evs 27

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Electric vehicle adopters' motivation, utilization patterns and environmental impacts: A Lisbon case study

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In collaboration with EVAAP EDTA

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Project: EV monitoring Green Parking Permit

- Promoted by **EMEL – Lisbon's municipal mobility and parking company**

- The recruitment of the participants was conducted with the dissemination among electric vehicle private users.

Introduction

- Transportation sector faces constant pressure to reduce fossil fuel dependency;
- Solutions to overcome this trend:
  - Change travel behavior (shift to public transportation, share car, etc.)
  - New fuels (biofuel, electricity, hydrogen, etc.)
  - **Alternative vehicle technologies (electric, hybrid, etc.)**
- What will be the new challenges in peoples' lives when adopting alternative vehicle technologies?

Introduction

- New challenges:

- What are the impacts of alternative vehicle technologies in people's travel behavior, driving patterns, safety performance and environmental impacts?

- What will be the users' vehicle recharging, interaction with infra-structure and management?

- How and what will change in peoples' mobility and driving patterns?

Research goals

- Evaluate user's satisfaction and adaptation to an alternative vehicle technology, this case the Electric Vehicle (EV):
  - Driving behavior;
  - Mobility Patterns;
  - Satisfaction and Comfort;
  - Recharging routines;
  - Interaction with Infra-structure.
- Quantify potential environmental impact:
  - Energy consumption;
  - CO_2 emissions.

Methodology

1. Conditions for participants:

- Full electric vehicles;
- Participate in interviews and surveys during the project;
- Collect data regarding vehicle recharging and operation;
- Parking permit allowing drivers to park in Lisbon for free during the project;

Methodology

2. Vehicles:

Nissan Leaf

Mitsubshi iMiev

Renault Fluence

Smart EV

Goupil

Think

Futi

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Methodology

3. Interview:

- Private drivers and fleet drivers;
- Composed by 20 to 28 open-ended questions;
- Focused on aspects: motivation to use, vehicle advantages and disadvantages, driving behavior, mobility patterns, charging routines, improvements and expectations;
- Taped and transcript was made;
- Qualitative analysis and several answer categories were created for each theme.

Methodology

3. Energy meter

- Given to drivers to collect recharging data;

4. On-board diary

- Monitoring period between 3 to 10 months;

Data	Kms percorridos	Kwh abastecidos	Nº de viagens efectuadas	Observações

Methodology

5. Participants

- Private drivers:
  - Use vehicle daily for different purposes

- Fleet drivers:
  - Use vehicle as a working instrument;
  - Use vehicle daily
  - Use vehicle rarely

Methodology

5. Participants

Private: 13 drivers

Private Users' Charaterization	
Male	10
Female	3
Average age	49,2
Average Driving experience	29,9
Brand of vehicle (number of users)	
Electric Vehicle - Nissan Leaf	9
Electric Vehicle Renault Fluence	1
Electric Vehicle Mitshubishi Imiev	1
Electric Vehicle - Other	2
Ownership and usage	
Vehicle possession (average months)	12
Conventional vehicle ownership	1,7

Fleet: 13 drivers

Fleet Drivers' Charaterization	
Male	11
Female	1
Average Age	37.4
Average Driving experience	19.6
Brand of vehicle	
Electric Vehicle Smart	11
Electric Vehicle Mitshubishi Imiev	11
Electric Vehicle - Other	3

Results

- 1. Interviews
  - Private drivers *vs.* Fleet drivers
- 2. On-board diary data
  - Private drivers
  - Mobility profile
  - Environmental impacts

Results - Interviews

1.1. Factors influencing purchase

Factors influencing purchase	Private users
Environmental	62%
Economic	62%
Professional	8%
Changes in personal life	8%
Interest in the technology	8%
None	8%

Factors influencing purchase	Fleet users
Environmental	75%
Image status	33%
Economic	25%
Type of trips	25%

- Environmental and economic (energy cost and running costs) stand out as the main motives for private users to acquire an EV.
- For fleet drivers, image status stands out as an important factor influencing companies EV purchase

Results - Interviews

1.2. EV advantages and disadvantages

Advantages EV	Private users	Fleet users	Disadvantages EV	Private users	Fleet users
Economic	85%	8%	Autonomy	77%	83%
Driving comfort	77%	50%	Charging infra-structure	15%	25%
Environmental	46%	67%	Purchase cost	15%	33%
Fossil fuels independence	23%	0%	Vehicle design	15%	0%
Vehicle design	8%	33%	Vehicle safety	8%	8%
Safety	8%	0%	Vehicle speed	0%	17%
Vehicle Power	0%	25%	Absence of vehicle noise	0%	17%
			None	8%	8%

- Private users mention economic, driving comfort and environmental factors as main advantages;
- Fleet drivers consider environmental and driving comfort as main EV advantages;
- Autonomy, charging infrastructure and purchase cost are main disadvantages of EV.

