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Electric Mobility Scenario building blocks

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Abstract:
With the threat of natural energy sources being significantly depleted in the not too distant future and the drive to reduce greenhouse gas emissions, car manufacturers are looking at ways to efficiently propel vehicles by electric energy. If electricity is produced from renewable sources then the total CO_2 emissions for road transportation can be significantly reduced. Fundamental for the deployment of electrical vehicles is the availability of a reliable charging infrastructure.

The integration of the charging infrastructure in the evolving smart electrical grid and in the transport infrastructure is an important issue and requires information exchange between the grid infrastructure, the transport infrastructure, the vehicle information systems and the charging points using a sophisticate communication network infrastructure.

This deliverable describes the initial investigations of the FINSENY project by Work Package 5 that focuses on the specific issue of electric mobility. The deliverable defines a set of five scenarios and functions for electric mobility, investigating the interests of a wide range of stakeholders and the likely evolution of their ICT requirements in the coming years as market conditions evolve.

Keyword list:

FI-PPP, FINSENY, Electric Mobility

Executive Summary

Fundamental for the development of electric mobility is the availability of a reliable charging infrastructure. This includes the integration of the charging infrastructure in the evolving Smart Grid developments in order to provide a reliable and cost-efficient energy supply for the charging services and help the grid to manage the wide deployment of renewable energy resources with their fluctuating generation. Furthermore new services and functions like optimized routing of electrical vehicles based on the battery status, the current traffic situation and the availability of charging services and predicting the energy need for charging in a certain region based on the traffic patterns of the electric vehicles in this area have to be considered.

The core of this document is structured around five main scenarios, which are:

- Short Journey (10 – 30 km)
- Medium Journey (<350 km)
- Long Journey (>350 km)
- Grid Operations
- Value Added Services

Some of the initial input towards this deliverable included location awareness of electric vehicles in real time, their battery indication, location of charging services in the area and the real-time utilisation of the collected data to accurately predict electric vehicle charging requirements and hence to support charging scheduling planning by energy providers. Projections of the impact of electric mobility on the transport system and on the energy gird have been developed for a range of countries. These projections and the early results of discussions were used to define the parameters of the scenarios.

Attempts are made within many of the scenarios to accommodate the different types of charging mechanisms and practices. For example, domestic charging can take approximately 6 – 8 hours as a vehicle can fully charge overnight from a residential electricity supply. However, charging in public requires a network of easily accessible charge points e.g. on-street locations, shopping centres, car parks, etc. Users of public charging facilities will typically only charge their car for 2 – 6 hours. Another option is “fast” charging which can be located at service stations and where an 80% full charge can be achieved in 2-25 minutes.

Concurrently, consideration has been given to the operation of the network and the significance of the interface(s) between grid operators, intermediaries and electric vehicle users. Grid load balancing and optimised scheduling issues illustrate the need for smart, intelligent grid management.

The deliverable concludes with some views on the changes to be expected in relation to the roles of a range of energy domain stakeholders, the challenges that lie ahead for electric mobility and the impact on public communication networks. Finally, the deliverable outlines plans to move this work forward into collecting, analyzing and specifying requirements for a Future Internet Core Platform from an electric mobility perspective.

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List of Abbreviations

This document uses the list of abbreviations defined in the general FINSENY Glossary and Terms [1] and also a number of abbreviations which are not included in the FINSENY Glossary and Terms [1] and are thus defined within this document.

3G	Third Generation (Mobile)
AC	Alternating current
API	Application Programme Interface
BMS	Battery management system
BSOC	Battery State of Charge
BSP	Billing Service Provider
BSSO	Battery Swap Station Operator
CMP	Car Maintenance Provider
CP	Charge Point
CPO	Charge Park Operator
CSP	Communication Service Provider
DASM	Driver Assistance System Manufacturer
DASP	Driver Assistance Service Provider
DC	Direct Charge
DCH	Demand Clearing House
DSO	Distribution System Operator
ECM	Electric Car Manufacturer
EEM	Electronic Energy Marketplace
EFO	Enterprise Fleet Operator
EGO	Electricity Grid Operator
ELP	Equipment Leasing Partner
EMSP	E-Mobility Service Provider
EPS	Electric Power Supplier
ESA	Energy Services Aggregator
ESO	Equipment Sales Organization
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCH	Financial Clearing House
GPS	Global Positioning System
G2V	Grid to Vehicle
IAS	Identification and Authorization Server

ID	Identity
ICT	Information Communication Technologies
IEC	International Electrotechnical Commission
IMO	Intermodal Mobility Operator
IMP	Individual Mobility Provider
ISU	Intermodal Services User
ITSP	Inter-modal Transportation Service Provider
IVU	Individual Vehicle User
LTE	Long Term Evolution
NFC	Near Field Communication
OEM	Original Equipment Manufacturer
PAYG	Pay as you go
PC	Personal Computer
PHEV	Plugin Hybrid Electric Vehicle
QoS	Quailty of Service
RFID	Radio-frequency identification
SMP	Shared Mobility Provider
SVU	Shared Vehicle User
TBM	Traction Battery Manufacturer
TCO	Total Cost of Ownership
TSO	Transmission System Operator
V2G	Vehicle to Grid
VAS	Value Added Service

1. Introduction

Transforming today's electric grid into a Smart Grid is a monumental undertaking that faces significant challenges in a number of areas. Much work is underway to address the technical challenges that will make the Smart Grid possible.

In the future, electricity will be the most important energy carrier. As a consequence, the demand for electricity will surge. But not only that: more and more power will be generated from renewable sources. And this presents a challenge since – due to fluctuations in their supply – renewable sources like wind and solar power place a heavy strain on existing power grids. The key to mastering this challenge is a flexible, state-of-the-art smart grid that can adapt to changes in consumer requirements.

At the same time, the tragic consequences of the events in Fukushima, Japan earlier in 2011 have given rise to a change in public opinion toward power generation around the world. The eight oldest nuclear reactors in Germany were taken off the public electricity grid in May this year. Increased electricity generation from gas fired power stations are the short term solution to Germany's energy generation requirements. France is now following a similar path towards reducing its' reliance on nuclear power and many other countries are considering their options. Renewable sources of energy have come into focus as the replacement options of choice. From wind power to biomass and solar energy, all options are being considered as long term solutions.

All of these developments focus attention on finding solutions to problems of balancing the irregular supply of energy from renewable sources (wind and solar power in particular) with the likely demand for power by consumers and industry. In many countries, the introduction of electric vehicles, required to reduce pollution levels of fine dust to the agreed planned levels in the coming years, in many cities in developed countries, is expected to bring with it a change in demand patterns for electricity. The need for electrical energy to charge electric vehicles is expected to become a major energy demand factor, which will be as fluctuating as the energy generated by renewable energy resources. While the total energy demand for electric vehicles is not seen as critical compared to the overall demand, it can be critical for certain regions in the distribution grid which will see a high demand during certain times and at certain places.

The merging of the traditionally separate infrastructures and sectors of energy and transport will require new innovative enabling technologies, particularly ICT technologies. Integration of systems for the vehicle, the user, and the energy and transport infrastructure has the potential of enabling a large scale optimisation of energy usage and particularly of energy generation, contributing valuable cost savings to energy providers and users and reducing the environmental impact of transport and energy provision.

The large scale introduction of electrical vehicles will have an impact on the energy infrastructure by providing the necessary charging points, but also requires interaction between the energy infrastructure, the transport infrastructure, the vehicle information systems and the communication network infrastructure, in order to collect, process and deliver the needed information. It is clear that electric vehicles – which can store electricity and return it to the grid when needed – will play a major role here.

1.1 FINSENY motivation and background

In order to maintain a stable and reliable power supply in the coming years, the large scale introduction of electric vehicles will need to be accompanied by the introduction of a new ICT infrastructure to balance supply, demand and storage in the Smart Energy grids. In this context, the objective of the FINSENY project is to investigate the requirements which will be placed on the new ICT infrastructures in Europe for Smart Grids, and to plan pan-European pilot trials of possible solutions to the requirements. Parallel studies, organized as parallel work packages, of the ICT requirements resulting from changes in the energy distribution network, in regional and micro-grids, in energy management in smart buildings, in the scale of introduction of electric mobility and in the growing electronic marketplace for energy form the core of the work plan of the two year FINSENY project. Descriptions of future scenarios and use cases will be developed for the above listed areas and ICT requirements will be derived from the scenario descriptions.

The work of defining scenarios is reported in a range of deliverables of FINSENY, all due for publication the end of project month 4, which is July, 2011. This report is one of the deliverables of FINSENY describing scenario building blocks.

The report describes the results of the initial investigations of the FINSENY project by work package 5, which focuses on the specific issue of electric mobility. Work in the project began on 1st April, 2011 and the initial task addressed by WP 5 was to define likely scenarios and use cases associated with the introduction of electric vehicles.

1.2 Methodology of the Task

The aim of the deliverable is to define a typical set of scenarios and functions for electric mobility, investigating the interests of a wide range of stakeholders (as defined in section 2.2) and the likely evolution of their requirements in the coming years as market conditions evolve.

In this document, five scenarios were identified:

1. Short journey
   In this scenario, it is envisaged that a car journey would be quite short (approximately 10km – 30km) and would not require an additional charge during the journey; for example, an electric vehicle being used to travel between work and home or from home to work.

2. Medium journey
   In contrast to the short trip, the critical requirement of the medium trip scenario is that the journey can not be completed on one charge, thus requiring that the user has to stop to refuel.

3. Long journey
   For this scenario, the focus is on a very long journey (e.g. greater than 400km) taking in a number of countries. As such, international issues relating to availability of charge points and payments methods are considered.

4. Grid Operations
   Grid Operations scenarios focus on capacity management issues of the power grid. For example, the handling the local distribution grid will be critical in the shorter term; while in current operations environments, distribution systems are less automated than transmission systems. In the future, ICT will play a significant role in balancing this inequality.

5. Value Added Services
   For these scenarios, it is envisaged that there will be requirement for electric vehicles to be equipped with new interactive features and services. As with all new technologies, the usability of devices and services will improve and, looking toward 2025+, these scenarios assume better devices and interfaces with constant internet access.

Figure 1 shows the process for defining the functions in more detail to allow the scenario development to evolve and continue on into the work of the follow on deliverable of WP5 under Task 5.2, which will capture the ICT requirements.

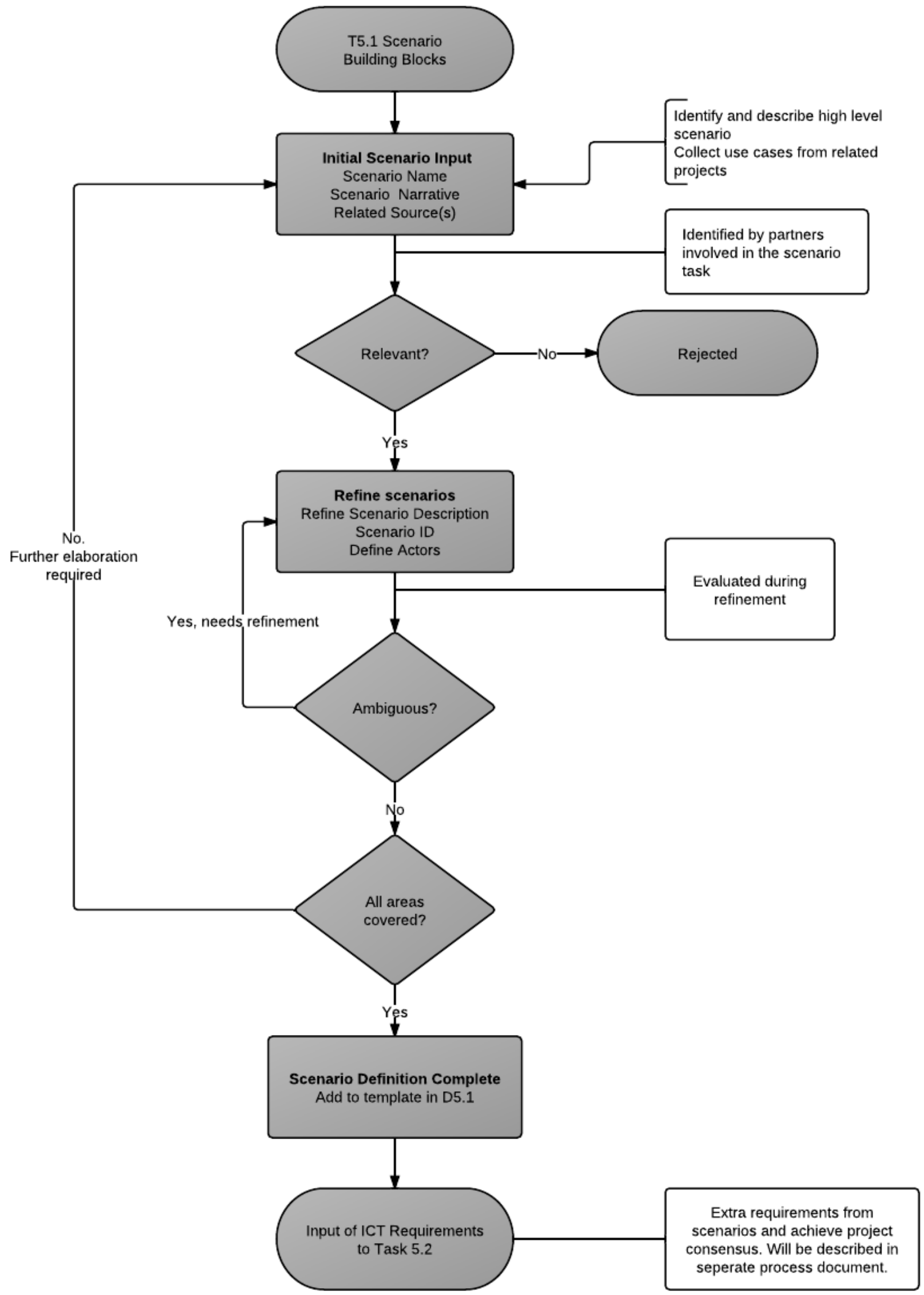


Figure 1 Process flow approach to deliverable D5.1

The initial content to these scenarios came from the partners' expertise and knowledge of existing European and international projects on electric mobility. Research was also carried out into other international E-Mobility projects, standards, programmes and technical bodies which helped to substantiate and enhance the scenarios that were being considered. This research encompassed, but was not limited to:

- EV-MERGE, a major EU-financed project to prepare the European electricity grid for the spread of electric vehicles [2]
- eE-Tour Allgäu project – ICT for electric vehicles [3]
- Future Fleet Future Fleet - Mobility of the Future [4]
- MeRegioMobil ICT for Electric Mobility - An Initiative of the BMWi [5]
- GridSurfer - Taking electric mobility into the countryside [6]
- Harz.EE-mobility - electric cars and a smart grid enable environmentally friendly mobility [7]
- Smart Wheels - Integration of electromobility in the municipal works infrastructure [8]
- LEMNet - Charging stations for electric vehicles [9]
- National Institute of Standards and Technology (NIST) – Priority Action Plan 11 (PAP 11): PEV Use Cases [10]
- "Plugged-In Places" – a UK initiative which aimed to create a network of electric car charging points in a bid to stimulate the market for low carbon vehicles [11]
- British Standards Institution (BSI) ISO 15118-1 Road vehicles - Vehicle to grid communication interface [12]
- SAE International "Use Cases for Communication Between Plug-in Vehicles and the Utility Grid" [13]
- TC (Technical Committee) 69 - electric road vehicles and electric industrial trucks. In particular, "ISO/IEC 15118-1 Ed. 1.0 Road vehicles - Vehicle to grid communication interface" [14]

Each scenario has clear requirements for ICT support and the functions of these scenarios were identified and consolidated as part of the process illustrated in Figure 1 above

The scenario map in **Figure 2** highlights, in the five black boxes, the five scenarios that were described above. Within these scenarios, a number of critical areas were identified from which detailed functions were developed. These are represented by the light grey boxes (with black borders) with direct connections to each of the scenarios that they are strongly associated with:

<u>Payment methods</u>
Short Journey
Medium Journey
Long Journey
Value Added Services

<u>Authentication</u>
Short Journey
Medium Journey
Long Journey

<u>Inter-modal</u>
Long Journey

<u>Charging Point</u>
Short Journey
Medium Journey
Long Journey
Grid Operations
Vehicle Information

<u>Enhanced Services</u>
Short Journey
Medium Journey
Long Journey
Value Added Services

The significance of the role of "Charge Points" in future smart grids is illustrated by variety of connections to the many sub-topics represented by the various blocks that branch off "Charging Points" (white with black border) – these represent functions in terms of their technical capabilities, widespread requirements and ability to deliver enhanced services. Finally, grid connectivity also has additional requirements and is connected to the main Grid Operations scenario via the dotted line.

(Note: please see Appendix I for a table which maps the use case acronym as seen in Figure 4 with the titles of use cases)

The aim of this deliverable is to define a representative set of scenarios and functions that best illustrate the challenges and complexities that face the growth and success of the electric vehicle and to highlight the possible ICT requirements and functional architecture which fall out from this. The scenarios are discussed in much more detail throughout the rest of this document.

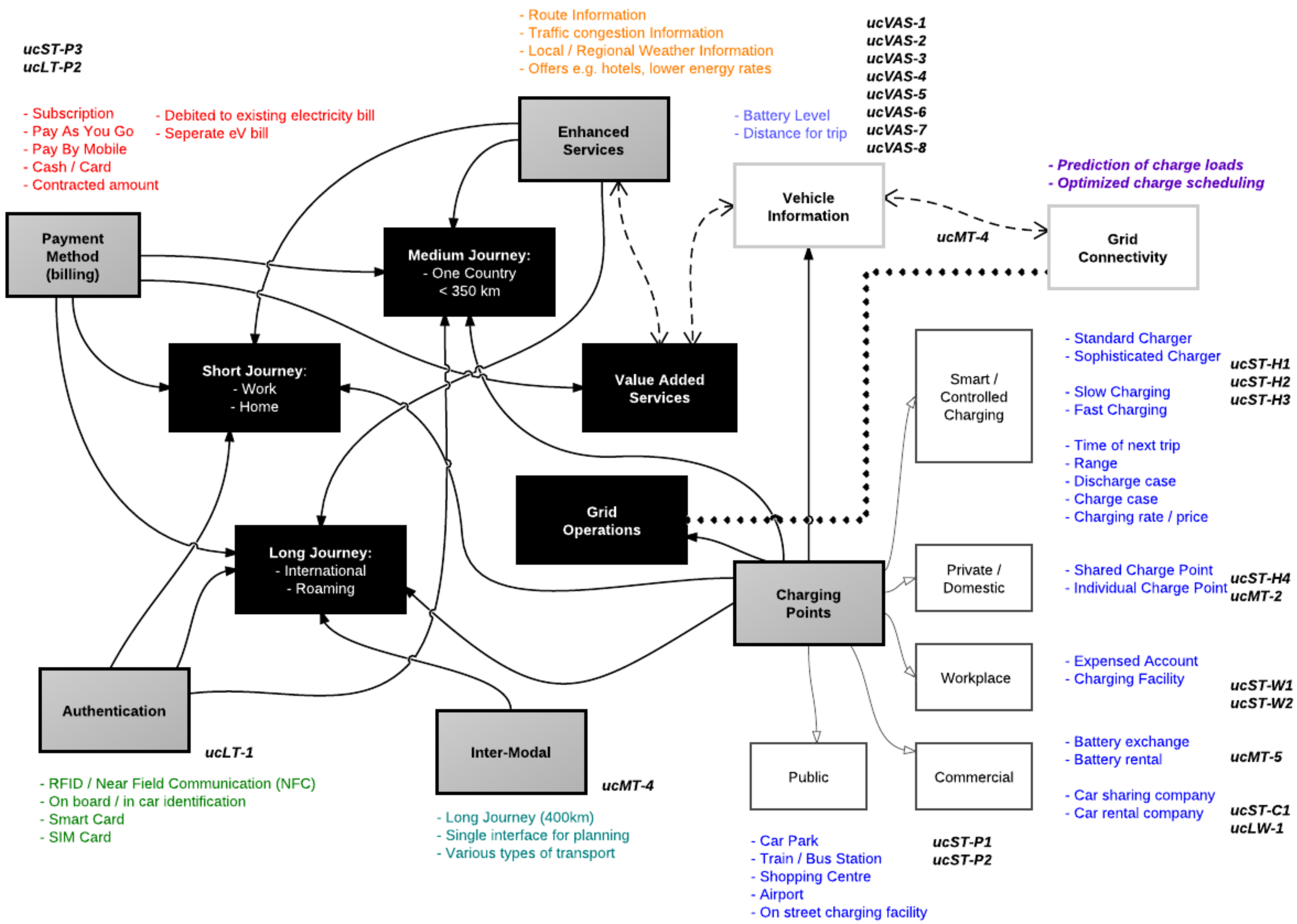


Figure 2 Map of Electric Mobility scenarios and functions

2. Scenarios and functions

In section 1.2, a high level outline of the scenarios and functions is provided – short journey (10-30km), medium journey (one country), long journey (international), grid operations and value added services.

In this section, the following list of scenarios attempts to represent the challenges of future electric mobility:

UC ST [**U**se **C**ases **S**hort **T**rip]
- UC-ST-H (Home)
  - *Scenario A: "Dumb" charging at individual domestic charging points using standard sockets*
  - *Scenario B: Power charging at individual domestic charging points using sophisticated home chargers*
  - *Scenario C: Smart charging at individual domestic charging points using sophisticated home chargers*
  - *Scenario D: Shared domestic charging points*
- UC-ST-P (Public)
  - *Scenario A: Municipal parking place*
  - *Scenario B: Professionally operated car park*
  - *Scenario C: Customer parking place*
- UCST-W (Workplace)
  - *Scenario A: Visitor parking place*
  - *Scenario B: Employee parking place*
  - *Scenario C: Fleet parking places*

UC MT [**U**se **C**ases **M**edium **T**rip]
- UCMT-CPA (Charge Point Accessibility)
  - *Scenario A: Dynamic V2G/G2V Energy Exchange*
  - *Scenario B: Community EVSEs*
  - *Scenario C: Planned charging using operator pre selection*
- UC-MT- AM (Alternative Method)
  - *Scenario A: Battery swap station*
- UC-MT-I M (Inter-Modal)
  - *Scenario A: Ad-hoc inter-modal transportation*

UC LT [**U**se **C**ases **L**ong **T**rip]
- UC-LT-A (Authentication)
  - *Scenario A: Authentication of Users*
- UC-LT-IRCP (International Roaming Charge Points)
  - *Scenario A: Public Charge Points*
- UC-LT-PM (Payment Methods)
  - *Scenario A: Payment Methods: Pay by Mobile*
- UC-LT-EVC (EV User in another Country)
  - *Scenario A: Car rental company allowing for use of commercial fast charging stations*

UC GOps [**U**se **C**ases **G**rid **O**perations]
- UC-GO-CLM (Charge Load Management)
  - *Scenario A: Prediction of charge loads*
  - *Scenario B: Optimized charge scheduling*
- UC-GO-SES (Stationary energy Stores)
  - *Scenario A: Management of Stationary Energy Stores*

UC VAS [**U**se **C**ases **V**alue **A**dded **S**ervice]
- UC-VAS-ES (Enhanced Services)
  - *Scenario A: Electricity Grid Load Balancing*
  - *Scenario B: Multimedia Applications*
  - *Scenario C: General Information Services*

2.1 Methodology

The Intelligrid template, which was developed by the US Electric Power Research Institute (EPRI), was used to capture the building blocks for these scenarios. As such, the following details are provided for each of the scenarios:

- Function Name
- Function ID
- Brief Description
- Narrative
- Actor (Stakeholder) Roles
- Information Exchanged
- Activities / Services
- Contracts / Regulations
- Step-by-step analysis of function
- Use Case interaction
- Diagram

UML diagrams are used to complement the descriptions of the scenarios. In the step-by-step analysis of the functions, message sequence diagrams provide useful illustrations of the messages (and flow of messages) that are communicated between actors, stakeholders and entities.

2.2 Electric Mobility Stakeholders

When looking at the possible stakeholders involved in the electric mobility use cases during the early stages we had identified in the region of 12 stakeholders as shown in the diagram below:-

Figure 3 Initial set of Electric Mobility Stakeholders

In evaluating and expanding the use case descriptions the number of stakeholders has expanded enormously and we have categorized them in the following way:

- Users
- Endpoints
- Hardware and Service Providers
- Intermediates
- Observers

Figure 4 provides a comprehensive diagram of all the stakeholders that were considered and elaborated on in sections 2.2.1 to 2.2.5.

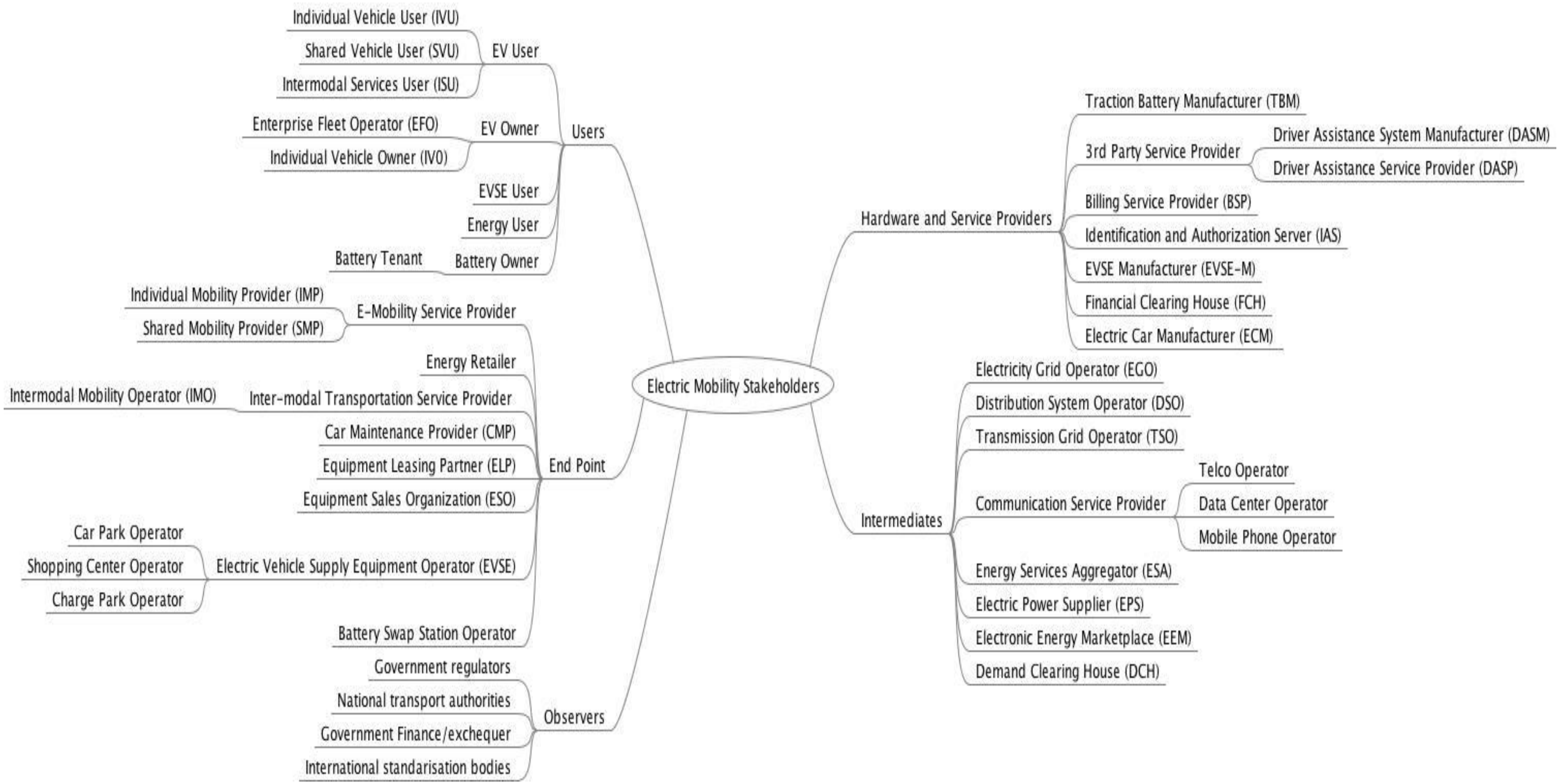


Figure 4 Electric Mobility Stakeholders mind map

2.2.1 Users

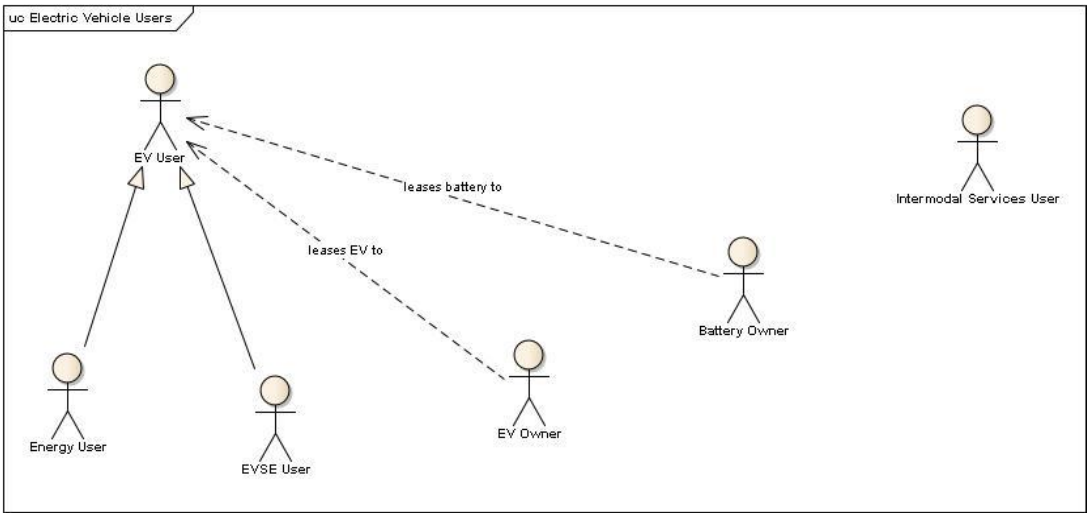


Figure 5 Electric Mobility Users

Grouping (Community) '		*Group Description*
Users		*Person or organization that is a consumer of electric vehicle products and services.*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
EV User	Person	A person that uses the electric vehicle (EV) at a specific point in time (whether in a professional or private capacity). A sub-definition of the EV User would be: Individual EV User (IVU): uses the same vehicle all the time (by either buying or leasing it or getting it for individual use from an IMP) Shared EV User (SVU): uses a given set of vehicles on demand together with other users (e. g. in a car sharing partnership, using a car rental system or a company car pool)
EV Owner	Person or organization	Entity owning the car. This could be a person in which case the car is privately owned or it could also be a car sharing or car rental organization. An example car sharing company would be a Enterprise Fleet Operator (EFO) which runs a company's car fleet.
Battery Owner	Person or organization	Entity that owns one or more batteries.
Intermodal Services User (ISU)	Person	Uses (public or private) services to get from A to B with the ever best means of transport
Electric Vehicle Supply Equipment User (EVSE) User	Person, organisation	The EV User will need to be a Electric Vehicle Supply Equipment User in order for them to use a charge point.
Energy User	Person	A person contracted with a specific Energy Supplier.

