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EVIC
(Electric Vehicle Intelligent Charging)

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Abstract

The reduction of greenhouse gas global emissions, the increasing cost of carbon-based fuels, expected demand growth in the upcoming years, highlight the need of efficient and environmentally sustainable vehicular technologies that do not generate CO2 emissions. Within this context, the Electric Vehicle constitutes the most promising alternative to conventional automobiles. However, one of the main challenges faced in the European Union is the development of a framework for the successful integration of large volumes of EVs into electrical power systems. Currently, a few sparsely distributed charging stations give service to a reduced number of EVs in those areas where the EV has initiated its introduction. Yet, as the number of EVs driving around rises smart demand management systems are required in order to avoid power allocation failures and to optimize the electricity flow across the grid.

Additionally, there are other challenges in order to achieve such a smooth integration of the EV. In this sense, the introduction of new business models in the European electricity grid ecosystem is of paramount importance. Likewise, end-user acceptance of an electric based car technology represents an ultimate barrier for a widespread deployment of the EV (range anxiety). It´s then necessary to define added-value services to enhance the EV driving experience and to support the mobility needs of its users. To that end, one must consider the knowledge of the real-time location of the EV user as a key requirement not only for the provision of added value location-based services but also for the development of new functionalities needed by the electricity grid operators and Electric Vehicle Aggregators such as smart real-time demand management and demand load prediction, amongst others.

EVIC shall consider EV processes as originally defined by other reference European projects on this subject, and build additional services on these processes using GNSS-enabled enhancements. The project will demonstrate it in different operational contexts with close interaction with fleet managers by a wide variety of communications-related applications intended to increase travel safety, minimize environmental impact, improve traffic management and maximize the benefits of transportation for both commercial users and the general public.

Keywords— *Sustainability, infrastructure, charging, energy management, electric vehicle*

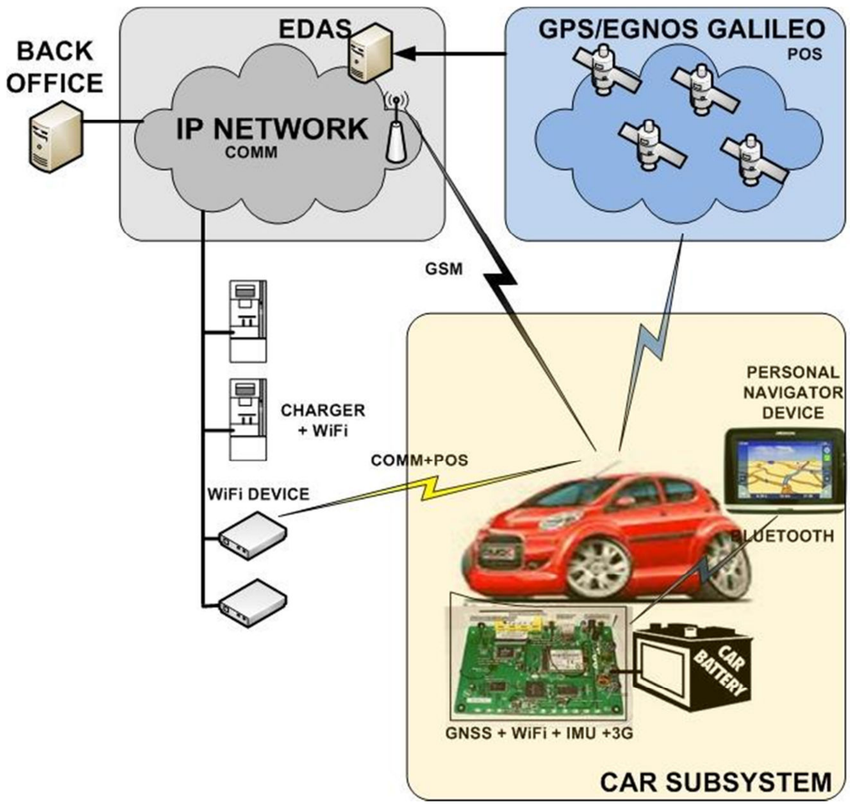
1. Introduction

The current small penetration of EV has very little impact on the electricity demand from the grid, but as EV penetration increases this impact will become noticeable. This impact could be managed in two different ways: by reinforcing the grid infrastructure (expensive and inefficient) or by implementing demand management methods.
EVIC aims to answer one of the major utility companies/operators needs in the frame of EV market introduction: the control of the electric grid loading through energy demand management. To achieve that, EVIC will enable the knowledge of the geographical distribution of EVs and their updated power needs. The focus of the project will be the development of location-based added-value services for different operational scenarios, which increase EV attractiveness and user acceptance to release position and battery status information to EVAs and utilities.
In order to achieve this objective EVIC project set the following sub-objectives:

