E-Mobility
Smart Charging

WG Smart Charging

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Report about Smart Charging of Electric Vehicles in relation to Smart Grid

CEN-CENELEC

E-Mobility Coordination Group (M/468)

and

CEN-CENELEC-ETSI Smart Grid Coordination Group (M/490)

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1. Introduction

This report is a result of work made by a working group under the CEN -CENELEC eMobility Coordination Group (EM-CG) and the CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG), with the purpose of documenting different aspects of Electro Mobility Smart Charging.

2. Scope

The scope of WG Smart Charge and the resulting report looks to:

- Define and document generic role models for different actors and their roles in the domains of E-mobility and power system (Smart Grid)
- Define and document a reference architecture for smart charging of electric vehicles (EV), which will be aligned with the Smart Grid (M/490) reference architecture (correlation with other smart grid functionalities is required in order to maximize system-wide impact and benefits)
- Collect and adapt a set of typical, relevant reference use cases from E-mobility stakeholders to the sustainable processes defined by SG-CG, with focus on Smart Charging of electric vehicles (EV).

Note: Information Security in relation to E-Mobility is not covered in this report. SG-IS for more information about this topic.

2.1 Working method

The working group for Smart Charging under the CEN-CENELEC EM-CG and CEN-CENELEC-ETSI SG-CG was established in June 2012. One of the first tasks was to make a 'call for experts' in EM-CG and SG-CG in order to establish a working group with experts from different technical domains and expertise with the E-mobility areas.

A group of about 35 experts was formed and divided into 6 tasks-groups (definition of smart charging, link to smart grid, generic role model, reference architecture, charging types/scenarios and final report) to support an efficient working method for the defined scope of work.

The draft report was circulated for comment to the EM-CG and SG-CG, for alignment with existing reports. Subsequent amendments were made with final version in December 2013

After delivery of the final report, the working group Smart Charge will be disbanded.

2.2 Executive summary

Smart Charging is the charging of an EV controlled by bidirectional communication between two or more actors to optimize all customer requirements, as well as grid management and energy production including renewables with respect to system limitations, reliability, security and safety. These four requirements which are already required by conventional non smart charging.

This report gives an overview of the individual elements of 'Smart Charging' from recommendations and definitions to reference models for E-Mobility as a whole.

The main focus for this report has been to link the different E-mobility definitions and concepts together, from the current standardizations activities in ISO/IEC and focus activities under the European mandates – to the real life projects and demonstrations activities described in Annex B.

E-mobility and especially 'Smart Charging' is still a new domain with many interesting possibilities. This report provides a status on the current and basic definitions of 'Smart Charging'.

2.3 Recommendations

- **Agree on a European set of actor definitions and use cases**

Establish a single repository of actor definitions and use cases to systematically identify existing and future standardization needs.

- **Develop a new standard for data communication between EV supply equipment and EVSE operators**

A standard for data communication between the EVSE (Electric Vehicle Supply Equipment) and EVSE Operator is missing under the European Standardisation organisations. It is recommended to work on a New Work Item Proposal (NWIP).
Also a standard for data communication between the EVSE Operators and E-Mobility Service Providers for standardized business transactions and roaming issues is missing under the European Standardisation organisations.

- **The quality of service and reliability of the Smart Charging is of prime importance from the customer point of view. New standards addressing the information to be sent to the customer in case of troubleshooting have to be started.**

3. What is Smart Charging?

Smart Charging of an EV is when the charging cycle can be altered by external events, allowing for adaptive charging habits, providing the EV with the ability to integrate into the whole power system in a grid=and user-friendly way. Smart Charging must facilitate the security (reliability) of supply and while meeting the mobility constraints and requirements of the user. To achieve those goals in a safe, secure, reliable, sustainable and efficient manner information needs to be exchanges between different stakeholders.

External events in this context can be classified as implicit changes to the physical properties of the grid as well as the explicit communication of information and services between e-mobility and smart grid technologies, service providers and operators but also user interaction with the EV or the station.

Besides Smart Charging there is also ‘Value Added Service’ like location and reservation of charging spots, easy and secure identification methods and other services that could make charging easier for the user. However, ‘Value Added Services’ might interact with Smart Charging sequences in several ways.

Key to the requirements outlined for smart charging is interoperability between actors, e-mobility and smart grid technologies. Two or more systems (devices or components) are interoperable, if the two or more systems are able to perform cooperatively a specific function by using information which is exchanged.

Interoperability in the context of Smart Charging describes the integration of tasks and refers to the exchange of information between two or more devices from the same actor, or different actors and the use of information for correct cooperation. The functionality of Smart Charging is to optimize the charging of the EVs taking into account different goals like the requirements of the user, battery, grid and energy efficiency and other vehicle needs (e.g. ‘thermal management’ or pre- and post conditioning). Therefore it describes the compatibility of components within a charging system which will ensure access to and use of a safe and reliable charging process for an EV.

Safety is mandatory for any kind of charging, including Smart Charging.

4. Link to Smart Grid

4.1 Aim of smart charging

Smart Charging aims to satisfy the needs of an EV user through an optimal charging process that adjust power load profile considering systems capacities, grid stability and efficient management of power demand and energy use. Smart Charging requests exchange of information between the actors involved.

Considerations have been made for:

- Power system constraints, like grid congestions due to power peak and voltage stability; information exchange deals with power limitation parameters over the grid, taking into account necessary anticipation time according to EV charging duration
- Energy Price, based on supply and demand from the energy market; Information exchange deals with tariff tables providing price versus time or price versus power
- Energy Mix with the requested amount of renewable energy as far as possible; information exchange deals with parameters such as share of renewable energy or CO2 emission rate

This has to be done under several background conditions and objectives, which may apply simultaneously or not:

- To guaranty the interoperability and smart cooperation between systems and components of e-mobility
- To foster satisfaction of needs of the EV user (determined by energy charging cost, journey plan, load to carry, available charging time etc, in accordance with legal requirements for data privacy). This leads to an energy charging request in a given time
- To manage technical and financial constraints of the EV and its accessories (e.g. thermal management of the battery)
- To achieve a sustainable transport system with a positive impact on the economy and the environment, e.g. to minimize the negative externalities of the EV, through a maximum use of existing infrastructure for charging EVs and adoption of smart technologies that enable the use of renewable energy sources.
- To avoid increasing cost of power grid and system services where not necessary
- To reduce globally CO_2 production when using renewable energy to charge EVs
- To manage and store data through the use of smart meters in accordance with communication protocols and contractual relationship (billing)
- To associate other services as requested: parking, CO_2 emission information, combined transportation modes, production of data
- To promote new types of mobility. This includes reasoned mobility in the sense of choice of the most suited mobility for the customer need and efficient mobility with EVs having high performance in order to avoid any rebound effect.

4.2 Principles to follow

We recommend that the development of Smart Charging, and its practical implementation considers:

- A comprehensive approach covering all main M/490 and other relevant uses cases from standardization (Including Optimization of: customer wishes, renewable energy mix, energy production, grid management)
- High level of technical interaction with other systems (smart grids, home- and building automation, and smart meters).
- Harmonised international standards for communication protocols and data models (SGAM – see chapter 6)
- To ensure interoperability between the different equipment involved in Smart Charging in various situations, there is a need for harmonized standardization and conformance testing.

Some criteria in the functions and solutions have to be checked:

- Value chain: value at stake according to actor, organisation between actors in order to implement Smart Charging

- Regulatory aspects: markets organisation, contracts between actors, Service Level Agreements, protection profiles for data privacy, safety and security
- Customer relationship: Smart Charging must be organised to inform the customer before charging of the possibility to fully alternatively partially satisfy its request, and during the process if an anomaly occurs
- Customer acceptance of the service: the energy supply service shall be trustworthy and reliable. Therefore data privacy should be one of the key features to address

4.3 EV charging management and supervision

In the following section we focus on energy and technical aspects of Smart Charging, in relation with other work under European mandates. Referring to draft Report of the Working Group Sustainable Processes to the Smart Grid Coordination Group / Mandate M490 "Use Case Collection, Management, Repository, Analysis and Harmonization", 3 types of load control may be considered:

A. **Unconditional charging**: the battery management system determines by itself the load profile as soon as the EV is connected.
B. **Charging with demand response (open loop):** the charging is controlled using price signal applied to energy and/or power (e.g. low hour tariff). This type of control is "open loop", i.e. the customer may take the signal into account, or decide not to do so (and pay in consequence)
C. **Smart Charging (closed loop)**: the charging is controlled by price and technical signals in relation to a combination of constraints such as overload risk, lack of balance between production and consumption, or coordination between loads to avoid peak demand exceeding the capacity of a network. Contractual clauses initially settled imply that a consumer will take them into account (generally through automation and management systems which include optimization algorithms)

E-mobility Service Providers can offer the customer to manage the two types of load control charging with demand response (open loop) and Smart Charging (closed loop) based on different services with benefits for the user (access to charging infrastructure and price discount), but also with some constrains regarding availability for the power grid and energy market balancing issues.

As a result, these charging activities can work at local, regional or cross-country level. A control management based on incentives (such as price signals) or contract based control signals tries to incorporate all interests at once. These interests include:

- Congestion management and re-dispatch
- Disturbance management and system restoration
- Load shape management for preventing overload
- Balance keeping on local and regional area
- Implementing central and dispersed Renewable Energy Sources
- Power quality improvement
- Reducing energy losses
- Avoiding unnecessary investments in grid and electricity generating plants
- Reducing ecological footprint (of the whole chain)
- Reliable power system

The control management system may work on time scales which vary from days to milliseconds.

4.4 Technologies

The mass deployment of Smart Charging requires adequate control loops, protocols, technologies and standards to be adopted concerning:

- Communication protocols and data models
- Interoperability of systems and components

- Synchronisation of processes and (real time) requests
- Cooperative functions and interconnectivity with components such as EV, EVSE, smart meter (on-board, stationary), energy management system, clearing house etc.

The adequateness of smart metering and smart grid design with Smart Charging functions are of paramount importance. Two types of smart meters have to be distinguished: those for managing electricity supply revenue as specified by European Directive 2009/72/EC, which are generally situated at the public grid connection point, and those for information and control, especially for Smart Charging.

A smart meter can either be in the charging station or, onboard the EV.

With the smart meter including communication technology onboard of the EV (mobile meter) or inside the charging cable the following becomes possible as far as it is compatible with regulations applying to electricity supply revenue management:

- Fully automated, itemized billing per mobile meter
- Separate billing for mobile electricity (when EV charges at home)
- EV drivers select different electricity tariff (e.g. price, quality of energy etc.) for their mobile meter and can charge everywhere with regard to that tariff (electricity roaming)
- In case of separate billing of electricity, record of overall consumption
- Provide information about CO_2 content of electricity production in order to allow the EV to select the time when more renewable energy is available

Several issues are however related to the mobile meter:

- Double billing is expected, coming from both the EVSE related head meter and the on board meter; this should be properly managed;
- Calibration and maintenance of the mobile meter are not part of the vehicle OEMs' core competences and could bring additional complexity to the car maintenance operations.

Given those perceived pro's and con's, solutions with mobile meters are currently only evaluated in pilot projects and feasibility studies.

See ANNEX B for Smart Charging Concepts with examples of technologies and system integration.

4.5 Energy metering and data transmission for billing

Two options for public charging are considered about electricity purchase and billing, which determines metering and data transmission organisation:

- ESR, chosen by EIOP: EV customer obtains a charging service including electricity, possibly through an EMSP
- ESR chosen by EV customer, or by his EMSP, who buys charging service to EIOP without electricity ("electricity roaming"): MID system under MO control has to be extended to EVSE

Besides the energy meter reading, the billing process can require other data to be transmitted. The type of data required depends on the business model in use. To give a few examples:

- The time connected to the charging spot or the time parked at the charging spot can be required for the billing
- In case of fleet owners, an overall contract could be in place not requiring any billing but only authorization
- In case of loyalty cards additional information needs to be transmitted to reward the customer and or reduce the bill
- Another model could be free energy if intermittent renewable energy is accepted in a Smart Charging way

Depending on the business model, the energy bill for the user could as well be addressed to another stakeholder, for example, the fleet owner. It is expected that future business models request several data elements for billing.

4.6 Interoperability for E-Mobility

Electric cars will become more integrated into the intelligent traffic infrastructure and energy networks of the future than conventional combustion engines, with modern Information and Communication Technologies (ICT) forming the backbone for the integration of EVs into these networks. Over the last few years significant progress has been achieved in this field in a range of research projects across Europe. The diverse range of services that have emerged from these projects now need to be connected on a global level to ensure that electro mobility can be established as a sustainable alternative to conventional combustion engines.

The "eMobility ICT Interoperability Interest Group" (eMI3), a unique joint initiative by leading electro mobility companies, therefore pursues a goal: to enable interoperable international services by harmonising current and future data standards. Especially end users will benefit from this, as harmonised standards and a diverse service offering in the global market will make it easy and attractive to use electro mobility.

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Methodology for interoperability under M/490

A conformance testing map should be provided by the end of 2013. Conformance tests are tests to evaluate the adherence or 'non adherence' of a candidate implementation to a standard, i.e. which provides to the user a guarantee that the considered implementation is not against the standard. Getting a conformance testing map will ensure that each selected standard (from the 1st set of standards in M/490) is provided with conformance testing tools and respective processes. This map will also raise conformance testing gaps.

5. EM-WG Role Model

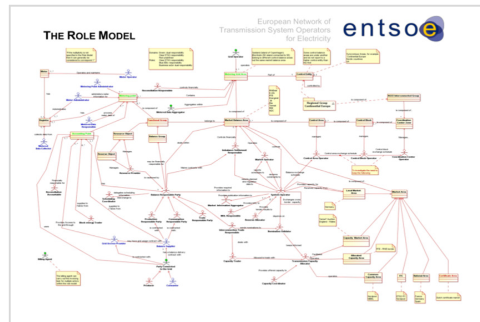
5.1 Introduction

The main task of this document is to define a role model for the E-mobility domain.

One of the most comprehensive role models for power systems is developed by European Network of Transmission System Operators for Electricity (ENTSO-E) and the associated organisations European Federation of Energy Traders (EFET) and ebIX, covering the electricity wholesale and retail markets.

The E-mobility role model developed in this document as a separate domain. It will reference to definitions of actors and roles in the ENTSO-E role model.

Actors like: Balance Responsible Party (BRP), Distribution System Operator (DSO) are referenced directly from the ENTSO-E role model.



For more information on the ENTSO-E role model:
http://www.ebix.org/content.aspx?ContentId=1117&SelectedMenu=8

- A role represents the external intended behaviour of a party
- A role model is an abstract framework consisting of parties which are interconnected. Each of the parties has clearly defined roles (interactions)
- The definition of an party is an entity (e.g. person, system or company) interacting with another entity
- Entities and interactions can be grouped into domains, defined by logical areas of technical or economic relations, business models, geographical or legal boundaries

5.2 The Role Model

One party can have several roles depending on the level of detail for the Role Model. It has been essential for the EM-WG Role Model to be as simple as possible, only describing the basic actors and roles.

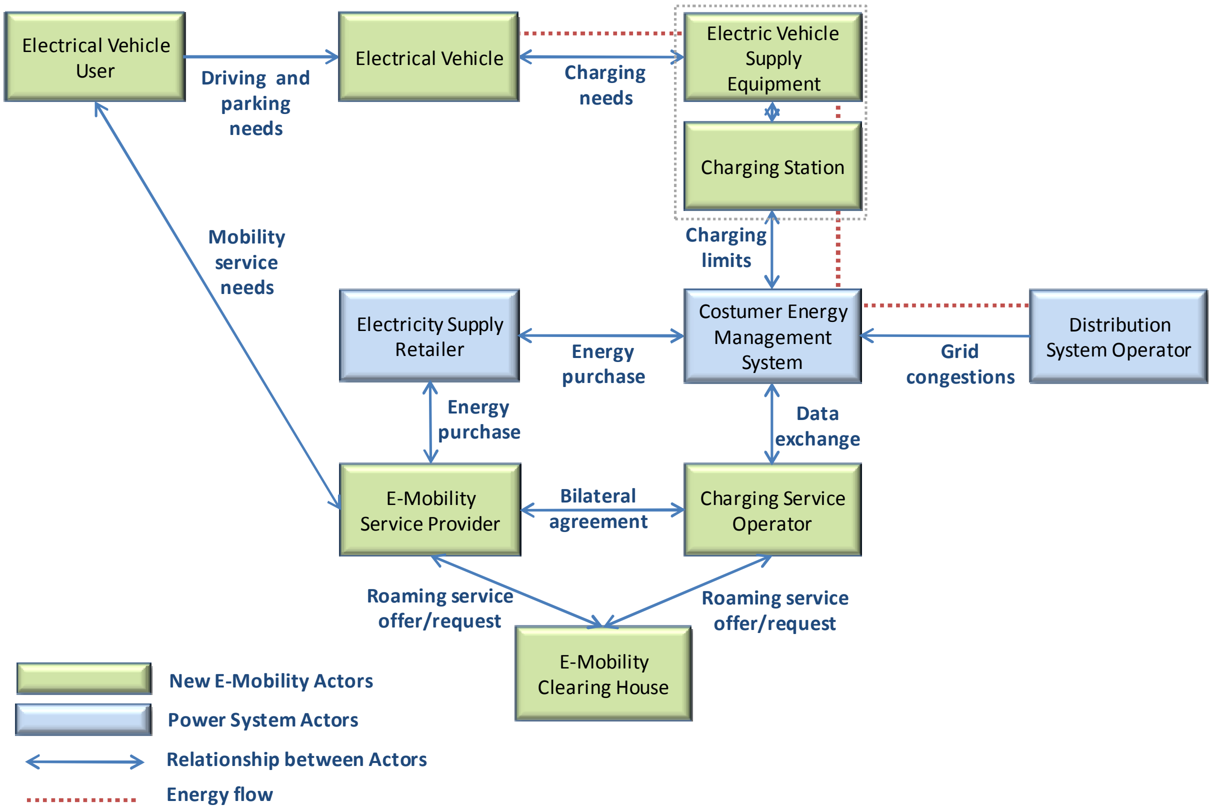


Figure 1 – EM-WG role model overview

Note: For more detailed information about the EM role model and definitions, see TC8 UML role model.

5.3 Detailed description of Roles

It is essential to keep the role definitions as simple and generic as possible, not describing business models or practical system integration or implementations.

