The Green Mobility Grid of the SmartCity

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Abstract. This paper aims to present an innovative grid service for SmartCity addressed to the mobility because of goals and solutions from FP7-SMARTV2G and FP7-MOBINCITY. The communications between charge stations-FEV-operators, the forecast of energy grid, the expected demand of loads and how to integrate this future mobility models into the SmartCity are mainly aspects covered in this paper.

1 Introduction

In most OECD countries the transportation and electric power systems contribute to the majority of CO2 emissions [1] and most of the fossil fuels (coal, natural gas and oil) which are used for transportation and to produce electricity have to be imported. By shifting currently non-electric loads to the grid, electric vehicles might play a crucial role in the integration of these critical elements of the whole energy system: power generation and transportation. But currently, the number of fully electric vehicles (FEV) is quite low. Also the public charging infrastructure for electric vehicles (EV) is very limited or non-existent in most cities, though a few cities have already installed significant infrastructure as part of pilot projects and other programs. So today, smart charging infrastructure for EVs seems to be a nice to have solution for the far future. But in fact problems with non-smart charging infrastructure may occur faster than expected. In order to improve the situation of electromobility, some governments are putting into practice politician strategies that promote the FEVs use. So Tesla became in 2013 the best-selling car in Norway even ahead of VW Golf. Also other EV manufacturers are facing a surprisingly high demand. E.g. BMW expects to sell 26.000 of its model i3 in 2014. For this growing stock of EV public charging infrastructure in shopping centers, working areas, public parking, etc. will be needed. But only installing enough public charging stations is not the solution. In this case, having at a major event like a football game with only 100 FEVs (less than 1% of all parked vehicles) will cause big grid problems. Public charging of an average FEV has an electric power consumption of about 10 kW, so 100 FEVs would cause a peek power demand of 1 MW at the same time and same grid segment. This is twice as much as the energy consumption of the floodlight of a big football stadium. Grid overload up to a breakdown might be the result. But also insufficient communication between EV and charging infrastructure is a problem of today. Nothing is as annoying

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as waiting hours for recharging an FEV only to find that the battery is still empty because the charging process has been cancelled at the very beginning. Also many present FEV drivers have no real access to most of the public charging stations because of missing roaming between different charging station operators (CSO), energy suppliers and countries. On the other hand there are also still unresolved issues of electromobility like short driving range, long recharging duration and the question how to find a suitable and free charging station. So there is an actual need not only for a smart charging infrastructure but also for a smart mobility enhancement solution for EVs. The EU funded FP7 projects Smart Vehicle to Grid Interface (SMARTV2G) and Smart Mobility in Smart City (MOBINCITY) are two matching solutions in order to meet these challenges.

2 SMARTV2G

The Smart Vehicle to Grid Interface project (SMARTV2G), funded by the European Commission within the FP7 Program, was designed to solve future deployment of charge stations in SmartCity regarding expected EV demand.

In that sense, the main objective targeted by the SMARTV2G Project aims at connecting the electric vehicle to the grid by enabling controlled flow of energy and power through safe, secure, energy efficient and convenient transfer of electricity and data. A Control Centre (the main intelligence of the smart charging infrastructure lies in the higher control level) provides commands and load schedules to the charging stations and EVs. Therefore, they only play the executive role in the whole network and energy management process by adapting the charging load according to the instructions given by the Control Center. The SMARTV2G Control Centre has to intelligently manage the energy demands received from the different charging stations through the day, based on the reservations made. It is able to communicate with all involved parties in order to supervise electrical levels and power quality, and to buy the energy needed for charging

SMARTV2G comprises features like EV load forecasting, estimation of vehicle to grid availability and an optimal management of charging stations according to Demand Side Management (DSM) based on charging user preferences. Furthermore, the system offers several services to the EV users like charging station booking, EV autonomy prediction, charging station finder and route planning.

SMARTV2G offers AC Smart Charging Stations as well as Fast DC Charging Stations. Both types of charging stations are based on the new IEC 15118-communication standard defining the communication between EV and charging station that helps to provide all the described new operational modes and services.

The project Consortium is comprised of a well-balanced group of seven partners (Electrical Technology Institute, Fraunhofer ESK, Etrel Svetovanje in Druge Storitve, CIT Development & Consulting, Sapienza University of Rome, Technomar and Elektro Ljubljana Podjete Za Distribucijo Elektricne Energije) from four European countries (Spain, Germany, Italy and Slovenia) with complementary skills and expertise, including all the necessary profiles to deal with the scheduled project work plan.

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Furthermore, key industrial companies in the field of electro-mobility have shown their interest and commitment to the project.

