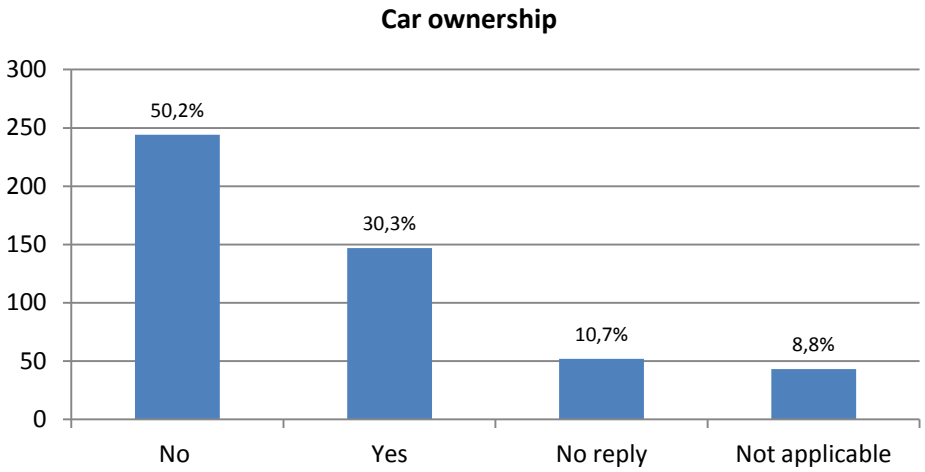


n=486

[2] This percentage corresponds to the most used transport ticket in Barcelona, the T-10, a multitravel ticket of 10 trips in the first transport zone (Barcelona and some nearby municipalities). It hat has passed from 7,70€ in 2009 to 10,30€ in 2014.

Question 8.0. Car ownership

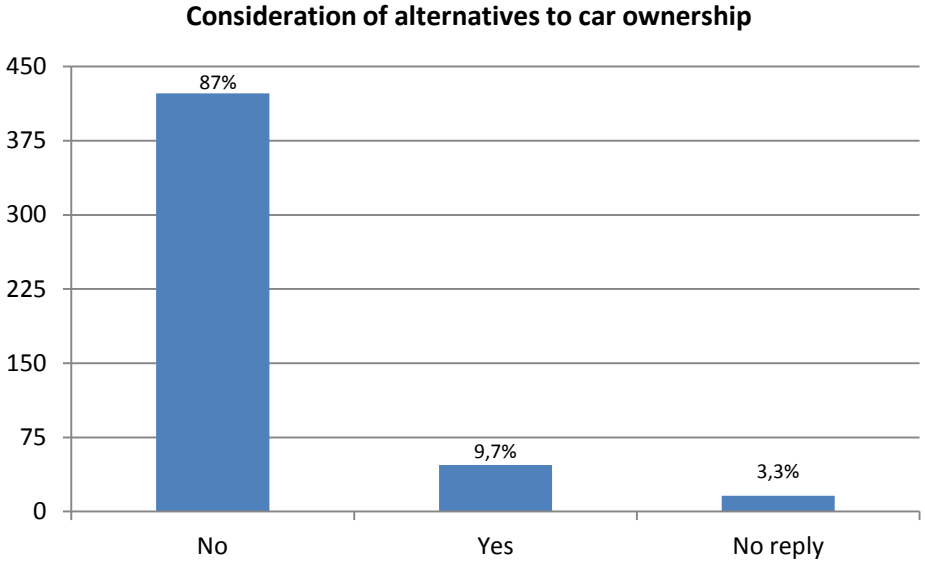
Approximately half of the interviewed residents do not have a car. Considering the valid answers the percentage of people owning a car represents just the 37,6%[3].



n=486

Question 8. Have you ever thought alternative solutions to the possession of the car?

Most of the answers are negative (90,6% of valid cases). That can be explained because this question was asked to everybody, independently if they had or not a car or a driving license.



n=486

[3] This question was included after the first day of interviews, for that reason some of the answers are not valid.

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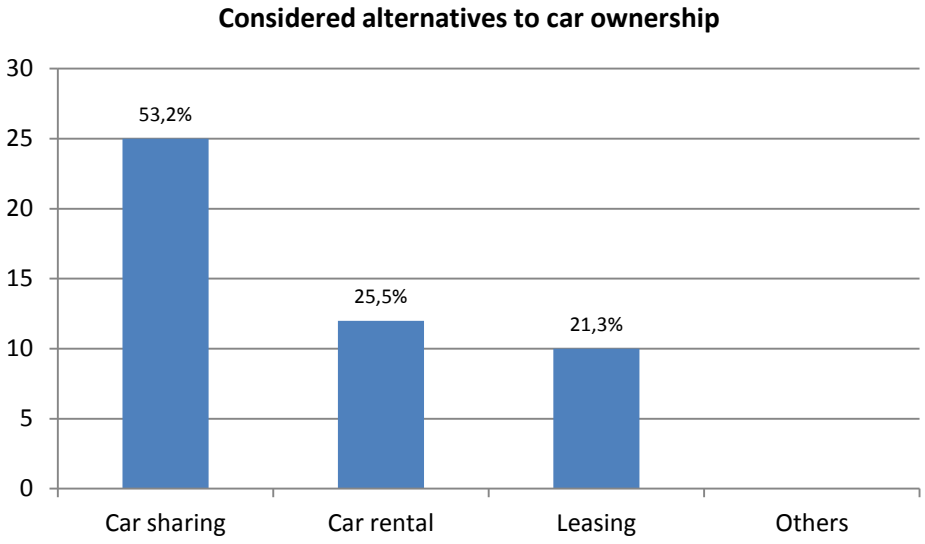
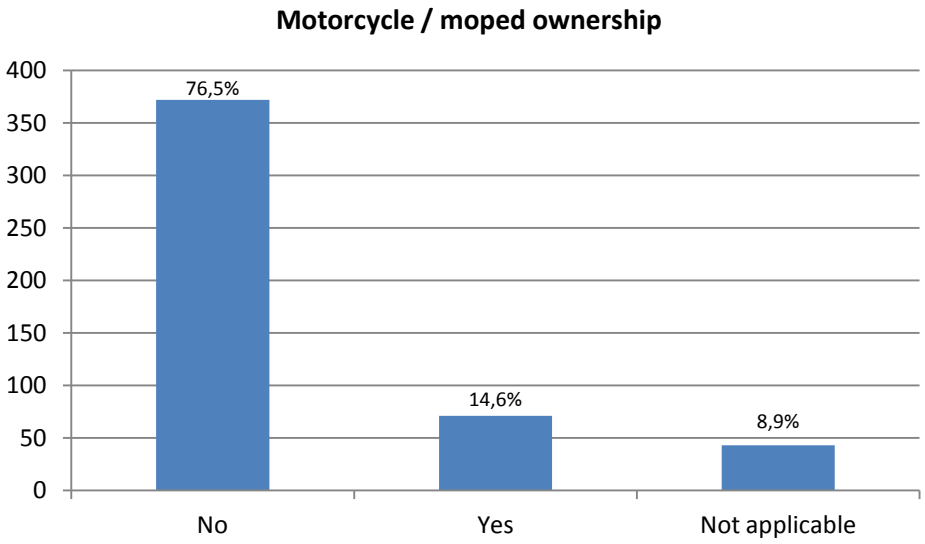
A car sharing system is the main option chosen among the 47 people that consider an alternative option to car ownership. Renting and leasing have similar results.



n=47

Question 9. Do you possess a motorcycle/moped?

14,6% of the surveyed residents (16,0% of valid cases) owned a motorcycle or a moped.



n=486

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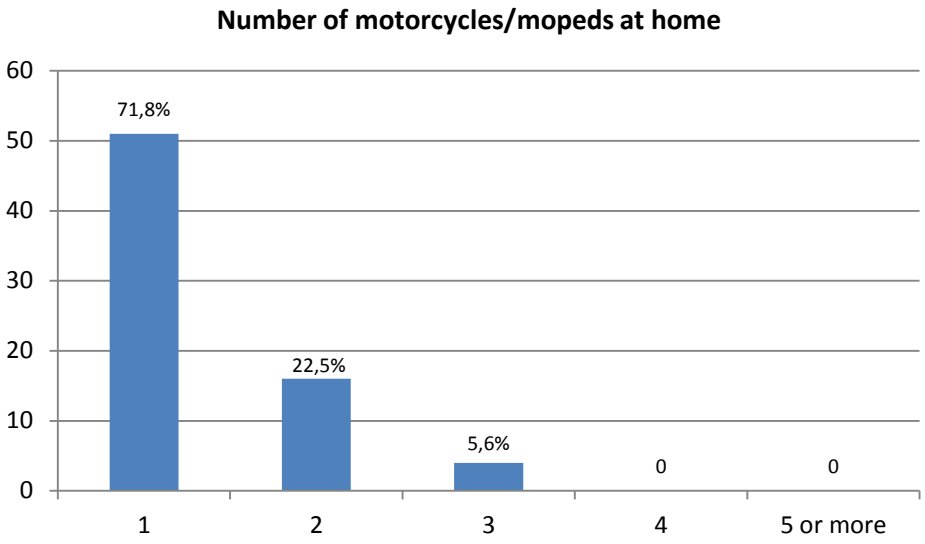
Question 9.1. If yes, how many motorcycles/moped do you posses in your home (including your own motorcycle/moped)?

Most of respondents have only one motorcycle or moped in their household while none of them has more than 3 motorcycles or mopeds.



n=71

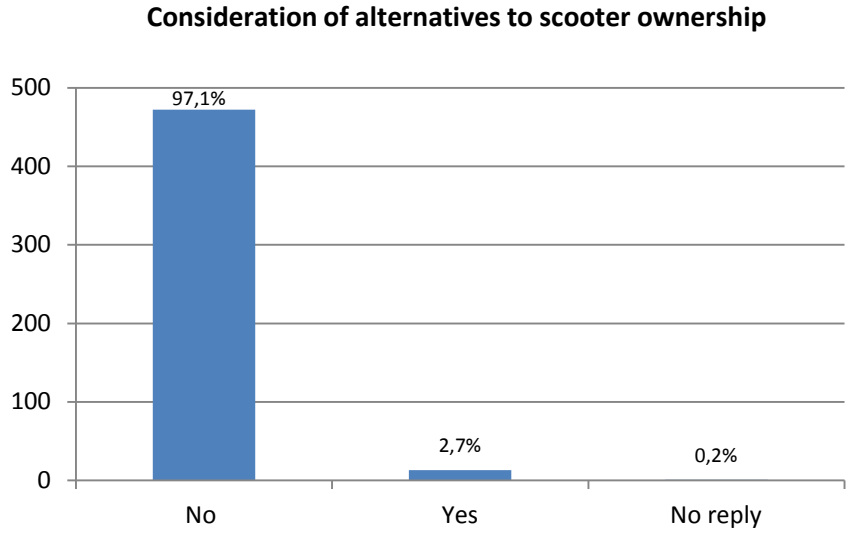
Question 9.2. If yes, how many miles per day do you walk by motorcycle?

