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## **Understanding User Representations, a New Development Path for Supporting Smart City Policy: Evaluation of the Electric Car Use in Lorraine Region**

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### **ABSTRACT**

Today electric car and Smart Grid are potential elements of any ‘Smart City’ initiative. According to several recent studies, French citizens are ready to purchase an electric car. Despite of these positive figures, sales of the electric cars are not really taking-off, but slightly increasing. Although, previous studies have identified motivation and barriers for the diffusion of electric cars (EC), we hypothesise, that the analysis of the *a priori* knowledge of the actors, in particular the users, can be enriched and it will provide a new understanding of the spread of EC. However, there is no studies explaining the types of representations people have of the EC, particularly for non-users, in order to have a better consideration of individuals, not so much as consumers or users, but rather as citizens. Thus, this paper explores the determining factors that determine how social groups perceive the emerging technology of EC and thus provide elements about a potential acceptability enabling its dissemination. In order to achieve this, this paper proposes a new approach based on the use of the AttrakDiff-2 questionnaire, a specific User eXperience (UX) method. This method assesses four different but complementary aspects of the social representation: the possibility of action of the subject on the system; the stimulation, caused, by the system; how the user will identify with the system and, the overall attraction. Data about the social representations of electric car for 131 potential users in the Lorraine Region of France were collected and analysed. Results show that there are differences of user representation regarding the socio-demographic variables. The proposed approach will provide relevant inputs to the infrastructure network design and Smart City policy decision makers.

**Keywords** — Electric Car; Attrakdiff-2 Tool; Users; UX Method; Social Representation; French Use; Dissemination of Innovation.

### **1 Introduction**

Smart City oriented public policies and in particular those related to urban mobility have attracted growing attention and funding of many supranational, national and local governments over the last few years. According to Caragliu and Chiara, Smart City policies do have a non-negligible positive impact on urban innovation. For example, these policies stimulate innovation that increases a city's stock of

knowledge (Caragliu and Del Bo, 2018). These authors also claim that Smart City models can have a positive impact on economic growth, quality of life, sustainability and overall well-being. In their research, they adopt “transport and ICT infrastructure” as one of the six axes of urban inputs supporting a Smart City. Both the most recent (Riva Sanseverino et al., 2017) and the previous (Giffinger et al., 2007) studies systematically highlight the role of mobility as one of the challenges of the smart city. Regarding this particular topic, Marletto uses a socio-technical approach to show that the future of urban mobility will depend on the competition between supporting coalitions of innovative stakeholders who contribute to making the use of alternative transport systems a social practice (Marletto, 2014). In this study, three transition pathways to the urban mobility of 2030 were designed: “AUTO-City”, “ECO-City”, and “ELECTRI-City”. In this last scenario, “local and national electric operators are interested in the adaptation of their systems to the diffusion of Electric Vehicles (EVs), because they aim at the new frontier of smart grids” (Marletto, 2014). Furthermore, the author identifies two time periods: 2013–2020 for local tests and 2021–2030 for consolidation on a global scale. Our research presented below is part of this stage of local tests.

Contrary to popular belief, the EV is not a recent phenomenon. Its history goes back to the origin of the automobile. The first EV, which appeared in 1834, precedes the first combustion car by 52 years (Beretta, 2005; Guignard, 2010; Husain, 2003; Mester, 2007). However, EV has not stopped returning to the automotive market. Indeed, over the past 100 years, it has tried to make its comeback four times, to such an extent that the Electric Car (EC) is identified by the authors as an “eternally emerging technology” (Sadeghian, 2013; von Pechmann, 2014). Nevertheless, it is more efficient and more successful each time. Electric Mobility (EM), when thought of in terms of usage segments, takes on a different dimension, and has had many successes (e.g. underground rail networks in many cities, the car-sharing system in Paris with “autolib” or in Luxembourg with “citymov”). Thus, EV has managed to get out of its qualification as an eternally emerging technology. EV technology is now operational and represents a concrete and realistic aspect of most smart city initiatives.

In France, since 2010, the EC has returned to the passenger car market, but even today it represents only a small share of this market (CCFA, 2018). Indeed, this study reveals that the share of EC sales among light vehicles represented only 1.2 % in France in 2017. A typical structural phenomenon of sales of light vehicles seems to explain this situation; when they buy a new means of transport, 48% of French people tend to prefer second-hand cars whereas 37% look for new cars from the biggest brands (Sofres, 2014). Despite this, EC sales are slowly but constantly growing (CCFA, 2018) and EC beats its own sales record each year (AVERE, 2017). Thus with 24,910 EC registrations, France is the second European market in 2017 with only 1.2% of the national market, while Norway is the first European market in volume and percentage with 33,025 EC registrations or 20.8% of its national market (CCFA, 2018). Nevertheless, 48% of French citizens are ready to purchase an electric car, even if only 36% of them consider that it perfectly meets their traveling needs (Auto Moto and Haris Interactive, 2017).

For ENEDIS, the company in charge of the management of the public electricity distribution network, and responsible for ensuring its installation, management and maintenance, the arrival of ECs is a source of concern (ENEDIS: Direction Clients & Territoires, 2015); because ECs could transform its industrial process and involve significant investments. Indeed, engineers have to choose between three different types of electric charging stations to equip public roads. The *normal* type, which is equivalent in power consumption to a water heater, does not require any modification of the electric network. However, at least 8 hours are necessary to recharge the batteries of an EC. The *accelerated* type, which represents the power consumption of a building, in most cases implies some adaptation of the electric distribution network. With this type of charging station an EC takes from two to four hours to recharge the batteries. The third is the *rapid* type, with a power consumption equal to a neighbourhood block. In this case the expansion of the network is compulsory, but by using this type of electric station, only 30 minutes are required for a full charge (ERDF: Direction du Développement, 2012). In France, public authorities generally set up the *accelerated* type (Etatlab, 2016) without enough decision-making elements to deploy an optimal network across a territory. From an innovation point of view, the EC is already developed, and is in its diffusion stage (Sadeghian, 2013). Nevertheless, the diffusion stage of EC depends, first of all, on the capacity to recharge batteries; it therefore relies on support technology such as the distribution network, charging stations, infrastructure etc. Secondly, it is also dependent on the citizens’ willingness to buy ECs.

This research analyses the EC as the dissemination in a delimited geographical area according to (Greenhalgh et al., 2004). At this scale, Biresselioglu and his colleagues identify the motivators and barriers for the diffusion of EM through three levels of decision-making: “Formal Social Units, Collective Decision-Making Units, and Individual Units” (Biresselioglu et al., 2018). In particular, it seems that at the individual level the lack of knowledge about climate change by the actors reduces the perception of EC benefits (Shao et al., 2016). We hypothesise then, that this analysis of the *a priori* knowledge of the actors, in particular the users, can be enriched and it will provide a new understanding of the spread of EC in a multilevel process: the market, the technology and the policy. In fact, as underlined by (Marletto, 2014), there is no studies explaining the types of representations people have of the EC, particularly for non-users, leading to a better consideration of individuals, not so much as consumers or users, but rather as citizens. Thus, in order to fill this gap, this paper explores the determining factors that determine how social groups perceive the emerging technology of EC and thus provide elements about a potential acceptability enabling its dissemination.

In order to do this, we designed an original approach, based on the adoption of the French version of AttrakDiff-2 questionnaire (Hassenzahl et al., 2003; Lallemand et al., 2015). a specific User eXperience (UX) method already suitable for non-users, that we have completed with a socio-demographic survey. Data about the social representations of the electric car for 131 potential users in the Lorraine Region of France were collected and analysed. This specific UX method assesses four different but complementary aspects of the social representation: the possibility of action of the subject on the system; the stimulation, caused by the system; how the user will identify with the system; the overall attraction. Results show that there are differences of user representation regarding the socio-demographic variables. Indeed, rural inhabitants have a more negative social representation of the electric car, than urban and suburban residents. It also reveals that individuals with an occupational profile on a higher or lower level have a higher appreciation of using an electric car than individuals with an intermediate occupational profile. Concerning the degree of education, the higher an individual’s educational level, the higher the social representation of using an electric car. It also reveals that the gender characteristic or the income of potential users does not influence their respective social representation.

