A Work Project, presented as part of the requirements for the Award of a Master's degree in Finance from the Nova School of Business and Economics.

The inefficiencies of car utilization in urban areas – characterization of utopic optimal carsharing scenario, enablers and barriers that lead to different future transports mix and the pivotal role of technology enhancements

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Work project carried out under the supervision of: Professor Miguel Pita

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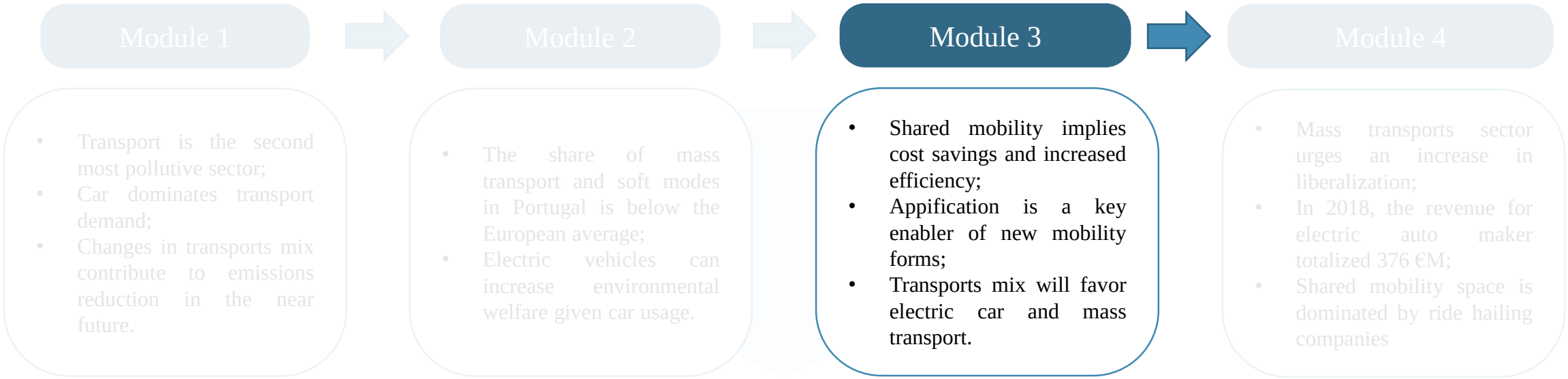

Abstract

Urban mobility is undergoing a very big transformation. Appification is the phenomenon enabling a rapid change and the rise of new players relying heavily on technology to reach end users. The benefits are of various kinds and have real implications on environment as well as on socioeconomic conditions of those who live in urban areas. The future of urban mobility ecosystem is not yet completely defined, although it will probably be greener and smarter.

Keywords: Appification, Mobility as a Service, Shared Mobility, Smart Cities

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Current Situation vs Optimal situation

- Carsharing and carpooling are two types of app-based urban mobility services.
- In a utopic optimal situation, the number of cars needed to fulfill demand would be lower than in the current situation. Assuming the utopic scenario in which all cars are shared, users would be able to save in commuting because carsharing costs are lower than ownership costs of private car.
- A lower number of cars reduces the number of parking lots needed and therefore increases available space for alternative uses.

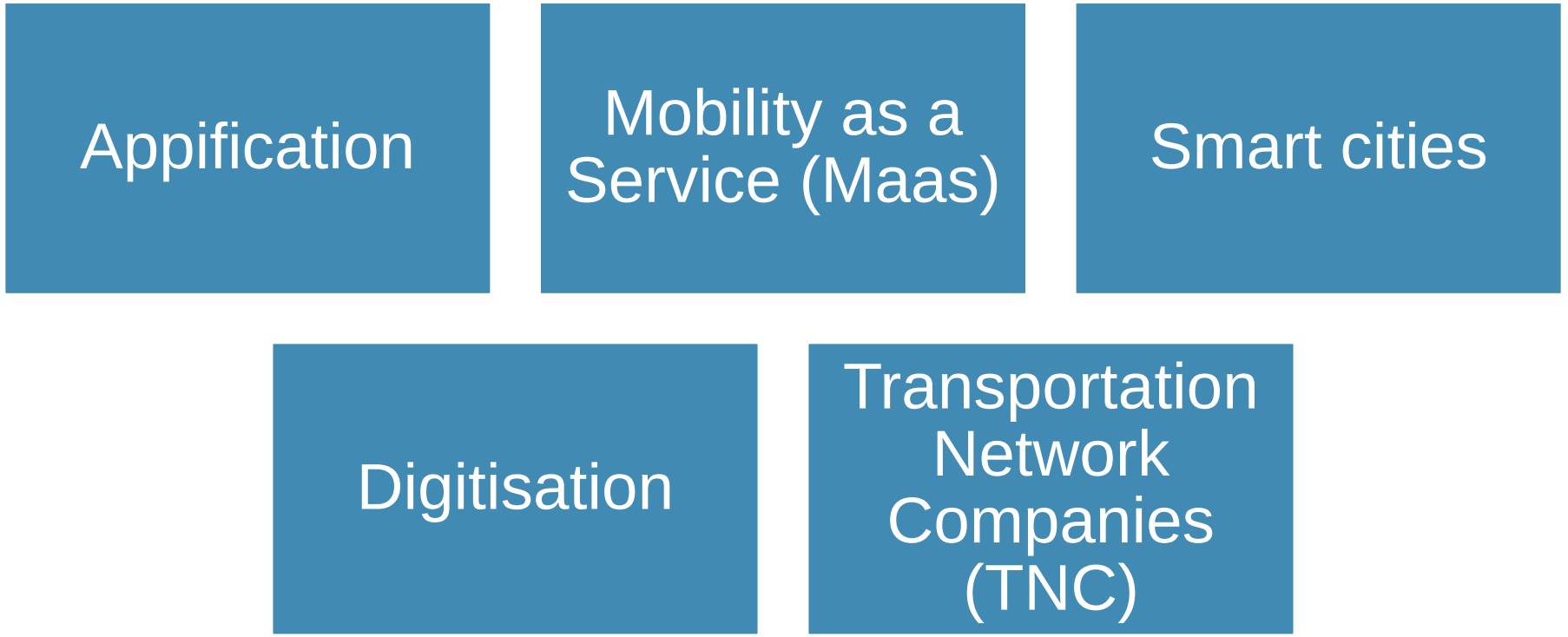
Enablers & Barriers

- Smartphone is the device that enables the operation of app-based players, which often enter the market with lower prices than incumbents.
- Generational renewal and change in mentality potentiate a social approach to mobility which is heavily reliant on technology.
- Lack of charging infrastructures and lower comparable autonomy of electric vehicles are key barriers for their growth.
- Fleet rotation from ICE cars to electric cars has a negative impact on fiscal revenues over fossil fuels.

Transports Mix Projections

- Overall CO2 eq. emissions are expected to be reduced by 42% in LMA and 48% in PMA.
- The transports mix projections up to 2050 reveal a shift from ICE cars to electric cars and a higher importance of mass transports in the urban mobility mix.

“Cities are increasingly witnessing the impact of more disruptive change, whether as a result of technological innovation, socioeconomic change or new policy interventions” (Rode and Hoffmann, 2015)



Source: made by the authors based on Reference list 73) to 77)

Carsharing and carpooling are shared mobility services enabled by TNCs and appification. An utopic carhsaring scenario is compared with the current situation to assess socioeconomic impact of all cars being shared

Carsharing

- Concept and features
- Main players operating in Portugal

Carpooling

- Concept and features
- Main players operating in Portugal

Optimal Carsharing Scenario

- *Rationale*
- Supply & Demand
- Socioeconomic impact

Carsharing is a shared mobility service in which the user pays a fee to go from point A to B using a car he does not own. DriveNow and EMOV are the main carsharing players in Portugal

People no longer face the car as a good, but as a service instead (Mobility as a Service). This allows for commuting without bearing ownership costs and enjoy, at least in developed carsharing markets, the availability and flexibility the private car provides.

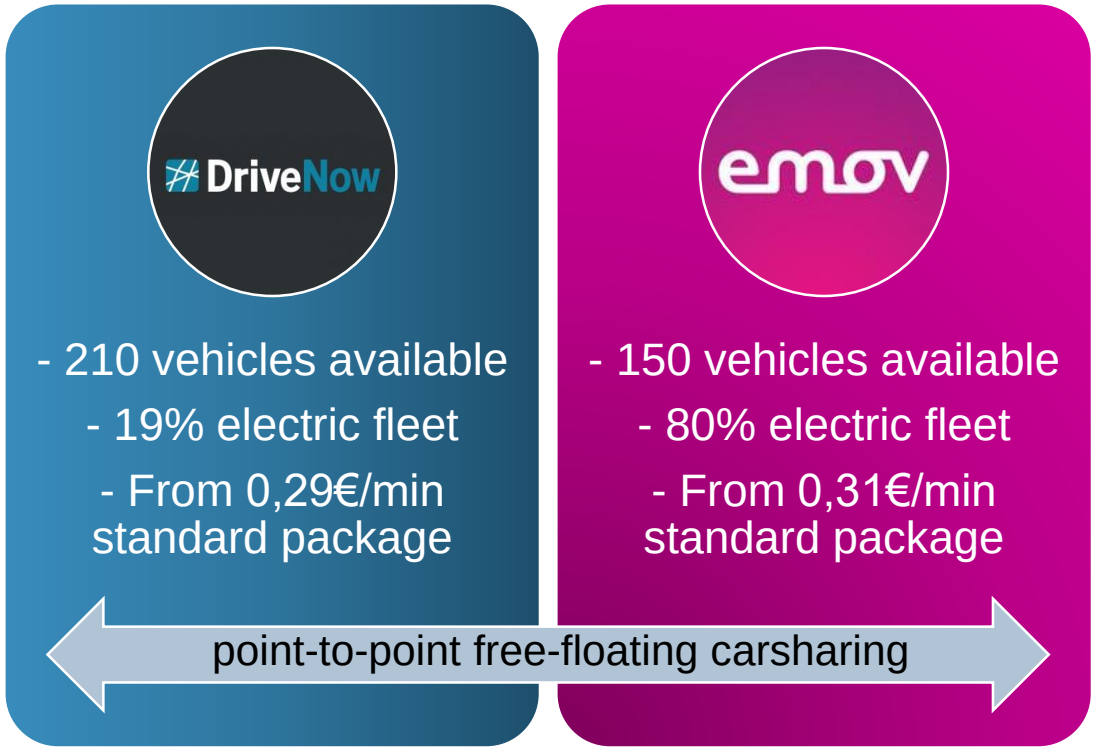
Features

- Pre-identification and qualification of end user
- Vehicle maintenance is of operator's responsibility
- Usage is billed in time increments and there is a one time registration fee

Types of carsharing

- Round-trip
- Peer-to-peer
- Point-to-point free-floating
- Point-to-point station-based

Source: made by the authors based on Reference list 96)



Source: made by the authors based on Reference list 93) to 95)

Carpooling consists on sharing a private car and the trips' costs between the various passengers. The two main players in Portugal are Via Verde Boleias and BlaBlaCar

With the appification phenomenon, many players have seen an opportunity to enter the carpooling market. By carpooling, occupation rates increase and need for cars decreases.