Some of the motorcycle / moped users answer that they run an average of only 1 km per day. Most of them correspond to people that has a motorbike but don't use it every day. The total average is 13,6 km/trip with a standard deviation of 14,4 km.

Kilometers/day	
Mean	13,58
Deviation	14,41
Minimum	1
Maximum	100
Median	10

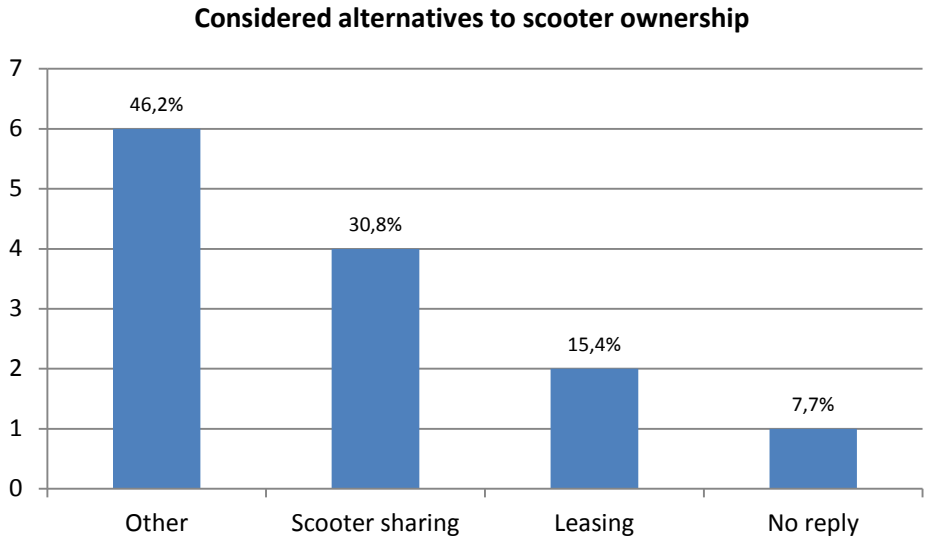
Question 10. Have you ever thought about alternative solutions to the possession of the scooter?

Most of the answers were negative (97,1% of valid cases). In the same way of cars, this can be explained because this question was asked to everybody, independently if they had a scooter or a scooter driving license.



n=486

From the 13 people who has considered an alternative option, almost the half part chose the option "other" (which in most cases corresponds to renting), followed by scooter sharing (30,8%).



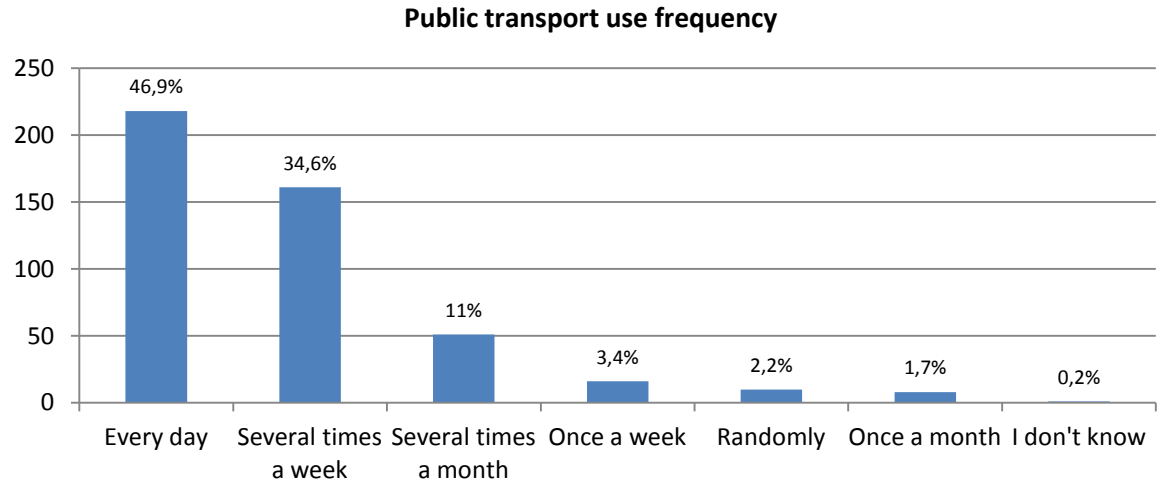
n=13

Question 11. Do you use public transport?

Almost everybody (95,7%) answered positively to the use of public transport.

Question 12. If yes, how often do you use public transport?

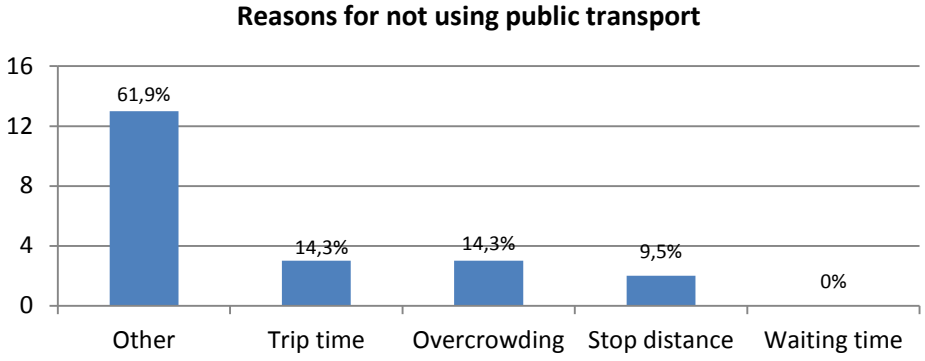
Almost half of the requested residents use public transport everyday and a third use it several times a week. That means that 81,7% of people use it frequently.



n=465

Question 13. Why don't you use public transport?

Most of the answers are classified in the category "others", which includes people that do not move often from their neighbourhood (mainly people under 16), that use their own vehicle for comfort reasons or that require the use of a private vehicle to work (commercial agents). None of the answers pointed at the waiting time of public transport as a problem, which is consistent with the high frequency of the metro, the most used public transport in Barcelona.



n=21

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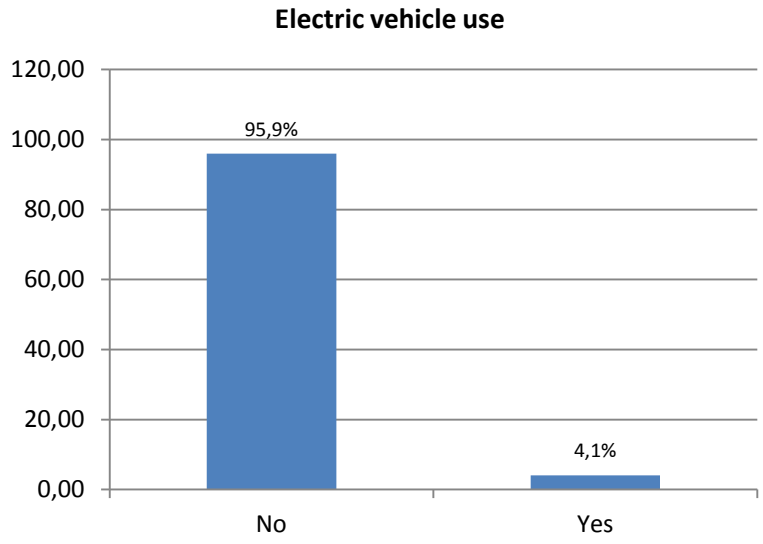
Question 14. Have you ever used an electric vehicle?

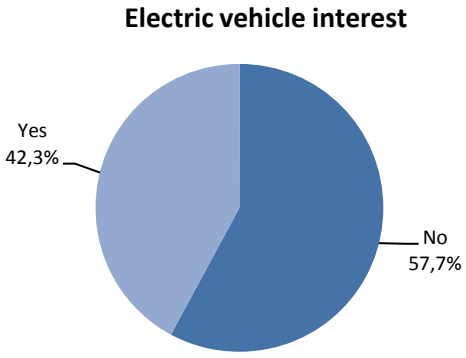
Most of the people have never used an electric vehicle. Only 4,1% of valid cases[4] gave an affirmative answer to this question.



n=443

Question 14.1 If no, would you be disposed to try/buy an electric vehicle considering its advantages: displacement time, comfort, safety, ecological, low consumption?

Despite the low use of electric vehicles almost half of the people (42,3%) would be willing to try or buy an electric vehicle.



n=421

[4] This question was not evaluated for residents under 16 years old.

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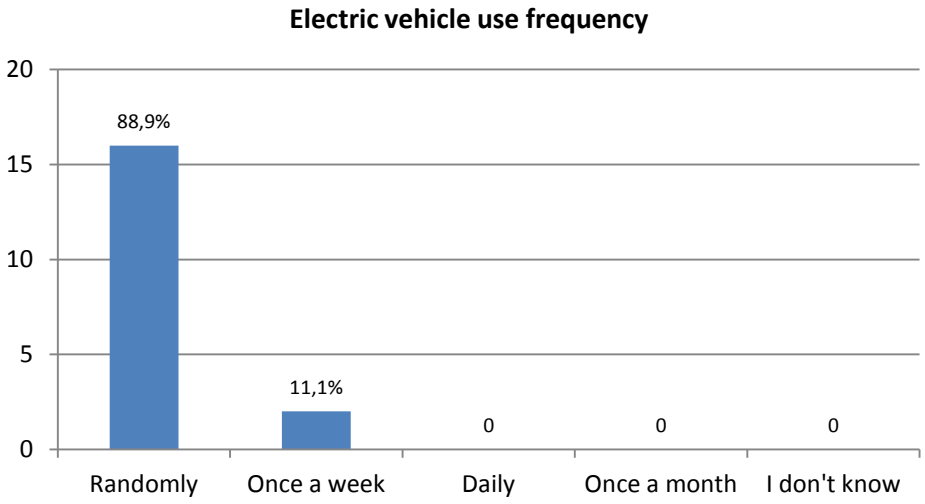
Question 14.2. If you have used an electric vehicle, how often?