Table1 – Role definitions (detailed)

Actor name	Definition of actor	Role of actor
Electric Vehicle User (EVU)	Person or legal entity using the vehicle and providing information about driving needs and consequently influences charging patterns. NOTE: Driving needs, such as range and time of availability are necessary to achieve the most appropriate charging	**Driving from A to B** The basic role of the user is to drive from A to B and give information about the trip (e.g. driving distance, route, estimated time of arrival) to the E-Mobility Service Provider **Parking where needed** Driving urban areas with high traffic density - parking with the possibility to charge, can be very important for the EV user. Information about location and availability of the charging supply equipment is an important part of 'Smart

Actor name	Definition of actor	Role of actor
	scenario. [ISO/IEC 15118-1]	Charging' and therefore it is beneficial to spread this information to the EV user. **Charging when needed and optimal** The need for charging depends on factors like: User needs, availability of Charging Supply Equipment, price of energy and grid constrains. 'Smart Charging' is the definition of a concept where all these issues are optimized automatically. The EV user can sign a contract with the E-Mobility Service Provider, which can provide the best solution for the user. Depending on the solution (e.g. charging instantly, according to price/green energy or grid friendly) the needed information has to be exchanged between the EV user and the E-Mobility Service Provider. *NOTE: There shall be a relationship/association between the EVU and the E-mobility Customer (EC). However, the exact nature of this relationship/association depends on the underlying business models and use cases*
Electrical Vehicle (EV)	Any vehicle propelled by an electric motor drawing current from a rechargeable storage battery or from other portable energy storage devices (rechargeable, using energy from a source off the vehicle such as a residential or public electric service), which is manufactured primarily for use on public streets, roads or highways. [ISO 8713, ISO/IEC 61851 and 15118-1]	**Driving the user from A to B** The main role for the EV will always be to drive the user from A to B. If for some reason this cannot be fulfilled (e.g. need for emergency cooling or heating of battery, empty battery, emergency repairs) the EV might provide this information to the user. **Charging according to the EV, user and grid needs** The energy needed to fulfil a specific driving demand, should always be available. First step is always to know the driving needs and constrains and next step for the EV to get the required energy. The EV will need information about grid congestions and market demands (Local Limit Profile). Locally measureable grid parameters such as frequency and voltage can serve as an indicator for the grid's local and overall system state.The E-Mobility Service Provider will need information about energy needs and user requirements (Target Settings) to fulfil the needs of 'Smart Charging'.
Electric Vehicle Supply Equipment (EVSE)	Conductors, including the phase, neutral and protective earth conductors, the EV couplers, attachment plugs, and all other accessories, devices, power outlets or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the EV and allowing communication between them if required [Ref: IEC61851-1]	**Charging the EV safely** The main role of the EVSE is to deliver power to the EV Independently of the infrastructure used, user, smart grid or market needs, the charging should always be safe and secure for the user and equipment. The Charging Supply Equipment should signal to the E-Mobility Infrastructure Operator if something is wrong.
Charging Station	All equipment for delivering	**Charging the EV efficiently and effectively**

Actor name	Definition of actor	Role of actor
(CS)	current to EVs, installed in an enclosure and with special control functions. [ISO/IEC 61851-1] One or several Electric Vehicle Supply Equipment (EVSE according ISO/IEC 61851) are enclosed within a charging station.	The Charging Station should always try to adjust the charging behaviours in a smart way to stabilize the grids and optimize the charging operations. The CS should always charge the EV as requested within the given limitations or constraints. When an EV has charged at a public charging supply, the information about amount of energy, tariff and operators will be stored, validated and send to the operator who needs the information.
Costumer Energy Management System (CEMS)	The CEM is a logical function optimizing energy consumption and or production based on signals received from the grid, consumer's settings and contracts, and devices minimum performance standards. The Customer Energy Manager collects messages sent to and received from connected devices; especially the in-home/building sector has to be mentioned. It can handle general or dedicated load and generation management commands and then forwards these to the connected devices. It provides vice versa information towards the "grid / market". Note that multiple loads/generation resources can be combined in the CEM to be mutually controlled. When the CEM is integrated with communication functionalities it is called a Customer Energy Management System or CEMS. [M/490]	**Saving energy cost for the costumer** It could also have the role of monitoring and managing the information exchange between the EVSE/CS and the Operators, like DSO, CSO or ESR.
Charging Service Operator (CSO)	A party offering charging service for electric vehicles. May be investor (owner) and operator of CS and of the private electricity networks to which they are connected. If these roles are organised separately, the CSO is responsible for the service management with the EVSE.	**Operate and maintain the data communication** and information exchange between the EV, user and supply equipment on the one side – and the E-mobility Service Providers on the other side, directly or through the EMCH. The CSO operates its charging stations through a Charging Service Management System or Costumer Energy Management System (CEMS).
E-mobility Service Provider (EMSP)	Provider of services in relation with the use of EV. For example: EV rental including access to any shareable EVSE, multi-mode transportation including EV,	**Providing E-mobility services to the EV user** The user signs up with one or more of these actors. The role of the E-mobility Service Provider is to manage all or some of the E-mobility services, like payment for the energy, location and reservation of Charging Supply Equipment and other value added services.

Actor name	Definition of actor	Role of actor
	Charging service management etc. Also called EMO and defined in ISO-IEC 15118-1. Also called EVSP within Green e-Motion project.	
E-mobility Clearing House (EMCH)	Managing exchange of data between operators in relation to mobility services so as to ensure interoperability and open access of EV users to these services.	**Clearing charging activities** The role of the E-Mobility Clearing House will be to establish an open and neutral service for making the charging activities available between different operators. **Providing interoperability between operators** When charging in public, the user should be able to use all the charging facilities available, including cross-board charging facilities. To support the interoperability of information exchange between the E-mobility actors, a clearing house service or an onboard smart meter could provide the needed exchange of information (e.g. ID of user, EV and operators, location and availability of charging supplies, charging profiles) Alternative: Entity mediating between two clearing partners to provide validation services for roaming regarding contracts of different E-mobility Service Providers with the purpose to: • Collect all necessary contract information like Contract ID, E-mobility Service Provider (ESP), communication path to E-mobility Service Provider, roaming fees, begin- and end-date of contract, etc. • Provide CSO with confirmation that an E-mobility Service Provider (ESP) will pay for a given Contract ID (authentication of valid contract) and transfer a corresponding Service Detail Record (SDR) after each charging session to the corresponding E-mobility Service Provider (ESP). *Note: This actor is important in relation to information security and data privacy issues.*
Electricity Supply Retailer (ESR)	Entity on the market selling electrical energy to consumers, in compliance with the regulation for market organisation. It can also have a grid access contract with the TSO or DSO.	In addition, multiple combinations of different grid user groups (e.g. those grid users that do both consume and produce electricity) exist. An ESR is in relation with a Balance Responsible Party according to the electricity market organisation.
Distribution System Operator (DSO)	According to European Directive: "a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its	**Safety of supply (no congestions)** Important for the DSO, will always be to secure access to energy and 'safety of supply' either by a smart grid or by a combination of a smart grid and manageable load, like shifting the EV charge to 'off-peak' hours. Information about forecast of possible grid congestions in the local distribution grid or a direct 'brown-out' signal in

Actor name	Definition of actor	Role of actor
	interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity". Moreover, the DSO is responsible for regional grid access and grid stability, integration of renewable at the distribution level and regional load balancing.	emergency situations, could be useful for the E-Mobility Service Provider, if this is part of the 'Smart Charging' concept. Also described in ISO-IEC 15118-1 as responsible for the voltage stability in the distribution grid (medium and low voltage power grid). - Electricity distribution is the final stage in the physical delivery of electricity to the delivery point (e.g. end-user, EVSE or parking operator). - A distribution system's network carries electricity from the transmission grid and delivers it to consumers. Typically, the network would include medium-voltage power lines, electrical substations and low-voltage distribution wiring networks with associated equipment. Depending on national distribution regulations, the DSO may also be responsible for metering the energy (MO).

6. Reference Architecture for E-Mobility (SGAM)

The method developed by SG-CG called Smart Grid Architecture Model (SGAM) is going to be supported for E-Mobility with the contribution in this section.

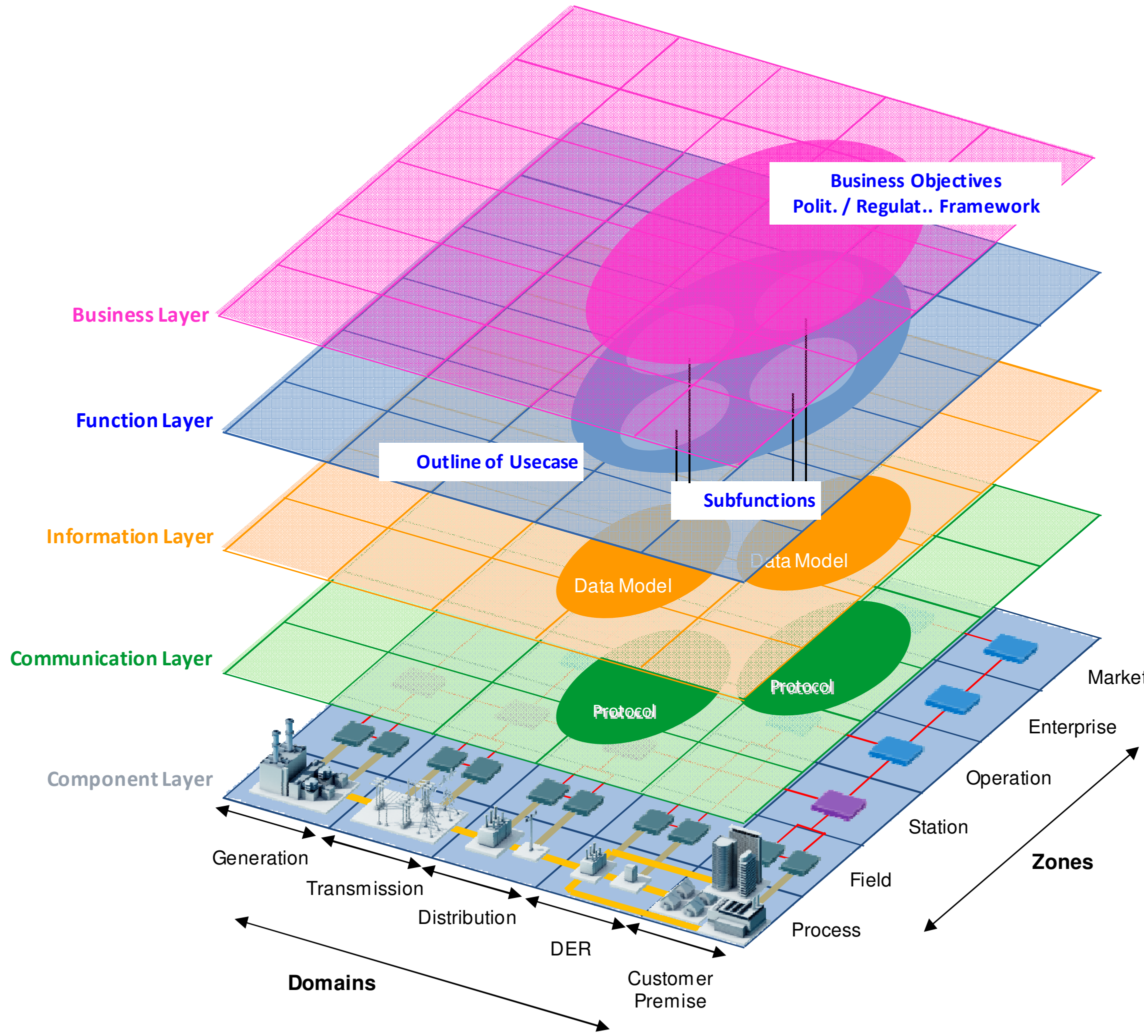


Figure 2: SGAM from SG-CG Sustainable Processes

With the purpose of harmonising all the relevant standards from component to business layer, considering the zones from field to market and the domains from costumer premise to bulk generation – the SGAM is the model or method which can do the task in a structured way.

Please refer to the report: **SGCG Report on Reference Architecture for the Smart Grid** for further explanation of the SGAM background and functionality.

SGAM is inspired by GWAC Stack. For more information on GWAC please see: **http://www.gridwiseac.org/about/imm.aspx**

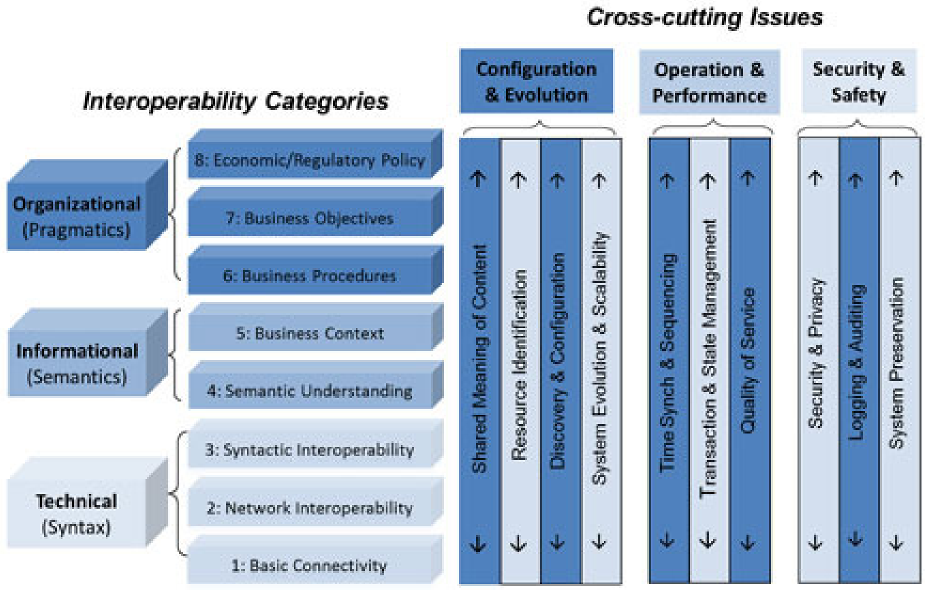


Figure 3: GWAC stack

6.1 Component layer

This layer is the physical components defined in a generic context with respect to the predefined zones and domains.

The component layer basically has 3 aggregation levels:

1. **Unit level** with the EVSE and RTU's in the field zone. This is the detailed aggregation level where the EV is connected to the grid (Smart Grid Connection Point)
2. **Station level** is an aggregation level which is automatically managed by systems based on signals and measurements from the unit level. A typical example could be a parking house where there is a need for congestion management because not all outlets can provide maximum power at the same time
3. **Operation level** is the highest aggregation level, where energy management, aggregation of metering and regional congestion management is performed. The operator in the enterprise zone is typically the operator which trades on the energy markets or directly with the TSO for balancing services and DSO for congestion management services

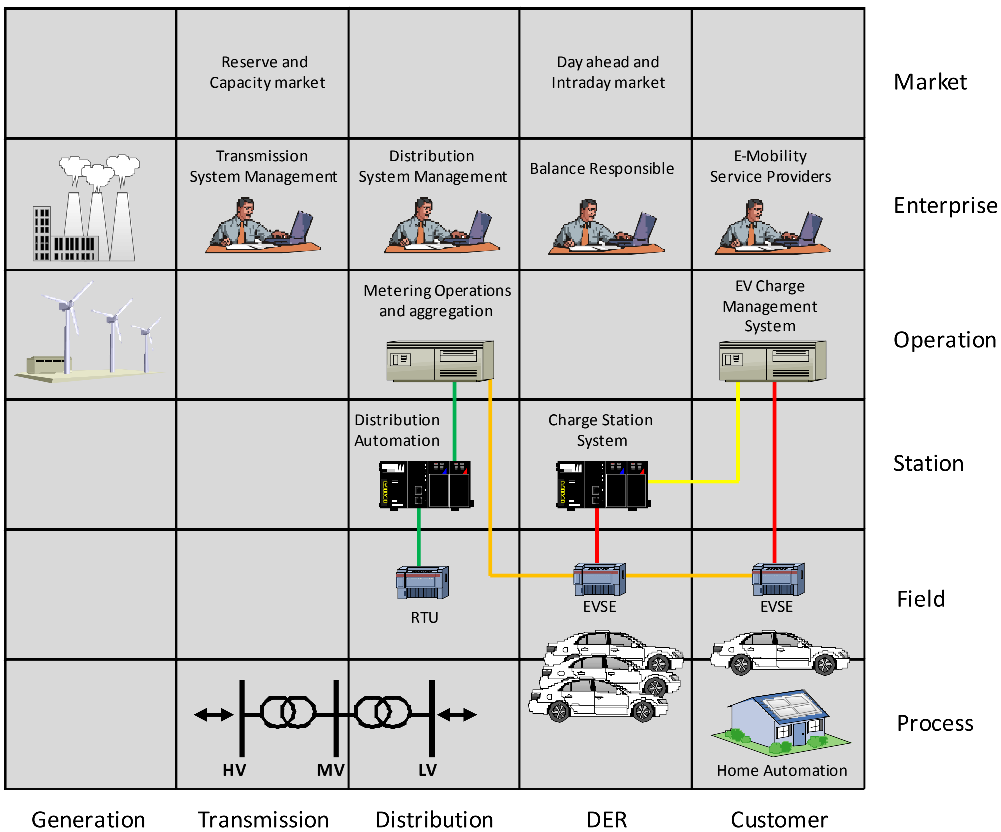


Figure 4: SGAM E-mobility component layer (example)

The component layer is the basic layer for the next 4 layers in the 'Smart Grid Architecture Model' which the protocols, information model and use cases are linked to.

6.2 Communication layer

Different protocol standards from IEC, ISO, ETSI, ITU and SAE are relevant for the different zones and domains in the E-mobility SGAM and the communication layer will give an overview of the technologies for the protocol and transport layers.

1. **Field zone** is basically dealing with the communication between the EV and the EVSE, which includes the following standards: IEC61851-1 (SAE J1772) **PWM** and ISO/IEC 15118-2 **XML (EXI) TCP/IP**
2. **Station zone** can basically be divided into 3 domains, based on the use cases:
   a. Metering: IEC 62056 **DLMS/COSEM**
   b. Power Grid: IEC61850 **ISO 9506 (MMS)**
   c. Charge Spot: ETSI TS 101 556-1 **ASN.1** and future standards for OCPP **XML/SOAP**
3. **Operation zone** with communication between the operators is mainly CIM-standards (Common Information Model) like IEC 61968 and IEC 61970 which is **XML TCP/IP** based.

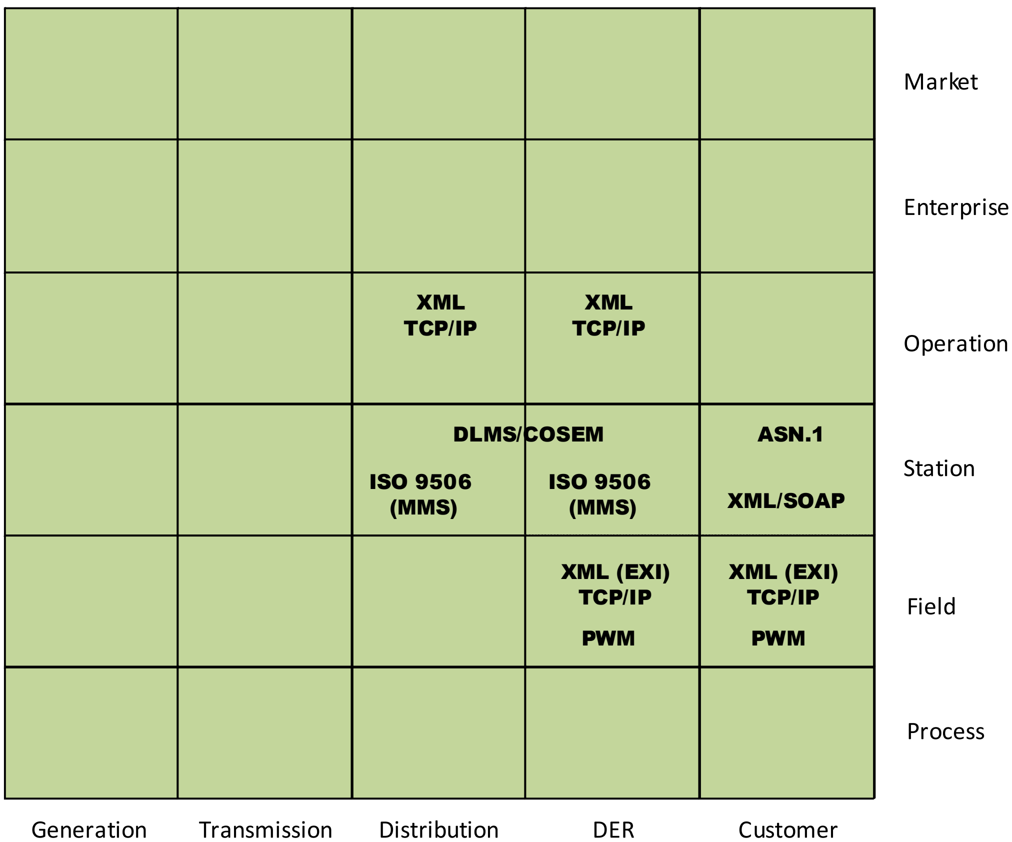


Figure 5: SGAM E-mobility communication layer (example)

Note: There are other protocols in this layer, which could be relevant especially from a US perspective: e.g. SEP2, OpenADR, DNP3, but they are not included in this report.

6.3 Information layer

This layer is closely linked to the ‘communication layer’ but with focus on the service and application elements, which basically means the naming and parameters of the data to be exchanged.

From an interoperability point of view this is an important layer, because independent of the ‘communication layer’, if the naming and definition of the individual data elements are harmonised, the exchange of information and interaction between different actors, will be more clear and easy to incorporate in existing management systems.

