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electro-Mobility-as-a-Service (eMaaS) in the EU funded STEVE Project experience

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Abstract

Today's modern light electric vehicles (*LEVs*) range from two-wheel motorbikes, e-bikes, to low speed micro four-wheelers, i.e. light and heavy quadricycles (L6e and L7e). In the context of the EU H2020 funded STEVE project, the future LEV users are involved. The concept of *profiling prospective LEVs users* refers to a non-commercial operation to gather and aggregate data and knowledge about present users' propensity to engage in with LEVs, co-modality and gamification services. This contribution targets new urban services, LEV solutions and relative pilot tests for final users' profiles as essential elements to increase and promote next generation mobility in Europe.

The paper aims to describe the STEVE methodological approach, preliminary results and recommendations on what prospective LEV users are revealing in terms of their needs, preferences and appreciation of future electric mobility services.

Keywords: automotive; electro-Mobility-as-a-Service (eMaaS); electric vehicle; LEVs, User experience and requirements.

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1. Introduction

Today's modern electric Light Electric Vehicles (LEVs) are to be considered a next generation transport modes and easily reaching out a turning point in the automotive "green" oriented worldwide market requirements [1, 14]. Although global LEV sales are still expected to generate revenues to target a $23.9 billion market by 2026, such electric drive vehicles are still lagging behind market expectations due a number of combined factors [2, 3]. First, oil and vehicle manufactures are still in a slow transition path towards full-fledged LEV market investments or business conversion. Secondly there is still a dispersed and volatile global business strategy and unclear social and unknown user perception on the LEVs argument [4].

In this sense, today's market automotive developments is leveraging research over sustainable next generation mobility with an increasing trend towards LEV promotion as well as sustainable transport modes. Overall, the following topics in Table 1 appear as of utmost importance across research and LEVs mobility for the future [7, 8, 15].

Table 1 - LEVs services for the future mobility [7, 8, 15].

Technology offer Next generation mobility concept is based on electric drive and social sustainability
Safety and Sustainability requirements LEVs have to meet both safety and sustainability criteria for social and legal acceptance
Infrastructure No LEV is sustainable and commercially sensitive if it is not fully embedded into a supportive and inclusive service-infrastructure
Market development needs The market is to be fit to the service, including gamification and co-modality features

In particular, this paper targets the problem of what future LEV user profiles, needs and propensity levels are, and how they are expected to interact with a supportive service-infrastructure including gamification and co-modality in urban areas [13]. Past research varied from studying LEV early adopters and individual consumer needs and interests to refined survey-based analyses on user acceptance of wireless electric vehicle charging [6, 16, 17]. This type of research is of utmost importance but not delivered to cross-generalize at European scale.

Instead, the present work brings findings (and new methodologies) on potential LEV users profiles at scale across at least three European countries and four different cities with varying types of social contexts and users per European Country. Such an effort was brought forward within the ongoing EU H2020 funded STEVE Project, a project about "LEVs applications and concepts" [5].

2. The STEVE project

STEVE stands for Smart-Taylored L-category Electric Vehicle demonstration in hEtherogeneous urban use-cases. It brings together cities, industrial companies, small and medium enterprises, and academic institutions from seven European countries, for the demonstration of the integration of LEVs in the urban transport system [5].

The STEVE goal is to capitalise on what is to be considered more a final strategic user service than a technological advantage: the electro-Mobility-as-a-Service (eMaaS). Specifically, the Project proposes a human-centric vision for LEVs based mobility, called the STEVE Move2Me vision described in Figure 1.