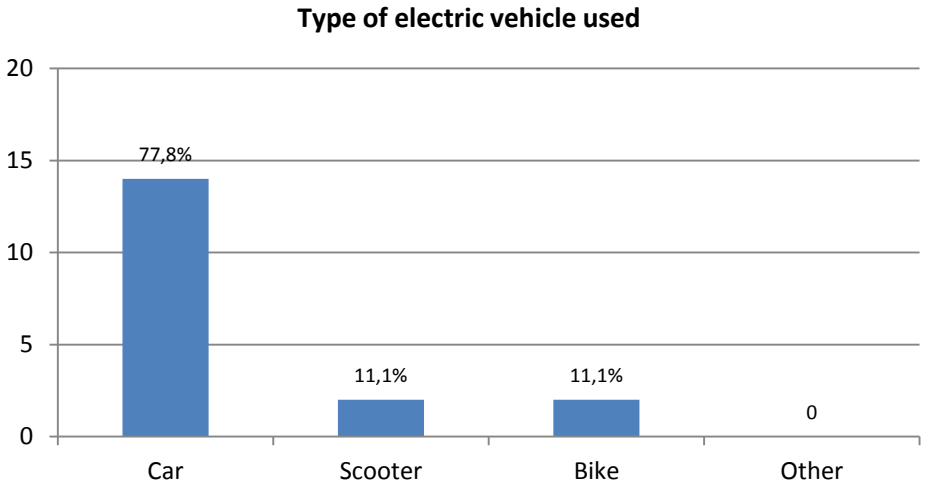
From the 18 cases that had used an electric vehicle, most of them (88,9%) was in a very occasional way.



n=18

Question 14.3. If you have used an electric vehicle, which kind of vehicle?

From those who had used an electric vehicle, electric car was the most common option (77,8%). Only 2 interviewed residents had used an electric scooter, the same number that had used an electric bicycle.



n=18

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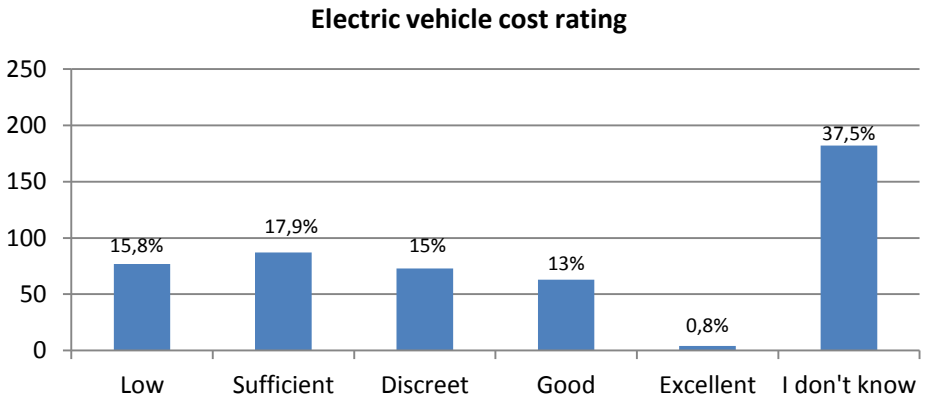
Question 15. How would you rate an electric vehicle on the following aspects?

This question is divided into five categories (cost, speed, comfort, safety and parking availability) and it is the one that was answered by fewer people. All the categories coincide for having around a third of unanswered questions, being sometimes the main answer, which reveals a lack of knowledge of the electric vehicle.

Cost

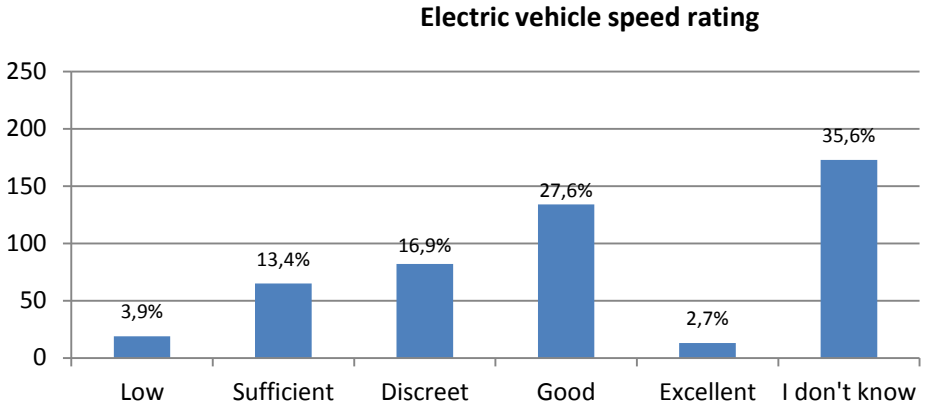
It shows a homogeneous answer, with very few ones evaluating it as excellent. This question can present some variability because it is not clear if the cost refers only to the acquisition of the vehicle or it includes also the operating cost (combustible or electricity, maintenance…).



n=486

Speed

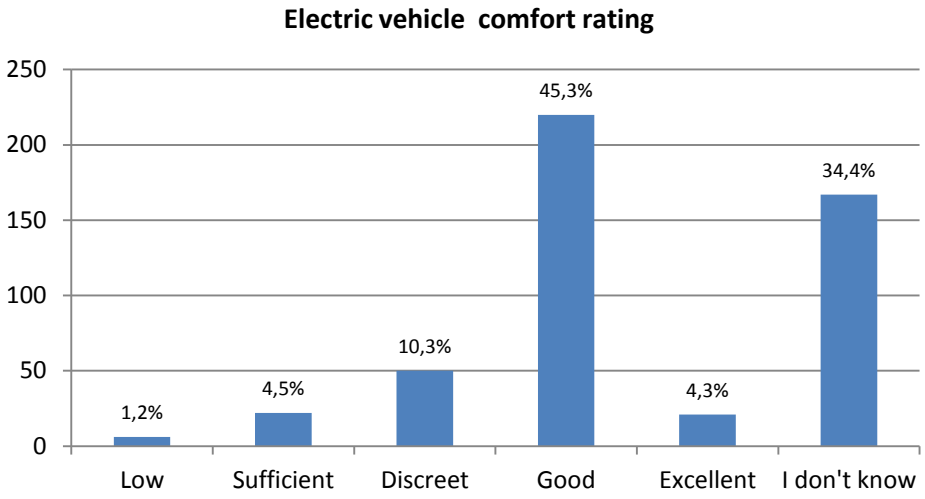
Most of the requested people (27,6%) rate electric vehicle speed as “good”, while the option “excellent” shows the lowest percentage.



n=486

Comfort

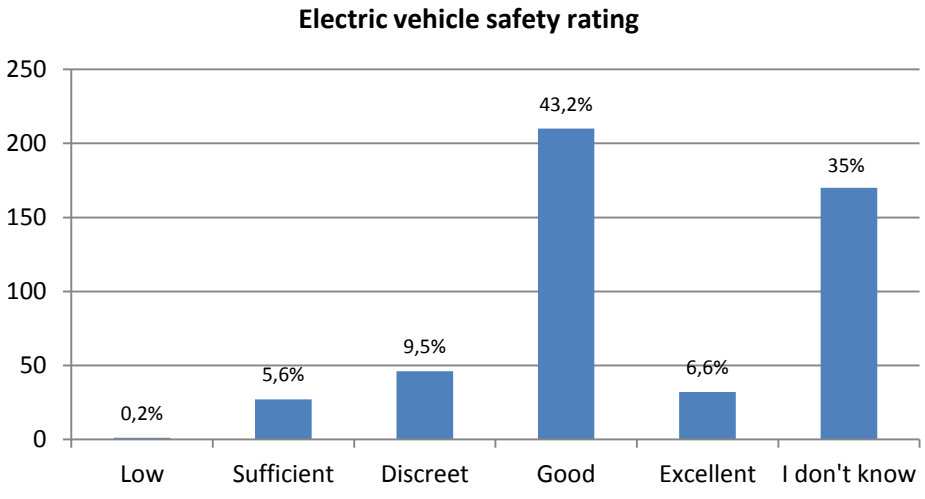
Almost all people that answer this question think that electric vehicles comfort of is good (45,3%). It is the aspect that gets more "good" ratings.



n=486

Safety

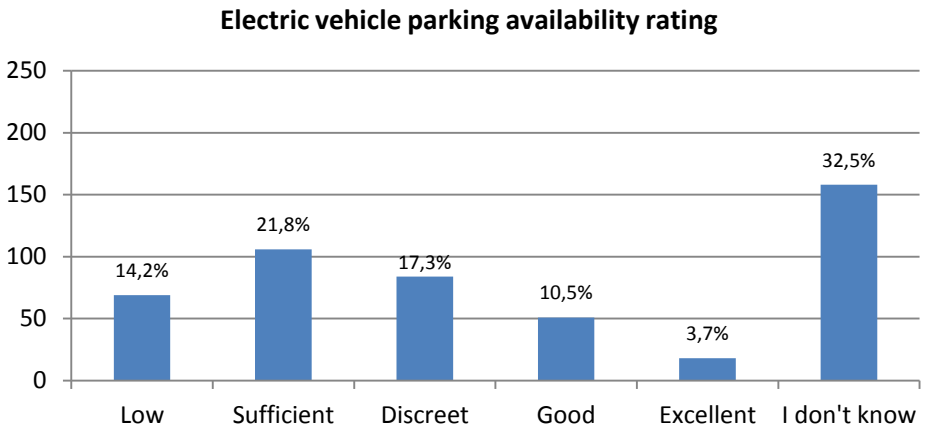
This question shows a similar pattern than the precedent, where "good" is the predominant option (in this case with 43.2%). This result can be explained by the perception of electric vehicles having a lower speed.



n=486

Parking availability

Parking availability for electric cars is very similar to a conventional one; therefore the general rating is quite low. However some people think that electric vehicles are easier to park because they think they have a more reduced size.