This new approach of analysis seeks to provide relevant inputs to the network design decision makers and avoid expansion and useless oversizing of the electrical network, and thus unnecessary investments. At the same time, a better understanding of users’ behaviour and needs give elements to support electric mobility (EM) democratisation. Indeed, understanding the uses and social representations is essential for encouraging this process and consequently the success of this innovation (Cardon, 2005).

The remainder of this paper is structured as follows. Section 2 presents an insight from literature about the diffusion of electric cars as a radical eco-innovation and the relevance of UX inspired methods to evaluate the social representation of the electric car. Then, section 3 exposes the methodological approach and the scope of this research. Section 4 describes the main research findings and analyses in detail the main results and implications. Section 5 discusses the main research outcomes and managerial implications. To Finish, conclusion and different research perspectives are addressed in section 6.

## **2 UX-Design as support for radical eco-innovation diffusion**

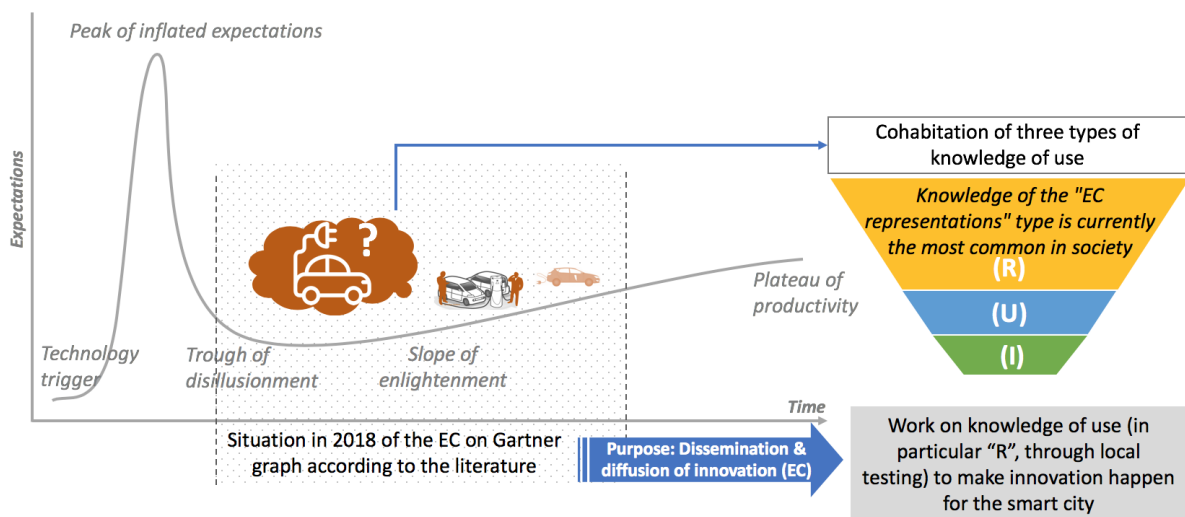
### *2.1 Electric car: Dissemination of radical eco-innovation*

According to Griset and Laroque, one of the reasons for the failure of the EC is the willingness of EM stakeholders to absolutely want to see the EC as a "replacement for the combustion vehicle" (Griset and Larroque, 2006). According to Sadeghian, it would be more efficient to identify its relevant use segments and work on their development in complementarity with the uses of gasoline vehicles (Sadeghian, 2013).

Pechmann's work tends to show that the EC is a radical innovation (Midler and von Pechmann, 2015; von Pechmann, 2014). The EC destabilizes carmakers in the manufacturing and marketing processes. Indeed, the battery and its charging system, but also the electric propulsion system requires the adaptation of production lines of the automotive industry. During marketing phase, the absence of local CO2 emissions production is traditionally undervalued by the market (von Pechmann, 2014). The sales process

must be redesigned to incorporate its new elements. In particular, they require new commercial techniques. EC also appears to be an “environmental innovation” (Hubert, 2017). These innovations are a more or less direct result of regulatory pressure and are a privileged way to satisfy compromises between multiple dimensions such as economic efficiency, product quality and environmental quality improvement (Oltra and Saint Jean, 2009). Many researchers also use the concept of “eco-innovation” for environmental innovation (Rennings, 2000).

On one hand, radical innovation has the particularity of creating a split in the practices of people, disrupting their habits. On the other hand, eco-innovation does not spread naturally and therefore requires support to become part of the daily lives of users (Jippes et al., 2013). Furthermore, according to researchers on EM who adapted the Gartner model initially developed to track the diffusion of ICT innovations (Bakker and Budde, 2012), EC could be between the “trough of disillusionment” and the “slope of enlightenment” of the hype cycle according to Hubert (Hubert, 2017) or between the “slope of enlightenment” and the “plateau of productivity” according to Sadeghian (Sadeghian, 2013). In other words, if the researchers do not fully agree on the level of maturity of the EC market, they admit the “peak of inflated expectations” has definitely passed and ECs might make their way to the market. Finally, this technology is therefore at a pivotal stage in which its success depends only on its adoption by users (Fig.1).



**Fig. 1** EC car challenge: moving from representations to use and instrumentation, adapted from (Fenn and Raskino, 2008; Hubert, 2017; Jippes et al., 2013)

The dissemination of the EC must focus on its ability to penetrate, not the economic market, but the daily lives of people. This requires providing decision-makers with relevant information about the barriers and levers to the adoption of this technology. In the following sections of this article, we will study how users interact with EC and what the representations are for potential users.

## 2.2 Electric car acceptance vs. user-centred electric mobility infrastructure design

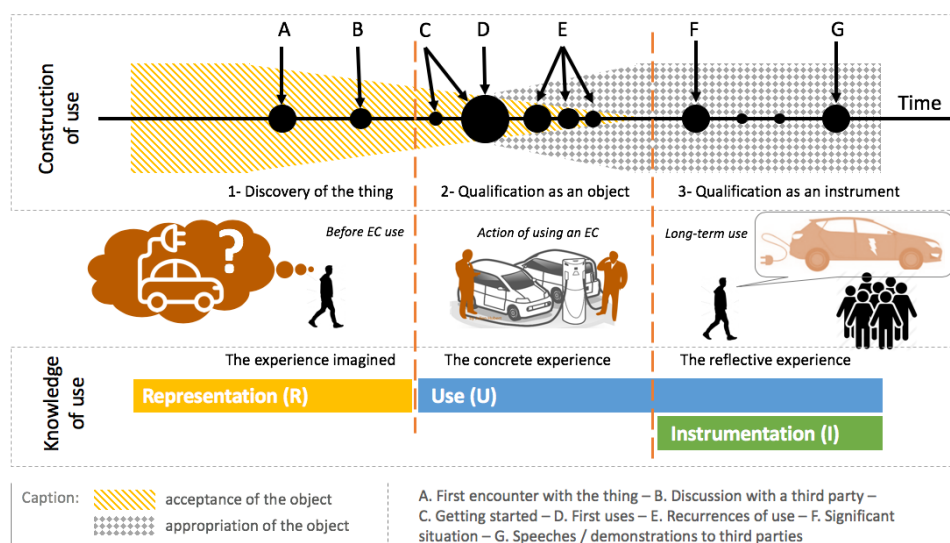
Companies designed and built EC for a long period of time. This technology is currently operational, but EC is just one aspect of the EM. This new mobility paradigm needs EVs and dedicated infrastructure, which transform roads, streets and cities. As constructors and distributors develop, manufacture and sell EVs, town planners, elected representatives, electricity suppliers and other stakeholders try to tackle the transformation of their territory. Making progress on EM means assessing the potential adoption and appropriation of a product already developed while also assessing the necessary adaptation of the current electrical distribution infrastructure at the same time.