Travel time savings	• Reduced traffic congestion due to increased occupancy rates.
Cost savings	• Users with higher commute distances are the ones that benefit the most
Less cars in circulation and reduced GHG emissions	• Up to 75% GHG emissions reduction when commutting
Improved accessibility for households	• There are jobs outside city centres and out of reach using public transport's network.
Improved safety	• Higher concentration levels • Increased attention to speed limits

Source: made by the authors based on Reference list 97 to 100)

Both Via Verde Boleias and BlaBlaCar allow for for on-demand ride arrangements through mobile apps.

- Operating since 2017
- Over 200 000 users
- Recommended price per km
- Launched as part of new of wave of Via Verde app-based services

BlaBlaCar

- 30M users worldwide
- In Portugal since 2012
- Over 300 000 users in Portugal
- Recommended price per km
- Improvement in occupation rate (2,8 vs 1,6 average private car in Portugal)

Source: made by the authors based on Reference list 101), 137) and 138)

The utopic optimal carsharing scenario evaluates the socioeconomic impact of eliminating excess supply of cars in LMA and PMA

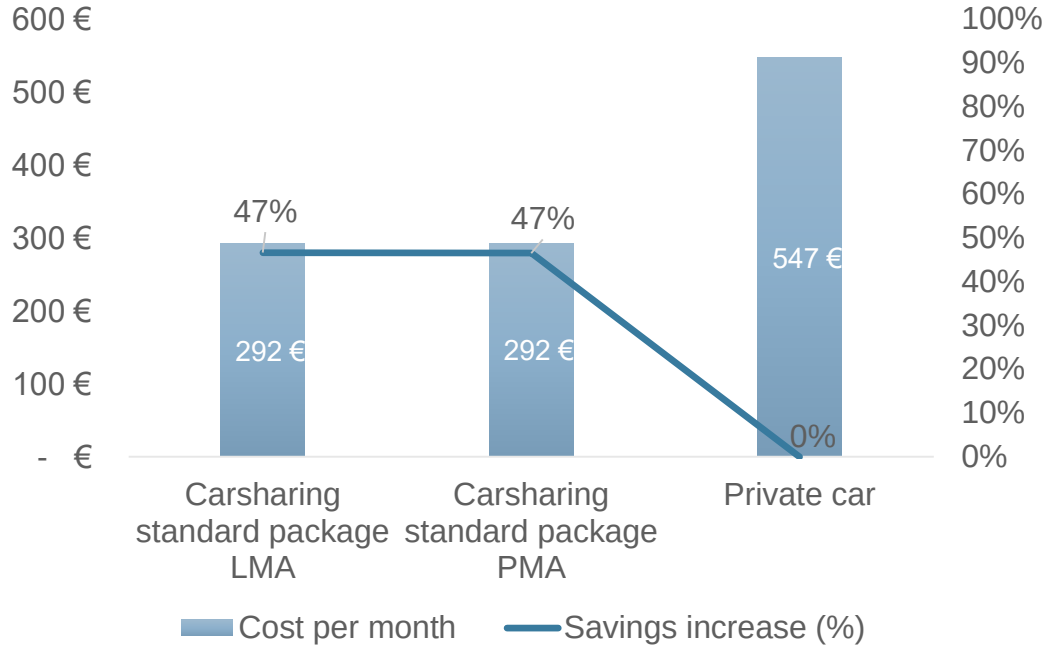
Rationale	• "If they can have access to a car occasionally, but avoid owning one, they will avoid ownership costs, and pay only for the car journeys that they make. In this way they are likely to make more rational choices about which mode to choose for a particular." (Mackett, 2012).
Supply and Demand	• There is excess supply of cars in urban areas. Current supply is measured by the number of cars existing in LMA and PMA and current demand by traffic congestion levels. It's possible to conclude that there could be a 28% reduction of cars supplied in LMA and 35% in PMA. In the optimal scenario, this reduction is assumed. It's also assumed all cars are shared and demand meets supply at its highest peak.
Socioeconomic impact	• The decrease in monthly commuting costs by opting for the carsharing solution instead of private car enables people to increase available income. Also, as there are less cars ciruculating, there is less space needed to park them when they're not being used.

Source: made by the authors based on Reference list 102)

Carsharing solutions can provide, on average, up to 47% in savings in LMA and PMA in comparison with the private car. Promotional packages of hours or km can boost savings further up to 78%

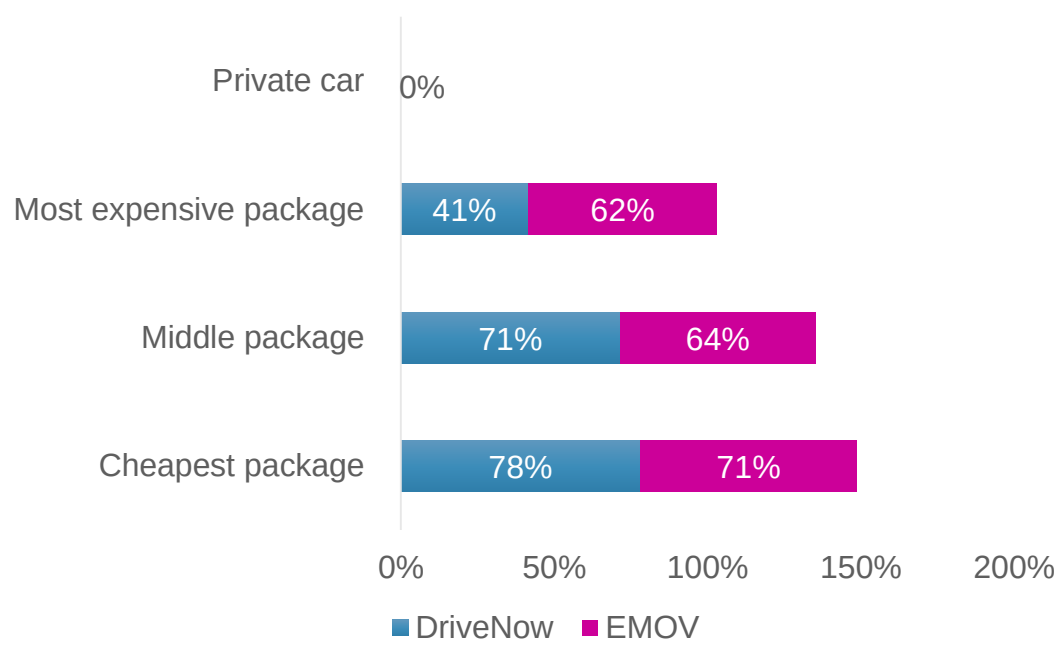
Not owning a car and opting for standard pay by trip plans offered by carsharing solutions represents an increase in savings of up to 255€ per month. By Choosing a promotional package, savings can increase up to 387€ and 427€, for EMOV and DriveNow respectively.

Graph 52: Carsharing standard package vs private car cost comparison



Source: made by the authors based on Reference list 103) and Appendix 13, part 1

Graph 53: Carsharing promotional packages savings % of private car cost



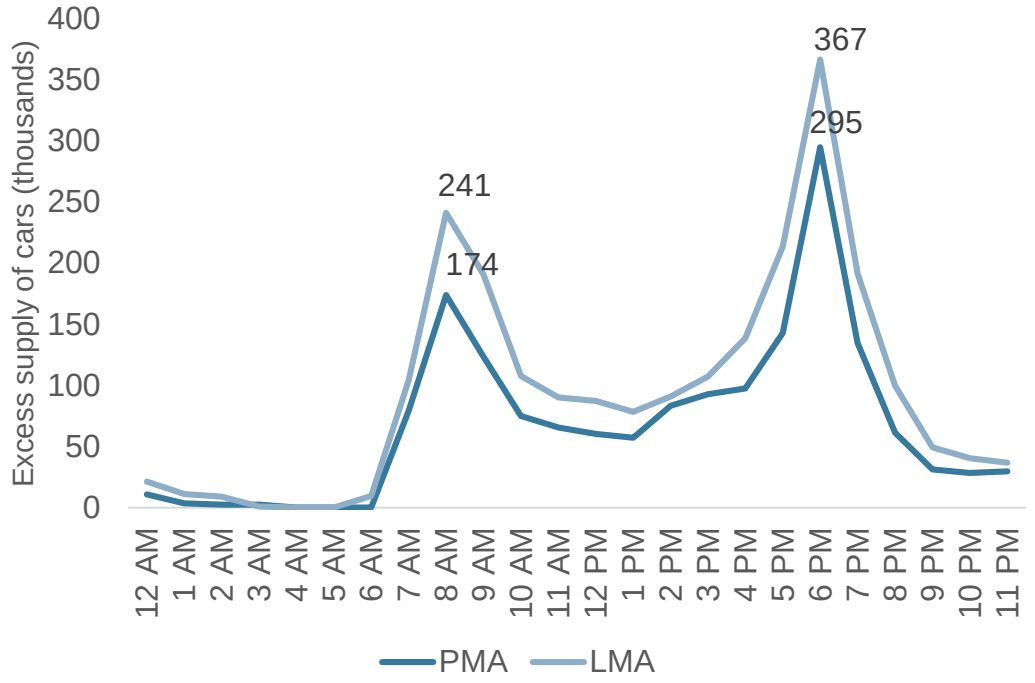
Source: made by the authors based on Reference list 94) and Appendix 13, part 2

There is excess supply of cars in both LMA and PMA. Considering the 72% and 65% peaks of average capacity utilization, the number of cars in LMA and PMA could be reduced by 28% and 35% respectively

Excess supply of cars in LMA can go up to 367 000 in LMA and 295 000 in PMA.

