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Electric L-category vehicles for smart urban mobility

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Abstract

The demand of personal mobility in EU cities is increasing the use of motor vehicles; consequentially, gas emissions, noise levels and traffic jams increase, affecting quality of life of city-dwellers. To tackle such problems, European-wide emission targets are becoming stricter and urban mobility plans are being drawn. Future scenarios for EU urban centres see a **modal shift in personal mobility** from cars to lighter, smaller, more specialised and environmentally friendly alternatives.
ELVs (Electric L-category Vehicles) **are part of such alternatives** that can cater to the average commuter's needs because of their small size and light weight; that means low on board energy requirement and small batteries, which allows lower costs and faster recharge. However, this modal shift offers new challenges: many urban users do not consider LVs as a viable and comfortable option for their needs. Urban policies could encourage ELV adoption, but four limiting factors are slowing down the diffusion of ELVs: **cost, energy efficiency, attractiveness of ELVs and drivers willingness to use**. RESOLVE EU project, co-funded under European Green Vehicles Initiative, is aimed at making ELVs practical alternatives to cars, by encouraging a number of commuters to switch to narrow-track ELVs. Led by 2 largest LV manufacturers in EU and complemented by top component suppliers, Research Institutes and Universities, RESOLVE will give a contribution to reduction of overall urban traffic congestion, cutting commuting time and easing parking.
To achieve its ambitious objectives, RESOLVE uses a holistic approach to explore solutions, culminating in **two demonstration vehicles** that will show the advances to the State-of-the-Art and could form a basis for attractive commercial ELV propositions. The project will start with user needs definition and market analysis, in order to ensure that expected technical results will be properly aimed. **User needs** will be identified taking into account the actual usage of either ICE (Internal Combustion Engine) PTWs or light-heavy quadricycles (L6-L7 category) and of supermini (M1 category) cars in cities and suburban areas, throughout European countries. The task will also allow seeing which is the **market potential** size and share (shift from car drivers) by analysing database on market data and trends for ICE and electric L vehicles. User needs will be both quantitative data (e.g. km

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ridden per days, travel path, time stop, required performance etc.) and qualitative ones (such as parking easiness, manoeuvrability, acceptability by **women/men, elderly/young, experienced/inexperienced, riders/drivers**, protection from rain, etc.).
Outcomes are the basis to develop a number of technological advances that aim to **maximise the energy efficiency of ELVs**, such as regenerative braking and lightweight design, as well as to **optimise ELV rider experience**, such as active vehicle stability and handling, human machine interface (HMI) and measures to enhance comfort and weather protection.

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Keywords: electric vehicles; L-category; powered-two-wheelers; urban mobility; energy efficiency

1. Introduction

European cities are even more congested due to the demand and usage of motor vehicles of a growing urban population. These vehicles cater to the daily mobility needs of residents and commuters and, as their density grows, traffic jam increase, parking gets scarcer, noise and emissions levels pollute the urban environment. These factors affect the quality of life and health of city-dwellers as well as inevitably gain more attention from policymakers.

According to the roadmap adopted by European Commission for next decade, one of the key goals is: no more conventionally-fuelled cars in cities by 2050 and “the use of smaller, lighter and more specialised road passenger vehicles” is encouraged in order to achieve clean urban transport and commuting (European Commission (2011)).

One of the most feasible solution to limit these factors is represented by L-category Vehicles (LVs), also called powered-two-wheelers (PTWs[1]), with a growing share of electric. Around 35 million users in Europe ride regularly PTWs because they give a concrete answer to practical needs: they are shorter and narrower than a car and remain more mobile in traffic jams. It’s a fact that over 60% of journeys are for commuting, utility and practical purposes. Journey times are cut by up to 48%. Land is used more efficiently: up to 5 PTWs can fit into one car parking space. Environmental impact is very low: in real life conditions, for the same journey, PTWs emit 50% less CO_2 than cars (Ducreux (2008)) However nowadays the rate of adoption of electric L-category Vehicles (ELVs) is not high enough to have a significant impact on the improvement in urban living conditions. Electric L-vehicles currently on the market are limited in their diffusion mainly by cost and operational range; therefore, in many cases they do not provide a superior experience to the rider in terms of comfort, handling, stability, etc.

Working towards that vision, RESOLVE EU project (www.resolve-project.eu) aims at enabling the development of a range of cost-effective, energy efficient and practical ELVs that will entice urban users to switch to ELVs for their daily urban commutes.