Grouping (Community) '		*Group Description*
Users		*Person or organization that is a consumer of electric vehicle products and services.*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
		EVSE Operator could also be an Energy User.

2.2.2 Endpoints

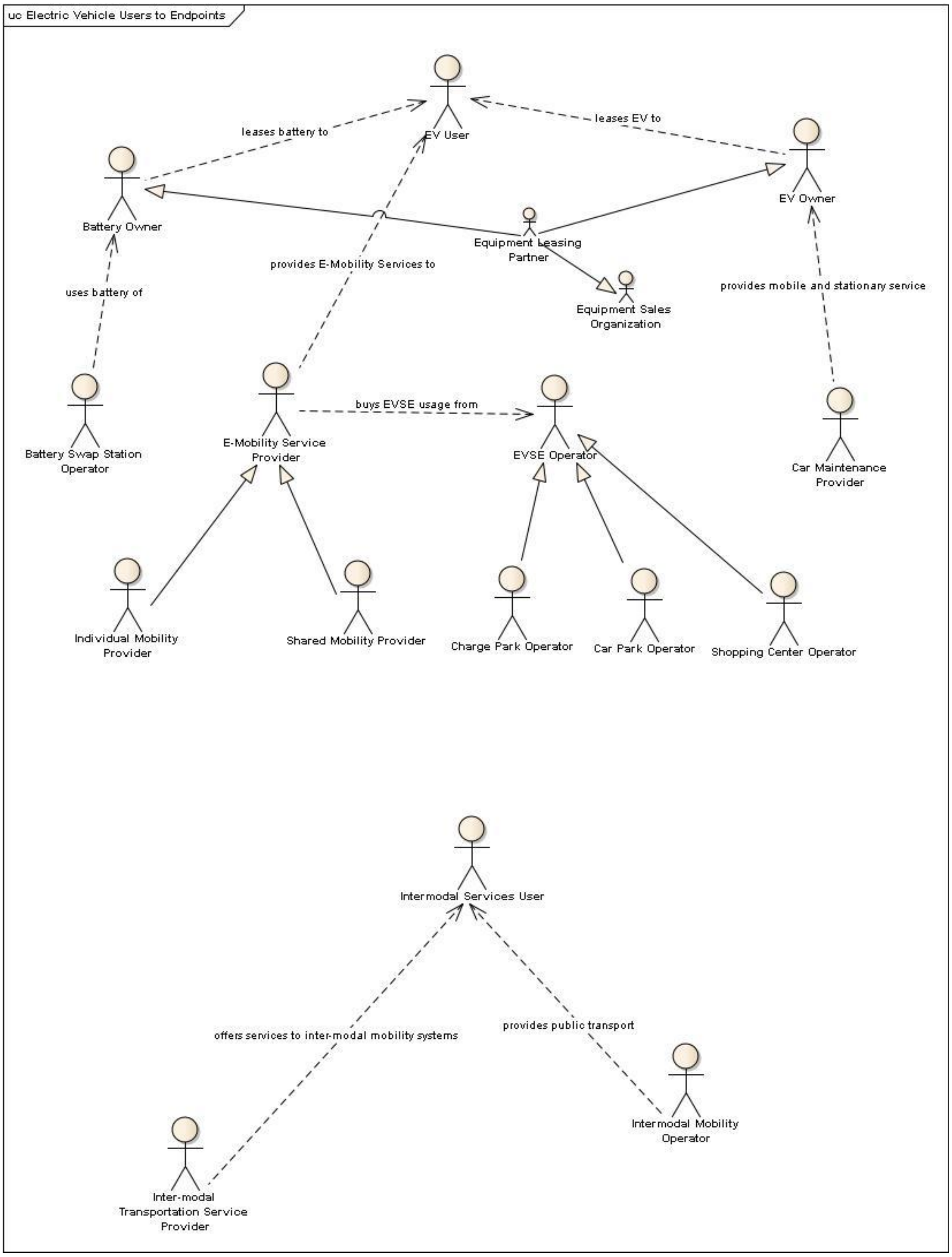


Figure 6 Electric Mobility Users to Endpoints Relationships

Grouping (Community) '		Group Description
Endpoints		*Organisations that have a direct relationship with the users of products and services.*
Actor Name	***Actor Type (person, organization, device, system, or subsystem)***	***Actor Description***
EVSE Operator	Organization	Operates a set of public or semi-public charge stations, uses the services of BSP, CHO, IAS, and FCH. It may have an agreement with the parking space operator.
Charge Park Operator (CPO)	Organization	Operates a locally connected set of charge spots like we know it from gas filling stations (allowing for optimization process in terms of grid connection and user services)
Battery Swap Station Operator	Organization	Company that offers battery swap service to Battery Tenants.
E-Mobility Service Provider	Organization	Provides value added services for individual mobility. Services to its customers include: • Mobility preference administration • EVSE availability • Special offers The difference between this stakeholder and an IMP is the ownership of EVs / batteries.
Individual Mobility Provider (IMP)	Organization	Owns vehicle and / or battery and has a contract with the end user to provide full service on the one hand side and multiple hardware and service providers on the other hand side (“sells the mile to an individual”)
Shared Mobility Provider (SMP)	Organization	Owns a vehicle fleet and provides it to a set of users on a pro rata temporis base, e. g. car sharing or car rental (“provides the right vehicle at the right time”)
Inter-modal Transportation Service Provider	Organization	Company that offers services to inter-modal mobility systems (IOM), e. g. schedule planning and reservation tasks etc.
Intermodal Mobility Operator (IMO)	Organization	provides public transport (local or long distance) partially using EV and PHEV, providing the optimal means of transport at the right time
Car Park Operator	Organization	Operates the Car Park. Might be at the same time the EVSE Operator.
Shopping Centre Operator	Organization	Operates a store or similar, might be responsible for the Car Park and / or the charging stations in front of his shopping centre (the actual operation of the charging stations might be outsourced).
Car Maintenance Provider (CMP)	Organization	Provides mobile and stationary services. AN example of this actor would be a vehicle repair garage.
Equipment Leasing Partner (ELP)	Organization	Investor or financer for intermediates and / or end users.
Equipment Sales Organization (ESO)	Organization	Sells vehicles and / or batteries. An example of this actor would be a car dealer with a forecourt.

2.2.3 Hardware and Service Providers

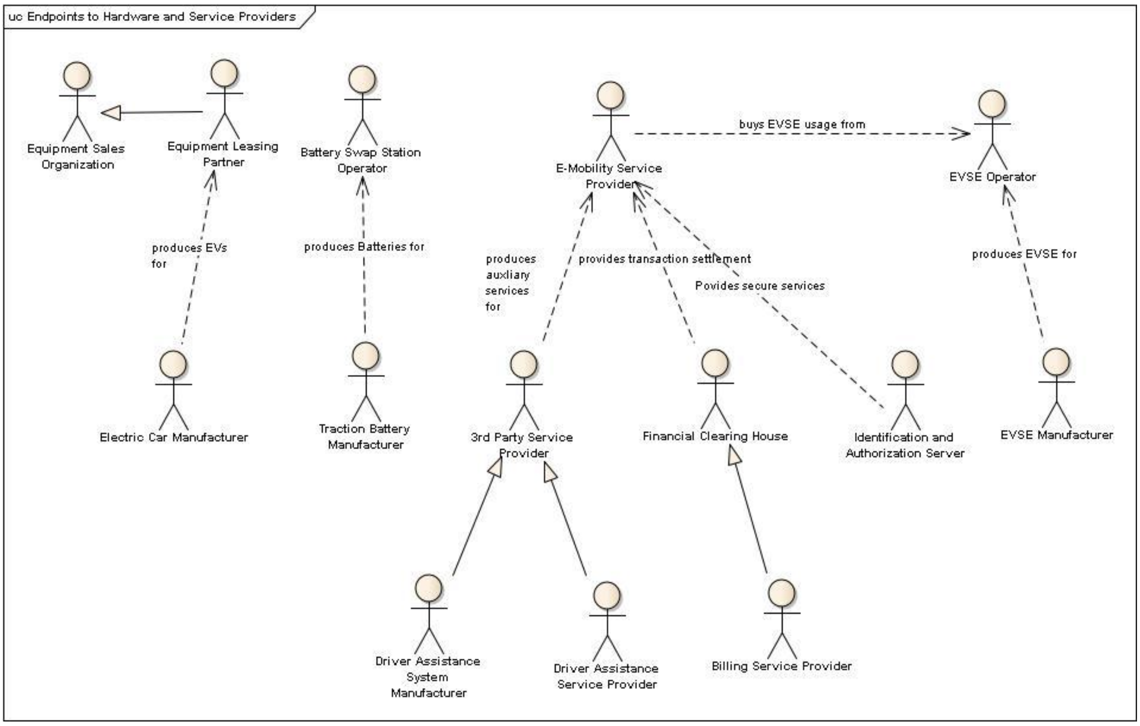


Figure 7 Electric Mobility Endpoints to Hardware and Service Provider Relationships

Grouping (Community) '		*Group Description*
Hardware and Service Providers		*Original manufacturer, developer or provider of EV hardware and services.*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
Electric Car Manufacturer (ECM)	Organization	OEM producing full electric vehicles (EV) or plugin hybrid vehicles (PHEV).
Traction Battery Manufacturer (TBM)	Organization	Producer of batteries for EV and / or PHEV.
3rd Party Service Provider	Organization	3rd Party (Auxiliary) Service Provider maintain additional services (weather, road topology info) that can be used by E-Mobility provider to offer auxiliary services to the EV user. 3rd Party (Application) Service Providers develop, provide and maintain mobility applications for the electric vehicle app store market place.
Driver Assistance System Manufacturer (DASM)	Organization	IT provider for Car-PCS / car-boxes etc. and related IT to connect them to a mobility centre or similar.
Driver Assistance Service Provider (DASP)	Organization	Providers of (IT) services to support EV user such as range estimation, landscape profiles, free charge spot info etc.
Financial Clearing House	Organization	Company that takes over financial clearing. It may also issue billing between involved partners. allows for cooperation of multiple BSPs.
Billing Service	Organization	Supporter for billing of charging events.

Grouping (Community) '		*Group Description*
Hardware and Service Providers		*Original manufacturer, developer or provider of EV hardware and services.*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
Provider (BSP)		
Identification and Authorization Server (IAS)	Organization	Provides various secure services to intermediates such as user authentication, guarantees for privacy etc.
EVSE Manufacturer (EVSE-M)	Organization	Manufacture of home and / or public or semi-public charging equipment.

2.2.4 Intermediates

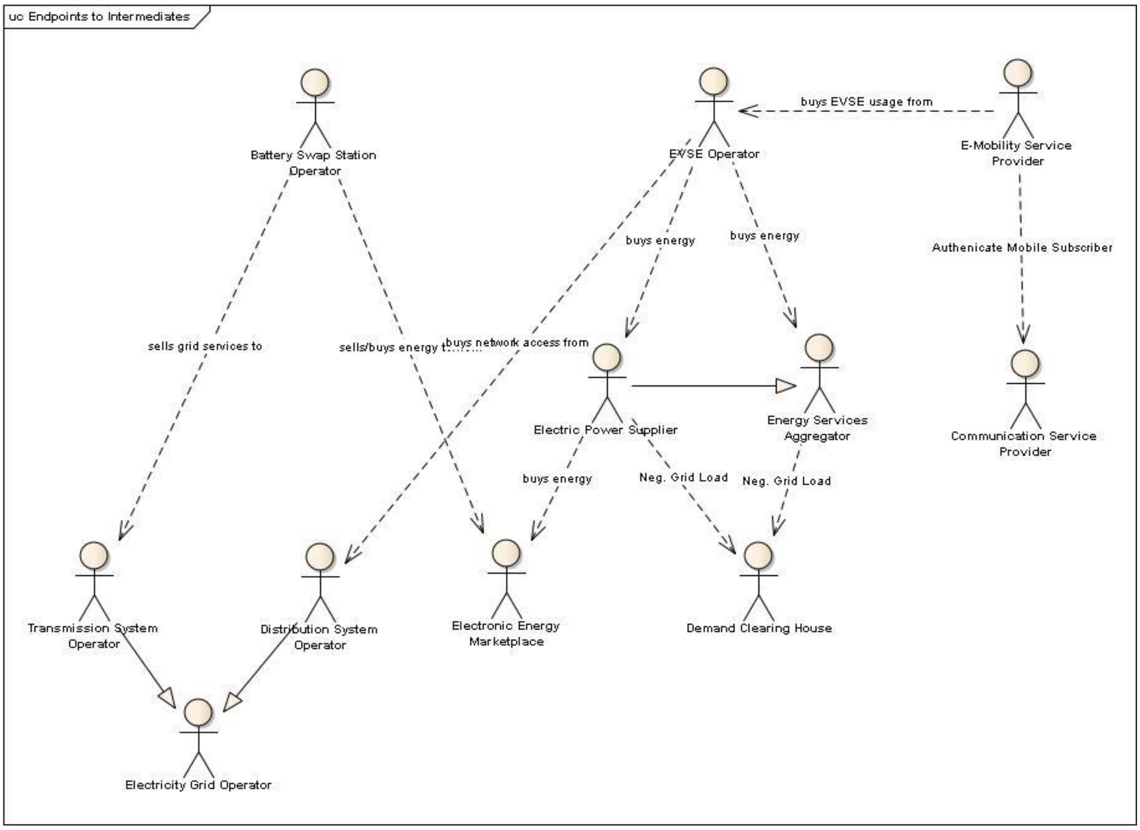


Figure 8 Electric Mobility Enpoints to Intermediates Relationships

Grouping (Community) '		*Group Description*
Intermediates		*Organisations involved in the system operation of core infrastructure to support electric vehicle deployments.*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
Electricity Grid Operator (EGO)	Organization	Operator of electricity grid, can be a DSO or TSO.
Distribution System Operator	Organization	Operates the local power grid infrastructure, and substations, over which energy is supplied to EVSE or

Grouping (Community) '		Group Description
Intermediates		*Organisations involved in the system operation of core infrastructure to support electric vehicle deployments.*
Actor Name	***Actor Type (person, organization, device, system, or subsystem)***	***Actor Description***
(DSO)		the end user.
Transmission System Operator (TSO)	Organization	Operates transmission grid.
Communication Service Provider	Organization	Operates a communication network infrastructure and provides services to communicate e.g. price signals, contracts with the Aggregator.
Electric Power Supplier (EPS)	Organization	Vendor of electricity, synonym to Energy Retailer.
Energy Services Aggregator (ESA)	Organization	Deregulated participant in the energy market which contracts multiple distributed energy generators (e. g. virtual power plants) and / or consumers to optimally manage their energy generation and use as a group, especially by bringing their flexibilities to the market place (in the sense of generation side or demand side management).
Demand Clearing House (DCH)	Organization	Company for grid negotiation that provides information on the load of “the grid” and processes demand clearing. This actor may also have a financial clearing element to it.
Electronic Energy Marketplace (EEM)	Organization	Operator of a market place on which ESAs and potentially IMPs can buy and sell energy and energy related services. Following market rules, energy price is calculated and physical and financial transactions are made. Owing specific issues of Energy, normally, there are day-ahead transactions and then a several intraday transactions in order to maintain stability.

2.2.5 Observers

Grouping (Community) '		Group Description
Observers		*National and international organizations with interests in the deployment of electric vehicles.*
Actor Name	***Actor Type (person, organization, device, system, or subsystem)***	***Actor Description***
Government Regulators	Organization	Observes policies been implemented and has the power to change policies in regard to EV deployments.
National Transportation Authorities	Organization	Observes E-Mobility service offerings.
International Standards Bodies	Organization	Defines standards for EV deployments.

2.3 Use Case Short Trip

The short trip use cases reflect usage of EV for trips within a range of full battery (typically < 150km). The trip destinations are therefore "nearby", e.g. the place of work, shopping places or places of leisure activities (typically workdays evening or the weekend).

2.3.1 Function: Home Charging

2.3.1.1 UC-ST-H Brief Description

Home charging reflects cases in which a (typically privately owned) EV is being charged at home.

2.3.1.2 Diagrams

Scenario	A	B	C	D
Charging Power	< 3,6 kW	< 11 kW	< 11 kW	< 11 kW
DSO ripple control	Possible	Yes	Yes	Yes
Separate Meter for EV charging	No	Possible	Yes	Yes
Separate EV Tariff	No	Possible	Yes	Yes
Intelligent Charging	Only within „smart demand"	Only within „smart demand"	Yes	Possible
V2G possible	No	No	Yes	No

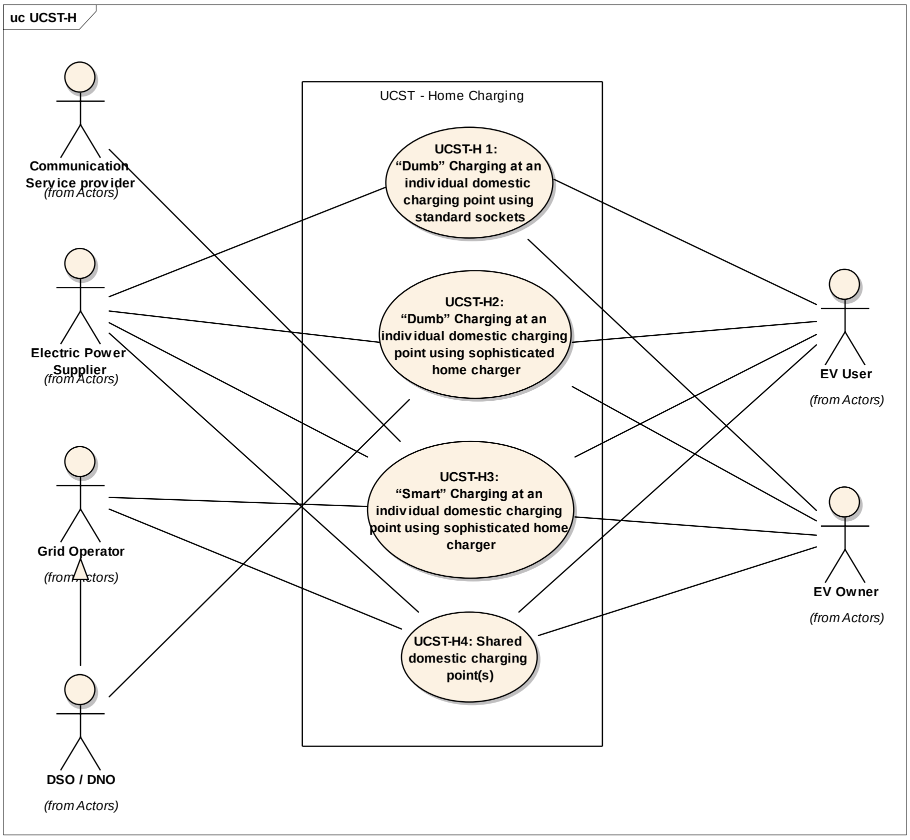


Figure 9 Stakeholder Diagram for UC ST Home

2.3.1.3 Narrative

Preamble

Homer runs his EV for "everyday life" usage. The EV has a battery of 30kWh and with an average consumption of 20 kWh per 100 km, Homer can drive 150 km with a fully charged battery. In the morning, he drives to work (25 km one way). When it rains, he carries his children to school (extra 10 km). When returning from work, he sometimes passes a shopping centre (extra 10km). In the evening, the EV is used for leisure activities of him and/or his wife (max. 30 km round-trip). So all in all, at a "normal" week, Homer never needs to drive more than 100 km, corresponding to 20 kWh. Therefore, Homer normally charges overnight at home. Actually, he simply always plugs in when parking the EV at home. Thereby, he does not need to bother much about range. Although Homer never uses the navigation system for these short trips during the week, the EV is able to precisely show him the lasting range. This is done via an AI-algorithm in the EV based on the day, the time and the actual driving profile. This algorithm is also basis for supporting long trips as described in use case UC-LT-P (section 2.5.3) where more information on intelligent in-car services is given.
Dependent on the type of the standard parking place at home, Homer could opt for one of the following charging infrastructures:

Scenario A: "Dumb" charging at individual domestic charging points using standard sockets

Homer has a standard socket (e.g. CEE 7/7) for conductive charging. The energy transmission is uni-directional from the grid to the EV. On the EV side, a standard AC charger is used (max. 3,6 kW). This allows him to fully charge his vehicle overnight, assuming the EV to be plugged-in at least from 11 p.m. to 7 a.m. (8 h * 3,6 kW = 28 kWh). No particular charging installation for EV exists at the premises of Homer. In this scenario, the EV charging is not separately controlled by the electric power supplier or grid operator. However, control of Homer's EV is possible via smart metering and smart demand concepts as applied for all other devices of his household ("intelligent outlets").

Scenario B: Power charging at individual domestic charging points using sophisticated home chargers

Instead of using the standard socket (cf. Scenario A), Homer disposes of a particular charging station ("home charger") at the parking place of his EV (e.g. in a garage). The charging station and the EV are connected via a particular cable and corresponding plugs (e.g. IEC 62196 Type 2). Through the protected charging (e.g. IEC 61851-1 mode 3), higher charging power is available (e.g. 400 V * 32 A = 12 kW). In order to prevent black outs in residential areas due to high power concurrent charging, the need means to influence the charging process. The home charger device could be part of a particular tariff from the electric power supplier for EVs and energy flows could be metered with a gauged counter.

Scenario C: Smart charging at individual domestic charging points using sophisticated home chargers

As in Scenario B, Homer disposes of a home charger at the parking place of his EV. The charging station and the EV are connected via a particular cable and corresponding plugs (e.g. IEC 62196 Type 2). Through the protected charging (e.g. IEC 61851-1 mode 3), higher charging power is available (e.g. 400 V * 32 A = 12 kW).
The home charger device is part of a particular EV tariff with the electric power supplier. This tariff does provide special charging conditions depending on global grid and generation capacities and rewards grid services. To apply this EV tariff, a separate gauged meter for the charging station is installed that also supports near real-time (<10sec) communication with the electric power supplier. Authentication and authorization methods are applied in the background by the ICT. Section 2.5.1 (UC-LT-1) provides more detailed information on authentication of users.
Electric power supplier's charging conditions are provided via the standard communication of Homer by a Communication Service Provider (e.g. within a Smart Home offer). If communication is interrupted, a defined and secure default behaviour guarantees that the charging station continues to act grid-friendly.
Additionally, the DSO can control the home charger to protect the local grid (in these cases, the conditions of the electric power supplier are ignored). While the DSO can fix the upper limits of charging, the actual charging power is fixed by vehicle intelligence of the EV (e.g. a sophisticated battery management system (BMS). Homer does not worry about tariffs and trusts the ICT components to automatically determine best charging times. The only thing he needs to do is a one-time configuration.

Scenario D: Shared domestic charging points

Homer does not have access to an own personal parking place for its EV, but shares many places with other residents (e.g. a shared garage for a large block of flats). In this scenario each charge point is metered separately in order to allow for different users to pay separately; on top of this there would need to be some way of determining which one of the many residents is using that charge point so that the bill can be generated for the correct person. Authentication and authorization methods are applied, which are described in section 2.5.1 (UC-LT-1).

2.3.1.4 Actor (Stakeholder) Roles

Grouping (Community) '		*Group Description*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
EV User	Person	A person that uses the electric vehicle (EV) at a specific point in time (whether in a professional or private capacity). A sub-definition of the EV User would be: Individual EV User (IVU): uses the same vehicle all the time (by either buying or leasing it or getting it for individual use from an IMP) Shared EV User (SVU): uses a given set of vehicles on demand together with other users (e. g. in a car sharing partnership, using a car rental system or a company car pool)
EV Owner	Person or Organization	Entity owning the car. This could be a person in which case the car is privately owned or it could also be a car sharing or car rental organization. An example car sharing company would be a Enterprise Fleet Operator (EFO) which runs a company's car fleet.
Distribution System Operator (DSO)	Organization	Operates the local power grid infrastructure, and substations, over which energy is supplied to EVSE or the end user.
Communication Service Provider	Organization	Operates a communication network infrastructure and provides services to communicate e.g. price signals, contracts with the Energy Services Aggregator.
Electric power supplier (EPS)	Organization	Vendor of electricity, synonym to Energy Retailer
Home Charger	Device	Particular small charging station at home.
BMS	Device	Battery Management System; controls the charging by evaluating all kind of input information. Standard BMS is limited to technical input values, sophisticated BMS can exploit commercial data as well (e.g. prices).
EV	Device	Electric Vehicle

2.3.1.5 Information exchanged

Information Object Name	*Information Object Description*
BSOC	Battery State of Charge
Range	Lasting distance to drive in km.
EV Temperature	As part of remote air conditioning.
Alarm message	If EV is moved without knowledge of EV user/owner.
Energy prices	When they are variable, they can effect as an incentive to delay charging.
DSO control signal	A mean for the DSO to control EV beyond "commercial" incentives to guarantee grid stability in extreme situations.
Authentication token	In order to proves one's identity.

2.3.1.6 Activities/Services

Activity/Service Name	*Activities/Services Provided*
OEM VAS	Total transparency about the EV user relevant state of the EV (SOC, range, temperature, fraudulence, …)
Charging	Getting energy for the mobility needs.
Authentication	Basic service that testifies a claimed identity.
Authorization	Basic service to testify the permission to use some resources for an authenticated identity.
Configuration	The home charger and other devices need to be configured.

2.3.1.7 Contracts/Regulations

Contract/Regulation	Impact of Contract/Regulation on Function
Energy Supply Contract	Homer contracts with the Energy Supplier
Grid Connection Contract	Homer contracts with the DSO. Only this allows Homer to additionally contract for energy. At the same time, it obligates him to use a home charger that can react on the ripple control of the DSO.
Communication Service Contract	Between Homer and a Communication Service Provider. Sets the framework for the communication available for controlling and optimizing the energy supply. (e.g. bandwidth, QoS, etc.)

2.3.2 Step by Step Analysis of Home Charging Function

2.3.2.1 Steps to implement Home Charging function

Intelligent Charging

2.3.2.1.1 Preconditions and Assumptions

Actor/System/Information/Contract	Preconditions or Assumptions
BMS	Is able to get valid price information via the charging cable or via mobile communications.
EV User	Has a valid contract with the energy supplier allowing for variable prices.
EV User	Has configured its mobility preferences to be applied in the algorithm of the BMS

2.3.2.1.2 Steps – Scenario B: Power charging at individual domestic charging points using sophisticated home chargers

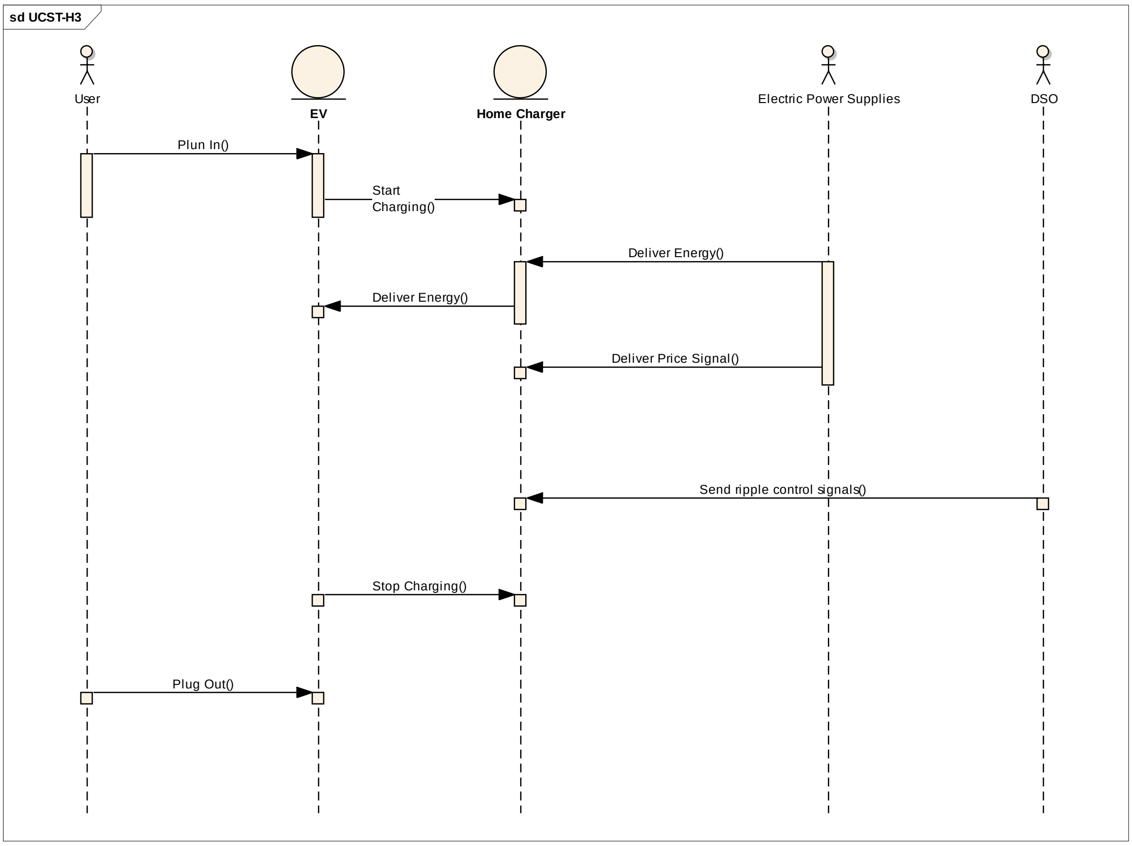


Figure 10 UCST-H Scenario B

2.3.2.1.3 Post-conditions and Significant Results

Actor/Activity	Post-conditions Description and Results
EV User	Has the amount of energy available in its EV at every moment in time and corresponding to his preferences at a minimal price.
Electric Power Supplier	Could optimize its portfolio via postponing charging of EV.

