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Use as essential factor for Technology Adoption: Case study of electric vehicle's uses in French regional Ecosystem

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Abstract— This article explores the interaction between electric vehicles and their users. It gathers the use's determinants of electric vehicle of international studies. Reinforced by a qualitative field study and contextual (focus group). We have identified the determinants of uses valid in north eastern France within electric vehicle users. We posed the foundation for understanding the French use of the electric vehicle. For Then understand, in this article, the influence they can have on the purchase of electric vehicles. Allowing us to establish a critical reading of diffusion of electric vehicles through use.

Keywords— electric Vehicle; Users; UX method; focus group; French use.

I. Introduction

Transportation is the main cause of CO₂ gas. Electric vehicles are one the best solutions to reduce those greenhouse gas emissions. Indeed in France, 90% of energy is CO₂ gas free. Among those 90% energy, 75% is produced by nuclear energy and 15% by renewable energy. The rate of Co₂ emit by the french electrical vehicle is low or very low. [1]

As the relevance of ecologic problems, the french government improve the accessibility of electrical vehicle. They propose financial assistance, wich can upgrade to 10 000 euros (if the owner undo his 10 years diesel car). French leaders mobilizing also on deployment of electric charging point with support policy and global piloting. The french state is supporting a project about 16 000 recharging points on the national territory.

Despite those incitatives, the electrical vehicle market got difficulty to move towards. Indeed, electrical vehicles represents less 1% of vehicles sales in France [2].

According to current scientific research [3] in France electrical vehicle buyers are describe as « Pionners ». And according to Model's Rogers [4] the french market is in the early of his spread state . Industrials and the french government need to find levers to go on the next steps in order to get the mass market.

In view of the potential impact on professions and land use planning, the land actors decide to combine their capacities: Erdf lorraine (French electric network), locals collectivities and University of Lorraine are working together to inform about industrials and societals problematic through the prism of use. But also to propose methology to push forward the mass deployment in a Smart City way of thinking [5].

In the absence of massive users and studies about relative use of territory, France doesn't get any qualitative and contextual visibility on using electrical vehicles from his population. It is necessary to impulse, to implement and to do some research on the user's experiences therewith to support the public and private decision making process for the deployment of electrical mobility.

In this paper, after a literature review relative to electrical mobility of use studies – section 2, we will enrich, share and confront those international uses with a field's study realised by professionals users and private users of electrical mobility in North Est of France (Lorraine area) .

-section 3 is presenting the method used and section 4 is showing the results.

II. Litterature review electric mobility and user-driven approach

A. User-driven approach

[6] highlighted in literature, role and attitude of users have significantly evolved in the conception. They become a mandatory chain link in user's center approach. So, many perspectives to catch them income: for example the contextual concept [7] the emotion concept [8], the user experience concept [9].

Resuming the holistic vision of interactions between Man-Machine from Norman, user experience's has to describe and understand the differents relations between an person and a system [10]. « Technology Experience refers to something

larger than the usability or to its dimensions such as satisfaction or attitude » [11].

Based on the method of UX [12], we focused our analyses on emotions, usability, behaviour, attitude, satisfaction and human's interactions.

For us, all those approaches have a specific purpose: integrate population's uses in the conception and diffusion's process . User's approach allowed to support those two innovation process's steps by qualitative elements due to their concrete nature. We try to supply electrical vehicle's innovation process: modifications about step's conception and political deployment (economic, territorial, legal, etc) to help the diffusion's step. Then, we had to describe and qualify electrical vehicle's use and users therewith identify determinants who impact the acquisition of one.

B. Electric mobility's Usages

There are some studies about electric vehicles. Never the less, most of them have been done overseas. Among those studies, one [3] took place in France. So we had to look after the determinants relating to use. We did observe the interactions between three elements : users, system and environment [13]. They have been screened by their concrete relation and thematic application of UX (emotions, usability, behaviour attitude, satisfaction and human's interactions [12].