- To analyze EV market and value chain in order to identify user needs and Business Cases.
- To collect end-user requirements in different operational scenarios and types of EV Fleets.
- To develop a system prototype based on the implementation of an on-board unit providing EV positioning and updated battery status and an energy demand management application.
- To develop and demonstrate added-value services for the end user (navigation to the closest/cheapest or fastest charging point and messaging, find-my-vehicle and stolen vehicle detection and tracking), which would increase user acceptance of EV.
- Ensure user privacy.
- To validate the overall system prototype through an in-field trial performed in LIVE, a Living Lab located in Barcelona, and other existing pilots.
- To link the project results with ITS and Smart Grid community by sharing EVIC technical results and conclusions.
- To elaborate a business plan addressing EV market forecasts and standardization and regulation evolution and analyzing main drivers and barriers for market adoption.

2. System Architecture

The overall system architecture is shown in the figure below:



The main following components have been identified in the EVIC system that will be developed:

1. Electric Vehicle:

    - Vehicle battery (together with a battery status reporting system)

    - On-board Unit (OBU): consisting on a platform integrating sensors for positioning (GNSS receiver + IMU), WiFi/WAVE wireless communications and interface with the battery. Connected to CAN bus for obtaining basic vehicle data. It also incorporates the wireless telephony modem capable of communicating all acquired data to the cloud. Localization Unit is one of the main blocks of the On-board Unit that will be embedded in the electric vehicle. It will be designed so it can calculate the geographical location of the vehicle at any point, both indoor and outdoor. Outdoor positioning will be carried out through a standard low cost GPS receiver. As to the indoor positioning functionalities, the OBU will process signals from neighbouring local wireless networks (i.e., WLAN) to estimate the position of the vehicle when GPS satellites are not available (or reliable). Different Wi-Fi positioning techniques will be tested in order to figure out what is the technique that best fits the user requirements stated in the earlier phases of the project. Finally, GPS and Wi-Fi signals will be combined (hybridized) in order to provide a robust and ubiquitous position data to the user as well as the back-office at any time.

2. Terrestrial Communications Infrastructure: based on WiFi/WAVE Road-side Units, which might be deployed on charging stations or independently on any location in the city (including indoor parkings)

3. Energy Demand Management System, which:

    - Can process the positioning information and the charging level sent by large fleets of EVs.

    - Does an efficient leverage of electric power and distributes it depending on the needs of the users at any time. The system managed by a fleet operator will have to try to make most of recharges when electricity is cheaper, no matter the time of the day when that happens. Moreover, the manager will have to take into account the restrictions on the EV battery state, its positioning, and the localization of the closer charging point.

    - Gets mobility patrons from users to elaborate predictions on demand in the short term which allow advancing unexpected peaks or surpluses of energy. This information will be useful by the EV Aggregator because it allows having a better knowledge of consumer habits and thus, allowing the elaboration of personalized contracts. But also, it will help to prevent unexpected demand peaks and it will help EV Aggregator to assign charging points and energy flows under certain prioritization criteria (emergency management, or VIP access to fast charge spots to name some). This will require a permanent communication link between vehicles and control centre which sends bidirectional information towards and from the vehicle. Furthermore, it will be necessary to use smart algorithms to aggregate the data received by all EVs and to extract mathematical models which allow to optimize user recharges depending on their current or future situation.

    - Influences on users demand by tariffs and geographic variability.