2.3.3 Function: Localised Public Charging

2.3.3.1 UC-ST-P Brief Description

Public charging reflects cases in which an EV is charged at places that are practically accessible to everyone (e.g. private parking places of supermarkets or public parking places of municipalities).

2.3.3.2 Diagram

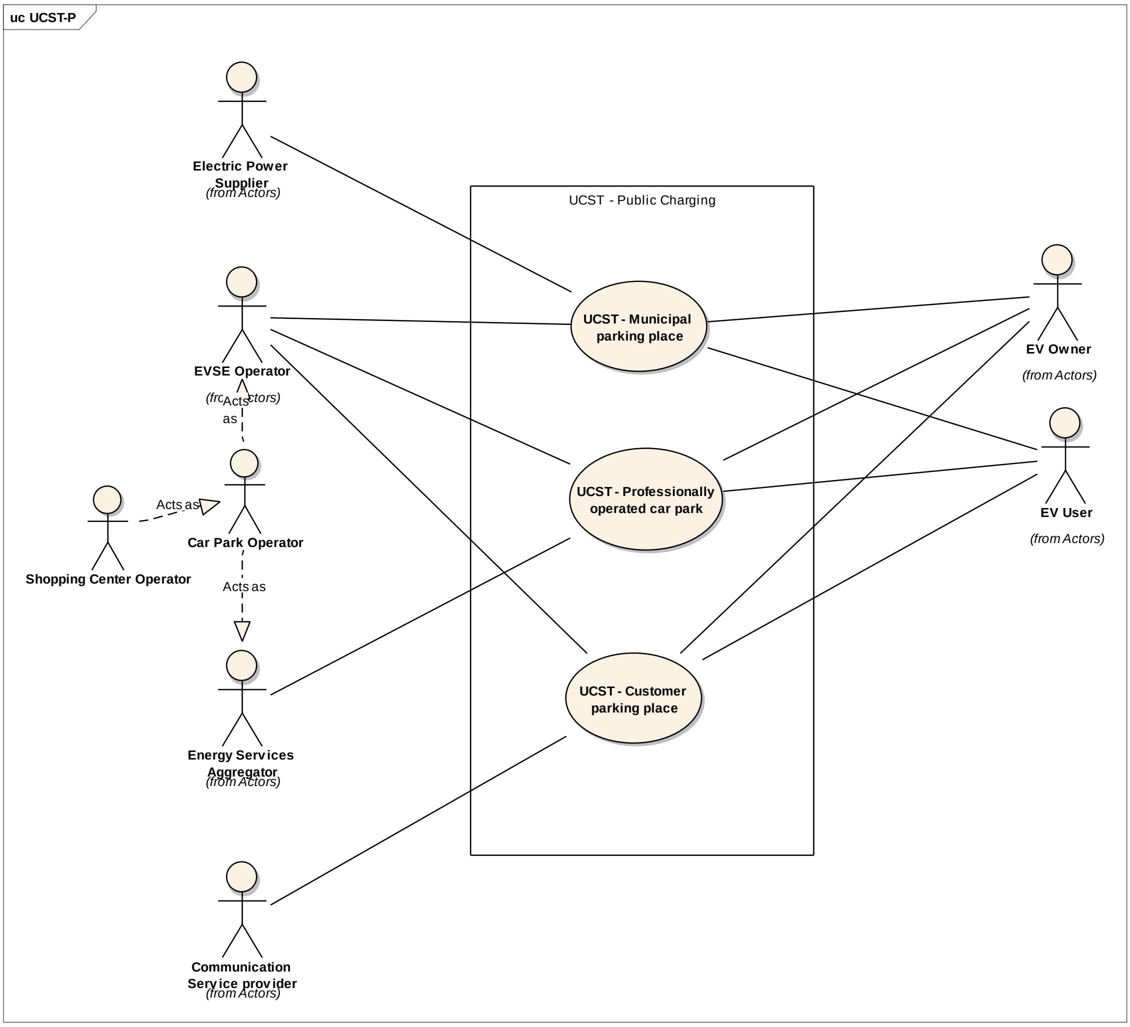


Figure 11 Stakeholder diagram for UC ST Public Charging

2.3.3.3 Narrative

Scenario A: Municipal parking place

Homer and his family leave for vacations by night train (900 km distance). Since the destination area is rather rural, they rented an EV for short trip joint adventures in the area (e.g. visiting castles or hiking in the mountains). The rented EV has a range of only 200 km. Therefore, they are always looking for parking places with charging stations (EVSE) thereby preventing the more expensive fast charging. The installed navigation system suggests them the corresponding charging stations automatically when entering a tourist destination. Homer can reserve these stations together with the corresponding parking place, but has to pay the Charging Station Operator for this service. Similar services are described in UC-LT-P (Public Charging Points) in section 2.5.3, where more information is given on this topic. Homer uses the authentication token (e.g. RFID card or NFC handy) of his standard E-Mobility Service Provider to access these charging stations. Another mean of authentication could be phone authentication (dialing a specific number). Since the charge point allows open access to all licensed Electric Power Suppliers, Homer will also be able to choose the electric power supplier that offers the lowest tariff for energy at the time. A similar point is discussed as well in section 2.3.1 (Scenario C).

Same scenario but different story: Homer's friend Barney does live in an apartment without own parking space. Therefore, he needs to park curb side and uses whenever possible the municipal charging stations.

Scenario B: Professionally operated car park

On some Saturdays a year, Homer and his family go shopping in the city centre. He parks his EV in a large public car park (e.g. multi-storey car parks), in which vehicles are likely to be parked for a couple of hours. This car park might be operated by a public authority or a private company. The access to the park

is controlled by a gate so that only customers (which you become by pulling a ticket) can enter. So, this indoor parking space as well as the charging station can be used by everybody entering the car park.
Since Homer's wife plans to visit a friend in the evening (distance 100 km one-way), they would like to have the vehicle charged during strolling through the streets. Therefore, Homer plugs the EV in a charging station of this car park. For the connection, special e-mobility plugs (e.g. IEC 62196 Type 2) must be used for security reasons. The direction of energy transfer is normally uni-directional from the grid to the EV. However, Homer could opt for participating in bi-directional V2G-Services so that the Car Park Operator can act as Energy Services Aggregator and sell grid services to the DSO or TSO.
As already common for the parking places, Homer can pay the usage of the charging station at a central pay machine via credit card or in cash. However, to prevent queues in the evening in front of these machines and to allow for more comfort, the car park operator offers a communication dongle to be installed in the EV that allows to enter and to exit the car park automatically. Usage of parking space and charging stations is registered automatically via secured communication, so that Homer only gets one monthly bill which includes all usage of these car parks. For being up to date on the charges, he receives an SMS when leaving the car park that contains information on the amount of energy consumed/provided and costs for the charging cycle and parking space.

Scenario C: Customer parking place

When returning from work, Homer passes from time to time one of the big shopping centres in the periphery. Since the mean residence time of people there is more than one hour, the shopping centre operator offers charging stations at most of the parking spaces. Charging is very cheap for customers of the shopping centre. However, the maximum charging power is low (<6 kW) and a certain charging power is not guaranteed. The latter means that whenever many EV tries to charge simultaneously, the charging power is reduced for all of them so that the shopping centre operator does not exceed power levels agreed on with the DSO. No authentication is necessary; however, in combination with bonus cards, Homer gets the best charging prices.

2.3.3.4 Actor (Stakeholder) Roles

Grouping (Community) '		***Group Description***
Actor Name	***Actor Type (person, organization, device, system, or subsystem)***	***Actor Description***
EV User	Person	Uses the EV for private mobility needs such as commuting, carrying children, go shopping, … (here: Homer)
EV Owner	Person	Owns the EV in order to use it. Must consider TCO for the EV. Risks could (partly) be covered by insurance companies (here: Homer)
Charging Station (EVSE) Operator	Organization	Operates the charging station (EVSE) and has an agreement with the parking space operator (if not identical with him)
Electric Power Supplier	Organization	Could change depending on the contracts of the Charging Station Operator.
Transmission System Operator (TSO)	Organization	Operates transmission grid.
Energy Services Aggregator	Organization	Aggregates several EV
Car Park Operator	Organization	Operates the Car Park. Might be at the same time the Charging Station Operator.
Shopping Center Operator	Organization	Is responsible for the charging stations in front of his shopping center (the actual operation of the charging stations might be outsourced).
Communication Dongle	Device	Is used to automatically register the parking and charging behavior of registered customers.
Central pay machine	Device	Is used to pay for parking space usage and charging.
EVSE	Device	Electric Vehicle Supply Equipment; synonym to a

Grouping (Community) '		*Group Description*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
		charging station, sometimes also use for one particular charge point).
Communication Service Provider	Organization	Operates a communication network infrastructure and provides services to communicate e.g. price signals, contracts with the Aggregator.

2.3.3.5 Information exchanged

Information Object Name	Information Object Description
Parking Space	Signals whether a parking space is free or not.
Reservation	Request the reservation of parking space. Reserved could be one particular (with ID) or only the guarantee to get one out of several.
Authentication Token (IDs)	For authentication in front of municipal charging stations or at the car park entry via the communication dongle or via bonus cards of the shopping centre. E.g. via an internationally standardized Contract ID or EVSE ID.
V2G-Service information	All information that allows Homer to evaluate whether he was correctly paid for his V2G-Services (and the accompanying battery degradation).
Reservation Request	Request the reservation of parking space. One particular parking space (with ID) could be reserved or only the guarantee to get one out of several parking spaces.

2.3.3.6 Activities/Services

Activity/Service Name	*Activities/Services Provided*
OEM VAS	Total transparency about the EV user relevant state of the EV (SOC, range, temperature, fraudulence, …)
Charging	Getting energy for the mobility needs.
Authentication	Basic service that testifies a claimed identity.
Authorization	Basic service to testify the permission to use some resources for an authenticated identity.
Configuration	The EV needs to be configured when and how far Homer wants it to take part in V2G actions.
Reservation	The EV needs to be configured when and how far Homer wants it to take part in V2G actions.

2.3.3.7 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
E-Mobility Contract	Regulates the services accessible in front of EVSE with an EV User. It is identified via an international standardized “contract ID”.
Temporary EVSE contract	For the time using an EVSE, there is always “temporary” contract concluded with the EVSE operator.
Bonus program agreements.	Homer can join bonus programs of e.g. shopping centers, that include charging tariffs on their parking spaces.

2.3.4 Step by Step Analysis of Localised Public Charging Function

2.3.4.1 Steps to implement public charging function

Parking Space and EVSE Reservation

2.3.4.1.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
EVSE / Parking Space	Sensors allow recognizing which parking lot is free or occupied.
EV User	Disposes of an ICT element (e.g. a smart phone or a navigation system) that allows to find and reserve EVSE.

2.3.4.1.2 Steps – Scenario B: Professionally operated car park

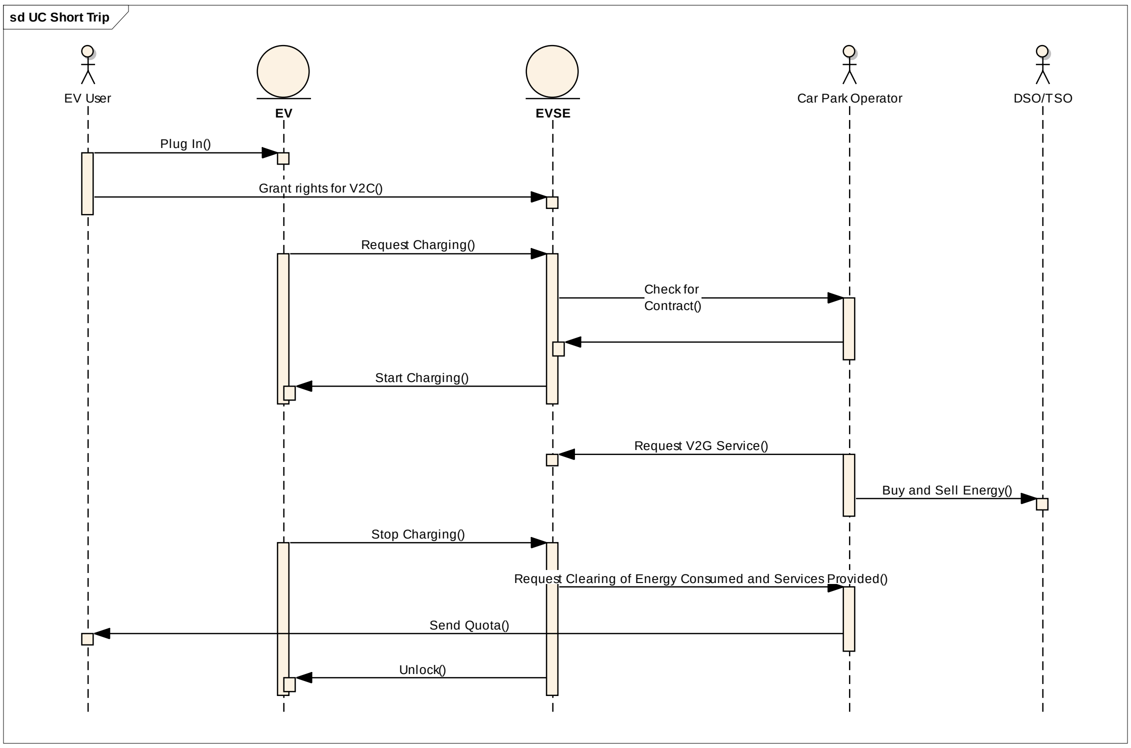


Figure 12 UCST-P Scenario B

2.3.4.1.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
EV User	The EV user parks his EV on the reserved parking lot and uses the EVSE.
EVSE Operator / Parking Space Operator	The Operator sees in his real-time system that the parking space is occupied now.

2.3.5 Function: Workplace Charging

2.3.5.1 UC-ST-W Brief Description

Workplace charging reflects cases in which EVs are charged on parking places of companies (fleet EVs or employee EVs) or where the companies at least have the exclusive right to use it (car sharing, taxi, etc).

2.3.5.2 Diagram

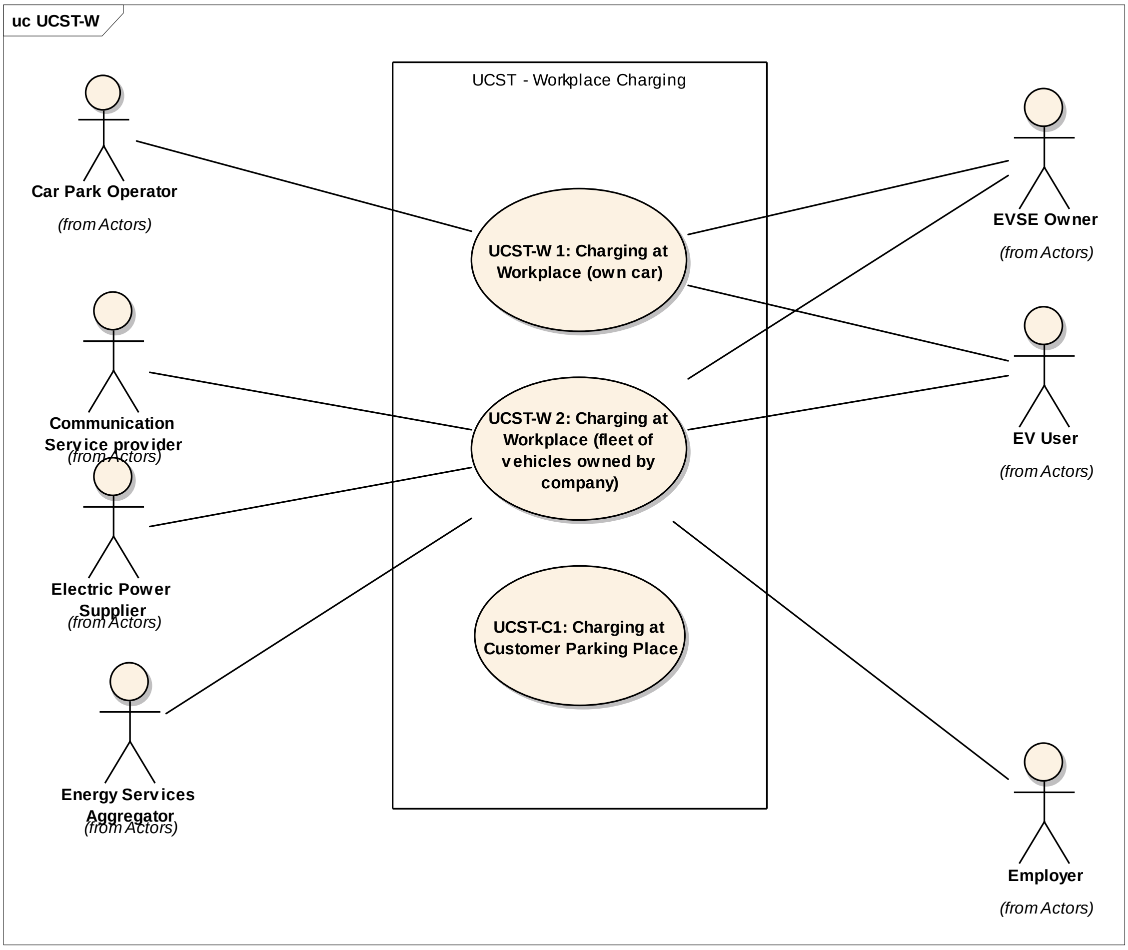


Figure 13 Stakeholder Diagram for UC ST Workplace Charging

2.3.5.3 Narrative

Scenario A: Visitor parking place

Homer sometimes uses his private electric vehicle (EV) for one-day, local business trips (he certainly gets compensated for the EV usage by his company). A local business trip never exceeds 200 km a day (for longer trips he uses the train or airplane). Since fast charging is more expensive, he likes to use charging places at the visitor parking place of his customers. Access is restricted to registered visitors and charging as a B2B-service is for free, yet only on small power levels (<3,6kW).

Scenario B: Employee parking place

Homer parks for a large portion of the day at his workplace. This provides an opportunity for him to charge the vehicle during the day if desired. Due to tax issues, the employer needs to account the charging quantity of its employees as monetary benefit. Therefore, the charge points are metered individually. The Employer contracts with the Electric Power Supplier to deliver its EVSE. Employees who activate their EVs for V2G could even gain a small amount of money. The V2G-services are organized and operated by an Energy Services Aggregator that the Employer has a contract with. The Energy Services Aggregator himself needs support from a Communication Service Provider. A complete use case on V2G and G2V is considered in the Mid Term Scenario A (UC-MT) in section 2.4.1.

Scenario C: Fleet parking places

Companies operating a fleet of vehicles want to be able charge their EV day and/or night at the standard parking place. Therefore, charging stations (EVSE) are installed at some or many of these parking places. For security reasons, the EV is connected via special e-mobility plugs (e.g. IEC 62196 Type 2) and cables to the EVSE.

The fleet operator has two main options:

1) No V2G: Energy flow is uni-directional. Individual metering is not required for the charge points. The electricity consumption for all EVSE at this location is measured by one meter and the fleet owner pays for this bulk power consumption.
2) V2G: The energy flows are bi-directional in order to allow for V2G-Services. Hence, each charge point is metered exactly in order to allow for accounting through an Energy Services Aggregator.

More details on V2G/G2V are given in section 2.4.1 (UC-MT Scenario A: Dynamic V2G/G2V Energy Exchange).

Many known business models are covered by this scenario:

- Car sharing with fix parking places
- Car rental companies
- Company fleets, e.g. service cars

All of them require additional fast charging possibilities. Beyond a certain number of EVs in the fleet, own fast charging stations could be economic.

2.3.5.4 Actor (Stakeholder) Roles

Grouping (Community) '		*Group Description*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
EV User	Person	Uses the EV for private mobility needs such as commuting, carrying children, go shopping, … (here: Homer)
EV Owner	Person/ Organization	Owns the EV in order to use it. Must consider TCO for the EV. Risks could (partly) be covered by insurance companies (here: Homer or a company)
Employer	Organization	Employs an employee (here: Homer).
Communication Service Provider	Organization	Provides services to communicate e.g. price signals; contracts with the Energy Services Aggregator
Electric Power Supplier	Organization	Contracts with the Employer in order to delivers energy (here: for the EV's of his customers).
Energy Services Aggregator	Organization	Aggregates several EV for V2G-services.
EVSE	Device	Electric Vehicle Supply Equipment (charging station) at the parking spaces of the workplace.
EV	Device	Electric Vehicle
Car Park Operator	Organization	Operates the Car Park. Might be at the same time the EVSE Operator.

2.3.5.5 Information exchanged

Information Object Name	*Information Object Description*
V2G-Information	All kind of technical and commercial information, such as kW, kWh, temperatures, … and prices, SLA, …
Authentication Token (IDs)	E.g. via an internationally standardized Contract ID or EVSE ID.
Driving Profile	In order to estimate the possible V2G-usage (delay of charging as well as feeding energy back to the power grid), it is necessary to know when the EV User needs how much range.
Charging Profile	To perfectly harmonize the V2G-usage with EV User mobility needs, it is useful to know at which EVSE (charging power) the EV will be

Information Object Name	*Information Object Description*
	parked when and for how much time.

2.3.5.6 Activities/Services

Activity/Service Name	*Activities/Services Provided*
V2G local grid service	Sold to the DSO via an Energy Services Aggregator
V2G global grid service	Sold via an Energy Services Aggregator to a TSO using nergy markets.

2.3.5.7 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
Employer-Employee	As part of the labor agreement; defines conditions of EVSE usage
Employer-Electric power supplier	In case of non-V2G-services, the employer contracts with the electric power supplier directly.
Employer-Communication Service Provider	For the IT infrastructure of the employing company, there are already contracts with a Communication Service Provider that could be adapted to include communication around EVSE usage.
Employer-Aggregator	In case of V2G-services, the employer contracts with an Energy Services Aggregator that himself contracts with corresponding Communication Service Providers and Electric power suppliers.

2.3.6 Step by Step Analysis of Workplace Charging Function

2.3.6.1 Steps to implement workplace charging function

Providing V2G-services

2.3.6.1.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
EVSE	Is prepared for V2G (bi-directional energy flow) and provides the necessary communication interfaces.
EV	Is able to react on V2G-signals of the Aggregator.
Energy Services Aggregator	Aggregates enough EV to offer grid services to corresponding markets.

2.3.6.1.2 Steps – Scenario B: Employee parking place

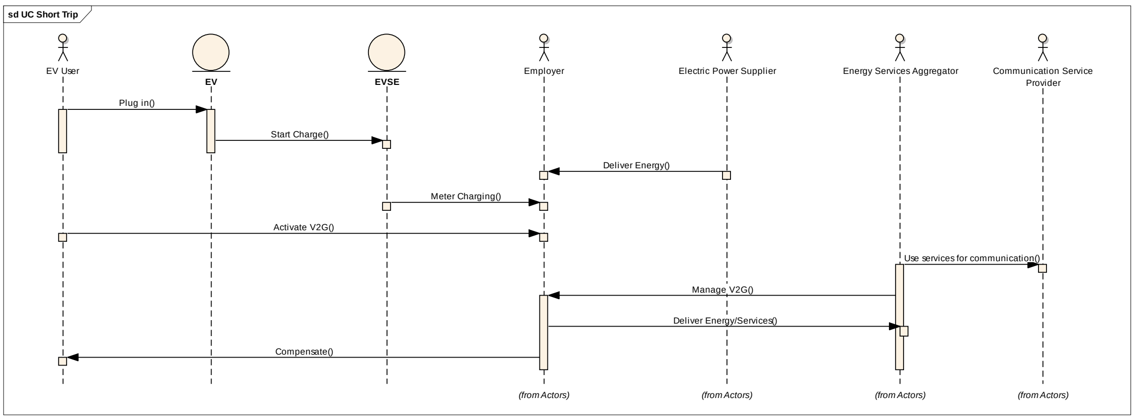


Figure 14 UCST-W - Scenario B

2.3.6.1.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
EV Owner	Is compensated
EV User	Was able to fulfill its mobility needs without any restrictions through V2G communication.

2.4 Use Case Medium Trip

2.4.1 Function: Charge Point Accessibility

2.4.1.1 UC-MT-CPA Brief Description

Functions described herein are derived from 5 different mobility scenarios for medium-ranged distance (<350 km) trips identified to be important for future electric mobility. All five scenarios are briefly described in the next section.

2.4.1.2 Diagram

Figure 15 depicts relevant relation between stakeholders for this use case. Relations could be of contractual nature, but also communication and energy interfaces between stakeholders are possible. The Communication Service Provider stakeholder takes a central role since most use case participants needs a communication infrastructure they are neither owning nor operating under normal circumstances. A contractual relation between Communication Service Provider and its counterparts is assumed for the rest of this section.

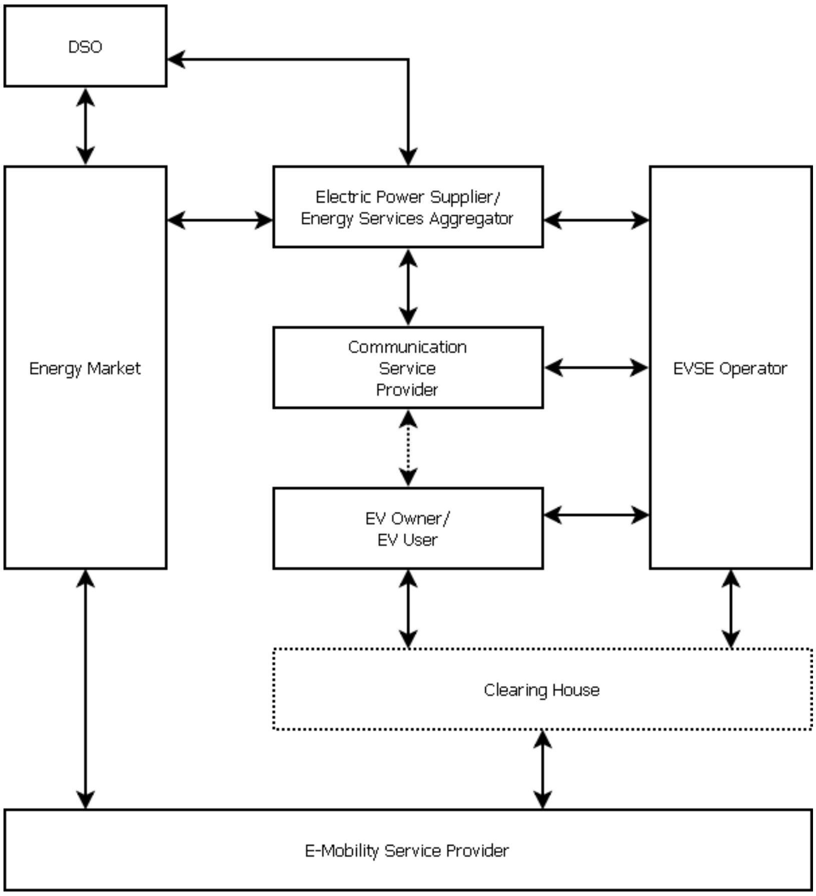


Figure 15 Medium Trip Use Case's Stakeholder Relations

2.4.1.3 Narrative

Scenario A - Dynamic V2G/G2V Energy Exchange

Increasing deployment of distributed generation – often with stochastic generation patterns – results in a need for coordinated control of the distribution network, capable of dealing with the arising dynamics of the network.
Since the stochastic generation cannot follow the load demand, coordinated methods to store energy in addition to other techniques will lead to more efficient and stable network operation.

The EV owners are assumed to have agreed contracts with an Aggregator, e.g. E-Mobility Service Provider (EMSP), to be able to offer services to the network. This is coupled to certain incentives for the EV owner. These incentives can be e.g. fixed or variable and dynamic tariffs for compensation for power provisioning and V2G services. In all scenarios in which EVs are unused for a longer time this opportunity has high potential. Two of these scenarios are described in ucST-W in section 2.3.5.