Our review of the literature is essentially based on 4 authors ([14] [15] [16] [17] [3] and one review of literature [18]. Completed by 26 others authors. This shows us that the use of the electric car is a subject strongly present in the literature. Studies of the literature review are recent, indeed most date after 2010

n°	Determinants of review	Sources
1	Having a driver license	[16]
2	Act to will for the environment	[14]/[19], 2014 / [20]/[21] / [22] / [23] in [18].
3	Ability to accept change to means mobility	[24]/ [25]
4	Positive sensitivity to the electric car	[14]/ [15]
5	Sensitivity to new technologies	[24]/ [25]
6	Ethical relationship with the entourage of the user	[26]/ [27]/ [28]/ [29] in [18].
7	Guilty's diminution to consume	[14]
8	Necessity of presence at the workplace when charging	[16]
9	Need to be at home when charging	[16]
10	Daily trip does not require charging for return	[16]/ [17]/ [3]
11	Daily trip require charging for return	[16]/ [17]/ [3]
12	Positive feeling about driving (questioning the speed and time related to mobility)	[14]
13	Creating positive emotions (relaxation, stress reduction while driving)	[14]
14	Performance felt positively	[15]

	(acceleration)	
15	Performance felt positively (speed)	[15]
16	The decrease of noises positive felt	[15]
17	Reduced CO2 emissions positive felt	[14]
18	Usability felt positive (not including charging point)	[15]
19	The car manufacturer origin	[29]/[30] in [31]
20	Estheticism of the car	[29]
21	Feelings about safety related to new energy (batteries that can catch fire)	[29]
22	Consideration of disabling nature of autonomy	[32] / [33]
23	Durability of the battery's performance of the car all along the use of the household	[34]/ [35]
24	Aid for the purchase of the French state	[17]/ [27]/ [36]
25	Cost of purchase	[37]/[14] / [38]/ [29]/ [39]/ [40]/[41] in [18].
26	Operating costs (electricity)	[42]/ [29]/ [39]/ [43]/ [40]/ [41] in [18]
27	Maintenance cost	[42]/ [29]/ [39]/[43] / [40]/[41] in [18]
28	Economic return of the use of electric vehicles	[42]/ [29]/ [39]/ [43]/ [40]/ [41] in [18]
29	Having charging stations at the workplace	[30] in [31]
30	Having charging stations on roads with high attendance (motorway, highway)	[30] in [31]
31	Having charging stations by the living areas (market, supermarket, public square, railway station etc.)	[30] in [31]
32	The nature electricity's origin (France: 90% of non-thermal (75% nuclear, 15% renewable) and 10% thermal)	[14]/[19], 2014 / [20]/ [21]/ [22]/ [23]
33	The vehicle's cost on household buying power	[16]
34	Household's ability to reimburse	[16]
35	Having a place to park next to home	[16]
36	Possession of a garage attached to home	[17] / [3]
37	Possession of a garage attached to apartment	[17] / [3]
38	Necessity to be owner residence	[17]/ [3]
39	Having multiple cars (minimum 2)	[16]/ [17]/ [3]
40	Flexibility of the main car with the electric car	[17]/ [3]
41	Frequent long trips monthly	[17]/ [3]/[16]

Figure:
Overview of the determinants of the use of electric vehicle in the literature

Lopes and all inform us that parking accessibility is essential in electric vehicle's use. But according to the nature of the determinant, (having a place to park far from home, having a place to park next to home, garage attached to home) this may determinate the acquisition's access. For this example, we

split 1 determinant of literature review in 3 determinants. We used this approach for «daily trips» and «geographical location of charging points».

In this part, we showed that in literature there are a lot of studies. They helped us to sustain our thoughts about electric mobility's use. So, we combined in this paper, all determinants connected to use. Reflecting to our centered users's approach, we develop a method integrating the users inside the research. That's why we are going to discuss our review to the ground's reality.

III. Research approach

Our overall approach is summed up in 3 phases. A summary of the literature: we extracted the usual determinants of electric vehicle. We wanted to complete the synthesis by the use of ERDF professionals. 3 focus groups were made to identify other determinants not from the literature.

A review of the literature reinforced our production. Then we validate the determinants by making 12 interviews from French users of electric cars. To conclude, we try an explanation and understanding's tentative of the influence of determinants.