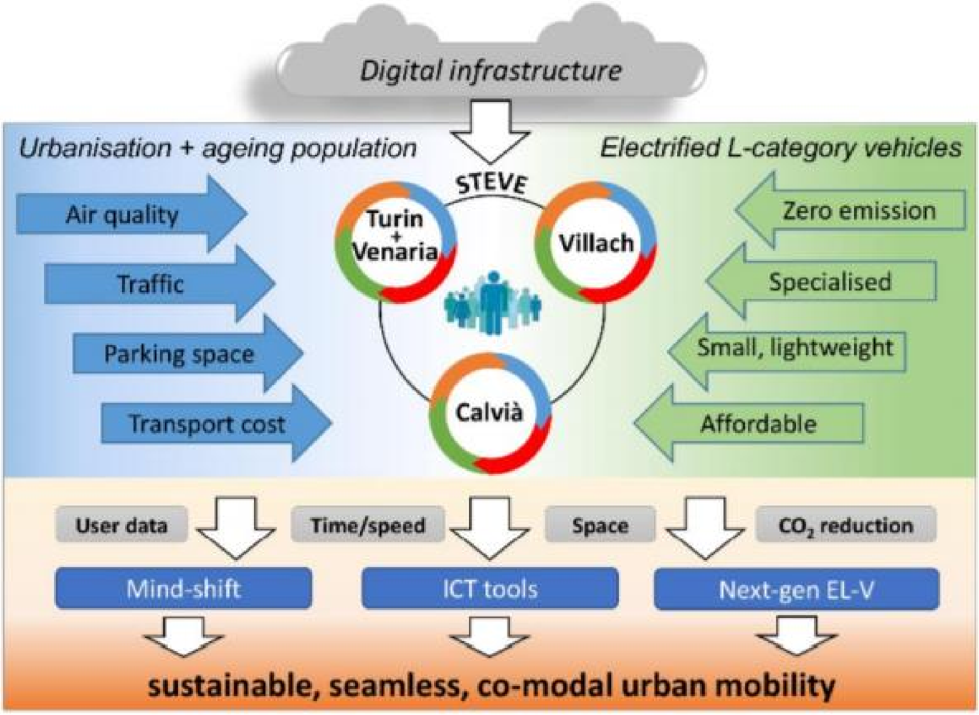

Figure 1 - STEVE Move2Me vision

In particular, STEVE is proposing: a low-cost and financially sustainable LEVs technical solution of electrical led quadri-cycles, L6e and L7e types, and two-wheel motorbikes (e-bikes). Also, other key factors are engineered to increase citizens' engagement and participation:

a) *Interior monitoring*: an innovative Time-Of-Flight camera will be used to show how vehicle interior can be monitoring for the benefit of the driver.
b) *Eco-driving functionality*: this functionality will be used to monitor the driver behaviour and to rate its driving style, to raise awareness about the importance of energy-efficient attitude [10, 11, 12] .
c) *Enhanced vehicle connectivity* to the cloud, which are rarely available on current LEVs.

The above features would ease the introduction of a city-oriented "gamified" service to enhance users' awareness and engagement. Also "co-modality" as a service for a coherent inclusive service-infrastructure could be evaluated as well in terms of urban transport combination with the STEVE LEVs solutions: cleary a key competitive advantage for the next generation electric mobility.

Overall, in order to assess the expected impact of the above innovative STEVE technological solutions a strategic *User Centric Approach* was developed and reported in the next sections to thoroughly assess and obtain a "profile" of the future most likely expected STEVE user.

3. STEVE User Centric Approach

Overall, user needs, requirements and expectations are playing a pivotal role in the STEVE Project. Shown in Figure 2 is the concerted STEVE User Centric Approach deployed in the first year of the project and based on Market Analysis and User Forum applications (http://www.steve-project.eu/index.php/en/activities/steve-forum) followed by a detailed STEVE User Survey deployment across Italy, Spain and Austria with participants from orino, Venaria, Calvià and Villach respectively (http://www.steve-project.eu).

All three approaches are presented below leaving more room to describe the utilization of statistical and machine learning methods to "profile and segment" the most likely future STEVE users expected to engage in future e-mobility services according to the Project.

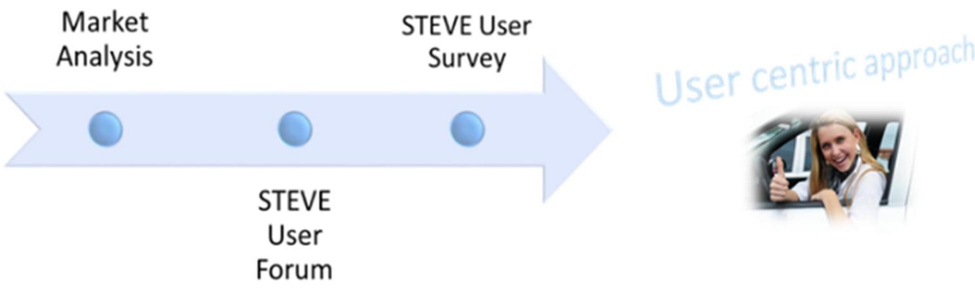

Figure 2 – three-fold strategy for STEVE User needs and requirements

3.1. Methods

3.1.1. STEVE Market Analysis

The Market Analysis survey aimed at investigating critical business development needs, like car-sharing, gamification or co-modality services and preferences. An example of such survey is given in Table 2 where the car-sharing feature is fully explored by respondents of the Italian sample of the Project.