In both technological aspects (vehicle and infrastructure), literature shows that considering the needs and behaviours of users is fundamental to succeed in this challenge. Indeed, according to Dupont and colleagues (Dupont et al., 2015a), the user becomes a key stakeholder of the innovation process. Previous studies explain many elements, such as: individual predispositions, compatibility with actual uses, pressure



on social learning or even impact on social status, are key factors conditioning the success of a new technology (Von Hippel, 1986, 1988); De Marez & De Moor, 2007; Draxler & Stevens, 2011; Salovaara, Helfenstein, & Oulasvirta, 2011; Serfaty-Garzon, 2003; Stocker, Richter, Hoefler, & Tochtermann, 2012). Furthermore, previous studies on technology acceptance are not new and methods already exist, such as the Technology Acceptance Model (TAM) (Davis, 1989), Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) or measurement instrument of (Verdegem and De Marez, 2011), that allow development of specific communication in order to persuade users to adopt a new technology. Nevertheless, the objective of these approaches is always focused on convincing users about the technology's usefulness value. In the context of EC, a more global strategy would include a full analysis, as suggested by Sovacool, who designs an integrative framework combining Automobility, Actors Network Theory and UTAUT based on semi-structured research interviews with knowledgeable experts (Sovacool, 2017). Nevertheless, this model is not yet validated by experience. To understand EC as a whole, we propose adopting the model of the diffusion of innovation in which use plays a fundamental role. The theory of diffusion of innovations links the characteristic of innovation and the favourable or unfavourable attitude towards adopting that innovation. Studies on the diffusion of innovation explored different dimensions, such as: spatiality (Cliff et al., 1981), temporality (Daude, 2002), offer (Brown, 1981) or demand (Rogers, 2003) and usage (Gaglio, 2011; Greenhalgh et al., 2004).

According to Blandin (Blandin, 2001), the construction of use is composed of three stages: representation (how the future user imagine the use), use (the action of use) and instrumentation (transformation and adaptation for other uses). For each of these three stages, specific knowledge is generated or mobilised as illustrated by Fig. 2, specifically in an EC context. Thus, (1) *Representations (R)* are all the assimilated and translated information that a non-user has about an object of which he has become aware. This information is limited and interpreted by the person. The person is in the register of the experience imagined with the object. This step is before use. (2) *Use (U)* is the interaction between a person and an object. It is the action of using an object. The person is in the register of the concrete experience with the object. This step covers the use. (3) *Instrumentation (I)* is the act of intentionally using the object. The person uses the object with an identified purpose. The interaction with the object is conscious and deliberate: it makes sense in the person's daily life. This is in the register of reflective experience. This step is after use. The authors have adopted these definitions for the present study. Furthermore, this study focuses on users as EC owners and/or drivers. Indeed, Hubert identifies that about thirty different types of actors are involved in the electric car use ecosystem (Hubert, 2017). He describes this ecosystem with four perimeters of use where the stakeholders have specific interactions in the EC system, as the Fig. 3 shows.



**Fig. 2** Construction of the use of an object and types of related knowledge, adapted from (Blandin, 2001; Haué, 2009; Hubert, 2017)



**Fig. 3** Ecosystem of the electric car user, adapted from (Hubert, 2017)

With 0.9% of electric cars registered in 2016 in Western Europe (1.2% in France) (CCFA, 2018), there are far more non-users than users. Although there are already some EC users, knowledge of the “EC representations” type is currently the most common in society and the market. In this context, as shown in the previous Fig. 1, the EC challenge is moving from “representations” to “use” and “instrumentation”.

In the second section, this paper will underline the users’ roles in innovation in an EM context. Since the middle of 2000, designers, manufacturers and marketers can widely mobilise users over the product lifetime with different methods and for various results. However, in 2016, in France, the vast majority of car drivers and potential EC buyers had no experience with EM. How can we transform EC representations into a source of innovation? This paper focuses on pre-use in the diffusion of EC, specifically the identification and evaluation of Social Representations (SR) in a specific geographical context. In other words, it focuses on understanding the EC image of individuals, even before the use of this type of vehicle, and on identifying the reasons why this vehicle does not attract any further segments of the population. Furthermore, the work of Schuitema and colleagues in the UK suggests that the intention to adopt EVs is stronger if people have a positive perception of their instrumental, hedonic and symbolic attributes (Schuitema et al., 2013). Their research, based on two online survey waves in the UK with paid participants, underlines the significant indirect effect of perceived hedonic attributes.

According to the state of the art, only four studies and one PhD thesis have been conducted on the uses of ECs and its French market. Table 1 describes and compares these references according the Blandin’s model for “use”. (Ipsos public affairs, 2014) describes the French expectations for EC (ChargeMap and Club Alsace Voiture Electrique, 2014) focuses on the uses and the use problems of the charging stations; (Hubert et al., 2016) identifies and evaluates 41 generic determinants related to the acquisition and use of EC from an international literature review and adds 6 generic determinants from the analysis of a regional case study; (Teyssaire, 2011) evaluate the EC’s use degree by regional households. Furthermore, (von Pechmann, 2014) on his PhD thesis explains and analyses the EC’ diffusion in France. However, no studies

dealing with “social representations” of the EC in France have been done. The next section explores this fundamental aspect to develop a relevant EM infrastructure. Furthermore, as pioneer work, this research explores a specific method to identify EC social representations.

**Table 1.** Comparison of previous studies on EC use in France

References	Topic of the study	Focus of the observation	Scientific material and panel	Panel’s area/ region	Main result	Stage of Use from (Blandin, 2001)
(Teyssaire, 2011)	Use of EC by Alsace Households	Macroscopic	250 questionnaires of private users	Alsace area in France	Degree of EC use	Use
(Ipsos public affairs, 2014)	Expectations for EC	Macroscopic	1000 questionnaires French people	France	Potential EC French buyers	(Potential) use
(ChargeMap and Club Alsace Voiture Electrique, 2014)	Use of the charging station	Macroscopic	504 questionnaires of private users	Alsace area in France	Use and problems with use of the charging station	Use
(von Pechmann, 2014)	EC diffusion	Macroscopic	INSEE Data	France	Identification of percentage of population who can use EC	Use
(Hubert et al., 2016)	Use of EC by private and professional users	Microscopic	30 international scientific references 12 scientific interviews of private users (12 persons agreed of 117 users) 4 focus groups (20 professional participants)	Lorraine area in France	Identification and evaluation of the 47 determinants related to the acquisition and use of EC	Instrumentations

### 2.3 The Social Representations of Electric Car

Carpentier (Carpentier, 2007) studied the relationship between people and cars within French society. He explains that people have a utilitarian vision of the cars: they describe it as practical, convenient and flexible. The user thus has a very strong dependency ratio on the object. Outside major cities equipped with a dense and efficient public transport network, the daily lives of many French people are organised according to the car (Petit, 2007). However, in the semantic field that the French use to describe cars, the rational and utilitarian aspects are only slightly present while the affective aspects and values are predominant. The representation of the car is partly cultural. The terms freedom, danger, fear, stress and beauty are the most commonly used terms associated with the car (Carpentier, 2007).

The French relationship to the car is not essentially based on a pragmatic aspect, in other words, the French do not have only a merely utilitarian vision of the object. This relationship can also be based on a hedonic aspect, i.e. an identification of the individual in relation to an object and a stimulation felt by the individual and generated by an object. To understand whether EC is governed by the same logic, we need to identify a user experience tool that integrates these two dimensions: the pragmatic dimension and the hedonic dimension.



Theories of *Social Representation* (SR) are relevant when trying to fully understand individuals' perception, insofar as it not only enables us to reveal the content and the structural organisation of such social constructs but also allows us to put it into perspective with the social representations of individuals (Degraeve et al., 2015).