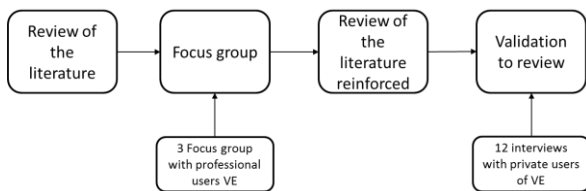


Figure:
Synthesis of our approach

A. Focus group

Within the enterprise of ERDF an exploratory survey was established though 3 focus groups [44] because ERDF got a lot of electrical vehicles, this enterprise get offenly feedbacks with their employee. Some of the employee got their own electrical vehicle are invited to share their experiences. Groups were composed by 5 to 8 persons[45]. We counted 20 different people. All focus groups were audio-recorded, transcribed, anonymized, and checked for accuracy to aid data analysis.

We use the constant comparative method [46] to identify the patters through the full data.

B. Review consolidated

We could identify the missing determinants in the review of literature that we put into a table.

C. Validation to consolidate's review

Then we have confronted those determinants to the fieldwork asking the users. So we met 12 heterogenous people. Those people were different as social criteria (family status, activity, age, sex) as structural criteria (housing typology, environment residential, type of vehicle and type of acquisition).

Sex	Age	Social status	Habitat	Family status	Acquisition	VE's model	use's historic	Area of habitat	N°profile
M	28	Executive officier	Single-family home	Family	Leasing	Zoé	6Months	Peri-urban	1
M	54	Executive officier	Single-family home	Couple	Leasing	Zoé	2 years	Peri-urban	2
M	55	Executive officier	Single-family home	Family	Leasing	Zoé	2 weeks	Peri-urban	3
F	28	Employee	Single-family home	Family	Leasing	Zoé	8 months	Peri-urban	4
F	55	Employee	Single-family home	Family	Leasing	Zoé	1 months	Peri-urban	5
M	50	Executive officier	Single-family home	Couple	Purchase	Nissan Leaf	2 years	Peri-urban	6
M	40	Employee	Apartment	Couple	Purchase	Smart	3 year	Urban	7
M	more 60	Retiree	Single-family home	Couple	Leasing	Zoé	6 months	Rural	8
M	more 60	Retiree	Single-family home	Couple	Leasing	Nissan Leaf	2 years	Rural	9
F	more 60	Retiree	Single-family home	Couple	Leasing	Nissan Leaf	2 years	Peri-urban	10
M	more 60	Retiree	Single-family home	Couple	Purchase	Zoé	1 year	Peri-urban	11
F	more 60	Retiree	Single-family home	Couple	Purchase	Zoé	1 year	Rural	12

Figure:
socio-demographic data on the population surveyed

D. The sampling procedure

The study has been realised in Lorraine area (North Est of France). Only one interviewer was leading the interviews therewith to get a hystorical and to limit the risk of different interpretations.

It was pretty hard to met the user panel. Indeed, any association and institution have been working on establishment of a list. In the french law through the CNIL (national comission of informatic and liberty) forbidden the construction and the diffusion of people list. We used the application CHARGEMAP to find users (of electrical vehicle) . This site aggregate people who propose private recharging points for electrical vehicles. Then we call them. There is 30% of refusals interviews.

E. The interviews

So we asked the interviewed to speak freely about their feedback, and to tell what they really think about electric vehicles. Then we ask them more precisely on the use and acquisition of their electrical vehicle.

We also ask in-depth about the reasons and the context (personal, family or environment) of any determinants identified in the literature. The interviews were holding from 40 to 80 minutes. The interviews were recorded, and notes have been written during the interviews.

F. The analysis of data

We also focus on the validation of criterias in literature and the description of what really care for individuals. Our work is based on the similitary concept to endorse criterias. Concerning the causes of heuristic explanation of determinants, we used an analysis based on ground theory[46]. Wich stand on data field and situational appearance. During our study, datas are collected, transcribed and analysed simultaneously as explain in the « enracinée » theory method[47].

IV. Findings

The focus group is a way to prepare an investigation. It is a method of exploration[48] for questioning users beside the system [49]. The focus groups have allowed us to complete the determinants.