Nomenclature

EU	European Union
ICE	Internal Combustion Engine
LV	L-category Vehicle
ELV	Electric L-category Vehicle
EV	Electric Vehicle
HMI	Human Machine Interface
PTW	Powered-two-wheelers
SotA	State of the Art

[1] The term ‘Powered Two-Wheelers’ (PTW) covers a wide range of vehicles from mopeds, scooters and other small capacity motorcycles, ideal for urban journeys, to large capacity custom, sports and touring models. Tricycles, minicars, light commercial quadricycles are also part of the PTW family.

2. The RESOLVE Project

The RESOLVE – Range of Electric SOlutions for L-category Vehicles Project is a three-year research project that started on 1st May 2015. It has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 653511.

The RESOLVE consortium is made of a well-balanced and qualified group of 14 partners and it is optimally positioned to drive such technological advancements and bring them to the market: PIAGGIO and KTM are the two largest L-category Vehicles (LVs) producers in the EU, while the complete ELV value chain is represented in the consortium, complemented by top component suppliers, research institutes, engineering companies and universities.

2.1. Objectives

RESOLVE objectives in terms of measureable indicators are:

- to develop an **integrated, scalable, modular range** of fully electric LV drivetrains that will have marginal unit manufacturing costs of not more than €300 (4 kW drivetrain), for a design volume of 10,000 per year;
- to showcase advances to State-of-the-Art (SotA) in two **tilting four-wheelers demonstrators,** belonging to L2e and L6e categories, with **energy efficiencies of 35 Wh/km and 41 Wh/km**[‡2].
- to improve the **rider experience** of ELVs. This includes to improve handling/stability significantly validated by several performance parameters and HMI improvements that address range anxiety and rider concerns such as safety and comfort, as shown by user surveys.
- To make ELVs more attractive to urban users, resulting in an increase in the percentage of drivers that consider LVs as a viable alternative for their urban travel needs.

2.2. Concept and approach

Urban policies should encourage more ELV adoption but four limiting factors are limiting their diffusion: **cost, energy efficiency, attractiveness** and consequently **willingness to use.** RESOLVE's concept centers on making ELVs more attractive for urban mobility and ease a larger uptake, contributing to overcome these obstacles. RESOLVE aims to use a holistic approach to explore solutions, culminating in **two demonstration vehicles.** That will show the advances to the SotA and will form a basis for attractive commercial ELV propositions, which can generate widespread market uptake.

In the following a detailed description of RESOLVE objectives is presented.

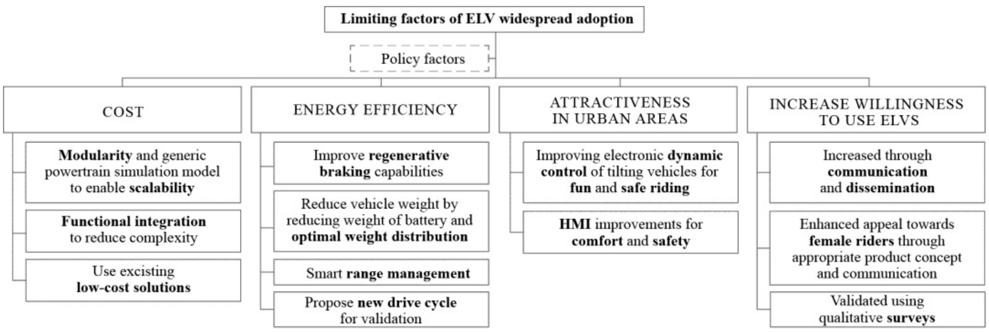

Fig. 1. Factors limiting ELV adoption and RESOLVE solutions.

[2] Measured on a urban journey profile, with reference to the standard cycle (R47 and in the future, World Motorcycle Test Cycle) and/or specific L-vehicle urban driving cycle to be investigated within RESOLVE.

2.2.1. Powertrain cost reduction

The target will be achieved by two ways:

1. reducing the marginal unit manufacturing cost of the powertrain modules;
2. reducing the design effort required to realize a powertrain by creating reference designs and a powertrain simulation tool.

Marginal unit manufacturing costs of electric powertrains are comprised of three main components: battery pack, drivetrain electronics and electric motor. RESOLVE aims at reducing the cost of the drivetrain electronics (comprised of inverter, DC/DC-converter, battery charger and vehicle management unit) by achieving functional integration of all these electronic functions into one configurable Drivetrain Management Module (DMM).

