FABRIC

Feasibility analysis and development of on-road charging solutions for future electric vehicles

FABRIC final use cases

Deliverable No.		D4.3.1	
Workpackage No.	WP4.3	Workpackage Title	**Final use cases definition**
Authors		In next page	
Status (Final; Draft)		Final	
Dissemination level (Public; Restricted; Confidential)		Public	
Project start date and duration		01 January 2014, 48 Months	
Revision date		2014 - 06 - 17	
Submission date		2014 - 07 - 14	

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 605405

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Revision and History Log

REV	DATE	CHANGE
0.1	10/02/2014	Deliverable structure and Table of Contents.
0.2	15/02/2014	Methodology section added.
0.3	20/02/2014	Actors section added.
0.4	05/03/2014	Scenario narratives added.
0.5	10/03/2014	Use cases for DSO added.
0.6	18/03/2014	Content updated (additional narratives).
0.7	08/04/2014	Contribution from ENIDE regarding use cases and modules.
3.0	09/04/2014	Integration of VEDE contribution: Proposal of a new generic driver scenario experiencing stationary charging on a queuing lane.
4.0	05/05/2014	Preliminary charging modes supported by FABRIC added (chapter 5). Architecture updated. New modules/functionalities introduced (chapter 6). Use cases for Load Balancing while charging functionality. Updated DSO use cases based on new architecture proposed by CRF/ENIDE (chapter 7). Energy retailer actor introduced and corresponding use cases (chapters 3 and 7). Consolidation of contributions from CIRCE, ENIDE.
5.0	17/06/2014	Final use cases added in chapter 6. Charging modes updated. Formatting changes. Chapter restructuring. Chapter 5 was integrated in chapter 3. New architecture diagrams and modules description in chapter 3.
6.0	26/6/2014	Chapter 4 finalized. UML diagram added. Authors added. Deliverable finalized.

Abbreviation List

ABBREVIATION	MEANING
CO2	Carbon Dioxide
DXX.X	Deliverable XX.X
DSO	Distribution System Operator
DSRC	Dedicated Short Range Communication
ERG	External Reference Group
EV	Electric Vehicle
FABRIC	FeAsiBility analysis and development of on-Road chargIng solutions for future electric vehiCles
HDV	Heavy Duty Vehicle
I2I	Infrastructure to Infrastructure
ICT	Information and Communication Technology
LDV	Light Duty Vehicle
LTE	Long Term Evolution
MX	Month X
NIST	National Institute of Standards and Technology
OBU	On-board unit
OEM	Original Equipment Manufacturers
POI	Points of Interest
RES	Renewable Energy Sources
SP	Sub-Project
SuD	System under Design
SVD	Selective Vehicle Detection
TX.X.X	Task X.X.X
UC	Use Case
UML	Unified Modeling Language
UTMC	Urban Traffic Management and Control
V2G	Vehicle to Grid
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
WP	Work Package

Executive Summary

FABRIC aims at studying and facilitating the large-scale integration of electromobility in the global transportation system by developing technologies that will allow the seamless, wireless recharging of EVs even while travelling. This innovation will help increase the autonomy of future EVs and reduce the range-anxiety of potential electromobility adopters which is a major hindering factor for electromobility growth. Another important benefit is the reduction in size and manufacturing cost of EV batteries, which will lower the price of future EVs.

The work in FABRIC SP4 focuses on the integration of the ICT components and charging solutions that will be developed during the project's lifetime in SP2 and SP3 respectively. This deliverable is the outcome of FABRIC Task 4.3.1 "Use cases definition". Within the document detailed use cases are defined for the ICT and charging solutions foreseen in the project for the main end-users of the system: the driver, the Distribution System (grid) operator and the road operator.

FABRIC is not just a project which will develop, demonstrate and assess charging technologies, but it is also a feasibility project, meaning that it aims to assess the potential of large-scale electromobility adoption. With that in mind two types of use cases are described in the document:

- the demonstrable ones that relate to the ICT tools and services that will be used in the project in order to demonstrate and test the charging solutions to be developed within FABRIC,
- the feasible use cases that take into account ICT tools and services that are being developed in other projects or are commercially available and could be integrated within a system such as FABRIC in the foreseeable future, adding value and making it more user friendly, aiming at wide adoption from the consumers.

The use cases are global in the sense that they are suitable for different vehicle types (e.g. car, van and truck) and different types of on-road charging solutions such as conductive dynamic, inductive dynamic and inductive en-route charging, so as to cover all systems considered in FABRIC.

1. Introduction

1.1. About use cases in general

A use case defines the system's behavior under various conditions and is initiated from one of the system stakeholders, called the primary actor in order to accomplish some goal, while respecting the interests of all stakeholders. Different sequences of behavior, or scenarios, can unfold, depending on the particular requests and the conditions surrounding them. The use case collects those different scenarios.

Use cases are written as a planning document, to link stakeholder needs to system requirements, to define clear boundaries of a system, to capture and communicate desired behavior of the system, to identify who, what and when interacts with the system, to validate/verify requirements.

Use cases are popular largely because they unfold coherent stories about how the system will behave in use. The users of the system get to see just what this new system will be like. They get to react early, to fine-tune or reject the stories. That is, however, only one of ways they contribute value.

The use cases begin to create value when they are named as user goals that the system will support and collected into a list of goals which announces what the system will do. It reveals the scope of the system and becomes a communication device between the different stakeholders on the project [1].

That list is examined by user representatives, executives, expert developers, and project managers. They will estimate the cost and complexity of the system starting from that list, they will negotiate over which functions get built first and how the teams are to be set up. The list is a framework onto which to attach complexity, cost, timing and status measures. The next particularly valuable moment is when the use case writers brainstorm all the things that could go wrong in the successful scenario, list them, and begin documenting how the system should respond. At that moment, they are likely to find out something that they or their requirements givers had not thought about.

This document summarizes the work done mainly in WP43 "Final use cases definition", T4.3.1 "Use cases definition", which also includes contributions and findings from SP2 and SP3 workpackages, namely WP22 and WP32, both named "User needs and requirements". FABRIC aims at studying and facilitating the large-scale integration of electromobility in the global transportation system by developing technologies that will allow the seamless, wireless recharging of EVs even while moving. This innovation will help increase the autonomy of future EVs and reduce the range-anxiety of potential electromobility adopters which is a major hindering factor for electromobility growth.

Within the document detailed use cases are defined for each ICT and charging solution selected in the project for the main end-users of the system: the driver, the Distribution System (grid) operator and the road operator.

FABRIC is not just a project which will develop, demonstrate and assess charging technologies, but it is also a feasibility project, meaning that it aims to assess the potential of large-scale electromobility adoption. With that in mind two types of use cases are described in the document:

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The use cases are suitable for different vehicle types (e.g. car, van and truck) and different types of on-road charging solutions such as conductive dynamic, inductive dynamic and inductive en-route charging, so as to cover all systems considered in FABRIC.

1.2. Contribution to FABRIC objectives

This deliverable contributes to the objectives of FABRIC in several ways. At the beginning of the project a generic system concept was drafted by compiling several scenarios (or storylines) describing the everyday use of FABRIC-enabled vehicles and infrastructures, by the potential end-users' point of view.

This document was later enriched and it was delivered to SP2 and SP3 partners as a basis to create the questionnaires that gather the needs and requirements of users and stakeholders identified according to this concept of FABRIC, which is presented in Chapter 3 of this document. These activities and interactions were the basis for the research and development within the project.

Use cases connect many other requirement details and provide scaffolding that connects information in different parts of requirements. They help crosslink user requirements, system requirements and design. While designing the FABRIC use cases, the need for several ICT modules and infrastructure components and interfaces with other systems was identified. This provided input in the form of a preliminary modules list as a starting point for T2.2.2, whose main goal is to define the system's ICT boundaries and functionalities.

Besides the requirements document, the use cases help structure project planning information such as priorities, and development status. They help the design team track certain results, particularly the design of the user interface and system tests [1].

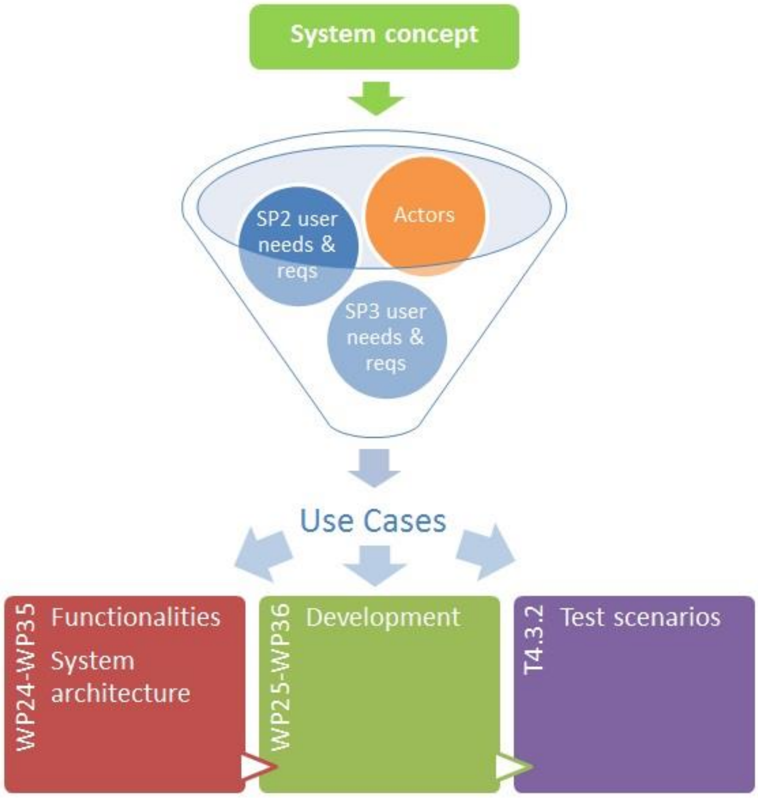

Figure 1: Use cases role in the system design process flow.

While the above areas and specifications are not included in the use cases, they are connected to the use cases: they act as the hub of a wheel, and the other information acts as spokes leading in different directions. The contribution of the use cases to the objectives and the development of the project will be analyzed in more detail in the next section.

1.3. Process and Methodology overview

The definition of use cases in FABRIC has been an iterative process, due to the fact that several of the required inputs were scheduled for delivery after M6 which was the delivery deadline for D43.1. In Figure 2 one may see the complex interactions between T4.3.1, SP2 and SP3. However, SP2 and SP3 tasks also needed a concept of the system to present to the various stakeholders during the conduct of the surveys for the definition of the user needs and requirements.

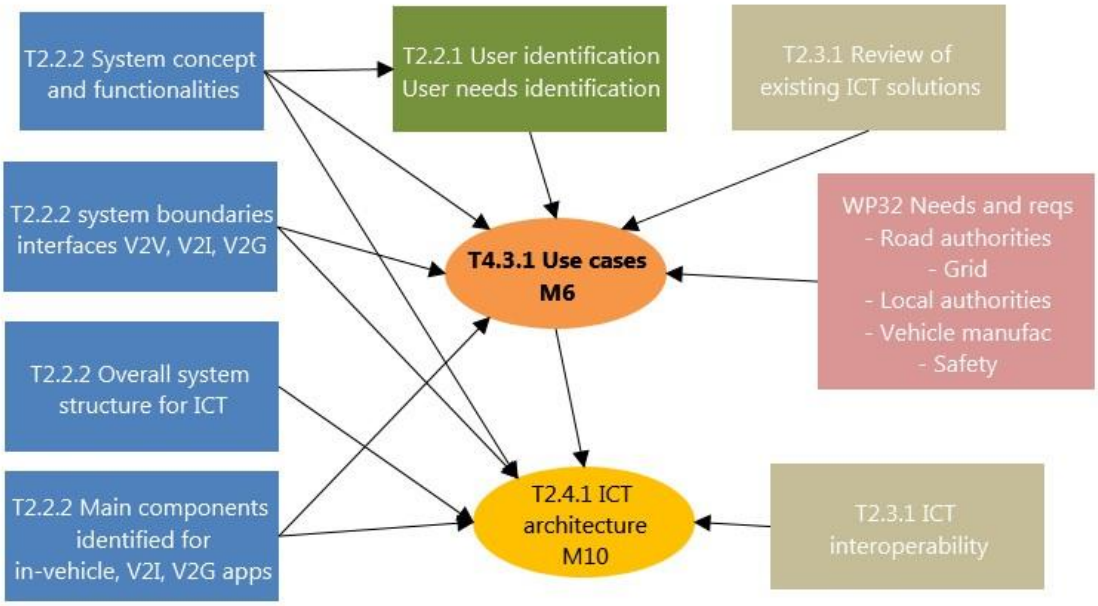

Figure 2: Inputs and outputs of Use Cases definition task

Due to this interaction the first step was the drafting of generic scenarios of use for a FABRIC concept. These generic scenarios of use were brief narrative storylines (presented in Chapter 2) describing feasibility and potential functionalities of the system, from the point of view of the various stakeholders.

They explain how stakeholders could use the system and how it would affect their daily routine if several ICT modules, developed in research projects or commercially available, were used in conjunction to FABRIC main technology outcome, which is a wireless dynamic charging system for EVs.

Since these ICT modules are either commercially available or the R&D objective of other ITS and electromobility projects, their re-development is not within the R&D scope of FABRIC. Only the ICT modules that are necessary for the demonstration of the developed technology will be integrated in the FABRIC platform. These ICT modules and the necessary functionalities were specified within SP2 and out of the plethora of available ICT solutions a subset was selected for integration.

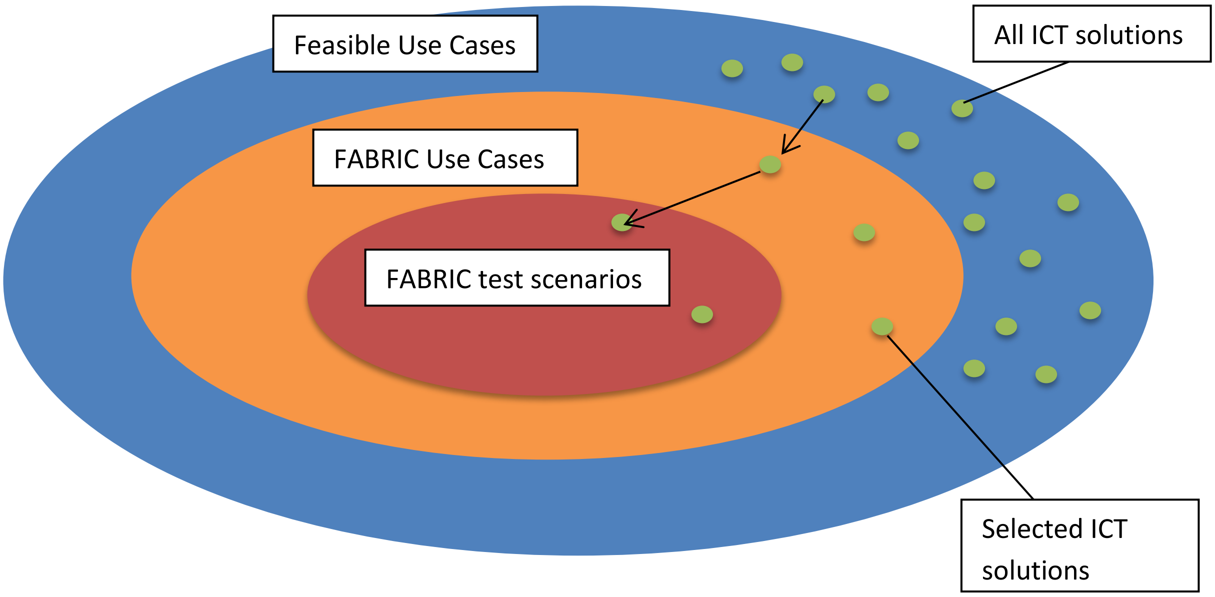

Figure 3: ICT solutions filtering towards the FABRIC prototype

These modules define the boundaries of the FABRIC system and based on those boundaries the FABRIC use cases are determined. In the future, FABRIC functionality can be extended by integrating more ICT solutions in a modular manner. To achieve this, interoperability should be investigated and communications should follow widely accepted standards to make exchange of messages between FABRIC and other ICT modules straightforward.

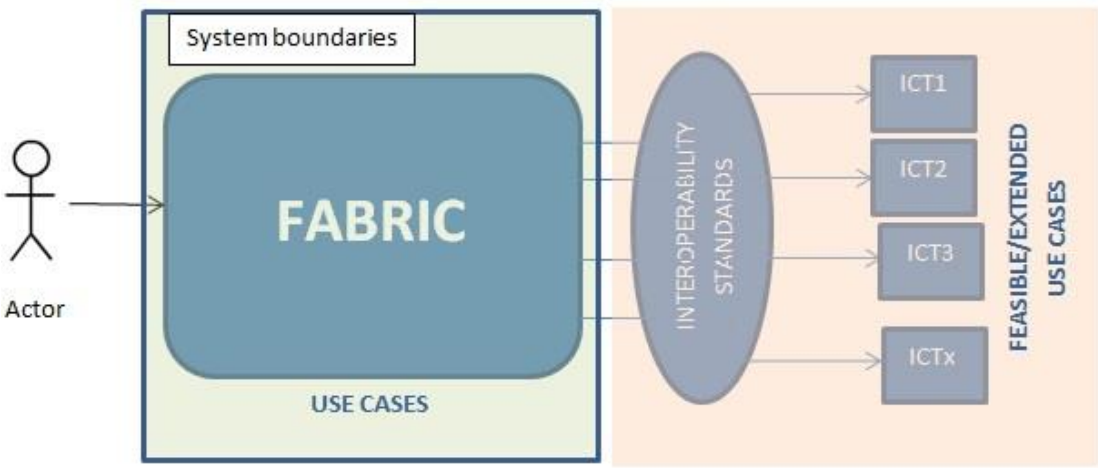

Figure 4: FABRIC extensibility by interfacing with third party ICT solutions

In parallel with the previous step the primary and supporting actors of the system were identified and they are listed in Chapter 0. These stakeholders were surveyed so as to collect their needs regarding the charging of EVs, the shortcomings of current technology and their requirements from a system such as FABRIC. These requirements were matched with FABRIC use cases in order to ensure the relevance of the project.

To compile the preliminary use cases a template was created by ICCS to collect the contributions of the ICT and charging solutions developers. Using the template, partners who develop or adapt

modules to facilitate the functionalities of the system, describe the foreseeable way their module will work, but also situations that may lead to abnormal termination or alternate endings (exceptions and extensions). Trigger events and also parameters that may affect the operation and functionalities are also included.

The preliminary use cases were then prioritized and the final ones that describe the system to be developed in the project were selected during a use cases workshop that took place in Turin, Italy on the 27th of May 2014.

Finally, out of the identified FABRIC use cases, the most representative of the system's capabilities were used as guidelines for the definition of the system's test scenarios (D43.2).

The methodology described above is depicted with a flow of information in the following figure.

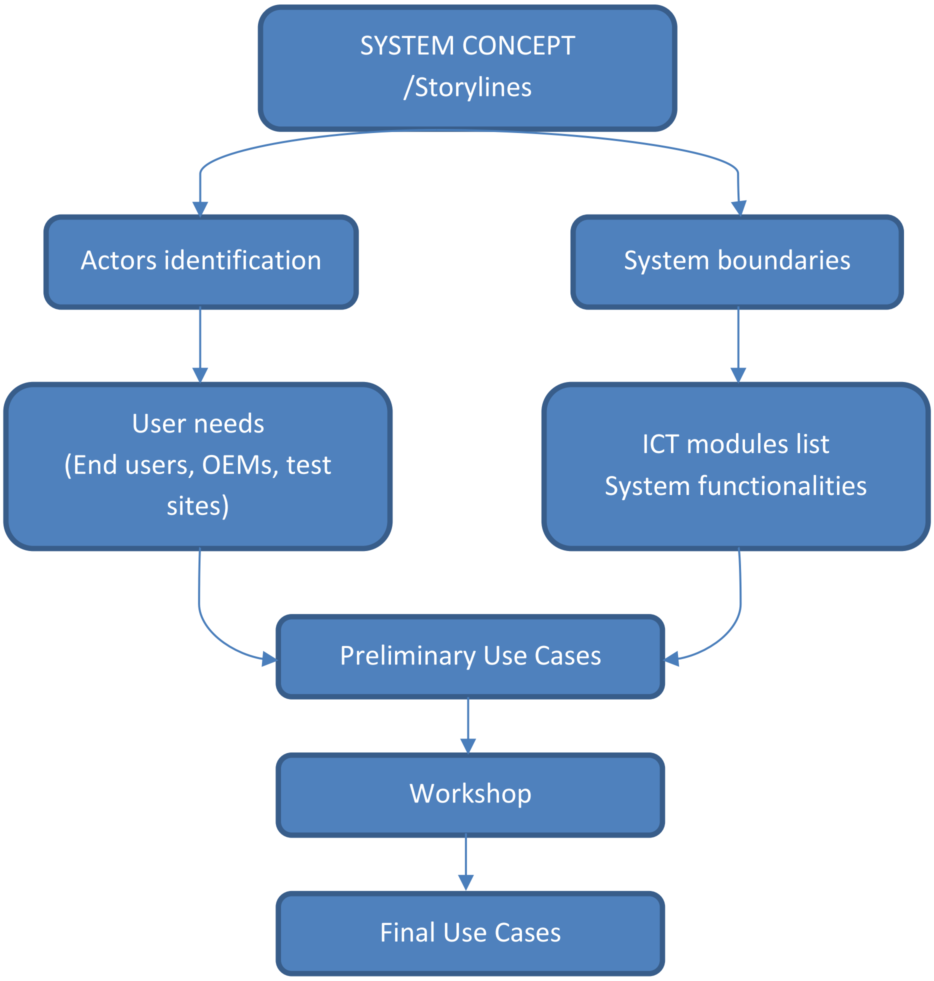

Figure 5: FABRIC Use Cases definition flow

1.4. Deliverable structure

Chapter 1 is an introductory chapter that specifies the role of use cases for a system's design and development. It also describes the importance of the use cases definition task within the project and its intra and inter-SP interactions with other tasks.

Chapter 2 contains the preliminary storylines that draw the preliminary concept of FABRIC. These scenarios of use refer to a foreseeable future based on ICT and charging solutions developments in this project but also currently investigated in other ITS and ICT-related state of the art research projects and industries.

Chapter 3 introduces the concept of an actor who interacts with the system. The users and stakeholders of FABRIC are being identified and their role described. The main building blocks of the system are identified and their functionalities described. This is a preliminary architecture for the system which will be refined and extended in SP2. Its objective is to identify the main interfaces of the system with the various actors and also describe major system entities that initiate and handle important functionalities which are described as use cases.

Chapter 4 contains the input from SP2 regarding the preliminary user needs and system requirements. These are correlated with the use cases in order to show the relevance of the project and its functionalities with the actual needs of the public.

Chapter 5 provides the definitions of the charging modes that will be investigated in FABRIC. The static mode is the well-known charging method for EVs, however FABRIC will focus on wireless static charging. The second mode is the stationary wireless charging, aiming to facilitate buses and other light duty vehicles that stop frequently for short durations. The third mode is the dynamic charging of an EV while it is travelling on a wireless charging lane. This is the most ambitious mode of operation and the main objective of the project.

Chapter 6 presents the actual use cases, both feasible and demonstrable. This is the core of this deliverable.

Chapter 7 summarizes the document and draws the final conclusions.

2. FABRIC descriptive scenarios of use

The following descriptive scenarios of use intend to define the FABRIC system concept from the end-users point of view, that is:

- the drivers who want to re-charge their vehicle while on the move (dynamic charging),
- the grid operators who want to regulate the energy flowing to the EV charging infrastructure in order to safeguard the security of the grid,
- the road operators who want to monitor and manage the traffic, and the access to the charging infrastructure and also guarantee the safe operation of the road by warning in advance drivers for abnormal situations while preventing traffic jams and accidents.

The scenarios are focused mainly on dynamic wireless charging which is the main innovation of FABRIC and its most anticipated result.

These scenarios have been a starting point for the definition of the final detailed FABRIC use cases. They were also a starting point that defined some very generic system boundaries that would later be restricted and specifically defined within SP2, aiming to define more specific use cases from the ICT and charging solutions developers in SP2 and SP3 but also from the test site partners.

The narratives were also the basis for the development of user needs and requirements questionnaires for the surveys that were conducted within SP2 and SP3 and provided a preliminary context for the technical feasibility of ICT and charging solutions study that was performed in WP42.

2.1. Driver scenarios of use

2.1.1.Scenario 1: Dynamic charging on a highway: access and exit

Professor Jim intends to travel from Turin to Milano on Wednesday morning. As he is an experienced user of electrical vehicles he plans to use his FABRIC-equipped electric car.

Before departure, Professor introduces the location of the destination in Milano into his navigation system, which has accurate range prediction and knows that Professor is driving an electric car and that one charge will not be enough for driving the entire distance without recharging. The navigation system automatically pre-books charging time slot on the inductive charging lane, but during the trip to Milano, Professor Jim is delayed due to traffic congestions, so this information is automatically sent to the FABRIC infrastructure responsible for the inductive charging lane and when possible, the rescheduling is made.

On the arrival to the inductive charging lane, Professor Jim's smartly connected vehicle gets in contact with the charging lane infrastructure, which performs the authentication of the vehicle and grants access to entering the charging lane to the Professor. A message on the Professor's dashboard invites him to enter the lane.

