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Electric mobility functional ICT Architecture Description

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Abstract:

This deliverable is the final deliverable of the FINSENY project on the topic of electric mobility. It describes the final status of the functional architecture defined for electric mobility. Additionally, it explains the refinement and consolidation of the use cases defined earlier in the project and relates the architecture to the FI-Ware generic enablers, to relevant standards for information and data models and for communication architectures and infrastructures. A review of security measures related to the security requirements of the architecture is presented. Many tables and diagrams are provided to illustrate the inter-relationships of different aspects of our technical work on electric mobility. The conclusions section of the deliverable draws together the key conclusions of the work package efforts as a whole. The conclusions validate the approach of the FI-PPP programme, for the specific domain of electric mobility, in offering the set of FI-WARE Generic Enablers as ICT functionality which is useful in implementing new functionality and new business models in a diverse range of domains.

One of the three consolidated use cases described in this document, the use case on demand side management achieved through remote control by an energy provider of the charging of electric vehicles and providing the benefit of balancing the grid should a load shedding event occur, was developed as part of the FI-PPP Phase II field trial proposal, entitled FINESCE. The proposal was approved for funding, and work on the implementation of a trial of this use case, and many other use cases related to the investigations of FINSENY, started on 1 March, 2013. It is intended to further expand the scope of the trial with a Phase III proposal to enable a wide range of SME's to work with the trials.

Keyword list:

FI-PPP, FINSENY, FI-WARE, Electric Mobility, Functional Architecture

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Executive Summary

The FINSENY project is Phase I project of the FI-PPP programme identifying the ICT requirements of a range of use case scenarios and relating these requirements to the capabilities of a set of Generic Enabler software components developed by the FI-WARE project for use in Phase II field trial projects. Within the FINSENY project, Work Package 5 addressed the challenge of defining use cases and their associated ICT requirements and functional architecture in the domain of electric mobility.

In this final deliverable of Work Package 5, we describe the final set of three consolidated use cases and derive a functional architecture from their ICT requirements. The three consolidated use cases described in this report illustrate ICT enabled demand side management, international roaming of electric vehicles, and the potential use of electric vehicles to support the power grid as electrical sources. The innovative nature of the scenarios was developed with a view to their potential use as part of field trials in phase II of the FI-PPP programme and in recent months, the FINESCE project was approved to implement field trials of key functionality described in the ICT enabled demand side management use case.

We used the Smart Grid Architecture Model, developed by the European Commission organised Smart Grid Coordination Group, as a basis for our architecture work, as did the other work packages in FINSENY. We defined data models, interfaces and key building blocks for the use case scenarios as well as defining the relationship of the ICT requirements to the capabilities of the Generic Enablers offered by the FI-WARE project and commenting on the security issues of implementing the use cases and providing a description of a Future Internet communications networking technology which will deployed in the follow- on project, FINESCE.

The key strategic conclusions of the Work Package 5 investigations are that:

- **Electric Mobility use cases can be implemented today by developing solutions based on available ICT technologies and components**
  Our investigations showed that it is feasible to implement the use cases we identified by developing solutions based on integrating existing ICTs and developing appropriate domain specific enablers. We did not identify a need to develop new fundamental technologies which would have constituted a barrier to the near term large scale rollout of our identified consolidated use case scenarios.

- **The FI-PPP approach is valid for the electric mobility use cases**
  The investigation of the consolidated use case scenarios showed that the general functionality offered by the generic enablers of the FI-WARE project relates well to the ICT functionality needed to implement the use cases for electric mobility foreseen in the FINSENY use cases. This result validates the approach of the FI-PPP programme, for the domain of electric mobility, of offering generic ICT capabilities to a diverse set of domains, to create a critical mass in the market for the generic capabilities, improving the business case for deploying innovative new services and business models which rely on ICT functionality. The requirements confirm the proposition that the definition of commonly used interfaces would lead to economies of scale, scope and cost benefiting European citizens and businesses. Domain specific enablers required to implement electric mobility were identified and would need to be developed to complement the generic enablers.

  The scaling up of solutions for mass market use, as the proportion of electric vehicles on European roads grows, will require the use of Future Internet technologies, including cloud based services, sensor fusion technologies and big data management and analysis solutions.

- **E-Mobility offers the potential to develop innovative new services and markets**
  As a majority of basic requirements of E-Mobility can be met with solutions developed from available technologies, there will be many opportunities for service providers to offer innovative services to E-Mobility customers, further developing the market for services offered to people who are travelling. An example of such new services would be the development of a market for the sale of the option to control load shifting by individual users or by energy sector aggregators, implemented by having control of their charging. The customers who provide energy providers with the ability to control the charging of their vehicles will need to be compensated for their flexibility and this compensation control of charging service could be developed into a market

for the capacity to shift power network load. This function relates to the usage scenario for a market for user demand control under investigation in FINSENY in WP6.

- **A common regulatory environment for E-Mobility roaming in Europe would accelerate the development of the market for E-Mobility services supporting economic growth**
  We concluded that the development of a pan-European scale market for E-Mobility services could be accelerated through the development of a common regulatory environment for E-Mobility roaming within the European Union.

- **E-Vehicle charging management will be an essential component of all Smart Energy solutions in coming years**
  The development of the usage scenarios and the investigation of their ICT requirements led to the conclusion that charging facilities for electric vehicles will be part of every smart building scenario, will influence the design of the distribution network as they will be a new heavy load on the network, will be part of micro-grid solutions and provide the opportunity to develop new electronic markets for the sale of the control of the charging of the vehicles and for the sale of other services to travellers.

- **The use cases offer a solid basis for standardisation and planning of electric mobility**
  The use cases have provided many organisation with a good basis for planning how they can benefit and take part in the deployment of electric mobility and they have been extensively used in standardisation activities at European level.

- **Field trial proposals funded by partners and the European Commission**
  The main field trial proposal we developed in WP 5, integrates many aspects of the Smart Energy grid, potentially enabling a cost-effective improvement in the ability of energy providers to manage their energy grids while increasing their use of energy from renewable energy sources. It has been approved for funding as part of the FINESCE field trial project, which started operation on 1 March, 2013.

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Abbreviations

AAA	Authentication, Authorisation and Accounting
AAAA	Access, Authentication, Authorisation and Accounting
AC	Alternating Current
ACS	Automation of Complex Power Systems
API	Application Programming Interface
ARP	Address Resolution Protocol
ASCII	American National Standard Code for Information Interchange
ASN.1	Abstract Syntax Notation One
B2B	Business to Business
B2C	Business to Consumer
BEMS	Building Energy Management System
BES	Backend System
BSP	Billing Service Provider
CAPEX	Capital Expenditures
CBT	Cross-Border Transactions
CHAdeMO	CHArge de Move
CIM	Common Information Model
DC	Direct Current
DER	Distributed Energy Resource
DMS	Distribution Management System
DoS	Denial of Service
DSE	Domain Specific Enabler
DSM	Demand Side Management
DSO	Distribution System Operator
DSOCC	Distribution System Operator Communications Controller
EBCDIC	Extended Binary Coded Decimal Interchange Code
ECU	Electronic Control Unit
EEM	Electronic Energy Marketplace
EEX	European Energy Exchange
EGO	Electricity Grid Operator (TSO and/or DSO)
EMS	Energy Management System
EMSP	Electric Mobility Service Provider
ENTSO-E	European Network of Transmission System Operators for Electricity
EPS	Electric Power Supplier
ESA	Energy Services Aggregator
EV	Electric Vehicle
EVCC	Electric Vehicle Communication Controller
EVSE	Electric Vehicle Supply Equipment
FCH	Financial Clearing House
FI	Future Internet
FI-PPP	Future Internet-Public-Private-Partnership
FTP	File Transfer Protocol
GE	Generic Enabler
GenCo	Generation Company
HEMS	Home Energy Management System
HTML	HyperText Markup Language
IAS	Identification and Authorisation Server
ICT	Information and Communication Technologies
ID	Identifier
IEC	International Electrotechnical Commission
I/F	Interface
IoT	Internet of Things
IP	Internet Protocol
IPSec	IP Security
ISO	International Organization for Standardization
ITU	International Telecommunication Unit
LV	Low Voltage
MC	Microgrid Control Centre
MEP	Message Exchange Pattern
MGCC	Microgrid Control Centre

MMS	Mobility Management System
MO	Microgrid Operator
MV	Medium Voltage
O&M	Operations & Maintenance
OCHP	Open Clearinghouse Protocol
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
OPC	Open Process Control
OSI	Open Systems Interconnection
PGP	Pretty Good Privacy
PLS	Protective Load Shedding
PLST	Protective Load Shedding Trip
PWM	Pulse Width Modulation
QoS	Quality of Service
RES	Renewable Energy Supply
REST	Representational State Transfer
RFID	Radio-Frequency Identification
RTDS	Real-Time Digital Simulator
SAE	Society of Automotive Engineers
SCADA	Supervisory Control And Data Acquisition
SECC	Supply Equipment Communication Controller
SEOCC	Supply Equipment Operator Communication Controller
SGAM	Smart Grid Architectural Model
SGCG	Smart Grid Coordination Group
SLA	Service Level Agreement
SNMP	Simple Network Management Protocol
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SoC	State of Charge
SOTA	State of the Art
TCP	Transmission Control Protocol
TLS	Transport Layer Security
TSO	Transmission System Operator
TSOCC	Transmission System Operator Communications Controller
UDP	User Datagram Protocol
USDL	Unified Service Description Language
V2G	Vehicle to Grid
VAS	Value Added Service
VPN	Virtual Private Network
WAN	Wide Area Network
WANem	Wide Area Network Emulator
XaaS	{Infrastructure, Platform, Software} as a Service
XGCC	2/3/4G Communication Controller
XML	eXtensible Markup Language

1. Introduction to the functional architecture deliverable

This deliverable is the final deliverable of the FINSENY project on the topic of electric mobility.

In this chapter, we place the work of the work package on electric mobility in relation to the world external to the work package. We start with the context of the FI-PPP programme and its focus on Generic Enablers, then focus on the context of the FINSENY project efforts on defining a Smart Energy system and then describe recent developments in the marketplace in relation to electric mobility. It concludes with an introduction to the structure of this report as a whole and points to the further work on the results of FINSENY already started in the FINESCE project.

1.1 FINSENY as an FI-PPP Project addressing a new approach to meeting ICT requirements

The need to address global warming and pollution through increasing the use of renewable energy for electricity generation is driving efforts to develop the Smart Grid. Hence, it is the topic of many research projects, both national and international. Hence, FINSENY is one of many projects addressing the challenge of defining a Smart Energy system.

The FINSENY project contributes to these global efforts by defining the requirements that the future electricity grid will place on ICT systems. The unique contribution of FINSENY is to place the ICT requirements of the Smart Grid in the context of the common ICT requirements of a diverse range of applications, such as those needed for smart and safe cities, multi-modal travel and smart agriculture. FINSENY and a range of other projects in the FI-PPP programme investigate the feasibility of using a common ICT platform, in particular the one developed in the FI-WARE project [1], in field trials of the applications in a set of Phase II projects in the Future Internet-Public-Private-Partnership (FI-PPP) programme. Phase II projects begin in March and April 2013 and will run for the duration of 24 months, overlapping with Phase III projects, which will enable many new partners to work with the established trial infrastructures. FI-WARE offers instantiations of Generic Enablers (GEs) on this common ICT platform for use in Phase II and Phase III field trials.

FINSENY project results show that ICT systems will be needed to support the transformation of the largely unidirectional and static energy network, where energy only flows from energy generators to energy users, into a bi-directional dynamic network, where energy users are also energy providers and energy flows into the grid from the private users as well as from the public energy providers. Supporting the increasing use of renewable energy sources (RES), such as solar and wind energy, requires that the grid can adapt to the low predictability of the energy generation capacity of these sources, storing and releasing energy in large quantities as needed to balance supply and demand in the energy network that encounters unprecedented dynamics. The FINSENY project refined its initial requirements definition in year 2 of the project and then described the functionality which could be investigated in field trials in follow-on projects. The focus of FINSENY efforts is on describing functionality which is likely to result in the creation of new value chains and business models in the energy sector.

The large scale introduction of electric vehicles (EVs) will have an impact on the energy infrastructure as the necessary charging points will have to be provided. However, the widespread use of electric vehicles also requires interaction between the energy infrastructure, the transport infrastructure, the vehicle information systems and the communication network infrastructure, in order to collect, to process and to deliver the needed information. WP5 of the FINSENY project has focussed on the many implications of electric mobility on the ICT infrastructure needed to support the widespread introduction and use of electric vehicles.

1.2 The E-Mobility Context in the FINSENY Project

It is clear that electric vehicles – which introduce a new demands on the grid, with challenging quantitative and qualitative effects, as the switch from combustion engines to electric vehicles takes up momentum – will play a major role in the development of the Smart Grid. A wide range of use cases was developed in WP 5 for different types of journeys, as well as for grid operations and value added services to ensure a comprehensive definition of ICT requirements (as described in D5.1 [2]). Building on the earlier FINSENY work of defining use case scenarios and initial ICT requirements, all FINSENY scenario work packages have defined a functional architecture with associated data models, interfaces and key building blocks.

The first version use case definitions described in D5.1 [2] have been refined and consolidated into three consolidated use cases which promised to be the most interesting ones for the functional architecture. These consolidated use cases include the key functionality of the first version use cases. The consolidated use cases were defined as the basis for pan-European field trials in Phase II of the FI-PPP.

The descriptions of the functional architecture in the deliverable have been related to these usage scenarios which cover almost all of the first version use cases (see Table 1, p. 23 for a use case mapping). The implications of the use case scenarios for the usage of FI-WARE GEs and the potential need to develop Domain Specific Enablers (DSEs) were addressed in the last project phase with the results being reported in this deliverable.

1.3 Recent Market Developments in E-Mobility

One of the notable features of working with the subject of electric mobility during the two years of the project has been the rapid changes in the commercial expectations in relation to electric mobility products, services, standards and market development rates.

At the outset of the FINSENY project there were many aspects of electric mobility infrastructure and standards which were still unclear. During 2012 many of these factors have become much clearer with industry stakeholders focusing efforts in specific directions. The European 'Cross-Border Transactions (CBT) directive' has specified the Type 2 connector for AC charging of electric vehicles and has endorsed 'Combo 2' as a method of DC fast charging. Furthermore the European commission has mandated levels for installation of charging infrastructure for member states. Meanwhile, they have been changes in the market which have come in recent months and which were taken into account in recent elaboration of use cases (as described in this deliverable). For, example in Germany, the government announced in 2011 the goal to have one million electric vehicles on the road by 2020 and six million electric vehicles by 2030 according to their plans for the German Energy Turn ("Energiewende"). Yet, in the beginning of 2012, only 4,500 electric cars were registered. In Germany, the new goal for 2020 is a minimum of 600,000 registered cars (announced by Chancellor Angela Merkel at the car producer summit in October 2012). On the other hand pedelecs and e-bikes have turned out to be a success story and sales figures are increasing dramatically (from 110,000 in 2008 up to 310,000 per year in 2011 [3]).

While E-Mobility field trials are still being developed in some countries, commercial services have already been launched in others (e.g. electric car rental service introduced in late 2011 in Paris, as well as in 2012 in Amsterdam and Ulm/Germany). The so called "combined charging system"-plug is a European alternative, which enables at least two charging modes with one being fast charging, to the CHAdeMO specification that is only aimed at fast charging. Additionally, the topic of inductive, contactless charging was regarded as a research topic as recently as 2010, and would take many years to reach market maturity. However, recent developments show that field trials of inductive charging have already started in a number of European countries. They show that the technology could be introduced to the market many years earlier than had been anticipated, with immediate applications for buses and taxis (which can be stationary for short periods and therefore can be charged in this way).With respect to ICT, an association has been founded in 2012 called "E-Mobility ICT Interoperability Interest Group" which is pushing standards for roaming processes, data objects and protocols. This group is driven by OEMs (e.g. Renault, BMW, Daimler), energy suppliers (e.g. ESB, Enel, EnBW), technology providers (e.g. Bosch, Siemens), mobility providers (e.g. Betterplace, Inteli) as well as navigation providers (e.g. TomTom). The primary focus of the interest group is user identification and data formats rather than the technology used. It is recognised that the technologies will change over time; however the crucial consideration is to create a unified standard on data formats, so as to accommodate future developments in the industry. They will publish standards that are using and extending existing standards (e.g. IEC 15118 [4], [5], [6], Open Charge Point Protocol (OCPP) [7], [8]) in order to allow for European E-Roaming.

2013 is set to present a much wider offering of electric vehicles:

- Renault will expand their offering with the addition of the 'Zoe',
- BMW will offer the 'i3',
- VW will offer the 'E-U',
- Nissan will offer its European manufactured range of three different level 'Leaf's'.

These ranges are set to increase further with BMW's 'i8' and VW's E-Golf. This bumper offering from a growing number of recognised and trusted OEMs is expected to boost consumer confidence in the arrival of electric mobility era.

1.4 Structure of this deliverable and plans for further work

In the following chapters, we describe the methodology used to derive the functional architecture and the refinement of our earlier work on use cases and key building blocks. We relate the functional architecture to the FI-WARE Generic Enablers and to information and data models and communication and protocol architectures. We provide examples of component and communications infrastructures and elaborate on the Exemplar Distributed Switch Network, which will be used in the field trial of one of consolidated use cases in the FINESCE FI-PPP Phase II project.

The final conclusions of the report are presented in Chapter 10 and they show that the result of our evaluation of the potential to use the FI-WARE Generic Enablers in the domain of electric mobility, in the context of efforts to develop a Smart Energy system, is technically feasible on paper and worth pursing in field trials which will help in the assessment of the technical and commercial viability of the concepts proposed. From our work so far, we can confirm the thesis of the FI-PPP programme that the set of Generic Enablers and available ICT technology enables the implementation of the key functionality required for a range of Electric Mobility use cases.

We have prepared detailed trial plans for a representative use case using a range of Generic Enablers and after overlapping with the final month of the FINSENY project, we have started a the work of running a field trial of this use case in the FINESCE project to test the practical applicability of the approach we propose for demand management using the charging of electric vehicles as a tool to help balance the power grid in the event of load shedding events. A further expansion of the trial to include many smaller companies in the trial once the trial infrastructure has been installed and taken into operation in planned in Phase III of the FI-PPP programme.

2. Methodology

2.1 Introduction of the FINSENY Methodology

FINSENY uses scenario techniques to identify the prominent ICT challenges. The term ‘scenario’ refers to an application domain in the evolving Smart Energy landscape, expected to be of significant importance, and requiring advanced ICT technologies.

ICT technologies are playing a critical role in the development of Smart Energy infrastructures by enabling new functionality while reducing costs. And these new features are the result of the analysis of scenarios and requirements that support them. Therefore, one of the most relevant objectives for this project is to identify, describe and consolidate the ICT requirements of electric mobility use case scenarios from the view point of general categories and architectural layers.

The activities performed to produce the results in this deliverable can be clustered in four steps. These four steps could not be completed in a pure sequential manner. At first, recent market developments (cf. Section 1.3) needed regular adoptions in the former steps in order the work to be aligned with the current state of the art. Secondly, an iterative approach is able to improve the results up to the point where significant improvements are no more possible. The iterative revisions were done in particular for the ICT requirements and the final use cases, but also for some part of the functional architecture. The four steps are as follows:

1st step: Specification of electric mobility scenario and its use cases

This step and its results have been described in detail in D5.1 [2].

2nd step: Identification of ICT requirements needed for identified use cases

The interim results of this step for the electric mobility scenario have been documented in an internal report. All scenario ICT requirements have been consolidated in WP7 and have been documented in D7.1 [9].

3rd step: Select electric mobility use cases for a subsequent detailed analysis

The following four criteria for this selection process were:

- relevance according to the work package scope,
- innovation aspect with respect to intelligent connection to the power grid,
- inter-WP trial potential, and
- expected relevance with respect to ICT beyond the state-of-the-art.

4th step: Drill-down from the final use cases and the derived ICT requirements to a fitting ICT architecture

At first, a suitable architectural approach was needed to apply the drill-down approach. Inspired by the Open Systems Interconnection (OSI) model, the Smart Grid Architectural Model (SGAM) framework from the Smart Grid Coordination Group (SGCG) proved to be an adequate framework for this task. Not only WP5 of FINSENY, but also international standardisation organisations where convinced from this approach. For example, the „Ad hoc Working Group for Smart Charging of Electric Vehicles” is using the SGAM framework in order to give definitions and recommendations for the intelligent charging of electric vehicles in Europe. This joint working group is led by CEN/CENELEC and works under the EU-mandates “E-Mobility Coordination Group (M/468)” and “Smart Grid Coordination Group (M/490)”. Members of the FINSENY consortia are actively participating in this working group in order to guarantee as much coherence as possible. However, slight deviations cannot be excluded, due to differences in the domain that is to be covered (FINSENY use cases need to cover more than smart charging).

In the following, the Smart Grid Architectural Model (SGAM) is described (Section 2.2) as well as the way in which it was applied (Section 2.2.3)

2.2 Smart Grid Architectural Model (SGAM) Framework

The following subsections are mainly excerpts from the SGCG reports [10]. They were interpreted, where appropriate, from the context of the electric mobility scenario.

2.2.1 Overview

The SGAM framework is a model and a methodology that presents the design of Smart Grid use cases in an architectural manner, but in a way that is technology- and solution-agnostic. The SGAM framework allows the validation of Smart Grid use cases and their support by current or future ICT standards.

The SGAM (Figure 1) consists of five layers representing the business context (objectives and processes), functions (mainly ICT), data and information, communication (mainly links and protocols) and components. These five layers represent an abstract version of the interoperability categories. Each layer covers the Smart Grid plane, which is spanned by domains and zones. The intention of this model is to allow the presentation of the current state of implementations in the electrical grid, but furthermore to present the evolution to future Smart Grid scenarios by supporting the principles of universality, localisation, consistency, flexibility and interoperability.

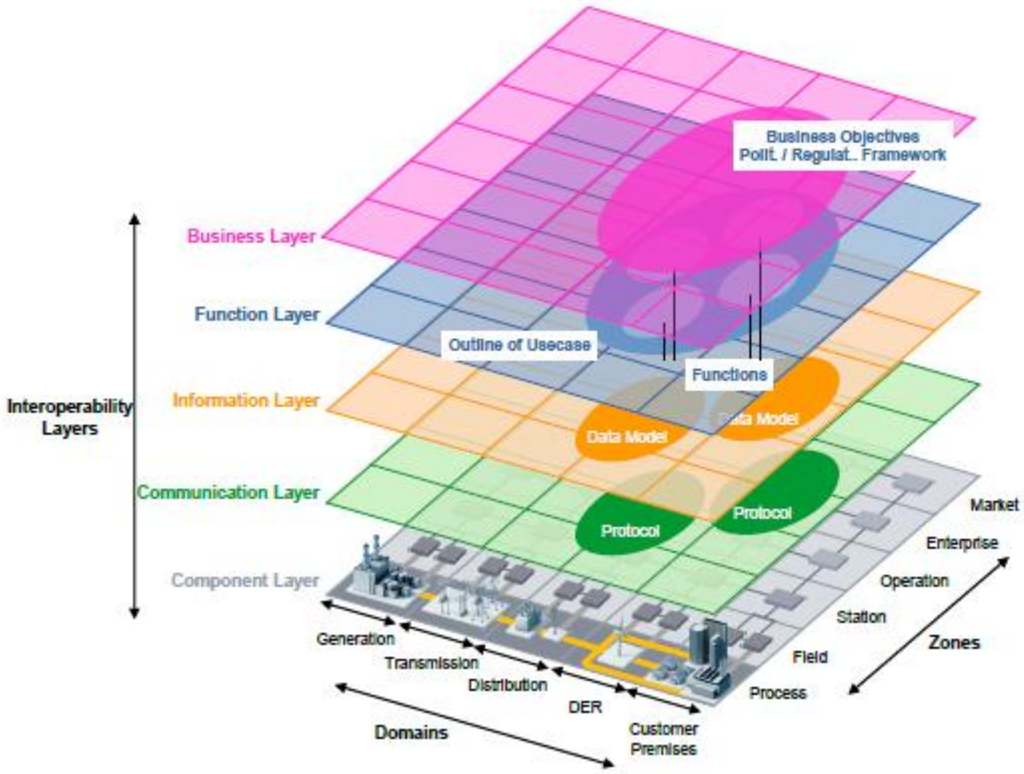

Figure 1: SGAM Framework (source: [10])

2.2.2 Domains and Zones

The SGAM domains can be arranged with the electrical energy conversion chain and the zones of power system management [11]. As a result this arrangement spans the Smart Grid plane (Figure 2).

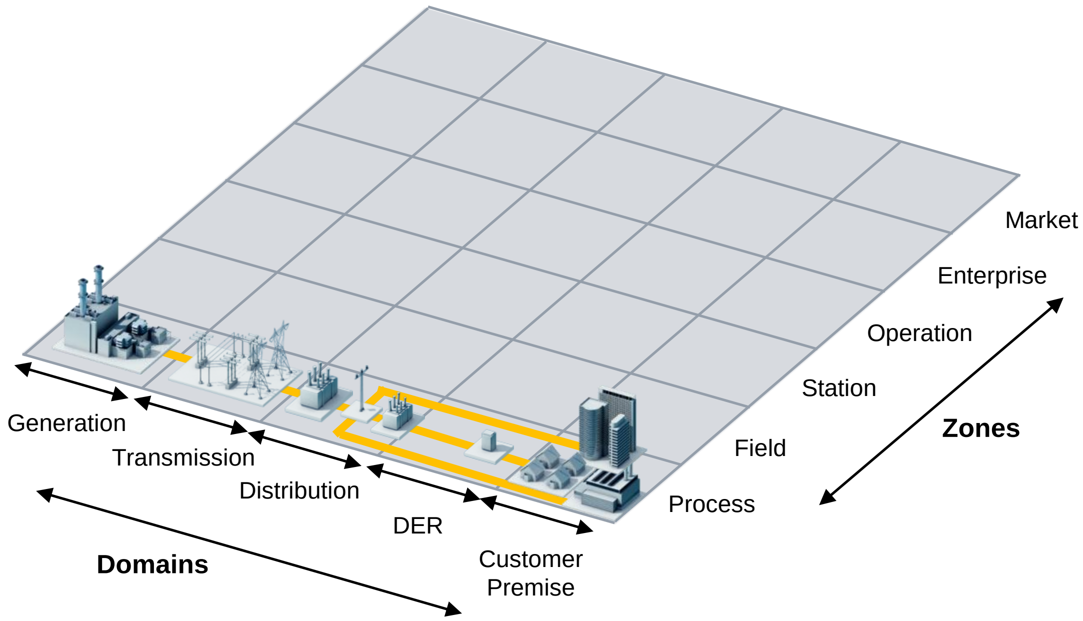

Figure 2: Smart Grid plane - domains and zones of scope/organisation (source: [10])

The Smart Grid Plane covers the complete electrical energy conversion chain classified by the following ***domains:***

Generation
Generation of electrical energy in bulk quantities, such as by fossil, nuclear and hydro power plants, off-shore wind farms, large scale photovoltaic parks – typically connected to the transmission system.

Transmission
Infrastructure and organisation which transports electricity over long distances.

Distribution
Infrastructure and organisation which distributes electricity to customers.

Distributed Electrical Resources (DER)
Applying small-scale power generation technologies (typically in the range of 3 kW to 10,000 kW).

Customer Premises
End users of electricity, also producers of electricity (prosumers) that are industrial, commercial or home based.

The ***zones*** represent levels of power system management by:

Process
Includes the primary equipment of the power system, e.g. generators, transformers, circuit breakers, overhead lines, cables and electrical loads at the component layer.

Field
Includes equipment to protect, control and monitor the process of the power system, e.g. protection relays, bay controller, any kind of sensor and actor devices.

Station
Represents the aggregation level for fields, e.g. data concentration.

Operation
Hosts power system control operation in the respective domain, e.g. distribution management systems (DMS), energy management systems (EMS) in generation and transmission systems, micro grid management systems, virtual power plant management systems (aggregating several DERs), Electric Vehicle (EV) fleet charging management systems.

Enterprise
Includes processes and infrastructures for enterprises (utilities, service providers, energy traders, etc.), e.g. asset management, staff training, customer relation management, billing and procurement.

Market
Reflects the market operations possible along the energy conversion chain, e.g. energy trading, mass market, retail market, etc.

2.2.3 Layers

In general the Smart Grid can be seen as a “system of systems”, meaning the Smart Grid consists of heterogeneous but interacting systems, which themselves include various components. This interaction is enabled by the use of information and communication technologies, which are implemented in systems and components. Consequently from an architectural point of view the implementation of Smart Grid use cases can be decomposed into five layers representing business procedures, functions, information models, communication protocols and components. Each of these layers is comprised into domains and zones, these five layers establish the SGAM (Figure 1).

Business Layer
The business layer represents the business view on the information exchange related to Smart Grids in order to map regulatory and economic (market) structures and policies, business models and business portfolios of market parties involved. Also business capabilities and business processes can be represented in this layer.

Function Layer
The function layer represents use cases, functions and services independent from their physical implementations in systems and components. It is intended to map the use cases including actors, sub-functions and functional and non-functional requirements. Typically, a list of use cases will cover a business case.

Information Layer
The information layer describes the information objects or data models, which are required by the use cases, function or service. These information objects or data models represent the common semantics for functions and services in order to allow an interoperable information exchange via communication means.

Communication Layer
The emphasis of the communication layer is to describe protocols and mechanisms for the interoperable exchange of information between components in the context of the underlying use case, function or service and related information objects or data models.

Component Layer
The emphasis of the component layer is the physical distribution of all participating components in the Smart Grid context. This includes power system equipment (typically located at process and field level), protection and tele-control devices, network infrastructure (wired-/wireless communication connections, routers, switches, servers) and any kind of computers.

2.3 E-Mobility Adapted SGAM (EM-SGAM)

2.3.1 Aim of Adaption

The SGAM provides a useful starting point for the task of modelling an E-Mobility functional architecture. However, the framework aims at covering all domains relevant for coherent Smart Grid system coverage. From the perspective of E-Mobility, the Smart Grid is just one component which is a very essential one. As such, an E-Mobility adapted SGAM (EM-SGAM) is now introduced that is better tailored to model and visualise the particular qualities of E-Mobility. Therefore, the SGAM was adapted in a way that:

1. allows it to represent all E-Mobility specific aspects, while
2. remaining fully compatible with SGAM.

More information on the requirements of adaptations can be found in [12].
While the layers are not changed in EM-SGAM, the domains and zones are adapted as follows.

2.3.2 Adaption of Domains

Since the Generation domain of SGAM covers bulk energy generation facilities in a classical sense, this domain has only very indirect relevancy for this scenario. Also the distinction of transmission and distribution grid is important only for vehicle to grid (V2G) and therefore does not need to take most of the domain space. Therefore, the EM-SGAM defines three domains that can be characterised as follows:

Power Grid

This domain contains objects related to energy generation and distribution (interface to SGAM domains of generation, transmission and distribution).

Charging Infrastructure

This domain comprises objects related to charging infrastructure for users (charging and parking). It also represents distributed energy resources (DER), more specifically charging infrastructure and all power equipment needed for V2G scenarios. This domain corresponds to SGAM DER domain.

Infrastructure User

This domain includes objects related to users of infrastructure (EV and EV user) that typically appear at numerous and manifold infrastructure elements and types. All contained objects are located at customer premises (and its devices). This domain corresponds to SGAM Customer domain.

2.3.3 Adaption of Zones

Due to the ICT focus of the functional architecture, the very electrical zones (process, field) are not needed in that level of detail, so that they are aggregated to one zone “process & field”.

2.4 SGAM Drill-down Methodology

In order to use the SGAM for the task of modelling a generic ICT architecture for e-mobility, two general approaches are possible:

- Top-down: Starting with the derivation of functions and going down the layers till the components. Main question: what should be or what is wished?
- Bottom-up: Starting with the components and going up the layers till the functions. Main question: what exists or what can be used?

In both cases, the feasible things have to be brought together with what is physically and economically available. For the purposes of WP5, it was more adequate selecting the top-down or more precisely the “drill-down” method. Yet, the process is clearly iterative, so that the functional layer is not designed once and never touched again, but is revised after a first draft of e.g. the component layer in order to get a coherent picture.

In order to model the function layer, the starting points for further investigations were the considered use cases. The result is a pool of required functions and sub functions which were abstracted to provide generic functionality, possibly also applicable to other use cases. Functions including their stakeholders, devices, systems and interfaces are also described at a high level allowing us to identify interfaces to other FINSENY scenario WPs.

In order to fill all SGAM layers the following steps were performed (“drill-down”):

1. Derive functions from use cases and ICT requirements and distribute them in the Smart Grid plane by identifying domains and zones affected by the use case.
2. Derive information and communication objects from the functions and distribute them adequately in the Smart Grid plane.
3. Derive components fitting to all other layers and distribute them adequately in the Smart Grid plane.
4. Iterate on steps 1–3 until the anticipated coherency, consistency and level of detail is reached.

In order to understand the first step best (1. derivation of functions), the next chapter at first presents the way of deriving final use cases from the first version use cases (section 3.1). The final use cases have been identified to be at the same time most representative as well as most valuable for a trial in Phase II of the FI-PPP. Section 3.2 contains a short description of these final use cases.

3. Use Cases and ICT Requirements

3.1 Derivation of Consolidated Use Cases

3.1.1 Methodology for the consolidation

On the basis of the many first version use cases [2], three final consolidated use cases were derived in order to reflect the key requirements and to build the functional architecture. Our reasoning in undertaking this consolidation was that we wanted to:

- Reflect new market developments, such as the increasing importance of fast charging stations for EVs in the consolidated use cases,
- Highlight those use cases which were more probable to be tested in trials in Phase II projects, and to
- Reflect our improved understanding of what might be a Generic Enabler and what could be a Domain Specific Enabler, having received more detailed information from FI-WARE via the Architecture Board.

Therefore, the final use cases are not only domain-specific, but also generic in the sense that FI-WARE can provide Generic Enablers for them. At the same time, the chosen use cases reflect near term E-Mobility developments as a whole and are expected to be representative of likely developments in Europe. Therewith, it should be possible to transfer the use of Generic Enablers of these use cases also to other use cases in the E-Mobility domain not identified and described in this deliverable.

The three consolidated use cases which we derived and further developed in Task 5.3 were the following ones:

- ICT-enabled Demand Side Management
- E-Roaming
- Vehicle to Grid (V2G)

We describe each of the three consolidated use cases in this chapter, first providing an overview of the relationship between the consolidated use cases and the earlier first version use cases.

3.1.2 Relationship of the consolidated use cases to the first version use cases of Year 1

In order to show the coverage of the three final use cases, Table 1 maps the use cases identified and documented in D5.1 [2] (in rows) to the final use cases (in columns). The final use cases were formed by regrouping sub scenarios of the first version use cases. An "X" in this table means that the particularities of that use case (sub-)scenario are reflected to a large extent by the final use case.

First Version Use Cases		*Final consolidated use cases*		
Use case Scenario	*Sub scenario*	*1. ICT Enabled Demand Side Management*	*2. E-Roaming*	*3. Vehicle to Grid*
Use Cases Short Trip (UC ST)	Home (UC-ST-H)	X		X
	Public (UC-ST-P)		X	
	Workplace (UC-ST-W)	X	X	
Use Cases Medium Trip (UC MT)	Charge Point Accessibility (UC-MT-CPA)	X	X	X
	Alternative Method (UC-MT-AM)	X		
	Inter-Modal (UC-MT-IM)		X	
Use Cases Long Trip (UC LT)	Authentication (UC-LT-A)	X	X	X
	International Roaming Charge		X	

First Version Use Cases		*Final consolidated use cases*		
Use case Scenario	*Sub scenario*	*1. ICT Enabled Demand Side Management*	*2. E-Roaming*	*3. Vehicle to Grid*
	Point (UC-LT-IRCP)			
	Payment Methods (UC-LT-PM)		X	
	EV User in another country (UC-LT-EVC)		X	
Use Cases Grid Operations (UC GO)	Charge Load Management (UC-GO-CLM)	X		X
	Stationary Energy Stores (UC-GO-SES)	X		
Use Cases Value Added Service (UC VAS)	Enhanced Services (UC-VAS-ES)	X	X	X

Table 1: Mapping of first version use cases defined in D 5.1 to final use cases

These three use cases are described in more detail in the following sections.