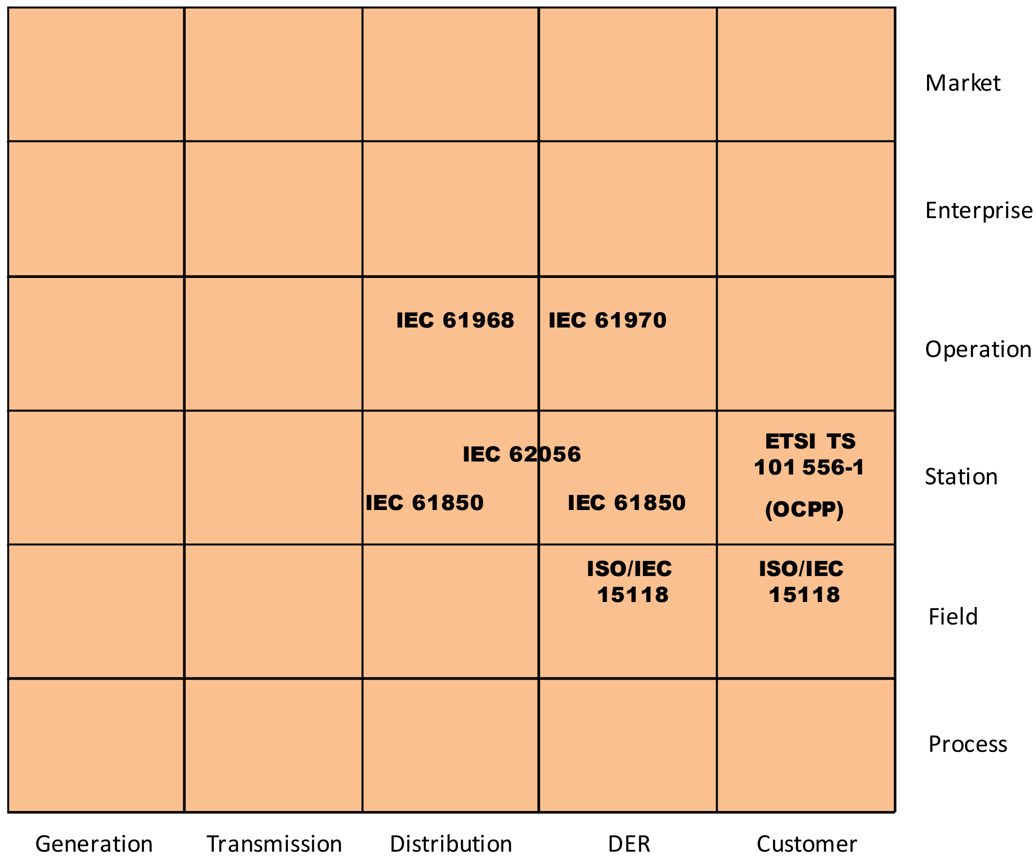


Figure 6: SGAM E-mobility information layer (example)

6.4 Function layer

This report will for the function layer, describe the ‘technical’ use case elements which will be the link between the information layer and business layer (business use cases).

1. **Field zone:** ISO/IEC 15118-1 describes a list of use case elements for the communication between the EV and EVSE e.g.:

    a. Begin of charging process with forced high-level communication
    b. Begin of charging process with concurrent IEC61851-1 and high-level communication
    c. EVCC/SECC communication setup
    d. Certificate update
    e. Certificate installation
    f. Authorisation using Contract Certificates performed at the EVSE
    g. Authorisation using Contract Certificates performed with help of SA

2. **Station zone:** With respect to the sub-division into metering, power system and charging spot domains, the technical use case elements can be of a different nature. An example could be from power system standards, e.g. TR 61850-90-7, where use case elements for control of inverters in DC charging could be:

    a. Function INV1: connect / disconnect from grid
    b. Function INV3: adjust power factor
    c. Volt-var mode VV11: available vars support mode with no impact on watts
    d. Voltage-watt mode VW52: volt-watt management: charging by voltage

3. **Operation zone:** Technical use cases for DSM and EMS could be defined by TC57 WG13 and WG14, but also by TC57 WG17 for Distributed Energy Resources. For technical use case elements regarding management of the charging spots it would be the responsibility of ETSI and OCPP/OCHP to provide this material.

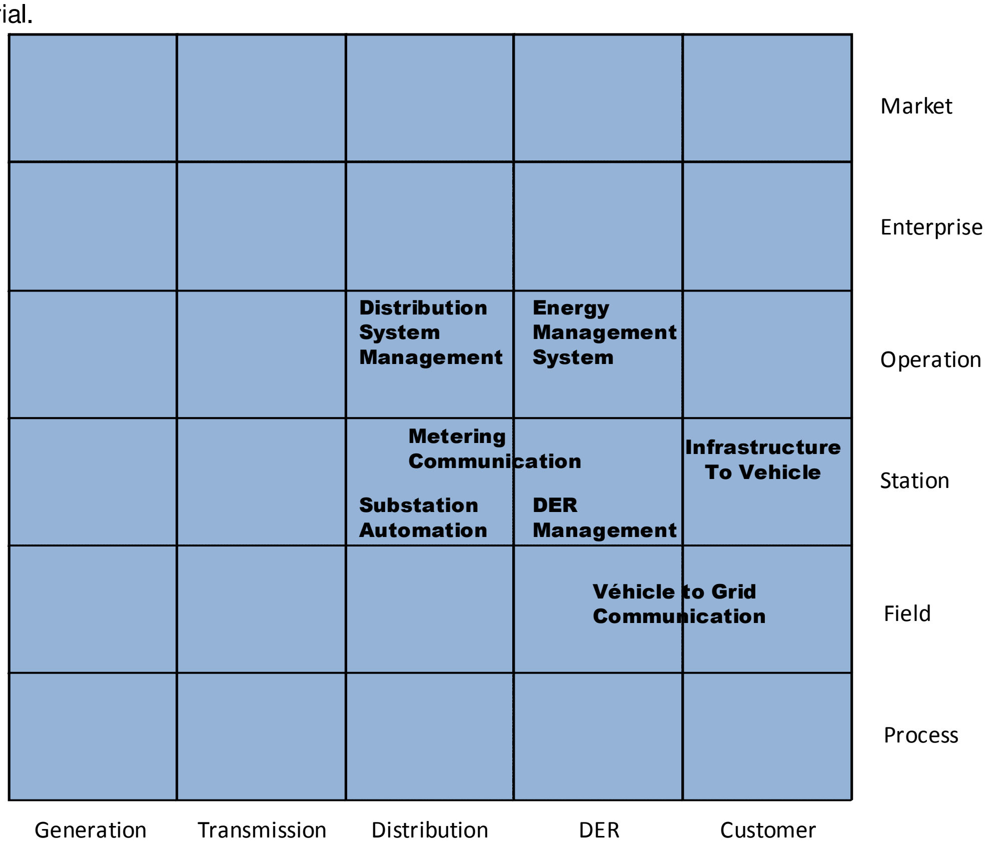


Figure 7: SGAM E-mobility function layer (example)

6.5 Business layer

The top layer in the SGAM is the business layer, which gives an overview of the business oriented use cases and authority regulations like grid codes.

It is important that this report is aligned with the work under M/490 for Sustainable Processes, which means that the basic use cases from the SG-SP process is referenced in this report. See section 7 in this report.

1. **Field zone**: Basic use cases for uncontrolled charging, charging with demand response and Smart Charging.

2. **Operation**: Basic use cases for manage charge infrastructure and interoperability settlement.

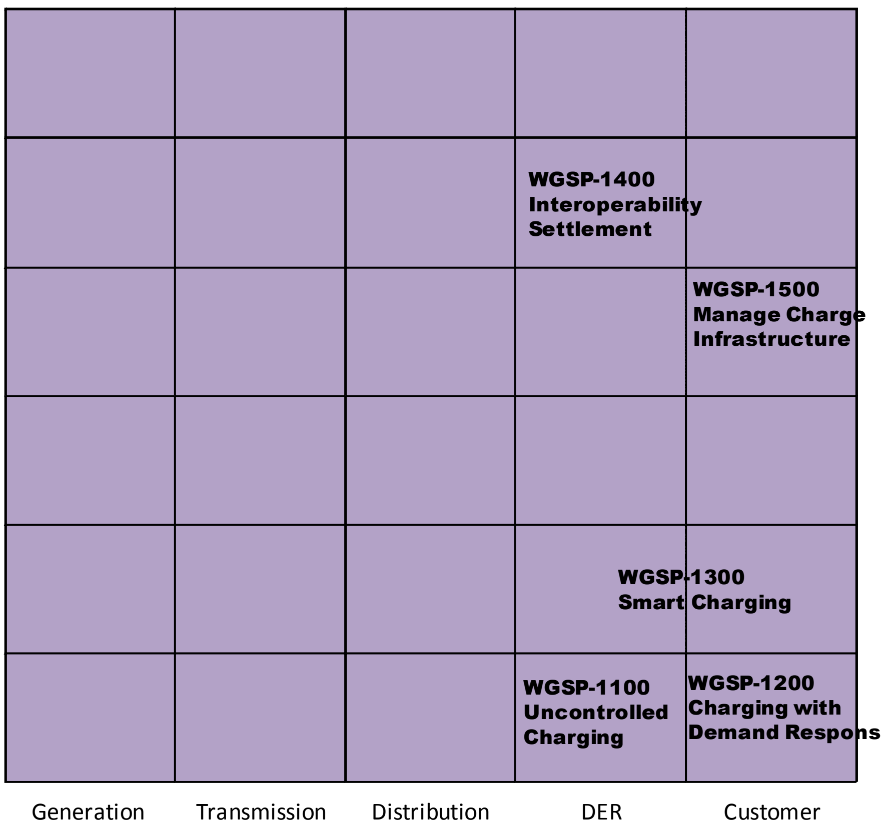


Figure 8: SGAM E-mobility business layer (example)

Note: National grid codes are not referenced in this business layer, because there is not cross country harmonisation of these grid codes.

7. Use cases in ISO/IEC 15118

7.1 Introduction to ISO/IEC 15118

The ISO/IEC 15118 is a complete set of standards.

- ISO/IEC 15118 consists of the following parts detailed in separate ISO/IEC 15118 standard documents
- ISO/IEC 15118-1: General information and use-case definition
- ISO/IEC 15118-2: Network and application protocol requirements
- ISO/IEC 15118-3: Physical layer and Data Link Layer requirements
- ISO/IEC 15118-4: Network and application protocol conformance test
- ISO/IEC 15118-5: Physical layer and data link layer conformance test
- ISO/IEC 15118-6: General information and use-case definition for wireless communication
- ISO/IEC 15118-7: Network and application protocol requirements for wireless communication
- ISO/IEC 15118-8: Physical layer and data link layer requirements for wireless communication

ISO/IEC 15118 standard focusses on the vehicle to grid communication interfaces. ISO/IEC 15118 does not specify the vehicle internal communication between battery and charging equipment and the communication of the charging equipment to other upstream actors and equipment (beside some dedicated messages related to the charging). All connections beyond the SECC, and the method of message exchanging are considered to be out of the scope as specific use cases.

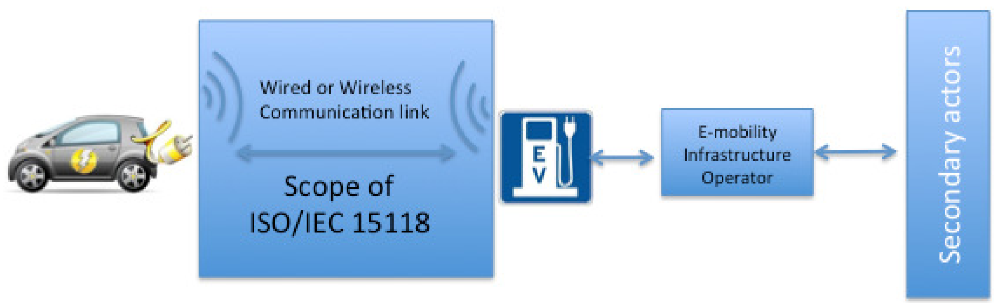


Figure 9: ISO/IEC 15118 illustration

ISO/IEC 15118 covers only the relation between EV and EVSE of Figure 4. However, the information stream from DSO and Charging Service Provider to the Charging Supply Equipment influences the charging session and then the 15118 messages.

7.2 Presentation of ISO/IEC 15118-1/2/3

The current ISO/IEC 15118-1 defines only eight simplified use cases dedicated to the charging process management.

These charging sequences are constructed from exclusives pre-identified sub sequences/ sub use cases.

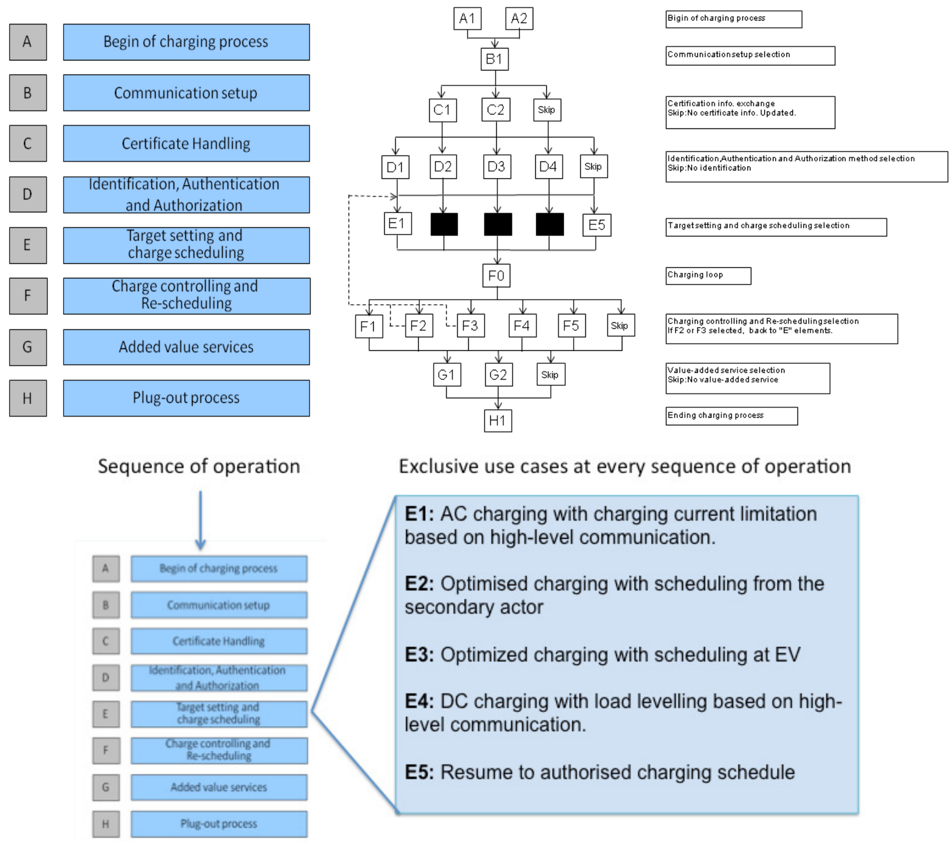


Figure 10: Sequence description of exclusive use cases in a charging session in ISO/IEC 15118.

These sub-use cases A1, A2… H1 described in 15118-1 are the basis for the charging scheduling description of 15118-2. They allow the elementary functions that have been identified until now but may lack some aspects of practical characteristics of future EV usages influencing the charging session.

7.3 Presentation of ISO/IEC 15118-6/7/8

Smart charging system may be part of a more complete system and could then requires more information and data exchange than the current ISO/IEC 15118-1/2/3 documents describe. The reservation of the charge spot as well as the reservation of energy could be made by other means than by using the current ISO/IEC 15118 wired communication.

The work on the ISO/IEC 15118 wireless communication has just started.

Three main challenges are addressed by these new standardization projects:

- The adaptation of the current ISO/IEC 15118 V2G communication solution to wireless communication means
- The harmonization of the current ISO/IEC 15118 V2G communication solution with the wireless charging control communication defined in the ISO 61890
- The harmonization of the current ISO/IEC 15118 V2G communication solution with the ITS (Intelligent Transport Systems) proposals such as the TS 101 556-1 v1.1.1 defining the Electric Vehicle Charging Spot Notification Specification and the TS 101 556-3 v1.1.1 dealing with Communications system for the planning and reservation of EV energy supply using wireless network in order to offer seamless services from driving to charging

7.4 Further improvement examples

As part of a more general system, new use cases, even out of scope of current ISO/IEC 15118, should be further explored:

- The vehicle is charged in the public or private domain and maximum power may be limited by contract with the DSO.
- The charging system is part of a complex system which will probably include an intermediate energy controller and the corresponding business case
- Management of the charging infrastructure and data flow
- The global (aggregation, statistical and provisional) influence of charging behavior
- Charging requirements and charging patterns will depend closely on the missions and usages of the particular vehicle and the particular client as well as the adjustment of the power demand towards the smart grid. The mission profile for each charging session must be established based on the client and system needs in regards to data privacy respect:
    - Journey to be accomplished (default or special) for fleet management for instance
    - Information related to scheduling and timing constraints
    - Desired price (Regular or Premium)
    - …
- The capacity and functionality of the complete system (vehicle, charge spot, local installation, grid capacity etc.)
- Charging spot accessibility and capability (appropriate to client needs)
- Geographical location of charging spot related to the journey

The future EVs will most certainly become part of a complete information system as remote wireless services expand. The client will benefit directly from the value added services and charging profiles will be better adapted. The structure for this additional information should be prepared in order to facilitate the integration into the vehicles.

Here are some examples of basic information that is likely to influence future charging sessions. Other use cases may of course enlarge this list (some are already included in pending standards).

Client requests for charging
- Time constraints (when I would like/is best to charge my car)
- Price constraint (price range for 1 kWh/ X km)
- Convenience (less than x km from my way, in the morning, afternoon or evening)
- Charging target (charging functions can be optimized according to one or more parameters such as km to cover,, % of battery capacity, CO_2 emissions accounting and/or energy prices)
- Roaming information (What are my preferred options today, might be different than yesterday or tomorrow)
- Pre-booking of a public charging spot.
- Spots availability along my journey

Information required at charging spot to optimize energy
- Remaining charge of the battery
- Time to next usage
- Required energy for next usage
- Time and money required to charge up to a certain level
- Power available at charge spot – power level accepted by vehicle
- Re-negotiation of power delivery accepted or not by EV, likely or not at this time of day/year
- Extra services required like heating or cooling the vehicle, map or video download
- Index of interruptible charging services (split between: battery charging, battery temperature control service and other technical services). A service could be non-interruptible before x sec or could interruptible instantaneously but with energy loss, or could be interruptible instantaneously with no technical consequences

Billing information
- Identification of client
- Smart Charging behaviours
- Smart Metering

- Consumption profile
- Environmental information
- Price information (before charging session in order to compare offers)

Other type of information difficult to handle precisely today
- Impact of Renewable (fluctuation, forecasts, price…)
- Impact of EV2Grid, EV2Home, EV2Neighbour

Note: The list of parameters provided is only examples and has to fulfil the legal requirement for data privacy.

If we look at the combinatory possibilities we get the following, still open, Vehicle-Charging Spot cross interaction table:

Client profile	**Vehicle profile**	**Travel profile**	**Charging profile**	**Billing profile**	**EV charge capability**	**Special needs.**	**Added value Services.**
Private	Plug in hybrid	Short point to point	3 – 6 kW or more	Single bill for multi service	AC low-high power	Cooling-Heating	Video, map…
Shared car	Short range	Commuting urban	Adjusted to available power	Electricity only	AC high power And AC low	Cooling-Heating	Maintenance messages
Company Fleet	Long range (>150 km)	Roaming	Fast charge	Single service inc. electricity	DC high power AC high-low	Check	Availability
Urban mobility	Priority.	National International	As a function of pricing, electricity network constrains…	Free	Etc.	Maintenance	Battery check
Other	Other	Other	Other	Other	Other	Other	Other

Figure 11: Charging combinations versus charging profiles

Charging spots will also have to adapt to different vehicle missions prefigured in the following table (these examples may reflect only part of future usages).