While the vehicle is driven in the charging lane, the dashboard also displays information on changing status, as well as on the driving style, such as lane alignment, that should be adopted to

optimize the charging process. If available, adaptive cruise control is engaged as well as the steering support functionalities, keeping the vehicle in a platoon with other charging vehicles.

During the entire time, a charging countdown is presented to the driver. When the vehicle is charged and countdown finished, the Professor Jim is requested to leave the charging lane, continuing his trip to Milano.

After the vehicle has left the charging lane and entered the ordinary motorway lanes, the dashboard display informs the Professor that his electricity bill has been charged with this charging cost.

2.1.2.Scenario 2: Dynamic charging on a highway: priorities, pre-booking, incentives

The following scenario presents a complex ICT scenario which takes as granted that there is large-scale implementation of ITS and seamless V2I and V2V communication. It may increase the user-friendliness value of the charging system, however at this point it remains a futuristic scenario that depends largely to business models and strategies that are custom to each future system installation and not an R7D objective of the project. It is included in this document only as a feasible scenario of use in the future.

On his way back from Milano, Professor Jim, who has been very pleased with using the inductive charging lane for the first time, prepares his trip in the same way.

This time, he receives a message from the road operator: there is a request from a vehicle with a higher priority to use the charging lane at the exact time as Professor Jim. A bus with school children on their way to ski-resorts has been delayed and would need to recharge. As all charging time slots are taken Professor Jim is asked by the road operator if he would be able to take a later charging time and to take a 15 minute coffee break at a near-by motorway café. As an incentive, the coffee would be free and Professor Jim would receive 20% discount on his next charge. Since he is no rush to get back, Professor accepts this offer by acknowledging it on his dashboard touch display.

Coming back to his university the Professor explains his experience with the new inductive charging lane to his students. One of them, Marko, mentions that he also had tried out the inductive lane charging. On his way to another city he did not make a pre-booking and he was still able to use the charging lane, as there were many spaces available. For him on the other side, there was no guarantee that he would have been able to charge his vehicle, if all charging slots had been taken. Professor Jim explains that the pre-booking is important because the road and energy operators are able to optimize the energy usage for charging the pre-booked vehicles.

Another student, Fabricio, stated that he also was in a similar situation. He had not pre-booked the charging time slot, but at the time he wanted to use the charging lane, all time slots were taken. He made a request to the road operator and suddenly there was another car leaving the lane and he was able to enter and charge.

Fabricio found out later that, since the road knew that Fabricio's vehicle was running on low battery, offered an incentive to the rest of the charging vehicles to give their charging slot to his car. One of the vehicles with 80% charge accepted the offer and left the lane, receiving a 50% discount on the charge costs. Fabricio on the other side was able to use the charging lane but had to pay the double amount compared to Professor Jim, for the same amount of energy charged.

At the end of the discussion, a third student wondered, what would happen if there would be an accident on the motorway. This would surely ruin all of the charging plans.

Indeed, Professor Jim incurred and explained that in those cases, the FABRIC infrastructure takes a regional mobility/charging approach, rescheduling most of the vehicles to other roads/charging locations.

2.1.3.Scenario 3: Stationary charging on a queuing lane

Gérard is taxi-driver in Paris and he uses an electric car equipped with both conductive charging with a plug and inductive wireless charging. During a typical weekday he drives several clients from Paris downtown to the Roissy-Charles de Gaulle airport, and, from there, he takes visitors to Paris or travellers returning back home in Paris or in a surrounding city. In total he would drive about 200 km a day. Although the brand new battery which equips his electric car should store enough energy to face this demand, Gérard actually needs partial recharging of his car battery during the day, when he has the opportunity to do so, in order to be safe in case of traffic jams, or adverse weather conditions when he needs to turn the heater or air conditioning on.

Usually he takes the opportunity of his one-hour break at lunch time to recharge his taxi at a static charging spot, either conductive or inductive. But he also uses the inductive charging queuing lane which is now available for electric taxis at the airport. Before arriving to the airport with a client Gérard send a request to the charging lane operator which informs him about the number of taxis already engaged in the charging lane and gives him an estimate of the typical time he would spend on the lane and on the energy he might collect when on the lane in semi-dynamic mode.

Gérard knows the rules for the stationary charging. In case there are not many cars engaged and that he can drive a minimum speed of 5 km/hr the emitter coils on the lane will be activated automatically successively when the car is passing over. But when the average speed decreases below 5 km/hr the dynamic system is deactivated for safety reasons to avoid the risk of overheating parts of the car or exposing taxi drivers that could be tempted to open their doors and walk along the lanes. Then the system requires the car to be at standstill exactly above the emitter coil to be charged, similar to a static charging spot, except that the time spent on the coil is limited to allow a flow of taxis along the lane. A buzzer is activated when the car has to move together to the next charging spot. The charging lane operator has well optimized this stationary charging service. Gérard thinks it would be even better if his taxi was automated so that the stepwise motion along the lane could be done automatically without requesting action from the driver. Then he would be able to read his favourite novel while the battery is being recharged. Indeed Gérard recently watched a TV advertisement announcing a new electric car with both inductive charging and automated driving and he is now considering buying it soon.

2.1.4.Scenario 4: Electric road – Heavy truck use case

The small fleet operator “Svensson Trucking” was an early adopter of using the new electric road between Stockholm and Gothenburg. By using the electric road they could offer their customers green and flexible transports. Today, two of their FABRIC-equipped electric vehicles were heading for the electric road.

Sven started his day early, his ferry arrived in Gothenburg at 3 am. Gothenburg decided some years ago to allow only quiet and clean transports to operate inside the city during night time. Sven therefore charged his batteries at the charging pads when he was waiting in line for the ferry in Kiel. The cost appears on the bill from the ferry. He drives quietly through the city and remembers how some years ago people thought it was odd seeing a 40 ton truck making almost no sound at all. Entering the electric road his battery only had 20% left, exactly as planned. ”Svensson Trucking” had specified the truck to transport frozen goods, not batteries, on this specific route. Still, the batteries also managed both to power the truck trough Gothenburg and to keep the cargo at a stable -18°C without using the small combustion engine. This engine is an extra security if he needs to deviate from his plan and leave the electric road for longer distances.

At 7 am Nils started his work day. He made the security check of his 60 ton truck at a truck stop 30 km west of Stockholm. The night before, he had managed to pass the congested routes around Stockholm before his permitted driving time elapsed. He had slept in his truck during night. Even if it was -10°C outside the electric heating system had kept the cabin warm. His cargo was filled with heavy machinery parts picked up in Skellefteå the day before. The parts will be delivered to the customer in Värnamo later today. Since the electric road does not continue north of Stockholm, his truck is of a hybrid type. It is equipped with a small battery and 150kW electric machine, that together with the 500hp (370kW) combustion engine makes the truck very efficient. Nils is proud of always being on top of the company’s monthly fuel efficiency competition. Yesterday he almost beat his own record when he averaged 0.2L of biodiesel per kilometer. If he would not have missed to connect to a truck platoon after his last break he could probably had made it…

Now, after unplugging the charging cable that made it possible to keep the cabin warm and charge the batteries he could drive off and enter the electric road. The combustion engine together with the electric machine accelerates the truck up to the cruising speed of 80 km/h and then switched over to fully electric mode. During his drive to Jönköping, where he departed from the electric road towards Värnamo, the combustion engine was only running during steep inclines.

The owner of “Svensson Trucking” Mr. Svensson explains why he chose to invest in hybrid electric vehicles adapted for electric roads:

The transport industry has a responsibility to offer as environmental friendly transports as possible in combination with a very high uptime. Our customers’ demands are the same! That in combination with the cost of fuel that always has been a key factor in my company made us chose these new types of hybrid vehicles. My drivers perform at their outmost when driving the hybrids! And I share the cost cut with them.

2.2. Distribution system operator and energy retailer scenarios of use

2.2.1.Scenario 1: Energy management depending on the grid load – unforeseen event

Alex the grid operator enters the control center which is equipped with a FABRIC interface module. Based on the pre-booking information, which is provided by the drivers with FABRIC-equipped cars, the module shows information about the expected energy that will be required by the grid during the next x hours for the dynamic charging of the vehicles. Alex checks the status of the grid and the energy reserves. There is no problem in covering the demand based on the guidelines of FABRIC manual that also include specifications to ensure the stability of the grid.

All of the sudden there is an unexpected drop of the supplied energy due to a power plant malfunction. The available power cannot safely satisfy the current but also the expected demand since it is unknown how long it will take for the power plant to go online. A specific protocol must be followed in order to reduce demand. Alex reduces the maximum power delivered to the charging vehicles through his FABRIC interface. The drivers are notified by FABRIC and real time calculations show to them how charging is affected, the new battery charge that will be achieved under the new conditions and the (now reduced compared to a full recharging) autonomy of the vehicle. The driver is presented with alternative charging options to ensure that the destination is reached. Due to the inconvenience the driver receives significant discount for the vehicle charging.

2.2.2.Scenario 2: Grid congestion with high demand at noon in winter

On a Monday morning in a very cold winter, the grid operator foresees a possible demand peak in the region where the inductive charging lane is connected to the distribution grid. As the charging lane is the only manageable load, the grid operator limits maximum charging power to 80% of the nominal value for one hour between 11-12 am. A fixed discount has been agreed in advance between the road operator and the grid operator which permits such limitations during 1h each week. If additional flexibility is needed, the grid operator pays a flexibility fee if the road operator agrees to limit charging power in the required time slot.

2.2.3.Scenario 3: Grid congestion with high solar generation at noon in summer

On a Sunday in summer, the inductive charging lane is used only by a few cars. There is an excess of solar generation from distributed generators scattered over the distribution network where charging infrastructure is connected and normally it should be discarded. As the situation has been foreseen by the grid operator, by using meteorological prediction tools, several actions are taken. First, he is able to adapt the tap changer at the transformer station in order to avoid over voltages in the LV system. All available storage units are recharged and finally, a message is sent via FABRIC to all EV owners with a special offer for recharging at just 25% of normal tariff during the afternoon (12 - 2 pm). That special offer is valid only if a time slot is reserved at least 2 hours in advance. This allows the grid operator to obtain a better estimate of the expected demand at the charging lane.

As a result of all these actions, over voltages are avoided and no solar energy must be dumped. Attracted by the discount, a number of FABRIC-equipped EV owners decided to recharge their vehicles, although they did not plan for it a day before.

2.2.4.Scenario 4: Price fluctuation based on the availability of Renewable Energy Sources

At the same time the FABRIC lane was built on the highway located several hundred km away from the city, a park of wind turbines was also built nearby since the place had strong wind potential. Alex receives the forecast for today's wind speed. It's going to be a usual day and the wind park will contribute the usual 20% of the overall energy needed for the charging of the vehicles. Suddenly there is an alert by the local wind speed forecast alertness system: in one hour there will be a significant rise of wind speed, lower than the cut-off speed, allowing the generators to produce 50% more power. Alex uses FABRIC to notify drivers in the vicinity that charging fees will be lower by 20% for the next 2 hours.

Later that evening there is heavy rain: the nearby hydroelectric station's deposit is almost full and there will be no need for the generators to pump water up at night. The water would be wasted, however there is another option. The hydroelectric station may continue producing power letting the water flow and this cheap energy can be used by FABRIC to charge the EVs. It's Saturday night and the traffic is heavier than usual; Alex notifies the drivers that the price for charging dropped by 10%.

2.3. Road operator scenarios

2.3.1.Scenario 1: Accident in the charging zone

An accident happens in the charging zone. FABRIC charging infrastructure detects (alone or in conjunction with traditional accident detection sensors, such as cameras) that there is an abnormal activity in the zone and sends an alert to the traffic center. Charging units in the area immediately affected by the accident are turned off automatically by the FABRIC systems as a safety precaution. Laurent, the traffic operator, checks the situation thanks to video cameras and stops immediately the charging system via the traffic management software (which is connected with FABRIC module). Traffic information is given to all the drivers within the zone via conventional media and emergency teams are called. Then Laurent uses the traffic management software to send a warning message to the equipped vehicles approaching the zone, asking them to be careful and informing them that the charging system is not available. The FABRIC system's internet connectivity allows it to generate wireless hot spots which can be used to deliver information to nearby vehicles upstream of the accident, informing them of the accident and advising them to slow down. Using the FABRIC road operator interface, Laurent identifies the vehicles approaching the zone that have a critically low level of charging and he notifies the drivers of these vehicles to re-route towards other charging zones, or to park on the closest rest area on which there are static charging spots available.

2.3.2. Scenario 2: Planned maintenance (to cut the grass) on the shoulder

Maintenance operation is required on the shoulder along the charging zone. As a safety precaution for the workers in the vicinity of the charging system during the maintenance operation, the system is turned off. Lionel, the manager of the maintenance team has scheduled the maintenance well in advance since this is a planned procedure and has notified the FABRIC system by updating the availability status of the charging infrastructure. However there are some drivers that have already made plans for charging that particular period. Once the maintenance operation is planned, Laurent, the traffic operator, sends a message to the drivers that had booked a slot for this period providing alternative charging spots and solutions. Then he changes the status of the availability of the system to "unavailable" for the period of maintenance.

2.3.3. Scenario 3: Access control and use of a shared hard shoulder charging lane on a motorway

A 2km section of a ring road (between two junctions) has its hard shoulder fitted with inductive charging infrastructure and is available for use by certain categories of vehicles: electric and hybrid vehicles (whether charging or not), buses, vehicles containing three or more people (high occupancy vehicles – HOVs) and emergency vehicles.

Enforcement is carried out by camera and Automatic Number-plate Recognition (ANPR), with approved regular users being on a "white list" and others not on this list are checked off on the national licensing database to determine the vehicle type and/or camera/video images are inspected manually.

Speed on the hard shoulder is limited to 90km/h for safety purposes and to allow efficient charging for electric vehicles (including buses). The motorway section is equipped with continuous Automatic Incident Detection and the hard shoulder segment exposed to the accident is closed to traffic and the electrical charging disabled over this segment in the event of a vehicle breakdown or accident which requires the shoulder to be used for safety/emergency purposes.

An electric vehicle intends to take the charging lane. The upstream virtual gate detects this vehicle and checks that the driver has neither pre-booked a charging slot nor made a last minute request for charging. As the FABRIC module is not able to communicate with this vehicle, the charging system remains switched off.

Another electric vehicle enters the charging lane without having pre-booked. Its driver activates the FABRIC system to make a last minute charging request and, as there is charge available and not immediately required for another user, the request is granted and the charging is activated. Shortly afterwards, the driver decides to overtake a slow moving bus in front of him, so he moves left from the hard shoulder charging lane into the first general traffic lane of the motorway without completing or switching off the charging. In this case, the charging is automatically stopped, as the driver has left the charging lane. After overtaking the bus, he moves back into the hard shoulder charging lane, but in order for the charging to re-activate, he needs to make a new charging request.

2.3.4.Scenario 4: Charging across all motorway lanes and using FABRIC to assist with demand management

Each motorway lane is equipped with charging segments across key routes. Drivers of vehicles that are capable of using the FABRIC system would register before using the system. They would register their vehicle with the charging scheme and set up an account for billing. FABRIC on board unit (OBU) in the vehicle will be updated remotely and assigned a unique FABRIC ID (e.g. via a mobile phone connection). Once this is complete a driver is able to use any compatible charging systems within the domain of the operator without further booking necessary. The unique FABRIC ID, used as identifier by the FABRIC system during communication between the vehicle and charging infrastructure, and the vehicle registration are used for enforcement purposes.

Vehicles that are not equipped with the FABRIC system do not interact with the system in any way although it is possible to subscribe to the Wi-Fi hotspots generated by the FABRIC charging segments.

An electric vehicle equipped with the FABRIC system but has not registered to set up a billing account is not able to charge but is prompted to register at earliest convenience when not driving.

An electric vehicle which is equipped with the FABRIC system and the driver has a corresponding billing account is allowed to charge while driving in the charging segments as long as it maintains a speed within the acceptable speed range. Once a compatible vehicle enters a compatible charging zone, the driver is presented with the current price per kWh and has to accept in order to proceed with charging. Power transfer will not commence until the user accepts the price shown. The maximum speed will be the same as the flow speed of the lane or speed displayed on variable message signs, whichever is lowest. If the driver exceeds this speed limit e.g. to overtake a slow moving vehicle the power transfer stops. Once the driver has returned to the charging segment and the vehicle speed is within the limit for that lane, tariff will be displayed again and the driver would need to accept before power transfer automatically resumes.

The road operator or the charging scheme operator sets the price per kWh and publishes this on the website and through a dedicated app at least an hour ahead and also provides estimated prices for the next 24 hours to allow planning of trips. The price is based on a combination of electricity cost from the supplier and the anticipated traffic conditions on that particular motorway route. The intention is to set higher tariffs for peak traffic times in order to discourage the use of heavily congested routes and lower tariffs during off-peak times and alternative routes.

The operator also manages the speed of the traffic flow by ensuring that the FABRIC system is working in tangent with the smart motorway system. The FABRIC solution provides power only to vehicles moving within the indicated speed limit thereby, encouraging them to maintain optimum flow.

2.3.5.Scenario 4: Access control on a shared bus way and charging lane in a city

A city has a 500-meter length of bus way, which is a dedicated piece of infrastructure either in a tunnel or elevated on a viaduct, hence it is not adjacent to any footpath and is forbidden to pedestrians, cyclists, etc. It is physically fenced off from the surrounding land (as is normal for a railway or motorway) and entry and exit have grids (to prevent access by animals) and detectors to

signal the presence of pedestrians. It is equipped with inductive charging infrastructure which is managed by the public transport operator (as it is primarily for buses) but can be used by private or fleet electric vehicles with an account.

Authorized vehicles (scheduled buses, electric vehicles, emergency services, etc) are fitted with a tag which allows them access (activating a traffic signal or barrier). Electric vehicle owners can buy a tag for their vehicle which is linked to the vehicle number-plate and a payment account for charging, as well as activating barriers or traffic lights controlling access to restricted roads.

A visiting driver wishes to use this busway to charge her electric car but does not have an electronic account or tag because she lives in another region and she is only making a one-off visit to this city. She uses her in-vehicle unit to make a request to the FABRIC back-office using a unique code which identifies the charging lane in question (the code is shown on a fixed road sign 1km before the busway and charging lane starts). The system accepts her request and an SVD system at the busway entrance recognizes her car and allows her access. She charges the car while driving on the dedicated busway, and the local public transport operator then bills the account she has in her own city of residence, via a clearing house operation.

3. FABRIC actors and entities

A system actor is primarily an individual who directly interacts with the system. However within FABRIC several devices, ICT tools or computer systems may initiate important system functionalities necessary for EV charging, that can be described in the form of a use case and in that sense they are also considered actors. Actors have the capability to make decisions and to exchange with other actors information necessary for performing tasks.

This chapter describes the Users and Stakeholders for the FABRIC system on the highest level. For detailed Stakeholder overviews please check D22.1 “User needs, system concept and requirements for ICT solutions” and D32.1 “Technical and user requirements” [2], [3].

In this first phase both Stakeholder and User needs have been collected. FABRIC users are defined as human actors or organizations that directly interact with the system or some of its components applications and therefore are within the FABRIC system boundaries. Stakeholders are those parties that are affected by the FABRIC system(s) and do not necessarily reside within the FABRIC system boundaries.

Entities are defined as the non-human actors that initiate a use case or play important role within use cases by exchanging information with other actors. A sensor, a software module or a system acting within the FABRIC boundaries can be an entity actor.

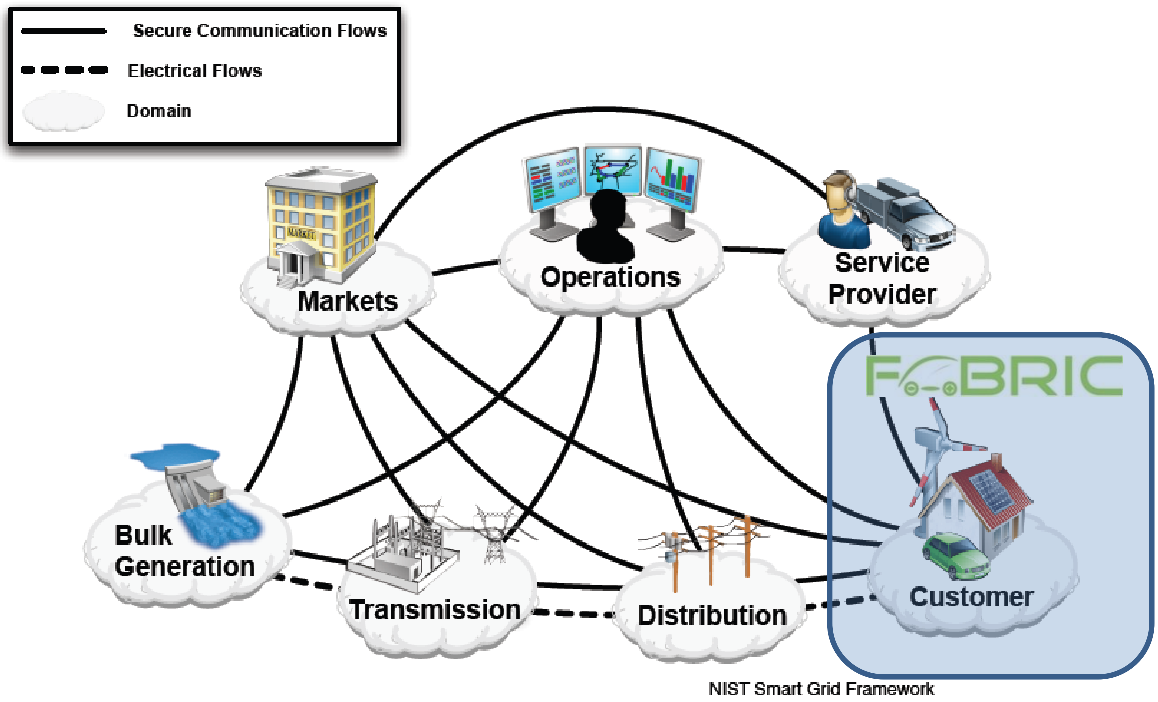

Figure 6: NIST Smart Grid Framework reference architecture [4] and FABRIC application area

3.1 Users for the FABRIC system

Users are external to the system, and can be humans or organizations. They will interact with the FABRIC system and are expecting certain functionalities that are expressed in terms of "user needs" and "requirements". Many times they also provide information to the system.

The main users that have been identified for the FABRIC systems are the following:

- **Drivers:** passenger car drivers as well as Light (LDV) and Heavy Duty Vehicle (HDV) drivers: these users directly interact with the systems that are inside the vehicle (pre-trip and on-trip) and some of the pre and post-trip applications; There are many different types of car drivers that also have different needs for a car charging system. The target for the FABRIC project is to reach as many drivers and vehicles as possible, which means that the system should be accepted by e.g. both regular drivers as well as professional drivers that require certain levels of system reliability and dependency or experienced drivers vs. young drivers.
- **The vehicle owner:** is the person who financed the vehicle and legally owns it. This could be the driver but also a leasing company or a company operating a fleet of vehicles. Depending on the payment scheme that will be used in the various installations of FABRIC, the owner may be the one that will be billed for the charging of the vehicle regardless of who drives it.
- **Transport planners**: the transport planner is the actor that directly interacts with the pre-trip planning application and in some cases also on-trip and post-trip applications. The interaction is similar or the same as with the driver user, however this is larger scale planning that may involve vehicle fleets or public transportation vehicles. Fleet operators are included in this user category.
- **Road operators:** Traffic managers & traffic engineers: these users directly interact with the applications defined in the FABRIC transport management & control applications. In addition **road contractors** that need to be able to build and maintain the FABRIC systems need to adjust their operations to ensure that the system as a whole remains functional.
- **Toll regulators/collectors:** This category of users may be included either in the road operators or in the DSO operators' category or be a category on its own. The "toll" may refer either to the use of the road infrastructure and/or the energy consumption by the vehicle.
- **Distribution System Operators:** distribution system operators (DSO) or grid operators have the responsibility to guarantee the secure operation of the electric network. In order to do that they will interact with the system in order to prevent in a timely manner threats that may escalate to cascading grid failures.
- **Energy Retailers:** Retailers or commercial aggregators buy energy at the electricity market and sell it to the customers using the distribution network of the DSO. They are able to send price signals to customers, if energy is very cheap (low consumption/high distributed generation) or very expensive (consumption peaks). In addition they may use the system to promote consumption of energy produced by RES.

- **Billing service operator:** the billing service operator manages the payment and reimbursement procedure for FEV users and for other operators. This operator is trusted by all FABRIC actors. In one possible implementation, the billing service operator can be considered as a part of the FABRIC system.
- **FABRIC operator:** A person that oversees the good operation of the system and communicates with the various external actors.
- **Map service provider:** the map service provider provides a map database and related map attributes.