Further cost savings will be obtained through modular and scalable design of the components.

2.2.2. Total vehicle energy efficiency

Energy efficiency is a key factor because, at equal autonomy, it has a huge impact on the energy to be carried on the vehicle; thus on weight and cost of the batteries. It will be increased by lightweight design, optimizing transmission losses and regenerative braking, taking into account vehicle geometry and driving conditions. An optimal regenerative braking algorithm, be implemented in the DMM, responds to the request of the driver and combines the action of the brakes and electric motor(s), used as generator(s).

This active braking in the vehicle dynamics control will lead to maximum energy efficiency keeping braking effect smooth and predictable on every surface.

2.2.3. Improving rider experience

To encourage urban users to adopt ELVs for part of their commuting needs, rider's use experience needs to be enhanced. RESOLVE aims at making advancements to the handling and stability of ELVs together with improving the user interface (HMI) concerning aspects such as safety and comfort.

RESOLVE's prototypes are based on tilting four wheelers architecture, an innovative vehicle formula which combines the agility of a two-wheeler with the stability of a four-wheelers, keeping the dynamic behavior of a motorcycle but increasing significantly its stability and control during braking and cornering, even on slippery or bumping surfaces. Upon this architecture, a multi-wheel vehicle control algorithm will be implemented to further improve its handling and stability, in such a way to make riding easier and safer.

The HMI will also provide riders with advice on road surface status, their riding style and optimal usage of ELVs such as how they would behave to take advantage from regenerative braking and to optimize active safety systems. Range anxiety will also be addressed within the HMI system, as the Smart Range Management system will give riders accurate information regarding the vehicle range and ensure the achievement of the destination address.

Different HMI architectures will be explored in order to maximize the ease of use, intuitiveness, and ad-hoc controls that will enable the rider to have better, safer and more effective interactions with the ELV.

2.2.4. Increasing attractiveness of ELVs

By proposing innovative electric L-vehicles with advanced safety and comfort features, the RESOLVE project is aimed at attracting those urban users that will consider ELVs as alternative means of transport for their daily commutes.

Female riders is a user's group especially relevant for the project, thus women are currently underrepresented in the L-category segment. RESOLVE represents a chance to redress the balance between male and female adopters.

To assess the attitude change, a sample group representative of European drivers will be surveyed at the beginning and at the conclusion of the project. A relatively low proportion of drivers willing to switch to ELVs (around 10%) is expected in the beginning; the project aim is to increase this by 15% by its conclusion.

2.3. RESOLVE vehicle architecture

RESOLVE will develop a new generation of electrified powertrains with more functional integration and modularity. The modularity will allow these components to be used in a range of vehicles with different engine power. A general simulation model will demonstrate the scalability of the powertrain components. This will reduce production complexity, design costs, and therefore production costs. The lower costs can result in an attractive market price of ELVs and, therefore, increase the market share.

As Fig. 2 illustrates, specifically related to cost reduction, RESOLVE will look to integrate components into clusters. The components that RESOLVE would integrate are the inverter, battery charger, DC/DC converter and vehicle management unit, as well as the BMS (Battery Management System) into the battery pack.

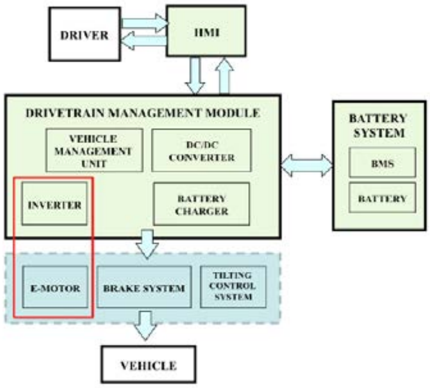

Fig. 2. Illustration of components that could be integrated, used from existing technologies or synergized.

3. Impact

3.1. Impact of RESOLVE on energy consumption

The average energy consumption of a RESOLVE ELV has been estimated to be 50 Wh/km. Compared with the average fuel consumption of the alternatives, this is quite an improvement: it is assumed that ICE cars use 5 l/100 km (= 500 Wh/km), ICE LVs use 2.5 l/100 km (= 250 Wh/km), and other (older) EVs use 100 Wh/km. The conversion from petrol consumption to electric consumption was done taking into account a thermodynamic factor of 10 kWh/l of petrol.