The methodology in this survey was a structured questionnaire-based tool delivered via multiple-choice items to a representative sample of Italian drivers recruited under the STEVE Project framework between 2017 and 2018.

Table 2-STEVE Market analysis: Car-sharing preferences in Italy (excerpt of results in 2018)

Question	**Most selected answer – percentage**
Q16. How do you prefer to sign up for the car sharing service?	Internet registration - 75%
Q17. Do you prefer a Member Card or an App to unlock the car?	App - 82%
Q18. Would you prefer payment by credit card or rechargeable subscription?	Credit card - 57%
Q19. Do you prefer to pay a registration fee and a discounted rate or to pay a higher rate for the rental?	Higher rate for rental - 57%
Q20. Would you rather pay a monthly fee, PPU (pay-per-use) or choose between them?	PPU (pay-per-use) - 57%
Q21. Do you prefer reserved parking areas or free parking?	Free parking - 61%
Q22. Would you accept to register you driving style to get some benefits (minutes free…..)?	Yes. - 91%
Q23. Would you like to have a loyalty card to collect points for a gift/benefit when you use a car sharing?	Yes. - 80%

Overall, from the different data collected during the market analysis, some key results emerged:

Torino/Venaria - In general, the concept of an electric vehicle is appreciated. The market expectation of an electric quadricycle is a 2-seat vehicle (side by side) with side doors, automatic gearbox and air-conditioner, which is able to travel about 70 km/h and reach 150 km with single charge. Considering the safety, the safety belt, airbags and ABS are strong preferred. The good handling (e.g. brake assist and steering assist) is also strongly preferred, but the willing is less strong than the safety aspects (Market analysis source: Project Survey, Table 2).

Villach - About 36% of Villach's citizens have more than five commuting a day. This fact needs multimodal mobility solutions. About 50% of employees in Villach live within a distance of 6-9 kilometres to their workplace, 61% have to go 10-15 kilometres. The society in Villach is changing and despite the actual classic cars usage as common commuting means is at 76%, there is serious opportunity to invert this trend by e-bike-sharing-system and quadricycle-test-routes out of STEVE project (Market analysis source: STEVE Survey analysis by Infineon).

Calvià – The city is a typical tourist scenario, where car sharing is already an affirmed reality, but only a few e-vehicles are present on the field; since bureaucracy constraints will impose a growth in the number of electric mobility solutions in the near future, the STEVE project may find good opportunities to enter the competition by providing new optimized solutions. The people preference relies on very high range e-quadricycle; conversely, a significant effort from the local authorities is required to establish a well distributed charging stations net. Most of potential users will be the island tourists and Calvià citizens. Electric vehicle have motor vehicle tax benefits programmes (Market Analysis source: STEVE survey campaign and Tourist office Calvià)

3.1.2. STEVE User Forum

A STEVE User Forum service was then designed. It was deployed to facilitate shared LEVs discussions, knowledge exchange as well as social interactions about the e-mobility proposal. Such a social media service would instill STEVE project discussions amongst occasional and tailored pilot test users for both the electric quadricycles and e-bike testing across all the incoming autumn pilot tests in 2019.

Methodologically the design of the STEVE User Forum implied several iterations across the STEVE partners. A set of key domains targeting specific arguments fed dedicated forum rooms threads about:

1. Benefits-Expectation about co-modality transportation (i.e. opportunity to have in a single service: car + bicycle)
2. Benefits-Expectation about special membership discount (i.e. elderly users, women, disable, etc.)
3. Benefits-Expectation about discount for special time slot (i.e. from 2.00 to 5.00)
4. Benefits-Expectation about support / tutorial to start using the car/ bicycle (i.e. for the first time)
5. Benefits-Expectation about where to return the car / bicycles (dedicated station / free-floating / specific areas)
6. Benefits-Expectation about "what" can be turned into "reward points"
7. Benefits-Expectation about how to spend "reward points"

All forum threads above constituted the means to integrate and share expectations, interests and free commentaries on the various arguments suggested around various STEVE services. At present, the forum is activated with a plan to increase its usage and social media coverage between end of 2019 and beginning 2020.