3.2 Final consolidated use cases

3.2.1 ICT-Enabled Demand Side Management

3.2.1.1 Rationale

In order to illustrate the requirements of the specific use case “ICT Enabled Demand Side Management”, this section provides a description of a real use case trial addressing the management of electric vehicle charging systems. The trial is currently being developed as part of the FINESCE project, which is proposed for Phase II of the FI-PPP.

The need to integrate renewable power sources into the electricity grid is a global imperative. However, the relative unpredictability of the outputs of renewable energies can hinder the extent of their penetration into the energy systems. In Ireland for example, Eirgrid the TSO for the energy system has needed to ‘constraint off’ wind generation when it has reached 50% of system demand due the risk of destabilising the countries entire electrical network, this is an obvious missed opportunity for utilisation of renewable natural resources. Today, balance can only be maintained by rapidly altering conventional power outputs to compensate for changes in renewable power generation. Ironically the facilitation of zero emission renewable energy is only practically achievable by operating some ‘combined cycle’ thermal generators at part load. This has the effect of increasing the emissions of the thermal plants beyond those at the more efficient ‘base load’ condition. This approach is, to a degree self-defeating and contrary to the strategic objective of reducing carbon emissions by 20% by 2020 [13].

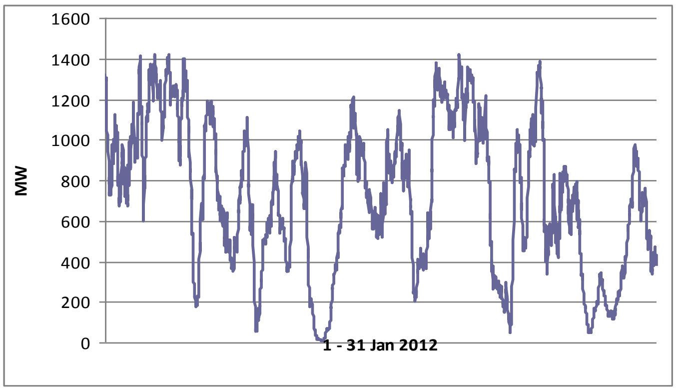

Figure 3: Wind power Ireland- Jan 2012 >100 wind farms

Where wind power is excessive, and has to be 'constrained off', it is both wasteful and incurs significant operator costs. Given existing emission commitments, both of these issues will only become more acute over the next two decades a radical solution to this dilemma, and one that will also support long term renewable targets, is to invert the normal approach and to make relatively static demand level more dynamic and track the supply. It should be noted that while the concentration of efforts have been due to achieving renewable targets, there is a second and very important consideration when the majority of generation is migrated to renewable sources, then this is the cost of energy to the consumer. Whether the consumer is a private individual or a multibillion euro industry, finances spent on energy is a resource that may otherwise have been spent on economy growing activities. The cost of energy forms a major part of expenditure both for large industry and small families alike.

The impact of renewables is also being felt in the electricity grid which is increasingly under stress from these same dynamic loads. The stress is due in part to the separation of renewable power generation from the major demand centres, which are located mainly in cities and towns. For example, in Germany alone, four Transmission System Operators (Tennet, EnBW Transportnetze, Amprion, and 50-Hertz Transmission) have identified the need for an additional 8,200km of new or extended transmission lines by 2022, at an estimated cost of €20 billion.

The distribution network will also be impacted and the International Energy Agency has estimated that the investments needed to strengthen Europe's distribution grid will reach €80 billion by 2035.

Supply tracking can be achieved using interruptible loads. While this approach has been used in the past, in this use case scenario a significant extension of the concept is proposed, taking advantage of the anticipated major shift to electric vehicle use, by linking tens or hundreds of thousands of electric vehicle battery chargers into one huge virtual load under the fine control of Future Internet (FI) based management systems. The use case implements such a virtual load on a practical scale, capable of dynamically responding to drops in supply while maintaining a quality customer experience.

3.2.1.2 Innovation

This use case shows how, by making user demand (i.e. charging of EVs) track renewable energy supply (wind, solar, wave), FI technologies, and in particular FI-WARE Generic Enablers, can be designed, developed and deployed to deliver a powerful tool for Electricity Grid Operators (EGOs) to manage their network as more and more renewables are supplied and, potentially, more and more unplanned events are encountered. This use case demonstrates the feasibility, scalability and reliability of such a supply-demand response system, at first in a lab environment but moving into a fully operational system and serving real customers and real equipment.

3.2.1.3 Trial Potential

3.2.1.3.1 Overview

Two different approaches are considered. The first will address the viability of one-off large scale load interruption in response to a significant grid event or supply failure, providing the Transmission System Operator with the commercially valuable capability to temporarily reduce load during a crises. The second approach will consider more permanent supply tracking, using FI based control systems. The figure below depicts the simulated results for an unscheduled renewable usage scenario on the left-hand side. The right-hand side shows a scheduled scenario that is the outcome of an optimisation process.

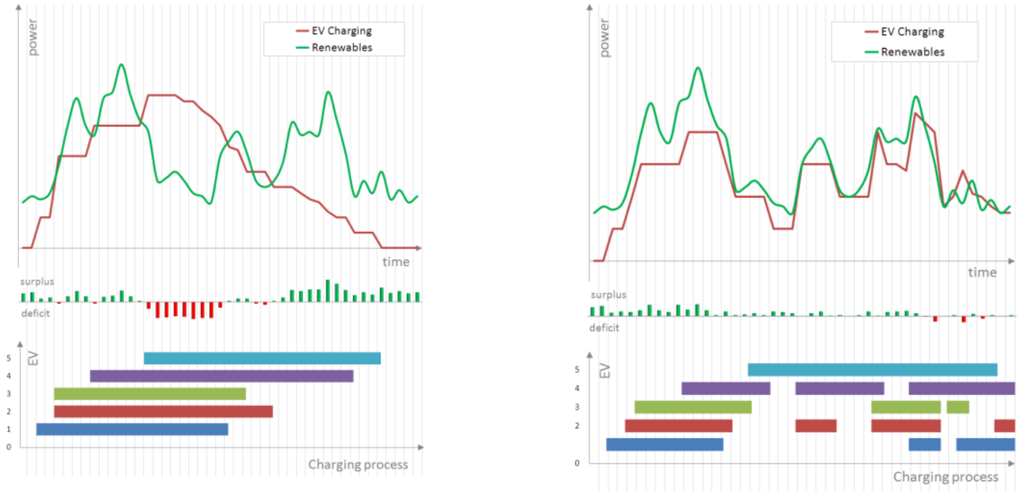

Figure 4: Unscheduled vs. scheduled renewable power usage

The solution, while illustrated with electric vehicles, can utilise other interruptible loads to gain greater spectrum of demand side management, over the full 24-hour cycle in future work. This trial will firstly demonstrate the practicality of supply tracking, and the technical and economic viability of a large scale FI based electric vehicle virtual interruptible load solution.

The trial exploits electric vehicle virtual interruptible load, but on a regional basis with the objective of matching regional demand to regional power production, minimising geographical imbalances, an approach which should reduce stress on the transmission network. Additionally, by introducing greater agility in the configuration of the distribution network, again using Future Internet based control systems, in response to dynamic load conditions, will ensure that where resources to carry loads are available, they are utilised. The issue can be addressed by increasing the local use of renewable power, minimising the need for long distance transmission. However to increase local usage requires much greater flexibility in control of both power usage and the dynamic configuration of the electricity distribution network.

3.2.1.3.2 Trial Architecture

The trial aims at controlling the load drawn by electric vehicles when they are charging to help maintain grid stability, while at the same time optimising renewable energy usage. Smart charging devices at home are utilised to adapt electric vehicle charging rates depending on these two constraints.

The voltage frequency deviation within the grid is monitored within the trial as a metric for grid stability. As frequency deviations are detected, the charging rates of electric vehicles connected to the grid at this instant are controlled in an attempt to offset any resultant instability in the grid.

The second order input parameter for controlling electric vehicle charging is the amount of power supplied by renewables at a specific time as well as a forecast of renewable power supply. This forecast is needed in order to decide when to charge depending on the desired electric vehicle battery state of charge.

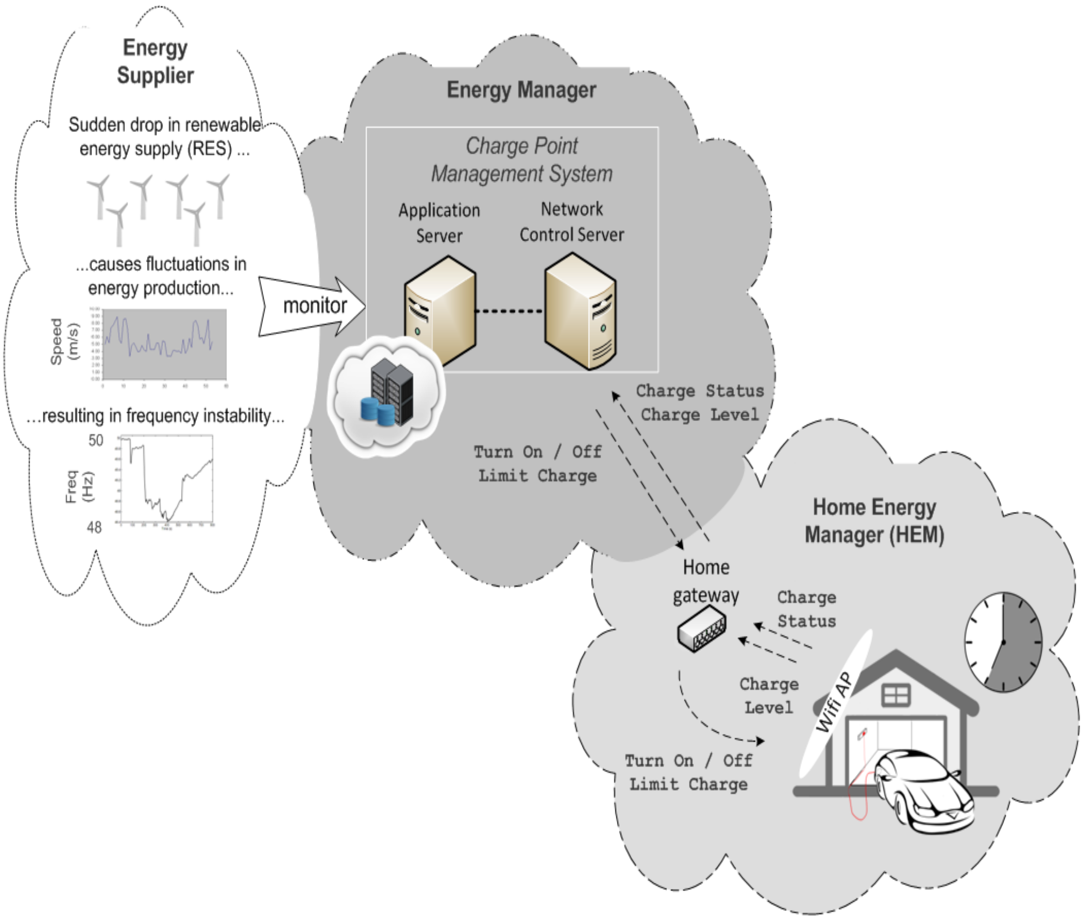

Figure 5: Supply tracking architecture

An overview of the trial setup is depicted in the figure above. As a first step towards system integration, a test setup will be deployed in order to:

- Implement the interfaces needed to connect all devices and subsystems,
- determine compliance of deployed equipment to the underlying requirements of the communications technology and charging control algorithms, and
- create external data connections to other sites for emulation and simulation purposes.

All necessary data is collected by a central Charge Point Management System (CPMS). All optimisation and control algorithm instances will be run and tested on that platform, and it will manage and control the CPMS instances for all connected Home Energy Management Systems (HEMS) which in turn control the smart charging devices. This platform will also provide and environment for the integration of the Generic Enablers, first via a cloud service, subsequently the GE software will be hosted on the platform, maximising system performance. In a second step, households with smart charging devices are connected to the control setup and real world trial scenarios will be run.

Regarding the objective of addressing geographic imbalances between renewable production and consumption, the trial components mention above will be further utilised and combined with grid simulation to determine the optimal approach to both charging management to minimise grid transmission and interconnect loading. The developing algorithm will be tested using grid simulation to determine the optimal approach consistent with significant constraint of maintaining a quality experience for electric vehicle customers.

3.2.1.3.3 Simulation as a Support for Potential Trials

In parallel to the described trial plans, simulation techniques can be deployed to help evaluate the result of trial on a large scale. The simulation efforts aim at the validation of the concept in a simulation environment and enable scalability of the concept.

An electrical network supplied by predominantly renewable generation and equipped with charging stations for electrical vehicles will be simulated reflecting the actual trial network as closely as possible. The number of charging stations and corresponding electric vehicles can be scaled up to a higher level in order to show the effects of tracking renewable generation by electric vehicle charging load in a future power system with high penetration of electric vehicles.

In order to allow for the connection of real communication and control infrastructure in a later step, the electrical network will be simulated in the RWTH’s real time digital simulator (RTDS) for electrical grids. Similarly, connected devices (electric vehicle batteries, generation, load, storage) can also be modelled in the RTDS or else on an external PC connected to RTDS with real-time capable modelling tools. A large number of similar devices will be aggregated to a larger unit in order to allow for proving the scenario concepts at a large scale on network level.

In order to analyse and optimise the control loop including the underlying communication solution, the simulated electrical network shall be connected to a measurement and control unit as used for the field test. Communication perturbations can be emulated on the communication links in the laboratory setup. In a similar way, developed additional ICT solutions based on FI-WARE enablers can be integrated into the simulation environment for validation and proof-of-concept.

In parallel to the field trial development, both the measurement and control functions as well as the communication architecture that are used in the simulation shall be continuously optimised. On the one hand, changes in the field implementation have to be reflected in simulation. On the other hand, optimisation efforts can be done in simulation in a friendlier and less risky environment compared to field tests. Therefore, iterations between optimisation steps in simulation and in the field shall lead to the most promising results.

3.2.1.4 Plans of future work in the FINESCE project

ESB, who are significant players in the generation and supply of electricity and who are the single DSO for the Irish electricity system recognise the potential for greater levels of renewable generation and are actively engaged in researching and demonstration both the hardware and the protocols necessary for Demand Side Management. The specific roles of DSM are to allow the switching in or out of certain loads to best utilise the available renewable generation and to allow the switching out of loads for short periods to counteract sudden losses of generation which can be experienced due to the nature of renewables such as wind power. ESB recognises that these functions can form important parts of future dynamic energy systems.

Therefore, in the work of WP5 on Task 5.4 on field trial plans, FINSENY partners, together with new consortium members, have developed plans to implement trials of the concepts described above in Phase II of the FI-PPP (in the FINESCE project). The project started operation on 1 March 2013 and is implemented this consolidated use case as a field trial in Ireland in addition to implementing trials on other use cases not focussed on electric mobility in other European countries.

3.2.2 E-Roaming[1]

3.2.2.1 Rationale

a) Application examples

Considering private car owners, they can be distinguished by the type of their standard parking place. Either car owners have a dedicated parking space such as a garage, or they park curbside somewhere nearby. The former can charge the EV by simply plugging it into a fixed socket-outlet in their garage. In this case, no identification and authorisation is needed – however, it is possibly useful in the future for providing grid services (Vehicle-to-Grid). While charging at the standard parking space can cover most trips, additional charging is necessary from time to time if the trip distance is higher than a typical EV-

[1] The following section is also published via the open science platform “opentech” (DOI: 10.5772/16859).

range or charging at the standard parking space is not possible. Hence, in such cases, these EV owners rely on foreign charging infrastructure for which physical access, authentication, authorisation and accounting (AAAA) is needed. The latter group, i.e. EV owners parking curbside, need foreign charging infrastructure every day.

Considering EV usage within business purposes, e.g. carsharing companies can have dedicated parking spaces for their cars. Carsharing companies can upgrade these parking spaces with electric vehicle supply equipment (EVSE). Thus, whenever an EV is parked there, it can be charged by using possibly different methods for AAAA. Since many carsharing companies still restrict the start and end of any rental to these dedicated parking spaces, regular charging is guaranteed. However, for two reasons this is not enough: First of all, in some cases, the user might need to additionally charge somewhere else. Secondly, the product "carsharing" mainly sells easy access to individual mobility. Therefore, the most successful carsharing companies will allow the start and end of a rental anywhere (cf. for example "car2go") which endangers regular charging at the dedicated parking spaces. A carsharing company can enable charging not only at those own dedicated parking spaces but also at foreign charging infrastructure by guaranteeing AAAA there.

b) Definitions

Term	Definition
E-Mobility Provider	Contracts with EV Users in order to offer services (e.g. charging) and can be EVSE Operator at the same time.
EV User	Uses an EV within a contract with an E-Mobility Provider.
EVSE Operator	Operates at least one EVSE as a service for E-Mobility Providers, but has no continuous contractual relation to EV Users.

Table 2: Terms to define E-Mobility roaming

All in all, these two simple and known examples (private cars and carsharing) already show that the usage of foreign charging infrastructure will occur regularly. This is often referred to as E-Mobility roaming, in analogy to the mobile communications sector. More precisely, roaming with cellular phones means the uninterrupted availability of all services while moving out of range of the former carrier to another one [14]. On this base as well as with the definitions in Table 2, E-Mobility roaming (or just roaming) refers subsequently to the situation in which an EV User is using an EVSE within a contract with an E-Mobility Provider that is not the EVSE Operator of the used EVSE (cf. Figure 6).

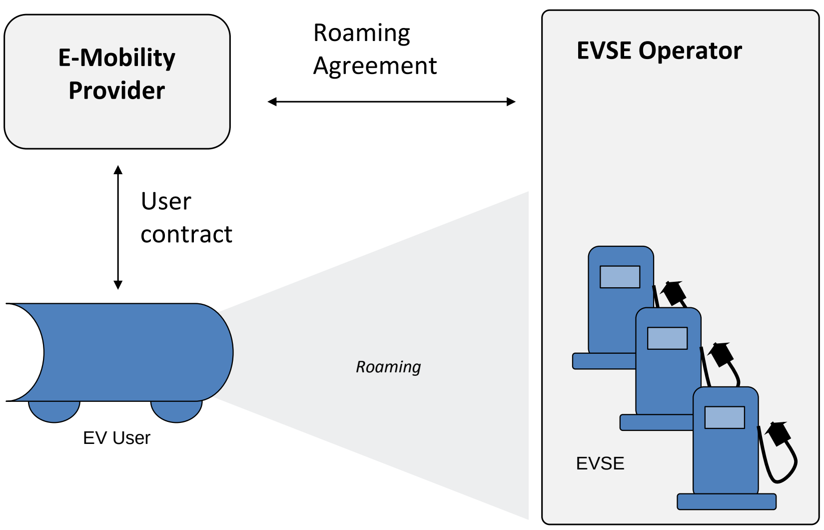

Figure 6: E-Mobility roaming

c) Challenges

Due to the still prevailing regional and local character of many power markets (e.g. in Germany), roaming is likely to happen not only international, but even within one town or street. Having a contract with every single provider is very uncomfortable. Hence, mechanisms to enable AAAA for roaming are inevitable.

In order to guarantee a user-friendly E-Mobility roaming experience, there are several challenges to cope with. Paying cash or via credit card is uncomfortable and requires more expensive infrastructure than identifying a user with an adequate contract.

On the basis of the above understanding of E-Mobility roaming and its business context, a closer look is taken at the preconditions of roaming. Since roaming involves two or more parties, the preconditions are closely related to questions of interoperability and the use of standards. Preconditions of roaming can be grouped into electrical and informational issues, each concerning aspects of the underlying medium or its use (Figure 7).

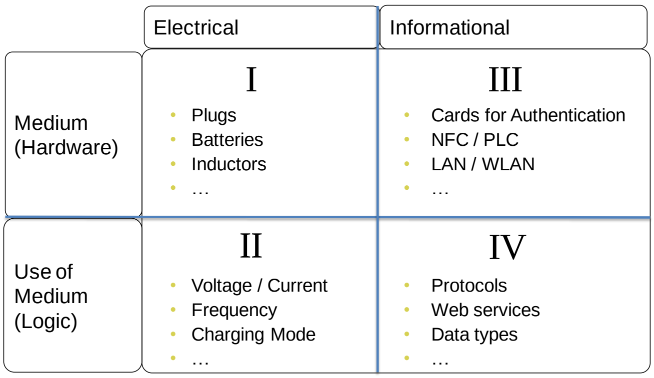

Figure 7: Categories of requirements for roaming in E-Mobility infrastructure

For example, a straight forward requirement for an electrical medium (I) is – assuming conductive charging – a standardised EV plug. Since the usage of adapters is very inconvenient, an EV plug should fit into the outlet of all EVSEs. The International Electrotechnical Commission (IEC) therefore currently revises the international standard IEC 62196. Considering other ways of getting power into an EV, such as induction or battery exchange, different requirements must be fulfilled. For inductive charging, a consistent form and position of the charger and the inductor is vital. For the battery exchange, especially the size and interface of the batteries as well as the security concept must be compatible. Beyond pure physical characteristics of the underlying medium, there is a need for its standardised use (II). For example, successful charging requires voltage, current, frequency and charge mode to be correctly adjusted on both sides as well as to the cable diameter. These basic parameters can be negotiated via a control pilot signal as defined in SAE J1772.

From a commercial point of view, the charging of an EV requires a medium for containing or conducting data for authentication, authorisation and accounting (AAA) (III). Authentication of a user in front of an EVSE could be done for instance via RFID cards, magnetic or smart cards, key panels or near field communication by cellular phones. Alternatively, authentication data can be transferred via a communication line directly out of the EV. In order to exchange the commercially relevant data, the use of the media must be further specified by standards for protocols and data types (IV). Considering protocol aspects, the standard IEC 15118 is currently developed. It will enable the automatic exchange of information between an EV and an EVSE. Therefore, standard message types for transferring session, status, metering and billing data are defined on different layers of the OSI Model. In addition to protocols using the communication connection, there is a clear commercial need for the definition of basic identifiers (IDs) that can be used throughout the information systems of involved companies. Therefore, one enabler for innovation is the introduction of IDs for roaming that are discussed in the following section.

3.2.2.2 Innovation

Every identifier (ID) has a certain scope in which it is valid. For roaming, the distinction of intra-company and inter-company IDs (henceforth called uniform ID) is essential. While intra-company IDs such as customer numbers are sufficient for many commercial applications, roaming requires uniform IDs for involved objects to allow for inter-company data exchange. Since uniform IDs require significant standardisation efforts, it is worth to investigate which IDs should be uniform in which cases. The cases clearly depend on the underlying business model(s) and technical choices. However, two abstract scenarios can cover many of them. Both scenarios differ from each other only with respect to the sequence of communication steps (Figure 8).

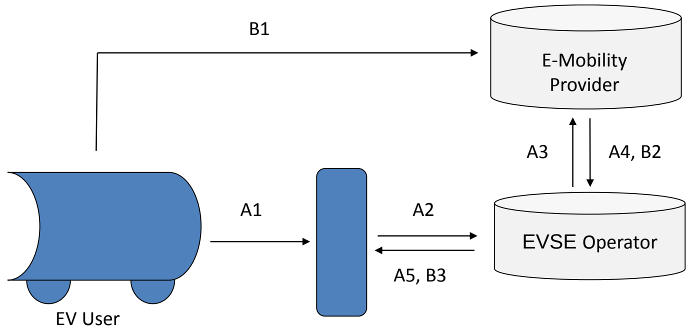

Figure 8: Two scenarios for the sequence of communication steps

In scenario A, the EV User (or its EV on behalf of him) passes all information needed for authentication through the EVSE (A1) to the EVSE Operator (A2). The EVSE Operator forwards the information to the E-Mobility Provider and requests AAA for the EV User (A3). If the response (A4) is positive, the EVSE Operator unlocks the EVSE for charging (A5). In scenario B, the EV User directly connects to the E-Mobility Provider (B1) for AAA. If successful, the E-Mobility Provider requests the EVSE Operator (B2) to unlock the particular EVSE for charging (B3).

Identifiers	Scenario A	Scenario B
E-Mobility Provider	Required *operator need to know which provider to contact*	Optional *provider known by operator*
EV User	Optional *user known by provider*	Optional *user known by provider*
EVSE	Optional *EVSE known by operator*	Optional *EVSE known by operator*
EVSE Operator	Optional *operator known by provider*	Required *provider need to know which operator to contact*

Table 3: Requirement of uniformity depending on scenario

Investigating four IDs relevant for roaming reveals that – with respect to the need for uniformity – each scenario requires at least one uniform ID (Table 3). However, even where uniform IDs are optional, standardisation of such IDs is advantageous. Assuming scenario B with authentication of an EV user by a cellular phone, the EV user needs to transfer the IDs of the EVSE and the EVSE Operator to the E-Mobility provider. If the EV User is required to manually type these numbers in his cellular phone, the ease-of-use decreases considerably when all EVSE Operators use very different formats for these IDs. Something which would be very user-friendly would be, say, an App that allows to take a picture of a code (e.g. bar code, matrix code, or simply number in standardised format) in order to get the EVSE ID via the smart phone. Two schemes which consider these arguments were recently defined as Contract ID and EVSE ID [15] and are available for international use.

3.2.2.3 Trial Potential

As seen above, roaming requires significant standardisation efforts on a European scale. In Germany for example, the projects in the programme “ICT for E-Mobility”, funded by the German Federal Ministry of Economics and Technology, standards and infrastructure were designed and implemented to allow for true national and international roaming. Current implementations often use Radio-Frequency Identification (RFID) technology for authorisation. An European consortium (Belgium, Germany and the Netherlands) already interconnected their national roaming solutions (Blue Corner, e-laad, ladenetz.de) to a European Clearinghouse (e-clearing.net). The platform operates as a central interface between the different operational systems (car leasing, network operators, utility systems, etc.) allows for simple usage of EVSE, including several value-added services (VAS) for both the provider and the consumer. Moreover, six German companies (BMW, Bosch, Daimler, EnBW, RWE and Siemens) have founded “hubject“, a company that also aims at providing roaming services E-Mobility providers (in the broadest

sense). Other platforms are "GIREVE" (France) or Fitsa (Spain). In order to harmonise data exchange between these platforms, over 20 organisations founded the "e-Mobility ICT Interoperability Interest Group".[2] A very relevant EU project currently running in this area is Green eMotion, whose results were actively followed by FINSENY and the results of FINSENY brought to their knowledge.[3]
Yet, despite all the work under way, there are some challenges left that might be mitigated by Future Internet technology and therefore perfectly fit to be part of trials in Phase II:

1. Connection of new partners (E-Mobility providers in all the countries) is still time-consuming, since adaptors are necessary. Using Generic Enablers for authorisation within an OCHP (Open Clearinghouse Protocol) is expected to decrease costs for new roaming partners. The critical number of partners therefore can be reached much faster ("network effect") than without Future Internet technology.
2. To allow a maximum of flexibility, partners shall be offered different levels of services via service level agreements (SLA). In order to allow both the clearing house operator as well as all partners to negotiate, apply and evaluate the SLAs, the Generic Enablers around SLA Management and Performance Management of the Future Internet core platform can be used.
3. Additionally, an instance of a flexible market offered by the Future Internet core platform can be used to provide VAS such as app-stores to the customers of the partners.

Further discussion between interested parties is necessary in order to identify the exact usage of Future Internet technology within the E-Roaming trial. However, an E-Roaming trial has the unique potential to smoothly connect different European Smart Grid regions (Figure 9). Although E-Mobility itself will not be the core issue of Smart Grids in the current decade, the trials with respect to distribution or regional micro grids, smart buildings or electronic markets, can be linked together.

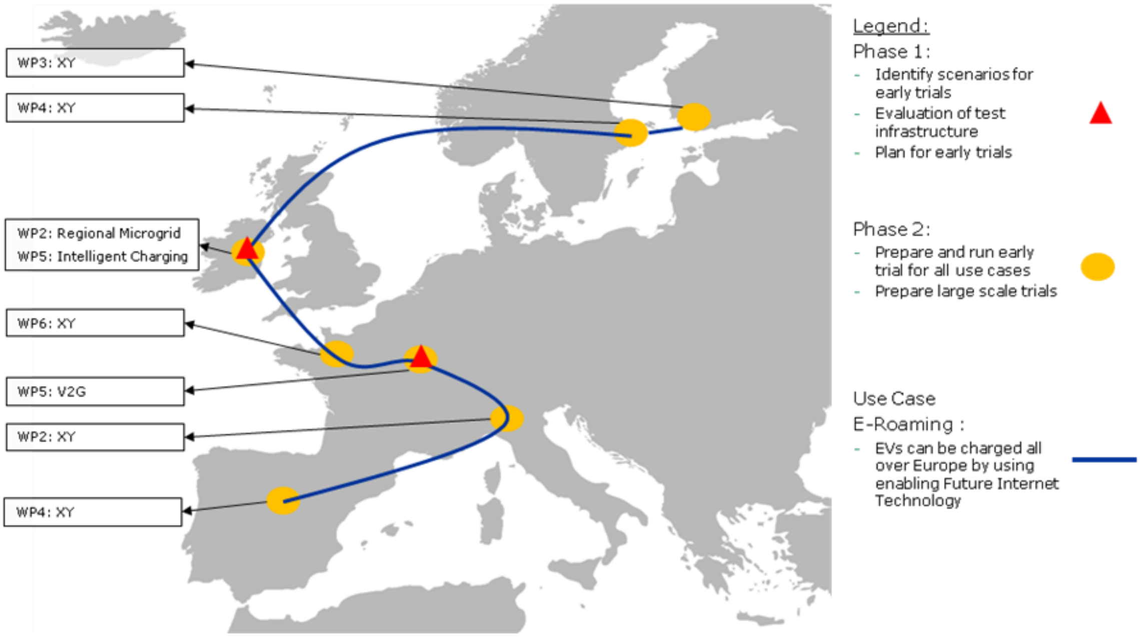

Figure 9: Connecting Smart Grid trial regions via E-Roaming

3.2.3 Vehicle to Grid (V2G)

3.2.3.1 Rationale

This use case describes future application of EVs to carry out power grid support tasks as described in chapter 2 of D5.1 [2] (cf. also the mapping in Section 3.1.1). The idea is to look at EV batteries not only as electrical loads, but also utilise them as electrical sources whenever it is a) affordable for the EV user or b) beneficial to the connected smart building, micro grid or regional distribution grid.

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[2] Members of FINSENY are actively contributing to eMI3 and promote the use of Generic Enablers for the new ICT solutions.

[3] Members of FINSENY presented at the Green eMotion Stakeholder Meeting in November 2012.

It is a use case anticipating the need for EVs to also offer controlling power range to the grid. This could be especially beneficial if the EV market share drastically increases and therefore also raise the potential of using collectively EV batteries to provide controlling power range.

3.2.3.2 Innovation

EVs batteries are not only seen to put a heavy load on distribution grids in the midterm and far future, but also to form a virtual electrical storage that can be used to stabilise distribution grids in some areas. ICT helps to manage this "virtual storage cloud" also to be able to form a reasonably sized power interface to the grid.

Inverter devices described in Section 5.4 of D2.3 [16] are required to realise this use case. At the moment, these devices are neither deployed in EVSEs nor in EVs. A deployment at the edges of distribution grids e.g., at the EVSEs would make sense from a Capital Expenditures (CAPEX) point of view as well as from a logical point of view.
CAPEX would be presumably smaller since the ratio between EVs and EVSEs will increase in the long run i.e., there will be less EVSEs than EVs. However, different stakeholders would have to spent these additional CAPEX depending on inverter locations i.e., EVSE operators in case of EVSE deployments and EV owners in case of EV deployments. Hence these CAPEX should pay off for their investors and therefore they have to satisfy a market demand for V2G.
Deployment of inverter devices in EVSEs also aids in keeping technical solutions inside EVs simpler which presumably also yields in reduced additional weight. In addition, V2G is a grid support use case and may contradict EV users' mobility demands. It is therefore questionable that car manufacturers will also support this use case. For the time being they are reluctant to support it since V2G is not the product (EV) application they intended it to be.

Different aspects have to be considered for V2G integration. On the one hand it has to be technically capable, meaning that it has to respond to the grid situation automatically, so that it can support the stability of the grid. On the other hand the V2G has to fulfil commercial grid services, what means that the EVs have to provide ancillary services. Moreover the V2G has to be profitable for the owners who are participating in the energy market.
The V2G can be used in different grid levels to support the grid stability. The following diagram shows the relationship between the grid levels and the respective control possibilities.

Grid level (role)	System Services	Energy Storage
Local (companies & individuals)	Power quality (e.g. for producing industries)	Grid autarchy (e.g. UPS)
Distribution (regulator)	Balancing power rules (e.g. frequency based, voltage control)	-
Transmission (aggregator)	Balancing power markets (e.g. frequency regulation, e.g. regelleistung.net)	Volume power markets (e.g. EEX)

Table 4: Grid levels and respective control possibilities in the V2G concept

3.2.3.2.1 Control possibilities in general

There are two major factors of grid stability. Firstly, grid frequency is as global quantity with various control possibilities. Secondly, voltage stability as a local issue will be a major topic which ought to lead to a higher distribution grid penetration. Without control strategies EVs can be seen as loads whereas the V2G enables a bidirectional power flow. Therefore, the vehicles can be seen as controllable loads as well as storage devices which can feed back power into the grid. The bidirectional power flow feature is highly necessary when the EV owner is interested in providing ancillary services.

Frequency Control in general

To avoid deviations of the nominal frequency, a frequency control has to be done, so that the system can be kept stable with respect to small signals. There are different corrective measures to achieve a stable frequency, which are briefly described in Section 3.2.1.1.

Self-regulation

The self-regulation is an effect of the frequency-dependency of generators and load.

Especially the demand of motor-loads linearly depends on the present utility frequency. This effect implicitly reduces the deficit of the demand. Also generators are conducive to the self-regulation, by reason that there rotating mass follows the frequency, in such way as to counteract overflow or deficit by their active power.

Primary Control

Primary Control occurs within the first few seconds following a disturbance in the system to stabilise the utility frequency. It is an active control of the generating stations, which adapts the motor-speed of the generators to the present frequency. For example in Germany, within 30 seconds the required reserve has to be deployed and stays activated for at least 15 minutes. The primary control will not return the frequency to the nominal value, but only stabilise it [17].

In the European Network of Transmission System Operators for Electricity (ENTSO-E) the primary control reserve amounts 3000 MW demand, so that a failure of two regular generation-units can be balanced.

Secondary and Tertiary Control

The secondary control e.g. in Germany typically includes the regulation between 30–900 seconds and the tertiary control operates between 15–60 minutes after the disturbance [17]. In contrary to the primary control both have an integral part thus they can stabilise the frequency to its nominal. Moreover they just control on a local area to normalise the power flow on the interconnected line.

Voltage Control in general

Another elementary factor of every AC grid is the voltage. Whereas the frequency is the same all over the grid the voltage can have huge local distinctions which depend on the characteristics of the grid. Similar to the frequency the voltage control occurs in the generators with the difference that it is just operative locally. Furthermore the voltage can be controlled by reactive demand flow by dint of capacitive regulator control elements. The voltage control is divided in three phases, too.

1. the primary control reacts automatically by transformers with alterable transformation ratio used as loads,
2. the secondary control interacts with individual chosen reactive current compensation plants, and lastly
3. the third superior authority is an economical improvement by minimising the reactive losses, which is done by the tertiary control.

The periods of time after which the DSO is operating are similar to the frequency control [18].

3.2.3.2.2 The EV in the V2G Context

One potential barrier of using the EV as a stabiliser within the distribution grid is the mismatch between power demand and generation. Energy can be stored first in the battery and transformed to mechanical energy later on, so potentially the charging process can be used for regulation of the grid. However, the availability is severely hampered by the availability of the vehicle, as often the charging time is irregular, unknown and is expected to last longer which would be very unwelcome for customers.

Frequency Control through EV

EVs can principally have different bearings on the grid stability. If the demand is fixed (“constant power load”, CPL) [19], they cannot have a stabilising effect on the grid frequency. In other words they can be treated as normal loads. However, a frequency dependent power-demand is used (“virtual synchronous machine”, VISMA) [20], the reduction of the consumed electrical power by a falling frequency and an increase of consumed electrical power by a raising frequency arranges a self-regulation of the deviating grid frequency.