Table 1. Energy Saving assuming one cold start every 30 km.

Vehicle type	Energy per km Wh	Cold start energy waste per start Wh	Cold start energy waste in 1 year use kWh	Total energy in 1 year use (10,000 km) kWh	Difference in 1 year use respect car (10,000 km) kWh	Difference in 1 year use respect ICE LV (10,000 km) kWh
ICE car	500	2,000	730	5,730	0	+2,865
ICE LV	250	1,000	365	2,865	-2,865	0
EV	50	0	0	500	-5,230	-2,365

It should be taken into account that ICE engines have increased fuel consumption until they reach their optimal operating temperature, whereas EV drivetrains do not suffer this “cold start” effect. It is estimated that a small car ICE engine burns an additional 0.2 l of petrol (= 2,000 Wh) before it gets to operating temperature, which will take 5–10 minutes. It is assumed that the engine is warm before the end of the 15 km trip.

In Table 1 total savings are calculated assuming, in an urban contest, a daily trip of 30 km and one cold start per day. 30 km per day in a year means about 10,000 km (assuming for easiness 333 days of real use). Total energy in 1 year use is calculated considering (energy per km) × 10,000 km + (cold start energy) × 333 days. Last two columns report the difference in terms of energy needed among the three different vehicle/powertrain compared.

This table confirms that the replacement of ICE cars by RESOLVE ELVs leads to the largest energy savings.

Furthermore, in this figure it has not be taken into account the fact that ELVs do not have to make additional kilometres to find a parking space – if a car on average has to drive some 2–3 km to find a parking space this would add another perhaps 5% to the fuel consumption on a 30 km round-trip journey. Based on these assumptions, the advantage of ELVs on cars rises from 5,230 kWh to 5,491 kWh.

3.2. Impact of ELVs on emissions

Plug-in ELVs, if used as pure electric, have zero local emissions; however, battery charging may generate global emissions depending on how energy is produced. If electric power is obtained from fossils, the result would only be the transfer of the CO_2 emissions and other pollutants from cities to energy production plants. The efficiency of the whole cycle may be better than the one of a fossil feed ICE. On the other hand, if ELVs use renewable energy, we would obtain a real zero emission scenario. There are significant synergies between electric vehicles and renewable energy (Ekman et al. (2011)). Due to the fact that some kind of production cannot be interlocked to demand (e.g. nuclear), renewables are used mainly intermittently at certain times (when they're needed in peaks of demands). Energy storage is difficult, not to say nearly impossible. ELVs batteries, when vehicles are charging in a smart grid, may be used as spread accumulators and they can help to buffer production peaks and allow a better usage of renewables.

3.3. Impact of RESOLVE's concept on emissions

RESOLVE focuses on reducing at least local emissions to improve urban air quality. Let's consider the mix of carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons (HC) and particulate matter (PM, "soot").

Table 2. Estimated local emission considering Euro 6 standard ICE vehicles.

	CO	NO_x	HC	PM
Euro 6 limit	1,000 mg/km	60 mg/km	100 mg/km	5 mg/km
Our assumption (50%)	500 mg/km	30 mg/km	50 mg/km	2 mg/km
Total emissions reduction kg (10,000 km per year)	**5.0**	**0.3**	**0.5**	**0.02**

Total emissions reductions are calculated using the same estimates for replacement km used in the previous paragraph. In Table 2 the total emission reductions are underestimated, as the "cold start" effect was not taken into account. Reductions in NO_x emissions are particularly relevant as many EU cities are failing mandated air quality standards in this respect (European Environmental Agency (2014)) – leading to large imposed fines (e.g. London faces fines of EUR 300 million per year, and Munich, Stuttgart, Florence and Paris have similar NO_x concentrations).

It is difficult to argue that this reduction in local emissions will lead to a noticeable improvement in air quality: the total RESOLVE ELV fleet of 120,000 vehicles by 2025 has to be compared to a total fleet of around 30 million LVs and 240 million cars (Mock, P. (2012)); it would only amount to less than 0.1% of the total European private powered transport fleet. Still it is a step in the direction of greener and cleaner urban transport.

3.4. Impact of RESOLVE's concept on journey time and traffic congestion

By encouraging a number of commuters to switch from cars to narrow-track ELVs, RESOLVE will contribute to easing congestion on urban roads.

