D9.1: Use cases value proposition considering the whole ecosystem

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T9.1: Preliminary analysis of use-cases. Users value network definition and Innovation penetration curves and demand scenarios

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Technical References

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Project Coordinator	CIRCE mzarzuela@fcirce.es
Project Duration	01/2020 – 12/2023

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[1] PU = Public

PP = Restricted to other programme participants (including the Commission Services)

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Document history		
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0.8	19/07/2022	Qi Arrow – First Draft
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0 EXECUTIVE SUMMARY

This document is the deliverable "*D9.1: Use cases value proposition considering the whole ecosystem"* of the H2020 project INCIT-EV (project reference: 875683).

INCIT-EV project aims to demonstrate an innovative set of charging infrastructures, technologies, and its associated business models, ready to improve the EV users experience.

The present report contributes to design the business models for the wide replication of the innovative charging infrastructures that will be demonstrated in 7 use cases. More specifically, it focuses on one of the key aspects of the business model, which is the value proposition.

Electric-vehicle (EV) charging solutions are complex systems of systems. Although a single charging point may seem simple, it may be virtually connected to other charging points to offer aggregated grid services and backed by information and communication technologies (ICT) that coordinate the booking, activation, and billing of the charging session, creating a complex system of systems with many stakeholders involved and multiple points of interaction with the end-user that ultimately could increase or reduce the barriers for massive adoption.

Being aware of the complexity of EV charging solutions in general, and INCIT-EV solutions in particular, this deliverable provides a structured approach to 1) analyse users' requirements, 2) match those requirements with the solutions' attributes, 3) analyse other stakeholders' requirements, and 4) match the objectives of different stakeholders in the ecosystem.

The report gathers information that was previously dispersed within the project consortium, but also deepens into the knowledge of the pains, gains and fears of the value chain and the end customers using primary sources (interviews with EV users and companies in the sector). The information is structured using well known modelling tools such as the value proposition canvas, the House of Quality, or the e3-value model tool, and finally analyse the results to extract conclusions that will be used to improve the value proposition and elaborate a complete business model canvas in subsequent project tasks.

The delivery of this report is done in accordance with the description in the Grant Agreement Annex 1 Part A with a deviation of 8 months behind of the initial schedule and no content deviation from the original planning.

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1 INTRODUCTION

1.1 Background

Today, the lack of attractive business models for charging infrastructures are hindering the EVs EU-wide deployment. INCIT-EV aims to demonstrate an innovative set of charging infrastructures, technologies, and its associated business models, ready to improve the EV users experience beyond early adopters, thus, fostering the EV market share in the EU. The project is setting up 5 demonstration environments at urban, peri-urban and extra-urban conditions for the deployment of 7 use cases, addressing:

1. Smart and bi-directional charging optimized at different aggregation levels
2. Dynamic wireless charging lane in an urban area
3. Dynamic wireless charging for long distance (e-road prototype for TEN-T corridors)
4. Charging Hub in a park & ride facility
5. Superfast charging systems for EU corridors
6. Low power DC bidirectional charging infrastructure for EVs, including two-wheelers
7. Opportunity wireless charging for taxi queue lanes in airports & central stations

These use cases pursue innovations in the current charging solutions as well as their seamless integration into the existing transport, grid, ICT, and civil infrastructures. For this purpose, the INCIT-EV Platform will be developed comprising a DSS and a set of APPs addressing the users and e-mobility stakeholders' needs.

1.2 Objective

The objective of this report is to present the process and the results of the **value proposition design**, that has been done considering the whole ecosystem around the 7 use cases and defining the interrelations and exchange of value among stakeholders.

This work is a starting point to address the lack of attractive business models for charging infrastructures (that will be finished in T9.3). Using Osterwalder and Pigneur's Business Model Canvas as reference, this report aims to contribute to 1) the *customer segments* block, by considering the users' perspective and other relevant stakeholders' expectations in a more accurate way; 2) to the *value proposition* block, by identifying the attributes of the charging solutions that match the users' demands; and 3) to the *key partners* block by drafting the value network involved in each use case.

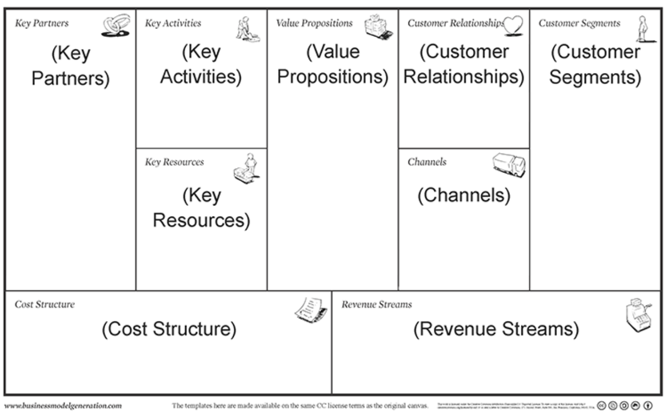

Figure 1. In yellow, blocks in the business model canvas to which this report contributes.

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1.3 Scope

To meet the main objective, this work has focused on the following specific objectives:

- To select the right **methodology** to user-centric and systemic value proposition design
- To analyse the actual **needs**, gains, and pains of the final users of charging infrastructure
- To analyse the charging **solutions** and INCIT-EV platform functionalities provided in the use cases
- To define the **value proposition**, i.e., matching of EV user needs with charging solutions
- To define the **value network**, i.e., the interrelations and the exchange of value among stakeholders
- To define the **architecture** of the global mobility system to be designed, highlighting how activities and resources are combined to deliver value.

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2 METHODOLOGY

The purpose of this chapter is to present the elements of methodology that support the design of the value propositions, the exploration of use cases and the modelling of the value ecosystems, in the sense of Business Modelling.

2.1 Introduction

Incit-EV aims to demonstrate the assumption that the proposed use cases, enabled by innovative technologies, will improve users' experience when charging electric vehicles and, as a results, will eliminate existing barriers and speed up the adoption of electromobility.

Although technology plays a very important role in the adoption of new charging solutions, there are many other factors that influence the result: from the adequate design and delivery of the solution to the right customer segment, to the coordination of the supply chain to create a seamless user experience or the consideration of second order impacts on stakeholders that may create barriers to the deployment of the envisioned business case.

Being aware of the complexity of the problem, INCIT-EV consortium has proposed an incremental analysis methodology consisting of the following steps:

1. **Analyse end-user needs**. To this end, users will be characterized, segmented and finally several users-persona will be formalized. In this step, the stakeholders to whom the solutions will be addressed, i.e., the clients and/or users of charging infrastructures (*category 1*). This analysis is understood in the sense of their needs, i.e., their expectations, the problems they wish to solve, as well as their fears.
2. **Analyse the functionalities of the charging technologies proposed**. Beyond the technical specifications, user-oriented functions must be clearly stated.
3. **Analyse the value proposition**. I.e., determine whether the functionalities provided by the charging solutions in each use case satisfy the user needs. This step will result in a preliminary value proposition from the viewpoint of the main business firm.
4. **Analyse the value network.** This analysis aims to widen the scope of the analysis to include those stakeholders that participate in the elaboration or delivery of the value proposition (*category 2*), as providers of components and services along the supply chain. In addition, other organizations with stakes in the mobility ecosystem (e.g., affected by the impacts of externalities such as traffic density, pollution,

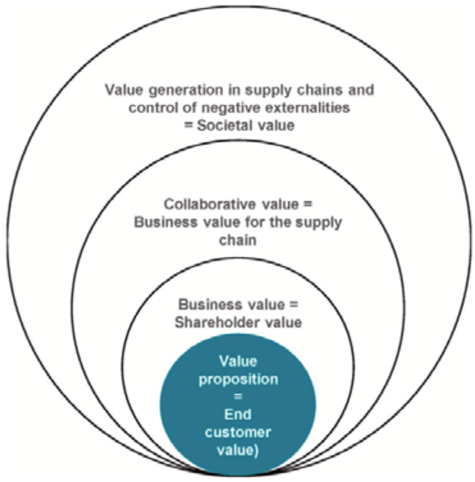

Figure 2. Meta-model comprising the views of business models, value networks and business ecosystems

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noise, etc.) will be also considered, including public administrations, associations, etc. (*category 3*). As a result, a value network will be drawn.

5. **Analyse the ecosystem architecture / application of the value network to the system design / feedback to the system design….** The methodology can be complemented with a final step, which is the definition of a set of guidelines (architecture) to help different engineering profiles to design a charging ecosystem that is compliant with the user and business perspective (i.e. value network).

The technologies and solutions to be tested are already defined. But the business models are still open because value creation and exchange will change over time to fit multiple interests from known and unknown players.

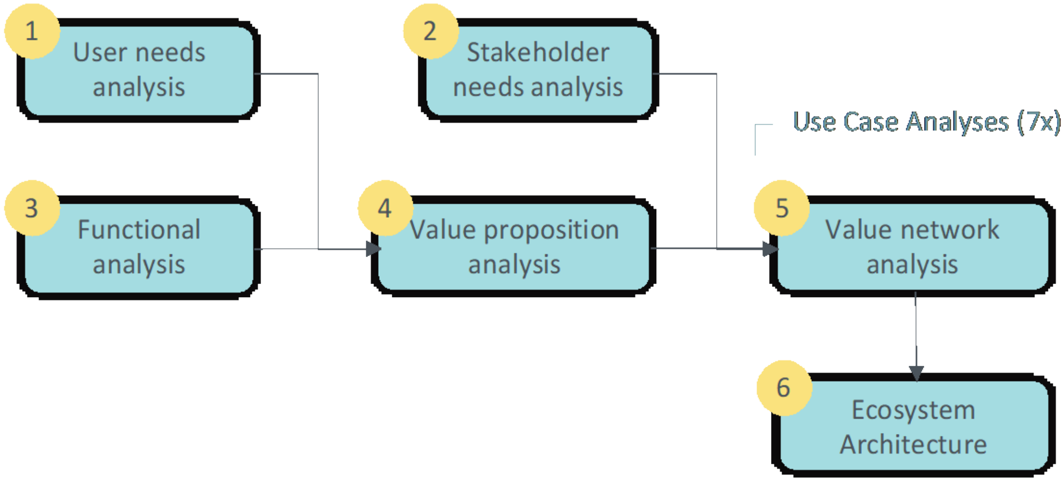

Figure 3. Methodology. Steps 2, 3 and 4 are performed for each Use Case. Steps 1 and 5 are common.

This methodology aims to perform several analyses to shed light on the existing gaps and the alternatives to configure a sound value proposition at ecosystem level. In the following sections, the steps of the methodology are further described.

2.2 User needs analysis

This analysis is based on the interviews that Bitbrain arranged with current and potential EV users within INCIT-EV's WP2. Using the interviews as input, the methodology consists of a qualitative analysis aiming to select the most relevant factors that could be of use to define the driving habits and the motivations or barriers to adopt an EV charging solution. E.g., type of vehicle, trip planning, age, etc.

Based on the most relevant characterization factors, an exploratory analysis should be done with real users' data to group them into clusters or segments.

Finally, the **formalization of users-persona** is done, resulting in a summarised description of a fiction character that represents one of the potential customers segments. This profile will be used in the subsequent steps.

The user needs analysis is initially performed once to share a few users-persona that may be relevant for all the use cases. However, it is open to add new profiles if needed by any demonstrator/pilot.

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Instructions and considerations for this analysis are provided in *"Annex I. Methodology for the analysis of end-users' needs"*.

2.3 Stakeholder needs analysis

This analysis is based on the interviews arranged with potential stakeholders of INCIT-EV's charging use cases. Using the interviews as input, the methodology consists of a qualitative analysis aiming to identify the needs of several stakeholder groups. Specifically, the needs are categorized in:

- Need to overcome the threats that other players or factors represent for their interests in the new electric mobility ecosystems.
- Need to leverage the opportunities arising from the changes that EV infrastructure deployment and EV mobility will create.

The summarized and categorized needs of stakeholders can be used in the value network analysis to balance the value exchanges and create business models that maximize benefits for the whole ecosystem.

Instructions and considerations for this analysis are provided in *"Annex II. Methodology for the analysis of stakeholders' needs"*.

2.4 Functional analysis

This analysis aims to obtain, for each charging solution proposed in the project, a **list of functional attributes** that may affect the end-user acceptance. I.e., the ability of the system to provide a smart charging session, to indicate the availability of charging points or to provide grid services.

The analysis may also include other specifications such as the charging speed, safety, pricing, etc.

Several outcomes of the project can be used as input to this analysis, including the project description, the work plan, and the deliverables D7.1 and D8.1 on the demonstration planning.

Instructions and considerations for this analysis are provided in *"Annex III. Methodology for the functional analysis of the charging solutions"*.

2.5 Value proposition analysis

The main objective of this analysis is to match the results of the two previous steps: the end-user needs with the use-case functionalities or attributes.

The methodology proposed consists of three steps:

1. *Static* approach: use the value proposition canvas from A. Osterwalder to intuitively do the matching.
2. *Dynamic* approach: use storytelling to go through the customer journey in a more comprehensive way, complementing the results of the previous approach.
3. *Synthesis*: use a structured method, *house of quality*, that has been used for years in the automotive industry to check that the user requirements are met by the engineering attributes and enable the possibility to trace it through the whole product development process.

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The result of this analysis is a summary of the **value proposition** for each use case (using a canvas and storytelling), as well as a diagnostic of the extent to which it meets the user needs, pains, and gains (using the *House of Quality* formal method).

Instructions and considerations for this analysis are provided in *"Annex IV. Methodology for the value proposition analysis"*.

2.6 Value network analysis

After the customer and business-oriented analysis of the value proposition, a value network analysis is performed for every UC. The objective is to understand how the core value proposition is reliant on other links of the value chain and how it affects other players in the ecosystem.

The first step of this analysis is the identification and characterization of stakeholders, to determine the relevance and interest of each group in the corresponding INCIT-EV use case. Then, a formal modelling methodology (e3value) is used to create a **diagram of the value exchanges among players**. Last, a qualitative or quantitative analysis can be performed on the network to extract conclusions that can help to maximize the value creation for the ecosystem.

Further details and considerations for this analysis are provided in *"Annex V. Methodology for the value network analysis"*.

2.7 Ecosystem architecture analysis

The value network represents the interests and interactions of stakeholders in the mobility domain from a business perspective. For this network to work, it requires systems and components working in a coordinated way. Thus, the last step of the methodology is the **proposal of a blueprint** to guide the construction of mobility solutions starting from the value proposition and its value network.

Different complementary models will be defined, as layers of the same reality, to show how the value proposition at the business level, can be translated and traced down to functional blocks, and these at the same time, translated into information, communication and physical resources that combine with each other using interoperable interfaces to deliver the expected value proposition at ecosystem level.

Further details and considerations for this analysis are provided in *"Annex VI. Methodology for the Architecture analysis"*.

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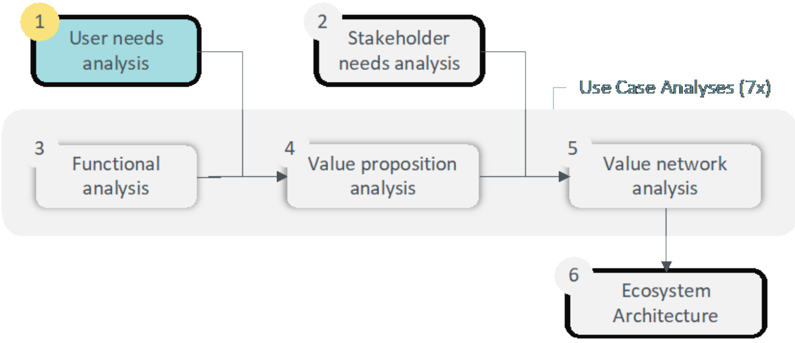
3 USER NEEDS ANALYSIS



3.1 End-user characterization

3.1.1 Identification and segmentation

The focus is on users/owners of electric vehicles, but also on people who have not yet converted.

Other segments will have to be considered and characterized, for example in the sense of companies, regarding all the customers typologies considered in the project.

The definition of persona is based on the answers received from the interviews performed by Bitbrain in the third quarter of 2021.

Three variables in the categorization were considered: EV experience, what car they own and how they use the car. Based on this, 5 personas were proposed grouped in 3 categories.

The details of each profile are provided below.

- **Profile 1: Experienced EV user**
  - 1.a: Manuel (only owns an EV and uses it for everything)
  - 2.a: Miguel (only short trips, rents conventional cars for longer trips)
- **Profile 2: Conventional Car user**
  - 2.a: Miriam (not interested in EVs)
  - 2.b: Sergio (with an interest and opinion about EV’s and owner of an hybrid car)
- **Profile 3: New EV user – Laura (short trips, also owns a conventional car)**

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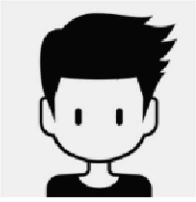
3.1.2 User-persona



MANUEL

Sociodemographic
Age: 40

Occupation: Engineer

Place of residence: Zaragoza, far from the center

Marital status : Married, with children

Hobbies: Practice sport, watching series.

House income: Around 4000€ monthly.

Type of vehicle owned: Tesla model S

Driving use and experiences
Daily km made: 35-50km
Use of the car during the week. Every week day. Mainly for:
1. Going work. Other short distance trips

Use of the car at weekends/on holidays (preferred destinations)
1. Going to the mountain at weekends (150km one way)
2. Visit other cities (more than 250km one way). Even visited England with the Tesla

How does he/she go work: Uses the car always, due to the distance
Preferred public transport: Tramway

Fears and problems

Problems / Fears shared by many
In long distance trips:
Problems related to the APP
Connexion problems
Unavailable charging point (not working)

Minor problems/fears
Conventional car parked in a charging point
Traffic inside the city

The EV:
Bought in: 2020-2021, second hand, through an app/friend.
Purchase process: Hard, compared to buying a conventional car. Specially in terms of receiving the grants (MOVES2...)
Experience of using it in the city: Great, the car responds very well to driving, it's very manageable. It doesn't make noises and it is comfortable
Satisfaction with the EV: 9,5/10

PROS of Evs: Silence
Comfort
No maintenance (oil, mechanics...)
Less consumption
Vehicle operating cost

CONS of Evs: Fear of running out of battery
Batteries capacity
Charging network

Charging the car

Charging at home: Happy what the charging point he has installed at home (10-11KW is enough)

Charging at work: He would like to have a free charging point installed.

Charging in Public: In Tesla superchargers or public car parks. The ideal would be having a fast charging point with well-prepared rest Areas, as in France

Ideal charging situation: charging point near work/home (free or low cost) and high powered.

Charging at: 30/50% of the car's battery.

How he plans the trips:
The day before, charge the car at 100% at home.
Regarding the route, 2 different options:

1. Using apps that have a map to see where the charging points are: Electromap
2. Setting the route on an APP: It gives the best route possible with the charging points on it: ABTrout planer

In case he changes his EV... It would be another EV. "Once you make the change, you can't go back"

MIGUEL

Sociodemographic
Age: 52

Occupation: Company's Director

Place of residence: Zaragoza, outer neighbourhood

Marital status: Married, with children

Hobbies: Jogging, take care of children

Income: More than 4000€ monthly

Type of vehicle owned: Nissan Leaf

Driving use and experiences
Daily km made: 50km daily
Use of the car during the week:
He uses his car everyday to go work.
He also uses it to do big purchases in shopping centers
Long distances: Uses a motorbike or rents a combustion-powered car when trips are longer than 100km. Also, fast trains, as a public transport mean.
How does he/she go work: Uses his car daily
Years of use of the EV: 8 years
Travel priorities: He likes trams but due to Covid has reduced its use

Fears and problems

Main problems
Traffic jams
As a fear: Stress during rush hour and driving at weekends

Minor problem
Parking places

The EV:
Bought in: 2013 in Denmark
Purchase process: it was very simple, and the car was first hand
Experience of using it in the city: Positive, if you avoid the city center
Expectations: "The car will only be used for travelling around the city. Inside we will use alternative means of transport"
Satisfaction with the EV: 8/10

PROS of Evs: Comfort
Easier to drive
Reduced cost of use
Less pollution

CONS of Evs:
Autonomy ("they should have 300km")
Battery
More planification needed

Charging the car:
Charging in public: There are few and they are usually inoperative. "There's a lack of fast charging points"

Ideal charging situation: 10-12KW and regulated to the house consumption (dynamic power control). In public, semi-fast charging points

Charging at: 10-30% of the car's battery.

Longer distances:
He rents a conventional car (petrol, diesel...) when he has to drive outside the city

Why doesn't he use his EV for this? "Due to the lack of chargers. This gives you uncertainty. Moreover, many of them don't work"

Aspects to improve the EV
- Functionalities from the EV APPs
- Percentage of charge at which you want to charge

In case he changes his EV... It would be another EV, with greater autonomy.

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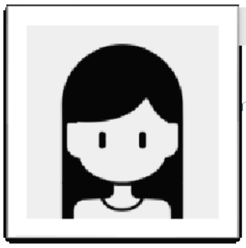
MIRIAM



Sociodemographic
Age: 38

Occupation: Administrative

Place of residence: Zaragoza, city center

Marital status: Married, with children

Hobbies: Jogging, reading, going to the cinema.

House income: Around 3000€ monthly.

Type of vehicle owned: Mazda CX5

Driving use and experiences
Daily km made (on average) with the car: 10-20km
Use of the car during the week: Several times a week. Mainly for:
1. Going work, but other means of transport are also OK, including walking
2. Going shopping (to make large food purchases)

Use of the car at weekends/on holidays (preferred destinations)
1. Going to the mountain at weekends (150km one way)
2. Beach (but on longer holidays) (More than 250km one way)

How does he/she go work: Uses the car, it takes 10 mins approx. (5km)

Preferred public transport: Bus, due to the good connections.

About his car…
Bought in: 2013-2014, second hand.
And why? It was small, had a Good Price and its fuel consumption was low
Did he know about electric cars when he bought it? No. In fact, she is not interested and has no knowledge nowadays
Experience of using it in the city: Positive, but starting to get worse (mainly in the center)

PROS of Evs: Silence
Advanced technology
ECO-friendly
Less consumption

CONS of Evs: Price
Batteries durability.
Charging network is not enough

What about electric vehicles?
Opinion: They are innovative and expensive: "I don't have much information on these cars"

Perception of the EV in the city: They are quiet and consumption would be much lower, ideal in this context of use

Perception of the EV for long-distance trips: "Problematic, would have to charge a lot and the batteries are not prepared for the distances"

Expectations about the future: Lower prices and better charging network

Fears and problems

Problems / Fears shared by many
Lack of parking
Too many traffic lights
Hard to drive in the center due to pedestrianisation

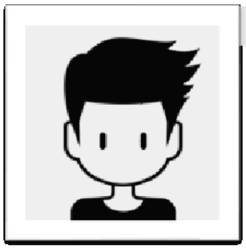
Minor problems/fears
Scared about the new electric scooter users or bicycles users. "More regulation should be implemented"

Fear of other drivers driving style.

Barriers in buying an EV car:
1º Initial cost of the car
2º Insufficient charging network
3º Lack of information

In case he bought an EV it would be… First-hand plug-in Hybrid car

SERGIO



Sociodemographics
Age: 31

Occupation: Engineer

Place of residence: Zaragoza, city center

Marital status lives alone in a rented house

Hobbies: Riding the bike, meeting friends

House income: Around 3000€ monthly

Type of vehicle owned: Mercedes A class

Driving use and experiences
Daily km made (on average): 10-20km approx.
Use of the car during the week: Mainly to go shopping

Use of the car at weekends/on holidays (preferred destinations)
1. Going to the mountain at weekends (150km one way)
2. Beach (but on longer holidays) (More than 250km one way)

How does he go work : He uses his bike or motorbike (works near his house)
Preferred public transport: Electric trains or trams
Experience of using his car: Positive, but he is concerned that there are starting to be areas where conventional cars cannot enter

About his car…
He has different cars available at home (2-3) and uses them with a different purpose: Hybrid: Long journeys and city driving, Petrol: Long journeys, Diesel: City driving.
Bought in: Last year (Mercedes)
And why? It was powerful and safe ->"If I wanted an EV with the same conditions, I would have to spend a lot more"
Did he know about electric cars when he bought it? Yes, and although he thinks they are innovative and technological vehicles, he believes it will be difficult for them to be implemented in the future, at least in his city

PROS of Evs: Less noisy
Advanced technology
Maintenance

CONS of Evs: Installing a Wallbox (specially living in a rented house)
Price
Shortage of charging points
Battery replacement

What about electric vehicles?
Opinion: They are innovative and technological.

Perception of the EV in the city: Ideal for the city

Perception of the EV for long-distance trips: "Similar, but I would have to stop during the journey to charge it, that could be a problem."

Expectations about the future: A better charging network Will be developed, charging speed will be better and batteries will last longer

Fears and problems

Problem shared by many
Parking problems
Driving in the center

Minor problem
Weather (in case you use public electric scooters or motorbikes)

Barriers in buying an EV car:
1º Price
2º Charging network
3º Finding a place with space enough to park it

In case he bought an EV it would be… Tesla model 3 (if not possible, an hybrid car, due to the lack of charging points)

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LAURA

Driving use and experiences
Daily km made (on average): 15km approximately.
Use of the car during the week: Taking the children to school
Meeting friends
Use of the car at weekends/on holidays (preferred destinations):
She doesn't use the electric vehicle for long distance trips, so its use during the weekends or holidays is very unusual
How does he/she go work (include distance). Mainly using her motorbike and sometimes the car (not the electric) , due to comfort.
Preferred public transport: She doesn't' use it due to the bad connections of it. For long-distances she uses high speed trains (public transport)

Fears and problems

Main problems
Traffic
Parking areas
Long distance trips with an EV:

Minor problem
Single vehicle lanes
Lack of regulation of electric scooters (she perceives them as dangerous)

Sociodemographic

Age: 43

Occupation: Administrative (part time)

Place of residence: Zaragoza center

Marital status: Married, with a baby

Hobbies: Walk or read

Type of vehicle owned: Peugeot E-208

Income: 2500-3000€

The EV:
Bought in: 2019.
Purchase process: Fast but misleading. She didn't receive any of the subsidies they promised, and the characteristics of the car are not what the seller promised
Experience of use: Marvellous, no noise and no parking fees
Changes in use: More information, knowledge about the tariffs for EV, what the market of EV's consist of…
What she expects in the future: Improvements in autonomy, more charging points and more subsidies.
Satisfaction with the EV: Good

PROS of Evs: Forget about petrol stations
Night charging comfort (at home)
Less pollution

CONS of Evs: Autonomy (she can only do short trips)
Wrong information about them
Lack of charging points (she almost gave the car back due to this)

Charging the car
Installing the charging point: "It was a mess, I didn't know I had to pay for installing this"
Charging at home: Charging during the night at low consumption.
Monthly payment for charging: Less than 30€

How she plans long-distance trips
She doesn't use her electric vehicle for this because she thinks she would have problems (in terms of autonomy, charging points…) so she has a conventional car for this purpose

In case she changes her EV… It would be another EV, but with greater autonomy.

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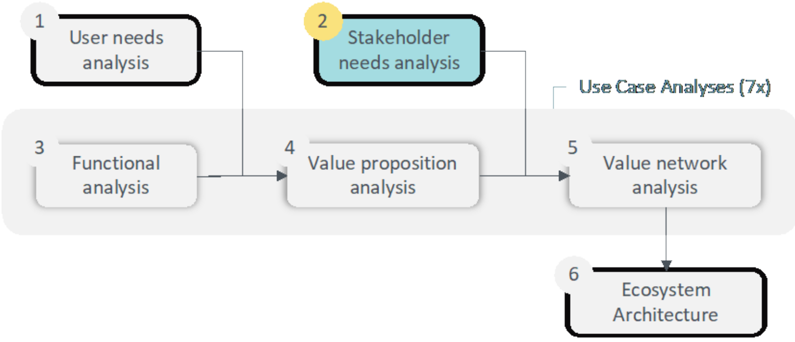
4 STAKEHOLDER NEEDS ANALYSIS

This analysis aims to understand the barriers, pain points and needs or expectations that some of the most relevant stakeholders find when trying to adopt electric mobility. The results are an input to the value network analysis.



4.1 EV rental and sharing companies

These stakeholders are companies owning electric vehicles for their exploitation through rental or carsharing.

The first type of companies rent cars for short periods of time, generally ranging from a few hours to a few weeks. It is often organized with numerous local branches and often complemented by a website allowing online reservation.

The second type of company offers its members access to a dispersed network of shared electric vehicles 24-hours, 7 days a week at unattended self-service locations.

During the interview, the companies used the following terms or sentences to complete the definition of their own company and activity:

- Car-Sharing combined with Carpooling applied to industrial estates.
- Small car fleet of around 10 vehicles with aims to acquire or rent more vehicles.
- Deployment, service, and maintenance of electric vehicles

The interviews revealed technical, commercial, and political barriers that currently prevent this companies from increasing the share of EVs in their fleets.

Technical Barrier

- Only slow chargers installed, fast chargers are costly. Still, the company is managing to charge cars with slow ones.
- Parking underground may not be preferred due to the connection loss (unless uses a technology that allows this).
- Availability of charging stations
- The models are less and less adapted to AC charging, and this will be the case for the next models. AC charging will not meet our needs

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Commercial Barrier	• Small company • Expressed difficulty to get financing because of being a Startup • They need one or two cars as reserve vehicles in case one breaks, as they have a small fleet, it means 20-30% of the fleet not to be available to use. • Some companies don't allow vehicles to leave certain areas • Parking access on cities may be too difficult to use carsharing • Some cities are more interesting on carsharing than others (as well as countries) this behaviour can be something to study and analyse • lack of understanding of what the autonomy of an electric vehicle is (that's why it's expressed sometimes in km)
Political Barrier	• Not enough financing to vehicle's acquisitions • Users pay 21% VAT, 13% more than public transport. They claim their service to be regulated as public transport

The full or partial use of EVs in their fleets is also seen as an opportunity in many ways:

Identified Opportunities	• Improves connections to industrial estates on small-medium sized cities • Cheaper than a regular Carsharing company • More dynamic than using a bus to transport workers to the factory. • No parking fees on the city centre as it's free for electric cars • During work time it's used as carpooling, and on the weekends, it can be used as carsharing to go shopping or making sporadic errands. • Providing natural alternatives to replace car's possession. • Self-developed optimization algorithms to choose the best route of the vehicles • User interaction for reducing maintenance costs (offering them 5€ to plug in cars under 60% battery capacity) • Vehicle cleaning without water in order to not move the car and reduce risk of accident or increase traffic. • Free parking places for floating actors • Vandalism is sth to study.

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4.2 Delivery service company

These stakeholders are last-mile delivery companies operating a fleet of vans in urban and interurban routes.

During the interview, the companies used the following terms or sentences to complete the definition of their own company and activity:

- Last-mile package delivery company
- They use LCV with a capacity of minimum 6m3
- Logistics is usually subcontracted
- Fleet is a mix of energies
- There's a tendency in removing the LCV for bicycles or pedestrians

The interviews revealed technical, commercial, and political barriers that currently prevent this companies from increasing the share of EVs in their fleets.

Technical Barrier	• Temperature affects a lot in the vehicle autonomy • There's a need for slow-recharge places to recharge at night • If so, fast charging for daily operations, as well as opportunity charging inside the city to reduce driver's anxiety while driving.
Commercial Barrier	• roaming charging: how much time can we allocate to this charging, which represents non-productive time?
Political Barrier	• uncertainty about the commissioning of the charging stations, i.e., providing the right power to supply the charging points, which can take several months.

The full or partial use of EVs in their fleets is also seen as an opportunity in many ways:

Identified Opportunities	• More smaller logistics centres may be more energy efficient than Less but bigger in order to shorten the last-mile package delivery and optimize the energy for the EV. • With inductive charging, opportunity charging issue is solved • During working brakes, stationary charging could be interesting once compared the CAPEX of AC with this technology

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4.3 Association/Organization promoting electromobility

Electromobility associations are non-for-profit organizations that pursue and defend the interests of their associates toward electric vehicle adoption. They perform lobby activities, communication activities, etc.

During the interview, the following terms or sentences were used to complete the definition of their own association:

- Association that represents the industrial, technological, and service value chain for electric mobility
- 15.000 public chargers, 1.600 fast. 100,000 in 2030

The interview revealed technical, commercial, and political barriers that, according to their knowledge of the sector are currently preventing their associates from adopting or contributing to the adoption of EVs.

Technical Barrier	• High dependency from Asian markets. Atomized markets with newcomers • Dynamic charging seems to be expensive with low efficiency
Commercial Barrier	• Mix-information and infoxication that there is not sufficient infrastructure (the primary grid is already done) • Seeing electric mobility through the eyes of combustion. No need to recharge full tank. • No training at schools on electric cars • Electric Vehicles are still 15% more expensive (if we do not consider TSO)
Political Barrier	• Incentives to infrastructure and EV is essential • Granting licences and permits very slowly and at various administrative levels

The interview also identified multiple opportunities that the EVs bring to the wider mobility sector:

Identified Opportunities	• Renting of electric vehicles instead of purchasing them. • The figure charge managers have been eliminated in the new Royal decree • No need of so many charging opportunity stations as the 80% of the charges are linked at home. • The rise of petrol and electricity benefit EVs • Less maintenance, advantages on parking, special lanes in highways, etc • Bidirectional recharging, energy efficiency • Logistics changing the tractor of a truck every 450 km and changing the driver like in the far west. • The ban of ICE cars in 2035 will move manufacturers to eliminate them before. • Create the full ecosystem in Europe reducing dependency from Asia • Use of used batteries in second life applications • Models where every three years you change the car and don't fully buy it • Stationary charging make sense • Plug and charge systems must be the future (identification of owner by the car)

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4.4 ICT/tech provider

These stakeholders are companies providing ICT or technology solutions (also technical architectures) to be implemented/installed in charging stations.

During the interview, the companies used the following terms or sentences to complete the definition of their own company and activity:

- Reuse Lithium-ion batteries
- Energy storage providing systems for fast chargers.
- End-of-life service to electric vehicle batteries

The interviews revealed technical, commercial, and political barriers that currently prevent this companies from selling more charging solutions.

Technical Barrier	• Not enough extraction and processing capacity of raw materials (bottleneck effect) • Lifetime of a battery is limited and its capacity decreases over time • Raw materials that arrive to Europe should not leave Europe to give them a second life here • Batteries are different and they cannot work with a random battery if they don't have the technology system developed for this specific battery. • It would be helpful a standardization protocol to ask a battery it's serial number or it's health status.
Commercial Barrier	• Only focussed on lithium-ion batteries • Mentality of consumer is still not ideal for EVs adoption (adoption barrier commented on the interview) • Chinese batteries' raw materials are worth almost nothing, so no one wants to recycle them • Self-developed software for the batteries (not for sale)
Political Barrier	• Subsidies situation a bit unstable • Lack of public infrastructure (and private as well)

The interview also identified multiple opportunities that would contribute to deploy ICT and charging technologies faster:

Identified Opportunities	• Second life battery is a nascent industry • Few companies are specialized in the management of second life batteries (low competition) • Extraction problems of minerals needed on EVs production • New European battery regulation that forces a percentage of recycled raw materials on batteries • Manufacturers are obligated to reuse 95% or recycle 85% of the vehicle • New regulation (R14) applied to electrical and electronic waste that needs special treatment

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4.5 Energy/Electric utility

These stakeholders are companies in the electric power industry (often a public utility) that engage in electricity generation and distribution of electricity for sale generally in a regulated market.

During the interview, the following terms or sentences were used to complete the definition of their own activity:

- installation of charging infrastructure in homes and private car parks of companies
- installation of recharging points on public roads
- sale of a bundle of services associated with recharging for large and small customers who are interested
- They also sell electricity
- And other cross services that can be sold through the charging point.
- Participation in Car Sharing companies and other related to electrification of transport

The interviews revealed technical, commercial, and political barriers that currently prevent this companies from contributing to a faster deployment of charging solutions.

Technical Barrier	• Charging Infrastructure on domestic chargers is associated with the difficulty of the infrastructure (domain of the electrician rather than an electric company) • In a community of neighbours not everyone may want to do pre-installation on the complete building, so it makes it difficult to install it for a single user • To put a hub, they need to ensure a certain demand • Battery recycling needs to improve, probably solid-state batteries might within 3 years • Dynamic charging seems not to be as efficient as it should be
Commercial Barrier	• Acquisition prize of EVs (upfront price) • Number of EV models available • Number of interurban public recharge options. • User expects EVs usage to be as close to Internal combustion Vehicles as possible • EVs need to plan how to recharge before a long trip because of the scarcity of infrastructure (ICV don't need to plan) • Density of population is important to make interurban chargers profitable
Political Barrier	• Low voltage chargers are easier and faster to obtain authorization, so other voltage chargers are poorly installed in cities • Public access charging infrastructure support not enough to eliminate the barriers that already exist today • Municipalities don't want cars and don't want them parked on the street

The interview also identified multiple opportunities that would contribute to boost the electric mobility industry from the viewpoint of utilities:

Identified Opportunities	• Autonomy is not a limitation • Sales numbers grow along the raise of number of models available and subsidies • There's a minimum of pre-installation required in new constructions and reconstructions

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- Different alternatives of electricity rates depending on user's preference (especially at night)
- Fleet emission reduction policy allows to increase the number of models available (helpful to give more offer)
- If you attract domestic and business costumer, you can sell more things, including supplying electricity
- Static inductive load and stationary more interesting than dynamic, especially stationary.

4.6 Charging station manufacturers

These stakeholders are companies that build charging stations in which electric vehicles can recharge the battery.

During the interview, the following terms or sentences were used to complete the definition of their own activity:

- Manufacture, sell and maintenance of chargers
- Mainly focused towards public chargers
- They don't provide the App for the end-user.

The interviews revealed technical, commercial, and political barriers that currently prevent this companies from achieving a faster deployment of charging solutions.

Technical Barrier

- Majority of garages in flat building areas don't have pre-installation for electric chargers (new ones do have it by law)
- People without garage needs to park in the street, and a solution for that must be found.
- Batteries are at their technological limit, and it doesn't allow faster charging
- You must be able to charge your car to be able to do some more km than you need when you are travelling
- there must be a medium-voltage line in the area, and since it is not always there, sometimes you have to make a branch of a line to get to where the charger is and it is not always profitable
- Chargers that need to be removed from use cannot be reused because at a mechanical level they are obsolete
- Dynamic charging is not that interesting, it's quite inefficient

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Commercial Barrier	• If there's not a charger close to your home, some people will discard buying an electric car • Not enough public chargers at night (some people must unplug in the middle of the night to let others charge) • Not many models can charge more than 120 kW, so it doesn't make much sense installing the highest power chargers while their prizes are still high. • today there are not enough charging points to stop whenever I want, although there are applications that make it very simple.
Political Barrier	• Procedures to get financial support from the government are crazy, both the procedures to obtain the subsidies and the procedures themselves to legalizing the installation are very absurd • Main problem for massive introduction of charging infrastructures is bureaucratic rather than technological • Interoperability at a European level bust be standardized to avoid problems or to get chargers work with all vehicles instead of testing every single model on the market

The interview also identified multiple opportunities that would contribute to boost the electric mobility industry from the viewpoint of charger manufacturers:

Identified Opportunities	• Wide range of chargers o Apart from the AC charger, they have a wider range of DC chargers, starting from 50 kW to 400 kW. • In some cities, you can park and charge on the street at night because blue zones are free at night so people would only pay for charging (city councils should determinate that) • it's important to combine many slow chargers with some ultra-fast recharging Hubs, as fast as possible • With current cars there are no big problems on daily use unless you plan a long trip for vacations or work. • Bidirectional Inductive charging is interesting at a domestic level (but on a reasonable prize) • Plug & Charge technology is interesting so that makes charging easy and fast

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4.7 Regional and National Public authorities

Public authorities are government or other public administrations, including public advisory bodies, at regional/national level; any natural or legal person performing public administrative functions under national law, including specific duties.

During the interview, the following terms or sentences were used to complete the definition of their own activity:

- office for environment and energy in a Region that:
- support the transition towards sustainable sources of energy
- support the development and implementation of low-carbon mobility, through the implementation of enabling infrastructures
- Support the development and implementation of renewable sources of energy, increasing the power grid efficiency
- Coordination and support to local public entities in the development of actions to decrease the carbon footprint related to energy production and consumption

The interviews identified technical and commercial barriers that that, according to public authorities, avoid a faster deployment of charging solutions.

Technical Barrier	• Different standards for charging still exist
Commercial Barrier	• The costs for the electric power supply, already perceived as high by the users, is furtherly increasing in the last months • The number of publicly available charging points needs to be increased, as currently users feel hard to find them where and when they need

The interview also identified multiple opportunities that would contribute to accelerate the adoption of electric mobility:

Identified Opportunities	• Develop and test innovative charging solutions to increase the market share of EVs • Innovative charging solutions to optimise the power consumption and balance the demand • Integration of the payment systems of different means of transport (public and private) and services (EVs charging) • Collect data on users to forecast the potentials of replicability and scalability of the tested solutions

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4.8 Local public authority

Local public authorities are government or other public administrations, including public advisory bodies, at local level (e.g., mobility planners, policy makers); any natural or legal person performing public administrative functions under national law, including specific duties.

During the interview, the following terms or sentences were used to complete the definition of their own activity:

- Mobility division of a Municipality
    - increase the quality of urban and extra-urban mobility
    - the SUMP (Sustainable Urban Mobility Plan) has the objective to foster the usage of collective and shared transport modes to reduce the circulation of private vehicles, and incentivising the adoption of intermodality for a better integration of private and public transport
- Infrastructures division of a Municipality
    - planning and implementation of actions aimed at increasing the quality of mobility infrastructures, ensuring the access potentials, the effectiveness, and the sustainability for the users

The interview identified opportunities that would contribute to accelerate the adoption of electric mobility:

Identified Opportunities	• Implementation of charging infrastructures is not sufficient • The three directions in which the SUMP will be developed are o Deployment of **strategic transport infrastructures**, to design the future of public transport in the urban area. o Improve the **accessibility to the different urban areas**, ensuring safety for the citizens and environmental sustainability. • Set up of **management actions** to improve the accessibility by the citizens to the different transport modes

4.9 Public transport company

These stakeholders are companies offering the service of transportation for people with buses and other vehicles having a capacity of more than 5 people.