Charging spot profiles	**Charging spot usage examples**									
	Home charging	**Curb side**	**Parking area**	**Shopping center etc.**	**Office parking**	**Fleet depot**	**Dedicated mobility systems**	**Taxis**	**Urban deliveries**	**Small entrepreneur**
3kW–6kW available all the time	x	x	x	x	x	x	x	x	x	x
3kW–6kW on/off, off peak charging	x		x	x	x	x				x
Charging adjusted to global limit (16–64A)	x	x	x	x	x	x	x	x	x	x
Charging with respect to pricing	x		x	x		x		x	x	x
Fast AC or DC		x	x	x	x	x		x	x	

Figure 12: Charging spot usage examples versus charging profiles

8. Terms, definitions, acronyms and organization of use cases

For the purposes of this document, the following abbreviations, terms and definitions apply:

Table 2 – Abbreviation list

Abbreviation	Term
ACM	Adjustment Capacity Market
BRP	Balance Responsible Party
CEMS	Costumer Energy Management System
DH	Data Hub
DER	Distributed Energy Resources
DERO	Distributed Energy Resources Operator
DSO	Distribution System Operator
EMCHO	E-mobility Clearing House Operator
EC	E-mobility Customer
EIP	E-mobility Infrastructure Producer
EIOP	Electrical Installation Operator
EIOW	E-mobility Infrastructure Owner
EMSP	E-mobility Service Provider
EEM	Electric Energy Meter
EV	Electric Vehicle
EVCC	Electric Vehicle Communication Controller
EVM	Electric Vehicle Manufacturer
EVSE	Electric Vehicle Supply Equipment
EVU	Electric Vehicle User
EM	Energy Market
ESR	Energy Supply Retailer
FLO	Flexibility Operator
MID	Measuring Instruments Directive
MO	Meter Operator
OEM	Original Equipment Manufacturer
PO	Power Outlet
RES	Renewable Energy Sources
SDR	Service Detail Record
SECC	Supply Equipment Communication Controller
SGCP	Smart Grid Connection Point: border between two grids operated by different entities, especially between DSO and EIOP.
SG-IS	Smart Grid Information Security
TSO	Transmission System Operator

Annex A – Use cases

The current process in M/490 for collection and consolidation of E-mobility use cases is managed by SG-CG sub-group ‘Sustainable Processes’ and a separate section for E-mobility is illustrated below (WGSP-1000):

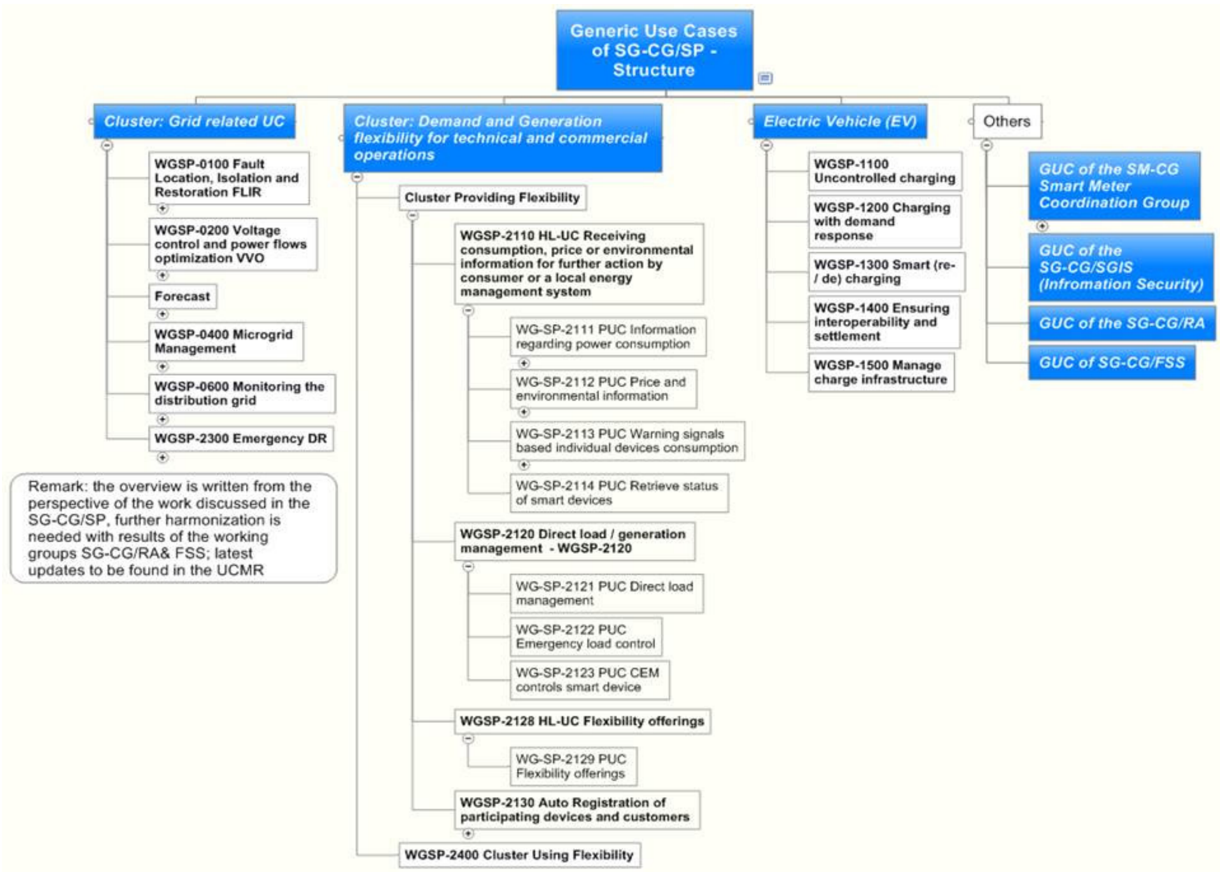


Figure 13: E-Mobility use cases under M/490

For a detailed description of the E-mobility use cases under M/490 see: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/xpert_group1_sustainable_processes.pdf

Annex B – Smart Charging concepts

This annex is a collection of different Smart Charging concepts with focus on different areas of Smart Charging, from agent based communication concept to EV Service Provider management activities.

All concepts have been documented based on the same template, which should make it easier to compare and reference in the different report sections.

All the examples in this annex has not been edited or validated by the WG Smart Charging group. All information in this annex is to be handled ‘as is’.

The main purpose of this annex, is to give practical examples of different ‘Smart Charging’ concepts, from R&D to demonstration projects and real life implementations.

The following concepts are described (alphabetically):

B1 **Context Aware Charging**

B2 **CROME : CROss-border Mobility for Evs**

B3 **EDISON VPP**

B4 **ELVIIS – Electrical Vehicle Intelligent Infrastructure**

B5 **Energy Conservation**

B6 **ESBN Winter Trials**

B7 **Finseny Project**

B8 **GÖRLITZ E-Mobility Smart Charging Solution**

B9 **Green eMotion congestion management in DSO business model case**

B10 **IntelliCharge by ERDF**

B11 **MUGIELEC**

B12 **PowerMatcher**

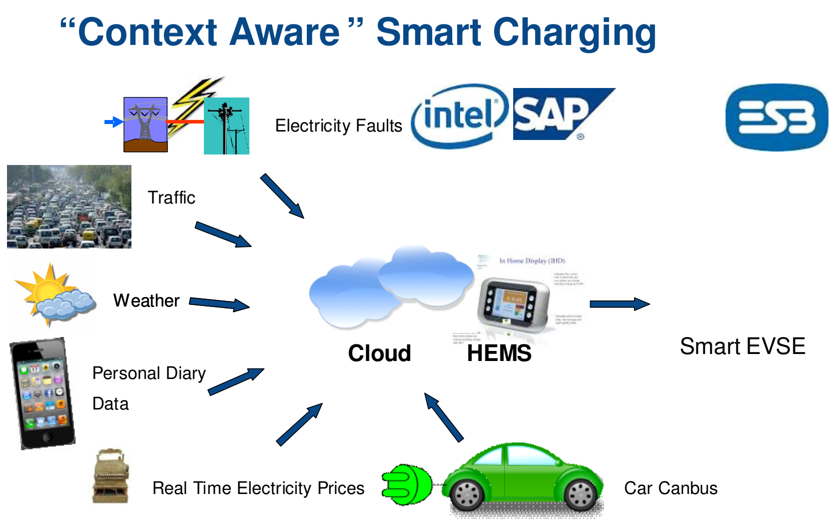
B13 **VISMA**

Name of concept	Context Aware Charging
Concept partners	ESB, Intel, SAP
Project reference	N/A
Reference report	N/A

Scope

The project tests and demonstrates Context Aware Charging. Home and workplace EV chargers are controlled via a Home Energy Management System, allowing an unhindered user experience, while offering energy cost savings to the customer and allowing greater use of sustainable energy while charging the electric vehicle.

Illustration



Description of the concept

Wind energy as a variable energy source is difficult to integrate with fossil fuel generation due to the need to vary the outputs of other generation sets to balance supply and demand while maintaining system frequency. Weather forecasts combined with electrical generator profiles can predict the availability of wind energy over the coming hours and days. As energy markets develop to provide a more dynamic pricing structure at the retail level, the opportunity exists to maximise the use of renewable energy sources for the EV driver, while benefiting from lower energy pricing.

The user however must still have the confidence that their lifestyle and transport arrangements are unhindered by this process.

Once a user plugs in the vehicle to charge, the HEMS generates a charging profile to optimise the charge pattern of the vehicle to best utilise renewable energy and lower electricity prices for the customer. Data from the customer diary is used to predict the distances the user will travel in the coming day as well as the unplug time for the vehicle. Over time the system learns from the driving profile and energy consumption of the driver and vehicle, allowing the HEMS to predict more accurately with limited input from the user.

The HEMS will assess weather patterns and price contracts to best fit the energy requirements to the available charge time while guaranteeing the user the required charge will be available at the time of unplugging.

User inputs include: Unplug time, reserve charge level and journey planner.

Other inputs include vehicle battery level, GPS, system demand, renewable generation, weather and price contracts.

Name of concept	CROME : CROss-border Mobility for Evs
Concept partners	EDF, ENBW, Renault, PSA, Daimler, Porsche, Bosch, Schneider, Siemens, KIT…
Project reference	http://crome-project.eu/
Reference report	http://crome-project.eu/

Scope

The project integrates results from existing EV projects in French-German border: Project Kleber in France, MeRegio and ecars in Germany. The scope is to operate full interoperable charging stations with easy access, charging and billing of all EVs over the Crome area.

Illustration

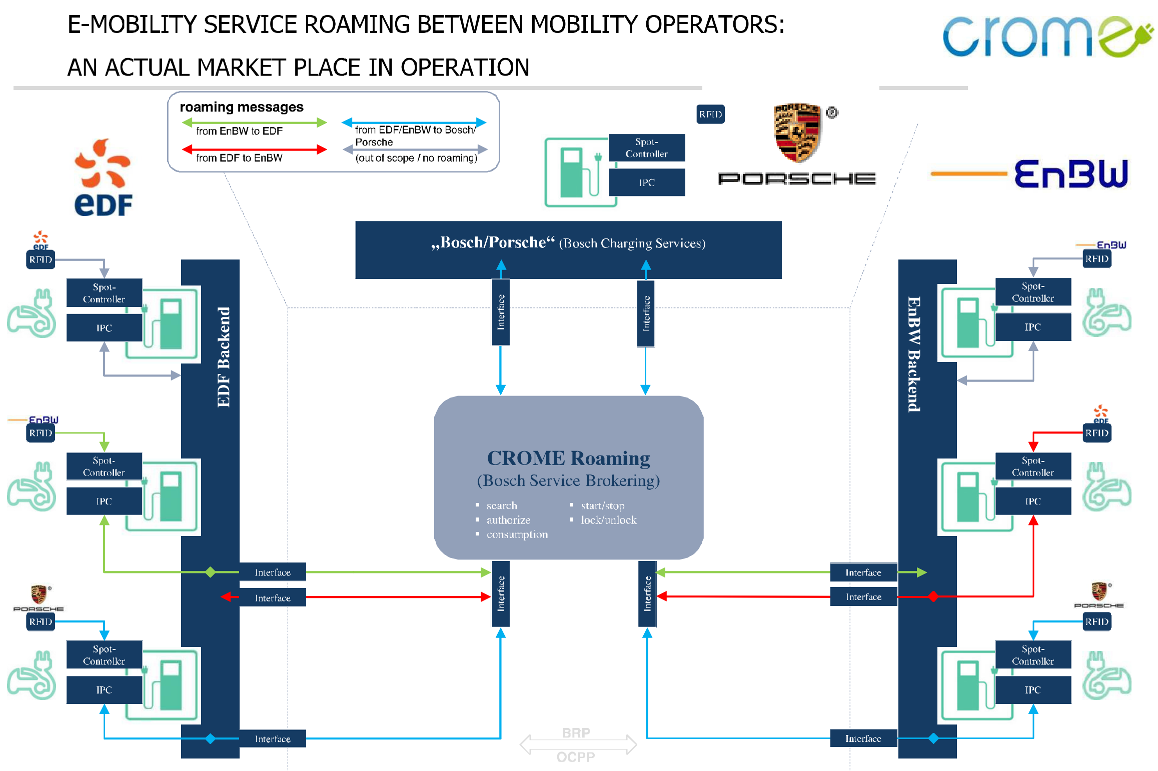
General vision of the project

With the CROME project French and German cars can charge in both countries.

EVs stay unchanged so any car, including those not part of the project (e.g. from Toyota or Nissan), can charge. Only charging stations need adaptation to be able to read special CROME RFID cards.

Autentification and charging control is made through smartphone.

Common ICT servide platform ensure the roaming of information and billing.



General vision of the Roaming process in the CROME project

Description of the concept

CROME is a safe, user-friendly and reliable cross-border e-mobility project between France and Germany.

It demonstrates an interoperable easy-to-use charging infrastructure (plug, cable, etc.) and customer-oriented services (authentication, billing, roaming, reservation, etc).

A particular emphasis is placed on Customer-oriented services demonstration like:

- Simplified identification (uniform access to French and German EVSE with contactless RFID card)
- Localization, availability and reservation of charging spots with smart phones
- Transparent Roaming of e-mobility services between infrastructure operators (based on OCPP)

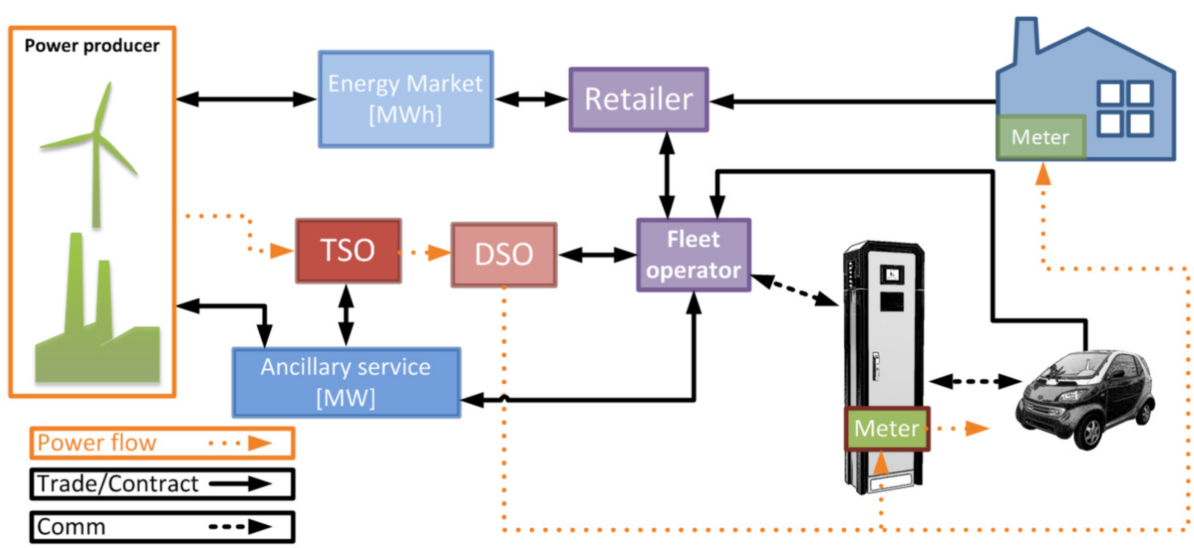
The project has now entered in an active exploitation phase; so far 100 CROME charging points have been installed along the Rhine corridor. Other border countries are expected to join the program.

Name of concept	EDISON VPP
Concept partners	IBM, DTU, EURISCO
Project reference	EDISON project
Reference report	http://www.edison-net.dk/Dissemination/Reports/D3.1.aspx

Scope

The conceptual role of a fleet operator, which can be implemented by different commercial players, is introduced to allow groups of EVs to be actively integrated in the power system. Towards the grid and market stakeholders, the fleet operator will operate as a Virtual Power Plant (VPP).
The Virtual Power Plant concept describes an aggregated system in which distributed energy resources (DERs) are partly or fully controlled by a single coordinating entity. In this way, DERs can be actively integrated into the power system and market, for which individually they would be too small – in terms of power output and availability – to participate in. The concept has been demonstrated in the European FENIX project [3] and studied by Shi You et. al [4].
In the case of EDISON a fleet operator could mimic a traditional power plant by aggregating a group of electric vehicles. The fleet operator would also need to interact with each individual electric vehicle to optimize charging. The technical implementation of this concept is called the EDISON VPP (EVPP)

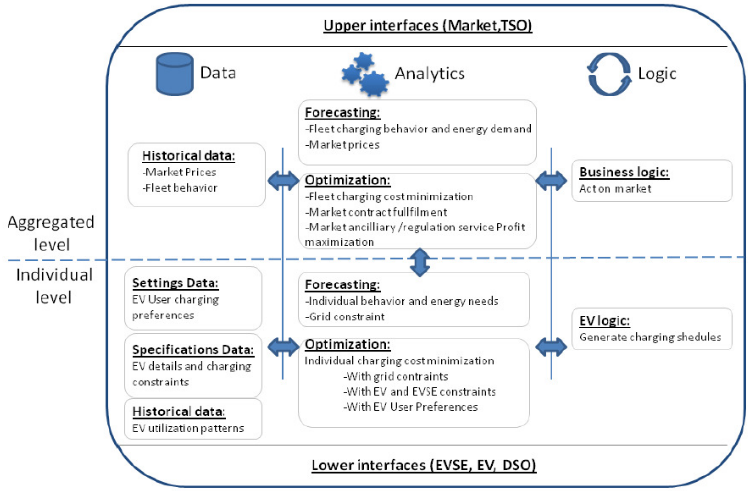
Illustration



As illustrated, the fleet operator could participate in the energy market and in ancillary services (for example the FO could plan capacity that could be used for up or down regulation). The first project phase, however, will put its emphasis on the former and indirectly connect the EVs with the day-ahead spot market by controlling the charging in correspondence with hourly energy prices.

Description of the concept

The EDISON VPP is a server-side software system that coordinates the behaviour of a fleet of EVs while communicating with external power system stakeholders. To illustrate the internal workings of the EVPP it is useful to group its functions into three groups: data, analytics and logic. This is done in the figure below, which also differentiates between the aggregated and the individual level of EV management.



The EVPP handles the EV fleet as an aggregated group when acting and optimizing towards market players (upper interfaces), but will have to take individual considerations into account when handling the behaviour of a single car (lower interfaces). The three main functional groups perform the following functions:

DATA:

This group stores previous market prices and fleet behavior on an aggregated level, enabling better forecasting and optimization for acting on the power market. On an individual level, data is stored that describes the service level agreement between the EVPP and an EV owner e.g. to which degree the EVPP should control the charging process. EV hardware specifications, like battery size and supported charging powers, are also stored. Finally the EVPP stores the EV user's plug-in habits i.e. where, when and for how long the EV is typically connected to the grid for charging. These parameters are all vital for individually optimizing the charging of an electric vehicle.

ANALYTICS:

'Analytics' means the mathematical computations necessary to support the logic of the EVPP. Forecasting relies on historical data to predict market prices on an aggregated level which supports better bids and strategies. Forecasting also determines future individual EV usage patterns. The latter helps the EVPP predict when the EV user will need the EV for the next trip and can thus better estimate the time period available for smart charging. Such a prediction can be based on the statistical methods of Exponential Smoothing or using the Markov Chain approach. Optimization is used to minimize charging costs of the EVs on both the aggregated and individual level. The individual optimization is limited by the constraints introduced by the distribution grid, EV specifications and EV user energy requirements. On the aggregated level, profit maximization can be done when acting on the regulating and reserve markets. Such optimization can be achieved through stochastic or linear programming.

LOGIC:

The logic defines the main operational goals of the EVPP, namely to act on the power market to generate savings or revenue for itself and its clients, and to intelligently manage the charging behavior of EVs through individually tailored charging schedules.