Firstly, the individual commuter using RESOLVE ELV instead of a car can expect to cut his journey time in half (Ducreux (2008)). Considering an average commute time by car of 38 minutes, this will be reduced to 19 minutes using a Powered Two Wheelers (PTW), both electric or ICE. As an ELV will be recharged at home, users will also not spend additional time driving to/from a fuel station, leading to additional time savings.

Secondly, parking spaces for cars are scarce in inner cities. PTWs ease parking congestion as typically 5 PTWs can be parked in the space of one car. PTW parking spaces can also be positioned more flexibly, as PTWs can be maneuvered more easily than cars. It will also save commuters time as they are much less likely to have to hunt for a parking space, and can likely park closer to their final destination. According to studies in different EU cities, the average time spent looking for a parking spot can be around 12–15 minutes or even more. If theoretically a PTW rider spends even 10 minutes less in parking search (probably very moderate estimate) and assuming that perhaps half of the riders do not pay for a rental parking space at work, it sums up to about (10 minutes/day * 333 travelling days per year =) 55 h 30' saved annually for each user.

Further to the above direct effects for the ELV riders, it has been shown that an increasing traffic share of PTWs reduces overall congestion and speeds up traffic for all vehicles on the road. All drivers (car or PTW) tend to adapt their speed to the apparent traffic density around them: if it feels that traffic is crowded they reduce speed, and speed up again when they experience more space.

An increased share of PTWs would mean that traffic density, in terms of Passenger Car Equivalent (PCE), per kilometer goes down for the same people density on the road, and average traffic speed for all vehicles will go up. While in high average traffic speed PTWs behave similar to cars and take up similar space, in slow moving, "normal" city traffic studies have shown PTWs to take up around 0.3 PCE. This means that 3 PTWs contribute roughly as much to traffic density as a single passenger car. This density-effect was modelled in a study in Leuven/Brussels (Transport & Mobility Leuven (2010)), where a modal shift of 10% of car drivers moving to PTWs reduced traffic congestion by 40%.

3.5. Impact of RESOLVE's concept on traffic safety

A number of the proposed advances of RESOLVE will lead to greater traffic safety for LVs:

- The tilting architectures explored by RESOLVE combine maneuverability of PTWs with stability and handling more aligned with cars. They are inherently more stable and can break in a shorter distance than 2-wheelers, especially when piloted by riders used to cars.
- Active stability control will make sure that the vehicle can be optimally controlled, and stability maintained when cornering, braking, and riding over uneven road surfaces. ELVs with the RESOLVE HMI will signal to the rider under what conditions energy consumption is lowest. Hard acceleration and hard braking are discouraged. Overall a more defensive driving pattern produces both best energy efficiency and therefore greatest range and better safety.
- Chassis architecture and protective bodywork increase rider comfort and safety; a more comfortable rider is a safer rider.

4. Market analysis and user needs definition

First project activity is aimed at ensuring that demonstrators' concept and technical solutions meet the users' needs of light personal mobility vehicles mainly addressed to urban and suburban areas. In order to get into technical specifications of powertrain architecture and vehicle concept, RESOLVE started from user needs definition and market potential analysis. User needs are gathered through a user survey implemented within the first three months of project while market potential is identified by analyzing market figures of LV circulating park among EU countries.

4.1. Market potential

The market data are provided from member countries through a number of different sources, such as National Associations of ACEM (e.g. ANCMA), Ministry of Transport (e.g. AKE Finland), Ministry of Statistics (e.g. Statistika Centralbyrand (SCB), Sweden), private companies (e.g. VWE, Netherlands).

The organization or company examples listed above are directly or indirectly responsible for registration of vehicles, hence the data supplied are the numbers of vehicles registered in each country, and are classified into different types of L-category as defined in in Regulation (EU) No. 168/2013 of the European Parliament and of the Council of 15 January 2013.

The actual market figures of L-vehicles on the years account for about 1.2 million of vehicles sold in 2014, showing a significant reduction in total sales for EU-countries respect to 2009 (about 1.9 Million of vehicles in EU-28).