A. Focus group

n°	Focus group determinants
1	Necessity to replace an old vehicle
2	Experimented use of electric vehicle
3	Possibility to sell the vehicle as second hand
4	Easy identification (visibility in user's nearby environment) of electric charging stations
5	Having quickly and easily information's access to the

	availability of a recharging point
6	Reloading time of the electric vehicle

Figure:

Summary of the determinants generated by the focus groups

- 1- *Necessity to replace an old vehicle* : For us, it is important to check if the attraction of electric vehicles may be related to the need of a substitute's means of transport.
- 2- *Experimented use of electric vehicle*: after focus group, we realised that the participators who had already try an electric vehicle (in theirs work environment or in theirs private environment) could be affected by acquire one; but it is the same thing for reverse ? The fact that the participators never try an electric vehicle before could be a restriction to the electric mobility's access.
- 3- *Possibility to sell the vehicle as second hand*: we try to understand why, most of the people, are following leasing during acquisition of electric vehicle.
- 4- *Easy identification (visibility in user's nearby environment) of electric charging stations*: we would like to know about format and frequency's information of recharging point. Moreover, we are wondering about the shape of a charging point.
- 5- *Having quickly and easily information's access to the availability of a recharging point*: we would like to know, what would be the best way to inform users : tools and information's nature.
- 6- *Reloading time of the electric vehicle*: Time is experienced differently depending on the individual. Time can be both, a constraint and a facilitation factor.

B. Validation to consolidate's review

Déterminants	Profils												TT
	1	2	3	4	5	6	7	8	9	10	11	12	
Necessity to replace an old vehicle	x	x	x	x	x	x	x	x	x	x	x	x	12
Having a driver license	x	x	x	x	x	x	x	x	x	x	x	x	12
Act to will for the environment			x	x	x	x		x	x		x	x	8
Ability to accept change to means mobility	x	x	x			x	x		x		x		7
Positive sensitivity to the electric car	x	x				x			x		x	x	6
Sensitivity to new technologies		x		x	x	x					x		5
Ethical relationship with the entourage of the user				x	x		x		x	x	x		6
Guilty's diminution to consume				x	x	x	x		x			x	6
Experimented use of electric vehicle	x	x	x			x			x				5
Necessity of presence at the workplace when charging													0
Need to be at home when charging													0
Daily trip does not require charging for return	x	x	x	x	x	x	x	x	x	x	x	x	12
Daily trip require charging for return						x			x			x	3
Positive feeling about driving (questioning the speed and time related to mobility)	x	x	x	x		x	x	x	x	x	x	x	11
Creating positive emotions (relaxation, stress reduction while driving)	x	x	x	x		x	x	x	x	x	x	x	11
Performance felt positively (acceleration)	x	x	x	x	x	x	x	x			x		9
Performance felt positively (speed)	x	x	x	x	x	x	x	x			x		8
The decrease of noise positive felt	x	x	x	x	x	x	x	x	x	x	x	x	12
Reduced CO2 emissions positive felt			x	x	x	x		x	x	x	x	x	9
Usability felt positive (not including charging point)	x	x			x		x		x		x		6
The car manufacturer origin	x		x	x	x			x			x		6
Estheticism of the car	x	x	x	x	x								5
Feelings about safety related to new energy (batteries that can catch fire)													0
Consideration of disabling nature of the autonomy			x		x			x	x	x			5
Possibility to sell the vehicle as second hand						x	x			x	x		4
Durability of the battery's performance of the car all along the use of the household	x	x	x	x		x		x	x	x	x		9
Aid for the purchase of the French state	x	x	x	x	x	x	x	x	x	x	x	x	12
Cost of purchase	x	x	x	x	x		x	x	x	x		x	11
Operating costs (electricity)	x	x	x	x		x	x	x			x	x	9
Maintenance cost	x	x	x	x		x	x	x			x	x	9
Economic return on the use of electric vehicles	x	x			x	x	x						6
Easy identification (visibility in user's nearby environment) of electric charging stations				x	x	x			x	x	x	x	7
Having charging stations at the workplace	x	x	x	x	x	x	x	x	x	x	x	x	12
Having charging stations on roads with high attendance (motorway, highway)	x		x			x	x	x	x		x	x	9
Having charging stations by the living areas (market, supermarket, public square, railway station etc.)				x		x	x	x	x			x	6
Having quickly and easily information's access to the availability of a recharging point	x	x	x	x	x	x	x	x	x	x	x	x	12
Reloading time of the electric vehicle		x	x			x	x		x	x			6
The nature electricity's origin (France: 90% of non-thermal (75% nuclear, 15% renewable) and 10% thermal)						x	x		x				3
The vehicle's cost on household buying power							x				x	x	3
Household's ability to reimburse							x						1
Having a place to park next to home	x	x	x	x	x	x	x	x	x	x	x	x	12
Possession of a garage attached to home			x	x									3
Possession of a garage attached to apartment	x	x	x	x	x	x	x	x	x	x	x	x	12
Necessity to be owner residence												x	1
Having multiple cars (minimum 2)	x	x	x	x	x	x	x		x	x	x	x	11
Flexibility of the main car with the electric car	x	x							x	x	x	x	6
Frequent long trips monthly	x								x	x			3