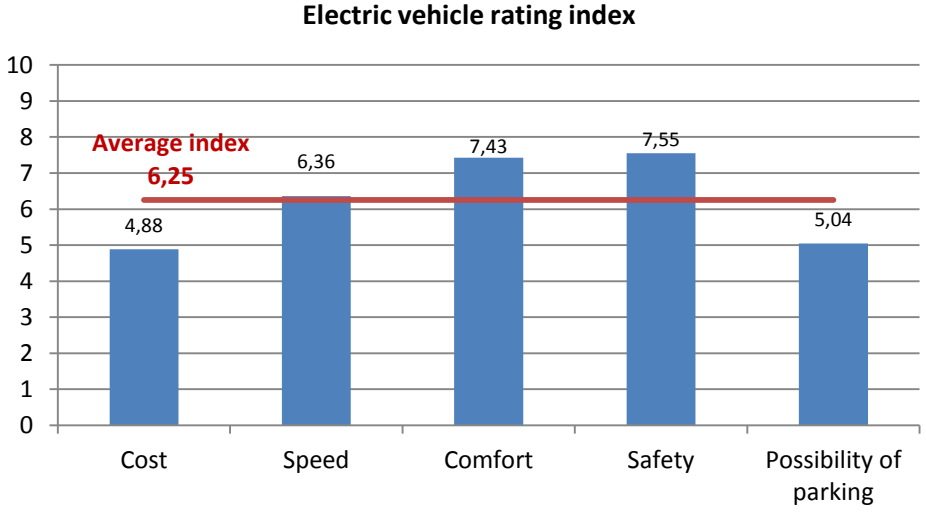


n=486

Index

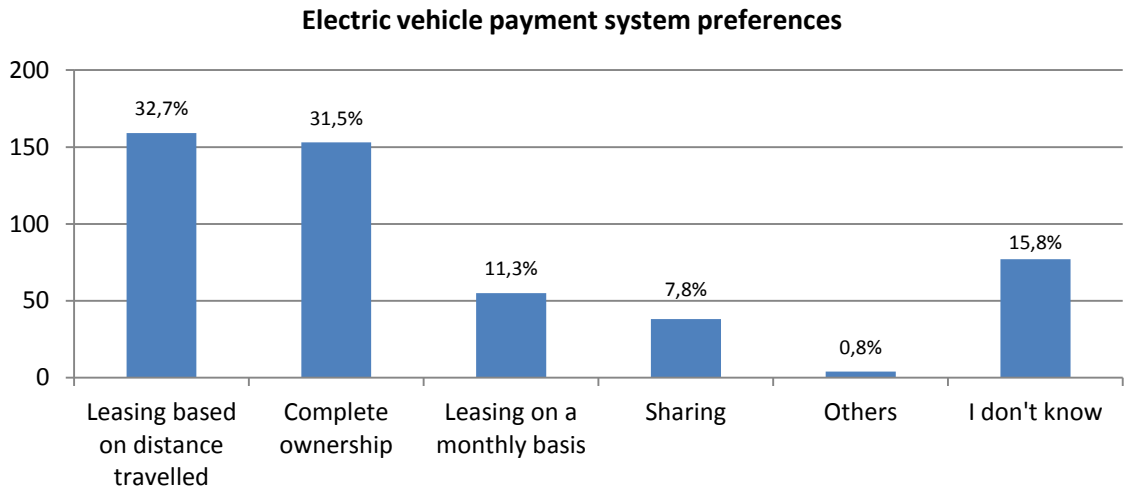
To have a general rate for this question an index has been created assigning a value for each answer (low = 2, sufficient = 4, discreet = 6, good = 8 and excellent = 10) and calculating the average value. To calculate this index only valid answers have been considered (excluding NS/NC).

Average index is 6.25. Safety and comfort are the most valued aspects achieving an index of 7,5 and 7,4 respectively. Speed is also over the average rate. Parking availability and cost are the aspects with the lowest rating.



Question 16. Which system do you think would be appropriate for the use of the electric vehicle in your city?

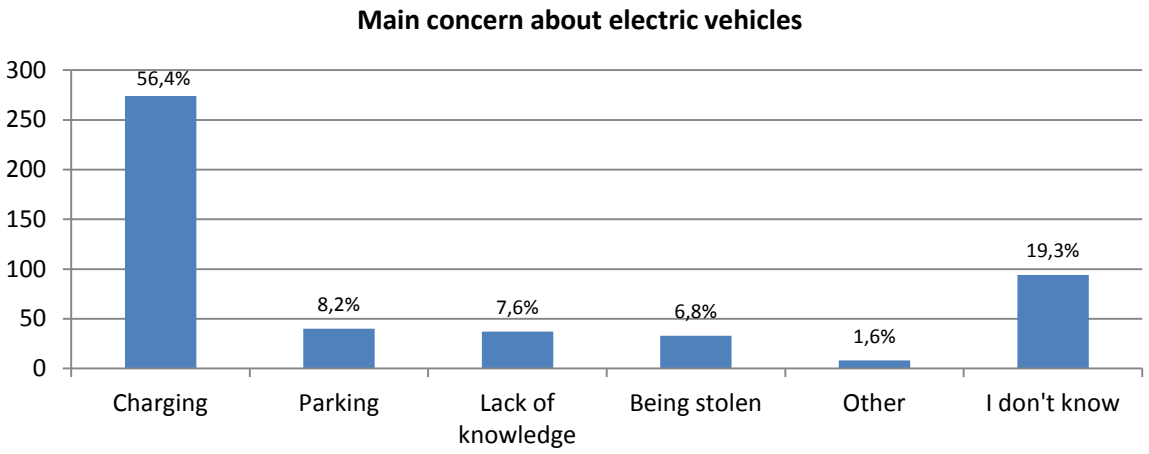
The favourite payment system for electric vehicles would be the leasing based on the travelled distance. This answer may be explained by the few people that have used electric vehicles, given that this option reduces the economic risk of a monthly leasing. Complete ownership is the second option due to the fact that in Spain is the most usual payment system of all vehicles.



n=486

Question 17. What bothers you about the use of electric vehicles in your city?

The main inconvenient for more than the half of the surveyed residents is the battery charging (69,9%). It's important to note that most people do not know that there are several charging points in the public space of Barcelona or they think that there are very few.



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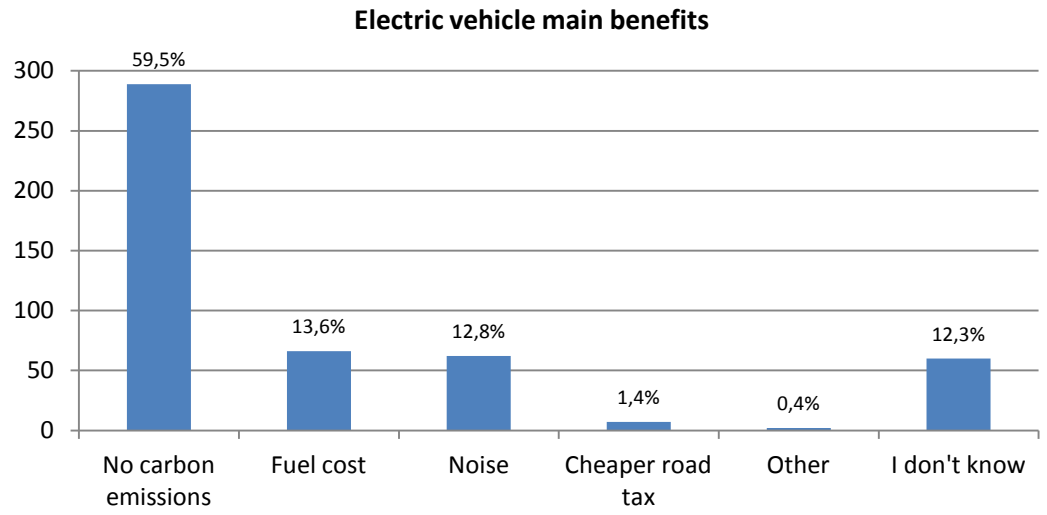
Question 18. Which advantage would have the electric vehicle in your city?

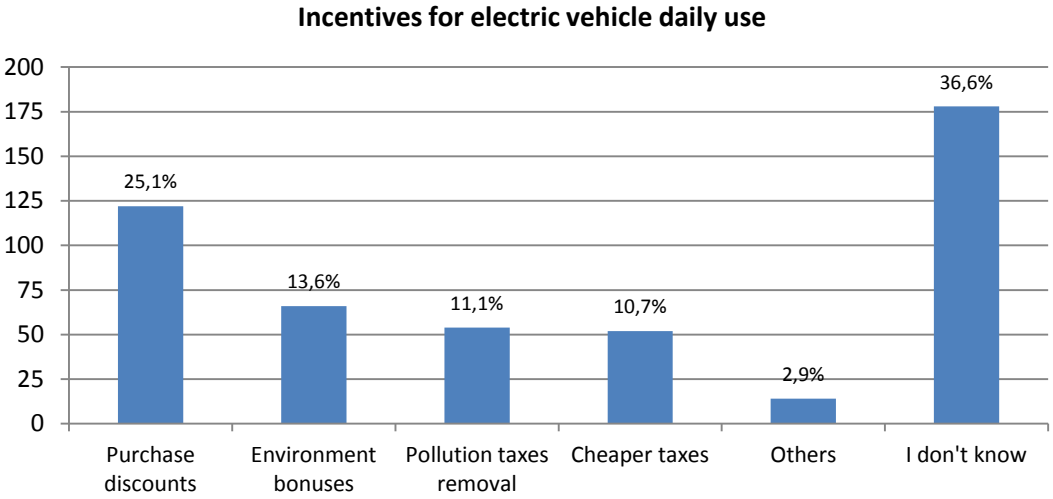
The reduction of CO_2 emissions is the most common pointed benefit (67,8%). It is remarkable that it seems to be a lack of knowledge about noise reduction potential of electric vehicles in a city like Barcelona, where noise levels are high.