3 MOBINCITY

The MOBINCITY project, founded by European Commission within the FP7 Program, aims the optimization of FEV autonomy range and the increase in energy efficiency thanks to the development of a complete ICT-based integrated system able to interact between driver, vehicle and transport and energy infrastructures. This innovative solution will take advantage of the information provided from these sources in order to optimize both energy charging and discharging processes (trip planning and routing).

In that sense, there have been identified four main objectives. (1) Develop a system to be installed within the vehicle able to receive information from the surrounding environment, which can have influence in the vehicle performance (traffic information, weather and road conditions and energy grid). (2) Optimization of the trip planning and routing of FEV using information from these external sources including alternatives from other transport modes adapted to user's needs. (3) Definition of an efficient and optimum charging strategy (including routing) adapted to user and FEV needs and grid conditions. Moreover, MOBINCITY will (4) implement additional energy saving methods (as driving modes and In-Car Energy Management Services) within the FEV interaction with the driver.

The project Consortium is comprised of 13 partners (Energy Technology Institute, Fraunhofer Institute for Communication Systems, Electronic Trafic, Energy Institute Hrvoje Požar, Enel Distribuzione, CIT Development & Consulting, Elektro Ljubljana Podjete Za Distribucijo Elektricne Energije, Hrvastki Telekom, Technomar, Oprema Ravne, Etrel Svetovanje in Druge Storitve, Consortium for Research in Automation and Telecommunication and Zabala Innovation Consulting) from 5 different countries (Spain, Germany, Slovenia, Italy and Croatia), covering relevant sectors as traffic management, energy, ICT and telecommunications and automotive industry.

4 Interlinking Between SMARTV2G and MOBINCITY

Interaction with energy infrastructure, which refers to the integration of Fully Electric Vehicles in electricity grids. Main solutions are related with the correct management and monitoring of electricity consumption by means of smart meters and smart grids deployment. Smart Grids are characterized by a more efficient distribution and generation systems allowing individual energy consumers adapt their needs depending on the situation of the grid and generation in each moment.

The Demand Side Management (DSM) achieved by SMARTV2G provides algorithms of charging infrastructure control allowing better exploitation of FEV charging capabilities by the power network operators.

On the other hand, the communication between control center and Electric Vehicle Supply Equipment (EVSE) is another feature, which SMARTV2G and MOBINCITY share together.

The mainly current energy standards apply in both projects are (1) based on the new ISO standard of Vehicle to grid communication interface [2] defining the communication between FEV and charging station that helps to provide all the described new operational modes/services, and (2) on the grid side, the safety function for power management defined by the IEC 61851 standard - Electric vehicle conductive charging system [3], which harmonizes plugs and charging modes for EVs.

The mainly current communication standards apply in both projects are the ITS-G5 and GeoNetworking standards (which both issued by ETSI to specify the wireless communication among Intelligent Transport Systems (ITS)) [4] the Intelligent Transport Systems (ITS); Infrastructure to Vehicle Communication; Electric Vehicle Charging Spot Notification Specification [5] and the Communication system for the planning and reservation of EV energy supply using wireless networks [6] in order to enhancement the Vehicle to infrastructure communication (V2I).

5 Architecture of SMARTV2G Project

The architecture of SMARTV2G is based on a cloud solution, which enables the interaction between EVs, charge station grid and users. Several interfaces have been achieved in order to allow the data flowing between these actors. The DashBoard-control center implemented enables operators (such as energy suppliers and business operator) real time and forecast behavior of the electro mobility grid. Moreover, several proactive functionalities are allowed due to the communications protocols established between Smart Charge Stations and this central server. A native APP for Smartphones allows EV users and owners to order a load-charge of his EV (as mainly functionality), real time level of battery, estimated autonomy of EV and availability of sockets to load it.

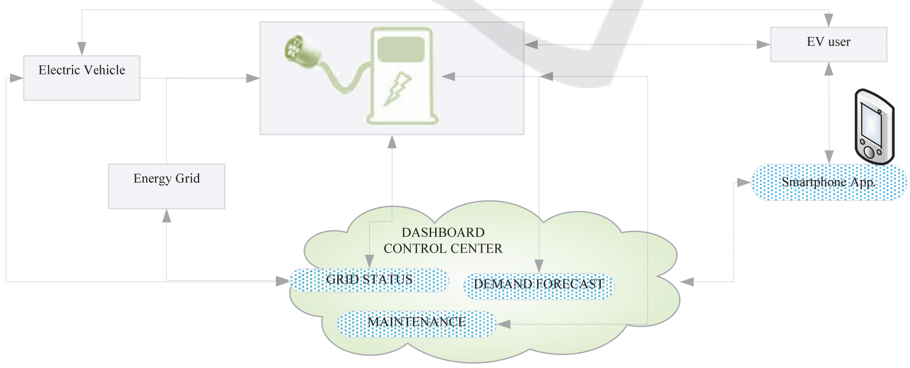

Fig. 1. The SMARTV2G architecture based on a cloud control center. This shows all actors involved in the project.