3.1.3. STEVE User Survey

Finally, the STEVE User Survey describes the actual STEVE user population segments of interest: Residents, Commuters, Students, Business and Leisure Travelers. All survey data collection amounted to 3037 active and valid records evenly spread across countries and the four cities.

Figure 3 gives a successful distribution of participants across the cities of Calvià and Villach as planned. These two cities topped up over 600 subjects each as requested. Torino with 1636 valid responses has the highest number of participants. Venaria Reale had to merge in the Torino sample due to a very limited response rate sampled until end of July 2018.

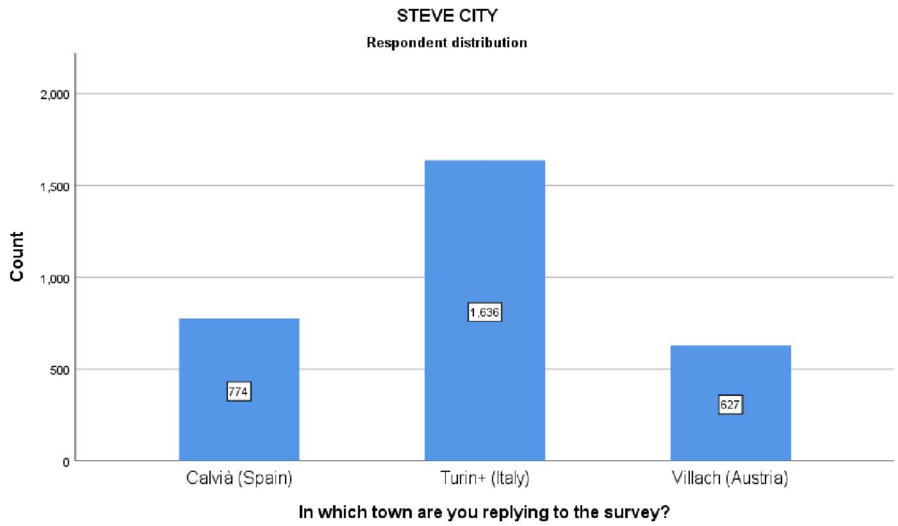

Figure 3 - Dsitribution of STEVE Survey across European Cities

Figure 4 instead shows descriptives for Resident, Commuter and Traveller groups (combining Business/Leisure/Tourist) with 1259, 954 and 824 respondents respectively. Calvià city has a very large majority of Traveller and Tourist as respondents. Torino and Villach instead a very low sampling of such business travellers and tourists respondents.

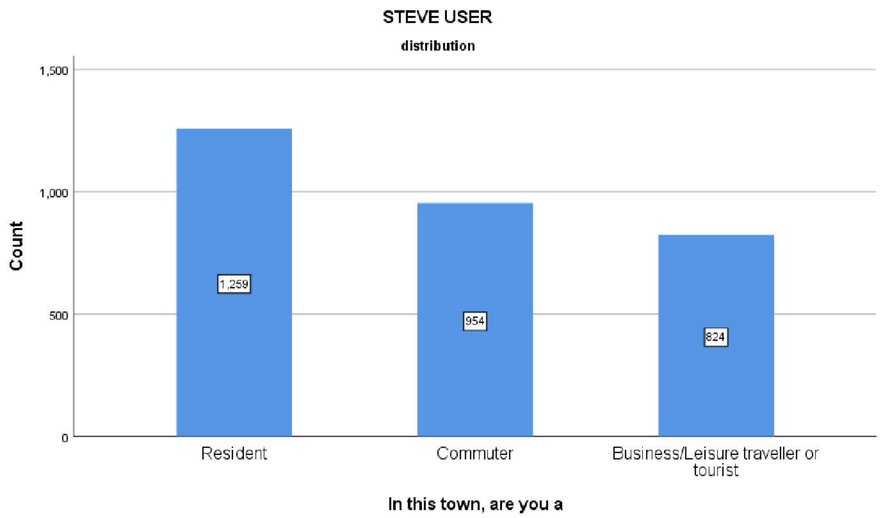

Figure 3 - Distribution by type of respondend to the STEVE Survey

Multivariate analyses then tested relevant potential sample differences and group separations by application of MANOVA statistical models (multivariate analysis of variance models) as shown in Figure 5. For instance, the difference in the *satisfaction levels on actual commuting modes across the cities was verified accordingly.*