During the interview, the following terms or sentences were used to complete the definition of their own activity:

- public transport operator in a municipality
- Public transport provider in a municipality
- Bus transport organisation
- About 4700 buses and 25 bus centres

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- A bus centre only uses one type of energy (hydrogen has been considered but not investigated yet)

The interviews revealed technical, commercial, and political barriers that currently prevent this companies from achieving a faster deployment of electric mobility and charging solutions.

Technical Barrier	• Charging speed • Payment systems integration need more development • Lack of data about EVs users • Gradually change of a technology in a bus centre, not immediate. • Lifespan of 15/20 years of inductive charging. And infrastructure needs development.
Commercial Barrier	• Availability of charging infrastructures • Opportunity chargers can be difficult to place due to unpredictable traffic in some cities • Chargers' sizes on the lines have a certain size and can be difficult to urbanely integrate. • Lack of inductive static charging offers and standards to be considered.
Political Barrier	• Lack of regulations for underground parking • uncertain which is the correct mix of different charging technologies (in terms of charging speed) • Possible ban of diesel might cause an impact on the acquisition planning of electric buses. • There's no standard for dynamic inductive charging, so, if different technologies coexist on the road from one line to another, there's a loss of flexibility • If dynamic inductive charging, vehicles wouldn't be able to park

The interview identified opportunities that would contribute to accelerate the adoption of electric mobility:

Identified Opportunities	• Close to bus centres, opportunity chargers can be placed (take into consideration the load capacity to not reduce charging time on buses while charging electric vehicle) • May be interesting to study battery recycling into bus companies, they were the "early adopters" on electric mobility • Static charging can be used when the autonomy is not sufficient. • Dynamic inductive charging

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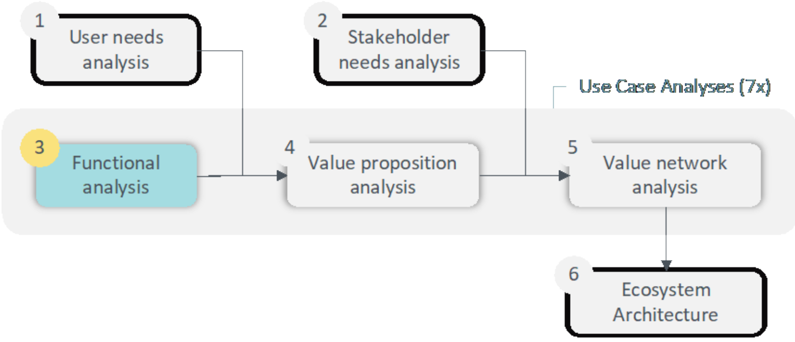
5 UC1 ANALYSES

5.1 UC1 functional analysis

This section contains a description of the UC1 and the result of the functional analysis, based on previous project documentation, which is a list of functionalities and/or quality requirements of the charging solution that will be tested in UC1 and may affect the end-user acceptance.



5.1.1 UC1 objectives and expected user benefits

5.1.1.1 OBJECTIVE

Current smart charging models allow little influence and hardly any direct benefits for the users of charging infrastructure. More importantly, smart charging will often reduce the user-orientation as delayed charging or reduced charging-speed are the common methods of smart charging. However, research and earlier experiences from GreenFlux and Pitpoint show that the benefits of smart charging increase dramatically when several charging stations are aggregated into one group.

Instead of managing the total power consumption of each individual charger/grid connection, the total power consumption of a group of chargers is managed. Simulations show that if charging stations are managed this way, the number of charging stations that can be installed in an area multiplies by a factor 10 to 20.

The aim of UC1 is to test a regional smart charging infrastructure for public charging can serve several goals:

- Avoiding grid congestion
- Improve the business case of EV-charging
- Increase sourcing of (locally produced) sustainable electricity

5.1.1.2 DESCRIPTION OF NEW PRODUCTS OR SERVICES

UC1 will test one of the project technical results:

Product	**Aggregated smart charging to avoid net congestion**
Added value	Net congestion management avoids investments in grid capacity.

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IPR Strategy	Possibly IPRs on algorithms and/or smart charging methods
Exploitation route	Offering flexibility on energy markets
Time to market	12 months

5.1.1.3 USER EXPERIENCE IMPROVEMENTS

Users in the demonstrations will have access to shared private and public charging infrastructure at lower user costs and with an improved user experience.

Other future users in European inner cities will have improved access to shared private charging through the online quick scan function of the APP and the project best practices.

Extensive knowledge on charging behaviour will allow decision makers to predict what energy demand and connection time could be expected.

The user will not need to give additional information before starting each charge session and could still contribute to smart charging aims.

The application of these algorithms and monitoring in practice will allow further improvements to optimise user experience and the accuracy rate of user behaviour.

5.1.1.4 USER BENEFITS

The following user benefits can be highlighted:

- Reliable recharging for the end user
- Better user information on smart charging
- Total control of the user, having an opt-out function

5.1.2 UC1 functional or quality specifications

The system allows end users of either the charging infrastructure or the related software services to:

Install more charging stations with the same grid capacity (the system requires less peak power per point)
Be available close to home, let's say at least within 300 meters walking distance.
Identify as user to the charging station
Opt-out smart charging (enable or disable the function) using a mobile device with QR code reader
Charge with full load over in about 2,5 hours, or half load in 5 hours.

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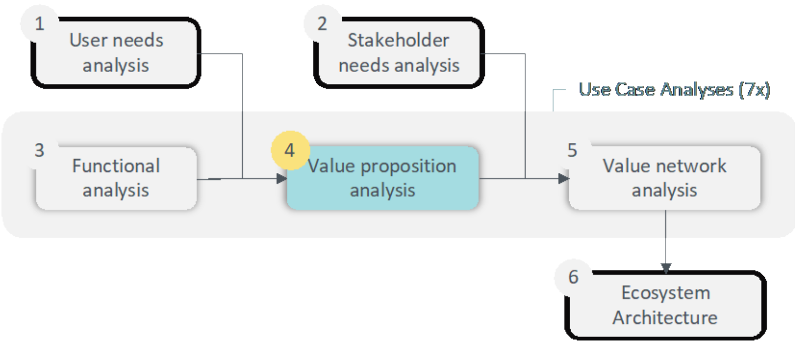
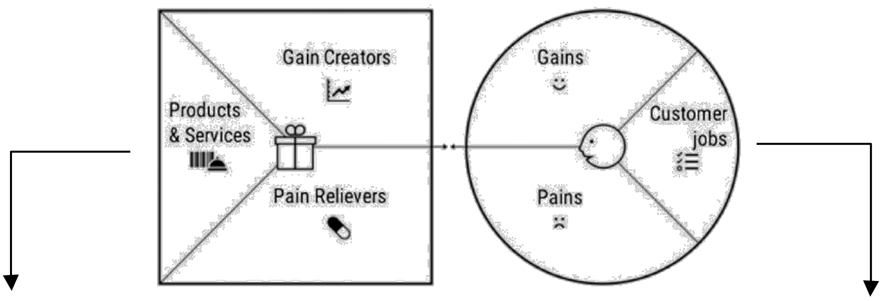
5.2 UC1 value proposition analysis

This analysis aims to match the end-user needs with UC1 functionalities or attributes, and indicate the gaps that may exist between them, i.e., check the problem-solution fit. Three steps are performed: static analysis, dynamic analysis, and synthesis.



5.2.1 Static approach. Value proposition canvas



UC1 solution				Manuel / Miguel
11kW public charging point	Products & Services	⇔	Customer jobs	Charging for daily commuting to work
Smart charging software				Charging for weekly shopping trip
App for interaction with user				Charging for annually holiday trip
Installing more charging stations with the same power grid	Gain Creators	⇔	Gains	Reliable charging in a vast and growing charging network not limited by the power grid congestion.
Opt-out function for smart charging	Pain Relievers	⇔	Pains	Short charging sessions unsuitable for smart charging
				Individual charging sessions become less reliable.
				Not having enough energy for the next ride.

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5.2.2 Dynamic approach. Scenarios

5.2.2.1 SCENARIO 1

5.2.2.1.1 Scenario description

ID	Scenario 1
Action	Charge at origin to drive (or ride) …
Vehicle	Private EV
From	Extra-urban (near the city)
Site A	Home
To	Peri-urban (city suburbs)
Site B	Office
Frequency	All weekdays
Type of route	Road
Trip distance	20-60 km
Trip duration	20-40 minutes
Destination activity	Work (full working day)
Activity Duration	6-12 hours

5.2.2.1.2 User objectives

1. Recharge for an amount of energy that allows a round trip, 120 km. Equalling about 25 kWh. Therefore, charging with full load over about 2,5 hours, of half load 5 hours.
2. A public charger must be available close to home, let's say at least within 300 meters walking distance.

5.2.2.1.3 Relevance of the objectives for each persona

	Manuel	Miguel	Miriam	Sergio	Laura
Objective 1	X	X			
Objective 2	X	X			

5.2.2.1.4 Storytelling - Steps

Manuel / Miguel

		Story for each step (sub-objective)	Experienced emotions	Overall emotion rating
O1	**Step 1**	Connecting and identifying to charging station	Satisfied if works	Good
	Step 2	Scan QR code and decide on opt-out for smart charging	Satisfied with option, probably not using it.	Good

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	Step 3	Updates on recharging status	Updates from car app are confusing as it does not recognise smart charging session.	**Bad**
	Step 4	Disconnecting and reviewing energy recharged	Satisfied, fully recharged.	**Good**
O2	**Step 1**	Find a charging station near home. Or only finding one far from home.	Dependence on hard to influence factors. Frustration if there is low availability. Otherwise, happy with governments efforts to support e-mobility.	**Mixed**
	Step 2	Determining that it is available.	Happiness, feeling lucky. Or sadness that availability is hard to determine beforehand.	**Mixed**

5.2.2.2 SCENARIO 2

5.2.2.2.1 Scenario description

ID	Scenario 2
Action	Charge at origin to drive (or ride) …
Vehicle	Private EV
From	Urban (city centre)
Site A	Home
To	Far-off (long distance from the city)
Site B	Hotel
Frequency	Once or twice per year
Type of route	Highway
Trip distance	> 60 km
Trip duration	> 40 minutes
Destination activity	Long holiday stay
Activity Duration	> 1 week

5.2.2.2.2 User objectives

1. Leave with a full battery, so about 60 kWh. Therefore about 6 hours of recharging at full load.
2. A public charger must be available close to home, let's say at least within 300 meters walking distance.

5.2.2.2.3 Relevance of the objectives for each persona

	Manuel	Miguel	Miriam	Sergio	Laura
Objective 1	X				
Objective 2	X				

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5.2.2.2.4 Storytelling - Steps

Manuel

		Describe the story for each step (sub-objective)	Describe the experienced emotions	Overall emotion rating
O1	Step 1	Connecting and identifying to charging station	Satisfied if works	Good
	Step 2	Scan QR code and decide on opt-out for smart charging	Satisfied with option, probably not using it.	Good
	Step 3	Updates on recharging status	Updated from car app are confusing as it does not recognise smart charging session.	Bad
	Step 4	Disconnecting and reviewing energy recharged	Satisfied, fully recharged.	Good
O2	Step 1	Find a charging station near home. Or only finding one far from home.	Dependence on hard to influence factors. Frustration if there is low availability. Otherwise, happy with governments efforts to support e-mobility.	Mixed
	Step 2	Determining that it is available.	Happiness, feeling lucky. Or sadness that availability is hard to determine beforehand.	Mixed

5.2.2.3 SCENARIO 3

5.2.2.3.1 Scenario description

ID	Scenario 3
Action	Charge at destination after driving (or riding)…
Vehicle	Private EV
From	Peri-urban (city suburbs)
Site A	Rented apartment/house
To	Urban (city centre)
Site B	Shopping mall
Frequency	Once or twice a week
Type of route	Urban
Trip distance	5-10 km
Trip duration	10-20 minutes
Destination activity	Shopping
Activity Duration	1-2 hours

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5.2.2.3.2 User objectives

There is no real need to recharge as it is a short trip and the possible recharging time is also short. The main reason for recharging is probably finding a parking spot and using an EV recharging reserved spot for it.

Should the user decide to recharge anyway, then a full load should be given as otherwise the whole interaction becomes confusing. more futile and possibly frustrating.

5.2.2.3.3 Relevance of the objectives for each persona

	Manuel	Miguel	Miriam	Sergio	Laura
Objective 1	X	X			X

5.2.2.3.4 Storytelling - Steps

Manuel / Miguel / Laura

		Describe the story for each step (sub-objective)	Describe the experienced emotions	Overall emotion rating
O1	**Step 1**	By coincidence seeing a charging station	Happy, as it offers a good parking spot.	Good
	Step 2	Connecting and identifying to charging station	Satisfied if works	Good
	Step 3	Scan QR code and decide on opt-out for smart charging	Satisfied with option, probably not using it.	Good
	Step 4	Updates on recharging status	Updated from car app are confusing as it does not recognise smart charging session.	Bad
	Step 5	Disconnecting and reviewing energy recharged	Does not care as recharging was not needed.	Mixed

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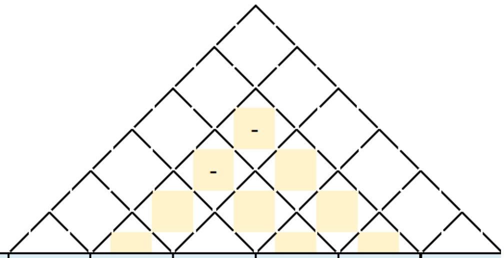
5.2.3 Synthesis. House of quality

5.2.3.1 HOQ DIAGRAM



		Column #	1	2	3	4	5	6
		Stage	Pre-charge				Charge	Post
Row #	Source of the requirement	Customer Requirements (Explicit and Implicit) / Functional Requirements	Chargers installed close to homes, lets say at least within 300 meters walking distance	Less peak power required per charger	User identification to the charging station	Opt-out smart charging (enable or disable) using a mobile device with QR code reader	Charge with full load over in about 5 hours, or half load in 2.5 hours	
1	Gains	Availability of chargers close to home	X					
2	Gains	Reliable charging not limited by net congestion		X				
3	Pains	Need to stay for long charging sessions. Short ones are unsuitable for smart charging				X		
4	Pains	Individual charging sessions become less reliable.		X				
5	Pains	Not having enough energy for the next ride.					X	
6	Pains	Updates from car app are confusing as they do not recognise smart charging session						
7	Fears	Unavailable charging point in long distance trips						
8	Fears							

Figure 4. House of Quality for UC1

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5.2.3.2 HOQ ANALYSIS

The HoQ shows that most of the end user requirements are met by the service features. Only confusing car apps and unavailable charging points in long distance trips seem to be ignored by the value proposition.

Technically, there are two correlations that should be taken care of when developing the product or service:

- The possibility to opt-out smart charging is detrimental to the objective of using less peak power per charger. If smart charging is disabled by many users, the management capacity of the system will be reduced.

- The same applies to the objective of charging in less time. If smart charging is not chosen, charging times could be longer and/or peak power would be higher.

Therefore, the value proposition should be careful to provide the right incentives for end users to choose smart charging against the conventional mode.

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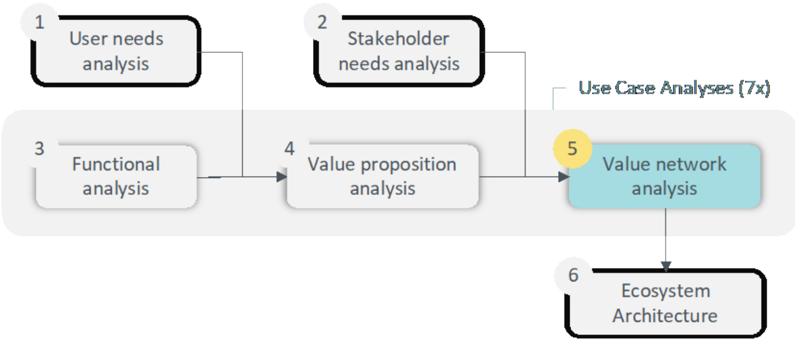
5.3 UC1 Value Network Analysis

This analysis aims to widen the scope of the value proposition drafted so far, to include not only the end users but also those stakeholders that participate in the elaboration or delivery of value.



5.3.1 Stakeholder identification and characterization

In this section, the stakeholders are rated based on their potential power and interest on the use case. Then, the most relevant ones are considered, listing their objectives.

5.3.1.1 STAKEHOLDERS PROFILES

Involvement in the charging network development	Stakeholder	Key group	Power	Interest
Direct	Local public authority (e.g., mobility planners, policy makers)	Government	**High**	**High**
	Charging Point Operator (CPO)	Business	**High**	**High**
	E-Mobility Provider (EMP)	Business	Low	High
	Fuel station company (petrol stations)	Business	Medium	High
	Motorway company (operator)	Business	Medium	Medium
	Land and parking space owner (supermarket, mall, parking area, …)	Business	High	Medium
	Power grid operator (DSO)	Business	High	Low
Indirect	Regional public authority (e.g., mobility planners, policy makers)	Government	**High**	**High**

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	National public authority (e.g., mobility planners, policy makers)	Government	Medium	High
	Energy (electric) utility	Business	Low	Medium
	EV manufacturer (cars, vans, motorbikes, bikes, etc.)	Business	Low	High
	Charging Station manufacturer	Business	Medium	High
	ICT/tech provider	Business	Medium	Medium
	Public Research Institute	Research	Low	Low
	Private Research Institute	Research	Low	Low
	University	Research	Low	Low
	Start up	Business	Low	Medium
	Private drivers associations	Civil society	Low	Medium
	Transport and logistic sector association	Business	Medium	Medium
	Association/Organization promoting electromobility	Civil society	Low	High
	Environmental organization	Civil society	Low	High
	Telecom operators	Business	Low	Low
	E-mobility roaming platform operators	Business	Medium	High
	Mobility service information providers	Business	Low	Medium

5.3.1.2

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5.3.1.3 STAKEHOLDER OBJECTIVES

For the three most relevant stakeholders in terms of power and interest, their main objectives have been identified:

Distribution grid operator (DSO)	Avoid grid congestion in a reliable, scalable, and significant way.
Charging Point Operator (CPO)	Cost-efficient service
	Combining societal smart charging goals with financial revenues.
Regional public authority	Provide reliable charging services
	Avoid grid congestion in a reliable, scalable, and significant way
	Allowing multiple goals for smart charging
	Have control over smart charging goals

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5.3.2 Value Network Modelling

The following figure shows the relations among stakeholders in the ecosystems using e3-value modelling methodology.

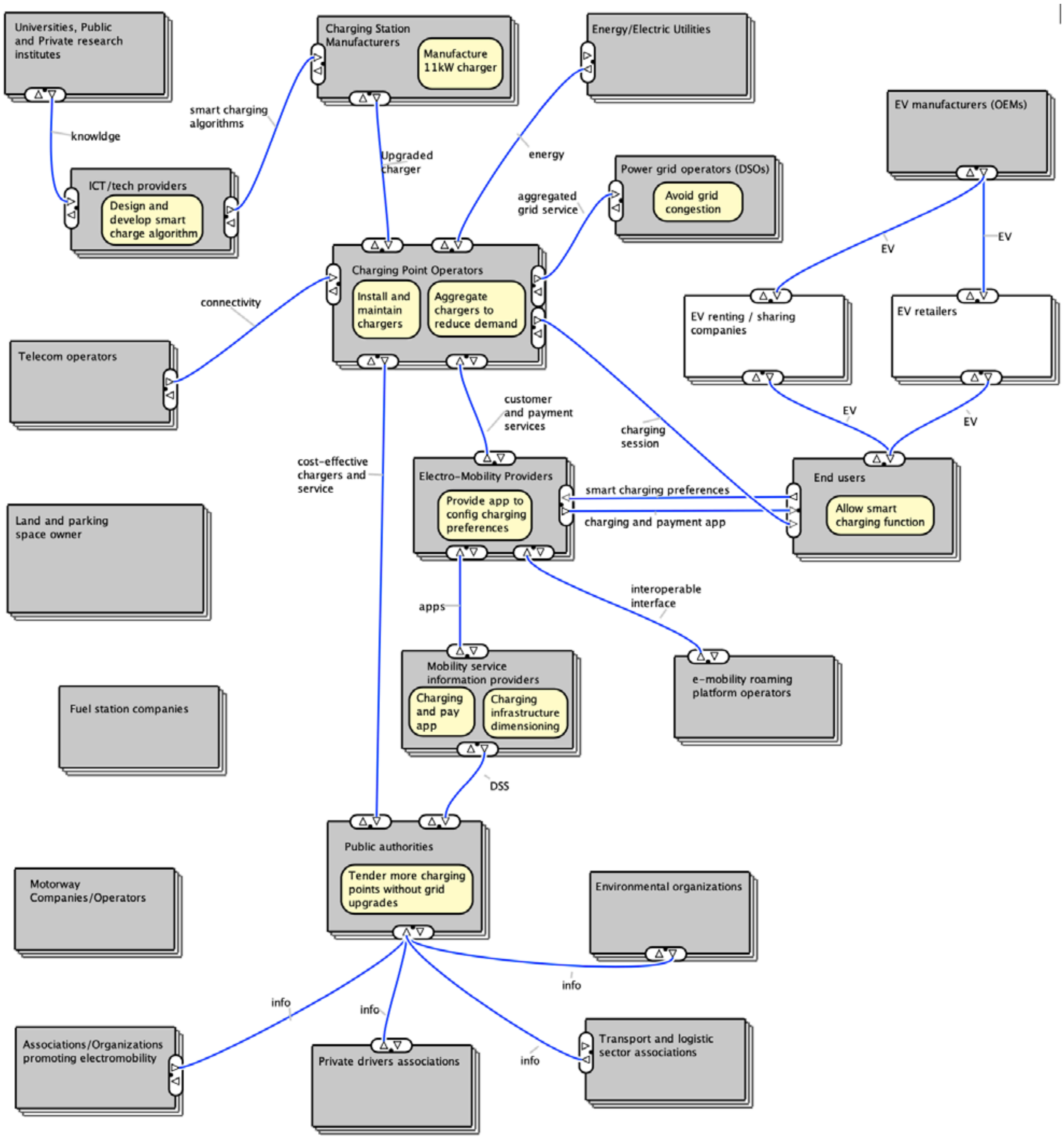

Figure 5. Value Network Model for UC1

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5.3.3 Value Network Analysis

In UC1 value network, different supply chains can be distinguished.

On the one hand, the **11kW smart charger** is enabled by ICT/Technology providers. They deliver the intelligent algorithms to the charging station manufacturer that will sell these upgraded chargers to the Charging Point Operator (CPO).

On the other hand, mobility information providers offer a sizing service of public infrastructures to the city authorities (using INCIT-EV's **DSS**) and offer charging and payment applications (using INCIT-EV's platform **apps**) to the electromobility providers so they can manage the customer relations on behalf of the CPO which, ultimately, is responsible for the charging service concession.

The CPO has a central role in the ecosystem, performing at least two key activities from which it obtains revenues: 1) procure, install, maintain, and operate the chargers under a public procurement contract (subcontracting the customer relations, connectivity, etc.); and 2) virtually aggregate multiple chargers to reduce demand and provide power grid balancing services to the Distribution System Operator (DSO). 3) Additionally, if the Electro-Mobility Provider is only responsible for being the interface between the customers and the CPO via the mobile app, the CPO would legally receive a third revenue stream from the charging sessions (although managed by the electro-mobility provider).

The electro-mobility provider is important in the operational phase, as they must deal with the charging requests, sent through the users' mobile app, and ensure that they get it after checking the user registration and connection with the payment system regardless the CPO and the user subscription platform (considering that roaming service is enabled).

This qualitative value network analysis is preliminary and will be resumed in subsequent tasks such as the cost-benefit analysis and the business model design.

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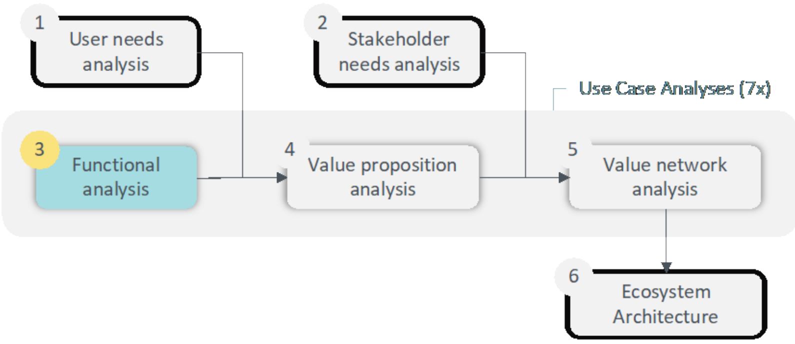
6 UC2 ANALYSES

6.1 UC2 functional analysis

This section contains a description of the UC2 and the result of the functional analysis, based on previous project documentation, which is a list of functionalities and/or quality requirements of the charging solution that will be tested in UC2 and may affect the end-user acceptance.



6.1.1 UC2 objectives and expected user benefits

6.1.1.1 OBJECTIVE

The overall objective of UC2 can be split into three general objectives:

1. Achieve a sufficiently large dynamic energy transfer over a short time and a shorter distance (The main specificity of the low-speed use case is the fact that the energy transmitted per km is significantly higher than for the long-distance higher speed use case)
2. Ensure that there is no health and safety risk (electromagnetic stress) for living beings (internal and external to the vehicle) and sensible device (pacemaker, hearing aid, digital communication, sensible electronic device).
3. Project and exploit the physical characteristics of the UC2 system throughout the city's traffic flow to determine the distance, the number of load zones needed to ensure the intended impact.

6.1.1.2 DESCRIPTION OF NEW PRODUCTS OR SERVICES

UC2 will test one of the project technical results.

Product	Dynamic wireless power transfer charging for urban environments.
Added value	Modular and interoperable DWPT for different type of vehicles sizes allowing to charge the battery of the vehicle.

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IPR Strategy	VEDECOM and STELLANTIS will own the design and prototype of the vehicle adapted to wireless charging. VEDECOM will own the design of the primary coil. COLAS and EUROVIA will own the formulation and the coils embedment solution for urban and roads, respectively. IFSTTAR will own the know-how and the protocols for the tests for the DWPT integration on the grid. COLAS, EUROVIA, ENEDIS and IFSTTAR will jointly own the testing methods for the civil infrastructure integration.
Exploitation route	VEDECOM will license the DWPT software system design to stakeholder (OEM, suppliers) for its commercialisation. VEDECOM and STELLANTIS will include the vehicle adapted to wireless charging among their portfolios. IFSTTAR will standardise DWPT integration tests and provide services for the performance of these tests. COLAS and EUROVIA will offer services for the integration of the DWPT in urban and road environments, as well as licensing the first-of-a-kind method for embedding and integrating the DWPT. PARIS will benefit from increasing the available charging infrastructure in their municipality and comply with the objectives of their SUMP. ENEDIS will benefit from a smoother grid integration of charging infrastructure, particularly of the DWPT.
Time to market	The DWPT for urban environments will be market ready three years after the project end (2027)

6.1.1.3 USER EXPERIENCE IMPROVEMENTS

The user experience regarding charging is seamless, as there is no need to worry about finding available charging spots, which could be expensive in town with the current business models and costs (energy cost + parking cost).

Moreover, the interoperable system will ensure the possibility to charge the battery wherever the service is available.

In addition to the extra-urban DWPT use case 3, the integration of the DWPT in the existing EV ecosystem (and therefore also ICT system) will provide easy navigation, access, and payment, particularly for high mileage vehicle such us taxis or cars sharing.

6.1.1.4 USER BENEFITS

The following user benefits are pursued in UC2:

- Increased Zero Emission vehicle (ZEV) range without stopping at a charging station.
- Low-mass battery, low-cost vehicle.
- Prevent the need to recharge (meaning stop activity) during the day for high mileage vehicle such us taxis or cars sharing.
- Charging solution for all types of urban vehicles (multiscale concept)

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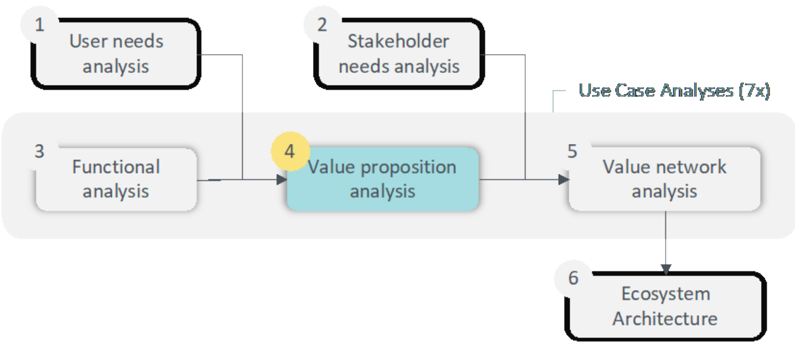
6.1.2 UC2 functional or quality specifications

The system allows end users of either the charging infrastructure or the related software services to:

Use smaller batteries in the EVs, providing sufficient autonomy for urban use and keeping the EV cost low.
Design PHEVs compatible with low emission zone
Avoid buying another vehicle for long distance
Avoid buying an own charging point
Save time charging while driving
Avoid searching for a charging point
Activate or deactivate the charging service when available
Use the system free of risk for health
Display in the car's dashboard the key indicators (SOC, transfer rate, time to full charge…)
Check the amount of energy transferred and pay the bill using an app

6.2 UC2 value proposition analysis

This analysis aims to match the end-user needs with UC2 functionalities or attributes, and indicate the gaps that may exist between them, i.e., check the problem-solution fit. Three steps are performed: static analysis, dynamic analysis, and synthesis.



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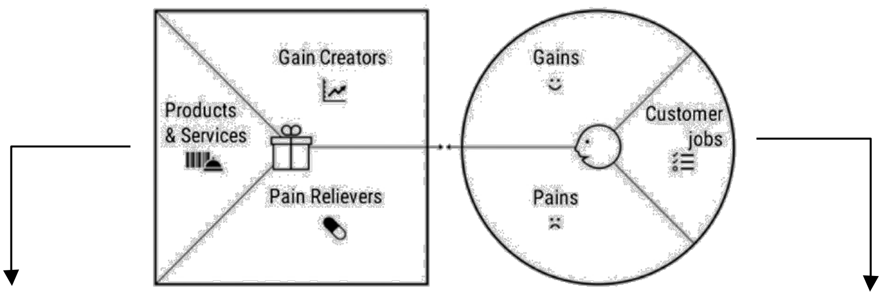
6.2.1 Static approach. Value proposition canvas



UC2 solution				Miguel
Mobility service	Products & Services	⇔	Customer jobs	Drive to work
DWPT service				
EV with smaller battery	Gain Creators	⇔	Gains	Cheaper EV
Charging while driving. No stops required.				No need to stop just to charge
Avoid buying an own charging point station	Pain Relievers	⇔	Pains	Need to modify route to charge
				Insufficient autonomy in the city
Avoid searching charging point				Complexity of the charging process for the driver
				Unavailable charging points

UC2 solution				Laura
Mobility service	Products & Services	⇔	Customer jobs	Charging in town centre
DWPT service				Secure the HY electric range
				Have enough EV range to drive in town
EV with smaller battery	Gain Creators	⇔	Gains	Cheaper EV
Charging while driving. No stops required.				Save Time
				Thermal engine off
Avoid buying an own charging point station	Pain Relievers	⇔	Pains	Charging Point search
Avoid buying another vehicle for long distance				
Avoid searching charging point				

UC2 solution				Ignacio
Mobility service	Products & Services	⇔	Customer jobs	Charging in town centre
DWPT service				Secure the HY electric range
				Have enough EV range to drive in town

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PHEV easily compatible with Low Emission Zone	Gain Creators	⇔	Gains	Thermal engine off
Charging while driving. No stops required.				Save Time
				No charging points search
Avoid buying an own charging point station	Pain Relievers	⇔	Pains	Charging points search
Avoid buying another vehicle for long distance				Downtown fixed
Avoid searching charging point				

UC2 solution | Pedro

Taxi service	Products & Services	⇔	Customer jobs	Transport people
				Guarantees the comfort of the customer with the car comforts availability
Charging while driving. No stops required.	Gain Creators	⇔	Gains	Save Time
	Pain Relievers	⇔	Pains	Charging points search

UC2 solution | Carmen

Low Emission Zone compatible vehicle	Products & Services	⇔	Customer jobs	Charging in town centre
				Working in the low emission zone
allows food deliveries to be made while respecting the cold chain				deliver all customers in the same timeframe
				Ensure compliance with the cold chain
allows you to make a full delivery round without stopping to recharge the vehicle	Gain Creators	⇔	Gains	Do not stop to recharge the vehicle while on tour
guarantees the respect of the cold chain without modifying the duration of the tour	Pain Relievers	⇔	Pains	insufficient autonomy to carry out the tour and supply energy to the refrigeration unit
				delivering fewer customers due to insufficient autonomy

UC2 solution | Rossy

Low Emission Zone compatible vehicle	Products & Services	⇔	Customer jobs	Charging in town centre
allows deliveries to be made while respecting the planning				Working in the low emission zone
				Deliver all customers in the same timeframe
allows you to make a full delivery round without stopping to recharge the vehicle	Gain Creators	⇔	Gains	Do not stop to recharge the vehicle while on tour
	Pain Relievers	⇔	Pains	Delivering fewer customers due to insufficient autonomy

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guarantees the respect of delay without modifying the duration of the tour				Charging points search

6.2.2 Dynamic approach. Scenarios

6.2.2.1 SCENARIO DESCRIPTION

6.2.2.1.1 Scenario description

ID	Scenario 1
Action	Charge on the way while driving…
Vehicle	EV sharing
From	Peri-urban (city suburbs)
Site A	Home
To	Urban (city centre)
Site B	Office
Frequency	All weekdays
Type of route	Urban
Trip distance	5-10 km
Trip duration	10-20 minutes
Destination activity	Work (full working day)
Activity Duration	6-12 hours

ID	Scenario 2
Action	Charge on the way while driving…
Vehicle	Private EV
From	Peri-urban (city suburbs)
Site A	Home
To	Urban (city centre)
Site B	Office
Frequency	All weekdays
Type of route	Urban
Trip distance	10-20 km
Trip duration	10-20 minutes
Destination activity	Work (half working day)
Activity Duration	3-6 hours

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6.2.2.1.2 User objectives

User objectives or requirements for all scenarios:

1. Reach destination without having to stop to charge
2. Allows an energy exchanger for storage in the battery, in addition to drive
3. Allows an energy exchanger for storage in the battery from 0km/h to 50km/h speed
4. Can easily match the amount of energy transferred and the associated cost
5. Find unconstrained and straightforward urban & peri urban roads that allow DWPT
6. Do not cause any health or gene constraints for persons (inside and outside vehicle)
7. Be informed of the transfer of energy
8. Be able to refuse the transfer of energy

6.2.2.1.3 Relevance of the objectives for each persona

	Miguel	Laura	Ignacio	Pedro	Carmen	Rossy
Objective 1	X	X	X	X	X	X
Objective 2	X	X	X	X	X	X
Objective 3	X	X	X	X	X	X
Objective 4	X	X	X	X	X	X
Objective 5	X	X	X	X	X	X
Objective 6	X	X	X	X	X	X
Objective 7	X	X	X	X	X	X
Objective 8	X	X	X	X	X	X

6.2.2.1.4 Storytelling – Steps

Applicable to all user persona.

		Describe the story for each step (sub-objective)	Describe the experienced emotions	Overall emotion rating
O1	**Step 1**	I look on my smart phone the SOC of my car	I organize my day	Good
	Step 2	I take in account my day planning	I organize my day	Good
	Step 3	I choose my itinerary: with DWPT or Charge Point or free	I organize my day	Mixed
	Step 4	I reach my car and go to work	I have a solution	Good
O2	**Step 1**	I'm on slow driving almost stopped due to traffic and i see the transfer of energy on the car dashboard	I check the SOC level, recharge exercise is transparent	Good
O3	**Step 1**	I'm on slow driving almost stopped due to traffic and i see the transfer of energy on the car dashboard	I check the SOC level, recharge exercise is transparent	Good

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O4	**Step 1**	The vehicle dashboard indicates the end of the DWPT transfer	I aware	**Good**
	Step 2	The vehicle dashboard indicates a quantity of energy recovered and store	I'm thinking if it would be enough	**Mixed**
	Step 3	My smart phone received a bill linked with an quantity of energy transfer through the DWPT application	I see that there's 11 percent difference in the amount of energy due to efficiency	**Mixed**
O5	**Step 1**	I'm driving slowly towards urban crosses because that's often where DWPT zones are	I listen Radio	**Good**
O6	**Step 1**	I see no difference in traffic in DWPT areas (pedestrian, bicycle, scooter…)	I check the surrounding behaviours	**Mixed**
	Step 2	I see a blind pedestrian and see that his dedicated guidance system does not seem to be disturbed by the power transfer system	I check the surrounding behaviours	**Good**
O7	**Step 1**	I'm in a traffic jam and my car IHM dashboard indicate that à DWPT is available for 100m	I see the opportunity	**Good**
	Step 2	I activate the DWPT car function	I make a choice	**Good**
O8	**Step 1**	I'm in a traffic jam and my car IHM dashboard indicate that à DWPT is available for 100m	I see the opportunity	**Good**
	Step 2	I'm not activate the DWPT car function because I have got sufficient SOC	I make a choice	**Good**

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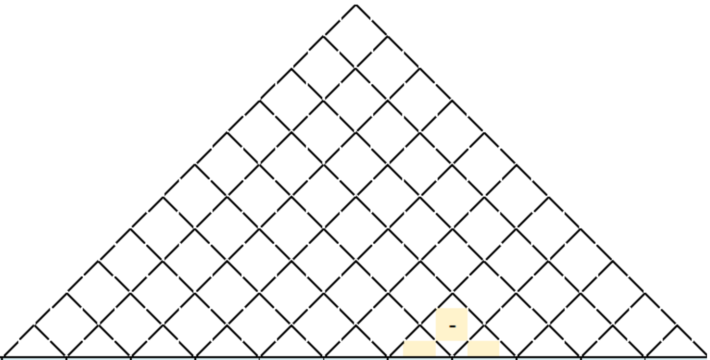
6.2.3 Synthesis. House of quality

6.2.3.1 HOQ DIAGRAM



Row #	Source of the requirement	Customer Requirements (Explicit and Implicit) \ Functional Requirements	1	2	3	4	5	6	7	8	9	10	11
		Stage	Pre-charge					Charge			Post-charge		
			EV with smaller battery	PHEV with wireless charging avoids the need for another vehicle for long distance trips	Possibility to switch the thermal engine off	No need for users to buy their own charging point station	Wireless lanes can be easily found and avoid to search charging point	Charging while driving. No stops required	Charging while driving. Extend battery range seamlessly	Activate or de-activate the charging service when available	Use the system free of risk for health	Check the amount of energy transferred using an app	pay the bill using an app
1	Gains	Cheaper Electric Vehicles	x			x							
2	Gains	No need to stop just to charge		x								x	x
3	Gains	Save charging time		x				x					
4	Gains	Compatibility with Low Emission Zone			x								
5	Gains	No need to search for charging points					x	x					
6	Pains	Need to modify route to charge					x						
7	Pains	Insufficient autonomy in the city							x				
8	Pains	Complexity of the charging process for the driver								x		x	x
9	Pains	Insufficient autonomy to supply energy to the refrigeration unit							x				
10	Pains	Downtown closed to internal combustion engines			x								
11	Pains	Delivering fewer customers due to insufficient autonomy			x				x				
12	Fears	Possible health issues due to radiation									x		
13	Fears	Unavailable charging points					x	x	x				

Figure 6: House of Quality for UC2

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6.2.3.2 HOQ ANALYSIS

The House of Quality shows that the end-user requirements are totally met by the functionalities of the envisioned solution. Some of these requirements are even reinforced by several product attributes, which is very positive.

The wireless charging solution provides value along the whole user journey, from the pre-charging to the post-charging phase, and addresses pains, gains, and fears.

The roof of the HoQ shows that the product features are mostly independent. Only one negative correlation has been highlighted: the possibility to activate or de-activate the service (which on the other hand is a mandatory feature) could affect the seamless experience of the user. This point should be considered to ensure that the selection of one option or another is very easy and accessible for the driver.

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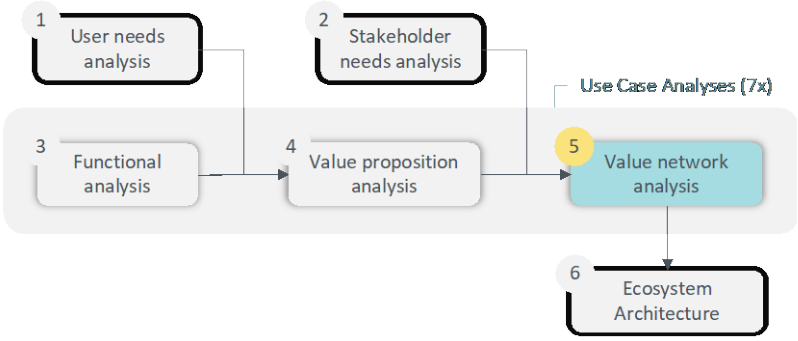
6.3 UC2 Value Network Analysis

This analysis aims to widen the scope of the value proposition drafted so far, to include not only the end users but also those stakeholders that participate in the elaboration or delivery of value.