Results - Interviews

1.3. Perceived differences between EV and ICE

Differences between driving EV and ICE	Private users	Fleet users
No trips to gas station	31%	25%
Alert of estimated available autonomy in EV dashboard	31%	8%
EV driving smoothness	23%	33%
EV higher vehicle power	23%	8%
No gear changes in the EV	15%	8%
EVs less running costs	15%	0%
EV doesn't use fossil fuels	8%	0%
EV smaller size	8%	0%
Different trip management with EV	0%	17%
Need to search for charging station with EV	0%	8%
None	0%	33%

- Main differences for private drivers are: no trips to gas station and existence of autonomy alert;
- For fleet drivers, driving smoothness stands out as main difference.

Results - Interviews

1.4. Impacts of EV on mobility routines

Impacts on everyday mobility routines	Private users	Fleet users
No	54%	50%
Yes	46%	50%
Changes observed in mobility routines		
More trips with the EV	67%	0%
Different type of road	50%	0%
Different trip management	50%	100%
Higher number of persons aboard	17%	0%

- Private and fleet drivers consider that the EV has an impact on their daily routines;
- Private drivers make more trips, drive in different road types, and have manage their trips differently
- Fleet drivers make a different trip management with the EV

Results - Interviews

1.5. Impacts of EV on driving style

Impacts on driving style	Private users	Fleet users
No	31%	33%
Yes	69%	67%
Changes observed in driving style		
Less speed	78%	17%
Less aggressive driving	22%	25%
More efficient driving	17%	25%
More aggressive driving	0%	38%

- Private drivers consider that their driving style changed: speed less, are less aggressive and drive more efficiently;
- As opposed to private drivers, 38% of fleet drivers consider that their driving style becomes more aggressive when driving the EV .

Results - Interviews

1.6. Mobility patterns

Mobility Patterns	Private users	Mobility Patterns	Fleet users
Commute to work/school	85%	Short trips (0-15km)	100%
Errands	54%	Medium trips (16-40 km)	8%
Urban	62%	Urban	92%
Inter-urban	38%	Inter-urban	17%
7 days a week	100%	One day per week	83%
		Several days per week	42%

- Private drivers use the vehicle essentially to commute, mainly in urban areas;
- Fleet drivers make small trips with EV, also in urban areas and use the vehicle one day per week.

Results - Interviews

1.7. Charging routines – Private drivers

Charging location	
Home	92%
Street	38%

Home charging routines		Street charging routines	
Day time	17%	Day time	100%
Night time	100%	Night time	20%
7 days a week	33%	Slow charging points	80%
2 Times a week	17%	Fast charging points	40%
4 Times a week	42%	7 days a week	60%
		2 Times a week	20%

- Private drivers charge mainly at home (92%), during the night;
- When charging in the street, drivers do it during the day, and 20% also at night time, using mainly slow charging points;

Results - Interviews

1.8. Charging routines – Fleet drivers

Charging patterns	
Doesn't charge EV after using it	42%
Work (one day per week use)	33%
Work (use EV several days a week)	42%
Home (use EV several days a week)	17%
Street	25%
Slow charge	100%
Fast charge	67%

- Fleet drivers don’t charge the EV after using it (42%);
- When they charge, they do it mainly at the working place;
- In the street, drivers charge mainly at slow charging stations.

Results - Interviews

1.9. EV improvements

Improvements	Private users	Fleet users
Autonomy	77%	67%
Charging infrastructure	69%	33%
Design	8%	25%
Purchase cost	8%	25%
Vehicle performance	0%	17%
Vehicle management	0%	8%
Vehicle promotion	0%	8%

- Autonomy and charging infrastructure mentioned as main improvements by private drivers;
- Fleet drivers also mention autonomy and infrastructure as a necessary improvement, but refer also vehicle design and purchase cost.

Results – On-board diary data

2.1. Mobility Profile

Days	km	Trips	Charges	kWh
1243	49786	5132	831	8529

- A total of 1243 days were monitored;
- Drivers made 5131 trips, travelling ≈ 50000 km;
- 831 charges were made, corresponding to 8529 kWh charged.

Results – On-board diary data

2.1. Mobility Profile

	km/day	Trips/day	Charges/day	kWh/day	kWh/km	kWh/trip	kWh/charge
Average EV	39.9	3.5	0.6	6.3	0.157	2.2	10.3
STDEV EV	24.4	2.3	0.2	3.1	0.1	1.2	3.3
Sample (90% CL, 20% Deviation)	21.05	24.58	8.19	13.87	6.42	16.66	5.71

- Participants made on average 3.5 trips per day and travel 39.9 km per day.
- Drivers made on average 0.6 charges per day consuming 6.3 kWh a day, corresponding to 0.157 kWh per km travelled.
- On average, drivers charged 10.3 kWh per charge.
- A larger sample is needed in order to have more robust results.