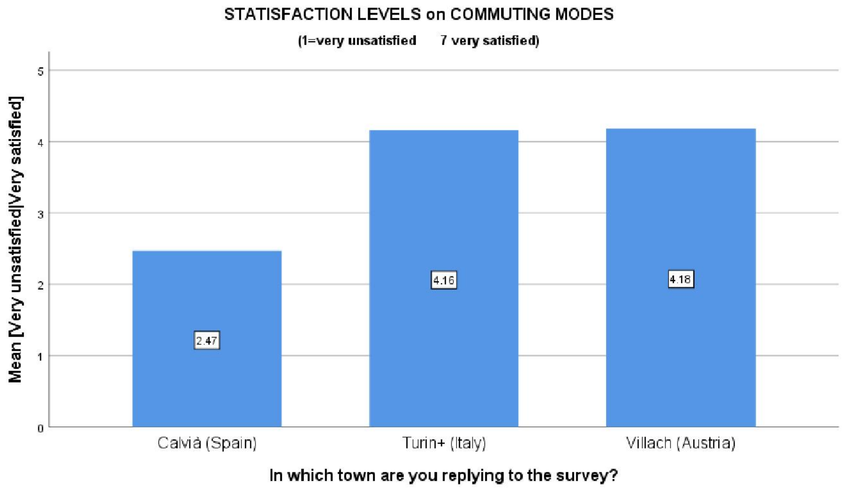

Figure 4 - STEVE Survey: satisfaction levels about commuting modes (across cities)

Highly informative is the analysis on the *estimated propensity scores towards the use of specific STEVE quadricycles (e.g., EL-V 90km/h)* across the cities under analysis. This is shown in Figure 6. Propensity scores are averaged non-weighted linear combination ratings derived from subscales of the STEVE Survey. This measure in Figure 6 reflects the degree of motivated interest to use the STEVE L7e type quadricycles.

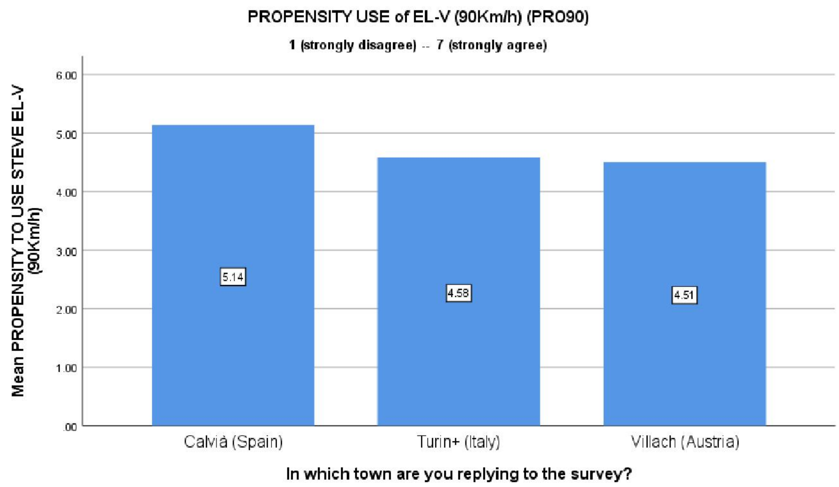

Figure 5 - propensity scores towards STEVE L7e type quadricycles

3.2. Data analysis: Users Profiles

More important the STEVE approach moved beyond descriptive or differential statistics by application of *machine learning* methods to obtain consistent profiles of future end users with higher preferences (or propensity) towards e-mobility. Such segmentation of profiles could be of great relevance to take municipal, territorial and community decisions on "what" and "how" to offer STEVE services that fit best with such expected profiles.

The Chi-Squared Automatic Interaction Detection (CHAID) Trees classifiers (IBM Modeler version 18.1 software) was chosen as primary machine learning process and exposed to the available data sample of 3072 subjects from the STEVE Survey.