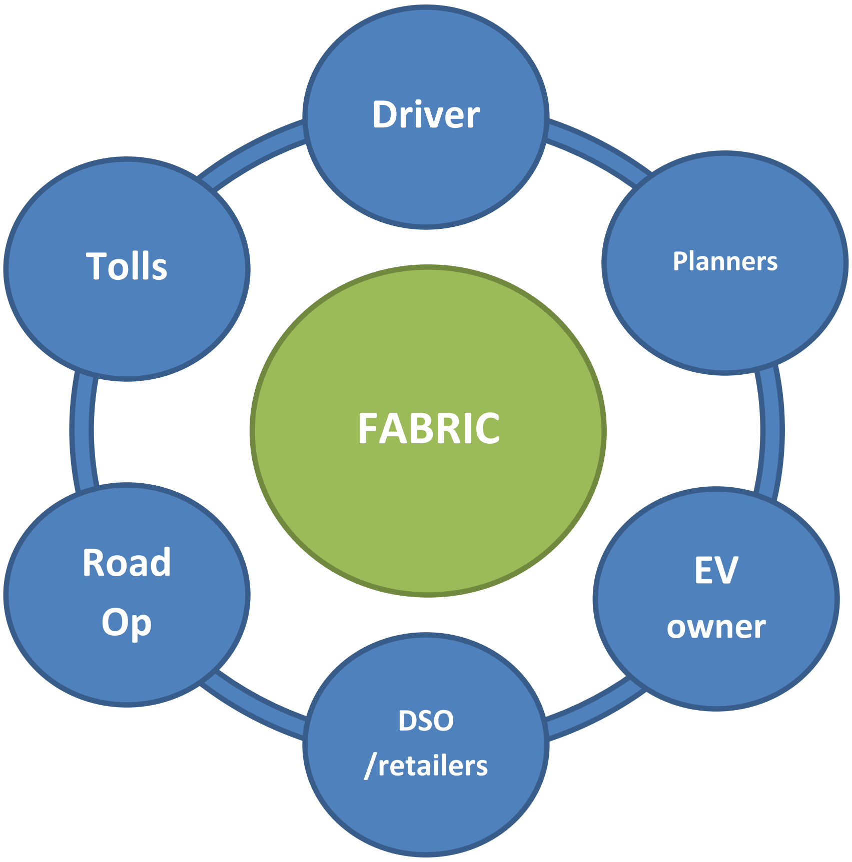

Figure 7: FABRIC main users

3.2 FABRIC Stakeholders

In each of the application and charging solution SPs (SP2 and SP3) a stakeholder analysis has been done. Stakeholders have been identified and the relations they have with the FABRIC system have been described.

To identify the needs of the different stakeholders, external stakeholders have been invited to provide feedback on the intended applications and use cases via interviews and web-based questionnaires. In addition, within FABRIC an External Reference Group (ERG) of experts is formed which acts as a consulting body on various aspects of system development. For an overview per subproject, one should refer to D22.1 and D32.1 [2], [3]. The ERG is invited at

every physical project meeting and convenes in a parallel session discussing issues relevant to the project and providing insights and guidelines. At the moment of writing the ERG comprises 23 experts that represent research institutes and major companies that are actively involved in electromobility and wireless charging, spanning from Asia to Europe to USA. Expert representatives of the energy industry and market are also included.

The stakeholders that are important for the FABRIC project are identified as follows:

- Car manufacturers / OEMs: these stakeholders aim to manufacture and sell vehicles that meet customer needs; EV range is a principal purchasing criterion for EVs as is the price of the EV which is proportional to the battery manufacturing cost.
- Automotive suppliers: these stakeholders want to sell systems and components to OEMs and also meet driver needs with new / better products.
- Service providers: these stakeholders offer back-end services that can help the driver to reach the destination without worrying about the autonomy of the vehicle. Services can vary from providing a traffic prediction to reservation of charging stations and pre-booking of charging lanes as well as infrastructure availability updates and re-routing/re-scheduling services. Automatic payment is also a major area that interests service providers.
- Technology providers: these stakeholders also want to provide front-end third-party applications and devices on e.g. smart phone equipment that help the driver to reach charging spots, to offer alternative routes and charging options and to allow monitoring and control of the charging process.
- Energy suppliers: These stakeholders are interested in selling as much energy as possible, while maintaining the secure grid operation. EVs are a potentially huge, new energy market.
- Renewable energy solution providers: De-carbonization of transport cannot be achieved if the energy consumed by the EVs is produced by conventional sources that pollute the environment. Thus the clean energy of RES will be promoted for the charging of EVs. RES offers decentralized production and in that way the energy plant can be built close to the consumption area, in FABRIC's case the charging lane or spots. RES OEMs are interested in manufacturing and installing distributed RES parks and FABRIC offers such an opportunity. Comparing to the conventional vehicles, the EVs offer the big advantage that they can be used as decentralized energy storage units. This presents a great potential for much larger RES penetration, without sacrificing the grid security.
- Smart metering OEMs: smart metering is an integral part of FABRIC. Both hardware OEMs and software providers have interest in this domain.
- Smart grid authorities: FABRIC offers the opportunity to integrate transportation into the smart grid concept.
- Standardization bodies: Governmental and private organizations involved in the standardization of the smart grid, the wireless power transfer to and from EVs and the

modernization of the energy production and distribution networks will be very interested in FABRIC technology and solutions.

Indirectly involved stakeholders are:

- Local authorities / cities: reduce the level of CO2-emissions in the road network.
- Road administration or governmental authorities are institutions regulating transport of goods on a national or European level. Their main concern is the compliance to regulations. These regulations are incorporated into the policies of local authorities which creates some overlap.
- Road manufacturers: they will be involved in the construction of future electrified roads (e-roads).
- Toll collectors: Toll / Tax collection for the use of infrastructure (e.g. roads) or causing environmental "damage" becomes daily practice.
- Consumers' and organizations' awareness about CO2 and the consequences for the environment is increasing. Therefore they will be interested in detailed information about CO2 savings that are possible by FABRIC-enabled vehicles and may be persuaded to buy one or upgrade a whole fleet of vehicles.

Stakeholders that are not directly involved in the project, but are as well important:

- Other road users: vehicles without the FABRIC system, pedestrians, cyclists, motorists, etc., their main need is to be able to safely use the road network.
- High level urban traffic managers: these traffic managers control the traffic within a city by all available means (e.g. traffic light control); from FABRIC perspective these stakeholders want to ensure that the driver follows recommendations given by the traffic center or the FABRIC control center which may be part of and interfacing with an existing traffic center.
- Everyone involved in the car sales field: these stakeholders sell cars produced by the OEMs to the drivers; for these stakeholders it is important that the features in the car can be easily explained and offer an added value for the vehicle in order to sell better.

In the figure below the stakeholder diagram shows the different stakeholders that are relevant for the FABRIC project and how they are related to each other and to the FABRIC system. In this diagram users are shown in blue and stakeholders in green.

Figure 8: Stakeholders diagram for FABRIC

3.3 FABRIC Entities

The entities presented here are part of the FABRIC system: they contribute to the different services and functionalities of the system and can describe devices or functional blocks.

In order to identify a list of possible FABRIC entities, a preliminary, high-level, conceptual architecture was conceived and is depicted in figures 9 and 10. The basic modules that it comprises are described below and are used to draft the use cases. Since the time of writing this deliverable is at an early stage in the project's lifetime and actual development has not yet begun, changes are expected until the delivery of the final prototypes. However these changes are not expected to alter the functionality concept in major ways.

In the following figure a simplified first concept of the system is presented. The major points that can be derived from it are the following:

- FABRIC will comprise two major units: an "on-board" unit located in the EV and an "off-board" one located at the infrastructure.
- The various operators (DSO, energy retailer, road operator) will not interact with the drivers directly but through FABRIC interfaces, the information will be assessed by FABRIC EV mobility platform and potentially combined with information from other sources before presented to the drivers in a way that is designed simply enough so as to not confuse and distract them during driving.

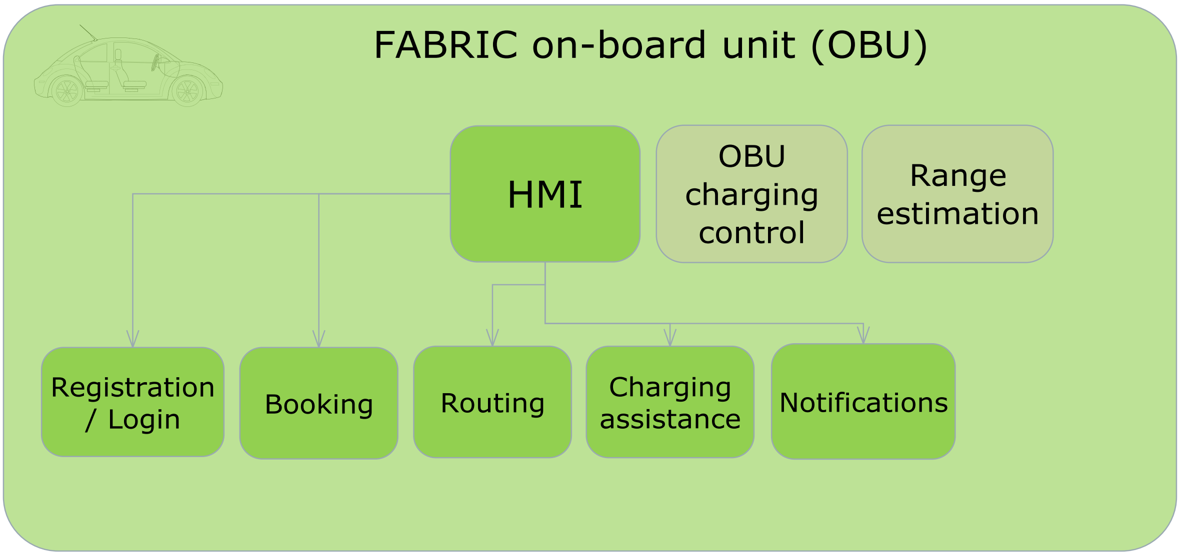

Figure 9: FABRIC OBU preliminary functional architecture

The FABRIC OBU comprises:

- The in-vehicle charging hardware which includes the secondary coils needed for inductive charging and the control electronics.
- A module that controls at a low level the charging of the battery based on parameters set by the user, the charging system and also the vehicle and battery characteristics called the OBU charging control.
- A range estimation module as almost all modern ICE vehicles; however instead of calculating the autonomy based on the current fuel volume, this range estimator takes into account the battery charge, the characteristics of the EV and the route and potentially weather information. Such accurate range estimators are being investigated in other research projects, thus they are not a development objective of FABRIC.
- The HMI which provides the following functionalities:
  - Registration and login of the driver. The drivers should register their data (billing information, name, contact details etc) and the EVs characteristics to the FABRIC database in order to use the system. This functionality could also be provided via a mobile phone or a desktop computer. After registration the driver could login to the system. The identification of the EV prior to charging is linked to this account.
  - Booking. The driver may book in advance a charging infrastructure. The booking can also be done automatically by the system based on the route, infrastructure availability and the driver's preferences.
  - Routing. The HMI will provide navigation functionalities as current navigation systems but with extended functionalities and features to facilitate EV charging.
  - Charging assistance. Once the drivers are close to the charging facility, the HMI will guide them through the whole process.

- Notifications. Messages from FABRIC or other sources will be displayed to the driver as needed during the trip in a non-distracting manner. Payment information will also use this functionality.

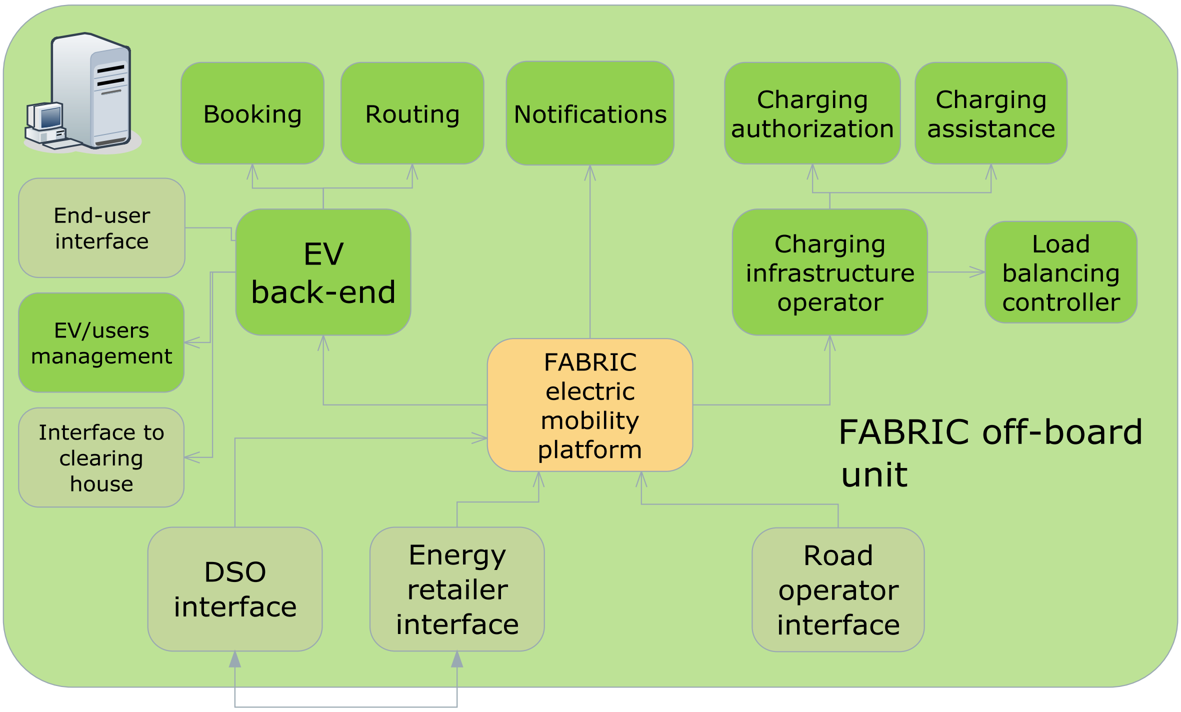

Figure 10: FABRIC off-board unit preliminary functional architecture

The off-board unit of FABRIC comprises several interfaces for the different external actors of the system:

- The DSO interface. This can be accessed via an internet secure connection and gives the ability to the DSO mainly to control the amount of energy allocated to a charging infrastructure. Other functionalities may be possible.
- The energy retailer interface provides them with a means to update the energy tariff which will then be used by the system for the estimation of the final EV charging price.
- The road operator interfaces provides an access point to FABRIC so that the charging and road infrastructure availability status can be updated in order to notify drivers for scheduled or unscheduled events that may affect their charging scheduling. The road operator also has the ability to control directly the infrastructure in cases of emergency.
- The clearing house interface pushes the aggregated payment and user/EV information for each charging session to a third party which performs the necessary actions to ensure the proper billing of the user who used the FABRIC EV charging service. Through this interface validation of the billing information that the user enters in the profile may take place.
- End-user interface provides a gateway other than the FABRIC OBU to the FABRIC platform for the driver or fleet operator or EV owner. Several functionalities may be

achieved through this interface such as remote charging monitoring, profile management, route planning prior to the trip, overview of charging sessions and billing statistics etc.

A module called “FABRIC electric mobility platform” will be the core element of the entire system and will coordinate the actions of all peripheral modules by processing, filtering and routing the communications and information flow. All information coming from the external actors of the system, pass through this module and are processed in order to present the driver with notifications that are coherent and discrete enough so as to not distract from driving. With the cooperation of the EV back-end it validates booking operations taking into account grid and road status.

The EV back-end module is an internal system actor and contains the users and EVs database. It also handles booking and routing operations mirroring and working in tandem with the corresponding functionalities of the FABRIC OBU. It also may store information about the charging sessions to the drivers’ profiles so that statistics can be extracted either by the system or the drivers.

The charging infrastructure operator is an internal actor and controls the actual charging of the EVs and will probably be physically installed close to the infrastructure or integrated in it. It provides charging authorization and charging assistance functionalities but also handles the low-level balancing of the load among the many EVs that will be charging at the same time. This is an algorithm that takes into account many parameters and produces charging profiles for each EV in near real time.

With this preliminary information it was possible to design the use cases at a level which is low enough to provide guidelines to development whilst providing a complete picture of how FABRIC is expected to operate and which functionalities it will provide to the several external actors.

4. User needs and requirements

4.1 Overview of expected high level user needs

A system has a purpose when it fulfills the needs of a group of people, its users. Thus in order to define the desired functionality of a system and the way that it will interact with the users (use cases) one of the first steps is to enquire the user requirements and the gaps between users' needs and what existing systems offer.

The existing electromobility systems for private vehicles rely entirely on static charging. Static plugin charging nowadays is a mature technology and the norm in EV charging. There is already a large number of static electric plug-in chargers installed around the world [5] and this number is increasing continuously due to government initiatives that promote the change to electromobility [6], [7].

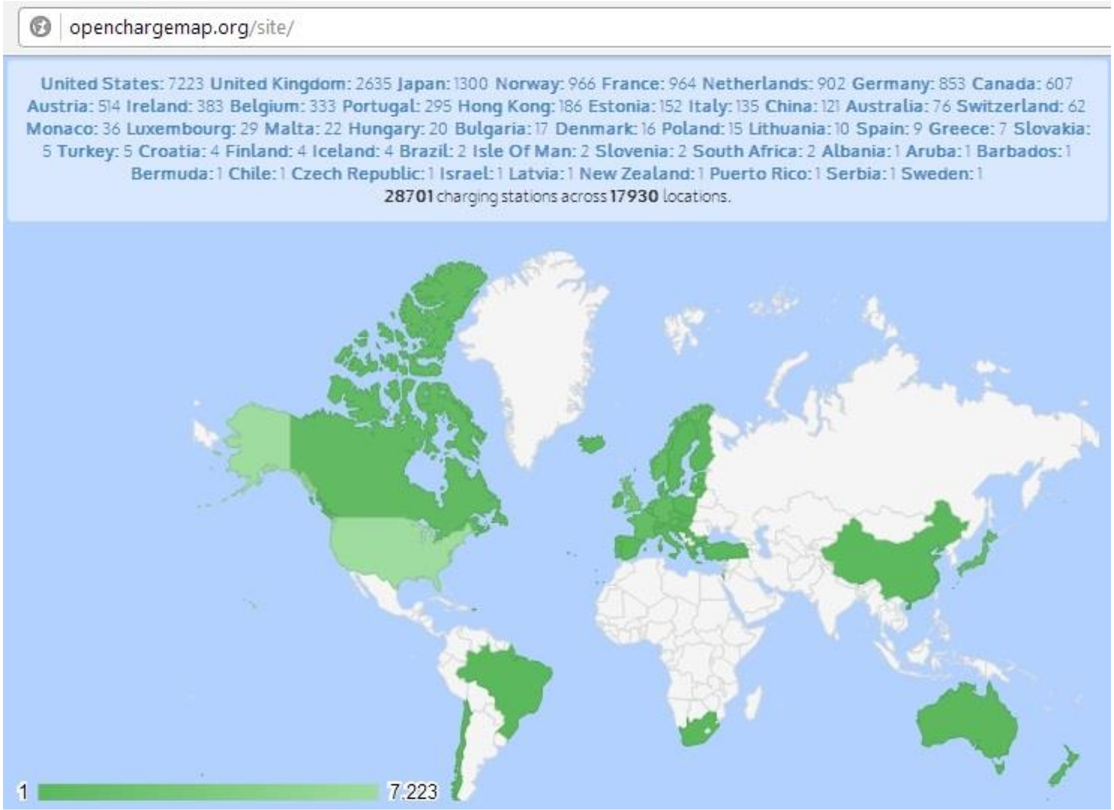

Figure 11: Static charging stations around the world.

Plug-in systems have some inherent issues that hinder the wide adoption of EVs. A major obstacle is the time needed to recharge the batteries. Typically, recharging lasts for several hours when using low voltage and amperage power outlets, which limits the usage of EVs. The typical scenario of use for these vehicles entails usage during the day and charging during the night. Even though this scenario is feasible it causes a feeling of limitation to the EV owners, which when paired with the limited range of current EVs, prevents the large penetration of EVs in the transportation market. Furthermore, dedicated charging facilities are required at the user's home such as garages with dedicated power line, however this infrastructure is not easy

to be found in apartment building dominated cities. Another scenario is charging during the day when the EV owner is working but this scenario also suggests the availability of infrastructure in large parking lots, while there is the additional problem of adding another load to the grid during demand peak hours. Advances in static charging technology have reduced the time needed to 30 minutes using fast chargers, however when travelling, this time is still long when compared to refueling time of conventional ICE vehicles that also have greater range.

A second factor for the low EV penetration is the cost of the batteries which is relevant to the battery size. In order to increase EV range the manufacturers are pushed to use larger batteries, which affects the car's weight and price.

Finally many users may not like the hassle associated with plugging in the EV for recharging, particularly for short periods.

Dynamic charging aims at alleviating some of these issues thus easing the path towards large-scale adoption of electromobility. The advantages of dynamic charging comparing to static are:

- Smaller batteries, since the EV will be able to pick up energy from the road while travelling. This should also affect the price of the EV.
- Hassle free charging. In theory recharging the vehicle could be as unobtrusive as driving normally on a highway lane. No need to plug in cables thus also avoiding safety risks associated with worn-out infrastructure cables and vandalism.
- Charging on the go means that the EV will not have to stop to recharge which is an advance even compared to conventional ICE vehicles. The comfort factor is expected to be a major decision factor for buying an EV in the future.

On the other hand, dynamic charging would clearly require more expensive infrastructure compared to static charging (even in a future scenario where dynamic charging facilities are widespread) – the lower efficiency of energy associated with inductive charging will also raise costs. So it is likely that this cost will be reflected in the price to the end user unless governments pay the investments required via taxation in order to promote the transition to electromobility. Hence it could be considered complementary to static charging, used more on-trip to boost the EV range or where the user does not have time to effectuate a full charge using plugin technology.

In the figure below one can see that while plug-in technology can support only static charging, conductive and inductive power transfer technologies can charge a vehicle while stationary but also on the move, adding significant flexibility to EVs. Detailed definitions of the charging modes in FABRIC are included in Chapter 5.

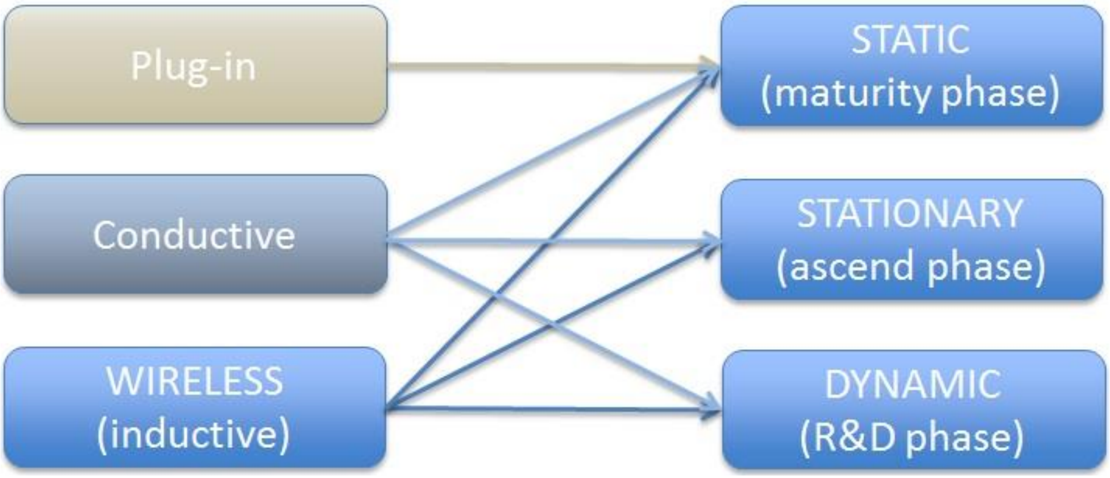

Figure 12: Charging types support by different charging technologies

Plug-in		Conductive		Inductive	
Cons	Pros	Cons	Pros	Cons	Pros
User discomfort	Mature technology	Visual pollution	Easy installation	Expensive infrastructure	Smaller batteries
Long charging duration		Expensive pantograph systems	Smaller batteries		Cheaper EVs
Large and expensive batteries			Extended range		Extended range
Expensive EVs			Comfort		Comfort
Vehicle must be parked			Increased mobility		Increased mobility
					No visual pollution

Figure 13: Advantages and disadvantages of EV charging technologies

4.2 User survey preliminary findings

In order to validate the above points, surveys for the collection of user needs have been carried out in FABRIC SP2 and SP3. At the moment of defining the use cases a first survey was still in progress, so only preliminary results are presented in this document. This data was presented during the user needs workshop (within the 2nd FABRIC plenary meeting) and utilized during the use cases workshop that took place in Turin at the same date. The final results and analysis of the survey data will be included in FABRIC D22.1 ”User needs, system concept and requirements for ICT solutions” and in D32.1 “Technical and user requirements” respectively.
The methodology for the collection of user needs and requirements entails a two-stage process. On the first stage a simple to complete generic survey was conducted which was aimed

at a wide audience which does not necessarily comprise experts in electromobility. This provides a first snapshot on the public's views and provides the basis for a deeper more technical analysis at a later stage. The questionnaire collected information about

- the participant's profile, such as experience with and knowledge about electromobility,
- views on strategic priorities, prospects and business cases with regard to electromobility,
- views on simple cases relating to charging infrastructure.