Even the relevance of electric vehicles within L-class market is still quite low, the absolute value of sales being about two order of magnitudes smaller in comparison with total sales (see Fig. 3 (b) vs. (a)), it should be noted that the trend for the sales of electric vehicles is increasing (see Fig. 4); in particular, for the most representative categories (L1e, L2e, L3e and L6e-L7e combined) the relative value of sales has been particularly significant especially for L6e-L7e, that is four wheel vehicles, recently being estimated more than 4% of total sales on the category after a peak of 10% in 2012, probably due to the introduction of relevant new products on the market; L2e vehicles also are slightly below 4%.

(a) (b)

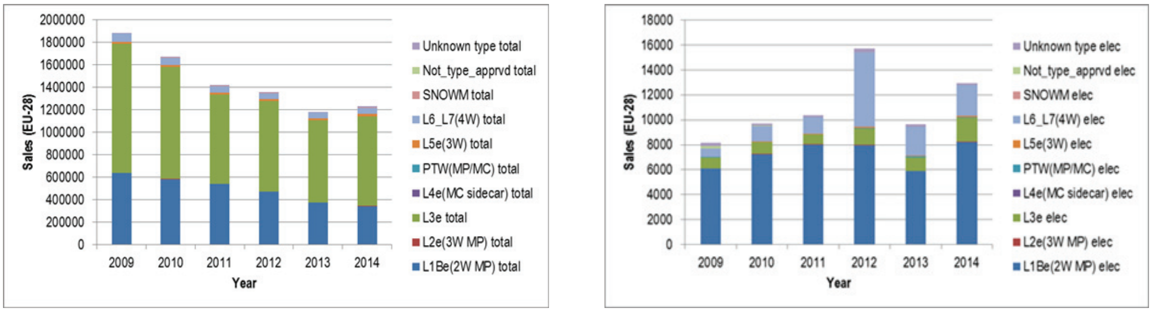

Fig 3. Sales of L-vehicles on the period 2009–2014, EU-28 countries, (a) both conventional and electric vehicles; (b) only electric vehicles.

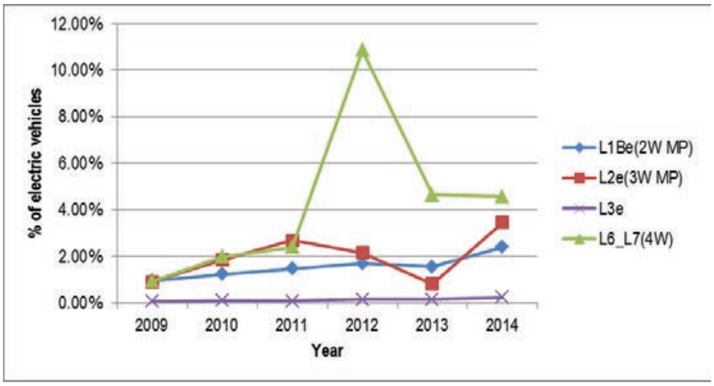

Fig. 4. Percentage of sales of L-vehicles on the period 2009–2014, EU-28 countries only L1e, L2e, L3e and L6e-L7e (four wheels vehicle).

4.2. User needs definition

Even several analyses of users' need and opinion about electric vehicles have been carried out in recent years; a tailored survey has been deemed necessary because of the peculiarities of RESOLVE targets, aimed at proposing innovative vehicles, not comparable with those existing on the market yet. The survey proposed for RESOLVE is aimed at identifying the needs for a range of possible users and to understand, both in direct and indirect way, their opinion and their willingness to use light vehicles mainly for urban commuting. An on-line survey in English and Italian language has been proposed to open public, providing the link to the dedicated website and promoting it via e-mail, social networks and other communication channels such as:

- ACEM website (www.acem.eu),
- Ele.C.Tra Project Consortium homepage (www.electraproject.eu), which includes the municipality of the city of Florence;
- ACI – Automobile Club of Italy (www.aci.it), starting from the office of Florence, which presented RESOLVE activities and included link to the survey on main news page.

The main advantage of such approach has been that an international public has been reached and participated to the questionnaire. On the other hand, considering that the participation is based on a voluntary initiative, a known limitation of the study is that the data can result in a certain "polarization", such as that the attitude on compiling the questionnaire has been more frequent for those users which are already interested on the topic. For this reason, the survey includes a number of questions that are aimed to describe the person itself and to estimate his/her experience as driver, rider and EV user. Such questions have been proposed in order to give the possibility to analyze and group the data during post-processing phase. The survey is structured in four sections, each one having a different objective:

- Person description
- Vehicle ownership and mobility needs
- Extended description of mobility needs
- Your opinion about Electric Vehicles

The "Person description" section is focused on the acquisition of general information about the user, such as age, gender, household structure, instruction level, driving license owned, income; in addition, the user is invited to indicate the country and the postal codes of home and workplace area. Such data are those mainly necessary for the grouping activities through clustering.