In the literature, four theories tackle the issue of the SR. The first is socio-genetics, which strives to describe the conditions and the processes involved in the emergence of the representations (Moscovici, 1989). The second is the structural approach that is focused on the contents of the representations and their dynamics (Abric, 1976). The third is about the connections between social relationships and social representations. It is a socio-dynamic approach (Doise, 1990). The last is a dialogical approach, which focuses on the role of language in the construction of representations (Markova, 2003).

For Moscovici (Moscovici, 1961), the construction of representations is connected to the appearance of an innovative situation. The fact that the unknown object is new implies that the piece of information connected to the object is limited, causing anxiety in or attracting the attention of the individual, who will try to understand or master this novelty. However, if the object is not mastered and not completely understood, it will be merged with what is already known and expressed by analogy (Moscovici, 1988). It can be concluded, then, that the interaction that the potential user will have with EC is a perception.

According to Hassenzahl, the perceived quality of a product mainly depends on two attributes: the pragmatic aspect and the hedonic aspect (Hassenzahl, 2005). The perception of the instrumental (pragmatic) or non-instrumental (hedonic) qualities is at the origin of consequences in the form of judgements and behaviours (Mahlke, 2008). Moreover, these behaviours and judgements impact the use (Lallemand and Gronier, 2016). The pragmatic qualities refer to the instrumental aspects of the system or product. These pragmatic qualities enable us to reach objectives through action (called do-goals). It is necessary to measure the clarity of the system, its structure or its predictability to understand its pragmatic aspect. The hedonic quality is non-instrumental and refers to someone's pleasure. It is related to the user and is based on the potential of the product to provide pleasure. The capacity of the system to stimulate the user, to connect him with others, to give him a feeling of control or to confer some social status is related to the hedonic quality (Lallemand and Gronier, 2016). For example, research on business management software shows that the hedonic quality of a tool seems to be an important factor in the perception of its users (Schrepp et al., 2006). The challenge here is to study this aspect for EM.

The approach described above includes several tools to evaluate those two qualities (Lallemand and Gronier, 2016):

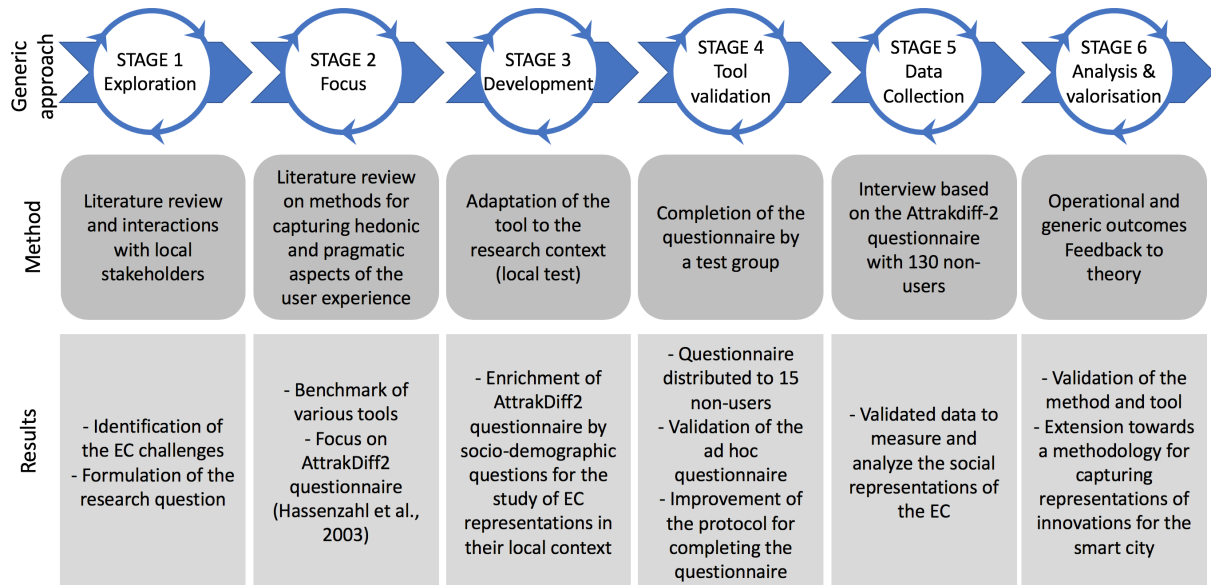
1. The "MeCUE" tool (Minge and Riedel, 2013) is based on Hassenzahl's theoretical model (Hassenzahl, 2003), constructed to investigate the perception of the product, the emotions generated, the consequences of the use and global evaluation of the product. It is composed of 34 items divided into these four previously quoted themes.
2. The *user experience questionnaire* is also based on Hassenzahl's model. It includes 26 items divided into six themes, namely: attractiveness, efficiency, clarity, reliability, stimulation and novelty.
3. The *AttrakDiff-2* questionnaire was created by Hassenzahl (Hassenzahl et al., 2003) and validated by his research. This tool includes 28 items taken across four subscales, namely: pragmatic quality, hedonic stimulation quality, hedonic-identification quality, and global attractiveness.

The hedonic qualities can only be processed by the *AttrakDiff-2* questionnaire (Laugwitz et al., 2008). In contrast to the two previously described tools, this is the only tool that has been translated and scientifically validated into French under the name of (Lallemand et al., 2015). This is an important point because these tools are entirely dependent on language, even on the culture of the surveyed population (Hartson and Pyla, 2012). In their study, Holm and Lehtiniemi show that applying the *AttrakDiff-2* questionnaire in a foreign language (English) to the target population (Finnish) was a significant obstacle to its comprehension as only nine people out of 41 were able to understand and properly answer the questions (Holm and Lehtiniemi, 2011). Thus, the *AttrakDiff-2* questionnaire is the most relevant tool for understanding the SR considering the native culture of users.

Our findings from literature review allow us to design a research method involving an UX-Design tool focusing on representations and supporting the future diffusion of EC.

### 3 Research design

#### 3.1 General method adopted for this research



**Fig. 4** Stages, decision points and result to evaluate existing UX tools and develop a new approach for the representations of ECs.

This study was conducted in the scientific framework of the REVES Chair (Dupont et al., 2015b) under a PPPP (Public-Private-Population Partnership) approach. The main objective of this research project is to engage citizens in tackling major societal challenges. This article focuses on the design of a protocol to understand the possible deployment of ECs based on social representations and a study located in a specific territory. As shown in Fig. 4, the first two steps are a literature review and a first understanding of the study area. Then, we identify the most appropriate collection and evaluation method to analyse the hedonic and pragmatic aspects of the user experience: the already validated AttrakDiff-2 questionnaire in French. The third and fourth stages explain how we enriched the questionnaire with socio-demographic questions and how we distributed it. Finally, collected data are analysed and this research is discussed.

#### 3.2 AttrakDiff-2 questionnaire adaptation

As shown in Table 2, the AttrakDiff-2 is composed of four themes: (1) Pragmatic Quality (PQ) enables us to question the possibility of action by the subject on the system; (2) Hedonic-Stimulation Quality (HS-Q), enables us to know the stimulation caused by the system; (3) Hedonic-Identification Quality (HI-Q), enables us to understand how the user will identify with the system; (4) Overall attraction brings together both qualities to give an overall indicator.

AttrakDiff-2 is presented as 28 semantic differentiators allowing the person being surveyed to adopt a position and to identify him with the relationship and the interaction he has with the interactive system.