Invitations to participate to the survey were extended to more than 200 people via the following channels:

- ERTICO network (213 invitations)
- www.erticonetwork.com
- www.automobile-propre.com (French portal)
- www.hyer.eu (European association)
- www.ev-observatory.eu
- LinkedIn groups (ITS, iMobility, Transport Research, new FABRIC group)
- FABRIC External Reference Group

At the moment of writing 41 participants filled-in the online questionnaire. The respondents came from 14 countries, 12 of these countries (representing 36 of the 41 respondents) being EU Member States, with the remaining 5 respondents being from the USA and Canada.

The participants represent a mix of research and development and academic institutes (28%), public authorities (both local and national - 19% in total), 50% were from industries and SMEs in the areas of intelligent transport systems and information and communication technologies, vehicle manufacturing, energy production and distribution, road infrastructure management, freight and passenger transport. The remaining 3% were from associations.

The majority of the participants were aware or were experts on fields relevant to FABRIC research: electromobility, ICT infrastructure, Intelligent vehicles and energy supply and distribution. In that way they could provide informed opinions to a degree that depends on their expertise. However even the non-expert opinions are very important since electromobility systems such as FABRIC refer to the average consumer who has no deep knowledge of these scientific and technical fields. Deliverable D22.1 will provide further breakdown of results by level of knowledge or expertise in the different domains related to FABRIC, as well as sector of employment.

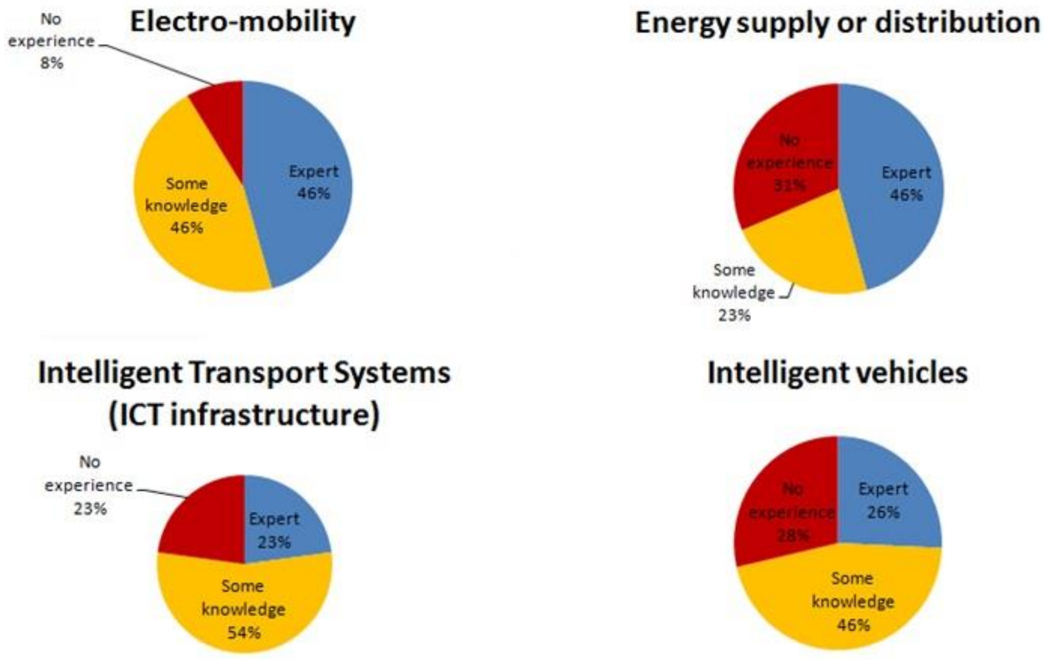

Figure 14: Participants' experience on FABRIC related fields.

In the following figure there is an analysis of the participants' experience regarding the various vehicle propulsion methods. As expected the vast majority owns and uses conventional ICE vehicles. 16% of the respondents own or regularly use fully electric vehicles: higher than the population as a whole but given the target audience of this questionnaire it is more likely that people who have direct experience of EVs would be interested in participating than people with no such experience. Another 34% reports occasional usage of fully electric vehicles, bringing the percentage of participants with hands-on experience with EVs to a 54%. This allows the extraction of informed opinions from this survey group regarding the needs of people who actually have experiences the current EV technology and know its limitations.

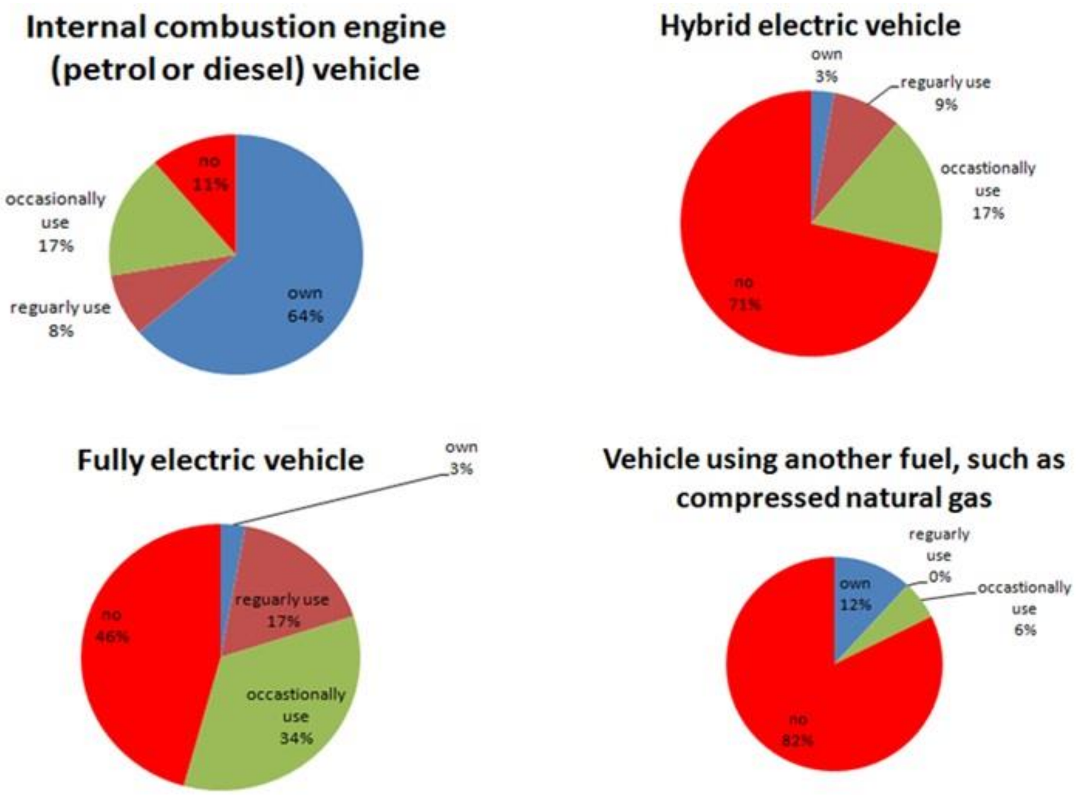

Figure 15: Participants' experience with vehicle propulsion technologies

The following figures show the level of satisfaction from the current EV charging systems for various functionality aspects. These questions were only answered by respondents who have used a public EV charging point (e.g. in a street or parking facility), hence only 22 out of the 41 questionnaire respondents answered this question. Price and payment seem to have mixed dissatisfaction levels. This could reflect the different pricing strategies and rates in operation around Europe. Indeed, some conventional plug-in EV stations are currently free to use (e.g. provided by public authorities) in order to encourage take-up, but with more EV use, free facilities will probably become chargeable. On the other hand it seems that only about half are satisfied with safety, even though even though most are neutral and no accidents related to EV charging are known. About half report that they are satisfied with the ease of use but the satisfaction level drops significantly when it comes to the duration of charging. It is evident that users wish to have faster charging vehicles while the satisfaction percentage could be attributed to the fact that there is no alternative to plug-in EV charging technology at the moment in order to compare.

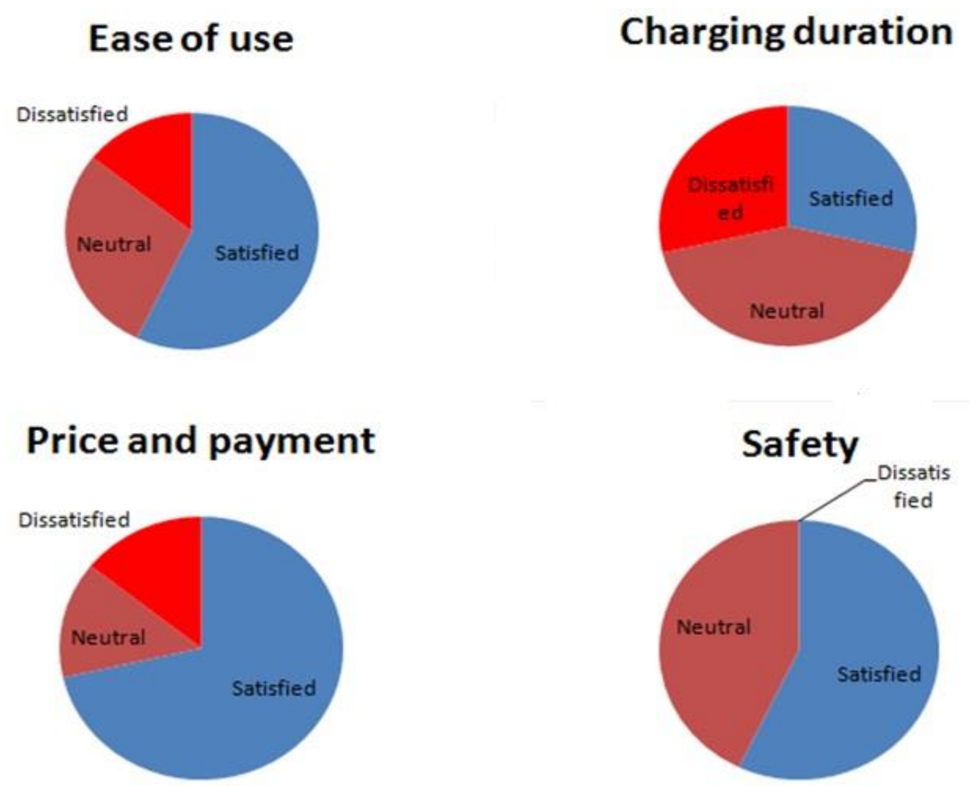

Figure 16: Satisfaction levels for current plug-in charging systems (public charging stations).

The above assumption may be strengthened by the subsequent replies which indicate that the participants feel positive towards other modes of charging their EVs. The positive sentiment increases as the charging process become more unobtrusive. Specifically we see that stationary charging, meaning charging of the EV during short stops is considered to bring a medium increase to electromobility adoption and more specifically for urban use, something which is logical since vehicles stop most frequently in cities. On the other hand dynamic or on-the-go charging is expected by the participants to bring a large increase to electromobility adoption both for urban and interurban usage scenarios which basically cover all transportations.

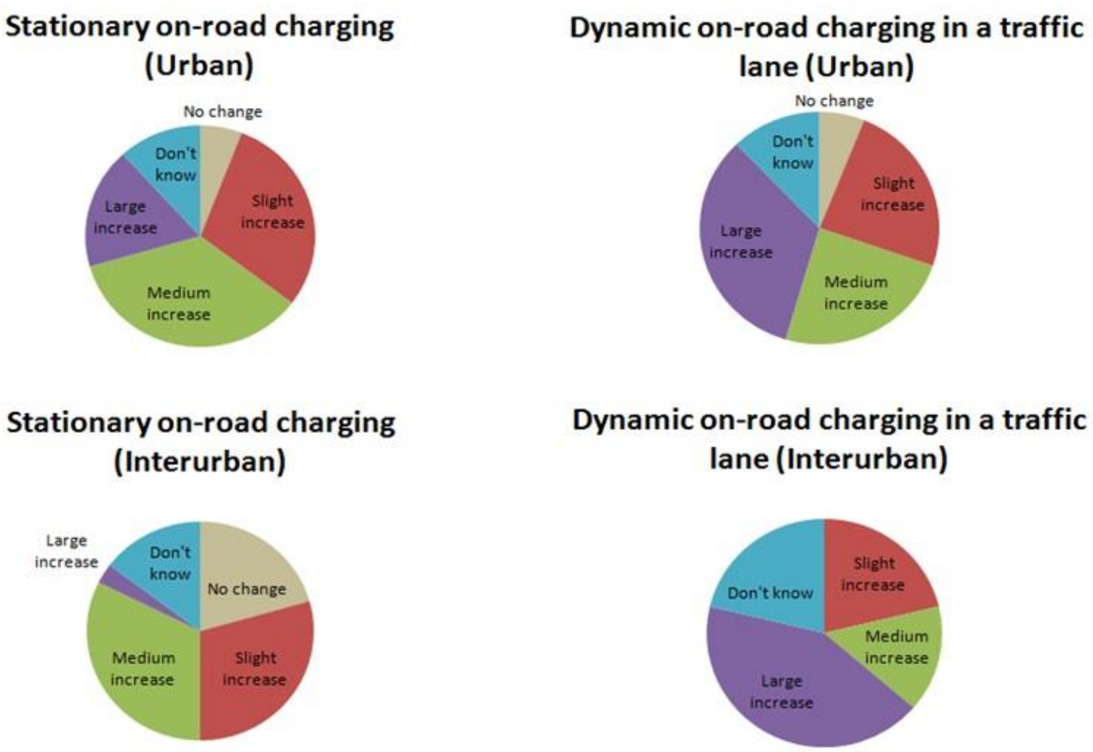

Figure 17: Potential increase in electromobility adoption after stationary and dynamic charging modes are introduced.

Regarding the provision of information about the charging infrastructure the vast majority said its location and availability should be publically available and easily accessible, however there were mixed opinions on who should provide the information.

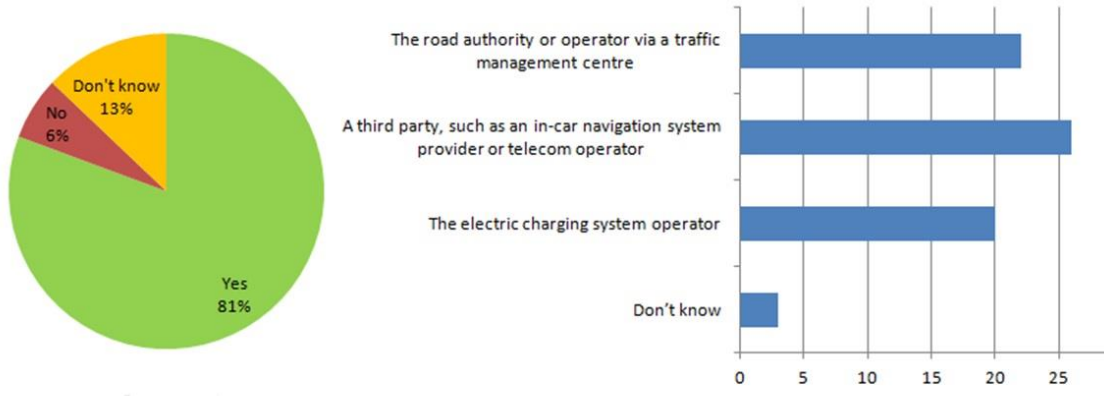

Figure 18: Should location and availability of dynamic charging facilities be shown publically in urban areas and who should provide the information?

In the figure below the impact on the existing electric grid is assessed. Since this is a future technology and even now, although static charging of EVs is a mature technology, the number of EVs on the streets is low, there is a mixed impression on the impact that EV charging might have on the grid. Today for the majority of privately owned EVs the power consumption during charging is low, and is compared to an air conditioner while it lasts for several hours. This may be the reason that 42% of the participants replied that the impact will be low. However when the numbers of EVs increase exponentially and when the power transmission during stationary

and dynamic charging creates load spikes up to 200kW for each vehicle, the impact is expected to be significant. This is understood by the 32% of the participants. The great majority however considers that it is essential to implement safeguards to guarantee the secure grid operation.

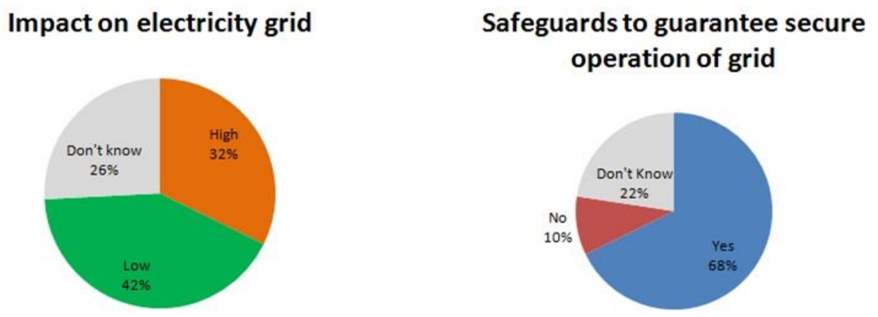

Figure 19: Estimated impact on the electric grid and need for safeguards.

Although these are only the headline results and are not broken down by respondent type or area of expertise, we can extract some needs directly or indirectly from the above replies. These preliminary user needs are listed below and assigned an ID so that they can be easily referenced in the use cases template. As is already mentioned, the data collection from the survey is on-going but in addition more surveys and webinars will be organized to collect further information and analyze deeper the needs of FABRIC stakeholders on more specific and technical aspects. In case the new data show new trends and new user needs the present deliverable will be updated to take into account the new information. The updated user surveys data will be included in the corresponding SP2 and SP3 deliverables D22.1 and D32.1.

ID	User need	User
#UN1	Faster EV charging	Driver
#UN2	Easier, less obtrusive charging procedure	Driver
#UN3	Safer charging infrastructure	Driver
#UN4	Similar to existing payment models	Driver
#UN5	Stationary charging mode	Driver
#UN6	Dynamic charging mode	Driver
#UN7	Information about the location and the availability of charging infrastructure	Driver
#UN8	Need for privacy and data protection	Driver
#UN9	Safeguards to guarantee secure grid operation	All

The following user needs are extracted indirectly by observing, on a high level, the functionality of state of the art charging systems.

ID	User need	User
#UN9	Charging assistance within the vehicle	Driver
#UN10	Ability to monitor the charging process remotely and from within the vehicle	Driver
#UN11	Ability to control an ongoing charging process	Driver
#UN12	Navigation towards charging facilities assistance	Driver
#UN13	EV range extension	Driver

#UN14	Ability to control the power allocated to a charging infrastructure	DSO
#UN15	Ability to control access to a charging/road infrastructure	Road operator
#UN16	Common practice in ICT/ITS	

5. FABRIC EV charging modes

Charging modes are defined in FABRIC for charging solutions (focusing mainly to on-road charging) in order to allow more precise definition of their functionality and thus a better representation of requirements and necessary specifications and architectures.

A charging mode, as defined in FABRIC, is intended to be technology, or solution, agnostic and aims to define the "mode" of operation for any on-road charging solution. It is anticipated that any on-road charging solution will also be capable of operating under static or stationary conditions. The modes of operation in FABRIC are therefore defined as:

- **Static charging**: Power transfer to the vehicle while the vehicle is static for a long period of time (>5 minutes) and while there is no driver on-board the vehicle.
- **Stationary en-route charging**: Power transfer to the vehicle while the vehicle is stationary for a short amount of time (< 5minutes) but is en-route and therefore would typically have driver (and maybe passengers) on-board.
- **Dynamic charging**: Power transfer to the vehicle when the vehicle is in motion. Driver and passengers are expected to be on-board.

FABRIC's main objective is to assess the feasibility of the dynamic charging mode. However, the dynamic charging mode cannot be taken in isolation from the static and stationary modes as any on-road charging solution capable of operating in a dynamic mode would be expected to also operate in static or stationary modes. The three modes of operation are described in more detail below.

Charging mode 1: Static Charging

Power is transferred to the vehicle while the vehicle is static for a long period of time (>5 minutes) and with no driver on-board the vehicle.

- **Short description**

This mode refers predominantly to charging of vehicles while they are parked. This mode is analogous in its principle to conventional plug-in charging which would also be described as static mode charging. The vehicle would be parked in a dedicated space where charging would commence either automatically with the driver's confirmation from within the vehicle or, manually by driver starting the charging process through some sort of off-board user interface. Note that in either case, no handling of a connector is necessary to couple the vehicle to the charger, this is done automatically. Typically, no driver or passenger would be present on board during charging (other than to confirm the charging process).

- **Example application scenarios:**
  - Car parking in a garage or car park.
  - Bus parking at a bus terminus or station.

- Freight vehicles while loading or unloading.

- **Mode Definition parameters**

Estimates for each parameter defining the charging mode are provided below. Note that at this stage of the project, these are provisional estimates only and may be subject to revision once the solutions have been developed.

Table 1: Static charging parameters.

Parameter	Range	Comments
Vehicle speed (km/h)	0	Mode applicable if stationary for longer than 5 minutes
Vehicle acceleration (m/s^2)	N/A	
Transmitted power level range (kW)	3 to 50	Similar to existing plug-in charging solutions and wireless charging solutions
Power transmitted to which component	N/A	Power transmitted to the vehicle on-board energy storage system only
Charging time (minutes)	>5	Upper limit of charging time is subject to use, power rating and vehicle on-board energy storage system capacity
Vehicle status	N/A	Vehicle engine / power will generally be off during charging (but may be on for a short time while initiating coupling / charging process)

Charging mode 2: Stationary en-route charging

Power is transferred to the vehicle while the vehicle is stationary for a short amount of time (< 5 minutes) but is en-route and therefore would typically have a driver (and maybe passengers) on-board.

- **Short description**

This mode refers predominantly to charging of vehicles while they are stationary for a short period of time but are en-route to another location. This mode could in theory be satisfied in some cases by conventional plug-in charging, however, in reality this is unlikely to be practical or safe and is therefore, considered to be a mode unique to on-road charging solutions (either inductive or conductive). The vehicle would stop in a location that would be suitably equipped but is not a dedicated stopping / parking spot, typically this would be on a road but power transfer would only be activated when the vehicle is stationary. Charging would commence automatically with the driver's confirmation from within the vehicle. Typically, the driver (and passengers) would be present on board the vehicle during charging.

- **Example application scenarios:**
  - Taxis queuing in a taxi rank
  - Bus stopping at bus stops
  - Vehicles stopping at junctions, traffic lights, tolls, rail level crossings, etc.

- **Mode Definition parameters**

Estimates for each parameter defining the charging mode are provided below. Note that at this stage of the project, these are provisional estimates only and may be subject to revision once the solutions have been developed.

Table 2: Stationary charging parameters.

Parameter	Range	Comments
Vehicle speed (km/h)	0	Mode applicable if stationary for less than 5 minutes
Vehicle acceleration (m/s^2)	N/A	
Transmitted power level range (kW)	20 to 200	Similar to existing fast and rapid charging solutions (plug-in and wireless)
Power transmitted to which component	N/A	Power transmitted to the vehicle on-board energy storage system only
Charging time (minutes)	<5	Upper limit of charging time is subject to use, power rating and vehicle on-board energy storage system capacity
Vehicle status	N/A	Vehicle engine / power can be on or off depending on the vehicle powertrain control and exact application

Charging mode 3: Dynamic charging

Power is transferred to the vehicle when the vehicle is in motion at constant or variable speed.

- **Short description**

This mode refers predominantly to power transfer between the charging infrastructure and the vehicle while the vehicle is moving. The electric power / energy flow is variable depending on the conditions, including also possible phases with power flowing from the on-board energy storage and the grid to the on-board traction system.

The vehicle could be travelling at a variable speed and power transfer level could be responsive in real time to vehicle power demand or the condition of the electric grid / distribution system, within the constraints of the system capability or other fixed parameters. Charging would commence automatically with the driver's confirmation from within the vehicle, once the vehicle enters a charging zone on the road. The driver (and passengers) would be present on board the vehicle during charging.

Variation of the vehicle speed that results in increased power demand, e.g. acceleration, could result in increased power transfer level, subject to grid availability and other potential conditions such as price, charging solution capability, demand from other nearby vehicles, etc.

- Example application scenarios:
  - Highways (multiple lanes)
  - Urban roads with dedicated charging lanes
- **Mode Definition parameters**

Estimates for each parameter defining the charging mode are provided below. Note that at this stage of the project, these are provisional estimates only and may be subject to revision once the solutions have been developed.

Table 3: Dynamic charging parameters.