4. GNSS infrastructure (GPS, EGNOS, Galileo)

2.1.Component description

2.1.1. On Board Unit (OBU).

This component is the piece in charge of several functions:

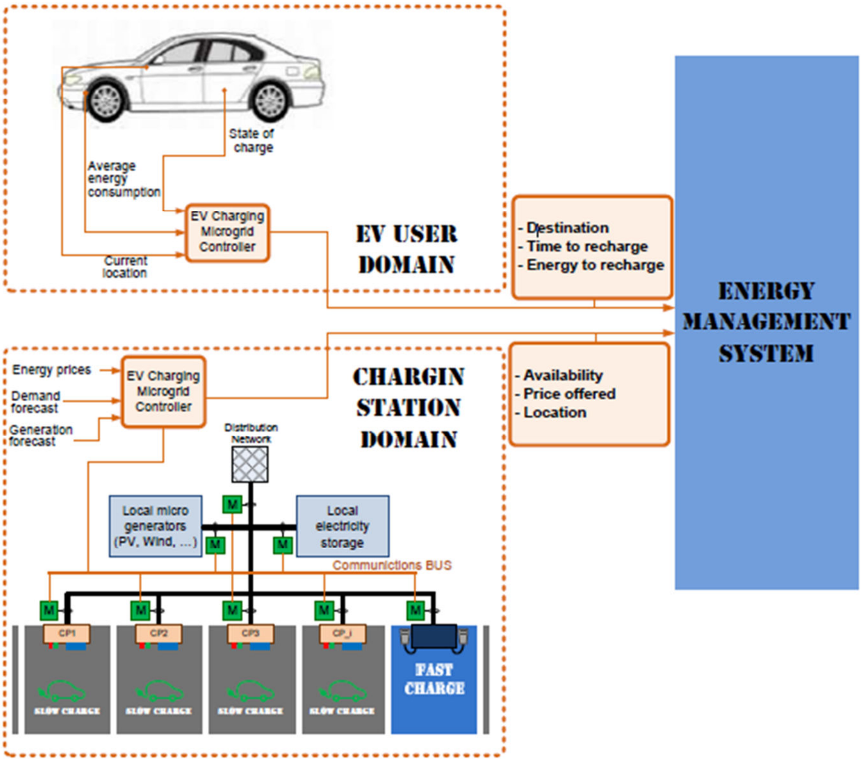
- GNSS receiver
- WiFi transceiver
- Telephony 2G-3G modem
- Processor
- CAN bus interface

The GNSS receiver is the module charged to track the position of the vehicle. Thanks to this position, several other services are enabled. When there is a problem on the reception of satellite positioning signals, there is an alternative positioning algorithm. It consists of Wi-Fi positioning. Thanks to information stored on the cloud, about Wi-Fi access point positioning, accurate positioning in garages and other non-open sky places can be achieved. This is especially important in the case at hand, because vehicles have to be tracked at all times, not only when they are in open sky.
The Wi-Fi transceiver is the module in charge of the positioning when the satellite signal is not received. Together with some algorithms and CAN bus data received from the vehicle, accurate positioning can be achieved.
The telephony modem is the module in charge of the long range communications. Via this module, data about vehicle electric charge, location and other parameters is communicated to the back office server. Conversely, the server communicates with the vehicle on this same channel.
The CAN bus interface allows the OBU to gather data from the vehicle. Battery status and other important data is gathered and processed in the unit.
All these hardware modules are governed by a processor where all the algorithms and control and communications are supervised.
Antennas for the different wireless communications are embedded in the module, thus simplifying a lot the installation in the vehicle.