6.3.1 Stakeholder identification and characterization

In this section, the stakeholders are rated based on their potential power and interest on the use case. Then, the most relevant ones are considered, listing their objectives.

6.3.1.1 STAKEHOLDERS PROFILES

Involvement in the charging network development	Stakehoder	Key group	Power	Interest
Direct	Local public authority (e.g. mobility planners, policy makers)	Government	High	High
	Charging Point Operator (CPO)	Business	Medium	High
	E-Mobility Provider (EMP)	Business	Medium	High
	Fuel station company (petrol stations)	Business	Low	Low
	Motorway company (operator)	Business	High	High
	Land and parking space owner (supermarket, mall, parking area, …)	Business	Medium	Medium
	Power grid operator (DSO)	Business	High	Medium
Indirect	Regional public authority (e.g. mobility planners, policy makers)	Government	High	Medium
	National public authority (e.g. mobility planners, policy makers)	Government	High	Medium
	Energy (electric) utility	Business	Low	Low

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	EV manufacturer (cars, vans, motorbikes, bikes, etc.)	Business	High	Medium
	Charging Station manufacturer	Business	Low	Medium
	ICT/tech provider	Business	Medium	Medium
	Public Research Institute	Research	Low	High
	Private Research Institute	Research	Low	Medium
	University	Research	Medium	Medium
	Start up	Business	Low	High
	Private drivers' associations	Civil society	High	High
	Transport and logistic sector association	Business	Low	Low
	Association/Organization promoting electromobility	Civil society	High	High
	Environmental organization	Civil society	High	Medium
	Telecom operators	Business	Medium	High
	E-mobility roaming platform operators	Business	Medium	High
	Mobility service information providers	Business	Medium	High

6.3.1.2 STAKEHOLDER OBJECTIVES

For a selection of the most relevant stakeholders in terms of power and interest.

Local public authority	Safe from electromagnetic exposition
	Safe from specific urban communication constraint (e.g., blind help system guid - communication)
	Save parking space in town (to be efficient)
	Be effective: efficiency and amount of energy transferred to use
	Do not degrade the resistance of the road
E-mobility provider	To be interconnected with traditional charging points
	To be interoperable with every inductive charging solution
	To be cost efficient in comparison with conductive charging point (slow or fast charging)

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Power Grid Operator	Connection to the grid should be planned carefully to avoid competition with fast charging creating potential grid congestion
	The power supply required to power the inductive system should be adjusted to allow energy storage in the car (unlike the high-speed DWPT)
EV manufacturer	Be effective: efficiency and amount of energy transferred to use (global transfer energy efficiency)
	Respect the durability of the elements of the car traction chain

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6.3.2 Value Network Modelling

The following figure shows the relations among stakeholders in the ecosystems using e3-value modelling methodology.

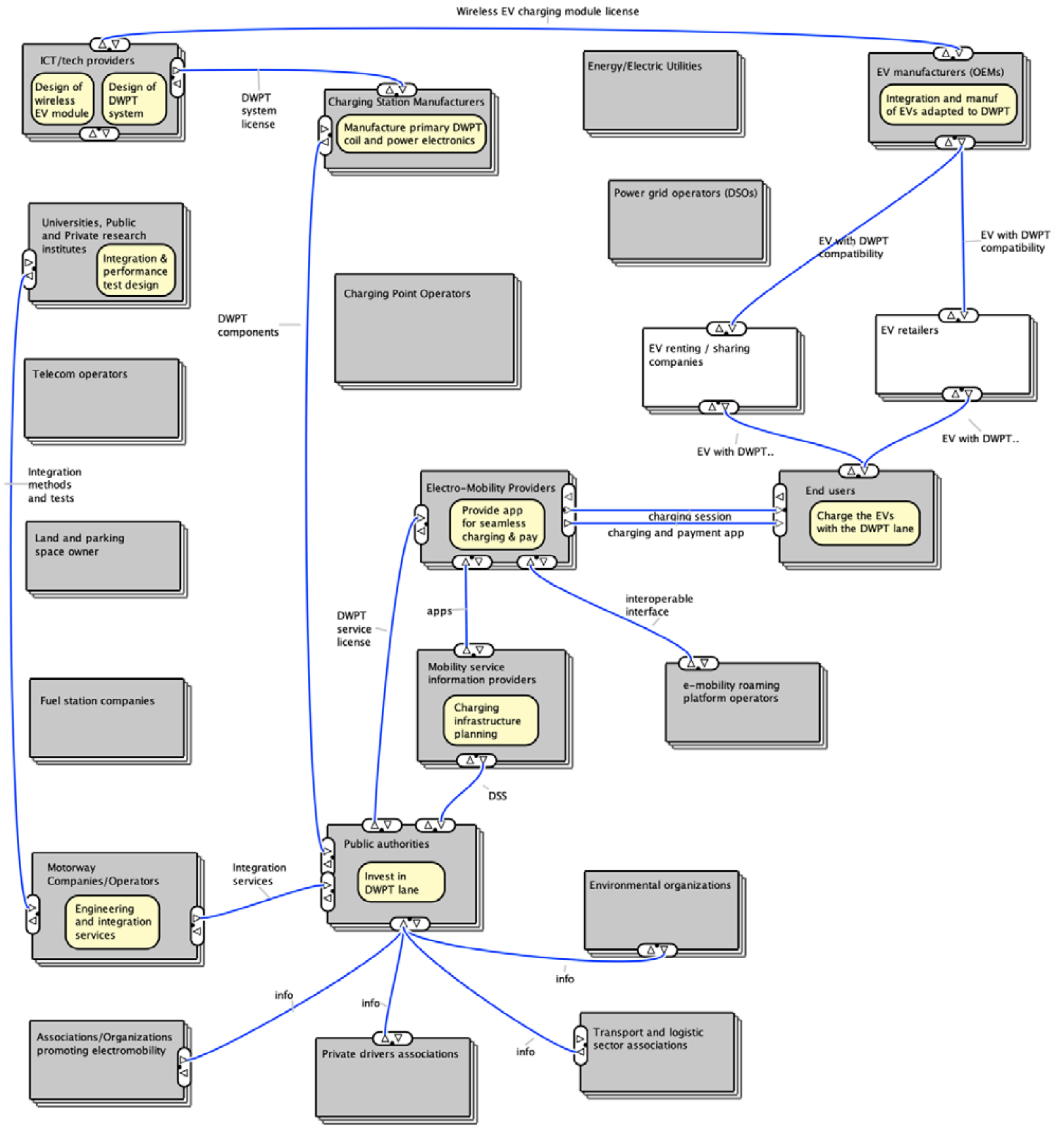

Figure 7: Value Network Model for UC2

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6.3.3 Value Network Analysis

In UC2 value network there are different supply chains.

On the one hand, the technology provider would license the EV wireless charging module to OEMs and the primary coil of the DWPT to a different manufacturer that could be a charging station specialist or a more generalist power electronics company. OEMs integrate the new technology in their EVs that will be rented or sold to the end users, while the charging infrastructure manufacturer will sell the system to public authorities.

On the other hand, there is the software technology supply chain, in which the mobility service information provider delivers a Decision Support System to the public authorities and an application for charging and payment to electro-mobility providers.

Another value chain is related with the knowledge about engineering and integration of DWPT in urban environments. At least research institutes providing test methods and tools, and engineering or construction companies in the road building sector would be involved.

In this use case, public authorities play a critical role as they are the promoters of the project, investors, and owners of the infrastructure. Typically, mobility planning supported by the DSS (and a cost-benefit analysis) would lead to the decision of investing in a DWPT infrastructure. The project tender would be published, and different packages would be granted to undertake the engineering phase, the procurement of the DWPT charging system and the electro-mobility service provision.

If the operation and maintenance requirements are low enough, the Charging Point Operators would have no participation at all in this use case.

This qualitative value network analysis is preliminary and will be resumed in subsequent tasks such as the cost-benefit analysis and the business model design.

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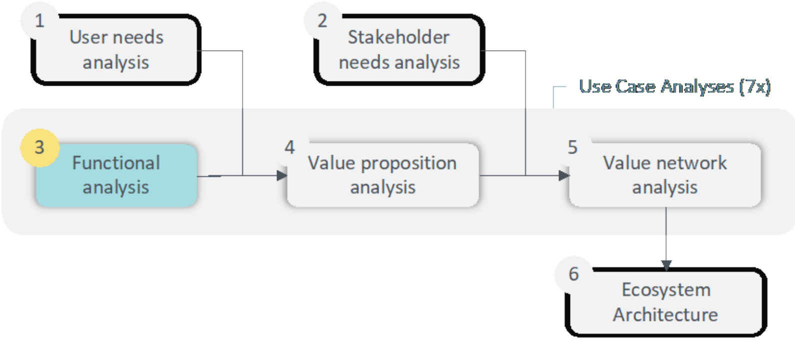
7 UC3 ANALYSES

7.1 UC3 functional analysis

This section contains a description of the UC3 and the result of the functional analysis, based on previous project documentation, which is a list of functionalities and/or quality requirements of the charging solution that will be tested in UC3 and may affect the end-user acceptance.



7.1.1 UC3 objectives and expected user benefits

7.1.1.1 OBJECTIVE

The aim of UC3 is to address the remaining challenges identified for long range dynamic wireless charging technology, i.e., demonstrate its reliability and interoperability in all relevant dimensions (DWPT system, car, use case, etc.). Given the low technological maturity of the DWPT for this use case, a real demonstration in a circulated road can be considered as extremely challenging. Therefore, the objective of the UC is to address the following topics:

- The main challenge of the high-speed use case is the fact that the energy transmitted per km is significantly smaller than for the urban lower speed use case.
- A second challenge is the road surface requirements in terms of continuity which reduces the number of road integration process possibilities.
- A third challenge is the absence of frequent intersections and the different road users (important presence of heavy duty-vehicles, no light vehicles…).

Integrating all these specific aspects, this “last step to real life” demonstration/use case is designed to enable the direct replication for long distance/highway trials (provide infrastructure/vehicles wireless ready) to pave the way for future improvements.

7.1.1.2 DESCRIPTION OF NEW PRODUCTS OR SERVICES

UC3 will test one of the project technical results:

Product	**Dynamic wireless power transfer charging for electric roads**

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Added value	Modular and interoperable DWPT for different type of vehicles sizes allowing to charge the battery of the vehicle while driving ready in highway (up to 130 km/h) environments.
IPR Strategy	RSA and VEDECOM will own the design and prototype of the vehicle adapted to wireless charging. CIRCE will own the design of the primary coil. COLAS and EUROVIA will own the formulation and the coils embedment solution for urban and roads, respectively. IFSTTAR will own the know-how and the protocols for the tests for the DWPT integration on the grid. COLAS, EUROVIA, ENEDIS and IFSTTAR will jointly own the testing methods for the civil infrastructure integration.
Exploitation route	VEDECOM will license the secondary DWPT system design for its commercialisation. CIRCE will license the primary DWPT for its commercialisation. RSA will include the vehicle adapted to wireless charging among their portfolios. IFSTTAR will standardise DWPT integration tests and provide services for the performance of these tests. COLAS and EUROVIA will offer services for the integration of the DWPT in urban and road environments, as well as licensing the first-of-a-kind method for embedding and integrating the DWPT. PARIS will benefit from increasing the available charging infrastructure in their municipality and comply with the objectives of their SUMP. ENEDIS will benefit from a smoother grid integration of charging infrastructure, particularly of the DWPT.
Time to market	Five years after the project end (2030)

7.1.1.3 USER EXPERIENCE IMPROVEMENTS

The user experience regarding charging is seamless, while there is no need to worry about finding available charging spots.

Moreover, the interoperable system will ensure the possibility to charge the battery wherever the service is available.

In addition to the urban DWTP use case, the integration of the long-range DWPT in the existing EV ecosystem (and therefore also ICT system) will provide easy navigation, access, and payment

7.1.1.4 USER BENEFITS

The following user benefits will be demonstrated for UC3:

- Extended range autonomy (3.5 km per km of e-road)

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- Potential 27% reduction in vehicle cost
- Opportunity to develop jointly RES systems close to highways (local production and distribution).

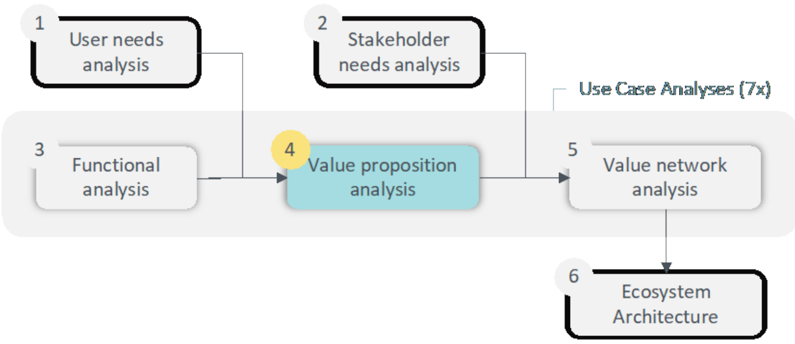
7.1.2 UC3 functional or quality specifications

The system allows end users of either the charging infrastructure or the related software services to:

Charge at moderate power and in a more diffuse manner along the road, which is less impacting for the network than ultra-fast charging at petrol stations.
Charge the EV in a simple way for the driver
Charge as the battery is refilled while driving
Use the motorway at a speed that is close to maximum authorized speed (no limitation)
Know the bill of the service or energy used during the wireless section of the trip
Indicate whilst driving on inductive lane the charging status and rate
Provide additional services like internet connection
Check and inform users that electromagnetic field exposure is null
Know the maximum power available depending on number of cars currently using the solution.

7.2 UC3 value proposition analysis

This analysis aims to match the end-user needs with UC3 functionalities or attributes, and indicate the gaps that may exist between them, i.e., check the problem-solution fit. Three steps are performed: static analysis, dynamic analysis, and synthesis.



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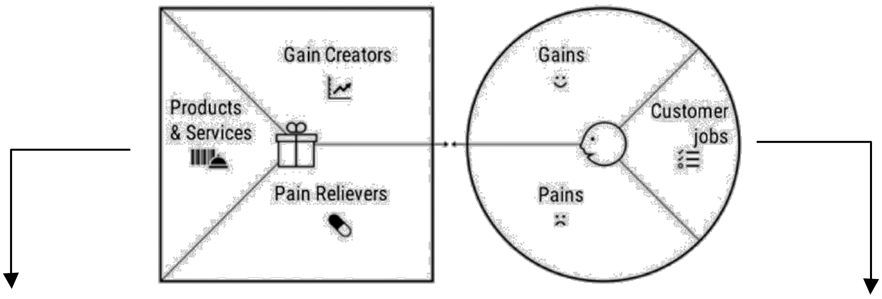
7.2.1 Static approach. Value proposition canvas



UC3 solution

Manuel

UC3 solution				Manuel
Dynamic wireless power transfer charging for electric roads	Products & Services		Customer jobs	Charging while traveling long distances
Reduction in battery size and therefore in the cost of EVs, and space saving in cities. In addition, charging is carried out at moderate power and in a more diffuse manner along the road, which is less impacting for the network than ultra-fast charging at petrol stations.	Gain Creators	⇔	Gains	Do not require specific stop to charge as the battery is refilled while driving
				No need to think about charging, with seamless on road charging.
				Intermediate SOC level opposed to full charge might provide peace of mind regarding fully charge battery damage apprehension
				No range anxiety, piece of mind
Simplicity of the charging process for the driver	Pain Relievers	⇔	Pains	Queuing at charging stations on highway
				Loss of time for extra stops
				Need to get out of the car

7.2.2 Dynamic approach. Scenarios

7.2.2.1 SCENARIO 1

7.2.2.1.1 Scenario description

ID	Scenario 1
Action	Charge on the way while driving…
Vehicle	Private EV
From	Peri-urban (city suburbs)
Site A	Home
To	Far off (long distance from the city)

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Site B	Rented apartment/house
Frequency	Once every two or three months
Type of route	Highway
Trip distance	>60 km
Trip duration	>40 minutes
Destination activity	Long holiday stay
Activity Duration	>1 week

7.2.2.2 SCENARIO 2

7.2.2.2.1 Scenario description

ID	Scenario 2
Action	Charge on the way while driving…
Vehicle	Private EV
From	Urban (city centre)
Site A	Office
To	Far off (long distance from the city)
Site B	Office
Frequency	Once a month
Type of route	Highway
Trip distance	>60 km
Trip duration	>40 minutes
Destination activity	Work (half working day)
Activity Duration	3-6 hours

7.2.2.3 SCENARIO 3

7.2.2.3.1 Scenario description

ID	Scenario 3
Action	Charge on the way while driving…
Vehicle	EV sharing
From	Far-off (long distance from the city)
Site A	Second residence
To	Urban (city centre)
Site B	Home
Frequency	Once every two or three months
Type of route	Highway
Trip distance	>60 km

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Trip duration	>40 minutes
Destination activity	Sport or leisure
Activity Duration	1-2 hours

7.2.2.3.2 User objectives

User objectives or requirements for all scenarios:

1. Reach my destination without having to stop to charge
2. Use the motorway at a speed that is close to maximum authorized speed (no limitation)
3. Billing of the service or energy used during the wireless section of the trip is known
4. Clear indication whilst driving on inductive lane that I'm charging and how much
5. The charging lane, should also be able to provide additional services like internet connection
6. The system should be able to let me know that electromagnetic field exposure is null
7. The system should give indication of the maximum power available depending on number of cars currently using the solution.

7.2.2.3.3 Relevance of the objectives for each persona

	Manuel	Miguel	Miriam	Sergio	Laura
Objective 1	X				
Objective 2	X				
Objective 3	X				
Objective 4	X				
Objective 5					
Objective 6	X				
Objective 7					

7.2.2.3.4 Storytelling - Steps

Manuel

		Describe the story for each step (sub-objective)	Describe the experienced emotions	Overall emotion rating
	Step 1	I take my car and check that state of charge sufficient to reach inductive highway lane	Light anxiety, as I have not charged the car ahead of this long trip	Mixed
	Step 2	I have reached the highway, but I'm not sure if the available power will be sufficient to charge my car at the speed required to reach my destination in time,	I'm confident, that I will reach my destination now that I have reached the highway. Being able to use it at full power would be a nice to have	Good

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	Step 3	I'm on the highway, power supply from the road is sufficient and battery state of charge is maintained high enough so I will reach my destination when leaving the highway I have also a real time indication, that the system is working fine, safe with no impact of the inductive charging on my health	I feel relaxed and reassured	**Good**
	Step 4	I leave the highway; my battery is fully charged. I receive in real time the amount of energy I have used, the (total?) efficiency and the invoice regarding the trip that will be directly linked to my mobility service provider bill (ok the price par kWh should be known before taking the decision to use the service - AFIR regulation principle)	I'm pleased that thanks to inductive charging, I was able to use my own day to day electric car to cover this long-distance trip, without making a break just for this service, it was seamless	**Good**

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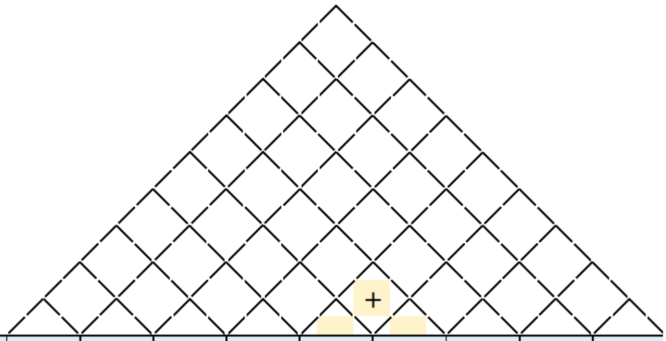
7.2.3 Synthesis. House of quality

7.2.3.1 HOQ DIAGRAM



Row #	Source of the requirement	Customer Requirements (Explicit and Implicit) / Functional Requirements	1	2	3	4	5	6	7	8	9
		Column #	1	2	3	4	5	6	7	8	9
		Stage	Pre-charge		Charge						Post
			Check and inform users that electromagnetic field exposure is null	Know the max power available depending on number of cars currently using the solution.	Charge the EV in a simple way for the driver	Charge as the battery is refilled while driving	Use the motorway at a speed that is close to maximum authorized speed (no limitation)	Charge at moderate power and in a more diffuse manner along the road	Indicate whilst driving on inductive lane the charging status and rate	Provide additional services like internet connection	Know the bill of the service or energy used during the wireless section of the trip
1	Gains	Do not require specific stop to charge as the battery is refilled while driving				X					
2	Gains	Intermediate SOC level provide peace of mind regarding full charge battery damage apprehension						X	X		
3	Gains	No need to think about charging, with seamless on road charging. No range anxiety.					X				
4	Pains	Queing at charging stations on highway				X					
5	Pains	Lost of time for extra stops			X						
5	Pains	Need to get out of the car			X						X
6	Fears	Problems related to the APP operation or connectivity in long distance trips								X	
7	Fears	Unavailable charging point (not working)		X							

Figure 8. House of Quality for UC3

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7.2.3.2 HOQ ANALYSIS

The HoQ shows that all the end-user requirements are addressed by the proposed wireless charging solution in UC3. All types of requirements (pains, gains and fears) have been taken into account in the value proposition. Moreover, the features of the charging service are delivered along the whole customer journey: in the preparation, during the charging and after the actual use of the wireless lane.

The roof of the HoQ points out that no major dependencies affect the design considerably. I.e., there is a low correlation between pairs of technical features and thus changes in one of the attributes should not affect the others. Only one aspect has been highlighted, which is a positive correlation between the possibility to use the motorway at a speed that is close to the maximum authorised, and the charging in a diffuse way along the road at moderate speeds. If charging constraints are more relaxed, the user will be able to drive at a speed that is closer to the maximum allowed without effort.

One of the technical attributes does not match any customer requirement: the communication to the user that the electromagnetic field is null. This is considered a must and, as it affects the health of the user, is in its own interest to ensure it. The fact that there is not a match is only because the users did not explicitly mention it in the interviews.

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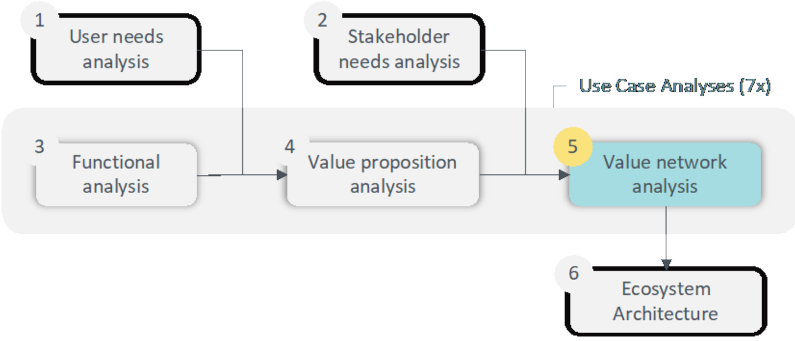

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	E-Mobility Provider (EMP)	Business	Medium	Medium
	Fuel station company (petrol stations)	Business	High	Medium
	Motorway company(operator)	Business	High	High
	Land and parking space owner (supermarket, mall, parking area, …)	Business	Low	Low
	Power grid operator (DSO)	Business	High	Medium
Indirect	Regional public authority (e.g., mobility planners, policy makers)	Government	High	Low

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	National public authority (e.g. mobility planners, policy makers)	Government	High	Low
	Energy (electric) utility	Business	Low	Low
	EV manufacturer (cars, vans, motorbikes, bikes, etc.)	Business	High	Medium
	Charging Station manufacturer	Business	Low	Low
	ICT/tech provider	Business	Medium	Medium
	Public Research Institute	Research	Low	High
	Private Research Institute	Research	Low	High
	University	Research	Low	High
	Start up	Business	Low	High
	Private drivers associations	Civil society	Low	Low
	Transport and logistic sector association	Business	Medium	Medium
	Association/Organization promoting electromobility	Civil society	Medium	Medium
	Environmental organization	Civil society	Low	Medium
	Telecom operators	Business	Medium	Low
	E-mobility roaming platform operators	Business	High	High
	Mobility service information providers	Business	High	High

Table 1

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7.3.1.2 STAKEHOLDER OBJECTIVES

For a selection of the most relevant stakeholders in terms of power and interest.

Local/Regional/National Authorities	Safe from electromagnetic exposition
	Cost of infrastructure should not be borne by local authority
E mobility provider	To be interconnected with traditional charging points
	To be interoperable with every inductive charging solution
	To be cost efficient in comparison with fast charging
Motorway Company	Needs and solutions to diverse transport electrification and provide a mix of solutions to their customers avoiding queuing on charging station.
	Once implemented, system is not visible and leads to smoother traffic.
Power Grid Operator	Connection to the grid should be planned carefully to avoid competition with fast charging creating potential grid congestion
	Power required to supply the inductive system should be tuned to encourage sobriety by allowing more energy transfer for drivers within speed limits

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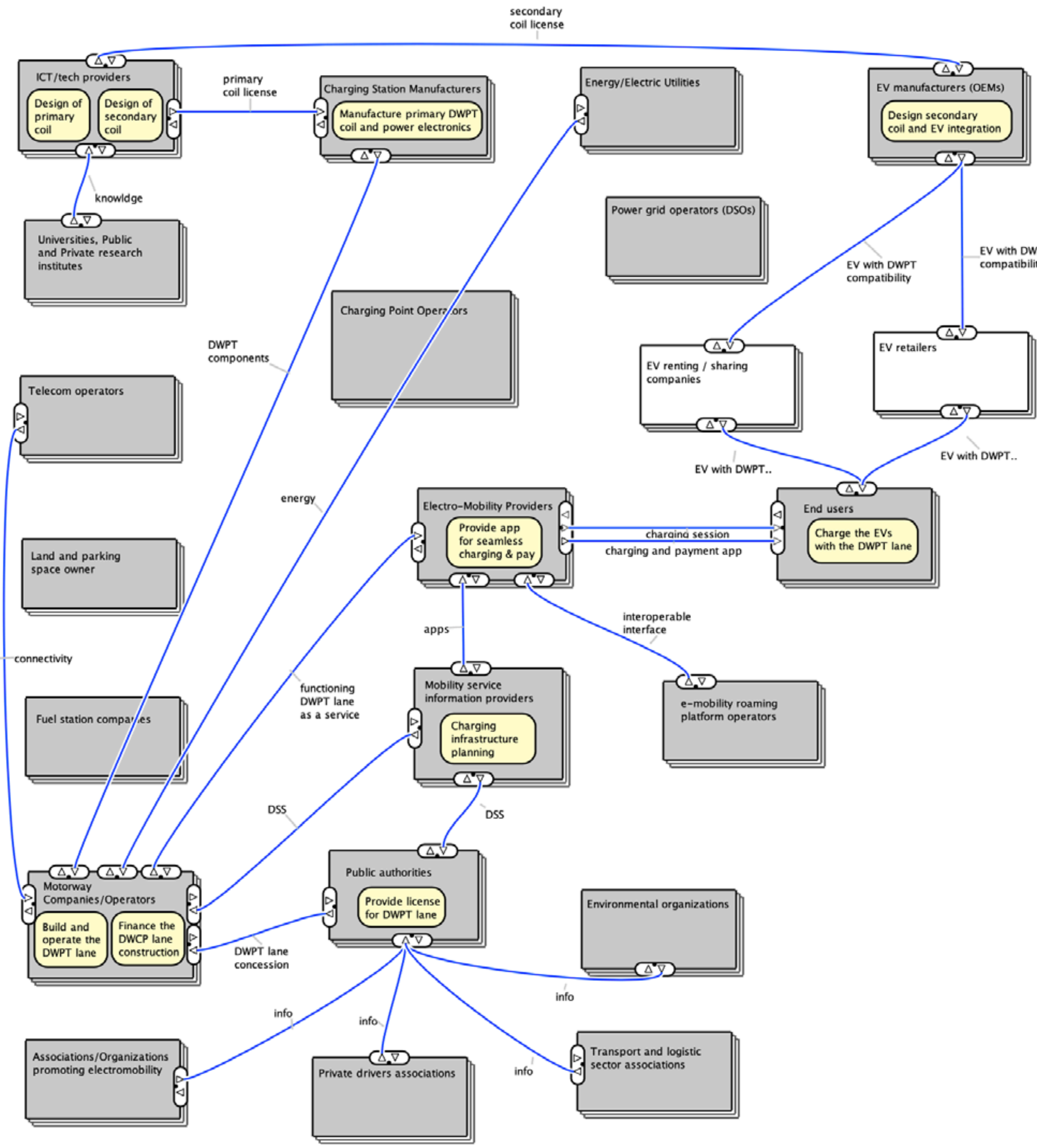

Figure 9. Value Network Model for UC3

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7.3.3 Value Network Analysis

UC3 is enabled by a supply chain made up of universities, research institutions and technology providers that license the new DWPT technology to charging station manufacturers (primary coil and power electronics) and to EV manufacturers (secondary coil and power electronics).

Another enabler is the set of digital solutions: DSS for public authorities and Apps for electro-mobility providers that, at the same time, are distributed to end users to facilitate their seamless interaction with the wireless charging service.

Unlike UC2, where public authorities play the role of promoter and investor, in this scenario those roles are assumed by the private sector, specifically by Motorway companies/operators. They pay for the services of the telecom operators and electric utilities, invest in the coils, and power electronics, and undertake the construction of the DWPT lane. That package could be offered as a service to the electro-mobility providers that would be responsible for the service, payment charge and support to the end users.

If the operation and maintenance requirements are low enough, the Charging Point Operators would have no participation at all in this use case.

This qualitative value network analysis is preliminary and will be resumed in subsequent tasks such as the cost-benefit analysis and the business model design.

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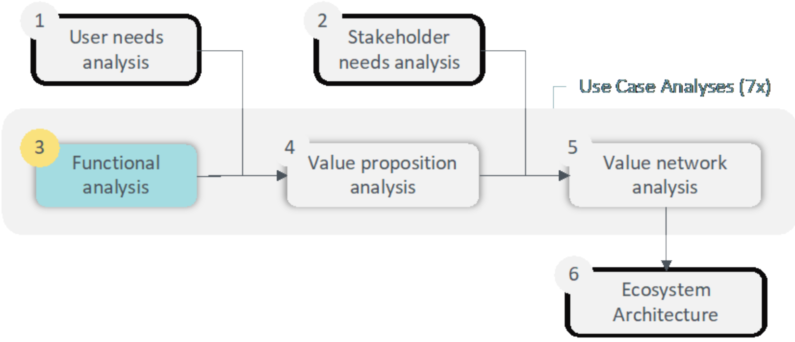
8 UC4 ANALYSES

8.1 UC4 functional analysis

This section contains a description of the UC4 and the result of the functional analysis, based on previous project documentation, which is a list of functionalities and/or quality requirements of the charging solution that will be tested in UC4 and may affect the end-user acceptance.



8.1.1 UC4 objectives and expected user benefits

8.1.1.1 OBJECTIVE

The aim of UC4 is to test a smart micro-grid, including several DC charging stations with different technologies and performances, powered by the tramway DC network. The test field will also integrate the facilities and the knowledge developed in previous projects.

8.1.1.2 DESCRIPTION OF NEW PRODUCTS OR SERVICES

UC4 will test two of the project technical results.

Product	**Bidirectional low Power (3.6kW) CCS2 DC/DC charging station**
Added value	Bidirectional low power DC/DC converters enabling power transfer from one another to the 150kW ultrafast charger also present in the demo site. No AC/DC conversion at any stage of the infrastructure (native DC tramway grid as power source).
IPR Strategy	Prima Electro will own the charging hardware asset (chargers, 50 kW conversion modules) for the duration of the project and will own all eventual IP related to its assembly and production, if any. Iren Mercato will own the electric hardware needed for the connection to the substation located inside the substation itself as well as the whole charging infrastructure asset after the INCIT-EV project will end.

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Exploitation route	During the project, there will not be a public access to the chargers for customers. Only consortium partners EVs will be recharged in the experimentation. Prima Electro will donate the charging infrastructure to Iren after the project's end. The charging infrastructure will be added to IrenGo's (Iren Mercato's subsidiary for mobility products) portfolio of chargers, and it will be included in the IrenGo app for booking and payment activities by the future users. The City of Torino will lease to IrenGo the parking places that are served by the charging infrastructure. The whole UC4 consortium, led by Iren, will collaborate to eventually extend the application of the system in other conversion substations.
Time to market	Approx. 6 months after the project's end.

Product	**Unidirectional Ultrafast (150kW) CCS2 DC/DC charging station**
Added value	Native CCS2 DC/DC Ultrafast charger that doesn't require AC/DC conversion, thus saving raw materials, complexity and increasing energy efficiency. Power source is the existing tramway conversion substation.
IPR Strategy	Prima Electro will own the charging hardware asset (chargers, 50 kW conversion modules) for the duration of the project and will own all eventual IP related to its assembly and production, if any. Iren Mercato will own the electric hardware needed for the connection to the substation located inside the substation itself as well as the whole charging infrastructure asset after the INCIT-EV project will end.
Exploitation route	During the project, there will not be a public access to the chargers for customers. Only consortium partners EVs will be recharged in the experimentation. Prima Electro will donate the charging infrastructure to Iren after the project's end. The charging infrastructure will be added to IrenGo's (Iren Mercato's subsidiary for mobility products) portfolio of chargers, and it will be included in the IrenGo app for booking and payment activities by the future users. The City of Torino will lease to IrenGo the parking places that are served by the charging infrastructure. The whole UC4 consortium, led by Iren, will collaborate to eventually extend the application of the system in other conversion substations.
Time to market	Approx. 6 months after the project's end.

8.1.1.3 USER EXPERIENCE IMPROVEMENTS

The charging hub will provide users with several technologies with different performances and prices to make available a wide bouquet of choices. Depending on their specific needs the user will be able to choose the most suitable option (i.e., usually commuters can leave the car all day long and benefit of lower prices, and if once they need a fast charge of few minutes, they can use the superfast chargers).

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The interoperability of the payment system with the current public transport electronic ticketing system (BIP) will ensure the maximum accessibility of the charging and a better user experience. Thanks to the connection with the tramway network, new business models can be tested (i.e., involving the public transport operator) allowing to reduce the prices for the final users and to foster the use of public-transport to get into the city.

Moreover, the development of new, collaborative business models can increase the integration and data exchange between different involved actors (i.e., Municipality, public transport operator, carsharing services, power grid management, etc.), paving the way for future improvements and applications.

8.1.1.4 USER BENEFITS

The following user benefits will be demonstrated for UC4:

- Cost savings for the charging of EVs thanks to the optimisation of the electric power network through the implementation of V2G technologies.
- Improved intermodality in urban area, providing park-and-ride with charging facilities.
- Test site for innovative solutions to replicate them in other areas, increasing the market share of EVs.
- Collect data about the mobility behaviours of EV users to improve the effectiveness of future actions.

8.1.2 UC4 functional or quality specifications

The system allows end users of either the charging infrastructure or the related software services to:

Access geolocation and availability of charging points in real time through mobile app
Access facilities placed in an intermodal point with connections with other transport means (public transport, sharing vehicles)
Choose the type of charge (level, speed) according with park duration.
Book charging points via app
Protection measures for both people and objects
Bidirectional low power charging
Unidirectional ultrafast charging
Monitor the charge status trough mobile app
Manage all the payment processes (charging fees and public transport costs) in an integrated way, to easily control all the costs

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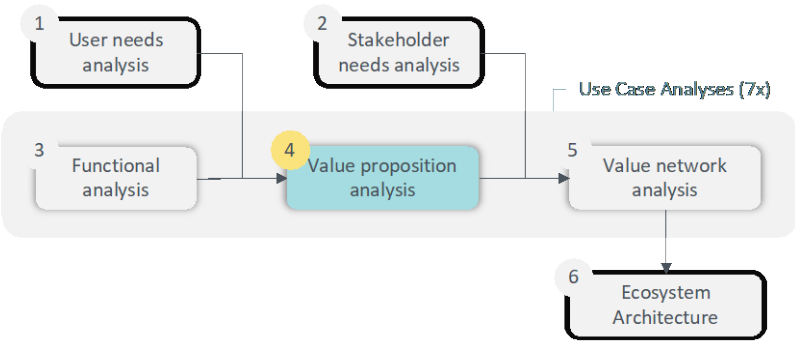
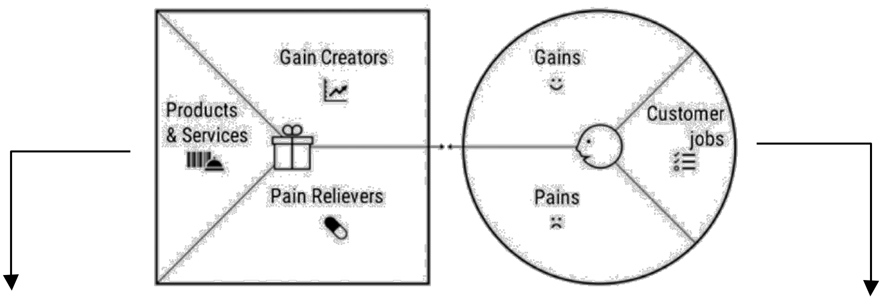
8.2 UC4 value proposition analysis

This analysis aims to match the end-user needs with UC4 functionalities or attributes, and indicate the gaps that may exist between them, i.e., check the problem-solution fit. Three steps are performed: static analysis, dynamic analysis, and synthesis.



8.2.1 Static approach. Value proposition canvas



UC4 solution

Manuel

Bidirectional low Power (3.6kW) CCS2 DC/DC charging station	Products & Services	⇔	Customer jobs	Commute to work
Unidirectional Ultrafast (150kW) CCS2 DC/DC charging station				Charge his EV during the day
				Charge his EV in short time (for emergency)
Provide low power facility to charge the EV during the day	Gain Creators	⇔	Gains	Travelling to work, find a park-and ride in which to leave the car for the entire day
Provide ultrafast charging in case of emergency				In case of emergency, find a public charging point with ultrafast mode
Facilities placed in an intermodal point with connections with other transport means (public transport, sharing vehicles)				Plan his trip in intermodal way

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Be sure to find the available place through mobile app	Pain Relievers	⇔	Pains	Not sure to find the charging point available
Unique payment system to manage both charging fees and public transport costs				Too many APPs needed to manage the daily travel routine

UC4 solution — Miguel

Bidirectional low Power (3.6kW) CCS2 DC/DC charging station	Products & Services	⇔	Customer jobs	Charge his EV (night hours) in public spaces near home
Unidirectional Ultrafast (150kW) CCS2 DC/DC charging station				Commute to work
				Make shopping (once a week)
Network of public charging points with different charging options	Gain Creators	⇔	Gains	Find public charging points
Integrated payment system to manage the EV charging in urban area				
Possibility to book charging points	Pain Relievers	⇔	Pains	Not sure to find the charging point available
Availability of different charging modes (and speeds)				Range anxiety due to reduced time for charging

UC4 solution — Laura

Bidirectional low Power (3.6kW) CCS2 DC/DC charging station	Products & Services	⇔	Customer jobs	Use the car for personal and family needs
Unidirectional Ultrafast (150kW) CCS2 DC/DC charging station				
Network of public charging points with different charging options	Gain Creators	⇔	Gains	Find places with available charging facilities
Integrated payment system to manage the EV charging in urban area				Plan her trips keeping into account EV charging needs
				Be ready in case of unexpected events
Possibility to book charging points	Pain Relievers	⇔	Pains	Difficult to find available charging points near destination
Availability of different charging modes (and speeds)				Range anxiety in case of unexpected needs

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8.2.2 Dynamic approach. Scenarios

8.2.2.1 SCENARIO 1

8.2.2.1.1 Scenario description

ID	Scenario 1
Action	Charge at origin to drive (or ride) …
Vehicle	Private EV
From	Peri-urban (city suburbs)
Site A	Home
To	Peri-urban (city suburbs)
Site B	Office
Frequency	All weekdays
Type of route	Road
Trip distance	10-20 km
Trip duration	20-40 minutes
Destination activity	Work (full working day)
Activity Duration	6-12 hours

8.2.2.1.2 User objectives

1. To be able to charge the EV near home overnight, to use it to go to work the day after (round-trip of about 40 km).
2. To be able to maintain the charging level over a certain threshold in case of unplanned needs (emergencies).
3. To be able to keep the EV charged to make some longer trips during weekends.