<table>
<tr><th>Parameter</th><th>Range</th><th>Comments</th></tr>
<tr><td>Vehicle speed (km/h)
– Low Speed scenario</td><td>>0, <50</td><td>Constant or variable speed</td></tr>
<tr><td>Vehicle speed (km/h)
– High Speed Scenario</td><td>>0, <130</td><td>High speed scenario - Constant or variable speed</td></tr>
<tr><td>Vehicle acceleration (m/s^2)</td><td>>0, <5</td><td>Range covers possible accelerations of vehicles ranging from cars to trucks</td></tr>
<tr><td>Transmitted power level range (kW) – Low Speed Scenario</td><td>7 to 140</td><td>Maximum Power. Refers to both cars and trucks.</td></tr>
<tr><td>Transmitted power level range (kW) – High Speed Scenario</td><td>18 to 360</td><td>Maximum Power. Refers to both cars and trucks.</td></tr>
<tr><td>Power transmitted to which component</td><td>N/A</td><td>Power transmitted either to the vehicle electric drive or, to the on-board energy storage system or, both</td></tr>
<tr><td>Charging time (seconds) – Low Speed Scenario</td><td>N/A</td><td>Depends on vehicle speed and dimensions of the primary charging infrastructure. Possible range indicated below:
<table>
<tr><th>Charging time (sec)</th><th colspan="2">Size of primary charging infrastructure</th></tr>
<tr><td>Speed</td><td>1m</td><td>100m</td></tr>
<tr><td>10 Km/h</td><td>0.35</td><td>35.7</td></tr>
<tr><td>50km/h</td><td>0.07</td><td>7.14</td></tr>
</table></td></tr>
<tr><td>Charging time (seconds) – High Speed Scenario</td><td>N/A</td><td>Depends on vehicle speed and dimensions of the primary charging infrastructure. Possible range indicated below:
<table>
<tr><th>Charging time (sec)</th><th colspan="2">Size of primary charging infrastructure</th></tr>
</table></td></tr>
</table>

		<table><tr><td>Speed</td><td>1m</td><td>100m</td></tr><tr><td>70Km/h</td><td>0.05</td><td>5.1</td></tr><tr><td>130km/h</td><td>0.028</td><td>2.8</td></tr></table>
Vehicle status	N/A	Vehicle engine / power is on during the power transfer process

6. FABRIC use cases

6.1 Feasible versus demonstrable use cases within FABRIC

FABRIC's main goal is to assess the feasibility of wireless charging focusing on dynamic charging so as to promote the large-scale adoption of electromobility. In order to do that, two wireless charging solutions will be developed and demonstrated in order to validate their operational capability and assess their efficiency. A basic set of ICT functionalities is required in order to test the developed prototypes. These functionalities are listed in the DoW at WP2.5 "Design of ICT applications and development of components". Specifically the following necessary functionalities are foreseen:

- T2.5.1 ICT solutions development for an on-board system:
    - A driver assistance HMI to facilitate charging procedures.
    - Energy supply management considering battery charging status.
- T2.5.2 ICT solutions adoption for off-board system:
    - A local traffic control module.
    - A road-charging infrastructure management module able to provide
        - Long distance information to in-coming vehicles.
        - Charging request handling and authorization.
    - Power management and connection to the grid.

The respective deliverables are:

- D25.1 "Prototype of ICT modules for the on-board driver information strategies".
- D25.2 "Prototype of ICT modules for the on-board charging system alignment".
- D25.3 "Prototype of ICT modules for the off-board charge planning system".

Based on the above, a set of use cases that are necessary for the demonstration, testing and validation of the prototypes has been defined. These use cases have emanated from consultation meetings and continuous brainstorming among the FABRIC consortium members, based on their experience and expertise and are depicted in the following table.

Table 4: FABRIC demonstrable use cases.

	Use case	Rationale	Included in
1.	Driver and EV registration to a central FABRIC database	It is essential for EV identification prior to charging	T2.5.1
2.	Driver login to FABRIC	The end-users need to be able to log-in to FABRIC in order to manage their account and the stored information. This is also helpful in order to bill a specific person/driver and not an account that is linked to the EV.	T2.5.1
3.	User account management	The end-user should be able to update the information stored or delete the account.	T2.5.1

3.	EV identification	It is essential in order to authorize an EV to charge, for creating custom charging profiles that fit the specific vehicle and for billing purposes.	T2.5.1 T2.5.2
4.	Charging assistance	Driver assistance is needed in order to ensure alignment of the primary and secondary coils during the wireless charging. This is true for all charging modes: Static, stationary and dynamic. In addition, the driver needs to be provided with information regarding the charging process.	T2.5.1
5.	Charging management high-level and low-level (load balancing)	The power that reaches the EV depends on many parameters and it has to be carefully controlled. Two types of power management are foreseen and will be implemented in FABRIC: 1) a high level restriction of available power to the infrastructure which will be imposed by the DSO in order to guarantee the security of the grid. 2) a low level power management at EV level which will distribute the available to the infrastructure power to all EVs by creating custom charging profiles for each EV based on several parameters.	T2.5.2
6.	Energy supply tariff modulation	The energy retailer needs to be able to update the cost of energy that will be used by FABRIC to estimate the final charging cost for the end-user.	T2.5.2
7.	Charging and road infrastructure availability status updating	In case of emergencies or scheduled maintenance, the operators need to be able to shut down the infrastructure or the road and inform via the FABRIC system the end-users for the unavailability of the infrastructure.	T2.5.2
8.	Billing	The charging chain of events ends with the calculation of the charging cost and the billing of the end-user. Even though this is an essential part for the installed systems, the functionality is not expected to be crucial for the demonstration purposes of FABRIC. The billing procedures depend on company policy and each installation is expected to follow a different path using different service providers and clearing houses. So within FABRIC it is expected that only the charging cost will be calculated but the actual charging procedures of an end-user are left out of the prototyping and demonstration planes.	T2.5.2

The use cases above allow the demonstration and testing of complete charging scenarios for static, stationary and dynamic wireless power transfer. In that way they are adequate for the technology assessment part of FABRIC.

FABRIC is also a feasibility assessment project, looking ahead to a time where electromobility is widespread. For this reason the use cases are not restricted to the ones that will be demonstrated in FABRIC but enriched with “feasible” ITS use cases that can be foreseen for the near future based on existing products but also on current research taking place in other ITS oriented projects.

With that in mind, one can complement the technology demonstration-focused use cases with functionalities that are either currently available as off-the-shelf products, or are under research and development in current EU funded research projects. Since these products and services are already being developed, it would not be efficient to repeat and re-develop them within FABRIC. One could expect though that with the appropriate interfaces in place, these products and services could be integrated seamlessly in a future, feasible FABRIC system. The foreseen use cases that apply to a system such as FABRIC and extend its user friendliness are the following and are characterized as "feasible" use cases to differentiate them from the "demonstrable" use cases of FABRIC.

Table 5: FABRIC feasible use cases.

	Use case	Rationale	Feasible use in FABRIC	Availability in
1.	Planning of a trip	This is a mainstream functionality present in almost all modern vehicles. Current navigators allow for detailed route planning, including passage from specific POIs. Traffic information and ETA estimation are not uncommon. ITS research projects have focused heavily on the subject and each exploits dynamic navigation and mapping for its own purposes such as ecological driving.	This functionality may allow the pre-booking of charging facilities Along a route, taking into account the range of the EV.	- GPS navigators - ECOFEV [8] - MYWAY [9] - ECODRIVER [10] - ECOGEM [11]
2.	Guidance to a charging facility or to a destination	This is a very common functionality. Research projects focus on exploiting open standards and maps for ITS routing.	Leading the EV towards a charging facility based on dynamically updated charging facilities database.	- GPS navigators - ECOMOVE [12] - MYWAY - ECOGEM - ELVIRE [13] - …
3.	Dynamic route and booking management	Dynamic routing is a functionality of all GPS navigators and it is activated when the vehicle deviates from the route. Smart re-routing is the objective of several ITS projects based on different criteria.	In real traffic conditions, major delays compared to the planned time of arrival at a pre-booked charging infrastructure are to be expected. This is why a system that automatically makes the necessary booking and rerouting adjustments without the interference of the end-user is very desirable. The same system can be used in cases the infrastructure goes offline unexpectedly.	- MYWAY - GOOD-ROUTE [14] - ECOMOVE - ECOGEM - ELVIRE - iTETRIS [15]
4.	Emergency charging	This functionality does not contribute to the technology assessment of FABRIC prototypes but focuses on user convenience in the future when EVs are adopted by the public in a large-scale.	This is a functionality that is foreseen to exist when electromobility is widespread and systems such as FABRIC are common place. This functionality reduces range anxiety by providing a means to charge the EV without prior planning. However this will be done in a	-

			structured and organized manner so as to guarantee the good operation of the overall system but also discourage this practice.	
5.	Integration of FABRIC with UTMC	This is a foreseen functionality/system service for the road operators. However this is a feasibility use case because of different UTMC systems and standards that cannot be address within FABRIC and because it does not contribute to the technical assessment of wireless charging.	FABRIC charging infrastructure should be integrated with Urban Traffic Management and Control systems to ensure good traffic flow and enforcement.	Several R&D projects focus on vehicle-UTMC cooperative systems for traffic management and eco-driving.

In the following figure one can see how the use cases, (demonstrable and feasible) bind together to form a system that allows the seamless wireless charging of an EV. The feasible use cases are depicted with dashed outlines while the demonstrable are depicted with continuous outlines. The green arrow shows the typical charging path.

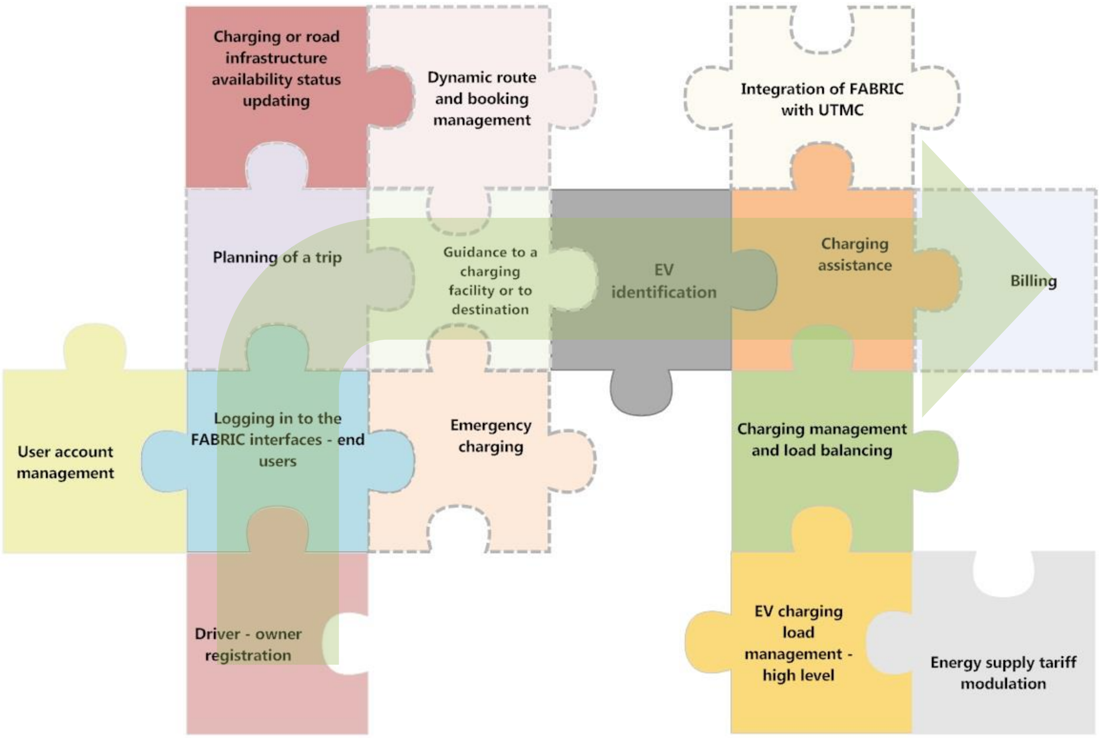

Figure 20: FABRIC use case interdependencies and connections.

6.2 Use cases detailed description

In this section the use cases, both feasible and demonstrable are described in detail. A color coding is used to easily differentiate the type of use case:

- Green for demonstrable and
- Blue for feasible.

The use cases were grouped according to the primary actor. This was not possible in some cases since this is a highly interconnected system and the roles/responsibilities are not always clear at least in this early stage of development.

The structure followed is shown in the table below:

Table 6: List of FABRIC use cases.

UC No.	Primary actor	Use case ID	Use case name	
1.	End-user (driver)	#1.1	Driver-owner registration	
2.		#1.2	Logging in to the FABRIC interfaces – end users	
3.		#1.3	User account management	
4.		#1.4	Planning of a trip	
5.		#1.5	Guidance to a charging facility	
6.		#1.6	Emergency charging	
7.		#1.7	Guidance to destination	
8.		#1.8	Assisted charging – static	
9.		#1.9	Assisted charging - stationary	
10.		#1.10	Assisted charging - dynamic	
11.	DSO	#2.1	EV charging supply management – high level	
12.	Energy retailer	#3.1	Energy supply tariff modulation	
13.	Road operator	#4.1	Integration of FABRIC with UTMC	
14.		#4.2	EV identification	
15.		#4.3	Charging or road infrastructure availability status updating (scheduled)	
16.		#4.4	Charging or road infrastructure availability status updating (unscheduled)	
17.	All operators	#5.1	Logging in to the FABRIC interfaces – operators	
18.		#5.2	Messaging to FABRIC platform – operators	
19.	FABRIC EV backend	#6.1	Dynamic route and booking management	
20.	Charging infrastructure operator	#7.1	Charging management and load balancing - static	
21.		#7.2	Charging management and load balancing – dynamic and stationary	
22.	FABRIC platform	#8.1	Billing	

6.2.1. Registration to FABRIC – end users

Use case name	**Registration to FABRIC – end users**	
Use case ID	#1.1	
Rationale	The end users of the system (drivers) need to register before using the FABRIC controlled infrastructure. When registering the user should be able to create a profile and select the preferred method of payment. Information regarding the FEV should also be provided at this stage in order to be used during the charging planning and process.	
Status (draft/final)	Final	
Short description	This use case covers the registration of the drivers or EV owners to the FABRIC system. It provides the means for the end user to create a profile and provide information that is essential for the charging and billing processes. The information required regarding the billing depends on the payment method that is chosen during the implementation of the system so it will not be described in detail at this stage. Payment methods may include credit cards, paypal, direct charging of bank accounts, prepaid cards etc. The second set of information that the user provides is the EV-related ones. This information is essential for EV identification and authorization to charge (e.g. number plate) and also for charging (type of charging equipment, maximum charging power etc)	
Primary Actors/Entities	- FABRIC end-users (driver/EV owner). - Fleet operators.	
System	FABRIC EV backend.	
Secondary Actors/Entities	Bank operator/clearing house.	
Vehicle type	All types	
Charging mode	All modes	
Preconditions	-	
Trigger event	The actor accesses the FABRIC registration interface and chooses to register.	
Successful end condition	- The actor is registered to the FABRIC user database.	
Failed end condition	- The actor is not registered to the FABRIC user database.	
Main success scenario description	Step	
	1.	The actor accesses the FABRIC user management interface and selects to register.
	2.	The system displays the user registration form.
	3.	The actor enters the personal identity information. [X1]
	4.	The system acknowledges the information.
	5.	The actor enters the payment related information. [X1]
	6.	The system validates the information with the bank

		operator. [X2]
	7.	The actor enters the EV related information. [X1]
	8.	The system acknowledges the information. [E1]
	9.	The actor finishes the registration. [X1]
	10.	The system displays the information and requests confirmation.
	11.	The actor confirms. [X1]
	12.	The system confirms user registration and provides access credentials (login and password).
Exceptions	Step	[X1] at Steps 3, 5, 7, 9, 11.
	1.	The actor selects “cancel”.
	2.	The system aborts.
	The use case fails.	
	Step	[X2] at Step 5.
	1.	The information cannot be validated by the bank op.
	2.	The system informs the actor.
	The use case continues at Step 5.	
Extensions	Step	[E1] at Step 8.
	1.	The system asks if the actor wants to register another EV.
	2.	The actor selects “yes”.
	The use case continues at Step 7.	
FABRIC modules involved	- FABRIC OBU. - FABRIC web interface for end-users. - FABRIC EV backend. - FABRIC clearing house interface.	
Critical parameters	- Communications quality with FABRIC.	
Type of environment	FABRIC OBU or personal computer or smartphone.	
Related Use cases	#1.2	
User needs	#UN8, #UN16	
Corresponding requirements	- The system should securely store sensitive personal data and the user’s privacy. - Secure communication with the FABRIC system. - The system should be compliant with security standards.	
Open issues	- The information that the user needs to insert during registration regarding the EV specifications and the billing information. - The validation technique for the user-provided data. - The user interface.	
Comments		

6.2.2. Logging in to the FABRIC interfaces

Use case name	Logging in to the FABRIC interfaces	
Use case ID	#1.2	
Rationale	In order to access the services of FABRIC, plan a trip, book infrastructure etc, the driver, or owner, or fleet operator should provide their identity. The identity needs to be authenticated for security reasons. Comparing to the login procedure for the operators, the login of the end user is more forgiving since the end users have no capability to alter FABRIC operating parameters and the offered services relate to individual and not global level.	
Status (draft/final)	Final	
Short description	The system allows access only to registered end users. In case the user forgot the credentials a solution is offered to restore them.	
Primary Actors/Entities	EV drivers, owners or fleet operators.	
System	FABRIC interface end users.	
Secondary Actors/Entities	FABRIC EV backend	
Vehicle type	All types	
Charging type	All modes	
Preconditions	- The Actor is registered and the credentials are stored into the system's database.	
Trigger event	The Actor selects to access FABRIC	
Successful end condition	- Actor is logged in	
Failed end condition	- Actor is not logged in	
Main success scenario description	Step	
	1.	Actor selects to access the system
	2.	The system displays input fields for login and password
	3.	The Actor enters login and password
	4.	The system validates the Actor credentials [X1] [X2] [X3]
	5.	The system informs the Actor when previous login took place
	The use case succeeds	
Exceptions	Step	[X1] at Step 4.
	1.	System notifies the Actor that password does not match the stored one and that X number of retries remain
	The use case continues at Step 2.	
	Step	[X2] at Step 4.
	1.	The system notifies the Actor that there is no user with that login name.
	The use case continues at Step 2.	
	Step	[X3] at Step 4.
	1.	System notifies the Actor that password does not match the stored one and offers to re-send password to the

		email address of the actor that was used for the registration.
	2.	The actor selects to resend the password.
	The use case fails.	
Extensions	Step	
	-	
FABRIC modules involved	- FABRIC OBU. - FABRIC web interface for end-users. - FABRIC EV backend.	
Critical parameters	- Communications quality with FABRIC	
Type of environment	FABRIC OBU or personal computer or smartphone.	
Related Use cases	#1.1	
User needs	#UN8, #UN16	
Corresponding requirements	- The system should securely store sensitive personal data and the user's privacy. - Secure communication with the FABRIC system. - The system should be compliant with security standards.	
Open issues	- The user interface.	
Comments		

6.2.3. User account management FABRIC

Use case name	User account management FABRIC	
Use case ID	#1.3	
Rationale	The end users of the system (drivers) need to be able to edit their information stored in the FABRIC database. This refers to their identity information, their payment-related information and their EV(s) information. The users should also have the ability to delete their account.	
Status (draft/final)	Final	
Short description	This use case describes the system's functionality to manage an existing account from the user's side. The registered users have the ability to edit their accounts and update their information but also delete the air accounts altogether.	
Primary Actors/Entities	FABRIC end-users (driver/EV owner) FABRIC fleet operator	
System	FABRIC EV backend	
Secondary Actors/Entities	Bank operator	
Vehicle type	All types	
Charging mode	All modes	
Preconditions	The actor has an active account stored in the FABRIC database and is logged into the account.	
Trigger event	The actor accesses the FABRIC user account interface and chooses to manage the account	
Successful end condition	- The actor has updated the information or deleted the account	
Failed end condition	- The actor was not able to update the account	
Main success scenario description	Step	
	1.	The actor accesses the FABRIC user management interface and selects to update the information
	2.	The system displays the user information form
	3.	The actor edits the personal identity information [X1][E1]
	4.	The system acknowledges the information
	5.	The actor edits the payment related information [X1][E1]
	6.	The system validates the information with the bank operator [X2]
	7.	The actor edits the EV related information [X1][E1]
	8.	The system acknowledges the information
	9.	The actor finishes the update [X1]
	10.	The system displays the updated information and requests confirmation
	11.	The actor confirms [X1]
	12.	The system confirms user account update
Exceptions	Step	[X1] at Steps 3, 5, 7, 9, 11.

	1.	The actor selects "cancel"
	2.	The system aborts
	The use case fails.	
	Step	[X2] at Step 5.
	1.	The information cannot be validated by the bank op.
	2.	The system informs the actor
	The use case continues at Step 5.	
Extensions	Step	[E1] at Step 3, 5, 7.
	1.	The actor selects "skip"
	2.	The system displays the next screen
	The use case continues.	
	Step	[E2] at Step 1.
	1.	The actor accesses the FABRIC user management interface and selects to delete the account
	2.	The system requests confirmation to delete
	3.	The user confirms, the account is deleted
FABRIC modules involved	- FABRIC OBU. - FABRIC web interface for end-users. - FABRIC EV backend.	
Critical parameters	-	
Type of environment	FABRIC OBU or personal computer or smartphone.	
Related Use cases	#1.1, #1.2	
User needs	#UN8, #UN16	
Corresponding requirements	- The system should securely store sensitive personal data and the user's privacy. - Secure communication with the FABRIC system. - The system should be compliant with security standards.	
Open issues	- The user interface. - The validation technique for the user-provided data.	
Comments		

6.2.4. Planning of a trip

Use case name	**Planning of a trip**	
Use case ID	#1.4	
Rationale	The end users of the system (drivers) need to be able to drive to their destination, without having range anxiety. The system should be able to increase confidence levels of the consumers towards the use of EVs.	
Status (draft/final)	Final	
Short description	This use case describes the system's functionality to plan a trip having as sole input from the driver the desired destination. The system calculated the route between the current point of the EV and the destination point. In order to calculate the route, the system calculates the range of the EV based on current battery level and in case the range is shorter than the route length it searches for charging options along the route. If charging options along the route are not available, it recalculates the route to include charging facilities. Several routes are proposed to the driver along with timing information (such as how long the charging is expected to last in case of static charging, the ETA to the charging facilities, expected cost of charging etc). When the driver selects the route, the system makes the necessary booking arrangements with the charging infrastructure and proceeds with guiding the driver towards the destination.	
Primary Actors/Entities	FABRIC end-users (driver/EV owner)	
System	FABRIC EV backend	
Secondary Actors/Entities	Charging infrastructure operator, FABRIC platform	
Vehicle type	All types	
Charging mode	All modes	
Preconditions	The actor is registered in the FABRIC database and is logged into the system.	
Trigger event	The actor accesses the FABRIC trip interface and selects to plan a trip.	
Successful end condition	- The actor is provided with a route towards the destination.	
Failed end condition	- The actor is not provided with a route towards a destination.	
Main success scenario description	Step	
	1.	The actor accesses the FABRIC trip interface within the EV and selects to plan a trip. [E2]
	2.	The system displays a screen where the actor is able to enter the destination.
	3.	The actor sets the destination. [X1]
	4.	The system calculates several routes and distances. It compares the distances to the current range of the EV. It

		displays the routes and ETAs to the actor. Weather and traffic information may be included if available for more accurate ETA calculation. [E1][X2]
	5.	The actor selects a route. [X1]
	6.	The system proceeds with driver guidance to the destination.
Exceptions	Step	[X1] at Steps 3, 5.
	1.	The actor selects "cancel".
	2.	The system aborts.
	The use case fails.	
	Step	[X2] at Step 8.
	1.	The system is unable to provide a route due to various reasons (the range is smaller than the distance for all routes, there are no charging options between departure and destination points, there is no information available regarding charging infrastructures, communication with FABRIC is not feasible).
	2.	The system informs the actor.
	3.	The system provides information about parking places in the vicinity of the EV and within its range.
	The use case fails.	
Extensions	Step	[E1] at Step 4.
	1.	The system detects that the EV range is smaller than the route distance. The system searches for available charging options along the route.
	2.	If no charging options exist along the route, the system calculates new routes that include compatible charging infrastructures. Charging infrastructures status, availability, characteristics, are provided by the FABRIC platform.
	3.	The system displays alternative routes with charging-related characteristics such as ETA, maximum charging power, estimated charging duration and other.
	4.	The actor selects a route.
	5.	The system makes the necessary booking arrangements for the charging infrastructures in the selected route and for the estimated times of arrival there.
	The use case continues at step 6.	
	Step	[E2] at Step 1.
	1.	The actor accesses the FABRIC trip interface from a browser (pc or mobile) and selects to plan a trip at a later time.
	2.	The system displays a screen where the actor is able to enter the destination, the time of departure OR the preferred time of arrival to the destination.
	3.	The actor sets the destination and time of departure or time of arrival.
	The use case continues at Step 4. The system provides means to print or store the selected route.	
FABRIC modules	- FABRIC OBU.	

involved	- FABRIC web interface for end-users. - FABRIC EV backend.
Critical parameters	- Coomunication quality with the infrastructure. - Quality of POI data regarding the charging facilities information.
Type of environment	FABRIC OBU or personal computer or smartphone.
Related Use cases	#1.1, #1.2
User needs	#UN16
Corresponding requirements	- The system should securely store sensitive personal data and protect the user's privacy. - Secure communication with the FABRIC system. - The system should be compliant with security standards. - There should be a dynamically updated POI database with charging facilities locations and specifications. - There should be a database containing the operational status of all charging facilities - Open maps and software should be used as much as possible. - Compliance with open standards.
Open issues	
Comments	Enough charging infrastructures should be available so that all routes are covered and the driver is not stranded with empty battery. Until there are enough charging installations perhaps mobile recharging services could be envisioned.