Name of concept	ELVIIS – Electrical Vehicle Intelligent Infrastructure
Concept partners	Ericsson, VOLVO, Viktoria Instiute, Göteborg Energi
Project reference	ELVIS project
Reference report	http://www.ericsson.com/thecompany/press/mediakits/electric_car_charging http://www.ericsson.com/res/thecompany/docs/press/media_kits/elviis_content_summary_v6.pdf

Scope

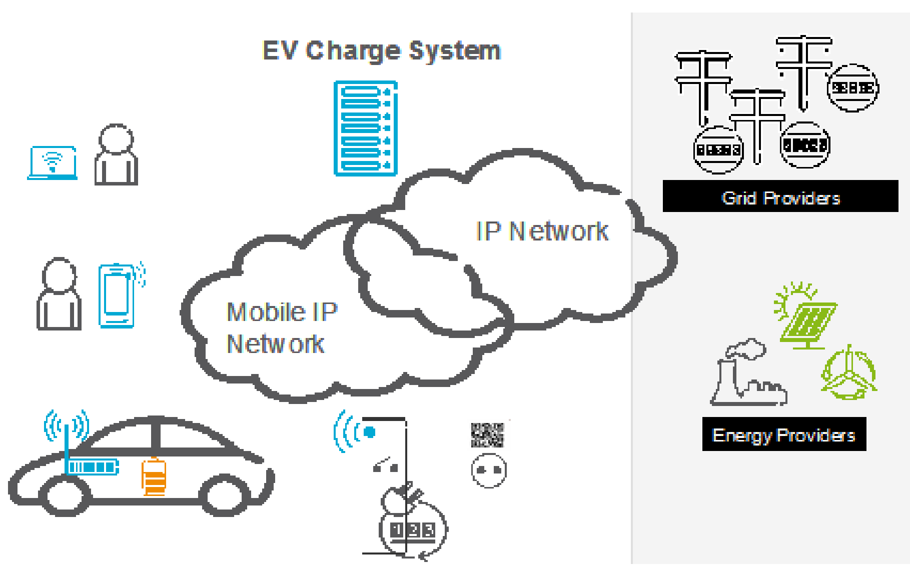
Electric vehicles introduce roaming between different utility grids: Using an electric vehicle means that you will have a need to charge the car using outlets that you do not own, and which may not be public charging points. An electricity outlet at a friends' house may be connected to an electricity provider that you do not have a relation (subscription) with. The ELVIIS Vehicle Charging System (EVCS) ensures that your friend will always be credited for the electricity to use from her outlet to charge your car.

The electrical vehicle charge system, concept developed by the ELVIIS project, is capable of supporting utilities companies providing them with roaming and settlements functionality for electricity consumed from private and public charging outlets. EVCS support two types of outlets i.e., smart and dumb outlets. The ELVIIS project focuses on dumb outlets.

ELVIIS is joint project initiative with Ericsson, Göteborg Energi, Volvo cars and the Viktoria Institute. In this project, knowledge about system architecture for future communication requirements, new actors and new value chains are developed and implemented. Services are being evaluated in a field test with electrical vehicle users which will start early in 2013. The project aims to collect the necessary knowledge for full scale deployment of such infrastructure and services and to identify the need for international standards and regulations.

EVCS functionality allows a user to pay for the electricity consumed by the battery charging process when using a dumb outlet belonging to someone else. A prerequisite for this is that the car is equipped with functionality to monitor energy usage, and has the capability to communicate it to EVCS. This is implemented on top of the connected vehicle platform that is used within the ELVIIS project.

Illustration



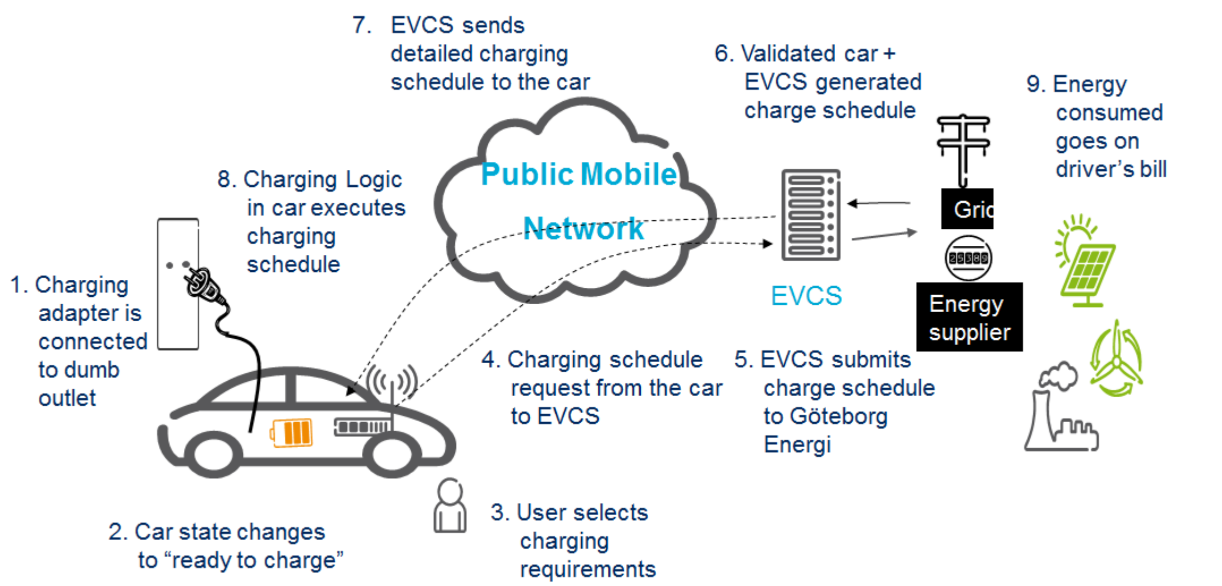
Ericsson has (together with an industry partner) developed and provided a reference platform in the Electrical Vehicle Proof of Concept to secure the connectivity of and intelligence in the car. It communicates through a mobile broadband module, HMI and an interface towards the CAN bus in the car. The interfaces and interworking with cars, energy and grid providers has been developed and verified by the project partners.

Description of the concept

The Electrical Vehicle Charge System (EVCS) is deployed on a server that plays a central role in the solution. It communicates with all actors, and optimizes and manages remotely the battery charge process based on input from the driver, grid operators, energy providers and car characteristics. It enables a user with the possibility of paying for the electricity used to charge his vehicle to a private householder by ensuring that the householder is credited for the energy taken by the vehicle. The vehicle is assumed to have an on-board electricity meter and the user must have a contract for the vehicle with any public energy provider of her choice. The electricity taken to charge the vehicle is always measured by the vehicle and is always charged to the account of the vehicle owners' account and supplier regardless of the outlet used and its ownership. The sockets are identified using QR tags or using GPS coordinates. In the first phase of the trial, QR tags have been used to identify sockets.

The optimization can be based on a cost perspective, sustainability perspective (i.e., CO_2 emission and type of energy), by time (charge as fast as possible, charge now) or at the time that the energy grid has the lowest load. The driver has the possibility to monitor the charging and control parameters via an app downloadable to a Smart phone.

One of the main benefits of EVCS is that it enables the large scale usage of electrical vehicles e.g., connecting multiple actors such as grid operators, energy suppliers and car manufactures as illustrated in the scenario for charging from a dumb outlet shown below.



The main component in the architecture that has been developed in this Proof of Concept is the Electrical Vehicle Charge System, EVCS. The EVCS can be deployed as an application server (AS) in an IMS-based service environment, but it can also run independently of IMS.

- EVCS can take advantage of an intelligent car communication, but it is not dependent on such communications. This assumes however that there are smart outlets connected to the service.

- EVCS can take advantage of smart outlets, but it is not dependent on them. This assumes however that there is an intelligent car connected to the service.

- EVCS fits well into the smart grid concept. Its power is that it be deployed independent of a smart grid implementation potentially providing services for charging with reduced requirements for investment in a private environment compared to the investment needed to provide public charging infrastructures, which will often not be commercially viable in sparsely populated regions.

The main benefits of the EVCS can be summarized as follows:

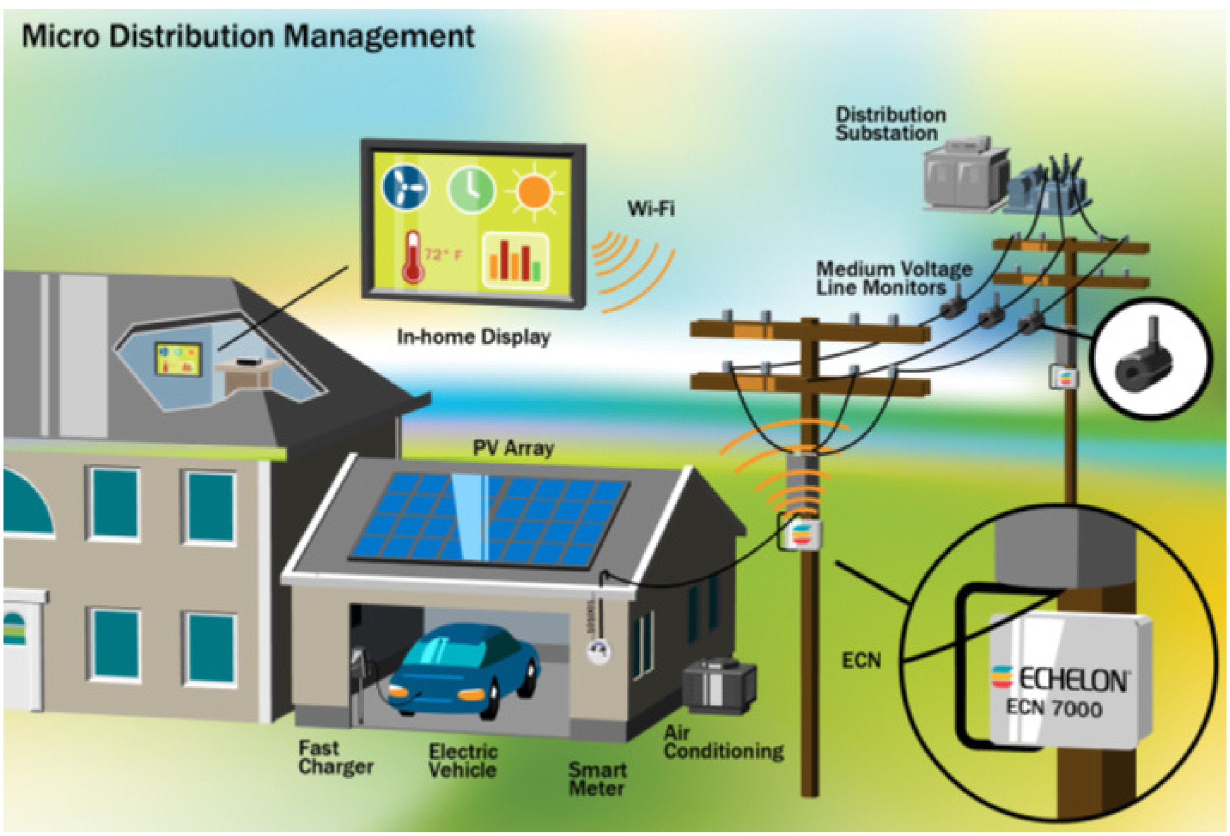
- It provides freedom to users to charge where it is convenient, at friends' houses or other non-public locations, and make it easier to use and drive electrical vehicles by providing drivers with independence from public charging infrastructures, which may not be available in all locations where the user may want or need to charge,
- It secures that the cars connected to the service are charged to the right level and in time to fulfil the driver's preferences,
- It provides for load balancing in the energy grid,
- It minimize the impact on the existing grid of charging electric vehicles,
- It provides efficient energy transport and usage,
- It provides a steering mechanisms to reduce CO_2 emissions,
- It provides a sustainable transport solution concept,
- It supports the roles of service providers,
- It supports interfaces to all of the actors in the ecosystem, and
- It minimizes the number of agreements that each actor has to make in order to establish business relationships within the eco-system.

Name of concept	Energy Conservation
Concept partners	Southern California Edison (SCE), California Energy Commission (CEC), Echelon Corporation, VaCom Technologoies
Project reference	Peak Load Reduction Program (PLRP)
Reference report	LonWorks Demonstrates Watts New in Energy Conservation (http://www.vacomtech.com/Downloadfiles/Echelon%20SCE%20Battery%20Charger%20Control%20Story.pdf)

Scope

The goal of the project was energy conversation and reducing peak loads, included shifting the recharging of batteries to off-peak hours. Southern California Edison (SCE) wanted to enable customers to be able to conveniently and easily shift their battery charging to off-peak times. SCE determined that by providing customers with the proper control equipment, they would be able to accomplish this goal.

Illustration



Description of the concept

Southern California Edison (SCE) realized that if it could shift the recharging of just 3-5% of the estimated 70,000 such vehicles within its territory to off-peak hours, the utility could reduce peak loads by 8 megawatts. SCE applied to the California Energy Commission (CEC), proposing a program to reduce industrial electric vehicle on-peak charging loads. Under the program, funded by the State of California, companies that installed energy management equipment on their battery charging systems would be paid up to $150 per kilo-watt (kW)if they shifted from on-peak to off-peak weekdays during the summer months.

Developing the charger management solution for the Peak Load Reduction Program (PLRP) was a joint effort between SCE's Electric Transportation Division and several industry trade allies, including VaCom Technologies, an Open Systems Alliance member and Echelon Authorized Network Integrator located in La Verne, California.

VaCom recommended using controls based on Echelon's LonWorks open technology along with using Echelon products. The systems had built-in compliance and override verification plus Internet communications options. In addition, a LonWorks network did not require expensive, custom coding that would have taken months to create. Doug Scott, president of VaCom, points to another, longer-term benefit of the program. "An open system could also be viewed as a starting point for additional energy management control within these same businesses; the core of an energy efficiency infrastructure building block that could be expanded over time, saving even more energy in the future."

Charged Up and Ready to Go

VaCom named their technology solution the Battery Charger Control Panel (BCCP). The BCCP system is compact and self-contained. All required control, remote monitoring capability, and power switching devices are included in one simple-to-install package, completely pre-wired and pre-programmed.

The size and configuration of the installation varied based on individual requirements of each business. However, each BCCP installation consisted of one or more of Echelon devices, which monitored current flow and controled the battery charger relays; an Echelon scheduler, which works like a timer; LonWorks data logger that provides a history of on/off cycles and power usage; Echelon LonWorks based communications; internet connectivity; and smart meters.

Leading the Charge for Conservation

The PLRP program was an immediate success with businesses. Over half of all firms contacted signed up. More than 50 companies participated. "The return on investment for these companies is excellent with up to $500 savings per vehicle per year," says Scott.

The expectations for this effort have been truly met and exceeded. "This program has opened everyone's eyes to potential energy cost savings for vehicle battery charging, and shown what a win-win proposition it really is," adds says Dick Cromie, Program Manager with Southern California Edison.

Key Benefits

• Businesses realized energy cost savings and rapid ROI (return on investment)

• Utility reduced chance of blackouts, lowered need for new generating capacity

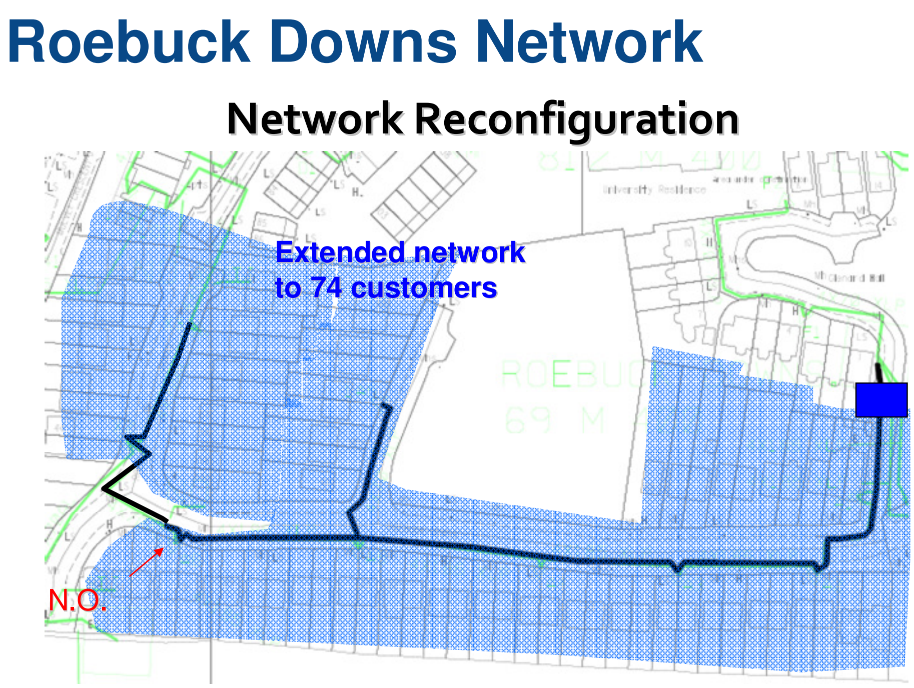
• Easy installation with pre-packaged system

Name of concept	ESBN Winter Trials
Concept partners	ESB Networks, ESBecars, Intel, SAP
Project reference	N/A
Reference report	N/A

Scope

The trial will analyse the network impact of controlled charging of EV's. The EV's will be used by seven selected residents of a test housing estate in Dublin. Each house will be fitted with a smart charging device and a computer interface, which will allow the control of charging to avoid amplification of system peaks. The Network will be monitored to assess a suite of power quality factors.

Illustration



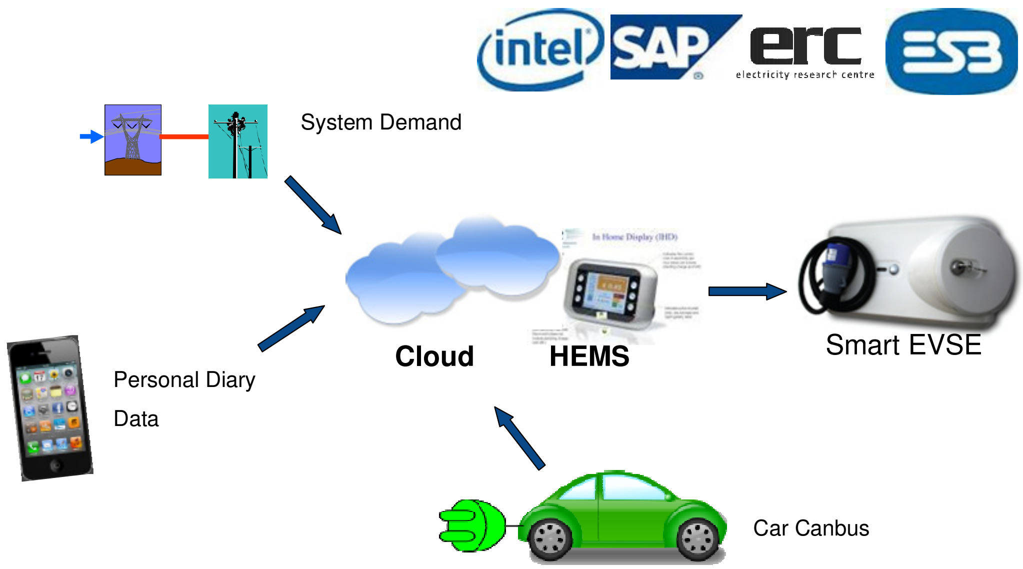
Description of the concept

The project is in phase 2 of a network monitoring trial. Phase 1 monitored the grid impact from the introduction of 7 EV's on an electricity network. With 70 households on the network, the vehicles represent the Irish government target of 10% of all road transport to be electric by 2020. During phase 1 the charging was conducted without intervention and the impact of voltage levels amongst other factor was monitored. In phase 2 the charging will be controlled in order to counteract any undesired affect of additional loads during system peaks. The trial will demonstrate the usefulness of smart charging in facilitating higher penetrations of electric vehicles on the grid. Furthermore it will demonstrate the preparation for additional loads created by mass adoption of EV's.