A possible scenario could be that a person called Homer is the owner of an EV equipped with a reversible converter and has a contract with an EMSP allowing for V2G service. Homer's local Electric Power Supplier (EPS) could take the E-Mobility Service Provider's role in this case. Homer knows that he will not use the car for some hours and connects his car to an Electric Vehicle Supply Equipment (EVSE) in order to provide a V2G service for the Distribution System Operator (DSO) the EVSE is attached to. The EVSE Operator is receiving price signals from the EPS and calculates its energy selling price and energy buying price respectively. These prices are then communicated to Homer's EMSP that updates Homer's account balance according to V2G session outcome.

After authentication and authorization procedures were validly completed, Homer communicates the following data to his EMSP (either directly or by means of data post processing by his car computer):

- Battery SoC
- Time & day when he will start his next trip
- Expected maximum range of next trip
- Minimum energy price to allow for V2G service (this can be a preconfigured default setting) for discharging
- Maximum energy price to allow for extra charging (this can be a preconfigured default setting) for charging
- Maximum total cost in case of extra charging

All these preferences are forwarded to the connected EVSE Operator. Together with Homer's car's charging capabilities the EVSE Operator schedules:

- (Dis-)charging periods
- Charging current

The EVSE Operator activates EVSE (dis-)charging procedures. Optionally, the EV may send notification messages to Homer in order to inform him about state changes.
Since the EVSE Operator receives energy price information from the EPS, it is able to monitor dynamically changing energy prices and react according to Homer's preferences. In the future, energy tariff finding in the market could also depend on regional distribution grid state and therefore Homer's grid-connected EV could indirectly (through price threshold settings) help to maintain distribution grid's health.
Communication between EVSE Operator and EPS is of continuous nature, e.g. price changes are propagated to the EVSE Operator and connection state changes are communicated back to the EPS which in turn forwards information to the market.

In any case the E-Mobility Service Provider has to ensure that the required minimum battery conditions for Homer's next trip are met at all times. This condition has to also be maintained even if Homer decides for earlier use of his EV than planned.

It has to be considered that the EMSP in question has several customers like Homer that it needs to handle in parallel and it has to negotiate with Energy Markets on their behalf for provision of ancillary services.

Scenario B - Community EVSEs

Homer owns a EV and wants to travel a distance of 350 km. He predicts, he has to recharge his EV battery at least one time on the way to his destination. In addition to his EV, Homer also has an own EVSE at his private premises able to sustain 11 kW charging power (AC) which could also be used by other EV owners.

A community of EV owners is providing and using these privately operated EVSEs and they are mutually granting access to these community EVSEs. A similar service is already established in [15], but it is lacking support for advanced feature like EVSE status updates.

Three different models are envisaged, similar to what the FON community is offering for WiFi hotspots [16]:

- Offer/Use charging service for free
- Offer/Use charging service and account for monetary equivalent of kWh leading to a monthly balance
- Offer charging service to non-community members and get a revenue in this case

Community members giving free access to their EVSEs are either using an established platform for their communication means like a social networking platform (Facebook, Diaspora, etc.) or they use their own platform implementation running inside a networking cloud.

Community members offering commercial service to non-community members have to register with an entity that administers community member balances. This service could in turn be a commercial one like in the FON business model.

Homer therefore tries to find reasonable EVSEs on his travel route depending on the time he wants to invest to reach his destination. But certainly he wants to use community EVSEs. Therefore he uses mobile communication means (smartphone, telematics services) to find out EVSE locations as well as their occupancy.

Scenario C - Planned charging using operator pre selection

Homer owns an EV and wants to travel a distance of 350 km. He predicts that he has to recharge his EV battery at least one time on the way to his destination.

In order to get the best recharging tariffs on his way, he uses a service provided by his E-Mobility Service Provider that enables him to choose between different EVSEs offering different tariffs in advance, i.e. he can reserve a charging time slot at an EVSE in advance. Homer is able to do this dynamically either by using his telematics system installed in his EV or by using his smartphone while travelling. Provision of these up to date information and persistent connectivity is also needed in other use case scenarios like *UC-ST-P Scenario A* located in section 2.3.3 and *UC LT-P1* described in section 2.5.3.

Homer already has a contract with an Electric Power Supplier. Within the contract with his, he sets his preferred ESPS. He would ideally want to use EVSEs operated by his ESPS. But unfortunately there is not any EVSE available that is covered by his contract and he has to use an EVSE owned by another EVSE Operator which could be another ESPS or even another EMSP. Nevertheless, Homer is able to recharge his car by connecting to his EMSP through a Clearing House (or several, e.g. one for authorization and another for billing purposes) that has contracts with several EMSPs including his. An alternative to involving a Clearing House is roaming between different EVSE Operators that cooperate or have contracts with EMSPs and therefore may not charge additional costs. EVSE Operators that do not cooperate could charge a reasonable roaming fee. Homer has to use a universal ID for authentication in these cases.

2.4.2 Function: Alternative method for charged battery

Scenario A - Battery swap station

A company (Battery Swap Station Operator, BSSO) runs a commercial battery swap station. The “parking place” as well as the exchange infrastructure is operated by this company to offer the battery swap service. The service provider could also be an Individual Mobility Provider (IMP) or a Shared

Mobility Provider (SMP) fleet operator, e.g. car sharing company that offers this service to their customers.
All customers are entitled to use the operators' battery swap stations. The customers using this service are guaranteed to get a quick battery "recharge" with a reasonable battery SoC for long distances (> 200 km).

The energy transfer direction is (in summa) uni-directional to the EV. Nevertheless, the battery station can be used as a big electrical energy buffer to offer grid operation support services, i.e. controlling power range, store energy generated by nearby wind farms, etc.

Ownership of EVs and batteries normally differ in this scenario with batteries being leased by EV owners from Battery Owners which have contracts with BSSOs. Battery owners could be car manufacturers (operating their own stations or having multilateral contracts with swap station operators) or from the fleet operators (using the similar contractual models as car manufacturers).

2.4.3 Function: Inter-modal

Scenario A - Ad-hoc inter-modal transportation

Homer wants to travel a distance of 350 km. He does not possess any vehicle he could use to go from his location A to location B. He uses his ICT equipment (PC, Smartphone, etc.) to connect to an internet platform that schedules Homer's envisaged travel.

Besides the time schedule, it also calculates vehicle types to use on the way. The outcome could be that the platform proposes Homer to use local public transportation for the first 10 km then he switches to use the trains for the main part of his journey to finally take an EV offered by a car sharing company to finally arrive at location B.

The platform keeps track on Homer's progress approaching his destination and is able to quickly suggest alternatives in case something unexpectedly happens (accidents, delays, etc.).

2.4.3.1 Actor (Stakeholder) Roles

Grouping (Community) '		***Use Case Medium Trip***
Actor Name	***Actor Type (person, organization, device, system, or subsystem)***	***Actor Description***
EV Owner	Person or organization	Entity owning the car. This could be a person in which case the car is privately owned or it could also be a car sharing or car rental organization. An example car sharing company would be a Enterprise Fleet Operator (EFO) which runs a company's car fleet.
EV User	Person	A person that uses the electric vehicle (EV) at a specific point in time (whether in a professional or private capacity). A sub-definition of the EV User would be: Individual EV User (IVU): uses the same vehicle all the time (by either buying or leasing it or getting it for individual use from an IMP) Shared EV User (SVU): uses a given set of vehicles on demand together with other users (e. g. in a car sharing partnership, using a car rental system or a company car pool)
Battery Owner	Person or organization	Entity that owns one or more batteries.
Battery Tenant	Person or	Entity that leases one or more batteries from battery

Grouping (Community) '		*Use Case Medium Trip*
Actor Name	***Actor Type (person, organization, device, system, or subsystem)***	***Actor Description***
	organization	owners.
E-Mobility Service Provider	Organization	Provides value added services for individual mobility. Services to its customers include: • Mobility preference administration • EVSE availability • Special offers The difference between this stakeholder and an IMP is the ownership of EVs / batteries.
EVSE operator	Person or organization	Entity that operates one or more EVSEs. This could be a person in which case this person normally only owns a single EVSE at his premises. This could also be a company owning an EVSE network.
Electric Power Supplier (EPS)	organization	Vendor of electricity, synonym to Energy Retailer
DSO	Organization	Operates the local power grid infrastructure, and substations, over which energy is supplied to EVSE or the end user.
Energy Services Aggregator (ESA)	Organization	Deregulated participant in the energy market which contracts multiple distributed energy generators (e. g. virtual power plants) and / or consumers to optimally manage their energy generation and use as a group, especially by bringing their flexibilities to the market place (in the sense of generation side or demand side management)
Substation	System	Primary or secondary substation. Performs state estimation based on real-time measurement data. Derives control actions from analysis of power flow situation.
Energy Market	System	Following market rules, energy price is calculated and physical and financial transactions are made. Owing specific issues of Energy, normally, there are day-ahead transactions and then a several intraday transactions in order to maintain stability.
Financial Clearing House	Organization	Company that takes over financial clearing. It may also issue billing between involved partners. allows for cooperation of multiple BSPs
Communication Service Provider	Organization	Operates a communication network infrastructure and provides services to communicate e.g. price signals, contracts with the Aggregator.
(P)EV	System	(Plug-in) Electric Vehicle
Battery Storage System	Subsystem	Customer-owned storage and charging system that allows control by the DSO (as per contractual agreements): (Plug-in) electric vehicles when connected to a charging station
Battery Swap Station Operator (BSSO)	Organization	Company that offer battery swap service to Battery Tenants.
Battery Station	System	Station in which a stockpile of batteries is stored. The batteries are connected to the grid in order to charge

Grouping (Community) '		*Use Case Medium Trip*
Actor Name	***Actor Type (person, organization, device, system, or subsystem)***	***Actor Description***
		them or even offer
Data Center	System	System installed to hold arbitrary data sets like customer data, usage statistics etc.
Intermodal Services User (ISU)	Person	Uses (public or private) services to get from A to B with the ever best means of transport
Inter-modal Transportation Service Provider (ITSP)	Organization	Company that offers services to inter-modal mobility systems (IOM), e. g. schedule planning and reservation tasks etc.
Intermodal Mobility Operator (IMO)	Organization	provides public transport (local or long distance) partially using EV and PHEV, providing the optimal means of transport at the right time
Billing	System	System that collects billing information and manages and issues bills.

2.4.3.2 Information exchanged

The following table lists message types exchanged in each scenario.

Information Object Name	*Information Object Description*
Notification	Digitalized information that can be a list of information items or an event notification, e.g. - Charging and storage capabilities - Price signal update - EV disconnection
Request	Digitalized message requesting a particular task, e.g. - Smart charging - Price signal update - Market price negotiation
Answer	Digitalized message answering a request, e.g. - Charging and V2G capabilities - Price negotiation
Command	Digitalized message to order a concrete action, e.g. - Start/stop charging - Start/stop discharging

2.4.3.3 Activities/Services

Activity/Service Name	*Activities/Services Provided*
Availability of contribution to network services	Identify what entities can contribute to network services including their constraints.
EVSE information	Information on EVSEs' location, status (occupied), features etc.
Authorization	Authorize a person or organization for service access
(Dis-)Charging	Offer bi-directional energy transfer

Activity/Service Name	Activities/Services Provided
Battery Swap	Swap a low SoC battery with a higher SoC battery
Preference Management	Manage users' default preferences like local energy supplier, minimum battery SoC to be maintained in V2G scenarios
EVSE reservation	Reserve a charging time slot with a specific preselected EVSE

2.4.3.4 Contracts/Regulations

Contract/Regulation	Impact of Contract/Regulation on Function
Contracts regarding provision of ancillary services	Required contracts between the following actors: - EV User – EMSP - EV User – EPS
Energy Market involvement	Negotiations to take place between: - EMSP (Aggregator) – Energy Market - EPS – Energy Market
Battery Leasing Contract	Required contract between Battery Tenant (normally EV User) and the Battery Owner.
Energy Provision Contract	Required contract between the following actors: • EPS – EVSE Operators, Battery Swap Station Operator • EPS – EV User
Battery Management Contract	Required contract between Battery Owner and Battery Manager (could be Battery Swap Station Operator).

2.4.4 Step by Step Analysis of Charge Point Accessibility Function

2.4.4.1 Steps to implement function – EV User EVSE Authorization

2.4.4.1.1 Preconditions and Assumptions

EV User has a contract with an E-Mobility Service Provider that offers Value Added Services (VAS) to the EV User such as user V2G preferences or discounts on charging rates.
The EVSE Operator has a contract with an EPS that is providing energy to the EVSE operator.
The EMSP and the EVSE Operators are both running a data center where they maintain EVSE IDs and their operators IDs and EMSP IDs respectively. This could be established through contracting or simple registration without any further service provisioning.
The EV must have communication means to its User.

2.4.4.1.2 Steps – EV User EVSE Authorization

Figure 16 below depicts the envisaged overall EV User authorization process.

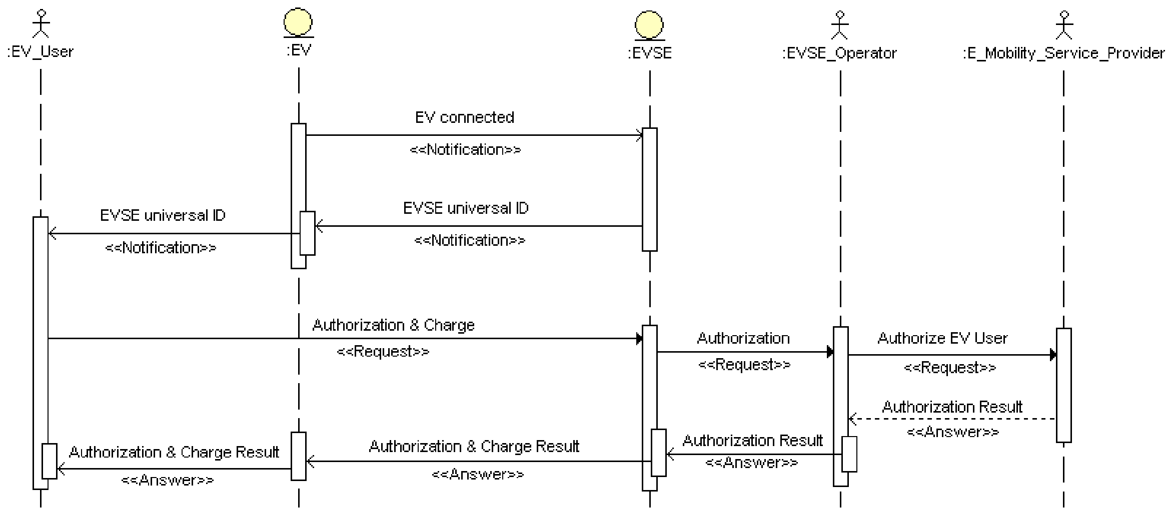


Figure 16 EV User EVSE access Authorization

2.4.4.1.3 Post-conditions and Significant Results

After completion of a successful authorization process, the EV user should be able to access V2G services.

2.4.4.2 Steps to implement function – V2G Operation

2.4.4.2.1 Preconditions and Assumptions

EV User has a contract with an E-Mobility Service Provider that offers Value Added Services (VAS) to the EV User such as user V2G preferences or discounts on charging rates.
The EVSE Operator has a contract with an EPS or Retailer that is providing energy to the EVSE Operator.
EV User authorization process successfully finished and EV supports V2G interface.
The EV must have communication means to its User.

2.4.4.2.2 Steps – V2G Operation

Figure 17 depicts messages exchanged. Sequences with blue background are running asynchronously to each other and may be of periodic nature. Battery SoC notifications and energy price notifications are sent in a periodic manner to guarantee correct base data for EVSE Operator (dis-)charge decisions.

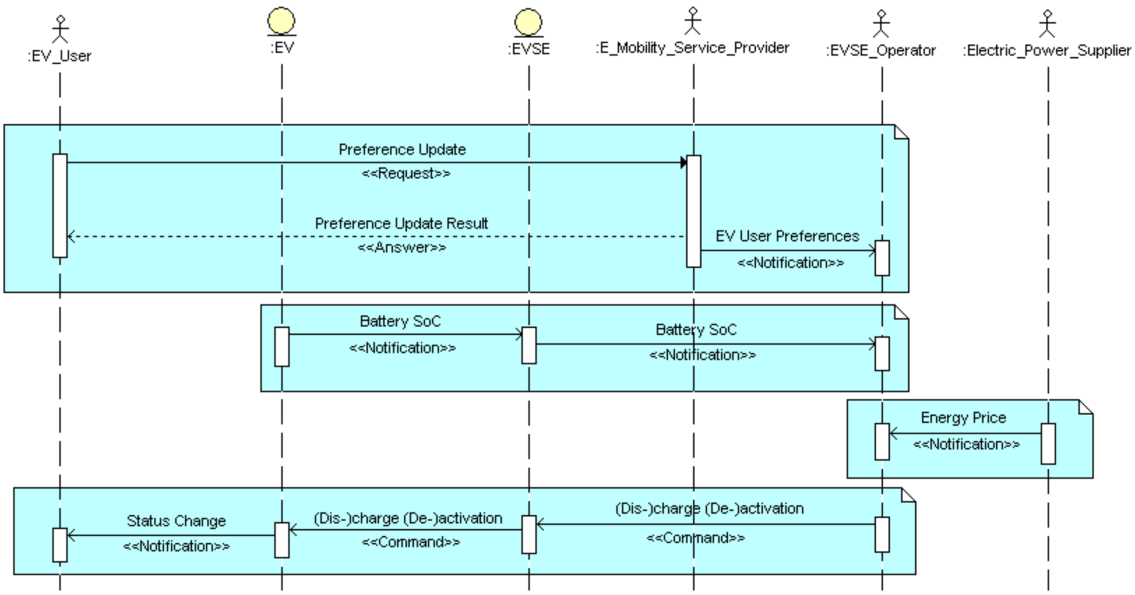


Figure 17 V2G Operation

2.4.4.2.3 Post-conditions and Significant Results

EV minimum battery SoC, defined by EV user preferences is maintained.

2.4.5 Step by Step Analysis of Alternative method for charged battery function

2.4.5.1 Steps to implement function – Battery Swap

2.4.5.1.1 Preconditions and Assumptions

Battery Tenant (normally the EV User) has a contract with the owner of the battery that is deployed in her/his EV. The Battery Owner has a contract with a battery manager that is represented by a Battery Swap Station Operator (BSSO). The BSSO in turn operates a data centre where universal Battery IDs and Battery Owner IDs are stored. This data centre could be potentially used to store statistics about station usage per battery owner etc.

2.4.5.1.2 Steps – Battery Swap

The following figure depicts messages exchanged. Optional statistics stored in data centre.

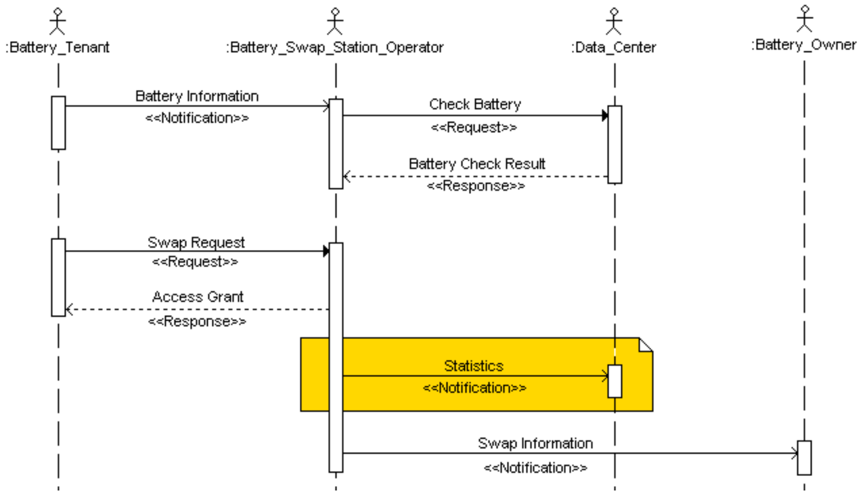


Figure 18 Battery Swap

2.4.5.1.3 Post-conditions and Significant Results

Battery Tenant’s EV battery is swapped for a battery with a higher SoC if station access was granted to the Battery Tenant else station access is refused and battery is not swapped. Data is delivered to Battery Owner containing information on swapped battery, e.g. station ID, battery ID, battery health conditions etc.

2.4.5.2 Steps to implement function – Battery Station 2 Grid

2.4.5.2.1 Preconditions and Assumptions

The BSSO has a contract with an Energy Retailer Services Aggregator (ESA) which in turn has access to the energy market. The battery station is equipped with power inverters to offer battery 2 grid service.

2.4.5.2.2 Steps – Battery Station 2 Grid

The following figure depicts messages exchanged. Parts with a blue background may run asynchronously.

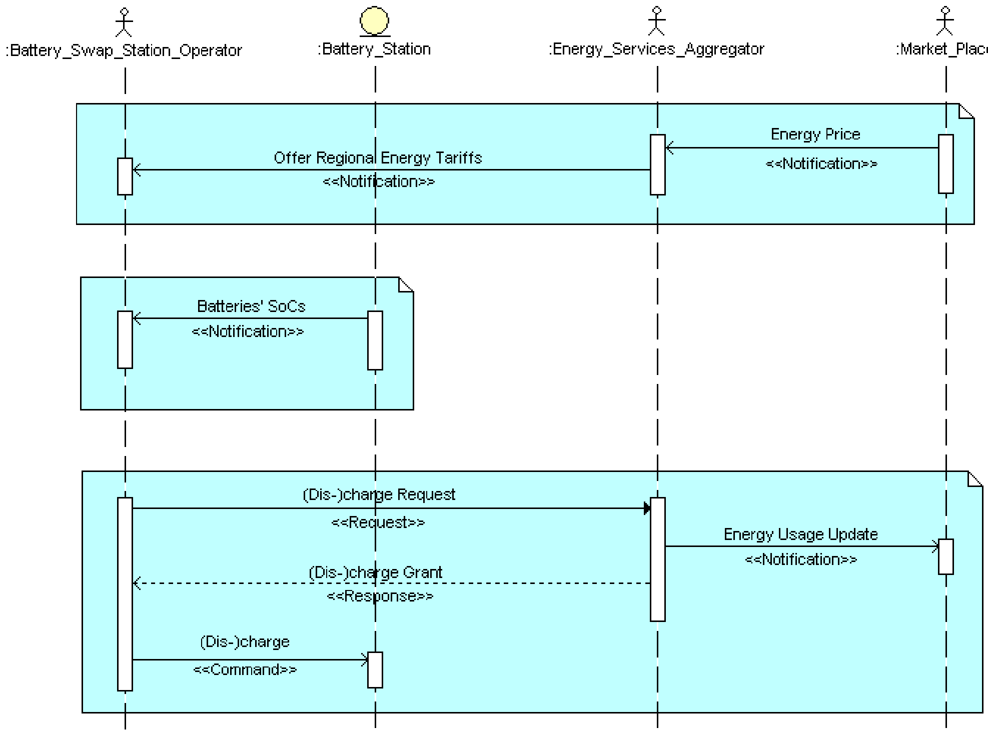


Figure 19 Battery Station 2 Grid

2.4.5.2.3 Post-conditions and Significant Results

The BSSO is able to offer a battery 2 grid service using its battery stock. It can decide weather to offer power to the grid in case the compensation is high enough. It can also decide when it is best to charge batteries located inside the station.

2.4.6 Step by Step Inter-modal function

2.4.6.1 Steps to implement function – Ad-hoc inter-modal transportation

2.4.6.1.1 Preconditions and Assumptions

To provide an ad-hoc inter-modal transportation system the following preconditions have to be fulfilled:

Actor/System/Information/Contract	*Preconditions or Assumptions*
Inter-modal Transportation Service Provider (ITSP)	Provide the portal and the backend system for using the inter-modal transportation service. This service has to be available for the Inter-modal Services User (ISU).
Inter-modal transportation service provider	Should have the ability to the check the availability and to book EV, trains etc. from Inter-modal Mobility Operators (IMOs).
Inter-modal Services User	Should be able to access the inter-modal transportation service portal anytime by using devices (e.g. smart phone, route guidance system, …)

2.4.6.1.2 Steps – Ad-hoc inter-modal transportation

The following two figures depict actions needed to implement ad-hoc inter-modal transportation process as well as the overall message exchange sequence.

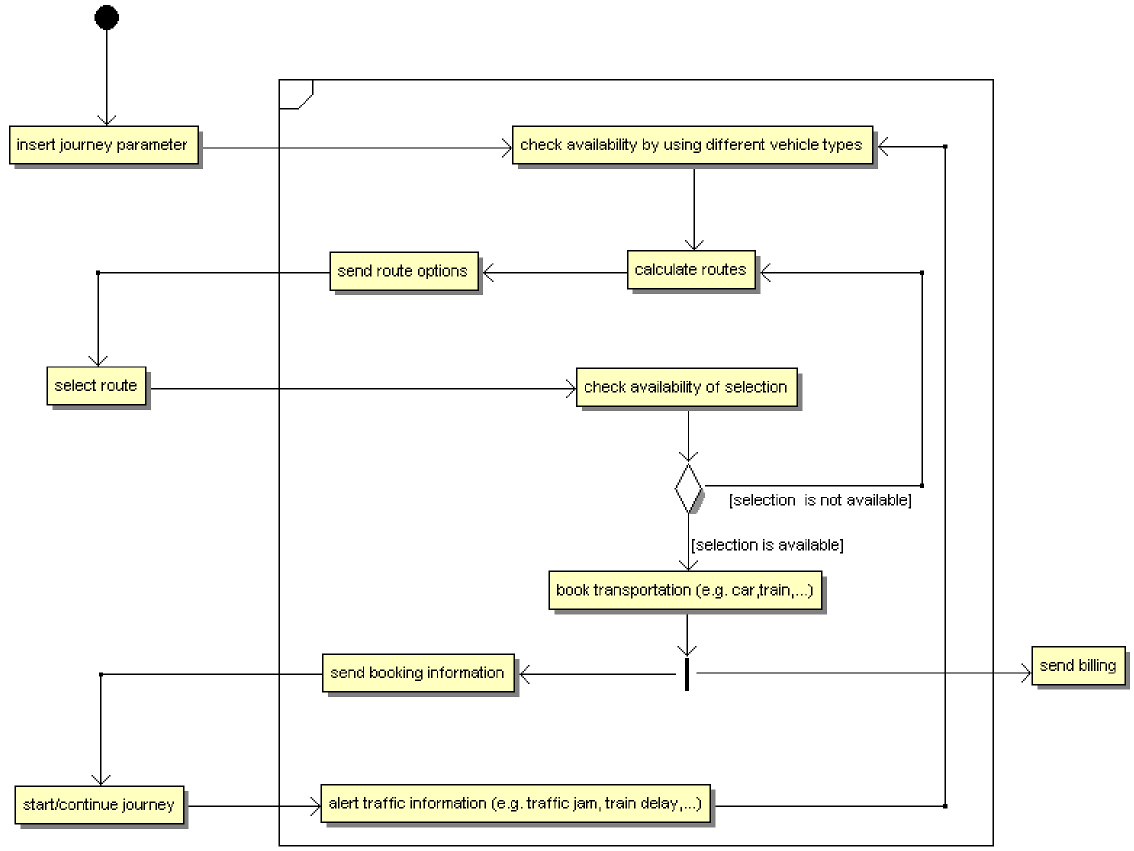


Figure 20 Ad-hoc inter-modal transportation action diagram

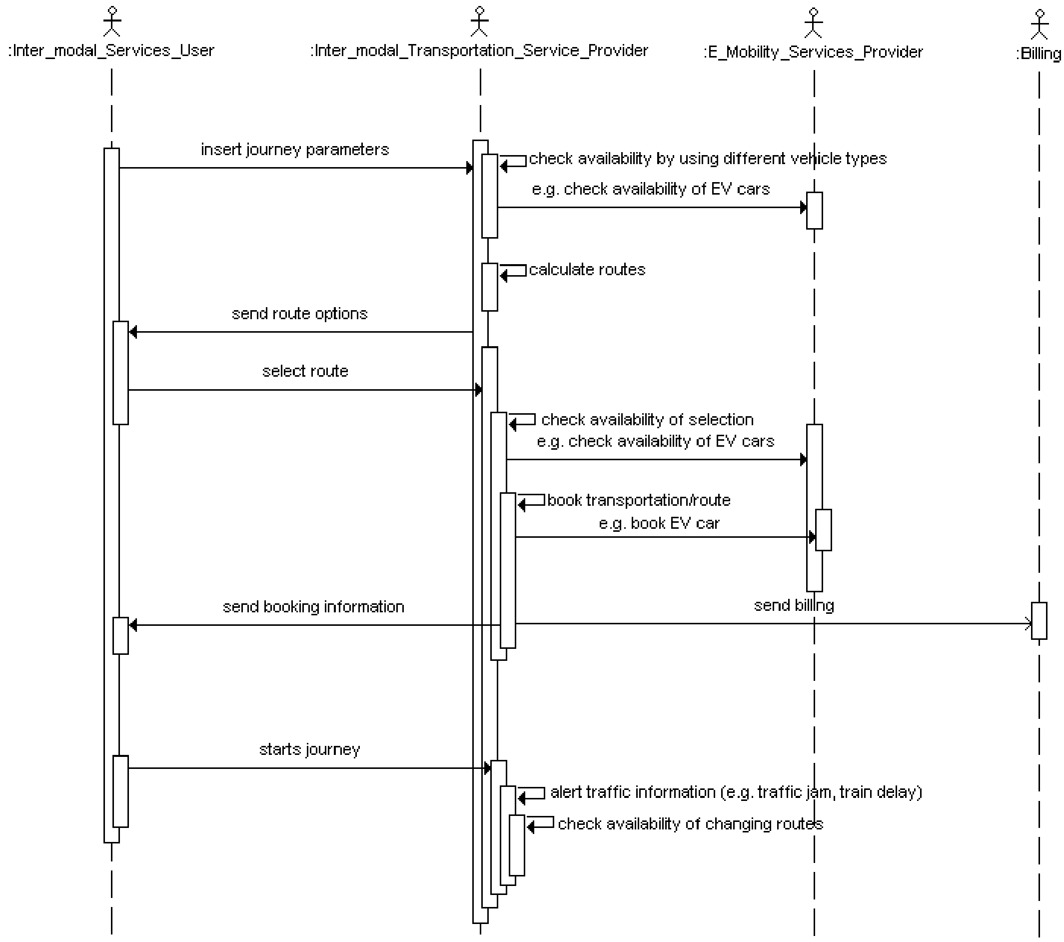


Figure 21 Ad-hoc inter-modal transportation sequence diagram

See Appendix I for a table which provides a step by step analysis of this sequence.

