Politecnico di Torino

Ph.D. in Civil and Environmental Engineering XXXVIII

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Modelling and simulation of transport systems considering new trends in mobility: vehicle electrification and automation

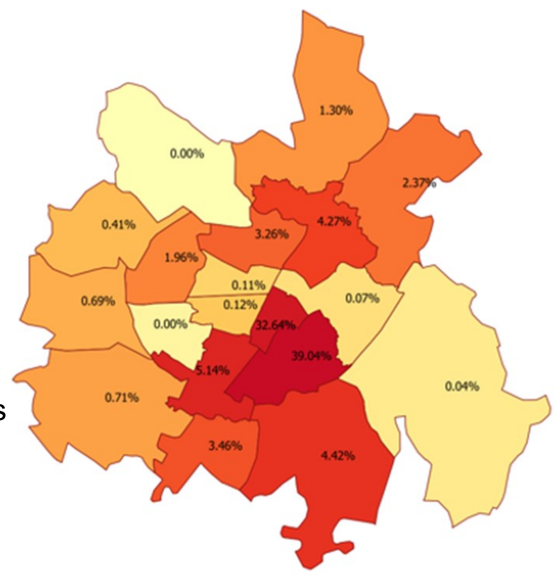
RESEARCH CONTEXT AND PURPOSE

In recent years, the circulating vehicle fleet has been rapidly changing. **Electric-powered vehicles** are gaining a significant share of the market, and in the meantime, vehicle **automation** is becoming a widely discussed topic. The main goal of my research activity is to analyze, using **simulation** and **modelling** techniques, the effects of vehicle evolution on user travel habits, traffic, and infrastructures. Specifically, I have delved into the study of electrifying mobility through analyses related to various aspects such as user purchasing behavior, consumption patterns, and charging choices.

Modelling EVs charging demand

Application of a **nested logit model** aiming to estimate the zonal EVs **charging demand** in urban areas

- The **Turin conurbation** was assumed as case study
- **19 zones** were identified following administrative borders (municipalities)
- A zonal aggregate dataset including informations about **charging infrastructures and population features** was collected
- The model was applied considering **nested logit** structure
- Zones having high population density and attraction poles present high charging demand values
- It was observed that the distribution of the **demand** is strongly **influenced** by the **supply**, given the factors included in the models
- Population features, as education and income, have a meaningful influence on charging behaviour



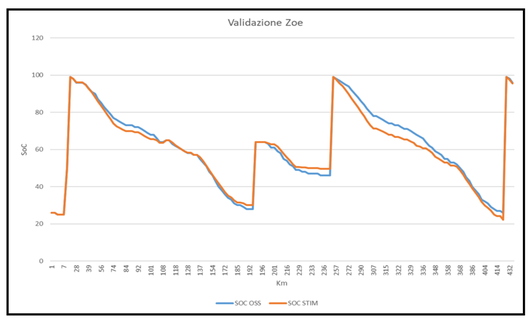
Modelling BEVs consumption

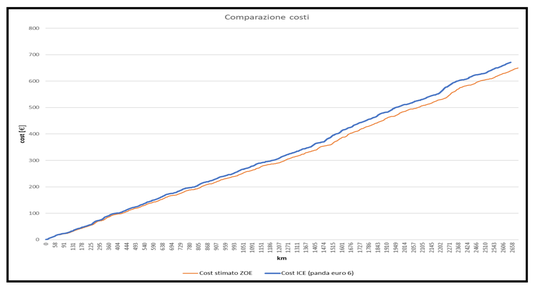
Calibration of an energy **consumption model** for battery electric vehicle.

- **Trip observation** for various BEV and ICE vehicles were available
- The model formulation assumed includes variables as speed and gradient, and four parameters to calibrate:

$$FC = \left(\alpha + \frac{\beta}{V} + \gamma V + \delta V^2\right) * RGF$$

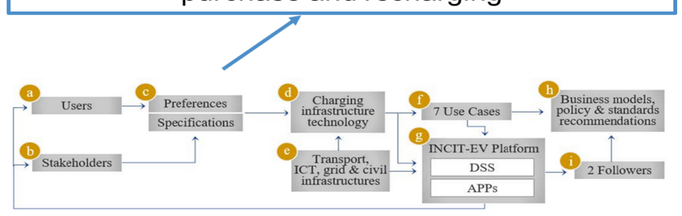
- Estimation of consumption for **different typology of vehicles (**BEVs or ICEs)
- Simulation of trips with estimation of BEVs **state of charge** level and possibility to estimate **charging operations**
- Comparative analysis of **costs** and **consumption** between ICE and BEV