To use EVs in the primary control of the grid frequency, the individual EVs have to be combined to a virtual power plant (pooling), due to the fact that a primary control unit has to provide at least 2 MW of power in Germany [21]. Research has shown that even during the peak traffic periods 90% of all vehicles are standing still and therefore are potentially connected to the grid [22] and could theoretically provide ancillary services.

Voltage Control through EV

The capacitive power of EVs can be used for voltage stability. There are different modes of voltage control based on EVs, which can be used by the DSO.

Individual voltage compensation

The individual voltage compensation tries to balance the self-induced voltage drop.

- ***The arbitrary power factor compensation mode*** enables a complete compensation of the voltage drop by reason that the reactive power provision is unlimited. To compensate this drop the power factor of vehicle gets reduced so that the voltage difference is smaller than a certain threshold value.
- ***The limited power-factor compensation*** mode is similar to the first one, with the difference that the power-factor is limited. Therefore the individual voltage drop cannot always be compensated. This restriction exists due to the fact that a real converter cannot provide or absorb inexhaustible reactive power. Energy providers mostly require a power-factor of at least 0.9 [23].
- ***The limited power-factor with a reduction of load performance compensation mode*** is a tightened version of the second mode. The EV has to compensate its self-induced voltage drop. If the feed-in of reactive power is limited by the power factor, the active power input will have to be reduced. Through the decrease of the charging power the voltage drop decreases, because the EV has to compensate less.

Collective voltage compensation

The objective of the collective voltage compensation is that just the EVs with available current capacity can provide reactive power. Thus voltage drops, which are generated by vehicles in a constant current charging, should be reduced. But if the voltage drop reaches the limit of the voltage range, the vehicles will reduce their charging power to provide reactive power. A 10% drop of the maximum charging power will increase the charging time at most by 3.5%. Hence, the collective voltage compensation is not a big burden on the EV owners.

Dynamic voltage compensation

Dynamic voltage compensation means that the charging process of EVs gets stopped immediately in case of voltage interruption. Consequently, the EVs cannot consume active power anymore and the voltage drop caused by them gets eliminated. This is comparable to the load shedding in the frequency control.

During a voltage interruption the active dynamic compensation achieves that the EVs which are fully charged feed the system with active or reactive power. The EVs are using their stored energy to stabilise the grid.

Control Mode Comparison

Among the shown methods individual voltage compensation causes the best conservation of the voltage, but the disadvantage is that the reactive power output rises above the demand of the grid. This can lead to feed back of the reactive power into the distribution grid. Hence, the individual voltage compensation is not technically appropriate from the DSO’s view.

However, the collective voltage compensation (pooling) is proving to be efficient due to the fact that it does not need an over-dimensioning of the converters which provide the reactive power output. The passive dynamic compensation does not have a strong effect on the voltage stability. On the contrary the active dynamic compensation is profitable for the DSO. However, it is currently not permitted to feedback power into the low voltage grid during a voltage interruption. The prohibition exists to protect the grid and prevent grids in islanding-mode.

Requirements for the V2G	**voltage control**	**frequency control**
Utility supply interface		
Energy meter in the vehicle or in the charging spot (two-way)	**X**	**X**
Frequency measurement and related technology for realisation of frequency dependency		**X**
Certain design of the dis-/charger for power quality improvement	**X**	
Capacitive regulator control elements	**X**	
Bidirectional converter in the charger	**X**	**X**
LOM (loss of mains) and other protections	**X**	**X**
ICT interface		
Communication of the aggregator with its EVs (fleet) for the controlling and monitoring of the charger load	**(X)**	**X**
Corresponding electricity tariff (and the buy/sales conditions of the consumers), in coherence with offer of aggregator	**X**	**X**
Communication from TSO to aggregator based on nominal grid frequency		**X**
Communication from DSO to aggregator based on nominal gird voltage	**X**	
Communication with customers to consider individual mobility needs (time and range if next drive)	**X**	**X**

Table 5: Utility supply and ICT requirements in the V2G concept

3.2.3.2.3 Ancillary Services

In order to design the V2G economically for the EV owners, they have to enter into contracts with an aggregator, to be able to offer ancillary services for the DSO. To make the V2G attractive for the EV owners a certain incentive bonus has to be paid. This incentive bonus can be a fixed, variable or dynamic tariff for compensation by provision of power. This takes place after the EV owner has defined the conditions under which he wants to provide his stored power to the DSO and obtain power for his EV from the grid.

These conditions for the EV owner could be:

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

On the basis of an analysis the aggregator has to buy or sale energy e.g., at the European Energy Exchange (EEX), taking into account the conditions mentioned previously, to archive profit for the owners. It follows from the above that the DSO has to increase the price in times of a voltage drop and decrease it in times of a voltage peak. Analogically, the TSO could regulate the frequency.

3.2.3.2.4 Second Life of EV Batteries

Every rechargeable battery will gradually lose its capacity to store energy after certain numbers of charging and discharging cycles. Therefore it is not able to provide the performance the consumer expects. Nevertheless the most part of the battery capacity is still available. Hence, batteries, which are

ineligible for electric vehicles, could power other less demanding purposes. This will also allow consumers to continue profiting from them by lowering their energy bill by either using the battery at home for additional power, feeding power back into the grid or selling the battery to their utility or other purchases. The time at which the consumer wants to change the EV batteries depends on his or her personal requirements resting upon the maximum range he wishes to drive.
Another possibility might be the leasing of EV batteries. After certain losses of capacity the utility could replace it and use the old batteries to participate in energy trading or to sell grid stability services to the DSO.

3.2.3.3 Trial Potential

As described above, the V2G concept seems to be a decent way to stabilise distribution grid in the future. The V2G vehicles can provide power to help balance loads by valley filling or peak shaving. Trial wise a micro as well as a macro view is imaginable. The micro view can be demonstrated with one EV that supports V2G mode in conjunction with an EVSE including a power inverter. This can be tested within a laboratory environment. Macro wise it would be interesting to investigate how the “virtual storage cloud” can be managed in an efficient manner. Since 2008, in Germany the project “Flottenversuch Elektromobilität” with E.ON together with VW and other partners funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is testing intelligent charging in order to integrate the renewables into the grid. To control the charging process, smart meters are used that receive variable prices that are updated one day ahead. Furthermore, the EV User is capable to obtain information about the actual prices as well as to see his or her charging behaviour by accessing a secured area on the Internet or using his or her smart phone.

3.2.3.3.1 Simulation as a Support for Potential Trials

In a similar way as described in Section 3.2.1.3.3, real-time simulation techniques can be used for validation of the concept and scaling of the trial results onto a higher level. The simulation setup from the use case ICT-Enabled Demand Side Management can be extended to allow for V2G by modelling the electric vehicles to be equipped with bidirectional converters allowing for feeding energy back to the grid.

More tangible trial results will be achieved by the addition of large-scale simulation because this allows an analysis of the concepts on network level, which is not possible to reach in a pure field trial.

4. Functional Architecture & Key Building Blocks

This section describes all functional building blocks and their interfaces in terms of communicating sub parts and data to be exchanged on the basis of updated use cases described in the prior section. The result is a pool of functional building blocks that can be used for each envisaged use case by picking functions required to implement these use cases.

4.1 FINSENY High-Level Building Blocks

A high level picture (Figure 10) was derived in a cross work package architecture group in order to identify informational relations between scenario work packages as well as important entities related to them. It sketches the overall ICT connectivity between architecture parts developed in each WP and therefore it also depicts where cross WP interfaces are located.

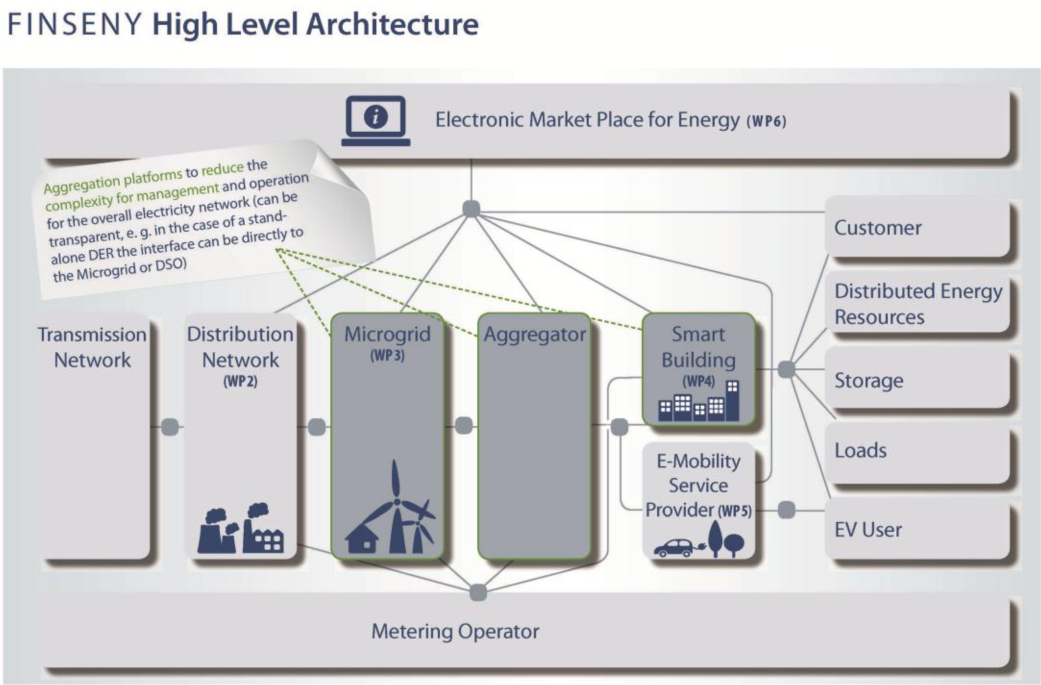

Figure 10: FINSENY high level interoperability picture

The relation to the energy market is of major importance and therefore will be presented in more detail in the following.

4.2 Relation to Energy Marketplaces

Energy marketplaces are commonly used to negotiate energy prices, but also prices for other energy-related products such as demand-side management. This section explains how the functional architecture in FINSENY WP5 relates to energy marketplaces, particularly to energy marketplaces as investigated in FINSENY WP6. To this end, this report first briefly summarises the concepts from WP6 and then discusses the relationship of electric vehicle supply equipment operators (EVSE operators) from WP5 to energy marketplaces.

How such an Electronic Energy Marketplace (EEM) can be operated will be part of investigations in the FI-PPP Phase II project FINESCE (Future Internet Smart Utility Services) in Terni (Umbria region), North Italy. This EEM will be designed with the goal of implementing a real-time marketplace that allows stakeholders to place bids and orders nearly in real-time. Therefore, a high performance and scalable communication and information platform is envisaged to be set up.

4.2.1 Energy Marketplaces in FINSENY WP6

WP6 proposes in D6.3 [24] an architecture which is based on the idea of having two electronic energy marketplaces (EEMs):

1. a *B2C marketplace* where energy users can subscribe to different energy contracts, particularly including demand-side-management programmes;
2. a *B2B marketplace* where Energy Services Aggregators (ESAs) can trade their bids for shifting energy demand.

The role of the ESA might be taken on by the local DSO, by electric power suppliers (EPS, also called energy retailers) or by dedicated ESA companies. Generally, energy contracts and demand-side-management programmes may include negative energy, e.g., energy feed into the grid in V2G scenarios.

The B2C Marketplace

Energy users have access to the B2C marketplace on the Internet (operated by an electronic energy marketplace operator, EEM operator) where they can see different offerings for energy contracts and demand-side-management programmes from Electric Power Suppliers (EPS), ESAs etc. The offers for energy contracts might be coupled with demand-side-management programmes and might involve dynamic pricing. Contracts for demand-side-management programmes may vary in the incentives on how much money is paid (or reduced from the bill) when an energy user actually reacts to demand-side-management signals (DSM signals). By contracting such a service, the energy user allows the ESA to send DSM signals to her or his Building Energy Management System (BEMS). The signals are used to initiate actions in the appliances connected to the BEMS, in order to schedule operations. This particularly includes charging electric vehicles, if this is done in the EV user’s premises. As mentioned before, the B2C marketplace can be used to trade contracts for dynamic energy pricing, but this B2C marketplace does not actually trade energy as such and does not derive the respective prices (however, contracts for dynamic pricing traded at the B2C marketplace would include certain parameters such as the average price, the maximum price etc.). In case of dynamic energy pricing, the EPSs have to derive their prices by their own and have to communicate them to their customers. They may use prices from a large-scale energy exchange or further electronic energy marketplaces (EEMs) do derive their own prices.

The B2B Marketplace

The B2B marketplace (operated by an EEM operator) uses market mechanisms for trading flexible loads for demand-side management purposes. Energy retailers considering a DSM measure (e.g., to avoid high energy prices on the intraday market) can send their request to the electronic B2B marketplace. Equally, if overloads or frequency problems are detected, the grid operator can issue a similar request. Then, all affected ESAs receive these requests from the B2B marketplace, and each ESA can place an offer (a bit) including a price for reacting to the request. The B2B marketplace then selects a combination of offers which fulfils the request based on economic principles. The respective ESAs are then responsible to conduct the DSM request. To do so, the ESAs send priority signals to the BEMSs of their contracted energy users. These systems then do some optimisation and send signals to intelligent devices in the energy user’s premises as well as to charging infrastructure of electric vehicles in EV user’s premises.

This description of the marketplace architecture of WP6 shows that it is dedicated to energy users, who can contract energy services on the B2C marketplace and can participate in demand-side-management programmes via ESAs. This includes the case where energy users who are also EV users charge their vehicle in their own premises. However, besides the latter case, even if WP6 does not consider electric vehicle supply equipment operators (EVSE operators) explicitly, there are possibilities to connect the architecture from WP5 to the one from WP6. This is discussed in the following section.

4.2.2 Relation of Electric Vehicle Supply Equipment Operators to Energy Marketplaces

Electric vehicle supply equipment operators (EVSE operators) operate charging equipment and buy electrical energy from electric power suppliers (EPS, also called energy retailers). Based on contracts between EV users and electric mobility service providers (EMSPs), EVSE operators have a certain flexibility to offer charging services at different rates to EV users. At the same time, EVSE operators may have dynamic energy contracts or participate in demand-side management, which gives them some flexibility in offering different charging tariffs to EV users and thus to maximise profits (this is realised in the (dis-)charge scheduling & optimisation functionality, cf. Section 4.3.3.3.4). Given the marketplace architecture defined by FINSENY WP6 (cf. Section 4.2.1), EVSE operators have different possibilities to connect to this architecture:

1. EVSE operators can use the B2C marketplace to contract with EPS, possibly using dynamic pricing schemes (such contracts may also include feeding energy into the grid in V2G scenarios). The B2C marketplace can also be used to easily switch to other EPS offering better conditions. In case of dynamic pricing, they can adjust their pricing for (dis)charging services or reschedule (dis)charging processes.
2. EVSE operators can use the B2C marketplace to contract with ESAs in order to take part at demand-side-management programmes (possibly in conjunction with an energy contract). Then, using the DSM signals originating from their contracted ESAs, they can adjust their pricing for (dis)charging services or reschedule (dis)charging processes.
3. EVSE operators can take on the role of an ESA. Then, they can directly take part at tendering processes at the B2B marketplace. Once a bid of the EVSE operator is successful, the requested demand shift can be realised by adjusting prices for (dis)charging services or rescheduling (dis)charging processes. This option may be particularly suited in cases of many charging spots and in V2G scenarios.

4.3 Electric Mobility High-level Functional Building Blocks

4.3.1 Overview and Semantics

The following sections describe the identified functional building blocks (in the following simply called "functions") that have been identified during analysis of chosen key use cases. The described functions have been identified to belong to SGAM's function layer and are required by at least one key use case investigated.

Functions can be grouped into function clusters that are the base for systems in their respective realm. The function sections contained in a specific realm is given in the following list of the six realms defined:

- Energy Distribution (Section 4.3.3.1 to Section 4.3.3.1.4)
- Mobility Management (Section 4.3.3.2 to Section 4.3.3.2.4)
- Charging Management (Section 4.3.3.3 to Section 4.3.3.4.5)
- Device Management (Section 4.3.3.5 to Section 4.3.3.5.3)
- Energy Management (Section 4.3.3.3 to Section 4.3.3.3.4)
- Account Management (Section 4.3.3.6 to Section 4.3.3.6.10)

Figure 11 represents the function realm plane which enables us to map stakeholders (see Section 4.3.2) to appropriate realms from which they require functionality. This gives a good overview on E-Mobility stakeholders' functional needs depicted in Figure 13 on page 44.

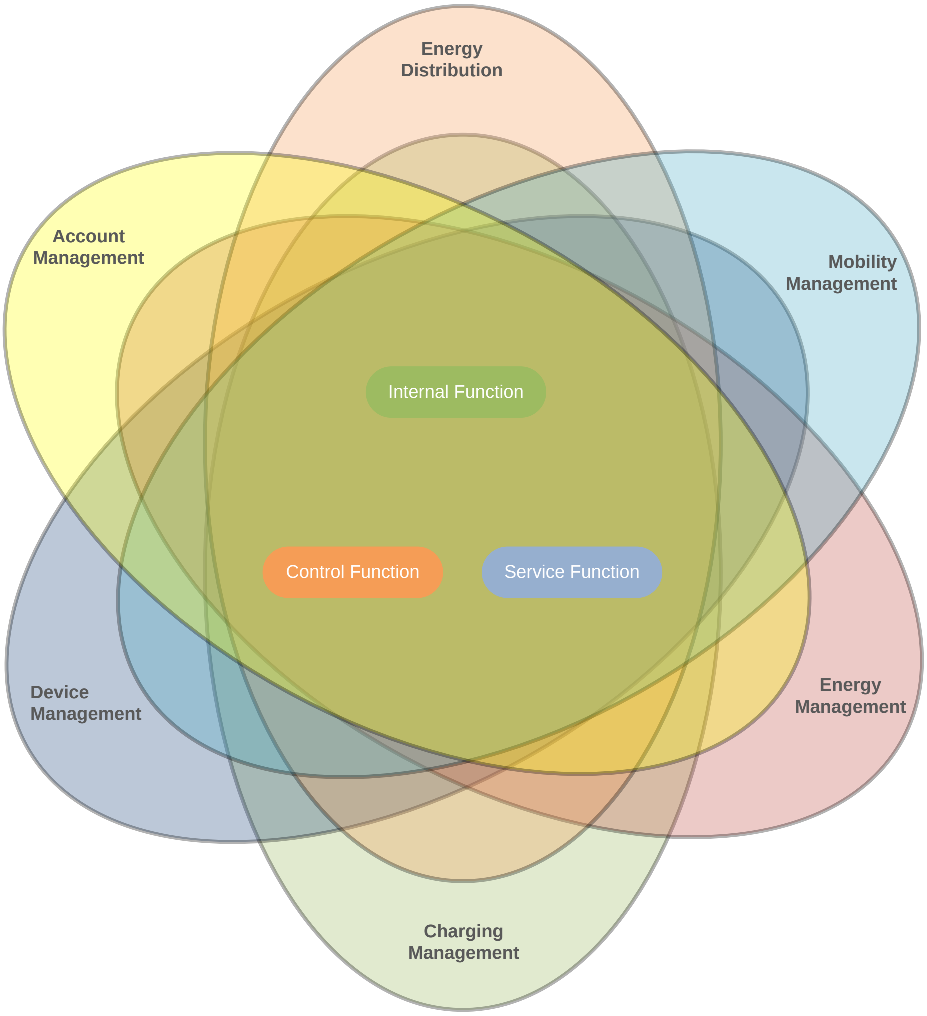

Figure 11: Function Realms

Functions as realm elements are depicted in three different colours identifying them as either control function (orange), service function (blue) or internal function (green). An internal function is of operational importance for the given scenario, but they do not expose their functionality to external processes in contrast to control and service functions.

The Energy Distribution realm hosts all functions related to grid operations that are also important to be implemented for E-Mobility. It does not cover power generation functions which serve this realm but only affect E-Mobility functions indirectly.

The Mobility Management realm hosts all functions related to the management of customers' mobility needs and for that takes into account real time status information of EVs and the charging infrastructure, but also hosts functions required to implement E-Roaming (Section 3.2.2).

The Energy Management realm hosts functions for Demand Side Management (DSM) such as forecasting of power consumption and energy demands and scheduling of available resources. It also hosts EEM relevant functions to publish tradable power figures at the EEM.

The Charging Management realm hosts all functions related to charging processes.

The Device Management realm hosts functions that implement interfaces towards components, entities and things. It also implements Operations & Maintenance (O&M) related processes like control and monitoring.

The Account Management realm hosts function related to Customer Relation Management (CRM) in addition to customer related security functions and financial functions.

The semantics of key concepts used in this deliverable is given in Figure 12.

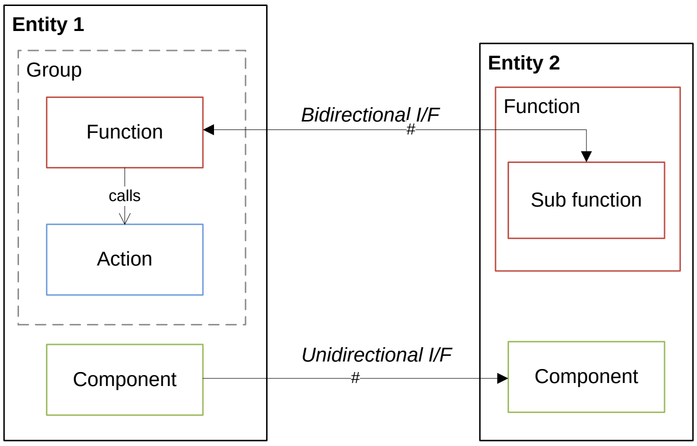

Figure 12: Functional block schematic semantics

Entity x could be a stakeholder or a very high level component like EV. The # sign is a placeholder for I/F enumeration to reference them in the describing text. Grouping functions, actions or components is depicted by a *Group* rectangle and is used to collect information exchange for the contained elements. Before the functions are described, the following section explains the stakeholders that are involved in the application of the identified functions.

4.3.2 Stakeholders Participating in Functions

Many different stakeholders are involved in the use cases and scenarios underlying this functional analysis. A detailed overview on all stakeholders used in this section is given in Section 2.2 of D5.1 [2]. Yet, for convenience, a short summary is provided in the following sections. The electric mobility scenario stakeholders listed in Tables 6 to 8 have been classified as follows: users (Table 6), service providers (Table 7) and operators (Table 8). The base of the classification is explained in each header of the respective table.

Grouping (Community) '		***Group Description***
Users		***Person or organisation that is a consumer of electric vehicle products and services.***
Actor Name	***Actor Type (person, organisation, device, system, or subsystem)***	***Actor Description***
EV User	Person	A person that uses the electric vehicle (EV) at a specific point in time (whether in a professional or private capacity). A sub-definition of the EV User would be: Individual EV User (IVU): uses the same vehicle all the time (by either buying or leasing it or getting it for individual use from an IMP) Shared EV User (SVU): uses a given set of vehicles on demand together with other users (e. g. in a car sharing partnership, using a car rental system or a company car pool). An EV User becomes an EVSE User in front of a charging station.
EV Owner	Person or organisation	Entity owning the car. This could be a person in which case the car is privately owned or it could also be a car

Grouping (Community) '		***Group Description***
Users		***Person or organisation that is a consumer of electric vehicle products and services.***
Actor Name	***Actor Type (person, organisation, device, system, or subsystem)***	***Actor Description***
		sharing or car rental organisation. An example car sharing company would be a Enterprise Fleet Operator (EFO) which runs a company's car fleet.
Energy User	Person or organisation	A person contracted with a specific Energy Supplier. EVSE Operator could also be an Energy User.

Table 6: User stakeholder group

Grouping (Community) '		***Group Description***
Service Provider		***Organisations that provide EV related services.***
Actor Name	***Actor Type (person, organisation, device, system, or subsystem)***	***Actor Description***
E-Mobility Service Provider (EMSP)	Organisation	Provides value added services for individual mobility. Services to its customers include: • Mobility preference administration • EVSE availability • Special offers The difference between this stakeholder and an IMP is the ownership of EVs / batteries.
Energy Services Aggregator (ESA or aggregator)	Organisation	Deregulated participant in the energy market which contracts multiple distributed energy generators (e. g. electric vehicles) and / or consumers to optimally manage their energy generation and use as a group, especially by bringing their flexibilities to the market place (in the sense of generation side or demand side management).
Financial Clearing House (FCH)	Organisation	Company that takes over financial clearing in E-Roaming scenarios. It may also issue billing between involved partners.

Table 7: Service Provider stakeholder group

Grouping (Community) '		***Group Description***
Operators		***Organisations involved in the system operation of energy related infrastructure and services to support electric vehicle deployments.***
Actor Name	***Actor Type (person, organisation, device, system, or subsystem)***	***Actor Description***
EVSE Operator	Organisation	Operates a set of public or semi-public charge stations, uses the services of Billing Service Provider (BSP), Identification and Authorisation Server (IAS), and

Grouping (Community) '		***Group Description***
Operators		***Organisations involved in the system operation of energy related infrastructure and services to support electric vehicle deployments.***
Actor Name	***Actor Type (person, organisation, device, system, or subsystem)***	***Actor Description***
		Financial Clearing House (FCH). It may have an agreement with the parking space operator.
Microgrid Operator (MO)	Organisation	The Microgrid Operator acts as system operator in the Microgrid and is responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system of the Microgrid.
Power Generation Company (GenCo)	Organisation	Operator of bulk energy generation plants.
Distribution System Operator (DSO)	Organisation	Operates the local power grid infrastructure, and substations, over which energy is supplied to EVSE or the end user.
Transmission System Operator (TSO)	Organisation	Operates transmission grid.
Electronic Energy Marketplace (EEM)	Organisation	Operator of a market place on which ESAs and potentially IMPs can buy and sell energy and energy related services. Following market rules, energy price is calculated and physical and financial transactions are made. Owing specific issues of Energy, normally, there are day-ahead transactions and then a several intraday transactions in order to maintain stability.
Electric Power Supplier (EPS)	Organisation	Vendor of electricity, synonym to Energy Retailer.

Table 8: Operation stakeholder group

The following figure illustrates which stakeholder uses which function realm e.g. the EVSE operator implements or uses functions from all realms whereas the FCH only implements or uses functions from the Account Management realm.

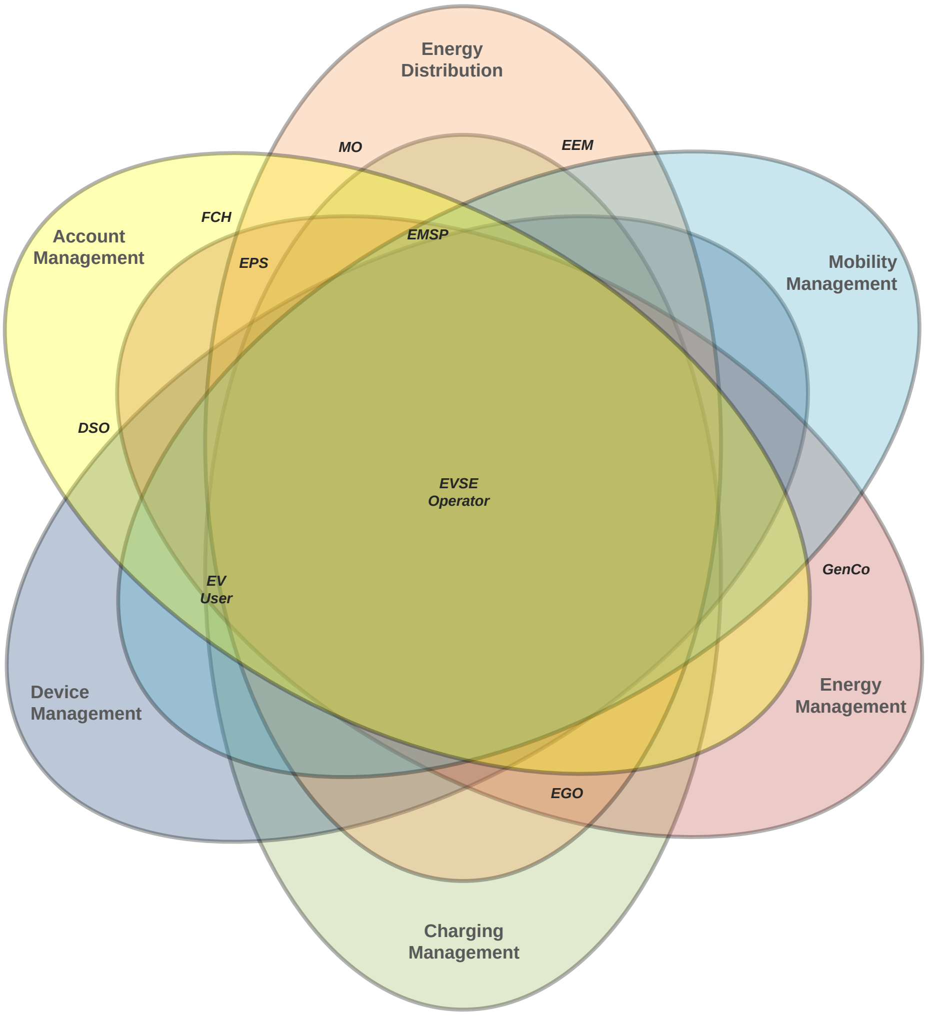

Figure 13: Stakeholder - function realm mapping

As follows, these stakeholders are referred to in the following section when presenting and explaining the functions identified during the SGAM drill down.

4.3.3 Functional Building Blocks

4.3.3.1 Energy Distribution

This function realm is composed of four functions as depicted in Figure 14.

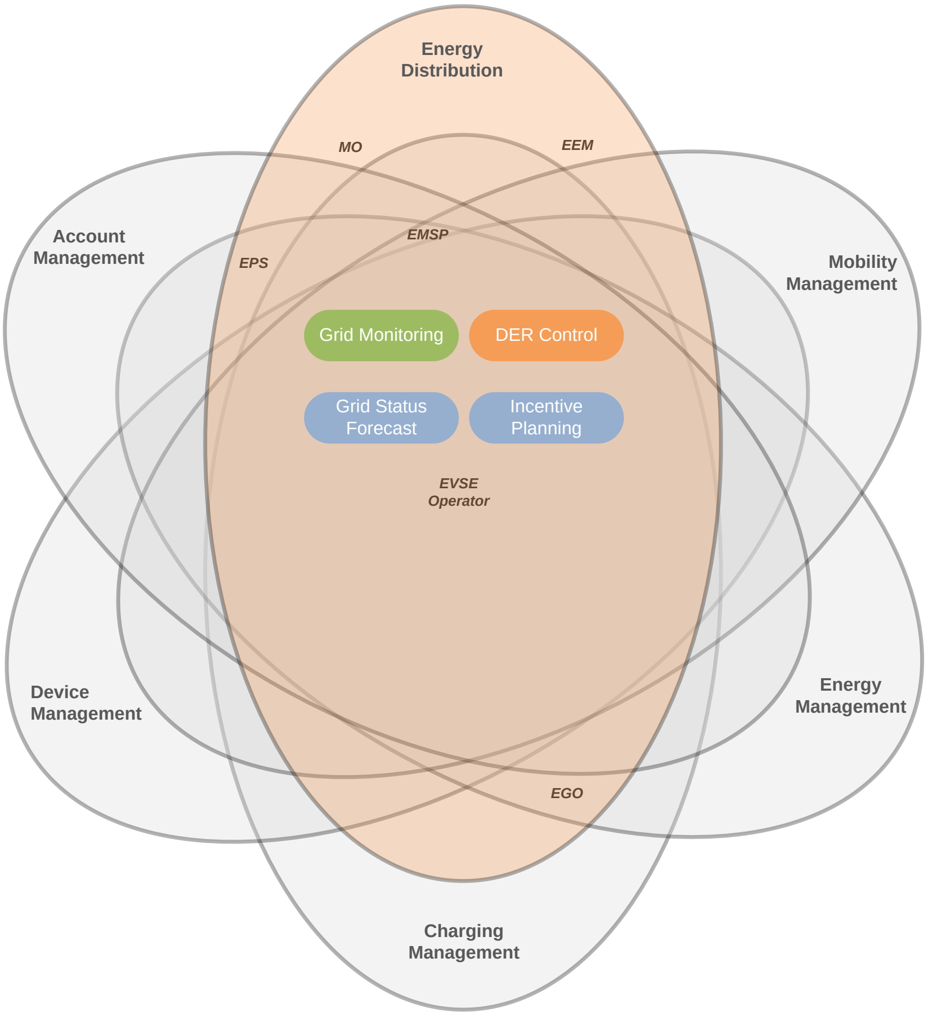

Figure 14: Functions hosted in the Energy Distribution Realm

4.3.3.1.1 Grid Status Forecast

Description

This function forecasts the power grid status based on signals received by generation plants and using weather forecast information which influences distributed energy generation using renewable energy sources on one hand and on demand forecast figures on the other hand.

Grid Status Forecast is implemented at EGOs and basis on external input from generation and load sides. The EPS buys energy contingent from the market ahead in time and sends this information to the affected EGOs which also get information on planned generated energy from the generation companies (GenCo). The EGO then calculates the difference between these values and tries to negotiate with the EPS and the GenCo modified supply and load patterns in order to match both sides.

This function is useful in order to plan ahead for V2G scenarios and specifically for EV scheduling and optimisation (Section 4.3.3.3.4). Grid status forecast is a DSO network operation function and is mentioned in D2.3 [25].

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Power Grid	Operation	ICT Enabled demand side management, V2G	EPS, Electric Mobility Service Provider (EMSP), Electric Vehicle Supply Equipment

			(EVSE) Operator, TSO/DSO

Assessment

The implementation of this function lies totally in the hand of the grid operator. The outcome may be provided to other market participants that use this information for further planning e.g., schedule for EV (dis-)charging in V2G scenarios.

GEs from the Data/Context Management chapter may be used to help processing input data used for forecasting. Candidates are Big Data that can be used to determine input data patterns and Complex Event Processing can be used to detect special input data conditions and extracting important events from it. In addition, the Cloud Hosting chapter's GEs Object Storage and {Platform, Infrastructure, Software} as-a Service (XaaS) may be utilised to store data in a flexible manner. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.1.2 Grid Monitoring

Description

The DSO sends information about available grid capacities to the market. The market can use this information to set up a demand/price function which is visible to the EMSP and/or EVSE operator via standard bidding routines. Based on this information, the EMSP or EVSE operator can decide about (dis-)charging operations.

Grid monitoring involves the provision of distribution grid status to the market. The market is capable of transforming this information to a demand/price function whose application result is made available to other market participants like the EMSP. The EMSP shall include this information in order to assess whether there is potential for V2G/G2V operations. For areas with charging stations, the DSO has to communicate preferences whether more or less power is needed in the distribution grid.

Monitoring is an important function that is described in detail in [16]. This function retrieves non-real time information from meters. In the future Smart Grid it is expected that 100% of secondary substations and 100% of DERs will have meters that could be measured remotely from a control centre. There are two main systems involved in the execution of this function:

- The Measurement Hub that is in charge of updating non-real time information from meters from a centralised data base.
- The Grid Control Application that is in charge of presenting this information to the grid operator with a visual interface in order to facilitate the visibility.

The Measurement Hub updates non-real time information periodically with the configured frequency (daily, hourly, monthly) from meters. Meters could store measurements in different periods (quarter of hour, hour, day…).
The Grid control Application interfaces with the Measurement Hub to retrieve non-real time information and presents it to the grid operator in a graphical manner.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Power Grid	Operation	ICT Enabled demand side management, V2G	EGO, EMSP, EVSE operator

Assessment

This function can be realised by using the GEs Marketplace and Connected Device Interfacing from FI-WARE. The GE Marketplace enables functionality for people to offer and deal with services. Therefore, this GE manages these services to be accessible by aggregators/customers. Connected Device Interfacing can be used to enable the possibility to exploit device features and capabilities through the implementation of interfaces and related APIs towards the connected devices. Therefore, DSO can use this GE in order to send information about available capacities. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.1.3 DER Control

Description

Distributed Energy Resource (DER) control is a function implemented at the grid operations side and could be implemented as an alternative for traditional ripple control functions. The control can be direct with the DSO having direct access to the DERs or indirect in sending control signals to a management entity, e.g. Microgrid Operator (MO) or Building Energy Management System (BEMS), having itself local control over a set of DERs. A prerequisite for this function is DER registration with the controlling entity that could be one of the before mentioned.