2.5 Use Case Long Trip

The basic premises of the Long Trip use cases (ucLT) are that the owner/driver of an electric vehicle will:

a) make long distance journey
b) need to recharge multiple times
c) encounter such roaming issues as availability of charge points and payment options

In these sections, use cases for the following four functions are described in detail:

1. UC-LT-A Authentication
2. UC-LT-IRCP International Roaming Charge Points
3. UC-LT-PM Payment Methods
4. UC-LT-EVC EV User in another country

Figure 22 below illustrates these four use cases within the Long Trip scenario and shows the high-level interaction of various stakeholders to these use cases.

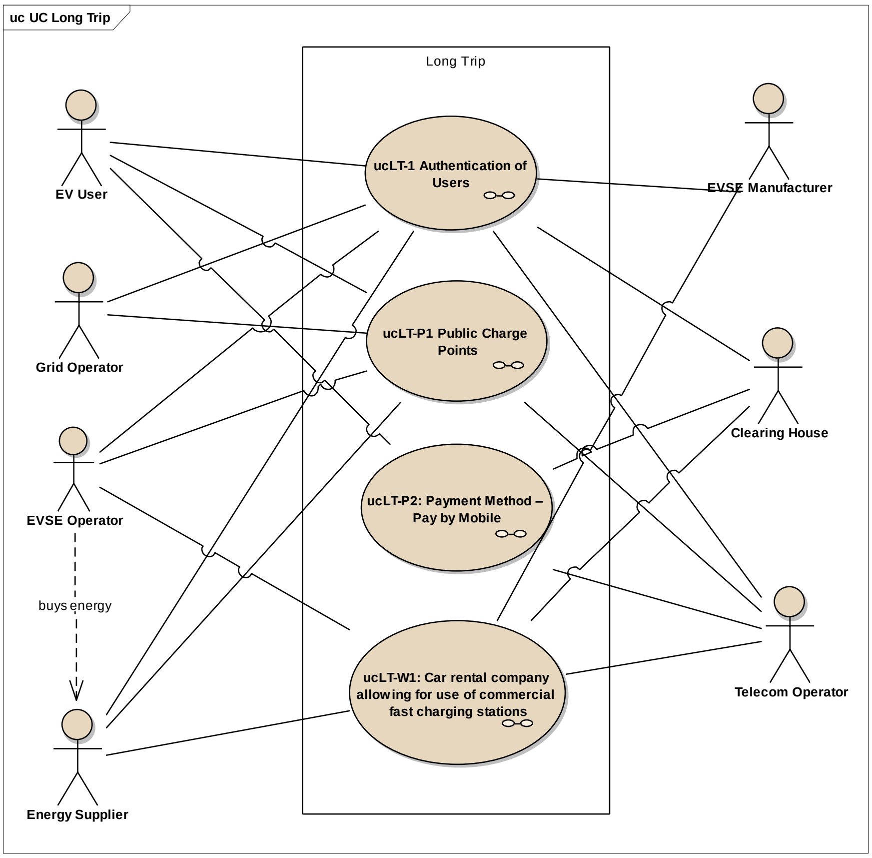


Figure 22 Stakeholder diagram for Long Trip scenarios

2.5.1 Function: Authentication

The user will need to provide data about their identity or authority to use the EVSE charge point (CP).

2.5.1.1 UC-LT-A Brief Description

For a EVSE's charge point the user will need to provide information about their identity or authority to use the charge point (CP) and to draw energy from it. This could be for many reasons such as to unlock a protected outlet socket on the CP, to prove that they have credit to pay for their energy, to prove that they are a customer of that EVSE's CP, or so that access can be withdrawn from users who do not pay.
There are a number of means for the EV user to provide their token to be authenticated, it could involve:-

1. The user authenticating at the CP with a RFID smart card or key fop.
2. The user authenticating at the CP with an access card or near field communication enabled mobile device.
3. The user communicates with the provider (e.g. obtaining an access code for the CP) via SMS or web based application.
4. The CP communicates directly with the EV Users electric vehicle (e.g. via an on-board PC).

Given that the EV User is on a long trip, and possibly roaming into another country this use case considers the possibility that the EVSE owner and operator of the charge point, is different to the energy supplier selected to provide energy through the charge point.

2.5.1.2 Diagram

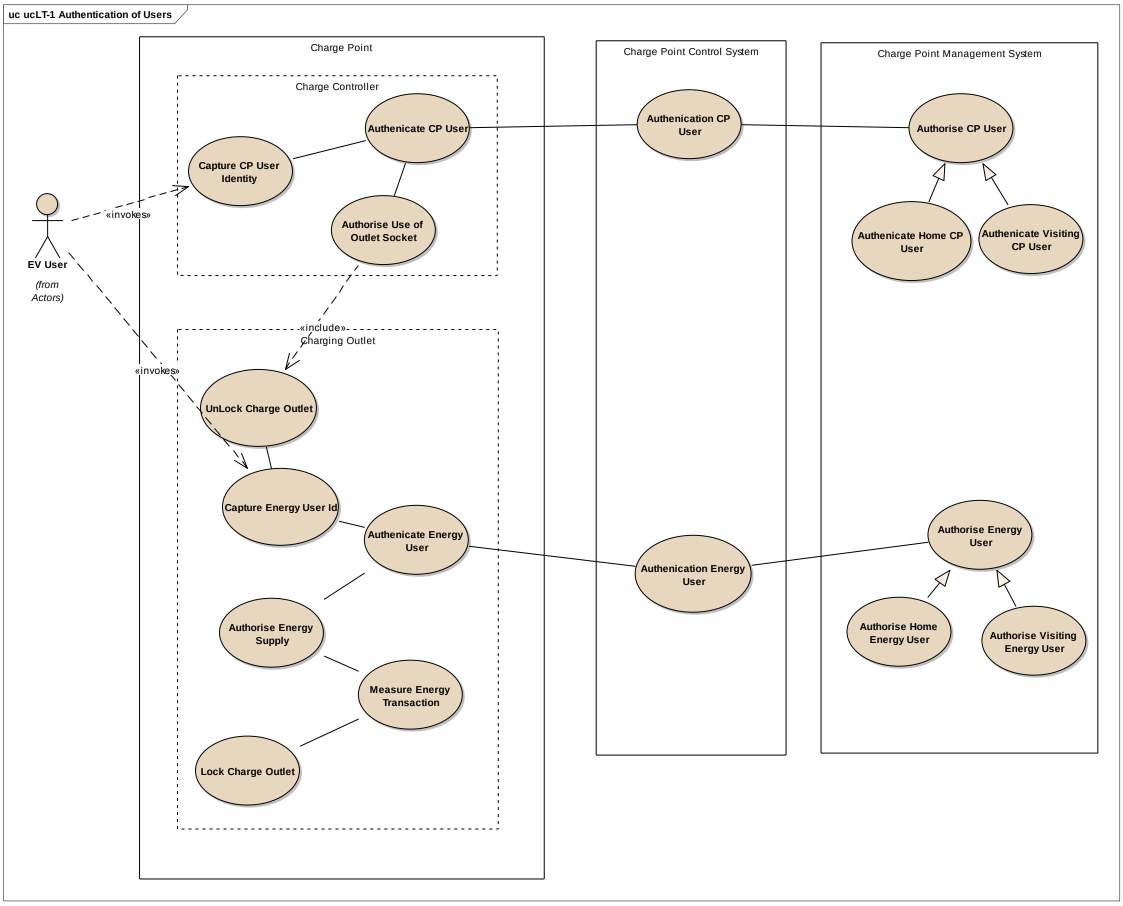


Figure 23 Authenticate User UML diagram

2.5.1.3 Narrative

The EV User parks their car at a EVSE charge point, and using a RFID smart card or key fop their credentials are read by the CP, authenticated and the charge point outlet socket is unlocked. The EV User must now validate the payment method for the energy to be received, this is done automatically once the EV plug is placed into the outlet socket and through the communication line of the socket, credentials from the EV on-board PC are checked with the Electric Power Supplier (EPS) and once authorized the energy transaction is started.
The EV User may choice to stop the energy transaction, or due to credit limitations of the EV User, the EVSE CP may be requested to stop the transaction.

2.5.1.4 Actor (Stakeholder) Roles

Grouping (Community) '		*Long Trip Use Cases*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
EV User	Person	For this building block it is foreseen that the EV User is an Individual EV User (IVU) that has brought their EV on an international long trip.
EVSE User	Person, organisation	The EV User will need to be an EVSE User in their home country.
EVSE Operator	Organisation	Owner and operator of the EVSE.
E-Mobility Service Provider	Organisation	Given that the EV User has travelled from his home Country A to a visited Country B, the E-Mobility service provider offers a roaming contract, which will

Grouping (Community) '		*Long Trip Use Cases*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
		allow the EV Users EVSE ID to be used on the EVSE in Country B.
Energy User	Person	A person contracted with a specific Electric Power Supplier (EPS)
Electric Power Supplier (EPS)	Organisation	Provides energy to the EVSE Operator and will have contracts with Energy Users.

2.5.1.5 Information exchanged

Information Object Name	*Information Object Description*
Notification	Digitalized information that can be a list of information items or an event notification of the charging point and/or service, e.g. • Access to EVSE charge point. • EVSE Authentication is being negotiated. • Charge Outlet is connected to EV. • Charge Outlet is disconnected from EV. • Charge Transaction is complete.
Request	Digitalized message requesting a particular task, e.g. • Authenticate EVSE User ID. • Start Energy Transaction request. • Authenticate Energy User ID. • Stop Energy Transaction request.
Answer	Digitalized message answering a request, e.g. • Authentication Response for EVSE User ID. • Authentication Response for Energy User ID. • Start Energy Transaction response. • Stop Energy Transaction response.
Command	Digitalized message to order a concrete action, e.g. • Unlock/Lock charge outlet socket. • Start/Stop charge.

2.5.1.6 Activities/Services

Activity/Service Name	*Activities/Services Provided*
E-Mobility Service Provider	Authentication Service for the EVSE Operator as the EV User provides their EVSE User ID
Energy Services Aggregator	Authorization Service for the EVSE Operator as the EV User provides their Energy Supplier ID
Identification and Authorization Server	Can act as a roaming broker for Authentication and Authorization services across international boundries.

2.5.1.7 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
EVSE User -> E-Mobility Service Provider	EVSE Operator will have to use the E-Mobility providers' authentication services.
E-Mobility Service Provider -> EVSE Operators	E-Mobility Provider and EVSE Operator will need a Communication Service Provider in order to connect and communicate.
Energy User -> E-Mobility Service Provider	EVSE Operator will have to use the E-Mobility Providers authorization services.
E-Mobility Service	E-Mobility service provider will have to use the Electric Power Supplier

Contract/Regulation	Impact of Contract/Regulation on Function
Provider -> Electric Power Supplier	authorization services which may increase authorization time delay.
EVSE Operator -> Electric Power Supplier	EVSE Operator will have to use the Electric Power Supplier authorization services.

2.5.2 Step by Step Analysis of Authentication Function

2.5.2.1 Steps to implement function – EV User Authentication

2.5.2.1.1 Preconditions and Assumptions

The EV User must have a way to access and use the EVSE charge point. The EV User will have a RFID smart card / key fop or token/pin from either:-

1. A single EVSE Operator.
2. A E-Mobility Service Provider.

In the case of a RFID smart card, the card must hold an EVSE User ID and cryptographic material.

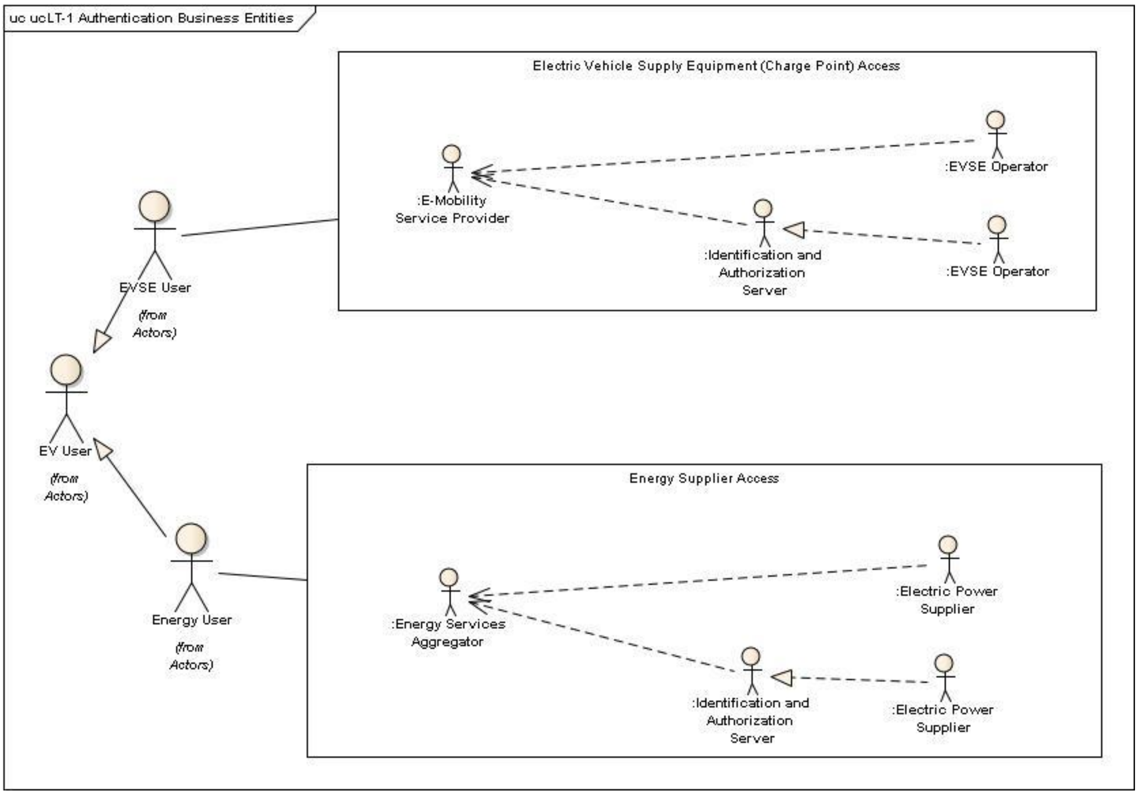


Figure 24 Authentication of Business Entities

The EV User must also be authorised to have an energy transaction start once the EV plug is connected into the EVSE outlet socket, and so in this case the EV User:

1. Is a contracted energy user to an Electric Power Supplier
2. Is a contracted user of an E-Mobility Service Provider
3. Can use a credit card at the charge point.
4. Can use a mobile ePayment method.

If the EV User has either a contract with an Electric Power Supplier or an E-Mobility Service Provider, then the EV User can store their Energy Supplier ID and cryptographic material on the EV on-board PC.

Actor/System/Information/Contract	Preconditions or Assumptions
EV User	Has a EVSE Universal User ID
EV User	Has a Energy Supplier Universal ID
E-Mobility Service Provider	Has a Roaming agreement with EVSE Operators in the country to

Actor/System/Information/Contract	*Preconditions or Assumptions*
	which the EV User has travelled to.

2.5.2.1.2 Steps – Authentication of EV User to EVSE

Once the EV User parks at an EVSE CP, the EV User has to unlock the Charge Outlet socket

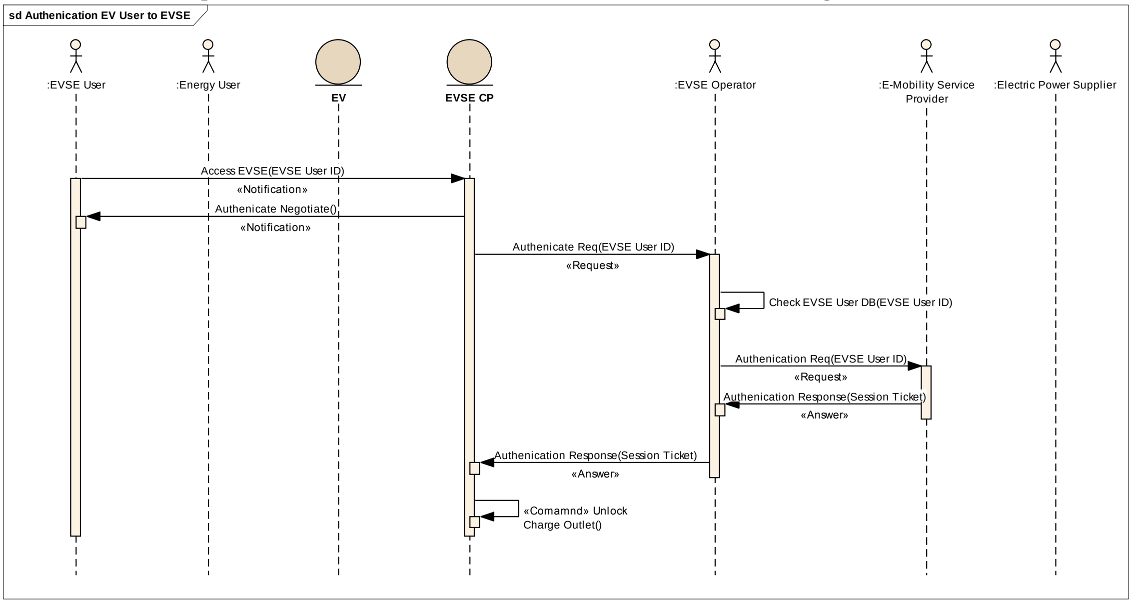


Figure 25 Authentication of EV User to EVSE

Once the EVSE CP outlet socket is unlocked, the EV User can plug the EV into the EVSE CP outlet socket, at this point the EV can communicate with the EVSE CP to authorise the starting of an energy transaction.

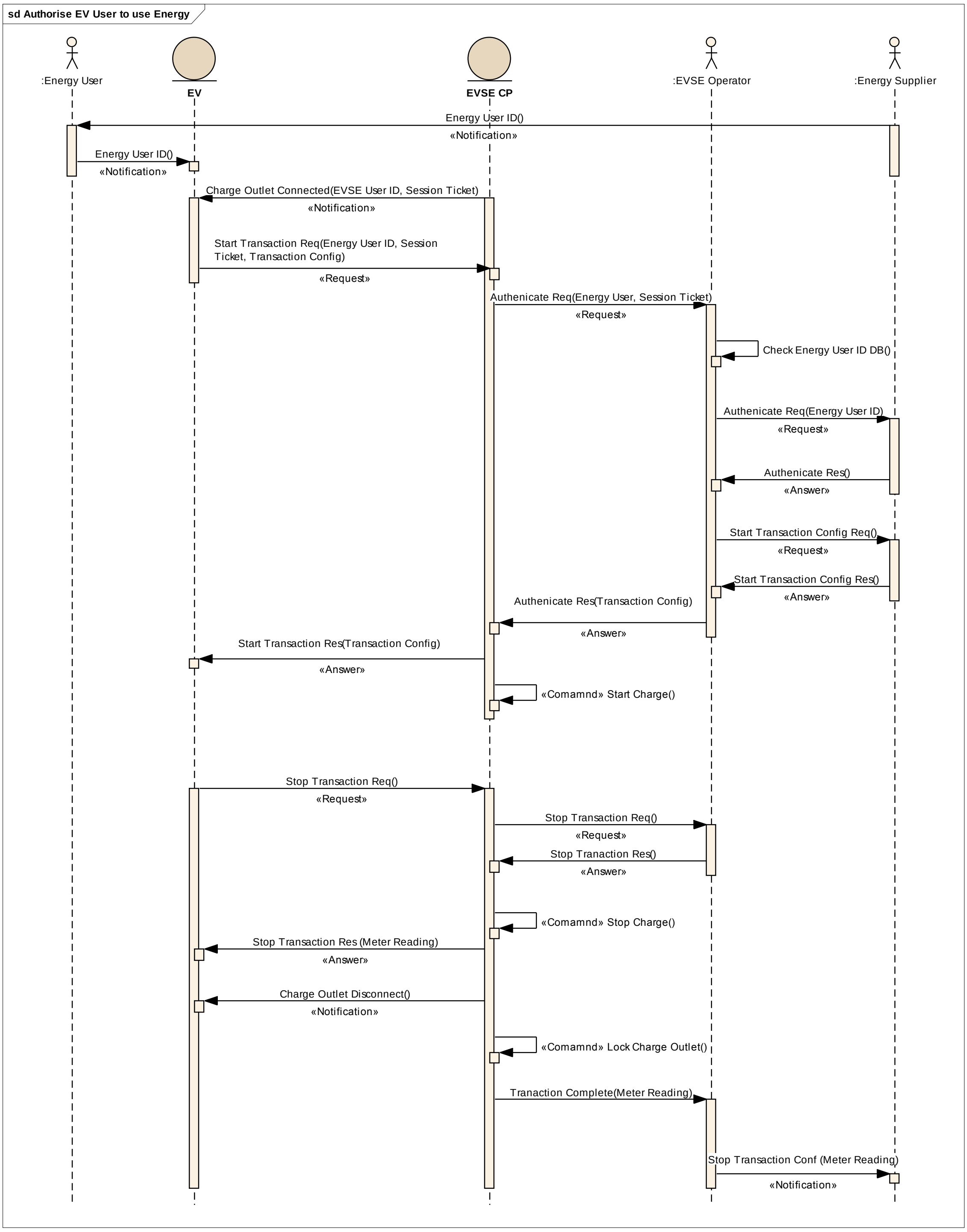


Figure 26 EV User requests energy from Energy Supplier

2.5.2.1.3 Post-conditions and Significant Results

The energy transaction is complete, EV battery is charged to the configured amount, and a meter reading of the energy consumed by the Energy User is logged with the Energy Supplier.

Actor/Activity	*Post-conditions Description and Results*
EV	Battery is charged
EV User	Energy transaction recorded

2.5.3 Function: International Roaming Public Charge Points

2.5.3.1 UC-LT-IRCP Brief Description

This function focuses on when an electric vehicle owner / user has to travel a long distance crossing an international boundary and therefore, the user knows that they will have to recharge his EV battery at least twice during his journey and, as such, they will need to make use of public charging point facilities in another country.

In order to get the best recharging tariffs, he uses a service provided by a third party that enables him to identify available charge points and then choose between different tariffs that can be offered by these charge points (charge points can have different tariffs on a single post).

The service will monitor the user's current position and track the progress of the vehicle. At the same time, the service knows the location, cost and availability of nearby charging points (CP) and relays this information to the customer. Battery conditions, consumption requirements, trip duration, as well as weather conditions and landscape profile are the key information to determine the estimated range of the EV. All conditions need to be available and regularly updated in the mobility centre.

Since the charge points will allow open access to all licensed energy suppliers, Homer knows he will be able to choose the supplier that offers the lowest tariff for energy, though he will be obliged to pay the supplier at the time that he uses the charge point via the local payment facility.

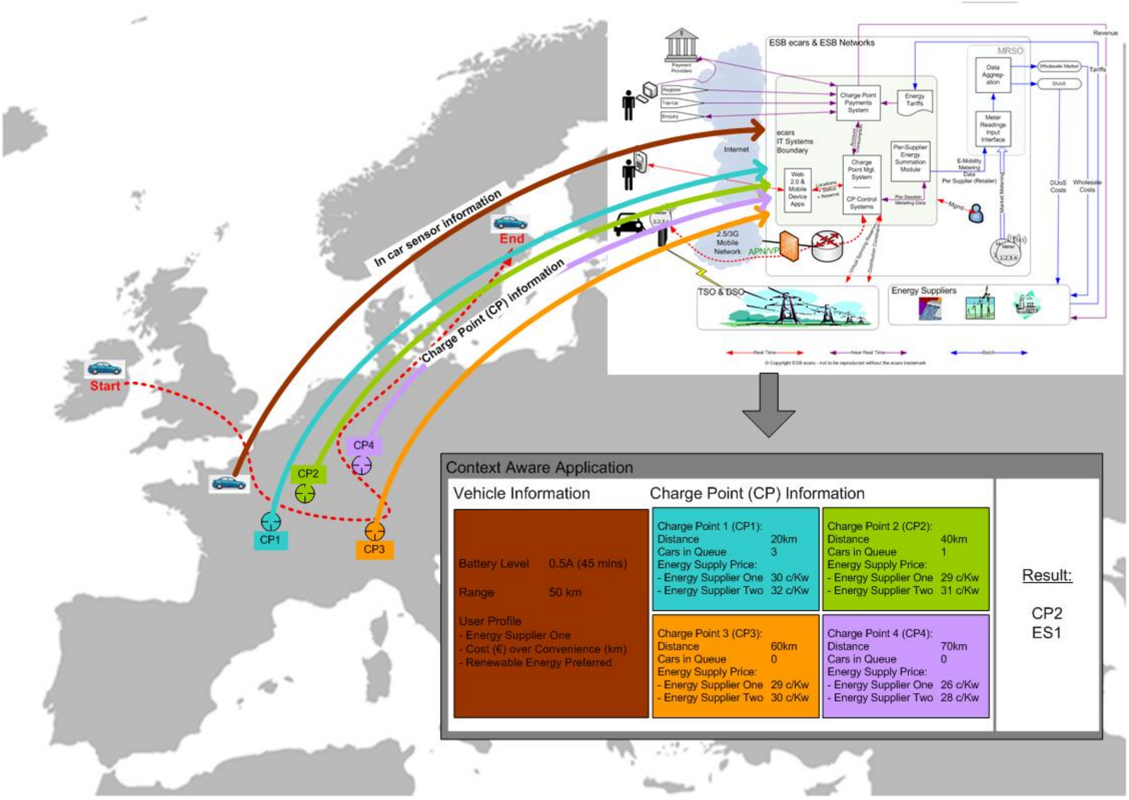


Figure 27 Storyboard for the availability of charge points

2.5.3.2 Diagram

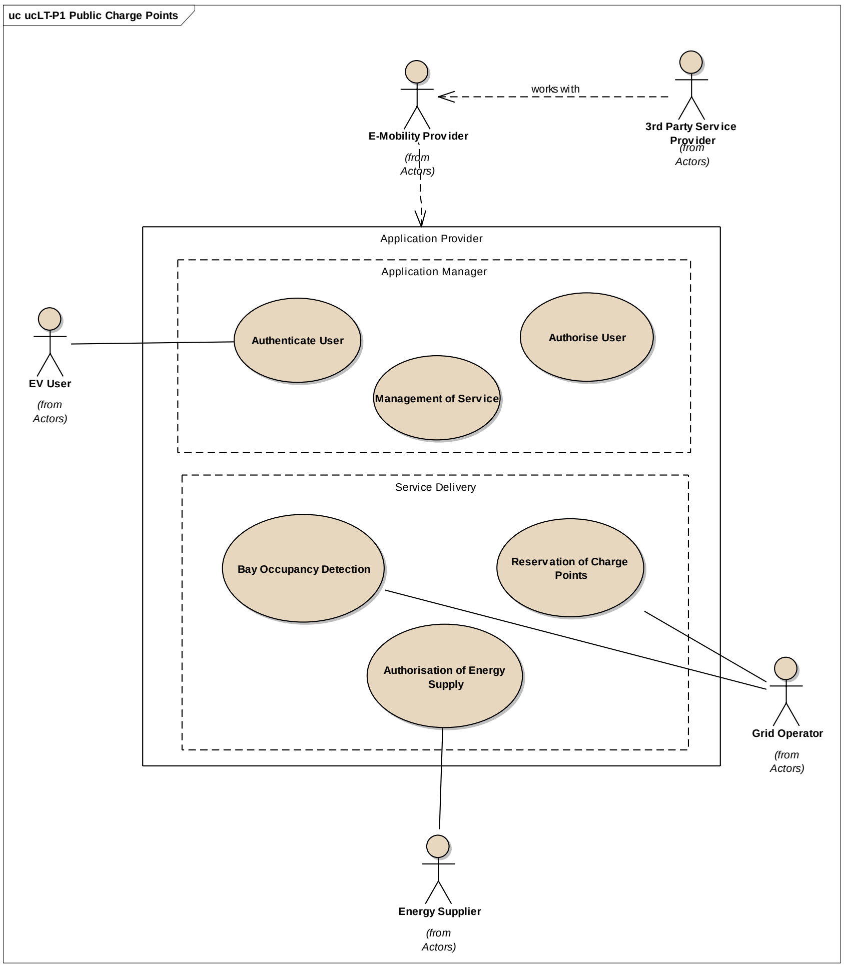


Figure 28 Stakeholder diagram for UC-LT-IRCP International Roaming Charge Points

2.5.3.3 Narrative

The context information about the user, his journey and the vehicle he is travelling in will be continuously uploaded to a geo-location service which will provide up-to-date intelligence about the availability, cost and accessibility of any charging points (CP) en-route to his destination. Concurrently, the service provides information about the tariffs, the queue length (how many users are currently waiting to use the CP), distance to nearest CPs and current battery level for optimum CP selection.

This scenario aims to understand how user-context and operator-context information can be integrated to create and support enhanced services for the end-user. This service takes critical information from the in-car sensors (battery level, localized weather, driving conditions) and combines it with additional general information such as route congestion, distance, topology, regional weather forecasts, etc. as well as user-sensitive profile information (preferred supplier, cost over convenience, etc.). Finally, the service merges all of this with information related to the supply capabilities of the grid and associated charging points.

