Deliverable 8.5

Summary report demonstration experience of
European framework for electromobility

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List of Abbreviations

B2B	Business to Business
CA	Consortium Agreement
DoW	Description of Work (Annex I of Grant Agreement)
EV	Electric vehicle
EVSE	Electric Vehicle Supply Equipment
EVCOID	Electric Vehicle Contract IDentifier
ICE	Internal Combustion Engine
PPP	Public Private Partnership
RES	Renewable Energy Sources
RFID	Radio-Frequency IDentification
WP	Work Package

1 Executive summary

Green eMotion was launched in the context of the European Recovery Plan to support research and development in the area of road transport which have the potential to achieve a breakthrough in the use of renewable and non-polluting energy sources, as well as in safety and mobility. The goal is to develop and demonstrate a commonly accepted and user-friendly framework consisting of interoperable and scalable technical solutions in connection with a sustainable business platform. Within the twelve Green eMotion demo regions the developed solutions for the European framework for electromobility were tested and evaluated.

Interoperability is one of the most important prerequisites for successful roll-out of electromobility. Green eMotion has developed an ICT architecture that is capable of bringing together most of the existing local solutions. The definition of actors and roles and the promotion of these in Europe was a great success factor as all business partners in the field of electromobility must have the same understanding of the market processes. Only with standardized processes and identifiers it will be possible that the existing islands of electromobility grow together.

As an example and to show the functionality of the ICT architecture Green eMotion realized a full set of software components that all together enable the EV driver to:

- Search for a suitable charger within all those operated by Green eMotion partners via web site or mobile phone app
- Start charging (authentication of EV driver contract) at public charging infrastructure of all Green eMotion partners via RFID card or mobile phone app
- Exchange of charging session report between the business partners for billing purposes

The grid integration of charging infrastructure is an important cost factor for electromobility. On one hand the need for grid reinforcement might raise the costs; on the other hand the opportunities for integration of renewable energy sources (RES) might bring relevant savings in the future. With the development of smart grid management schemes the potential of this solution could be shown whereas the power quality measurement revealed no relevant issues in the evaluated grids.

Even with all technical solutions at hand the consumer acceptance for electromobility stays the key factor for a successful mass market roll-out. Green eMotion helped to increase consumer awareness by demonstrations of electric buses for public transport and EV sharing. The public infrastructure for individual transport was enhanced and several measures for improvement of convenience were tested. Especially the tested plug&charge, where the EV authenticates the contract automatically, and inductive charging, where not even a plug in is needed, are seen as milestones for future handling of EVs.

Viable business cases for electromobility are very difficult to find in this premature market. Especially the operation of public charging business is seldom a positive business on its own as the usage frequency at most charging locations is too low. A possibility to improve the business case is the combination with other services like parking in a parking lot or shopping. Within Green eMotion chargers were installed at 12 REWE sites. A finding was that customers indeed appreciate the offer of fast charging during shopping. A real effect of the charging service in the form of an increased business with the shopping could not be validated due to the low number of customers owning an EV. Cost reduction measures like public private shared EVs or software as a service for operation of charging infrastructure were also tested.

2 Introduction

2.1 GeM overview

Green eMotion was launched in the context of the European Recovery Plan to support research and development in the area of road transport which have the potential to achieve a breakthrough in the use of renewable and non-polluting energy sources, as well as in safety and mobility. The goal is to develop and demonstrate a commonly accepted and user-friendly framework consisting of interoperable and scalable technical solutions in connection with a sustainable business platform.

2.2 The demo regions

Green eMotion connects ten ongoing regional and national electromobility initiatives (and two starting as replication regions) leveraging on the results and compare the different technology approaches to ensure the best interoperable and consumer friendly solutions prevail for the EU single market.

Figure 2.1: Green eMotion Demonstration Regions

Within these Green eMotion demo regions the developed solutions for the European framework for electromobility were tested and evaluated.

The detailed reports of each demonstration are documented in the deliverables D8.2 [6] and D8.3 [7]. This deliverable D8.5 summarizes the main experience gathered and the conclusions drawn by executing the respective demo cases.

3 Demonstration studies

3.1 Interoperability of the European charging network

3.1.1 Introduction

Interoperability of hardware and software within the electromobility environment is a mandatory prerequisite for an open and convenient access of EV drivers to public charging infrastructure. Not only that the plug of his EV must fit into the charging station's socket, first the driver needs to find an available charging station (Electric Vehicle Supply Equipment: EVSE) at an appropriate driving distance. Then he needs to authorize himself to gain access, meaning that he can plug in and start a charging session.

The goal of the Green eMotion project is to come up with solutions to precisely these problems. The ICT systems of all participating companies are networked by means of a so-called "Marketplace," which enables drivers to locate and utilize charging stations on their travel route. Because the network also allows for exchanges of real-time data, drivers can determine whether the desired charging station is in fact available.

By virtue of a contract with the electromobility services provider, the driver can charge his electric vehicle anywhere, regardless of the charging station operator. For these services, the electromobility service provider bills the driver, either for services actually utilized or on a flat-rate basis. The charging station operator, who does not have a direct contract with the driver, is paid for the use of his charging stations by the electromobility service provider. These two parties utilize the "Clearing House" to settle accounts with each other on basis of the charging session report. The whole process is depicted in figure 3.1.

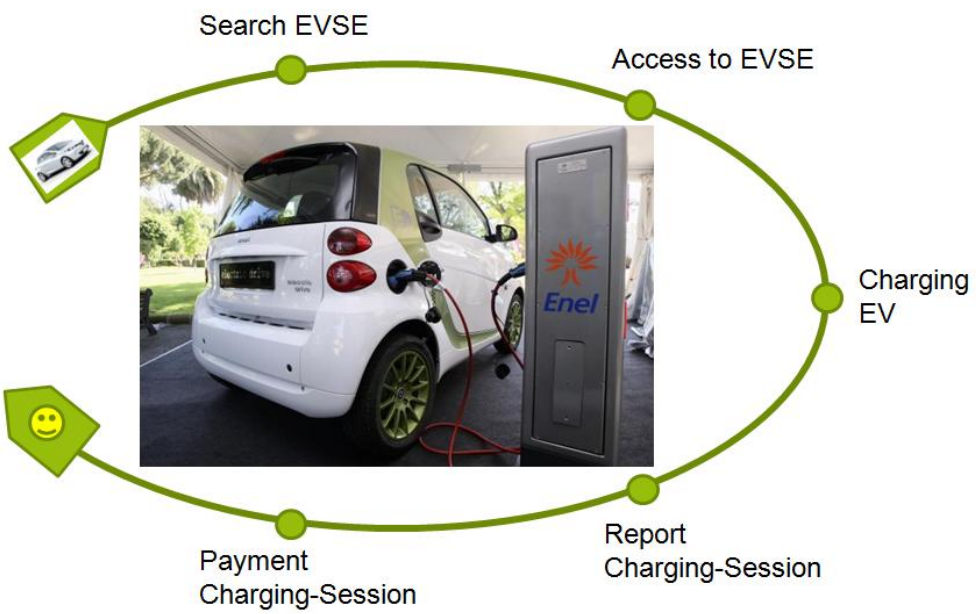

Figure 3.1: Process steps of Interoperability

3.1.2 Search for public charging infrastructure

Search is one example of a business service according to the Green eMotion ICT reference architecture, see D3.2 [1]. Basically the demo case “Search” was demonstrated successfully, by showing the charging stations of the demo regions in a web front end and a mobile application available for Android and iOS.

Search is a service allowing e.g. the EV driver to actually find an EVSE which fulfils 3 main requirements:

- The EVSE can be properly located on a map
- The EVSE offers the needed plug (e.g. Type2, Combo2, CHAdeMO, ..)
- The EVSE offers free outlets

During the project step by step all demo regions have delivered their EVSE data to be included in the Search database. Initially all partners have delivered static data, i.e. information like location, type of EVSE, were available. That way an EV driver will be informed on EVSEs which fit to his needs (e.g. plug type).

Two partners have taken the Search functionality to a next step. ESB and the City of Malmo provide dynamic EVSE status data. That way Search of EVSE can provide much better information, actual status data, to an EV driver using the service. With the information on the actual status (available, in use, not available, planned) it is possible to decide which EVSE to drive to in case one is looking for a charging possibility.

Feedback from ESB users of the web portal in general has been very positive. The inclusion of real-time status information has been viewed as a huge breakthrough, and is something EV users in Ireland have been requesting for some time.

The demonstration for Search clearly showed that an end user services relies on proper reaction times. This is probably the most crucial point. In case a UI does not react in “near real-time” the user has the feeling that the application is broken. This is true for a smart phone app as well as a web based application.

Right afterwards come reliable data. The user needs to be sure that the data displayed is correct and complete. In case the data displayed in the application would not fit to what a user finds in reality on site he would lose confidence in the application. Dynamic EVSE status data thus is a big and important plus for a Search application.

For further details and information on the executed demonstrations, please check the chapter 3 in deliverable D8.2 [6].

3.1.3 Barrier free access to public charging infrastructure

The Green eMotion Marketplace together with the service “Clearing House” makes it possible to offer a wide range of services throughout Europe, including “roaming” that is the use of charging stations outside the territory of the contractual provider of electromobility services, similar to the market for mobile telephony. As a routing system, the Marketplace is also suitable for handling the data flows of a mass market, so it will remain a viable system solution into the future. For more details see D3.5 [2].