Results – On-board diary data

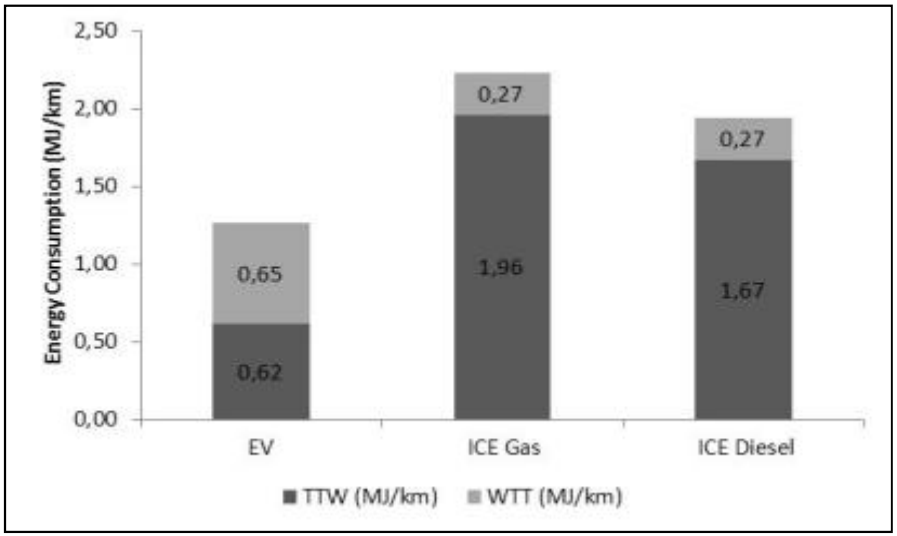
2.2. Environmental impacts

- Assessment done using the life cycle analysis approach, considering the Well-to-Wheel (WTW) stage:
  - Tank-to-Wheel (TTW)
  - Well-to-Tank (WTT)

- Comparison between technologies: EV, ICE Gasoline, ICE Diesel

Results – On-board diary data

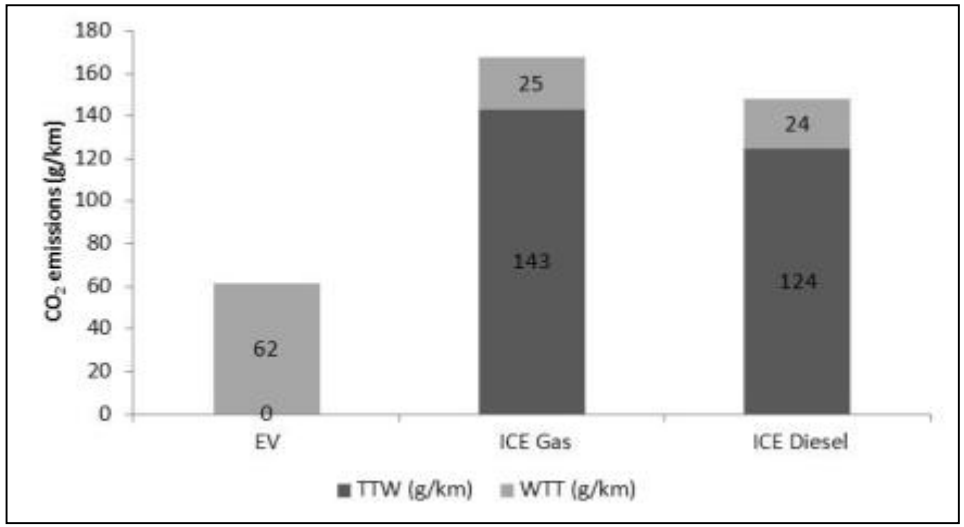
2.2. Environmental impacts – Energy consumption



- The EV has a smaller contribution (0.62 MJ/km) in the TTW stage than ICE Gas and ICE Diesel, 1.96 and 1.67 MJ/km, respectively;
- The opposite is observed when considering the WTT stage, which incorporates the electricity production values for Portugal in 2007;
- Overall, the EV presents lower WTW results, with an energy consumption of 1.30 MJ/km, while ICE Gas presents higher consumption results of 2.23 MJ/km.

Results – On-board diary data

2.2. Environmental impacts – CO_2 emissions



- In TTW electricity input is zero;
- However, in WTT electricity contribution is substantially higher (63 g/km) than that of fossil fuels, 25 g/km for gasoline and 24 g/km for diesel internal combustion engines.

Conclusions

- **Economic and environmental aspects** associated with the EV are referred as **main factors influence purchase** for private drivers;
- Fleet drivers introduce the **image status factor** as a reason for using EVs in companies;
- **Autonomy and charging infrastructure** stand out as main disadvantages;
- EV impacted daily routines and driving style;
- Private drivers **charge mainly at home** and use street charging occasionally (**plan trips and determine charging routine**);
- When compared to the conventional technology, in a life cycle analysis approach, EV reveals **considerable reductions in energy consumption and CO_2 emissions.**

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