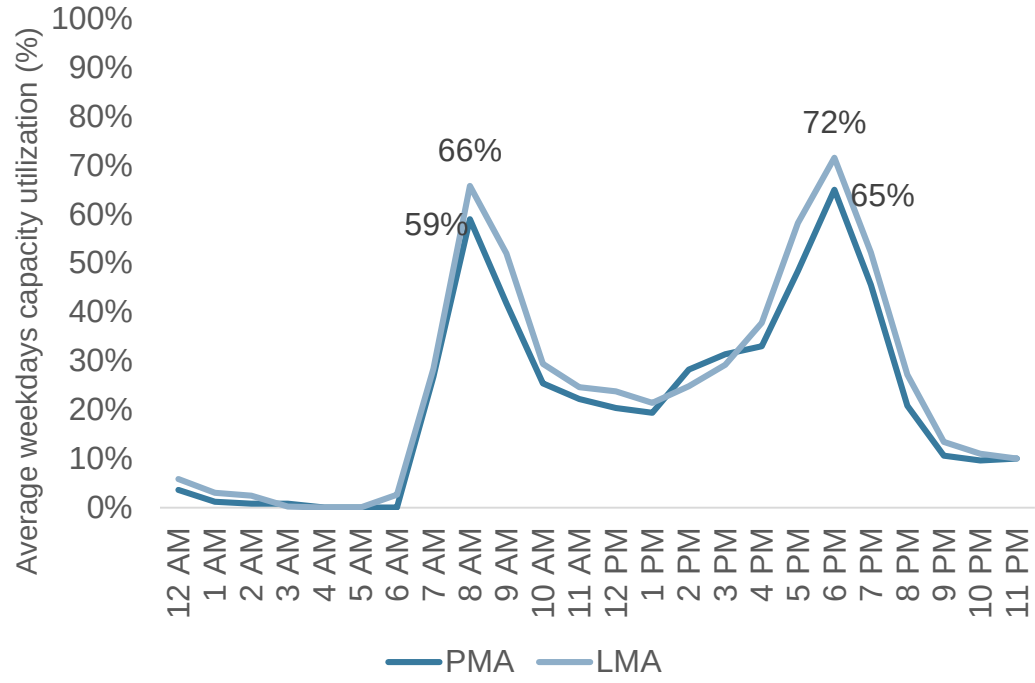
At morning and evening peaks of demand, LMA can reach higher levels of capacity utilization than PMA, although it can only achieve 66% and 72% respectively.

Graph 54: Excess supply of cars in LMA and PMA



Source: made by the authors based on Reference list 104) and 108) and Appendix 14

Graph 55: Average hourly capacity utilization in LMA and PMA



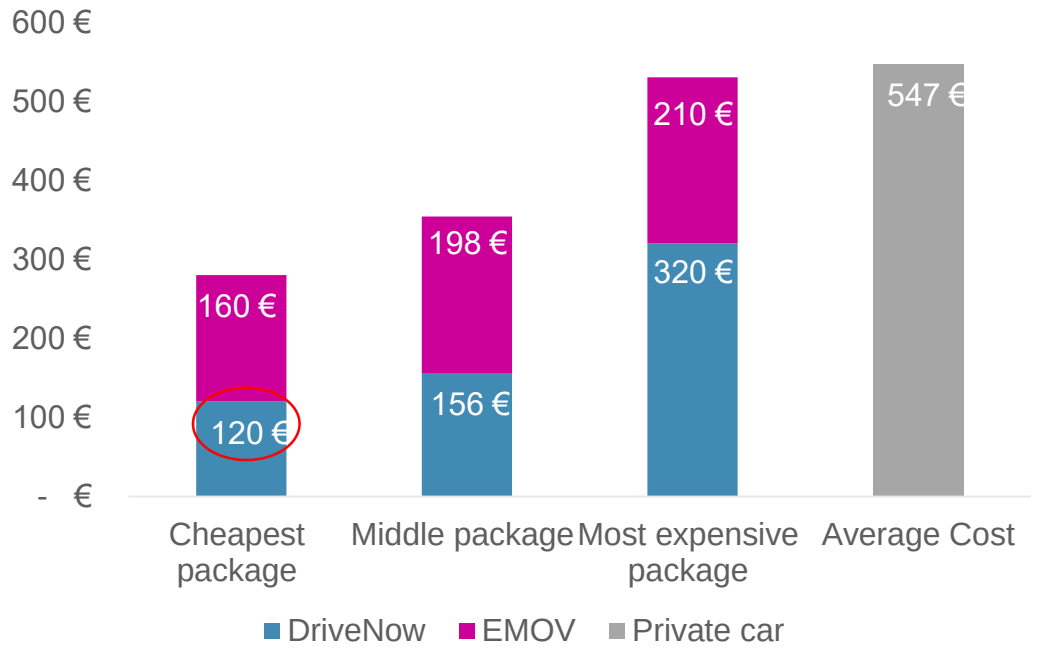
Source: made by the authors based on Reference list 105) and 108) and Appendix 14

Average annual gain from leaving the private car and using exclusively carsharing solutions can reach 5 045€ and 5 201€ per individual, in LMA and PMA respectively

The best carsharing option is to go for 3h promotional package provided by DriveNow with a cost of 120€ per month.

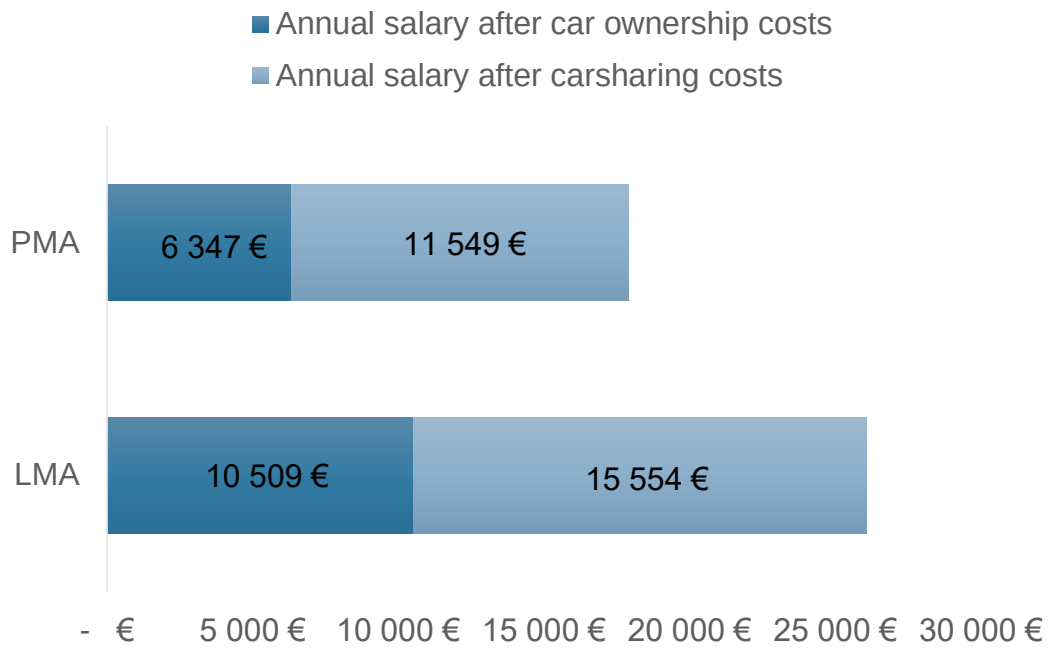
The optimal carsharing scenario reduction of 28% and 35% of cars in LMA and PMA would imply salary savings of 30% and 40%,respectively.

Graph 56: Private car vs carsharing solutions cost comparison



Source: made by the authors based on Reference list 103) and 94) and Appendix 15. part 1

Graph 57: Impact of carsharing costs and car ownership costs on annual salary



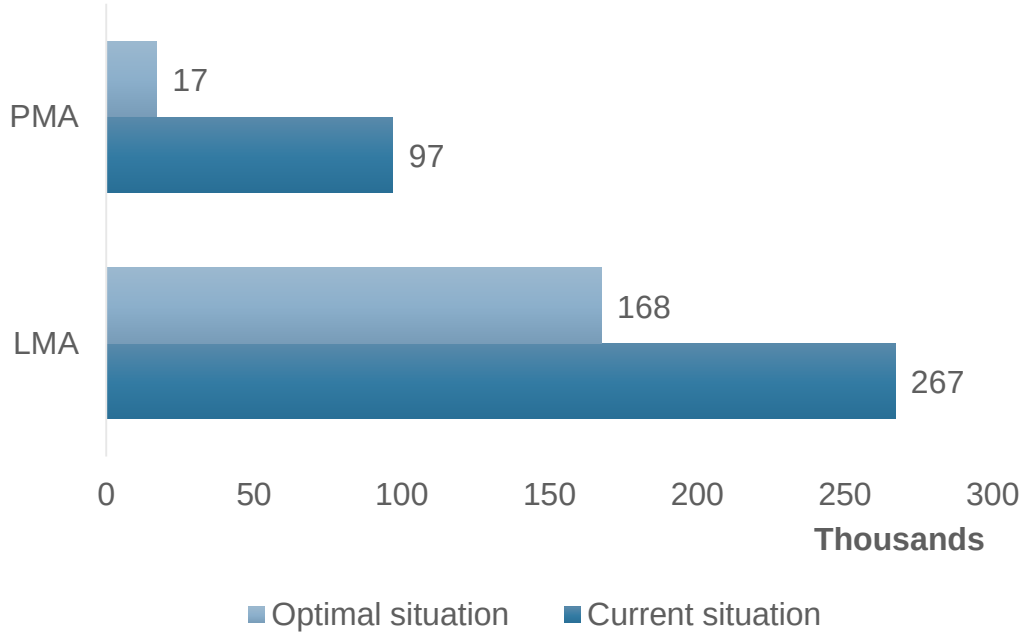
Source: made by the authors based on Reference list 109) to 111) and Appendix 15. part 1

In an optimal scenario, number of parking lots could be reduced by 99 400 in LMA and 79 985 in PMA

The 28% and 35% reduction in number of cars in LMA and PMA respectively, would imply a decrease in need for parking lots of 37% in LMA and 82% in PMA.

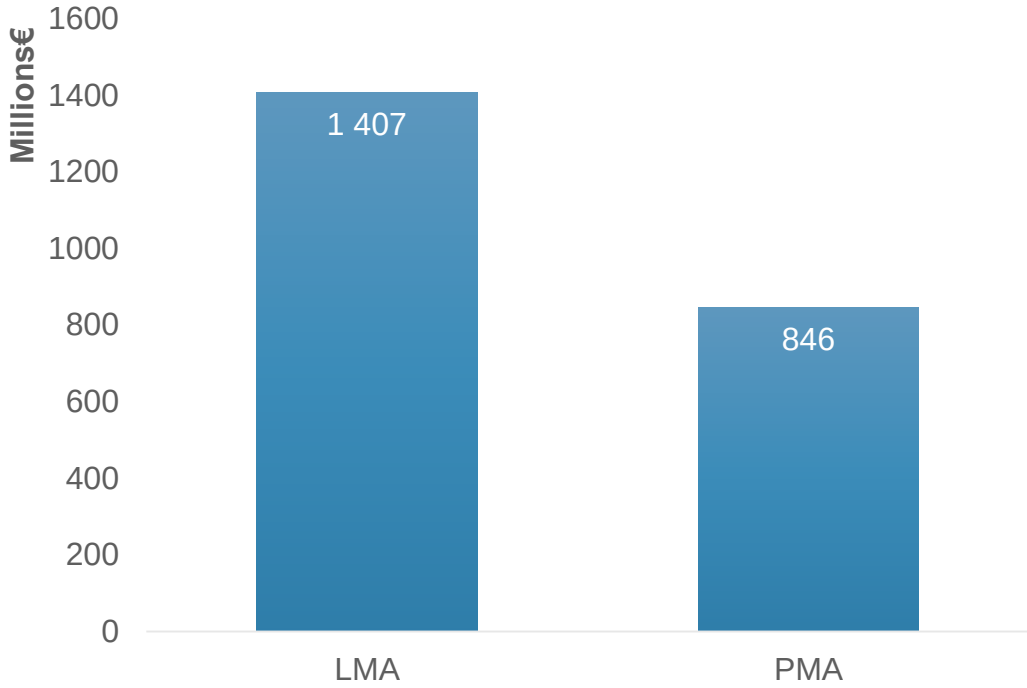
The amount of freed public space from the reduction in parking lots could have an alternative use with a reference value of 1407 M€ in LMA and 846 M€ in PMA if cost of space in considered.