8.2.2.1.3 Relevance of the objectives for each persona

	Manuel	Miguel	Miriam	Sergio	Laura
Objective 1	X				X
Objective 2	X				X
Objective 3	X				

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8.2.2.1.4 Storytelling - Steps

Manuel

		Describe the story for each step (sub-objective)	Describe the experienced emotions	Overall emotion rating
O1	Step 1	Access the service via mobile app to check the availability of a charging point near home.	Satisfaction, comfort (if charging point is available)	Good
	Step 2	Book the charging point and choose the type of charge (level, speed)	Satisfaction, easiness (if charging point is available)	Good
	Step 3	Park the car and connect to charging point	Comfort, trust	Good
	Step 4	Monitor the charge status trough mobile app	Comfort, trust	Good
	Step 5	Disconnect the car and move it to another park	Satisfaction, if EV fully charged	Mixed
O2	Step 1	Access the service via mobile app to check the availability of a charging point near home.	Satisfaction, comfort (if charging point is available)	Good
	Step 2	Book the charging point and choose the type of charge (level, speed)	Satisfaction, easiness (if charging point is available)	Good
	Step 3	Park the car and connect to charging point	Comfort, trust	Good
	Step 4	Monitor the charge status trough mobile app	Comfort, trust	Good
	Step 5	Disconnect the car when fully charged (or over the defined threshold)	Satisfaction, comfort	Mixed
O3	Step 1	Access the service via mobile app to check the availability and book a charging point near home.		Good
	Step 2	Park the car and connect to charging point	Satisfaction, comfort (if charging point is available)	Good
	Step 3	Monitor the charge status trough mobile app	Comfort, trust	Good
	Step 4	Disconnect the car and move it to another park	Satisfaction, comfort	Mixed

Laura

		Describe the story for each step (sub-objective)	Describe the experienced emotions	Overall emotion rating
O1	Step 1	Access the service via mobile app to check the availability of a charging point near home.	Satisfaction, comfort (if charging point is available)	Good
	Step 2	Book the charging point and choose the type of charge (level, speed)	Satisfaction, easiness (if charging point is available)	Good
	Step 3	Park the car and connect to charging point	Comfort, trust	Good
	Step 4	Monitor the charge status trough mobile app	Comfort, trust	Good
	Step 5	Disconnect the car when charging level is over the planned threshold	Satisfaction, if threshold have been reached	Mixed

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O2	**Step 1**	Access the service via mobile app to check the availability of a charging point near home.	Satisfaction, comfort (if charging point is available)	Good
	Step 2	Book the charging point and choose the type of charge (level, speed)	Satisfaction, easiness (if charging point is available)	Good
	Step 3	Park the car and connect to charging point	Comfort, trust	Good
	Step 4	Monitor the charge status trough mobile app	Comfort, trust	Good
	Step 5	Disconnect the car when charging level is over the planned threshold	Satisfaction, if threshold have been reached	Mixed

8.2.2.2 SCENARIO 2

8.2.2.2.1 Scenario description

ID	Scenario 2
Action	Charge at destination after driving (or riding) …
Vehicle	Private EV
From	Extra-urban (near the city)
Site A	Home
To	Urban (city centre)
Site B	Office
Frequency	All weekdays
Type of route	Road
Trip distance	20-60 km
Trip duration	> 40 minutes
Destination activity	Work (full working day)
Activity Duration	6-12 hours

8.2.2.2.2 User objectives

1. To be able to leave the EV in a peri-urban park and ride facility and charge it during the working day (commuting to work by public means).
2. To be able to maintain the battery level over a certain threshold to allow to come back home, and in case make some shopping or short trips for family matters.
3. To be able to manage all the services (parking, charging, public transport) through an integrated payment method.

8.2.2.2.3 Relevance of the objectives for each persona

	Manuel	Miguel	Miriam	Sergio	Laura
Objective 1		X			
Objective 2		X			
Objective 3	X	X			X

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8.2.2.2.4 Storytelling - Steps

Manuel

		Describe the story for each step (sub-objective)	Describe the experienced emotions	Overall emotion rating
O3	Step 1	Access the service via mobile app to check the availability of a charging point at park and ride facility.	Satisfaction, comfort (if charging point is available)	Good
	Step 2	Book the charging point and choose the type of charge (level, speed) according with park duration.	Satisfaction, easiness (if charging point is available)	Good
	Step 3	Park the car, connect to charging point and commute to work by public means	Comfort, trust	Good
	Step 4	Monitor the charge status trough mobile app	Comfort, trust	Good
	Step 5	Take the car at the end of working day and go home.	Satisfaction, if EV fully charged	Good
	Step 6	Manage all the payment processes in an integrated way, to easily control all the costs	Comfort, satisfaction, easiness	Good

Miguel

		Describe the story for each step (sub-objective)	Describe the experienced emotions	Overall emotion rating
O1	Step 1	Access the service via mobile app to check the availability of a charging point at park and ride facility.	Satisfaction, comfort (if charging point is available)	Good
	Step 2	Book the charging point and choose the type of charge (level, speed) according with park duration.	Satisfaction, easiness (if charging point is available)	Good
	Step 3	Park the car, connect to charging point and commute to work by public means	Comfort, trust	Good
	Step 4	Monitor the charge status trough mobile app	Comfort, trust	Good
	Step 5	Take the car at the end of working day and go home.	Satisfaction, if EV fully charged	Good
O2	Step 1	Access the service via mobile app to check the availability of a charging point at park and ride facility.	Satisfaction, comfort (if charging point is available)	Good
	Step 2	Book the charging point and choose the type of charge (level, speed) according with park duration.	Satisfaction, easiness (if charging point is available)	Good
	Step 3	Park the car, connect to charging point and commute to work by public means	Comfort, trust	Good
	Step 4	Monitor the charge status trough mobile app	Comfort, trust	Good

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	Step 5	Take the car at the end of working day and use it for leisure or family matters.	Satisfaction, if EV fully charged	**Good**
O3	**Step 1**	Access the service via mobile app to check the availability of a charging point at park and ride facility.	Satisfaction, comfort (if charging point is available)	**Good**
	Step 2	Book the charging point and choose the type of charge (level, speed) according with park duration.	Satisfaction, easiness (if charging point is available)	**Good**
	Step 3	Park the car, connect to charging point and commute to work by public means	Comfort, trust	**Good**
	Step 4	Monitor the charge status trough mobile app	Comfort, trust	**Good**
	Step 5	Take the car at the end of working day and go home.	Satisfaction, if EV fully charged	**Good**
	Step 6	Manage all the payment processes in an integrated way, to easily control all the costs	Comfort, satisfaction, easiness	**Good**

Laura

		Describe the story for each step (sub-objective)	Describe the experienced emotions	Overall emotion rating
O3	**Step 1**	Disconnect the car when charging level is over the planned threshold	Satisfaction, if threshold have been reached	**Mixed**
	Step 2	Access the service via mobile app to check the availability of a charging point at park and ride facility.	Satisfaction, comfort (if charging point is available)	**Good**
	Step 3	Book the charging point and choose the type of charge (level, speed) according with park duration.	Satisfaction, easiness (if charging point is available)	**Good**
	Step 4	Park the car, connect to charging point and commute to work by public means	Comfort, trust	**Good**
	Step 5	Monitor the charge status trough mobile app	Comfort, trust	**Good**
	Step 6	Take the car at the end of working day and go home.	Satisfaction, if EV fully charged	**Good**

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8.2.3 Synthesis. House of quality

8.2.3.1 HOQ DIAGRAM

Row #	Source of the requirement	Column #	1	2	3	4	5	6	7	8	9
		Stage	Pre-charge				Charge				Post
		Functional Requirements / Customer Requirements (Explicit and Implicit)	Access geolocation and availability of charging points in real time through mobile	Facilities placed in an intermodal point with connections with other transport means	Choose the type of charge (level, speed) according with park duration.	Book charging points via app	Protection measures for both people and objects	Bidirectional low power charging	Unidirectional ultrafast charging	Monitor the charge status trough mobile app	Manage all the payment processes in an integrated way, to easily control all the costs
1	Gains	Travelling to work, find a park-and ride in which to leave the car for the entire day	X					X			
2	Gains	In case of emergency, find a public charging point with ultrafast mode	X		X				X		
3	Gains	Plan trip in intermodal way		X		X					
4	Pains	Not sure to find the charging point available				X					
5	Pains	Too many APPs needed to manage the daily travel routine									X
6	Fears	Problems related to the APP operation or connectivity in long distance trips									
7	Fears	Unavailable charging point (not working)					X			X	

Figure 10: House of Quality for UC4 applied to Manuel in Scenario 1.

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8.2.3.2 HOQ ANALYSIS

The functional requirements of the solutions that will be tested in UC4 are fitting with the customer needs in terms of personal mobility. In particular, the proposed solutions will address the need to find and book a charging point in a specific area (near home for overnight charging for some users, near workplace or near an intermodal point for others), thus reducing the range anxiety and fostering the market penetration of EVs. Data collected during the demo are extremely useful to evaluate the actual positive impact of these solutions in the market acceptance of EVs, thus improving their scalability and replicability.

The House of Quality shows that all the product features respond to one or more user requirements. However, in the opposite way, there is one user requirement that has no match with any product specification. This user requirement is the fear of having problems with the app operation or connectivity in long distance trips. Although it is understandable, it could be considered as being out of the scope of the solution. However, it could be a good idea to address also that fear by offering a connectivity service (e.g., open wi-fi network) at the park & ride facility.

The roof, with no indications, means that the charging solution features are independent. No relevant correlations have been highlighted and, as a result, it is possible to modify one of them without altering the other ones.

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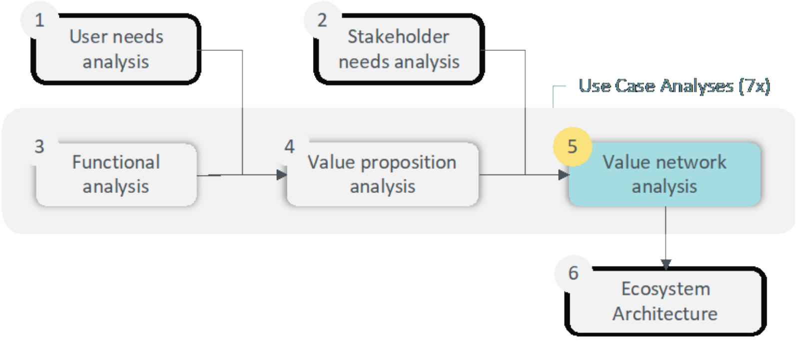
8.3 UC4 Value Network Analysis

This analysis aims to widen the scope of the value proposition drafted so far, to include not only the end users but also those stakeholders that participate in the elaboration or delivery of value.



8.3.1 Stakeholder identification and characterization

In this section, the stakeholders are rated based on their potential power and interest on the use case. Then, the most relevant ones are considered, listing their objectives.

8.3.1.1 STAKEHOLDER PROFILES

Involvement in the charging network development	Stakeholder	Key group	Power	Interest
Direct	Local public authority (e.g., mobility planners, policy makers)	Government	High	High
	Charging Point Operator (CPO)	Business	High	High
	E-Mobility Provider (EMP)	Business	Medium	High
	Fuel station company (petrol stations)	Business	Low	Medium
	Motorway company (operator)	Business	Low	Low
	Land and parking space owner (supermarket, mall, parking area, …)	Business	Medium	High
	Power grid operator (DSO)	Business	High	High
Indirect	Regional public authority (e.g., mobility planners, policy makers)	Government	High	High

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	National public authority (e.g., mobility planners, policy makers)	Government	**High**	**High**
	Energy (electric) utility	Business	High	High
	EV manufacturer (cars, vans, motorbikes, bikes, etc.)	Business	Medium	Low
	Charging Station manufacturer	Business	Medium	High
	ICT/tech provider	Business	Low	Medium
	Public Research Institute	Research	Low	Medium
	Private Research Institute	Research	Low	Medium
	University	Research	Low	Medium
	Start up	Business	Low	Medium
	Private drivers associations	Civil society	Medium	High
	Transport and logistic sector association	Business	Medium	High
	Association/Organization promoting electromobility	Civil society	Medium	High
	Environmental organization	Civil society	Medium	High
	Telecom operators	Business	Medium	Medium
	E-mobility roaming platform operators	Business	Medium	High
	Mobility service information providers	Business	Medium	High

Table 2

8.3.1.2 STAKEHOLDER OBJECTIVES

For a selection of the most relevant stakeholders in terms of power and interest.

Local / Regional / National Authorities	To be able to test innovative charging solutions to be scaled and replicated in other areas and contexts.
	To be able to collect and analyze data to understand the mobility patterns of the Evs users, thus improving the quality of the services provided.

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	To be able to collect and analyze data to develop effective and reliable action plans for future policies and regulations.
	To be able to cope with European and national environmental policies by improving the share of EVs in urban areas.
Charging Point Operator (CPO)	To be able to develop and test innovative solutions in a pilot site, evaluating the results before scaling them in wider contexts.
	To be able to collect data about EVs users to develop future strategies (e.g., which type of charging solution is the preferred one in certain areas).
	To be able to increase their presence on the market, as well as their reputation.
	To be able to test, for future exploitation, specific technologies.
Land and parking space owner (supermarket, mall, parking area, …)	To be able to provide innovative solutions to existing customers and attract new ones.
	To be able to collect data about customers, to offer them customized services.
	To be able to comply with European and national policies and regulations (for public parking space managers) in terms of charging infrastructures.
Power grid operator (DSO) / Energy (electric) utility	To be able to collect and analyze data to evaluate the impact of EVs market adoption on the power grid performances, thus improving their strategic decisions processes.

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8.3.2 Value Network Modelling

The following value network has been designed using the "generic INCIT-EV value network" and adding (in yellow) the most relevant Value Activities or new stakeholders involved specifically in UC4.

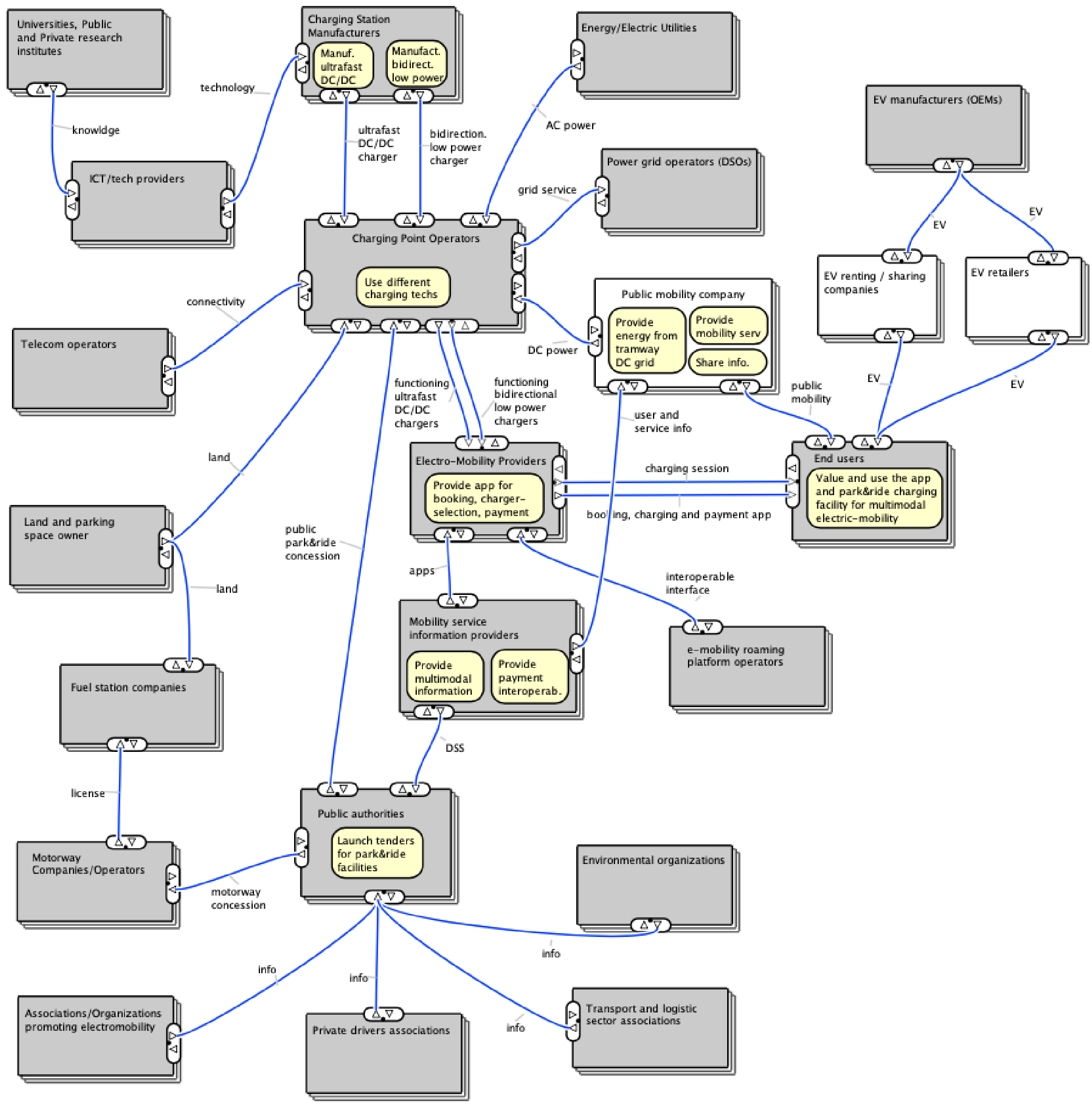

Figure 11. Value Network Model for UC4

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8.3.3 Value Network Analysis

In this UC, multiple stakeholders play an active role, and many combinations and business models could be designed.

From the visual analysis of the e3value network diagram, it is evident that the Charging Point Operator (CPO), as it receives 7 inputs and generates 3 outputs, becoming the most connected role in the ecosystem.

Some of the inputs received by the CPO are common to this role in other UCs: charging stations from the manufacturers, electricity from the utilities and connectivity from a telecom operator. However, there are at least 3 key differences in other inputs: 1) power could be provided by the utility, but in this case, it could be also (or exclusively) delivered by the public mobility company through the tramway DC grid; 2) land and parking space owners are key for the CPO in this case, as the park & ride facility requires a considerable amount of space; 3) public authorities would foster this business model because of the synergies it has with public infrastructure and mobility services. For this purpose, tenders would be launched specifying the requirements of such park and ride facility.

Regarding the outputs, CPOs will offer at least 3 value propositions from one single asset: 1) grid services would be sold by to the DSOs, using aggregation of loads and smart management of charging sessions; 2) ultrafast chargers and 3) bidirectional low power chargers are the other two value propositions delivered by the CPO together with parking and easy access to multi-modal transport. These latest value items are aimed to electro-mobility providers (EMPs), that would pay for the park and ride facility as a service and monetize it by selling the charging sessions to the end-users and managing the payment processes. EMPs would also manage the complex payment processes required to ensure interoperability between public and private mobility solutions, getting as a reward the payment from the public mobility company.

This qualitative value network analysis is preliminary and will be resumed in subsequent tasks such as the cost-benefit analysis and the business model design.

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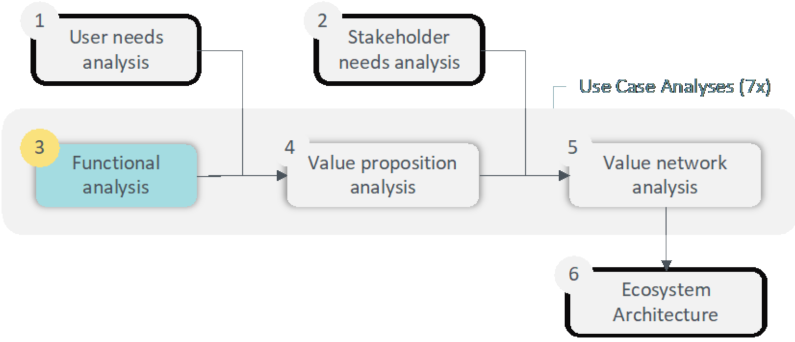
9 UC5 ANALYSES

9.1 UC5 functional analysis

This section contains a description of the UC5 and the result of the functional analysis, based on previous project documentation, which is a list of functionalities and/or quality requirements of the charging solution that will be tested in UC5 and may affect the end-user acceptance.



9.1.1 UC5 objectives and expected user benefits

9.1.1.1 OBJECTIVE

The aim of UC5 is to demonstrate high power 200 kW DC chargers ready to provide grid services. They will be controlled by specified software to use its power electronics to assist the grid according to DSO needs when no electric vehicles are connected to the charger.

9.1.1.2 DESCRIPTION OF NEW PRODUCTS OR SERVICES

UC5 will test two of the project technical results.

Product	**DC superfast chargers with extended High Power Charging system capabilities**
Added value	200 kW DC chargers can provide ancillary services under DSO commands (i.e., reactive power compensation, voltage peaks and hollow balancing, and frequency regulation)
IPR Strategy	CIRCE will own the design and the prototype of the superfast charger and protect it through patent.
Exploitation route	CIRCE plans to include the charger among their product portfolio. Eesti will benefit from a better management of the distribution grid thanks to the V2G ancillary services provided by the charger.
Time to market	One year after the project end (2025)

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9.1.1.3 USER EXPERIENCE IMPROVEMENTS

Proposed system will reduce charging times up to 72 % compared to the current 50 kW level chargers, significantly improving drivers experience and fostering the utilisation of EVs for long range travels. Furthermore, High Power Charging systems could serve a dual purpose and act as controlled active/reactive loads that support the stability of the power system during time periods when it is idle from charging electric vehicles. Therefore, the investment cost for setting up the HPC system would become smaller since the DSO would no longer need to invest into installing additional operational assets.

9.1.1.4 USER BENEFITS

- 72 % lower charging time

9.1.2 UC5 functional or quality specifications

The system allows end users of either the charging infrastructure or the related software services to:

Reserve the charging spot in advance
Access EV chargers in the main European highways
Activate the charging spot with the app or NFC card
Check the cable is correctly connected with green light
Access 24/7 support service
Charge the EV in 10 minutes
Charge the EV at a lower cost than an ICE
Monitor the charge status trough the mobile app
Check consumed electricity and pay through the mobile app

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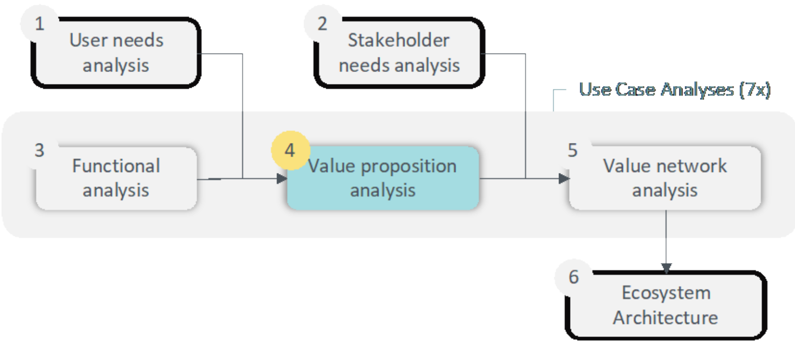
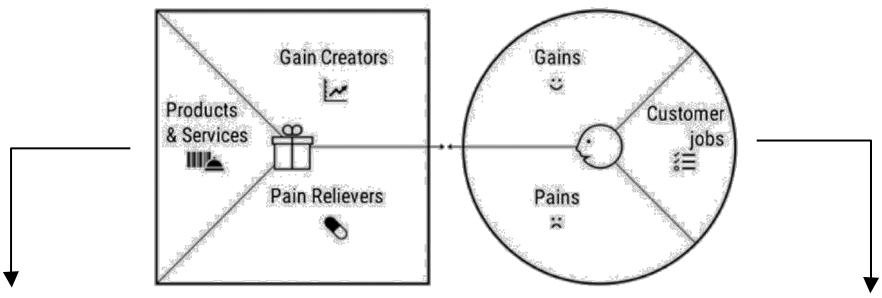
9.2 UC5 value proposition analysis

This analysis aims to match the end-user needs with UC5 functionalities or attributes, and indicate the gaps that may exist between them, i.e., check the problem-solution fit. Three steps are performed: static analysis, dynamic analysis, and synthesis.



9.2.1 Static approach. Value proposition canvas



UC5 solution				Manuel
Ultrafast charging with the power level of 200 kW (10 minutes)	Products & Services	⇔	Customer jobs	Finding ultrafast chargers
Enefit Volt application				Using Enefit Volt service to quickly charge the EV because of lack of time, or the wish to not stay in the gas station too long
Ultrafast charging with 10 min	Gain Creators	⇔	Gains	EV charging with 6-10 minutes
Adding two ultrafast chargers near Tallinn, to avoid queue	Pain Relievers	⇔	Pains	Not many ultrafast chargers, waiting after others
The chargers' locations were chosen according to TEN-T strategy, where the main European highways should be covered with the EV chargers				Charger location does not match with the journey
In the future the fossil fuel prices are higher and the renewable energy prices will be lower				Ultrafast charging today costs same as fossil fuels

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UC5 solution				Miguel
Ultrafast charging with the power level of 200 kW (10 minutes)	Products & Services	⇔	Customer jobs	Finding ultrafast chargers
Enefit Volt application				Using Enefit Volt service to quickly charge the EV because of lack of time, or the wish to not stay in the gas station too long
Ultrafast charging with 10 min	Gain Creators	⇔	Gains	Everyday fast charging
In the future EV ultrafast charging is cost effective	Pain Relievers	⇔	Pains	Charging is expensive
				Charger location is out of the city

9.2.2 Dynamic approach. Scenarios

9.2.2.1 SCENARIO DESCRIPTION

ID	Scenario 1
Action	Charge on the way while driving
Vehicle	Private EV
From	Urban (city centre)
Site A	Home
To	Far-off (long distance from the city)
Site B	Second residence
Frequency	All weekends
Type of route	Highway
Trip distance	>60km
Trip duration	>40 minutes
Destination activity	Short holiday or weekend stay
Activity Duration	2-3 days

9.2.2.1.1 User objectives

1. To be able to use the highway to reach the destination quickly (no deviations to charge)
2. To be able to reserve the charging spot in advance
3. To be able to charge either with the Enefit Volt app or RFID card
4. To be able to do only 1 quick charging at the beginning of the trip
5. To be able to see if the cable is correctly connected and ready to charge, also green light for instance if the charging is in progress
6. To be able to check in the application the consumed electricity and do the payment
7. To be able to receive 24/7 service support

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9.2.2.1.2 Relevance of the objectives for each persona

	Manuel	Miguel	Miriam	Sergio	Laura	New user1	New user2
Objective 1	X	X				X	X
Objective 2	X	X				X	X
Objective 3	X	X				X	X
Objective 4	X	X				X	X
Objective 5	X	X				X	X
Objective 6	X	X				X	X
Objective 7	X	X				X	X

9.2.2.1.3 Storytelling - Steps

		Describe the story for each step (sub-objective)	**Describe the experienced emotions**	**Overall emotion rating**
O1	**Step 1**	Open the Enefit Volt app and looking ultra-fast charger locations	Enefit Volt have chargers map, easy to find	**Good**
O2	**Step 1**	Reserving suitable time for charging	might be concerned about available times also about price	**Mixed**
	Step 2	Driving to the charging point	Available spot is waiting for the customer, he/she is happy	**Good**
O3	**Step 1**	Choosing with the app/RFID card to start charging	quite intuitive, easy progress, customer is happy	**Good**
O4	**Step 1**	Start charging 8 -10 min	happy that charging is very fast	**Good**
	Step 2	Finishing charging, journey with the EV can be continued	overall experience is good, happy customer	**Good**

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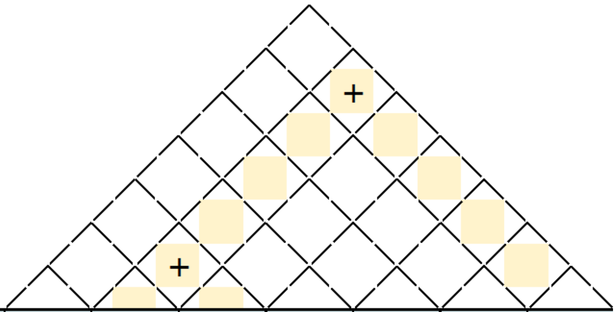
9.2.3 Synthesis. House of quality

9.2.3.1 HOQ DIAGRAM



		Column #	1	2	3	4	5	6	7
		Stage	Pre-charge				Charge		Post
Row #	Source of the requirement	Customer Requirements (Explicit and Implicit) / Functional Requirements	Charger placed in the highway. No deviations from the main route are required	Booking of the charger in advance via app	Charging point activated via app or RFID card	24/7 support	200kW point charges in 6-10 minutes enough for a long trip	Cable connection indicator for easy handling	Consumed electricity and price data available via app
1	Gains	EV charging within 6-10 minutes					x		x
2	Pains	not many ultrafast chargers, waiting after others		x					
3		charger location does not match with the journey	x						
4		Expensive. Ultrafast charging today costs same as fossil fuels							
5	Fears	Unavailable charging point or not working		x				x	
6		App not working due to connectivity problems			x	x			

Figure 12. House of Quality for UC5

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9.2.3.2 HOQ ANALYSIS

The House of Quality shows a good matching between the end-user requirements (pains, gains, and fears) and the attributes of the solution.

All the functional attributes of the fast charger respond to, at least, one user requirement; and all the user requirements, except for one, are addressed by one or more functional attributes. The end-user pain referring to the high cost of ultrafast charging seems to be ignored in the value proposition. At this regard, it is highly recommended during the definition of the business model to consider using part of the incomes (e.g., from grid services provide by the charging stations to the DSO), to subsidize the cost of charging sessions.

The roof indicates that a couple of the product attributes belonging to the pre-charge and post-charge stages benefit from one another. More specifically, the app used for booking can also be used for activating the charging point and for information or billing purposes. If the app became an important artifact in the user experience, the RFID card could make no sense, or be digitalized and embedded in the same app using the RFID capabilities of the mobile device.

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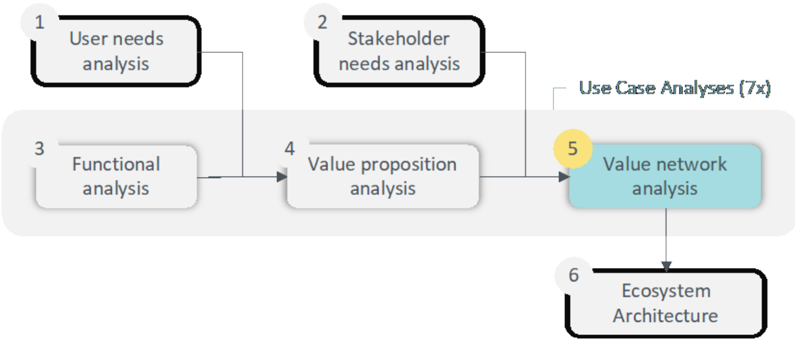
9.3 UC5 Value Network Analysis

This analysis aims to widen the scope of the value proposition drafted so far, to include not only the end users but also those stakeholders that participate in the elaboration or delivery of value.



9.3.1 Stakeholder identification and characterization

In this section, the stakeholders are rated based on their potential power and interest on the use case. Then, the most relevant ones are considered, listing their objectives.

9.3.1.1 STAKEHOLDERS PROFILES

Involvement in the charging network development	Stakeholder	Key group	Power	Interest
Direct	Local public authority (e.g. mobility planners, policy makers)	Government	High	High
	Charging Point Operator (CPO)	Business	High	High
	E-Mobility Provider (EMP)	Business	High	High
	Fuel station company (petrol stations)	Business	Medium	Medium
	Motorway company (operator)	Business	Low	Low
	Land and parking space owner (supermarket, mall, parking area, …)	Business	Low	Medium
	Power grid operator (DSO)	Business	Medium	High
Indirect	Regional public authority (e.g., mobility planners, policy makers)	Government	High	Medium

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	National public authority (e.g. mobility planners, policy makers)	Government	High	Medium
	Energy (electric) utility	Business	High	High
	EV manufacturer (cars, vans, motorbikes, bikes, etc.)	Business	High	Medium
	Charging Station manufacturer	Business	High	High
	ICT/tech provider	Business	Medium	Medium
	Public Research Institute	Research	Low	Medium
	Private Research Institute	Research	Low	Medium
	University	Research	Low	Medium
	Start up	Business	Low	High
	Private drivers' associations	Civil society	Low	Low
	Transport and logistic sector association	Business	Medium	Medium
	Association/Organization promoting electromobility	Civil society	Medium	High
	Environmental organization	Civil society	Low	Low
	Telecom operators	Business	Low	Low
	E-mobility roaming platform operators	Business	Medium	Medium
	Mobility service information providers	Business	Medium	Medium

Table 3

9.3.1.2 STAKEHOLDER OBJECTIVES

For a selection of the most relevant stakeholders in terms of power and interest.

DSO	To be able to reduce investments regarding EV uptake
	To be able to undertake a smooth transformation to E-mobility
	To be able to develop products to reduce grid stress

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	To be able to use charger as static reactive compensator with high response time to avoid voltage drops that will cause power failure
TSO	To be able to reduce investments regarding EV uptake
	To be able to smooth transformation to E-mobility
	To be able to develop products to reduce grid stress
CPO	To be able to provide cost-effective charging option
	To be able to help to compensate reactive power in the grid
	To be able to provide reliable charging service for the customers
	To be able to create public interest in EV charging
	To be able to reduce customer concerns regarding driving range and charging availability
	To be able to develop the smart charging platforms

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9.3.2 Value Network Modelling

The following figure shows the relations among stakeholders in the ecosystems using e3-value modelling methodology.

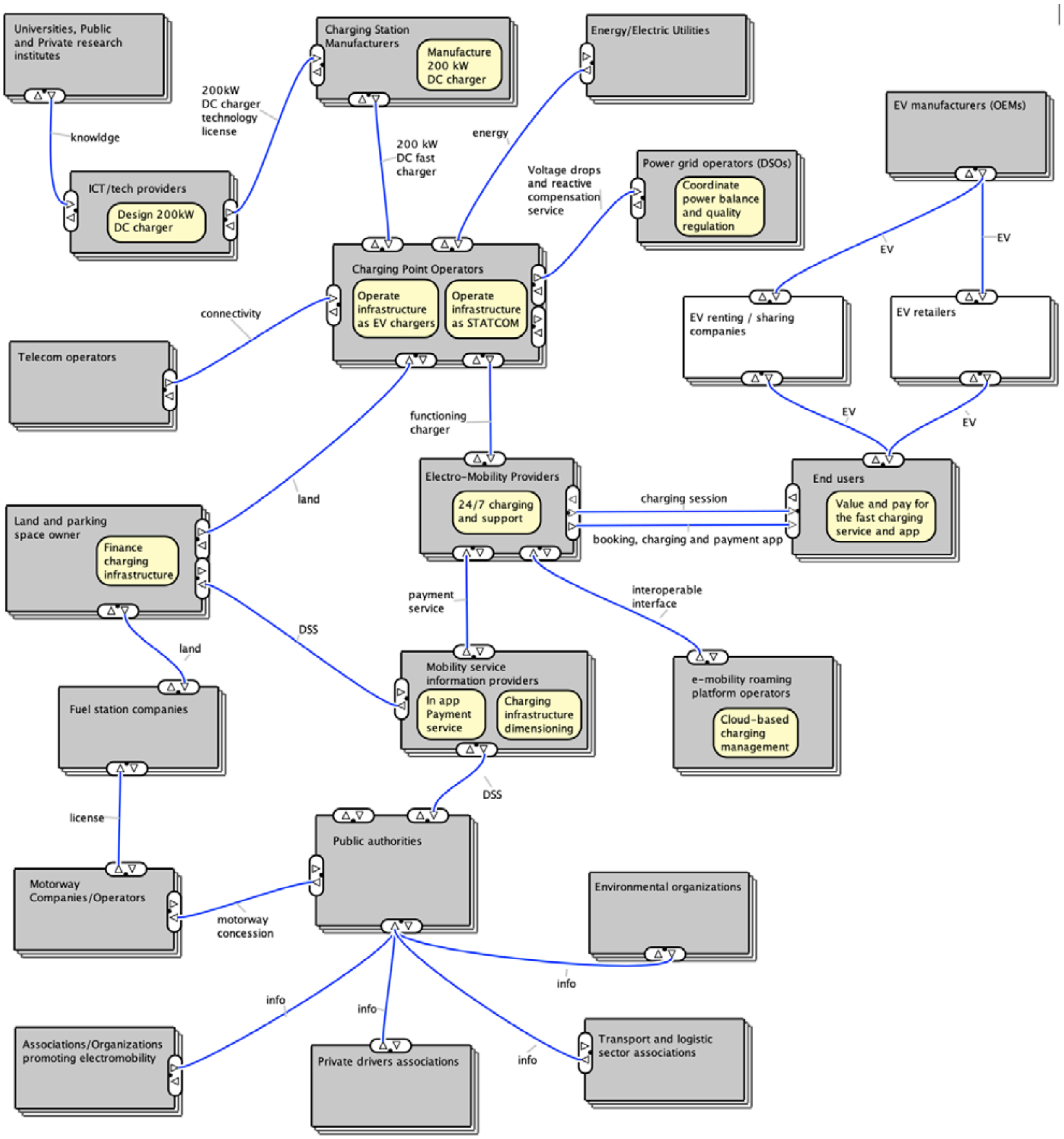

Figure 13. Value Network Model for UC5

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9.3.3 Value Network Analysis

Unlike other UCs, the value network analysis of UC5 shows that private initiative could be enough to promote superfast charging infrastructure. Public authorities could have a secondary role.

A hardware value chain can be observed at the upper left side of the network diagram. Starting from the knowledge created by universities and research centres, a high-power DC charger would be developed by a technology provider, manufactured by a specialized company, and finally installed and operated by a CPO.

The CPO is key also in this ecosystem, but maybe the largest difference with similar UCs is the relation between the landowner and the CPO. The former could provide the land and the financing of the charging infrastructure in exchange of a recurrent revenue.

To pay for the land and the infrastructure, the CPO would get income streams from the DSO in exchange for grid services (compensation of voltage drops and reactive power) and from the electro-mobility providers that would collect the payments from the end users of the charging sessions service.

The business of the landowner can only be de-risked by using the decision support system (DSS) offered by the mobility service info provider.

This qualitative value network analysis is preliminary and will be resumed in subsequent tasks such as the cost-benefit analysis and the business model design.

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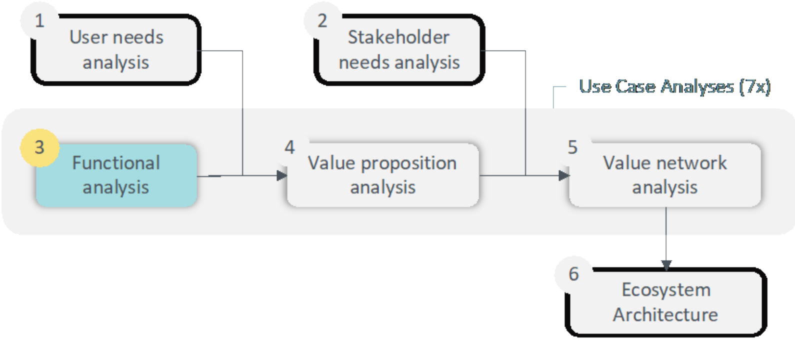
10 UC6 ANALYSES

10.1 UC6 functional analysis

This section contains a description of the U6 and the result of the functional analysis, based on previous project documentation, which is a list of functionalities and/or quality requirements of the charging solution that will be tested in UC6 and may affect the end-user acceptance.



10.1.1 UC6 objectives and expected user benefits

10.1.1.1 OBJECTIVE

The aim of UC6 is to demonstrate a highly replicable use case along Europe which can be achieved through the development of controllable Low power bi-directional CHAdeMO and CCS DC chargers (V2X) with an output power between 7,4kW – 25kW per vehicle, integrated in a DC micro grid.

Additionally, a theft proof charging station rack for shared bicycles or other two wheeled vehicles, with an output power ranging from 120W up to 3,4kW to charge multiple bikes at the same time will be disposed in parallel to the rest of charging points.

The system will be able to integrate AC/DC converters for the connection of RES and ESS in the same DC bus to reduce the energy needed from the grid and manage the peak load, as well as to enable its easy scale-up. Instead of using one low power AC/DC converter for each low power DC/DC converter, CIRCE will integrate one 25 kW AC/DC converter connected to various low-medium power DC/DC converters.

10.1.1.2 DESCRIPTION OF NEW PRODUCTS OR SERVICES

UC6 will test two of the project technical results.

Product	**Low power V2X charging infrastructure**
Added value	Low-power DC/DC converters connected to a master AC/DC converter, enabling V2G and V2B energy trading as well as P2P energy exchanges between EVs
IPR Strategy	CIRCE will own the design and the prototype of the V2G charger and protect it through patent.

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Exploitation route	CIRCE will license the design of the V2G chargers and will include them among their products protfolio. AYZ will benefit from increasing the available charging infrastructure in their municipality and comply with the objectives of their SUMP
Time to market	One year after the project end (2025)

Product	**Secure low power DC racks for LEVs**
Added value	Theft-proof low-power DC e-bicycles and scooters to minimise logistic cost to charger these LEVs and avoiding free parking of the vehicles
IPR Strategy	IDNEO will own the design of the theft-proof system and the bicycles rack, as well as of the low-power chargers with the support of CIRCE
Exploitation route	IDNEO will incorporate the LEVs rack among their products portfolio and provide turnkey services for its installation. IDNEO will also commercialise the low-powers DC chargers. AYZ will benefit from fostering the use of LEVs in their municipality and comply with the objectives of their SUMP.
Time to market	One year after the project end (2025)

10.1.1.3 USER EXPERIENCE IMPROVEMENTS

The user experience improvements pursued by UC6 are mainly focused on four aspects:

- **Vehicle charging optimization**: promoting the aggregation and trade of part of the energy charged by the user, providing the user with an economic compensation. The battery can be charged attending to the user habits, allowing the utilization of the EV battery as a buffer of the microgrid (building, offices...) or the distribution grid
- **Trading between office/home installations and EVs**: The development of the Electric Balance Control Service platform will allow to carry out real time monitoring of the microgrids (offices, buildings...) in order manage the consume of the microgrid assets counting with a long-term forecasting. Microgrids buildings will automatically buy electricity from the EVs when the prices of the grid are higher than the ones offered by the EVs users.
- **P2P market between vehicles**: Bi-directional contracts between EVs users will be enabled by a simple and quick platform, in order to use higher power for charging EVs thanks to the use of another EVs battery as a load supplier.

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- **Secure DC racks for LEV**: sharing companies will reduce their risk when operating the business thanks to the theft prove infrastructure, as well as reduce the logistics needed to replace the replace batteries. Moreover, cities will reduce the disorder caused by LEV which are currently being freely parked hindering the cities pedestrian flows.