DER Control is implemented at different levels in the Smart Grid. Depending on the scenario the following entities may implement direct DER control i.e., there exists direct access means to the addressed DERs:

- DSO network operation centre
- MO operations centre
- BEMS
- EVSE operations centre

Another level is indirect control which may be implemented in certain scenarios i.e., there is an intermediate entity receiving the request for a control operation. In this case the actual direct DER control takes place at a lower level.

Figure 15 depicts this control scheme for DERs. There may exist even more intermediate levels of control than that shown in this figure.

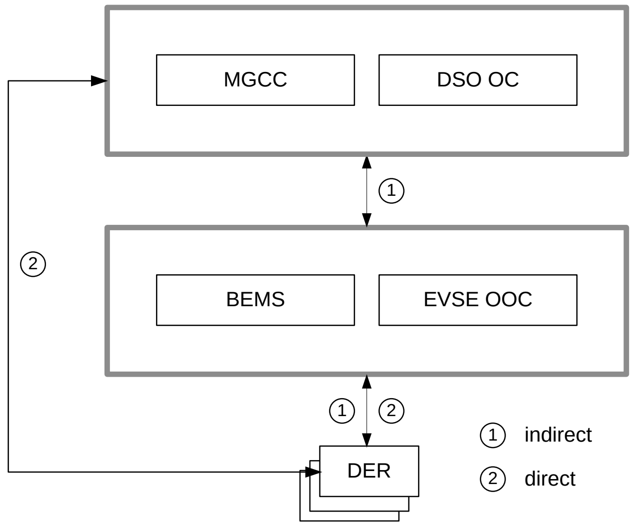

Figure 15: DER control scheme

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Power Grid	Operation	ICT Enabled demand side management, V2G	EGO, EMSP, EVSE operator

Assessment

IoT (Internet of Things) chapter backend and gateway GEs are candidates for DER control implementation. It also contains a security API interface that potentially enables access control functions on specific DERs. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.1.4 Incentive Planning

Description

This function calculates an incentive plan which is then offered to the market place. An example is incentivising charge rate adaptations (which may also include V2G). Some kind of rebate is offered in turn for gaining control over charging rates. The scheduled incentives are transmitted to the EEM where they are available to be contracted from aggregators like EMSP or EVSE operators.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Power Grid	Enterprise	ICT Enabled demand side management, V2G	EGO, EEM, EMSP, EVSE operator, EPS, MO

Assessment

The implementation of this function clearly resides in EGO facilities, but an EEM must exist in order to make an offer to the market. This EEM could be realised with the help of the Applications/Services Ecosystem and Delivery Framework chapter's Marketplace GE. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.2 Mobility Management

This function realm is composed of four functions as depicted in Figure 16.

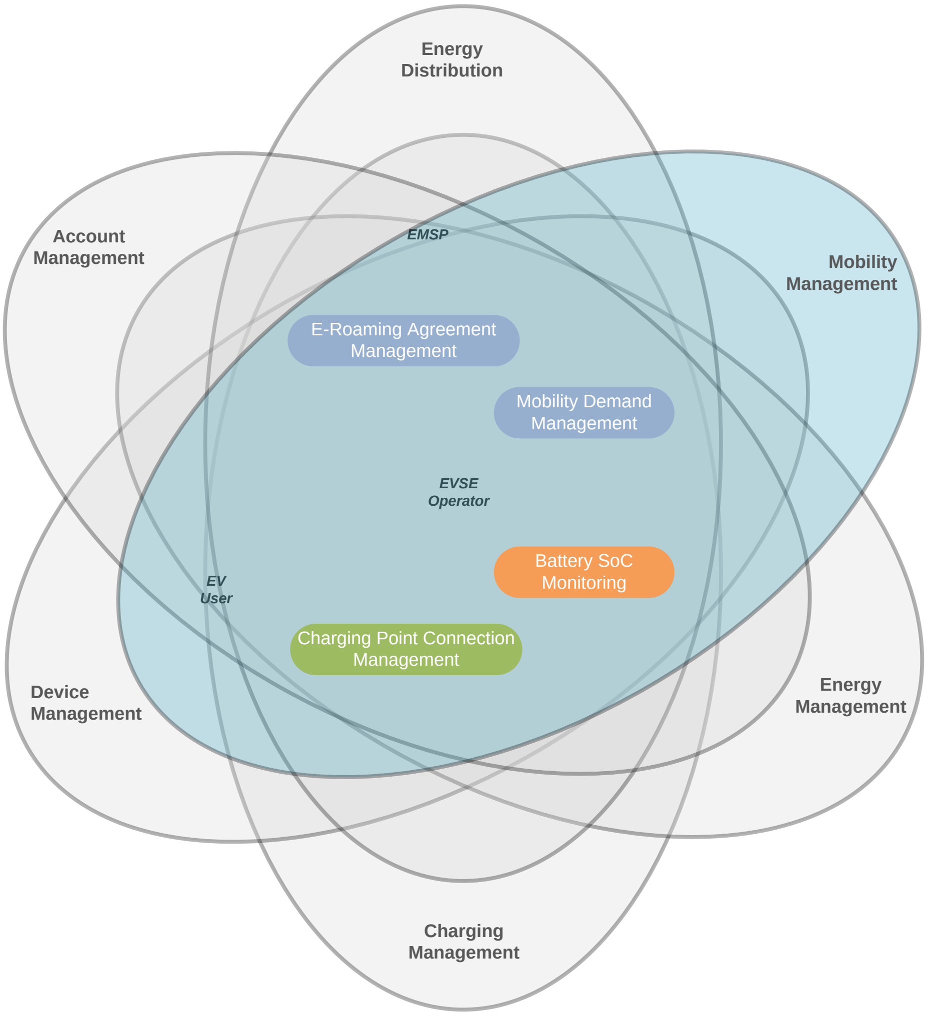

Figure 16: Functions hosted in the Mobility Management Realm

4.3.3.2.1 E-Roaming Agreement Management

Description

Energy roaming (E-roaming) agreement management is comprised of all functions conducted in checking whether two or more energy roaming partners have an agreement.

E-roaming, partners involved in the roaming process need to be able to identify/check if an agreement is valid between them at the moment it is activated. Section 3.2.1.1 describes in detail the scenario that is envisaged for E-roaming. If an EV user connects to a charging station of a particular EVSE operator that operator needs to check whether the connected EPS is a roaming partner of the EV user and/or EMSP, respectively i.e., checking if charged energy can be billed over the EV user's home EPS. Therefore, the involved EMSP receives the EVSE operator's EPS information and checks if a roaming contract between the EV user and that EPS exists. If there is an active roaming contract, settlement and billing functions could be performed using the EV users home EPS.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User, Charging Infrastructure	Enterprise	E-Roaming	EMSP, EVSE operator

Assessment

This function can be implemented using standard programming paradigms or by using existing systems, e.g., from the field of mobile communication. Mobile communication network operators are already operating their networks including roaming capabilities. For that a customer's home network operator is checked to have a roaming contract with the local network operator. This scenario could be transferred to the energy sector in replacing mobile network operators with EPS. The FI-WARE chapter Application/Services Ecosystem and Delivery Framework provides GEs that may be utilised to implement part of this function e.g., storing service contract data accessible to multiple parties. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.2.2 Mobility Demand Management

Description

Each EV user has a mobility demand that can be determined by dynamically collecting EV users' driving patterns. This mobility demand can then be used in conjunction with battery SoC to estimate when and where the EV user needs to additionally charge the battery of his/her car.

This function is normally implemented by an EMSP, it is of dynamic nature i.e., EVs send status information at defined trigger conditions like reaching a specified SoC level. The service provided to the customer is up to date information on charging possibilities dependent on the actual EV battery SoC. Statistics may be collected and offered to the customer and EVSE operators. Figure 17 gives an overview on functions and high level components needed to implement mobility demand management.

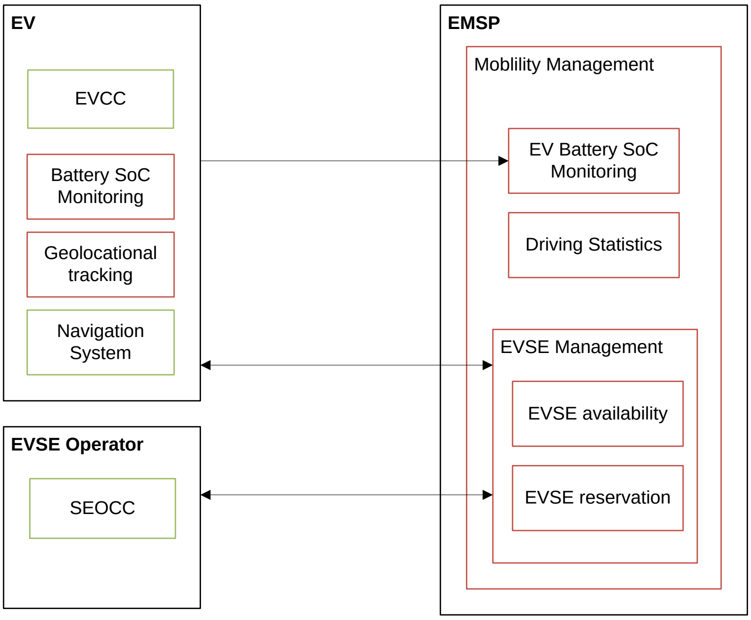

Figure 17: Mobility demand management function scheme

The EV has to transmit the following information to the EMSP's Mobility Management System (MMS):

- Battery SoC
- Geographical location
- Planned route (optional)

The current geographically distributed charging requirements can be determined using Battery SoC and geographical location information. Additionally the EV may also provide the planned route to the MMS for it to consider any potential future charging spot locations. This is not mandatory for managing the assignment of EV charge points, but it can help to predict any near term energy demand trend.

One can think of several events that trigger EV status delivery to the MMS utilising a push/pull message exchange pattern (MEP):

- Battery SoC falling below certain threshold levels defined in advance
- Status update messages every *x* minutes or hours

- Status update messages triggered by the EV user in case the user does not want to use automatic status update transmissions

The MMS sends charging point availability update messages to the EV if the user wishes to receive them. Again this may be done periodically or on a request/response basis issued by the EV user. If charging point status update messages should be transmitted periodically to each of the EVs under management the amount of small sized messages may lead to excessive small packet transmissions. A solution could be multicasting this information to EV groups located into different geographical areas by only considering a certain area size on which to provide the status. Broadcasting may also be an option, but could also lead to excessive amounts of data if a huge geographical area has to be covered.

Manual status update triggering potentially also takes place if the EV user wants to reserve a charging station based on his/her current travelling route. This can be done after a charging point availability update message has been sent to the EV.

EVSE operators have to provide status updates on their EVSE usage for the MMS to provide reasonable information to its connected EV users. Information exchange is triggered by the function in Section 4.3.3.2.3 that deals with EV to EVSE connection management. Static information like EVSE charging mode support and supported payment methods are provided by the function in Section 4.3.3.4.4.

An EVSE reservation could be initiated by the EMSP on behalf of its customer. A reservation should request a time window in which the scheduled charging process is planned to take place. This can be realised using a request/response MEP initiated by the MMS at the EMSP. The EVSE management system at the EVSE operator replies to this request. The EV user gets a feedback on the reservation's outcome from the MMS at the EMSP.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User, Charging Infrastructure	Operation	ICT Enabled Demand Side Management , E-Roaming, V2G	EV User, EMSP

Assessment

This is an important function that also helps in reducing the range anxiety phenomenon that is connected to electric mobility these days. Range anxiety will persist as long as the range one can reach with a full EV battery is in stark contrast to ranges reachable with combustion engine cars.

Several GE candidates exist to implement parts of this function. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.2.3 Charging Point Connection Management

Description

This function manages all EV to EVSE connections, i.e. all connection changes are communicated to the EMSP. The process of plugging an EV to an EVSE is specified in IEC 61851 standard documents [26] and ISO/IEC 15118 draft standard documents.

The EMSP has to know to which EVSEs its customers' EVs are connected to in order to be able to schedule and optimise charging processes on a macro level. This is especially useful for the ICT-Enabled Demand Side Management use case (Section 3.2.1) where there is a need to have an overview of controlling power range capabilities in conjunction with spatial information on distribution grid level.

Figure 18 gives an overview of involved components and their interfaces.

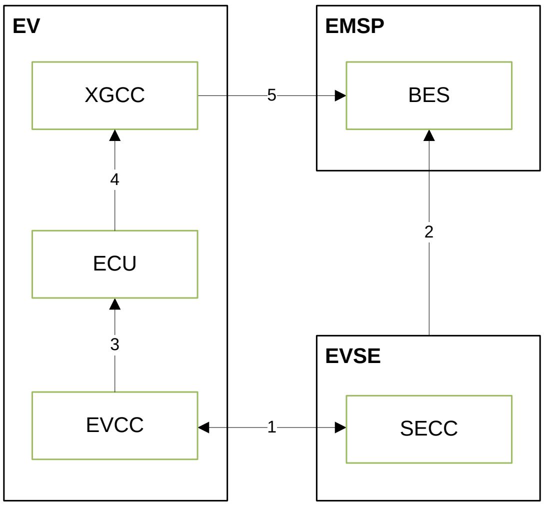

Figure 18: EV – EVSE connection management components/interface overview

The following interfaces need to be implemented:

1. Negotiation interface on charge rate (ISO/IEC 15118) and communication of EV (user) ID to the EVSE
2. Communication interface to exchange EV (user) ID and EVSE identification credentials to set an EV – EVSE mapping at the home EMSP
3. EV internal connection notification event to the ECU
4. EV internal connection notification event to the XGCC in order to forward this information to the home EMSP
5. Wireless interface to submit EV – EVSE connection information to the EMSP

Interfaces 2 and 5 may both transmit information on the connected EV (user) ID. This could be used to conduct internal plausibility checks at the EMSP and may also be used to add additional security functions. Interface 5 can also be used to transmit geo spatial data in conjunction with an EVSE credential to fill an EVSE database at the EMSP if that EVSE has not been added to this database, yet. If it is not intended to use these extra functionalities, one interface can be omitted in favour of the other one.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure, Infrastructure User	Operation	ICT Enabled Demand Side Management , V2G, E-Roaming	EV User, EMSP, EVSE operator

Assessment

This is an E-Mobility specific function, which heavily depends on component implementations inside EVs and EVSEs. Therefore, this function has to be implemented locally inside these entities. FI-WARE's Data/Context Management chapter's Publish/Subscribe Context Broker can be utilised to subscribe EMSPs with EV to EVSE connection information which is then published to all subscribers in case connection changes occur. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.2.4 Battery SoC Monitoring

Description

Monitoring battery SoC of the EV is an indicator for the range of the car. The information can be also used as an indicator how much energy can be provided to the grid to discharge the car and to improve the process of charging, too.

The EV User gets the information about the range of the EV by an onboard unit. The onboard unit reads the current voltage of the car battery and is able to estimate the range by analysing external parameter (e.g. battery SoC, weight of the car, the route, the weather, etc.).

By connecting EV with charging stations, the battery SoC information will be monitored by the charging station. So the EVSE Operator can provide the information to the EMSP for it to manage its car fleet.

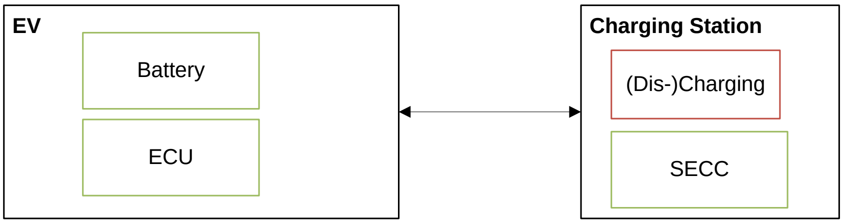

Figure 19: Battery SoC monitoring functional overview

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure	Station	ICT Enabled Demand Side Management , V2G, E-Roaming	EV, EV User

Assessment

Battery SoC Monitoring is an EV internal function at the moment. Battery SoCs should be exposed to the EMSP in order for the EMSP to be able supporting mobility demand management (Section 4.3.3.2.2) for its customers. FI-WARE's Interface to Network and Devices chapter's Connected Device Interfacing GE may be used to implement EV battery SoC access. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.3 Energy Management

This function realm is composed of four functions as depicted in Figure 20.

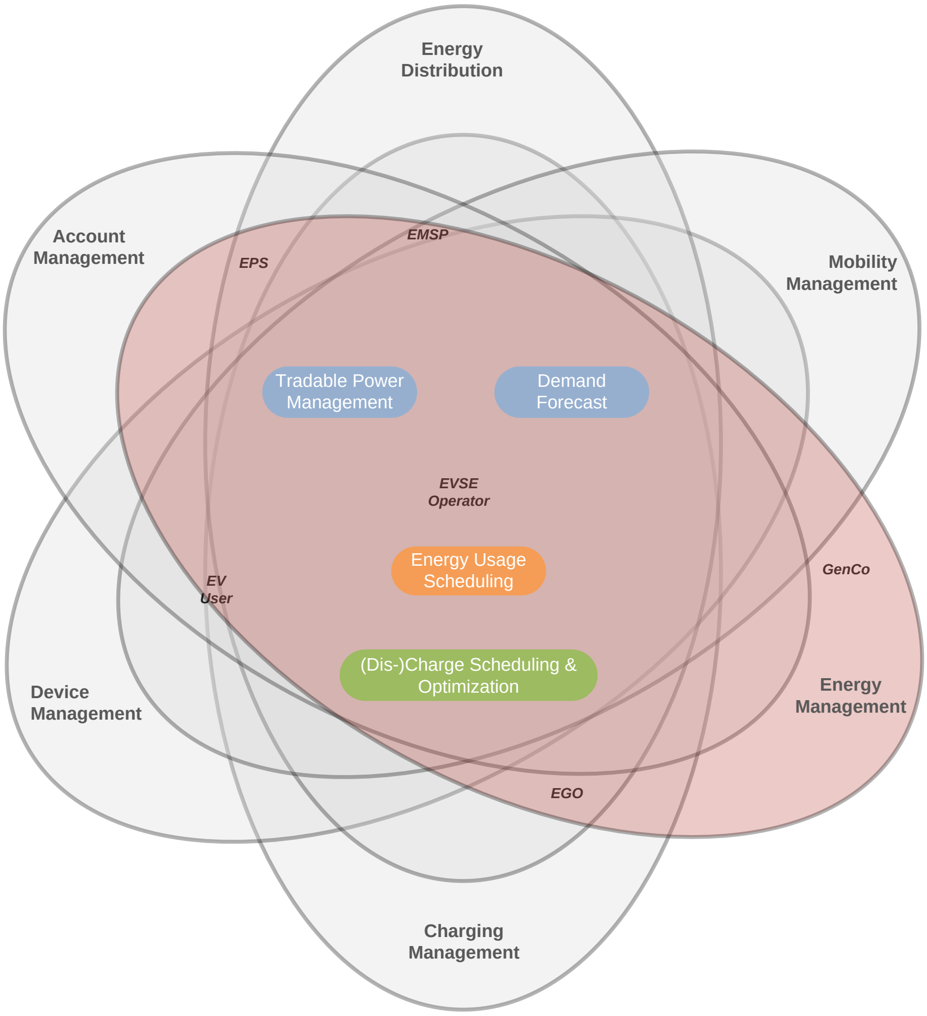

Figure 20: Functions hosted in the Energy Management Realm

4.3.3.3.1 Energy Demand Forecast

Description

Recognising energy usage patterns in a system like a household or micro grid and deriving an energy usage forecast can be used to set up a power consumption plan taking into account energy intraday market prices as well as the local load requirements. This information can then be used to optimise daily power consumption with the goal of, e.g. minimising costs.

Energy demand forecasting is done at different hierarchical levels and for different time horizons. In analogy to the microgrid operator that forecasts generation and consumption at the microgrid level (see Section 4.2.1.2 in D3.3 [27]), the BEMS is doing these forecasts for the building it is in charge for.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Operation	ICT Enabled Demand Side Management, V2G	EMSP, EPS, EVSE Operator, EV User (BEMS)

Assessment

This building block could be computing power intensive if lots of input parameters are involved or several forecasting scenarios need to be calculated. Same GEs used to implement Grid Status Forecast

(Section 4.3.3.1.1) are also candidates for this function's implementation. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.3.2 Tradable Power Management

Description

Taking into account DERs and power consumption capabilities under control, e.g. a household with all its consumer devices, this function calculates power availability figures for a set of devices that can be used to offer power adaptation services.

Energy demand forecast may generate valuable input for this function since the overall trade potential could be increased. The forecast given uncertainty has to be handled nevertheless such that the figures obtained from forecasting cannot be used as is.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Enterprise	ICT Enabled Demand Side Management, E-Roaming, V2G	EPS, EMSP, EVSE Operator, EV User (BEMS), EGO

Assessment

This is a local function implemented by the computing entity e.g. BEMS or a trade system at the EPS. FI-WARE's IoT Services Enablement chapter's Gateway Data Handling GE may be used for data filtering and aggregation. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.3.3 Energy Usage Scheduling

Description

This function schedules the energy consumption of a given amount of energy over a specific time taking into account all devices under control. Energy scheduling always tries to fulfil requirements like fair energy provision over all controlled devices or avoiding energy usage during peak tariff time periods.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Operation	ICT Enabled Demand Side Management, E-Roaming, V2G	EPS, EMSP, EVSE Operator, EV User (BEMS), EGO

Assessment

This normally takes into account a given set of parameters that is geographically restricted like the home building, the micro grid or even a sub tree of the distribution grid. Therefore, the scheduling algorithm runs on a diversity of components/systems like e.g. BEMS, Charging Station Server and MC. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.3.4 (Dis-)Charge Scheduling & Optimisation

Description

When an EV is plugged in for a long period and the available connection power exceeds the power necessary to charge up to what is needed at end of the charging, there is a potential for scheduling and optimisation of the charging. The central optimisation could be conducted by generic optimisation functions of a Future Internet core-platform. An optimisation cycle could be regularly triggered by a plug-in ("ready-to-charge") signal of the EV. An optimisation cycle should consist of three phases (Information Acquisition, Information Assessment (=optimisation), Result Communication) and should run continuously as long as the EV is plugged in.

Any EV needs to be plugged in and charged at some point in time. For battery EV this is the only way to get energy for mobility. For hybrid EV, despite being able to be driven with other fuels (e.g. gasoline), it is a cheap way to get energy and overall efficiency is higher when power from the grid can be used, at least for inner city trips.

An EV can be charged fast (80%-SoC in about 30min at a fast charging station) or slow (e.g. overnight) at a standard parking place (e.g. a private car in the garage at home). When an EV is plugged in and the available connection power exceeds the power necessary to charge up to what is needed at end of the charging process, there is a potential for scheduling and optimisation of the charging. This scheduling and optimisation is able to support the stability needs of the power grid and therewith supports the integration of renewables. The optimisation can be distinguished via the place where it is conducted:

- local optimisation within the EV → the information about generation and grid capacities needs to be communicated to the EV, e.g. encoded via price signals
- central optimisation within the infrastructure → the EV only gets the technical signals saying to charge or discharge with a certain power (and potentially additional technical parameters such as the phase angle phi)

In particular the central optimisation could be conducted by generic optimisation functions of a Future Internet core-platform. An optimisation cycle is regularly triggered by a plug-in ("ready-to-charge") signal of the EV. An optimisation cycle consists of three phases depicted in Figure 21:

- Information Acquisition: Sources of information that has to be considered are in particular the grid capacity, generation capacity and the current battery situation as well as mobility needs of the user.
- Information Assessment (=optimisation): An algorithm is needed to mediate all dimensions of information.
- Result Communication: The resulting schedule (at least its first value) needs to be communicated to the EV so that it can charge correspondingly.

During the EV is plugged in, the optimisation cycle needs to rerun continuously in order to reflect changes of the information sources.

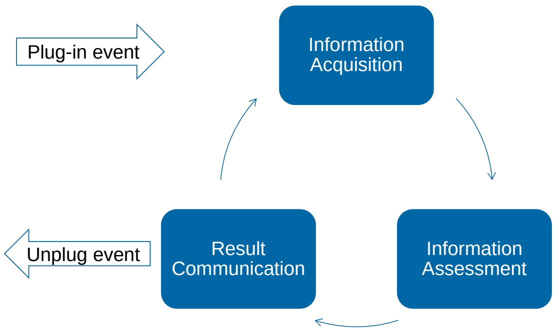

Figure 21: Optimisation cycle

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Power Grid, Charging Infrastructure	Operation	ICT Enabled Demand Side Management, V2G	EV User, GenCo, EGO

Assessment

The function (Dis-)Charge Scheduling & Optimisation as it is described above only relates to electric mobility. However, other elements in a power grid have similar optimisation problems to solve, such as

Distributed Energy Resources (DER) scheduling their energy flows to and from the grid. Therewith, this function could be not only an E-Mobility related function, but a Smart Grid Domain Specific Enabler. Moreover, basic algorithms that are needed for these optimisation applications could as well be needed for other domains such as logistics, production, etc. If generic optimisation routines and algorithms are to be seen as part of a Future Internet core platform, it might be a GE "implementing intelligent services" from Section 4.3 in [28]. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.4 Charging Management

This function realm is composed of five functions as depicted in Figure 22.

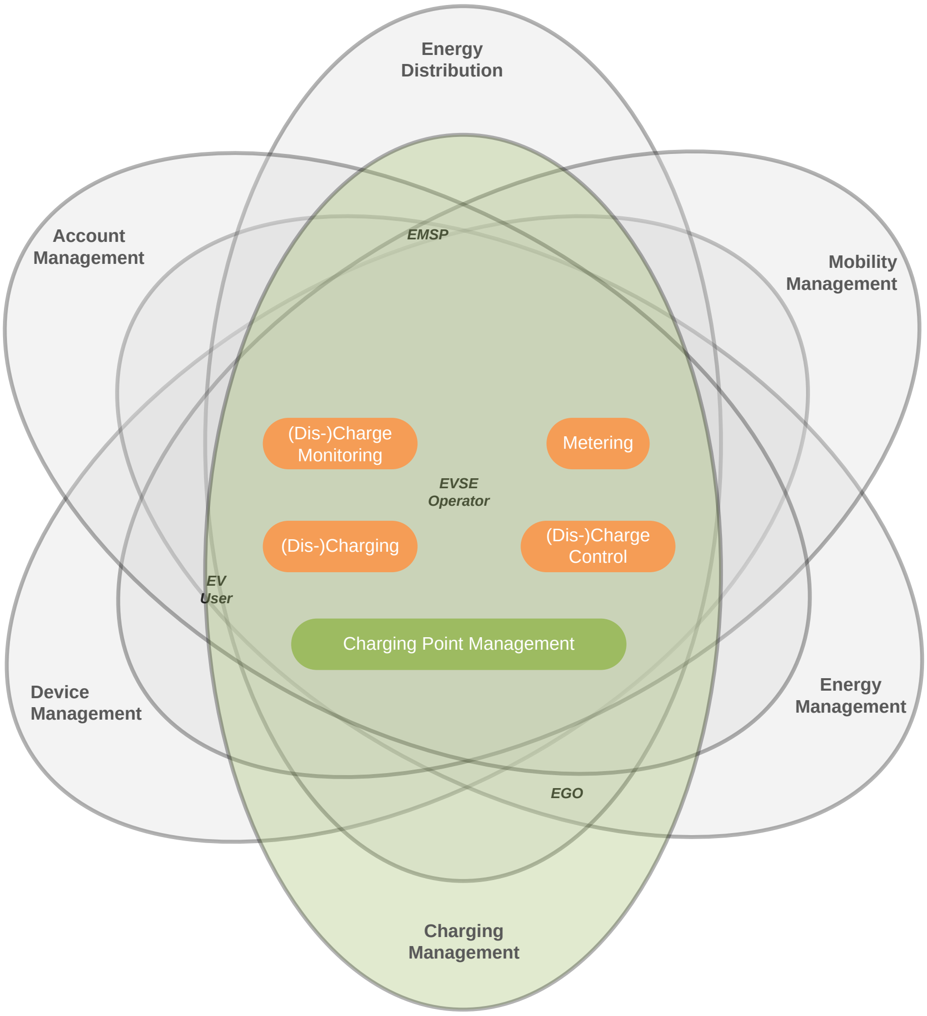

Figure 22: Functions hosted in the Charging Management Realm

4.3.3.4.1 (Dis-)Charging

Description

This function encompasses the complete (dis-)charge process and includes (dis-)charge control (Section 4.3.3.4.2) and (dis-)charge monitoring (Section 4.3.3.4.3). It is therefore a frame for the whole (dis-)charging process. This function may also be seen as entity local function implemented inside EVs and EVSEs.

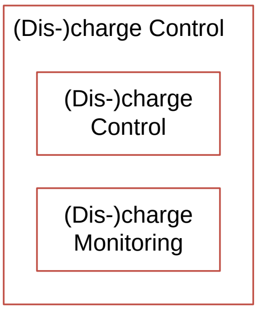

Figure 23: (Dis-)charging

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure	Station	ICT Enabled Demand Side Management , V2G, E-Roaming	EV User, EMSP, EVSE Operator, EGO

Assessment

The assessments of the following two function sections also apply here since this is a container function for these two functions. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.4.2 (Dis-)Charge Control

Description

This function relates to the safe and effective control of charging and discharging of an Electric Vehicle. The IEC Standard IEC61851-1 and the CHAdeMO specification are considered in the description of the function. The description will focus on Home Charging AC, Home Charging DC and Home Discharging via an external device.

V2G revolves around four sub functions; AC charging/discharging and DC charging/discharging (Figure 24). Any combination of which is conceivable, although AC Charging is the only commonly available sub function in the home.

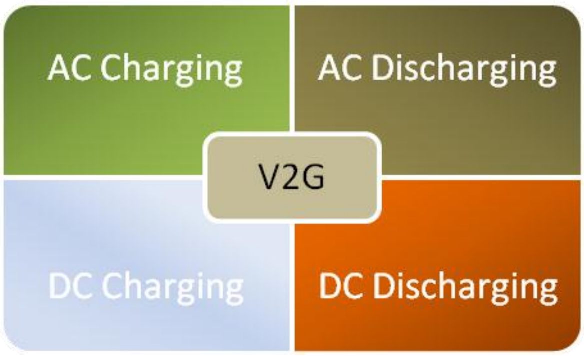

Figure 24: V2G Charging Functions

The charging functions are extensively documented in IEC61851-1 and the CHAdeMO specification. In a full V2G scenario, the existing charging control will be supplemented by a BEMS. The BEMS will consider user preferences, schedules and battery SoC.

- Charging / Discharging Control Signals
- Monitor compliance times
- Check for plug present
- Check circuit earth

- Check for connection cable rating
- Check for vehicle maximum rating
- Request for charge (EV)
- Cell temperature monitoring
- Permission to charge (BEMS)
- Charge level request
- Charge start
- Charge stop
- Request for discharge
- Grid frequency monitoring
- Inverter frequency control
- Synchronisation band reached
- Energy metering

Until such time as the capabilities apply within an OEM vehicle, the most likely route would be from an external device. It is foreseen that this device would need to control both the charging and discharging of the vehicle and would include energy metering.

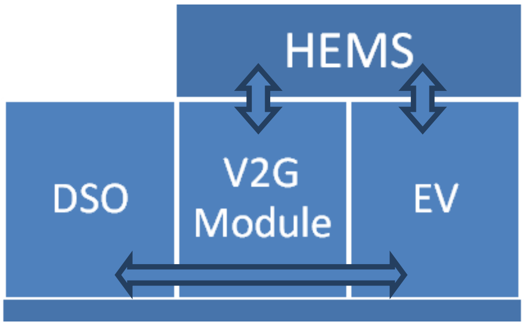

Figure 25: (Dis-)Charge Control Main Interfaces

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure, Infrastructure User	Station	V2G	EV User, EVSE, EGO

Assessment

Currently the discharge function of V2G is not supported in production EVs. While some work has taken place in the area, it has revolved around equipment external to the vehicle. The development of V2G will require its adoption by the vehicle OEMs to facilitate the control of the reverse power function and the specification of standards specific to the V2G function. In addition it is noted that not all vehicles coming to the market place have DC charging facilities. The use of AC only will limit the rate of power transfer between Vehicle and Grid.

FI-WARE's Interface to Network and Devices chapter's Connected Device Interfacing GE may be utilised in relation to Battery SoC Monitoring (Section 4.3.3.2.4). Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.4.3 (Dis-)Charge Monitoring

Description

This function monitors the (dis-)charging process and is a prerequisite to (dis-)charge scheduling and optimisation (Section 4.3.3.3.4).

(Dis-)charge monitoring mainly collects information on the (dis-)charging process itself. Its purpose is to inform the EV user and the EMSP on whether a change in the charging process occurred. This could be either an answer to a trigger event conducted as an output of the EMSPs optimisation algorithms (Section 4.3.3.3.4) or it can be an informational message to the EV user as a result to a charging mode change if requested by the EV user.

Figure 26 illustrates high level functions and interfaces needed for advanced (dis-)charging procedures. Charge status monitoring is a sub function in that context.

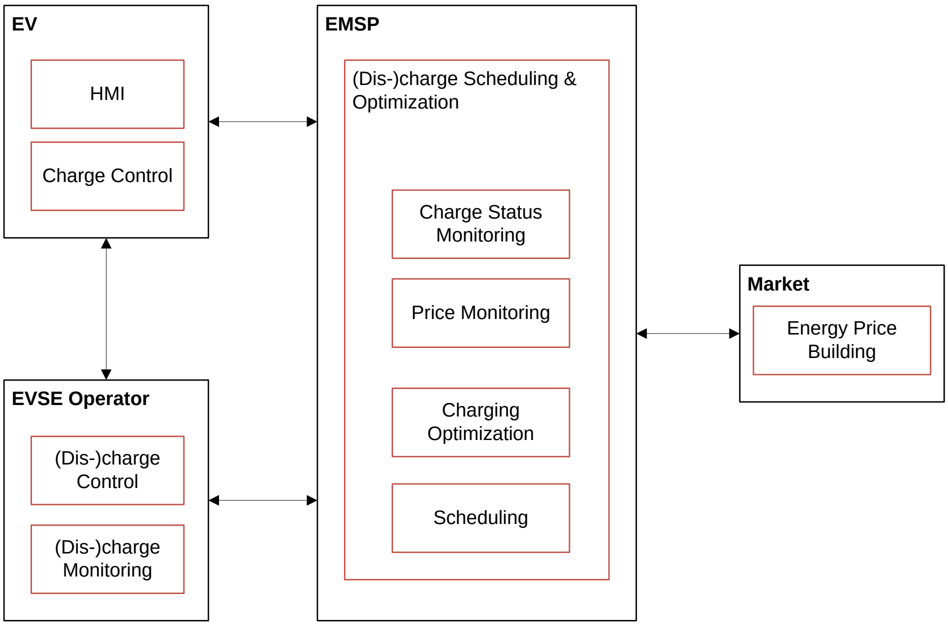

Figure 26: (Dis-)charge scheduling and optimisation functions/interfaces overview

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure, Infrastructure User	Station, Operation	ICT Enabled Demand Side Management, V2G	EV, EVSE Operator, EMSP

Assessment

Despite its simplicity, this function is an important prerequisite to the (Dis-)Charge Scheduling & Optimisation function (Section 4.3.3.3.4) since it is part of information acquisition process depicted in Figure 21. The processing speed and communication latency requirements depend on the optimisation and scheduling process speed. It has to be tuned towards their processing speed requirements. If these requirements are not to high then the Publish/Subscribe Context Broker GE from the FI-WARE chapter Data/Context Management may be used. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.4.4 Charging Point Management

Description

This function deals with creating an inventory for charging points and itemising their capabilities and configurations and sharing information about charging points characteristics with accepted partners. The information can be of static or of dynamic nature.