From a methodological point of view, a tree classifier is a tree-based algorithm that iterates a search in the information space, the predictor features, which will maximise information gain (or minimize information entropy) to maximally separate some target feature values. In STEVE case: "high" propensity" vs "low propensity" scores. This is shown in Figure 7.

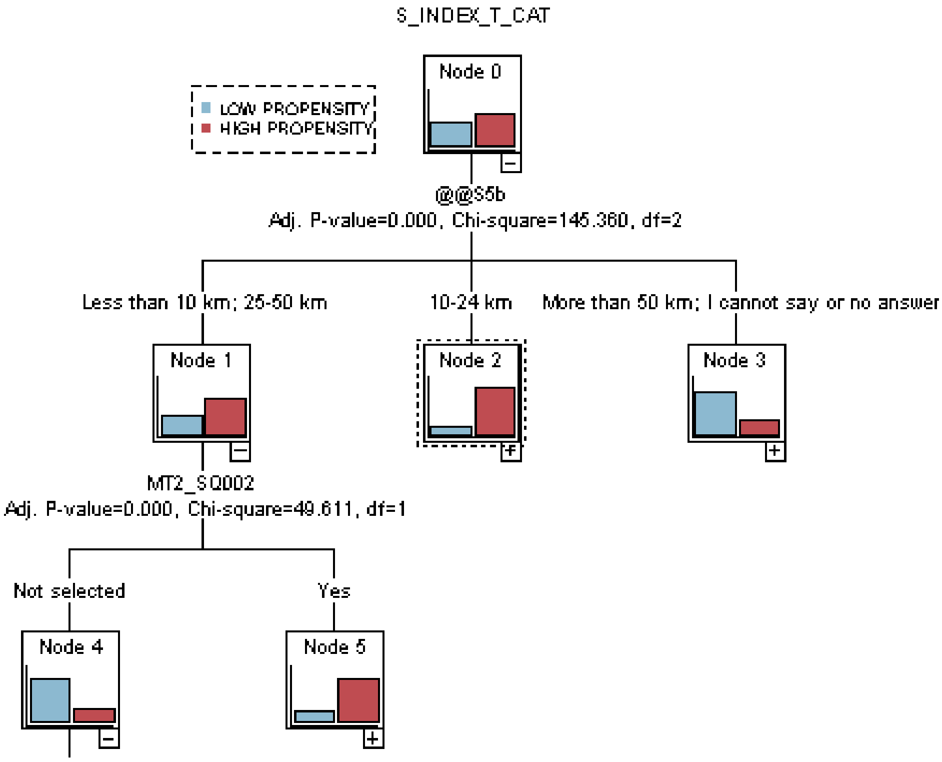

Figure 6 - CHAID tree algorithm to classify high vs low propensity towards STEVE eMaaS services

Specifically the selected CHAID Tree classifier is a type of tree algorithm that incrementally splits the tree nodes (i.e., the sample space of features) by ranking significant *p*-values of the chi square statistics used to maximise information gain at prediction. As an example, Figure 5 shows that Node 1, 2 and 5 maximise the red prediction High Propensity class. Node 3 and 4 instead are predicting Low Propensity.

The very same tree can be represented as a set of *if-then* decision rules at each node split as shown in Table 3.

Table 3 - Example of tree-derived decision rules for STEVE eMaaS services

IF	MODERATE INTEREST (COLLECT REWARD POINTS)
And	MODERATELY CONCERNED (buying tickets with smartphone)
And	(NO or) MAYBE interested in combining use of e-bikes/quadricycles with other services if a discount available
And	MALE
And	SHOPPING Max 20km range
THEN	**HIGH PROPENSITY (0.78 confidence)**

If STEVE Survey participant would match a profile of "moderate interest to collect rewards points" and "moderate concern to buy public transport tickets with smartphone" and "maybe interested in combining use of e-bikes/…if a discount available" and "male" and accepting "shopping in a 20km range" then this person would be predicted as an HIGH PROPENSITY case for STEVE eMaaS services.

With this approach, it was possible to obtain potential user profiles of at least four types of propensity measures: Comodality Propensity (preference to use multiple transport modes), STEVE Sentiment (level of adoption of the STEVE Services), PROPENSITY towards L6 quadricycles, and PROPENSITY towards eBikes. A general description of such user profiles matched over the 3037 Survey participants is in Table 4.