6 Architecture of MOBINCITY Project

Mobility actors, acting as information providers, are involved in the overall architecture of MOBINCITY. The Smart Transport Middleware (STM) is a software based on a standard approach which allows correct optimization from related information gathered. The Proactive Intelligent Information Service (PIIS) is a software designed to request for available and the most suitable mobility options on route. Additionally, it is considered the re-routing functionality. Onboard solutions, including integration with EV(s) are also involved in MOBINCITY architecture. Moreover, grid agents are integrated based on a bidirectional communication model with our mobility information acquisition and mining.

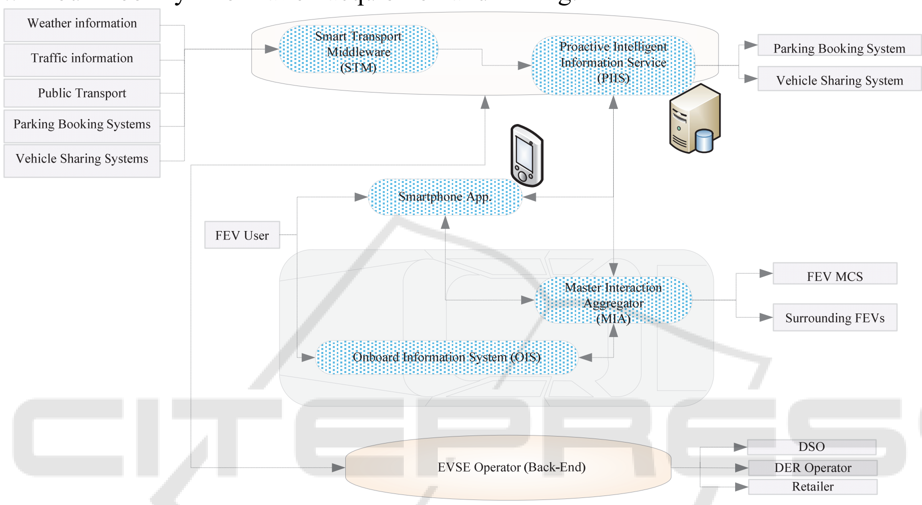

Fig. 2. The complex architecture of the MOBINCITY project aims to involve all mobility actors. This scheme shows several subsystems shall be implemented in along the project duration.

7 Actual State of SMARTV2G Project

According with the work plan, there have been successfully achieved all individual goals distributed along duration of SMARTV2G project. At beginning of this last year, there has been implemented a laboratory test in order to integrate each subsystems through three use cases.

As a result of this integration test, there has been successfully tested capacity to manage load profile and power during load process (at charge stations), control strategy, EV load forecasting tool, vehicle to grid availability tool and FEV monitoring (at Control Center), usability of charging stations finder, load booking and autonomy estimation tools (at System Interface APP).

The SmartV2G final field test is mainly sited in Ljubljana through integration with Charging Station Web Portal of Elektro Ljubljana enabling current users a set of homologous features with the System Interface solution. V2G Control Centre has

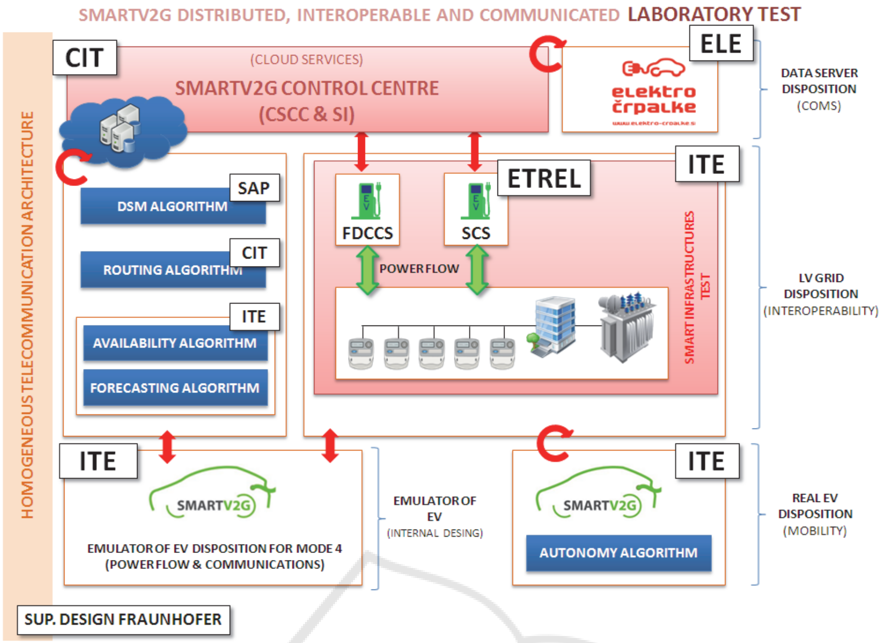

Fig. 3. the planning model of laboratory test achieved in where all subsystems of SMARTV2G have been tested and validated in a common scenario.