Charging point management is comprised of all sub functions dealing with static management of charging stations. Two kinds of information need to be handled: static and dynamic. Static information comprises all data related to physical parameters that hardly change over a reasonable short time whereas dynamic information comprise all data related to be also communicated to the customer and which brings added value to EMSP services. The following information on charging stations is collected and maintained:

Static

- Geo location
- Plug type
- Supported charging modes
- Connected grid operator
- Payment methods
- Authorisation methods

Dynamic

- Tariff
- Roaming conditions
- Availability
- Supported charging modes
- Supported payment methods
- Supported authorisation methods

Static information listed above is maintained by the EVSE operator that owns the charging points, but they are also valuable for the EMSP in order to offer the information in a filtered manner to the customer.

Dynamic information is the most important for the EMSP since it founds the basis for up to date information on availability which is an important aspect for electric mobility market ramp up due to the range anxiety problem. This data has to be delivered by the EVSE operator either directly to the partnering EMSPs or to a third party service provider implementing the interface between numerous parties.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure	Station, Operation, Enterprise	ICT Enabled Demand Side Management, V2G, E-Roaming	EVSE Operator, EMSP

Assessment

Numerous platforms that collect information on charging infrastructure already exist covering several geographical regions e.g., ladenetz.de [29]. Despite the collection of static information on charging points, a reliable and save information on charge point availability is not implemented. But that is exactly a future requirement for a provided electric mobility service.

FI-WARE's Application/Services Ecosystem and Delivery Framework chapter's Registry GE may be used to implement status information publishing and to enable access to this information to authorised actors. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.4.5 Metering

Description

A prerequisite for functions Rating (Section 4.3.3.6.7), Clearing (Section 4.3.3.6.8), Billing (Section 4.3.3.6.9) and Settlement (Section 4.3.3.6.10) is metering the consumption of the EV charging process as well as the supplied energy to the grid. For providing the information to the operator, the Metering function meters the energy exchange between EV and energy grid, stores the raw data of the measurement and provides the measurement data to the operator or to the systems of the operators.

Metering the energy flow between EV and the grid to provide measured data to operators is a required step before conducting rating, billing, clearing and settlement services.
The smart metering device, that meters the data of the whole household, will provide this data to the household's contracted EPS in case of home charging and discharging. A separate meter (e.g. integrated in the car or charging station) could be useful to the operator for controlling charging and discharging processes depending on the grid situation.

The smart meter sends the measurement to the Metering Management. The measurement data has to be encrypted and signed to ensure data privacy. So the Metering Management function has to decrypt this data and check the message signatures. The Metering System directly stores measurements without modification (raw data). This data can be utilised to clarify billing results in case frictions. Metering Management links measurements to respective charging stations and EVs. Afterwards, they will be aggregated and provided to the EVSE operator, who is responsible to ensure correct and complete measurements. The EVSE operator will provide the information to the EMSP.

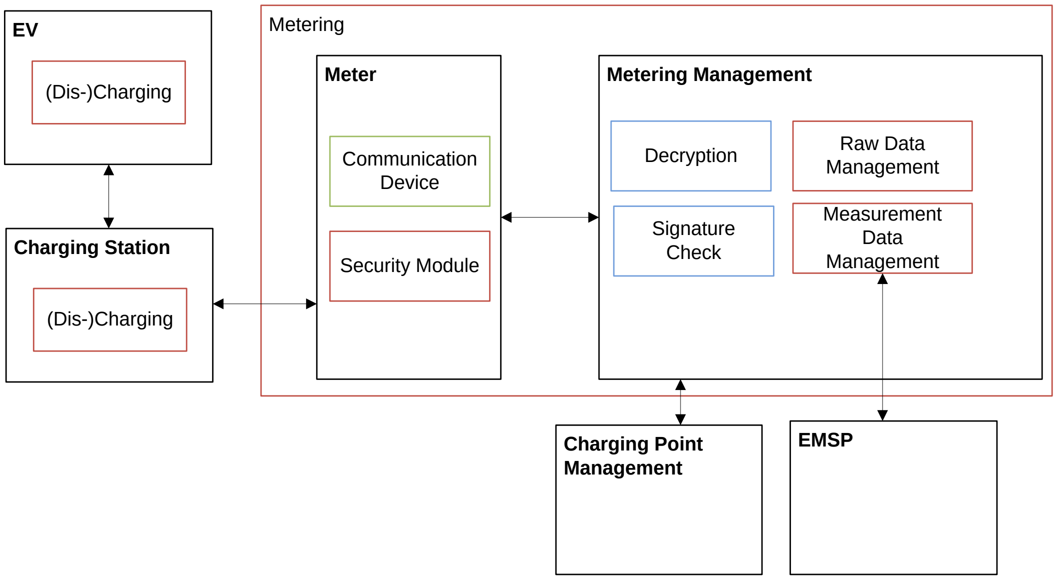

Figure 27: Metering functions overview

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure, Infrastructure User	Station, Operation	ICT enabled Demand Side Management, E-Roaming, V2G	EV, EVSE Operator, EMSP

Assessment

Metering is a key function for a Smart Grid roll out and, as stated before, it is also a prerequisite for Rating (Section 4.3.3.6.7). A lot of proprietary solutions are already available on the market. A meter must contain a communication interface that transmits metered figures either periodically or on demand to its preconfigured destination. Please refer to Table 11 on page 84 for a list of potential GEs to be used for this function.

4.3.3.5 Device Management

This function realm is composed of three functions as depicted in Figure 28.

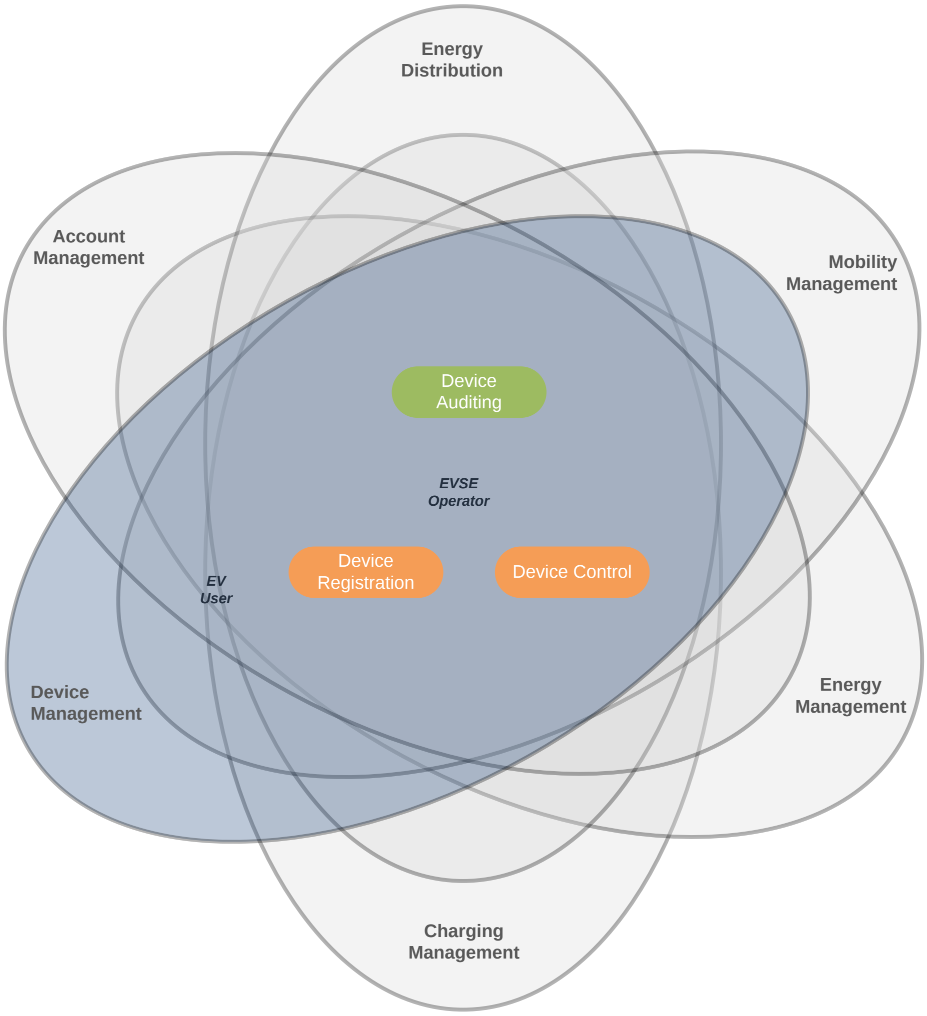

Figure 28: Functions hosted in the Device Management Realm

4.3.3.5.1 Device Registration

Description

Device registration is a prerequisite to the device's usage. When a device is connected to a network it should automatically register with a managing device in a plug & play manner. The device to be registered should communicate the desired registry class and further context information needed to determine its nature and purpose within the network. This function is a prerequisite for device control (Section 4.3.3.5.2) and device auditing (Section 4.3.3.5.3) functions.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure, Infrastructure User	Station, Operation	ICT Enabled Demand Side Management, E-Roaming, V2G	EVSE Operator, EV User (BEMS)

Assessment

FI-WARE's Interface to Networks and Devices (I2ND) chapter's Connected Device Interface (CDI) GE could be used to register specific types of devices, but it requires the GE to be implemented at the given device that can then connect the device to arbitrary services and applications. Another candidate to be used is the IoT chapter's Gateway Device Management GE. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.5.2 Device Control

Description

Once a device is registered with its context it is under the control of this function. Control functions are needed, e.g. for operation and maintenance (O&M), reconfiguration and firmware upgrade tasks. Device control is an important function, since it also enables control of local loads like smart charger etc.

This function is quite generic since each device needs to be controlled in some way or the other. So there is a multitude of implementation possibilities. Looking at the EVSE to BEMS connection alone, there is no standard for this home EVSE control at the moment, but a tendency can be detected towards open information and data models. For instance SOAP/XML is used in OCPP for information exchanges between EVSE and controlling entity.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure, Infrastructure User	Station, Operation	ICT Enabled Demand Side Management, E-Roaming, V2G	EVSE Operator, EV User (BEMS)

Assessment

This function is part of FI-WARE's IoT chapter's Device Management GEs. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.5.3 Device Auditing

Description

This function evaluates specific operational device characteristics like, e.g. security features. It generates an audit report summarising the results which can then be used to judge if the device works as expected. Device auditing could be implemented as a permanent supervision process auditing all devices in the system or it is manually triggered and analysed accordingly.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure, Infrastructure User	Station, Operation	ICT Enabled Demand Side Management, E-Roaming, V2G	EVSE Operator, EV User (BEMS)

Assessment

Usage of this function is rather optional. It could be part of the Inventory Manager in the FI-WARE's IoT Services Enablement chapter's Backend Device Management GE. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6 Account Management

This function realm is composed of ten functions as depicted in Figure 29.

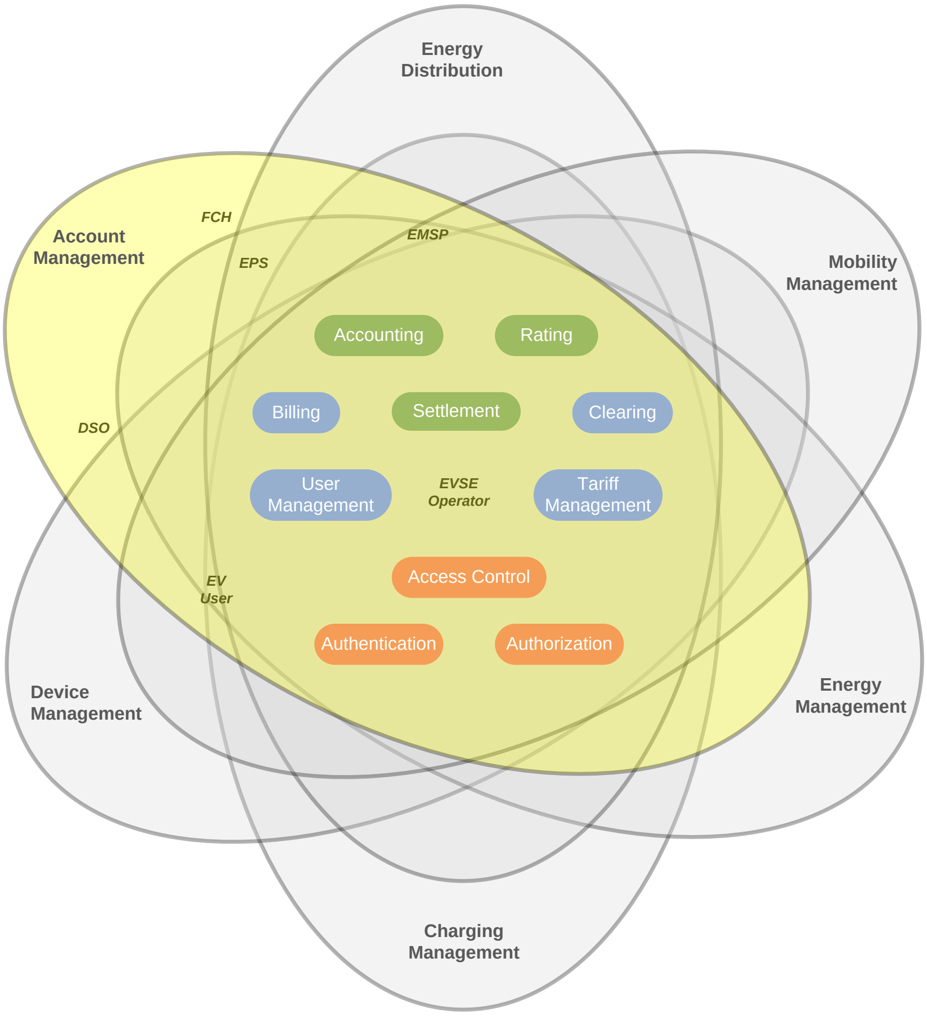

Figure 29: Functions hosted in the Account Management Realm

4.3.3.6.1 User Management

Description

User management is a prerequisite to all end user related functions, e.g. user identification, authentication, authorisation, billing etc.

User Management is based on contractual relations between market participants e.g., if an EV user (customer) has a contract with an EMSP (service provider) this service provider needs to maintain customer information on its behalf to assure a customer – service mapping is available for all actions the customer is allowed to do. Figure 30 depicts user management internal functions and actions for the V2G use case scenario.

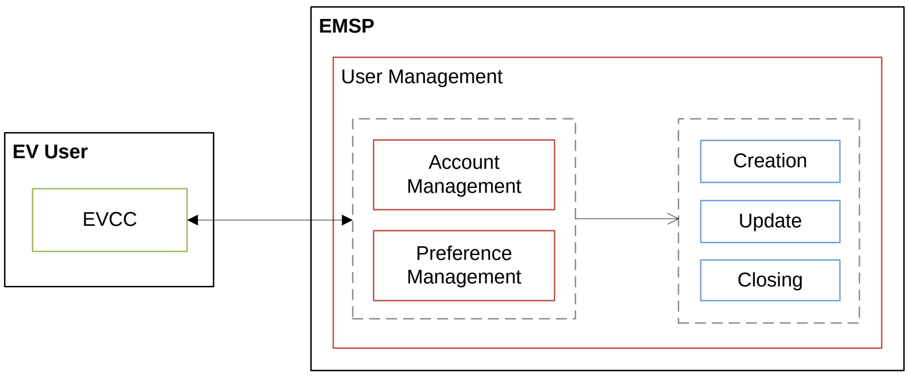

Figure 30: V2G User management function scheme

User Management could be further separated into account management and preference management functions. Account management deals with all kinds of personal, contractual and financial information and preference management realises management of service-related preferences that could be of dynamic nature e.g., an EV user may update his/her preferences during a (dis-)charge process which needs to be further propagated to involved entities like the EV-connected EVSE operator.

Once a customer account is created and his/her information is initialised, which is normally included within the contracting process, customers should be able to update their personal data and preferences at any time. Prerequisites to start such an update process are successful authentication (Section 4.3.3.6.3) and authorisation (Section 4.3.3.6.4) function outcomes. Besides updating personal data offline, customers should have the ability to also do it online using a web portal or a specific app on a computing device.

Customers' personal data normally include but is not limited to name, surname, postal address and a bank account or credit card number for payment. Functional requirements needed for a comfortable customer data update are relaxed given that an Internet connection can be used to access the accounts.

In case of the V2G use case the customer data also comprises preferences for service functions like minimum energy price to allow for V2G service (this can be a preconfigured default setting) for discharging, maximum energy price to allow for extra charging (this can be a preconfigured default setting) for charging, maximum total cost in case of extra charging.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Enterprise	ICT Enabled Demand Side Management, E-Roaming, V2G	EV User, EMSP, EVSE Operator

Assessment

In general user management is a common function since every commercial web service needs to implement this function in order to manage service access. However, special considerations have to be done in the context of E-Mobility. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6.2 Tariff Management

Description

Tariff management is responsible for managing the tariffs including all relevant conditions for (dis)charging EVs. This is part of a contract between EV users and EMSP and may include monthly fees, price spreads and roaming conditions.

The role of the tariff management function, performed by the EVSE operators (or the EMSP if it is an EVSE operator as well), is to define the contractual relationship between the EV users and their EMSP. The EMSP can offer various tariffs for the different needs and habits of the users, similarly to the telecommunications market. The EVSE defines the individual components (cf. the following paragraph) of the tariffs according to the user needs and the inputs from external stakeholders such as prices for electricity (EPS), for using or stabilising (via V2G) the grid (DSO) and for roaming (EVSE).

A tariff includes several individual components, for example the following ones:

- Monthly fees.
- Prices for standard/fast charging EVs.
- Prices for time spans where V2G is potentially possible.
- Prices for discharging EVs.
- Prices for roaming.

All prices mentioned may be for minimum and/or maximum prices – the actual prices may depend on the actual EVSE and on the time.

A tariff may further contain a number of restrictions, such as the following ones:

- A certain number of standard/fast charging processes with reduced/guaranteed prices.
- Minimum times where V2G is potentially possible.
- Maximum amount of energy used for V2G.
- Runtime of the contract.

All these components and restrictions form a tariff an EV user may subscribe to. When connecting to the EVSE, this tariff is the basis for offering the EV user a concrete price for charging, which is obtained via the (Dis-)Charge Scheduling & Optimisation function. The tariff-management function then supports the actual price-finding process with needed information, e.g., the remaining number of reduced-rate charging processes and the respective prices. Further, the user can access all static and dynamic data related to her/his contract via (mobile) web access.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Enterprise, Operation	E-Roaming, V2G	EPS, EV User, EMSP, EVSE Operator, DSO

Assessment

The tariff management function requires different functionality such as data management, connections to external inputs and interfaces to other functions which access tariff information. All this can be realised using traditional approaches such as relational database systems, standard programming paradigms and, e.g., web services.

To realise the function by means of the Future Internet, one has to decide if a cloud-based approach such as the FI-WARE's Cloud Hosting chapter's Object Storage GE is appropriate or if a standard database should be used for data management. For describing external interfaces and services, the usage of USDL Service Descriptions could be an option. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6.3 Authentication

Description

Authentication is an important security function providing the base of other security services. It is described in detail in [30]. It verifies the truth of an entity's identity claim.

Authentication between communicating parties is needed at several occasions e.g., logging into the EMSP system to receive status information on charging station occupancy. Authentication of EV users to an EVSE is detailed in Section 2.5.1 of D5.1 [2].

According to Section 3 of D1.11 [30] authentication could also be needed for system components to testify identity claims of critical infrastructure components like e.g., EVs.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Operation, Station	ICT Enabled Demand Side Management, E-Roaming, V2G	EV User, EVSE Operator, EMSP

Assessment

This is a common function already implemented with a diverse set of technologies like stored passwords or credentials or more advanced methods like PGP which at the same time encrypts transmitted data. When used in conjunction with User Management (Section 4.3.3.6.1) this function is included in FI-WARE's Security chapter's Identity Management GE (see Section 8.2.2 in [28]). Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6.4 Authorisation

Description

Authorisation is an important security function that is described in detail in [30]. It defines access rights of authenticated entities to a specific resource. Hence, it bases on a successful authentication.

A prerequisite for this function is authentication (Section 4.3.3.6.3) which always has to be successfully completed in order to authorise the authenticated entity to access the desired function, component, service etc.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Operation, Station	ICT Enabled Demand Side Management, E-Roaming, V2G	EV User, EMSP

Assessment

This is a common function already implemented in a huge amount of accounting systems worldwide. However, how an entity is authorised for accessing specific resources heavily depends on the resources and the hosting system (if any) itself.

The Unified Service Description Language (USDL) (see Section 5.2.1 in [28]) utilised in FI-WARE's Applications/Services Ecosystem and Delivery Framework chapter can be used to describe authorisation parameters i.e., defining access rights for the given system/service. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6.5 Access Control

Description

Determines access rights to a system or subsystem based on account credentials matching a specific access control class. Access rights could be diverse depending on the access requirements connected to the protected system, therefore access rights management is done in order to verify coarse grain or fine grain access control. This function only deals with remote access control and physical access control is an additional security feature that is out of scope in relation to ICT.

This function is always implemented whenever an EVSE access is requested by an EV user e.g. in the E-Roaming use case for granting access to an EVSE owned by contractually foreign operator.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure, Infrastructure User	Station	ICT Enabled Demand Side Management, E-Roaming, V2G	EV User, EMSP, EVSE Operator

Assessment

FI-WARE's Security chapter's Identity Management (IdM) GE (see Section 8.2.2 in [28]) can be used as a basis to implement access control function through its authentication capabilities. The Unified Service Description Language (USDL) (see Section 5.2.1 in [28]) utilised in FI-WARE's Applications/Services

Ecosystem and Delivery Framework chapter may be used in addition. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6.6 Accounting

Description

The accounting function deals with recording all (financial) transactions and generating reports on (financial) status on given interested entity. An example is accounting of the complete set of customers contracted with the accounting party.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Enterprise	ICT Enabled Demand Side Management, E-Roaming, V2G	EMSP, EVSE Operator, FCH

Assessment

This is a common function that is already implemented in service providers' backend systems. FI-WARE's Application/Services Ecosystem and Delivery Framework chapter's GEs may be used to realise this function. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6.7 Rating

Description

The rating function is responsible for collecting the metering data from the metering function (Section 4.3.3.4.5), calculating the actual price based on the respective tariffs from tariff management and providing this information to further systems.

The rating function is run by the EVSE operator. Using the metering functionality, the EVSE operator accesses the relevant metering information. Further, the EVSE operator runs the tariff management function and has therefore access to the relevant tariffs (which might be highly dynamic). The calculation is based on a quantitative evaluation of how much power has been used for charging or feeding into the grid in which time spans.

When the prices are calculated, the EVSE operator provides the information to the relevant actors and systems. This includes all systems needed for instant pricing feedback (e.g., at the charging station display or using other means such as the web/smart phone/car information systems via the EMSP) and billing/clearing purposes.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Charging Infrastructure, Infrastructure User	Enterprise	E-Roaming, V2G	EMSP, EVSE Operator

Assessment

The Rating function can be implemented using standard programming paradigms or by using existing systems, e.g., from the field of mobile communication. However, using a GE which can also be used for rating dynamic energy prices would be desirable.

FI-WARE's Application/Services Ecosystem and Delivery Framework chapter's Business Models and Elements Provisioning System GE may be utilised to define pre-defined business models for different Metering (Section 4.3.3.4.5) function results. For describing external interfaces and services, USDL

Service Descriptions could be an option. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6.8 Clearing

Description

Clearing functionality aggregates several bills a party sends and receives. This can be internally at an EMSP or as a FCH which brings together EMSPs and EVSE operators.

There are two scenarios:

- *Internal clearing at EMSPs (case b in the billing function)*
  If an EMSP is an EVSE operator as well, the EMSP receives bills from EVSE operators and sends bills to EVSE operators. In this case, the EMSP might perform internal clearing. If the EMSP has to pay more to an EVSE operator than this EVSE operator has to pay to him, the EMSP can reduce the amount of the bill accordingly, start the settlement and communicate this appropriately. If the situation is the other way round, the EMSP can send an updated and reduced (cleared) bill to the EVSE operator.
- *Clearing at a FCH (case c in the billing function)*
  In case of a dedicated FCH, the FCH collects the bills from several EVSE operators. The clearing process then sends unified bills including the positions from all EVSE operators to the EMSPs, potentially reduced (or even negative) if the EMSPs are also EVSE operators. The EMSPs then treat the bills like bills from EVSE operators and start their settlement processes accordingly. The FCH pays the money received from the EMSPs to the EVSE operators and communicates how the sums were calculated.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Enterprise	E-Roaming, V2G	EMSP, EVSE Operator, FCH

Assessment

Similar to the Rating (Section 4.3.3.6.7) and Billing (Section 4.3.3.6.9) functions, the Clearing function can be implemented using standard programming paradigms and databases or by using existing systems for this purpose, e.g., from the field of mobile communication. Using a GE which can also be used for clearing purposes in other fields – in particular (but not exclusively) in the fields of energy and mobility – would be desirable.

FI-WARE's Applications/Services Ecosystem and Delivery Framework chapter's Marketplace GE offers the service of a clearinghouse. For describing external interfaces and services, USDL Service Descriptions could be an option. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6.9 Billing

Description

When the EVSE Operator has finished the rating function, he starts a billing process which includes writing (electronic) bills and sending it to the EMSP who holds contractual relations with the EV users. Alternatively, clearing functionality might be called when bills are created.

When the EVSE Operator has finished the rating function, he starts a billing process. This includes everything which is needed to create a legally correct bill. Besides the price as calculated by the rating function, this includes particularly dealing with the appropriate taxes and charges and adding legally required information such as tax and bill numbers. Such bills might be electric bills or can be printed. The completed bill then needs to be sent

(a) to the EMSP who holds contractual relations with the EV users (the EMSP then creates its own bills and sends them to the EV users),

(b) to an internal clearing functionality (this is an option if the EVSE Operator is an EMSP as well) or
(c) to a FCH which clears the transactions of several EVSE Operators and EMSPs.

In all cases, several bills might be collected and sent at dedicated points in time, e.g., at the end of a month.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Enterprise	E-Roaming, V2G	EMSP, EVSE Operator, FCH

Assessment

Similar to the Rating (Section 4.3.3.6.7) function, the Billing function can be implemented using standard programming paradigms and databases or by using existing systems for this purpose, e.g., from the field of mobile communication. Using a GE which can also be used for billing other services – in particular (but not exclusively) in the fields of energy and mobility – would be desirable.

Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function. For describing external interfaces and services, the GE "USDL Service Descriptions" could be an option. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.3.6.10 Settlement

Description

When EMSPs receive bills, settlement is the process of paying them.

EMSPs receive bills from EVSE Operator or FCHs. They need to be certified according to the records. For instance, EMSPs may instantly receive information from the rating functions run by the EVSE operators. When the bills are correct, money is transferred.

The following table defines the function's location inside the EM-SGAM.

SGAM Domain	*SGAM Zone*	*Use Cases*	*Involved Stakeholders*
Infrastructure User	Enterprise	E-Roaming, V2G	EMSP, EVSE Operator, FCH

Assessment

Similar to the Rating (Section 4.3.3.6.7), Billing (Section 4.3.3.6.9) and Clearing (Section 4.3.3.6.8) functions, the Settlement function can be implemented using standard programming paradigms or by using existing systems for this purpose. Using a Generic Enabler which can also be used for settlement purposes in other fields would be desirable.

FI-WARE's Application/Services Ecosystem and Delivery Framework chapter's Business Models and Elements Provisioning System GE may be utilised to store payment data and charging logs to support payment processes. For describing external interfaces and services, USDL Service Descriptions could be an option. Please refer to Table 11 on page 84 for a complete list of potential GEs to be used for this function.

4.3.4 EM-SGAM Functional Assignment

This section gives the assignments of functions, described in the previous section, in the SGAM function layer. The component layer is also given to show which components implement these functions. The depicted components are further described in Section 8.1 starting on page 110.

4.3.4.1 ICT-Enabled Demand Side Management

An Overview of functions used in this use case scenario is given in Figure 31. It depicts a Technical Architecture Modelling (TAM) [31] block diagram at conceptual level.

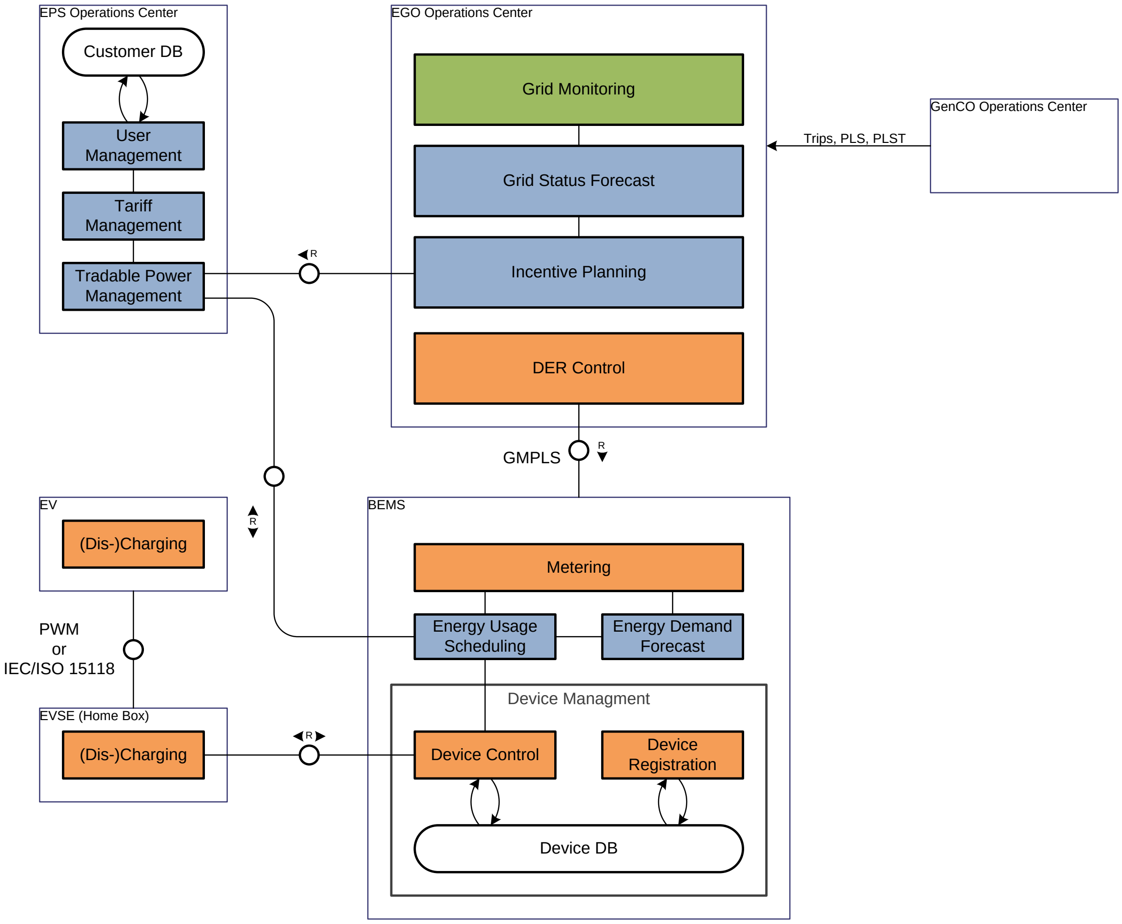

Figure 31: ICT-Enabled Demand Side Management conceptual TAM block diagram

The SGAM function layer containing all scenario functions is given in Figure 32.

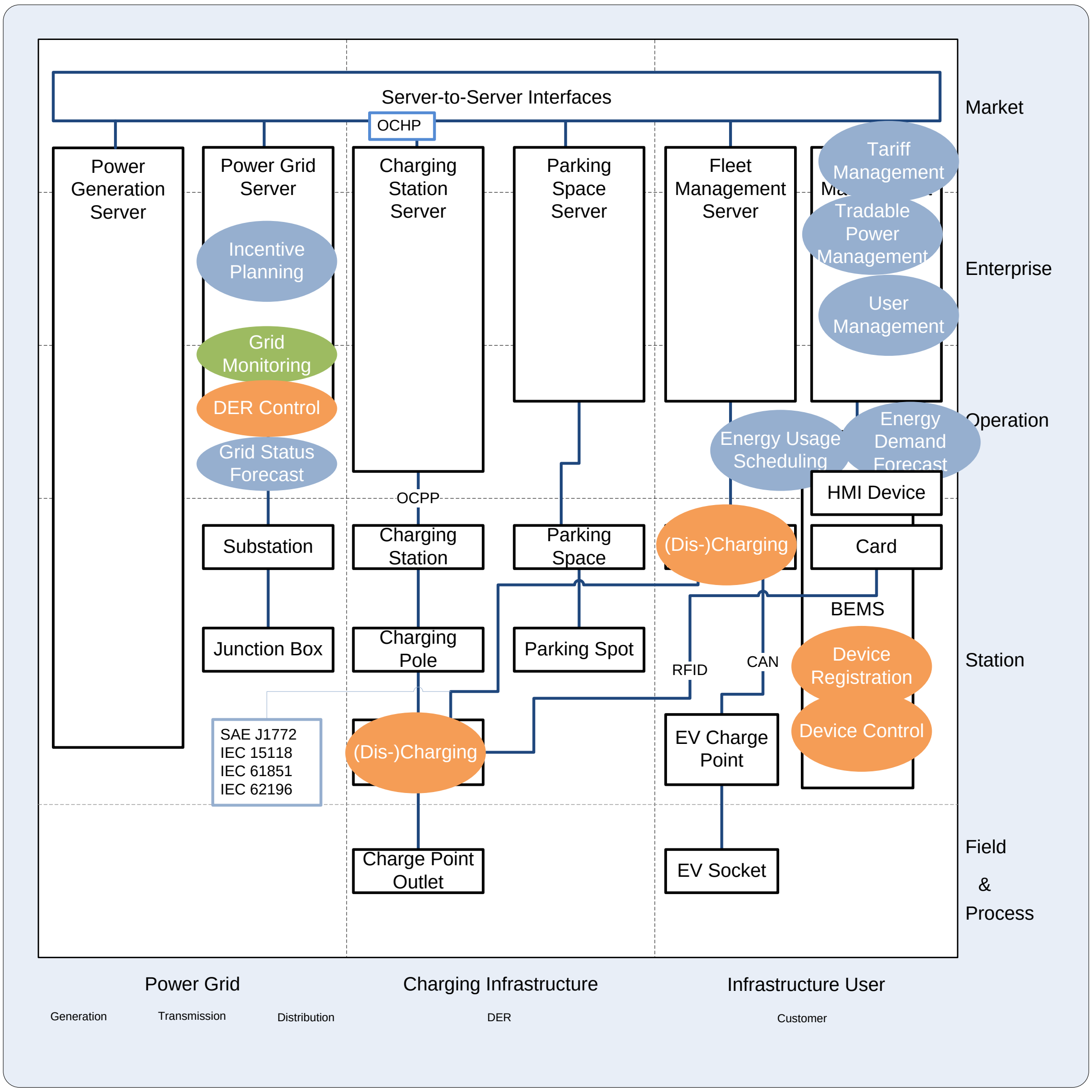

Figure 32: EM-SGAM Function Layer for ICT-Enabled Demand Side Management

4.3.4.2 E-Roaming

An Overview of functions used in this use case scenario is given in Figure 33. It depicts a Technical Architecture Modeling (TAM) block diagram at conceptual level.