The "Vehicle ownership and mobility needs" section contains questions about the current habitudes of the user. The questions on this parts are expected to be useful to describe the current situation of the person involved in the survey, since the user is invited to declare the means of transport that he/she is using, the vehicle ownership (including type – car and/or motorcycle – and class – through type and/or engine displacement), the current mobility needs in terms of distance driven per day over a certain type of road (e.g. urban/rural/highway); such data are mostly descriptive and objective, even if some uncertainties are possible due to the fact that they are based on self-estimation. The last questions of this part are asking the user his/her opinion about certain mobility aspects, and are therefore mainly representative of his/her personal point of view. The questions include the evaluation of the relevance of common mobility issues in relation to the area where the user lives (e.g. relevance of air or noise pollution; traffic congestion; accessibility of restricted traffic zones, cost etc.). In this part, the user is also invited to indicate his/her willing to use or not PTWs and to rank the disadvantages that act as an obstacle; known issues such as weather protection, comfort, need to transport people/stuff, preference, lack of ability or driving license are the elements included in the evaluation, but the user can introduce new points using an "open text box" if needed.

The "Extended description of mobility needs" section is mainly related to the expectations of the user about new solutions to improve personal mobility. In particular, in the first question, the user is invited to rank the relevance of features that a "personal mobility vehicle" should have, such as the ability to transport passengers, goods, weather protection, easiness to park, costs, and information services. This question is partially mirroring the last question of former part and is intended, amongst others, to verify the coherence of the user in responding to the question. After this, the user is invited to indicate other general data in order to define him/her as a potential EV driver/rider: starting from the estimation of a suitable minimum range for the vehicle (in km), the user has to describe if he/she is going to buy a new vehicle in the next years and if he/she is considering certain EV categories (Hybrid EV, Battery EV; car, quadricycles or PTW). Finally, the user can indicate if charging infrastructure are or can be available on his/her area of interest. This part is mainly intended to understand which needs have to be satisfied considering not only the vehicle itself but also the system in which it is acting; as an example, in case of lack of charging infrastructures the problem could be solved both increasing the size of the energy storage on the vehicle or promoting the installation of new charging infrastructure. The section "Your opinion about electric vehicles" is mainly aimed at understanding the competence of the user regarding electric vehicles and the attitude amongst this kind of vehicles. Thus, it is related not only to the identification of user needs, but mainly to understand his/her current knowledge. This part has been prepared for two main reasons:

- to know his/her current perception and, in case, if it is based on former experiences (e.g. use of existing quadricycles/cars/scooters/pedelecs) which could be either good or bad; in this latter case, in fact, information initiatives could be needed to overcome existing opinion
- to understand the attitude about innovative vehicles and which elements could motivate the use of EV.

The attempt to individuate such motivations is based on the analysis of literature experiences, which showed that the “hedonic” and “symbolic” attributes can have the same weight as instrumental attitudes, so that certain users (e.g. early adopters) evaluate a vehicle not only on the basis of characteristics and performances but also considering its social perception, its environmental impact, the quality and the opportunities related to innovative products.

The results will be presented as plots; considering that some questions included a large number of points, data could be reduced and/or adapted for better readability. Currently, the survey has been closed, including a total of 791 responses (166 in Italian and 625 in English), of which about 60% are almost completed. Post processing of the data is undergoing.

5. Conclusions

This paper presents the aims and objectives of the EU project RESOLVE, funded under GV5-2014 Call and started on the 1st May 2015. The project findings will enable a most eco-friendly urban transport system, by developing a new and affordable technology for Electric Vehicles for L-category (ELVs). To achieve that, the project will tackle the shortcomings of current ELVs by developing a range of modular and scalable electric powertrains and battery architectures specifically designed for ELVs, significantly reducing their cost. It will also develop a number of technological advances that aim to maximize the energy efficiency of ELVs, such as regenerative braking and lightweight design, as well as to optimize ELV rider experience, such as active vehicle stability and handling, human machine interface (HMI), and measures to enhance comfort and weather protection. These advances will be demonstrated in two tilting four-wheelers demonstrator ELVs.

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