Graph 58: Reduction in parking lots adjusted for the number of houses with garage place



Source: made by the authors based on Reference list 107 and 108) and Appendix 15, part 1

Graph 59: Opportunity Cost of added space



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Urban mobility is being reshaped to fight GHG emissions and traffic congestion. Enablers are monetary, technological and generational. Barriers are related to infrastructures and the dependence on fossil fuels

Enablers

- On-demand mobile internet access through smartphone and appification

- Cost advantage of new entrants

- Generation renewal and increased reliance on technology

Barriers

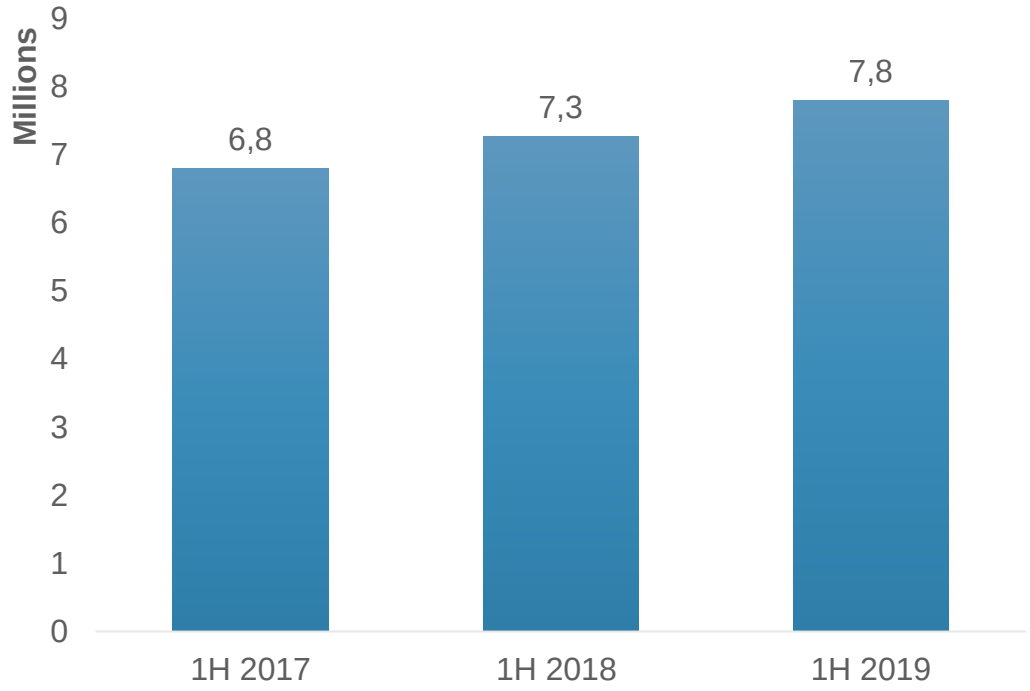
- Mismatch between new solutions in the market and infrastructures available for its full use

- Fiscal revenues from fossil fuels expected to decrease

App-based urban mobility trend surged a few years ago and is expected to last - the smartphone is the tool that allows app-based players to interact with customers

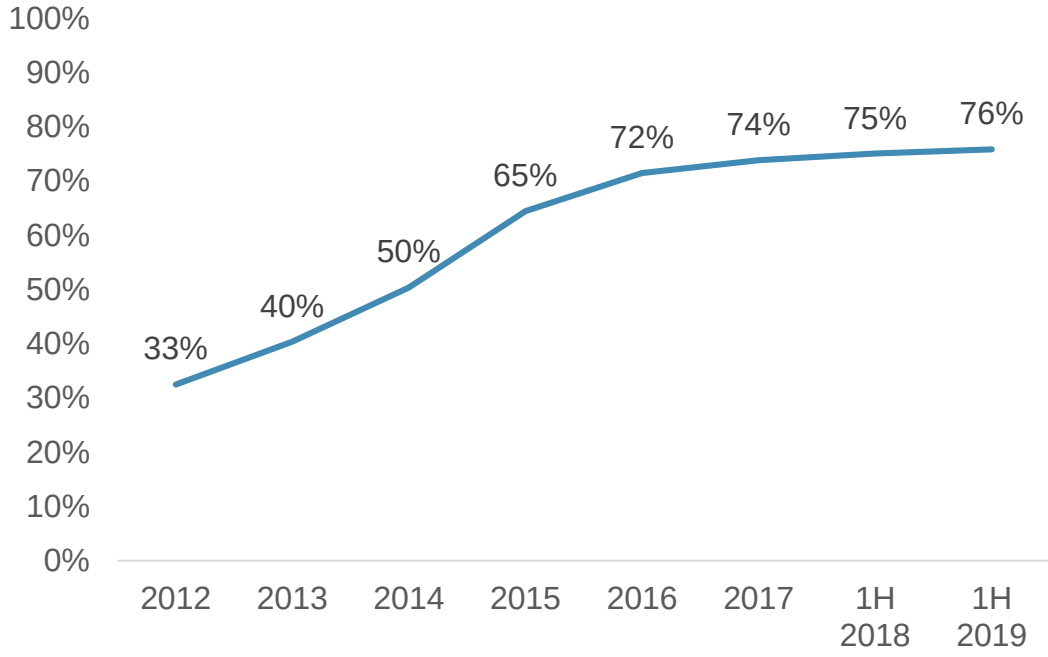
Efective number of mobile internet users increased 13% between the end of first half of 2017 and 2019. The penetration rate of smartphone on portuguese population has also been growing, from 33% in 2012 to 76% in the first half of 2019.

Graph 60: Effective number of mobile internet users



Source: made by the authors based on Reference list 78) and Appendix 9

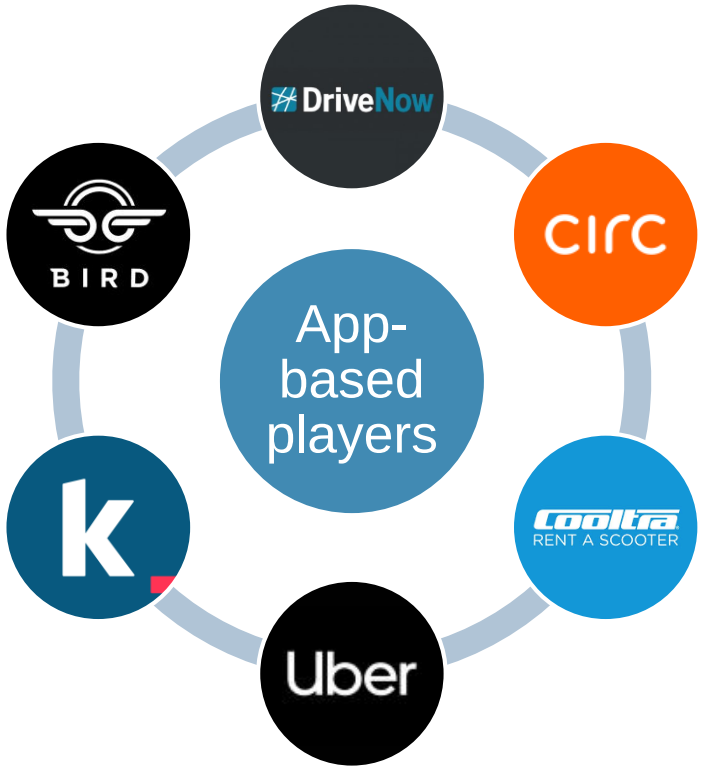
Graph 61: Penetration rate of smartphone on portuguese population



Source: made by the authors based on Reference list 79) and 131) and Appendix 9

Some app-based players offer a cost advantage over traditional ones. Others only extend the range of mobility options in urban areas

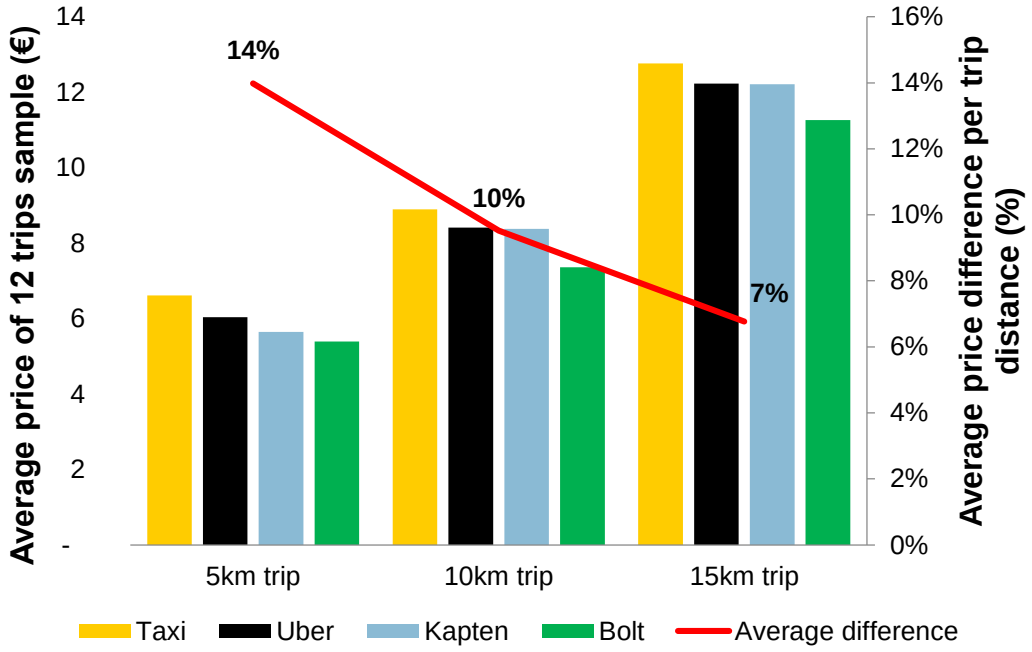
New players operating in the mobility field have emerged thanks to appification. Companies such as Uber replicate already existing services while DriveNow or Circ offer completely new solutions.



Source: made by the authors based on Reference list 132) to 137)

There is a cost advantage for users when going for new app-based players. On average, the top 3 new entrants can be up to 14% cheaper than traditional taxi.