**Table 2.** 28 items of AttrakDiff-2 tool

Pragmatic quality	Technical - Human	Hedonic quality – stimulation	Conventional - Inventive
	Complicated - Simple		Unimaginative - Creative
	Impractical - Practical		Cautious - Bold
	Cumbersome - Straightforward		Conservative - Innovative
	Unpredictable - Predictable		Dull - Captivating
	Confusing - Clearly structured		Undemanding - Challenging
	Unruly - Manageable		Ordinary - Novel
Hedonic quality – identification	Isolating - Connective	Attractiveness	Unpleasant - Pleasant
	Unprofessional - Professional		Ugly - Attractive
	Tacky - Stylish		Disagreeable - Likeable
	Cheap - Premium		Rejecting - Inviting
	Alienating - Integrating		Bad - Good
	Separates me - Brings me closer		Repelling - Appealing
	Unpresentable - Presentable		Discouraging – Motivating

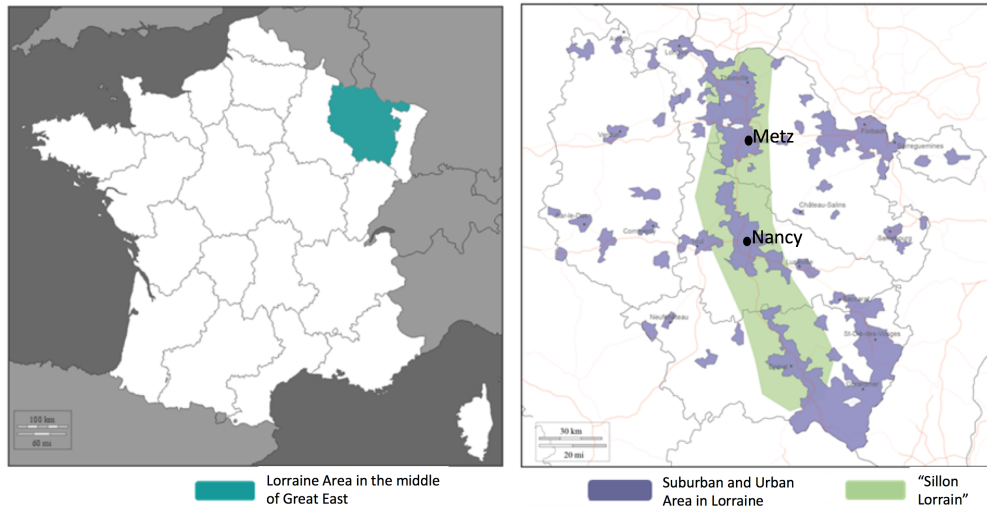
Hassenzahl explains that there are three types of application of the questionnaire: the *unique*, the *before and after use comparison* and the *comparison between two different products* (Hassenzahl, 2010). In the case study presented below, the Hassenzahl questionnaire allows us a unique analysis of the before use of EC. Indeed, the representations are materialised before use and their identification does not require any comparison with the use of the object. Nevertheless, the representations are culturally rooted, and semantic differentiators are strongly dependent on the language. This tool, originally designed in the German language, was translated and validated in English and French by (Lallemand et al., 2015).

User experience rating scales are based on the Hassenzahl, Thüring and Mahlke models (Hassenzahl, 2005; Thüring and Mahlke, 2007). They are based on the usability measurement scales that appeared in the 1980s (Gedigia et al., 1999). Measurement is an important aspect of UX because it gives an objective reading of the users' perception and allows the development and improvement needs of the system to be formulated (Roto et al., 2011; Thayer and Dugan, 2009). Moreover, the questionnaires follow defined rules to produce metrics based on participants' responses. Self-assessment questionnaires are among the most commonly used tools to evaluate UX (Lallemand, 2015). *AttrakDiff-2* respects this logic, so each semantic differentiator is attached to the following metric: -3;-2;-1;0;1;2;3 (Lallemand and Gronier, 2016). The semantic grid of the *AttrakDiff-2* qualifies the values that individuals assimilate to EC and the metric scale makes it possible to measure their quality. All this data will provide a generic and descriptive reading of the representations.

The addition of some socio-demographic questions can enable us to link the representations to social logic, in order to better understand the structure of these representations. The socio-demographic issues added to the *AttrakDiff-2* questionnaire are: gender, postal code, level of education and socio-professional category. Furthermore, the SRs are usually studied through interviews whose results are validated by heuristic saturation. This research offers another method to interrogate the SRs of EC.

### 3.3. Local test: The Sillon Lorrain Case study

Adopting the Marletto strategy (Marletto, 2014), we constructed a local test in a specific area: the Sillon Lorrain. This is a territory of about 23,547 km<sup>2</sup> and 1,200,000 inhabitants concentrated around two large cities and two metropolises. It is also a European axis of mobility. ENEDIS, as a regional stakeholder, and the research team selected this area as an experimental territory. Thus, data collection was conducted on a convenience basis in several towns and cities in north-eastern France (Fig. 5): two main cities, namely Nancy and Metz (urban area with more than 105,000 inhabitants), and several other small cities such as Vandœuvre-lès-Nancy (urban area connected to Nancy with 29,923 inhabitants in 2015), Saulxures-lès-Nancy (suburban area, 4,101 inhabitants in 2015), etc. This area offers a first working basis to test the approach by *AttrakDiff-2*, based on the assessment of four aspects: pragmatic quality (P-Q), stimulation and identification for hedonic quality (HS-Q & HI-Q) and attractiveness (ATT).



**Fig. 5** Geographical location of the study

### 3.4 The sampling procedure

The AttrakDiff-2 tool is used to understand the user experience. It is necessary for the interviewee to have a minimum level of knowledge of the innovation or product to be evaluated. However, we are working on the representations of an innovation. Our target audience is people who have not yet used the EC.

A pre-questionnaire has been distributed to 15 individuals in order to validate our survey protocol or make the necessary corrections. Initially, the participants had to answer the questionnaire alone by choosing the representation degree of the object to a proposed pair of words. For example, the extent to which the electric car is considered as been “Technical” *versus* been “Human” on a scale of -3 (Technical) to 3 (Human), the zero being neutral. The nature of the questionnaire has caused many problems for the respondents. Indeed, the Attrakdiff-2 tool investigates the representations using a complex semantic register. It was very difficult for these 15 respondents to understand for themselves the terms proposed by the tool. It was then decided that each questionnaire should be monitored to help the respondents to understand it. And the research team adapted the form of the questionnaire to facilitate its application.

The respondents’ panel included 131 individuals as described in Table 3. The respondents were selected according to their geographical situation (urban, suburban, rural). They were then selected based on their gender and professional category. Heterogeneity was sought according to socio-demographic variables. All the individuals were interviewed in person in the Lorraine region (north-eastern France).

**Table 3.** Composition of the case study panel.

	<b>Number of respondents</b>
<b>Place of residence</b>	
Suburban	64
Urban	42
Rural	24
<b>Gender</b>	
Male	63
Female	68
<b>Age</b>	
18 to 25 years old	31
26 to 35 years old	32
36 to 45 years old	31
46 to 55 years old	24
56 to 78 years old	13
<b>Income</b>	

from €0 to 1,000	24
from €1,000 to 1,500	34
from €1,500 to 2,000	34
from €2,000 to 5,000	38
Non-respondent	1
<b>Educational qualifications</b>	
<i>French BEP / CAP diplomas</i>	28
<i>French secondary school diploma</i>	21
Two-year university or technical degree	31
Three-year university degree / Bachelor's degree	31
Master's degree or PhD	20
<b>Socio-professional category</b>	
Executives and higher intellectual professions	34
Intermediate professions	37
Employees	28
Workers	10
Others	20
Non-respondent	2
<b>Total</b>	<b>131</b>