Users will input the 'unplug' time they require for each day, While the system will learn the user pattern's, the user will have the ability to enter a time for special days or just work from a standard time. The user can override the system in the case where they require to start charging the vehicle immediately. The vehicle will always charge to a minimum reserve level if the battery is below this level at the time of plugging in. Of primary consideration is that there will be no negative experience from the trial for the vehicle user while trialling the EV.

User inputs include: Unplug time, and reserve charge level.

Other inputs include vehicle battery level, GPS, system demand, system voltage and frequency.

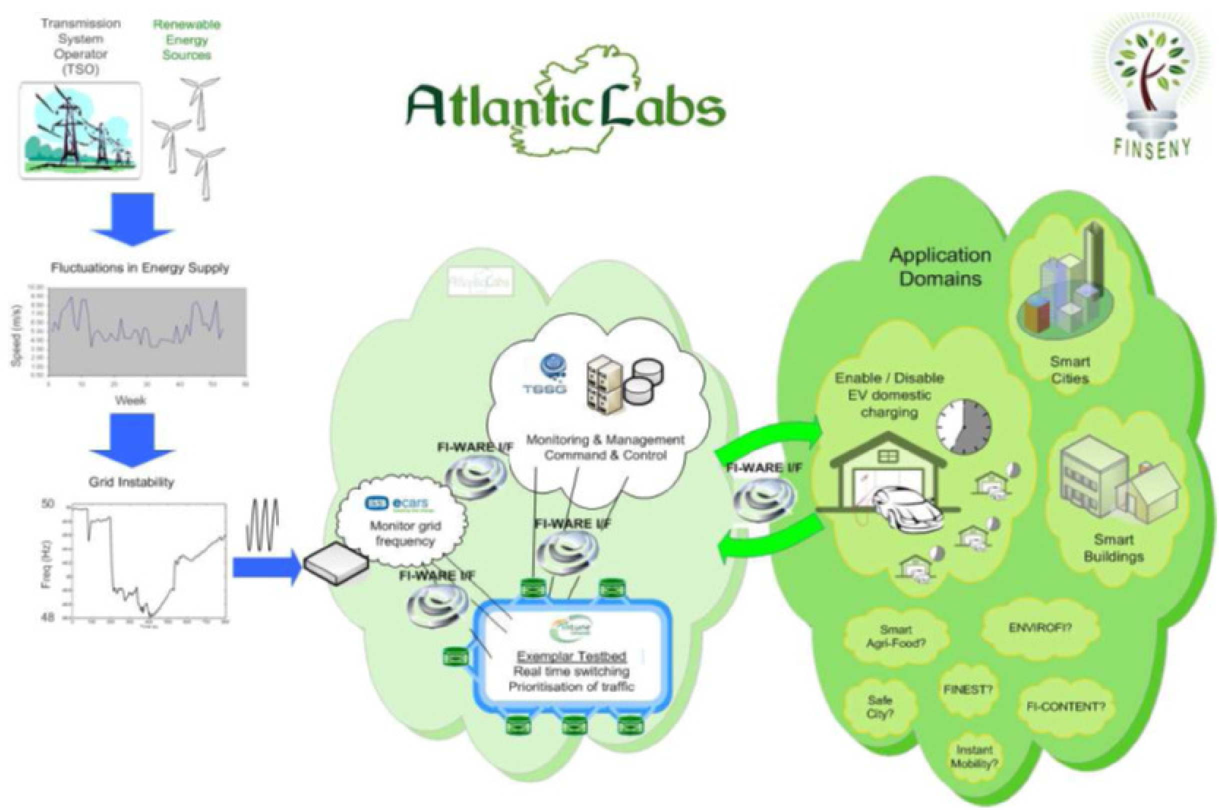


Name of concept	Finseny Project
Concept partners	ESB, TSSG, Intune Networks, RwTH Aachen (Wider project partners)
Project reference	NFI.ICT-2011-285135 FINSENY
Reference report	WP5 – D5.1 & D5.2

Scope

Using the Future Internet and FI-Ware platform, Finseny will demonstrate the control of vehicle charging to react to grid fluctuations and disturbances. It will work within notional service quality contracts and assess the factors of Demand Side Management (DSM) including speed and amplitude of responses as well as the impact on the grid. Furthermore the project will model the scalability of DSM control along with response times and evaluate the cost benefit of increased integration. The project will assess a range of technology options for implementation and report on the effectiveness of each.

Illustration



Description of the concept

Within the Finseny Project, the area of DSM has been considered. As part of a Phase 2 proposal the partners will demonstrate the use of the FI-ware Generic Enablers (GE's) and Domain Specific Enablers (DSE's) in the implementation of a DSM control system. The project will evaluate Fibre networks and 4G technologies in the control of charge, as well as considering the impact on the electrical system. While the infrastructure and trial vehicles will be located in Ireland, analysis and modelling will take place at RwTH, Aachen University.

Where a user opts for an interruptible supply tariff, the DSO can interrupt the charging of the vehicle for short periods of time in response to grid conditions thus introducing a 'virtual spinning reserve' to the grid. The effect will be to allow rapid balancing of supply and demand, either due to a generation faults or fluctuating generation as is sometimes experienced at wind farms.

The main benefits are expected to be 3 fold, Firstly the user will benefit from lower energy prices, secondly, there is an opportunity to decrease investment requirements in generation and infrastructure, finally the amount of renewable generation which can be integrated into the grid is likely to increase due to better response control.

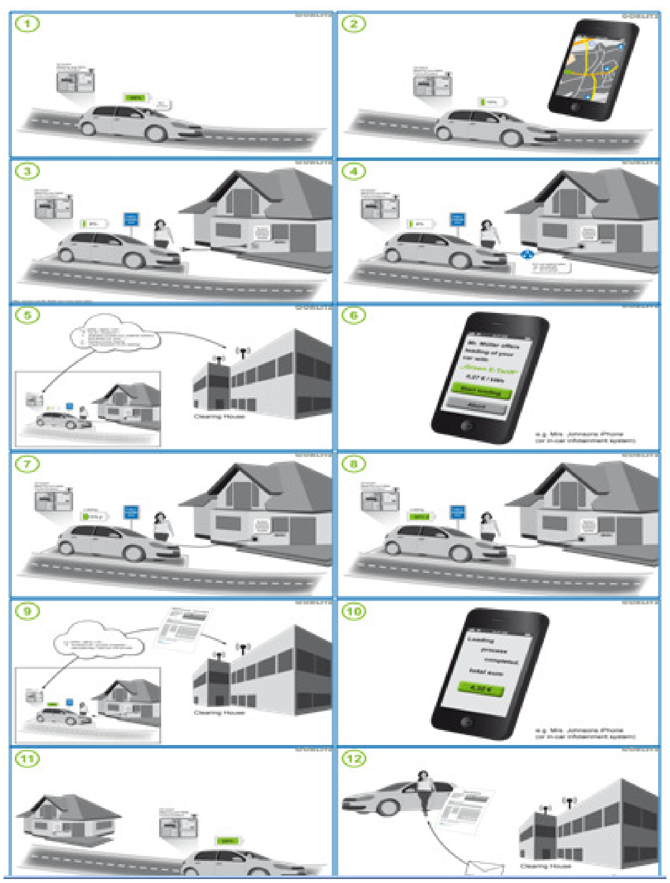
Ultimately, easier integration of renewable energy will bring the 'zero tail pipe' emissions to 'zero emissions'.

Name of concept	GÖRLITZ E-Mobility Smart Charging Solution
Concept partners	GÖRLITZ AG, Koblenz, Germany
Project reference	-
Reference report	-

Scope

The main scope of GÖRLITZ' Smart Charging Solution for electrical vehicles is to enable the existing electrical infrastructure to cope with EVs in a mass market also including an accounting and billing concept which allows fair cost allocation for generation and consumption of electrical mobility energy. With the massive use of electric vehicles the requirements for charging infrastructure rise comparably. The investment costs for public charging spots, where the energy will be delivered to the EVs are pretty high. Charging pole vendors currently can't provide an interoperable and standardized accounting and billing concept which allows the customers to charge their electric vehicles anywhere and receive a correct invoice for the consumed electricity afterwards. Beside the missing standardized accounting and billing concept it is impossible to abet electricity for mobility to promote the use of electrical vehicles and later on to charge taxes on the mobility electricity as soon as the amount of petroleum taxes decrease, because it is not possible to prevent tax fraud, when customers charge their electric vehicles at their standard home sockets, which will obviously be the most frequented charging spot.

Illustration



Description of the concept

The Smart Charging Solution of GÖRLITZ has already been implemented successfully in pilot a project with a major German car manufacturer. The basic idea is to enable the already existing infrastructure to cope with the wide use of electric vehicles. Each standard socket may become a private or even public charging spot for electric vehicles which will be billed according to its usage correctly. Therefore it is necessary to enable the socket to identify itself and to communicate with the electric vehicle, e. g. via the charging cable by adding a simple communication (e. g. PLC) and identification module to the socket itself. In a mass production the module will be very cheap and may also be integrated into every standard socket later on by default.

The owner of the identifiable standard socket registers his EV charging socket at a clearing house. The owners of electric vehicles also register themselves and their vehicles at the same clearing house.

The electric vehicles will have an on-board meter and, if not already integrated into the vehicle itself by default, a communication device like a GPRS/UMTS/LTE modem (illustration #1).

When an electric vehicle is running on low battery, the owner of the car will be offered charging spots in the surrounding of the current position. This information may be provided e. g. via a mobile phone, like an iPhone, or via the in-car infotainment system directly integrated into the navigation solution of the car (illustration #2) and the traveling route may be directed to the next or desired charging spot.

The EV may be plugged into every Smart Charging Solution prepared standard socket even without knowing the owner of the socket. Neither does the owner of the socket need information about the EV, which shall be charged nor its owner (illustration #3). After plugging the EV into the socket and a successful handshake for the communication, the PLC chip of the socket sends its unique ID to the car (illustration #4). The car adds his own unique ID and forwards this set of data including some other technical information to the clearing house asking for validation and approval (illustration #5). Several business logical validations may be run at the clearing house, e. g. if the owner of the EV is solvent, which type of electricity will be offered (e. g. green electricity, electricity from nuclear power plants, …) and, of course, which price per kWh the owner of the socket offers (this information will be already displayed in the in-car infotainment system provided by the clearing house in relation to the nearest charging spots to enable the customer to select the cheapest or appropriate spots). If everything is fine, the owner of the car receives an offer for charging his vehicle which may be accepted e. g. by pressing a button (illustration #6) and initiates the loading process (illustration #7) and closes the loading contract for this action. After the charging process is completed (or interrupted by failure or accident) (illustration #8) the amount of consumed energy measured by the on-board meter of the car will be transmitted to the clearing house (illustration #9). This generates the delivery receipt for the energy consumed by the EV. The owner of the EV then receives a notification that the loading process is completed incl. the total sum of costs on the mobile phone and the in-car infotainment system (illustration #10). The owner of the EV may now continue the journey (illustration #11) and will receive an invoice for the electricity and service later (illustration #12).

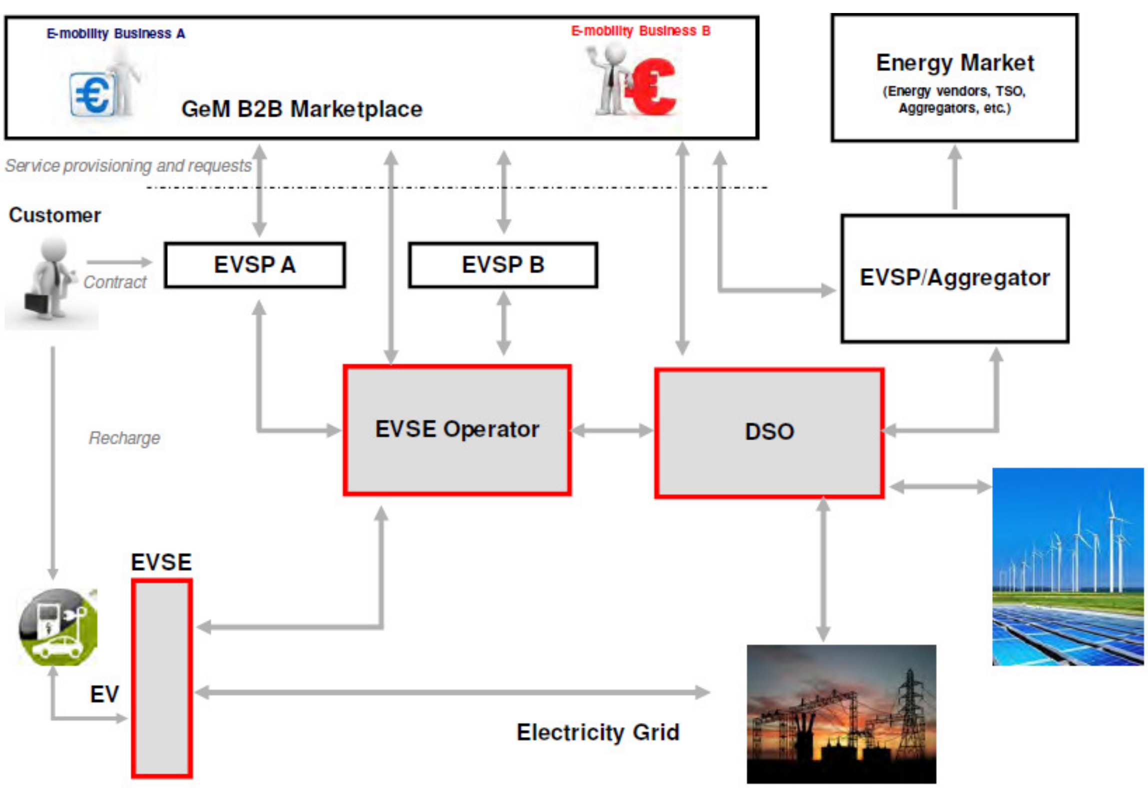
With this Smart Charging Solution every standard socket may become a private or even public EV charging spot, which is ready for accounting, billing and taxation. The already existing infrastructure may be used to cope with a massive use of e-mobility without the need to install multiple charging poles. Surely this solution works everywhere, where electrical sockets are available – at the grocery, at work and where most charging procedures of EVs will be done: at home and at the homes of relatives and friends and other private persons.

Name of concept	Green eMotion congestion management in DSO business model case
Concept partners	Many, see http://www.greenemotion-project.eu/partners/index.php
Project reference	GA MOVE/FP7/265499/Green eMotion
Reference report	Green eMotion D4.2: http://www.greenemotion-project.eu/dissemination/deliverables-infrastructure-solutions.php

Scope

The very heart of cost effective EV integration into the grid is the management of the recharge process itself, also referred to as charge management or smart charging. The framework in the next figure foresees an active role of the DSO, which can be directly in communication with either EVSE Operator or EVSP, depending on the regulatory framework adopted in a specific country, in order to exchange relevant information for EV integration into the grid. The customer has a service contract with one (or more) EVSPs, that in a generally unbundled ecosystem are only selling B2C services (like charging, for instance) and buying/selling B2B services through the B2B eMobility Marketplace.

Illustration



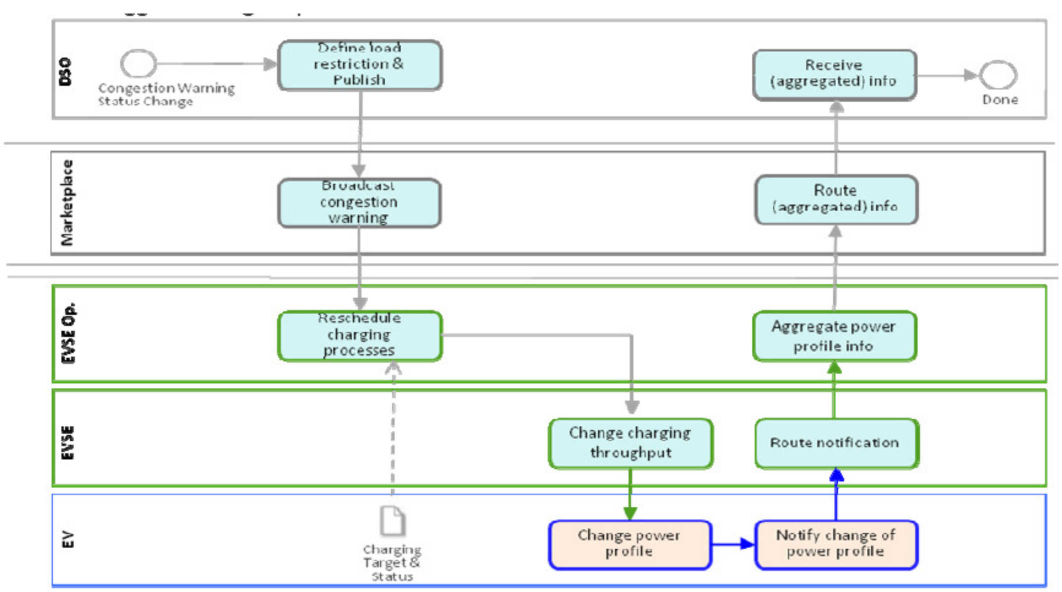
Description of the concept

According to business models and regulatory framework, different patterns of the above depicted roles may be involved in the charge management process, mainly depending on the ownership and management of the EVSEs deployed in public premises, which are the ultimate gateway where charge management processes are deployed and are key for the whole charge management architecture. Roles may be played by different stakeholders as hereby summarized:

- EVSE is part of the regulated business and is included in the DSO activities: leading to a scenario in which the DSO acts as the provider of a multivendor technology platform by acting as EVSE operator, allowing different EVSPs to provide services on the very same EVSE. In this case, if the DSO also acts as Metering Point Operator (case of Italy and partially of Netherlands), the EVSE can embed a revenue-grade smart meter that enables EVSPs to bill customers.
- EVSE is owned and managed by a dedicated business, the EVSE operator, that might allow different EVSPs to recharge on its EVSEs by signing specific B2B agreements to implement a multivendor platform. However, the EVSE operator might alternatively act as the only EVSP on that EVSE, leading to a gasoline station-like business model. Here the meter can also be embedded in the EVSE to certify the billing to the customer in pay-per-kWh use case. However, the information regarding the energy consumption towards the DSO is the only constraint to be fulfilled, therefore the smart meter can be outside of the EVSE and owned by another actor.

The former case, currently under test in Italy, foresees the most active role of the DSO, in which the DSO itself plays also the role of EVSE Operator, leading to a scenario in which EVSPs (and at a later stage the Aggregators) can bring value through charge management processes from the energy market (where flexibility is sold) up to the end-user (who trades a lowering in degrees of freedom, getting his EV charge-modulated, in exchange of a convenient tariff). Large Scale Load Management demo case in Green eMotion project will be deployed according to this scenario.

The communication features to be demonstrated in the first release of Green eMotion are here modeled through diagrams that show the actions between the different actors involved in the charge management processes. A variety of other processes can be thought up based on the different actors interests, however here we have pictured a model that is one of the references in the demonstration activities in Green eMotion.



The figure above describes the process of Congestion Management, which allows the DSO to fulfill one of its main objectives that is to minimize the shortages of electricity provisioning to end customers. Congestion management is a real-time process, specified as follows:

- As soon as network congestion is detected, the DSO front-end calculates reduced load profiles for EVs recharging in the congested area.
- The DSO then forwards the (reduced) load profiles to the EVSE Op. back-ends, which will in turn break down and distribute the load profiles to all EVSEs in the congested load area according to their algorithm/contractual constraints.
- At last, the EVSE Op. back-end aggregates the updated power profiles from the EVSEs and makes this update available to the DSO as a fulfillment of its initial request. A mandatory condition is that the

recharging infrastructure is able to provide fast, reliable and secure communication between its back-end systems and the DSO front-end system.

Name of concept	IntelliCharge by ERDF
Concept partners	ERDF, EDF R&D and projects partners
Project reference	Articulation of three projects
Reference report	Under course

Scope

Intellicharge by ERDF is a series of projects which share a common logic for smart charging in relation with technical and economical aspects of distribution system.