Graph 62: App-based players vs traditional taxi price comparison

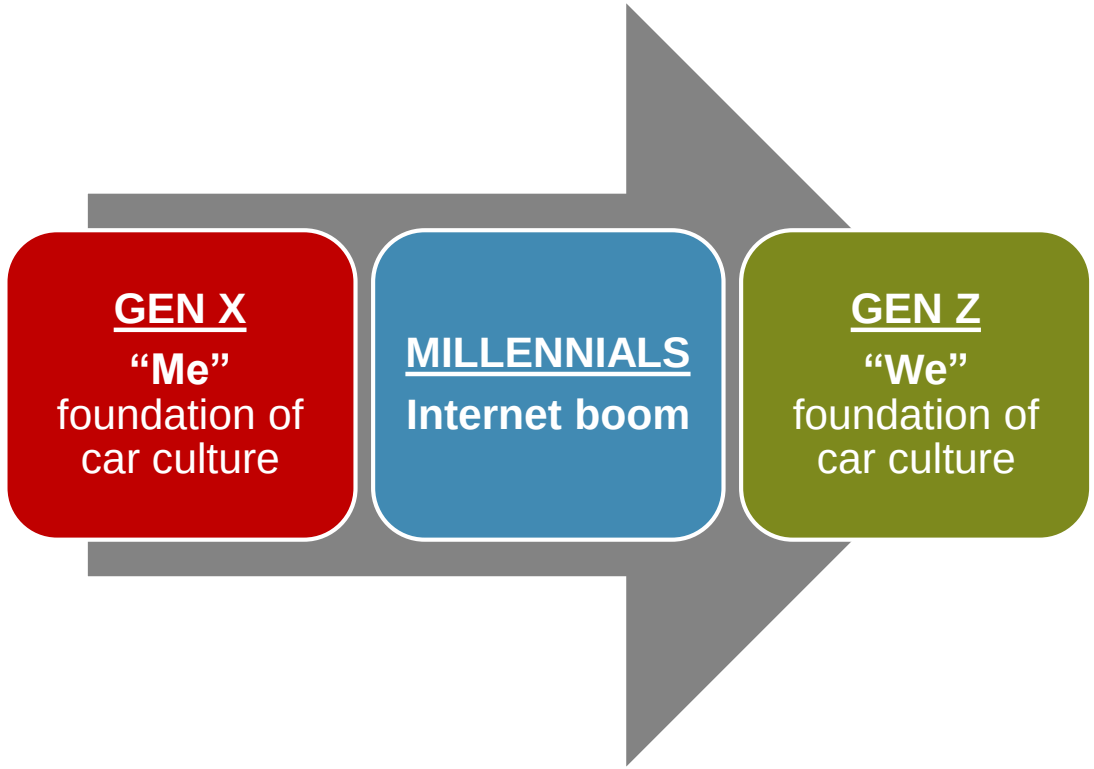


Source: made by the authors based on Appendix 10

Generational renewal is shaping the urban mobility by making it more technological and oriented to the community

From Generation X (ages 39-54) to Millennials (ages 23-38) and finally to Generation Z (ages 22 & under), several technology enhancements were introduced and with it, a new way of looking at urban mobility.

"Gen X transitioned from analog to digital with the rise of the personal computer. Millennials grew up *foreverconnected* to the Internet. In this same way, Gen Z is more comfortable with connected technology, digital devices, AI and machine learning than any previous generation." (Allison+Partners, 2019)



Source: made by the authors based on Reference list 80 and 81)

Source: made by the authors based on Reference list 82)

Lack of charging infrastructures and lower comparable autonomy are the main barriers slowing down the change of portuguese consumers to electric vehicles

More than 50% of Portuguese inquired showed willingness to change to an electric vehicle, but issues as lack of infrastructures and lower comparable autonomy make some of them postpone the decision.

51% • of Portuguese participating in the survey showed their will to change to an electric vehicle.

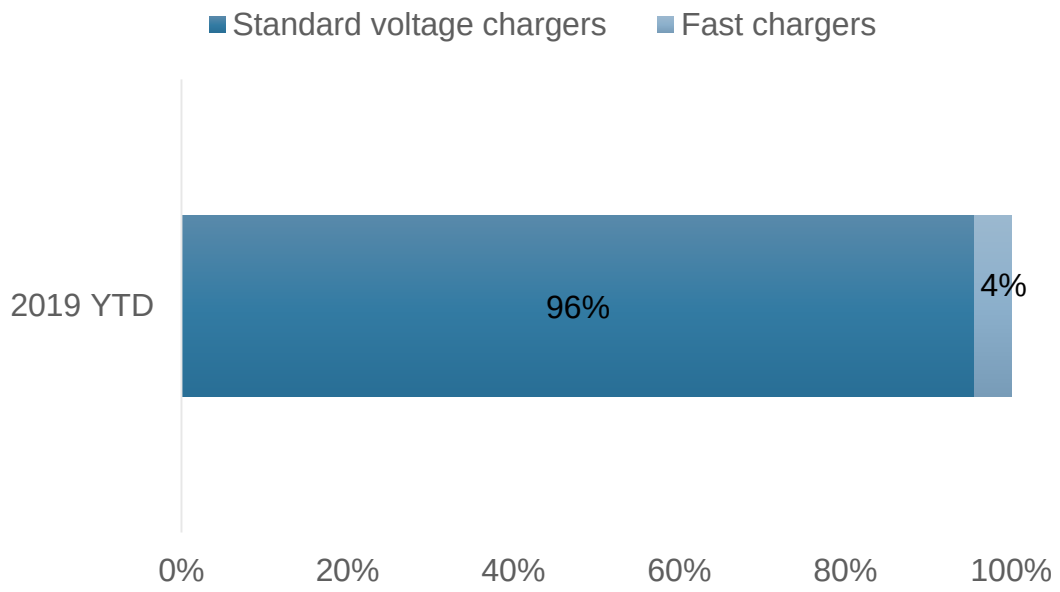
53% • of Portuguese planning to buy a new car in the next five years refers the lack of infrastructure as main issue.

67% • of Portuguese consumers considering a change to an electric vehicle see autonomy as main concern.

Source: made by the authors based on Reference list 83)

The portuguese government is committed to almost triple the network of quick chargers (from 61 to 161). Even after the increase, fast chargers will only represent 4% of the whole network.

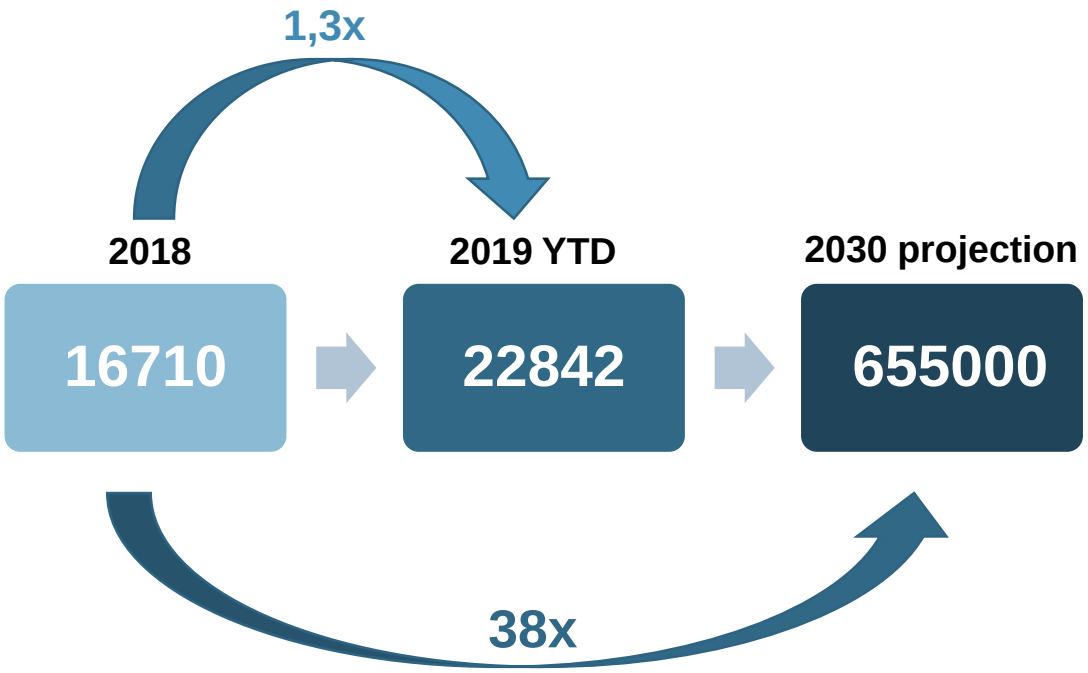
Graph 63: Portuguese charging network by type of charger



Source: made by the authors based on Reference list 84 and 85) and Appendix 11

Increase in number of electric vehicles sold has negative impact on fiscal revenues over fossil fuels

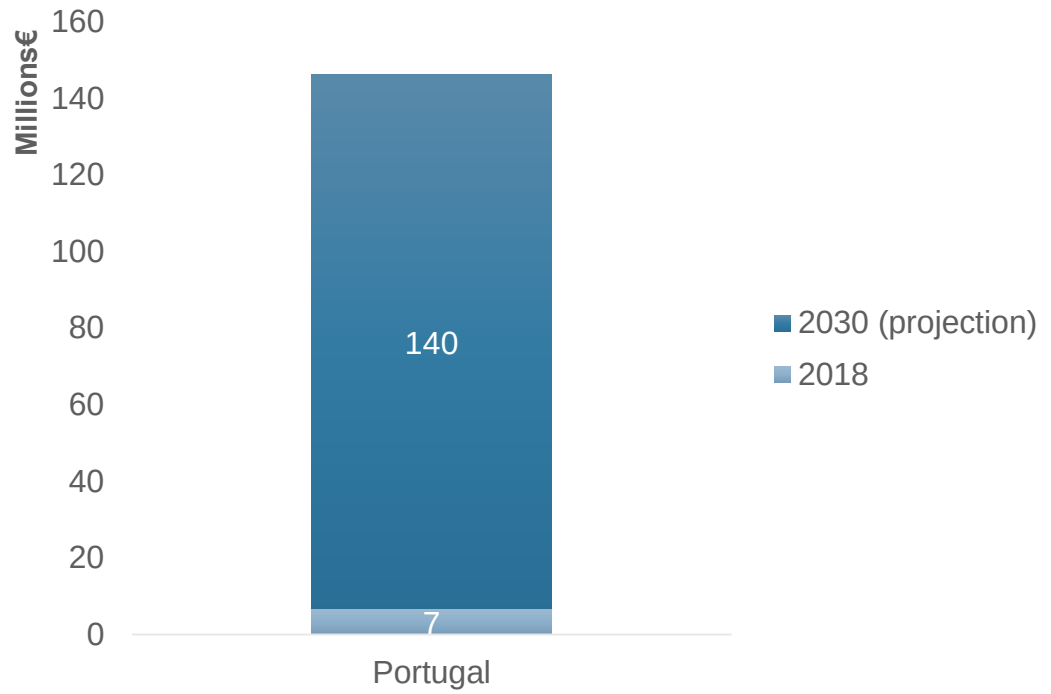
Electric vehicles' sales are expected to increase more than 38 times EV sales up to 2018.