Table 4 - STEVE User Profiles as recommendation system (generated by CHAID trees; descriptive terms only)

Comodality Propesity Score (CPS) *Measure the frequency to multiple transport modes utilization*
1. CPS is moderate across the total sample 2. CPS is slightly higher for Turin and Residents, although the level is low 3. Female, younger, and low-income respondents have lower CPS.
STEVE Sentiment score (SENT) *Measure the level of adoption/inclination towards STEVE Transport modes*
1. SENT scores are low and moderate for the total sample 2. Sent is very low in Calvià and for middle age respondents 3. It is higher in Turin and for very low income ("less than 14.999€)
PROPESITY TO USE (90km/h) (PRO90) *Degree of motivated interest to use the STEVE L6 (LEV Quad (45Km/h version))*
1. The PRO90 scores quite positive on the total sample 2. Calvià shows the highest propensity to PRO90 3. There is a general positive level of moderate propensity for PRO90 with no large descriptive differences by gender, age, users and income. 4. To note that very old potential users are less prone to this quad ("70 or over") 5. Income shows PRO90 ratings high across all levels except the highet income over 75.000€
PROPESITY TO USE eBikes (PROBike) *Degree of motivated interest to use the STEVE eBikes*
1. There is a moderate positive propensity on PROBike 2. Turin is has more propensity PROBike than Villach with Calvià in the middle 3. Residence show more propensity to PROBike than residents likewise males over females 4. Notably age between 18-29 and 60-69 have highe PROBike scores than other ages 5. There is a clear trend in Income with higher scores on PROBike towards lower incomes

Conceptually, it is now possible to deploy such machine learning models derived in Table 4 as general *recommendation system* to inform territory/municipality decision making on the range of eMaaS services that best fit propensity profiles. This AI oriented method is to be considered an innovation in user centric approach applications.

4. Discussion

STEVE user needs and profiles are key drivers for any prospective action on the basic LEV's concepts, co-modality and gamification features as well as products. Generality of a product seem to address the fact that the

STEVE Project identified different levels of STEVE needs for various populations, at least across three different European countries. In substance, there is not a single STEVE service but a network of STEVE opportunities to develop, deploy and marked new concepts for transport models and strategies from 2020 onwards.

About *mobility and commuting*, there is a clear indication that, across cities and users the "most common travel mode to work or study" is still "personal car" then, classic "public transport". "Walking" and classic "Bicycle" follow. All forms of STEVE LEVs Services are still an uncommon commuting travel mode. Notably, "the lack of feasible alternatives" is the key constraints when commuting across cities and users. Thus, STEVE have to put LEVs, co-modality and gamification into this context and leverage it. Notably, *shopping* or *hobby commuting* has the same trend. Also. a "need to transport heavy equipment, shopping bags, luggage etc." is the first key constraint to shopping travels in future e-mobility services.

Notably, business or leisure Travellers require STEVE LEVs Services to target the role of e-mobility with "the public transport" and "rental car" as the most preferred commuting modes at destination.

About *Shared mobility* and *gamification* the top key factors determining the willingness to rise interest in using electric quads or microcars are "the distance to pick up station" for Villach, and "free park when using a shared vehicle" both in Torino and Calvià. Nevertheless, "no need to worry about where to park", "traffic, safety considerations", "range of vehicle", "environment friendly" and "the distance to pick-up station" remains all very significant factors to choose a STEVE service. Such conditions above seem to generalise across all STEVE users as well (Residents, Commuters, Travellers). Notably the design of the vehicle in Villach is quite high and differentiated as factors toward interest in Steve services.

The role of *Apps* like the "the need to install an application" or "register to a new service" limits the interest to STEVE LEVs engagements overall. Moreover, factors for choosing e-bike services have similar trends with "distance to pick station", "parking is easy" and "traffic safety considerations" clearly in evidence. Instead, "Booking with a smartphone app with registration" is most preferred modality to STEVE Services (quads or ebikes) across Turin and Villach, Commuters and Residents, across gender and income indifferently. "Credit card online" for payment is the preferred way in Turin and Villach, across Residents and Commuters, Males, income above 28.000€. finally, sharing your information "on your mobility behaviour" is less accepted in Villach and favoured in Turin. Male are more hesitant to share their mobility information than Female like older users with higher income.