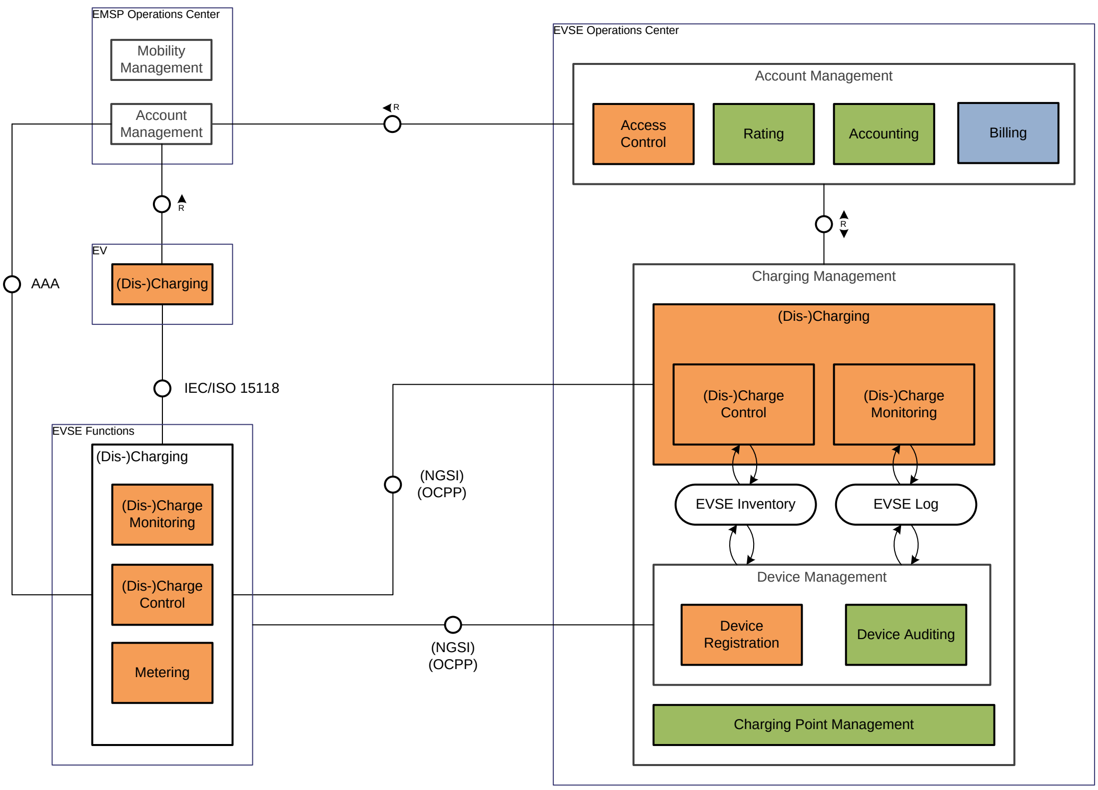

Figure 33: E-Roaming conceptual TAM block diagram

The SGAM function layer containing all scenario functions is given in Figure 34.

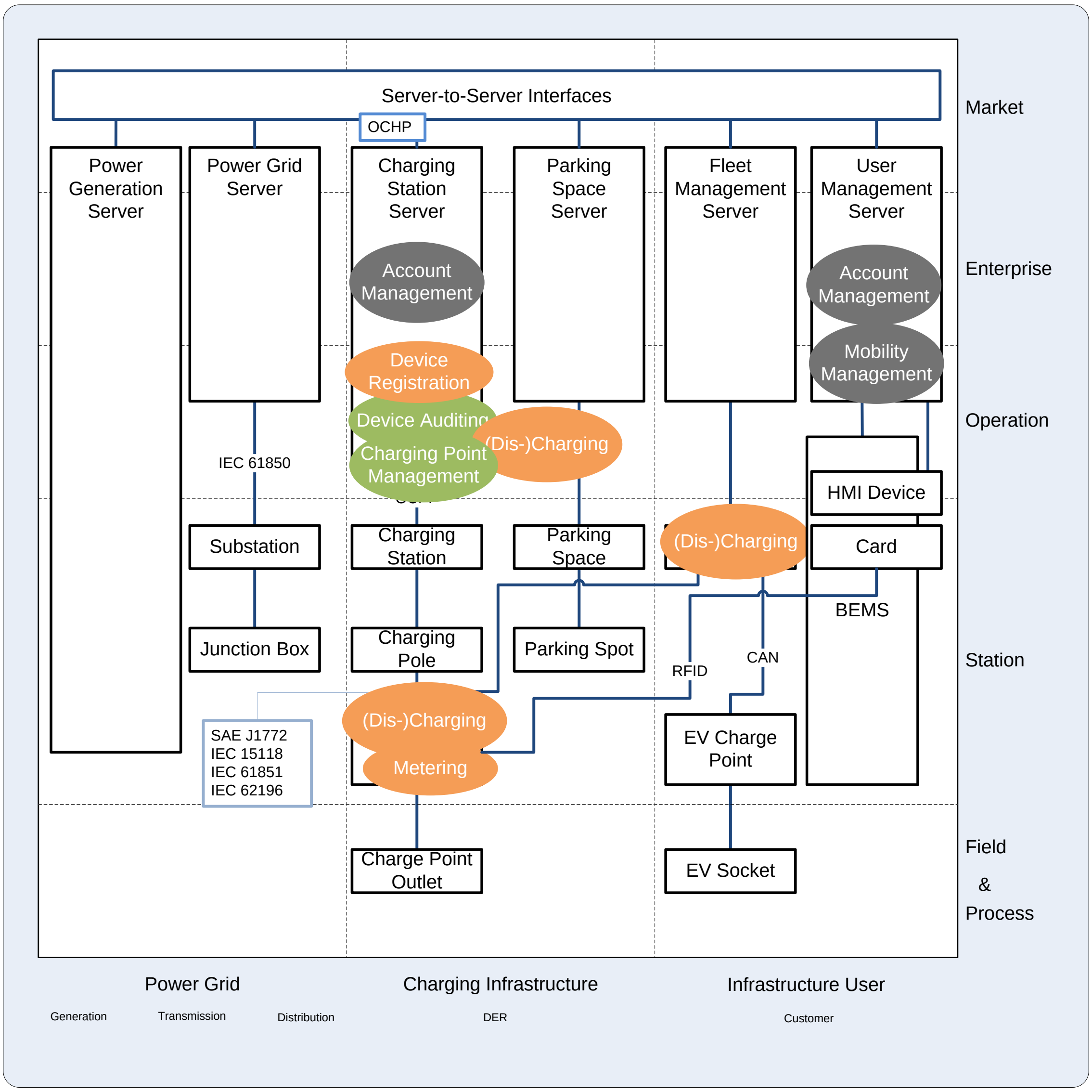

Figure 34: EM-SGAM function layer for E-Roaming

4.3.4.3 Vehicle to Grid (V2G)

Functionally, this use case scenario is comprised of all functions also needed in the two other scenarios. The operational aspects are more related to ICT Enabled Demand Side Management since V2G not only allows for EV charging rate adaptations, but also for operating EVs as DERs.

The SGAM function layer containing all scenario functions is given in Figure 35.

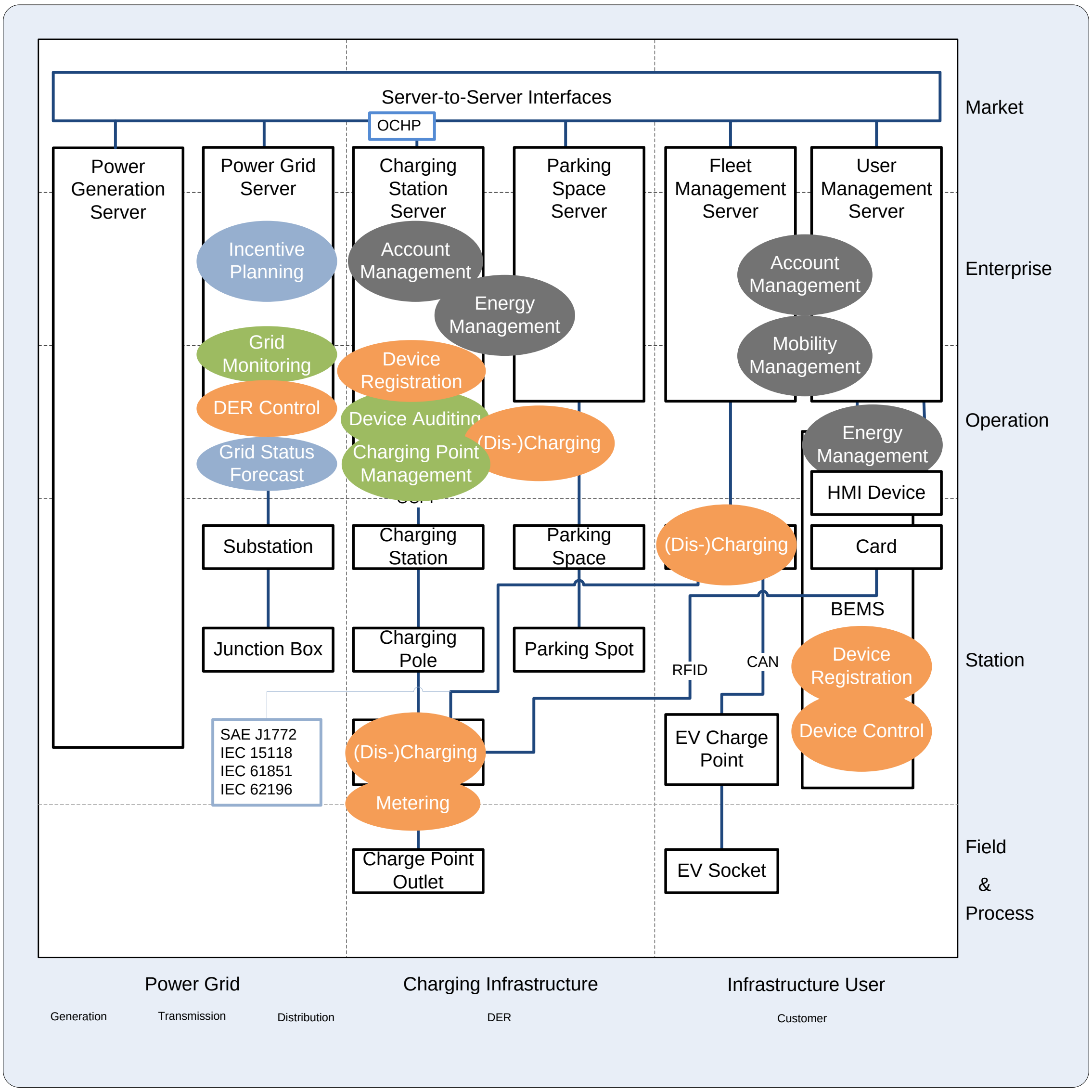

Figure 35: EM-SGAM Function Layer for Vehicle to Grid (V2G)

4.3.5 Mapping of ICT Requirements to functions

In a first step, WP5 collected use cases and then derived a first set of requirements. These requirements were consolidated over the different working packages and are to be found in deliverable D7.1. The final use cases (Section 3.2) as well as the consolidated WP5 requirements from D7.1 were the base to identify the first set of required functions (Section 4.3.3). A mapping between ICT requirements and these functions is given in Table 9.

ICT requirements	*Functions*
Billing and Payment Mechanism	User Management, Authentication, Authorisation, Tariff Management, E-Roaming Agreement Management, Metering, Rating, Billing, Clearing, Settlement, Accounting
Derivation of energy prices	Mobility Demand Management, Tariff Management, Grid Monitoring, Incentive Planning, Tradable Power Management, Energy Usage Scheduling
Forecast of grid loads	Mobility Demand Management, Grid Monitoring, (Dis-)Charge Scheduling & Optimisation, Charging Point Management, Grid Status Forecast, DER Control, Energy Demand Forecast
Smart charging scheduling	Tariff Management, Battery SoC Monitoring, Grid Monitoring, (Dis-)Charge Scheduling & Optimisation, (Dis-)charge Control, (Dis-)Charge Monitoring, Metering, DER Control, Energy Usage

ICT requirements	*Functions*
	Scheduling
Modularity of Communication Devices	User Management (for different smart phone technologies), Charging Point Connection Management, Device Control, Device Auditing, Device Registration
Future-proof system design requirements	<All functions are required to respond to this non-functional requirement>
Multi-Communication Media	User Management (for different smart phone technologies), Charging Point Connection Management
Low latency of data transmissions	Charging Point Management, Authentication, Authorisation
Support of different SLAs of network infrastructure	User Management, Authentication, Authorisation, EV Charging Point Connection Management
Varying Energy suppliers at one Public Charge Point	User Management, Authentication, Authorisation, Charging Point Management, Charging Point Connection Management, Tariff Management, Grid Monitoring, E-Roaming Agreement Management
Data management Performance	<All functions are required to respond to this non-functional requirement>
Simple Communication EV User - Charge Station	User Management, Authentication, Authorisation, Charging Point Connection Management, (Dis-)Charge Scheduling & Optimisation, E-Roaming Agreement Management, Metering
ICT Interoperability	Authentication, Authorisation, (Dis-)Charge Scheduling & Optimisation, (Dis-)Charge Control, (Dis-)Charge Monitoring, Charging Point Connection Management
Performance Management	Battery SoC Monitoring, Grid Monitoring, (Dis-)Charge Monitoring, (Dis-)Charge Scheduling & Optimisation
Availability	<All functions are required to respond to this non-functional requirement in on the right level>
Reliability	<All functions are required to respond to this non-functional requirement>
Scalability	<All functions are required to respond to this non-functional requirement, in particular with respect to expected increasing EV numbers>
Availability of Public Charge Points	Mobility Demand Management, Charging Point Management, Charging Point Connection Management
Remote Upgrades	User Management, Mobility Demand Management, Authentication, Authorisation, Device Control, Device Registration, Device Auditing
Network aggregation nodes	<All functions are required to respond to this non-functional requirement>
Wireless coverage	Charging Point Connection Management, User Management
Database system	User Management, Authentication, Authorisation, Charging Point Management, Charging Point Connection Management, Tariff Management, Grid Monitoring, E-Roaming Agreement Management
Authentication and authorisation	User Management, Authentication, Authorisation, Charging Point Connection Management, Access Control
Data backup and recovery	<All management functions are required to respond to this requirement in their particular way>
Data confidentiality	User Management, Authentication, Authorisation, Tariff Management, Mobility Demand Management, Metering
Data integrity	<All functions are required to respond to this non-functional requirement>
Non-repudiation	Authentication, Authorisation, Charging Point Connection Management, Grid Monitoring, (Dis-)Charge Monitoring, (Dis-)Charge Scheduling & Optimisation
System protection against malicious code	<All functions are required to respond to this non-functional requirement>
Denial-of-service (DoS) protection	<All functions are required to respond to this non-functional requirement>
Data privacy	User Management, Authentication, Authorisation, Charging Point Connection Management, Access Control

ICT requirements	*Functions*
Fault detection/monitoring system	Charging Point Connection Management, Grid Monitoring, (Dis-)Charge Monitoring, (Dis-)Charge Scheduling & Optimisation
Secure Software/Firmware Updates	User Management, Mobility Demand Management, Authentication, Authorisation
Security Management	<All functions are required to respond to this non-functional requirement>
Logging and Audit	User Management, Authentication, Authorisation, Charging Point Connection, Metering
Web-Service-enabled technologies for electricity network management	Charging Point Connection Management, Grid Monitoring, (Dis-)Charge Monitoring, (Dis-)Charge Scheduling & Optimisation

Table 9: ICT requirements to functions mapping

5. Mapping onto FI-WARE Generic Enablers

In this chapter a mapping between the functional components identified in Section 4.3.3 to FI-WARE platform Generic Enablers is described as applicable. The next two sections provide a short description about the FI-WARE Generic Enablers and a table that depicts the one to one mapping and justifies the rationale behind each pair is laid out in Section 5.3.

5.1 FI-WARE Architecture

The high level goal of the FI-WARE project is to build the core platform of the Future Internet. Generic Enablers are the building blocks of FI-WARE platform [28]. Any implementation of a GE is made up of a set of components which together support a concrete set of Functions and provides a concrete set of APIs and interoperable interfaces that are in compliance with open specifications published for that GE.

Specifically, the core platform provided by the FI-WARE project is based on GEs linked to the following main architectural chapters:

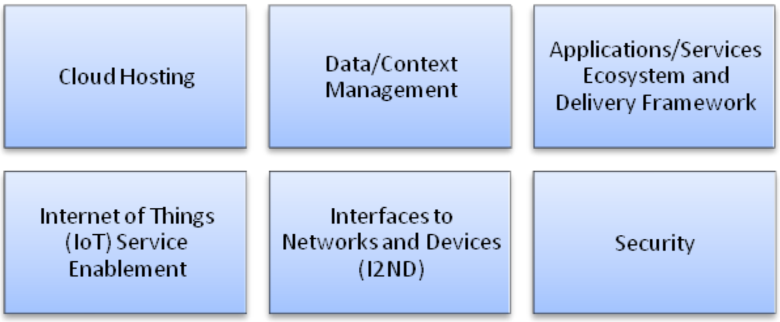

Figure 36: FI-WARE chapters

5.2 FI-WARE Generic Enablers included in FI-WARE Chapters

The following summarising information is taken from the FI-WARE product vision [28].

Cloud Hosting – offers Generic Enablers that comprise the foundation for designing a modern cloud hosting infrastructure that can be used to develop, deploy and manage Future Internet applications and services.

The list of GEs belonging to this chapter is:

- IaaS DataCenter Resource Management
- IaaS Cloud-Edge Resource Management
- IaaS Service Management
- PaaS Management
- Object Storage
- Monitoring
- CMDB
- Data Warehouse
- Metering & Accounting

Data/Context Management – aims at providing outperforming and platform-like GEs that will ease development and provision of innovative Applications that require management, processing and exploitation of context information as well as data streams in real-time and at massive scale..

The list of GE belonging to this chapter is:

- Publish/Subscribe Broker
- Complex Event Processing
- Big Data Analysis
- Multimedia Analysis
- Unstructured data analysis
- Meta-data Pre-processing

- Location
- Query Broker
- Semantic Annotation
- Semantic Application Support
- Generic Enablers Implementing Intelligent Services
  - Social Network Analysis
  - Mobility and Behaviour Analysis
  - Real-time recommendations
  - Behavioural and Web profiling
  - Opinion mining

Applications/Services Ecosystem and Delivery Framework – comprises a set of Generic Enablers for creation, composition, delivery, monetisation, and usage of applications and services on the Future Internet.

The list of GE belonging to this chapter is:

- Repository
- Registry
- Marketplace and Store
- Business Elements and Models Provisioning System
- Revenue Settlement & Sharing System
- SLA Management
- Composition editors
- Composition execution engines
- Mediation: Data Mediation, Protocol Mediation, Process Mediation
- Multi-channel / Multi-device Access System

IoT Services Enablement – comprises those Generic Enablers in FI-WARE enabling a large number of distributed and heterogeneous things and associated IoT resources to become available, searchable, accessible and usable by Future Internet Applications and Services.

The list of GE belonging to this chapter is:

- IoT Communications
- IoT Resources Management
- IoT Data Handling
- IoT Process Automation

Interface to the Networks and Devices (I2ND) – open interfaces to networks and devices, providing the connectivity needs of services delivered across the platform.

The list of GE belonging to this chapter is:

- Connected Devices Interfacing (CDI)
- Cloud Edge (CE)
- Network Information and Control (NetIC)
- Service, Capability, Connectivity and Control (S3C)

Security - mechanisms which ensure that the delivery and usage of services is trustworthy and meets security and privacy requirements.

The list of GE belonging to this chapter is:

- Security Monitoring (par of overall Security Management System in FI-WARE)
- Identity Management
- Privacy
- Data Handling

More detailed information can be found on the FI-WARE wiki page [32].

5.3 Mapping of the functional architecture to the Generic Enablers

The following table shows the mapping of the building blocks of the E-Mobility functional architecture to selected Generic Enablers. An individual building block can be realised by one or more GEs, and also an individual GE can be applicable to one or several building blocks. The mapping is not a 1:1 functional mapping, but for some functions parts of GEs are used and other functions use complete GE implementations for their realisations. A justification of the mapping is also given.

The mapping is based on the available documentation of the FI-WARE project [1, 33, 28, 34, 35, 32, 36]. The mapping of the building blocks to enablers was done on a high level, based on the available documentation. Technical details will have to be investigated case by case before a real implementation can be performed. It should also be mentioned that there are some cases of rather local or system internal functions which most probably will be implemented with proprietary solutions rather than with GEs. Still also for those cases a possible GE for potential implementation is suggested.

The chosen GEs to which the functional building blocks are mapped that have been derived in this work package are shortly described in Table 10, while the mapping that was performed is shown in Table 11.

FI-WARE Chapter	***FI-WARE Generic Enabler***	***Short Description***
Cloud Hosting	Object Storage	A storage service that operates at an abstract level. It stores items as units of both opaque data and meta-data and provides functionalities for the versioning of objects, the storage of objects along with user and provider specified metadata into logical and/or physical groupings as well as further possibilities to manage the data and integrate with other applications.
	Platform as a Service (PaaS)	An application delivery model in which the clients, typically application developers, follow a specific programming model to develop their applications and or application components and then deploy them in hosted runtime environments. This model enables fast development and deployment of new applications and components.
	Infrastructure as a Service (IaaS)	A model of delivering general-purpose virtual machines (VMs) and associated resources (CPU, memory, disk space, network connectivity) on-demand, typically via a self-service interface and following a pay-per-use pricing model. The virtual machines can be directly accessed and used by the IaaS consumer (e.g., an application developer, an IT provider or a service provider), to easily deploy and manage arbitrary software stacks.
	Software as a Service (SaaS)	In this model the client, typically end-users, rent the use of a particular hosted Final Application, e.g., word processing without needing to install and execute the application on top of equipment owned by the client (consumers) or assigned to the client (employees in a company). Applications delivered following a SaaS model are always available so that clients get rid of maintenance tasks (including upgrading, configuration and management of high-availability and security aspects, etc.). Computing resources needed to run applications on owned/assigned clients get minimised since they are hosted on the Internet/Intranet.
Data/Context Management	Complex Event Processing	The CEP GE is a Complex Event Processing Engine, providing event processing functions based on the design and execution of Event Processing Networks (EPN). Processing nodes that make up this network are called Event Processing Agents (EPAs). A framework is provided to assist in specifying the logic and defining the events to enable real-time information processing.
	Big Data	The Big Data platform provides a key-value database on an extended Map-Reduce framework and a bunch of functionalities to abstract from the differences in processing batch data (data previously stored for later analysis) and stream data (continuously unbounded and large streams of data analysed to extract relevant insights on the go).
	Localisation Platform	Designed to help with retrieving mobile device positions and location area events in difficult environments where GPS does not work probably such as urban canyons and light indoor environments. Various positioning techniques such as A-GPS, WiFi and Cell-Id are provided, but also end-user privacy is addressed.

FI-WARE Chapter	***FI-WARE Generic Enabler***	***Short Description***
	Publish/Subscribe Context Broker	Context Broker GE will enable publication of context information by entities, referred as Context Producers, so that published context information becomes available to other entities, referred as Context Consumers, which are interested in processing the published context information.
Applications/ Services Ecosystem and Delivery Framework	USDL Service Descriptions	The Unified Service Description Language (USDL) is a platform-neutral language for describing services. A wide range of services is targeted for coverage through USDL, from purely human/professional (e.g. project management and consultancy), transactional (e.g. purchase order requisition) to security and technical infrastructure (e.g. CPU and storage services).
	Business Models & Elements Provisioning System	Supports the setup of business models such that the specific parts of them will be available for applications, services, parties and users. Revenue sharing models are linked to applications, users and/or user groups and mechanisms to describe offers, prices, policy rules, promotions, business SLAs and more are provided.
	Registry	The Registry acts as a universal directory of information used for the maintenance, administration, deployment and retrieval of services. Existing (running) service endpoints as well as information to create an actual service instance and endpoint are registered.
	Marketplace	The marketplace is a platform to offer and trade services (in multiple stores). It enhances combinations of existing services and building of new business models and allows searching for and comparing offers. The final business transaction (buying) is done at the single store and the whole back office process is handled by the store.
	Revenue Settlement & Sharing System	Manages distribution of the revenues produced by a user's charges for the application or services he consumed. Different revenue models are provided for direct use.
	Repository	Together with the Registry and the Marketplace, the Repository is a core enabler of the FI-WARE Business Framework. The repository provides a consistent uniform API to USDL service descriptions and associated media files for applications of the business framework.
IoT Services Enablement	IoT Communications	The IoT Communications GE utilises RFID, wireless sensor networks and M2M technologies to support and manage communications between distributed things and device. Standard interfaces and interoperable solutions are developed and several protocols are integrated to coordinate the communication and interaction between things and high-level applications and services.
	Backend IoT Broker	The IoT Broker GE is a component for retrieving and aggregating information from the Internet of Things. It is the point of contact for accessing information about entities and their attributes.

FI-WARE Chapter	***FI-WARE Generic Enabler***	***Short Description***
	Backend Device Management	This GE is the central component for the IoT backend. It provides the resource-level management of remote assets (devices with sensors and/or actuators) as well as core communication capabilities such as basic IP connectivity and management of disconnected devices.
	Gateway Protocol Adapter	The Protocol Adapter GE deals with the incoming and outgoing traffic and messages between the Gateway and Devices registered to be served by the gateway. It is capable of serving non-IoT devices, i.e. devices that do not support ETSI M2M.
	Gateway Data Handling	The Data Handling GE addresses the need of filtering, aggregating and merging data from different sources; merging data is considered to be the main value-added feature.
	Gateway Device Management	This GE is responsible for the communication with the Backend and IoT and non-IoT devices. The Gateway Device Management GE includes the functional components to handle the registration/connection phases towards the Backend/Platform, to translate the incoming data or messages in an internal format and to send the outgoing data or messages in the ETSI M2M format. It is also capable of managing the communication with the IoT Resources, i.e. the devices connected to the IoT Gateway, and resources hosted by the gateway.
Interface to Networks and Devices	Connected Device Interfacing	Enables access to connected devices and provides applications to execute on the device, such as battery state-of-charge readings or location information.
Security	Identity Management (IdM)	Provides authentication/access control and identity/attribute assertion as a service as well as functions to support user management, user authentication, identity federation, credential management, access policy, administration and external directory services.

Table 10: Descriptions of GEs used in mapping

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
Grid Status Forecast 4.3.3.1.1	1,3	Data/Context Management	Big Data	Data stream analysis is provided.	Data Stream analysis	Streaming analytics can be used to determine a forecast pattern.	Object Storage, XaaS
			Complex Event Processing	CEP analyses event data in real-time.	Pattern Detection	Pattern detection based on retrieved data can support the forecast generation.	
Grid Monitoring 4.3.3.1.2	3	Applications/Services Ecosystem and Delivery Framework	Marketplace	This GE enables functionality for people to offer and deal with services. Therefore, this GE manages these services to be accessible by aggregators/customers.	Offering & Demand	Offering and demand of energy can be realised with the help of this GE.	
		IoT Services Enablement	Backend Device Management	Device information can be stored and event information can be retrieved.	Inventory Manager	Information on grid components can be stored and status information can be retrieved.	CDI

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
			IoT Broker	This GE acts as point of contact for accessing information about entities and their attributes.		Support in query and subscriptions to retrieve the required information for the defined context of grid status monitoring.	
DER Control 4.3.3.1.3	1,3	IoT Services Enablement	Gateway Device Management	Allows for communication with the Backend, including registration.	Resource Management, Communication Core	Retrieval of information as well as sending outgoing data.	
			Protocol adapter	Allows for protocol conversion for device specific protocols and translates them to a uniform internal API.	Protocol Adapter	Might be required for devices that do not support ETSI M2M.	
			IoT Gateway Data Handling	This GE takes care of filtering, aggregating and merging data from different sources.	Northbound, CEP	Support in data evaluation for DER Control purposes.	IoT Broker
Incentive Planning 4.3.3.1.4	1,3	Applications/Services Ecosystem and Delivery Framework	Marketplace	The Marketplace provides functionality necessary for bringing together offering and demand for making business.	Offering & Demand	This incentive planning will be based on offering & demand capabilities.	

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
E-Roaming Agreement Management 4.3.3.2.1	2	Applications/Services Ecosystem and Delivery Framework	Registry	The registry can store and make accessible both static and volatile information.	Register Entries, Deregister Entries, Retrieve Registry Entries	Services contract information can be stored, updated and retrieved in the registry.	Repository
Mobility Demand Management 4.3.3.2.2	1,2,3	Cloud Hosting	Object Storage	Could be used to implement storage for user's driving patterns. Big Data GE seems to be the more suitable solution, since it offers appropriate storing mechanisms and methods and algorithms for analysing the data gathered at once.	Versioning of Objects	Maybe used to store activities and battery level according to their timestamp.	Big Data GE for storage and batch processing
					Object storing along with user	An activity/battery level is automatically stored in connection with the user	
					Tools to group objects logically or physically as well as metrics	Sorting and first insights into user behaviour patterns	
		Data/Context Management	Big Data GE	Storage and analysis of user's driving patterns and battery levels to ensure accurately timed additional charging. Choice between CEP and Big Data GE should mainly base on	Key-value storage	Storage of user patterns and battery level; good scalability with regard to later extensions	Object Storage

Functional Building Block & Section	*WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)*	*FI-WARE Chapter*	*FI-WARE Generic Enabler*	*Comment/ Mapping Justification*	*Functionalities probable to use*	*Mapping Explanation*	*alternatively proposed GE*
				the needs of real-time analysis regarding this building block. Additionally, there is an integration of these two GEs planned which could be highly useful for mobility demand management.	Batch Processing	Useful to analyse a huge amount of previously stored user patterns and battery levels in order to monitor and control charging processes.	
			Complex Event Processing	This GE may be used as part of mobility management implementation for event processing purposes.	Tools to define different Event Processing Nodes (Agents) in an Event Processing Network	Define the network of EVs and their users as an event processing network, were each Event Processing Agent (EPA) processes the activity and battery events of one EV	Big Data GE for Stream processing
			Localisation Platform	This GE could be used for EV localisation purposes.	Provides mobile location and geo-fencing events	Locate EVs and generate appropriate events to represent user patterns and battery levels	
					Configurable end-user privacy management per third-party application	Manage privacy of EV users	

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
		Interface to Networks and Devices	Connected Device Interfacing	This GE may be used to connect EVs or parts of it to services offered over networks.	On Device Interface, Remote Management Interface, Mobility Manager Interface	Status update messages (general for devices) as well as battery state and geographic location can be provided.	IoT Communications (product vision)
Charging Point Connection Management 4.3.3.2.3	1,2,3	Data/Context Management	PubSub Context Broker	Registers context information and updates, based on NGSI Context Management specifications.	Publish, subscribe, register update, notify, query	Connection notifications including attributes can be registered and queried.	IoT Communications (product vision)
Battery SoC Monitoring 4.3.3.2.4	1,3	Interface to Networks and Devices	Connected Device Interfacing	This GE may be used to read the battery status information from the EV.	On Device Interface, Remote Management Interface, Mobility Manager Interface	Status update messages (general for devices) such as battery state can be provided.	IoT Communications (product vision)
Energy Demand Forecast 4.3.3.3.1	1,3	Data/Context Management	Big Data	Data stream analysis is provided.	Data Stream analysis	Streaming analytics can be used to determine a forecast pattern.	Object Storage, XaaS

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
			Complex Event Processing	CEP analyses event data in real-time.	Pattern Detection	Pattern detection based on retrieved data can support the forecast generation.	
Tradable Power Management 4.3.3.3.2	1,2,3	IoT Services Enablement	Gateway Data Handling	This GE takes care of filtering, aggregating and merging data from different sources.	CEP component	Filtering and aggregation of data can support determining the available tradable power.	
Energy Usage Scheduling 4.3.3.3.3	1,2,3	Data/Context Management	Big Data	Data stream analysis is provided. Data volumes are not expected to be extremely high.	Data Analytics	This GE enables analysis of data from different sources to be used for scheduling optimisation.	
(Dis-)Charge Scheduling & Optimisation 4.3.3.3.4	1,3	Interface to Networks and Devices	Connected Device Interfacing	This GE enables the possibility to exploit device features and capabilities through the implementation of interfaces and related APIs towards the connected devices.	On Device Interface, Remote Management Interface	Acquisition of information from the grid and the EV can be performed.	IoT Communications (product vision)

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
		Data/Context Management	Big Data	This GE enables analysis of data from different sources.	Data Stream analysis	This GE enables analysis of data from different sources to be used for scheduling optimisation.	
(Dis-)Charge Control 4.3.3.4.2	1,3	Interface to Networks and Devices	Connected Device Interfacing	This GE may be used to read battery information from the EV.	On Device Interface, Remote Management Interface, Mobility Manager Interface	Status update messages (general for devices) such as battery state can be provided.	IoT Communications (product vision)
(Dis-)Charge Monitoring 4.3.3.4.3	1,3	Data/Context Management	PubSub Context Broker	Registers context information and updates, based on NGSI Context Management specifications.	Publish, subscribe, register update, notify, query	Connection notifications (changes in charging status) including attributes can be registered and queried.	IoT Communications (product vision)
Charging Point Management 4.3.3.4.4	1,2,3	Applications/Services Ecosystem and Delivery Framework	Registry	The registry can store and make accessible both static and volatile information.	Register Entries, Deregister Entries, Retrieve Registry Entries	Charging Points can be registered (and updated) with their properties, which can then be retrieved by agreed actors.	IoT Communications (product vision)

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
Metering 4.3.3.4.5	3	Interface to Networks and Devices	Connected Device Interfacing	This GE may be used to read the charging information from the charging station.	On Device Interface, Remote Management Interface	The metering results from the charging stations can be retrieved.	IoT Communications (product vision)
		Data/Context Management	BigData	Data storage is provided for later processing	NoSQL	Metering data can be stored and made available for later processing.	
Device Registration 4.3.3.5.1	1,2,3	IoT Services Enablement	Gateway Device Management	The GE also contains Resource Management capabilities, i.e. to keep track of IoT Resource descriptions that reflect those resources that are reachable via the gateway.	Resource Management	The devices can be registered and device information is administered.	Connected Device Interfacing, Backend Device Management
Device Control 4.3.3.5.2	1,2,3	IoT Services Enablement	Backend Device Management	Devices need to be remotely controlled and managed.	Device Control	Control commands can be sent to devices.	
			Gateway Device Management	The Gateway Device Management GE enables basic communication with resources hosted on devices outside the gateway as well as resources hosted by the gateway.	Accessing Resources	This GE provides basic functionality required for Backend Device Management.	

Functional Building Block & Section	*WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)*	*FI-WARE Chapter*	*FI-WARE Generic Enabler*	*Comment/ Mapping Justification*	*Functionalities probable to use*	*Mapping Explanation*	*alternatively proposed GE*
		Interface to Networks and Devices	Connected Device Interfacing	Remote Management actions like Device Configuration and Firmware Update are planned in this GE.	Remote Management Interface	The required O&M functions like reconfiguration and firmware upgrades are supported by this GE.	
Device Auditing 4.3.3.5.3	1,2,3	IoT Services Enablement	Backend Device Management	The Inventory Manager provides the basic business logic for maintaining an inventory of connected M2M devices and their relationship to remote assets, allowing to access data of remote sensors.	Inventory Manager and Inventory Blocks	Device auditing could be part of the inventory management process.	
User Management 4.3.3.6.1	1,2,3	Security	Data Handling	This GE may be used optionally in order to enable users to define access policies for their personal data.	Access policy definition	Different access policies can be needed for different providers	
Tariff Management 4.3.3.6.2	2,3	Cloud Hosting	Object Storage	To be decided whether a cloud approach such as the GE “Object Storage” is to be used or if standard database technology would be preferred.	Storage of objects including metadata into logical or and or physical groupings	Storing of the tariff information of one EV user as an object (logical grouping) and/or of user tariff information according to locations/areas (physical grouping)	

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
					Versioning	Versioning of tariff details per user to support tariff management and enable offer of add-on offers or similar	
		Applications/Services Ecosystem and Delivery Framework	Marketplace	Tariff information has to be stored and matched to the end user.	Register Entity, Create/Update Offering	The consumer information and tariff information can be stored and matched.	
Authentication 4.3.3.6.3	1,2,3	Security	Identity Management (IdM)	IdM also encompasses support for authentication of things for services, objects and users as relying parties.	Authentication	IdM directly provides this functionality	
Authorisation 4.3.3.6.4	1,2,3	Applications/Services Ecosystem and Delivery Framework	USDL Service Descriptions (*)	Authorisation for granting access to resources is realised locally within the system. Unified Service Description Language (USDL) may be used to describe SLAs that can be used as input for authorisation.			