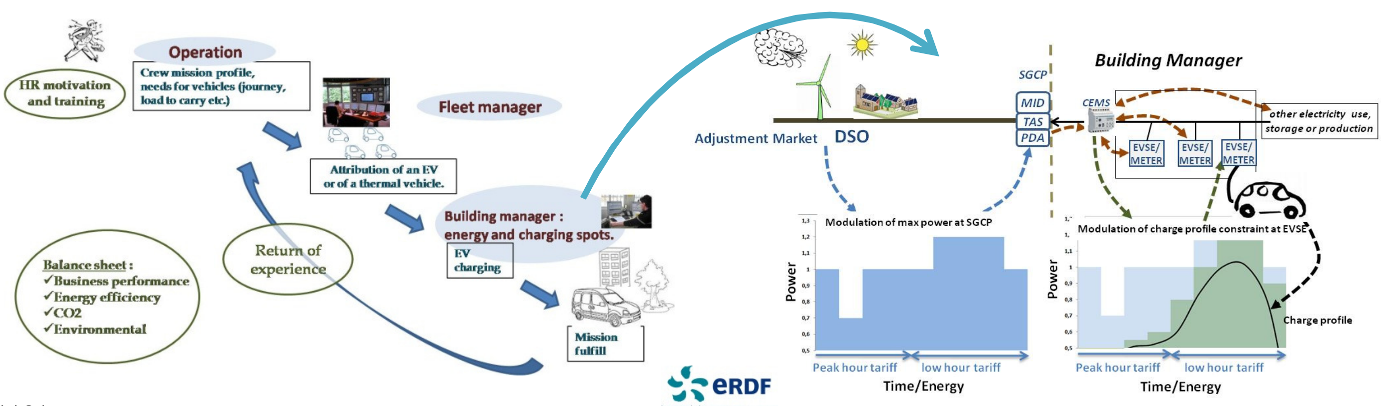
The scope of the first project is to design ERDF fleet management including a high rate of EV, and develop smart charging within its parking buildings. This comes with the purchase of about 2000 EV, to be delivered until 2015.

ERDF leads two other project to fit smart charging for residential buildings, especially inside multi-unit dwellings, and for public charging spots within a city.

Altogether, these projects aim at a common interface between the DSO and charging spots installation in all situations so that global charging of multiple EV in a network area be organised optimally, taking into account cost and quality of service of the distribution system.

Illustration

Example of a global eco-system (case of company fleet), and the place of smart charging into it.



Description of the concept

The goal is to ensure the availability of charging infrastructure adequate for a massive conversion of thermal to electrical vehicles, its integration within the premises electrical installations, and the design and organization of smart charging fitting to any category of use. It has to fulfill constraints from the end user point of view, in terms of operational and economical efficiencies, while making the best use of networks and energy resources, including upstream electrical system at stake (DSO, TSO, energy and capacity markets).

The concept relies on a global approach of the eco-system, beyond the charging spot and the EV which are part of it, as illustrated on the above left figure in the case of a company fleet. Smart charging *per se* takes place in interaction with this eco-system, as illustrated on the above right figure.

Smart charging itself is based on the adequate design of the customer energy management system (CEMS) and its communication with the smart grid connection point (SGCP) of the distribution system, which includes three functions: metering compliant with regulation for electricity purchase on the market (MID), energy tariffs information (TAS) and maximum power availability control (PDA).

The projects will be led until 2015 with intermediate results, and will produce recommendations and proposals of standards.

Name of concept	MUGIELEC
Concept partners	MUGIELEC is led by ZIV, and TECNALIA is its technical coordinator. Other project partners are: AEG, CEMENTOS, LEMONA, FAGOR, GAMESA, IBERDROLA, INCOESA, INDRA, INGETEAM, ORMAZABAL and SEMANTIC SYSTEMS.
Project reference	http://www.mugielec.org/es/
Reference report	*EVS26 Los Angeles, California, May 6-9, 2012* A whole approach for the Electric Vehicle infrastructure in the Basque Country

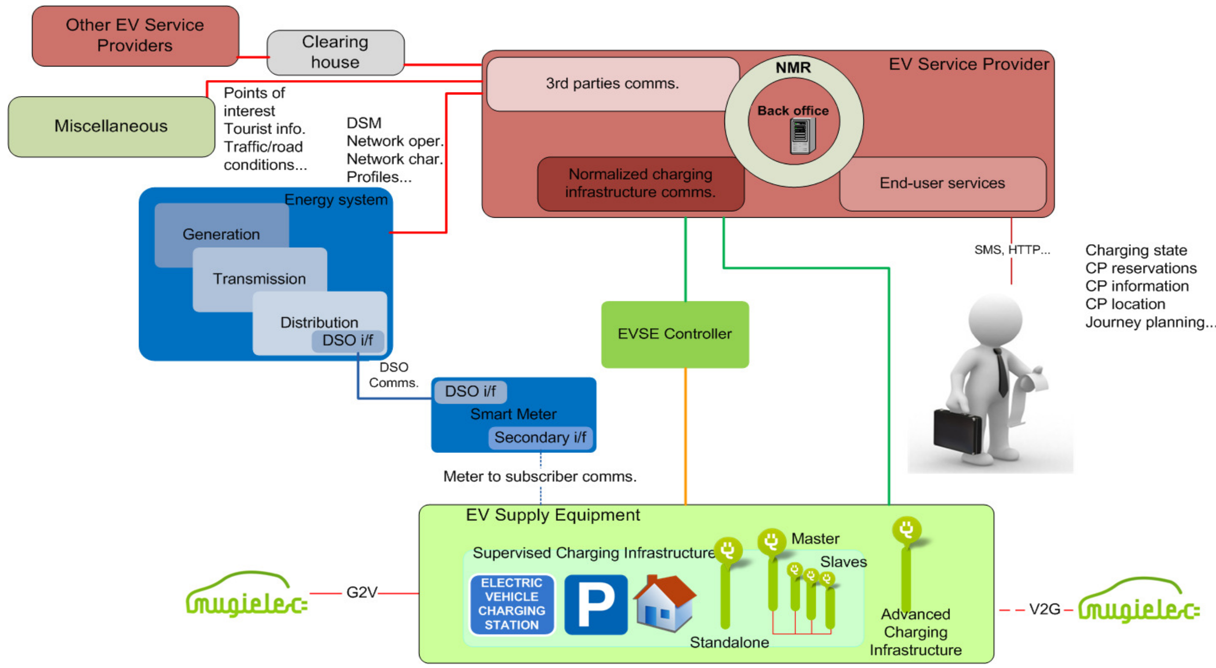
Scope

MUGIELEC, focused mainly on the charging infrastructure, has a global and complete vision, considering not only the technological attributes, but also the relationship, integration, and communication needs with both electricity networks (and its Operators) and EVs (and their Users). As a result of this, MUGIELEC performs a deep analysis of the different recharge scenarios proposed for the short to long term, carefully tackled from the point of view of the electricity grid.

In principle, looking at the grid and the consumers, the EV is like any other load. However, their geographic and temporal uncertainty for connection, the fact that they include storage instead of mere loads, and the specific load profiles according to customs, EV types, etc., bring specific challenges and opportunities. This need for an intelligent management and communication obliges to set up at least a minimum level of intelligence at every relevant stakeholder and device.

Multiple car parks are another key usage scenario for electric vehicles in the early adoption phase. Different parking topologies are considered, from small parks outside to complex several storey parking lots with different charging managing companies.

Illustration



Description of the concept

The MUGIELEC approach to EV charging systems tries to stay business-model independent, by depicting the functionalities that are required for the successful deployment of an EV charging infrastructure and the associated services: Energy supply, EVSE and end user services. These functionalities have been wrapped up in three generic boxes corresponding to the main systems that are necessary to provide advanced charging services to an EV-driver:

The **Energy System** is depicted in blue, with the functions carried out by the traditional stakeholders of the electricity system. Advanced equipment, such as metering devices with bidirectional communication capabilities and an additional interface with electricity subscribers, can be used to exchange metering information, price signals, etc. enabling active local electricity management. Global demand management can be carried out by means of the direct interconnection between the energy system and the eMobility system.

The systems related with **eMobility** management are depicted in maroon, where the contractual relationship with EV-users, EV-charging related information and services, etc., are carried out. eMobility systems relay on MUGIELEC's Information and Knowledge management system.

The **EV Supply Equipment** is depicted in green. Integration into the charging infrastructure can be intended by a variety of CPs with quite different capabilities.

The **EVSP Management System** must perform whatever activity in relation with EVSE remote control, monitoring and communication within a certain infrastructure. It manages the logical base of the business model.
The core of the Management System is built around a set of Functional Modules containing the necessary functions to operate all the EVSE:

- **EVSE Inventory**: for inserting, modifying and deleting the specific information which is directly or indirectly referred to EVSE.
- **CP Monitoring**: to allow users to visualize EVSE location as well as their real-time status on a geographical application through a code of colours. Also, it will be possible to navigate from this module to the EVSE Operations Module.

- **Operation on EVSEs**: to carry out the EVSE remote operation by means of certain operations that will depend on their own capabilities, such as start/stop the charging process, lock/unlock the Access, reboot the EVSE, etc.
- **Configuration management**: for remotely looking up and updating one or several EVSE configuration.
- **Reception of events**: to collect and manage every event sent by EVSE, including those not needing an immediate intervention, as well as the incidences on the Management System itself as a result of any problem on the application modules.
- **Management of the historical records**: for storing a historical record of user data and EVSE charges. Also, it manages deleting criteria of those historical records based on the parameters that had been configured.
- **Access management**: to perform on-line user authorization process for recharging.
- **Reporting management**: to provide, according to some reports templates defined previously, the needed information of EVSE infrastructure to be managed and operated by EVSP.
- **Security management**: to manage different system access profiles and levels of permissions.

These examples of EV Service Provider management system are important elements in the link between eMobility and Smart Grid – in relation to Smart Charging of Electric Vehicles.

Name of concept	PowerMatcher
Concept partners	FlexiblePower Alliance Network, see also www.flexiblepower.org
Project reference	http://www.powermatcher.net/
Reference reports	See last page

Scope

PowerMatcher is an intelligent distributed coordination technology from TNO. The PowerMatcher is a multi-agent based system that uses electronic exchange markets to coordinate a cluster of devices to match its electricity supply and demand. A multi-agent system is a structured framework for implementing complex, distributed, scalable and open ICT systems in which multiple software agents are interacting in order to reach a system goal. Such a software agent is a self-contained software program that acts as representative of something or someone (in this case the Electric Vehicle). A single software agent carries out a specific task. For this task, it uses information from and performs actions in its local environment. It is able to communicate with other entities (agents, systems, humans) for its task.

Illustration

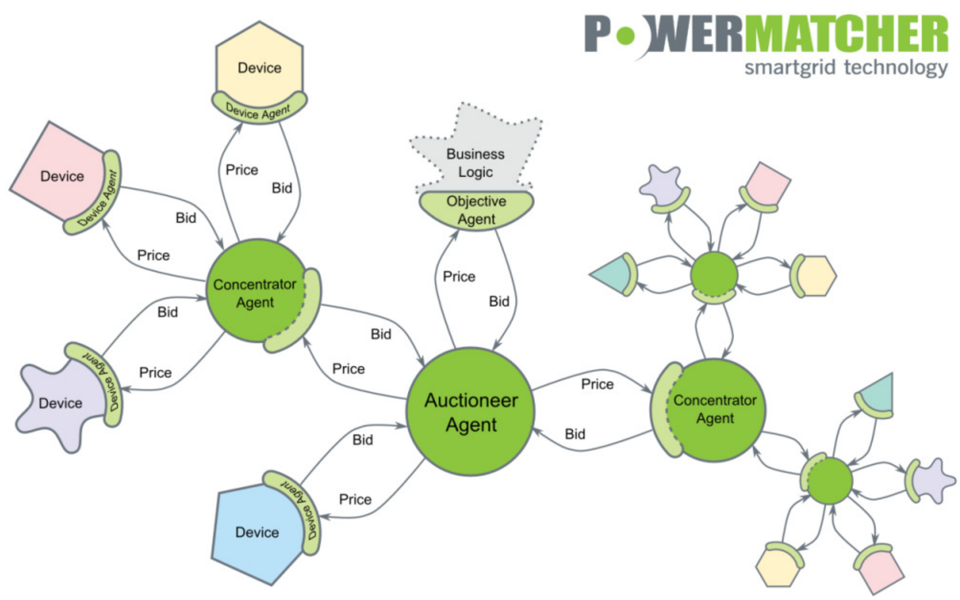


Figure 1: Schematic overview of the PowerMatcher concept.

Description of the concept

Every flexible device in a cluster (in our smart charge case the EV itself) is represented by a device agent, a piece of software that looks after the interests of that device. Such agents attempt to operate the associated processes in an economically optimal way, whereby no central optimization algorithm is necessary.

Using an electronic market (the auctioneer) in the multi-agent system allows the agents to trade scarce resources (that can also be network restrictions) that are necessary for the agent to carry out its task. The only information that is exchanged between the agents and the auctioneer are bids. These bids express to what degree an agent is willing to pay or be paid for a certain amount of electricity. Bids can thus be seen as the priority or willingness of a device to turn itself on or off. For example an EV with a low battery state of charge is willing to pay a higher price. Bids are sent at irregular (event-based) intervals, i.e. only when an agent's bid has changed. This keeps the communication between PowerMatcher entities to a minimum.

The auctioneer collects the bids and calculates the market clearing price. This price is communicated back to the device agents, which react appropriately by either starting to produce or consume electricity, or wait until the market price or device priority (state) changes. The concept of the PowerMatcher has been tested in a number of field demonstrations.

PowerMatcher implementation example for EVs with congestion management

An implementation of the PowerMatcher concept with several EV charging stakeholders would likely be as follows:

- Device agent in the Electric Vehicle, representing the vehicle and user’s needs
- Concentrator agent in the DSO area, probably located in the substations, to add grid limitations
- Auctioneer agent in/near the electricity market (if a more neutral environment is necessary also the TSO would be an option)
- Objective agent can be in the eMobility service provider aggregator, these bids are coupled to the open market electricity price

To describe this scenario in more detail. Suppose we have several EVs that want to charge. When the EVs want to start charging it will create a bid, this is a curve with price versus power, when the price is low the charging power is likely maximal, when the price is high the charging power offer is probably low or even zero. This curve and bid heavily depends on the battery state of charge and the expected next departure time (given by the EV user), this differentiation will also ensure that we get different bids, and that guarantees a smoother curve for easer supply demand matching.

All the bids per substation are collected (bids are so generic that EV charging bids can be added and combined to for example heat-pump bids) and added by the substation concentrator agent, who on his turn will make an offer to the next layer, in this case the (market) auctioneer. Since a substation has a limited power it will adapt the sum of the bids received to make sure the substation does not get overloaded, and as such perform congestion management.

The auctioneer adds the other bids its receives, the next step is that the price where supply and demand matches, will be sent out by the auctioneer, which will establish the equilibrium.

The concentrators will on their turn also send the price signal to de device agents. In the case described above that a substation did limit the offer due to power limitations it needs to send a higher price to the agents in his domain to establish this lower power (this is called local marginal pricing).

The end result is that several EVs charge later or with a lower power. A simulation in the G4V EU project with 200 EVs and real user driving behavior as input, resulted in the improved red instead of uncontrolled blue load curve for a substation.

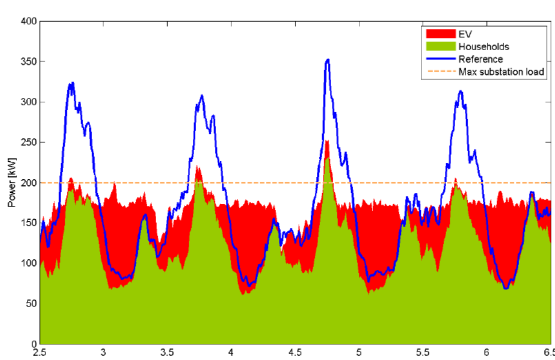


Figure 2: Load curve on a substation with charging EVs with and without PowerMatcher.

Conclusion and Recommendation

Although at first sight the PowerMatcher concept looks complex, the simple and uniform device independent communication of bids and prices ensures a high scalability. The device agent is simple and therefore can with low cost be implemented also in household appliances. The price is not necessarily the price the consumer/EV user needs to pay, that depends on the business model, in these cases the price can be seen as a control signal to steer the demand. So the billing process can be different implemented and based on other prices or tariffs.

To enable open access to PowerMatcher, a FlexiblePower Alliance Network (FAN) in being launching in Q4 2012 as a non-profit organisation with as main goal: Extending the PowerMatcher Suite specifications with connectivity to equipment (e.g. electric vehicles, home appliances) and flexible coupling with energy management applications.

Of course there can be other ways to establish smart charging for EVs or perform Supply Demand Management in Smart Grids, and since we do not want to push one technology as the only solution, we also work in the FlexiblePower Alliance Network on more generic platforms and interfaces, that could also use other types of smart charging and smart grid technologies. We strive there to generic standards that enable multiple technologies to be used. For example we noticed that most other smart algorithms (for example the ADDRESS control mechanism) all interact with the EVs/customers based on (real-time) prices/tariffs and bids/demands and limited local intelligence (energy box, device agent, ...).

Therefor the key recommendation is to at least create open extendible bidirectional communication between the EV BMS and the Smart Grid/Charging Point, so that these entities can negotiate on the charging. This communication should be compatible with several smart grid/charging technologies (of which PowerMatcher is one). This is not an obvious task, and it is expected that different smart charging modes could appear. Careful steps needs to be made preventing too many options that cannot be supported by all EVs or Charging Points. A recent field trial with PowerMatcher and ISO/IEC 15118 already resulted in some suggestions for this communication interface. It would be good to combine the experience of this trial with other trials using ISO/IEC 15118.

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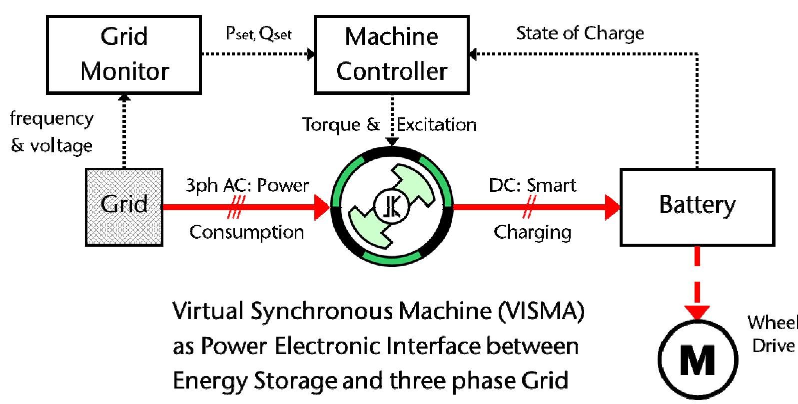
- Green eMotion WP7 Harmonisation of technology & standards deliverables on http://www.greenemotion-project.eu/dissemination/deliverables.phphttp://www.greenemotion-project.eu/dissemination/deliverables.php
- PowerMatcher information site http://www.powermatcher.net/
- PowerMatching City demonstration living lab http://www.powermatchingcity.nl/UserPortalhttp://www.powermatchingcity.nl/UserPortalhttp://www.powermatchingcity.nl/UserPortal

Name of concept	Optimized System Integration of Plug-In Vehicles utilizing the VISMA concept
Concept partners	Technical University Clausthal (TUC), Bornemann AG (BAG), Business Communication Company GmbH (BCC), Bundesverband Solare Mobilität e.V. (bsm), Forschungsstelle für Energiewirtschaft e.V. (FfE), RegenerativKraftwerke Harz GmbH u. Co. KG (RKWH)
Project reference	Refueling in the Smart Grid: Optimized System Integration of Plug-In Vehicles (Tanken im Smart Grid: Optimierte Systemintegration von Plug-In Vehicles) http://www.metropolregion.de/pages/themen/schaufenster_e-mobilitaet/projekte/subpages/ct_11512/index.html
Reference reports	N/A

Scope

Scope of this project is to develop and test an innovative smart charger for plug-in vehicles. The charge controller will contribute to dynamic grid stability by choosing its charging power in regard to frequency and local voltage. Thus, power drain is optimized with respect to available energy while still taking into account user preferences and safe operation of the batteries.

Illustration



Description of the concept

Description of concept

The overall objective of the project is to facilitate the integration of fluctuating non-dispatchable renewable energy sources by delivering auxiliary services with grid connected electric vehicles. These auxiliary services are provided by grid adaptive battery chargers, of which the charging algorithm reacts to locally measured grid parameters such as frequency and voltage [1]. As a comprehensive solution the VISMA concept is proposed and will be implemented in experimental models.