10.1.1.4 USER BENEFITS

- Up to 32% cost reduction of charging for commuters
- EVs with CHAdeMO/CCS charging protocol enabled for V2G
- Flexible charging scheme depending on user's needs
- Integration of EV in Smart Grids / Self-consumption

10.1.2 UC6 functional or quality specifications

The system allows end users of either the charging infrastructure or the related software services to:

Monitor and communicate the status of the charging infrastructure availability.
Identify the user’s vehicle via CCS protocol and start the smart charging process automatically
Define manually the preferences and charging strategy for the charging session
Define flexible charging preferences to automatically maximise user benefits
Adjust charging power (1,5-25 kW) to adapt and control automatically surplus energy from renewable sources.
Provide grid services (frequency control, voltage, phase unbalancing...) and remunerate the user.
Aggregate and trade part of the energy charged by the user
Buy/sell (trade) energy automatically to/from building microgrids when grid prices are higher.
Buy/sell (trade) energy automatically between EV users (P2P) simply and quickly
Provide the user with an economic compensation.
Check net profit/loss of the charging session

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10.2 UC6 value proposition analysis

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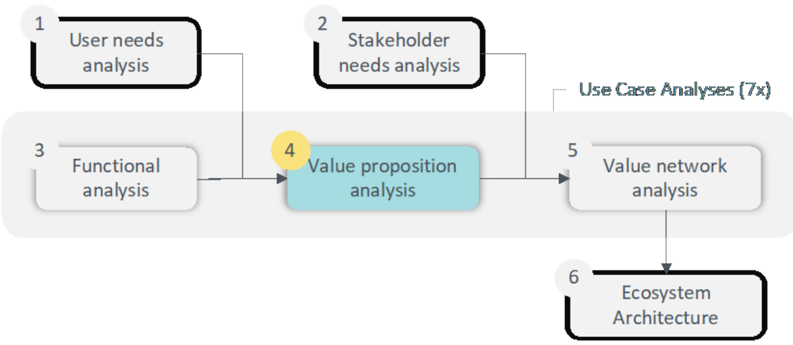
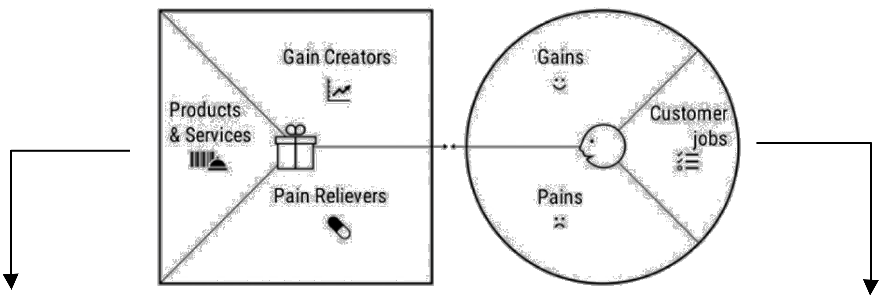


10.2.1 Static approach. Value proposition canvas



UC6 solution				Manuel
Low power V2X charging infrastructure to charge at work or in public places in the city	Products & Services	⇔	Customer jobs	Charging at home
				Charging at work
				Charging in Public chargers
				Charging while traveling long distances
Vehicle charging optimization: promoting the aggregation and trade of part of the energy charged by the user, providing the user with an economic compensation.	Gain Creators		Gains	At work, he would like to have a free charging point installed.
V2G and V2B energy trading: Microgrids buildings will automatically buy electricity from the EVs when the prices of the grid are higher than the ones offered by the EVs users		⇔		In public places, he would like to charge In Tesla superchargers or public car parks. The ideal would be having a fast-charging point with well-prepared rest Areas, as in France

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P2P energy exchanges between Evs: Bi-directional contracts between EVs users will be enabled by a simple and quick platform, in order to use higher power for charging EVs thanks to the use of another EVs battery as a load supplier.				While traveling, he likes to use APPs to know the charging points location and the best route possible.
Our Product includes a functionality allowing to monitor and communicate the status of the charging availability (in use, free, N/A). We will use the OCPP/OCPI protocol to publish the status to provide this information.	Pain Relievers	⇔	Pains	Finding conventional cars parked in a charging point
We could contemplate an additional functionality to allow our charging point to detect with proximity sensors the presence of obstacles or other vehicles blocking the access without charging.				Traffic inside the city
				In long distance trips: APP problems, connection problems or unavailability of charging points (not working)

UC6 solution				Miguel
Low power V2X charging infrastructure	Products & Services	⇔	Customer jobs	Check the actual charging percentage and compare with the autonomy needed to get to my destination and back
				Check in Google maps the availability of charging points in my route and, eventually, book a charging slot in advance
				Look for the right car to rent, pay it and manage all the renting process if my destination is further than 100Km away
V2G chargers can control dynamically the vehicle charging power, adapt and even control surplus energy from renewable sources	Gain Creators	⇔	Gains	At home, being able to charge the car with the remaining available power from the household (Dynamic Power Control)
This charger model is capable to charge from 25-50kW				In public, I would like to see more charging points +25-50kW
A higher penetration of EVs will lower manufacturing costs and this increase the number of charging points				In public, I would like to see a higher amount of charging points and with higher availability

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Thanks to our bi-directional electronics, we can include bi-directional technology with the same manufacturing costs of a conventional ACDC, that allows to buy energy outside the electricity market at a more convenient price (charged in off-peak hours and bought in peak hours at off-peak hour cost). It would also give the bonus of providing grid services that will be imminently remunerated under a specific market (TSO - DSO). In this way the ROI is increased and/or the Payback is decreased.				
	Pain Relievers	⇔	Pains	Not having enough battery when I want to use my car
				Finally finding a charging point, reaching it and finding it is inoperative

10.2.2 Dynamic approach. Scenarios

10.2.2.1 SCENARIO DESCRIPTION

ID	Scenario 1
Action	Charge at destination after driving (or riding) …
Vehicle	Private EV
From	Urban (city centre)
Site A	Home
To	Peri-urban (city suburbs)
Site B	Office
Frequency	All weekdays
Type of route	Urban
Trip distance	10-20 km
Trip duration	20-30 minutes
Destination activity	Work (half working day)
Activity Duration	6-12 hours

10.2.2.1.1 User objectives

8. To be able to charge my own EV inside my company's parking lot
9. To be able to save as much costs as possible when charging in the parking
10. To be able to sell my car's energy because it was cheap for me to charge at home

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11. To be able to offer my car's battery charge to my company energy demand in exchange of free charging or economical compensation
12. To be able to have my car fully charged before my departure
13. To be able to charge my car's battery with surplus energy production from company's FV

10.2.2.1.2 Relevance of the objectives for each persona

	Manuel	Miguel	Miriam	Sergio	Laura
Objective 1	X	X			X
Objective 2	X	X			X
Objective 3	X	X			X
Objective 4	X	X			X
Objective 5	X	X			X
Objective 6	X	X			X

10.2.2.1.3 Storytelling - Steps

		Describe the story for each step (sub-objective)	**Describe the experienced emotions**	**Overall emotion rating**
O1	**Step 1**	I go out from home with my battery fully charged at a low price	happy because today i can sell energy, but anxious due to limited charging spots at my company's parking	Mixed
	Step 2	I get to the office and connect my car to V2G charger	Happy because I found a free charging spot	Good
	Step 3	The V2G charger identify my vehicle via CCS protocol and the smart charging process starts automatically	Happy because I don't lose time	Good
	Step 4	User defines preferences and charging strategy for the charging session	Happy because I can choose today's strategy	Good
	Step 5	I hop on the car and drive back home	Satisfied because I have sold energy and still have enough battery to reach my destination	Good
O2	**Step 1**	I go out from home and this week and I don’t care about my battery charging level	Happy because I can use my car to make a profit from V2G as I don't need long range this week	Good
	Step 2	I get to the parking and connect my car to V2G charger	Happy because I found a free charging spot	Good

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	Step 3	The V2G charger identify my vehicle via CCS protocol and the smart charging process starts automatically	Happy because I don't lose time	Good
	Step 4	I define flexible charging preferences to maximise my benefits	Happy because I can choose today's strategy	Good
	Step 5	I hop on the car, check battery status and net profit/loss of the charging session and drive back home	Satisfied because I made a profit selling energy and still have enough battery to reach my destination	Good
O3	**Step 1**	I go out from home with my battery almost discharged	Anxious to know if I can charge my car at work	Bad
	Step 2	I get to the office and connect my car to V2G charger	Relieved to find a free charging spot	Good
	Step 3	The V2G charger identify my vehicle via CCS protocol and the smart charging process starts automatically	Happy because I don't lose time	Good
	Step 4	I define a full charge preference without smart charging and assume higher cost	Happy because I can choose today's strategy	Good
O4	**Step 1**	I hop on the car and drive back home with fully charged battery	Satisfied because I have charged enough battery today for my next trip	Good
	Step 2	I go out from home and this week I don't care about my battery charging level	Happy because I can charge with green energy and low-cost my battery	Good
	Step 3	I get to the parking and connect my car to V2G charger	Happy because I found a free charging spot	Good
	Step 4	The V2G charger identify my vehicle via CCS protocol and the smart charging process starts automatically	Happy because I don't lose time	Good
	Step 5	User defines preferences and charging strategy for the charging session	Happy because I can choose today's strategy	Good
O5	**Step 1**	I hop on the car, check battery status, and check how much money I saved in this charging session	Satisfied because I have charged enough battery today for my next trip with green and low-cost energy	Good
	Step 2	I go out from home with my battery fully charged at a low price	happy because today I can sell energy, but anxious due to limited charging spots at my company's parking	Mixed
	Step 3	I get to the office and connect my car to V2G charger	Happy because I found a free charging spot	Good

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	Step 4	The V2G charger identify my vehicle via CCS protocol and the smart charging process starts automatically	Happy because I don't lose time	Good
	Step 5	User defines preferences and charging strategy for the charging session	Happy because I can choose today's strategy	Good
O6	**Step 1**	I hop on the car and drive back home	Satisfied because I have sold energy and still have enough battery to reach my destination	Good
	Step 2	I go out from home and this week, and I don’t care about my battery charging level	Happy because I can use my car to make a profit from V2G as I don't need long range this week	Good
	Step 3	I get to the parking and connect my car to V2G charger	Happy because I found a free charging spot	Good
	Step 4	The V2G charger identify my vehicle via CCS protocol and the smart charging process starts automatically	Happy because I don't lose time	Good

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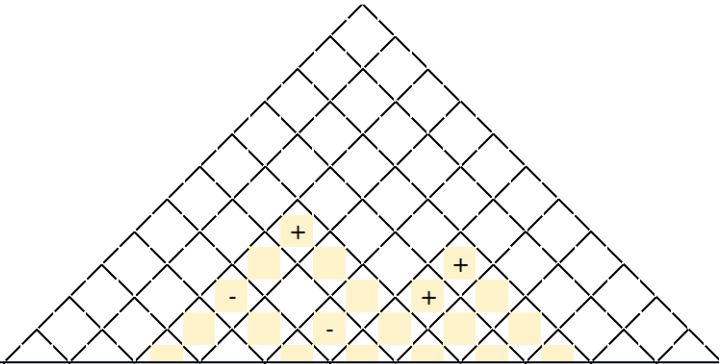
10.2.3 Synthesis. House of quality

10.2.3.1 HOQ DIAGRAM



Row #	Source of the requirement	Column #	1	2	3	4	5	6	7	8	9	10	11
		Stage	Pre-charge			Charge						Post-charge	
		Customer Requirements (Explicit and Implicit) / Functional Requirements	Monitor and communicate the status of the charging infrastructure availability.	Define manually the preferences and charging strategy for the charging session	Define flexible charging preferences to automatically maximise user benefits	Identify user's vehicle via CCS protocol and start the smart charging process	Adjust charging power (25-50kW) to adapt automatically surplus energy from	Provide grid services (frequency control, voltage, phase...) and remunerate the user.	Aggregate and trade part of the energy charged by the user	Buy/sell (trade) energy automatically to/from building microgrids when grid prices are high.	Buy/sell (trade) energy automatically between EV users (P2P) simply and quickly	Provide the user with an economic compensation.	Check net profit/loss of the charging session
1	Gains	At home, being able to charge the car with the remaining available power from the household								X			
2	Gains	To be able to have my car fully charged before my departure								X			
3	Gains	In public, I would like to see more charging points +25-50kW and with higher availability											
4	Gains	To be able to charge my own EV inside my company's parking lot			X					X			
5	Gains	To be able to charge my car's battery with surplus energy production from company's FV			X		X			X			
6	Gains	To be able to save as much costs as possible when charging in the parking			X			X				X	X
7	Gains	To be able to sell my car's energy because it was cheap for me to charge at home			X			X	X	X	X		X
8	Gains	To be able to offer my car's battery charge to my company energy demand in exchange of free charging or economical compensation			X							X	X
9	Pains	Not having enough battery when I want to use my car		X									
10	Pains	Finally finding a charging point, reaching it and finding it is unoperative	X										
11	Fears	Stress during rush hou and driving at weekends (traffic jams)	X										
12	Fears	Unavailable parking places	X										

Figure 14: Hose of Quality for UC6 applied to Miguel in Scenario 2.

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10.2.3.2 HOQ ANALYSIS

The House of Quality of UC6 evidences a good match between the end-users' requirements and the attributes and functional specifications of the solution. Nevertheless, several patterns suggest the need to pay attention to risks that may arise.

The first pattern that has been detected is that one column and one row are blank. The empty column is the automatic identification of the user's car using CCS. This means that it has not been raised by users explicitly. However, as it would be a "gain creator" or a "nice to have" feature, it will probably be appreciated by end users. The question is whether the cost-benefit ratio of adding this feature is good enough. That should be studied later in WP9 activities. The empty row is the expectation of the end users of more charging points and higher availability rates. It is of course the intention of the owners of the solution and the whole sector to speed up the deployment of charging points, but it is not technically addressed by the solution. In this case, having this empty row is not concerning for the product individually.

A second pattern is the existence of one single product attribute that responds to 5 user requirements (gains). This means that the feature "define flexible charging preferences automatically…"is probably an important feature that should be well designed and developed.

A third pattern is the existence of several user-requirements (gains in this case) that involve multiple product attributes. For example, "to be able to sell my car's energy..." involves 6 technical features. This means that it is a complex user-requirement to satisfy and should probably be carefully designed and tested to avoid adoption barriers.

The roof indicates that several product attributes are correlated or interdependent. For example, the automatic maximization of user benefits could have a negative effect on the automatic adjust of charging power according to the renewable power available. On the other hand, the automatic buy/sell attributes could reinforce the provision of grid services remunerated for the user. Overall, these dependencies require a careful design and development of the automatic algorithms to meet technical and user requirements and achieve a balanced network of value exchange. In this case, these relations could be further explored in the value network analysis.

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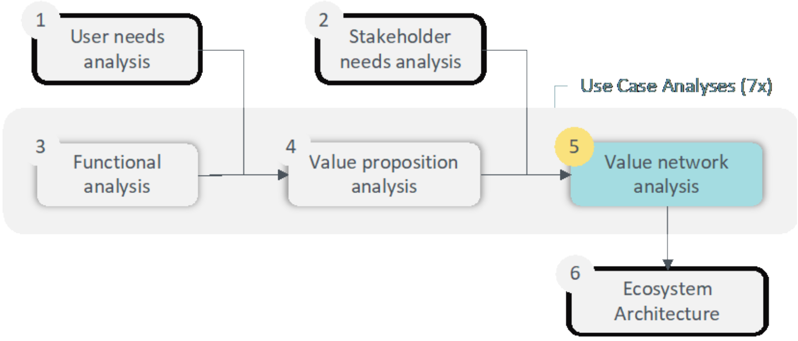
10.3 UC6 Value Network Analysis

This analysis aims to widen the scope of the value proposition drafted so far, to include not only the end users but also those stakeholders that participate in the elaboration or delivery of value.



10.3.1 Stakeholder identification and characterization

In this section, the stakeholders are rated based on their potential power and interest on the use case. Then, the most relevant ones are considered, listing their objectives.

10.3.1.1 STAKEHOLDERS PROFILES

Involvement in the charging network development	Stakehoder	Key group	Power	Interest
Direct	Local public authority (e.g. mobility planners, policy makers)	Government	High	High
	Charging Point Operator (CPO)	Business	High	High
	E-Mobility Provider (EMP)	Business	Low	Low
	Fuel station company (petrol stations)	Business	Medium	Medium
	Motorway company (operator)	Business	Low	Low
	Land and parking space owner (supermarket, mall, parking area, …)	Business	Medium	Low
	Power grid operator (DSO)	Business	High	High
Indirect	Regional public authority (e.g., mobility planners, policy makers)	Government	High	High

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	National public authority (e.g. mobility planners, policy makers)	Government	High	High
	Energy (electric) utility	Business	High	High
	EV manufacturer (cars, vans, motorbikes, bikes, etc.)	Business	High	High
	Charging Station manufacturer	Business	High	High
	ICT/tech provider	Business	Low	High
	Public Research Institute	Research	Low	Medium
	Private Research Institute	Research	Low	Medium
	University	Research	Low	Medium
	Start up	Business	Low	Medium
	Private drivers' associations	Civil society	High	High
	Transport and logistic sector association	Business	High	Low
	Association/Organization promoting electromobility	Civil society	Medium	High
	Environmental organization	Civil society	Medium	Medium
	Telecom operators	Business	Medium	Medium
	E-mobility roaming platform operators	Business	Medium	High
	Mobility service information providers	Business	Medium	High

10.3.1.2 STAKEHOLDER OBJECTIVES

For a selection of the most relevant stakeholders in terms of power and interest.

Private End User	I want to offer my car's battery to supply my home energy demand if my car's battery energy is cheaper than grid quotations
	I want to have my car charged with enough battery before my departure
	I want to know how much energy I have sell / recharged and its costs/profit

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	I want to change whenever I want the charge strategy
Business or retails	I want to differentiate my company from the competence by offering best services
	I want to use low-cost energy from client's/workers EVs parked when it is cheaper than the grid to lower bill costs
	I want to know how much energy I have sell / recharged and its costs/profit
	I want to let the EV owner to change whenever he wants the charge strategy
	I want to know how to estimate how many bidirectional chargers (power) I need, and what is my maximum capacity
	I want to know the profitability of this installation and its operation
	I want to know the costs of new installation, or retrofitting an existing one
DSO	Estimate the EVs connection: number EVs and demand power
	Interact with the Charging Station Operator and to request services
	Use the EVs for enabling grid services: active, reactive power compensation
	I want to know the exact power/signal quality at charging point
	Depending on the signal quality supplied, carry-out penalty or stimulating actions to the Charging Operator
Charging Point Operator	I want to know the grid and charger status and performance in real time
	I want to interact with the DSO to know what they demand in real time
	I want to monitor the energy transferred and the benefits of its charger
	I want to define and control the charge strategies
	I want to know the car battery status and demand/generation of the prosumer

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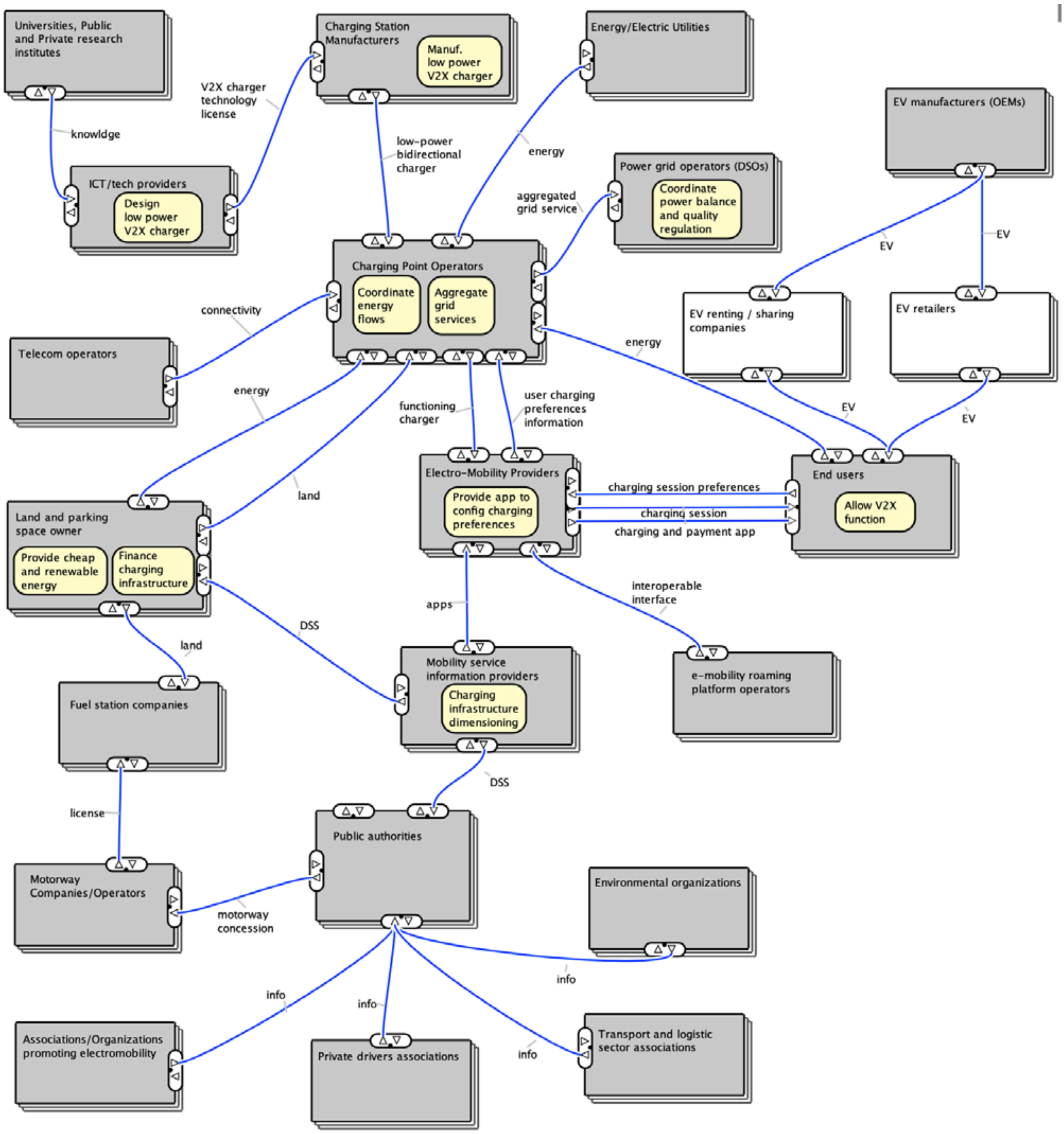
10.3.2 Value Network Modelling

The following figure shows the relations among stakeholders in the ecosystems using e3-value modelling methodology.



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10.3.3 Value Network Analysis

In UC6, the value network shows that the most critical stakeholder is the Charging Point Operator (CPO), who plays several roles.

From the infrastructure viewpoint, the CPO could buy and installs the low-power bidirectional chargers using its own resources, but it could also be the parking space owner who finance that infrastructure and sells the rights to use it including the parking space (asset as a service) to the CPO. A more detailed analysis would be useful to determine whether the CPO or the parking owner should own the charging infrastructure.

From the energy perspective, the CPO acts as the coordinator and aggregator of energy flows and flexibility services. It buys energy from the utilities to meet the base demand of the charging points, but it also buys the renewable energy produced by the solar panels installed by the parking owner or the energy stored in the EVs of the end users. Those energy flows can be aggregated and managed to sell grid services to the DSO.

From an information viewpoint, the CPO is not involved. This stakeholder subcontracts the interaction with the end customer to an Electro-mobility provider who gives users the access to the charging session and manages the payment through a mobile app. This app is also used to gather the user preferences and send it to the CPO who will use it to manage the energy flows accordingly.

The app is a relevant product in this scenario, as well as the Decision Support System (DSS). Both value propositions belong to the mobility service information provider. The first one is sold to the electro-mobility provider, while the second one is sold to the parking owner, who needs to simulate and plan carefully the technical and economic feasibility of the business before investing.

This use case enables multiple possibilities for end users to be in control of their EV and generate revenue streams. The value network drawn here assumes that a CPO will be necessary as aggregator and manager of the energy resources and flows. However, additional cases could be drawn involving V2V exchanges using decentralized solutions.

This qualitative value network analysis is preliminary and will be resumed in subsequent tasks such as the cost-benefit analysis and the business model design.

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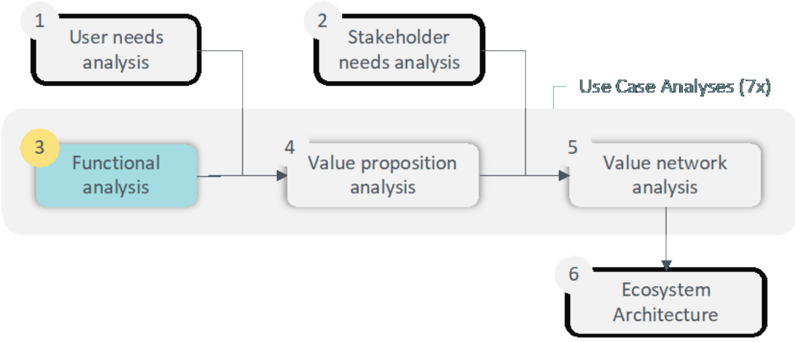
11 UC7 ANALYSES

11.1 UC7 functional analysis

This section contains a description of the UC7 and the result of the functional analysis, based on previous project documentation, which is a list of functionalities and/or quality requirements of the charging solution that will be tested in UC7 and may affect the end-user acceptance.



11.1.1 UC7 objectives and expected user benefits

11.1.1.1 OBJECTIVE

The aim of UC7 is to demonstrate underground static wireless charging stations located in taxi stops such as the ones at airports or central stations. These infrastructures will be incorporated for the opportunity charging of electric taxi vehicles. In this sense, CIRCE, together with TRIA will carry out the design, manufacturing, testing, and validation of two to four inductive charging systems of 50kW/85kHz using its previous experience in projects like Unplugged, VICTORIA or NIWE. This stationary charging lane will be placed in “Mobility City” and will have the capacity of charging one taxi while waiting for the passengers. Considering a consumption of 0.136 kWh/km (Renault ZOE consumption considering its 41kWh battery for 300 km range autonomy) and the 50kW opportunity charger which will be placed in the train station, a taxi will be able to charge 8.3 kWh in 10 min (a typical taxi stop) allowing the car to drive for 60 extra km.

The interoperability between this solution and the ones addressed in UC2 and UC3 for DWPT will be assessed, using the same 30 kW RSA/VEDECOM vehicles for validating this use case. All this infrastructure can be coupled with additional grid services, will be scalable just adding new modules to the taxi lane and will allow a smart connection between vehicle, infrastructure, and grid (demand rationalization).

There are currently more than 25 e-taxis in Saragossa. Since these vehicles are not adapted for wireless charging, their owners will be involved by offering them the opportunity of using the adapted vehicles to compare the charging experience to that with their current vehicles and show them the advantages of the wireless charging.

11.1.1.2 DESCRIPTION OF NEW PRODUCTS OR SERVICES

UC7 will test the following project technical result.

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Product	**Static wireless charging systems with V2X capability**
Added value	Interoperable high-frequency (85 kHz) wireless charger ensuring high efficiency performance (90%) for misalignment of 20% between the primary and the secondary coils.
IPR Strategy	CIRCE will own and protect the design of the inductive charger through patent.
Exploitation route	CIRCE will license the design of the wireless charger and will include this charger among their products portfolio and provide turnkey services for its installation. AYZ will benefit from increasing the available charging infrastructure in their municipality and comply with the objectives of their SUMP.
Time to market	One year after the project end (2025)

11.1.1.3 USER EXPERIENCE IMPROVEMENTS

The user experience improvements pursued by UC7 are mainly focused on three aspects:

- **Interoperable high frequency wireless charger**: ensuring high efficiency performance (90%) for misalignment of 20% between the primary and the secondary coils up to 50 kW enabling wireless high power wireless charging.
- **V2G ready capabilities**: Same improvements of UC6 can be reached under wireless charging
- **Seamless user charging experience**: Usually, professional drivers do not have the time to wait long periods to charge EV resulting in lack of interest on purchasing an EV. Additionally, taxi drivers, bus drivers and freight forwarders' stops do not normally take more than a couple of minutes, which makes conductive cable charging stations unfeasible for this type of stops. Moreover, an easy access to a charger when wanted is crucial to the drivers to avoid queue time for charging. Furthermore, taxi customers´ decision in alternative transports has been increasing. As an example, 40% of consumers in Sweden found worth it to pay a higher price for the use of e-taxis while 86% of consumers would choose an e-taxi over a conventional one after the first ride on it.

11.1.1.4 USER BENEFITS

- Seamless and reliable charging
- No time needed to start and finish the charge as it is wireless
- Flexible charging scheme depending on user's needs

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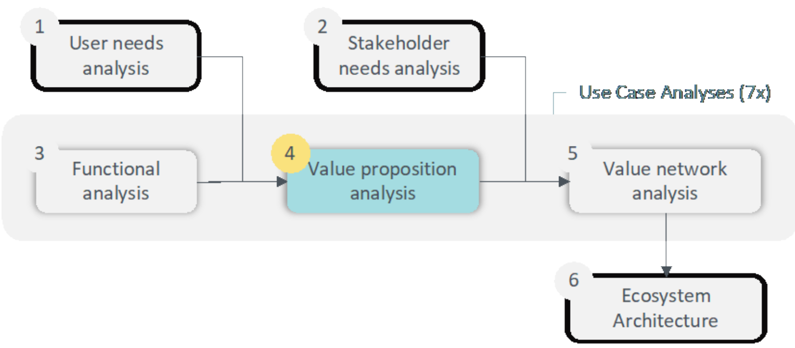
11.1.2 UC7 functional or quality specifications

Monitor the status of the charging system availability
Publish the charging system availability to provide this information to other Mobility Service Providers (eMSPs)
Detect unique vehicle identification (using RFID sensors) and operate according to the configuration preferences established by the user in the app (automatic charging, charging limits based on energy, money, or autonomy)
Adjust charging power (25-50kW) to adapt and control automatically surplus energy from renewable sources.
Help user to align the EV over the charging spot for the best charging performance
Stop charging automatically when leaving the position

11.2 UC7 value proposition analysis

This analysis aims to match the end-user needs with UC7 functionalities or attributes, and indicate the gaps that may exist between them, i.e., check the problem-solution fit. Three steps are performed: static analysis, dynamic analysis, and synthesis.



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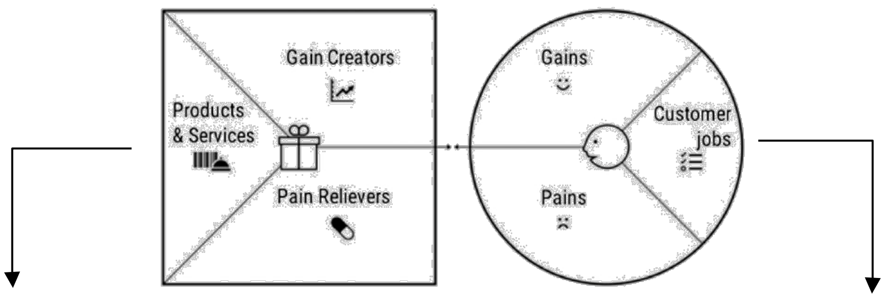
11.2.1 Static approach. Value proposition canvas



UC7 solution				Manuel
Static wireless charging systems with V2X capability	Products & Services	⇔	Customer jobs	Charging at home
				Charging at work
				Charging in Public chargers
				Charging while traveling long distances
Park & Quit: seamless premium charge experience everywhere. Forget to plug/unplug, don't get lost between the different connectors in the market (Chademo…)	Gain Creators	⇔	Gains	At work, he would like to have a free charging point installed.
				In public places, he would like to charge In Tesla superchargers or public car parks. The ideal would be having a fast-charging point with well-prepared rest Areas, as in France
				While traveling, he likes to use APPs to know the charging points location and the best route possible.
Our system will include a sensor in the primary coil to detect presence in the surface above to detect cars	Pain Relievers	⇔	Pains	Finding conventional cars parked in a charging point
Our Product includes a functionality allowing to monitor and communicate the status of the charging availability (in use, free, N/A). We will use the OCPP/OCPI protocol to publish the status to provide this information toother Mobility Service Providers (eMSPs)				Traffic inside the city
Thanks to the RFID sensors, our product is capable to detect unique vehicle identification and thus, operating according to the configuration preferences established by the user in the app (automatic charging, charging limits based on energy, money or autonomy)				In long distance trips: APP problems, connection problems or unavailability of charging points (not working)

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UC solution		⇔		Miguel
Static wireless charging systems with V2X capability	Products & Services	⇔	Customer jobs	Check the actual charging percentage and compare with the autonomy needed to get to my destination and back
				Check in Google maps the availability of charging points in my route and, eventually, book a charging slot in advance
				Look for the right car to rent, pay it and manage all the renting process if my destination is further than 100Km away
V2G chargers are able to control dynamically the vehicle charging power, adapt and even control surplus energy from renewable sources	Gain Creators	⇔	Gains	At home, being able to charge the car with the remaining available power from the household (Dynamic Power Control)
This charger model is capable to charge from 25-50kW				In public, I would like to see more charging points +25-50kW
For home use case we can scale-down our design to develop a 7kW charging system with same functionalities than conductive and V2X chargers				In public, I would like to see a higher amount of charging points and with higher availability
Keep always park your car in our charging station and can forget about the charging periods	Pain Relievers	⇔	Pains	Not having enough battery when I want to use my car
				Finally finding a charging point, reaching it and finding it is inoperative

UC1 solution		⇔		eTaxi Driver
Static wireless charging systems with V2X capability	Products & Services	⇔	Customer jobs	Charging in Public chargers
				Charging while waiting in a taxi stop
Park & Quit: seamless premium charge experience everywhere. Forget to plug/unplug, don't get lost between the different connectors in the market (Chademo…)	Gain Creators	⇔	Gains	At work, he would like to have a free charging point installed.
				In public places, he would like to charge In Tesla superchargers or public car parks. The ideal would be having a fast-charging point with well-prepared rest Areas, as in France
				While traveling, he likes to use APPs to know the charging points location and the best route possible.

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Our system will include a sensor in the primary coil to detect presence in the surface above to detect cars	Pain Relievers	⇔	Pains	I cannot charge on coventional charger while waiting clientes
Our Product includes a functionality allowing to monitor and communicate the status of the charging availability (in use, free, N/A). We will use the OCPP/OCPI protocol to publish the status to provide this information toother Mobility Service Providers (eMSPs)				Sometimes I don't know what is the SoC while I am charging. I don't want to leave the car while I am charging. I want to be ready to depart. Not possible if I am using conductive charger.
Thanks to the RFID sensors, our product is capable to detect unique vehicle identification and thus, operating according to the configuration preferences established by the user in the app (automatic charging, charging limits based on energy, money or autonomy)				Time to active the charging is very long until charge session starts. Need to plug and unplug cable.

11.2.2 Dynamic approach. Scenarios

11.2.2.1.1 Scenario description

ID	Scenario 2
Action	Charge at destination after driving (or riding) …
Vehicle	Taxi EV
From	Urban (city centre)
Site A	Central Station
To	Peri-urban (city suburbs)
Site B	Any
Frequency	All weekdays
Type of route	Beltway
Trip distance	10-20 km
Trip duration	10-20 minutes
Destination activity	n/a
Activity Duration	n/a

11.2.2.1.2 User objectives

1. To be able to charge my car's battery while waiting my next client
2. To be able to charge as fast as possible
3. To be able to not lose time in the charging process activation and being 100% automatic
4. To be able to stay inside the car during the start/stop of the charging process
5. To be able to continue charging as I move forward in the queue line

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11.2.2.1.3 Relevance of the objectives for each persona

	Manuel	Miguel	Miriam	Sergio	Laura	Taxi driver
Objective 1						X
Objective 2						X
Objective 3						X
Objective 4						X
Objective 5						X
Objective 6						X

11.2.2.1.4 Storytelling - Steps

		Describe the story for each step (sub-objective)	**Describe the experienced emotions**	**Overall emotion**
O1-O6	**Step 1**	Check which queue line has inductive charging systems	Anxious to know the queue time and charging systems available	Mixed
	Step 2	Arrive to the queue line	Anxious to reach the position where there is a inductive charging spot	Mixed
	Step 3	Align and stop over the charging spot	Thankful to the alignment system for helping me to stop at the best position for best charging performance	Good
	Step 4	My car will indicate the charging status	Happy I can check in real time the charging progress	Good
	Step 5	Charging stops when leaving my actual position	Just moving a couple of meters	Good
	Step 6	I move forward in the queue line and arrive to the next charging spot	Happy I can check in real time the charging progress	Good
	Step 7	My client arrives and I leave to my client's destination	Happy to start another run	Good
	Step 8	Charging stops and I check my new battery status and range	Curious to see the new range increase	Good

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11.2.3 Synthesis. House of quality

11.2.3.1 HOQ ANALYSIS

Row #	Source of the requirement	Column #	1	2	2	3	4	5	6
		Stage	Pre-charge		Charge				
		Functional Requirements / Customer Requirements (Explicit and Implicit)	Monitor the status of the charging system availability	Publish the charging system availability to provide this info to Mobility Service Providers (eMSPs)	Seamless premium charge experience everywhere. Forget to plug/unplug, and different connector	Detect presence and vehicle id to start charging according to user preferences established in the	Adjust charging power to adapt and control automatically surplus energy from renewables	Help user to align the EV over the charging spot for the best charging performance	Stop charging automatically when leaving the position
1	Gains	At work, to have a free charging point installed.							
2	Gains	To be able to charge as fast as possible				X	X		
3	Gains	In public places, to charge In Tesla superchargers or fast-charging point with rest areas							
4	Gains	To be able to not loosing time in the charging process activation and being 100% automatic				X			X
5	Gains	To be able to stay inside the car during the start/stop of the charging process				X			
6	Gains	To be able to continue charging as I move forward in the queue line						X	
7	Pains	I cannot charge on coventional charger while waiting clientes			X				
8	Pains	Sometimes I don't know what is the SoC while I am charging.							
9	Pains	I don't want to leave the car while I am charging.							X
10	Pains	I want to be ready to depart. Not possible if I am using conductive charger							X
11	Pains	Time to active the charging is very long until charge session starts. Need to plug and unplug				X			

Figure 15. House of Quality

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11.2.3.2 HOQ ANALYSIS

The observation of the UC7 HoQ evidence that the product attributes in the pre-charge phase are not demanded by the end user, at least not explicitly.

It also shows that two user requirements are not obviously addressed by the product: in row nº1, having free charging points installed at work is not a clear product feature, although it could probably be a free service for electric taxis if the right incentives are put in place. The same issue appears in row nº 8, the lack of SoC information during the charging process seems to be unsolved, although the system may include some interfaces for this purpose. Therefore, the value proposition should write clear statements of how the solution meets the requirements of the user.

Regarding the roof, which indicates potential conflicts, tradeoffs or synergies between product attributes, the automatic regulation of charging parameters based on user preferences could conflict with the automatic regulation of charging parameters based on available energy from renewables. This is a technical issue that must be carefully designed and implemented to maximize the value for the user and possibly also the value to other stakeholders. The later point can be assessed using the value network model in the following section.

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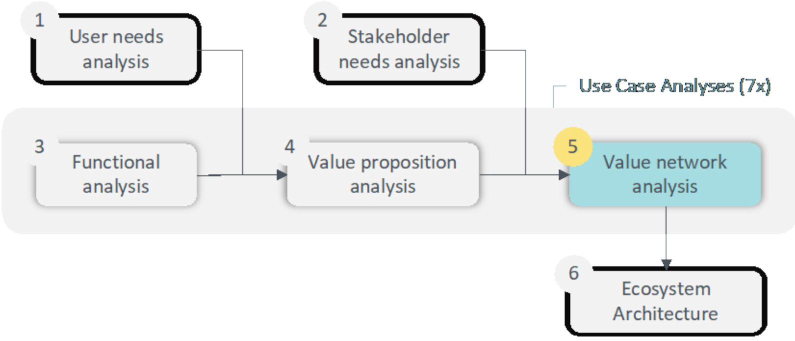
11.3 UC7 Value Network Analysis

This analysis aims to widen the scope of the value proposition drafted so far, to include not only the end users but also those stakeholders that participate in the elaboration or delivery of value.



11.3.1 Stakeholder identification and characterization

In this section, the stakeholders are rated based on their potential power and interest on the use case. Then, the most relevant ones are considered, listing their objectives.

11.3.1.1 STAKEHOLDERS PROFILES

Involvement in the charging network development	Stakeholder	Key group	Power	Interest
Direct	Local public authority (e.g. mobility planners, policy makers)	Government	High	Medium
	Charging Point Operator (CPO)	Business	Medium	High
	E-Mobility Provider (EMP)	Business	Medium	High
	Fuel station company (petrol stations)	Business	Low	Low
	Motorway company(operator	Business	Low	Low
	Land and parking space owner (supermarket, mall, parking area, …)	Business	Medium	Low
	Power grid operator (DSO)	Business	Medium	Medium
Indirect	Regional public authority (e.g. mobility planners, policy makers)	Government	High	Medium

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	National public authority (e.g. mobility planners, policy makers)	Government	High	Medium
	Energy (electric) utility	Business	Low	Low
	EV manufacturer (cars, vans, motorbikes, bikes, etc.)	Business	High	High
	Charging Station manufacturer	Business	High	High
	ICT/tech provider	Business	Low	Medium
	Public Research Institute	Research	Low	Medium
	Private Research Institute	Research	Low	Medium
	University	Research	Low	Medium
	Start up	Business	Low	Low
	Private drivers' associations	Civil society	High	Medium
	Transport and logistic sector association	Business	High	Low
	Association/Organization promoting electromobility	Civil society	Low	High
	Environmental organization	Civil society	Medium	Medium
	Telecom operators	Business	Medium	Medium
	E-mobility roaming platform operators	Business	Medium	High
	Mobility service information providers	Business	Medium	High

11.3.1.2 STAKEHOLDER OBJECTIVES

For a selection of the most relevant stakeholders in terms of power and interest.