6.2.5. Guidance to charging facility

Use case name	**Guidance to charging facility**	
Use case ID	#1.5	
Rationale	The end users of the system (drivers) need to be able to drive to a charging facility easily, without any prior knowledge, especially when the battery level of the EV is low.	
Status (draft/final)	Final	
Short description	This use case describes the system's functionality to guide the driver to a charging facility and make the necessary booking arrangements. In case charging in a preselected facility is not possible, the system will provide alternative options to the driver.	
Primary Actors/Entities	FABRIC end-users (driver/EV owner)	
System	FABRIC EV backend.	
Secondary Actors/Entities	Charging infrastructure operator, FABRIC electric mobility platform.	
Vehicle type	All types	
Charging mode	All modes	
Preconditions	The actor is registered in the FABRIC database and is logged into the system.	
Trigger event	The actor accesses the FABRIC trip interface and selects to charge the EV.	
Successful end condition	- The actor is provided with a charging point destination and a route towards it.	
Failed end condition	- The actor is not provided with a charging point destination.	
Main success scenario description	Step	
	1.	The actor accesses the FABRIC trip interface via the OBU and selects to charge the EV.
	2.	The system displays a list with available charging points and several parameters such as distance, estimated time of arrival, type of infrastructure (dynamic, static) and power limits. Only the charging points that are compatible with the EV charging characteristics and system are shown. The availability status of the charging infrastructure is updated regularly by the FABRIC platform.
	3.	The actor selects the preferred charging point. [X1]
	4.	The system displays charging infrastructure operating characteristics, time needed to charge the vehicle, availability status information etc.
	5.	The actor confirms to charge there. [X1]
	6.	The system calculates route and displays route and estimated time of arrival.
	7.	The system makes a booking of the infrastructure with the EVs id.

	8.	Charging infrastructure operator acknowledges the booking and verifies the availability of the infrastructure for that time period. [X2]
	9.	The system guides the actor towards the infrastructure and monitors for delays and deviations from the planned trip. [E1]
	10.	When the EV reaches the charging point the actor is notified.
Exceptions	Step	[X1] at Steps 3, 5.
	1.	The actor selects “cancel”.
	2.	The system aborts.
	The use case fails.	
	Step	[X2] at Step 8.
	1.	The information cannot be provided by the charging infrastructure.
	2.	The system notifies the actor.
	The use case continues at Step 2.	
Extensions	Step	[E1] at Step 9.
	1.	The system detects a deviation from the preplanned route or a delay.
	2.	“Dynamic route and booking management” use case.
	The use case continues at Step 3.	
FABRIC modules involved	- FABRIC OBU. - FABRIC EV backend. - FABRIC electric mobility platform. - Charging infrastructure operator.	
Critical parameters	- Parameters that may affect the EV range. - Traffic information. - Charging infrastructure status information. - EV charging system characteristics and specifications. - Charging infrastructure locations, operating characteristics and availability.	
Type of environment	- FABRIC OBU	
Related Use cases	#1.1, #1.4, #1.7, #6.1	
User needs	#UN7, #UN12, #UN13	
Corresponding requirements	- There should be a dynamically updated POI database with charging facilities locations and specifications. - Open maps and software should be used as much as possible. - There should be a database containing the operational status of all charging facilities. - Secure communication with the FABRIC system. - The EV backend should be able to match EV specs to infrastructure specs and present only the compatible ones.	
Open issues	There should be enough charging infrastructures available so that all cases are covered and the driver is not stranded with empty battery.	
Comments		

6.2.6. Emergency charging

Use case name	Emergency charging	
Use case ID	#1.6	
Rationale	A driver could send an emergency charge request and its management must consider the global status of the system, including energy supplier's status, road status and bookings status.	
Status (draft/final)	Final	
Short description	A FABRIC-equipped EV has very low battery level and requests to use a charging infrastructure. The system checks the vehicle status, the account status, the charging infrastructure status and if it is possible assigns the booking or reschedules other booking to allow the vehicle to charge.	
Primary Actors/Entities	Driver	
System	FABRIC on-board unit (OBU)	
Secondary Actors/Entities	FABRIC electric mobility platform	
Vehicle type	All types	
Charging mode	All modes	
Preconditions	- The driver is registered in FABRIC. - Communication is established with FABRIC. - Driver is en-route.	
Trigger event	A driver makes request for emergency charging.	
Successful end condition	- Emergency charging request is managed and a solution is proposed to the driver.	
Failed end condition	- Driver receives no response.	
Main success scenario description	Step	
	1.	The actor sends an emergency charging request via the user interface of the FABRIC OBU.
	2.	The system compiles vehicle data and sends the request with the vehicle data to FABRIC platform. The system notifies the driver that the request is being processed. [X1]
	3.	FABRIC searches available charging infrastructure near the location of the driver taking into account several parameters such as EV range, infrastructure compatibility with EV, capacity and availability.
	4.	FABRIC selects an infrastructure, calculates the charging tariff (which includes a penalty to discourage excessive use of this functionality) and transmits the information to the system. [E1]
	5.	The system notifies the actor that the request has been approved and displays the characteristics of the infrastructure and pricing information. A confirmation dialog is displayed.

	6.	The actor confirms the proposed charging plan.
	7.	The system calculates route and displays route and estimated time of arrival.
	8.	The system makes a booking of the infrastructure with the EVs id.
	9.	Charging infrastructure operator acknowledges the booking and verifies the availability of the infrastructure for that time period. [X2]
	10.	The system guides the actor towards the infrastructure and monitors for delays and deviations from the planned trip. [E1]
	11.	When the EV reaches the charging point the actor is notified and the “charging assistance” use case follows.
Exceptions	Step	[X1] at Step 2.
	1.	Communication with FABRIC platform is not possible. The system informs the driver and provides option to retry.
	2.	Driver selects to retry communicating.
	3.	Communication is still impossible.
	Use case fails.	
Extensions	Step	[E1] at Step 4.
	1.	FABRIC is unable to validate the booking due to constraints (availability, grid security, road operator restrictions, …). The information is passed to the system.
	2.	The system notifies the actor and calculates route to the closest parking spot, taking into account vehicle’s range.
	3.	The routing module presents route to the driver.
	4.	The system enquires whether the driver wishes to call for an emergency recharging service at the parking spot.
	5.	The actor selects yes.
	6.	The system transmits the request to FABRIC platform.
	7.	FABRIC arranges for an emergency recharge service using the vehicles data, the parking spot location and estimated time of arrival there.
	8.	The system informs the actor about the emergency recharging service status.
FABRIC modules involved	- FABRIC OBU. - FABRIC electric mobility platform. - FABRIC EV backend. - Charging infrastructure operator.	
Critical parameters	- EV charging specifications. - EV battery level. - Charging infrastructure status, locations, availability.	

	- Charging cost. - Time between the emergency charging request and the solution provision to the EV.
Type of environment	Any
Related Use cases	#1.1, #1.5, #6.1, #8.1
User needs	#UN7, #UN12, #UN13
Corresponding requirements	- The negotiation with the system must be fast. - The whole process must not be distracting for the driver especially when driving.
Open issues	- Implementation depends on the charging system operators' policies. - Incentives strategy for the renegotiation of bookings is not part of FABRIC research.
Comments	This is a use case which adds value to an already installed and established dynamic charging system. At the present time and within FABRIC it is not foreseen to assist with the development and demonstration of the prototypes, rather due to the complexity and the open implementation issues it is expected to hinder development. This is why it is characterized as feasible use case and it can be foreseen as functionality of an operational charging system in the future.

6.2.7. Guidance to destination

Use case name	Guidance to destination	
Use case ID	#1.7	
Rationale	Guidance to a destination for EVs differs from the classic GPS based guidance because it needs to take into consideration the EV's range, the time to recharge, the locations and availability of charging infrastructure so as to guarantee that the EV has enough energy to reach the destination. The importance of a system that takes into account automatically information from various sources and guides the driver in a seamless and ergonomic manner increases with the scarcity of charging infrastructures and the charging duration of the EV. The fewer infrastructures are installed and the longer the charging duration, the more careful and meticulous the trip planning and monitoring has to be in order to avoid lengthy delays and potentially EV immobilization due to drained battery.	
Status (draft/final)	Final	
Short description	This high level use case describes the system's functionality to guide the driver to a preselected destination, following a pre-planned route.	
Primary Actors/Entities	FABRIC electric mobility platform.	
System	FABRIC EV backend, FABRIC on-board unit.	
Secondary Actors/Entities	Charging infrastructure operator, road operator, FABRIC end users (drivers)	
Vehicle type	All types	
Charging mode	All modes	
Preconditions	- The driver is registered in the FABRIC database and is logged into the system. - The trip was planned, a route is available, booking arrangements are in place. - Weather and traffic information is available. - Communication with the FABRIC system is established.	
Trigger event	GPS location of the EV changes (EV is on the move).	
Successful end condition	- The driver reaches the destination	
Failed end condition	- Guidance becomes unavailable	
Main success scenario description	Step	
	1.	The system provides directions towards the destination as a typical GPS navigator. The position of the EV is transmitted to the FABRIC platform. [X1]
	2.	FABRIC monitors the availability of the charging infrastructures continuously and notifies the driver via the on-board unit for events that affect the trip planning. [X2]
	3.	FABRIC monitors the EV autonomy, weather and traffic

<table>
<tr><td rowspan="3"></td><td></td><td>conditions and notifies the driver via the on-board unit for events that affect the trip planning.</td></tr>
<tr><td>4.</td><td>FABRIC monitors the position of the EV and its autonomy and “Dynamic route and booking management” functionality is activated when needed.</td></tr>
<tr><td>6.</td><td>When the EV reaches the destination the driver is notified.</td></tr>
<tr><td rowspan="10">Exceptions</td><td>Step</td><td>[X1] at Steps</td></tr>
<tr><td>1.</td><td>Communication with FABRIC is broken.</td></tr>
<tr><td>2.</td><td>The driver is notified. The on-board unit operates as a regular GPS navigator utilizing the latest stored route and information.</td></tr>
<tr><td colspan="2">The use case fails.</td></tr>
<tr><td>Step</td><td>[X2] at Step 2.</td></tr>
<tr><td>1.</td><td>The information cannot be provided by the charging infrastructure.</td></tr>
<tr><td>2.</td><td>The system informs the driver.</td></tr>
<tr><td colspan="2">The use case continues at Step 4.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="2">Extensions</td><td>Step</td><td></td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td>FABRIC modules involved</td><td colspan="2">- FABRIC electric mobility platform.
- FABRIC EV backend.
- FABRIC OBU.</td></tr>
<tr><td>Critical parameters</td><td colspan="2">- GPS reception quality.
- Maps quality.
- Communication with FABRIC quality.</td></tr>
<tr><td>Type of environment</td><td colspan="2">In vehicle.</td></tr>
<tr><td>Related Use cases</td><td colspan="2">#1.1, #1.4, #6.1</td></tr>
<tr><td>User needs</td><td colspan="2">#UN16</td></tr>
<tr><td>Corresponding requirements</td><td colspan="2">- Communications lagging should be low.
- Maps and POIs should be updated frequently or in real time.
- Re-routing should be done as fast as possible.</td></tr>
<tr><td>Open issues</td><td colspan="2">The trip planning and routing/monitoring module can reside either centrally in the FABRIC platform or in the on-board unit. Each solution has advantages and disadvantages to consider:
Centralized solution:
Pros:
- fast and uninterrupted access to information from FABRIC system (weather, road, traffic, infrastructure availability and status etc)
- information of all EVs is available at all times to the FABRIC platform without the need for communicating large amounts of data V2I.
- a central installation has a lot of computing power to perform complex calculations in a small time.
- Algorithms are easily updated.
Cons:
- Privacy issues
- Perhaps very large computing power is necessary to perform synchronous routing and trip monitoring for thousands of cars.</td></tr>
</table>

	- There should be safeguards to allow autonomous operation of the on-board unit (without the updates of FABRIC) in case communication is lost with the FABRIC platform. Decentralized solution: Pros: - Calculations burden falls on the OBU for each vehicle. - The system can make plans autonomously in case communication with FABRIC platform fails. Cons: - More computationally powerful, thus expensive OBU. - Communication with FABRIC off-board unit may lag. - Algorithms need to be updated by the user for each OBU.
Comments	The system should protect sensitive personal data and the actor's privacy (e.g. actor's location).

6.2.8. Assisted charging – static

Use case name	**Assisted charging – static**	
Use case ID	#1.8	
Rationale	A user interface is necessary to assist the driver with the wireless charging setup as opposed to the plugged-in static charging. For wireless power transfer the coils must be aligned as perfectly as possible to ensure the maximum energy transmission.	
Status (draft/final)	Final	
Short description	This use case describes the functionality of the system to provide assistance for the charging setup and information regarding the charging progress to the driver of the EV. The interface will allow the driver to park within the tolerance limits above the charging pad and to control the charging.	
Primary Actors/Entities	FABRIC end-users (drivers).	
System	FABRIC on-board unit.	
Secondary Actors/Entities	Charging infrastructure operator.	
Vehicle type	All types.	
Charging mode	**Static.**	
Preconditions	- EV must be registered to FABRIC. - The infrastructure must be pre-booked by the driver for this EV using the FABRIC system. - The driver has been guided to the vicinity of the charging facility by FABRIC. - Communication with FABRIC is established. - The infrastructure should have clear signs to guide the driver towards the charging pad.	
Trigger event	The charging infrastructure is detected by the EV and the charging assistance user interface is displayed by the on-board unit.	
Successful end condition	- Actor is guided successfully through the charging process.	
Failed end condition	- Actor is not guided successfully through the charging process.	
Main success scenario description	Step	
	1.	The system displays graphical guidelines to assist with coil alignment similarly to existing parking systems. The system warns if the misalignment is greater than the tolerance limits. [E1]
	2.	The actor follows the guides. [X2]
	3.	When the coils are aligned, the system displays booking information, charging infrastructure operational characteristics, estimated time for full recharge etc.
	4.	The actor selects “next”. [X1]
	5.	The system displays a screen to optionally enter the duration of charging (must be smaller than the remaining

		booking duration) or the preferred percentage of battery recharge. Default option is full recharge.
	6.	The actor enters the information and selects “next”. [X1]
	7.	The system displays all information and requests confirmation to begin charging.
	8.	The actor confirms charging. [X1]
	9.	The system displays information about the charging process: battery charge level, time remaining for full recharge, updated EV range etc.
	10.	The actor is able to stop the charging at any point by driving away from the charging pad.
	11.	When charging stops (either as planned or before completion) the system presents summary information about the charging, such as power received, payment information and the additional range due to the recharging.
	12.	Actor presses “OK”.
	13.	System returns to the default user interface.
Exceptions	Step	[X1] at Steps 4, 6, 8.
	1.	The actor selects “cancel”
	2.	The system aborts
	The use case fails.	
	Step	[X2] at Step 5.
	1.	The actor is not able to follow the alignment guides
	2.	The system sends a notification to the FABRIC platform.
	The use case continues at Step 1.	
Extensions	Step	[E1] at Step 1.
	1.	The system asks if the actor wants to charge.
	2.	The actor selects “yes”
	3.	The EV self-drives above the charging pad with perfect coil alignment.
	The use case continues at Step 3.	
FABRIC modules involved	- FABRIC OBU. - Charging infrastructure operator.	
Critical parameters	- Coils alignment.	
Type of environment	- Static charging station. - In vehicle.	
Related Use cases	#1.5, #7.1, #8.1	
User needs	#UN2, #UN9, #UN10, #UN11	
Corresponding requirements	- There should be a beacon or some other means broadcasting the infrastructure present in the nearby area for use case triggering. - DSRC communication is expected. - The system should be able to authenticate the EV and confirm that it has booked the infrastructure.	
Open issues		
Comments	- An EV with self-driving capability is assumed for extension [E1]. - The driver may be able to monitor the charging process remotely by logging into FABRIC from a web interface.	

6.2.9. Assisted charging – stationary

Use case name	**Assisted charging – stationary**	
Use case ID	#1.9	
Rationale	A user interface is necessary to assist the driver with the automatic charging setup. The difference with the static charging assistance is that the stationary charging is opportunistic and repetitive during a trip. In that way, the interactions with the driver should be fewer than in the static case in order to avoid driver annoyance.	
Status (draft/final)	Final	
Short description	This use case describes the functionality of the system to provide assistance for the charging setup and information regarding the charging progress to the driver of the EV. The interface will guide the driver to park within the tolerance limits above the charging pad and provide unobtrusive charging information. The main success scenario refers to opportunistic charging of single vehicles for very short stops e.g. during stops at traffic lights. Extension [E1] refers to stationary charging in charging lane infrastructures envisioning for example long queues of taxis waiting at airport stands. In this case a semi-automated process could be drafted for future ICT applications, implementing vehicle platooning strategies that are currently explored in various research projects.	
Primary Actors/Entities	FABRIC end-users (drivers)	
System	FABRIC on-board unit	
Secondary Actors/Entities	Charging infrastructure operator	
Vehicle type	All types	
Charging mode	**Stationary**	
Preconditions	- EV must be registered to FABRIC - Communication with FABRIC is established - The infrastructure should have clear signs to guide the driver towards the charging pads. - The driver has activated the stationary charging mode in the vehicle. - The EV has detected a compatible charging infrastructure in the vicinity.	
Trigger event	The charging infrastructure is detected by the EV and the charging assistance user interface is displayed by the on-board unit.	
Successful end condition	- Actor is guided successfully through the charging process	
Failed end condition	- Actor is not guided successfully through the charging process	
Main success scenario description	Step	
	1.	The system displays graphical guides to assist with coil alignment similarly to existing parking systems. The system warns is misalignment is greater than the tolerance

		margins [E1][X1]
	2.	The actor follows the guides. [X2]
	3.	The system displays information about the charging process: battery charge level, updated EV range etc.
	4.	The actor is able to stop the charging at any point by deactivating the stationary charging mode.
	5.	System returns to the default user interface.
Exceptions	Step	[X1] at Steps 1.
	1.	Communication with the charging infrastructure fails.
	2.	The system aborts charging setup process.
	The use case continues at Step 5.	
Extensions	Step	[E1] at Step 1.
	1.	The system informs the actor that it will initiate the charging process and requests for confirmation.
	2.	The actor confirms.
	3.	The positions the EV at the beginning of the charging lane on top of the charging pad.
	4.	The system displays information about the charging process: battery charge level, updated EV range etc. The system also displays a counter that shows the time remaining until the vehicle has to move to the next pad (so that the line is moving). If there is another vehicle in front of the EV which is not moving the counter stops. When the counter reaches 0 the power to the charging pad is cut so that the driver is forced to move.
	5.	The system monitors the position of the vehicle in front and follows it when it moves ahead to the next charging pad.
	6.	When the EV reaches the end of the line or if battery is charged completely the charging stops. The system displays information about the charge received, payment information and EV range. The system deactivates the stationary charging mode automatically.
	The use case continues at Step 6.	
FABRIC modules involved	- FABRIC OBU - Charging infrastructure operator	
Critical parameters	- Coils alignment. - Charging duration. - EV charging specifications.	
Type of environment	- Urban roads. - Bus stops. - Taxi queues.	
Related Use cases	#1.5	
User needs	#UN2, #UN9, #UN10, #UN11	
Corresponding requirements	- There should be a beacon or some other means broadcasting the infrastructure presence in the nearby area for use case triggering. - DSRC communication is expected. - V2V communication may be needed for the platooning scenario - The system should be able to authenticate the EV.	

	- The EV should be able to transmit a signal to broadcast that it is in stationary (or opportunistic) charging mode so that charging is initiated automatically when the EV is above a charging pad.
Open issues	- Vehicle detection method.
Comments	An EV with self-driving capability is assumed for extension [E1].

6.2.10. Assisted charging – dynamic

Use case name	**Assisted charging – dynamic**
Use case ID	#1.10
Rationale	A user interface is necessary to assist the driver with the automatic charging setup. Interactions with the driver should be minimal in order to avoid distractions during driving.
Status (draft/final)	Final
Short description	This use case describes the functionality of the system to provide assistance during the charging and information regarding the dynamic charging progress to the driver of the EV. The interface will guide the driver to align the EV with the charging lane provide charging information unobtrusively.
Primary Actors/Entities	FABRIC end-users (drivers)
System	FABRIC on-board unit
Secondary Actors/Entities	Charging infrastructure operator
Vehicle type	All types
Charging mode	**Dynamic**
Preconditions	- EV must be registered to FABRIC - Communication with FABRIC is established - There should be clear road signs to guide the driver towards the correct lane. - Driver is guided by FABRIC near the booked infrastructure. - The charging lane is pre-booked or there is ad-hoc booking just prior to the charging lane access. - The EV has detected the charging infrastructure in proximity.
Trigger event	The EV is within X meters from the beginning of the charging lane and the charging assistance user interface is displayed by the on-board unit.
Successful end condition	- Actor is guided successfully through the charging process
Failed end condition	- Actor is not guided successfully through the charging process

Main success scenario description	Step	
	1.	The system displays the remaining distance to the charging lane. There is an easily accessible abort button on the user interface during the whole charging process.
	2.	The system displays a graphical representation of the EV relative to the charging lane axis.
	3.	The actor aligns the EV with the charging lane axis.
	4.	The system monitors the EV position and speed. It provides visual cues for trajectory and speed corrections while driving.
	5.	During the charging, the system displays information about the status of the charging process.

	6.	When the EV exits the charging lane the system returns to the default use interface.
Exceptions	Step	[X1] at Steps 1.
	1.	Communication with the charging infrastructure fails.
	2.	The system aborts charging setup process.
	The use case continues at Step 6.	
Extensions	Step	[E1] at Step 1.
	1.	The system informs the actor that it will initiate the charging process and requests for confirmation to assume control.
	2.	The actor confirms.
	3.	The system positions the EV at the beginning of the charging lane and aligns it with the coils.
	4.	The system displays information about the charging process: battery charge level, updated EV range etc. If there is another vehicle in front of the EV the system adjusts the speed to match the one of the preceding vehicle.
	5.	The system monitors the position of the vehicle in front and follows it until the end of the charging lane and as long as it is aligned with the coils.
	6.	When the EV reaches the end of the line or if battery is charged completely the charging stops. The system displays information about the charge received, payment information and EV range. The system returns driving control to the actor.
	The use case continues at Step 6.	
FABRIC modules involved	- FABRIC OBU. - Charging infrastructure operator. - FABRIC electric mobility platform.	
Critical parameters	- Coil alignment. - Vehicle speed. - Traffic. - Charging lane power capacity. - Communications quality.	
Type of environment	Charging lane on a highway or urban road.	
Related Use cases	#1.5	
User needs	#UN2, #UN9, #UN10, #UN11	
Corresponding requirements	- There should be a beacon or some other means broadcasting the infrastructure present in the nearby area for use case triggering. - DSRC communication is expected. - V2V communication may be needed for the platooning scenario - The system should be able to authenticate the EV. - The user interface should be ergonomic and not distracting. - The interactions with the driver should be as few as possible. - V2I communication should be very fast, depending on the vehicle speed.	
Open issues	- EV identification/authentication technical method to be selected.	

	- User interface design to be specified. - Visual cues design to be specified.
Comments	An EV with self-driving capability is assumed for extension [E1].

6.2.11. EV charging supply management – high level

Use case name	**EV charging supply management – high level**	
Use case ID	#2.1	
Rationale	At times when there is a risk for the secure operation of the grid due to low or negative energy supply reserves, demand needs to be shaped in a controlled and timely manner. When such condition is detected (in advance) and the foreseen demand for EV charging is high, the operator should be able to reduce/shape the load to the grid. In unforeseen events and emergencies, this functionality should also allow the real-time shaping of the actual demand	
Status (draft/final)	Final	
Short description	The Distribution System Operator detects a demand spike or a supply shortage. He selects to limit the supply for EV charging by setting a maximum power limit for a certain period of time. The power re-distribution to the vehicles is calculated in real time by FABRIC's load balancing function (low level).	
Primary Actors/Entities	Distribution System Operator (DSO).	
System	FABRIC DSO interface.	
Secondary Actors/Entities	Charging infrastructure operator, FABRIC electric mobility platform	
Vehicle type	All types	
Charging type	All modes	
Preconditions	- The Distribution System Operator is logged into the FABRIC DSO interface.	
Trigger event	The Distribution System Operator selects the respective FABRIC functionality.	
Successful end condition	- Charging supply has been reduced	
Failed end condition	- Charging supply has not been reduced	
Main success scenario description	Step	
	1.	Actor selects the FABRIC EV supply management module
	2.	System displays current supply and option to manage supply
	3.	Actor selects to manage supply [X1]
	4.	The system provides an option to reduce the maximum charging power of the charging infrastructure for specific time periods. [X2]
	5.	The Actor sets maximum charging power for selected time periods [X1]
	6.	The system displays new maximum load and asks for confirmation
	7.	The Actor confirms [X1]
	8.	The system goes to Step 2.

	9.	The Actor exits
	The use case succeeds	
Exceptions	Step	[X1] at Step 3.
	1.	The Actor selects "cancel"
	2.	The system leaves supply unchanged
	The use case fails.	
	Step	[X2] at Step 4.
	1.	Charging infrastructure is offline. The system notifies the Actor that no options are available and why.
	2.	The Actor acknowledges
	The use case fails.	
Extensions	Step	
	-	
FABRIC modules involved	- DSO to FABRIC interface. - FABRIC electric mobility platform. - Load balancing controller.	
Critical parameters	- Grid capacity. - Communications with FABRIC quality and security.	
Type of environment	Web based interface.	
Related Use cases	#5.1, #5.2	
User needs	#UN9, #UN14	
Corresponding requirements	- The system should be secure. - Data transmission should be secure.	
Open issues	Interfacing with industry load management modules.	
Comments	Out of scope: DSO load and power production forecasting modules.	