 : Users who accessed the electric car by leasing

Figure:
Summary of interviews of electric vehicle's users

Determinants 1, 2, 12, 14, 15, 16, 18, 19, 26, 27, 28, 33, 34, 36, 41, 43, 45 have been validated by the interviewees. For them, these are key determinants in their uses and the acquisition of their electric cars. As validated by different populations in different social and environmental contexts, we can assume that they are generic in nature.

Through testimonies, the essences "pragmatic" of determinants were mentioned many times. Indeed, "*Possession of a driving license*" (det 2) is required to drive a car.

It is the same for "*Necessity to replace an old vehicle*" (det 1). In view of the typology of households surveyed, acquire a vehicle by simple desire or enjoyment of a new acquisition is not intrinsic to the individual.

Another pragmatic criterion is « *Cost of purchase* » (det 28), our respondents find it too elevated. But this one who hides another truth: user's unanimous ascertainment that car manufacturers sell significantly more expensive electric vehicles to take advantage of government assistance (10 000 euros subject to a condition). A move understood by users but they strongly condemn. It expresses the fact that a risk is taken from them because they are pioneers in a new means of mobility. For the users, there is no real incentive to help the purchase. It benefits only vehicle manufacturers. "*Aid for the purchase of the French state*" (det 27), is therefore not an element that will encourage. It is a determinant that allows inclusion of the electric car in the choice of a replacement vehicle. Government assistance does not fulfil its incentive function.

"*Operating costs (electricity)*" (det29) and "*Maintenance cost*" (det 30) are also both expressed determinants as pragmatics. They are important in post-acquisition vehicle. Users have informed us that automobile dealership told them about low costs for use of the electric car. But users are suspicious about this announcement. When acquiring, they transfer the logic of uses thermal's vehicle (generating many costs to use) to electric car. This explains that the determinant "*Economic return on the use of electric vehicles*" (det 31) is composed of uncoordinated responses. This determinant is important for all interviewees but depends on the accuracy and authenticity of the speech of seller automobile. Something relatively few expressed by the profession.

Concerning charging stations for electric vehicles: "*The nature of the origin of electricity*" (det 38) or "*recharge time charging stations*" (det 37) it is not important for the interviewees. These elements are conscientized when

purchasing the vehicle and integrated by users is not possible to change in a short time.

It's the same for the availability of charging stations outside (det 33, 34, 35). Users are aware that outfitting the territory with charging stations is not possible in a short time. For them, it is necessary to concentrate efforts towards workplaces equipment with policy incentives. This is explained by the fact that the electric car is mainly choose to commuting to work and attached trips. For interviewees, it's essential to include a point of recharge in their workplace (whatever power recharging).

A sensitive issue was raised by two of interviewed: Access to electricity at the workplace was seen as a benefit by his colleagues. As a result, the leadership halted his access. This is a determinant bound to the French context. It is highlighted that the French state needs to position itself about the electricity access in enterprises.