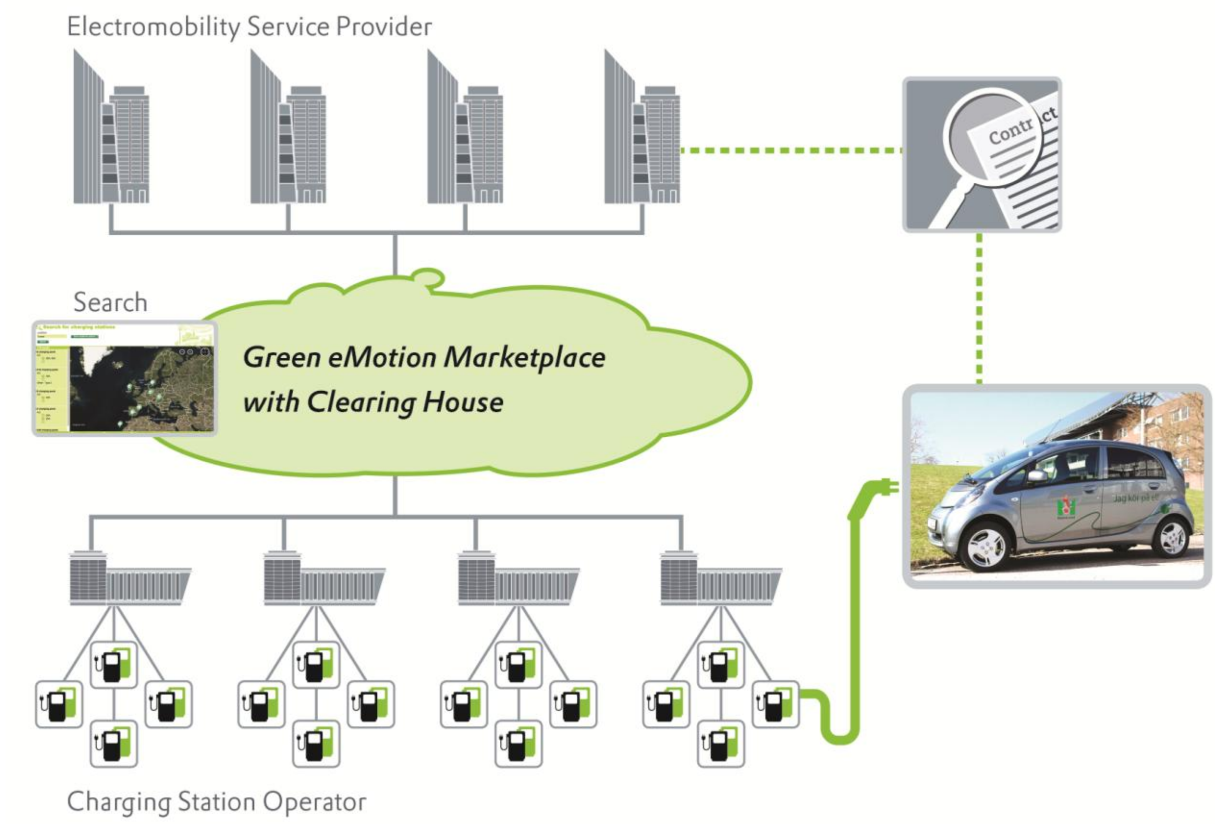

Figure 3.2: The Green eMotion Marketplace connects the ICT systems of market participants

All charging station operators connected to the marketplace may offer charging services via the service provider to the EV driver. After registration of the business partners at the marketplace, it is possible to check the contract of the EV drivers at all connected charging stations. Therefore an authorization of the driver can occur (depending on the contract) and the driver will get access to the charging station. The Service provider can settle the payments based on the charging session report he receives through the marketplace.

For identification within the IT system all business partner need their own unique identifier (EVSE-Operator-ID and/or EV-ServiceProvider-ID) depending on the role they intend to execute. To be able to use e.g. roaming between 2 business partners they need to conclude B2B contracts.

The Green eMotion demo regions were all connected to the marketplace and roaming could be shown between most of the regions. The most often used mean for authentication of the driver, respective his contract, is the RFID card. For the roaming demonstration between distant regions the RFID cards were exchanged, e.g. by using the RFID card of an Irish ESB customer in Spain the roaming between ESB and Endesa could be shown successfully.

The demonstrations within the demo regions and also during the “Rally to Brussels” event clearly showed that roaming is perfectly possible. But it also revealed the weakness of the RFID technology as it is used today. The different service providers hand out RFID cards that are all based on the standard ISO 14443 but use different sub-standards (type A or B) and different identifier lengths. This leads to a Babylonian situation where it might not be possible to identify a customer contract.

Therefore Green eMotion has defined the contract identifier (EVCOID) which fits the needs for roaming much better. It is easy to derive the correct EVSP from the EVCOID in order to identify the correct business partner. Together with eMI3 a standard for usage of the EVCOID for contactless authentication is on the way [13] [14] http://emi3group.com/.

However, based on a non standardized solution the project partners ENEL, Endesa and PPC used RFID cards and EVSEs which are able to read out the EVCOID. That way roaming, in a scalable way, is perfectly possible.

The other project partners still rely on the UID of the RFID card. Green eMotion has set up a working solution with the Marketplace/Clearinghouse too. Even reading the UID out of an RFID card can be tricky. Some RFID reader are not capable of reading 7Byte UIDs, the Byte order interpretation is not standardized and some partners even processed the UID as a decimal number. All those cases can be worked around – but not for each EVSE and not always in parallel. During the demonstration all those issues had to be solved in the different demo regions.

A convenient alternative to RFID cards is the use of a smart phone App that requests the authorization directly from the marketplace. The main difference is that now the IT system of the operator is not involved and has to accept the authorization coming from the service provider via the marketplace a so called PushAuthorization, see also D3.6 [3].

Using a smart phone app for roaming has been demonstrated in the Scandinavian region. The customers of Greenabout (Bornholm) used the app for charging at stations operated by Malmö. The issue that Greenabout customers do not have RFID cards, because they are not needed for the Greenabout infrastructure, could be solved in a very convenient way.

While realizing the PushAuthorization it became quite clear that a roaming platform with many partners requires properly defined interfaces.

Bringing together all experience gathered by executing the roaming demonstrations it sounds like there is 2 major options to enable a scalable Europe-wide roaming system:

- Usage of an RFID card with the EVCOID stored onto it
- Usage of a Smartphone app in conjunction with the EVCOID

Both options seem viable and the market will show which solution will turn out to be successful.

For the RFID card solution it is vital to standardize the way the EVCOID is stored. Furthermore the EVSEs will need to have a Multicard reader installed to be able to read out the EVCOID. The RFID card would continue to be a relatively cheap and easy to use media for the EV driver.

The Smartphone app requires a mobile roaming data contract for the EV driver. This is not considered critical as reasonable prices are charged for such contracts within the EU already today. The responsiveness of such an App is of course crucial. The Green eMotion App has shown that the concept works really fine. For a mass market usage timing and performance optimizations would be needed. Many ideas already exist on how to improve here.

For further details and information on the executed demonstrations, please check the chapter 3 in deliverable D8.3 [7].

3.1.4 Connecting the entirety of European public charging infrastructure

Green eMotion started with a more or less single market place approach. That allows roaming between the Green eMotion partners, because they are connected to this marketplace. However, in reality we have in Europe several marketplaces and other business partners on the market are connected to one of those.

Those market places are for example CROME, European Clearinghouse (www.e-clearing.net), MobiE (http://www.mobie.pt/). Besides these research oriented offers, commercial offers are available, namely Hubject (www.hubject.com) and GIREVE (http://www.gireve.com) which target not only the local but the European market. Based on these observations the necessity for a concept to integrate those activities is obvious. To not do so would contradict the initial aim of interoperability and integration of a European infrastructure. For the launch of an European mass market a comprehensive system must be established which allows all EV driver to access charging stations all over Europe.

Within Green eMotion the necessary interface between marketplaces was developed and tested by connecting the CROME marketplace to the Green eMotion marketplace, see figure 3.3. This set-up enables roaming of customers from CROME partners at charging infrastructure of Green eMotion partners and vice versa. More details are described in the deliverables D3.12 [4] and D3.13 [5].

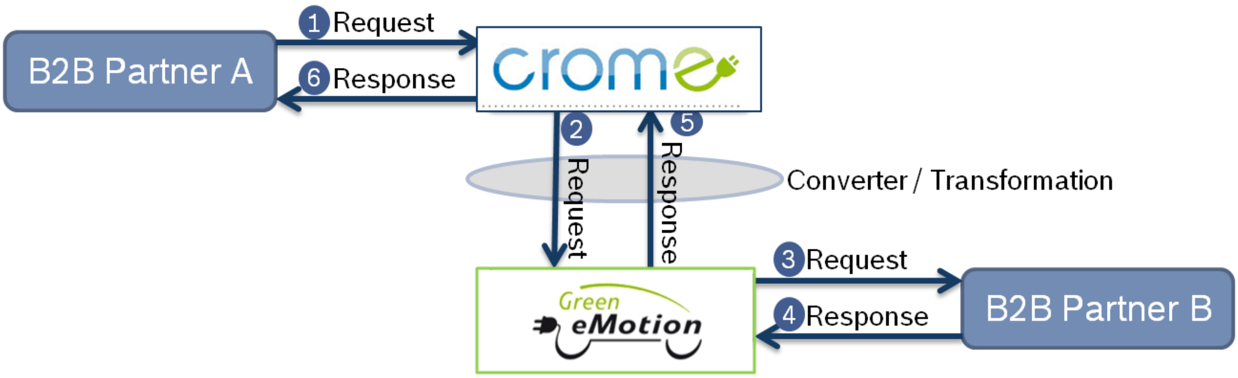

Figure 3.3: General communication set-up

During the Green eMotion event “Rally to Brussels” in October 2014 several partner from the demonstration regions in Europe travelled to Brussels. The RSE team driving from Milan crossed also France and due to the connection of the two marketplaces also charging stations operated by EDF were made available.

The importance of such connections for forming a European infrastructure for public charging is obvious. The only alternative would be a monopolistic European solution with one single marketplace that contradicts the idea of a free market.

There is a significant opportunity in the months ahead, right beyond the end of Green eMotion project, to implement a concrete set of IT infrastructure services to enable the interoperability between existing Platforms at EU level. The purpose of this business process to be established in Europe is to properly exchange data and services (EVSE Search, RFID Authorization info, Charge Detail Record) in a way that perfectly exploits the demonstration performed by the “Multi-Marketplace” or “Multi-Platform” demo case of Green eMotion. A wider scenario description could be found in Green eMotion deliverable D10.8 [9].

For further details and information on the executed demonstrations, please check the chapter 4 in deliverable D8.3 [7].

3.1.5 Interoperability from operator view point

From the EVSE operator point of view interoperability between the components of his charging network is extremely important. He might own charging stations from different manufacturers with proprietary protocols between charge station and remote management system. Also the still commonly used RFID readers might have limited capabilities for instance not being able to read additional information from RFID cards.

In the demo regions Austria the partner Verbund found himself in exactly the situation as described above. In total 85 Siemens recharging points, most of them AC with 22 kW power, were connected to the new Siemens ECar OC (Charge Management System). The move to the new system was successful and achieved without problems. At the same time it proved complicated to connect existing or new chargers from other vendors. Also, it was not possible to switch from RFID Unique ID to the usage of EVCOID information stored on the RFID card since the additional information could not be read by the reader nor transferred to the Charge Management System.

Usage data of all connected recharging points could be obtained and constitute a significant result of the demo case AC charging in Demo Region AT01. In total 5,032 recharging sessions were recorded with 51,351 kWh electricity transferred to vehicles. Some recharging points were used as often as 275 times; some were only accessed a few times. 17 recharging points were accessed more often than 100 times, and 40 stations more often than 50 times, while 44 stations were accessed less than 50 times since start of the system.