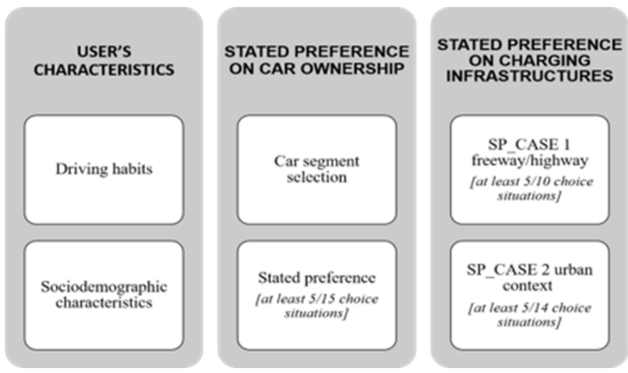
Factors effect analysis on EVs users behavior

Discrete Choice Model Experiment to understand the importance of the users' choice criteria/drivers and concerns related to EV purchase and recharging



INCIT-EV

- **SC survey** to collect users stated choice on vehicle adoption and charging preferences
- **16734 responses** recorded with a SP survey
- **4 European countries** (Italy, Spain, Estonia, Netherlands) during the **first months of 2023**



$$U_i = V_i + \varepsilon_i = \beta * x_i + \varepsilon_i$$

$$(MNL) \quad p(i) = \exp(V_i) / \sum_j \exp(V_j)$$

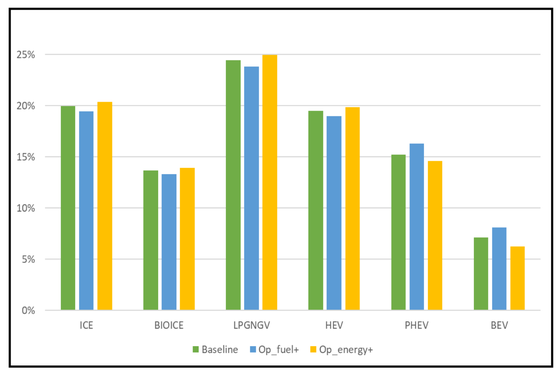
$$(NL) \quad p(i) = p(k) * p(i|k)$$

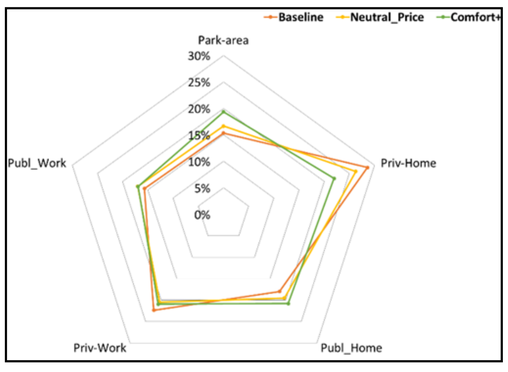
Discrete choice model formulations were considered to investigate users behvaiour. Particularly, **logit** formulation was assumed.

To calibrate discrete choice model the python package **Biogeme** was used

Calibration of a model aiming to investigate **vehicle adoption** among several powertrain.

- **Multinomial logit** formulation assumed
- Included **user**-related, **vehicle**-related and **policy**-related attributes
- Expoloration of **several scenarios** to test the effect of specific attributes on users choice (incentives policies)
- Focus on **electric vehicle** penetration





Calibration of a model aiming to evaluate EVs users **charging preferences** in urban context.

- **Multinomial** logit and **nested** logit formulations assumed
- Included charging **infrastructure-related** attributes
- Expoloration of scenarios to evaluate the possible shifting of preferences on **public infrastructures**

FUTURE WORKS

- Contribution in project "INCIT-EV": Evaluation of impact assessement connected to the use of electric vehicles and the related charging structures in urban context.
- Contribution in PRIN 2022 "Flash-FLOOD risk at crossings between ROAD and river networks.": Definition of road network model for topological and traffic flow analyses for large-scale scenarios considering congestion phenomena and road capacities during critical events.
- Contribution to project "EPIGNOSIS": Virtual testing scenarios for ADAS through the use of microsimulation tools.

PUBLICATIONS

- Sica, Lorenzo; Deflorio, Francesco (2023). *Estimation of charging demand for electric vehicles by discrete choice models and numerical simulations: Application to a case study in Turin*. In: Green Energy and Intelligent Transportation, vol. 2. ISSN 2773-1537
- Botta, Cristiana; Carboni, Angela; Deflorio, Francesco; Fappanni , Filippo; Sica, Lorenzo (2023). *Factors identification for the user adoption of electrified powertrains through Discrete Choice Experiments*. Presented at Euro Working Group Transportation 2023
- Botta, Cristiana; Carboni, Angela; Deflorio, Francesco; Fappanni , Filippo; Sica, Lorenzo (2023). *Analysis of user preferences on electric mobility in four european countries*. Presented at European Transport Conference 2023
- Botta, Cristiana; Carboni, Angela; Deflorio, Francesco; Sica, Lorenzo (2023). *Electric vehicle recharging options in urban areas: discrete choice modeling to estimate user preference*. In submission to Sustanible Cities and Society