Source: made by the authors based on Reference list 86 to 88)

The direct impact of increase in sales of electric vehicles is expected to decrease government fiscal revenue by 140 M€ by 2030, *ceteris paribus.*

Graph 64: Foregone fiscal revenue from EV sales

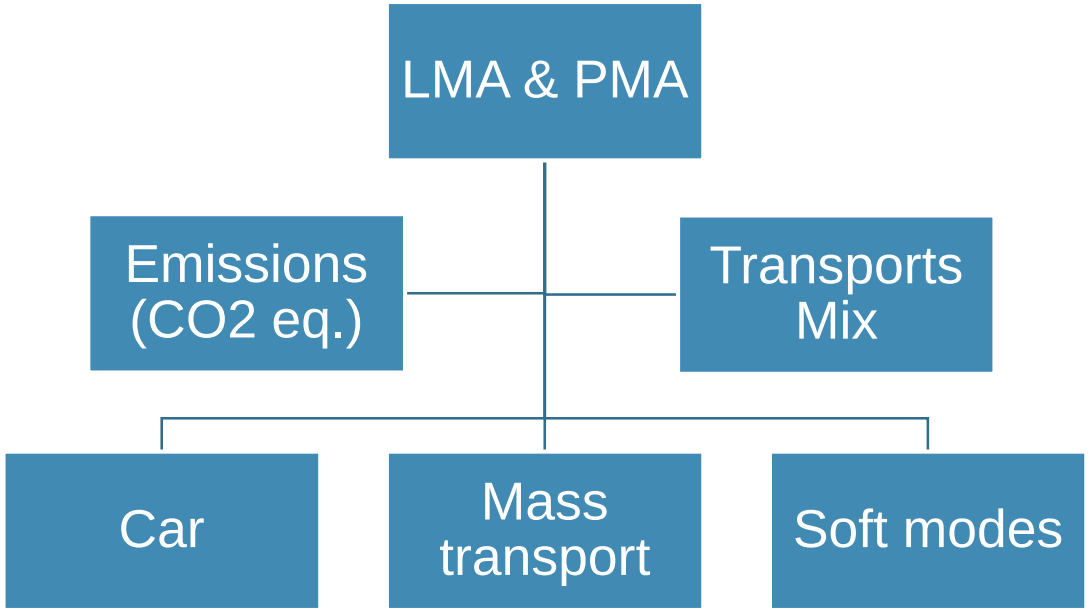


Source: made by the authors based on Reference list 89 to 92) and Appendix 12 – part 1 and part 2

Emissions and Transports Mix – 2017, 2030 and 2050

Forecasted emissions scenarios until 2050 show an overall decrease in both LMA and PMA.

Forecasted transports mix until 2050 shows a shift from ICE cars to electric cars as well as na increase in weight of mass transports.



Emissions

- Emissions of high-performance electric cars (Tesla Model S) are approximately 20% higher than those of compact electric cars (Renault ZOE).

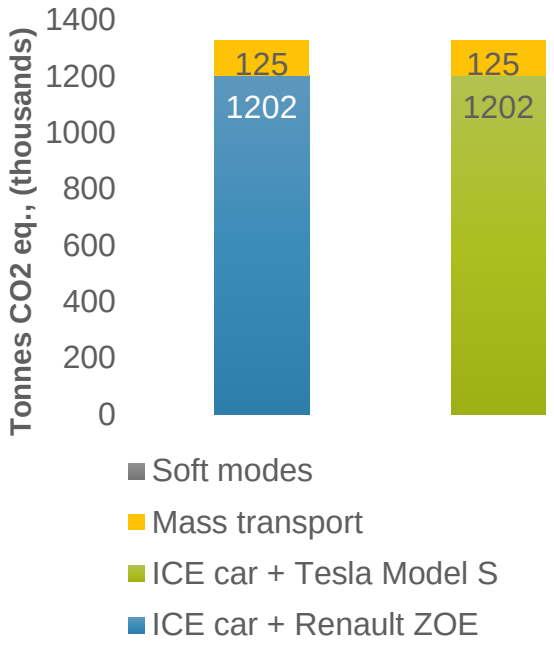
Transports Mix

- Soft transport modes (walking, ciclying and electric scooters) are assumed to have zero emissions.
- Electric cars' emissions in 2017 are too low to be considered (less than 0,1%).

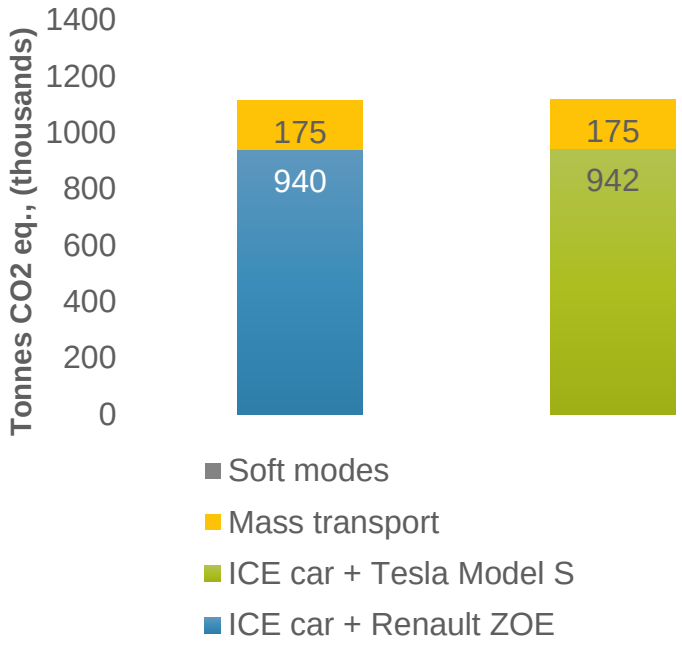
In LMA, total CO2 eq. emissions are to decrease by approximately 42% from 2017 to 2050

Mass transports' CO2 emissios are expected to quadruple from 2017 to 2050. Despite the increase, the total CO2 emissions are a 42% lower than in 2017, mainly due to the expected shift from ICE cars to electric cars.

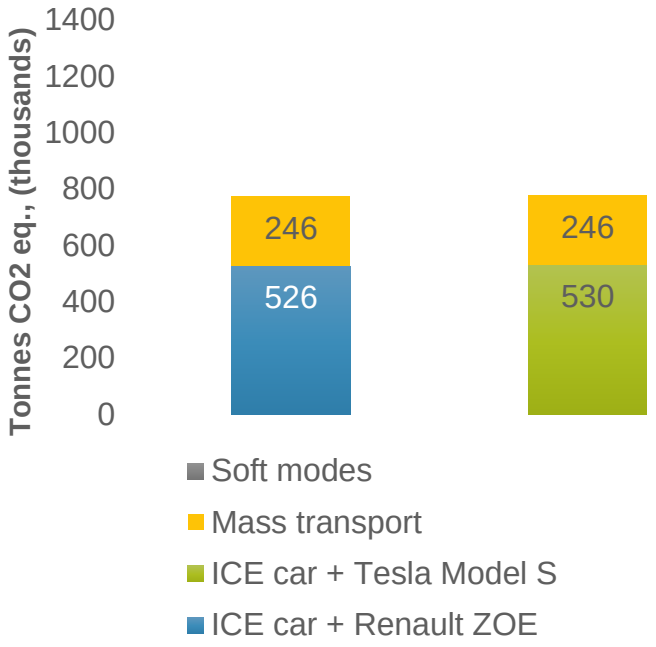
Graph 65: Emissions by transport mode in 2017



Graph 66: Emissions by transport mode in 2030



Graph 67: Emissions by transport mode in 2050

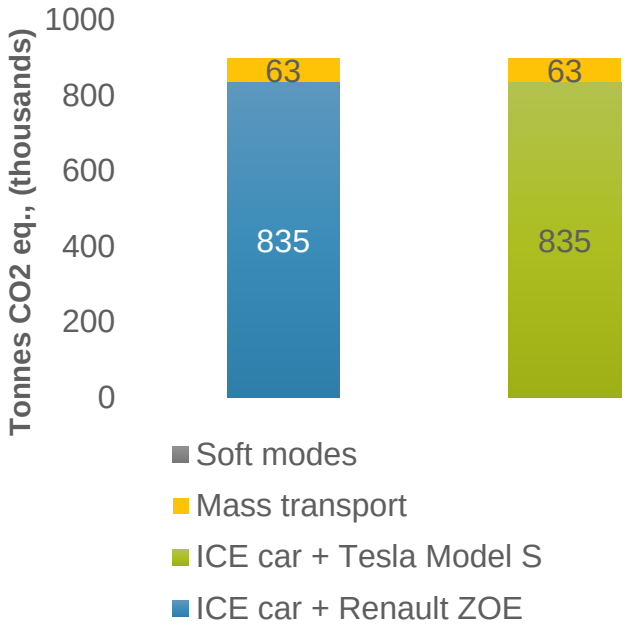


Source: made by the authors based on Reference list 9) to 13), 51), 52) and 67) to 72) and Appendix 4 and 8

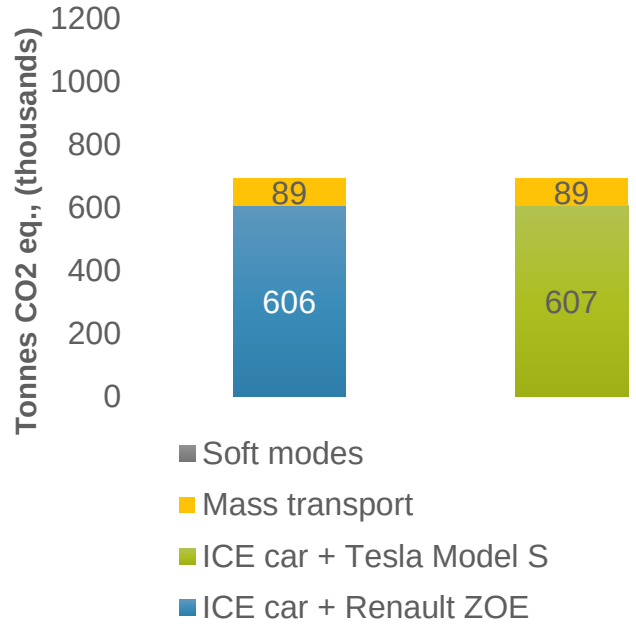
In PMA, total CO2 eq. emissions are to decrease by approximately 48% from 2017 2050

As in LMA, the reduction in CO2 emissions in PMA is mainly due to the shift from internal combustion cars to electric. This change, together with the increased weight of mass transports in the mix, contributes to decrease overall emissions.