n=486

Question 19. **Which incentive/s would encourage you to use an electric scooter/bike/car for daily commuting purposes?**

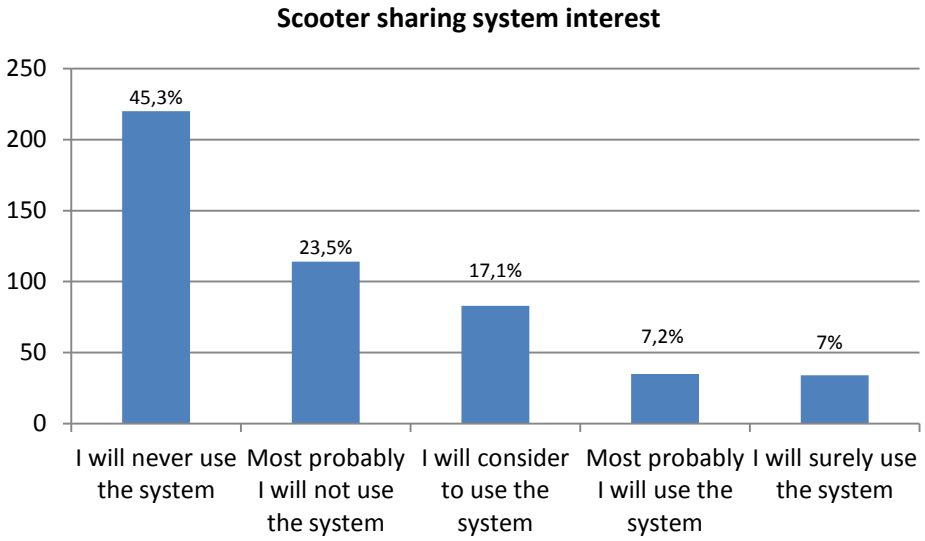
Purchasing discounts are the favourite option (25,1%). This is consistent with the previous question referred to the payment system, where complete ownership had a high rate.



n=486

Question 20. **If a scooter sharing system is provided in your city, would you be interested in using it?**

The answer to this question is fairly negative. Nearly half of the interviewed population (45.3%) say they will never use the system and the second option (23,5%) is that they most probably will not use it. There are a 14.2% of the surveyed residents that surely or most probably will use the system. However this percentage is highly superior to the current users of a motorbike or moped according trips (4,5 in question 6) and very similar to the percentage of motorbike/moped owners (14.6% in question 9).



n=486

Question 21. Advice about the development of sustainable mobility

This last question was an open one. Surveyed people were asked to suggest ideas to improve mobility sustainability. Each interviewed had a maximum of four suggestions, that give a total number of possible answers of 1944 (486*4), but 532 answers were collected (27.4%). Although the answer was open, residents were also provided with the next options if they had not clear suggestions:

a) *A model of sustainable mobility would be one in whose means of transport consume the least energy and produce less pollution per km travelled and passengers have greater recognition (travel on foot, by bicycle, collective transport and shared car);*
b) *Other alternative fuels and other technologies (natural gas, Liquefied Petroleum Gas (LPG), Bioethanol (alcohol, biodiesel) that allow different motorization (electric and hybrid vehicles;*
c) *Sustainable (green) transport infrastructure: greenways and foreshoreways, bikeways, busways, railways;*

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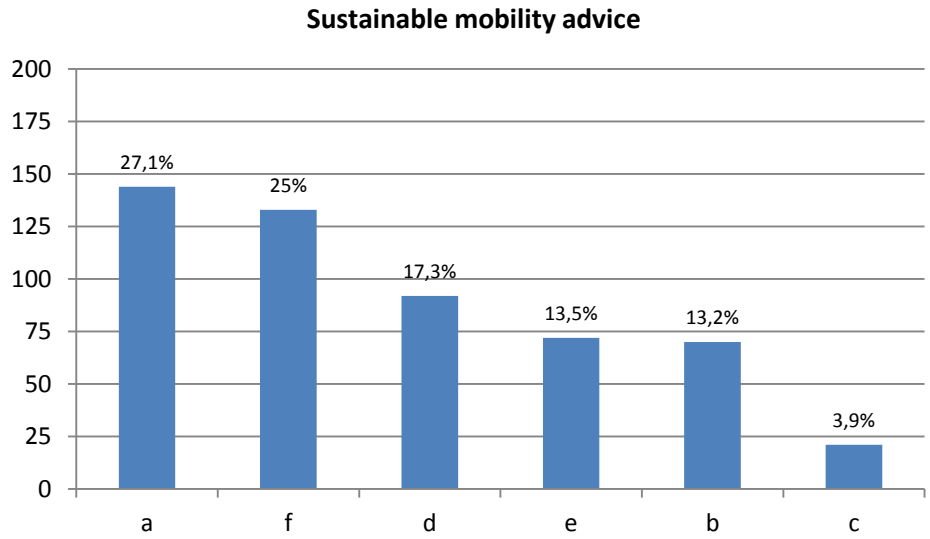
d) Access restrictions: Access management / Enforcement, Car Restricted Zones / Living Streets, Multifunctional areas, Parking management, Pedestrian zone, Traffic calming / Speed reduction;

e) Integrated pricing strategies: Congestion pricing, Integrated ticketing, Parking Management;

f) Collective passenger transport: Public transport, Bus services, Rail transport, Intermodal transfers, Integrated ticketing, Park & Ride, Accessible transport systems, Paratransit, Bus rapid transit, Quality of service, Security, including Transit police.

To facilitate data treatment all answers have been assimilated to one of the provided options. For example lower public transport prices are included in option "e", reducing the amount of vehicles circulation in option "d", etc.

Most common advices were those related with public transport, either in its use (a), promotion (f) or price decrease (e).It is also remarkable the number of answers related with traffic jams, specially with the decrease of circulating vehicles, the implementation of a tax for cars or limitations of circulation during specific days. Also 13,2% of the answers were related to the promotion of clean vehicles. Finally only 3,9% suggest an investment in infrastructures or paths designed to sustainable mobility systems.



n=532

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13.4. Bivariable analysis (contingency tables)

Once the descriptive analysis has been displayed, other statistical analyses have been performed to seek for possible cause relations between the given answers and characteristics of the interviewed population: income, gender, age, car ownership, etc.

In statistics, a contingency table (also referred to as cross tabulation or cross tab) is a type of table in a matrix format that displays the (multivariable) frequency distribution of the variables. In this section contingency tables have been calculated in order to analyze the associative relation between the questions that have been considered more relevant given the objectives of this survey:

> *Question 14.1 Iif you have never used an electric vehicle, would you be interested in testing/buying one taking into account the following advantages: speed, comfort, safety, environmental friendly, consumption reduction?*
>
> *Question 20. If a scooter sharing system was provided in Barcelona, would you be interested in using it?*

Although they are commonly used as an associative analysis tool, they can be also used to analyze causative associations. Some variables are defined as dependents and other as independents. For example, it has been considered that the age of people may determine the interest in the electric vehicle. The independent (or causative) variables are located in the columns of the contingency table, while the dependent variables are located in the rows.

Next table shows the analyzed relations and its significance[5], its probability and a global statistic which defines the strength of the global relation between variable (Cramér's V[6]). The table has been ordered by higher to lower relation, being the first one which shows a higher intensity.

Age and employment status seem to be the variables most related with electric vehicle interest, and also with the sharing system, while income does not seem to be related. Gender has intermediate positions.

[5] Any association with a probability lower than 0,05 Chi-square (5%) is considered as a significant, which means that exist a statistical relation with a probability error lower than 5%.

[6] This statistic has a value between 0 and 1. However in social relations it is considered that the maximum value that can be achieved is about 0,6, therefore a 0,3 value correspond to an intermediate relation.

Contingency table showing causal relations between variables

Relation		Significance		V Cramer
Independent variable	**Dependent variable**	**Significance**	**Probability**	
Age	Electric vehicle interest	Yes	0,000	0,319
Employment status	Electric vehicle interest	Yes	0,000	0,283
Employment status	Scooter sharing system (simplified)	Yes	0,000	0,202
Age	Scooter sharing system (simplified)	Yes	0,000	0,192
Gender	Electric vehicle interest	Yes	0,003	0,145
Car possession	Electric vehicle interest	No	0,335	0,05
Income	Electric vehicle interest	No	0,402	0,067
Car possession	Scooter sharing system	No	0,487	0,061
Income	Scooter sharing system	No	0,566	0,056
Gender	Scooter sharing system	No	0,728	0,036

To simplify the analysis and to get a better understanding of the relation between variables, some categories have been simplified:

ORIGINAL VARIABLE	NEW CATEGORIES
Activity status	**Recoded**
Employee	Employee/self-employed
Self-employed	
Unemployed	Unemployed
Student	Student
Housewife	Inactive
Other	
Retired	
Scooter sharing system	**Recoded**
I will never use the system	No
Most probably I will not use the system	
I will consider use the system	Maybe
Most probably I will use the system	Yes
I will surely use the system	

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The contingency tables for the most related variables, divided into their categories so they can be deeper analysed, are shown next:

Relation between age and interest in the electric vehicle

ELECTRIC VEHICLE INTEREST	AGE			TOTAL
	16 - 35	36 - 55	Over 55	
No	38,7%	57,5%	82,5%	57,7%
	48	115	80	243
	-19,0%	-0,2%	24,8%	
	-5,1	-,1	5,6	
Yes	61,3%	42,5%	17,5%	42,3%
	76	85	17	178
	19,0%	0,2%	-24,8%	
	5,1	,1	-5,6	
TOTAL	124	200	97	421
	100,0%	100,0%	100,0%	100,0%

Pearson Chi-square: 42.723; df: 2; Sig:0,000

Cramer's V: 0,319

The table shows that individuals between 16 and 35 years have a higher interest in electric vehicles, just unlike individuals over 55, that are highly related with "no interest".