VISMA describes a grid connected converter operating with dynamic behavior similar to electromechanical synchronous machines [2]. Frequency stabilization is supported by synthetic inertia and a higher level P(f)-droop controller. Dynamic voltage support is introduced by modeling the grid voltage interaction with virtual machine impedance. Q(U) and P(U) controllers are used for steady state voltage support. Machine parameters are freely configurable and changeable during operating.

On top, the project will use ICT to build up a grid quality map as a central database. The grid quality map is filled with local grid parameters measured by the electric vehicles during plugged in mode. Analysis of the collected data provides optimized charging parameters based on IEC/TR 61850-90-7.

The third objective of the project is to balance the energy flow within prosumer cells (eg. PV power combined with dispatchable consumption by plug-in vehicles).

References

[1] Kaestle, Vrana, Bentaleb: Smart Standards for Smart Grid Devices, 3rd European Conference Smart Grids and E-Mobility, München, 17. - 18. October 2011.

[2] Chen, Hesse, Turschner, Beck: Dynamic Properties of the Virtual Synchronous Machine (VISMA), International Conference on renewable energies and power quality (ICREPQ´11), Las Palmas de Gran Canaria, Spanien, 13. -15. April 2011.

Annex C – List of E-mobility related standards

Name/Number	Title of standard or specification
EN 13447:2001 (ISO 8713)	Electrically propelled road vehicles - Terminology
EN 13757-1 to -5	Communication system for and remote reading of meters
EN 50065-1:2001 +A1:2010	Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz. General requirements, frequency bands and electromagnetic disturbances
EN 50065-2-1: 2003 + A1:2005+ AC:2003	Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz -- Part 2-1: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in residential, commercial and light industrial environments
EN 50065-2-2: 2003 + A1:2005 + AC:2003	Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz -- Part 2-2: Immunity requirements for mains communications equipment and systems operating in the range of frequencies equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in industrial environments
EN 50065-2-3: 2003+A1:2005+ AC:2003	Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz - Part 2-3: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 3 kHz to 95 kHz and intended for use by electricity suppliers and distributors
EN 50272 -1 EN 50272 -2 EN 50272 -3	Safety requirements for secondary batteries and battery installations. Traction batteries
EN 55011 (CISPR 11))	Industrial, Scientific and Medical (ISM) Radio-Frequency Equipment - Electromagnetic disturbance characteristics --Limits and methods of measurement.
EN 55012 (CISPR 12)	Vehicles, motorboats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers
EN 55016-X-X (CISPR 16-X-X)	Specification for radio disturbance and immunity measuring apparatus and methods
EN 55022 (CISPR 22)	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement.
EN 55025	Vehicles, motorboats and internal combustion engines – Radio

(CISPR 25)	disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers
EN 60146-1	Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements
EN 60309 (IEC60309)	Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements
EN 60309-1 (IEC60309-1)	Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories
EN 60309-2 (IEC60309-2)	Plugs, socket-outlets and couplers for industrial purposes – Part 4: Switched socket-outlets and connectors with or without interlock
EN 60446	Basic and safety principles for man-machine interface, marking and identification. Identification of conductors by colors or numerals.
EN 60622 (IEC60622)	Secondary cells and batteries containing alkaline or other non-acid electrolytes Sealed nickel-cadmium prismatic rechargeable single cells
EN 60623 (IEC60623)	Secondary cells and batteries containing alkaline or other non-acid electrolytes Vented nickel-cadmium prismatic rechargeable single cells
EN 61429 (IEC61429)	Marking of secondary cells and batteries with the international recycling symbol ISO 7000-1135
EN 61434 (IEC61434)	Secondary cells and batteries containing alkaline or other non-acid electrolytes Guide to the designation of current in alkaline secondary cell and battery standards
EN 61951 (IEC61951-1)	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Portable sealed rechargeable single cells – Part 1: Nickel-cadmium
EN 61952 (IEC61951-2)	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Portable sealed rechargeable single cells– Part 2 :Nickel-metal hydride
EN 61959 (IEC61959)	Secondary cells and batteries containing alkaline or other non-acid electrolytes Mechanical tests for sealed portable secondary cells and batteries
EN 61960 (IEC61960)	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for portable applications
EN 61982-1 (IEC61982-1 under revision)	Secondary batteries (except lithium) for the propulsion of electric road vehicles - Part 1: Test parameters
EN 61982-2 (IEC61982-2)	Secondary batteries for the propulsion of electric road vehicles - Part 2: Dynamic discharge performance test and dynamic endurance test

EN 61982-3 (IEC61982-3)	Secondary batteries for the propulsion of electric road vehicles - Part 3: Performance and life testing (traffic compatible, urban use vehicles)
EN 62259 (IEC62259)	Secondary cells and batteries containing alkaline or other non-acid electrolytes Nickelcadmium prismatic secondary single cells with partial gas recombination
EN 62281 (IEC62281)	Safety of primary and secondary lithium cells and batteries during transport
EN 62576 (IEC62576)	Electric Double-Layer Capacitors for Use in Hybrid Electric Vehicles -Test Methods for Electrical Characteristics
EN 62660-1 (IEC62660-1)	Secondary batteries for the propulsion of electric road vehicles - Performance testing for lithium-ion cells and batteries
EN 62660-2 (IEC62660-2)	Secondary batteries for the propulsion of electric road vehicles - Reliability and abuse testing for lithium-ion cells
ETSI TR 101 607 V1.1.1	Intelligent Transport Systems (ITS); Cooperative ITS (C-ITS); Release 1
ETSI TS 101 556-1 V1.1.1	Intelligent Transport Systems (ITS); Infrastructure to Vehicle Communication; Electric Vehicle Charging Spot Notification Specification ; Release 1
ETSI TS 101 556-3 V1.1.1	Intelligent Transport Systems (ITS); Infrastructure to Vehicle Communications; Communications system for the planning and reservation of EV energy supply using wireless networks; Release 1
IEC 60038	IEC standard voltages
IEC 60059	EC standard current ratings
IEC 60073	Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators
IEC 60364-5-53	Erection of low voltage installations – Part 530: Selection and erection of electrical equipment – Switchgear and control gear
IEC 60364-5-54	Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors
IEC 60364-7-722	Low voltage electrical installations: Requirements for special installations or locations – Supply of electric vehicle
IEC 60364-4-41	Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock
IEC 60481	Coupling devices for power line carrier systems
IEC 60479-1	Effects of current on human beings and livestoc – Part 1: General aspects
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60664-2-1	Electric vehicle conductive charging system - Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. Supply

IEC 60755	General requirements for residual current operated devices
IEC/TR 60783	Wiring and connectors for electric road vehicles
IEC/TR 60784	Instrumentation for electric road vehicles
IEC/TR 60785	Rotating machines for electric road vehicles
IEC/TR 60786	Controllers for electric road vehicles
IEC 61000-3-2 (EN 61000-3-2: 1996 + A1:2009 + A2:2009)	Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current < 16 A per phase)
IEC 61000-3-3 (EN 61000-3-3: 1995+A1:2001 + A2:2005 + AC:1997 and EN 61000-3-3: 2008)	Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage systems for equipment with rated current ≤ 16 A per phase and not subjected to conditional connection
IEC 61000-3-3 Note: This technical report is replaced by IEC 61000-3-12 for equipment ≤ 75 A	Electromagnetic compatibility (EMC) - Part 3-4 Limits – Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current > 16 A
IEC 61000-3-11 (EN 61000-3-11: 2000)	Electromagnetic Compatibility (EMC) – Part 3-11 – Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage systems - Equipment with rated current ≤ 75 A per phase and subjected to conditional connection
IEC 61000-3-12 (EN 61000-3-12: 2005)	Electromagnetic Compatibility (EMC) – Part 3-12 – Limits for harmonic current emissions produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase
IEC 61000-4-1	Electromagnetic compatibility (EMC) – Part 4-1 – Testing and measurement techniques – Overview of IEC 61000-4 series
IEC 61000-4-2	Electromagnetic compatibility (EMC) – Part 4-2 – Testing and measurement techniques – Electrostatic discharge immunity test
IEC 61000-4-3	Electromagnetic compatibility (EMC) – Part 4-3 – Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test
IEC 61000-4-4	Electromagnetic Compatibility (EMC) – Part 4-4 – Testing and measurement techniques – Electrical fast transients/burst immunity test
IEC 61000-4-5	Electromagnetic Compatibility (EMC) – Part 4-5 – Testing and measurement techniques – Surge immunity test
IEC 61000-4-6	Electromagnetic Compatibility (EMC) – Part 4-6 – Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency

	fields
IEC 61000-4-7	Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto
IEC 61000-4-8	Electromagnetic Compatibility (EMC) – Part 4-8 – Testing and measurement techniques – Power frequency magnetic field immunity test
IEC 61000-4-11	Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests
IEC 61000-4-13	Electromagnetic compatibility (EMC) - Part 4-13: Testing and measurement techniques - Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests
IEC 61000-4-15	Electromagnetic compatibility (EMC) - Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications
IEC 61000-6-1:2005 (EN 61000-6-1:2007)	Electromagnetic Compatibility (EMC) – Part 6-1 – Generic standards Immunity for residential, commercial and light-industrial environments
IEC 61000-6-2 (EN 61000-6-2:2005+ AC:2005)	Electromagnetic compatibility (EMC) – Generic standards – Immunity for industrial environments
IEC 61000-6-3 (EN 61000-6-3:2007)	Electromagnetic compatibility (EMC) – Generic standards – Emission standard for residential, commercial and light-industrial environments
IEC 61000-6-4:2006 (EN 61000-6-4:2007)	Electromagnetic Compatibility (EMC) – Part 6-4 – Generic standards Emission standard for industrial environments
IEC 61140 (EN 61140)	Protection against electric shock – Common aspects for installations and equipment
IEC/TS 61382-1	cells and batteries – Guide to equipment manufacturers and users
IEC/TS 61438	Possible safety and health hazards in the use of alkaline secondary cells and batteries and health hazards in the use of alkaline secondary cells and batteries Guide to equipment manufacturers and users
IEC 61439-5	Low-voltage switchgear and controlgear assemblies – Part 5: Assemblies for power distribution in public networks
IEC 61508	Functional safety
IEC 61540	Electrical accessories . Portable residual current devices without integral overcurrent protection for household and similar use (prods)
IEC 60755	General requirements for residual current operated devices
IEC 61850-7-420	Communication networks and systems for power utility automation

IEC 61851-1	Electric vehicle conductive charging system – General requirements
IEC 61851-21	Electric vehicle conductive charging system – Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. supply
IEC 61851-22	Electric vehicle conductive charging system – a.c. electric vehicle charging station
IEC 61851-23	Electric vehicle conductive charging system – d.c electric vehicle charging station
IEC 61851-24	Electric vehicle conductive charging system – Control communication protocol between off-board d.c. charger and electric vehicle
IEC 61894	Preferred sizes and voltages of battery monoblocs for electric vehicle applications
IEC 61968	Application integration at electric utilities – System interfaces for distribution management
IEC 61970	Energy management system application Program interface (EMS-API
IEC 61980-1	Electric equipment for the supply of energy to electric road vehicles using an inductive coupling – Part 1: General requirements
IEC 61980-2	Electric equipment for the supply of energy to electric road vehicles using an inductive coupling – Part 2: Manual connection system using a paddle
IEC 61981	On board electric power equipment for electric road vehicles
IEC 61982-4	Secondary batteries for the propulsion of electric road vehicles – Part 1: Test parameters
IEC 61982-5	Secondary batteries for the propulsion of electric road vehicles – Part 5: Safety testing for lithium-ion cells and batteries
IEC 62040	Uninterruptible power systems (UPS)
IEC 62056 series	DLMS/COSEM
IEC 62133	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications
IEC 62196-1	Plugs, socket-outlets, vehicle couplers and vehicle inlets – Charging up to 250 A a.c. and 400 A d.c.
IEC 62196-2	Plugs, socket-outlets, vehicle couplers and vehicle inlets — Dimensional interchangeability requirements
IEC 62196-3	Plugs, socket-outlets, vehicle couplers and vehicle inlets – Dimensional interchangeability requirements for pin and contact-tube coupler with rated operating voltage up to 1 000 V d.c. and rated current up to 400 A for dedicated d.c. charging
IEC 62335	Circuit breakers – Switched protective earth portable residual current devices for class I and battery powered vehicle applications
IEC 62335-2	SPE-RCDS for inline-cable boxes
IEC 62351	Data and communication security (Security for

	Smart Grid)
IEC 62443	Industrial communication networks – Network and system security
IEC 62485-1	Safety requirements for secondary batteries and battery installations – Part 1: Stationary batteries
IEC 62485-2	Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries
IEC 62485-3	Safety requirements for secondary batteries and battery installations – Part 3: Traction batteries
IEC 62576	Electric double-layer capacitors for use in hybrid electric vehicles – Test methods for electrical characteristics
IEC 62619	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for large format secondary lithium cells and batteries for use in industrial applications
IEC 62660	Secondary batteries for the propulsion of electric road vehicles
ISO 6469-1 (EN 1987-1/2/3)	Electrically propelled road vehicles – Safety specifications – Part 1: On-board rechargeable energy storage system (RESS)
ISO 6469-2	Electrically propelled road vehicles – Safety specifications – Part 2: Vehicle operational safety means and protection against failures
ISO 6469-3	Electrically propelled road vehicles – Safety specifications – Part 3: Protection of persons against electric shock
ISO 6722-1	Road vehicles – 60 V and 600 V single-core cables – Part 1: Dimensions, test methods and requirements for copper conductor cables (Ed. 2.0)
ISO 6722-2	Road vehicles – 60 V and 600 V single-core cables – Part 2: Dimensions test methods and requirements for aluminium conductor cables
ISO/IEC 7498-1	Information processing systems -- Open Systems Interconnection -- Basic Reference Model - Part 1: The Basic Mode
ISO/IEC 7498-2	Information processing systems -- Open Systems Interconnection --Basic Reference Model -- Part 2: Security Architecture
ISO/IEC 7498-3	Information processing systems -- Open Systems Interconnection –Basic Reference Model - Part 3: Naming and addressing
ISO 7637-1	Road vehicles – Electrical disturbances by conduction and coupling – Part 1: Definitions and general considerations
ISO 7637-2	Road vehicles – Electrical disturbances by conduction and coupling – Part 2: Electrical transient conduction along supply lines only
ISO 7637-3	Road vehicles – Electrical disturbances by conduction and coupling – Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines
ISO TR 8713	Electric road vehicles – Vocabulary
ISO 9506-1:2003	Industrial automation systems -- Manufacturing Message Specification -- Part 1: Service definition
ISO 10483-1	Road vehicles - Intelligent power switches - Part 1: High-side intelligent power switch
ISO 10483-2	Road vehicles – Intelligent power switches –

	Part 2: Low-side intelligent power switch
ISO 10924-1	Road vehicles – Circuit breakers – Part 1: Definitions and general test requirements
ISO 10924-4	Road vehicles – Circuit breakers – Part 4: Medium circuit breakers with tabs (blade type), Form CB15
ISO 11451-1/4	Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy
ISO 11452-1	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General principles and terminology
ISO 11452-2	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Absorber-lined shielded enclosure
ISO 11452-3	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: Transverse electromagnetic mode (TEM) cell
ISO 11452-4	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI)
ISO 11452-5	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 5: Stripline
ISO 11452-7	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 7: Direct radio frequency (RF) power injection
ISO 11452-8	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 8: Immunity to magnetic fields
ISO 11452-9	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 9: Portable transmitters
ISO 11452-10	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 10: Immunity to conducted disturbances in the extended audio frequency range
ISO 11452-11	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 11: Reverberation chamber
ISO/IEC 12139-1	Information technology – Telecommunication and information exchange between systems – Power line communication (PLC) – High speed PLC medium access & control (MAC) and physical layer (PHY) – Part 1: General requirements
ISO 12405-1	Electrically propelled road vehicles – Test specification for Li-Ion traction battery systems – Part 1: High power applications
ISO 12405-2	Electrically propelled road vehicles – Test specification for lithium-Ion traction battery systems – Part 2: High energy applications
ISO 12405-3	Electrically propelled road vehicles – Test specification for Li-Ion traction battery systems – Part 3: Safety performance requirements

ISO 14572	Road vehicles – Round, sheathed, 60 V and 600 V screened and unscreened single- or multi-core cables – Test methods and requirements for basic and high-performance cables (Ed. 2.0)
ISO/TS 16553	Road vehicles – Data cables – Test methods and requirements
ISO/IEC 15118 Parts 1–4	Road vehicles – Communication protocol between electric vehicle and grid
ISO/IEC 15118-1	Road vehicles — Vehicle to grid communication interface — Part 1: General information and use-case definition
ISO/IEC 15118-2	Road vehicles — Vehicle-to-Grid Communication Interface — Part 2: Technical protocol description and Open Systems Interconnections (OSI) layer requirements
ISO/IEC 15118-3	Road Vehicles — Vehicle to grid communication interface — Part 3: Physical layer and Data Link layer requirements
ISO/IEC 15408	Information technology - Security techniques - Evaluation criteria for IT security
ISO 15764	Road vehicles – Extended data link security
ISO 16750	Road vehicles – Environmental conditions and testing for electrical and electronic equipment
ISO 23273	Fuel cell road vehicles – Safety specifications
ISO 23274-1	Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 1: Non-externally chargeable vehicles
ISO 23274-2	Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 2: Externally chargeable vehicles
ISO 26262-1/10	Road vehicles – Functional safety
ISO/IEC 27000	Information technology – Security techniques – Information security management systems – Overview and vocabulary
ISO/IEC 27001	Information technology – Security techniques – Information security management systems – Requirements
SAE J 240	Life Test for Automotive Storage Batteries
SAE J 537	Storage Batteries
SAE J 1495	Test Procedure for Battery Flame Retardant Venting Systems
SAE J1654:2004	High Voltage Primary Cable
SAE J1673:1996	High Voltage Automotive Wiring Assembly Design
SAE J 1715	Hybrid Electric Vehicle (HEV) & Electric Vehicle (EV) Terminology
SAE J1742:2005	Connections for High Voltage On-Board Road Vehicle Electrical Wiring
SAE J1766:2005	Battery Modules
SAE J1772:2010	SAE Electric Vehicle Conductive Charge Coupler
SAE J 1773	Electric Vehicle Inductively Coupled Charging
SAE J 1797	Recommended Practice for Packaging of Electric Vehicle Battery Modules
SAE J 1798	Recommended Practice for Performance Rating of Electric Vehicle Battery Modules

SAE J 2185	Life Test for Heavy-Duty Storage Batteries
SAE J 2289	Electric-Drive Battery Pack System: Functional Guidelines
SAE J 2464	Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing
SAE J 2288	Life Cycle Testing of Electric Vehicle Battery Modules
SAE J2289:2000	Electric Driver Battery Pack System Functional Guidelines
SAE J 2293-1	Energy Transfer System for Electric Vehicles–Part 1: Functional Requirements and System Architectures
SAE J 2293-2	Energy Transfer System for Electric Vehicles–Part 2: Communication Requirements and Network Architecture
SAE J 2380	Vibration Testing of Electric Vehicle Batteries
SAE J 2497	Power Line Carrier Communications for Commercial Vehicles
SAE J 2801	Comprehensive Life Test for 12 V Automotive Storage Batteries
SAE J 2836/1	Use Cases for Communication between Plug-in Vehicles and the Utility Grid
SAE J 2836/2	Use Cases for Communication between Plug-in Vehicles and the Supply Equipment (EVSE)
SAE J 2847/1	Communication between Plug-in Vehicles and the Utility Grid
SAE J 2847/2	Communication between Plug-in Vehicles and the Supply Equipment (EVSE)
SAE J 2847/3	Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow
SAE J 2894	Vehicle On-Board Charging Power Quality
SAE J 2929	Electric and Hybrid Vehicle Propulsion Battery System Safety Standard
UL1642:2005	Safety of Lithium-Ion Batteries – Testing
UL 2231-1:2002	Personnel Protection Systems for EV Supply Circuits: Part 1: General Requirements
UL 2231-2:2002	Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems
UL 2251:2002	Plugs, Receptacles and Couplers for EVs
UL2580:2009	Outline of Investigation for Batteries for use in Electric Vehicles

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