Context information can be transmitted from the in-car sensors to the sensor collection agents via high-speed mobile broadband access networks such as 3G or LTE. Beyond the access network, a secure, high-speed fixed network is required to ensure delay-sensitive applications can be supported.

These sensor agents may reside with the operator (mobile or energy) or be owned by virtual operators “in the cloud”. Availing of services in this way will allow for services to be deployed with increased efficiency and management, and allow for optimum service development by third parties.

For similar additional scenarios related to information, availability and usage of charge points please also refer to *UC-ST-P Scenario A: Municipal parking place* (section 2.3.3.3), *UC-MT-CPA Scenario C:*

Planned charging using operator pre selection (section 2.4.1.3) and *ucVAS Scenario C: General Information Services* (section 2.7.1.3).

2.5.3.4 Actor (Stakeholder) Roles

Grouping (Community)		*Public Charge Points*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
End user (Driver)	Person	A person that uses the electric vehicle (EV) at a specific point in time.
Energy Supplier	Organization	Company that provides energy to the location where it is requested.
EVSE Operator	Organization	Operates a set of public or semi-public charge stations, uses the services of BSP, CHO, IAS, and FCH. It may have an agreement with the parking space operator.
3rd Party Service Provider	Organization	3rd Party (Auxiliary) Service Provider maintain additional services (weather, road topology info) that can be used by E-Mobility provider to offer auxiliary services to the EV user.
E-Mobility Service Provider	Organization	Provides value added services for individual mobility. In this scenario, the service requires collating the necessary information from the grid operators, the EV user and the third party service providers in order to provide the EV user with information about the availability of charging points.

2.5.3.5 Information exchanged

Information Object Name	*Information Object Description*
Notification	Digitalized information that can be a list of information items or an event notification of the charging point and/or service. For operator • Idle • Vehicle Power • Access Door • Over-Temperature • Parking Bay Occupation Status • Number of vehicles queuing and estimated charge times of queued vehicles For Application Provider • Battery level of car • Bay Occupancy Status (busy / idle) For End User: • Battery Level
Request	Digitalized message requesting a particular task, e.g. • Bay Occupancy Status • Energy Supplier Availability • Charging Point capabilities (high speed / low speed) • Price signal update • Booking fee & cancellation fee • User Profile Details
Command	Digitalized message to order a concrete action, e.g. • Authenticate

Information Object Name	Information Object Description
	• Start charging • Stop charging • Reserve timeslot at charging point (Assume high speed)
Answer	Digitalized message answering a request, e.g. • Context Information • Supplier Details • Charging capabilities (high speed / low speed) • Price details • Confirmation of reservations

2.5.3.6 Activities/Services

Activity/Service Name	Activities/Services Provided
Authorization	Authorize a person or organization for service access
EVSE information	Information on EVSEs' location, status (occupied), features etc. • Idle (Ready) • Session Start • Charging in progress • Session Termination
Monitor and record	Charging stations should record & report measurements during charging sessions in parallel with energy readings
Process Reservation requests	EV users may reserve access to a specific Charging Station at a specific date & time via the Charge Point Management Station (CPMS).
Cancellation Management	Manage charges that apply for booking and not making use of allotted time e.g. failed arrival of EV User. Converse applies also - if EV User cannot make use of EVSE during allotted time e.g. if CP bay is blocked by another vehicle.
Bay Occupancy	To detect idle or occupied bays at charging station locations.
Service / Application information	Information on services
Service / Application reservation	Reservation of services

2.5.3.7 Contracts/Regulations

Contract/Regulation	Impact of Contract/Regulation on Function
Contracts regarding service delivery	Required contracts between end user and E-Mobility provider. Also, between E-Mobility Service Provider and 3rd Party Service Provider
Contract for energy delivery	Required contracts between the end user and energy supplier
Contract for connectivity	Contract between end user and communication network provider for network access and access to internet
Contract between E-Mobility Service Providers	Contract for management and maintenance of service between the domains of E-Mobility Service Providers

2.5.4 Step by Step Analysis of International Roaming Public Charge Points Function

2.5.4.1 Steps for Function "Availability of Public Charge Points using third party services"

2.5.4.1.1 Preconditions and Assumptions

The user in this scenario is not authenticated to the Smart Grid. Rather, their authentication lies with the service provider. As such, the method and process for authentication of users to some third party service (in the cloud) is outside the scope of EV scenarios.
In this scenario, EV User subscribes to a service provided by a third party which provides the EV User with information about the availability of charge points along his/her route.

Once authenticated by the service provider, the context information about the EV (user profile information, battery level, preferred supplier) is requested by and transmitted to the service provider. Concurrently, additional information (weather information, route information, etc.) as well as information about the charge points (occupancy status, supplier information (high voltage / low voltage) is also requested and provided.
The third party analyses all of this information and relays the options available to the EV User. The EV User reserves the charge point that best suits their needs.
Once the EV reaches the charge point, it is authorized to begin charging at which point the Energy Supplier provides the EV with energy.

2.5.4.1.2 Steps – Availability of Public Charge Points using third party services

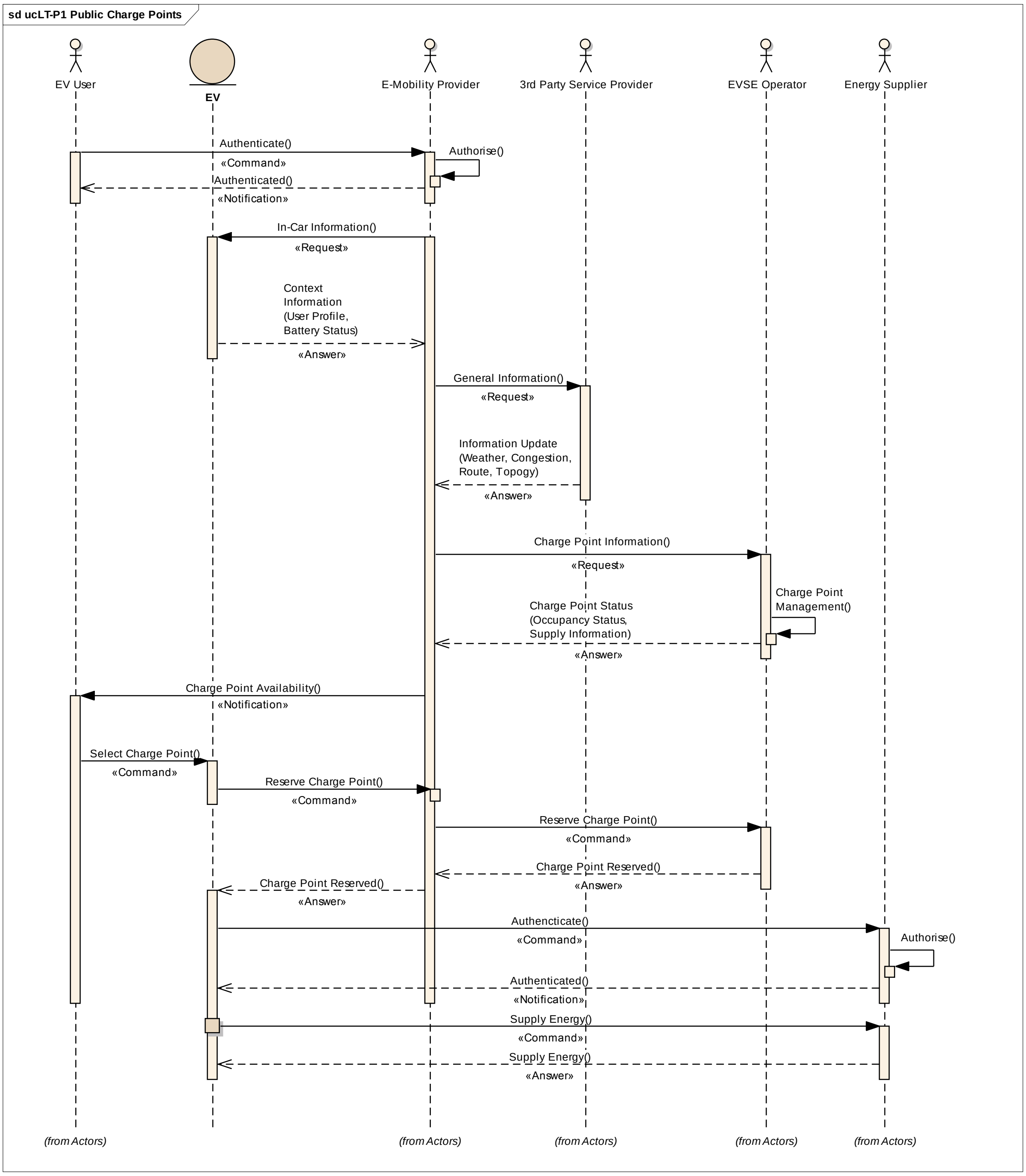


Figure 29 Availability of Public Charge Points

2.5.4.1.3 Post-conditions and Significant Results

The user is obliged to pay for any energy that is supplied – therefore, he/she must use a method of payment that is available at the charge point – credit card, phone payment, etc.

For further details on authentication and authorization techniques and processes, please refer to *UC-LT-A Authentication of User* (section 2.5.1).

2.5.5 Function: Payment Methods

This use case is analogous to the mobile phone Pay as you go (PAYG) ‘top-up’ system in which the user pays in advance to obtain a level of credit. This credit is then debited when the user charges their EV.

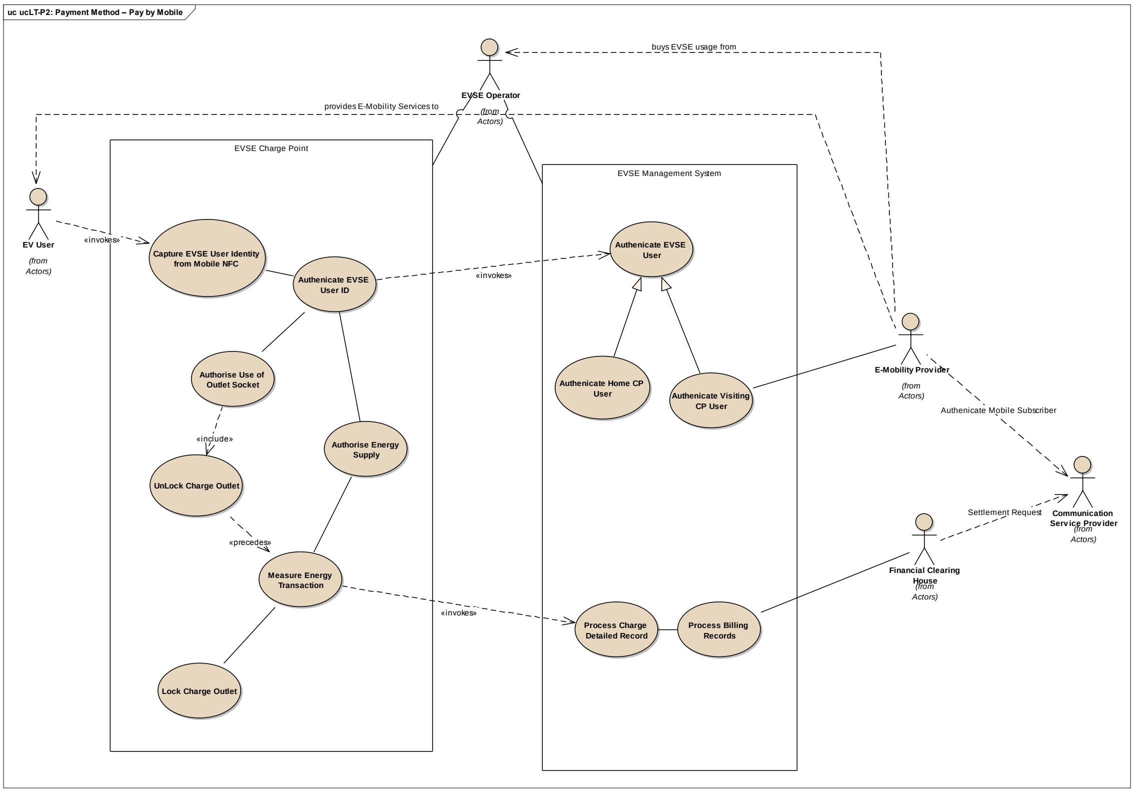
2.5.5.1 UC-LT-PM Brief Description

There are couple of possible ways in which the PAYG credit can be handled:

1. The EVSE communicates with the supplier/aggregator at the start of charging to verify the user's identity and the amount of credit they have available. After charging, the user and energy usage data are sent back to the supplier/aggregator where the amount of credit is requested from the EV Users mobile phone operator.
2. User details and the amount of credit remaining are stored on the device used for authentication (e.g. mobile phone, RFID smartcard), this device is updated with the new credit level once charging has completed. The user can purchase more credit from a central point (e.g. top-up station). This saves the EVSE from needing to communicate with the DSO, supplier/aggregator or mobile phone operator.
3. Text top up: The user sends a SMS to the EVSE Operator, who then charges the user’s mobile phone a fixed amount. The EVSE owner may also use this system to control access to the EVSE by sending an authorization code by SMS for the user to input to the EVSE CP.

This overall use case may not be as plug-and-play as originally thought; however it is convenient for the EV user. It also contributes additional administration to the bill generation as there will need to be a link between the EVSE Operator, Energy Supplier and mobile phone operator.

2.5.5.2 Diagram



2.5.5.3 Narrative

The EV User parks their car at an EVSE CP, and using a mobile phone with near field communication (NFC) their credentials are read by the EVSE. Their identity is authenticated for use of the EVSE and the supply of energy to the car battery. When the charge point outlet socket is unlocked and the EV plugged

in, the on-board-PC of the car and the EVSE exchange battery profile data about the amount of energy needed to charge the battery. The EVSE operator checks with the mobile phone operator that the EV User has enough credit to pay for the supply energy (based on the profile exchange) and if they do, the energy transaction is started.
Once the energy transaction is stopped, and the plug is removed from the EVSE outlet socket, the EVSE operator will send a charge detailed record to its billing system, which will in turn send a settlement request to a Financial Clearing House. The Financial Clearing House shall inform the mobile operator of the settlement request.

2.5.5.4 Actor (Stakeholder) Roles

Grouping (Community) '		*Group Description*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
EV User	Person	For this building block it is foreseen that the EV User is an Individual EV User (IVU) that has brought their EV on an international long trip.
EVSE Operator	Organisation	Owner and operator of the EVSE.
E-Mobility Service Provider	Organisation	Given that the EV User has travelled from his home Country A to a visited Country B, the E-Provider offers a roaming contract, which will allow the EV User to use an EVSE in Country B
Communication Service Provider	Organisation	As the EV User is using their mobile phone to pay for the electricity transaction, in this case the CSP may act as an authenticator of the EV Users' mobile subscribers credentials
Financial Clearing House	Organisation	Once the electricity transaction is complete the EVSE will send a financial settlement request to the FCH

2.5.5.5 Information exchanged

Information Object Name	*Information Object Description*
Notification	Digitalized information that can be a list of information items or an event notification of the charging point and/or service, e.g. • EVSE User id to the EVSE • Charge Outlet Connected / Disconnected • Stop Transaction • Transaction Complete • Bill Transaction
Request	Digitalized message requesting a particular task, e.g. • Authenticate User • Authenticate Roaming User • Start Energy Transaction request. • Bill Settlement • Settle Transaction
Answer	Digitalized message answering a request, e.g. • Authenticate User Response • Authenticate Roaming User Response • Start Energy Transaction Response • Bill Settlement Response • Settle Transaction Response
Command	Digitalized message to order a concrete action, e.g. • Start/Stop Charge

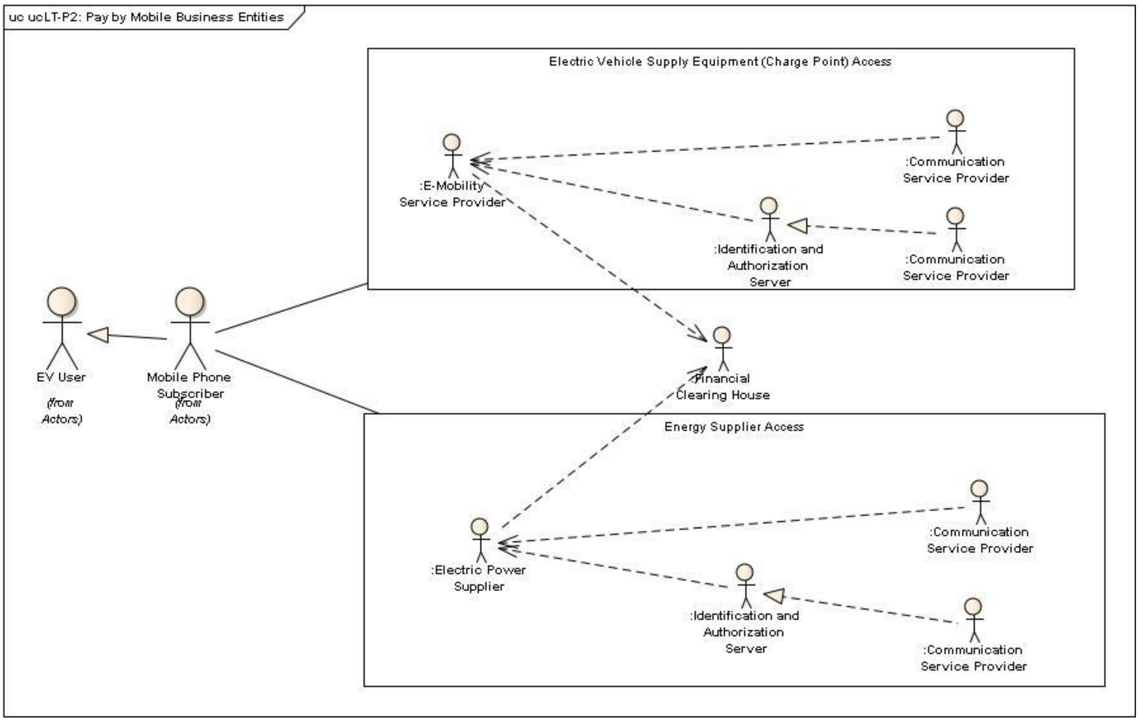
2.5.5.6 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
EV User -> E-Mobility Service Provider	EVSE Operator will have to use the E-Mobility providers' authentication services.
EVSE Operator -> E-Mobility Service Provider	The Billing systems of the EVSE and EMSP will have to communicate bill settlement messages, this may require international roaming agreements.
ESMP – Communication Service Provider	ESMP will have to use the CSPs authentication services.
ESMP & CSP -> Financial Clearing House	ESMP and CSP will have to clear their transaction through the FCH

2.5.6 Step by Step Analysis of Payments Methods Function

2.5.6.1 Steps to implement function – Pay by Mobile

2.5.6.1.1 Preconditions and Assumptions



Actor/System/Information/Contract	*Preconditions or Assumptions*
EV User	Has a Universal EVSE/Energy User ID stored on their mobile phone Has a subscription with a E-Mobility Service Provider.
EVSE Operator	Can use the authentication / authorisation services of the E-Mobility Service Provider.
E-Mobility Service Provider	Can use the authentication / authorisation services of the communications service provider (i.e mobile phone operator)
E-Mobility Service Provider	Can send settlement request to Financial Clearing House
Communication Service Provider	Can receive settlement request from FCH

2.5.6.1.2 Steps – Payment Methods Pay by Mobile

Once the EV User parks at an EVSE CP, the EV User has to be authorised to have the energy transaction started once the EV is plugged into the EVSE CP outlet socket.

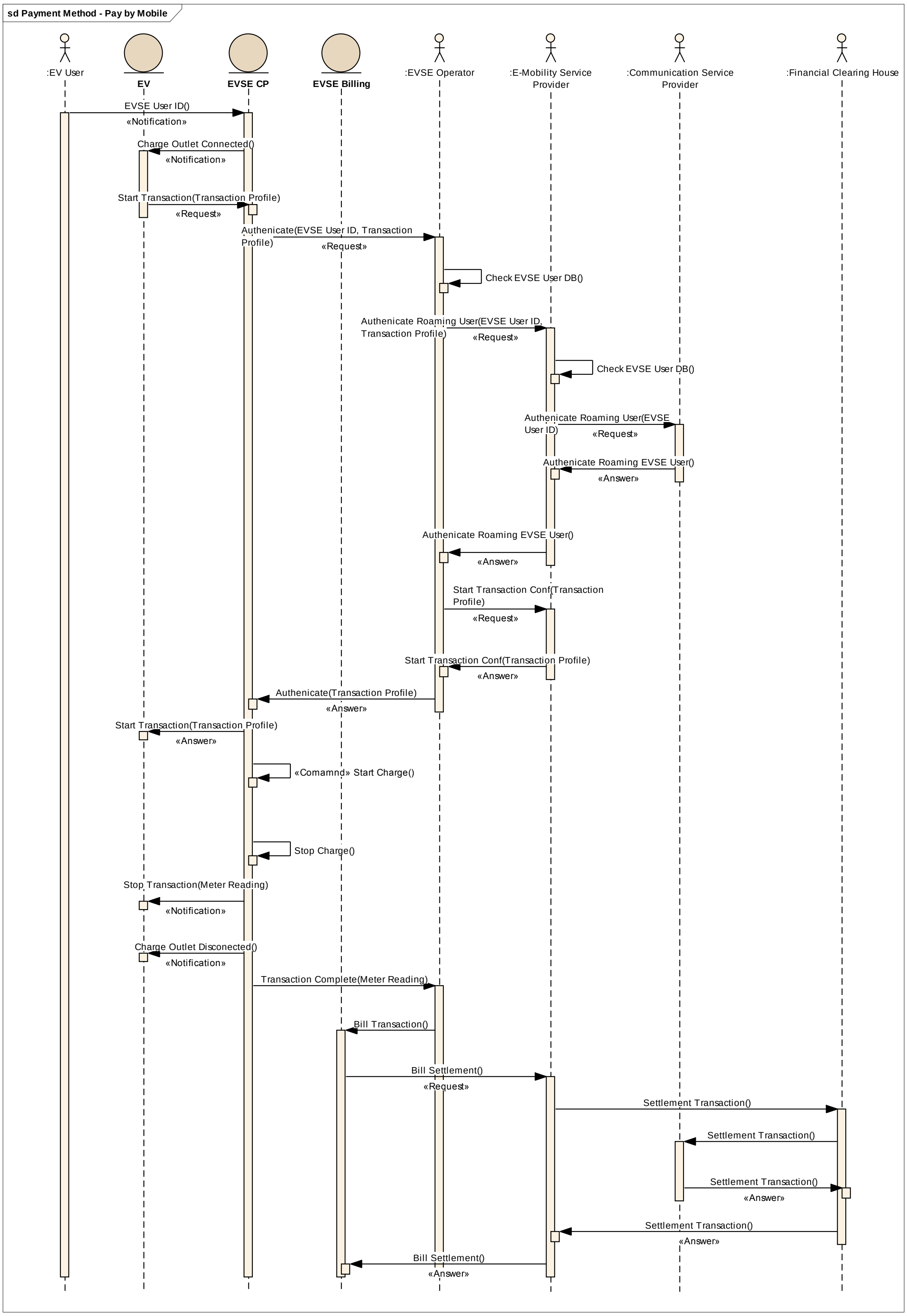


Figure 30 Payment Methods Pay by Mobile

2.5.6.1.3 Post-conditions and Significant Results

The energy transaction is complete, the EV battery is charged to a configured amount, and a settlement transaction for the energy consumed by the EV User is logged and sent to the financial clearing house.

Actor/Activity	Post-conditions Description and Results
EV	Battery is charged
EV User	Energy transaction recorded and paid via CSP (mobile phone provider) bill.

2.5.7 Function: EV User renting a car in another country

2.5.7.1 UC-LT-EVC Brief Description

A car rental company offers EV to customers and the EV is allowed to use commercial fast charging stations.

2.5.7.2 Diagram

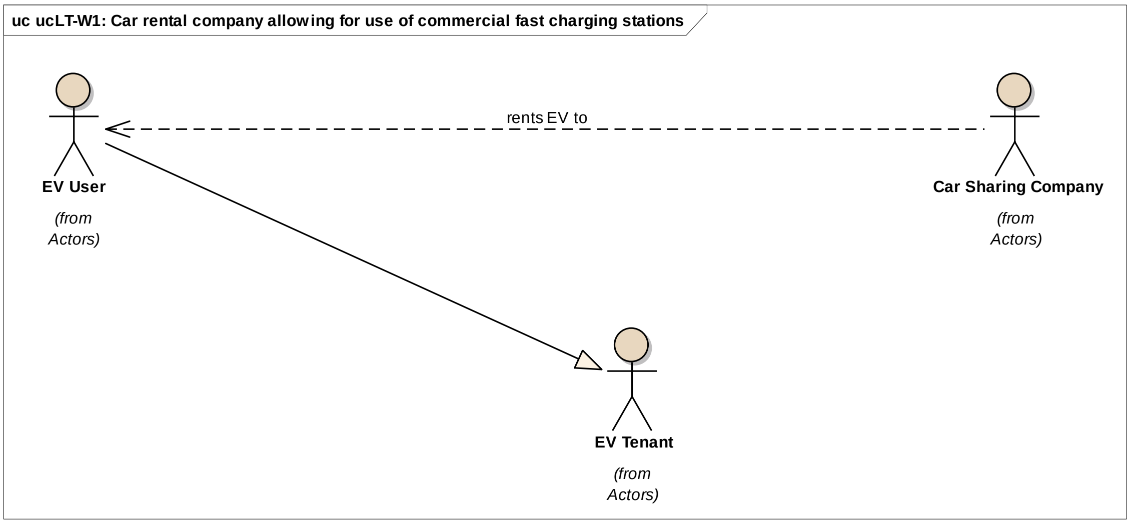


Figure 31 Stakeholder Diagram for UC LT Car Rental Company

2.5.7.3 Narrative

In this scenario, the EV user is offered with enhanced services (e.g. high share of city drives or ecological awareness of customer). The company manages to provide fully charged EV at car rental start, in many cases customers need to be able to charge on the way. Therefore, the company entitles everybody to use fast charging stations of a partner company (e.g. via charge cards). Just parking without charging is not permitted in these areas.

The energy is transferred conductively in a uni-directional way from the grid to the EV. No charger need to be installed on the EV side if DC charging is used for the fast charging, e.g. with CHADEMO plugs.

2.5.7.4 Actor (Stakeholder) Roles

Grouping (Community)		Rental Company allowing for EV to use commercial fast charging stations
Actor Name	Actor Type (person, organization, device, system, or subsystem)	Actor Description
End user (Driver)	Person	The EV User in this instance is someone who leases the EV from the Car Sharing Company
Shared Mobility Provider (SMP)	Organization	Owns a vehicle fleet and rents it to an individual or a set of EV users on a pro rata temporis base, e. g. car sharing or car rental
Energy Supplier	Organization	Company that provides energy to the location where it is requested.

2.5.7.5 Information exchanged

Information Object Name	*Information Object Description*
Notification	Digitalized information that can be a list of information items or an event notification of the charging point and/or service.
Request	Digitalized message requesting a particular task
Command	Digitalized message to order a concrete action
Answer	Digitalized message answering a request

2.5.7.6 Activities/Services

Activity/Service Name	*Activities/Services Provided*
Authorization	Authorize a person or organization for service access
Monitor and record	In car sensors should record
Service / Application information	Information on services
Service / Application reservation	Reservation of services

2.5.7.7 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
Contract for use of EV	Required temporary contract between EV tenant and Car Sharing company
Contract for energy delivery	Required contract between Car Sharing company and energy supplier

2.5.8 Step by Step Analysis of EV User renting a car in another country Function

2.5.8.1 Steps to implement function "Car Rental Company allowing for use of commercial fast charging stations"

2.5.8.1.1 Preconditions and Assumptions

The EV Tenant becomes the EV User for the duration that he/she rents the EV. They are granted access to the selected EVSE points of the energy supplier of the Car Rental Company. While it is likely that the electricity consumed will be placed on the car rental bill, for the purpose of this use case we have assumed that the EV User could use the EPS from their home country to pay for the fast charging facility that they are able access at the EVSE point.

The EV User need not have any prior association or contract with the Car Rental Company or energy operator. They should be able to arrive at the car rental company and drive away with an EV if they follow standard processes for renting a vehicle e.g. provide sufficient proof of identity, security deposits, etc.

The responsibility for authorized access to EVSE (for the EV tenant) lies with the Car Rental Company and their association with the energy supplier.