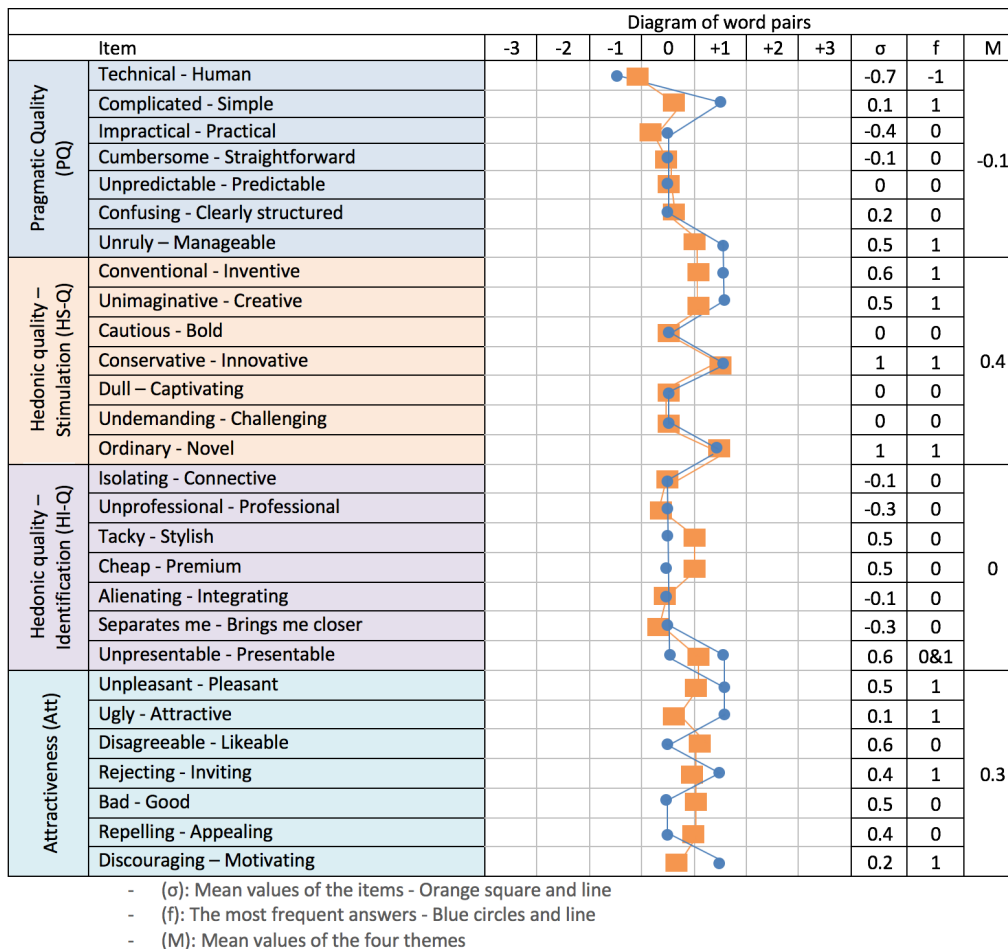
### 3.5 Data collection and analysis

With a panel of 131 people, a qualitative research system was chosen via the design of scientific interviews. The interviews were conducted at home. To complete the panel, a door-to-door strategy was deployed. The interviews were conducted in a time frame ranging from 15 to 25 minutes. Special attention was paid to the explanation and the definition of the notion of “representation” and semantic terms that can be found in the questionnaire to help the interviewees. The same researcher interviewed all the respondents for four months in the second semester of 2016.

All the statistical analyses were carried out with Excel software. This paper focuses on the descriptive mean of the results, followed by a comparative analysis between the different socio-demographic variables.

## 4 Findings

### 4.1 Attrakdiff-2 Score



**Fig. 6** Diagram of word-pairs.

Attrakdiff-2 generates a result matrix according to the word pairs proposed to the persons surveyed (Fig. 6). A focus on word pairs allows us to note that the respondents have a global positive vision of the EC. Indeed, the values that are close to the average (zones 0 to 1) are standard: the product meets its objective without having a negative impact. Values outside this neutral zone are to be considered positive or negative points. Electric cars are generally perceived positively. The majority of them have answered positively except for seven word pairs, in particular “technical-human” with an average value of -0.7. Nevertheless, the other results are limited between 0 and 1 point.

Nonetheless, the results are located within a minimum score. From Fig. 6, it can be observed that the pragmatic (P-Q) aspect is not completely assimilated by the respondents. Thus, while the car is used daily, the EC for its part does not conjure up a vision of ease of use. In the collective unconscious, the respondents associate the EC with major issues of high rates of use. The respondents succeed in identifying themselves with the EC. The projected image of the EC evokes an acceptable, even premium object. For them, the EC is an advantageous object that can be part of their daily life. They considered themselves as identified with the EC and it can be something that gives a certain degree of prestige: “I’m driving the car of tomorrow”, thus producing stimulation. The EC is innovative and tasteful. It evokes novelty and creativity, as qualitative answers seem to prove to us during the informal discussions with the study participants. The EC attracts and intrigues the respondents. With the same logic as the previous items, its attractiveness (Att) succeeds in having a positive score. With an average of 0.3 points, the EC is an object that does not leave the respondents indifferent. And yet, it is neither sought nor desired.

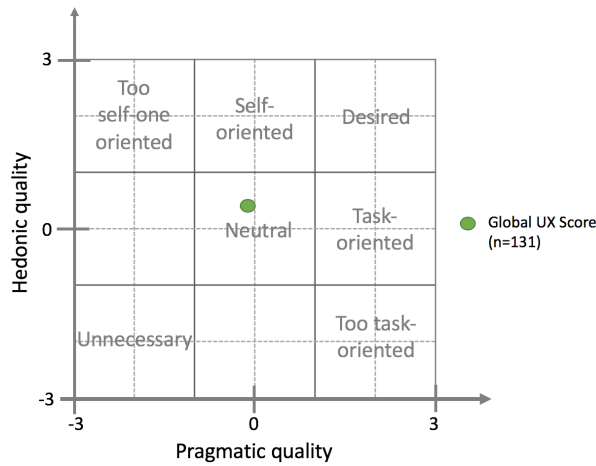
#### 4.2 Portfolio of results

As shown in Fig. 7, the UX score enables us to have visibility of the nature of the product. The EC is a “neutral” object with a “self-oriented” tendency. This result is generated by the *Attrakdiff-2* questionnaire Portfolio of Results. The EC inspires little demand and little desire. Potential users could tend to see the EC



as a “self-oriented” object. It is currently seen as an object, which does not yet generate a strong score in hedonic aspects under 1.

It responds to its primary function: a functional object that has battery-life and charging constraints with which a petrol-powered car is not confronted. The French EM’s stakeholders see the EC as a substitute for the conventional car (Sadeghian, 2013).



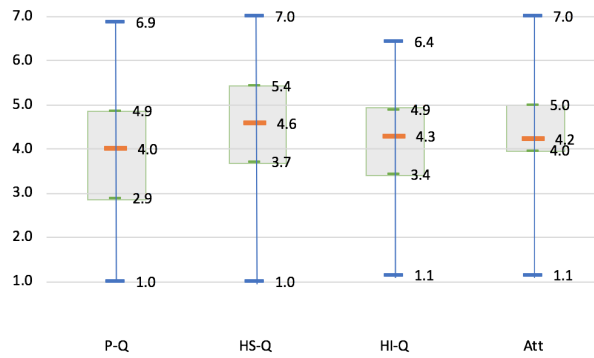
**Fig. 7.** Portfolio of results

It is difficult for the EC to make its mark when confronted with a technology which has existed for 100 years and which is used by the majority of French people every day. The UX score of “neutral” object with a “self-oriented” tendency, expressed by the potential users, demonstrates that users also see the EC as a substitute for the conventional car. Nevertheless, the EC cannot technically ensure the same expectations as the conventional car. It is therefore necessary to increase electric vehicle communication on the hedonic aspects. Additionally, our results from socio-demographic data show that the representation of the EC is not homogeneous. The following sub-sections highlight the differences observed within our panel.

#### 4.3 Diagram of box plot

The box-plot values lead to a global reading of the questioned panel’s representations, as it shows, for each category the minimum and maximum values, the median and also the corresponding quartiles of the distribution. Fig. 8 presents the variability of responses for each item. This graph and the following ones use a scale from 1 to 7. According to (Hassenzahl et al., 2003) the metric from -3 to 3 is transformed into a score from 1 to 7. Thus, the median of all the items (P-Q, HS-Q, HI-Q, ATT) is above 4. Individuals surveyed have a positive image of the EC. They succeed, to some extent, in identifying with the EC and in considering it as an attractive and stimulating object.