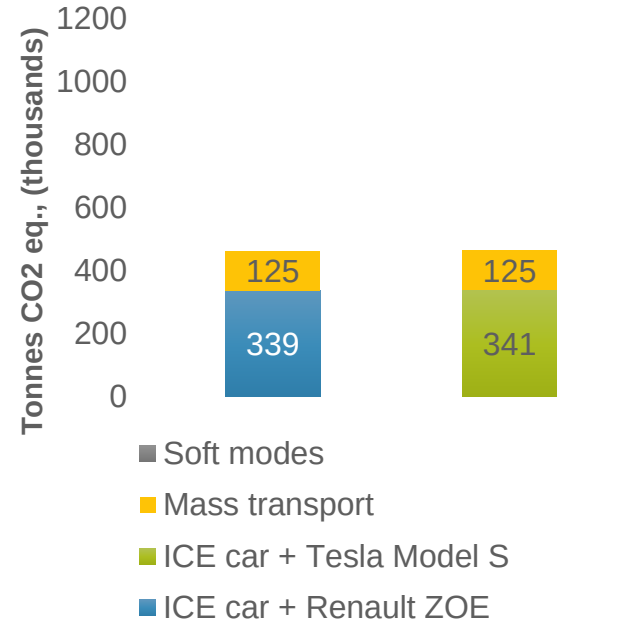
Graph 68: Emissions by transport mode in 2017



Graph 69: Emissions by transport mode in 2030



Graph 70: Emissions by transport mode in 2050

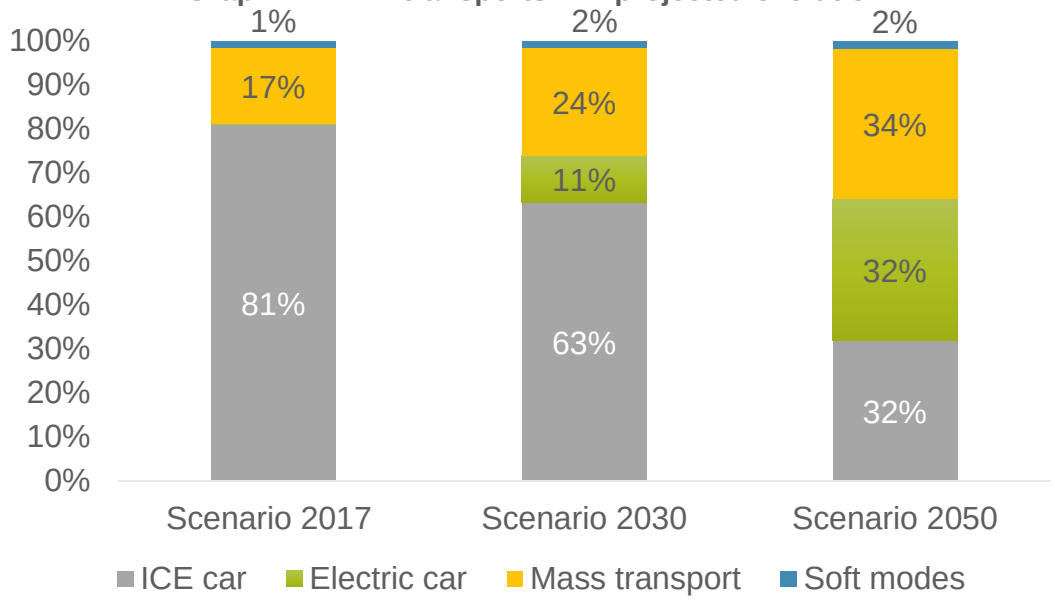


Source: made by the authors based on Reference list 9) to 13), 51), 52) and 67) to 72) and Appendix 4 and 8

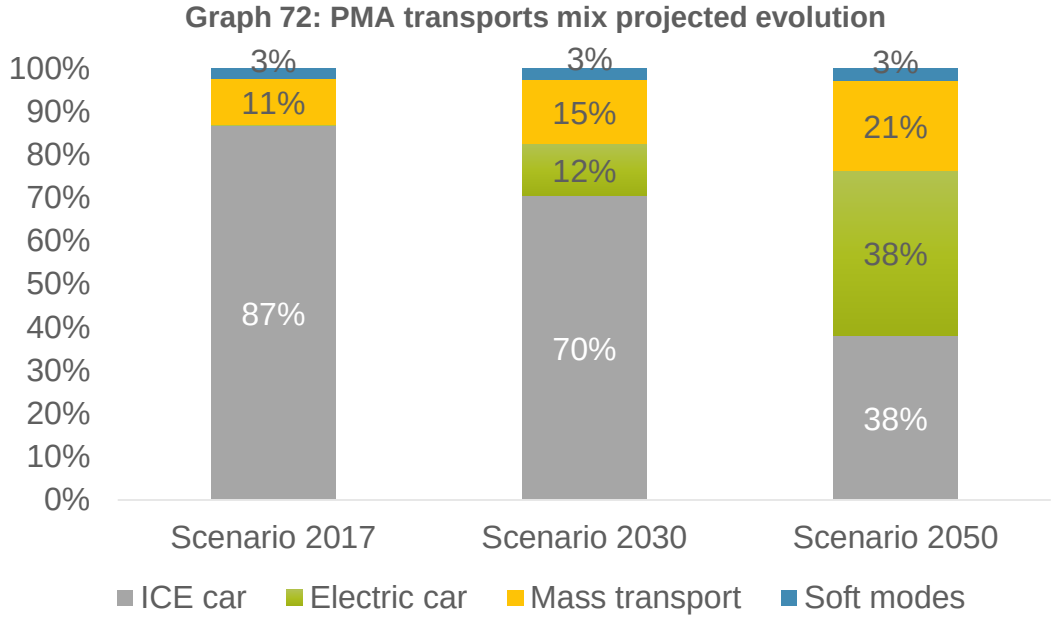
The forecasted scenarios between 2017 and 2050 show lower dependence on ICE cars and a shift to electric cars. Mass transports are expected to double current weight on the transports mix

In both LMA and PMA, 2050 is projected to be the year in which the weight on eletric cars equals the weight of internal combustion cars, regarding the metropolitan areas transports mix.

Graph 71: LMA transports mix projected evolution



Graph 72: PMA transports mix projected evolution



Source: made by the authors based on Reference list 7) to 13), 20), 27), 28), 51), 52) and 67) to 72) and Appendix 6 and 8

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Appendix 9 – Mobile internet users and smartphone penetration on Portuguese population

Table 42: Efective number of mobile internet users at the end of the first halfs of 2017, 2018 and 2019..

	Efective number of mobile internet users
1H 2017	6735267
1H 2018	7270000
1H 2019	7800000

Table 43: Penetration rate of smartphone on portuguese population..

	Penetration rate of smartphone on portuguese population
2012	33%
2013	40%
2014	50%
2015	65%
2016	72%
2017	74%
1H 2018	75%
1H 2019	76%

Appendix 10 – Real time simulation of 5km, 10km and 15km for 12 consecutive weeks for the following providers: Uber, Kapten, Bolt and Taxi.

Table 44: 5km trip prices by provider

	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6	Trip 7	Trip 8	Trip 9	Trip 10	Trip 11	Trip 12
Taxi	6,28 €	6,33 €	7,03 €	6,96 €	6,81 €	6,45 €	6,37 €	6,88 €	7,17 €	6,00 €	6,46 €	6,66 €
Uber	5,83 €	7,00 €	6,03 €	5,98 €	6,42 €	5,76 €	5,80 €	6,27 €	6,06 €	5,65 €	5,74 €	5,92 €
Kapten	5,59 €	5,36 €	5,54 €	5,70 €	5,66 €	5,92 €	5,84 €	5,65 €	5,55 €	5,72 €	5,53 €	5,70 €
Bolt	4,94 €	5,18 €	5,71 €	5,05 €	5,59 €	5,17 €	6,43 €	5,85 €	5,38 €	5,00 €	5,15 €	5,23 €

Table 45: 10km trip prices by provider

	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6	Trip 7	Trip 8	Trip 9	Trip 10	Trip 11	Trip 12
Taxi	8,73 €	8,85 €	9,38 €	8,67 €	9,02 €	8,85 €	8,48 €	8,93 €	9,04 €	8,77 €	8,90 €	9,13 €
Uber	7,87 €	8,92 €	8,11 €	9,61 €	7,23 €	7,98 €	8,00 €	7,47 €	7,04 €	8,26 €	12,50 €	7,91 €
Kapten	7,61 €	7,93 €	8,27 €	7,63 €	7,98 €	7,21 €	7,74 €	8,10 €	9,80 €	8,60 €	11,90 €	7,78 €
Bolt	6,95 €	7,25 €	7,41 €	7,22 €	7,35 €	6,42 €	7,95 €	7,44 €	7,00 €	7,18 €	8,80 €	7,35 €

Table 46: 15km trip prices by provider

	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6	Trip 7	Trip 8	Trip 9	Trip 10	Trip 11	Trip 12
Taxi	13,90 €	12,22 €	11,65 €	12,56 €	12,05 €	11,89 €	12,91 €	13,11 €	12,54 €	13,34 €	14,00 €	13,02 €
Uber	11,33 €	12,11 €	11,86 €	13,15 €	11,45 €	11,57 €	11,78 €	11,92 €	11,34 €	12,98 €	14,70 €	12,55 €
Kapten	12,08 €	11,46 €	12,11 €	11,98 €	12,55 €	11,28 €	11,93 €	12,98 €	11,56 €	13,06 €	14,20 €	11,40 €
Bolt	10,50 €	11,12 €	10,87 €	11,76 €	11,11 €	12,20 €	10,86 €	10,98 €	11,50 €	10,35 €	12,80 €	11,10 €

Table 47: Average price per trip and price difference between providers

	5km trip	10km trip	15km trip
Taxi	7 €	9 €	13 €
Uber	6 €	8 €	12 €
Kapten	6 €	8 €	12 €
Bolt	5 €	7 €	11 €
Average difference	**14%**	**10%**	**7%**

Note: Every 5km, 10km and 15km used the same route for the 12 observations. No discounts or promotional codes were used.

Appendix 11 – Number of charging connectors in Portugal

Table 48: Number of charging connectors in Portugal by type according to the latest data available.

	2019 YTD
Fast chargers	161
Normal chargers	3512
Total	3673
Standard voltage chargers	96%
Fast chargers	4%

Appendix 12 - Part 1 – Number of electric vehicles sold in Portugal up to 2018 and projected in 2030 and impact on Fiscal revenue from fossil fuels.

Table 49: Comparison between situations in 2018 and 2030 (projection). The columns 2018 Total and 2030 (projection total) show tax revenues from fossil as if all cars available were ICE cars. The columns 2018 ICE cars and 2030 (projection) ICE cars takes into consideration the number of electric cars.