Having quickly and easily information's access to the availability of a recharging point (det 36) is fundamental. For users, information must be reliable and updated. This applies above all for long trips (det 47) conducted by electric vehicles. There is an inherent risk of not being able to go back home or not to find a charging station. This risk prevents users to travel over long distances. That's why users generally respond that they needs more outfit roads (det 34) instead of living areas (det 35). Indeed local trips that can be done without necessarily charging.

Having a place to park next to home (det 41) is important for users. Interviewees can not recharge the car anywhere else except their home. Some of them find it necessary to have a garage (det 42). Security is one of the reasons expressed (fear of damage to their equipment or stolen charging cables). In an peri-urban and rural environment, the interviewees say that it is not necessary to have a garage. The residence is characterized by a larger space than houses. They can park their car at residence (Secure space symbolically by the concept of property) without necessarily parking it in a garage. On the urban environment, the property is defined primarily by the door of home. This explains that users living in town absolutely want a garage for their electric vehicle.

Necessity to be owner residence (det 44) is not essential. Being a tenant can take additional steps for installing charging stations at home but do not play on the motivation of wanting an electric vehicle.

Not having multiple cars (det 45) is eliminatory. The constraint of autonomy and the lack of alternatives by the territory does not allow him to make a long trip.

Although it became the leading household car, the electric vehicle is a complement to the thermal car.

For other people, it changes discreetly the way they move. Indeed, most interviewees expressed that their driving behavior changed. Driving is no longer seen as an anxiety action. It's positive now. Some said to put into question, on a daily journey, speed and time. For example, a person was capable to change his trip to loose from 5 minutes to 20 minutes journey (A path done for years). In order to save battery. The majority of interviewees expressed a game installed in their conduct: today how will I reduce my consumption?

The report to the conduct is changed. For the users, the performance of the electric car is greater than the thermal vehicle. The determinants "*Performance felt positively (acceleration)*"(det 16), "*Positive felt the decrease in noise*"(det 18) brings a feeling of relaxation and reduced stress (det 15). Driving an electric car does not produce a lot of greenhouse gas and is cheap from use; it reduces a sense of guilt users.

The daily trip distance isn't really important for users. The fact of recharging (12, 13) is cripple. If users are in this situation, they would not have bought electric car.

This shows a very important aspect of the new report from users of the vehicle relative to their means of transport. The electric car, due to the constraints of distance, is purchased for a certain function. We are faced with an object that no longer allows total freedom but essentially meets a specific need and limited. Future users are aware during acquisition. Similar to the bus or train, the individual is limited by the linearity of the journey, the individual using the electric vehicle is limited by autonomy (circumference limit). Unlike thermal cars, we are in a conscious and rational mobility. The low use of public charging stations is partly explained by this phenomenon.

The last item raises awareness to acquisition of electric vehicles is its changing nature (det 25, 26). To cope with this issue, interviewees are mostly leased. We note that before the electric vehicles, means of transport owned their users. Two reasons are expressed: the first one is economic. The cost of the purchase to electric vehicle is too high compared to the risk of being pioneers in this innovation. The second one is expressed is the determinant 26 "*Durability of the battery performance of the car throughout the use of the household*". Indeed, the rapid evolution of science is a anguish for users. Users do not want to be locked into a technology limitation. Then they see the new electric car models that reply their desire about unlimited autonomy. Habits (unlimited consumption) imported by thermal car resurface in hopes of users.

Conclusion

This paper leads us to discover the determinants related to the use of electric vehicles. We interrogated the influence they can have on the acquisition of electric vehicles. We were able to identify the determinants shared by all users and those requiring a deepening in their analysis. This work showed that the determinants are not excluded from a social environment. Analysis of determinants can be achieved through a comprehensive approach.

We proposed here an exploratory method that allowed us to validate the determinants in their context. And to see the links between determinants and their contexts. We would like to define more specifically the uses of electric vehicle by reading their hedonic and pragmatic's aspect. Next study will be the implementation of AttrakDiff2 survey [50], inspired by the approach by use [12] wich will distributed to users and non-users of electric vehicle.

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