Even if the score of the pragmatic quality (P-Q) is slightly negative (its mean value is 3.9 points), its median is 4. Additionally, it is a high variability oscillating between 2.9 and 4.9. The pragmatic aspect is not perceived in a homogenous manner. The variability of the obtained results is also strong for hedonic items (means values: QH-S = 4.4; QH-I = 4). The results are balanced between 3.7 and 5.4 for QH-S item and 3.4 and 4.9 for QH-I item. It is for the attractiveness item (mean value: ATT = 4.3) that the variability is the least pronounced. The first quartile is 4 and the third quartile is 5 with median at 4.2 points.

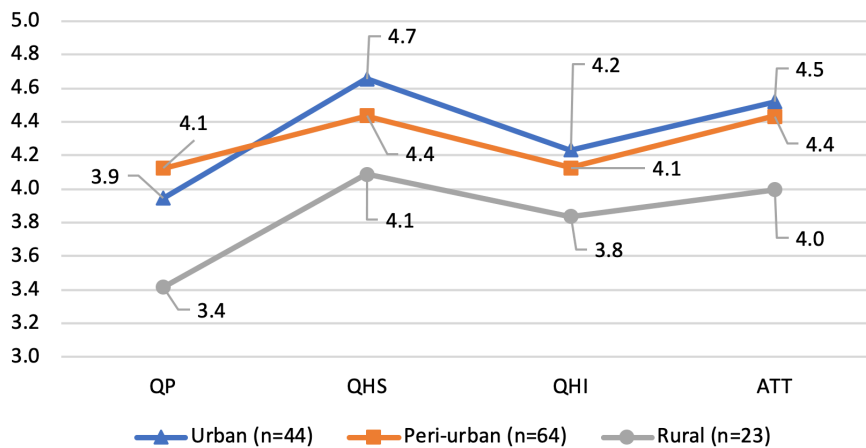


**Fig. 8.** Diagram of box-plot.

As a whole, the EC is absorbed but engenders lack of understanding in its use. The individuals surveyed consider that the EC is not totally convenient. Some elements (the charging system, the battery life) related to the environment handicap the pragmatic aspect of the EC. The individuals, who have never used the EC, project their negative representations onto the potential efficiency of the EC. The image of the latter therefore seems to be rooted in the issue of use.

When they are aggregated, all the results are rather positive. According to the socio-demographic variables, our research provides a more detailed understanding of the situation.

#### 4.4 Residence area



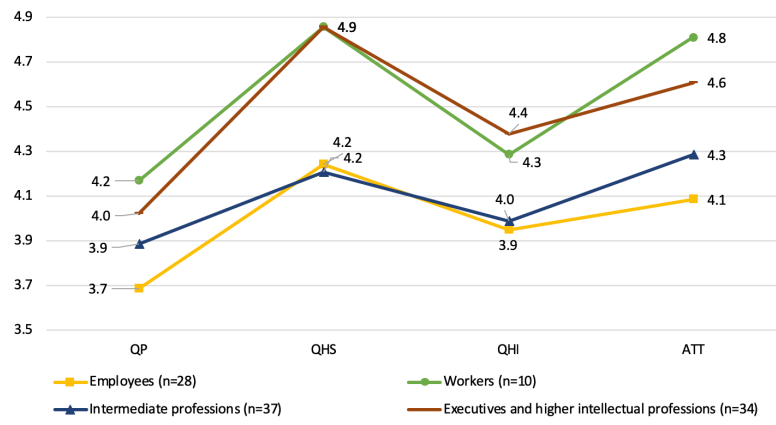
**Fig. 9.** Diagram of average value by place of residence.

The *suburban and urban* values obtained are quite similar in terms of results, except for hedonic-stimulation quality (QHS) with a difference of 0.3 points (Fig. 9). Anchored in the same urban logic (access to public transport, low daily mileage), the representations of all categories of users respect the same logic. Nonetheless, an important point differentiates the *urban* from the *suburban*: access to parking. This point seems to show within the gap (of 0.2 points) the pragmatic quality of the EC.

The difference can be clearly noted between the *rural* variable and the *urban and suburban* ones. Indeed, for the pragmatic quality, there is a difference of 0.7 points. As for the hedonic-stimulation quality and attractiveness, the difference is 0.6 points. These results can be explained by the fact that the relationship to mobility in rural areas is completely different. Depending on the car (subject to very few alternative transport solutions), the individual living in the countryside cannot accept a technology that does not guarantee full freedom of movement. Yet, in France, the EC is still presented as a low-autonomy vehicle (due to battery efficiency) and so does not offer enough freedom.

#### 4.5 Socio-professional category

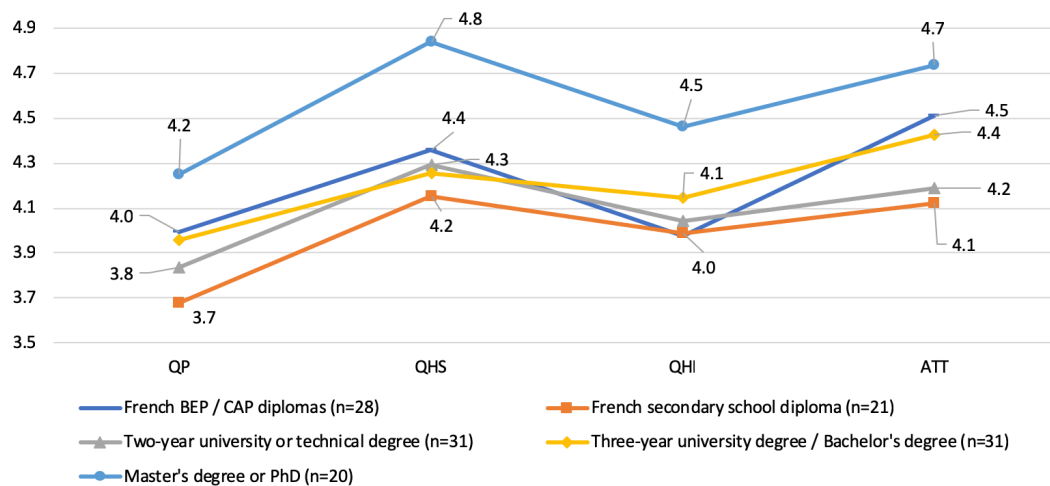
The representations of the EC are not the same according to the socio-professional occupation of the individual. For this analysis we do not consider socio-professional fewer than 10 participants (category “others” in Table 3 including farmers, students, retirees, craftsmen and unemployed people). As shown in Fig. 10, we can see two groups on the curve. The first includes the categories “workers” and “executives and higher intellectual professions”. The second represents “employees” plus “intermediate professions”. Except the Pragmatic Quality (P-Q) where the difference is not clear, the three other themes show a gap of up to 0.7 points between the two groups. The difference is interesting even if it is not easy to explain its origin. We can observe that two very different categories of users, one very intellectual, the other very manual, seem to have an attraction to the EC. The intermediate categories, a priori less typical in their practices, do not seem to develop a particular representation.