	2018 ICE Cars	2018 Total	2030 (projection) ICE cars	2030 (projection) Total
Average consumption Diesel car (l/100km)	5,05	5,05	5,05	5,05
Average consumption Petrol car (l/100km)	6,55	6,55	6,55	6,55
Number of diesel cars	3112172	3123228,507	2556567,971	2989957
Number of petrol cars	1591392	1597045,791	1307287,029	1307287
Litres spent per diesel car per km	0,0505	0,0505	0,0505	0,0505
Litres spent per petrol car	0,0655	0,0655	0,0655	0,0655
Number of km per year on average	9000	9000	9000	9000
Litres of diesel spent per year	1414482232	1419507356	1161960143	1358935416
Litres of petrol spent per year	938125685,1	941458493,8	770645703,8	770645703,8
Taxes per diesel litre	0,71 €	0,71 €	0,71 €	0,71 €
Taxes per petrol litre	0,92 €	0,92 €	0,92 €	0,92 €
Tax revenues from fossil fuels	1 867 819 783,78 €	1 874 455 447,00 €	1 534 365 080,06 €	1 674 020 548,61 €

Note: It's assumed the taxes over petrol and diesle remain the same and the number of cars per inhabitant is held at 0,459. The number of km per year made by car is also held constant at 9 000.

Appendix 12 - Part 2 – Population, fuel prices and distribution of cars by type of fuel.

Table 50: Petrol price per litre decomposition

Petrol				
	Price w/o taxes	Tax over petroluem prod & other	VAT	Final price
2015	0,45 €	0,62 €	0,24 €	1,31 €
2016	0,50 €	0,67 €	0,27 €	1,44 €
2017	0,56 €	0,65 €	0,28 €	1,49 €
2018	0,48 €	0,66 €	0,26 €	1,41 €
2019 to date	0,57 €	0,64 €	0,28 €	1,50 €

Table 51: Diesel Price per litre decomposition

Diesel				
	Price w/o taxes	Tax over petroluem prod & other	VAT	Final price
2015	0,44 €	0,40 €	0,19 €	1,03 €
2016	0,54 €	0,45 €	0,23 €	1,21 €
2017	0,58 €	0,47 €	0,24 €	1,29 €
2018	0,56 €	0,47 €	0,24 €	1,27 €
2019 to date	0,63 €	0,49 €	0,26 €	1,37 €

Table 52: Population, total km made per year by car and division of cars between electric and ICE cars.

	2018	2030 (projection)
Portuguese Population	10 283 822	9 845 000
Km per year	42482468682	40669695000
Total number of cars	4720274	4518855
Number of ICE cars	4703564	3863855
Number of eletric cars	16710	655000

Table 53: Distribution of cars per type of fuel

Percentage of diesel cars	66%
Percentage of diesel cars	34%

Table 54: Impact on fiscal revenues of 16710 electric vehicles in the portuguese fleet. This value is achieved by assuming the scenario where all cars would be ICE cars and then the real 2018 scenario where there are, in fact, 16710 electric cars. The impact on fiscal revenues of fossil fuels is the difference between the two scenarios mentioned.

	2018
Impact on fiscal revenue of 16710 electric cars	6 635 663,21 €

Table 55: Impact on fiscal revenues of having 655000 electric vehicles instead of 655000 ICE cars. The same rationale applied for the estimation of fiscal revenue impact in 2018 (Table 54) was applied for 2030.

	2030 projection
Impact on fiscal revenue of 655000 electric cars	139 655 468,55 €

Appendix 13 – Part 1 – Carsharing players cost comparison – standard packages

Table 56: Inputs for calculation of average monthly cost of carsharing solutions without considering promotional packages of minutes or km.

Average Monthly Cost Shared Solutions (standard packages average)	PMA	LMA
Credit received	15,00 €	15,00 €
Credit received in minutes	54	54
Number of Km	n.a	n.a
Number of trips per day	2,72	2,6
Average time per trip (minutes)	18,1	21,7
Cost per minute (standard fee)	0,305 €	0,305 €

Table 57: Average cost per month of private car vs carsharing solutions in LMA and PMA. It's assumed if carsharing operators were to offer in PMA the same services they offer in LMA, prices would be the same. The average cost is adjusted for commuting habits of different metropolitan areas, namely average time per trip and number of trips per day (Table 56).

Cost comparison between owning car vs using only shared solutions	Cost per month	Savings increase (%)
Carsharing standard package LMA	292 €	47%
Carsharing standard package PMA	292 €	47%
Private car	547 €	0%

Appendix 13 – Part 2 – Carsharing players cost comparison – promotional packages

Table 58: DriveNow cheapest package cost per month computed based on commuting statistics

Drive Now Promotional package 3h		
Price		**20,00 €**
Total minutes per month	1011	
Average time per trip (minutes)	21,7	
Average number of km per month	389,3	
Number of packages needed per month	**6**	
Cost per minute		0,111 €
Number of km included	80	
Monthly Cost		**120,00 €**

Table 59: DriveNow most expensive package cost per month computed based on commuting statistics

Drive Now Promotional package 12h		
Price		**80,00 €**
Total minutes per month	1011	
Average time per trip (minutes)	21,7	
Average number of km per month	389,3	
Number of packages needed per month	**4,00**	
Cost per minute (12h Package)		0,111 €
Number of km included	100	
Monthly Cost		**320,000 €**

Table 60: EMOV cheapest package cost per month computed based on commuting statistics

EMOV Promotional package "ALFAMA"	
Price	**80,00 €**
Total credit available (24€ credit bonus)	104,00 €
Average monthly time spent in trips (minutes)	1011,0
Average number of km per month	389,3
Number Alfama packages bought per month	**2,00**
Cost per minute	0,20 €
Valid for 1 year or	520 minutes
Monthly cost	**160,00 €**

Table 61: EMOV most expensive package cost per month computed based on commuting statistics

EMOV Promotional package "GRAÇA"	
Price	**42,00 €**
Total credit available (10€ credit bonus)	52,00 €
Average monthly time spent in trips (minutes)	1011,0
Average number of km per month	389,3
Number of Graça packages bought per month	**4,00**
Cost per minute	0,21 €
Valid for 1 year or	248 minutes
Monthly cost	**210,00 €**

Appendix 14 – Utopic optimal carsharing scenario characterization: Hourly supply and demand of cars in LMA and PMA

Table 62: Demand for cars measured by the traffic congestion level in PMA peaks in the evening. Optimal supply of cars was calculated by multiplying the demand for cars in percentage of total supply at the highest demand peak of the day (6 PM). The optimal supply at the demand peak implies 100% utilized capacity (all cars being used during that hour) and excess supply in other hours, although a lower excess supply than the one verified in the current situation. Only weekdays were considered.

PMA				
	Average demand weekdays	Current Supply	Optimal Supply	Excess Supply
12 AM	4%	30347	19725	10621
1 AM	1%	10116	6575	3540
2 AM	1%	6744	4383	2360
3 AM	1%	6744	4383	2360
4 AM	0%	0	0	0
5 AM	0%	0	0	0
6 AM	0%	0	0	0
7 AM	27%	225913	146843	79070
8 AM	59%	497346	323275	174071
9 AM	42%	352357	229032	123325
10 AM	25%	214112	139173	74939
11 AM	22%	187137	121639	65498
12 PM	20%	171964	111776	60187
1 PM	19%	163534	106297	57237
2 PM	28%	237714	154514	83200
3 PM	31%	264689	172048	92641
4 PM	33%	278176	180815	97362
5 PM	48%	407992	265195	142797
6 PM	65%	842959	547923	295036
7 PM	46%	384389	249853	134536
8 PM	21%	175335	113968	61367
9 PM	11%	89354	58080	31274
10 PM	10%	80924	52601	28323
11 PM	10%	84296	54792	29504

Table 63: Same rationale explained in the legend for table 62 was applied for LMA.

LMA				
	Average demand weekdays	Current Supply	Optimal Supply	Excess Supply
12 AM	6%	74879	53613	21266
1 AM	3%	38731	27731	10999
2 AM	2%	30984	22185	8800
3 AM	0%	2582	1849	733
4 AM	0%	0	0	0
5 AM	0%	0	0	0
6 AM	3%	33566	24034	9533
7 AM	28%	366649	262521	104128
8 AM	66%	849491	608235	241255
9 AM	52%	671330	480672	190658
10 AM	29%	379560	271765	107795
11 AM	25%	317591	227395	90196
12 PM	24%	307263	220000	87263
1 PM	21%	276278	197815	78463
2 PM	25%	320173	229244	90929
3 PM	29%	376978	269916	107062
4 PM	38%	488005	349412	138593
5 PM	58%	751373	537983	213390
6 PM	72%	1291019	924370	366649
7 PM	52%	673912	482521	191391
8 PM	27%	351157	251429	99729
9 PM	13%	172997	123866	49131
10 PM	11%	142012	101681	40331
11 PM	10%	129102	92437	36665

Appendix 15- Part 1 – Utopic optimal carsharing scenario characterization: Increase in gross annual available income and reduction in need for parking lots.

Table 64: Annual gain from the choice of carsharing solution presented on Table 58 of part 2 in Appendix 13.

	LMA	PMA
Total amount of cars	1291019	842959
Average monthly cost of owning car	540,40 €	553,47 €
Rational Carsharing choice (cheapest DriveNow package)	120,00 €	120,00 €
Saving from opting for carsharing solution	420,40 €	433,47 €
Reduction in number of cars	361485	295036
Number of people opting to leave private car	787550	642779
Yearly amount saved per person on average	5 044,80 €	5 201,64 €
Average yearly salary	16 993,92 €	12 988,80 €
Share of annual salary spent with car ownership	38%	51%
Share of annual salary spent with carsharing	8%	11%

Table 65: Annual gain from the choice of carsharing solution presented on Table 58 of part 2 in Appendix 13.

	LMA	PMA
Annual salary after car ownership costs	10 509 €	6 347 €
Annual salary after carsharing costs	15 554 €	11 549 €
Gain from carsharing	30%	40%

Table 66: Number of parking lots is approximately 27% in current situation assuming the same ratio in LMA. The same ratio is assumed for PMA. For the optimal situation, only 65% of parking lots are needed in PMA and 72% in LMA. It represents a reduction of 35% and 28% respectively.

	Number of parking lots
Current situation PMA	228529
Optimal situation PMA	148544
Current situation LMA	350000
Optimal situation LMA	250600

Table 67: After adjusting for the houses with garage places, it's possible to calculate the space that is actually available for alternative uses. There is a 82% reduction in parking lots in PMA and 37% in LMA.

	Current situation	Optimal situation	Variation
LMA	266990	167590	37%
PMA	97045	17060	82%

Appendix 15- Part 2 – Utopic optimal carsharing scenario characterization: Increase in gross annual available income and reduction in need for parking lots.

Table 68: The amount of freed sapce due to the reduction in need for parking lots should be adjusted for the number of houses with garage places in both metropolitan areas. It's assumed one garage place per house.

	LMA	PMA
Number of houses	456100	424142
Proportion of houses with garage places	18%	31%
Number of garage places	83010	131484

Table 69: By finding the average area per parking lot and the price per m2 in LMA and PMA, it's possibe to quantify the value of freed space.

	LMA	PMA
Reduction in parking lots	99400	79985
Average area per parking lot (m2)	10,24	10,24
Average price per m2	1 383,00 €	1 034,00 €
Added space (m2)	1017359,0	818649,0
Value of added space	1 407 007 497 €	846 483 101 €