Experience with this demonstration case leads to the following conclusions:

1. Integration of legacy charging stations into modern charge management systems can be achieved and allows for better management of the charge stations. Limitations arise from proprietary protocols between charge station and remote management system and from hardware and driver on the charge stations (for instance not being able to read additional information from RFID cards).
2. EVSE Operators will have to focus on charging stations compatible with open and standardized protocols as OCPP to allow for greater flexibility and easier integration in charge management systems.
3. Integration of prior isolated charging networks and service providers with a cooperative European network is feasible and leads to significantly increased service quality for some drivers.
4. While recharging networks still focus on core regions in most countries and cross border travel is scarce, missing links in networks can be identified and closed by installation of a limited number of additional stations.

For further details and information on the executed demonstrations, please check the chapter 5 in deliverable D8.2 [6].

3.2 Grid Integration – technical approaches

3.2.1 Introduction

Main issues for integration of charging infrastructure into the grid are the preservation of power quality, the connection of high loads to the existing grid with minimized reinforcement costs and the optimized integration of renewable energy sources. Green eMotion work package 4 has elaborated options for grid-supporting opportunities of EVs and grid impact studies of electric vehicles as reported in the deliverables D4.2 [10] and D4.3 [11]. Prototypes have been developed as part of WP5, mainly load management software and power management for distribution networks. Other solutions like buffer batteries or smart charging strategies were developed under the scheme of demonstration in WP8.

This chapter reports the demonstration of some technical approaches to tackle these issues, whereas the business aspects are highlighted in chapter 3.4.

3.2.2 Minimizing grid integration costs with buffer batteries

This demo case intends to test new and innovative energy management applications for the installations that Endesa is currently developing in Barcelona and Málaga. Despite the fact these two installations are EV charging facilities and, at the end, their purpose is to charge EV batteries, the way in which they perform the charges is considerably different: while the Barcelona EV parking lot was designed for charging the Endesa's EV fleet, the Málaga setup consists of three fast charging points that will supply all those EV users that need they batteries to be recharged as fast as possible.

An experimental set-up combining micro grid simulation, hardware emulation and real devices has been proposed, designed and implemented to test technical feasibility of smart grid management schemes including EVs, renewable energy sources (RES) and 2nd life batteries.

A cost minimization smart grid management scheme has been applied to the eParking micro grid considering real EV mobility profiles extracted from the Green eMotion Project data collection process (WP1) and real data concerning PV production. By means of this strategy 2nd life battery charging/discharging profiles are scheduled for minimizing energy purchasing during peak price periods and maximizing PV generation usage, thus reducing eParking operation cost while respecting EV users mobility needs and reducing CO2 emissions.

2nd life batteries can be used for reducing Malaga's fast charging stations CAPEX and OPEX by means of enabling the grid tie capacity requirements (and the corresponding power electronics) while maintaining quality of service (waiting time and level of service).

From on-line lab tests, it can be observed how the usage of 2nd life batteries for this kind of purposes is technically viable (in terms of system dynamics), efficient (in terms of energy consumption impact), and durable (in terms of internal temperature variations and its potential impact on batteries' state-of-health).

It has been also demonstrated how in addition to grid tie capacity reduction, 2nd life EV batteries (by means of its power electronics) can contribute to improve power quality compensating almost 100% reactive power consumed from fast chargers.

The integration of a battery with a DC fast charger was also shown in real life. The focus here is to understand how the 2nd life battery can help to connect DC fast chargers to a weaker grid connection.

The figure below depicts the installation done by Endesa in Malaga (ES 01).

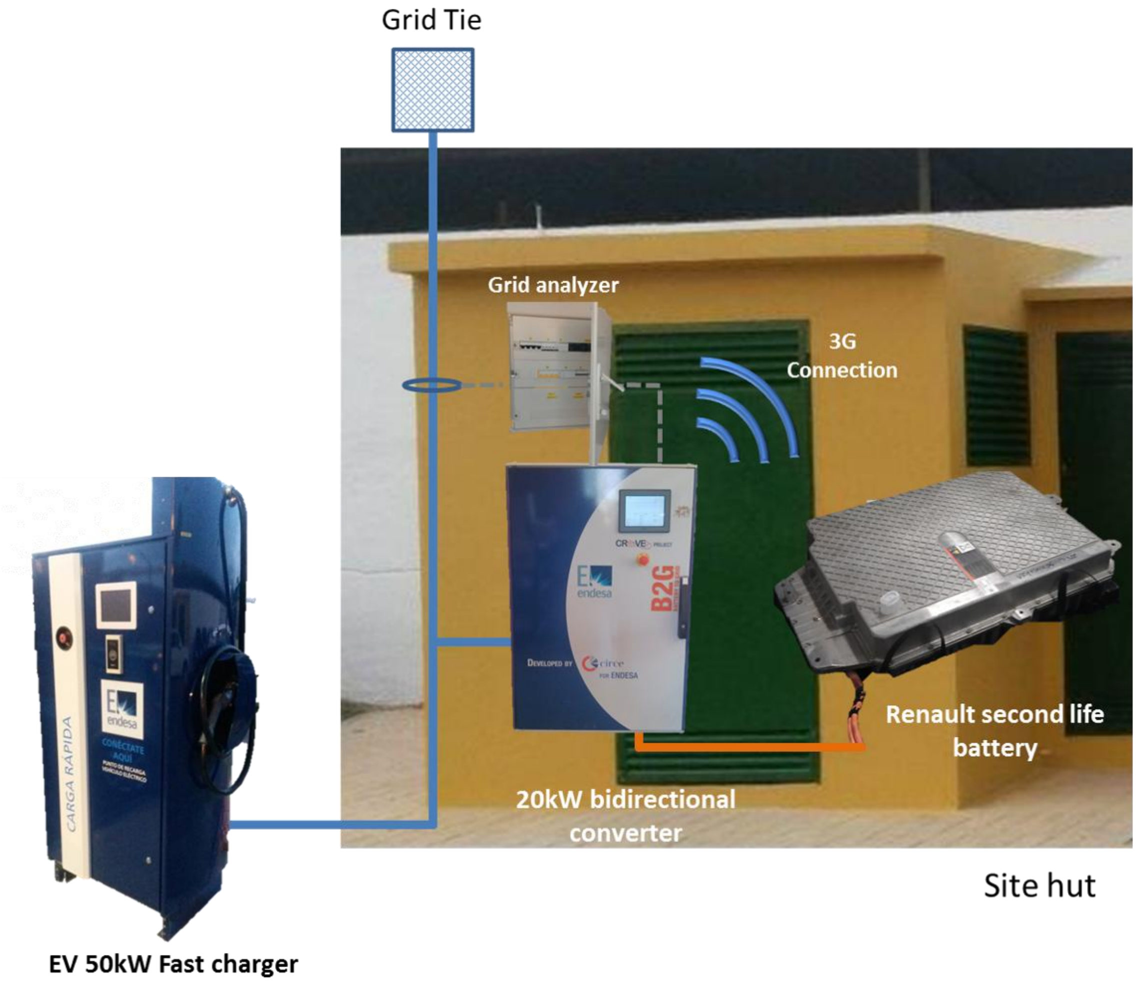

Figure 3.4: Demo case main components diagram

The battery together with a Power Electronics System which manages the battery builds the Energy Storage System (EES). This ESS is designed to reduce the peak demand of 50kW of a fast charger and to compensate the reactive power generated by the fast chargers, due to the typical topology of these chargers which use diode bridges instead of controlled bridges.

The ESS maximum charging and discharging power along the test is 10 kW (manufacturer recommendations). Therefore the maximum power drawn from the grid is reduced from 50 kW to 40kW. It could also be demonstrated that ESS almost compensates all the reactive power demanded by the fast charger. It can be concluded that the developed system allows reducing the impact of the EV fast charge on the electric grid: it reduces the maximum demand of the system at the same time that compensates the reactive power consumed by the charger. Nevertheless, the system is not fast enough to act upon fast variations of the EVSE demand, both active and reactive power. This problem could be solved by implementing a direct communication between the EVSE and the SCADA of the ESS.

Besides technical and economic viability assessments including in this work, one of the main research questions to be addressed regarding 2nd life batteries applications is how batteries' state-of-health will evolve along the time. This topic is out of the scope of the research objectives of this demo case because of the low number of cycles that has been imposed to the batteries during the testing periods. A result of the micro grid simulation with real second life batteries was that the state-of-health of the battery pack has remained constant at 93% during the whole testing period. Further research should be performed in this regard by means of battery degradation models and stress tests that shed more light on this topic.

An obstacle while installing batteries is that battery facilities require to meet a long list of regulations besides usual electrical facilities ones. This makes their installation and environment more complex that a single charging point one. It also involves a long and complex legalization process.

For further details and information on the executed demonstrations, please check the chapters 11.1.1 / 11.2.1 / 11.3.1 and 7.1.1 / 7.2.1 / 7.3.1 in deliverable D8.2 [6].

3.2.3 Power quality influence of charging infrastructure

This section contains a compilation of the different measurements performed to determine the impact level of the charging systems over the general electric grid. The reason of the inclusion of this demonstration case from a social and customer perspective is to consider the possible impact and effects of the quality of supply both in the final client installations (EV owner) and also in energy networks from the supplier side.

The vehicles available in Ataun and Pamplona demos are VE THINK City, whose main features are the usage of an AC inductive electric motor with nominal power of 20 kW (34 kW peak) and a battery of sodium chloride and nickel, model ZEBRA Z36-371-ML3X-76 (ZEBRA Z36). The charger that comes with the car can be adjusted to load at intensities of 10 or 16 A.

In Madrid a charging station of electric microbuses with a power supply of 414kW in total was monitored.

Considering the final results derived from the execution of the demo case, it has been demonstrated that the effects and distortions generated by the charging processes are not significant, even in the case if power of the chargers under analysis compared to the lines where they were connected was high. Also it has been observed that the protections of the grid would mitigate the negative effects and avoid the spread-out of these effects in case of resizing the charging process at a larger scale. Thus, it won’t be necessary to reshape the energy grid, taking into account the distortions derived from the EV charging process.

Further quality measurements were performed at a multi charger installation in Dublin. The multi-standard charge point is capable of fast charging two vehicles at any one time (CHAdeMO and Fast AC or CCS and Fast AC). Simultaneous CHAdeMO and CCS charging is not possible as there is only one convertor in the charge point and load sharing between the two DC fast charging standard has not been implemented in the charge point design.