End-User (e-Taxi Driver)	Not losing time in the charging process activation and being 100% automatic
	Stay inside the car during the start/stop of the charging process

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	Continue charging as I move forward in the queue line
	Pay automatically on an agreed tariff
	Check online and in real time the energy recharged and its cost
Charging Operator Owner	I want to know the grid and charger status and performance in real time
	I want a high efficiency in the charge
	I want to monitor the energy transferred and the benefits of its charger
	I want to know how much energy I have sell / recharged and its costs/profit
	I want to know the car battery status
	I want to know the profitability of this installation and its operation
	I want to know the costs of new installation, or retrofitting an existing one
Land and parking space owner (business, supermall, etc.)	I want to differentiate my company from the competence by offering best services
	I want that an EV taxi is always at my location
	I want to know how much energy I have sell / recharged and its costs/profit
	I want to know the profitability of this installation and its operation

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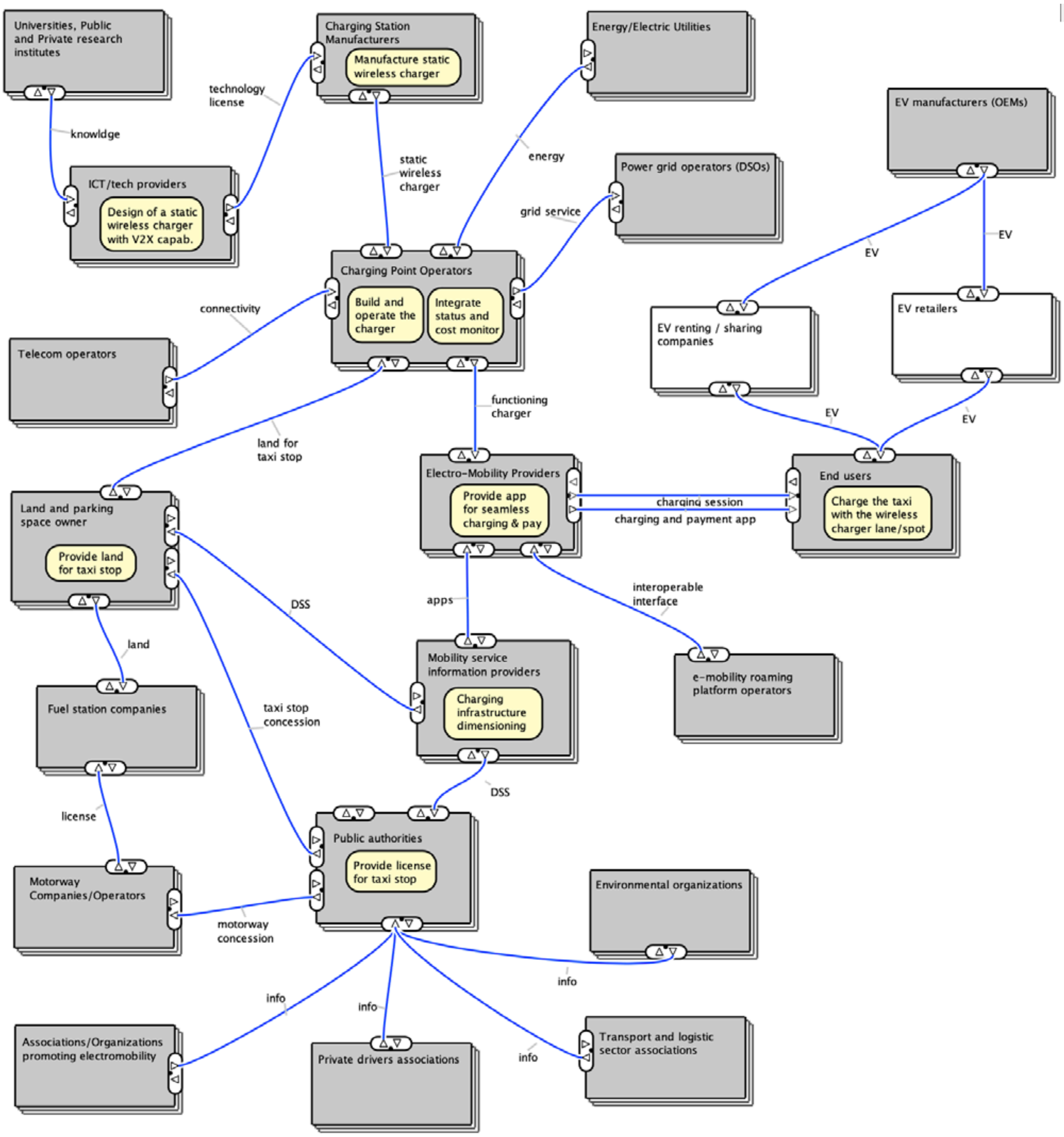
11.3.2 Value Network Modelling

The following figure shows the relations among stakeholders in the ecosystems using e3-value modelling methodology.



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11.3.3 Value Network Analysis

In UC7, there are two nuclear value chains and stakeholders.

On the one hand, the mobility service information providers develop apps for electro-mobility providers that centralize the service activation for end-users (i.e., interoperable access to the charging session and payment using an app), and provide a decision support tool (DSS) to the public authorities that develop mobility plans and give licenses to motorways and taxi stops.

On the other hand, the Charging Point Operators receive the static wireless charging system that has been developed thanks to the collaboration of academia, technology providers and manufacturers. The CPO manages the energy and communications supplies to construct and operate a static wireless charger with status and cost monitor capability. This infrastructure is offered to electro-mobility providers and DSOs. The former will monetise the infrastructure by selling charging sessions to end-users, while the later will could use V2G technology (although this case is not fully described here).

This qualitative value network analysis is preliminary and will be resumed in subsequent tasks such as the cost-benefit analysis and the business model design.

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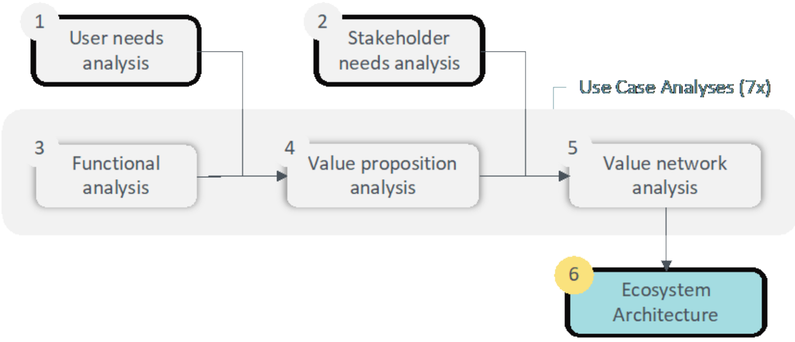
12 ARCHITECTURAL ANALYSIS

After defining a value proposition and testing different value networks that apparently could lead to a balanced and successful ecosystem, the question is: how can the concept be deployed in reality?



Here the tool proposed is the E-Mobility Systems Architecture (EMSA) which, in brief, can be defied as a model-based framework for managing complexity and interoperability. As advanced in the methodology section and detailed in the corresponding Annex, this blueprint can be used to map and coordinate several viewpoints (layers) of the problem and check that all the components and interfaces at business, functional, information and communication levels are covered.

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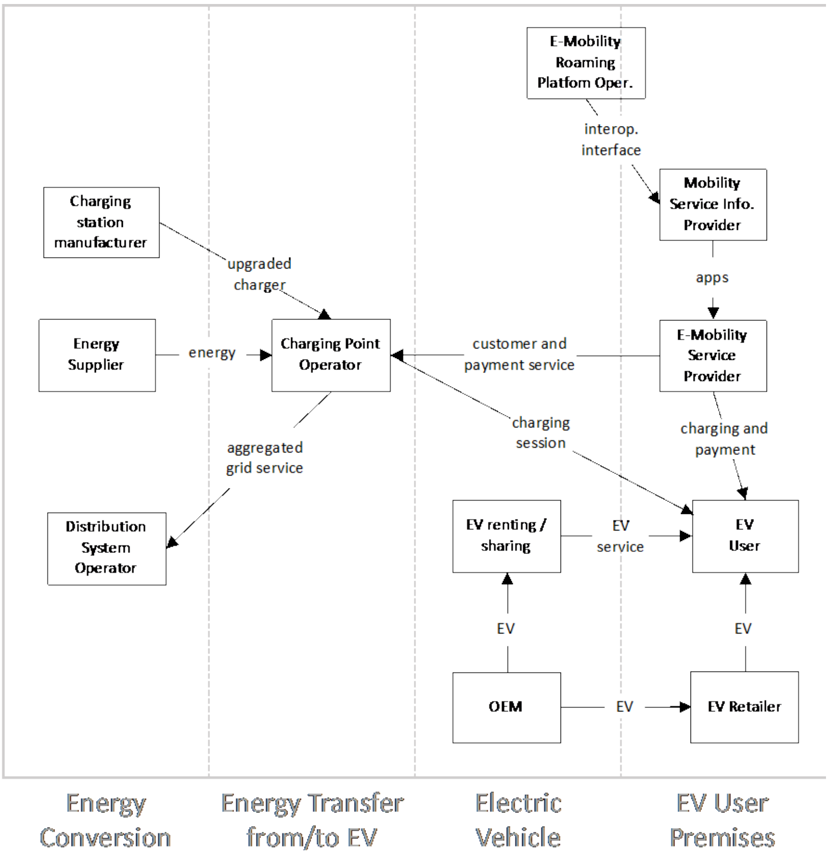
12.1 Mapping the value network in the EMSA business layer

The first step towards the implementation of the mobility ecosystem would be to fill the top layer, which is the business one.

In the following figure, the most relevant actors and value exchanges of Use Case 1 has been represented.



It should be noted that the categories in which the stakeholders are mapped refer to either the energy or the mobility domain. Some players thar have power and/or interests across many sectors could be placed in the box where their role is more relevant. Nevertheless, this architecture is not intended to consider all the stakeholders but mostly those participating in the supply chain.

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12.2 Completing the physical and technical layers

The second step to implement the mobility ecosystem could be the component (or physical) layer and, iteratively, the function layer that connects the business cases with their physical implementation by an abstraction of interconnected functions.

The figure below shows an example provided in "E-Mobility systems architecture. a model-based framework for managing complexity and interoperability".

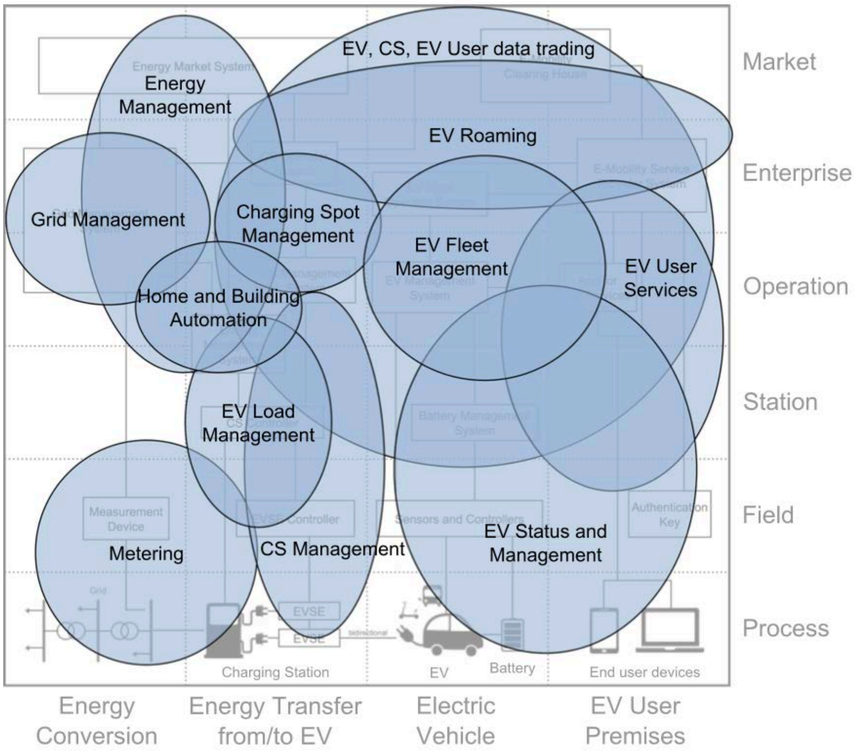

Fig. 5 EMSA function layer with grouped functions from e-mobility sector

Finally, the information and communication layers would be completed to ensure the technical operation of the use cases. I.e., the definition of technologies and protocols to orchestrate the system of systems that is the electric mobility domain.

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13 CONTRIBUTION TO EXPLOITATION & DISSEMINATION

This report is public and will be linked as open access in the project website. Therefore, it is not exploitable and will not be protected.

The objective is to disseminate the methodology and the results obtained specifically to similar R&D or demonstration projects, public authorities or consultancy firms that could benefit from INCIT-EV's approach to the value proposition and value network analysis in the context of electric mobility.

Results	Link to WP12: Dissemination results
D9.1 Use cases value proposition considering the whole ecosystem	The report could be explained in face-to-face meetings with similar H2020 or Horizon Europe consortia or with stakeholder groups that may be interested.

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14 CONCLUSIONS

This report is the result of a collective thinking process in which Use Case leaders went through 5 steps of a formal methodology to assess different perspectives of the EV-charging adoption problem.

Firstly, the end user and stakeholder needs were identified using primary information sources, i.e., interviews, to discover their perspective: pains, gains, barriers, etc.

Secondly, each Use Case performed three analyses: 1) functional analysis of the proposed charging solution; 2) value proposition analysis, matching the user needs with the solution; and 3) value network analysis, identifying the key players and detecting the main value chains involved in the delivery of the value proposition. The result of these steps is a non-technical look at the charging solutions, enriched by the user needs and the stakeholder constraints, evidencing that no feature is relevant if it does not mitigate a user pain or respond to the requirement of a key stakeholder. The patterns found using the House of Quality allowed to detect unmet user needs and unused product features. Last, but not least, the value network diagram and analysis showed that there may be many valid business models that should be further studied in the corresponding task (T9.3).

Finally, an architectural blueprint was selected and proposed as a powerful tool to translate the value network into business models and, together with a diagram of the physical elements of the charging solution, determine what are the functionalities, and information / communication infrastructures required to deploy such a complex system successfully and ensuring the coherence and interoperability among its building blocks.

Overall, this report has fulfilled its objective of undertaking a preliminary analysis of use-cases focused on the definition of a value proposition for users and a value network considering the whole ecosystem of each use case.

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ANNEX I. METHODOLOGY FOR THE ANALYSIS OF END-USERS' NEEDS

User characterization

The characterization of the Customer/user should be approached, not from the perspective of each charging technology, but at a higher level that is mobility. This premise is explained as follows:

- The user can be agnostic to any particular charging technology and use various charging solutions as part of his mobility, especially in a context of multi-criteria trade-offs (availability, price, vehicle downtime, etc.), and depending on the territory.
- The user manages his mobility before managing his charging, the latter being more of a constraint to this mobility. The latter integrates several dimensions: the vehicle, the itinerary, the charging, and the parking, knowing that the vehicle and the charging strategy (in particular, the choice of one technology rather than another) cannot be considered as independent, due to the autonomy of the vehicle, the parking time of the vehicle in relation to the duration of the activities, as well as to the chain of these activities[1];
- Being able to use different charging solutions could imply that all possibilities could be offered through a single "one-stop-shop" interface. Treating each recharging technology independently of the others might not lead to such a need, and focus the characterization on each technical system, independently of the others.
- From a mobility point of view, this "one-stop-shop" interface could be external to the recharging system, for example on a smartphone or on board the vehicle, with or without integration with the GPS system (route planning taking into account the territorial network of recharging solutions, as well as the vehicle's range).

This characterization is therefore common to all charging solutions and could allow, in the sense of the project (encouraging the adoption of the electric vehicle), to generate reflections around user gains in conversion to the electric vehicle. For instance, a user who uses a thermal vehicle and has difficulty parking, could find it convenient to book a parking space, and implicitly, a charging station.

User segmentation

Since the project focuses on technologies, some of which will not be mature before 2030, the focus is not on users of electric vehicles, but on future users of these vehicles. In other words, the focus is on users/owners

[1] Since the 1970s, mobility strategies have changed: there is no longer a quasi-systematic return to home between two activities. A mother may leave for work and drop her children off at school, then return home to run errands and pick up her children from daycare. This chaining of activities and the volume of purchases may explain why she takes her personal vehicle for all her activities, even if she has public transport offer available.

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of electric vehicles, but also on people who have not yet converted, which is made possible by the scale of characterization mentioned in the previous section.

This leads to consider at least two segments in the sense of possible different needs and expectations, due to a differentiated experience, considering the customers/users.

It should be noted that other segments will have to be considered and characterized, for example in the sense of companies, regarding all the customers typologies considered in the project.

The characterization phase could lead to refining the segmentation on each of these segments, if different needs are identified, for example according to socio-demographic or cultural criteria; the same segment groups together individuals who are normally homogeneous in terms of needs. This refinement could therefore lead to the proposal of sub-segments.

Nevertheless, it should be noted that:

- The multiplication of segments would lead to working on different offers from one customer segment to another, for personalization purposes (this is normally the objective of a segmentation),
- For some technologies that are not yet mature, and probably not well known by the public, a fine segmentation may not make sense, at least for the time being.

It will therefore be up to each experimentation territory, depending on the recharging technology it supports, to define whether it is developing a single offer to meet all needs, all segments combined, or whether it is addressing a specific offer (value proposition) to each identified segment.

Elements to be characterized

The characterization of needs consists in acquiring elements concerning the mobility experience of individuals, whether they use an electric vehicle or not. These elements of experience can concern the vehicle, the charging system, parking, route planning, ...

In the field of customer offer design, two models can be used: the model of Osterwalder & al.[2] and the model of Peter J. Thompson[3]

In a synthetic vision based on these two models, we can consider the following elements of characterization:

- **The user's role**: it corresponds to what the client wants to do, i.e., "things" that can be objectives to be achieved, tasks to be carried out, needs that the client is trying to satisfy, or problems that he is trying to solve. These things can be of different natures:
  - Functional: work, move, travel, ...
  - Social: gaining status, power, improving one's appearance, impressing friends or colleagues...

[2] Osterwalder, A., Pigneur, Y., Oliveira, M. A. Y., & Ferreira, J. J. P. (2011). Business Model Generation: A handbook for visionaries, game changers and challengers. *African journal of business management*, *5*(7), 22-30.

[3] Thompson, P.J. (2013). Value Proposition Canvas Template. [Online https://www.peterjthomson.com/2013/11/value-proposition-canvas]

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  - Emotional: aesthetics, well-being, having strong sensations, feeling safe, ...
  - Fundamental, in the sense of the primary needs of Maslow's pyramid: sleep, food, etc.

  These needs, which in our case concern mobility (as proposed in chapter 4.1.1), may be expressed, felt or even latent.

- **The expectations or gains expected** by the user in the accomplishment of his role, which can be of 4 kinds:
  - Required gains, without which a solution that does not meet these gains would be rejected.
  - The expected gains, which we could do without but do not want a priori, such as the aesthetics of a product. Satisfying these gains can constitute a differentiating element.
  - “Nice-to-have" gains, which are not necessarily naturally expressed, but for which a customer would respond positively if asked explicitly.
  - Unexpected gains, for which a customer would answer negatively if explicitly asked.
- **Problems encountered**: obstacles, frustrations, difficulties, or negative emotions that the customer encounters; elements that bother or disturb him in the context of the performance of his role, whether before, during or after the performance of the latter. These elements can be divided into 2 categories:
  - Undesired outcomes, problems, and features, which can be functional (a solution doesn't work, doesn't work well, or generates collateral effects such as extra cost or wasted time), or emotional (a customer doesn't like a design or has to go through a step they don't like, such as having to fill out a form they find tedious to register on a site).
  - Barriers that may cause the customer to give up on a task, such as lack of time. The problems are related to the reality of the situation and, regarding charging, should therefore mainly concern users who already own electric vehicles.
- **Identified risks or apprehensions/fears** of the customer, in the sense of anticipated possible outcomes that would not be desired, such as arriving late for an important appointment, that may lead to different arbitration and, for example:
  - Giving up a preferred mode of transportation (e.g., public transportation) to choose a more reliable mode at the expense of price,
  - Forgoing the purchase of an electric vehicle,
  - To give up a trip.

As previously mentioned, all the needs must be prioritized for arbitration purposes: in the sense of the project, if it is impossible to find solutions that meet all the needs, or possibly with reference to cost/benefit criteria (meeting a specific need could lead to a functionality that is too costly in relation to the value given to it by a user). A prioritization is understood in the sense of 4 prioritizations, one for each of the 4 headings presented above.

In fact, and more specifically in the framework of INCIT-EV project, on the basis of specific surveys aiming at the characterization of the needs, carried out by task 2.3, the persons in charge of tasks 2.3 and 9.1 will cooperate to formalize different personas, each persona having to describe the needs of a particular customer/user segment.

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Formalization of persona

The persona therefore crystallizes all the elements resulting from the survey data and makes it possible to formalize them in an intelligible form for all the stakeholders of a project. The persona is presented in the form of a synthetic sheet:

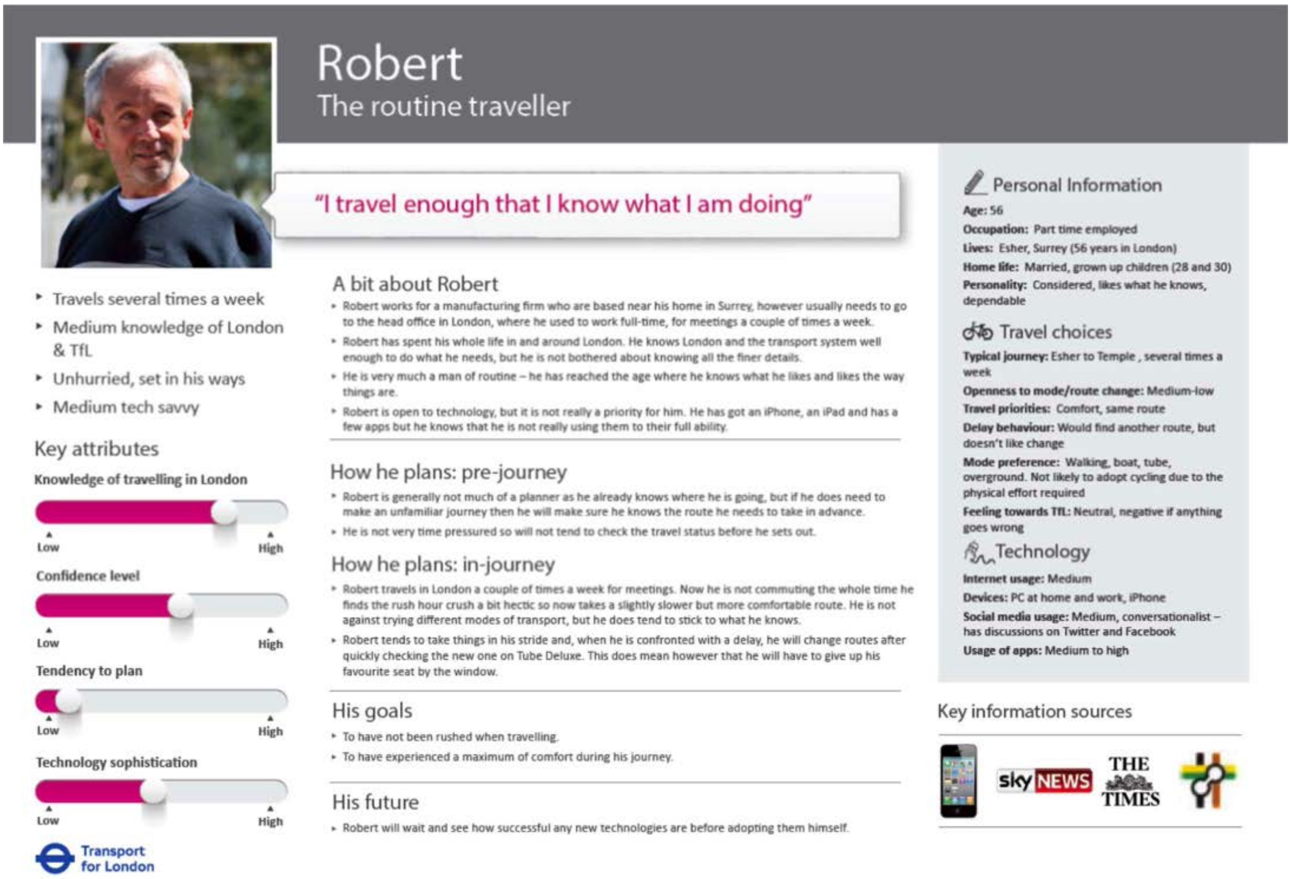

Figure 16: Example of persona - Transport of London[4]

A persona can be described as a composite/fictional portrait, or an archetype of the segment it is associated with. It is not a real customer/user but a realistic and stereotyped customer/user.

The "Persona" approach represents a way of "bringing to life" or humanizing a customer segment, making it easier to adopt an empathetic attitude towards the customer, and implicitly to better understand the latter's behaviors and expectations.

In this perspective, we fill in a certain number of headings to define a credible profile, and provide the necessary elements to humanize the persona:

- His profile: the objective is to build an identity that will rely on:

[4] https://content.tfl.gov.uk/onl-gui-108-tfl-website-personas.pdf

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  - A photograph,
  - A first name,
  - A biography presenting the history of the persona,
  - As well as its socio-demographic characteristics;
- His character traits and psychology;
- His behaviors, in the sense of his attitudes of living, consuming and seeking information, for example;
- His motivations, in the sense of what drives him to act: his needs and aspirations, the expectations he seeks to satisfy, as well as the problems he seeks to solve;
- His frustrations, in the sense of unmet needs, despite his actions,
- His brakes or blocks, in the sense of what can lead him to give up acting: apprehensions, fears or anxieties.

The persona sheet does not present the needs in structured and closed lists, as we presented in the previous section "Elements to be characterized". Between expressed, felt or latent needs, not all needs may emerge through the customer/user surveys. The persona must therefore be appropriated, and it is by taking on its role and putting oneself in its place that these complementary needs are likely to emerge, especially during the experiential projection phase, which can be likened to a cognitive simulation.

The persona thus has the advantage of a more open formulation, as opposed to closed lists. It represents a lever for adopting the customer's perspective and projecting oneself into a future situation in order to anticipate it. It is therefore the reference base to put oneself in the customer's shoes[5], in order to elaborate a value proposition in response to the needs.

Based on the persona, the creation of a first list of needs can nevertheless be carried out and prioritized according to the relative importance of these needs. This list can be enriched during the solution research phase (value proposition), when we project ourselves into the usage, as we will see in the following chapters.

In relation to the elements provided in the section “User Segmentation”, it is not clear how many customer segments will emerge, and implicitly how many personas to consider.

In the hypothesis of a unique answer/offer, this value proposition could not be built on the basis of a fusion of personas, which would be difficult in reference to the characterization elements of the latter (life habits, behaviours, ...): this fusion could only be considered on the value propositions built for each persona, thus later in the process.

[5] This approach implicitly assumes that the project is not based on a participatory design logic, which would imply that future users are involved in the design processes.

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ANNEX II. METHODOLOGY FOR THE ANALYSIS OF STAKEHOLDERS' NEEDS

Selection of stakeholders to analyse their needs

The deliverable D2.2 identified the users and stakeholders in order to engage them in the project use cases and in the elaboration of the INCIT-EV recommendations for drafting European strategies for the integrated and sustainable development of electric charging infrastructures, mobility, land use and energy.

In D2.2, a list of specific stakeholders was provided for all the countries represented in the consortium, aiming to contact them if needed during project demonstration or communication activities.

From all the stakeholders categories identified, 11 were selected and approached to gather information directly. The following table presents the category and the definition of the stakeholder categories selected:

Stakeholder	Definition
Association/Organization promoting electromobility	Groups developing the interest towards electric vehicle, in purchasing, usage and in renting.
ICT/tech provider	Company providing ICT or technology solutions (also technical architectures) to be implemented/installed in charging stations.
Energy/Electric utility	Company in the electric power industry (often a public utility) that engages in electricity generation and distribution of electricity for sale generally in a regulated market.
Charging station manufacturers	Company that creates charging stations in which electric vehicles can recharge the battery
Regional and National Public authorities	Any government or other public administration, including public advisory bodies, at regional/national level; any natural or legal person performing public administrative functions under national law, including specific duties.
Local public authority	Any government or other public administration, including public advisory bodies, at local level (e.g. mobility planners, policy makers); any natural or legal person performing public administrative functions under national law, including specific duties.
Public transport company	Company offering the service of transportation for people with buses and other vehicles having a capacity of more than 5 people

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Methodology applied for the analysis of needs

To deepen into the pains, gains and barriers detected by the stakeholders, 30 interviews were made: 7 in Spain, 18 in France, 4 in Italy and 2 in Estonia.

The format of the interviews was not restricted to a limited amount of questions or a specific set of topics. Instead, the interviewer allowed the stakeholder to speak freely about the activities, opportunities and difficulties found in the electric vehicle charging domain. The objective of the interviewer was to keep a natural conversation and ensure that some key points about charging infrastructure were mentioned.

The interviews were performed in the language of the country where the company is located. All the interviews were recorded with the permission of the interviewees, and the transcripts were translated into English.

The interviews were then grouped by stakeholder type and texts anonymised to avoid the possible bias that could exist if conclusions were taken from a non-anonymous conversation.

Finally, from the translations, the qualitative analysis extracted from the conversation two aspects:

- Barriers for the penetration of EVs and EV charging infrastructures: either technical, commercial, or political
- Opportunities for the penetration of EVs and EV charging infrastructures

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ANNEX III. METHODOLOGY FOR THE FUNCTIONAL ANALYSIS OF THE CHARGING SOLUTIONS

A use case is a description of the ways in which a user interacts with a system or product. In Incit-EV project, the term "Use Case" refers to the application of an innovative charging technology (implemented in a product or service) to improve user experience and foster the adoption of EVs in Europe, although the detailed description of the interaction among the users and other stakeholders and the system is part of the project activities and is not defined from the beginning.

Many aspects of the Use Cases were fixed at the proposal phase. Therefore, the pilots are not greenfield projects in which the user requirements can be gathered, analysed, and translated into specifications to create ad-hoc solutions from scratch. Instead, the approach followed was to select state-of-the-art charging technologies, involve the key stakeholders, and focus on the demonstration of the innovative technologies with new business models in different ecosystems, as well as their replication with the help of digital tools (DSS and apps).

Another key objective of Incit-EV Use Cases is to demonstrate the consistency of the obtained user's expectations, as well as the adequacy of the innovative charging technologies to them, taking into account that:

- Each Use Case will be deployed at-scale in one of the 5 cities involved, to demonstrate its performance in a real environment.
- Each Use Case demonstrates one or more mobility scenarios and tests one or more value propositions (charging technologies and services).

Keeping in mind that the Use Cases have already selected different technologies and drafted a value proposition, the effort of this task is put on the analysis of the starting point. More specifically, the analysis of the Use Cases aims to extract the engineering characteristics that may affect the end-user acceptance. For this purpose, the following documents will be used:

- *Incit-EV description of work* including basic information and user experience improvements pursued.
- D6.1 "*DSS and Service Layer Requirements and Specification*" including epics and user stories.
- D7.1 "*Demonstration and monitoring plan for the urban areas demo sites*" including the objectives, technology enablers and deployment plan.
- D8.1 "*Demonstration and monitoring plan for the peri-urban and extra-urban areas demo site*" including the objectives, technology enablers and deployment plan.

On top of the information gathered from the aforementioned documents, direct input from Incit-EV Use Case leaders will be requested using the value proposition canvas and the scenarios approach presented in the next section.

As a result of the analysis, a list of functional and non-functional (quality) specifications will be listed.

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ANNEX IV. METHODOLOGY FOR THE VALUE PROPOSITION ANALYSIS

To match end-user needs with UCs functionalities, two approaches are proposed:

- The static logic from Osterwalder & Pigneur's "Value Proposition" approach, because of its potentially quick implementation, as it is based on intuitive logics, for example through brainstorming sessions,
- The dynamic approach which uses “scenarios” and storytelling, based on objectives identified for customers/users. This second approach also allows to understand the value creation processes. Because it integrates an explanation of the customer journey in an unstructured way, and because it thus makes it easier to project oneself into the usage, in the sense of a cognitive simulation, it supplants in our opinion the customer journey map, at least in the upstream phase of elaborating the value proposition.

These two approaches are not independent of each other and feed into each other:

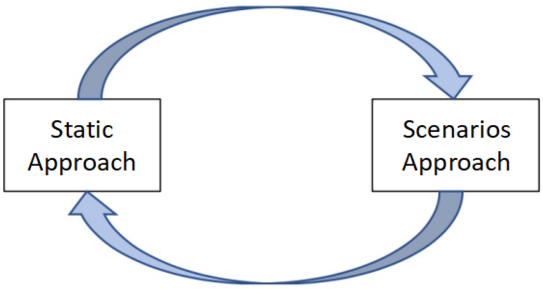

Figure 17: Value proposition articulation between static and dynamic approaches

- The static approach will allow the dynamic approach to check the integration of all the characteristics of the service in the storytelling phase, and to generate scenario variants in this sense. Indeed, the disadvantage of storytelling is that it tends to tell a single story.
- The "scenario" approach will allow us to enrich the list of service characteristics, thanks to the fact that it allows us to project ourselves into the use.

Static approach

Intuitive search for features/attributes of the offer can be done:

- Whether in a group, in brainstorming type sessions. However, this approach assumes that each person is in the presence of others, which can be a hindrance in the objective of putting oneself in the persona's shoes,
- Or individually, with pooling afterwards, and confrontation/discussion of the different individual proposals.

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We mentioned in chapter "Elements to be characterized" the fact that a list of needs could be extracted upstream (before any search for solutions) on the basis of the Persona sheet, by prioritizing them in terms of their relative importance. We also mentioned that this list might not be exhaustive, even if the additional needs could potentially be of lesser importance.

At this stage of the intuitive search for solutions, when a proposal for an attribute of the offer (functionality) emerges, it is mandatory to ask the question of the need(s) to which the attribute responds, in order to avoid the risk of taking into account one's own expectations, as opposed to those of the persona.

It is based on group exchanges that this question will have to be refined. It will also allow for further discussion about the persona and its real needs, thus making it possible to refine them, on the basis of data describing the persona, such as its character traits, its psychology, or its life attitudes. It is also based on these exchanges that the question of the hierarchy of needs will be addressed, always in reference to the persona.

Remark:

In the sense of design, needs are assimilated to the problem exposed, to which a solution must be brought/designed. As explored in the field of cognitive psychology, the initial problem is ill-defined and the design solution has to be imagined (Falzon, 1995[6]), leading to the consideration that the problems (and therefore here the needs) are progressively delimited over the course of intermediate productions.

Also, in general, when faced with a problem, various solutions may exist. If different solutions discussed in group and answering a need are proposed, at this stage of the research of attributes/functionalities, these different proposals should be kept and then evaluated:

- In a synthetic vision crossing all the needs and the proposed attributes, this synthetic vision allowing to take height and to check how an attribute allows to answer several needs, but also how different attributes can contribute to the same need,
- For final arbitration on which features to keep.

Remark:

This synthesis will be discussed in the following chapters.

Dynamic approach

As we have said, the objective of the "scenarios" approach is to project into the use, this projection bringing a dynamic point of view by integrating the temporal dimension, in opposition but also in complement of the static approach.

[6] Falzon, P. (1995), Les acitivités de conception: réflexions introductives, Performances Humaines & Techniques, 74, Dossier L'activité des concepteurs, pp. 7-12.

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This logic consists in describing usage scenarios based on storytelling. We will take as a reference the approach proposed by Alistair Cockburn[7], even if we will adapt it somewhat.

INVENTORY AND SCOPING OF USAGE SCENARIOS

The "scenario" approach begins by defining the objectives of the actors in the ecosystem. The notion of actor remains broad, since it can concern an individual, or a technical artefact, such as a computer (which aims at a treatment, for example, comparable to an objective).

At this stage of the use of this approach, the technical solutions do not exist since they are in the process of becoming. We therefore propose to focus only on individuals (i.e., stakeholders), and in this case, for this chapter, on customers/users.

The difficulty lies in identifying the objectives that the client/user would like to achieve. Considering the scale of characterization, we first propose to define and list different contexts in which a customer/user could be led to recharge his vehicle, such as:

- A local daily trip, for example to go to work, so a known place,
- A local move, to a not well-known place,
- A local move comprising a chain of activities in different locations,
- A business trip to a place he knows,
- A business trip to an unfamiliar location,
- A weekend or vacation trip, considered as a long-distance trip, to a place they know and on a route they know; the difference with a business trip is a longer stay,
- A weekend or vacation trip, considered as a long-distance trip, to an unfamiliar place; always with a longer stay than in the case of a business trip.

For each context, it is then a question of identifying the different objectives that the customer might want to achieve, particularly in terms of recharging his vehicle and/or parking, knowing that we are only thinking about customers/users who own/use rechargeable vehicles. For example:

- To be able to charge in a specific place.
- To be able to charge and find a place easily to do so, in a particular area (for example near his workplace).
- To be able to find where to charge once in the day, regardless of location, with respect to one's planned chain of activities.
- To be able to charge during lunch on a long-distance trip, with:
  - No preference (location, time, duration, technology), o A favorite place,
  - And/or a favorite time,
  - And/or a preferred duration,

[7] Cockburn, A. 2001. Rédiger des Cas d'Utilisation Efficaces, Ed. Eyrolles / Cockburn, A. 2000. Writing Effective Use Cases, Ed. Addison-Wesley Professional

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  - And/or a preferred technology,
- To be able to charge with the least amount of time,
- To take out a subscription for access to recharging solutions in a given territory,
- To pay for a refill consumption outside of one's subscription,
- Etc.

These examples make it clear that a scenario does not necessarily treat an end-to-end experience, e.g., from customer conversion to customer retention, through usage and support in usage. On the contrary, some objectives/scenarios may focus on payment methods, while others will focus on usage itself (assuming that payment methods are not addressed in the latter). Conversely, one may decide to aggregate the issue of payment and the use of the charging system in the same scenario.

In fact, the project stakeholders will have to agree on a common breakdown and list of objectives, regardless the proposed charging technologies. The objectives should therefore not be expressed for a given technology but, on the opposite, remain agnostic towards any charging technology.

The contexts and objectives can be common to all personas, although this will depend on the descriptions of the personas (life habits, activities, ...). But, in the sense of experience and in relation to their own profile, two personas can understand the achievement of the same objective differently:

- A persona might want to plan and anticipate everything,
- When another, more opportunistic, could adopt an opposite attitude.

This difference between personas will imply a specific scripting for each of them towards the same shared objective. This leads to identify the number of [Persona-Objective] duplets to consider for the scenario:

	Persona 1	Persona 2	Persona 3
Objective 1	X	X	
Objective 2	X		X
Objective 3		X	X
Objective 4	X		X
Objective 5		X	X

Table 4. Crossing Persona – Objectives

The example in the table above would involve considering 10 scenarios, each leading to a storytelling phase.

STORYTELLING

As mentioned before, this approach is based on a very free format that is less restrictive than the customer journey map. The storytelling phase can use free text, possibly enhanced with images.

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Like the customer journey map, scripting integrates a temporal dimension from the beginning of the story until the objective is reached. Conversely, it does not propose to qualify the customer experience.

Therefore, we propose to integrate some formatting, without going as far as to bring the structuring constraint that the customer journey map represents. To do this, we propose to use tables with 3 columns:

Steps	Story	Experience Emotions
Step 1	Bla Bla	Bla Bla Bla
Step 2	Bla Bla	Bla Bla Bla
Etc.	Bla Bla	Bla Bla Bla

Table 5: Value proposition – Shaping the storytelling

- The steps are understood in terms of sub-goals, until the final goal associated with the scenario is reached.
- The story makes explicit what the customer does, his thoughts, as well as the touch points / interactions he has with the ecosystem to be designed, such as an employee, an application, or the charging system. The explicitness of these touch points allows us to identify the functional attributes that constitute the value proposition, in the sense of what is seen by the customer/user.
- The customer/user experience can be formalized in the form of simple smileys, expressing the customer's emotions. However, as different experiences could exist within each step and a simple smiley does not necessarily explain how the experience is good or bad, we propose an explicitation in the form of colored text:
  - Green for a good experience,
  - Orange for a mixed experience,
  - Red for a bad experience.

The analysis of this experience is done by putting oneself in the persona's shoes. If an experience is not good, the story needs to be reworked with new attributes of the offer, until the experience becomes good from start to finish, until the objective associated with the scenario is reached.

The narrative approach describing the customer experience (whether it is based on a free text or a customer journey map) has a limit, in that the narrators tend to describe a single scenario, in which everything goes well.

In life, not everything goes according to plan, in the nominal sense. Endogenous (the charging system is down) or exogenous factors ((1): there are no more charging stations available; (2): a user wanted to use ERS on a highway, but there are many vehicles and the flow is slowed down, as some vehicles have reduced their speed to load more. The user was counting on saving time with the ERS, which will be impossible) can interfere with the nominal scenario, leading to a degraded customer experience.

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The objective being to develop a value proposition that provides a good customer experience, one must focus on identifying all the degraded scenarios, called "extensions", to consider corrective and/or palliative solutions to improve the customer experience in these degraded situations.

In practice, once the nominal scenario is formalized:

- The said scenario is taken up again by identifying all the endogenous or exogenous factors that could lead to its degradation,
- One evaluates how and to what extent this degradation impacts the customer experience,
- One then looks for corrective and/or palliative solutions to improve the customer experience, which

can enrich the list of features/attributes of the value proposition.

This logic makes it possible, in the face of hazards, to anticipate responses to guarantee a certain robustness of the value proposition, and its resilience.