Functional Building Block & Section	*WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)*	*FI-WARE Chapter*	*FI-WARE Generic Enabler*	*Comment/ Mapping Justification*	*Functionalities probable to use*	*Mapping Explanation*	*alternatively proposed GE*
Access Control 4.3.3.6.5	1,2,3	Security	Identity Management (IdM)	IdM realises authentication of users to a given system. This is the basis for access control which may only rely on successful authentication.	Authentication	IdM could be used to enable access control based on authentication function. Fine grained access control on a system is managed locally within the system e.g., operating systems Access Control Lists (ACL) for user accounts	Data Handling GE which realises access control to user account data
		Applications/Services Ecosystem and Delivery Framework	USDL Service Descriptions (*)	Authorisation for granting access to resources is realised locally within the system. Unified Service Description Language (USDL) may be used to describe SLAs that can be used as input for authorisation.			
Accounting 4.3.3.6.6	1,2,3	Applications/Services Ecosystem and Delivery Framework	Business Models & Elements Provisioning System	If this GE is used to set up the business model, it can then also be employed for accounting.	Support functions to define the business model.	Customers' accounting data has to be available before any transaction relevant action takes place in order clear the transaction and enable billing and	

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
						settlement.	
Rating 4.3.3.6.7	2,3	Applications/Services Ecosystem and Delivery Framework	Business Models & Elements Provisioning System	This GE could be used to support the process of calculating the actual charges due to the data from the metering building block.	Support functions to define the business model.	Pre-defined business models for different metering function results are possible.	
					Techniques regarding aggregation, composition, bundling, mash-ups, settlement and revenue sharing business models.	Could potentially help with defining new pricing models or react to unforeseen metering results, such that an appropriate reaction can follow much faster.	
Clearing 4.3.3.6.8	2,3	Applications/Services Ecosystem and Delivery Framework	Marketplace	Independent trustee and clearing house. (Product Vision)	Discovery and matching	This GE should include clearing functionality.	

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
Billing 4.3.3.6.9	2,3	Applications/Services Ecosystem and Delivery Framework	Business Models & Elements Provisioning System	If this GE is used to set up the business model, it can then also be employed to describe offers, prices, policy rules, promotions, business SLAs and more to the customers and link the appropriate revenue share model.	Offers functionalities to describe offers, conditions and prices.	Conditions and prices might be directly exported for billing.	Depending on the complexity of the overall business model and the revenue sharing model, maybe the revenue settlement & sharing GE is enough.
					Techniques regarding aggregation, composition, bundling, mash-ups, settlement and revenue sharing business models.	Could help to increase flexibility of the whole business model.	
			Revenue Settlement & Sharing System	When it comes to the billing of the EV users, this GE could be used manage the distribution of the revenue in advance.	Definition and storage of different revenue share models	Defining a revenue share model in advance were all parties involved could agree to.	
					Possibility of storage and log of payment and charging data.	Store payment data and charging logs to support billing processes.	

Functional Building Block & Section	***WP5 Use case (1= ICT DSM, 2=E-Roaming, 3=V2G)***	***FI-WARE Chapter***	***FI-WARE Generic Enabler***	***Comment/ Mapping Justification***	***Functionalities probable to use***	***Mapping Explanation***	***alternatively proposed GE***
Settlement 4.3.3.6.10	2,3	Applications/Services Ecosystem and Delivery Framework	Revenue Settlement & Sharing System	When it comes to the payment by the EV users, this GE could be used to determine and manage the distribution of the revenue between the parties being involved.	Definition and storage of different revenue share models	A provided revenue share model could be used or a new one could be defined to ease the distribution of revenues.	
					Possibility of storage and log of payment and charging data.	Store payment data and charging logs to support payment processes.	

(*) USDL Service Descriptions are not considered a separate GE but can be used for function implementation.

Table 11: Mapping to FI-WARE GEs

5.4 GE Gap Analysis

As can be seen from the mapping table in chapter 5.3 showing the possible realisation of the identified building blocks with FI-WARE Generic Enablers, all building blocks were judged to be implementable by support of Generic Enablers. However, due to the more domain specific nature of certain functions, it is believed that the implementation of e.g. EVSEs and also the algorithms for load shedding as part of the control room operations will rather remain domain-specific solutions. These functionalities were identified as Domain Specific Enablers by WP5 and are described in deliverable D8.2 [37].

6. Information & Data Models

This section gives an overview of information and data models related to this functional architecture. At first, existing standards including data models with relevance for e-mobility in a Smart Grid are listed and explained (6.1). Afterwards, information and data objects with most importance for this functional architecture are listed and described (6.2). Finally, the classes are elaborated in more detail (6.3).

6.1 Relevant Standards

6.1.1 Smart Grid Standards with Reference to E-Mobility

The International Electrotechnical Commission (IEC) has identified over 100 standards being relevant to the Smart Grid. Below is the list of the given core standards (cf. [38]):

1. IEC 62357: Power systems management and associated information exchange
2. IEC 61970: Common Information Model (CIM) / Energy Management
3. IEC 61850: Substation Automation
4. IEC 61968: Common Information Model (CIM)
5. IEC 62056: Data exchange for meter reading, tariff and load control
6. IEC 62351: Security (cf. Deliverable D1.11 [30], p. 53 ff.)

The complete list of IEC Standards (by importance and relevant application) is available for download (cf. [38]).

6.1.1.1 IEC 62357 – Power systems management and associated information exchange - Part 1: Reference architecture

The IEC Technical Committee (TC) 57 is developing standards for electric power system management and associated information exchange in the areas of generation, transmission and distribution real-time operations and planning as well as information exchange to support wholesale energy market operations. The TC specifies the IEC 62357, a reference architecture and framework for the development and application of further IEC standards for the exchange of power system information.

As a smart grid report, it needs to be considered in all cases where EVs are needed to be integrated smoothly into the distribution level of smart grids. It frames data standards such as IEC 61970 (CIM) or IEC 61850 that are explained in the following.

6.1.1.2 IEC 61970 – Common Information Model (CIM) / Energy Management

The IEC 61970 series of standards consist of five parts:

- Part 1: Guidelines and general requirements
- Part 2: Glossary
- Part 3: Common Information Model (CIM)
- Part 4: Component Interface Specification (CIS)
- Part 5: CIS Technology Mappings

Most importantly, part 3 defines data objects about the configuration and status of an electrical network, in particular the transmission network. This standard could be extended to integrate new data objects specific to EV usage as soon as there are more EVs on the market for services such as V2G.

6.1.1.3 IEC 61968 – Common Information Model (CIM)

IEC 61968 extends the CIM (as defined in IEC 61970-301) to meet the needs of electrical distribution.
Therefore, it defines standards for data exchanges between electrical distribution systems. IEC 61968 shall support utilities to collect data from different applications and integrate them beyond the border of different interfaces.

Since IEC 61968 focuses on the distribution level, data objects of EV e.g. for voltage stability could be integrated in this set of standard. Yet, an even better fitting place for the integration of these data objects might be IEC 61850, as described as follows.

6.1.1.4 IEC 61850 – Substation Automation

IEC 61850 is a standard for the design of electrical substation automation. IEC 61850 is a part of the International Electrotechnical Commission's (IEC) Technical Committee 57 (TC57) reference architecture for electric power systems. The abstract data models defined in IEC 61850 can be mapped to a number of protocols. Current mappings in the standard are to MMS (Manufacturing Message Specification), GOOSE, SMV, and soon to Web Services. These protocols can run over TCP/IP networks or substation LANs using high speed switched Ethernet to obtain the necessary response times below four milliseconds for protective relaying.

While the scope of IEC 61850 is mainly related to any kind of (smart) grid assets (e.g. substations, protection assets, all kind of DERs) and its communication to control centres, it was recently adapted for managing charging of electric vehicles. In the EDISON project [39], a charging station using IEC 61850 was built up and tested [40]. Moreover, a case study was conducted for EVs mapping IEC 61850 on RESTful services [41]. All in all, this general Smart Grid standard could be applied for communication between EVSE and an IT-backend. However, due to its complexity and grid focus, it will probably be applied mainly for larger aggregations of EVSEs, e.g. in parking garages or big parking places.

6.1.1.5 IEC 62056 – Data Exchange for Meter Reading, Tariff and Load Control

This set of standards refers to electricity metering and its corresponding data exchange, including tariffs and load control information.

Since in most use cases, the energy consumed for charging shall be registered and potentially billed per charging transaction, metering is a core functionality of most EVSE. In order to read this information, out of EVSEs, this standard could be used. However, depending on national rules, high security requirements are to be fulfilled that are not covered by this standard (e.g. in Germany, the protection profile of the Federal Office for Information Security).

6.1.2 E-Mobility Specific Standards

The following standards are specifically developed with respect to the domain of e-mobility. They all contain some data objects, e.g. as part of extended messages:

- ISO/IEC 15118 – Road vehicles — Vehicle to grid communication interface
- OCPP – Open Charge Point Protocol
- OCHP – Open Clearing House Protocol

Since these ICT standards can also be used for the interaction of EVs with the power grid, they are described in more detail, in particular with respect to their relation to data objects and its modelling.

6.1.2.1 ISO/IEC 15118 – Road Vehicles — Vehicle to Grid Communication Interface

The standard ISO/IEC 15118 is developed by the Technical Committee ISO/TC 22, Road vehicles, Subcommittee SC 3, Electrical and electronic equipment. It is currently in stage "Full report circulated: DIS approved for registration as FDIS" (40.99)[4]. The scope of ISO/IEC 15118 is "… the communication between electric vehicles (EV) […] and the electric vehicle supply equipment (EVSE)." [4]. Yet, the vehicle internal communication (e.g. between battery and charger) is out of scope. The focus of this standard is on electric road vehicles, but it should not prevent other vehicles from preventing this standard. The standard consists of three parts:

- ISO/IEC 15118 – Part 1: General information and use-case definition
- ISO/IEC 15118 – Part 2: Technical protocol description and open systems interconnections (OSI) requirements
- ISO/IEC 15118 – Part 3: Physical and data link layer requirements

Part 1 lists relevant primary and secondary actors, most importantly the Electric Vehicle Communication Controller (EVCC) and Supply Equipment Communication Controller (SECC), as well as the following eight use case function groups:

[4] For details about the different stages cf. http://www.iso.org/iso/home/standards_development/resources-for-technical-work/stages_table.htm.

- A: Start of charging process
- B: Communication setup
- C: Certificate handling
- D: Identification, authentication, authorisation
- E: Target setting and charge scheduling
- F: Charge controlling and re-scheduling
- G: Value added services
- H: End of charging process

Part 2 contains mainly the basic requirements for V2G communication and the specification of application layer messages. The message definitions are a kind of data model. Relevant data objects are hierarchically structured and typified. Annex C of [5] provides XML schema definitions for all the data objects that can be part of the defined messages.
Part 3 describes the OSI-layer 1 and 2 requirements and currently proposes an option on using Powerline Communication (PLC) via the “HomePlug Green PHY Specification” of the home plug alliance.
Many companies from different industry sectors are working together to finalise this standard. Since international standardisation takes its time, but many companies already wanted work with the content of IEC 15118, there was the DIN SPEC 70121:2012-08 [42] defined, that mirrors part 2 of ISO/IEC 15118. First EVs (e.g. VW E-Up, BMW i3) and charging infrastructure supporting communication via this standard are expected to appear end of 2013 on the market. Due to the broad support of this standard, Future Internet applications should strongly consider to apply this standard for modelling data objects at the interface between EV and EVSE.

6.1.2.2 OCPP – Open Charge Point Protocol

The Open Charge Point Protocol (OCPP) was initiated by the Dutch E-laad Foundation [43] as an open standard. It describes a method enabling EVSE to communicate with a central system and the backend of E-Mobility IT infrastructure. Both sides can initiate the communication, e.g. the EVSE (therein called charge box) to request authentication of users/EVs for charging or e.g. the IT backend (therein called central system) in order to request a firmware update. The standard uses the Simple Object Access Protocol (SOAP) over HTTP for data exchange. (cf. [7]) Chapter 6 of the standard contains the necessary message definitions. A message consists of several data fields whose types are defined in chapter 7. The current version of this specification is publicly available [8] and used by more and more EVSE operators all over Europe. Therefore, the data models and semantics provided by this standard should be considered by any Future Internet application at the interface between the EVSE Operators and its IT backend.

6.1.2.3 OCHP – Open Clearing House Protocol

The Open Clearing House Protocol (OCHP) was initiated by Ladenetz [29] together with its Dutch and Belgian partners (“Treaty of Vaals”). It enables different EVSE operators the provisioning of access to foreign customers for the usage of their charging infrastructure (cf. E-Roaming in Section 3.2.2). In order to prevent n:m-communication between the EVSE operators and/or EMSP, it is more efficiently to include a so called roaming hub respectively clearing house. While a roaming hub provides authentication, authorisation and exchange of data about the charge services, a clearing house also provides the service of a financial clearing (settlement). The publicly available specification [44] describes four functions (cf. Section 7.2.5).
For each of these functions, a message set is defined in order to provide the needed communication between EVSE Operator and its IT system (therein called Chargepoint Management System) and the IT system of the roaming/clearing hub/house (therein called Clearing House System). Each message set contains data fields ([44], Chapter 3) and for each field a type is defined ([44], Chapter 4).
An implementation of this specification is currently operating between the Roaming Hub “e-clearing.net” and its roaming networks (e.g. Ladenetz, E-Laad, Blue Corner, etc.). This specification is also considered by the E-Mobility ICT Interoperability Interest Group (eMI3) (cf. Section 1.3) for international roaming on a larger scale. Henceforth, Future Internet applications at the wholesale interface between EVSE operators, EMSP and roaming/clearing houses/hubs should consider using the data models provided by the OCHP specification.

6.2 Information Objects in the Functional Descriptions

As seen in the section before, there are many different E-Mobility specific data models defined in standards, each of them describing a certain area of management or interface. The following section tries to abstract from this specific interface descriptions and identifies data objects and classifications that could be used in many use cases and Future Internet applications – in particular in relation to the use cases of this document and its functional building blocks (Section 4.3.3). Therefore, Table 12 lists the functional building blocks along with the information objects that are processed by the functions. Information objects can be grouped into categories listed in the first column and further described in the next section.

Category	*Information Objects*	*Function*
User Information	*User credentials*: • name • surname • UID (Universal ID) • Cryptographic keys • postal address • financial details (bank account and credit card number) • contractual information • user status (valid, on hold, blocked)	User Management, Authentication, Authorisation, Access Control, Accounting, Billing
	User preferences: • minimum energy for V2G services • maximum energy price for extra charging • maximum total cost in case of extra charging • distance to go with next trip • minimum SoC to be maintained	User Management, Charging (Connection) Point Management, (Dis-) Charging, (Dis-)Charge Scheduling & Optimisation
	Authorisation credentials: • *User Credentials* (UID) • Equipment ID • Cryptographic keys • ACLs (Access Control Lists)	Authentication, Authorisation, Access Control
	Statistical Information: • recorded trips • charging frequency • used EVSEs • used charging modes • EVSE operator preferences • V2G statistics • Historical billed charging tariffs	Energy Demand Forecast, Energy Usage Scheduling, Tradable Power Management, Mobility Demand Management
EV Information	*Status information*: • EV ID • EV model • Communication capabilities • Battery capacity • Supported charging plugs • Supported charging modes • battery state of charge (SoC) • geographical location • planned route • charging trigger threshold • price trigger threshold	Mobility Demand Management, Charging Point Connection Management, Energy Demand Forecast, Tradable Power Management, Battery SoC Monitoring, (Dis-)Charge Scheduling and Optimisation
	Statistical Information: • *User Information(Statistical Information)*[5]	Mobility Demand Management, (Dis-)Charge Scheduling and Optimisation
Charging Process and Equipment Information	*EVSE availability and reservation information*: • EVSE IDs • EVSE capabilities (no. of charge point outlets, supported plug types, supported charging modes, payment options)	Charging Point (Connection) Management, Mobility Demand Management, (Dis-)Charging, (Dis-)Charge Scheduling &

[5] This information is linked to the user statistics or the other way around if several users use a single EV.

Category	*Information Objects*	*Function*
	• EVSE geo locations • EVSE status (idle, reserved, online, offline) • (dis-)charging tariffs • *User Information(User credentials, User preferences)* • *EV Information(Status information)*	Optimisation, E-Roaming Agreement Management
	EVSE control & monitoring: • Status information • (dis-)charging commands • EVSE version	Charging Point Management, (Dis-)Charging
Metering Information	*Consumption:* • Amount of energy • Timestamps *Power line quality:* • Frequency • Voltage • Reactive power	Metering, Rating, Grid Monitoring, Settlement
Financial Information	*Tariff information:* • Dynamic prices (time, charging mode) *Billing:* • Electronic bills • Tax information • Amount of energy charged • Price • Payment mode *Settlement:* • Charging records • Money transfer documents	Rating, Billing, Clearing, Settlement, Incentive Planning, Tariff Management, E-Roaming Agreement Management, Charging Point Connection Management
External Information	*Distribution grid status information*: • Grid capacity • Power generation capacity	Grid Monitoring, Grid Status Forecast, Tariff Management, (Dis-)Charge Scheduling & Optimisation

Table 12: Information Objects

6.3 Categorisation of Information Objects

The information objects listed in Table 12 can be categorised into the following groups:

- User information
- EV information
- Charging process and equipment information
- Metering information
- Financial information
- External information

The following paragraphs describe the different categories, list the affected functions and state where the categories are located in the SGAM framework.

6.3.1 User Information

User information comprises all information related to users of E-Mobility. This ranges from account information to rather technical details to customer preferences and to mobility needs. Some of this information is rather static (e.g., name, access credentials) while other information like preferences (e.g., acceptable prices for charging) and mobility needs (e.g., driving to work, visiting relatives, vacation) might change more frequently and depend on the daily habits and plans of the person. One property of all data in this category is that it is relevant for privacy risks and requires respective protection.

In the EM-SGAM framework, user information is naturally located in Infrastructure User domain and in the operation and enterprise zones. The zone allocation is like that as the EV users typically communicate with the charging management systems located in the Operation and Enterprise zones and have contracts with service providers located in the enterprise zone.

6.3.2 Electric Vehicle Information

EV information refers to both static information regarding a particular car (e.g., ID, type, capacity of the battery, maximum current) and the current status of a car (e.g., battery state of charge, geographical location). All this information is of technical nature and is needed as input for (planning) (dis-) charging processes. As cars are used by humans, status information of cars might be mapped to individuals. This requires the same privacy protection as with user information.

In the EM-SGAM framework, EV information is located in the Charging Infrastructure and Infrastructure User domains and in the operation zone. The domain is set to the Infrastructure User as EVs consume energy triggered by customers, and they can be used as a DER in the V2G scenario, therefore co-located in the Charging Infrastructure domain. The zone allocation is set to Station and Operation since EVs are connected to charging management systems located in the Operation zone as well as to EVSEs located in the Station zone.

6.3.3 Charging Process and Equipment Information

Information on charging process and equipment covers all information on the current and scheduled charging processes and the electric vehicle supply equipment (EVSE). Information on the EVSE can be of static nature (e.g., supported charging modes and payment methods) or dynamic nature (e.g., current and planned availability and reservation). Besides the information available in the EVSE and the supporting systems, also respective messages sent to EVs and their users (e.g., information regarding the current or scheduled (dis-)charging processes, connection messages inside EVs) represent information on charging process and equipment. However, this information is typically derived from the respective systems.

In the EM-SGAM framework, charging process and equipment information is located in the Charging Infrastructure and Infrastructure User domains and in the Station and Operation zone. The belonging to the domains Charging Infrastructure and Infrastructure User is reasonable since information on charging equipment belongs to Charging Infrastructure domain and Station zone and is needed in the Operation zone for further processing inside the management systems. They can also be used as a DER in the V2G scenario.

6.3.4 Metering Information

Metering information is concerned with all metered information of charging processes. This includes the metered data at the EVSE, in particular in relation to the time. The time might have different granularities and is important for realising a correct settlement when charging has different prices at different points in time. Metering information can be aggregated at different levels (e.g., all EVSE from one operator, all EVSE in the same segment of the grid), but should have a defined persistence at the metering location. Additional to information on charging processes, the current status of the electricity grid (e.g., frequency, reactive power) may be monitored locally for further processing.[6]

In the EM-SGAM framework, metering information is located in all three domains and in the Station and Enterprise zones. The domain is set to the Infrastructure User as EVs charging processes are triggered by the customers, it is set to Charging Infrastructure as EVs can be used as a DER in the V2G scenario, and it is set to Power Grid as local monitoring functions can provide important information on the status of the distribution grid. The zone allocation is set to Station as this is the place where metering takes place, it is set to Operation as EVs are connected to charging management systems located in this zone, and it is set to Enterprise as metering information is needed for all financial processes.

6.3.5 Financial Information

Financial information subsumes all information (in the context of (dis-)charging EVs) related to tariffs and possibly their negotiation on the one side and prices, bills and payments on the other side. Energy prices to be paid by the EVSE operator are considered to be external information. Charging Point

[6] This is not a classical metering function, but has a closer relation to Grid Monitoring (4.3.3.1.2).

Connection Management (Section 4.3.3.2.3) is also uses financial information as the EVSE is used to communicate tariffs and prices to the consumer.

In the EM-SGAM framework, financial information is primarily located in the Infrastructure User domain and in the Enterprise zone due to the fact that customers pay (are paid) for (dis-)charging and they have their relations with providers in the Enterprise zone. However, the Charging Infrastructure domain is also touched as EVs can be used as DER in the V2G scenario, and the Operation and Station zones are touched as providers' management systems and EVSEs are involved in communicating financial information.

6.3.6 External Information

External information subsumes all information which is not directly related to E-Mobility, but provides input for the respective processes. For instance, information regarding the state of the electricity grid and generation/DER capacities can be considered for scheduling charging processes and market prices can be used as an input for deriving (dis-)charging tariffs. Typically, all this information is dependent on time.

In the EM-SGAM framework, external information covers a broad area as it collects information from many different stakeholders in the whole energy system. It is therefore located in all three domain and in the Operation, Enterprise and Market zones.

7. Communication Protocol Architecture

7.1 Communication and Interoperability Layers

The communication protocol architecture needs to be specified for each e-mobility application supported by ICT systems and consists of several layers, as is used in the OSI-Model. SGAM's Communication Layer covers GridWise's network and syntactic interoperability categories [45]. They have a mapping to the OSI model defined by ITU-T's X.200 series of recommendations [46, 47] that is the classical model for communication systems' structuring. Both terms are defined after [45] as follows.

7.1.1 Network Interoperability

Exchange messages between systems across a variety of networks. This category is described in [45], Section 3.1.2, it covers OSI layers 3 (network), 4 (transport), 5 (session) and sometimes also 7 (application). This category serves two main purposes: addressing (physical to/from logical) and reliable and secure data transfer. Quotation from [45], Section 3.1.2:

- Translation of logical addresses and names into physical addresses in the same way that a phone book translates human names into numbers used by the phone system.
- Transparent and reliable transfer of data between systems. This usually includes end-to-end error recovery and flow control and the assurance of complete data transfer, which includes
    - transference of data between the source and destination through network intermediaries, such as switches and routers
    - management of network congestion
    - management of message delivery order.

Example protocols include: IPv4/v6, TCP, UDP, IPSec, ARP and FTP.

7.1.2 Syntactic Interoperability

*Understanding of data structure in messages exchanged between systems***.** This category is described in [45], Section 3.1.3, it covers OSI layers 6 (representation) and 7 (application). This category serves the following purpose (cited from [45], Section 3.1.3):

- Translation of character data from one format to another, such as Extended Binary Coded Decimal Interchange Code to American National Standard Code for Information Interchange (EBCDIC to ASCII).
- Message content structure, such as Simple Object Access Protocol (SOAP) encoding .
- Message exchange patterns, such as Synchronous Request/Response or Asynchronous Publish/Subscribe.

Example protocols include: SOAP, REST, XML, HTML, ASN.1 and SNMP.

7.2 E-Mobility Specific Protocols

Beyond general communication protocols currently used for Internet and Smart Grid applications (cf. Section 7.1), recently some protocols defining E-Mobility specific communication sequences and data exchanges were or are still specified. Most importantly there are:

- IEC 61851-24 – Electric vehicles conductive charging system - Part 24: Control communication protocol between off-board d.c. charger and electric vehicle
- SAE J1772 – Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler (→ IEC 62196-2)
- ISO/IEC 15118 - Road vehicles — Vehicle to grid communication interface
- OCPP – Open Charge Point Protocol
- OCHP – Open Clearing House Protocol

More E-Mobility related standards can be found in publications of NIST and the Standardisation Roadmap of the German National E-Mobility platform (NPE) [48]. Also, Annex C of the Smart Charging document of CEN/CENELEC that is currently under preparation (cf. Section 1.3) contains a list of such standards.

7.2.1 IEC 61851-24 – Electric Vehicles Conductive Charging System - Part 24: Control Communication Protocol between Off-Board D.C. Charger and Electric Vehicle

Part 24 of IEC 61851 describes the sequence of communication for conductive DC charging up to 1,500V. It refers to "off-board" charger as defined in charging mode 4 (IEC 61851-1) and is closely related to part 23 of IEC 61851 that describes the requirements for conductive DC charging. Communication is specified between the EVSE (DC) and the EV. The attachments explain specific instances of DC charging systems. This standard focuses very much on exchange of data for electrical security. Communication on that level is not likely to be supported/replaced by Generic Enablers, but Generic Enablers must be able to interwork with them.

7.2.2 SAE J1772 – Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler

This standard was released in 2001 and is maintained by the North American Society of Automotive Engineers (SAE). It specifies electrical connectors for electric vehicles and includes (among others) a specification of communication in order to secure the power flow via pulse wide modulation (PWM). The reworked version of 2009 has been added to IEC 62196-2 (Type 1). Recently, a conductive combo coupler for AC and DC charging has been developed within SAE J1772. As "combined charging system" it gets as broad support from German and North American car manufacturers. This standard focuses very much on electrics and physical forms. Communication on that level is not likely to be supported/replaced by Generic Enablers, but Generic Enablers must be able to interwork with them.

7.2.3 ISO/IEC 15118 – Road Vehicles — Vehicle to Grid Communication Interface

The context and general structure of this standard is already described in Section 6.1.2.1. Therefore, the following description refers only to the communication aspect of this standard. The requirements for communication sequence on all ISO-OSI layers are listed and explained in Chapter 7 of IEC 15118-2. On network layer, IP is applied as protocol. On the transport layer TCP, UDP and or TLS are used. For the session layer a new protocol called V2GTP is defined. The presentation layer uses EXI, a method to compress XML-messages and the application layer protocol is the "SECC Discovery Protocol". Future Internet applications need to consider and interwork with this standard. For future developments of this standard, Generic Enablers could be considered to increase efficiency.

7.2.4 OCPP – Open Charge Point Protocol

The context and general structure of this specification is already described in Section 6.1.2.2. Therefore, the following description refers only to the communication aspect of this specification. This protocol uses SOAP over http to communicate data between an EVSE and a central system. It differentiates between communication initiated by the EVSE (Chapter 4) and by the EV (Chapter 5). The corresponding operations are:

Initiated by EVSE	Initiated by EV
4.1 Authorise	5.1 Cancel Reservation
4.2 Boot Notification	5.2 Change Availability
4.3 Data Transfer	5.3 Change Configuration
4.4 Diagnostics Status Notification	5.4 Clear Cache
4.5 Firmware Status Notification	5.5 Data Transfer
4.6 Heartbeat	5.6 Get Configuration
4.7 Meter Values	5.7 Get Diagnostics
4.8 Start Transaction	5.8 Get Local List Version
4.9 Status Notification	5.9 Remote Start Transaction
4.10 Stop Transaction	5.10 Remote Stop Transaction
	5.11 Reserve Now
	5.12 Reset
	5.13 Send Local List
	5.14 Unlock Connector
	5.15 Update Firmware

Future Internet applications need to consider and interwork with this standard. For future developments of this standard, Generic Enablers could be considered to increase efficiency.

7.2.5 OCHP – Open Clearing House Protocol

The context and general structure of this specification is already described in Section 6.1.2.3. Therefore, the following description refers only to the communication aspect of this specification. Four communication sequences are specified on the application for the exchange of data between EVSE operators and a central roaming/clearing hub/house (Chapter 2):

- Authenticate
- Exchange authorisation data
- Exchange charge data
- Exchange charge point information

There are no protocols defined on other layers, although it is proposed to use SOAP. Future Internet applications need to consider and interwork with this standard. For future developments of this standard, Generic Enablers could be considered to increase efficiency.

7.3 Summary and Outlook

As seen, many different protocols on the network and syntactic interoperability layers are available as "state of the art Internet technologies" (cf. Section 7.1). These protocols clearly could also be used for e-mobility specific ICT-systems. Moreover, these protocols are also the base for many Generic Enablers. The e-mobility specific protocols recently developed are directly applying the general communication protocols and not using FI Generic Enablers. For future E-mobility specific communication, it is possible to use either directly the general Internet communication protocols, or use Generic Enablers that are partly bundling them, partly providing totally new functionality. In order to create synergies, the usage of FI Generic Enablers is estimated to be very useful and should be considered in further developments of the respective e-mobility specific standards. Members of the project FINSENY WP5 already brought in the ideas of Generic Enablers in different working groups on national and European level (cf. Section 2.1).

8. Component & Communication Infrastructure

8.1 Components

The following subsections list and describe the components identified for WP5. They belong to the SGAM's component layer (see Section 2.2.3) and are needed to realise the functions described in Section 4.3.3. Components are real ICT components or contain at least one ICT part to be able to process data and communicate. The main criteria for selecting these components are the significant relation to the selected E-Mobility use cases and its importance for being supported by ICT, e.g. Future Internet technologies.

User Device

The user device is a personal communications device capable of communicating with other equipment in the use cases. Examples are smart phones, tablet PCs, notebooks or regular PCs. While the first two could be used in the field, i.e. in front of charging stations, the last two are normally not used in the field but when the user is at home or in office. Additionally, all kinds of "cards" for authentication, e.g. RFID cards, can be interpreted as User Device. The device will be used to display current status of specific functions as well as to facilitate the input and transfer of user preferences.

Electric Vehicle (EV)

The EV refers to the complete suite of components which make up the control of the vehicle. They are in particular:

- ***EV Charge point / EV socket***
  Part of the EV charge point is an optional meter. All energy that flows from or to the EV passes by at least one (logical) charge point. One charge point can have several outlets, for example one for DC and one for AC charging.

- ***Engine Control Unit (ECU)***
  The ECU is the on-board computer which manages the effective control of vehicle operation. It controls all critical drive train parameters as well as many of the peripheral functions. The ECU is the main communications hub for control.

- ***Satellite Navigation (SATNAV) Device***
  The SATNAV device is the navigation system integrated into the vehicle dashboard. The device stores and displays information relating to route maps, route planning, charge-point locations and other areas of interest.

- ***EV Communications Devices (XGCC, EVCC)***
  Includes all communication controllers within the EV, such as the EVCC (cf. IEC 15118 [4, 5, 6]). The communication device facilitates the transmitting and receiving of all data, to and from the vehicle unit (excluding any personal devices such as a Smart Phone). The device manages connections with the ECU and the HMI for communications with external devices. The transmission takes place over 2/3/4G or in some cases might also be WLAN.

- ***Human Machine Interface (HMI)***
  The HMI is the main interface between the vehicle and the user. It displays settings and preferences relating to vehicle control, (dis)charging, climate control and timer settings. The HMI also relays information such as that used by the SATNAV and can be used for configuration of communications preferences.

- ***Battery and Battery Management System (BMS)***
  The Battery refers to the main traction battery within the vehicle. The battery, including its management system, communicates with external devices via the ECU and the vehicle communication device.

Charging Station

The charging station is a local facility comprising all charging equipment under the control of the given charging station operator (normally the EVSE operator running all EVSE within the charging station). A charging station is composed of the following components:

- ***Charging Pole***
  A charging station can consist of several distributed charging poles in front of several parking spaces. Either the charging station itself or each pole needs to communicate to the Charging Station Server or another controlling system such as a Building Energy Management System (BEMS). If the Charging Station communicates to one of these systems (as a master) each Charging Pole must communicate to the Charging Station. The BEMS is the main user interface within the home or office building. The BEMS allows the user to set preferences, and view settings and data. The BEMS also serves as a communications hub for near field devices.

- ***Electric Vehicle Supply Equipment (EVSE)***
  The EVSE is the charge point for the vehicle. It includes in particular all metering, protection and Pulse Width Modulation (PWM) control along with the necessary communications control to allow communication with other devices. The PWM Controller controls the charge level of the vehicle. The charger (AC in the EV) in turn adjusts the width of the pulses to instruct the vehicle how much current to draw. The Supply Equipment Communication Controller (SECC) (cf. IEC 15118 [4], [5], [6]) routes and controls all communications between the EVSE and its associated equipment. The communication can take place over a number of formats depending on the recipient. These formats include 2/3/4G, Wi-Fi and ZigBee. The EVSE includes one or more outlets.

- ***EVSE outlet***
  The EVSE outlet is one physical connection point between the EVSE and a cable that leads to the EV.

Parking Space

The parking space includes all controllers and communication infrastructure needed for the management of advanced parking services. For EV this is important to be considered, since an EV can only be (dis-)charged when it is parking (the charging during driving is in the near future only interesting for very special applications). In order to allow for guaranteed reservation services, not only an EVSE, but also a parking spot must be able to be blocked. Therefore, physical barriers or gates are needed. They are controlled from remote as soon as a reservation took place. These barriers or gates can be installed on a parking space or parking spot level. If they are installed on a parking spot level, there are sensors and controllers needed to monitor the status of a single parking spot.

Substation and Junction Box

These components are part of a distribution grid and are normally the place where charging infrastructure is connected with. In SmartGrids, a Power Grid Server (in particular the DSOCC) is envisioned to communicate with these elements in order to get a better understanding of the state of a branch in the distribution grid.

Power Grid Server

Power Grid Server monitor and control the different assets of the power grid (e.g. substations). The different functions and operating roles are more closely defined by D2.3 [25], but two main systems are to be distinguished:

- ***Distribution System Operator Communications Controller (DSOCC)***
  The DSOCC controls communication on the electrical distribution network. It communicates localised switching and system conditions for control purposes. Using information received from TSO Level as well as micro generation.

- ***Transmission System Operator Communications Controller (TSOCC)***
  The TSOCC manages all communications on the electrical transmission network. Data such as generation condition, electricity demand, scheduling, frequency and generation profile. It is the main channel between the grid condition and the EMSP.

Charging Station Server

The Charging Station Server (in some cases also the HEMS) communicates to the Charging Station or the Charging Poles. It controls the (dis-)charging from remote (if wished) and stores all the configuration data of the user. It also collets metering data and distributes them to the appropriate roles for billing.

Parking Space Server

A parking space server communicates with the controller of a parking space. They are useful for public charging when there are reservation services to be offered for EV.

Fleet Management Server

When the considered EV is part of a fleet, the fleet management server controls and manages not only the usage (reservation in car sharing or company fleets), but manages the battery storage. Therefore, the Fleet Management Server is connected to the Charging Station Server and the User Management Server (if it does not coincide already due to role coincidence).

User Management Server

The User Management Server or Back End System (BES) encompasses the communications and controls aspect of the EMSP entity. The BES transmits data to the user and home devices as well as accepting and processing user settings and preferences. Another function of the BES is the communication of trading data and contracts with the TSO. There can be communication to the Charging Station Server in order to allow for near real-time, user-adapted control of (dis-)charging.

The EV suite does not include devices such as smart phones which are specific to the user rather than the vehicle. Figure 37 gives an overview of these components and places them in the Smart Grid plane.