6.2.12. Energy supply tariff modulation

Use case name	**Energy supply tariff modulation**	
Use case ID	#3.1	
Rationale	The retailer needs to be able to provide energy tariff signals to the FABRIC platform to be used for the calculation of the charging cost to the end user. The flexibility in energy price management can be used also for charging lane traffic and load management. For instance, during peak demand hours, recharging may be more expensive. In addition, if distributed RES is available, special price offers can promote the use/storage of that extra energy in the EV batteries and congestions due to excessive generation may be avoided. This mode of operation however is only useful, if there is enough time for the user to plan taking into account the price fluctuations.	
Status (draft/final)	Final	
Short description	The energy retailer decides to change the cost of energy supply. This is done by using the corresponding FABRIC module. After the new price is set the system's database is updated and FABRIC calculates the new charging cost taking the energy pricing into account.	
Primary Actors/Entities	Energy retailer.	
System	FABRIC energy pricing management module.	
Secondary Actors/Entities	FABRIC interface for retailer.	
Vehicle type	All types	
Charging type	All modes	
Preconditions	- The energy retailer is logged into the system.	
Trigger event	The energy retailer invokes, energy supply tariff adaptation, by selecting the respective FABRIC functionality.	
Successful end condition	- Energy supply tariff has been updated.	
Failed end condition	- Energy supply tariff has not been updated.	
Main success scenario description	Step	
	1.	Actor selects the tariff management module
	2.	The system displays current pricing information and option to change it
	3.	Actor selects change [X1]
	4.	The system displays input field [E1]

	5.	The Actor enters new tariff [X2]
	6.	The system displays tariff and asks if the Actor wants to continue and update the system
	7.	The Actor selects "update" [X1]
	8.	The system displays updated information and notifies stakeholders
Exceptions	Step	[X1] at Steps 3, 7.
	1.	The Actor selects "cancel"
	2.	The system leaves tariff unchanged
	The use case fails.	
	Step	[X2] at Step 5.
	1.	The Actor enters invalid tariff (either letters or out of pre-specified range)
	2.	The system notifies the Actor that data is invalid
	The use case continues at Step 2.	
Extensions	Step	[E1] at Step 4.
	1.	The system provides option for automatic tariff estimation.
	2.	The Actor selects the option
	The use case continues at Step 6.	
FABRIC modules involved	- Energy retailer to FABRIC interface. - FABRIC charging cost management module.	
Critical parameters	- Communications with FABRIC quality and security.	
Type of environment	Web based interface.	
Related Use cases	#5.1	
User needs		
Corresponding requirements	- The system should be secure. - Data transmission should be secure.	
Open issues	- Interfacing with industry forecasting modules. - Price changing policy. Should prices change for already booked infrastructures and planned trips?	
Comments		

6.2.13. Integration of FABRIC with UTMC

Use case name	Integration of FABRIC with UTMC
Use case ID	#4.1
Rationale	In order for the FABRIC system to not cause adverse impacts on traffic congestion in a city or to affect driver behaviour in unexpected ways, it may be necessary to integrate FABRIC with city Urban Traffic Management and Control (UTMC) systems.
Status (draft/final)	Final
Short description	UTMC systems regulate traffic light sequences based on traffic conditions, determined by evaluating traffic data gathered by in-road, or road-side, sensors. The algorithms used to regulate traffic signals use a number of assumptions for vehicle behavior and characteristics, such as, average vehicle acceleration, speed, dimensions and others. Use of FABRIC system near traffic lights or junctions may alter driver behavior if a driver chooses to drive or accelerate slower in order to maximize charging time. Integrating FABRIC and UTMC systems may allow activating and deactivating power transfer in order to minimize any unwanted driver behavior. It may also be possible to alter traffic light sequences based on the number of vehicles charging in order to extend red sequences for those parts of the junction where many vehicles may be using FABRIC system – to increase available charging time while at the same time, minimizing red sequences for parts of the junction with largely ICE vehicles in order to minimize idling and therefore emissions. It could also be possible to use the FABRIC charging primary infrastructure itself as a sensor that can feed data into the UTMC in order to avoid having to install dedicated traffic counting sensors.
Primary Actors/Entities	- Road Operator - Driver
System	- FABRIC Road Operator interface - UTMC interface
Secondary Actors/Entities	- FABRIC charging infrastructure operator - Other vehicles - Traffic lights
Vehicle type	All
Charging type	Stationary, Dynamic
Preconditions	- The primary actor is logged into the system. - Road Operator enabled this feature via the FABRIC interface
Trigger event	FABRIC EV is detected close to the charging segment near junction.
Successful end condition	- FABRIC EV charging does not negatively impact traffic
Failed end condition	- FABRIC EV charging increases congestion

Main success scenario description	Step	
	1.	FABRIC EV approaches a junction equipped with FABRIC system.
	2.	Driver is prompted to confirm the charging.
	3.	Driver confirms charging [X1]
	4.	UTMC system receives notification of a vehicle using the FABRIC system [X2]
	5.	UTMC receives data from all FABRIC charging units on this junction about other vehicles present that are not using the system
	6.	UTMC algorithms determine optimum traffic light sequencing for the mix of vehicles using the junction
	7.	Traffic light changes to green for the FABRIC EV
	8.	FABRIC EV proceeds to cross the junction at normal speed while charging [X3]
	Use case succeeds	
Exceptions	Step	[X1] at Step 3.
	1.	Driver does not accept charging
	Use case continues at Step 4	
	Step	[X2] at Step 4.
	1.	No vehicles are using the FABRIC system
	The use case continues at Step 5.	
	Step	[X3] at Step 8.
	1.	FABRIC EV is moving slower than regular vehicles
	2.	UTMC stops power transfer at the affected part of the junction
	3.	User is notified that power transfer has been terminated and will resume when EV gains the indicated speed.
	Use case fails	
Extensions	Step	
	-	
FABRIC modules involved	- FABRIC Road Operator module. - FABRIC Electric mobility platform.	
Critical parameters	- UTMC parameters used in algorithms. - Number and type of vehicles present at junction. - Vehicles speed and acceleration on junction.	
Type of environment	City, junction.	
Related Use cases	#1.9, #1.10, #1.5	
User needs	#UN15	
Corresponding requirements	- Intefacing with UTMC.	
Open issues	- FABRIC interfacing with UTMC.	
Comments	This is a feasible use case for a future charging system which will be installed in existing road infrastructures and be integrated to the city transport system. Custom integration technologies will be used to address the various UTMC systems of different countries. Thus it is not a demonstration use case in FABRIC.	

6.2.14. EV identification (traffic and enforcement management)

Use case name	EV identification (traffic and enforcement management)	
Use case ID	#4.2	
Rationale	The vehicle identification and the access control to recharge zones, whether static or dynamic, is crucial for proper authorization to recharge and the subsequent billing activities. Being able to identify authorized vehicles and at the same time to prevent fraud is one of the primary tasks in the management of a charging resource. Finally, with a proper policy for identification and access control, the FABRIC system can create charging specifications for each type of user, thus optimizing the resources of the charging system.	
Status (draft/final)	Final	
Short description	The road operator module manages the traffic in the charging area by Automatic Number Plate Recognition (ANPR) cameras and is able to communicate to the charging system's interface the current configuration of the traffic and which vehicles are present in the charging area.	
Primary Actors/Entities	- Road operator. - ANPR system.	
Secondary Actors/Entities	- FABRIC platform.	
Vehicle type	All types.	
Charging mode	All modes.	
Preconditions	The charging lane/area is clearly identified.	
Trigger event	An Electrical Vehicle is approaching the charging infrastructure and is detected by Road Side Units.	
Successful end condition	The Road Operator has identified the EV and the charging infrastructure has reacted in accordance with the vehicle authorization or charging profile.	
Failed end condition	The EV has not been correctly identified.	
Main success scenario description	Step	Action
	1.	The ANPR detects an EV approaching the charging zone.[X1]
	2.	The road operator module sends the identified data of the vehicle to the FABRIC platform.
	3.	Charging management and load balancing use case follows
Exceptions	Step	[X1] at Step 1.
	1.	The ANPR fails to communicate and to exchange information.
	2.	The charging infrastructure operator interrupts charging until the communication is re-established.
	The use case fails	
Extensions	Step	

	-
FABRIC modules involved	- Road Operator interface. - FABRIC electric mobility platform. - EV back-end. - Charging infrastructure operator.
Critical parameters	- EV identification information. - Other (The final list of parameters will be defined at a later stage of project development).
Type of environment	- Static or dynamic charging infrastructure installed anywhere, with continuous connectivity to the FABRIC platform.
Related Use cases	#1.1, #7.1, #7.2, #8.1
User needs	#UN2, #UN8, #UN15, #UN16
Corresponding requirements	- Identification accuracy must be high. - Identification speed must be high.
Open issues	- Interfacing of existing ANPR systems with FABRIC.
Comments	EV identification can be done with Electronic Toll Collection (ETC) equipment as well or in conjunction with the ANPR to increase security and identification accuracy.

6.2.15. Charging or road infrastructure availability status updating (scheduled)

Use case name	**Charging or road infrastructure availability status updating (scheduled)**	
Use case ID	#4.3	
Rationale	The road operator needs to be able to inform in advance the FABRIC system and the end users about scheduled maintenance works that will result in the unavailability of the infrastructures during that period.	
Status (draft/final)	Final	
Short description	The road operator uses the FABRIC module to update the availability of the road/charging infrastructure that he/she controls. The updating takes place several days in advance (since it is scheduled) so this is not expected to cause major inconvenience to end users. However in case there are pre-bookings a notification is sent by FABRIC to the end users so that they re-plan their trip and charging bookings.	
Primary Actors/Entities	Road Operator.	
Secondary Actors/Entities	FABRIC electric mobility platform.	
System	Road operator interface.	
Vehicle type	-	
Charging type	-	
Preconditions	The actor is logged in to the FABRIC road operator module.	
Trigger event	The actor selects to update the availability of the infrastructure.	
Successful end condition	The availability of the infrastructure has been updated.	
Failed end condition	The availability of the infrastructure has not been updated.	
Main success scenario description	Step	Action
	1.	The actor selects to change the availability of the infrastructure for planned maintenance from the road operator FABRIC interface.
	2.	The system displays a form to enter the times when the infrastructure will be unavailable.
	3.	The actor enters the information. [X2]
	4.	The system provides a list with common causes for unavailability or a text box to write the reason of the unavailability.
	5.	The actor enters the reason for infrastructure status change. [X2]
	6.	The system displays the aggregated information and requests confirmation to submit.
	7.	The actor confirms. [X2]
	8.	The road operator module sends the information to the FABRIC platform. [X1]
	9.	The availability of the infrastructure is updated in the relevant FABRIC database.
	10.	FABRIC platform sends a notification to the end-users that have pre-booked the infrastructure for the duration that it will be unavailable so that they re-plan

		their trip.
	11.	FABRIC platform notifies the actor that the change has been registered.
	12.	The system returns to the main screen.
Exceptions	Step	[X1] at Step 8.
	1.	Communication with the FABRIC platform is not possible.
	2.	The system notifies the actor.
	3.	The system returns to the main screen.
	The use case fails	
	Step	[X2] at Steps 3, 5, 7.
	1.	The actor cancels.
	2.	The system requests confirmation to cancel.
	3.	The actor confirms.
	4.	The system returns to the main screen.
	The use case fails	
Extensions	Step	
	-	
FABRIC modules involved	- Road operator FABRIC interface. - FABRIC electric mobility platform.	
Critical parameters	-	
Type of environment	Secure workstation at the operators' facility running the corresponding FABRIC interface.	
Related Use cases	#5.1	
User needs	#UN7, #UN15	
Corresponding requirements	- The updating of the infrastructure availability status should be done as early as possible so as to minimize issues with the trip planning of the end users.	
Open issues	- Interfacing with existing road operator systems. - Definition of messages list.	
Comments		

6.2.16. Charging or road infrastructure availability status updating (unscheduled-emergency)

Use case name	**Charging or road infrastructure availability status updating (unscheduled-emergency)**	
Use case ID	#4.4	
Rationale	The road operator needs to be able to shut down the infrastructure in case of emergencies and notify the end-users as soon as possible so as to minimize adverse effects in traffic, accidents and end-user inconvenience.	
Status (draft/final)	Final	
Short description	The road operator uses the FABRIC module to update the availability of the road/charging infrastructure that he/she controls. The updating takes place immediately after an abnormal situation is detected, which prevents the operation of the charging or road infrastructure. FABRIC is used to notify oncoming drivers about the situation and re-route the traffic so as to minimize traffic congestion and accidents.	
Primary Actors/Entities	Road Operator.	
Secondary Actors/Entities	FABRIC electric mobility platform.	
System	FABRIC road operator interface.	
Vehicle type	-	
Charging type	-	
Preconditions	The actor is logged in to the FABRIC road operator interface.	
Trigger event	The actor selects the option to disable the infrastructure.	
Successful end condition	The availability of the infrastructure has been updated.	
Failed end condition	The availability of the infrastructure has not been updated.	
Main success scenario description	Step	Action
	1.	The actor selects to disable the infrastructure option from within an emergency-only menu at the system. [E1]
	2.	The system provides a list with common causes for the infrastructure unavailability or a text box to write the reason of the unavailability.
	3.	The actor enters the reason for infrastructure status change. [X2]
	4.	The system displays the aggregated information and requests confirmation to submit.
	5.	The actor confirms. [X2]
	6.	The road operator module sends the information to the FABRIC platform. [X1]
	7.	The availability of the infrastructure is updated in the relevant FABRIC database.
	8.	FABRIC platform sends a notification to the end-users that have pre-booked the infrastructure that it will be unavailable due to the reasons submitted by the actor. [E2]
	9.	FABRIC platform notifies the actor that the change has been registered.

	10.	The system returns to the main screen.
Exceptions	Step	[X1] at Step 8.
	1.	Communication with the FABRIC platform is not possible.
	2.	The system notifies the actor.
	3.	The system returns to the main screen.
	The use case fails	
	Step	[X2] at Steps 3, 5.
	1.	The actor cancels.
	2.	The system requests confirmation to cancel.
	3.	The actor confirms.
	4.	The system returns to the main screen.
	The use case fails	
Extensions	Step	[E1] at Step 1. Automatic action when emergency is detected without the involvement of a human operator.
	1.	The road operator has an infrastructure monitoring system (IMS) which is able to detect emergencies and also classify them automatically. The IMS detects an emergency.
	2.	The IMS shuts down the infrastructure and notifies the FABRIC road operator module. The emergency description is transmitted using standardized protocols such as DATEX.
	The use case continues at Step 6.	
	Step	[E2] at Step 8.
	1.	FABRIC platform sends a notification to the end-users that have pre-booked the infrastructure that it will be unavailable due to the reasons submitted by the actor.
	2.	Dynamic route and booking management use case is activated automatically.
	The use case continues at Step 9.	
FABRIC modules involved	- Road operator module - FABRIC platform	
Critical parameters	- Duration between the identification of the emergency and the notification of the oncoming drivers.	
Type of environment	Secure workstation at the operators' facility running the corresponding FABRIC interface.	
Related Use cases	#4.1, #4.3, #5.1, #5.2, #6.1	
User needs	#UN7, #UN15	
Corresponding requirements	- The road operator should be able to control the infrastructure directly in case of emergencies. - There should be a database containing the operational status of all charging facilities. - The road operator should be able to update this database. - Communication between FABRIC and road operator should be secure, fast and reliable. - Redundant communication channels.	
Open issues	- Interfacing with existing road operator systems. - Definition of messages list.	
Comments	- Since this is an emergency, in order to minimize the time	

	needed to notify the end-users, the access to this FABRIC functionality should be easy, the interactions with the road operator should be as few as possible, making sure however that mistakes don’t happen, since this action reaches the end-users and mistakes cannot be corrected. - Even though a very accurate and smart system is assumed in [E1] there should be a human supervisor at some point in the actions chain to confirm the emergency.

6.2.17. Logging in to the FABRIC interfaces – operators

Use case name	**Logging in to the FABRIC interfaces - operators**	
Use case ID	#5.1	
Rationale	Since FABRIC includes important functions that affect many people, only authorized personnel should access the system's functionalities. Operator identification/authentication is also required to keep a log of actions for accountability purposes.	
Status (draft/final)	Final	
Short description	The system allows access only to authorized persons. A limited number of retries is allowed. After that the account is suspended for security reasons.	
Primary Actors/Entities	- Distribution System Operator (DSO) or - Energy retailer or - Road operator or - FABRIC operator	
System	- FABRIC interface for DSO or - FABRIC interface for energy retailer or - FABRIC interface for road operator or - FABRIC EV mobility platform	
Secondary Actors/Entities	FABRIC platform	
Vehicle type	-	
Charging type	-	
Preconditions	- The Actor's credentials are stored into the system's database.	
Trigger event	The Actor selects to access FABRIC	
Successful end condition	- Actor is logged in	
Failed end condition	- Actor is not logged in	
Main success scenario description	Step	
	1.	Actor selects to access the system
	2.	The system displays input fields for login and password
	3.	The Actor enters login and password
	4.	The system validates the Actor credentials [X1] [X2] [X3]
	5.	The system informs the Actor when previous login took place
	The use case succeeds	
Exceptions	Step	[X1] at Step 4.
	1.	System notifies the Actor that password does not match the stored one and that X number of retries remain
	The use case continues at Step 2.	
	Step	[X2] at Step 4.

	1.	The system notifies the Actor that there is no user with that login name.
	The use case continues at Step 2.	
	Step	[X3] at Step 4.
	1.	System notifies the Actor that password does not match the stored one and suspends the user account.
	2.	The system informs the Actor that user account has been suspended and provides information on whom to contact.
	The use case fails.	
Extensions	Step	[E1] at Step 2.
	1.	The system invokes external biometric identification/authentication system or other means of authentication depending on the facility's security policy (out of FABRIC scope).
	The use case continues at Step 4.	
FABRIC modules involved	- FABRIC interfaces with the external operators. - FABRIC electric mobility platform.	
Critical parameters	- Number of allowed retries to access the system.	
Type of environment	Secure workstation at the operators' facility running the corresponding FABRIC interface.	
Related Use cases	#5.2, #2.1, #3.1, #4.3, #4.4	
User needs	#UN16	
Corresponding requirements	- Access to the FABRIC functionalities by the various external operators/actors needs to be secure. - Secure transmission of data between the operators and FABRIC. - Communication quality and reliability must be high. - Interoperability with existing operator systems.	
Open issues	- Interfacing with existing industry security systems and databases.	
Comments	In order for operators to login they must first be registered and have authentication credentials. Both the registration and the identification/authentication credentials production depend on the custom security measures and systems used in each external to the FABRIC operator facility. In that sense, the registration process for the external operators is out of FABRIC scope.	

6.2.18. Messaging to FABRIC platform

Use case name	**Messaging to FABRIC platform**	
Use case ID	#5.2	
Rationale	Communication with the FABRIC system (FABRIC Electric mobility platform) is a crucial element of the system since the external operators need to inform about changes of the infrastructure status or emergencies.	
Status (draft/final)	Final	
Short description	The operator selects to communicate a message to the the FABRIC system. There are several categories of messages depending on the scope e.g. emergencies or load approaching to critical limits. There is also the option to send free-text messages which should be used only in rare situations that are not covered by the available pre-defined messages. Whenever a message is sent there is a delivery report.	
Primary Actors/Entities	FABRIC external operators.	
System	FABRIC external operator interfaces.	
Secondary Actors/Entities	FABRIC Electric mobility platform/FABRIC operator.	
Vehicle type	-	
Charging type	-	
Preconditions	The primary actor is logged into the system.	
Trigger event	The primary actor selects to send a message	
Successful end condition	- Message has been delivered	
Failed end condition	- Message has not been delivered	
Main success scenario description	Step	
	1.	The Actor selects to send a message
	2.	The system displays a list of message categories [E1]
	3.	The Actor selects an option [X1]
	4.	The system displays a list of pre-defined messages
	5.	The Actor selects a message [X2]
	6.	The system asks for confirmation
	7.	The Actor confirms [X1]
	8.	The system displays delivery report, message has been delivered [X3]
	Use case succeeds	
Exceptions	Step	[X1] at Step 3, 7.
	1.	The Actor cancels

	The use case fails.	
	Step	[X2] at Step 5.
	1.	The Actor cancels
	The use case continues at Step 2.	
	Step	[X3] at Step 8.
	1.	The system displays delivery report, message has not been delivered
	The use case fails.	
Extensions	Step	[E1] at Step 4.
	1.	The system displays option to enter free text
	2.	The Actor writes free text and selects to send it.
	The use case continues at Step 6.	
FABRIC modules involved	- FABRIC interfaces with operators. - FABRIC Electric mobility platform.	
Critical parameters	- Connection speed. - Connection reliability. - Back-up solutions and redundancy.	
Type of environment	Secure workstation at the operators' facility running the corresponding FABRIC interface.	
Related Use cases	#5.1, #2.1, #3.1, #4.3, #4.4	
User needs	#UN16	
Corresponding requirements	- A database of pre-determined messages per operator. - Fast, reliable and secure communication channels between the operators and FABRIC. - Interoperability with existing operator systems.	
Open issues	- Define fixed message categories. - Define standard messages. - How FABRIC handles the received messages. - Which information should be forwarded to the end users/message filtering.	
Comments		

6.2.19. Dynamic routing and booking management

Use case name	**Dynamic routing and booking management**	
Use case ID	#6.1	
Rationale	Traveling by car does not allow for high confidence levels regarding the estimation of the arrival time to specific destinations or charging infrastructures. In order to address this issue there should be a system functionality that updates the bookings to charging infrastructures, performs re-routing in case of emergencies and notifies/guides the driver in a seamless way so as to not distract from the driving process.	
Status (draft/final)	Final	
Short description	This use case describes the system's functionality to re-plan a trip on-the-fly in case there are significant deviations from the original plan. The current position of the EV is compared in regular time intervals to the anticipated position of the EV based on the route and timeplan initially calculated by the FABRIC system. When significant deviations are detected, which will affect the ETA to charging infrastructures a re-booking process should take place to guarantee the availability of the infrastructure at the time of arrival of the EV. Re-routing may be required in cases when there is a accident on the road, when there is traffic that was not anticipated during the initial planning or when the charging infrastructure goes offline.	
Primary Actors/Entities	FABRIC EV backend.	
System	FABRIC EV backend.	
Secondary Actors/Entities	- Charging infrastructure operator. - FABRIC EV mobility platform. - FABRIC OBU. - Driver.	
Vehicle type	All types.	
Charging mode	All modes.	
Preconditions	A trip is already planned and on-going.	
Trigger event	- A significant deviation from the planned route or itinerary is detected by FABRIC. - Charging infrastructures selected for re-charging become unavailable during the trip or access to them becomes impossible.	
Successful end condition	- The driver is provided with an alternative route towards the destination - Booking of charging infrastructure is updated	
Failed end condition	- Re-routing or re-booking of charging infrastructure is not possible	
Main success scenario description	Step	
	1.	The actor detects a deviation from the planned trip which

		will affect the ETA to pre-booked charging infrastructures. [E1]
	2.	The actor attempts to re-schedule and make booking update.
	3.	FABRIC platform assesses the re-scheduling request and depending on the infrastructure status, availability, expected recharging time and potentially other affecting parameters informs the actor about the re-booking status [X1]
	4.	Actor notifies the driver about the new charging infrastructure booking status.
Exceptions	Step	[X1] at Step 3.
	1.	FABRIC platform informs the actor that re-scheduling is not possible.
	2.	"Planning of a trip" use case starting from Step 4.
Extensions	Step	[E1] at Step 1
	1.	Actor receives update from FABRIC platform regarding the unavailability of charging infrastructures.
	2.	"Planning of a trip" use case starting from Step 4.
FABRIC modules involved	- FABRIC OBU. - FABRIC EV back-end. - FABRIC EV mobility platform. - Charging infrastructure operator.	
Critical parameters	- Re-routing and re-booking speed.	
Type of environment	In vehicle.	
Related Use cases	#1.4, #1.5, #1.6, #1.7, #4.4	
User needs	#UN7, #UN12, #UN13, #UN16	
Corresponding requirements	- The communication and re-routing/re-booking should be done fast since this is a very dynamic environment. - The whole process should be as unobtrusive to the driver as possible so as avoid distractions during driving. - V2I communication must be fast and of high quality. - There should be a dynamically updated POI database with charging facilities locations and specifications. - Open maps and software should be used as much as possible. - Compliance with open standards. - The module needs to be able to handle re-routing and navigation of a very large number of vehicles at the same time.	
Open issues	- Re-routing strategies. - Re-routing software. - Interfaces with existing systems for dynamic routing and booking. - Compatibility of existing solutions with the FABRIC platform and OBU.	
Comments	Dynamic route and booking management does not contribute to the demonstration and testing of the FABRIC technologies. It is also the objective of other research project and in that way this ICT may be integrated to FABRIC in the future provided that there is the necessary interface and the same standards are being followed.	