Due to the close proximity of the charge points to the bulk supply point (the 10kV/LV substation), power quality measurements have shown that there is no voltage dip observed during the charging process. In addition to this, as the charge points are fed via a dedicated LV outlet on the nearby transformer it is unlikely that any harmonic effect will be visible to other customers on the network.

For further details and information on the executed demonstrations, please check the chapters 11.1.2 / 11.2.2 / 11.3.2 and 7.1.2 / 7.2.2 / 7.3.2 in deliverable D8.2 [6].

3.2.4 Optimized combination of photovoltaic with charging infrastructure

The incorporation of renewable energy generation in charging infrastructure allows that a portion of the energy used to charge the EV could be renewable energy and, as long as it is produced locally, the losses from the transmission and distribution of the electric energy are minimized.

Concerning the technical work of the demo case, it was analysed the photovoltaic facility sited in the marquee that protects the electric vehicles from the worst weather conditions along with their respective charging points in Ataun. From the operative data and through the use of simulations, different scenarios with several sizes on the photovoltaic system (PV) were analyzed in order to cover, with their power generation, part of the electric consumption from the charging and use of the EV.

This task is developed through the analysis of the possible synchronization between consumption by the EVs and generation by the PV, and considering a net balance using the network as an energy store or a system of batteries that allow an independent management of the network.

The analysis has been performed for a very specific facility that is made of 5 charging points and 5 cars. Considering the goal to obtain results that could be extrapolated to other possible facilities, it could be defined a group of KPIs:

1. Energy generated by a single unit of photovoltaic surface.

   It is a value dependant on the technology of the photovoltaic module and the location. For the case of study the generated energy is 800 kWh/kWp.

2. Vehicle annual demand.

   It is a value that depends on the car use. Using data from 2012, there are five vehicles with a total demand of 22.184 kWh that means 4.437 kWh/VE for each vehicle.

3. Necessary surface to cover the 100% of the demand with net balance per vehicle.

   For these conditions and considering the actual case, it is necessary to have a surface of 153 m2 that correspond to 93 modules, and they offer a value of 30,6 m2/EV.

4. Necessary surface of PV system and necessary capacity of the batteries to cover the 100% of the demand with accumulation per vehicle.

   The conclusion is that 108 modules are necessary, and this corresponds to 179 m2 and an accumulation of 2.100 kAh so the final values are 36 m2/EV and 420 kAh/EV.

For further details and information on the executed demonstrations, please check the chapters 11.1.4 / 11.2.4 / 11.3.4 in deliverable D8.2 [6].

3.2.5 Energy cost reduction by controlled charging at different tariffs

In the Aqua Multiespacio building is located the headquarters of Iberdrola in Valencia. Iberdrola has an electric car sharing service. The corresponding charger has two Schuko plug connections (CEE 7/4 SCHUKO type). They are monophasic with 230V and 16 A. The system has an Ethernet port communication that can be used to send and receive information.

Goal of the demo case is an economic study to assess the savings that can be achieved in a particular car sharing service by introducing certain management mechanisms.

It is concluded that the scenario in which you can move the EV charging until after midnight (TOU tariff have a lower tariff price):

1. With time discrimination tariff we could save € 103.92 regarding the COR (basic tariff), which accounts for 30.75 % of the total.

2. With DH3-supervalle (Spanish tariff scenario with 3 prices) we can save € 134.65 regarding the COR (basic tariff), which accounts for 39.85 % of the total.

It can be concluded that the use of management systems can contribute directly to savings for the consumer. In addition, the shifting of the charging consumption would also be benefits for the DSO as generation companies because a flatter demand curve will be obtained, globally.

Considering the social and client point of view, the savings provided by the usage of the smart grid would play an important role to convince the new users to change his old ICE to a new EV. These savings come from the action of performing the recharging during periods of time with lower prices. Moreover, thanks to future smart grid services, other charging strategies could be designed and implemented through the use of smart meters. These strategies, and other functionalities of the smart grid, allow making the load curve flatter, a goal desired by the electric utilities.

For further details and information on the executed demonstrations, please check the chapters 11.1.3 / 11.2.3 / 11.3.3 in deliverable D8.2.

3.2.6 Load management

The demo case AC load management is executed in 3 demo regions. All of them share the idea to understand how load management can help a DSO in operating the network. There are different types of load management depending on the main purpose of this feature.

- For protection of (weak) grid connection the load management distributes the available energy, based on the technical restriction of the substation / point of delivery (PoD). The main purpose is to prevent feeder overloading by a fair share mechanism providing the possibility to connect more charging ports to a secondary (Low Voltage) substation (PoD) than the provided current at the substation (PoD) is capable of, e.g. connecting three 32A chargers at a PoD which has a current limitation at 64A. The load management reduces and raises the current of single charging ports to keep the substation (PoD) always in a stable status. It is possible to remotely control the maximum power to be distributed from outside of the load manager by a third party such as the DSO. The EV driver behaviour and EV contract conditions will be reflected in the contract information (e.g. Basic, Gold) from the EVSP.
- For integration of renewables the power grid must always be balanced, meaning that energy production and energy consumption must be levelled. For environmental reasons, it is most preferred to use as much green energy as possible. Due to the fact that the production of the green energy changes based on weather conditions, etc., the energy provider tries to balance this factor by influencing the power demand in the grid. In case of load management for renewables, the DSO has to inform the EVSE operator to increase or decrease the energy consumption (charging EVs) to cover the short term variation. The Information will be exchanged done on a 15 minutes, common in energy market today, interval basis. The load management will also consider the charging time schedule and EV customer preferences and contractual terms, e.g. “Premium status”.

The use case “protection of grid connection” was demonstrated in Málaga with 10 Siemens CP500A charging points. These charging points have two Schuko and two Mennekes outputs, with a nominal input voltage of 230/400V and a nominal input intensity of 2x32A. Maximum charge intensity is 32 A, and their nominal output power is 22kW. Different car models have been used, Mitsubishi iMiEV and BMW i3, plus different RFID user cards, implying “GOLD” or “Basic“ user profiles.

The AC charging infrastructure available today is largely based on IEC 61851-1 / PWM signalization. The PWM signalling allows limiting the current which an EV may draw from the EVSE. This solution properly allows protecting a PoD / grid connection from overload. The EVs used in the demonstration quickly followed all changes of the current signalled by the EVSE. Combined with a wide range of power demand limits the demo cases resulted in a variety of situations that practically demonstrate feasibility of load management schemes for the protection of (weak) grid connection.

The use case "integration of renewable" was demonstrated within a test environment of Enel representing the demo regions Italy and Greece. The DSO Operator was simulated by a DSO IT mock-up system, in order to allow the definition of same Load Area to be communicated to the real EVSE Operation back-end system (EMM Platform).

The implementation of Load Management operations allowed demonstrating the possibility to manage modulation requests coming from the Distribution System Operator, in order to optimize the power available in a specific load area, in different conditions:

1. During a normal day under predefined peaks, depending on the season and type of day;
2. During a particular period, when power available at load area level is less than the normal standard value for a typical day.

However, the results of EV load management imply that no real time power balancing could be executed with today's available PWM ISO/IEC 618581-1. AC load management with PWM signalling can fulfil most requirements. Nevertheless there's one important requirement coming from the DSO that cannot properly be fulfilled and that is guaranteeing that a certain amount of energy is drawn per time interval. Therefore a realistic smart charging products in near future could only be marketed in a way that they do allocate EV customer charging process within the day based on a digital signalling (e.g. Turn ON at 3 PM in the afternoon until 6 PM), as any more dense load management request would be unreliable for power balancing. In the future a more powerful communication between the EVSE and the EV will be available. ISO/IEC 15118 will allow the negotiation of so called charge plans between the EV and the infrastructure. Once the implementation of ISO/IEC 15118 communication is available at the majority of EVs and EVSEs load management can bring even more benefit to the grid integration.

For further details and information on the executed demonstrations, please check the chapter 6 in deliverable D8.2 [6].

3.2.7 Power management for distribution networks

The Soft Open Point (SOP) project has tried to provide a solution to the problem which may arise when a weak, low voltage grid is supplying two separate types of loads via two feeders. The amount of loading of either of the feeders could vary at different time of the day. As an example one feeder could supply a number of EV chargers and the other may only supply a residential area. Thus for the latter feeder a notable margin is available whereas the "EV-feeder" is in danger of being overloaded. Figure 3.5 shows the SOP which has been designed and built to provide automatic power transfer from one feeder to the other based on the feeder load level.

The device was installed at ESB Networks (ESBN) Portlaoise Training School, Portlaoise Town, County Laois, Republic of Ireland by staff from ESB and Alstom. The ESBN training school contains a live network of utility assets with voltage levels ranging from 38kV to low voltage (LV) and hence the SOP was installed in a network which represented a typical scenario while still maintaining a controlled environment. The tests involved load transfer across the SOP with associated power quality measurement, thermal imaging and noise measurement.

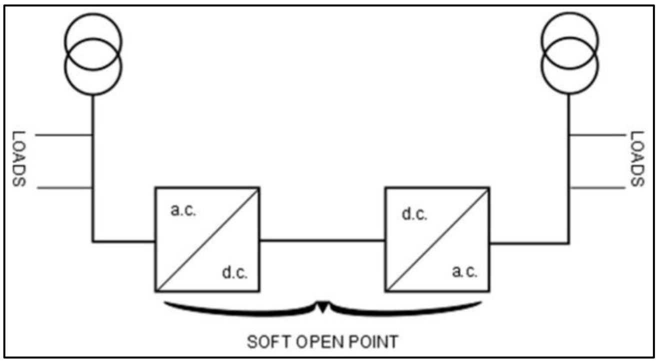

Figure 3.5: Block Diagram of SOP

Load was successfully transferred across the N/O point by the SOP both automatically and manually for various test scenarios and the SOP tripped successfully for a fault scenario. It is noted that advanced load balancing algorithms developed by Alstom were not implemented as part of the test due to the location of the load banks (substation adjacent) and the associated change in network impedances from reference values.

Power quality measurements were completed during the test and the values of current, voltage and power measured by the SOP were verified by the power quality meter. The percentage current total harmonic distortion during a high load transfer scenario was identified as a possible negative aspect of the SOP.

Thermal imaging was conducted during the test with measured temperatures remaining very low. Further thermal testing has been recommended during warm weather conditions and with more continuous load transfer.

Noise measurements identified possible nuisance noise from the SOP however as the device is a prototype it was determined that this could be easily addressed in future versions.