2.5.8.1.2 Steps – EV User using rented car to access ESVE

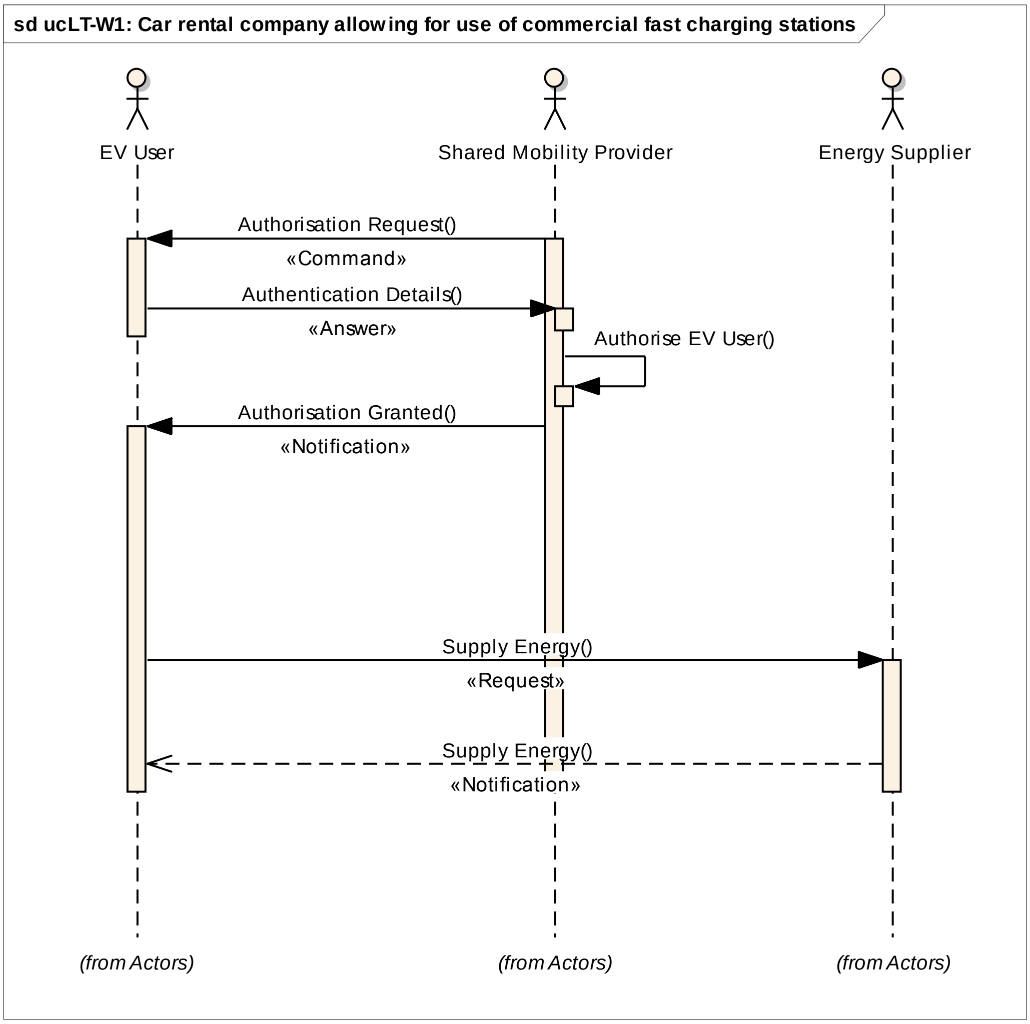


Figure 32 EV User using rented car to access ESVE

2.5.8.1.3 Post-conditions and Significant Results

Similar to normal car rental practices, the EV User is obliged to return the EV to one of the Car Rental Company depots, in which case there are two options:

1. the EV is fully recharged prior to being returned.
2. the EV can be recharged back at the depot. This is usually at a greater expense to the EV tenant than if they had recharged using normal recharging facilities.

2.6 Use Case Grid Operational

2.6.1 Function: Charge Load Management

2.6.1.1 UC-GO-CLM Brief Description

While energy suppliers (retailers) can benefit from an extension of their market, grid operators (DSO) might be faced with serious problems as to overload situations with parallel charging processes of many electric vehicles (EV). In general terms, DSOs need controlled charge mechanisms (see ucST-H in section 2.3.1). To support those mechanisms and to prevent harmful situations, DSOs might apply the following principles:

Scenario A: prediction of charge loads – to prepare for stress situations

Scenario B: optimized charge scheduling – to charge EVs without exceeding the capacity of the local power grid

2.6.1.2 Narrative

Scenario A: prediction of charge loads
A Grid Operator – let us call him Gropper - wants to prevent its infrastructure from unexpected demand peaks that originate from EV charging. Gropper contracts an intermediate (such as a clearing house or mobility provider) who in turn contract a private car owner – say Bob – or a group of such to announce their regular charge events one day, one week or one month ahead. While unannounced charging will always be possible EV-users will benefit from sticking to their prognosis.

The challenge is that Bob wants to participate in the model and get some remuneration – but he does not want Gropper or the intermediates that handle the system to be able to track his journeys and lifestyle. In general terms Gropper must provide Bob with the right to charge at a reduced rate if doing so in the announced area (i. e. the predicted part of the distribution grid) and time without knowing Bob as an individual.

Bob most probably will have a contract with an energy supplier or mobility provider. So while *Bob* does not have a contract with *Gropper,* remuneration of his prognosis support to *Gropper* should be done through a rebate, special tariff or other means on his normal EV charging bill.

Scenario B - optimized charge scheduling
The Charge Park Operator (CPO) wants to charge the EVs at his charge stations without exceeding the capacity of the local power grid belonging to the Distribution System Operator (DSO), taking further conditions into account. This is as the DSO wants to prevent its infrastructure from unexpected demand peaks and the CPO would be subject to penalties if the EV load exceeds the grid capacity.

Additional conditions refer to user preferences, energy prices or grid conditions. The EV Users want their EVs to be charged to a certain level by the time they are leaving the charging station. Fluctuating energy prices bear the potential to use EVs as energy buffers: reducing charging loads in times of high demand, and increasing loads during times of low demand. This has a stabilizing effect on the energy system and provides an incentive for the CPO as this may increase their profit (since the provider gets negotiated but fixed prices from the EV Users while the energy prices and local power grid capacities might change and further EV Users might want their EV charged).

The challenge is to continuously calculate a (near) optimal schedule for charging all EVs connected to the Charge Stations that fulfils the restrictions given by the EV Users as well as by the DSO. Further, this schedule should consider the current energy prices as this might generate further revenue for the CPO. Whenever the preconditions change (a further EV to be charged, changed energy prices etc.) the scheduling algorithm must adapt.

2.6.1.3 Actor (Stakeholder) Roles

Grouping (Community) '		*Group Description*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
Electric Vehicle (EV)	Device	an electric vehicle
Individual Vehicle User (IVU)	Person	uses the same vehicle all the time (by either buying or leasing it or getting it for individual use from an IMP)
Shared Vehicle User (SVU)	Person	uses a given set of vehicles on demand together with other users (e. g. in a car sharing partnership or using a car rental system)
EV User	Person	a general EV user, can be an ISU or an SVU
Individual Mobility Provider (IMP)	Organization	owns vehicle and / or battery and has a contract with the end user to provide full service on the one hand side and multiple hardware and service providers on the other hand side ("sells the mile to an individual")
Shared Mobility Provider (SMP)	Organization	owns a vehicle fleet and provides it to a set of users on a pro rata temporis base, e. g. car sharing or car rental ("provides the right vehicle at the right time")
Electric Power Supplier (EPS)	Organization	vendor of electricity
Electricity Grid Operator (EGO)	Organization	operator of electricity grid (in this case most probably distribution grid only)
Distribution System Operator (DSO)	Organization	an EGO, operates the local electricity distribution grid
Billing Service Provider (BSP)	Organization	supporter for billing of charging events
Financial Clearing House (FCH)	Organization	Company that takes over financial clearing. It may also issue billing between involved partners. allows for cooperation of multiple BSPs
Identification and Authorization Server (IAS)	Organization	provides various secure services to intermediates such as user authentication, guarantees for privacy etc.
EVSE Operator	Organization	Operates set of public or semi-public charge stations, uses services of BSP, CHO, IAS and may have an agreement with the parking space operator.
Charge Park Operator (CPO)	Organization	operates a locally connected set of charge spots like we know it from gas filling stations (allowing for optimization process in terms of grid connection and user services)
Charge Station	Device	a station for charging EVs belonging to a CPO

2.6.1.4 Information exchanged

Information Object Name	*Information Object Description*
Charging announcement	Information on planned charge events one day, one week or one month ahead. One announcement dataset can contain multiple announcements, each comprising: expected area or charge spot to be used + expected time range for charge event (start and stop) + expected amount of power to be loaded
Charging tokens	unique identifier that is linked to an announcement; token contains the ID of its issuer (i. e. EGO or EPS) and all predicted information
BSOC	battery state of charge
Charge Time Frame	Time frame during which the charging should be performed. At the end of the time frame, the BSOC must have the required Minimum BSOC.

Information Object Name	*Information Object Description*
Minimum BSOC	the desired state of charge to be reached during the Charge Time Frame
Energy Prices	the (expected) energy prices for the next hours
Grid Capacity	the (expected) capacities of the local power grid for the next hours
Charge Tariff	the price offer for charging the EV under the constraints given (Charge Time Frame, Minimum BSOC)

2.6.1.5 Activities/Services

Scenario A - prediction of charge loads

Activity/Service Name	*Activities/Services Provided*
contracting	IVU or SVU contract with EPS, IMP, ESA or FCH EGO contracts with various EPS, IMP, ESA and FCH
announcing	Using a well guided man-machine-interface IVU or SVU describe their charging plans for the next day, week or month ahead. For each event they announce the expected area or charge spot to be used, the expected time range for the charge event (start and stop) and the expected amount of power to be loaded and send it to their contractual partner. Announcements are forwarded to their contracted EPS, IMP, ESA or FCH
logging in	For each announcement (i. e. each predicted event) IVU / SVU receives a charging token which is stored in their charge management system
planning	The receiver of the announcements (i. e. EPS, IMP, ESA or FCH) forwards the announcements in the form of the token (i. e. info on planned area, time and amount of power) to the respective EGO
charging	When charging is started (using standard charging procedures, see other use cases) IVU / SVU present their token. The billing service provider (BSP) checks with the EVSE Operator if the token matches the actual charging area, time and amount. If so IVU / SVU gets a rebate.
reimbursing	in cases of matching prediction and action billing makes sure that the charge service providers gets reimbursed by the benefiting EGO
killing token	When predicted time expires tokens are remove from all places where they have been stored.

Scenario B - optimized charge scheduling

Activity/Service Name	*Activities/Services Provided*
Connecting	the EV User connects her/his EV to the Charge Station, the actual BSOC is exchanged automatically from now on
Specifying Preferences	the EV User specifies at the Charge Station the Charge Time Frame and the Minimum BSOC
Tariff Offer	the Charge Station provides an offer for charging the EV (Charge Tariff) or rejects the request if it cannot be fulfilled
Accepting	the EV User accepts the Charge Tariff
Rejecting	the EV User rejects the Charge Tariff
Charging	the EV is charged
Scheduling	the CPO calculates a new schedule which takes all current charging processes and all newly connected EVs into account, as well as the current Energy Prices and Grid Capacity

2.6.1.6 Contracts/Regulations

Scenario A - prediction of charge loads

Contract/Regulation	*Impact of Contract/Regulation on Function*
prediction contract	IVU or SVU contract with EPS, IMP, ESA or FCH: IVU / SVU promise to announce their charging events as good as possible. Their partners promise

Contract/Regulation	*Impact of Contract/Regulation on Function*
	to maintain privacy about the predictions as well as the charging events. Their partners make sure that IVU / SVU benefit from exact predictions.
planning contract	EGO contracts with various EPS, IMP, ESA and FCH: EGO will receive announcements from its partners as they get them from their IVU / SVU. EGO will remunerate its partners who in turn can give rebates to their IVU / SVU to honor their good predictions. (Note: Today's regulation framework may not allow such a contract. Still for the future we assume that this will be possible – maybe thru an intermediate such as the ESA)

Scenario B - optimized charge scheduling

Contract/Regulation	*Impact of Contract/Regulation on Function*
Grid Connection Contract	the CPO contracts with the DSO
Energy Supply Contract	the CPO contracts with the EPS
EV Charging Contract	the EV User contracts with the CPO (might be an instant one-off contract)

2.6.2 Step by Step Analysis of Charge Load Management Function

2.6.2.1 Steps to implement prediction of charge loads

2.6.2.1.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
Individual Vehicle User (IVU); Shared Vehicle User (SVU)	This function assumes that users of electric vehicles are prepared to deliver predictions as to charging events
EVSE Operator Billing Service Provider (BSP) Clearing House Operator (FCH)	This function assumes that there is a system in place to manage charge spots and to create bills inclusive roaming between multiple EVSE Operator
Electric Power Supplier (EPS) Electricity Grid Operator (EGO)	We assume that future regulation allows grid operators and power suppliers to jointly manage the load of the grid. This needs new approaches to the unbundled system. Maybe a new market role such as the Energy Service Aggregator (ESA) can close the gap.
Individual Vehicle User (IVU); Shared Vehicle User (SVU)	For privacy reasons users are assumed to not be willing to disclose their travel plans and executed charge events

2.6.2.1.2 Steps – Scenario A: prediction of charge loads

The following picture describes the information flow of the sub-function:

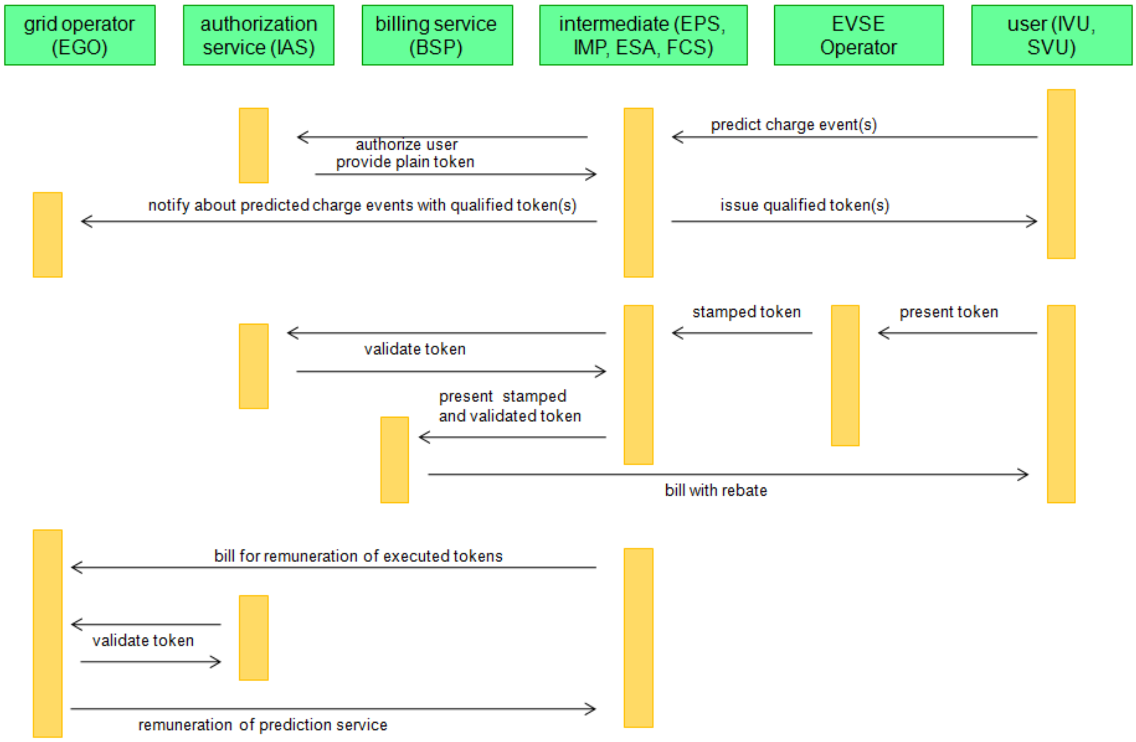


Figure 33 Information flow for prediction of charge loads

2.6.2.1.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
EGO	With many valid prediction tokens the grid operator is better in operating and balancing the grid.

2.6.2.2 Steps to implement optimized charge scheduling

2.6.2.2.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
EV User	We assume that the EV User is able to specify for how long the EV can be charged (Charge Time Frame), e.g., at which point of time she/he wants to use the EV again.
Distribution System Operator (DSO) Electric Power Supplier (EPS)	We assume that the DSO and the EPS send Energy Prices and Grid Capacity information automatically to the CPO on a regular basis.
Charge Park Operator (CPO)	For this function the exact scenario how the CPO is related to the EV User does not matter. Therefore, payment issues are not considered. EV User and CPO might have a long-term contract, roaming from other CPOs might be possible etc. Here we describe the easiest way – think that the EV User pays instantly at the Charge Station in cash or via credit card.

2.6.2.2.2 Steps – Scenario B: optimized charge scheduling

In this function, an EV User connects the EV to a Charge Station that belongs to a CPO and specifies preferences. If this charging request can be fulfilled, the CPO calculates a Tariff Offer for charging the EV according to the preferences, other current charging processes and further conditions. The User can Accept or reject this offer. In case of acceptance, the CPO calculates or updates its charging schedule. Depending on the EV User preferences, all other unfinished charging processes and on current Grid Capacity and Energy Prices, the CPO might start the charging process immediately or schedule it for a later point in time.

The following picture describes the information flow of the sub-function:

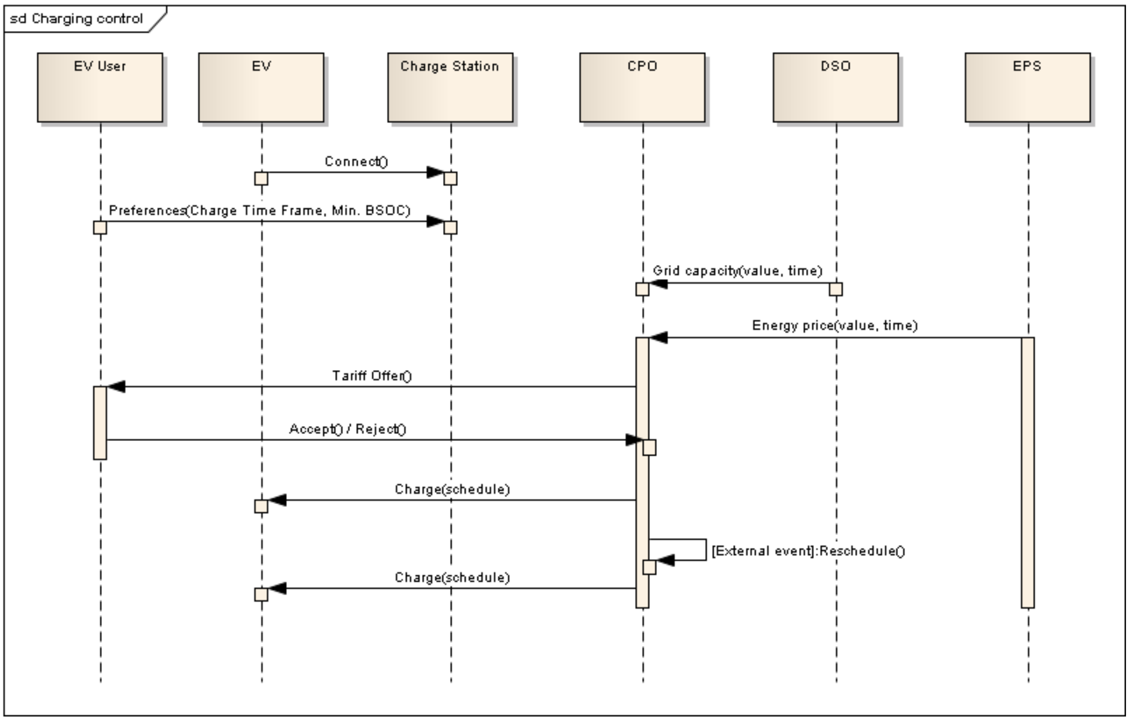


Figure 34 Information flow for optimized charge scheduling

2.6.2.2.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
EV User & EV	At the end of the specified Charge Time Frame, the EV is charged and its BSOC has at least reached the specified Minimum BSOC.
CPO	At the end of a day, all started charge processes have been successfully finished according to the EV User preferences. By calculating optimized schedules, the CPO has generated revenue (the CPO has shifted all possible charging processes to time slots where energy is cheap) and has avoided paying penalties to the DSO.
DSO	Due to an optimized charging schedule, there have not been any unstable situations in the distribution grid.

2.6.3 Function: Management of Stationary Energy Stores

2.6.3.1 UC-GO-SES Brief Description

Most of the renewable energies to charge EV's are volatile. And grid operators (DSO) might be faced with serious problems as to overload situations with parallel charging processes of a many electric vehicles (EV). To overcome both situations one might use stationary energy stores to outbalance load and generation peaks

2.6.3.2 Narrative

A Grid Operator – let's call him Gropper - might cooperate with the operator of a charge spot park – since such stations are similar to today's filling stations let's call him Filler – in a way that both together operate a stationary storage such as huge battery blocks. Another choice would be hydrogen tanks with fuel generated when the grid offers excessive power e. g. from volatile renewable production and using it with fuel cells to generate the power to charge car batteries.

With such an intermediate storage Filler will be independent of the availability of (cheap) power and the accessibility of the grid. He can fit all needs of his customers – at any time and even if many of them demand simultaneous fast charging.

The IT challenge is mainly an optimization problem. It will be in the interest of Filler to load his storage with cheap energy. On the other hand side Filler must have enough power available in case of heavy charge traffic. So in order to maximize his profit Filler depends on prognoses both from energy supply and EV users. In the unbundled energy system one of the questions is if Filler has a contract with his energy supplier – his natural partner – or with the grid operator who benefits most from the buffer at Filler's station. Or with a mobility provider who has contracts with Groppers and Fillers.

2.6.3.3 Actor (Stakeholder) Roles

Grouping (Community) '		*Group Description*
Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
Charge Park Operator (CPO)	Organization	operates a locally connected set of charge spots like we know it from gas filling stations (allowing for optimization process in terms of grid connection and user services) and in this case also owns local storage capacity
Energy Services Aggregator (ESA)	Organization	contracts multiple energy users and generators and especially consumers giving flexibility to the energy system (thru demand side management)
Electric Power Supplier (EPS)	Organization	vendor of electricity
Electronic Energy Marketplace (EEM)	Organization	operator of a market place on which ESAs and potentially IMPs can buy and sell energy and energy related services
Individual Mobility Provider (IMP)	Organization	owns vehicle and / or battery and has a contract with the end user to provide full service on the one hand side and multiple hardware and service providers on the other hand side ("sells the mile to an individual")
Shared Mobility Provider (SMP)	Organization	owns a vehicle fleet and provides it to a set of users on a pro rata temporis base, e. g. car sharing or car rental ("provides the right vehicle at the right time")
Financial Clearing House (FCH)	Organization	Company that takes over financial clearing. It may also issue billing between involved partners. allows for cooperation of multiple BSPs
Electricity Grid Operator (EGO)	Organization	Operator of electricity grid, can be a DSO or TSO

2.6.3.4 Information exchanged

Information Object Name	*Information Object Description*
energy price table	describes price of energy to load stationary storage (expected hourly price for the next 5 days); prices reflect the prognoses for power generation and use
expected charge traffic	statistical data plus data from prediction of charge loads (see function "charge load management")

2.6.3.5 Activities/Services

Activity/Service Name	*Activities/Services Provided*
optimized loading	using the electronic marketplace Charge Park Operator (CPO) regularly checks expected charging events (see function "charge load management") against the load status of the local storage and the table of predicted

Activity/Service Name	*Activities/Services Provided*
	(offered?) energy costs. Depending on those information CPO loads the local storage in times of cheap energy, high expected charge demands etc.
requested loading	CPO has a contract with an Energy Services Aggregator (ESA) and receives requests from ESA to load the stationary storage
charging	depending on the energy price offered from the grid, the load status of the stationary storage, predicted energy prices and the charging needs of the users (e. g. fast charging) CPO decides to charge the EV battery from either the grid or the local storage

2.6.3.6 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
energy contract	CPO has a contract with the Electronic Energy Marketplace (EEM) to receive price tables for 5 days ahead and to execute time and cost optimized energy procurement
charge prediction contract	CPO contracts with various EPS, IMP, ESA and FCH: like the EGO in function "charge load management" CPO receives predictions as to expected charge events at his charge park.
flexibility contract	Charge Park Operator (CPO) has a contract with an Energy Services Aggregator (ESA) to sell his flexibility as a means of grid stabilization

2.6.4 Step by Step Analysis of Management of Stationary Energy Stores Function

2.6.4.1 Steps to implement management of stationary energy stores function

2.6.4.1.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
Charge Park Operator (CPO)	We assume that there is a business case that justifies implementation of a local storage. The alternative would be centralized storages or storages at power generation stations. However, that could cause tremendous load for the distribution grid and unforeseeable grid instability
Charge Park Operator (CPO)	We assume that there is an electronic market place that gives CPO seamless access to intraday and day ahead prices for energy
Charge Park Operator (CPO)	Most probably the business case will work best if there is a charge event prediction system in place (as described in function "prediction of charge loads"

2.6.4.1.2 Steps – Information flow for the Management of stationary energy stores

The following picture describes the information flow of the function:

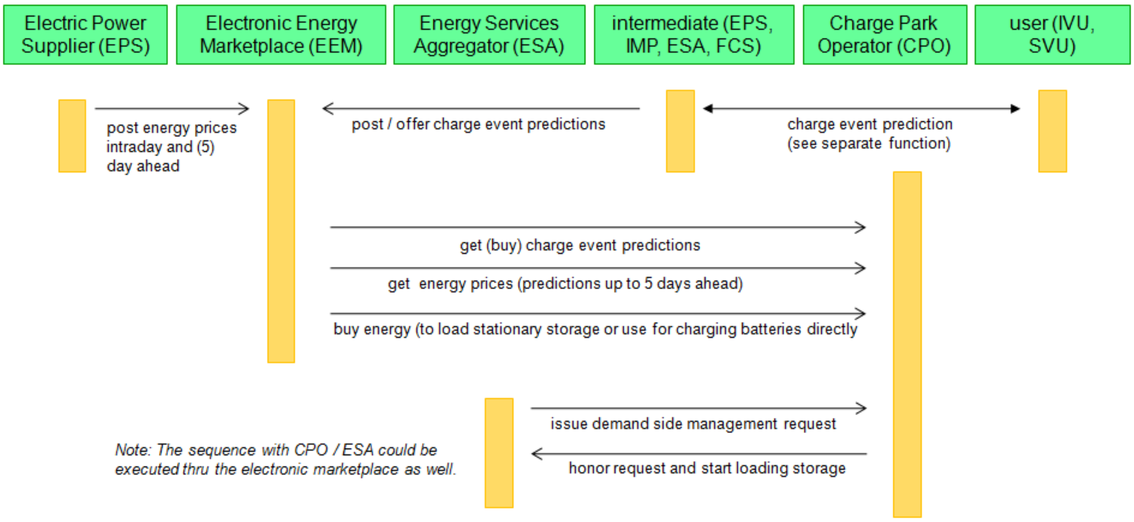


Figure 35 Information flow for the Management of stationary energy stores

2.6.4.1.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
Charge Park Operator (CPO)	By optimally managing its local storage CPO will have a maximum throughput (with few service interruptions or low speed charging due to grid limitations) and thus can maximize its turnover
Charge Park Operator (CPO)	By buying energy in low prices times CPO can maximize his income
Electricity Grid Operator (EGO)	CPOs with local storages help stabilize the grid and reduce need for grid repowering

2.7 Use Case Value Added Services

2.7.1 Function: Enhanced Services

2.7.1.1 UC-VAS Brief Description

This section also assumes that the following electro-mobility key enablers are all in-place and are embedded in national infrastructures. Building on these core set of key enablers, this section tries to identify a number of spin-off value added products and services. It is also assumed that electric vehicles can relatively easily be equipped with these new interactive features and services.

Key enablers include

- Future electric vehicles will have a high speed wireless internet connection
  - so that the driver / user can receive information on charging stations
- Future electric vehicles will have a smart device like an iOS, Android, Windows Mobile, QNX, TomTom, Garmin etc
  - so that the driver / user can visualise maps to closest charging points.
- Future electric vehicles will have embedded geo-location & GPS / Galileo technology
  - so that the driver / user can dynamically plot routes to closest free charging points.
- Data Roaming tariffs will be transparent across Europe and wider countries
  - So that the driver / user can confidently move between states / countries.
- Energy Roaming tariffs will be transparent across Europe and wider countries
  - So that the driver / user can confidently move between states / countries.

2.7.1.2 Diagrams

Figure 36 below depicts a high level view of electro mobility. It is assumed that all future electric vehicles will have high speed communications and cloud service connectivity.

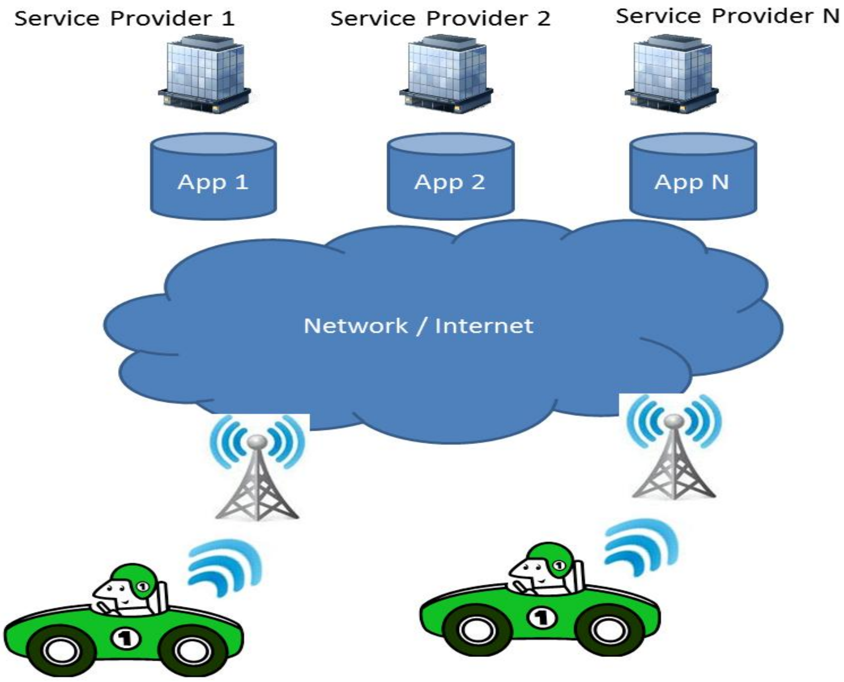


Figure 36 High Level view of electro-mobility

2.7.1.3 Narrative

In the last few years, smart phones and the thousands of applications have enabled a whole new mobile experience. Initially smart-phones were relatively featureless but open API's enabled developers to be creative and develop hundreds of thousands of applications. Key enabling features include new displays, new operating systems, low cost processors, high speed wireless connectivity and built in sensors. As it happens the enabling features for smart phones are the same features currently emerging in electric and regular vehicles and thus a new paradigm of in-car value added applications and services can be enabled. Bearing in mind the sheer volume of apps in the smart phone industry, this section will list a number of applications and scope out a few.