6.2.20. Charging management and load balancing - static

Use case name	**Charging management and load balancing - static**	
Use case ID	#7.1	
Rationale	EVs demand depends on several parameters that will be examined in the course of the project. Such parameters are the battery capacity, the time available for charging (full or partial charging), the characteristics of the charging station and the EV's charging equipment (which charging modes) it can support). Several EV charging stations in one location may be aggregated and present a compound load to the grid. This demand may be significant and there may be times that cannot be satisfied by the available energy supply. To balance charging station supply to EV demand a special module should exist that takes several parameters into account and creates charging profiles for every charging session.	
Status (draft/final)	Final	
Short description	The load balancing controller provides a charging schedule to an EV according to aggregated charging information parameters and the supply allocated to the charging station by the Distribution System Operator (DSO).	
Primary Actors/Entities	- FABRIC on-board unit. - Charging infrastructure operator.	
Secondary Actors/Entities	- FABRIC platform.	
Vehicle type	All	
Charging type	**Static**	
Preconditions	An EV has been detected over a charging pad.	
Trigger event	An Electrical Vehicle issues a request for charging to FABRIC service coordinator.	
Successful end condition	The EV has received a charging profile that respects charging parameters and does not cause grid power overload.	
Failed end condition	The EV has not received a charging profile.	
Main success scenario description	Step	Action
	1.	The EV sends an authorization request to the FABRIC platform.
	2.	FABRIC platform receives information about the vehicle id from the EV back-end.
	3.	The booking of the infrastructure by the EV is checked and validated.
	4.	FABRIC platform provides authorization to charge to the charging infrastructure operator [X3]
	5.	The EV transmits charging parameters to the charging infrastructure operator (Such as charging energy, maximum charging power, charging priority, departure time) [X1]

	6.	The charging infrastructure operator generates a power profile for the requested charging session with respect to the EV's arrival and departure times, EV priority, EV charging specifications, and power supply availability. [E1][X1][X2]
	7.	The charging profile is transmitted to the FABRIC on-board unit.
	8.	FABRIC on-board unit acknowledges reception of the charging profile [X1]
	9.	The charging infrastructure operator monitors the charging session's status information (Parameters such as: energy delivered, charging session status (on-going, stopped), etc.) [X1]
	10.	Steps 6-10 are repeated in regular intervals to update the charging profile if necessary until charging session ends.
	11.	When charging session ends the charging information is transmitted to the FABRIC platform.
Exceptions	Step	[X1]
	1.	Acting modules fail to communicate and exchange information.
	2.	The charging management module suspends charging until communication is re-established.
	3.	Detailed logs are being created by the FABRIC platform
	The use case fails	
	Step	[X2]
	1.	Current power availability information is not available
	2.	The charging management module suspends charging until information is available.
	The use case fails	
	Step	[X3] at Step 4.
	1.	The FABRIC platform does not provide authorization to charge to the charging management module
	2.	Dynamic route and booking management use case.
	The use case fails	
Extensions	Step	[E1] at Step 7.
	1.	In case the charging management module controls several charging stations it updates the charging profiles for other EVs currently charging respecting the original charging targets (charging percentage goal at the end of the charging session, charging priorities etc).
	The use case continues at Step 7 for all EVs	
FABRIC modules involved	- FABRIC on-board unit. - FABRIC EV mobility platform. - Charging infrastructure operator. - FABRIC EV backend. - FABRIC DSO interface.	
Critical parameters	- Identification information: EV contract ID, etc. - EV charging parameters: Requested charging energy,	

	maximum charging power, priority. - Energy supply availability. - Booking parameters: Power, duration, time. - Other (The final list of parameters will be defined at a later stage of project development).
Type of environment	Static charging station installed anywhere, with continuous connectivity to the FABRIC off-board unit and the grid.
Related Use cases	#1.1, #1.8, #7.2, #2.1, #4.2, #8.1
User needs	#UN9, #UN14
Corresponding requirements	- V2I communication must be of high quality. - Energy transfer metering needs to be accurate.
Open issues	- Communication protocols. - Charging schedule generation strategies.
Comments	Static charging management is not as challenging as the dynamic one because the charging duration is much longer allowing more flexible planning but also the EV is not moving so communications are easy to be established. This use case is found typically in existing plug-in charging systems and research projects such as Power-up. The main difference is that charging in FABRIC will be wireless, thus providing increased user comfort and friendliness.

6.2.21. Load Balancing Controller (Charging management) – dynamic and stationary

Use case name	**Load Balancing Controller (Charging management) – dynamic and stationary**	
Use case ID	#7.2	
Rationale	Due to the nature of dynamic charging, the charging duration is short and it depends on the vehicle speed and the length of the charging lane. To address this issue and provide adequate energy to the EV, the transmitted power should be very high. This short-lasting demand spike per EV, which may reach 200kW, stresses the grid, especially if there are many EVs charging at the same time on the same dynamic charging lane. Depending on travelling speed and the length of the lane, the aggregated demand for a single lane may reach several MW. Since accurate long term pre-booking is not realistic for the dynamic charging use case, a load balancing module needs to create custom charging profiles per vehicle but also adapt them in near real-time conditions to guarantee grid security.	
Status (draft/final)	Final	
Short description	The load balancing controller of the charging infrastructure operator provides a charging schedule to an EV based on aggregated charging information parameters and the supply allocated to the charging lane(s) by the Distribution System Operator (DSO).This profile may change dynamically, during the charging, depending on the lane's traffic load and the aggregated demand.	
Primary Actors/Entities	- Electric vehicle. (FABRIC on-board unit) - Charging infrastructure operator.	
Secondary Actors/Entities	- DSO operator module. - FABRIC Electric mobility platform.	
Vehicle type	All	
Charging type	**Dynamic and stationary**	
Preconditions	A FABRIC-equipped EV is in proximity of a charging lane and has established a communication link with the FABRIC platform.	
Trigger event	The EV issues a request for charging to the FABRIC platform.	
Successful end condition	The EV has received a charging profile that takes into account charging parameters and does not cause grid overload.	
Failed end condition	The EV has not received a charging profile and charging is not possible	
Main success scenario description	Step	
	1.	The EV sends a charging request to the FABRIC platform.

	2.	The FABRIC platform checks the registration status of the EV and the infrastructure booking status, authorizes the charging and notifies the charging infrastructure operator. [X3]
	3.	The charging infrastructure operator requests charging parameters from the EV. [X1]
	4.	The EV transmits charging parameters to the charging infrastructure operator. (requested energy, maximum charging power, charging priority, current vehicle speed & location, other) These parameters will be defined during the development phase of the project. [X1]
	5.	The charging infrastructure operator generates a charging profile for the requested charging session based on the Load Balancing algorithm, with respect to the EV charging parameters and the power supply availability. [E1], [E2], [X2]
	6.	The charging profile is transmitted to the EV.
	7.	The EV acknowledges reception of the charging profile. [X1]
	8.	The charging infrastructure operator monitors the charging session's status information (Energy supply, power delivered, charging session status (on-going, stopped), current position on lane, etc.) [X1]
	9.	Steps 5-8 are repeated in regular, short intervals to update the charging profile if needed until charging session ends. The interval frequency will be determined during the development phase, based on the duration of the charging process.
	10.	When charging session ends the charging information is transmitted to the FABRIC platform.
Exceptions	Step	[X1] at Steps 3, 4, 7, 8.
	1.	Acting modules fail to communicate and exchange information.
	2.	The charging infrastructure operator suspends charging until communication is re-established.
	The use case fails	
	Step	[X2] at Step 5.
	1.	Current power availability is not available
	2.	The charging infrastructure operator suspends charging until information is available.
	The use case fails	
	Step	[X3] at Step 2.
	1.	The FABRIC Electric mobility platform does not provide authorization to charge to the charging infrastructure operator.
	2.	FABRIC on-board module is notified. Dynamic route and booking management or emergency charging use cases follow.
	The use case fails	

Extensions	Step	[E1] at Step 5.
	1.	Supply availability information becomes unavailable.
	2.	The charging infrastructure operator creates charging profiles based on “safe mode” parameters.
	The use case continues at Step 6.	
	Step	[E2] at Step 5.
	1.	The charging infrastructure operator generates a charging profile for the requested charging session. Charging profiles for other EVs currently on charging lane are updated to take into account the additional load. Updates take into account several parameters such as prioritization, battery level, other (tbd during development phase)
	The use case continues at Step 6.	
FABRIC modules involved	- FABRIC on-board unit. - Charging infrastructure operator. - FABRIC EV mobility platform. - FABRIC EV backend. - FABRIC DSO interface.	
Critical parameters	- Identification information: EV contract ID, etc. - EV charging parameters: Requested charging. energy, maximum charging power, priority. - Energy supply availability. - EV speed, location. - Other (The final list of parameters will be defined at a later stage of project development).	
Type of environment	Charging lane with continuous connection to the grid and FABRIC platform.	
Related Use cases	#1.1, #1.9, #1.10, #2.1, #4.2, #8.1	
User needs	#UN9, #UN14	
Corresponding requirements	- V2I communication must be of high quality. - V2I communication must be high speed to transmit charging profiles in real time. - Energy transfer metering needs to be accurate. - Load balancing algorithm must be fast enough to support a large number of EVs charging at the same time, potentially moving at great speeds. - Control and power electronics must have very fast response for the dynamic charging scenario.	
Open issues	- Communication protocols. - Charging profile generation strategies. - Profile updating intervals. - Maximum vehicle speed supported. - Maximum number of vehicles charging at the same time.	
Comments	Stationary charging management For stationary charging mode the vehicle is en-route and is able to charge during short stops (i.e. at a red traffic light or	

	at bus stops). Since charging spots will be installed on road segments with traffic, the idle time during which a vehicle charges, is determined by traffic conditions and will span from seconds to some minutes at most. Due to this fact, pre-booking provides no useful information to the system (however it could be used as input for load forecasting algorithms from the DSO). As with dynamic charging the power transmitted to the EV should be high so as to provide enough energy during the short stop. So the charging is opportunistic rather than planned and it stresses the grid more than static, low-power charging. The charging management module should be able to make real-time adjustments for each charging session so that grid security is ensured. In terms of use case description, the stationary charging can be considered a special case of dynamic charging (we can consider it dynamic at much slower EV speed) and no differences are foreseen between dynamic and stationary charging regarding the use case steps.

6.2.22. Billing user for Use of FABRIC charging

Use case name	Billing user for Use of FABRIC charging	
Use case ID	#8.1	
Rationale	System service providers will need to ensure that they can generate revenue from the use of the FABRIC system on their infrastructure. This can either be from billing users directly for using the system or by subcontracting a third party to operate the billing system and receive the revenue from the contracted third party. This use case focuses on the FABRIC system billing the user directly.	
Status (draft/final)	Final	
Short description	FABRIC will charge the user (driver) for charging and using the road and grid infrastructures. Tariff imposed by the energy seller or the DSO and the road operator also influence the end tariff to user.	
Primary Actors/Entities	FABRIC platform Driver	
System	FABRIC platform (Billing Back-Office/clearing house)	
Secondary Actors/Entities	FABRIC charging infrastructure operator Billing Third Party DSO, road operator, energy retailer.	
Vehicle type	All	
Charging type	All types	
Preconditions	- The primary actor is logged into the system. - Driver has a valid billing account and a FABRIC compatible vehicle. - EV charging took place successfully.	
Trigger event	EV charging has ended.	
Successful end condition	- Billing transaction completed.	
Failed end condition	- Billing transaction fails.	
Main success scenario description	Step	
	1.	EV charging just concluded. [X1]
	2.	Metering equipment installed at the primary side measured the energy transferred to that particular user for the charging event. [E1][X2]
	3.	Energy usage data and charging cost rate (a function of several costs) is sent to the FABRIC clearing house for processing and billing.
	4.	FABRIC back office calculates the cost which may takes into account several parameters

		such as energy cost, charging penalties, vehicle type and priorities, special discounts etc. and bills the corresponding user account.
	5.	End users and operators are notified with regular reports about each user billing transaction.
	6.	The payment and user information is forwarded to a third party that handles the actual billing process.
	Use case succeeds.	
Exceptions	Step	[X1] at Step 1
	1.	Energy transfer does not occur for some reason.
	Use case fails – no billing record is created.	
	Step	[X2] at Step 2
	1.	For some reason the data cannot be measured at the primary.
	2.	Charging stops.
	3.	An error log is created and the EV back-end updates the charging history log of the EV profile.
	Use case fails.	
Extensions	Step	[E1] at Step 2
	1.	The energy consumed by the EV is measured on-board and the data is transmitted to the infrastructure in real time.
	The use case continues at Step 3.	
FABRIC modules involved	- FABRIC charging infrastructure operator. - FABRIC Electric mobility platform. - FABRIC clearing house interface.	
Critical parameters	- Energy consumption measurement accuracy. - Communications quality.	
Type of environment		
Related Use cases	#1.1, #1.2, #1.8, #1.9, #1.10, #3.1, #7.1, #7.2	
User needs	#UN4, #UN8, #UN16	
Corresponding requirements	- Transmission of information needs to be secure. - Communication quality needs to be high. - Energy transfer metering needs to be accurate.	
Open issues	- Interfacing with clearing houses. - Types of user payment. - Whether the consumed energy will be calculated on-board or off-board. - Parameters that should be included in the charging cost estimation.	
Comments	Given that various payment and billing services already exist nowadays for web based services, it is not the goal of FABRIC to develop and validate any payment service and money flow in back-end banking system. Therefore, FABRIC treats the banking and payment aspect only from accounting viewpoint, i.e.	

	to validate the appropriate user consumption accounting while benefiting the e-mobility service. In a real deployment of the FABRIC system, the billing and payment procedure may be selected per implementation case. The billing formula is subject to custom business models at each installation. This is why in FABRIC it is foreseen that there will be an estimation of the charging cost which is the demonstrable part of the use case and this information can be forwarded to a “dummy” clearing house operator which is the feasible part of the use case.

Below is the UML diagram for the above use cases.

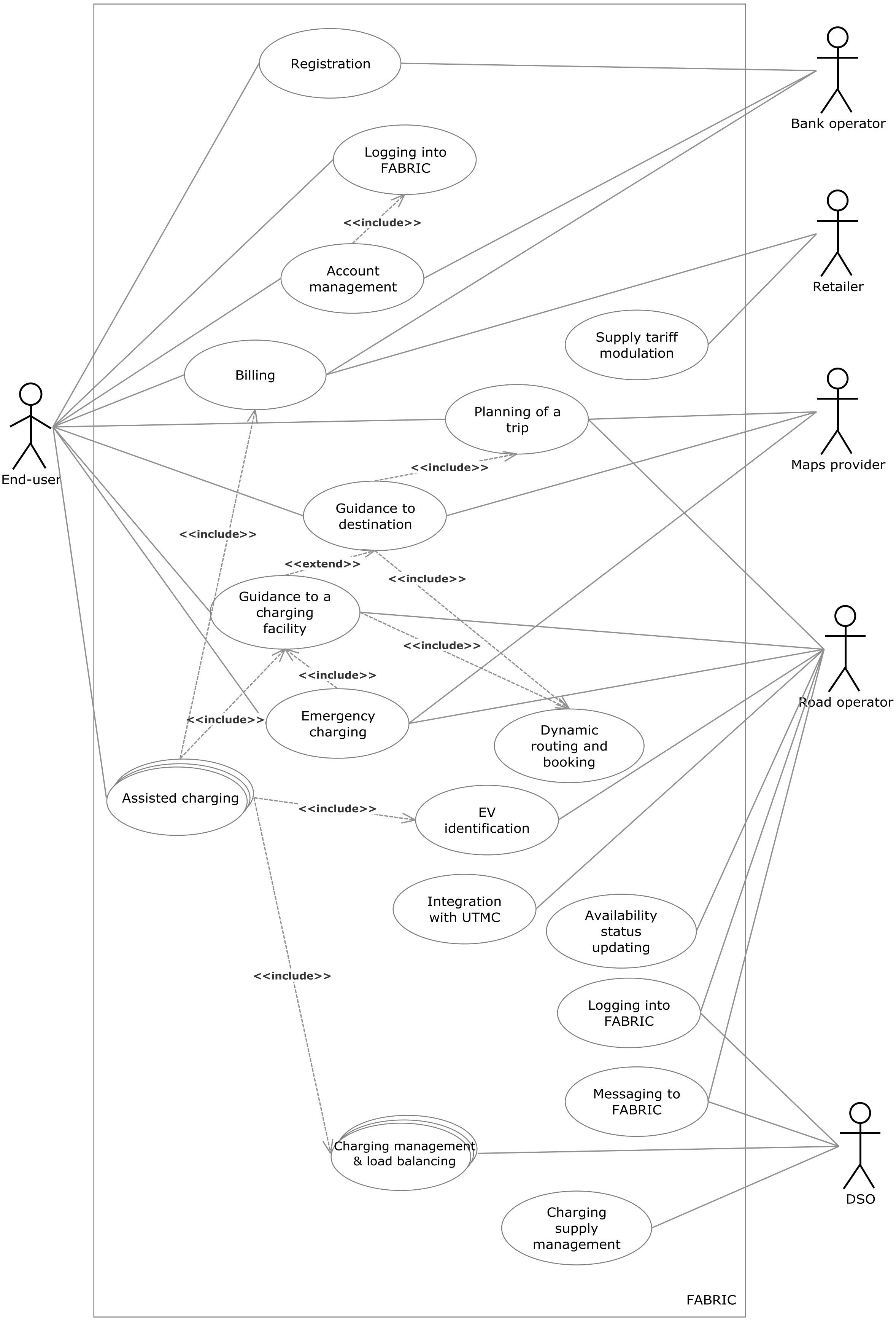

Figure 21: Use cases UML diagram.

7. Summary and Conclusions

This document summarizes the results of Task 4.3.1 “Use cases definition”. It includes contributions from SP2 and SP3 work packages: WP22 “User needs and requirements” that refer to the ICT solutions and WP32 “User needs and requirements” that refer to charging solutions. These work packages ran in parallel with the use cases definition task, starting at the project’s Kick-off Meeting. All of these tasks set the basis for research and development within the FABRIC project. Specifically, WP22 defined the actors and stakeholders of the system; in addition it specified the boundaries and interfaces of FABRIC ICT and the list of modules that should be included in the FABRIC platform, so as to provide the required functionalities to the identified end-users. WP32 defined the charging modes that would be considered and studied in FABRIC and the vehicles covered.

In addition, within SP2 and SP3 user and stakeholder surveys took place: these surveys allowed the identification of perspective user needs and requirements from a system such as FABRIC. They highlighted the shortcomings of current EV charging technologies, that dictate the development of a more flexible and convenient charging solution, thus revealing the areas that FABRIC development should focus. This direction was expressed in the design of the project use cases that describe the system’s practical scenarios of everyday use. The relevant input from the surveys (user need that is being addressed) is noted in each use case.

The tasks and work packages mentioned above run in parallel and the required inputs for T4.3.1 were available in their final form on M7 (based on the FABRIC DoW) which is later than the delivery deadline for this document. To address this issue, information from these work packages was integrated in the use cases when it was available in the form of internal reports from the respective SP2 and SP3 tasks. As a result of that the use cases in this document cannot be considered as completely final but they will be updated if necessary (however not in a major way) as the project progresses and more information becomes available. The use cases also aim to provide a general scope of the system and not to define specific system requirements, which is a task that will be performed by M10 in WP24 “Architecture and system specifications”.

The definition of use cases in this document follows two widely used formats to give a more complete picture of the system:

The first is the narrative format: scenarios of everyday use are drafted from the point of view of end-users, either drivers or infrastructure operators. Since FABRIC deals also with feasibility study of new electromobility technologies, these narratives provide a look into a possible future, when FABRIC or similar technologies are implemented in large scale and are part of the users’ everyday life.

The second format provides a detailed description of several use cases for system functionalities that are essential to a working prototype system that can be demonstrated within the project’s lifetime. Based on these use cases, the need for several ICT and supporting

infrastructure modules was identified. This outcome was provided to SP2 and SP3 developers as a starting point towards the actual implementation of FABRIC prototypes.

In that way the flow of information among relevant WPs was not cascading and linear but rather parallel and recurrent. This was a coordination challenge but also presented the opportunity for close inter-SP collaboration and closely knit-together results stemming from various partners, WPs and sources.

8. References

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[3] FABRIC D32.1 “Technical and user requirements”

[4] NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0.

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[7] US Transportation Electrification Program http://energy.gov/ig/downloads/audit-report-oas-ra-12-11

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[9] http://myway-project.eu/

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[11] http://srvweb01.softeco.it/ecogem/home.aspx

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[14] http://www.goodroute-eu.org/

[15] http://www.ict-itetris.eu/

ANNEX

I. User needs questionnaire

The online questionnaire is available at the following link:

http://www.surveymonkey.com/s/FABRIC-on-road-charging

II. Use cases template

The following template was used for the collection of input from the consortium regarding the system actors and proposed use cases.

USE CASES DESCRIPTION TEMPLATE

In a user-centred design approach, the use cases are described mainly from the point of view of the driver, the grid operator and the traffic/road manager, in order to ensure that the FABRIC applications that are considered are strongly focused on them.

Definition of an actor

An actor is an entity interacting with the system under design (SuD). Actors can be captured from the following interactions with the SuD:

- Primary actor of a use case, which is the entity initiating a response with the SuD
- Supporting actors within a use case i.e. entities that are involved with the scenario but do not initiate the interaction the SuD
- Internal entities within the SuD (depends where system boundary is drawn)

Actors and users are external to the system, and can be humans, organisations, machines, or devices. They will interact with the FABRIC system and are expecting charging and supporting to charging functionalities from the FABRIC system that will be expressed in terms of “user needs” and “requirement”. Sometimes they can also provide information to the system.

Actors need to be specified in FABRIC in the following manner (example)

Actor	**Name**	Driver
	Definition	A road user that is using the FABRIC System and is generally driving a motor vehicle.
Role	**Name**	FABRIC client
	Definition	The FABRIC end-user is the main client of the FABRIC system. He will receive charging for the vehicle, warnings, recommendations and any other kind of supporting service.

Comments	If no particular precision is given, any car, vehicle, truck or driver mentioned in the use cases are to be considered as a FABRIC End User.
Example context (optional)	Driver in car with on-board FABRIC system receives information about the car charging process
Relation to System component	FABRIC Client (SC)

Actor	**Name**	Road Operator Also named : Infrastructure manager, Assistance manager
	Definition	An authority responsible of managing, controlling and maintaining a part of the road network. It could be a public institution or a private company.
Role	**Name**	Road Operator
	Definition	Manage, control and maintain a part of the road network. They will use the FABRIC system to get related information and will also provide information to the system.
Comments		
Example context (optional)		
Relation to System component		FABRIC client and information provider

- **The same for “Grid operator”**
- **Which other actors can be identified?**

Definition of Entities

The entities presented here are part of the FABRIC system. They contribute to the different applications and functionalities of the system. They describe FABRIC devices or functional blocks that may initiate a use case automatically or respond to an action.

EXAMPLES

<table>
<tr><td rowspan="2">Entity</td><td>Name</td><td>The Infrastructure system

Also named : Infrastructure, Infrastructure based application, Roadside Unit (RSU)</td></tr>
<tr><td>Definition</td><td>It represents all the devices, sensors, transmitters and software that are not inside the vehicle but contribute to the FABRIC system.</td></tr>
<tr><td colspan="2">comments (optional)

sub-entities</td><td></td></tr>
<tr><td colspan="2">Example in FABRIC context (optional)</td><td></td></tr>
</table>

OTHER ENTITIES SHOULD BE DEFINED BY SP2 AND SP3 DEVELOPING PARTNERS

Use Cases template

Use case name	*Use case headline. Very concise description of the use case.*	
Use case ID	*To be determined after use cases are finalized*	
Author	*Author's name and company*	
Rationale	*A short description of the reasons for the inclusion of this use case.*	
Status (draft/final)	*Defines the status of the use case. Insert scenario completion status – draft for comment, completed for comment, finalised*	
Short description	*A short executive summary of the use case* *May include schematics*	
Primary Actors/Entities	*Role or name description for the primary actor / entity. The primary actor asks the system under design to deliver service or meet the goal of the scenario. See list of actors.*	
Secondary Actors/Entities	*Name and role description of any other actors involved in this scenario. See list of actors.*	
Vehicle type	*Passenger EV, LDV, HDV*	
Charging type	*Static, stationary, dynamic*	
Preconditions	*What are the preconditions necessary for the use case.*	
Trigger event	*The action from the actor or an event in the system that triggers this use case.*	
Successful end condition	*The scenario / situation or set of indicators that enable an assessment of the degree of success upon completion.*	
Failed end condition	*The situation when the purpose has been abandoned, include the reasons.*	
Detailed scenario description	Step	Action
	1.	*The steps of the scenario from triggering event to goal delivery.*
	2.	...
Extensions	Step	Extension [E1] at step x
	1.	*Extensions, one at a time, each referring to a step of the main scenario. The condition(s) under which the system takes a different behaviour path from the main scenario but the end condition succeeds. Actions which are taken for this condition are also described with steps. The condition may require a different use case to be called.*
	2.	...
Exceptions	Step	Exception [X1] at step y
	1.	*Same as with extensions but this time the use case FAILS meaning it results in the failed end condition.*
	2.	*…*
FABRIC modules involved	*Building blocks of FABRIC that participate in the use case.*	
Critical parameters	*Parameters that may affect the use case or are necessary for the completion of the use case.*	
Type of environment	*Where the use case takes place.*	

Related Use cases	*The id(s) of other use cases that are related to this one. The id(s) of other use cases in this document that are related to this one.*
User needs	*The id(s) of user needs that are related to this use case.*
Corresponding requirements	*The requirements that are derived from or related to this use case.*
Open issues	*Any issues that require further discussion or clarification.*
Comments	*Any comments on the contents of the use case.*