A number of applications for the SOP were discussed. The SOP has the potential to balance load across adjacent feeders and control local system voltages. The SOP has cost saving implications for utilities and represents a much more efficient use of the existing network

For further details and information on the executed demonstrations, please check the chapter 9 in deliverable D8.2 [6].

3.3 Consumer acceptance

3.3.1 Introduction

Consumer acceptance of electromobility depends on several factors. First of all people must get aware of EVs and the advantages they bring. Therefore it is important to raise the awareness by promoting electromobility and by real driving experience.

To achieve a positive perception the access to the EV and the process of charging should be as easy as possible. This can be supported e.g. by offering a smart phone app for start of charging or the convenient “plug and charge” service. Another aspect is the availability of suitable public charging infrastructure. Due to the limited range of the EVs as today, enough and compatible charging stations need to be installed in the right places. The access to all public chargers should be possible even across borders without complex handling processes.

Home charging is an important component for most of the EV drivers. It is the cheapest at easiest way to charge the vehicle when it is not in use. Hence it is important to make the cheap installation of home chargers possible whenever the circumstances may allow this. The preparation of buildings during the construction phase for later installation of chargers is an important step in this direction.

The Green eMotion demonstrations tackle the different aspects as explained above. Issues regarding enhancement of EV/battery technology are not addressed in this project.

3.3.2 Raise of awareness in new region

The pilot project in Greece incorporated 8 charging stations in Kozani and 7 charging posts in Athens, collaborating with a corresponding number of EVs. The installation of the charging posts started middle of June 2014 and the whole project was finalized in December 2014.

Kozani being a small municipality has good communication paths and quick solving of different problems by the executives of the municipality and other local authorities. The citizens of the city having a very good knowledge of the energy technology are very well adapting to new technologies like e-mobility and very eager to explore what the GeM platform can add to national e-mobility. Installing the appropriate communication paths between GeM representatives and Kozani’s authorities it became possible to define the location of the charging units approved by DSO or the distribution network executives and found a way to overcome the problem of not having in place national and local regulatory framework for the pavement occupancy for the charging units.

In Athens the problems arisen due to the lack of regulatory framework and predefined rules for the occupancy of the pavement from charging posts were bigger, so only the pilot nature of the project permitted the installation until establishment of the necessary regulatory frame.

Via GeM the opportunity was given to use electric cars and charging infrastructure, to individuals belonging to public bodies, ministries etc (the major of Kozani, the major of Athens, CEO of DSO, CEO of PPC, executives from ministry of Environment and executive of ministry of Transport), responsible to make the institutional framework for the electromobility, permitting more direct knowledge of the potential of electromobility and the necessary actions to support the easy electromobility deployment in Greece.

Having all the stakeholders involved in the project, a public presentation of the project on September 2014 achieved big publicity, making a very big promotion in electromobility and achievements of the Green eMotion project as seen by the numbers. From the Athens Green eMotion Congress overall came up: 31 positive articles on newspapers, 326 positive online articles (news sites & blogs) and 6 reportages on television channels (with national broadcasting).

For further details and information on the executed demonstrations, please check the chapter 4 in deliverable D8.2 [6].

3.3.3 Minibus service - Iberdrola

The objective of the demo case is the analysis of the gradual incorporation of electric buses to the transport network. Considering the social and client perspective, the incorporation of electric minibuses would allow the reduction of energy consumption, emissions and noise pollution (it could affect 26.7% of the urban homes1), which would be beneficial from a social perspective, especially in cities where the levels of pollutant emissions and noise pollution are too high.

Electric minibuses were tested in two Spanish regions. One demonstration is the evaluation of the electric minibus service offered by the public provincial transport company of Biscay, sited in Basque Country. The other one is based on a couple of electric minibuses that have been put into service inside the historic downtown of Madrid in 2008 a, a zone that due to its especial features never had public transport.

The infrastructure in Basque Country consists of 2 CP inside a garage in Derio and one for each route of the lines of minibus to make a total of four CPs. These CPs are 43 kW three-phase chargers, so the charging speed is remarkably higher than the standard chargers. The vehicle here is a Peugeot mini bus with nine seats.

The data to be analysed have been taken from the ones stored in the data logger during the bus trips on the line Mungia-Fika-Mungia-Arrieta in August 2011. The overall number of km during the whole month was 3671.087 km. The bus has had more failures than expected. In fact, one important failure has damaged the EV and the service is no longer provided by this electric vehicle. This leaves opened the discussion about the necessity of companies dedicated to, or at least with the ability to, repair the damaged EVs, especially the electric motor.

In Madrid EMT (agency for public transport in Madrid) has actually a fleet of 20 Tecnobus electric vehicles, model Gulliver, that provide service in two recently created lines. The maximum weight is enough to carry 7 sat clients and 18 standing, plus one disabled client on wheelchair. To recharge the Zebra batteries, the vehicle has two plugs (one per battery module) and a third connector to exchange data. The recharging procedure is completely automated. The on-board software takes care of the evaluation of the load level for each battery in order to supply the necessary energy. For the daily battery recharging process a charging station has been built inside the modern "*Centro de Operaciones de Carabanchel*". The yearly (2011) numbers of the service indicate that 500.000 citizens have used the minibuses, with a distance of 200.000 Km travelled by the electric bus fleet.

The social and client benefits derived by the activities regarding the enhancement of the electric minibus fleet come from two different perspectives:

- The advantages from the electromobility factor, consisting of the direct reductions of contamination (gases and noise) and the better energy management and optimization in usage.
- The advantages from the public mass transport, including the reduction in traffic and the indirect reduction of pollution (less vehicles means less pollution).

Considering its contribution to electromobility market entrance, and the traditional role of electromobility in mass public transportation, this is one of the few scenarios that really do not need to wait some years to become feasible. The extensively usage of electric buses brings prestige to the municipality, and indirectly helps to encourage further ecologic and sustainable initiatives.

For further details and information on the executed demonstrations, please check the chapter 7 in deliverable D8.3 [7].

[1] From "**Guía sobre la Eficiencia Energética en la Movilidad y el Transporte Urbano". Comunidad de Madrid, 2014**

3.3.4 Acceptance of eCar sharing in rural area

The purpose of this specific demonstrator is the analysis of a rental system and electric car-sharing set down in low density population areas. The municipality of Ataun located in the Basque Country is situated in a low density population area and the available public transportation system is limited.

The citizens of the Ataun village can be registered as users at the town hall and will receive and RFID card so they can unlock the car at the charging point and use it (a valid bank account is needed to be charged for the service). After that, the cars can be requested using a web page (specifying a date and time of start/finish for the car rental) or directly at the charging point. At the end of service the user will return the car to the same charging point (it's a captive fleet from the moment until more charging points will be installed in more villages). The user will be charged for the service in his/her bank account.

The fleet service in Ataun has 5 EVs and 5 parking spaces at the moment and is located in the centre of the municipality. The number of registered users in the car-sharing service of Ataun is 71 people.

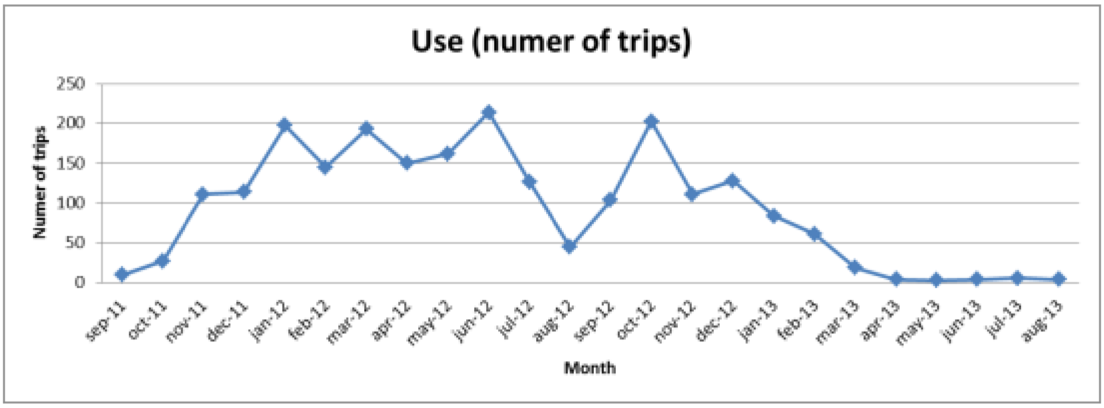

Figure 3.6: Use of EVs in numbers of trips by month

Description of Use (number of trips) graphics: The data reflect the total usage of the 5 vehicles during the evaluation time, counting the origin in the moment the car is unplugged from the CP and the end when the same car is plugged.

Considering just the analyzed time, it can be seen that usage of the service by the various registered users (71 users) has been fairly high during the most part of the period, so it can be concluded that the service has been successful. Thus it is shown that the use of electric cars in rural areas, and further characterized in this case by certain issues (like considerable slopes on the roads) is possible and attractive for clients of car sharing. Consequently, it has been a way to promote the EVs.

For further details and information on the executed demonstrations, please check the chapter 8 in deliverable D8.3 [7].

3.3.5 Buildings ready for home charger installation

The installation of charging infrastructure in already existing buildings can cause several technical issues. Therefore it is desirable that in new constructed buildings at least some preparations are done for a later installation.

The goal of the use case is to develop an EV ready certificate for buildings. Smatrics worked with building developers to set up a process in which charging infrastructure can be taken into consideration during the planning and construction phase of buildings, both office and residential buildings. One part consists of intelligent planning of charging infrastructure and integration into the in-house-energy and parking infrastructure (grid connection aspects, location of parking lots reserved for EVs etc.). A second part aims at the physical preparation of the garage for charging infrastructure (power cables, electric meter preparation etc.). Both parts are necessary to allow a later installation of charging stations for electric vehicles with comparable low costs.

A check list of minimum technical requirements for building (residence and office buildings) was defined. This serves on the one hand side as recommendations for architects and building developers. On the other hand side it serves as blueprint for the standardization of technical preparation of buildings.

A first set of recommendations was formulated. If a separate billing of charging electricity is required (private wall boxes with separate meters), it is important to reserve enough space on the switchboard for the installation of a second official electricity meter. A later change leads to significant investments since the switchboard installation has to be upgraded.

A second option is that the wall boxes of various customers are connected to a single meter. The accounting of the energy to the respective customer is being done by reading out the charge data records out of the back-end system to which the wall boxes are connected. Wall boxes have to be equipped with RFID readers so that every charge session can be assigned to the respective customer. The customers are being charged by the EV service provider.