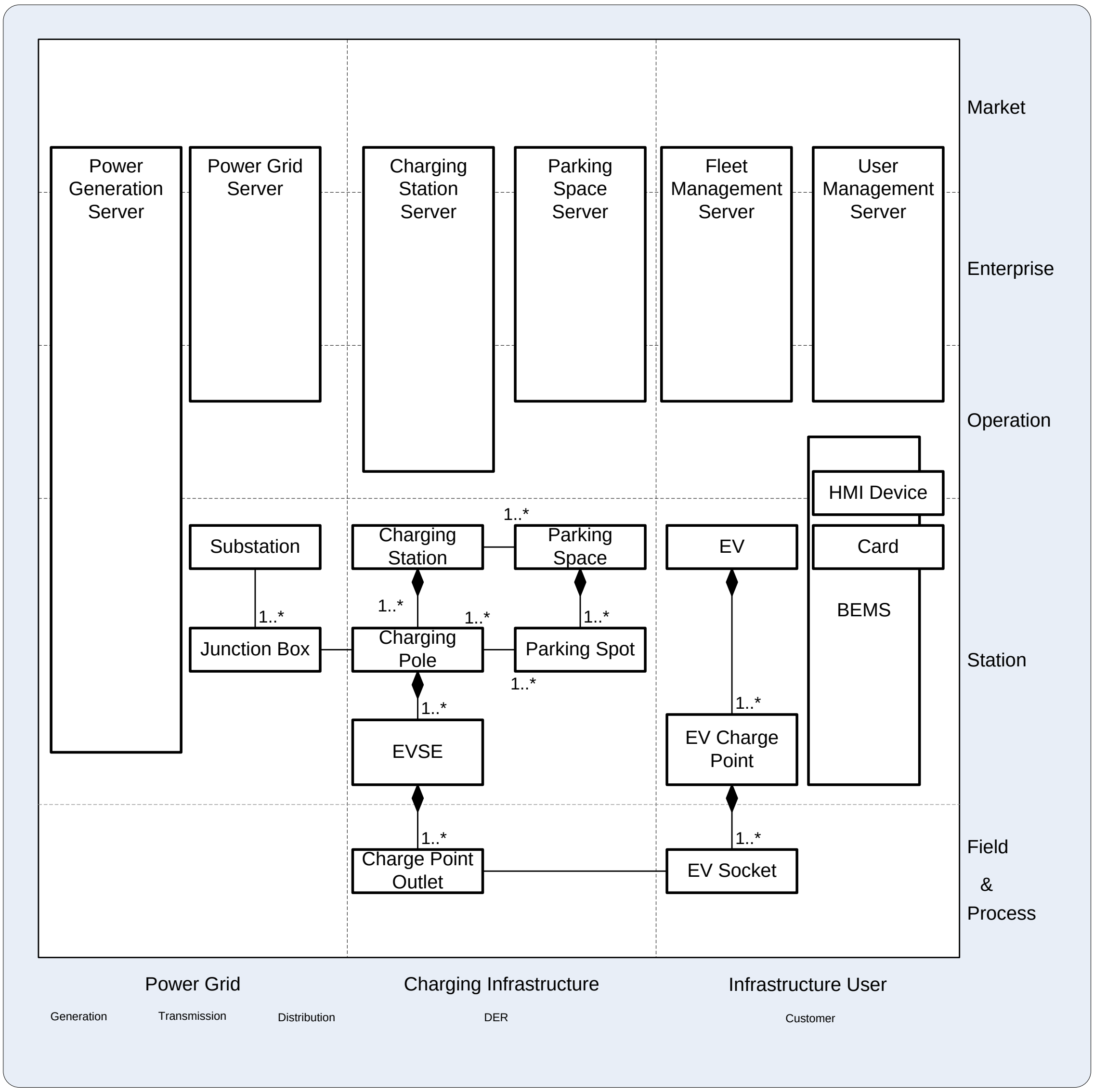

Figure 37: Component layer

8.2 Developments in Communication Networks

8.2.1 Introduction

E-Mobility probably will not need to invent new communication technologies, but rather built on existing standards and technologies as well as on the new possibilities of a Future Internet. A good description of these technologies is given in D3.3 [27], Section 8.2. The Future Internet is best described by the Generic Enablers as to be found in Section 5.2 or in [32].

In particular the Exemplar Distributed Switch Network deployed at Intune premises in Ireland is a good example of a state-of-the-art technology and is described in more detail in the next section. This particular networking technology is being deployed in Ireland to support the field trial of the consolidated use case scenario on demand control in the FINESCE project. It offers a low latency functionality providing optimal conditions for the investigation of the practical limits of the technical concepts proposed in the demand control field trial and is an excellent example of Future Internet networking technology invented and brought to market in Europe.

8.2.2 The Exemplar Distributed Switch Network

The Exemplar test bed is an, Irish Government owned, open access test-bed to support R&D and innovation in Ireland and is available for exploitation in this Future Internet PPP project. The Exemplar test bed is the 1st deployment of Sub-Wavelength Infrastructure and is hosted in Intune’s facilities in Dublin. With about 2Tb/s of distributed forwarding capacity, of which 400Gb/s can be made available to a Future Internet Phase II project, the Exemplar lab is large enough to emulate the traffic profiles of a major European city. The Exemplar test bed also contains several servers, and virtual developer environments, which can also be made available to the Future Internet Phase II project.

With the exception of high bandwidths, next-generation Smart Grid communications have many of the same architectural requirements as next-generation carrier networks including low-latency, guaranteed QoS, meshed distributed connectivity, simple control & management and physical separation of virtual networks. Where other IP architectures have difficulty satisfying these requirements, Sub-wavelength Networking naturally satisfies these requirements at a fundamental level, rather than by using advanced control plane or management systems.

Sub-wavelength networking is a robust packet switching and transport metro networking architecture under review in the standards bodies. Sub-wavelength networking implements both layer 2 switching and layer 1 transport functionality using a networking technique called OBS (Optical Burst Switching). OBS rapidly switches the transmission wavelengths of fast tuning lasers at packet rate, allowing the creation of multipoint meshed networks. Sub-wavelength networking is analogous to a single Ethernet switch with its ports geographically distributed over hundreds of kilometres. For utility grid operators, Sub-wavelength networking satisfies the stringent electrical protection requirements, enables physical separation of various DSO networks over the same physical infrastructure while providing advanced cyber security capabilities.

Sub-wavelength Networking is probably the only new clean-slate networking architecture in 20 years of telecoms development, and Intune has pioneered its development and standardisation over the last 10 years. Intune’s OPST (optical packet switch and transport) product is the world’s first commercial release of a carrier grade Sub-wavelength Networking architecture. OPST additionally features a single RESTful North Bound Interface and APIs, which arguably could be considered as a “Software Defined Network” which is increasingly being considered as the next big market evolution of ICT and networking. According to Cisco on SDN, “Service provider WANs cannot be fully meshed and be economically viable for optimised service delivery and costs to the service providers’ customers.” Sub-wavelength networking eliminates this problem by providing free fully meshed transport capability and eliminating L2/L3 stacking by aggregating and grooming all traffic enroute. Within the Future Internet Phase II project timeframe, Intune will upgrade the north bound interface of the Exemplar Network to be compatible with standard SDN/Openflow APIs for integration with FI-WARE I2ND Generic Enablers. Once complete, Intune will be the world’s first distributed switching company to extend Software Defined Networks (SDN) across carriers' infrastructure [49].

Figure 38: Exemplar Network

8.3 Communication Links and Interfaces between Components

All the components described in Section 8.1 at station level and above are able to communicate with other components. The main communication links between these components are described in Figure 39 (blue). Additionally, there is a new element called "Server-to-Server Interfaces" which represent the fact that on server level there are interfaces possible between all of the depicted servers. The actual interface instances between these servers depend on the realised application (roles and business model). The interface instances may vary in different countries due to regulation. Yet, this generic view of communication architecture allows for realising many applications over different regulatory frameworks. In particular, this view is able to realise the use cases identified in D5.1 [2] (cf. e.g. the final use cases described in Section 3.1). The element "Server-to-Server Interfaces" is depicted in the Market zone only due to ease visualisation. These interfaces are regularly implemented (also) on the Enterprise and Operation zone.

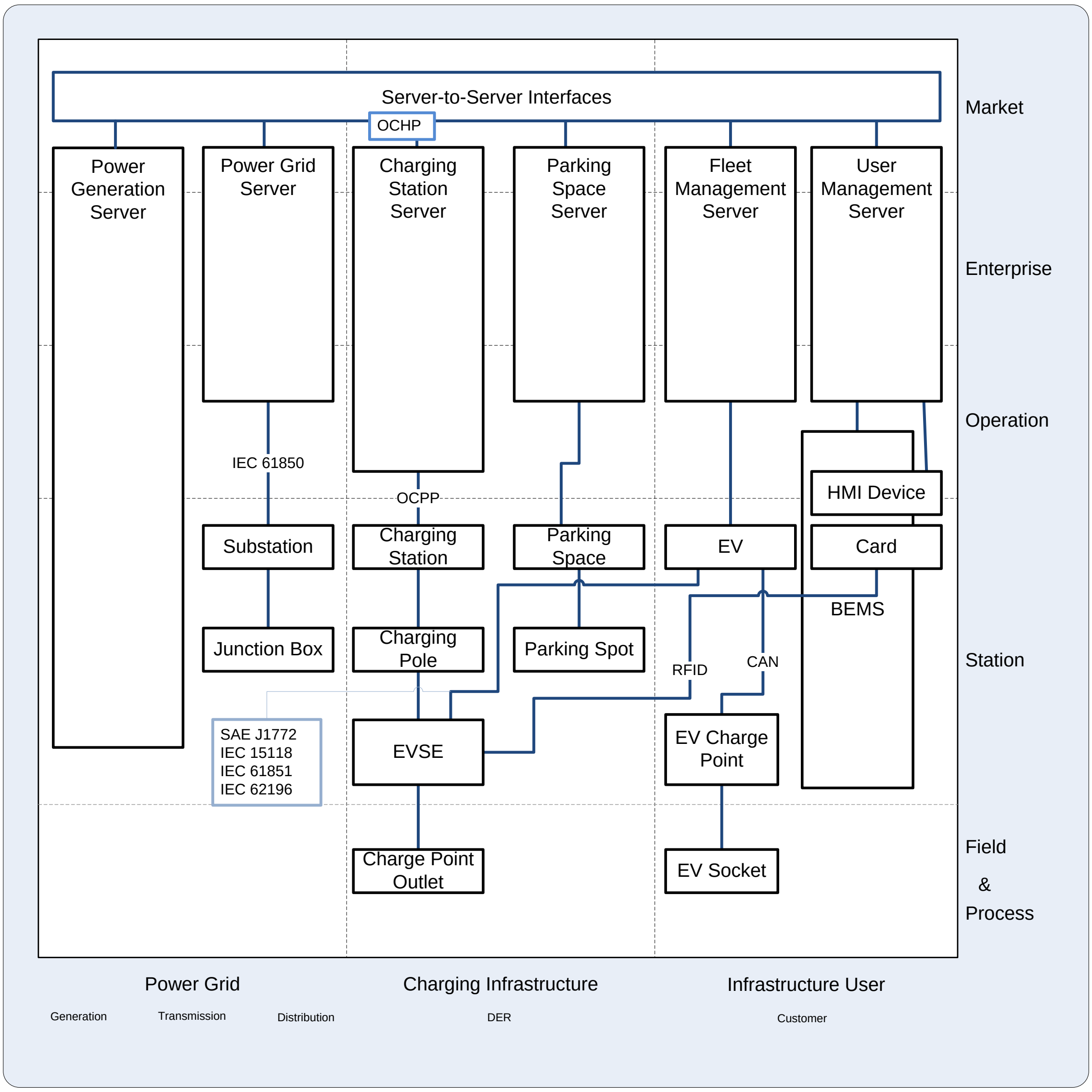

Figure 39: Component layer including most prominent communication links and standards

Additionally, Figure 39 also relates the communication protocol standards described in Section 7 to the identified communication links. Section 9 provides a further analysis to the specific requirements.

9. Security

This section describes use case specific security measures based on the identified security requirements.

9.1 General Approach

Security requirements for the FINSENY use cases have been derived based on a threat and risk analysis and described in D1.11 [30]. The substructure of this section reflects these requirements. It is assumed that most of the security measures will not be use case specific in terms of the applied technology. The technology is rather expected to be domain specific or general. Hence, only adaptations are described here. The security measures applied will use security architecture elements as defined in D1.11 [30]. Note that D1.11 elaborates on domain specific (Smart Grid) security architecture elements, which may either be defined in the Smart Grid domain or may be adaptations of existing generic security enabler, which are provided by FI-WARE. The following example depicted in Figure 40 for user authentication in the context of an application explains this approach.

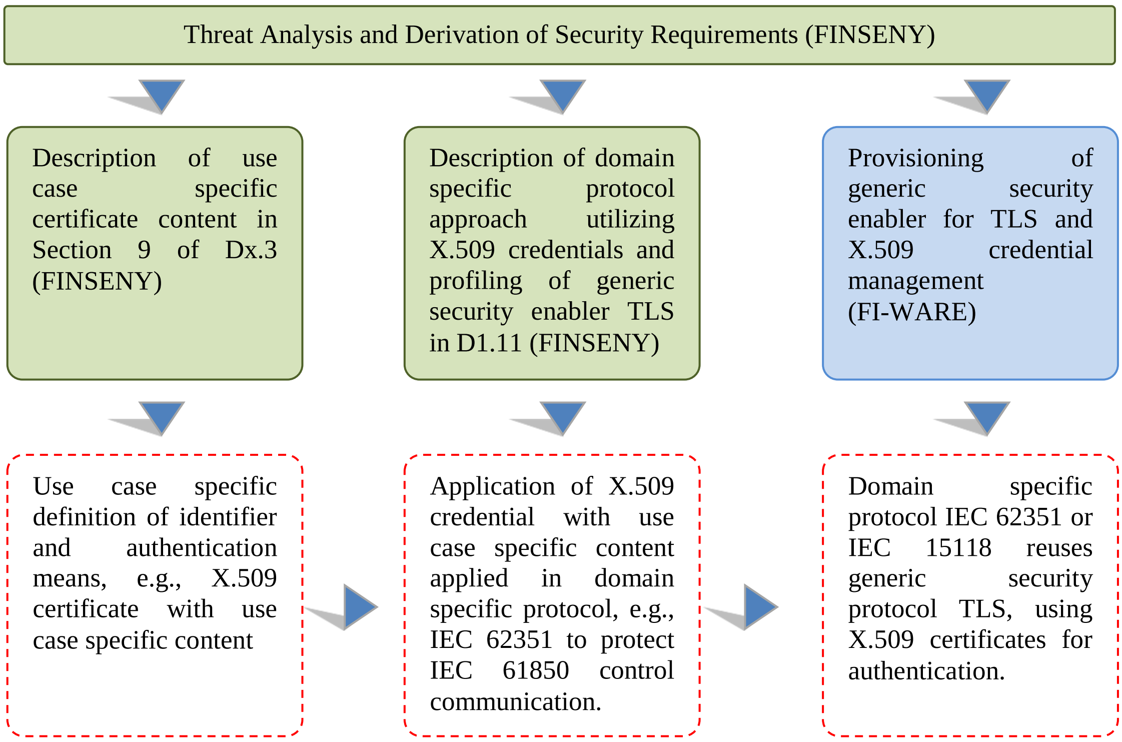

Figure 40: User authentication security solution example

As seen in the figure above, WP specific security, security architecture elements from D1.11 [30] and the Generic Enabler from FI-WARE in conjunction provide to the use case specific security solution.

For the sake of completeness the next Section 9.2 gives a short overview on the security requirements as stated in D1.11 [30] and the FI-WARE security Generic Enablers as stated by the FI-WARE documentation. Section 9.3 then concludes with the analysis of the E-Mobility specific security requirements. Note that for this security analysis the components and the communication relations as depicted in Section 8 and Section 7 build the base.

This approach of security analysis is covered by the SGAM framework [10]. Therein, a so-called security-by-layer approach guarantees that the cross-topic security is fully covered. Therefore, the identified and described security requirements are to be applied on all layers of SGAM. The following section lists the WP5 security requirements and depicts the main FI-WARE GEs.

9.2 Security Requirements and FI-WARE Security GEs Overview

This section at first gives a short summary of the security requirements related to E-Mobility. It shall provide a better understanding of the following Section 9.3. Details about the threats and risks are given in D1.11 [30].

As FINSENY is part of the FI-PPP programme, many FINSENY security aspects may also be addressed by the Security chapter's Generic Enablers defined in FI-WARE [34]. Thus, a short summary of the FI-WARE security chapter is given as well. Details can be found on the FI-WARE website [34].

9.2.1 Security Requirements Overview

As a consequence of the threat and risk analysis conducted in the FINSENY Security task T1.6, FINSENY must deal with the analysis of potentially new ICT security requirements that will come from different aspects of the Future Internet related to WP5:

- The introduction of Smart Energy Grids as such
- The connection of a charging infrastructure to the Smart Grid
- The incorporation of new actors and services

The list of security requirements applying to E-Mobility comprises:

- Authentication and authorisation: System components shall uniquely authenticate users and specific components e.g. before establishing a connection.
- Data confidentiality: It shall be possible to ensure the confidentiality of data by cryptographic mechanisms.
- Data integrity: It shall be possible to ensure the integrity of data and to verify whether the data has not been tampered with.
- Non-repudiation: It shall be possible to prevent the sender of information from denying having sent it.
- Data backup and recovery: Backup should be applied to all data and applications needed to replace failed components within a reasonable period of time. Synchronisation of the backup and operating data must be assured.
- System protection components: The devices deployed in the network shall employ system protection mechanisms (protection against malicious code, like viruses, intrusion detection and prevention, network access control, etc.).
- Secure Software/Firmware Updates: The system shall ensure software/firmware updates only with integrity protected packages from an authorised source.
- Secure Network Design: The system design should obey security design guidelines.
- Security Management: Security management has to consider all involved cryptographic protection means, including key management infrastructure, certificate management, security policies, addressing both, technical and organisational means.
- Logging and Audit: Logging processes shall be established on devices having appropriate resources to support monitoring, traceability, and auditing functionality.
- Time Synchronisation: Time synchronisation shall keep timer elements on different components synchronised.
- Observation of Policy and Laws: All applicable policies of the utility and its major business partners must be observed, as well as the relevant legislation and regulation.
- Transaction Security: It has to be guaranteed that whole transactions can be securely validated and archived for later disputes. Note that this is stated in D1.11 [30] for the market place explicitly, but is likely to also apply to electric mobility for payment.

9.2.2 FI-WARE Security Generic Enablers

The FI-WARE core platform also considers security and data protection aspects by means of a technical chapter about "Security" covering mechanisms which ensure that the delivery and usage of services is trustworthy and meets corresponding requirements. The list of GEs belonging to this chapter (as detailed in [34]) comprises:

- **Identity Management**: provides authentication/access control and identity/attribute assertions as a service to relying parties.
- **Privacy**: provides a set of functionality similar in scope to the Identity management Generic Enabler but enhanced using special privacy enhancing technologies.

- **Data Handling**: provides a mechanism for controlling the usage of attributes and data based on the concept of ‘sticking’ a data usage policy to the data to which it applies.

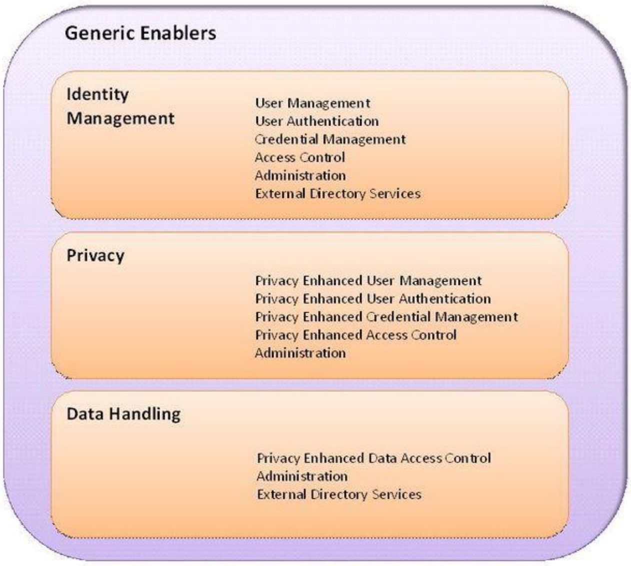

Figure 41: FI-WARE Security Generic Enablers

9.3 Applied Security Technology

The security requirements of the functional building blocks are summarised in Table 13, where ‘S’ stands for “Specific for e-mobility”. Based on this table, specifics for the FINSENY Electric Mobility use case are discussed in the following subsections. For all requirements, which can be addressed using either domain specific or generic security counter measures, D1.11 [30] or FI-WARE GEs are referenced.
The following table maps the security requirements resulting from the component layer and the associated communication on a higher level. Especially, some components are considered here as systems, which in turn are built out of other components, like the EV or the charging station

Security Requirement / Components & Communication	1: Authentication and authorisation	2: Data confidentiality	3: Data integrity	4: Non-repudiation	5: Data backup and recovery	6: System protection components	7: Secure SW/FW Updates	8: Secure Network Design	9: Security Management	10: Logging and Audit	11: Time Synchronisation	12: Observation of Policies & Laws	13: Transaction Security
Components													
User Device (Smart Phone/Tablet)	X	X	X	X			X		X	X	X	X	X
Engine Control Unit (EV)	S	S	X	X			X		X	X	X	X	X
Charging Station (EVSE)	S	S	X		X	X	X	X	X	X	X	X	
Substation + Junction Box (DSO)	S	X	X		X	X	X	X	X	X	X	X	
Power Grid Server (DSO)	X	X	X	X	X	X	X	X	X	X	X	X	
Power Grid Server (TSO)	X	X	X	X	X	X	X	X	X	X	X	X	
Charging Station Server (EVSE Op.)	X	X	X	X	X	X	X	X	X	X	X	X	X
Parking Space Server	X	X	X		X	X	X	X	X	X	X	X	
Fleet management Server	X	X	X		X	X	X	X	X	X	X	X	
User Management Server (BES)	X	X	X		X	X	X	X	X	X	X	X	

Security Requirement / Components & Communication	1: Authentication and authorisation	2: Data confidentiality	3: Data integrity	4: Non-repudiation	5: Data backup and recovery	6: System protection components	7: Secure SW/FW Updates	8: Secure Network Design	9: Security Management	10: Logging and Audit	11: Time Synchronisation	12: Observation of Policies & Laws	13: Transaction Security
Communication													
EV, EVSE (SoC Monitoring, Charging Control, Authentication)	S	S	X	X						X	X	X	X
EVSE Op, EMSP (User Management, Authorisation, Rating, E-Roaming, Dis-Charge Monitoring)	X	X	X	X						X	X	X	X
EVSE Op., EMSP, FCH (Settlement, Clearing, Billing)	X	X	X	X						X	X	X	X
EVSE Op., DSO (Ripple Control)	X	X	X							X	X	X	
EMSP, DSO (Grid Capacity Monitoring)	X	X	X	X						X	X	X	

Table 13: Security requirements

9.3.1 Authentication and Authorisation

Authentication and authorisation in the context of WP5 is performed on user level and on device level. On user level, authentication is performed towards the user related device, to the EVSE and also to backend services. Depending on the device and the communication path, the credentials used may vary and can be username/password, RFID token with access information, or X.509 certificates and corresponding private keys. Authorisation can be done directly within the credential (like in case of X.509 certificates as extension or indirectly e.g., using LDAP lookup. All of them are directly related to the user management responsible for managing user identities and profile information.

Examples for WP5 specific authentication means are:

- User (contract) authentication directly at the charging point can be performed based on RFID token at the charging spot. For the RFID token identifier information to enable the use case E-Roaming have to be defined. An identifier may look like:

  Identifier = {Name, ID-Number, …}

  Authentication based on RFID tags is outlined in D1.11 [30]. Note that there are certain privacy requirements related to handling of information in identifiers, which need to be considered (see Section 9.3.12 and [30], Section 4–6).

- User (contract) authentication from within the electric vehicle in the context of ISO/IEC 15118 is performed based on a contract certificate installed within the vehicle. The certificate needs to be an X.509 certificate using ECDSA and SHA-256 as algorithms to create a digital signature, while using secp256r1 as underlying elliptic curve domain parameters. Hence, the certificates have to carry the following IDs:
  - The OID to for ecdsa-with-SHA256 to be used is: iso(1) member-body(2) us(840) ansi-X9-62(10045) signatures(4) ecdsa-with-SHA2(3) 2.
  - The OID for secp256r1is: iso(1) member-body(2) us(840) ansi-X9-62(10045) curves(3) prime(1) 7.

An example for authorisation in terms of role based access control can be given through dedicated certificate enhancements as specified in IEC 62351. This approach is being discussed in D1.11 [30], Section 6.

For device communication the typical credentials used for authentication relate to symmetrically shared keys or to X.509 certificates and corresponding private keys. Authorisation may be realised as part of the X.509 credentials or by using additional mechanisms like SAML or LDAP lockups.

WP5 especially plans to make use of the FI-WARE Identity Management Generic Enabler in the context of this requirement. It is currently being clarified, if this GE copes with specific requirements for the credential management as stated above (e.g., additional fields or extensions in X.509 credentials, cryptographic algorithm support). Further information about security elements that can be used in the context of authentication and authorisation can be found in D1.11 [30], Sections 4–6.

9.3.2 Data Confidentiality

Data at rest (stored in server or user related components) or transmitted over networks needs to be confidentiality protected (e.g., customer ID, tariff information, load settings, etc.).

The security controls for communication security relate either to build in security functionality of the access and communication protocols used, like in the case of GSM/UMTS, ISO/IEC 15118, OCPP, or RADIUS (for AAA) or can be applied by using additional security protocols (like TLS for TCP/IP based communication). There are no domain specific requirements to e-mobility for data confidentiality in communication. Domain specific protocols like ISO/IEC 15118 or OCPP rely on standard encryption algorithms like AES. Specific here is mainly the key management to setup the encryption key. Especially ISO/IEC 15118 applies elliptic curve cryptography (ECDH and ECDSA).

As Section 4.3 also mentions further Future Internet technologies like the application of cloud services, corresponding cloud security is needed. In the context of data confidentiality either trusted cloud service providers based on service level agreements or (new) security elements like (Fully) Homomorphic Encryption are necessary. The latter enables operation on encrypted data without the need to decrypt the data. Decryption is only possible by the owner of the data. Security elements that can be generally used in the context of data confidentiality can be found in D1.11 [30], chapters 4–6. WP5 especially plans to make use of the FI-WARE Privacy and Data Handling Generic Enablers in the context of this requirement.

9.3.3 Data Integrity

There exist no further domain specific requirements for integrity protection additionally to the ones stated for authentication and authorisation in Section 9.3.1 and confidentiality in Section 9.3.2. These apply here as well as the key management for data integrity is closely connected to the credentials defined in Section 9.3.1. Data integrity is a core requirement, especially for control operations. Corresponding security elements that can be used in the context of data integrity can be found in D1.11 [30], Sections 4–6.

9.3.4 Non-repudiation

Non-repudiation is needed for business interactions between CSO/TSO/EVSE Operator/EMSP and clearing houses to e.g. assure that accounting gets accepted and cannot be quarrelled over after issuing an invoice. Another important point in this context is negotiation of contracts and the fact that all parties involved should be bound to the final result. Security elements that can be used in the context of non-repudiation can be found in D1.11 [30], Sections 4-6.

9.3.5 Data Backup and Recovery

All systems that participate in Electric Mobility and have requirements regarding availability and reliability should be configured for regular data backups. Storage and possible recovery of backups needs to be implemented as well. All actions have to be planned and executed according to given policies. Security elements that can be used in the context of data backup and recovery can be found in D1.11 [30], Sections 4–6.

9.3.6 System Protection Components

System protection components should be implemented for backend (e.g., user management) as well as edge components (e.g., EVSE). There are no domain specific requirements identified. Security elements that can be used in the context of system protection components can be found in D1.11 [30], Sections 4–6.

9.3.7 Secure SW/FW Updates

Every system that is in potential need of update of its software or firmware should not accept arbitrary updates. Secure SW/FW updates are seen as generic functionality with no specifics to the electric mobility scenario with one exception. While the updates can be enforced in the backend by policy, the user owned equipment cannot be forced to update e.g., the operating system. Security elements that can be used in the context of secure SW/FW updates can be found in D1.11 [30], Sections 4–6.

9.3.8 Secure Network Design

Every communication network realising electric mobility functionality should be carefully designed according to secure network design principles. Domain specific requirements arise through the application of security features of domain specific protocols like ISO/IEC 15118 or OCPP. Security elements that can be used in the context of secure network design can be found in D1.11 [30], Sections 4–6.

9.3.9 Security Management

Security management has to cope with domain specific requirements to the extent that the credential management needs to support specific credentials that may be applied in electric mobility scenarios. These comprise X.509 certificates with dedicated extensions or RFID token with specific identifier. While generic IDM solutions may provide the management functionality, it needs to be ensured that the format of the credentials is supported by these solutions. Moreover, specific power domain related guidelines have to be obeyed for the processes. ISO TR 27019 as power domain specific mapping of the ISO 27002 ISMS is one example. Security elements supporting security management can be found in D1.11 [30], Sections 4–6.

9.3.10 Logging and Audit

Logging and audit functionality in electric mobility is used to provide some means of evidence, especially for control operation, but also for billing and payment. Secure archiving and long-term security for the contract related information and also for control actions is needed. The amount of data may require a larger amount of storage. This is nevertheless no E-Mobility specific requirement but rather holds for the whole energy domain. Security elements that can be used in the context of logging and audit can be found in D1.11 [30], Sections 4–6.

9.3.11 Time Synchronisation

Time synchronisation as a basis for other mechanisms like control, tariff assignment or billing is needed for electric mobility, but no specific requirements can be seen. Security elements that can be used in the context of time synchronisation can be found in D1.11 [30], Sections 4–6.

9.3.12 Observation of Policies & Laws

Observation of policies and laws is of special importance in the context of processing person related data regarding the protection of privacy. As this is often a country specific regulation, the solutions may vary depending on the location a solution is deployed. Also existing export control regulations may influence the deployment of certain solutions as they apply specifically to security technology. This holds for almost all energy domain scenarios. Security elements that can be used in the context of observation of policies & laws can be found in D1.11 [30], Sections 4–6. Section 4.1.3 of D1.11 [30] especially addresses privacy aspects.

9.3.13 Transaction Security

Even though transaction security has not been identified as a main requirement for the electric mobility use case, it is applicable. The reasons are contract and tariff negotiations as well as billing and payment requiring a secure transaction. Section 4.4.7 of D1.11 [30] shows security elements that are potentially able to fulfil this requirement.

10. Conclusions

The efforts of WP 5 resulted in all of the goals of the work package being achieved and the plans of the participants for field trials, based on the results of the work have been approved for funding in a follow-on project.

10.1 The key strategic results of WP 5

The key conclusions of the work package investigations, taken as a whole, are that:

- **Electric Mobility use cases can be implemented today by developing solutions based on available ICT technologies and components**
  Our investigations showed that it is feasible to implement the use cases we identified by developing solutions based on integrating existing ICTs and developing some domain specific enablers. We did not identify a need to develop new fundamental technologies which would have constituted a barrier to the near term large scale rollout of our identified consolidated use case scenarios.

- **The FI-PPP approach is valid for the electric mobility use cases**
  The investigation of the consolidated use case scenarios showed that the general functionality offered by the generic enablers of the FI-WARE project relates well to the ICT functionality needed to implement the use cases for electric mobility foreseen in the FINSENY use cases. This result validates the approach of the FI-PPP programme, for the domain of electric mobility, of offering generic ICT capabilities to a diverse set of domains, to create a critical mass in the market for the generic capabilities, improving the business case for deploying innovative new services and business models which rely on ICT functionality. The requirements confirm the proposition that the definition of commonly used interfaces would lead to economies of scale, scope and cost benefiting European citizens and businesses. Domain specific enablers required to implement electric mobility were identified and would need to be developed to complement the generic enablers.

  Our studies showed that the generic enabler functionality, as described by FI-WARE on the wiki site, when implemented with appropriate communications facilities, would support the use cases we identified for electric mobility demonstrating the widespread applicability of the generic enablers. Many of the ICT requirements are within the scope of requirements from other usage scenarios in FINSENY meaning that Generic Enablers can be used in a range of Smart Energy scenarios including E-Mobility scenarios. We did not identify the need to develop new basic technologies to implement the use case scenarios. Integration of generic enablers with products to offer a solution should be sufficient to enable the use cases at a field trial scale.

  The scaling up of solutions for mass market use, as the proportion of electric vehicles on European roads grows, will require the use of Future Internet technologies, including cloud based services, sensor fusion technologies and big data management and analysis solutions. The detailed investigation of the scalability of the proposed solutions offered for mass market use was not within the scope of our study.

- **E-Mobility offers the potential to develop innovative new services and markets**

  As a majority of basic requirements of E-Mobility can be met with solutions developed from available technologies, there will be many opportunities for service providers to offer innovative services to E-Mobility customers, further developing the market for services offered to people who are travelling. An example of such new services would be the development of a market for the sale of the option to control load shifting by individual users or by energy sector aggregators, implemented by having control of their charging. The customers who provide energy providers with the ability to control the charging of their vehicles will need to be compensated for their flexibility and this compensation control of charging service could be developed into a market for the capacity to shift power network load. This function relates to the usage scenario for a market for user demand control under investigation in FINSENY in WP6.

- **A common regulatory environment for E-Mobility roaming in Europe would accelerate the development of the market for E-Mobility services supporting economic growth**

We concluded that the development of a pan-European scale market for E-Mobility services could be accelerated through the development of a common regulatory environment for E-Mobility roaming within the European Union.

- **E-Vehicle charging management will be an essential component of all Smart Energy solutions in coming years**

  The development of the usage scenarios and the investigation of their ICT requirements led to the development of an innovative scenario for the use of electric vehicle charging as an integral part of a Smart Energy solution, providing energy providers with a further option for them to control the demand for energy to help counterbalance dynamically changing energy generation by renewable energy sources, such as wind. Charging facilities for electric vehicles will be part of every smart building scenario, will influence the design of the distribution network as they will be a new heavy load on the network, will be part of micro-grid solutions and provide the opportunity to develop new electronic markets for the sale of the control of the charging of the vehicles and for the sale of other services to travellers. FINSENY project participants have discussed the consolidation of the results of WP5 with those of the other work packages and the impact of E-Vehicle charging on the scenarios of the other work packages shows that E-vehicle charging, and implementing of Electric Mobility in general, will influence the development of Smart Energy solutions in the coming years.

- **The use cases offer a solid basis for standardisation and planning**

  The set of representative use cases were adopted in standardisation efforts in Europe, providing a solid basis for standardisation efforts and increasing awareness and understanding of the many use cases of electric mobility, which will impact not just the power networks providers, but also public transport, the automotive sector and the newly emerging and growing mobility service providers. The use cases have provided many organisation with a good basis for planning how they can benefit and take part in the deployment of electric mobility.

- **Field trial proposals funded by partners and the European Commission**
  The main field trial proposal we developed in WP 5 integrates many aspects of the Smart Energy grid, potentially enabling a cost-effective improvement in the ability of energy providers to manage their energy grids while increasing their use of energy from renewable energy sources.

  Our proposed field trial use case has been funded by the European Commission and the project partners for implementation in Ireland in the FINESCE project, which builds on the results of the FINSENY investigations of smart grid challenges. The objective of the trial is to test the technical feasibility and limits as well as to enable an estimation of the commercial value of the large scale deployment of the proposed solution. It is intended to form the basis for an extension of the FINESCE trial in a FI-PPP Phase III project.

10.2 Detailed conclusions of the work on the Functional Architecture

The results of Task 5.3 support the following **detailed conclusions**:

- The Smart Grid Architecture Model (SGAM) has proofed to be a very good base for the modelling task of a functional architecture for E-Mobility. Yet, some adaptions were needed resulting in the E-Mobility adapted SGAM (EM-SGAM).

- The final E-Mobility use cases were a solid base for designing the comprehensive EM-SGAM. The sustainability of the identified trial potential of these use cases is evident since the follower project FINESCE will apply at least two of them.

- All defined functional building blocks were judged to be supported by Generic Enablers (cf. section 5.4). However, due to the more domain specific nature of certain functions, it is believed that the implementation of e.g. EVSEs and also the algorithms for load shedding as part of the control room operations will rather remain domain-specific solutions. These functionalities were identified as Domain Specific Enablers by WP5 and are described in deliverable D8.2 [37].

- With respect to data and information models (Section 6) as well as the communication protocol architecture (Section 7), it can be very well noticed that the novelty of e-mobility results in a few well-established ICT standards. However, the recent rise of e-mobility resulted in many standardisation activities as well as other collaborative working groups that concluded to some extend on the electrical level (e.g. Combined Charging System), but on the ICT level work is still ongoing (e.g. IEC/ISO 15118 [4, 5, 6]). The situation of standard availability will improve significantly in the coming years.

- Security issues are a cross-sectional topic and need to be taken seriously also for e-mobility applications. The selected approach of a structured threat analysis proofed to be effective and is advised to be conducted for each ICT-based e-mobility application.

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