Relation between employment status and interest in the electric vehicle

SCOOTER SHARING SYSTEM	EMPLOYMENT STATUS				TOTAL
	Employee/Self-employed	Unemployed	Inactive	Student	
No	69,0%	70,6%	92,2%	53,5%	68,7%
	171	24	71	68	334
	0,2%	1,9%	23,5%	-15,2%	
	,1	,2	4,8	-4,3	
Maybe	19,8%	8,8%	1,3%	23,6%	17,1%
	49	3	1	30	83
	2,7%	-8,3%	-15,8%	6,5%	
	1,6	-1,3	-4,0	2,3	
Yes	11,3%	20,6%	6,5%	22,8%	14,2%
	28	7	5	29	69
	-2,9%	6,4%	-7,7%	8,6%	
	-1,9	1,1	-2,1	3,2	
TOTAL	248	34	77	127	486
	100,0%	100,0%	100,0%	100,0%	100,0%

Pearson Chi-square:33.802 ; df: 3; Sig:0,000
Cramer's V: 0,283

Inactive people show a significant interest under the average, while students and workers have a greater interest, much higher than the average.

Only students and unemployed people have a significant relation. Inactive people have not interest in scooter sharing system, much lower than the average. In contrast, students are the collective with a higher interest in the system.

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Relation between age and willingness to use a scooter sharing system

SCOOTER SHARING SYSTEM	AGE				Total
	< 16	16 - 35	36 - 55	Over 55	
No	43,5%	60,0%	72,5%	83,8%	68,7%
	20	78	153	83	334
	-25,2%	-8,7%	3,8%	15,1%	
	-3,9	-2,5	1,6	3,6	
Maybe	34,8%	18,5%	17,5%	6,1%	17,1%
	16	24	37	6	83
	17,7%	1,4%	0,5%	-11,0%	
	3,4	,5	,2	-3,3	
Yes	21,7%	21,5%	10,0%	10,1%	14,2%
	10	28	21	10	69
	7,5%	7,3%	-4,2%	-4,1%	
	1,5	2,8	-2,3	-1,3	
TOTAL	46	130	211	99	486
	100,0%	100,0%	100,0%	100,0%	100,0%

Pearson Chi-square:35.713 ; df: 6; Sig:0,000
Cramer's V: 0,192

Similarly to the previous case, the most willing population to use the scooter sharing system has an age below 35, while people above 55 have a lower interest.

Relation between gender and electric vehicle interest

ELECTRIC VEHICLE INTEREST	GENDER		TOTAL
	Male	Female	
No	49,40%	63,90%	57,70%
	89	154	243
	-8,30%	6,20%	
	-3	3	
Yes	50,60%	36,10%	42,3%
	91	87	178
	8,30%	-6,20%	
	3	-3	
TOTAL	100%	100%	100%
	180	241	421

Pearson Chi-square:8.823 ; df: 1; Sig:0,003
Cramer's V: 0,145

The tables show that men have a greater interest on electric vehicle than women.

Bivariable analysis main conclusions

The groups with greater interest in electric vehicles are young employees or student men. In contrast, people above 55 years, women and inactive people show little interest in electric vehicles.

In relation to scooter sharing system, young people and students are the most interested people, while inactive and older people do not have interest. Men and women have similar interest

13.5. Multivariable analysis

13.5.1 Multiple correspondence analysis

In the previous section the main significant relations between variables and categories were analyzed in a bivariable level. However to have a more visual and complete analysis a multivariable analysis is required (in this case 8 variables with 31 categories) to see the relation between categories both significant or not.

This analysis has been performed by a multiple correspondence technique using SPAD software (version 5.6.). This technique creates from factorial punctuations a number of factors which resume the different variables (8 in this case) in a reduced number of factors (2 in this case), losing some of the initial information variability (variance) and reducing a minimum of 70% of the initial variance, that is, pointing out more exact relations.

Chosen variables

The chosen variables are the same used in the bivariable analysis from the previous section adding also an index created from the questions referred to the evaluation of electric vehicle (question 15). This index has been divided in quartiles according to the frequency of the cases. Also, like in the bivariable analysis, some variables have been simplified to have a wider sample for each one.

VARIABLE	LABEL OF CATEGORIES
Electric vehicle interest	No
	Yes
	Not applicable
Scooter sharing system	I will never use it
	Probably not
	Maybe
	Probably yes
	I will use it
Gender	Male
	Female
Age	< 16 anys
	16 - 35
	36 - 55
	Over 55
Income	< 20.000
	20.000 - 40.000
	> 40.000
	No answer
Car possession	No
	Yes
	Not applicable
Electric vehicle interest index	Low/Sufficient
	Discreet
	Good
	Excellent
	Not applicable
Employment	Employee
	Self-employed
	Unemployed
	Inactive
	Student

Variable composition by factors

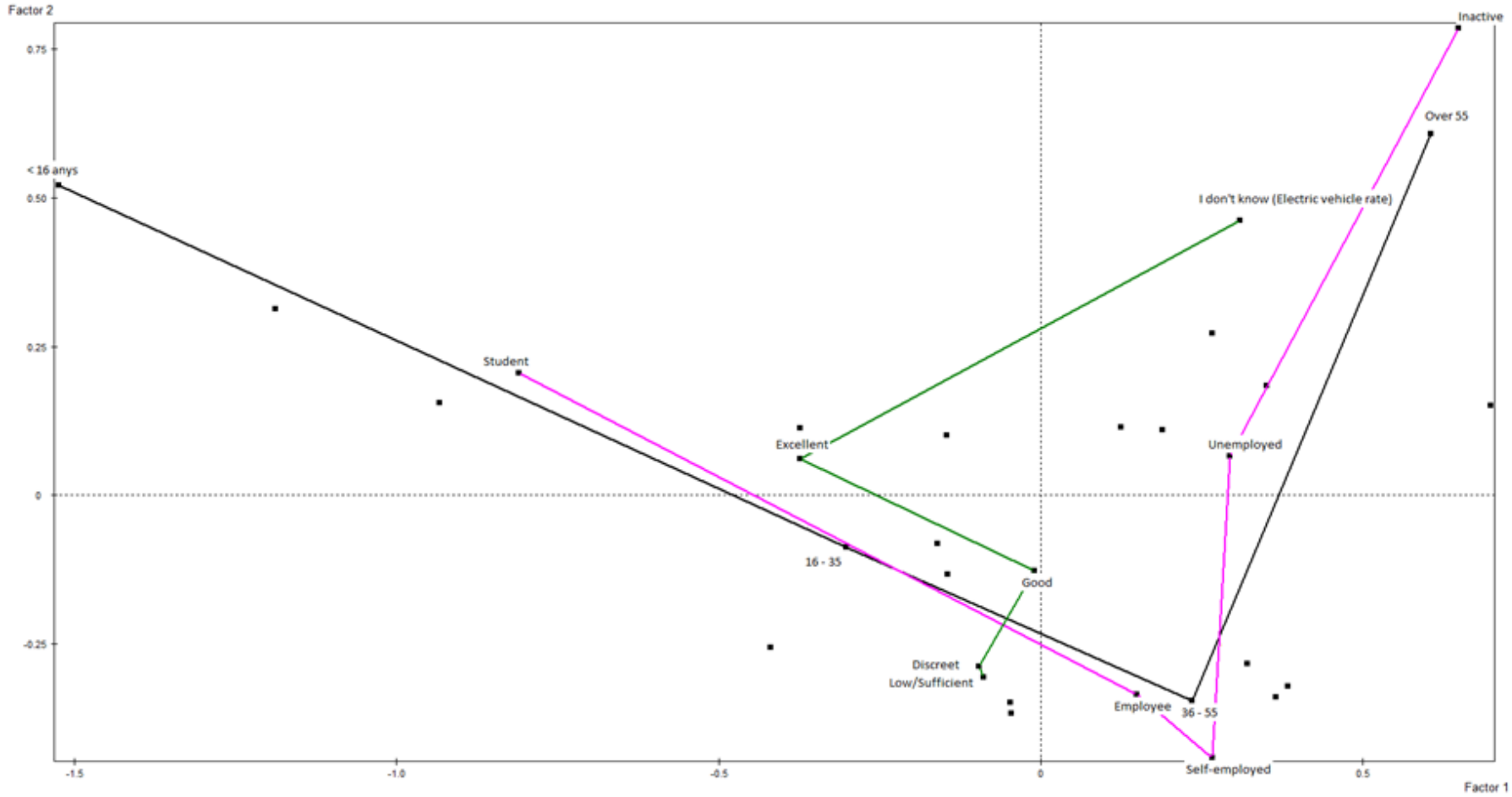
In the next graph the most important factors are represented in abscises and coordinates axis. Factor 1 (the most important, represented in horizontal axis) it's composed by age and employment status. Factor 2 (represented in vertical axis) also includes the same two variables but it's distinguished from factor 1 for including the variable "evaluation of electric vehicle".

The next graph shows the trajectories of these variables. There, the variables contributing to factor 1 have more horizontal trajectories, while the variables contributing to factor 2 have more vertical trajectories. In this graph the tags from the not relevant categories have been eliminated to have an easier visualization.

This graph gives an obvious conclusion: there is a clear relation between age and employment status. Younger people are students, older are inactive and mid age (35-55) are currently working or unemployed.

Also, referring to vertical axis, it can be seen that the electric vehicle evaluation "low-sufficient", "discreet" and "good" is more common between young and adult people, while the "excellent" point is located near the young people zone and "I don't know" is near inactive and older people.

Multivariable analysis by factors: Age, employment status and electric vehicle rating index



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The next graph includes all categories: employment status, age, income, gender, interest in electric vehicle and willingness to use a scooter sharing system.. The closer the points are, the higher relation they have. It's interesting to analyze each of the four quadrants:

Upper-left quadrant:

In this zone are included students, low income people and young people. They have good valuation of electric vehicle and they will use it.

Down-left quadrant:

It includes people between 16 and 35 years. They have good and discreet valuation of electric vehicle and probably they will use it.