A storytelling scenario thus includes its nominal and all its extensions, allowing the customer objective associated with the scenario to be reached, to be partially reached, or not to be reached. Indeed, despite the search for corrective and/or palliative solutions, it may not be possible to find optimal solutions to bring the experience up to the best level, especially in the case of exogenous factors.

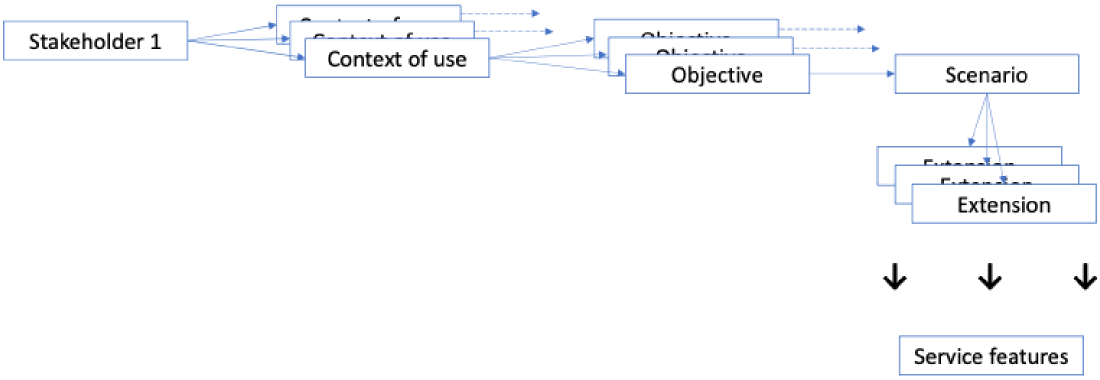

Figure 18. Scripting. Summary diagram.

Synthesis

We have seen that the static and dynamic approaches feed each other. Once the scripting is completed, one obtains:

- From the static approach, a list of requirements and attributes mirrored each other for each duplet [Technology-Persona],
- From the dynamic approach, this same set of needs and attributes, but more segmented because they are divided by scenario, noting that the same need and the same attribute can be found in several scenarios.

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SUMMARY BY SCENARIO

We saw in chapter in the static approach that several attributes/functionalities could emerge in the face of the same user need, pointing out the fact that these potentially competing attributes should ideally be kept in view of a trade-off based on a synthetic vision, since:

- A same functionality could ultimately meet several needs,
- Different functionalities could concomitantly improve the customer experience (or, on the contrary, constitute a costly redundancy).

As we have seen, this question of alternative attributes arises in the same way in the dynamic research phase (storytelling). The static and dynamic phases feeding each other, once these two phases have converged for the same persona, a synthesis should be formalized to arbitrate on the attributes to be considered regarding the persona's needs, and their ability to meet these needs to the extent necessary. This question of the right need arises in relation to considerations of Cost/Benefit balance, which will only be addressed later in the project (tasks 9.2 and 9.3).

To do this, we propose to rely on the formalism of the QFD or Quality Function Deployment approach, which is a "Quality Design" tool also known as the "Quality House"

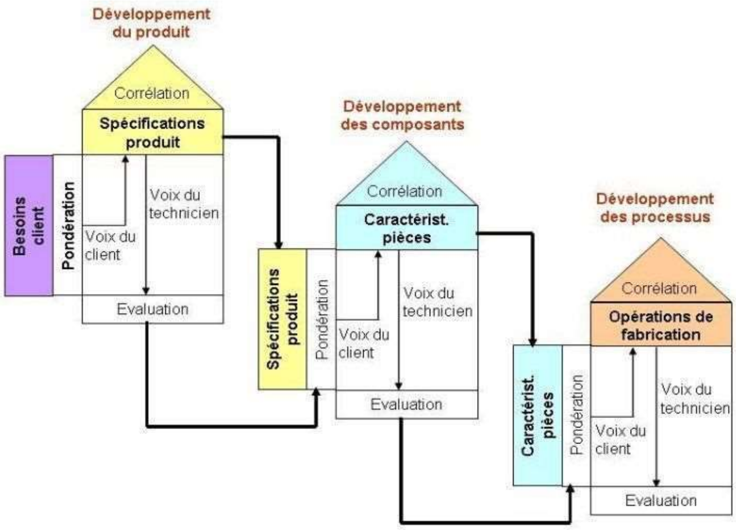

Figure 19: Synoptic of the QFD approach[8]

In its essence, the method proceeds by declination within an organization, as for example in the case of a product:

- The Product or Marketing Department defines the product characteristics (How) to meet the customer's needs (What),

[8] Frey E, et. al. (2007) QFD et Conception intégrée: Projet CodeKF. [online: https://www.knowllence.com/blog-qualite-conception-production/qfd-et-conception-integree.html]

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- The product specifications then become the What, sent to the Design Office which must respond with the How in terms of design solutions,
- Then the design solutions are addressed as What to Manufacturing. At each level, one tries to optimize the match between the What and the How. In our appropriation of the central part of the quality house:
- The "what" (what needs to be answered) is equated with the needs of the customers/users,
- The "how" (the way of answering the What) gathers the design solutions, thus the functionalities/attributes having emerged in static and dynamic phases.

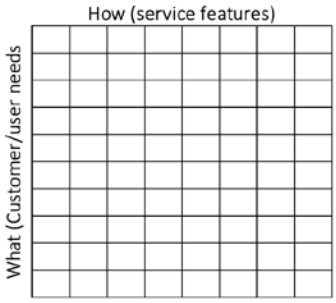

Figure 20: Central part of the QFD matrix

In the QFD approach, the What implies a weighting of each element of the persona, and thus of each customer/user need. As we have already mentioned, the formalization of a persona does not necessarily bring all the needs, since it depends on the completeness of the surveys, nor their explicit hierarchy, as proposed by Osterwalder & al. But we have also pointed out that this identification of needs as well as their hierarchy would be refined during the static and dynamic phases.

Therefore, at this stage of the process, and based on these last approaches, a list of needs and their prioritization should be formalized for each duplet [Technology-Persona], in view of the elements that will be presented below.

The integration of all the needs and attributes identified in a given scenario leads us to consider the following synthesis matrix format:

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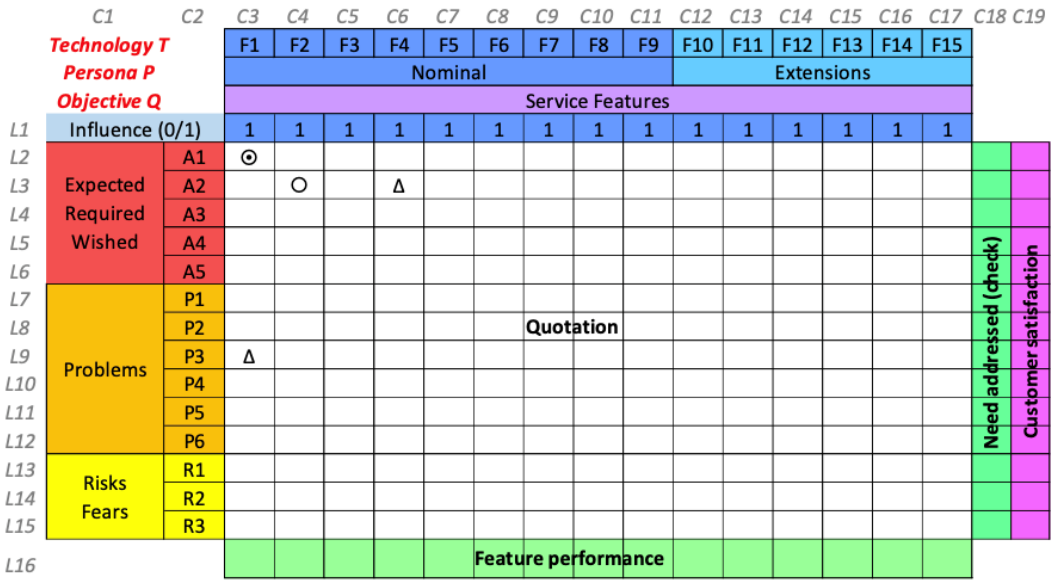

Figure 21: Needs-Features synthesis matrix for a persona

- Lines L2 to L15 of column C1 list all the needs of the persona. Each need is weighted in the sense of its hierarchy, for example by a score from 1 to 5 (column C2). This hierarchy is done in a relative way, between all the identified needs.
- Columns C4 to C18 list all the attributes/functionalities identified as answers to the needs of the persona considered, during the nominal scenarios and the extensions. As we have been able to keep alternative attributes (in the sense of the ideas found), we will have to test which of the alternative attributes best answers the problem posed (needs). To do this, line C1 will allow us to set a given attribute to 1 or 0 in order to test the overall impact of taking it into account or not taking it into account.
- The internal part of the matrix is documented in terms of the contribution of the attributes to the different needs. We propose to use the scoring principle of the QFD approach. If a functionality has been apprehended on a one-off basis during the scripting process, i.e. in the sense of a need identified at a given moment in the customer experience, it is necessary at this stage to ask oneself whether this same functionality could meet other needs.

Quotation

⊙	Strong Contribution	9
O	Average contribution	3
Δ	Low contribution	1
	No contribution	0

Figure 22: Logic of internal rating of the Needs-Features synthesis matrix

- The performance of a functionality is evaluated in the sense of its ability to meet one or more needs. It is calculated by a Sum-Product of the internal rating of the matrix, specific to this functionality, and the weighting of the needs (column C2):

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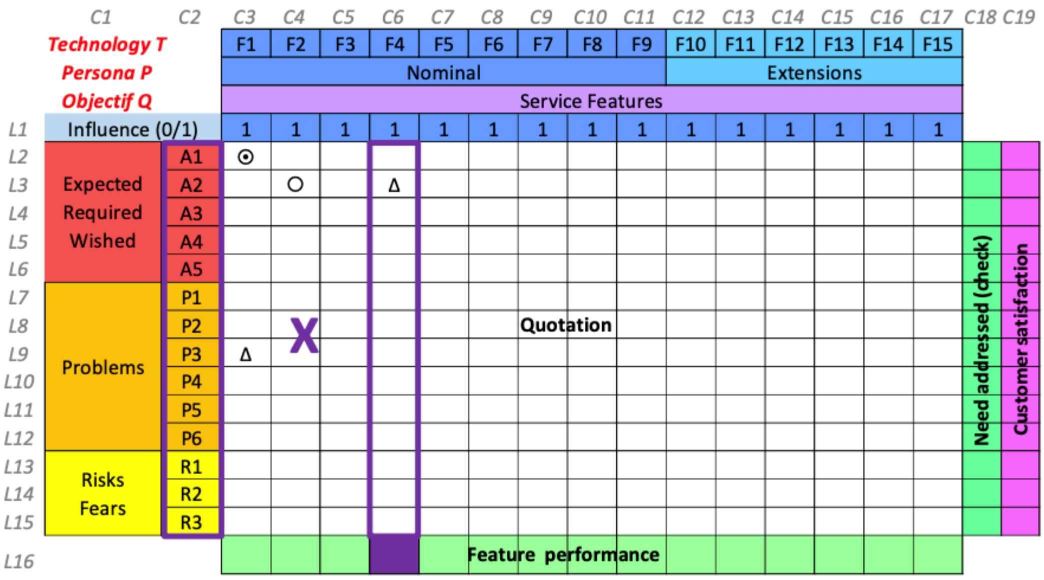

Figure 23: Calculation of the value of the F4 functionality

It is on the basis of this calculation that two alternative attributes can be compared in terms of comparative performance.

Based on this comparative performance, one will choose an attribute from among the alternative attributes, setting the influence level (line L1) to 0 for the attribute not selected. one must then check by a horizontal Sum-Product that the rejection of a feature does not imply the presence of a need that would no longer be addressed.

In the example below, features F4 and F5 are alternative and we retain feature F4 by setting line L1 to "0" for feature F5. To evaluate the ability of the global solution thus chosen to answer need A3, one will carry out a Sum-Product as follows, which must be carried out for each need.

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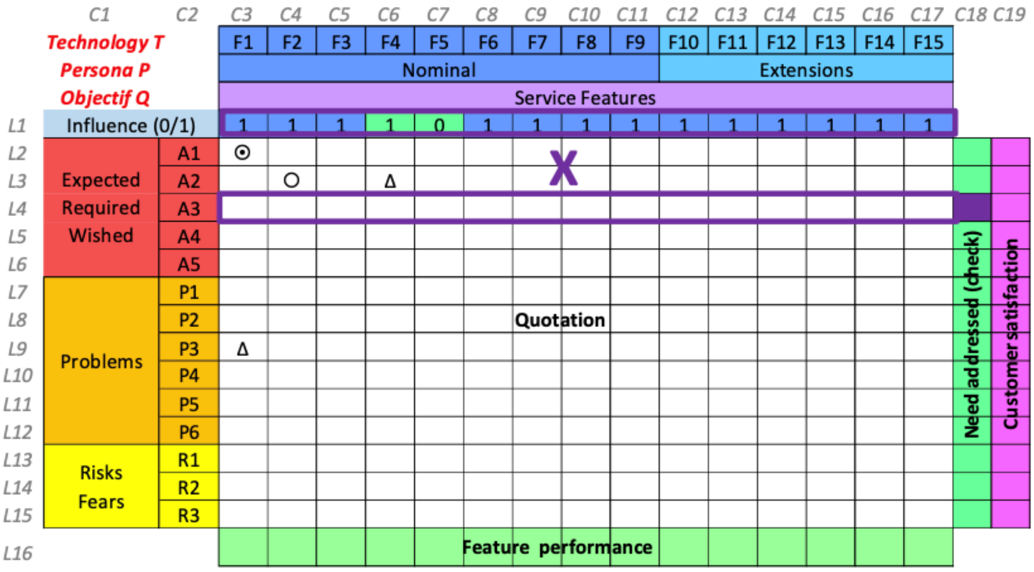

Figure 24: Check for completeness in addressing needs

- In column C19 (customer satisfaction), one documents the level of customer satisfaction with each of his needs. This rating is done subjectively (i.e. in groups), without using the internal rating of the matrix. This score is to be positioned in comparison to the weighting of each need in column C2:
  - If the need is fully met, the score is equal to the weight of the need,
  - If the need is not completely met, the grade is lower,
  - One can also consider that he is responding beyond the need, which should raise questions.

This notation can also be represented graphically via a semantic curve:

Figure 25: Comparative Semantic Curve for Modal Choice – Need versus Supply

The semantic curve above highlights the main criteria/needs that make sense for any user in the mobility field.

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The roof of the quality house, consisting of a half-matrix, highlights the correlations between the different responses to the What. The objective is to characterize the level of interaction between the characteristics or functions (the How), which can be:

- Positive: the functions help each other,
- Neutral: the functions do not influence each other,
- Negative: functions block or degrade each other.

For example, on a given vehicle battery technology:

- The attributes weight and capacity are positively correlated: as capacity increases, weight increases, and vice versa,
- Conversely, the attributes lightness and capacity are negatively correlated: when one increases, the other is negatively impacted.

We propose in our implementation of QFD to appropriate this roof differently. Since we have potentially retained in both static and dynamic phases alternative attributes on which a trade-off has not yet been made, we propose to use this roof to point out alternative attributes. In the sense of this appropriation, a single index could be used to mark the alternative character, such as "X" or "•".

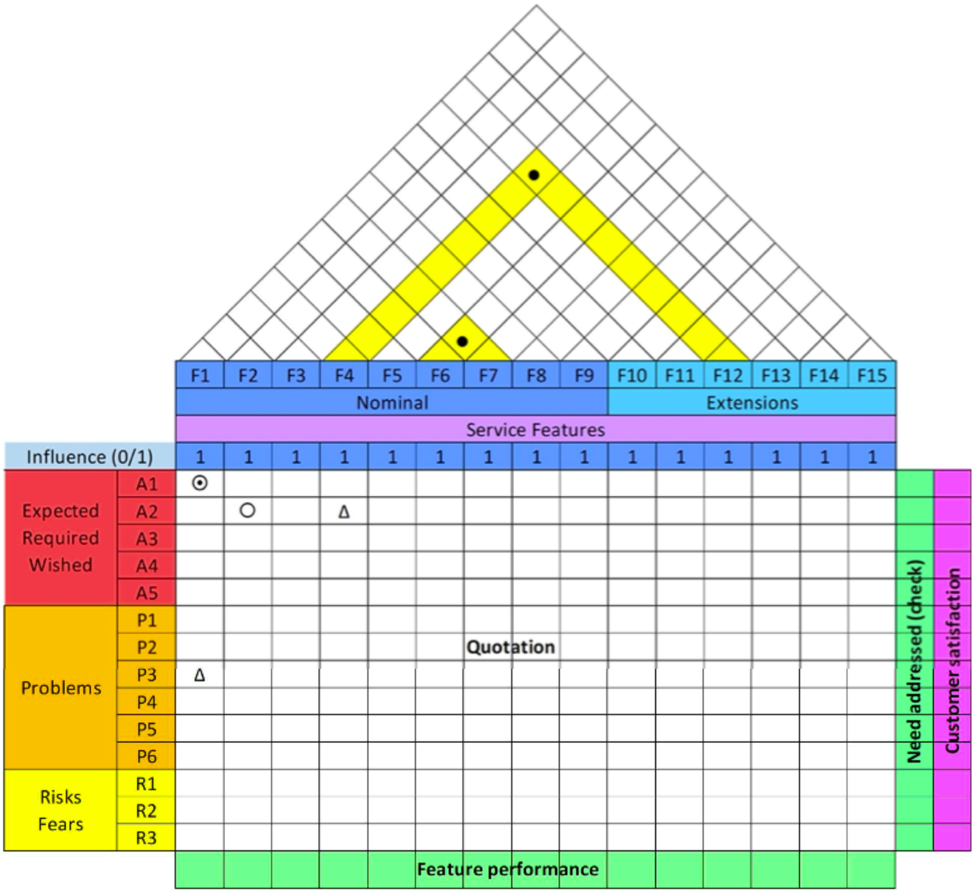

Figure 26: Roof of the needs-attributes synthesis matrix

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Remark:

The purpose of this appropriation of the quality house roof is to keep a visual record of the alternatives among the set of features identified. For simplicity, this roof will not be represented in the graphs on the following pages.

As mentioned before, the product development matrix is only the first step of the QFD approach. Once it is finished, it is translated into a matrix of components and that into a matrix of manufacturing processes.

The QFD method is coherent with the dynamics of traditional value chains as introduced by M. Porter, which assumes a linear value flow and where resources flow in dyadic relationships from raw material providers to manufacturers to suppliers to customers. However, as Basole[9] explains, critics found that Porter's approach did not adequately describe the multidirectional nature and complexities of the potential myriad of business-to-business (B2B), business-to-consumer (B2C), and emerging consumer-to-consumer (C2C) relationships observed in business environments today. Indeed, products and services are now designed, created, delivered, and provided to customers via complex processes, exchanges, and relationships.

A QFD system and way of thinking can make adapting to changing customer needs more costly, difficult, and complex. The process of capturing, documenting, and incorporating customer needs into products is time-consuming, and once production starts, it isn't easy to change. At the same time, customer needs can change quickly and with little warning. Therefore, QFD has the potential to leave a business with products that don't meet these new requirements and that it can't sell[10].

To solve the drawbacks identified, our methodology uses the QFD only partially, as a first step in the value design process, to match the user-perspective with the service features. We believe that value chains have evolved into value networks and, consequently, the second step of the methodology is to undertake an incremental iteration considering other stakeholders in the ecosystem through the value network analysis.

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[9] Basole, R. C., & Rouse, W. B. (2008). Complexity of service value networks: Conceptualization and empirical investigation. *IBM systems journal*, *47*(1), 53-70.

[10] Lohrey, J. (2017) The Disadvantages of Quality Function Deployment. [Online: https://bizfluent.com/info-8705664-disadvantages-quality-function-deployment.html]

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ANNEX V. METHODOLOGY FOR THE VALUE NETWORK ANALYSIS

Definition of the value network concept

The network perspective shifts the focus of a resource-based view of the firm to a perspective in which examination of resource dependency, transaction costs, and actor-network relationships is critical (Basole[9]).

Keviakangas[11] argues that whilst Osterwalder[2] and Porter[12] focused on the value creation process of a single company or organization, clearly individual companies form various configurations that work in a B2B relationship and deliver services and products to the end-user market, sometimes being linked with each other in the value creation process. The author cites Stabell and Fjeldstad[13], who came up with idea of a *value network*.

Biem[14] defines value inter-organizational exchanges in value networks as an attempt to address the increasing intricateness of inter-firm relationships, pushed by a more and more connected economy. According to Biem, the role of the strategist is to find the proper bundling of the assets and capabilities available to all network participants, by creation of transfer links in order to maximize the value proposition at the end consumer node.

Every node within a value network can be analysed based on its contribution to that central value propositions. Thus, a value network analysis involves a firm's understanding of how its offering is positioned in terms of the final customer value, and how other nodes effect that final proposition.

Financial statements are limited to the current and past financial indicators and valuations of capital assets. In contrast, value network analysis is one approach to assessing current and future capability for value creation and to describe and analyse a business model[15].

Some authors go beyond the value network concept to capture a wider stakeholder view or ecosystem that includes also third parties subjected to externalities and regulators trying to control those externalities. According to Leviakangas, what is relevant with the ecosystem view is the holism that especially in the transport context must entail the recognition of externalities, such as accidents and emissions. Without considerations of safety, sustainability, and socio-economic efficiency, it is hard to see meaningful development of the entire system, especially because these externalities are considered in any standard

[11] Leviäkangas, P., & Öörni, R. (2020). From business models to value networks and business ecosystems–What does it mean for the economics and governance of the transport system?. *Utilities Policy*, *64*, 101046.

[12] Porter, M., 1985. The Competitive Advantage.

[13] Stabell, C.B., Fjeldstad, Ø.D., 1998. Configuring value for competitive advantage: on chains, shops, and networks. Strat. Manag. J. 19 (5), 413–437.

[14] Biem, A., & Caswell, N. (2008, January). A value network model for strategic analysis. In *Proceedings of the 41st annual Hawaii international conference on system sciences (HICSS 2008)* (pp. 361-361). IEEE.

[15] Wikipedia. Value network analysis. [Online: https://en.wikipedia.org/wiki/Value_network_analysis]

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transport investment cost-benefit analysis. Therefore, the perspective of the public administrator, as a benevolent actor on behalf of the transport system's end customers, must be included in the ecosystem view.

The following figures are extracted from Leviakangas[11]

Table 1
Ontology of business models, value networks and business ecosystems.

Model	Ontology	Theory base	Focus
Business model	Value proposition, cost factors, revenue factors	Agency theory, shareholder value maximization	Single firm
Value network	Business actors, value creation process, customers	Systems theory, value theory, network theory	Network of firms
Business ecosystem	Business actors, customers, alternative value networks, stakeholders, regulators	Systems theory, stakeholder theory	Network of firms, customers and stakeholders

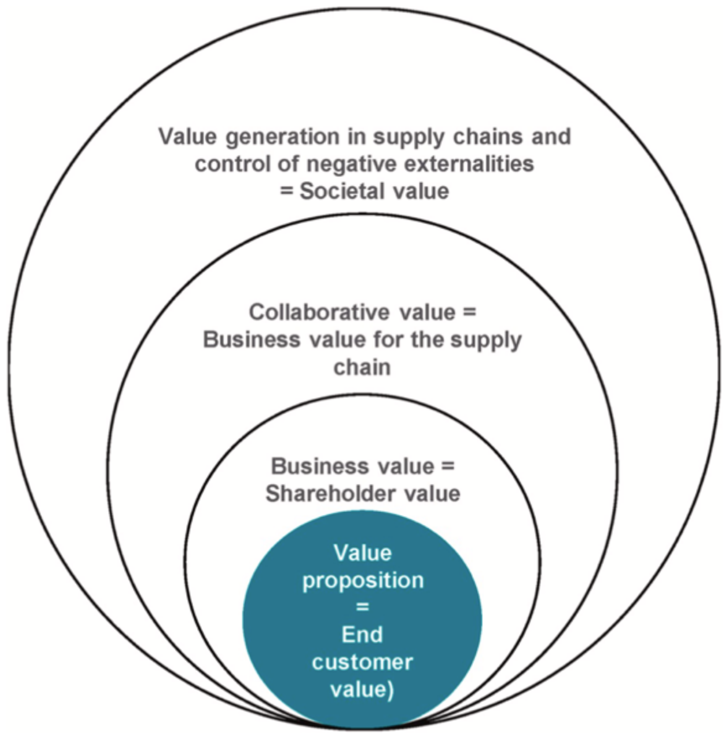

Fig. 4. Meta-model comprising the views of business models, value networks and business ecosystems.

Identification of stakeholders

POTENTIAL STAKEHOLDER

Within the Task 2.2 of Incit-EV project, a list of stakeholders' categories potentially affecting or influencing or interested in the development of charging infrastructures for the deployment of EV were identified.

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Involvement	Stakeholder	Key group
Direct	Local public authority (e.g. mobility planners, policy makers)	Government
	Charging Point Operator (CPO)	Business
	E-Mobility Provider (EMP)	Business
	Fuel station company (petrol stations)	Business
	Motorway company (operator)	Business
	Land and parking space owner (supermarket, parking area, …)	Business
	Power grid operator (DSO)	Business
Indirect	Regional public authority (e.g. mobility planners, policy makers)	Government
	National public authority (e.g. mobility planners, policy makers)	Government
	Energy (electric) utility	Business
	EV manufacturer (cars, vans, motorbikes, bikes, etc.)	Business
	Charging Station manufacturer	Business
	ICT/tech provider	Business
	Public Research Institute	Research
	Private Research Institute	Research
	University	Research
	Start up	Business
	Private drivers associations	Civil society
	Transport and logistic sector association	Business
	Association/Organization promoting electromobility	Civil society
	Environmental organization	Civil society
	Telecom operators	Business
	E-mobility roaming platform operators	Business
	Mobility service information providers	Business

STAKEHOLDER CHARACTERIZATION

The characterization of stakeholders focuses on 3 components:

- Their **power** over the project, in the sense of the impacts, positive or negative, that the stakeholders could have on the project, whether in its design phase or in its operational phase. For example:
  - An institutional stakeholder could be a hindrance to the success of the project in its design phase, if the project outline as defined did not fit with its objectives,
  - Or, local residents could damage or divert facilities that they do not use but which impact them, as in the case of a reduction in parking spaces allocated to ICE vehicles.

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Power plays can be understood as standalone (in the sense of ascendancy over others, via advanced argumentation for example), but also via the influence of other stakeholders, or the formation of internal alliances.

This analysis is understood in a relative way between the stakeholders. It is also delicate because it focuses on the stakeholders and cannot be done without them. It can nevertheless be done with a limited number of stakeholders, provided that it is possible to position the various stakeholders objectively.

- Their **interest** in the use case / business model: A confirmed interest indicates the stakeholder's ability to engage resources in the project.
- Their missions and purpose, which refer to the **objectives** they carry, in a general way and independently of the use case / business model. These objectives concern the expectations and needs, expressed as goals/issues, as perceived/expected by the stakeholder. They can be the reduction of CO2 emissions, the profitability of its investment, a higher penetration of electric vehicles, the reduction of car congestion, a better management and allocation of public space, the smoothing of energy demand peaks on the electrical production network, etc.

STAKEHOLDER INVOLVEMENT IN THE PROJECT

To categorize, manage and cooperate with the stakeholders that are more relevant for each use case, the power/interest matrix will be used.

The strategy of cooperation and exchange with the different stakeholders, as proposed in this chapter, comes from the field of sociodynamics. The approach consists of positioning each stakeholder in a Power-Interest space. In this respect, as in the case of the "Power" dimension, a comparative synthesis between the different stakeholders on the "Interest" dimension must be carried out in order to fill this two-dimensional space.

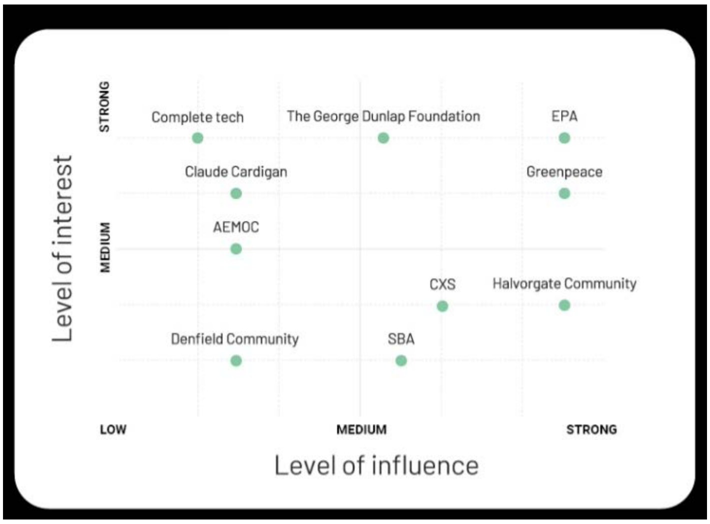

Figure 27: Distribution of stakeholders in the Power-Interest space

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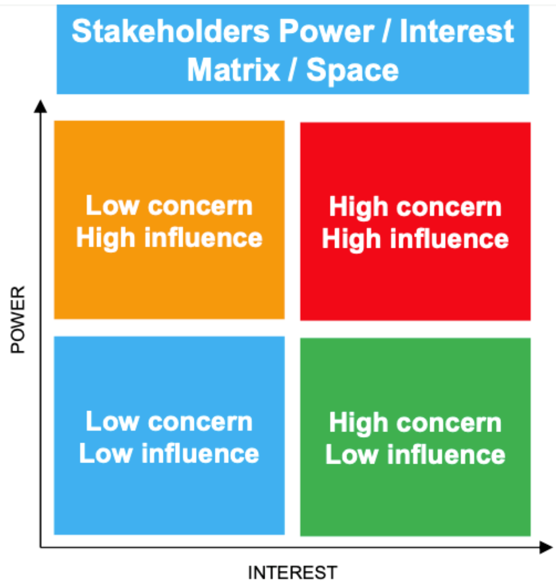
The space is segmented into 4 quadrants characteristic of the weak or strong degree of both power and interest, leading to the allocation of stakeholders to one or other of these quadrants. The membership of a stakeholder in a given quadrant will determine the mode of cooperation with the stakeholder:



SATISFY * Insure the stakeholder is satisfied * Deliver quality information * Increase his interest in the project	INVOLVE with attention * Consult the stakeholder * Propose a partnership * Involve in decisions * Close cooperation
WATCH * Do not go to meet him * Information is available * Take the temperature	INFORM * Delivering information * Polling opinions * Propose an ambassadorial role

Figure 28: ower-Interest Space - Cooperative Strategies

This approach should be repeated as the project progresses for two reasons:

- As part of the project's learning leverage, a stakeholder's views and needs may change, and with them their interest and possible influence on the project,
- As new stakeholders are identified and integrated over the course of the project, they should be represented in the Power-Interest space. Their own objectives should be integrated in addition to the others, with possible implications for the overall prioritization of all objectives, as presented in the next chapter.

OBJECTIVES ENRICHMENT

At this point:

- The objectives for end users have been formalized and prioritized, by making their needs explicit;

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- The objectives of other stakeholders have just been formalized, whether they remain at the level of the project's goals/issues and/or, possibly, if they cannot be entirely carried by the project, their translation into internal project objectives.

We keep the objectives/needs of these two stakeholder groups separate because they are not positioned at the same level:

- The needs of end-users can be considered as primordial, in the sense that, if they are not met, the project will be a failure in its deployment, despite the investments; but also in the sense that projects can also be done, notably in a purely "private" mode, by considering only this category (as well as the company that carries the business, as a return on investment);
- Other stakeholders will be more likely to formulate rational and measurable goals, while those in the first group may also express desires, and implicitly non-rational needs.

The objectives of other stakeholders are aggregated and synthesized. Indeed, this work constitutes a real step because two stakeholders may come from different backgrounds and not share the same language frame of reference:

- They may have a common goal without necessarily expressing it in the same way,
- They could verbalize a goal in the same way, without necessarily associating the same thing with it.

Formal modelling of value networks

THE E3-VALUE METHOD

The e3-value method is a business modelling methodology to elicit, analyse, and evaluate business ideas from an ecosystem perspective. It is used to evaluate economic sustainability of value networks by modelling the exchange of things of economic value between actors[16].

E-value is a language and set of techniques to represent and analyse value networks. A value model is a representation of a value network in e3-value.

A value model does not represent processes but economic exchanges in which two or more parties exchange something of value for them. It does not represent when and how these exchanges take place. It represents:

- who exchanges what value objects with whom;
- which customer needs are answered by this, and
- what revenue and expenses are generated by this for each actor.

A value model represents a value network during a period of time, called the contract period. The exchanges among actors represented in the value model are agreements about what objects of economic value the

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[16] Gordijn, J., & Akkermans, J. M. (2003). Value-based requirements engineering: exploring innovative e-commerce ideas. *Requirements engineering*, *8*(2), 114-134.

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actors will exchange during the contract period. e3-value can be used to understand existing value networks and to design new ones.

What follows are some definitions of terms and concepts employed in the model.

- **Actor**. An actor is an independent economic (and often legal) entity. By carrying out value activities, an actor makes a profit or increases its utility. In a sound, viable, e-business model, each actor should be capable of making a profit.
- **Value object**. Actors exchange value objects, which are services, products, money, or even consumer experiences. A value object is valuable to one or more actors.
- **Value port**. An actor uses a value port to show that it wants to provide or request value objects. The concept of port enables us to abstract away from the internal business processes and focus only on how external actors and other components of the e-business model can be plugged in.
- **Value interface**. Actors have one or more value interfaces, grouping individual value ports. A value interface shows the value object an actor is willing to exchange in return for another value object through its ports. The exchange of value objects is atomic at the level of the value interface.
- **Value exchange**. A value exchange connects two value ports with each other. It represents one or more potential trades of value objects between value ports.
- **Value offering**. A value offering is a set of value exchanges that shows which value objects are exchanged via value exchanges in return for other value objects. A value offering should obey the semantics of the connected value interfaces: Values are exchanged through a value interface on all its ports or on no ports at all.
- **Market segment**. A market segment is a concept that breaks a market (consisting of actors) into segments that share common properties. Accordingly, our concept of market segment shows a set of actors that for one or more of their value interfaces, value objects equally.
- **Composite actor**. For providing a particular service, several actors might decide to work together and to offer objects of value jointly by using one value interface to their environment. We call such a partnership a composite actor.
- **Value activity**. An actor performs a value activity for profit or to increase its utility. The value activity is included in the ontology to discuss and design the assignment of value activities to actors. As such, we are interested in collecting activities that can be assigned as a whole to actors. Consequently, such an activity should be profitable or increase utility.

Riasanow[17] uses the e3-value method to visualize the value network of the automotive industry based on the identified generic roles and the value streams between the generic roles.

[17] Riasanow, T., Galic, G., & Böhm, M. (2017). Digital transformation in the automotive industry: towards a generic value network.

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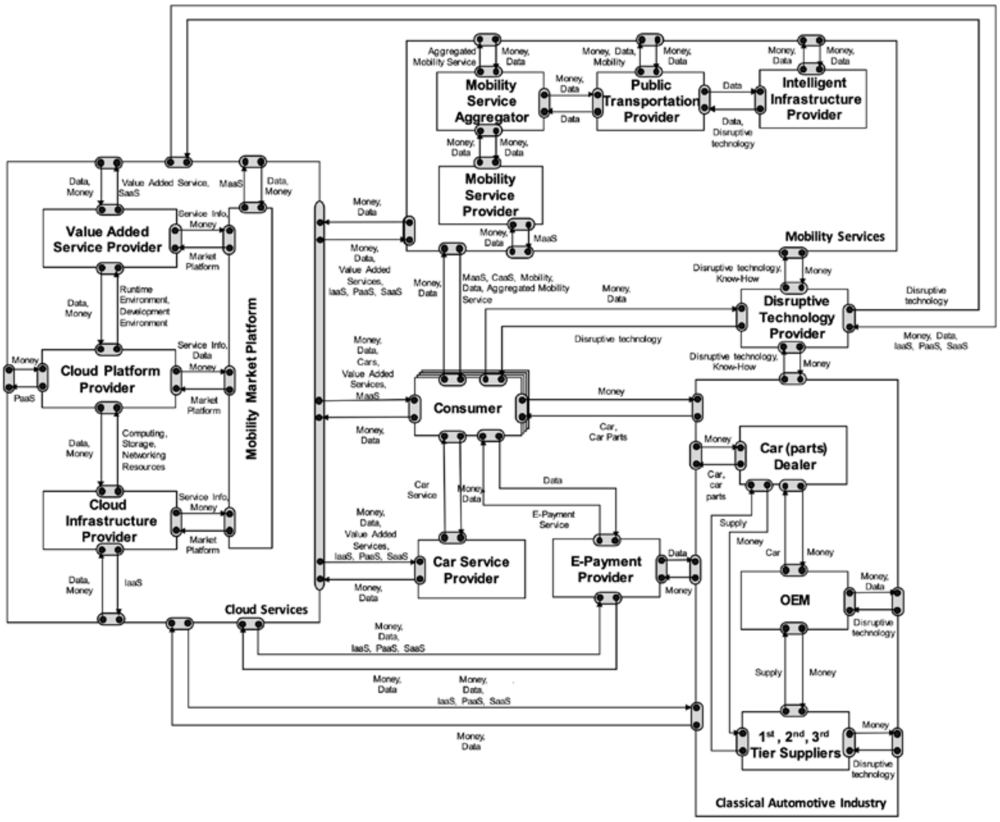

Figure 1. *Proposed Generic Value Network for the Automotive Industry*

BIEMS'S METHOD

Biem's method views the value network as a set of economic entities (EE) connected through transfer of offerings that yields a structural network whose purpose is to deliver a common value proposition to a specified end-consumer or market. It is a structure where value is created, recognized, and captured. The common value proposition is targeted towards a specific economic entity whose role is to appreciate, evaluate, and consume the value proposition.

The focus on the end consumer automatically sets the boundaries of the analysis and a clear path for prescriptive analysis. The focus on economic entities gives a clear granularity in the unit of analysis.

Economic entity. An economic entity is defined in legal terms as an entity whose activities are clearly separated from the activities of its owner. It is an accounting term destined to clearly identify financial responsibilities and accountabilities. Thus, in our model, economic entities may be firms, business units, or individuals.

An economic entity can be viewed through three perspectives: actor, capabilities, and assets.

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- The **actor** represents the legal entity endowed with a will, business intent, and a valuation function that appreciates and values the economic landscape and takes decision accordingly. In this respect, economic entities are not dissimilar to Actors in the e3-value framework.
- The **capability** perspective describes the set of activities, processes, and dynamics that are specific to the economic entity; they are an aggregate result of the ability of the economic entity to deliver and differentiate itself from the competition.

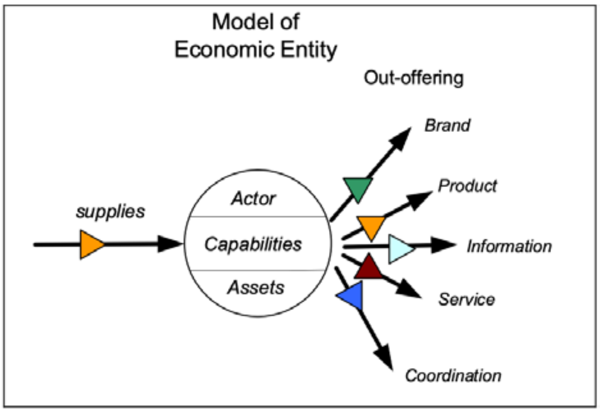

Figure 29. The model of an economic entity for value network analysis

- The **asset** perspective describes the material, technology, capital, and knowledge, possessed by the economic entity. They are the (tangible and intangible) static resources that are tied permanently or semi-permanently to the firm.

Offerings refer to any transferable from one economic entity to another. The transferable could be a manufactured product, a service, knowledge or brand. Offerings are transferred through unidirectional links. Transfer of offerings does not necessarily include a transaction. Offerings are transferred in and out. In-offerings are referred to as supplies and are transformed into specific out-offerings by the actor using capabilities and assets. Out-offerings are of five types: product, services, brand, information, and coordination. A product is any transferable out where the ownership of the transferable is also transferred to the recipient.

Financials are flow of revenue between economic entities. They may or may not be tied to the transfer of offerings.

End consumer. An end consumer is a special node in the network. It is the "sink" whose role is to consume and appreciate the value proposition of the overall network. Similar to the e3-value model, the end consumer represents either aggregated customers or a market segment, meaning that the end-consumer is not necessarily an economic entity. The end consumer is endowed with a valuation function, for evaluating and appreciating the whole network' value proposition.

Value proposition. A value proposition is a clear statement of the benefits that the end consumer gets from using the products or services the network provides. It could represent the aggregated business intent of all nodes in the network (descriptive approach) or the realization of a node's business intent through the network (prescriptive approach). Traditionally, the value proposition is supposed to capture the relationships between the suppliers' offerings and immediate customer's needs. Biem's view of value propositions contrasts with this traditional view in that a value proposition is targeted at end consumers but not at intermediate supply chain partners. This does not mean that the direct customer is neglected. He is simply viewed as a means to the end goal of realizing the value proposition at the final consuming point.

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The model provides a blueprint for the strategist and the practionner in analyzing and configuring the network for potential gain.