The role of *co-modality and gamification* is well differentiated across cities and users. In general, all subsamples (city, users, and gender/level groupings) are positive to combine STEVE services like quadricycles or ebikes with other services like public transports, museums, hotels etc. The positive preferences to the above comodality features show differences by cities where the preferred service to integrate with STEVE is "combined with hotel room" in Calvia, and "combined with public transport in Turin and Villach. Another key trend is favouring practice towards reward points collection. For instance, Female, younger users ("18-29" yrs), with low income ("less than 14999€") are more prone towards reward point collection. Notably the key type of reward point addressed across all subset of users is "Rewards related to the sharing service, e.g., free ride after 10 rides made".

5. Conclusion

Today's modern light electric vehicles, *LEVs,* are now exposed to a detailed investigation and development within the EU funded STEVE Project. The STEVE *add-on* operational concept by 2020 is to have selected STEVE LEVs (i.e., electric quadrycicles L6 and L7 and e-bikes) integrating concept of urban co-modality, gamification and advanced built-in features. Such interaction and integration called *Move2Me vision* is becoming a real electro-Mobility-as-a-Service (eMaaS) for all EU Member States and beyond.

The methodologies described in the previous sections about market analysis, future user needs and requirements as well as estimated propensity scores out of machine learning methods are all coordinated towards a common STEVE objective: *to contribute to the larger adoption of electric mobility within the EU so as to improve EU's citizens quality of life by sustainable mobility*.

Results so far across four European cities, Torino, Venaria, Calvià and Villach across three EU member States, Italy, Spain and Austria respectively are comprehensive but would lead to further investigations in the future. It is of utmost importance to substantiate the present results with new research and operational actions. Especially STEVE service pilot testing and related activities.

In this line of thoughts, the STEVE project in mid 2019 entered some pilot testing phases for a range of tailored LEVs services and applications. More research is indeed required but the future prospective STEVE Users have been fully detailed projected and analysed. By the end of the Project in 2020 the concept of *profiling prospective LEVs users* will allow to gather new knowledge on propensity scores and preferences about specific STEVE services in such pilot applications. Such action will be evaluated by dedicated surveys on the pilot-drive tests across the cities and evaluated by selected Key Performance Indicators. Such final surveys will measure the overall STEVE impact.

To note also the importance of public communication and dissemination activities within the project framework. For instance, a very important public event, jointly organised by the City of Turin and Venaria Reale, took place on 9th April at the Reggia di Venaria. The aim of the event was to inform the public authorities and the media about the availability of the LEVs and the upcoming start of the experimental activities in both cities as planned.

The City Major of Turin (Ms. Chiara Appendino) and the City Major of Venaria Reale (Mr. Roberto Falcone) were present at the event and had the opportunity to drive the STEVE LEVs. As a formal way to start the experimental phase, the keys of the LEVs were delivered to both Majors by the project's partners (Figure 8 and 9).

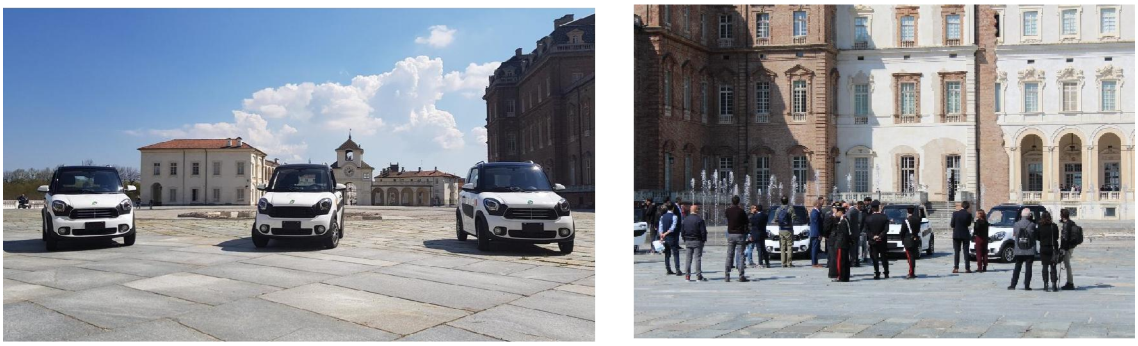

Figure 7 STEVE LEVs during the official public event

Figure 8 - Keys delivery to the Majors of the Cities of Turin and Venaria (left), the Majors of the Cities driving the LEV (right)

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