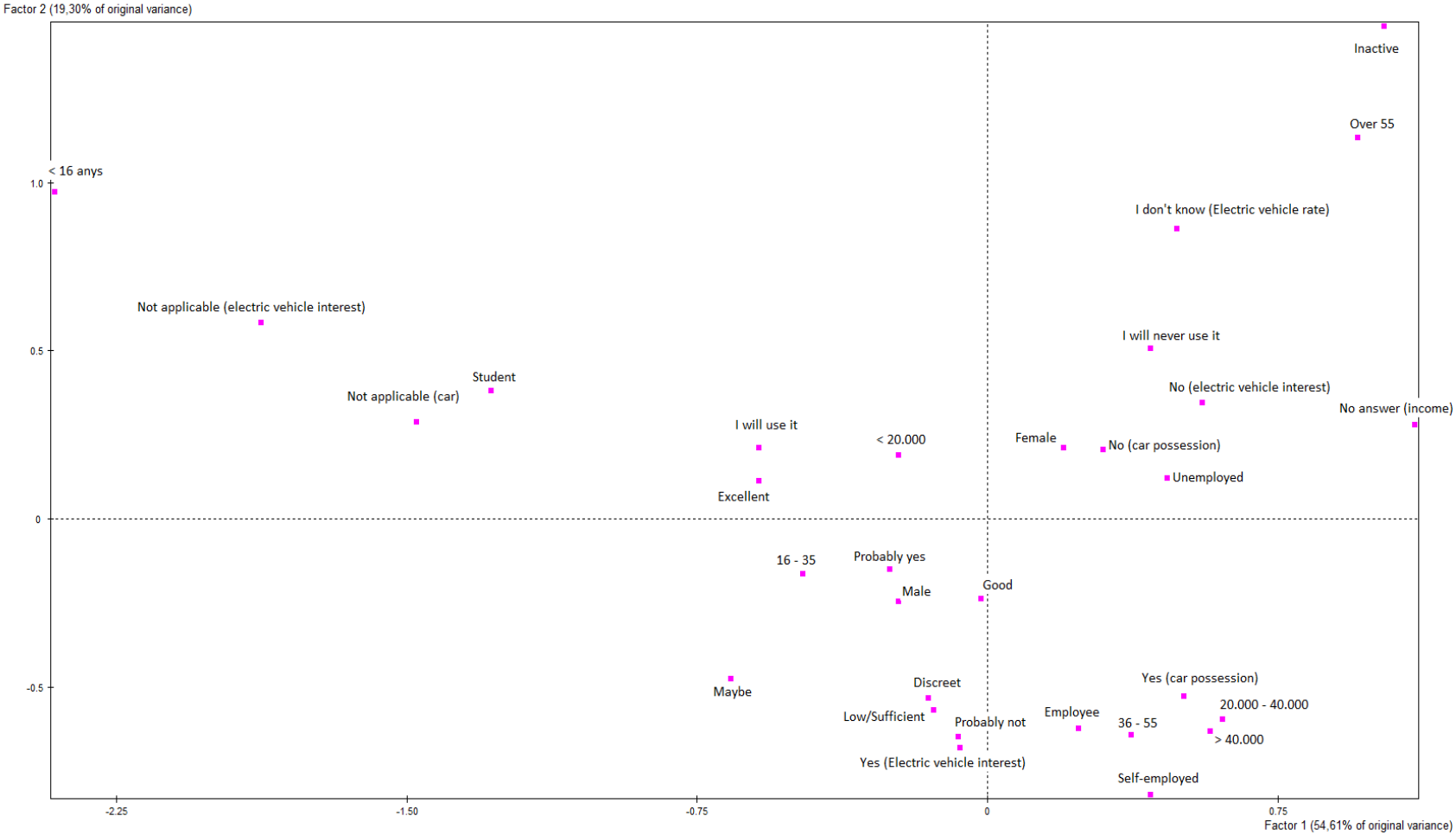
Down-right quadrant:

It includes people between 25 to 50 years, employed and with medium incomes. They possess a car and it's not clear it's predisposition to use the electric car (some of them yes and other not), while probably they will not use the sharing scooter system.

Upper-right quadrant:

It includes old and inactive people. They don't have a car and can't valuate the aspects of the electric vehicle. They don't have interest in the electric car use or scooter sharing system.

Multivariable analysis: employment status, age, income, gender, interest in electric vehicle and willingness to use a scooter sharing system



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13.5.2 Classification analysis

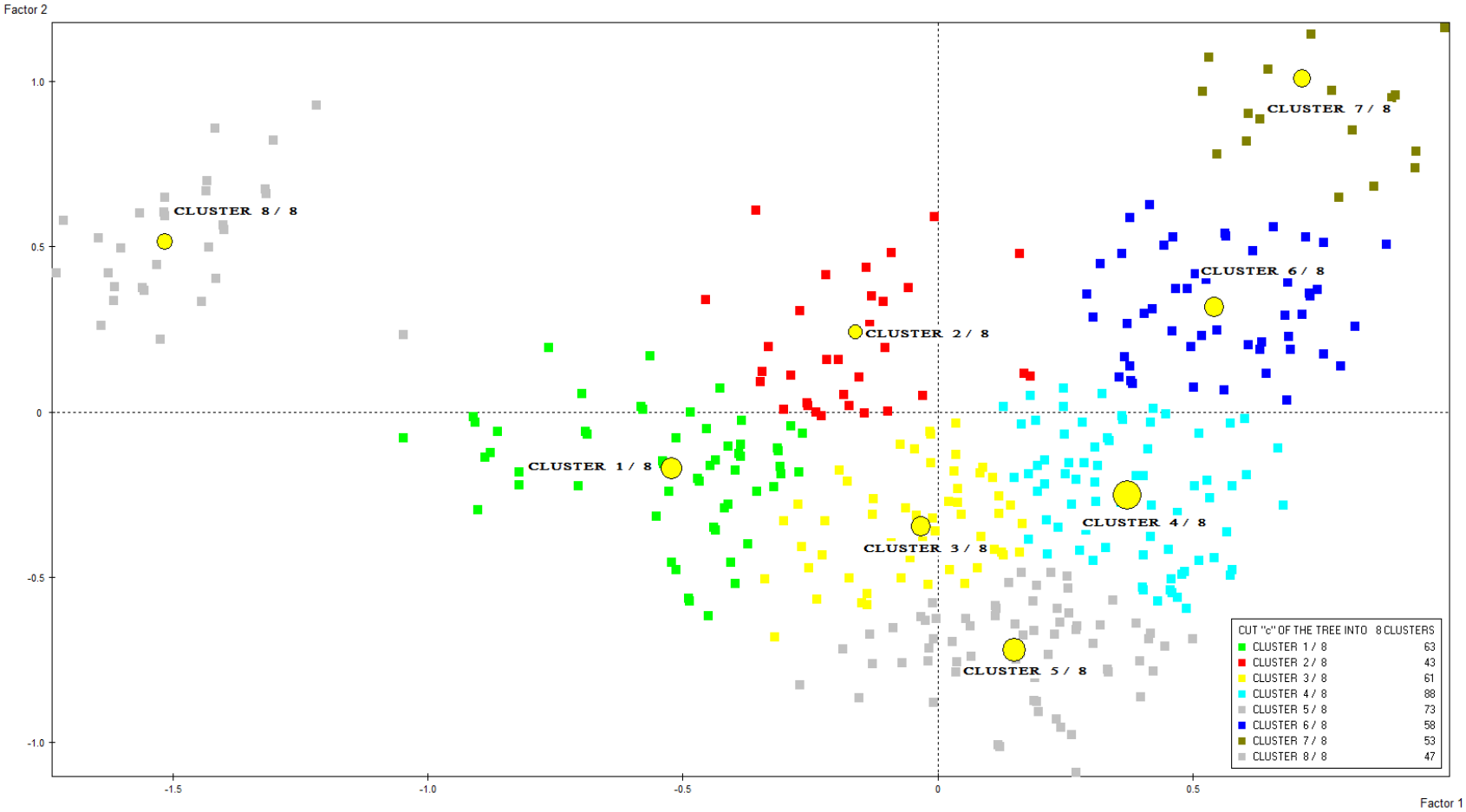
Once the relations have been established and visualized, a classification analysis groups the total amount of cases (486) in eight categories according to common characteristics of the individuals that pointed out on the multivariable analysis. In the first graph each group is assigned a colour and their cluster is clearly visible.

Some groups can have similar characteristics, for example group 3 have some similarities with groups 1, 2, 4 and 5, that's why is located between them in the graph. In the other side group 8 have very particular and distinctive characteristics (includes all the students younger than 16 years) and it's located far from the other groups.

Also the similarities between the individuals of a group can be observed by looking at the point dispersion. As closer as the points are, more similar they are.

In the second graph there are different point categories and the centre point for each group. In this way it's possible to appreciate in a more clear way the main characteristics of each group. As bigger the point of a group is, the more cases it includes.

Classification analysis: cluster identification (population groups)