VERBUND and SMATRICS, together with the Austrian E-Mobility association Austrian Mobile Power, of which VERBUND and SMARICS are members, started a dialogue with the Austrian federal authority Austrian Institute for Construction Engineering (OIB) to integrate the above recommendations into the OIB guidelines. An integration of the EV ready criteria into the OIB guidelines is very likely to bring E-Mobility and especially home charging to a broader attention in Austria. The process of defining the specifications is still ongoing.

For further details and information on the executed demonstrations, please check the chapter 14 in deliverable D8.3 [7].

3.3.6 Enhancing the charging network for commuters

Commuters form a plausible early adopting user group. Their usage pattern allows them to make maximum use of the limited range of today's battery electric vehicles. Almost all their trips are well below EV range and at origin as well as at destination, they spend enough time to recharge.

When demonstrating the use of fast charging infrastructure by commuters, the best sites for fast chargers in this use case was determined by traffic analysis. The sites "A1 Steinhäusl / West Highway connecting Vienna with St. Pölten and Linz" and "Triester Straße / State road B17 connecting Vienna with the densely populated southern suburban area" were selected. Both locations were equipped with fast charging stations based on the rationale that only fast charging with power > 22 kW provides sufficient service for commuters who require recharging service on their way home or to work.

The data available is not yet complete but already indicates the increased use of the fast chargers in after work hours, most likely by drivers on their way home. This might indicate that:

- Most drivers do have an opportunity to charge at home, thus they do not need a fast charging station at their way to work.
- Most drivers seem to lack an opportunity to charge their EV at work, thus – in certain circumstances – require fast charging in their way home between 15:00 to 18:00.

For further details and information on the executed demonstrations, please check the chapter 11 in deliverable D8.3 [7].

3.3.7 Reduce queuing at fast chargers

The demo case DC fast charging is being run in Ireland and involves the installation of a second DC fast charge point at a site that already has an existing multi-standard fast charge point. It offers 50kW DC power (via CHAdeMO and CSS) and either 22kW or 44kW AC power.

Even though sales of EVs in Ireland have not reached the levels of some of the other European countries, such as Norway and The Netherlands, ESB ecars have observed queues at certain fast charge point locations. The data study period was defined as from June 1st 2014 to December 1st 2014. During that period, the 40 queue sessions occurred. Ongoing monitoring of the usage patterns at the site will verified whether the installation of the new DC fast charge point will partially or completely eliminate queuing.

For further details and information on the executed demonstrations, please check the chapters 7.1.2 / 7.2.2 / 7.3.2 in deliverable D8.2 [6].

3.3.8 Cross boarder roaming demonstration

In 2010 ESB ecars commenced the roll out of an Electric Vehicle (EV) charging infrastructure in the Republic of Ireland (ROI). Later that year ecar NI was setup in Northern Ireland (NI) as part of a UK Plugged-in-Places (PiP) project. Cross border traffic of Internal Combustion Engine (ICE) vehicles between ROI and NI is very common and the border is fully open. It was envisioned that EV owners' travel patterns would mirror those in the Internal Combustion Engine (ICE) community, hence the requirement for a cross-border charging solution. This demo case shows how the cross border ROI-NI roaming has been achieved.

In order to verify that cross-border roaming is being used, the public charging behaviour of a randomly selected EV owner was analysed as a case study. The customer was registered with the electromobility operator in ROI (ESB ecars) however their charge point access card also allowed them access to the charging infrastructure in NI. The period of analysis was from July 2013 to December 2014. A summary table of the key values is shown below.

Total Number of Charging Events	486 (100%)
Charging Events in ROI	454 (93%)
Charging Events in NI	32 (7%)
Total Energy Consumed	2129 kWhrs (100%)
Energy Consumed in ROI	1977 kWhrs (93%)
Energy Consumed in NI	152 kWhrs (7%)

Table 3.1: Summary Values for Sample Case Study

As can be seen from the table above, the customer has used their ROI charge point access card to access the charging infrastructure in NI on numerous occasions, thus enabling further travel and reducing range anxiety. The charging session user interface is identical in both jurisdictions and hence customers should experience a seamless charging process.

This demo case has demonstrated that a system to enable cross-border charging of electric vehicles between ROI and NI is in place and functioning as shown by a sample case study of an EV owner's charging patterns.

This roaming system will enable greater distances to be reached in electric vehicles and hence reduce of range anxiety. In addition the system allows settlement of charging session costs between different jurisdictions and is likely to encourage an increase in EV sales, particularly in border regions. In general the system removes some of the barriers to EV adoption in ROI and NI and is deemed a success.

For further details and information on the executed demonstrations, please check the chapter 6 in deliverable D8.3 [7].

3.3.9 Convenient access to eCar sharing vehicles

Our goal is to combine public transportation, bus / train, with easy access to car sharing programs. We put up a system, which allows the customer to use the same card to travel with public transportation as to open and rent an electric car for the last mile.

We have made a technical solution that uses the same RFID standard as the public transportation ("Rejsekort": travel card) and for the car sharing. We have installed readers in a number of cars to identify the customer via the travel card. We have placed EV in a car sharing program near to the railway in Copenhagen/Malmø area and made it easy for train passengers/commuters to get off the train and use the car sharing system the last mile.

The system has been running for 1year and above 120 users signed in. It will definitely be continued after the project end. The first customer feedback was very positive:

> *"damn fantastic with the technique.*
> *Then Up`en back and plugged in - Thanks for the ride"*

For further details and information on the executed demonstrations, please check the chapter 10 in deliverable D8.3 [7].

3.3.10 Start charging with smart phone

As part of the Green eMotion project, a user portal was developed and trialled. This user portal is a smart phone app that allows the user to authenticate himself and to start and stop a charging session. It is therefore a replacement of an RFID card, but with enhanced convenience for the customer.

The purpose of the trial was to assess a technology which is anticipated will add value to the EV driver by providing greater flexibility of control and additional, early information on charge point suitability and availability.

The portal was experienced by two users over an extended period. The configuration allowed the users access to the charge points which they would most regularly use, as well as charge points within their normal commute zone.

The flexibility of the Portal compared with an RFID card was noted by both users. One user noted that where a vehicle is driven to a Charge Point by one user and collected from the Charge Point by another user e.g. their spouse or partner, the portal allowed the termination of the charge event by the second person without the need for a shared device.

The EV User Portal, while set up primarily to start and stop charge events, also offers the opportunity to provide the EV user with other services, beyond those available through an RFID Card. These services will in time evolve, however initial suggestions such as roaming authentication and Charge Point reservation are definite opportunities. As roaming becomes more desirable with EV drivers, the obstacles caused by differing RFID configurations can be overcome through the use of smart phone or SMS format devices.

For further details and information on the executed demonstrations, please check the chapter 10 in deliverable D8.2 [6].

3.3.11 Simply plug and charge

In the DE1 region, Daimler vehicles (Smart ED2, Smart ED3, Daimler A-Class) contains a PLC technology with a specific protocol (SCCPS, PRE15118 and 15118). Those vehicles support smart charging functionality, which include automatic authorization and scheduled charging. Thus the user will be authenticated just by plugging in his car to the charging station. All necessary identification steps, even for roaming customers (if the relevant contract between the e-Mobility Service Providers is concluded) are performed automatically without any additional user interaction

The feedback and comments from people using this technology were very promising, as most people said, that it is a very convenient feature to know, that just plugging in the vehicle is all they need to perform for start charging.

This encourages RWE to continue promoting ISO/IEC 15118 technology for AC and DC charging, knowing that for a full scale solution certain questions and procedures regarding the management of certificates are still an open issue between actors in the market. This is due to the fact, that those certificates are the basis for rolling out ISO/IEC 15118 in a large scale. Therefore RWE recommends building up a common, European-wide certificate infrastructure on a shared cost- basis for the whole e-Mobility

For further details and information on the executed demonstrations, please check the chapter 5 in deliverable D8.3 [7].

3.3.12 Cable free charging

The Induction Charging demo case for Green eMotion sees the retrofit of induction charging coils in a Nissan Leaf as well as the installation of corresponding primary coil, power electronics and switchgear for the controlled charge of the vehicle. The prototype was designed by fka, Siemens, and Alstom.

Inductive charging was demonstrated at ESB's Head Office in Ireland. The location of the area was chosen to allow a controlled test space while providing an opportunity to allow visiting stakeholders to view the process and developments. As the vehicle was a modified version of the Nissan Leaf, a small group of 5 users were chosen to be suitably trained in the operation of the induction charging equipment.

In the trial period it could be shown that the inductive system is more user friendly compared to a cable bound (conductive) charging of the EV. In detail the advantages of the inductive system are:

- Tripping hazards are eliminated as the is no charging cable,
- Extra time outside the vehicle in possible inclement weather conditions is avoided,
- Wear and tear on the charging cable and connectors is reduced,
- There is no possibility of a charging cable being locked in a charge point or stolen

For further details and information on the executed demonstrations, please check the chapter 8 in deliverable D8.2 [6].

3.4 New Business models for electromobility

3.4.1 Introduction

The Green eMotion deliverable D9.4 “Envisaged EU mobility models, role of involved entities, and Cost Benefit Analysis” [8] analysis the business models for public charging infrastructure. The results lead to the conclusion that the business case of public charging as standalone business can only be profitable within such mid-term business scenario in case of highly frequented EVSEs. Hence, the chargers need to be located at points of interest, so that people are willing to pay for the usage and usage time is short enough to allow for several charging events per day. The upcoming second report on business model analysis (D9.4.-2) [8] will focus on infrastructure with selected features like location at point of interest or fast charging at highways. It will be analyzed which part of the public charging business might show a positive business case in the mid-term future, considering the whole stakeholders value chain.

Another option to improve the business case of public charging is the combination of different businesses as parking in a parking lot, e.g. in the city centre or to use the charging to attract people for other services like shopping, cinema, eat & drink etc.

Some business ideas were evaluated as part of the demonstration activities. These and also options for reduction of costs are described in this chapter.

3.4.2 Combined business “Park and Charge”

Future charging services will not only include home charging or charging at highways, but also charging at public or semi public places where a lot of customers park for a certain time, e.g. in parking lots or underground parking in city centres.

This service will not be limited to the general availability of chargers in underground parking but require the seamless integration of parking and charging services in terms of customer information, guidance, booking and billing.

As part of the Green eMotion Project a concept for bundling parking and charging offers was to be developed. Also, legal issues were addressed.