2.1.2. Energy Demand Management System

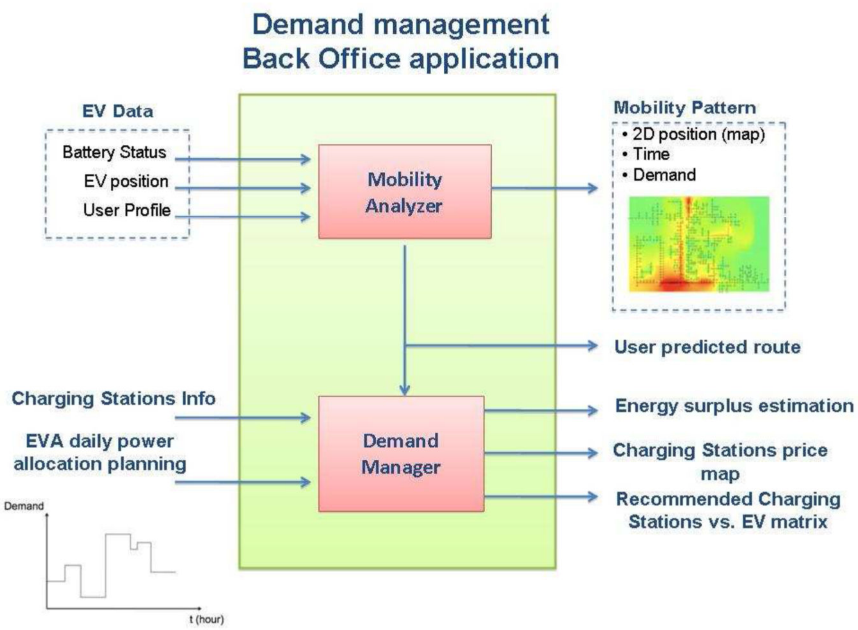
The objective of the Energy Demand Management System (EDMS) is to optimally manage the energy available for electric vehicles recharging based on users needs and preferences. EDMS will optimize this question by using both technical and economical criteria based on the location and the charging state of EVs, user preferences, energy demand forecasts and the state of distribution network. One of the main advantages of EDMS is the possibility to do a forecast on the EVs demand and influence to get the best Quality of Service (QoS) levels.

Next figure shows EDMS concept used by EVIC project.



EDMS central system is an application which implements all back-office algorithms. Its main purpose is to obtain EV's mobility patrons and predictions on their consumption based on current and past state (geographic location and battery level) and the user profile (preferences). Depending on the current availability and future forecast of energy at the recharging stations, and the EV's patrons, the demand management module will update prices of stations in order to influence on users and so prevent jam situations on recharging spots.

Next figure illustrates the concept of this subsystem:



3. EVIC Benefits

In view of their expanding business and marketing strategies, EVIC anticipates achieving ground-breaking future GNSS-based applications for EVAs through three categories of end user needs:

- Electric vehicle mobility and usage patterns reflecting user behaviour are required by the grid operators to define the grid topology (optimal grid dimensioning). EV urban mobility tracks must be complete and include deep urban and even indoor areas. In addition, near real time monitoring of electric vehicle positions together with their energy requirements is needed by the grid operators in order to detect and predict demand loads and thus to anticipate congestion alerts and maximize efficiency.
- Electric Vehicle energy demand management is crucial for the optimization of EVA internal processes: in order to meet the daily energy purchase from the energy provider to influence the user demand (through a customized pricing scheme) to reduce demand curve peaks, and to optimize the distributions and dimensions of the charging stations. Furthermore, EVA needs to detect the surplus of energy that could be sold on an hourly basis to the energy market. This can increase of EVA revenues.
- GNSS positioning is a key enabler for added value services for the EV user, e.g. navigation towards the closest/cheapest or fastest charging point, alert sending and messaging depending on the position of the EV user, find-my-vehicle and stolen vehicle detection and tracking.

4. EVIC Consortium

The consortium includes research institutions, hardware and software developers, business developers, service developers and end users. This range of technical capabilities to cover all the aspects that can influence a technological solution proposed. Additionally, all participants accumulate experience in electric mobility and electric vehicles. This is especially beneficial for the consortium as such because it can look forward to the project since it is based on a solid understanding of the reality of VE and its environment.

Business Cooperation to be held in this project and will be enriched by scientific and technological knowledge provided by the technology center, will expand the strategy of the participating companies. The method and system of cooperation is to develop a competitive advantage in its target market today thanks to the achievement of a product and / or service innovation. But it also allows them to strategically position itself in a unique position to capture market share when the VE bulk introduced.

Finally, all the consortium institutions are very active in R & D at European level with participation in projects funded by the European Commission, GSA and ESA. Therefore, the proposed project arises not as an end in itself but as a step on a path to some of the international technological lines that currently enjoy great interest by the scientific community.