been installed within the Elektro Ljubljana intranet in order to allow V2G Load area operator to (1) collect and store the data of by receiving information about the performed charging sessions from several charging stations, (2) remotely management of the charging station within the same Load Area, (3) creation of new charging stations within the system, using a guideline to create them, (4) manage of charging station maintenance. Firstly, managing the maintenance of each charging station, selecting time, duration, frequency, etc. Secondly, the capacity of apply a corrective maintenance if something goes wrong in one of those charging stations, (5) fitted with an innovative module based on a Demand Side Management algorithm which allows the local area operator of make a simulation for this day load profile taking into account the already saved reserves for each charging station inside the local area and (6) visualization of several interactive charts (representing the output of several developed algorithms) are provided to the local area operator, which contains relevant information about the current grid status and some prediction about charge availability, load forecast, etc.

8 Actual State of MOBINCITY Project

During the initial phase of MOBINCITY project there have been designed and developed STM, PIIS and the integration with Electric Vehicle System Equipment. This electro-mobility system provides a collection of live traffic information, periodically, the system server queries traffic information to some traffic detectors. From these detectors, the MOBINCITY software receives road information including occupation, speed, intensity, composition of light and heavy vehicles, measured length of vehicles and average distance between vehicles. Moreover, it collects weather information, relative humidity, temperature, wind speed, wind direction, pressure, solar radiation and rain and ice conditions, which can have effect on the road conditions and, consequently, on the electric vehicle performance (speed, energy consumption and other useful variables). Furthermore, charging station-parking information becomes into an input of MOBINCITY system including the distance between the car and the station or the duration of the trip between the car and the station. This provides to users the necessary information to avoid traffic congestions and use the most convenient route, taking into account traffic, road and weather conditions.

This route planning algorithm is an optimization algorithm providing service to MOBINCITY users as a navigation support tool taking into account all the FEV mobility specifics and constraints, as well as the FEV user - the mobile citizen preferences regarding other modes of transport and driving preferences.

On the other hand, there has been working on the adaptation of charging infrastructure management (development of the Electric Vehicle Supply Equipment (EVSE) and its operation) to FEV user needs without deterioration of grid operation and with maximum possible benefit for the FEV user as well as for the Electric Vehicle Supply Equipment Operators (EVSEO) and the grid agents (Distribution System Operators (DSO), Retailers and DER Operators).

Following activities will deal with the integration of all communication systems through the Master Interaction Aggregator (MIA) get information from the slave aggregators, process it with the algorithms developed and find the best-optimized routes. Moreover, the MIA will be integrated in a real FEV, connecting this information unit to other systems of the car. The main connections with the Main Control System of the FEV (MCS) will be with the battery management system (BMS) and the in-wheel drive controller. By the time connections and interfaces will be established, in order to validate the system in nearly real conditions, before testing in real city environments, next activities will be developed an (1) integration of the new information system EV on board and test, (2) establish communication with EV-Information Network (EVIN), (3) test of the stability and availability of links in various telecommunications networks and (4) testing in pilot facilities.

9 Future Outlook and Conclusion

Despite the great progress that has been made in the two FP7 funded projects, SMARTV2G and MOBINCITY, there is still a long way to a European wide smart charging infrastructure as well as for a smart mobility enhancement solution for EVs. So even after the successful completion of the two projects there is still big demand for further development in order to bring them to market maturity. Many of the used standards are still under development moreover they must also prevail on the vehicle side. Financing and business models for the development and operation of the infrastructure have to be established as well as the charging and roaming agreements between all kind of operators and involved countries. Nevertheless, now is the right time to establish a standardised European wide smart charging infrastructure and related smart mobility enhancement solutions, because they have to be in place when the EV will become a mass market product.

Abbreviations

BMS	Battery Management System
CSO	Charging Station Operators
DER	Distributed Energy Resources
DSM	Demand Side Management
DSO	Distribution System Operators
EV	Electric Vehicle
EVIN	EV-Information Network
EVSE	Electric Vehicle Supply Equipment
EVSEO	Electric Vehicle Supply Equipment Operators
FEV	Fully Electric Vehicle
ITS	Intelligent Transport Systems
MCS	Main Control System of the FEV
MIA	Master Interaction Aggregator
MOBINCITY	Smart Mobility in Smart City
PIIS	Proactive Intelligent Information Service
SMARTV2G	Smart Vehicle to Grid Interface
STM	Smart Transport Middleware
V2G	Vehicle to Grid
V2I	Vehicle to Infrastructure

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