In the developed concept it is foreseen that Green eMotion partner SMATRICS customers will have the possibility to upgrade their charge package with a parking add-on which allows free parking for a certain amount of hours in parking garages for the purpose of charging. Commercial agreements therefore will be made between Smatrics and parking garage operator APCOA. This could include a long term rent of parking lots by SMATRICS which are equipped with charging infrastructure (Wallboxes with up to 22 kW output power). SMATRICS customers are free to use these parking lots while charging.

Also, concepts for technical solutions for joint access control were discussed between APCOA and SMATRICS. The concept includes access to the garages with Smatrics RFID cards, the record of timestamps and mutual reporting about duration of stay and charge data records.

The following conclusions can be drawn from the results in the demonstration case:

- **Integration**: Charge stations in parking lots and underground parking require the careful coordination of hitherto uncoordinated services; without the coordination the service level for customers is too low.
- **Technical challenges**: Several hurdles have to be overcome regarding the technical realization: Access control systems at the gates usually employs different technology than the current EV RFID cards; GSM network signal strength is low in lower levels; systems are not ready to be linked;

- **Business Integration**: On a commercial level it is not clear yet who will act as EVSE Operator and as Service Provider, i.e. who will have commercial control of the charge points and who will be responsible for billing customers.
- **Legal Framework**: Technical requirements targeted at legacy lead acid battery vehicles pose a serious barrier for deployment of chargers in underground parking.

For further details and information on the executed demonstrations, please check the chapter 13 in deliverable D8.3 [7].

3.4.3 Combined business "Charge and Leisure services"

An interesting business approach is the installation of (semi) public charging infrastructure in cooperation with service companies. The basic idea is that the customer will spend time with entertaining activities while his/her EV charges. This can be restaurants, shopping centres, petrol stations (with shops) and most of all supermarkets. By this the business of those companies is increased and a cross financing of the charging infrastructure would be possible.

SMATRICS has concluded framework agreements with several supermarket chain companies, whereof the one with most installed charge points is REWE. REWE runs 4 supermarket brands in Austria: BILLA, MERKUR MARKT, Penny and ADEG.

In the framework of the agreements, various responsibilities and liabilities are distributed between REWE and SMATRICS. The site owner maintains the parking lot (e.g. snow plowing) and marks the parking lots as reserved for EV users, whereas SMATRICS is responsible for the electrical equipment. Separate metering ensures that (i) 100 % energy from renewable resources is used and (ii) independent accounting for electricity is viable. A combination of REWE's customer loyalty programs and SMATRICS E-Mobility services will be implemented, e.g. 2 charge sessions per month for free for REWE customers. SMATRICS reports to REWE annually the cumulated charged energy on the various sites, average charge duration, average duration of stay (fair use) etc.

Main results from the cooperation at the 12 supermarket sites with modern SMATRICS charging stations and customer feedback to REWE:

- Charge stations were functional and available, which the legacy charge stations prior in use were not;
- Customer acceptance of the higher service quality was good, but the change to fees from the prior free service needed explanation;
- Access to the charge station was only possible with SMATRICS RFID card, with customers complaining about additional cards necessary;
- The higher power of the new charging stations lead to positive feedback and was welcomed by customers;
- Synergies between shopping and charging seem likely but cannot be confirmed based on the available data;
- Combined offers were not yet developed due to the small customer base.

Conclusions by REWE:

- Slow charging does not fit to supermarket business
- Accelerated or fast charging fits to the short stops at supermarkets
- Cable attached provides higher convenience than plugs;
- REWE will only install chargers on sites with enough parking available to avoid conflicts regarding the space left for shoppers.

REWE also formulated minimum requirements towards charging infrastructure for customer convenience:

- Accelerated or fast charging infrastructure
- Reliability
- Access control
- Roaming functionality

However, even without a clear positive business case this first electromobility experience was positive for REWE and they will continue their activities in this field.

For further details and information on the executed demonstrations, please check the chapter 12 in deliverable D8.3 [7].

3.4.4 Reduction of costs by PPP shared EVs

The original car sharing system on the island Bornholm (Denmark) was set up to ensure that municipalities, private companies and citizens (tourists) could share the same EV. The cars is locked during daytime, and can only be used by municipal- and company employees but after 4 pm Monday to Friday the cars are available for other citizens after working hours, same goes for weekends and on public holidays. The system has been up and running and tested at the island from 2013.

The task was to adapt and improve the system to Malmø in Sweden and in Copenhagen. That would allow people to travel from Bornholm / cross border to Copenhagen in EV's – and only pay for transport when it's used.

Unfortunately it was not possible to establish cooperation with a public Swedish agency/ municipality. Cars running in Sweden and used by a public Swedish agency/ municipality must be registered in Sweden. Our fleet is Danish. And the Municipality of Malmø had no funds to buy a new EV for this test.

The best and easiest way to continue the project was to take over activities from a Norwegian company placed in Denmark. Since 2009 they had offered public car sharing in Copenhagen. This company has subsidiaries in Sweden. By this cooperation we can offer our solution in Malmö / Sweden and ensured that customers in Denmark also have access to book cars in Sweden.

For further details and information on the executed demonstrations, please check the chapter 9 in deliverable D8.3 [7].

3.4.5 Reduction of costs by lean software

The main purpose of the EVSE Network Infrastructure Portal is to provide small EVSE operators with access to a management console for their own charging network. Alternatively, it may be used as a mechanism to facilitate the delivery of a country and / or continent wide network as a service offering. The envisioned business model is for the portal developer to sell it via the Green eMotion Marketplace to EVSE operators, or for it to be purchased by national charging network providers who may subsequently offer it to small EVSE Operators.

A series of screenshots from the portal are shown in the following scenario. The eCars staff member logs into the Network Portal account when arriving in the office in the morning The homepage appears displaying an overview of the ESB eCars network, where the staff member can quickly view energy and financial information for the past 24h period, as well as make a quick search for malfunctioning chargers on the map.

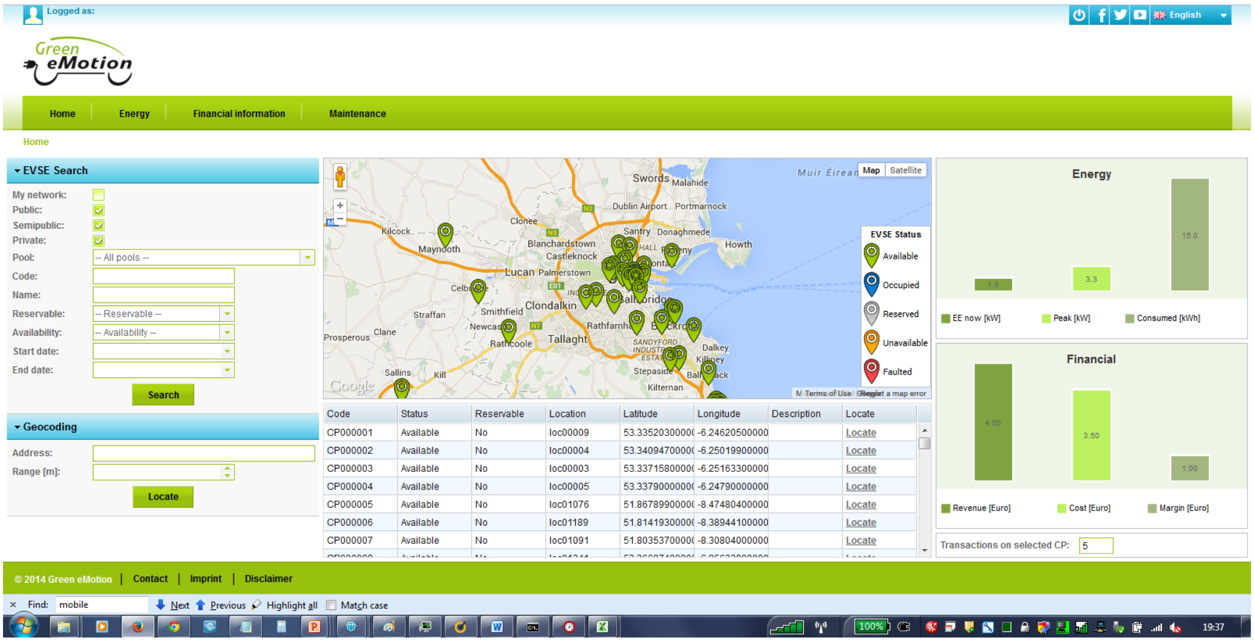

Figure 3.7: Home screen of the Network Operator Portal

The Network Portal designed and co-developed by Green eMotion provides a convenient mechanism for efficiently monitoring, managing and maintaining a charging network of any size.

For further details and information on the executed demonstrations, please check the chapter 12 in deliverable D8.2 [6].

4 Conclusion

4.1 Interoperability

Improvement of interoperability, especially for public charging, was one of the main objectives of Green eMotion. Therefore the project partners analyzed carefully the existing systems we already had in Europe and came up with a system architecture that would allow European wide, convenient usage of public charging infrastructure.

The core of this solution is an IT backbone, the marketplace, which connects all necessary business partners. Together with the so called Clearing House this system allows roaming between all partners, meaning that EV drivers can use public charging infrastructure independent from whom it owns or operates. The goal is a situation comparable with that in the mobile phone market where also the customer can use his mobile phone everywhere.

A limitation to this solution is the fact that both, the charging infrastructure operator and the service provider, having the contract with the EV driver, need to be connected to the same roaming system. However, if those business partners are connected to any roaming platform, this can also be achieved by connecting the existing roaming platforms.

In the Green eMotion demonstrations all demo regions were connected to the marketplace and the feasibility of this solution, especially for roaming between all the demo regions, was successfully demonstrated. Learning from this real life tests was that the usage of RFID cards for authentication of the EV driver has many obstacles. Due to different sub standards used in Europe the interoperability is limited and in general the usage of the UID of the RFID card is not a good solution as it is no unique identifier.

Therefore Green eMotion has defined the contract identifier (EVCOID) which fits the needs for roaming much better. It is easy to derive the correct EVSP from the EVCOID in order to identify the correct business partner. Together with eMI3 a standard for usage of the EVCOID for contactless authentication is on the way [13] [14] http://emi3group.com/.

Roaming is a basic step for interoperability, but we also need to develop a system which improves the convenience for the EV driver. Therefore Green eMotion partners developed the service “Search”. This service collects geographical and technical data about the public charging infrastructure that is connected to the marketplace. These data was then used by a web site (http://evse.greenemotion-project.eu/search.html) and by a mobile phone application to enable the EV driver to search for chargers that suit his needs regarding travel distance and compatibility with his EV. In the specific case of Malmö and Ireland this data link was dynamic so that also the actual status/availability of the charger could be shown. From Irish users we received the feedback that the inclusion of real time data is highly appreciated.