**Fig. 10.** Diagram of average value by socio-professional category

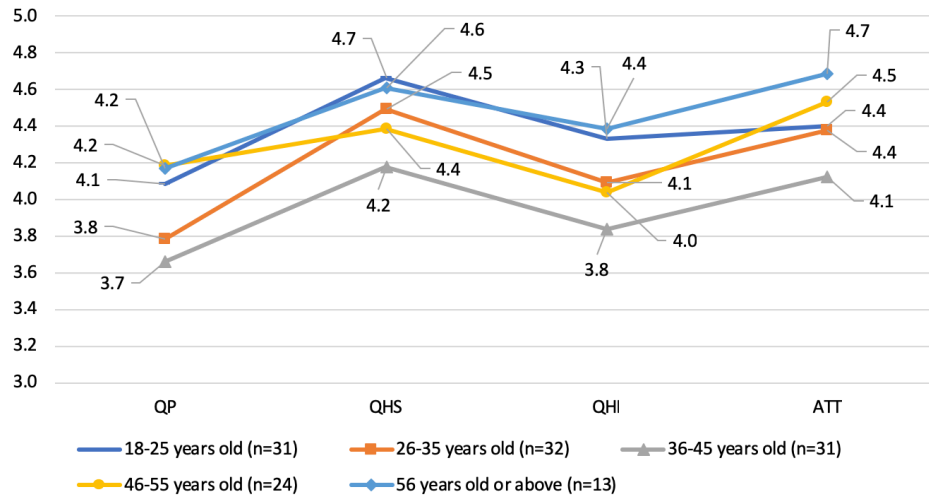
#### 4.6 Educational level

The variable with the best score is the Master’s degree and the Doctorate (Fig. 11). From these results, it can be concluded that the higher the university level, the higher are the average scores. Furthermore, people with French BEP or CAP diplomas (level under French secondary school) have a higher score than people with higher education, except for QH-I where the score is the same for French BEP/CAP and French secondary school diplomas.



**Fig. 11.** Diagram of average value by level of educational.

#### 4.7 Age

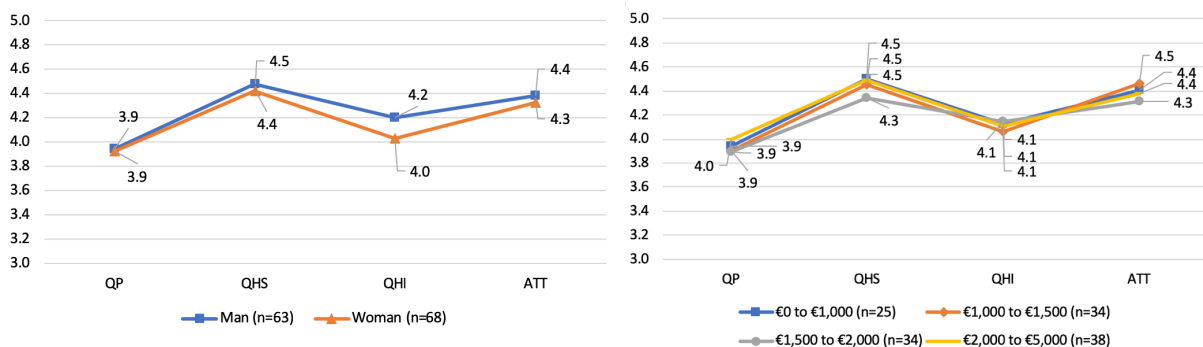


**Fig. 12.** Diagram of average value by age

Fig. 12 shows that the category with the lower score is this of the people who are 36–45 years old (Fig. 12). It is interesting to see that the highest scores are achieved by the youngest and oldest, except for Attractiveness. Indeed, the score for older people is lower than the score for people who are 46–55 years old. Furthermore, if the EC market is to grow in the coming years, it is interesting to see that the younger generation seems to express some interest in it. We cannot identify clearly the reasons explaining the score of people who are 36–45 years old category. Nevertheless, according our data it doesn't necessarily seem to be related to having children or being separated because the distribution of its variables is similar to the 26- to 35-year-old group.

#### 4.8 Variables without impact on representations

The variables gender and income per month do not depend on the representations of the EC. The mean values are quite similar for all the different groups (Fig. 13).



**Fig. 13.** Diagram of average value by gender and by income

## 5 Discussion

The results obtained could be interpreted for the geographical context of the Lorraine Region. Those results allow us to conclude that representations of the EC are mostly positive. In the UX score matrix, the majority of items oscillate between 0 and 1. The hedonic stimulation quality is the most effective, followed by attractiveness, to explain that the EC stimulates the potential users. We can therefore state that individuals are able to imagine themselves using the EC in their daily lives, which makes it more engaging. Also, there are only a few obstacles to pragmatic use of the EC, with the exception of its battery life.

However, the whole system in which the EC is immersed (recharging and its issues of use) represents many obstacles in the respondents' imagination, thus explaining the low score of the UX. So, regarding the obtained results, it could be said that the EC is an object that does not register a negative representation, but which the participants perceive as being in strong competition with the object it is trying to replace. However, its main features are not perceived as being necessarily better. On the other hand, its hedonic image allows it to be more attractive to the potential users, and so they could consider it as a potential choice when it comes to buying a new means of transport. Nevertheless, the perceived pragmatic aspect and its complications of potential use (parking, available recharging system, autonomy etc.) stop them when making this choice.

This study examines the specific contents of the SR associated with potential EC users. The objective for the coming years is to fuel the communication of the EC to provide the basis of SR understanding of the main industrial stakeholders of the EM by helping them to know on which aspects they can rely on for their communication campaign. Indeed, it is not on the pragmatic (Q-P) and identification (QH-I) aspects that the industrial stakeholders of mobility must accentuate their communication but rather on the aspects of attractiveness (ATT) and stimulation (QH-S).

The study allows us to determine which targets are most relevant and sensitive to the EC. Thus, we were able to identify that the most relevant population to use electric vehicles, rural and suburban, are the least attracted to this means of transport. But those individuals with higher occupations who potentially have the means to buy electric vehicles are most attracted to EC.

Strengths of the present study include the relatively large and heterogeneous selected sample from diverse spatial areas across the "Sillon Lorrain". The inclusion of a wide socio-demographic range should also be regarded as a strength.

The method generically evaluates the SR and also examines socio-demographic variables (i.e., place of residence, socio-professional category, education level, gender). It would be interesting to compare SR with other socio-demographic variables such as family status and automotive equipment. Furthermore, it is a much more structured approach as semi-structured interviews and is easily applicable. One limitation of the study is the cross-sectional design, which does not allow causal interpretations. An important issue pertaining to this is whether we can expect people to behave in accordance with their reported respective social representations of the electric car. Nevertheless, future studies should aim to include a comparison between use and representation in order to better understand the rationale of acceptance.

## 6 Conclusion

Understanding the rationale behind spreading an innovation through the prism of use implies an understanding of the mechanisms of the link between innovation and individuals. In the present article we argue that this link is composed of two stages, namely: the representations that an individual generates before using the new object and the ways in which he will use it once he is able to use it

This paper aimed to identify the representations of the EC by using a UX based evaluation tool, the Attrakdiff-2. Among other aspects, the tool has made it possible to qualify the pragmatic and hedonic attributes of the relationship between the potential users and the image and attractiveness they have of the EC. Identifying does not mean understanding. Thus, the Attrakdiff-2 tool crossed with a socio-demographic analysis has enabled us to identify the trails for understanding the rationale behind of the construction of social representations. Our structured approach using the UX design tool could enrich the Marletto scenarios for smart mobility, initially based on two axes: the "propulsion technology" and the "business model". Indeed, we could imagine a third axis as "innovation diffusion" with use as an assessment criterion and considering representations, real use and instrumentation. These data could be used to implement sustainable public policies that promote the emergence of multi-modal mobility based on a technological mix. Furthermore, it could be interesting to reproduce our study regularly to measure the evolution of representations with regard to the diffusion of electric cars. This methodology could also be tested with pure users of EC and see to what extent the methodology discriminates to bring out prospective uses.

Further work will be needed to transpose our approach to other technologies and topics of the Smart City model. Nevertheless, regarding the decision-making process to decide on infrastructure investments, the proposed approach will enrich the purely technical and demographic considerations, enabling decision

makers to simultaneously consider a holistic vision of the project as well as the representation of the technology among the population within the project's particular area of influence. This original approach allows a better understanding of the users' representation. It could be adapted and replicated on different territorial topics for smarter cities involving users and citizens.

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