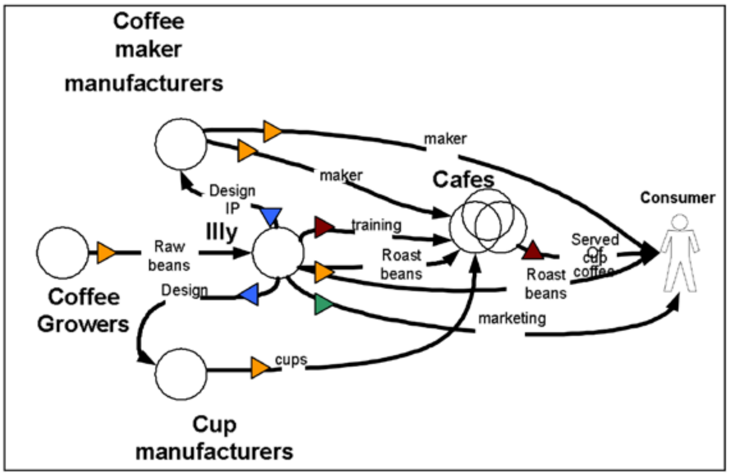

Figure 30. Illycaffè's value network. The company has generated offerings transfer to coffee machine makers, cup manufacturers, and cafés in order to 'provide an excellent cup of coffee' to the end consumer.

ALLEE'S METHOD

In order to fully develop a value network strategy it is necessary to first map out the value exchanges across the network. This mapping method relies on only three simple elements – roles, deliverables, and transactions:

1. **Roles** are played by real people or participants in the network who provide contributions and carry out functions. Participants have the power to initiate action, engage in interactions, add value, and make decisions. They can be individuals; small groups or teams; business units, whole organisations; collectives, such as business webs or industry groups; communities; or even nation states.
2. **Transactions**, or activities, originate with one participant and end with another. The arrow is a directional link that represents movement and denotes the direction of what passes between two roles. Solid lines are formal contract exchanges around product and revenue, while the dashed lines depict the intangible flows of market information and benefits.
3. **Deliverables** are the actual "things" that move from one role to another. A deliverable can be physical (e.g. a document or a table) or it can be non-physical (e.g. a message or request that is only delivered verbally). It can also be a specific type of knowledge, expertise, advice, or information about something, or a favor or benefit that is bestowed upon the recipient.

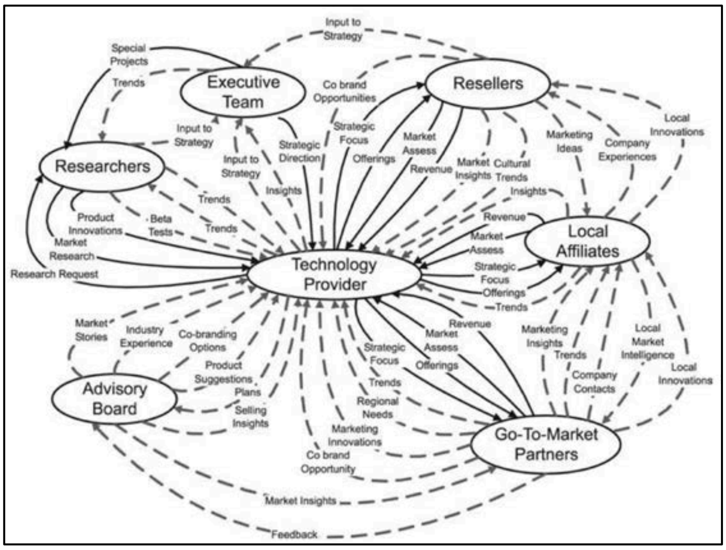

Figure 31. Allee's representation of a value network

In the figure, the nodes depict roles in an activity, and the arrows with labels indicate all the important transactions through which deliverables are conveyed from one role to another. The diagram shows an external facing value network focusing on market innovation for a technology company.

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COMPARISON AND SELECTION OF VALUE NETWORK MODELLING METHOD

Biem’s and Allees’ models use a restricted ontology to represent the most relevant aspects of the network. Both have a dedicated element to represent organizations or individuals, and both have a dedicated element to represent the good or service exchanged. There are two differences between these models. The first one is that Allee’s model defines the flow of value as a “transaction” explicitly, while in Biems’s model it is implicit in the lines linking the entities of the network. The second difference is that the end consumer is represented using the generic “role” in Allee’s model, while Biem’s uses a dedicated element to represent it.

E3-value uses a more exhaustive and complex ontology to represent physical or abstract concepts. The main difference is the use of aggregated actors and value offerings, the possibility of representing activities, and the concepts of port and interface.

Although Biem’s and Allee’s methods could be sufficient for our purpose, the possibility to aggregate actors and flows of valuable items can be convenient to model Incit-EV use cases.

	e3-value	Biem	Allee
Organisations (public / private) or individuals providing or consuming value	Actor	Economic Entity	Role
Aggregation of organisations jointly providing value	Composite actor	-	-
Individual or aggregated recipients of the value propositions	Market segment	End consumer	-
Good or service that is valuable to one of the parties	Value object	Offering	Deliverable
Flows of goods, services or money between parties	Value exchange	-	Transaction
Aggregation of flows of valuable items	Value offering	-	-
Activity performed to create or increase utility or value	Value activity	-	-
Chanel used to deliver an individual / an aggregated good or service	Value port / Value interface		

Table 6. Comparison of value network models

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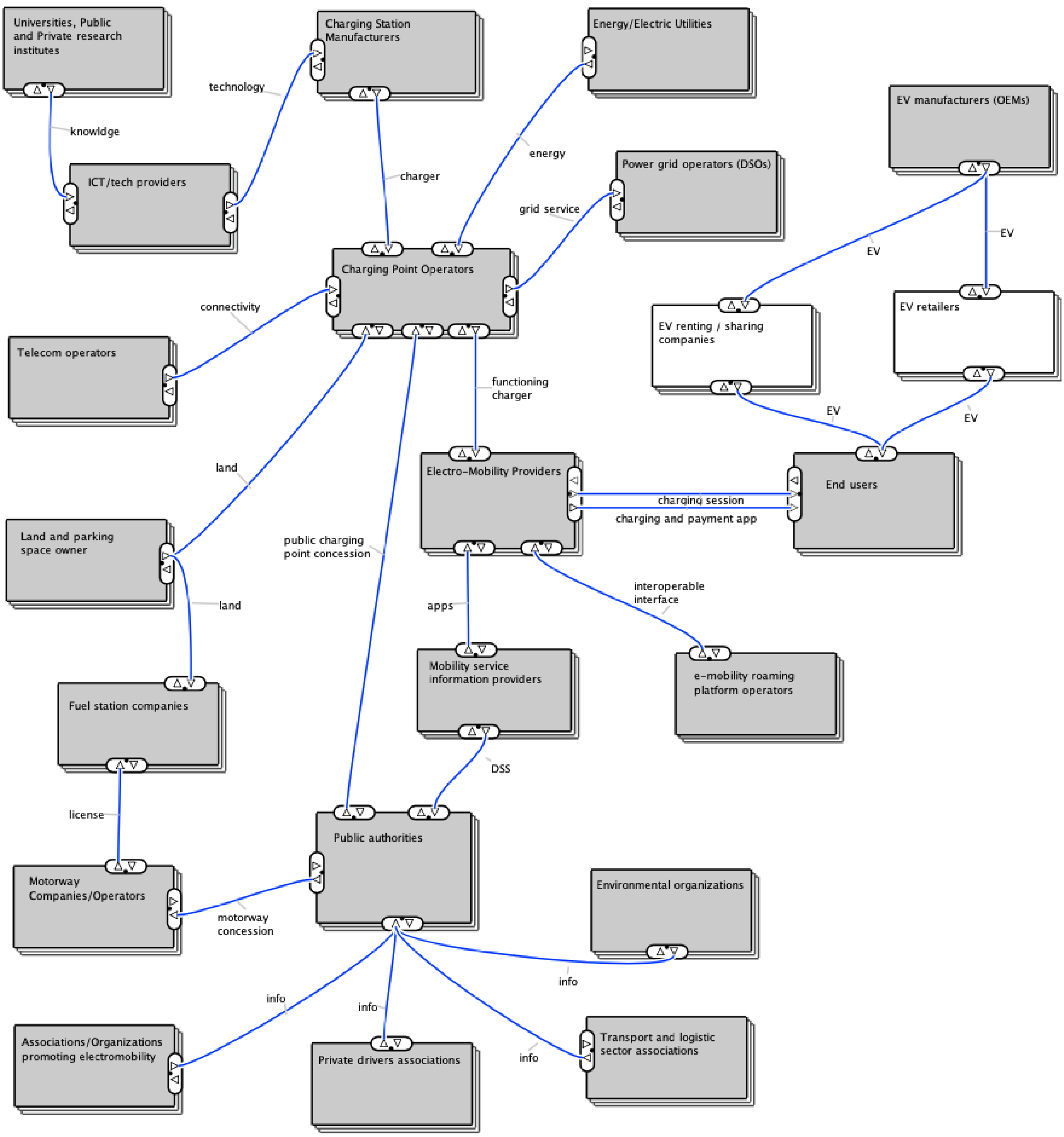
GENERIC VALUE NETWORK FOR INCIT-EV

The following value network has been elaborated using e3value tool[18] and the roles described in D2.2.



18 Jaap Gordijn (2022) [Online: https://research.e3value.com/tools/]

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Value network analysis

THE E3-VALUE METHOD

The e3-value method can be used to perform quantitative analyses under different circumstances. It can be used to identify and fix inefficiencies in existing models, or to identify the strong and weak points of a new business idea.

Software tools to edit and analyse e3value are available from the researchers' website. Currently there are several tools that can be downloaded and a web tool that runs in any browser and will, eventually, integrate the functionality of all tools.

Among the analyses that can be performed, the 2021 user guide includes:

- **Quantification of market scenarios**: to quantify an e3value model, it is necessary to specify how many times value transfers occur in a contract period, and what the value of the transferred value objects for the participating actors is. A contract period is the period of time represented by an e3value model. A market scenario contains the quantifications for one contract period.
- **Net value flow analysis of a market scenario**: a trace is followed through the model from customer needs to boundary elements and compute the value flows into and out of the actors along this trace. for each actor, these numbers are added to give its net value flow. If the net value flow of an actor is positive, the scenario is financially sustainable for this actor. If the net value flow for all actors in a value network is positive, then the scenario is financially sustainable for the entire value network. If we do a value flow analysis for the money transfers only, we get a cash flow analysis.
- **Discounted Net Value Flow Analysis of a Time Series**. New business ideas require investment and usually lead to a negative net cash flow initially. To analyze the financial sustainability of the idea, it is necessary to do a net cash flow analysis of a sequence of market scenarios, which we call a time series. There are several methods to compute return on investment, including calculation of the pay-back period of investments, internal investment rate calculation, real option theory, and Discounted Net Present Cash Flow (DNPC) technique.

BIEMS'S METHOD

The value network models designed with Biem's method can be subject to qualitative and quantitative strategic analyses. The following steps define the value network design and analysis process as described by the author:

(1) Define a strategic value proposition and understand its focus (e.g. quality, cost, or both).
(2) Specify the offerings each partner in the network can provide and evaluate the impact of each offering on the value proposition (for example in terms of quality and cost). This evaluation could be done in a binary fashion in the form of impacting versus not impacting the value proposition. More sophisticated measuring methods, like ranking offerings, could also be taken.

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(3) Select proper partners based on the evaluation of offerings and determine the links that transfer the offerings. The strategy now is to create transfer links for those offerings which have impact on the value proposition. Note that Steps (3)-(4) may be iterated for several times to achieve a balanced picture of offerings. The focal node can add new offerings in the form of services or information and transfer them to selected nodes, based on the dual impact of the focal node' offerings and the targeted nodes' offerings on the value proposition.
(4) Add value and cost to each offering and analyze the VNA model theoretically or by simulation. In general, a qualitative configuration provided through Steps (1)-(4) is sufficient. When data is available, theoretical analyses can be performed using Petri-net, system dynamics, or statistical models. For example, maximize the profit in the supply chain while delivering value to the end consumer as expected. Based on the analysis, new offering may be added or existing offerings may be modified or deleted.
(5) Steps (3)-(5) may be repeated several times until a satisfactory model is achieved.

Whereas traditional value chain analysis usually considers only the horizontal elements across the supply chain, value networks consider vertical elements such as complementors, competitors, influencers and strategic alliances partners.

ALLEE'S METHOD

When using Allee's method, full value network analysis can be performed after the critical roles, value exchanges and transactions have been identified.

According to the author[19], analyzing a value network requires addressing three basic questions. The first question is about assessing the value dynamics, health and vitality, and value conversion capability of the system as a whole. The second and third questions concentrate on each specific role as it relates to value conversion. The basic questions and analyses are:

1. **Exchange analysis** – What is the overall pattern of exchanges and value creation in the system as a whole? How healthy is the network and how well is it converting value?
2. **Impact analysis** – What impact does each value input have on the roles involved in terms of value realization?
3. **Value creation analysis** – What is the best way to create, extend, and leverage value, either through adding value, extending value to other roles, or converting one type of value to another?
   Value creation analysis explores five dimensions of value creation. It not only considers the sources of value and the assets, but also assesses how value is created and what impact it has on other participants.

Analysis within the Allee's framework is mostly visual and consists of detecting patterns of exchanges between participants, especially the ones involving intangibles, with the assumption that value is created

[19] Allee, V. (2008). Value network analysis and value conversion of tangible and intangible assets. *Journal of intellectual capital*.

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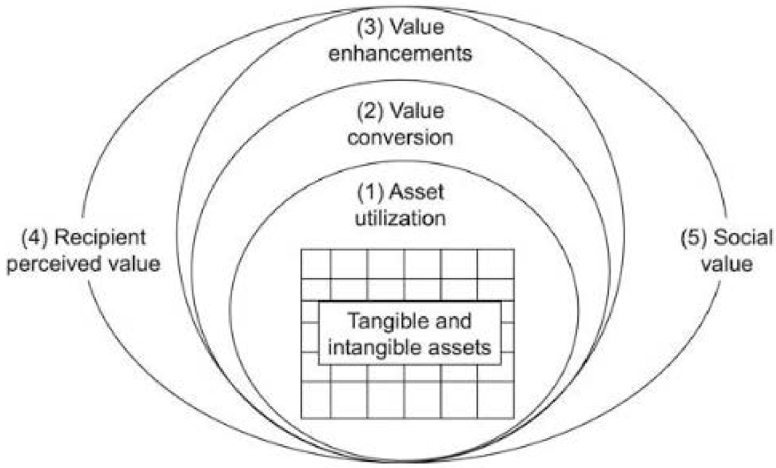
through exchanges (Biem). However, the author also proposes using tables to rate the impact and the value creation in value networks:



Transactions			Impact Analysis							
Deliverable	From	To	What activities generated	Impact on financial resources	Impact on intangible assets			Overall cost/risk	Overall benefit	Perceived value in view of recipient
					Human Compe-tence	Internal Structure	Business Relationships			+2 +1 Neutral -1 -2
Intangible										
Tangible										

Transactions			Perceived Value	Value Creation Analysis		
Deliverables	**From**	**To**	**Recipient highly values this deliverable.** Strongly agree (+2) Agree (+1) Neutral (0) Disagree (-1) Strongly disagree (-2)	**Tangible asset utilization** is: H = high M = medium L = low	**What are the tangible costs?** (financial and physical resources)	**How high is the risk factor in providing this output?** H = high M = medium L=Low
Intangible	<Please select>	<Please select>				
Tangible	<Please select>	<Please select>				

Value Creation Analysis (continued)									
Intangible asset utilization is: H = high M = medium L = low (Human competence Internal structures Business relationships)			**What are other intangible** costs or benefits? (Industry, society, environment)			**How do we** add to, enhance, or extend value?	**What is the overall combined cost / risk** for this input?	**What is the overall benefit** for us in providing this input?
HC	IS	BR	Industry	Society	Env			

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SELECTION OF VALUE NETWORK ANALYSIS METHOD

Although the qualitative and quantitative analysis techniques review could provide interesting insights about the value network balance, and the value exchange at different levels, this report will use the network model to intuitively find patterns and discuss the overall picture.

In subsequent reports such as the cost-benefit analysis and the complete business model design, this methods will be considered again.

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ANNEX VI. METHODOLOGY FOR THE ARCHITECTURE ANALYSIS

Definition of the Reference Architecture Concept

When engineering and integrating electric mobility systems into even more complex systems-of-systems, it is vital to handle interoperability and complexity. Model-based system architectures support the engineering process of information systems with the concepts of abstraction, reduction and separation of concerns.

Reference architecture models have been successfully used in complex domains such as power grids. The Smart Grid Architecture Model (SGAM) was proposed and has soon become the de-facto reference model for the engineering and analysis of intelligent energy management systems with a special focus on power grid systems. This framework can be used to design, engineer, visualize and validate smart grid architectures and to analyze smart grid use cases and systems regarding interoperability and standardization gaps in a structured way.

In the context of Incit-EV project, the technical architecture of the ecosystem is a methodology or blueprint that guides the mapping of the city mobility needs with the most adequate solutions (UCs) represented by a set of activities and resources that deliver value.

Objective of the Reference Architecture in this deliverable

The municipality intending to deploy an EV charging infrastructure will use the Value Network as a blueprint to draw their own lines (value exchanges) and achieve a balanced and thriving ecosystem at business level. E.g. decide if the municipality will install, own and operate public charging points or only tender the concession.

Beyond the business domain, a reference architecture would allow Incit-EV to draw, for each UC, the underlying functionalities that form the value proposition, as well as the physical components and the interfaces that enable the provision of such functionalities.

Therefore, the objective of the selection and application of a reference architecture to Incit-EV project, is to facilitate the coordination of value propositions, functionalities, technologies and interfaces to materialize the concepts into working, profitable and impactful ecosystems.

Review of Reference Architectures

After revising the literature regarding reference architectures in the mobility sector, two alternatives were selected for further evaluation:

- **E-Mobility Systems Architecture** (EMSA) model developed and applied in the Horizon 2020 ELECTRIFIC project.

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- **GreenCharge Reference Architecture** developed and applied also in the homonym Horizon 2020 project.

E-MOBILITY SYSTEMS ARCHITECTURE

The E-Mobility Systems Architecture (EMSA) model is the result of multiple iterations and discussions of system engineering and domain experts, who applied the model and framework during the three-year ELECTRIFIC project for multiple systems.

For the EMSA, the scope includes all types of electric drivetrain vehicles, not limited to battery energy storage, and the model is adapted from the CEN/CENELEC/ETSI reference architecture for smart-grids (SGAM). Therefore, it is defined by three parameters:

- **Layers**. To handle complexity, different concerns are separated in different architecture viewpoints such as business, functional or communications, here implemented as layers. On each layer, the corresponding standards are drawn to ensure interoperability and detect standardization gaps. The five interoperability layers are: business, function, information, communication, and component.
- **Zones**. It has six zones that represent the hierarchical levels of e-mobility management and use the concept of aggregation and functional separation. The zones are: process, field, station, operation, enterprise, and market. Although the zones are kept the same as in SGAM, their definition is adapted to be more appropriate for the context of e-mobility.
- **Domains**. While the SGAM represents the links in the energy supply chain, in the EMSA the whole e-mobility process chain is represented. The proposed domains are classified as immobile (Energy Conversion, Energy Transfer from/to EV) and mobile (Electric Vehicle, EV User Premises).

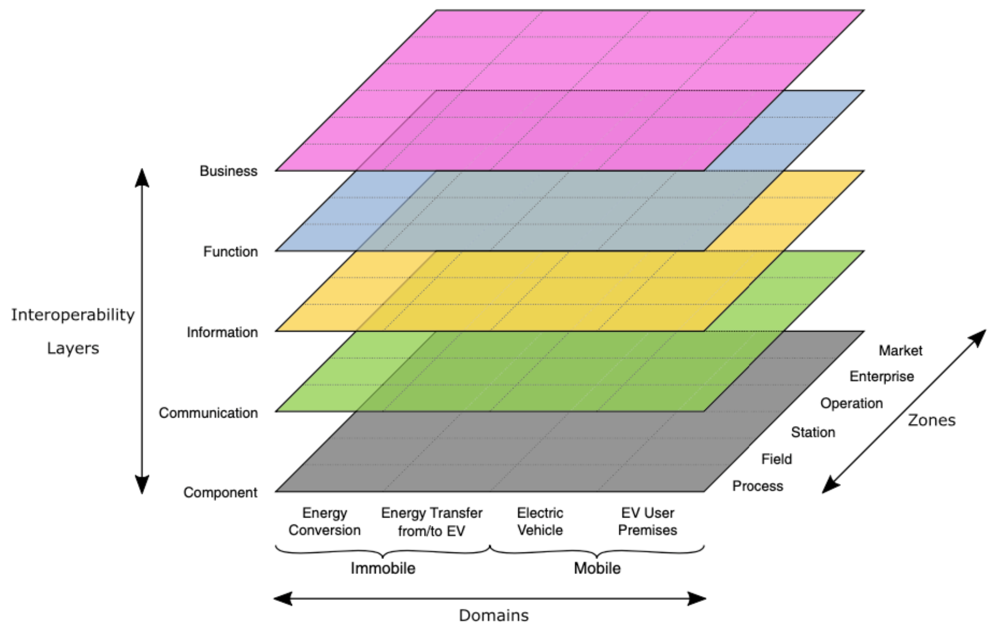

Fig. 3 Visualization of the E-Mobility Systems Architecture (EMSA) model

Figure 32. Visualization of the E-Mobility Systems Architecture (EMSA) model. From Kirpes et. al.[20]

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Next, we reproduce the definitions provided in the article by Kirpes[20] for each element in the domain axis, the zone axis and the interoperability layers.

Definition of domains

- **Energy Conversion** includes energy sources and the energy conversion chain. This contains the electricity system with all levels including generation, transmission grid, distribution grid and local power generation like photo-voltaic systems. It can also represent energy from other sources that is later transformed into electrical energy, like hydrogen fuels that may be generated locally or transported via a piping system.
- **Energy Transfer from/to EV** includes the necessary infrastructure for transferring the energy to the EV and vice versa. As example, CSs, catenary wires for trains or hydrogen fuel stations can be listed. In addition, the CS management system and all kind of entities required for the process of getting energy to/from the EV, like vehicle-to-vehicle, vehicle-to-grid, grid-to-vehicle, vehicle-to-home or home-to-vehicle, are included.
- **Electric Vehicle** includes the entities to perform the electric driving process. This includes e-bikes, e-scooters, e-cars, e-buses and e-railway. In addition, all components and systems, that are part of the moving EV, like the battery, Battery Management System (BMS) or monitoring systems as well as EV (fleet) management systems are part of this domain.
- **EV User Premises** includes interfaces for the end users like mobile devices, personal computers or (RFID) charging cards. This could be an interface for the purpose of managing the EV (e.g. smartphone app for EV preconditioning) or searching/booking/reserving CSs or vehicles, e.g. train and car-sharing. In addition, intelligent route planning, navigation and all kind of e-mobility services for end users are located in this domain

Definition of zones

- **Process** includes the physical or chemical transformation of energy (electricity, hydrogen fuel, etc.), the information flow in all domains, and all directly involved physical equipment. This can be entities of the power grid, CSs, EVs, end user devices or any kind of sensors and actuators which are directly associated with the e-mobility process.
- **Field** includes equipment to protect, control, monitor and support the process of e-mobility such as (1) protection relays at a CS, power grid or in the EV, (2) metering devices and any kind of intelligent electronic devices which acquire, process and use related data like the RFID authentication method.
- **Station** represents the areal aggregation for the field zone, e.g. for data concentration, functional aggregation or local sensor systems. An aggregation level could be a charging spot with multiple CSs or the internal communication and control system of an EV (e.g. in-car Ethernet, FlexRay or CAN bus).

[20] Kirpes, B., Danner, P., Basmadjian, R., Meer, H. D., & Becker, C. (2019). E-mobility systems architecture: a model-based framework for managing complexity and interoperability. *Energy Informatics*, *2*(1), 1-31.

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- **Operation** hosts management entities in the respective domain for the processing of aggregated data, e.g. Local or Grid Energy Management System, EV Management System, CS Management System, Human Machine Interface Devices for input from the user or data provision services.
- **Enterprise** includes commercial and organizational processes, services and infrastructures for enterprises (utilities, service providers, energy traders, etc.), such as asset management, logistics, work force management, staff training, customer relation management, billing and procurement.
- **Market** reflects the market operations possible along the e-mobility chain, e.g. charging service networks, e-mobility provider services, EV sharing, energy trading, as well as (user) data trading platforms.

Definition of interoperability layers

- **Business layer**. In this layer, different economic and legal aspects of the business architecture can be modelled, e.g. business cases, business services, business processes, business models and regulatory constraints. Harmonization and abstraction are the major constituents to handle complexity on this layer. Besides standardized notation languages such as UML, a harmonized business actor role model is essential. The most important business actor roles in the domain of e-mobility, compiled from different standards, are shown and allocated to the EMSA domains (not considering zones) in Fig. 4.
- **Function layer**. Describes the functional architecture and elements of the system. It connects business cases with their physical implementation by an abstraction of interconnected functions. The interactions of the functions indicate required information exchange between them. Depending on the level of abstraction, the functions can be described, grouped and clustered differently. In Fig. 5, the most relevant high-level function groups of e-mobility sector (extracted from CEN-CENELEC (2015)) are allocated to the EMSA function layer. The functional architecture can be detailed, e.g. by utilizing UML activity or sequence diagrams.
- **Component layer**. Is the basis for the upper four layers. In Fig. 6, the component layer of the EMSA Model and the most relevant systems and hardware/software components for battery-electric mobility are shown. To comply with the case study in the validation section, here the focus is limited to battery- electric mobility.
- **Information layer.** Is closely linked to the communication layer. The focus of the information layer is on the three aspects of *data management*, *integration concepts* and the required *information exchange interfaces*. Standardized information flow and data models between services are important for homogeneous connected sub-systems, ultimately leading to interoperability of the whole complex system- of-systems. In Fig. 7, the most relevant standards and protocols for the e-mobility sector, in specific for battery-electric mobility, are categorized.
- **Communication layer.** The main objective of the communication layer is to visualize the communication infrastructure (protocols, technology) and identify gaps in the existing communication standardization, or to show lack of standards implementation in the respective system. Fig. 8.

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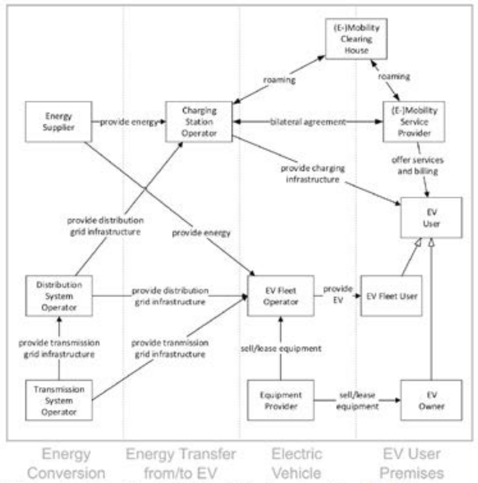

Fig. 4 Harmonized Business Actors in EMSA. Compiled from Open Charge Alliance (2018); Nationaal Kennisplatform Laadinfrastructuur et al. (2019); ISO Central Secretary (2016)

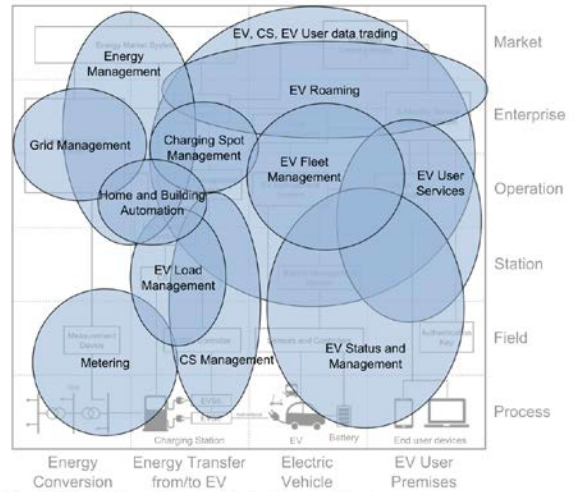

Fig. 5 EMSA function layer with grouped functions from e-mobility sector

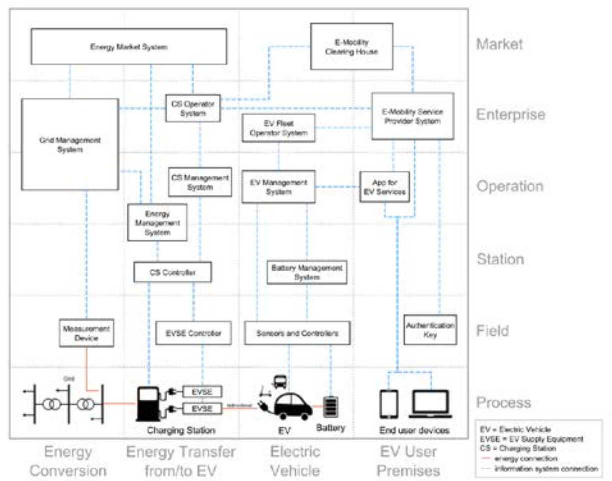

Fig. 6 EMSA component layer with relevant systems for battery e-mobility

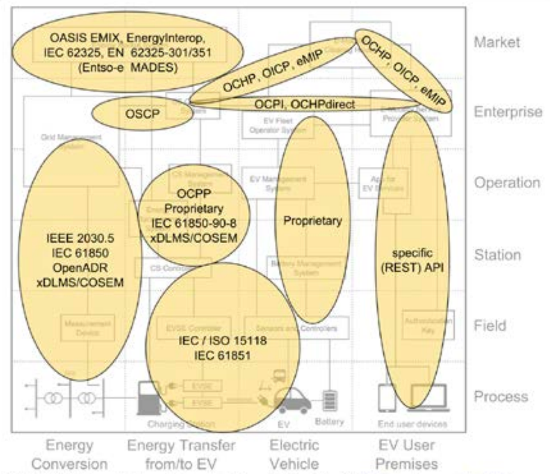

Fig. 7 EMSA information layer with standards. Compiled from ElaadNL (2017); Rodríguez et al. (2015); Schmutzler et al. (2013)

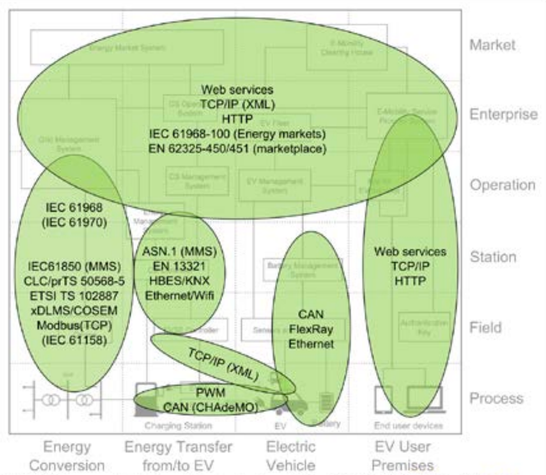

Fig. 8 EMSA communication layer with protocols. Compiled from CEN-CENELEC (2015); ElaadNL (2017); Rodríguez et al. (2015)

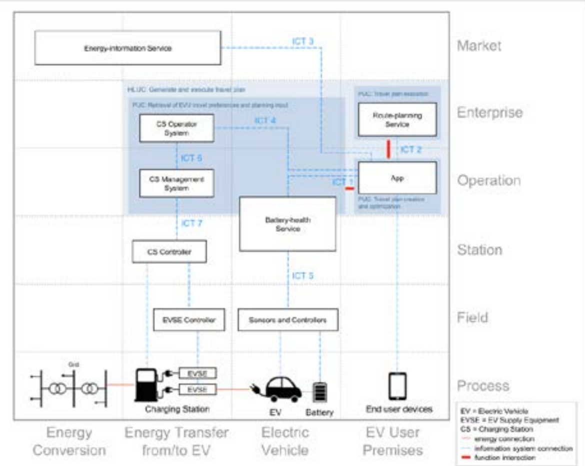

Fig. 12 Mapping of considered High Level UC to the component, information and communication layers of EMSA Model

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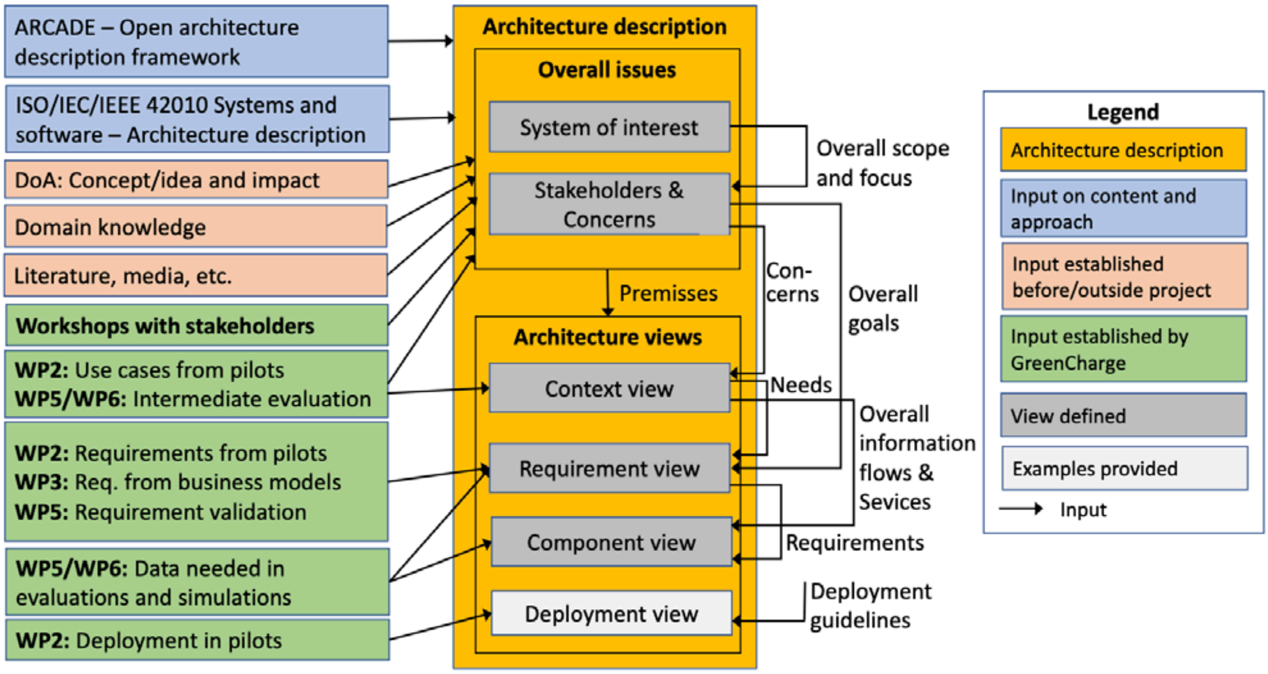
GREENCHARGE ARCHITECTURE

As reported in GreenCharge's "*D4.2: Final Architecture Design and Interoperability Specification*", two frameworks guided the work on the reference architecture description:

- ISO/IEC/IEEE 42010 Systems and software engineering — Architecture description[21]
- The ARCADE architecture description framework[22]. ARCADE is based on the standard 1471-2000-IEEE Recommended Practice for Architectural Description for Software- Intensive Systems[23],



As depicted in the figure above, the architecture views part of the architecture description describes the architecture views. These views are described according to relevant viewpoints that are selected to support:

- The need for a common understanding of the GreenCharge solution. The extensions needed for smart and green charging are emphasized. Some issues in addition to this are however also included to show how the extended solution relates to traditional functionality.
- System integrations. The GreenCharge solution is based on integrations of existing systems, which are extended to support smart and green charging.

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[21] Chaabane, M., Bouassida, I., & Jmaiel, M. (2017, April). System of systems software architecture description using the ISO/IEC/IEEE 42010 standard. In *Proceedings of the Symposium on Applied Computing* (pp. 1793-1798).

[22] Stav, E., Walderhaug, S., & Johansen, U. ARCADE an open architecture description framework (2013).

[23] IEEE Standards Association. (2000). 1471-2000-IEEE Recommended Practice for Architectural Description for Software-Intensive Systems.

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- The reference architecture approach. Detailed requirements to functionality that will be specific to the individual systems and the realisation of physical system components are not addressed since these aspects will vary from system to system.

The viewpoints selected are described below:

- **Context viewpoint:** It aims for a common understanding of and a clear definition of the GreenCharge solution with respect to how it should work at a functional level. The model kinds used are:
    - o *Use case model* expressed by UML 2.0 use case diagrams. The model defines the required functionality, and the content is based on the identified concerns as well as input from the GreenCharge pilots.
    - o *Use case to service mapping model* defined by a combination of UML 2.0 use cases and components. The components are logical components stereotyped as "services" and not physical software components since the reference architecture description does not address the physical components implementing the solution. The model defines which use cases the different services support.

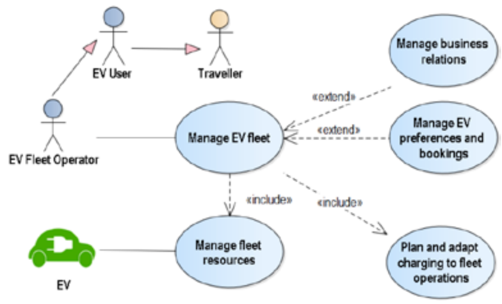

Figure 5-4 Manage EV Fleet use case

    - o *Environment model* expressed by UML 2.0 component diagrams. The model defines the external components which the GreenCharge solution may interact with.
- **Requirement viewpoint:** It aims to specify requirements regarding different aspects of the solution. However, since this is a reference architecture description, the requirements cannot be very detailed. They are overall and principal requirements that must be in place to realise the GreenCharge concept. Requirements addressing detailed functionality, user interface issues, etc. are not addressed. The model kind used is:
    - o *Motivation model* expressed by ArchiMate motivation elements. The model defines the overall requirements derived from the goals identified in the Stakeholder and Concerns part of the architecture description.

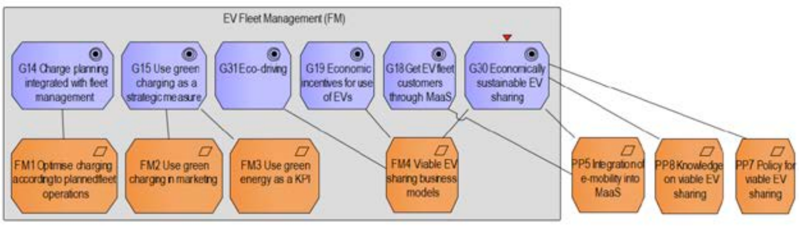

Figure 33

Figure 6-3 Overall requirements for EV Fleet Management (FM)

- **Component viewpoint:** It aims to specify the logical components, i.e., the services identified in the context view, collaborate and interact. This includes the definition of the information exchanged and the definition of when and how the information is exchanged. The model kinds used to describe the component view are:

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- o *System information model* expressed by UML 2.0 class diagrams. The model defines the information classes of relevance and documents the information elements in each class.
- o *System component and interface model* expressed by UML 2.0 component models. The model identifies and defines the interfaces used for communication between the services (logical components).
- o *System collaboration model* expressed by UML 2.0 sequence diagrams. The model defines how the services will interact.

- **Deployment viewpoint:** This viewpoint is not defined by the reference architecture description since the realisation in physical system components is not decided by the reference architecture. The deployment view should however be included in concrete system architectures based on the reference architecture description. Thus, this document has sections for the deployment view and provides
  - o *Advice* on how to establish this view in actual system architectures derived from the reference architecture description.
  - o *Content examples* from the deployment of systems in the GreenCharge demonstrrators.

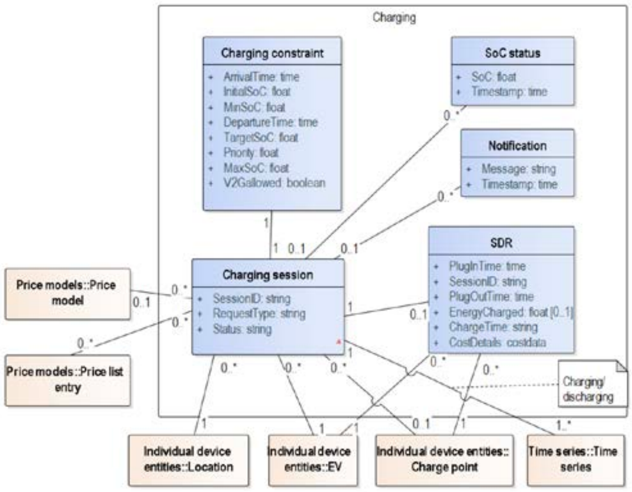

Figure 7-6 Information sub-model: Charging

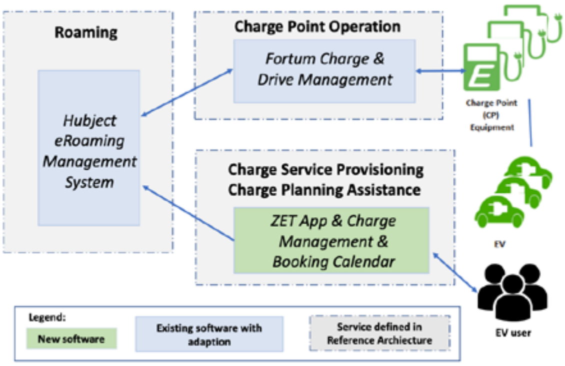

Figure 8-2 System components and interactions for the OSL.D2 prototype

RECOMMENDATION OF A REFERENCE ARCHITECTURE

Incit-EV consortium includes several companies and technology centres working in the electricity sector (DSOs, utilities…) who are familiar with the SGAM reference model. From this perspective, it seems convenient to adopt EMSA model, that would be easily understood and applied.

On the other hand, the project faces the challenge of comparing charging solutions and recommending the most adequate technologies and business models for a fast deployment in many cities. This need also suggests that the SGAM-based EMSA reference model would be an effective tool to represent in a clear and structured way different alternatives. It is also easy to detect standardization gaps with this approach.

For these reasons, the recommended architecture is the one developed in ELECTRIFIC project: EMSA.

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