However, the app developed within Green eMotion could not only be used for the search of public chargers, but also for the authentication itself. That means with his EVCO-ID the EV driver is able to start a charging process at the chargers connected to the marketplace. In this way the issue of different sub standards for reading an RFID card could be overcome. Especially for the customers of the electromobility service provider Greenabout this was an important feature as Greenabout infrastructure does not require RFID cards and the EV drivers therefore don’t have those. With the Green eMotion app they were able to use the public chargers of the City of Malmö in a very convenient way.

Establishing standards is the most important measure for interoperability. Beside the definition of several identifiers needed for unambiguous identification of the electromobility players, Green eMotion has also worked on standardized interfaces. In Austria we face the situation that chargers of different manufacturers need to be connected to the same charge management software (CMS) of the operator Verbund. Due to several proprietary interface protocols of the chargers it was complex and costly to connect all chargers to one CMS. In cooperation with eMI3 a standard for the interface between charger and CMS is under development, see also D7.8 [12] and public summary of D7.9.

4.2 Grid integration – technical approaches

The power quality impact of charging infrastructure was studied under real life and lab conditions. These measurements revealed no issues in the concerned low voltage grids. However, with lab tests it could be shown that a buffer battery would compensate for reactive power and though stabilize power quality if necessary.

A reduction of energy costs can be achieved by optimization of energy demand over time if different tariffs are in force. For the headquarters of Iberdrola in Valencia it could be shown that by considering the Spanish DH3-supervalle tariff savings of almost 40% were possible. That means that such a tariff structure might be an important measure to motivate customers to adapt their charging behaviour to the grid conditions.

Smart grid management schemes are useful for the optimization of integration of renewable energy sources (RES). By controlling the charging process and shifting it to certain time slots, the usage of renewable energy, e.g. from photovoltaic, can be optimized. However, this is limited by the mobility needs of the EV driver. To ensure customer satisfaction, the system might use an energy buffer to compensate time offsets between production of energy and the demand. In the easiest case that will be accomplished by the grid itself meaning that the grid tie must be able to deliver the maximum requested power. Another option is the usage of a buffer battery. In that way the grid tie can be much weaker and depending on the local grid that might save a lot of costs for grid reinforcement. A lab simulation showed the potential of this solution. Yet, a real life demonstration in Malaga also revealed the issues evolving from the installation of a medium sized Li-Ion battery. The regulatory situation is complicated and requires a long legalization process.

Another and cheaper option for controlling the power demand from the grid resulting from EV charging is load management. On a local level it can be used to reduce the necessary grid tie capacity and therefore save grid reinforcement cost. The load management demonstrated in Malaga showed that under consideration of customer needs and by applying different customer profiles like “Gold” or “Basic” the maximum requested energy could be limited to a preset value.

But load management can also be used for the optimized integration of RES on a broader level. By aggregating and controlling the power demand for so called “load areas” the DSO is able to control the power demand from his distribution network. With a high number of EVs connected to the grid this might become in important feature to prevent curtailment of RES or the need to activate reserve power production. However, the results of simulation performed for the demo regions Italy and Greece brought out that with the communication and control possibilities that is most common at the moment a real power balancing is not possible. Due to the limitations of the EV interface – using PWM signalling based on 61851 - it cannot be guaranteed that the EVs really draw a certain amount of energy per time interval. Only with communication capabilities as with the EV interface protocol ISO/IEC 15118 it will be possible to negotiate so called charge plans between the EV and the infrastructure. Once the implementation of ISO/IEC 15118 communication is available at the majority of EVs and EVSEs load management can bring even more benefit to the grid integration.

An option to avoid grid reinforcement costs for the low voltage grid is a power management for distribution networks (Soft Open Point). The SOP has the potential to balance load across adjacent feeders and control local system voltages. The SOP has cost saving implications for utilities and represents a much more efficient use of the existing network.

4.3 Consumer acceptance

A first step to consumer acceptance is the awareness of the advantages of electromobility by the public and also by the local policymakers. In Greece 15 chargers were installed in Kozani and Athens; EVs were acquired. Electromobility was a totally new experience in those cities and especially local authorities were invited to use the EVs. This direct experience will motivate the policy makers to support necessary actions for the further electromobility roll-out.

But also citizens should have the possibility to use EVs and learn more about their features. In the Basques Country and in Madrid electric bus services were established. Hence people come to know firsthand how environmental friendly and quiet electric buses are. Unfortunately learning was that some of the first generation vehicles suffer from technical problems.

Beside public transport, also the implementation of EV sharing is a good measure for giving more people the possibility to use an EV without the need to directly buy one. In the rural area of Ataun, located in the Basques Country, an eCar sharing service was established. 5 EVs were made available with a dedicated location in the city centre. Most of the observed time, the usage of the EVs was around 150 per month meaning one trip per EV per day. For a rural area, where the driven distances are usually higher, this is quite a good number and shows the good acceptance of the citizens even in smaller towns.

Another prerequisite for consumer acceptance is the availability of sufficient charging infrastructure. Most of the EV drivers prefer to charge their EV at home if and whenever possible. Therefore it is very important to support the installation of home chargers if feasible. EV ready buildings are a good way to ensure that new buildings are prepared for a later installation of chargers at low costs. The partner Verbund started a dialogue with the Austrian federal authority OIB on respective guidelines.

Even with the possibility for home charging commuters will use public chargers for their travel purposes. In the demo region Austria two new fast chargers were installed on typical commuting routes to Vienna. The increased use of the fast charger in the evening hours indicates that these commuters have an opportunity for home charging not needing to charge on their way from home to work. Yet they use the chargers in the evening on their way home implying they have no possibility to charge at work. A recharge at the fast charger on the route may then be necessary if either the commuting distance is high or the EV is planned to be used for another evening trip. At some locations in Europe the demand for fast charging has increased in the last months so that queuing occurs at single locations. In the city of Dublin a multi standard fast charger was installed next to an already existing multi standard fast charger to reduce queuing.

The bare existence of enough public chargers might not be sufficient. The user must also be able to find and use those chargers even across borders. The necessity for interoperability covering also the search of public chargers and roaming was already highlighted in chapter 4.1. A specific cross-border demonstration was done between the Republic of Ireland (ROI) and Northern Ireland (NI). EV drivers could use the same RFID card for charging on both sides of the border. Such experience will help to reduce the range anxiety we observe at the moment.

Consumers will be more prone to accept electromobility if convenience is comparable or even better then with using ICE vehicles. To motivate commuters to use eCar sharing for the last mile, an EV for sharing was deposited at a train station near Copenhagen/Malmö area. For easy access the EV was equipped with a reader that accepts the travel card people use to authenticate for the public transport anyway. Therefore it is one card for all permitting a seamless perception of mobility.

In public transport we see generally the trend to switch from payment by cards of any type to mobile phone applications. Such an app was developed and tested in several demo regions. One prototype was tested with users of partner Greenabout giving them the possibility to use the infrastructure of Malmö without RFID card. Another prototype, the so called user portal, was trialled in Ireland. Feedback from test users indicates a good usability with several advantages compared to physical means like a RFID card. An option with no authentication by the user but rather by the EV was tested with the so called “plug&charge” system. In the demo region Berlin, EVs and charging stations were equipped in a way that, simply by plugging them in, the authentication will automatically been done. EV drivers gave very positive feedback and this might be the most convenient way of starting a charging process.

After authentication to get access to the charging infrastructure, the process of charging itself needs to be handled. The most common way is to either draw a cable from the trunk or in case of DC fast charging to plug in the cable coming with the charger. In both cases the user needs to handle a more or less heavy cable which also might be dirty from prior usage. An alternative is the wireless inductive charging. By positioning the EV above a dedicated spot on the ground the EV can be charged without physical connection to the charger. The advantages for the EV driver are obvious. A limitation of this technology is the maximum power that can be transmitted with the actual technology.

4.4 New Business models for electromobility

A possibility to improve the business case for public charging infrastructure is the combination with other services, e.g. shopping. The idea is that the option for charging increases the attractiveness of the basic service. In case of shopping that means that more people would visit the shop or buy more while charging.

As part of the Green eMotion demonstration chargers were installed at the parking facilities of 12 REWE sites. The chargers were operated by SMATRICS and also the charging service was provided by SMATRICS. A detailed agreement between REWE and SMATRICS about the liabilities was concluded.

The result of this demonstration was that customers indeed appreciate to have the opportunity for charging during shopping. The requirement is fast charging as the shopping duration is not suitable for slow charging. Based on the available data it cannot be evaluated if the basic business of shopping was really supported by the charging service. However, REWE will continue its engagement in electromobility. A combination of REWE customer loyalty programs and the SMATRICS charging service offer might enhance the positive effect of combined business.

Another opportunity for combined business, also evaluated by SMATRICS, is the charging service in parking lots. People are used to pay for parking in city centre located facilities, so that might be a good starting point for making real business also with charging services. Within Green eMotion a concept for bundling parking and charging offer was elaborated.

A main still open point in this concept is the question who will act in which role. The parking lot is in general operated by a company that also sells the parking service. Additionally we have the roles of the EVSE operator and of the service provider. The latter sells per definition the charging service to the end customer, the EV driver. Different approaches were discussed whereas both services might be offered by one company including the operation or not. It can be concluded that the combination of such services is complex and needs a careful coordination to ensure customer convenience especially in access control and billing.

An option for improvement of the business case for eCar sharing is the reduction of costs. Therefore the partner Greenabout thought about enlarging their public private partnership they already have on the island of Bornholm. In this set-up, municipalities, private companies and citizens (tourists) can share the same EV. During daytime it is used by the municipality, but after office hours the EV is available for private use by citizens. The system has been up and running and tested at the island from 2013 on. Unfortunately this could not be replicated with the city of Malmö due to organizational reasons. However, the idea to save costs by reusing EVs, that are otherwise unused half of the time, is promising.

Beside the costs for EVs, also costs for the operation of public charging infrastructure should be minimized whenever possible. The costs for the hardware itself have already dropped and it can be expected that while chargers become a mass product the prices will decrease further. But also the operation, meaning control and maintenance, should be reduced. On the software side this can be achieved by sharing of a charge management systems in the form of software as a service. Within Green eMotion IBM developed the “Network Infrastructure Portal” (NOP) which can be offered via the marketplace. Therefore the operator has not to develop or buy his own charge management software but can take this offer from the marketplace and pay only for the service he really uses. The functionality of the NOP was tested with the ESB charging infrastructure in Ireland. It provides a convenient mechanism for efficiently monitoring, managing and maintaining a charging network of any size.

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