- **FICOSA**: Ficosa is an independent industrial group founded in 1949, engaged in the research, development, production and commercialization of automotive systems and components. Based in Barcelona (Spain), the Ficosa Group has a global team of 7500 professionals and a presence in 19 countries around the world over 3 continents. With a consolidated turnover of over 973 million euros in 2011, Ficosa is currently the official supplier and technological partner of the main car manufacturers worldwide. Ficosa allocates 4% of its profit to R+D activities. At an operational level, Ficosa is made up of 5 business units based on different production lines. The Group’s business units are: Rear-view systems, Command and Control Systems, Underhood Systems, Advanced Communications and Commercial Vehicle. Ficosa employs a highly qualified team of specialized engineers and technicians and state-of-the-art electronic and mechatronic technology to develop its products. The research activity and high level of innovation of the Ficosa Group counts with a portfolio of around 400 valid patents.

- **GTD Information Systems**: GTD Sistemas de Información S.A.U. (gtd.es) is a Catalan SME which is leader in software and systems engineering in areas such as energy, space, aeronautics, security, defense, transport and specific programs. It was founded in 1987 with offices in Barcelona, Madrid, Germany and French Guyana (European Space Center). GTD is active in all phases of the development cycle: conception, design, implementation, commissioning, operation and maintenance; always applying the most appropriate standards and engineering methodologies.

- **Mobecpoint**: is a company dedicated to developing applications for the sectors of: media, mobility, and web communication. However, in recent years, has expanded its activities in the energy market. Mobecpoint is primarily an aggregator of electric vehicles and charging infrastructure operator also. However, it provides the electrical energy management and mobility to end users. Mobecpoint has extensive experience in the supply of power stations and power management as well as in the development of energy management applications on mobile platforms.

- **Edenway**: is a consulting firm with offices in Barcelona and Paris. Edenway offers public institutions and private companies specific solutions for their transformation. Moreover, Edenway help small and medium enterprises to grow domestically and internationally.

- **Private Foundation Ascamm - Aerospace Technology Centre (CTAE):** Ascamm the private foundation, which owns the Aerospace Technology Centre (CTAE), is a non-profit organization. It is a technology center, TECNIO Network member who is already involved in major research projects in the field of electric vehicles and SmartGrid. This organization, puts his knowledge and research to serve the industrial consortium. His areas of expertise include global positioning systems satellite systems (GNSS) positioning in indoor environments telecommunication technologies in mobility and embedded control systems.

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Lucía is a founding partner at EDENWAY and she is involved in each project . She has more than 8 years of experience in engineering and innovation consulting. She has a three dimensional experience: business development, team management and project management that she gained in various sectors: transportation, energies, public sector, etc. Lucía has been studying the advances of sustainable development worldwide. She is convinced that the only way to give sustainable development a chance is to implement concrete solutions at both social and environmental levels. Lucía graduated from the University of Navarre where she received a degree in industrial engineering.

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Hector is Program Manager at the Infrastructures Unit in GTD, with more than ten years of experience in the field of systems and software engineering. He now deals with projects related to sectors such as: Energy, Intelligent Transport Systems, Security and R&D+i. Where he manages projects involving a varied number of technologies: Instrumentation & Control, SCADA, Neural Networks and Fuzzy Logic, Big-Data, Clearing-House, Artificial Vision or Communications.

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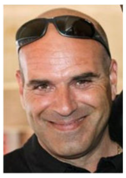
Esteban Gutiérrez holds a Master degree in Telecommunications Engineering and a Master in Aerospace Science and Technology both from the Technical University of Catalonia (UPC). His final degree projects have been mainly focused on signal processing techniques for wireless communication and navigation systems. In 2009 he participated in the International Space University Space Program at NASA Ames Research Centre (California, US). He is a CTAE staff member since May 2007 working in the Navigation and Communications group with special focus on Intelligent Transport Systems. Besides, he is currently preparing his PhD thesis in the field of digital signal processing for navigation and positioning.



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Pere's background is composed of more than 20 years in the electronic system arena. Basically in the control electronics, secure payments and telecoms industry. From October 2012 works as Systems Achitect for V2X technologies at the Advanced Communications Business Unit of FICOSA, managing all aspects related to the emerging technology. Having held positions as R&D Director at TinyTronic where he dealt with localisation systems. From 2001 to 2010 has worked at Ingenico as R&D Engineering Manager leading the engineering of secure payment terminals for worldwide customers. He was responsible for the requirements, development, certification and relay to mass production areas..