Scenario A - Electricity Grid Load Balancing

Electric Mobility presents some of the same challenges as mobile phone telecommunications networks. The advent of mobile phones and more recently smart phones has resulted in a massive increase in traffic in the network. However the increase in mobile phone traffic is different to traditional traffic patterns. Mobile phones by their nature are mobile devices which results in random traffic patterns for the network operators. Traditionally network engineers were able to plan and engineer telecoms networks with respect to repeatable traffic demands. The mobility aspect of mobile services makes it increasingly more difficult for network operators to plan and engineer networks for random traffic patterns. The mobility aspect of electric vehicles presents a similar challenge to energy providers particularly if spikes in the load occur randomly in the network. Such scenarios may occur during sports events, music events or any other mass congregation. These events need to cater for 1000's of additional electric vehicles, all charging together. Currently there is no mechanism for electricity providers to know the distribution of electric vehicles within their geographical coverage and to dynamical switch power grids in real time, in response to these random demands. One mechanism for facilitating this service is for electric vehicles to wirelessly broadcast their geo-location and route map to the energy providers whereby enabling energy providers to dynamically plan their energy services.

Scenario B – Multimedia Applications

Homer is a business development executive and regularly travels to meetings across various locations in Europe. Homer also has two children and every weekend he brings them to see their grandparents in the neighbouring city. Homer owns an electric vehicle for normal use and when travelling abroad, Homer normally uses rented electric cars and inter-city train services as his primary transport mechanisms. As Homer spends a lot of time travelling he avails of a variety of multimedia services including

- Homer frequently makes high definition & high quality video conferencing calls to customers and family from random locations including his car, the train and his various residential and office locations across Europe.
- On some train journeys, Homer avails of movie rentals from the Amazon store.
- On some car journeys to his parent’s house, Homer purchases interactive multi-media gaming and e-learning services to keep his kids occupied.
- While driving to meetings, homer avails of Google’s Street-View mapping service to guide him through new city road networks.
- Homer is also a keen football fan and enables his profile to interrupt all of the above multimedia services to receive targeted high definition video clips on all goals on the English football premiership.
- Homer is also a keen music fan and enables his profile to interrupt all of the above multimedia services to receive targeted high definition video advertisements of upcoming music, cultural and entertainment events in his current location.

Scenario C – General Information Services
Homer is a diabetic and is travelling across Europe. Homer needs to pick up some insulin to restore his blood sugar levels. To help him on his journey, homer queries the car for the following information

- Real-Time road congestion information. All electric vehicles are equipped with geo-location services which broadcast their location to an online mapping service. The mapping service is able to monitor the throughput of traffic through various parts of the city and select the best route with the least congestion.
- Weather Information. All electric vehicles are equipped with temperature and weather sensors which broadcast their data to an online mapping service. Homer is able to plot a route to avoid potentially icy roads which are still frozen. For similar additional scenarios related to information, availability and usage of charge points please also refer to *ucST-P Scenario A: Municipal parking place* (section 2.3.3), *ucMT Scenario C: Planned charging using operator pre selection* (section 2.4.1) and *ucLT-P1 Public Charging Points* (section 2.5.3).
- Health Information. All electric vehicles are equipped with Smart Interfaces. Homer enables a health alert service application in his electric car which can notify emergency services of potentially risky situations. If homer were to enable this function in an emergency situation, emergency services would be automatically dispatched to Homer’s current geo-location to provide emergency treatment.
- Charging Station Utilisation Services. Homer is under pressure to find a vacant charging point with only 15 minutes of battery remaining. Due to the Champions league semi-final, there are 10,000 additional electric vehicles in town and are all plugged in and charging in preparation for the return journey to Germany and Spain. Homer is not worried because his web-services car graphical user interface tells him exactly where the nearest vacant charging point is and Homer drives directly to it. For similar additional scenarios related to information, availability and usage of charge points please also refer to *ucST-P Scenario A: Municipal parking place* (section 2.3.3), *ucMT Scenario C: Planned charging using operator pre selection* (section 2.4.1) and *ucLT-P1 Public Charging Points* (section 2.5.3).
- Homer’s Wife is also an electric vehicle owner but only uses her car occasionally and is unhappy with her yearly insurance and tax tariffs. She subsequently elects to switch to a new pay as you go tariff and is only billed accordingly to the actual journeys made. Geo-location services inform her tax and insurance providers with real time information on her journeys.

Figure 37 below depicts a more detailed level view of electro-mobility and the relevant stakeholders for this use case. It is possible that all future electric vehicle users may have a one-stop-shop for all their electric vehicle services – so a single entity may be e-mobility service provider, third party service provider whom will provide energy, network connectivity and cloud services to the electric vehicle customer. This way, electric vehicle owners will not have to manage all of the individual contracts and relationships. However, in this scenario, each of these are considered separately.

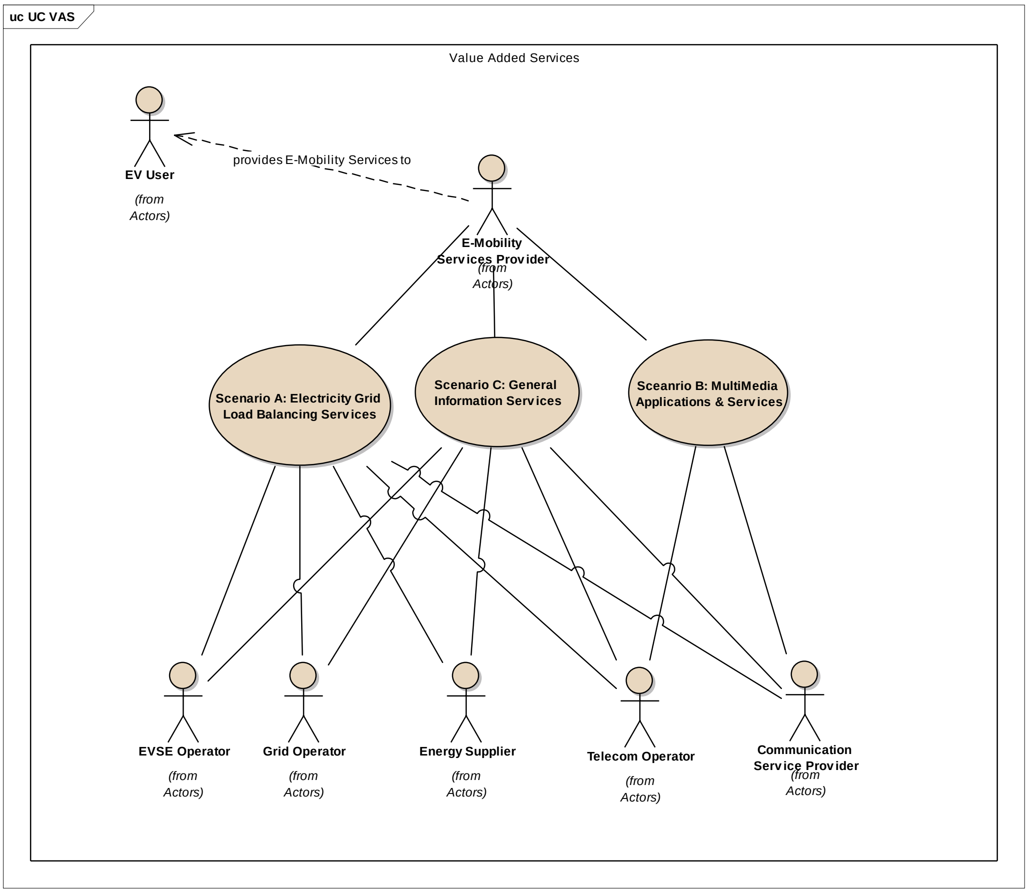


Figure 37 Value Added Services

2.7.1.4 Actor (Stakeholder) Roles

Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
EV User	Person	Uses the EV for private mobility needs such as commuting, carrying children, go shopping, … (here: Homer)
E-Mobility Services Provider	Organization	Market participant providing mobility services to its customers like: - Mobility Preference Administration - EVSE availability - Special Offers
Communication Service Provider	Organization	Operates a communication network infrastructure and provides services to communicate e.g. price signals, contracts with the Aggregator.
Energy Supplier	Organization	The supplier of energy to the end user
Grid Operator	Organization	Owner and operator of the grid infrastructure over which the energy is supplied to the end user
EVSE Operator	Organization	Owner and operator of Electric Vehicle Supply Equipment.

2.7.1.5 Information exchanged

The following table lists message types exchanged in each scenario.

Information Object Name	*Information Object Description*
Notification	Digitalized information that can be a list of information items or an event notification, e.g. - Price signal update - EV (dis-)connection
Request	Digitalized message requesting a particular task, e.g. - Request for Service - Price signal update - Market price negotiation
Answer	Digitalized message answering a request, e.g. - Service Confirmation - Content availability - Price negotiation
Command	Digitalized message to order a concrete action, e.g. - Start/stop content

2.7.1.6 Activities/Services

Activity/Service Name	*Activities/Services Provided*
Availability of contribution to network services	Identify what entities can contribute to network services including their constraints.
Authorization	Authorize a person or organization for service access
EVSE information	Information on EVSEs' location, status (occupied), features etc.
EVSE reservation	Reserve a charging time slot with a specific preselected EVSE
Service / Application information	Information on services
Service / Application reservation	Reservation of services

2.7.1.7 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
Contracts regarding provision of multimedia and general services	Required contracts between the following actors: - E-Mobility Service Provider – Energy Supplier - E-Mobility Service Provider – Communication Networks Provider - E-Mobility Service Provider – 3rd Party Service Provider

2.7.2 Step by Step Analysis of Enhanced Services Function

2.7.2.1 Steps to implement function

2.7.2.1.1 Preconditions and Assumptions

- The EV User has a contract with an E-Mobility Service Provider that offers a mixture of all possible related services.
- The E-Mobility Service Provider has various contracts will all the ancillary, multimedia and general service providers.
- The E-Mobility Service Provider and its suppliers are responsible for the management and control of the physical infrastructure and all of its associated services and applications.

2.7.2.1.2 Steps – Value Added Services

Figure 38 below depicts a more detailed level view of electro mobility and the relevant stakeholders for this use case. It is assumed that there will be various communication connections between the EV user and all of the various actors in the supply chain. There are various value added use cases described and it is assumed that all use cases will generally follow the same communication procedure.

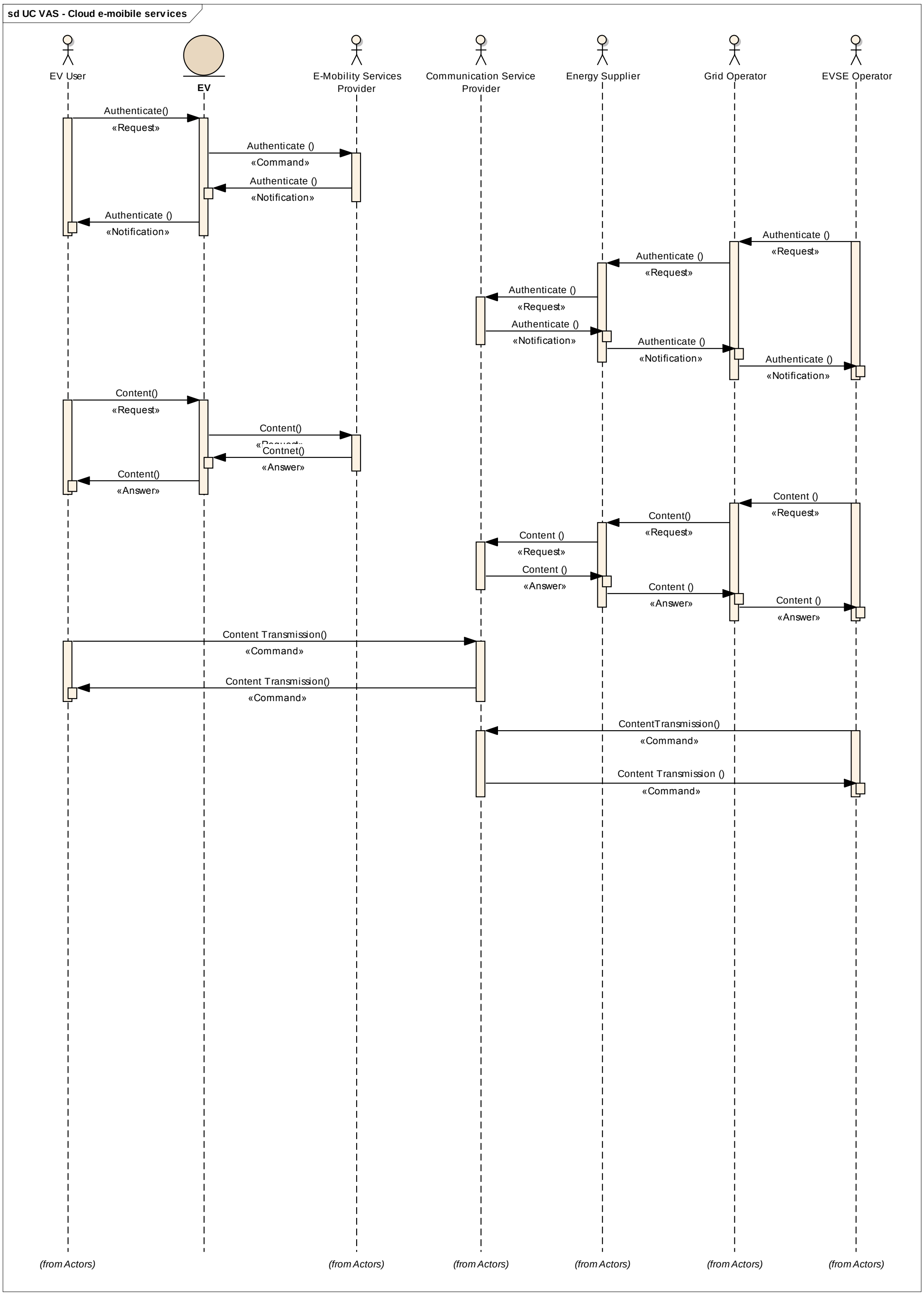


Figure 38 Value Added Services Interfaces

2.7.2.1.3 Post-conditions and Significant Results

After completion of the scenario, the user has successfully interacted with content and services enhancing their mobile experience.

3. Long and winding road ahead for Electric Mobility

To conclude this deliverable some views are expressed on the changes to be expected in relation to the roles of a range of energy domain stakeholders, the challenges that lay ahead for electric mobility and the impact on public communication networks. Finally the deliverable highlights how we plan to move this work forward into collecting, analyzing and specifying requirements for a Future Internet Core Platform from an electric mobility perspective.

3.1 Business to system mapping

The scenarios and electric vehicle functions elaborated in Chapter 2 demonstrate that the introduction of electric mobility will lead to new stakeholders in the energy market as well as a wide range of new business opportunities for energy providers and for e-mobility service providers. Changes in the roles of stakeholders are to be expected – homeowners with solar panels will be able to generate at least some of the electricity they will need to charge their cars, while the current clear boundaries between the transport and energy provision sectors will blur in many countries, depending on how regulatory and licensing provisions evolve.

Some of the changes to be expected in relation to the roles of a range of energy domain stakeholders are summarized in the following list. Changes can be expected in the role of:

- The EV User:
  - who will increasingly be a producer of electricity as well as being a consumer, and who will be encouraged to use the electricity they generate to charge their own vehicles,
  - who will buy services to help them manage their energy usage to minimize its environmental impact and cost, and as a result help to reduce the difficulty in managing an increasingly unpredictable energy network,
  - who will be less likely in future to own their own car, especially if they live in a city, preferring instead to use public transport and a serviced car from a pool when they require one.
- The current Electric Power Supplier:
  - who can continue to sell energy using their current business models,
  - who will also have the opportunity to provide a range of new services, related to mobility of people and goods,
  - who will need to avail of ICT services, and probably those of specialist ICT service operators, to keep the costs of running the electricity network at manageable levels as the proportion of energy coming from unpredictable renewable energy sources increases.
- New players in the energy market, such as Aggregators and alliances of energy providers started for the purpose of providing the same service to customers on an international and inter-regional basis. They will have the opportunity to:
  - provide charging of vehicles at public charging points on an international or inter-regional basis, providing the same payment possibilities to customers in a wide range of locations,
  - make alliances with transport providers to provide new possibilities for multi-modal transport to customers.
- Intermodal Mobility Operator, Car Park Operator and Shopping Centre Operators:
  - who will have to adapt their business operations to allow for the time required to charge vehicle batteries, considering battery swopping where relevant, perhaps for fleets of identical vehicles and to reduce the time the vehicle is idle when charging,
  - who will need to develop commercial relationships with electricity suppliers of a similar type as they have currently with fuel providers,
  - who will increasingly need to develop standards for the interchange of information on the real-time location and projected arrival times of a range of means of public and private transport options, so that multi-modal transport, with its reduced environmental impact compared to the sole use of private cars for transport, can become a large scale reality,
  - who will need to enable services for the reservation of parking places with charging possibilities for commercial and private vehicles,
- E-Mobility Services Providers:
  - who will be able to leverage the fact that electric vehicles are very likely to be connected wirelessly to the internet during most of the time they are being used,

creating possibilities to offer the travelers a wide range of travel related services such as information on hotels, restaurants, free charging points etc in the neighborhood of the vehicle,
  - who will be able to offer entertainment and other services to travelers in conjunction with mobility services.

Many of the changes to business models described above will require new regulation to support the timely development of electric mobility in Europe. Regulation on the mechanisms and rules for charging for electricity differ from country to country in Europe making it difficult to offer customers a uniform service as they travel within Europe. A new regulatory environment for electric mobility would facilitate the development of a valuable pan-European market for services in Europe, enabling the creation of jobs in Europe and the development of products and services to a European standard which could then be sold on international markets to the advantage of European citizens.

3.2 Electric Mobility Challenges

While in this deliverable we have tried to highlight through the scenarios the possible integration of ICT systems for the vehicle, the user, and the energy and transport infrastructure there were a couple of challenges that stood out. On the one side there are the user-focused challenges such as:

- Payment methods: Given the multitude of different options from, EV user subscription models, to Pay as You Go, Pay by Mobile, Pay by Cash/ Credit card, or even a separate EV bill all will require tighter ICT solutions for the full settlement of the energy transaction.
- Authentication: RFID key cards/ fobs are the prevalent solution at this moment in time, however as we move towards mobile near field communication (NFC) and on-board / in vehicle identification use a whole set of new security issues will come to the fore.
- Charging Points: Given the different types of charge point options that maybe available to the EV User from public, private, workplace and commercial charge stations, picking the right option will not be easy for the user, and even harder for the grid operator to predict.
- Enhanced Services: This may be a way tackle the multiple charge point options, however it brings its own challenges when bringing in 3rd party developed and maintained ICT services.
- Inter-modal: A very interesting CO2 emissions saver however it brings in many scheduling difficulties which could be solved with ICT solutions.
- International Roaming: While communication service providers like mobile phone companies have addressed this issue, when EV Users start to roam into other countries will their identities be authorised to draw down and pay for electric energy from a charge point in a foreign country.
- Security and Data Privacy: One overarching issue is the security and privacy of the data in the electric mobility environment especially given that some use cases require a lot of user specific data.

There is huge potential for Future Internet technologies to address these challenges. However and it is worth noting that there are still many electric mobility challenges from an energy grid perspective that will need to be addressed also:

- Increasing numbers of EV’s will impact the profile of power consumption in built-up residential areas. This may in turn require changes in infrastructure design and availability.
- DC fast chargers draw large loads for short periods. Utilisation of multiple fast charge outlets at a single location or more powerful chargers will amplify this affect.
- The variable factor of the usage of EV’s compared to other large consumers generates a difficulty in planning for generation needs. This is particularly important in the early stages of EV utilisation prior to a true understanding of usage patterns. Information on events calendars for particular geographical areas may affect the usage patterns for a given day.
- The charging profiles and power quality impact on the grid is as yet not fully understood for situations of concentrated usage.
- The business model of variable customers at single metered charge points requires significant changes to the previously experienced model within the industry.
- The availability of potentially interruptible EV consumers will require solutions to efficiently utilise this facility. This can significantly assist in smoothing of grid events.
- The potential for energy storage and battery to grid energy supply provides challenges for the efficient utilisation of available generation, particular from renewable sources.

3.2.1 Impact on communication networks

The introduction of electric mobility is likely to have an impact on public communication networks as well as on the private communication networks of energy providers and those of building and home owners. Some first indications of the likely general impact of electric mobility on public and private communications networks, and a more detailed description of communications to the car, can be derived from the scenarios developed in Chapter 2 and both topics are elaborated in this section.

Public communication networks will be impacted as:

- The number of vehicles and individual travelers using public wireless networks to stay connected while on the move increases, as the vehicles themselves communicate information to service providers and the travelers increasingly need real-time information on transport alternatives. Although the volume of data transmitted may be low for individual transactions, the volume of the transactions and their requirements for a range of security and privacy levels will require the continuous upgrading of public network facilities and improved backhaul facilities.
- Energy providers increasingly need to know the charging status of the vehicles in the vicinity of their networks, in order to better predict the requirements for electricity required to charge those vehicles overnight,
- Energy providers will have increased requirements of communications facilities as they add measurement and control points to the low and medium voltage networks. In many cases, public communications networks could be used as a cost-effective means of supporting this communication. Again, the capacity of the networks and security and trust services available on the networks will need to be further developed to ensure a reliable and secure service.

The private communications of network providers will be impacted as:

- The new measurement and control of the energy network will need to be implemented to ensure the reliable and cost-effective operation of the energy network as the proportion of renewable energy sources in the network increase. Not only will new physical layer communications facilities be needed to interconnect the measurement and control points but also new operations and management systems and new information processing systems will be needed to analyse the incoming information and control the network.
- The scale of the use of communications and information systems technologies being used by energy providers will increase by orders of magnitude compared to today’s systems as the gird control and measurement systems are rolled out. Professional service providers can be expected to play an increasing role in the operation of the communications networks of energy providers as their scale and complexity increase.

The private communications networks of building and homes will be impacted as:

- Energy management in building and groups of buildings is taking on increased economic importance as energy prices increase and the need to save energy by optimizing energy generation through solar panels, and its use in heating and cooling systems and in future, in electric vehicles, and insulation becomes a national priority in many countries. The networks need to connect the systems and to enable their remote operation by service providers are becoming increasingly complex. While private networks are normally used in buildings, the remote operation of the networks and energy management is often undertaken using public communications networks. As such systems are implemented in legacy buildings and not just in a small proportion of new buildings, their communications needs will increasingly require more capacity to be made available on public networks.
- Devices in the home become equipped with smart communications devices enabling them to use electricity at times when it is cheaper or beneficial to the operation of the energy network. The electric vehicles used by the household will be some of these devices as their use becomes widespread. These devices need to be networked in the home and to be connected to the information systems of energy providers. Often, wireless networking will be used in homes to interconnect devices in older business while fixed networking will be an option in new buildings. The impact of the increased interconnection of devices to energy providers will increase the data traffic on networks. It could also mean that consumers become less likely to switch off network connections at

night changing patterns of usage of IP addresses. A wide range of protocols have been implemented in commercial home communication networks. As yet, widely implemented standardized interfaces have yet to emerge in the market.

Communication to the car:

The impact of electric vehicles on telecoms networks is still in its infancy however the current assumption is that each car will have similar communications requirements as smart-phones. The key enablers of electro-mobility services are similar to the key enablers of smart-phones. Key enablers include high speed wireless communications, advanced graphical user interfaces, application services, geo-location and sensor technology. In a Gartner 2009 prediction the number of battery-powered vehicles in industrialised automotive markets, (plug-in full-electric and plug-in hybrid EVs) as a percentage of all vehicles sold using various types of propulsion technologies will range from 5 percent to 8 percent of all vehicle sales by 2020, and from 15 percent to 20 percent of all vehicle sales by 2030 [17]. Some analysts forecast global electric car production to top 16 million in 2021 [18].

Cisco has published figures stating mobile data traffic is growing at a rate 3.2 faster than fixed data traffic. It also predicts that mobile video, P2P, gaming and VOIP will drive mobile data growth by a factor of 39 from 2009 to 2014 globally. In 2010, Smartphones represent only 13 percent of total global handsets in use today, but they represent over 78 percent of total global handset traffic. Globally, 31 percent of Smartphone traffic was offloaded onto the fixed network infrastructures. Global mobile data traffic grew 2.6-fold in 2010, nearly tripling for the third year in a row and was three times the size of the entire global Internet in 2000. Mobile video traffic will exceed 50 percent for the first time in 2011. Mobile network connection speeds doubled in 2010. Globally, the average mobile network downstream speed in 2010 was 215 kilobits per second (kbps), up from 101 kbps in 2009. The average mobile network connection speed for Smartphones in 2010 was 1040 kbps, up from 625 kbps in 2009 [19].

Even with advances in communication networks, there are however various electro mobility challenges to overcome. Many of the electro-mobility services and use cases described in this document are mission critical services, such as guiding EV users to EV charging stations and information on multi-modal transport. Unlike smart-phone services, failure of electro-mobility services could cause city wide transport disruptions. Electro mobility will need to provide the same or better consumer confidence in both the fixed and wireless broadband products. Analysis Mason reported in Feb 2011 that attempts to sell mobile broadband as a substitute to fixed are likely to fail as there is a strong perception among consumers that mobile broadband is not as fast, more unreliable and more pricey than fixed broadband [20].

Investments in communications and smart grid technologies will be crucial to realising the commercial electro-mobility forecasts described above. However, it is also anticipated that operators will have to open up their networks, provide API platforms and form partnerships with 3rd party operators in order to provide new services and secure additional revenue opportunities. The fusion of cloud services more intimately with NaaS (network as a service) architectures will also be key where the network can be dynamically and directly controlled and programmed by electro mobility web-services. The key competitive differentiator for operators will always be their relationship with the end customer and their ability to offer quality of service and service level agreements.

3.3 Next Steps and Future Work

Work package 5 of the FINSENY project aims at collecting, analyzing and specifying requirements for a Future Internet Core Platform from an e-mobility perspective. In order to make sure quality, completeness of the requirements we follow a classical approach for Requirements Engineering which is illustrated in Figure 39 [21][22].

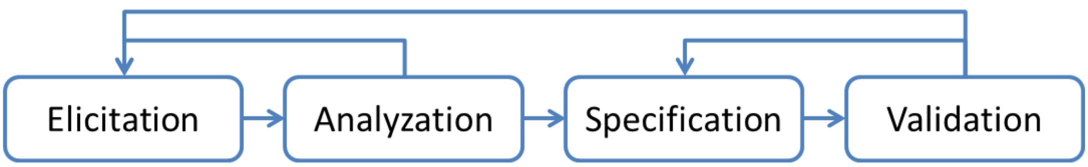


Figure 39: Requirements Engineering

This document is a preliminary work for the elicitation of requirements. It provides the input needed in form of use cases. These use cases cover a wide variety of scenarios so that all relevant aspects can be covered. Special attention was given to the description of ICT-related use cases as they are the focus of this project. In the next step, an initial set of functional and non-functional requirements will be collected that can be derived from the use cases. They will be analyzed for completeness, uniqueness, consistency and other criteria. As a result of this analysis additional or more specific requirements can be elicited if needed. Otherwise a detailed specification of the requirements follows. Finally, validation of the specified requirements guarantees the validity of the requirements. This final set of requirements will then be the basis for the development of the Future Internet Core Platform, together with the requirements from the other research areas in Work Package 2 to 7.

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Appendix I

Use Case	Title
ucST-H1	“Dumb” Charging at an individual domestic charging point using standard sockets
ucST-H2	"Dumb” Charging at an individual domestic charging point using sophisticated home charger
ucST-H3	“Smart” Charging at an individual domestic charging point using sophisticated home charger
ucST-H4	Shared domestic charging point(s)
ucST-P1	Public Charging – Business Trip
ucST-P2	Public Charging – Car Sharing
ucST-P3	Public Charging – Payment methods
ucST-W1	Charging at Workplace (own car)
ucST-W2	Charging at Workplace (fleet of vehicles owned by company)
ucST-C1	Charging at Customer Parking Place
ucMT-1	Dynamic G2V – V2G Energy Exchange
ucMT-2	Community CPs
ucMT-3	Planned charging using operator pre selection
ucMT-4	Ad-hoc inter-modal transportation
ucMT-5	Battery swap station
ucLT-1	Authentication of Users
ucLT-P1	Public Charge Points
ucLT-P2	Payment Methods - Pay by Mobile
ucLT-W1	Car rental company allowing for use of commercial fast charging stations
ucGOp-1	Prediction of charge loads – to prepare for stress situations
ucGOp-2	Optimized charge scheduling – to charge EVs without exceeding the capacity of the local power grid
ucVAS-1	Electricity Grid Load Balancing
ucVAS-2	Charging Station Utilisation Services
ucVAS-3	Traffic Services
ucVAS-4	Weather Services
ucVAS-5	Tax and Insurance Services
ucVAS-6	Entertainment – ebooks, Pod-Casts and Music Streaming
ucVAS-7	Entertainment – Games
ucVAS-8	Entertainment – Video Conferencing

uc	Use Case
ST	Short Trip
MT	Medium Trip
LT	Long Trip
GOp	Grid Operations
VAS	Value Added Services