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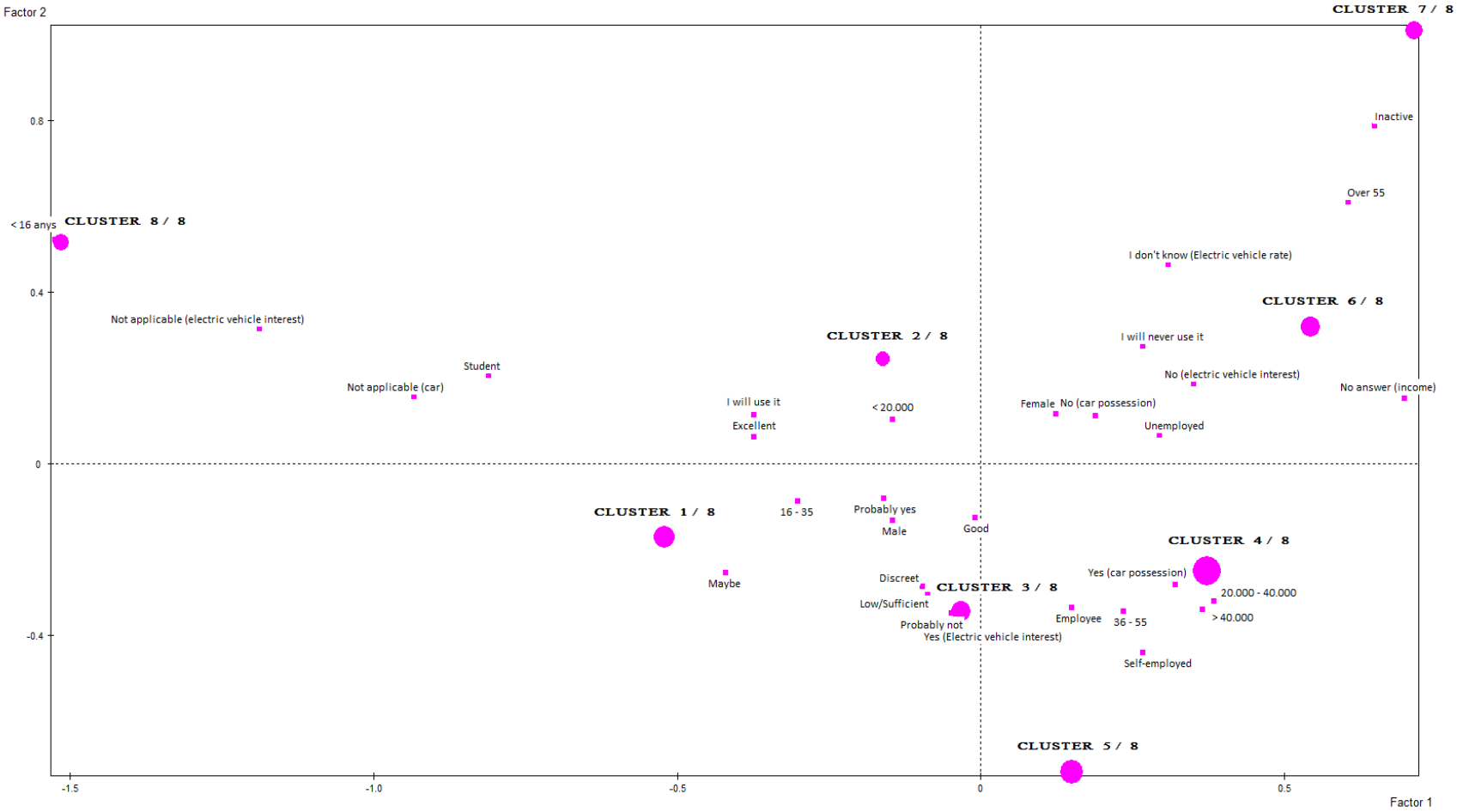
Classification analysis: cluster visualization (population groups) according their common characteristics



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Group characterization

Next tables show the main characteristics of each group - cluster. The column "% of category in group" expresses the percentage of individuals that possess those concrete characteristics. For example in the first table (group 8) all its members (100%) are students and 34,04% of them rate the electric vehicle as excellent.

Group 8 (47 cases; 9,67%)

Variable label	Characteristic categories	% of category in group
Electric vehicle interest	Not applicable	100,00
Car possession	Not applicable	100,00
Employment	Student	100,00
Income	< 20.000	100,00
Age	< 16	97,87
Electric vehicle index	Excellent	34,04
Scooter sharing system	Maybe	34,04

Group 1 (63 cases; 12,96%)

Variable label	Characteristic categories	% of category in group
Income	< 20.000	98,41
Age	16 - 35	93,65
Employment	Student	77,78
Electric vehicle interest	Yes	65,08
Gender	Male	65,08
Electric vehicle index	Discreet	39,68
Electric vehicle index	Low/Sufficient	33,33

Group 2 (43 cases; 8,85%)

Variable label	Characteristic categories	% of category in group
Income	< 20.000	100,00
Age	16 - 35	88,37
Gender	Female	74,42
Employment	Student	69,77
Car possession	No	69,77
Scooter sharing system	I will never use it	67,44
Electric vehicle index	I don't know	55,81

Group 3 (61 cases; 12,55%)

Variable label	Characteristic categories	% of category in group
Employment	Employee	73,77
Income	< 20.000	86,89
Electric vehicle interest	Yes	65,57
Age	16 - 35	40,98
Scooter sharing system	Probably yes	18,03

Group 4 (88 cases ; 18,11%)

Variable label	Characteristic categories	% of category in group
Age	36 - 55	90,91
Electric vehicle intrerest	No	81,82
Employment	Employee	65,91
Car possession	Yes	52,27
Income	20.000 - 40.000	34,09

Group 5 (73 cases; 15,02%)

Variable label	Characteristic categories	% of category in group
Age	36 - 55	89,04
Electric vehicle interest	Yes	78,08
Employment	Employee	72,60
Gender	Male	64,38
Car possession	Yes	60,27
Income	20.000 - 40.000	52,05
Scooter sharing system	Probably not	49,32
Electric vehicle index	Discreet	34,25
Scooter sharing system	Maybe	32,88
Electric vehicle index	Low/Sufficient	28,77
Employment	Self-employed	27,40

Group 6 (58 cases; 11,93%)

Variable label	Characteristic categories	% of category in group
Scooter sharing system	I will never use it	82,76
Electric vehicle interest	No	82,76
Gender	Female	72,41
Age	Over 55	53,45
Electric vehicle index	I don't know	53,45
Car possession	Yes	46,55
Employment	Inactive	36,21
Employment	Unemployed	24,14

Group 7 (53 cases; 10,91%)

Variable label	Characteristic categories	% of category in group
Age	Over 55	100,00
Employment	Inactive	98,11
Electric vehicle interest	No	98,11
Scooter sharing system	I will never use it	96,23
Car possession	No	90,57
Electric vehicle index	I don't know	81,13
Gender	Female	73,58

Interpretation

Scooter sharing system:

Group **3** is the most predisposed to use the scooter sharing system (18% would probably use it). In this group are included young (16-35 years) employees earning less than 20.000 €/year. Groups **8** (students under 16 years) and **5** (employees, males, 35-55 years, with a salary between 20.000-40.000 years and owning a car) would be also interested in that system.

In the other hand groups **6** and **7**, composed mainly by inactive or unemployed old people (over 55 year) are the less predisposed to use the system.

Electric vehicle interest:

Groups **1**, **3** and **5** are the most interested in electric vehicle. Group **1** includes students between 16-35 years. The group **8** was not asked this question.

The groups less interested in the electric vehicle are **4**, **6** and **7**. Group **4** is mainly composed by 35-55 years old, employed people (20.000-40.000 €/year) that owns a car.

Evaluation of electric vehicle:

Group **8** gives the best rating to electric vehicles, followed by group **1** and **5**. In contrast Groups **6** and **7** give the worst ratting.

14. Conclusions

The city of Barcelona has a population of 1.615.448 inhabitants, but its metropolitan region (RMB) counts 4.777.042 people. The city generates 7.833.495 trips/day, 64% are internal (BCN-BCN) and 36% connection trips (BCN-RMB).

Public transport is the preferred transport mode, with 40% of trips. Although the use of public transport has risen progressively in Barcelona the last decade with a total of 935.4 million trips in 2011, the demand has remained more stable in recent years, probably due to the effects of the current economical crisis.

Modal distribution shows the high proportion of pedestrian mobility, with 32% of all trips, encouraged by the density, compactness and climate characteristic of the city, and the significant low bicycle utilization, linked to the lack of tradition in the use of this transport in our country.

Barcelona has favorable conditions for pedestrian mobility. Moreover, some municipal activities are currently promoting this mode of mobility such as the continuously improving accessibility in pedestrian areas, the extension of the “30 zones”.

Although bicycle represents only 1.5% of all trips, with 118.151 bicycle trips/day in 2011, cycling mobility is the mode that shows the most significant rise with a continued increase (237.5% increment between 2005 and 2011).

The modal distribution of private vehicle in Barcelona has positively decreased from 29.1% to 26.7% between 2007 and 2011 (8.4% reduction), mainly due to the economic crisis. This tendency shows that now is the time to take restricting actions towards private vehicles and to promote more sustainable transport modes.

As a Mediterranean city, Barcelona has a long tradition in the use of motorbikes. They represent 17.4% of private vehicle mobility, and have become a good scenario to introduce and popularize cleaner vehicles, especially electric mobility.

Private vehicle mobility represents 18% of internal trips, but up to 42% of connection trips. That means that traffic reduction in Barcelona involves discouraging private vehicle mobility between the surrounding municipalities and the city of Barcelona.

Regarding environmental issues, the City Council has set in the 2013-18 Sustainability Urban Mobility Plan (SUMP), where its main goals are:

- Achieve a figure of 43% for trips by public transport (currently it stands at 40%).
- Compliance with policy environmental quality parameters: EU directive, Kyoto, etc. (annual average limit values: NO2: 40µg/m3, PM10: 40µg/m3, PM2,5: 25µg/m3).
- Reduce noise from traffic in 60% of public space.
- Reduce traffic victims.

- Increase to 58% street space for pedestrians.
- Reduction of the number of private vehicle trips from 26.7% to 18,6% of the modal distribution.

With this intention, the council is carrying out a number of improvements to encourage the use of public transport. In addition, the council continues its commitment to the use of cleaner vehicles, as evidenced by the recent pilot incorporation of the first electric bus to the metropolitan bus fleet, or the presentation of the city's first all-electric taxi. Electric vehicles are considered a basic element.

As reducing private mobility and traffic accidents are one of the main objectives of the SUMP, the city Council does not seek for a rise of motorbike trips but for the penetration of the electric motorbike in the city and the progressive change of the current motorbike fleet. This would be the main role of electric bikes in the city of Barcelona.

In this framework, Ele.C.Tra survey has measured the level of acceptance of the electric vehicle, and more specifically an electric bike sharing system in the city as a way to promote this vehicle.

The main results of the survey are:

- Alternatives to vehicle ownership are not popular in Barcelona; only 9.7% of the interviewed people have considered alternatives to car ownership, and this percentage is even smaller regarding alternatives to motorbike ownership (2.7%).
- There is a high lack of knowledge about electric vehicles, consistent with the small penetration of these vehicles in Barcelona. When rating electric vehicles in terms of cost, speed, etc. around one third of the interviewed people did not know how to do it.
- Few people has used electric vehicles (4,1%) but despite this, there is a good interest on trying (42,3%)
- The percentage of people that would probably use an electric bike sharing system in Barcelona is 14,2%.
- There are little differences regarding the interest on the electric vehicle between residents and tourists

Age and employment status seem to be the variables most related with electric vehicle interest, and also with the sharing system, while income does not seem to be related. Gender has intermediate positions.

The groups with greater interest in electric vehicles are young employees or student men. In contrast, people above 55 years, women and inactive people show little interest in electric vehicles.

In relation to a possible scooter sharing system, young people and students are the most interested, while inactive and older people show no willingness to use the system. Men and women have similar interest.