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Publishable Summary

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Table of Contents

1 Executive Summary

The ELVIRE project was the first research project partially funded by the European Commission which took a close look at the expected new market of e-mobility and its needed technical improvements. Since Electrical Vehicles (EVs) are known for their limited driving range the adoption of these new cars was doubtful, although the media enthusiastically reported on this new possibility. The expectation was set, that EVs would soon replace the conventional cars.

However the limited driving range of EVs of about 100 to 150 kilometres needed to be overcome or the users of such cars would experience a phenomenon known as Range Anxiety, which is the fear to break down with an empty battery before the destination has been reached. Therefore Range Anxiety was seen as a market limiting factor of EVs.

The 39 months long project looked at solutions to overcome these problems, excluding battery technology and wireless recharging while driving. The technologies investigated and the solutions developed came solely of the area of Information and Communication Technology (ICT).

First of all it was clear from the start, that EVs require new kinds of information and energy supply services so a Service Provider had to be established, a role which was taken by Better Place in our project. The service provider had to develop a scalable back-end system which would generate services and deal with EV user requests. Also there was the need of charge infrastructure and ideally this had to be full coverage. Better Place also filled this role of an infrastructure operator. The required connection to a utility grid was filled by ENDESA and CEA helped with the development of an energy demand prediction system. SAP looked at the possibilities of roaming and developed a clearing house so that vehicles could charge at foreign infrastructure without the need to sign an additional contract.

Vehicle Equipment was needed to provide a dashboard integrated communication and service terminal to the EV driver. Since the equipment was meant to be installed in vehicles the car manufacturers Renault and Volkswagen as well as automotive supplier Continental took this work package, accompanied by ATB from Bremen. The equipment was developed and cars were equipped so that open road tests could be conducted. Lindholmen Science Park verified the system successfully and the final demonstration presented it to the Community of Interest.

A Business Model was also needed to prove that e-mobility also has potential to become a self-sustaining business, which is capable to bear it s operational expenses and infrastructure investments.

After the project finished with a successful demonstration and dissemination event the question remains: why are EVs not more successful by now? Where are the cars? Where are the customers? One of the projects conclusions was that Political Power has to set the course for success now. The technology is ready for mass deployment, the Business Model would work, but only if critical mass can be reached soon. Legislation and regulation have to help to give EVs more weight in the market place.

2 Summary Description of the Project Context and Objectives

In the centre of this project stands the development of those Information and Communication Technologies (ICT) and Services that are needed to neutralize the electric vehicle (EV) driver's "Range Anxiety": the fear to break down due to the vehicle's driving range limitation and at the same time to cope with the sparse distribution of electrical supply points.

Therefore the objective of "ELVIRE" was to develop an on-board electric energy communication & service platform for realistic use-cases including the relevant external communication and services. For this purpose the following actions were taken:

- selection representative use-cases according to realistic scenarios and business-models
- identification & development of ICT & services needed to comply with the use cases
- development of "prototypes" for on-board Communication and E-energy service unit
- Verification of all integrated sub-systems on prototype level and demonstration of the proof of concept.

Based on a typical mission of an EV as use case, the project's purpose was to develop a customer oriented, open service platform required for the optimum interaction between the user in his vehicle, the service provision layer and an intelligent electricity infrastructure.

ELVIRE was structured into five work packages, with:

WP 1000 covering the project administration, legal aspects and dissemination and the inclusion of complementary RTD

WP 2000 defined relevant mission data for the use cases in consideration of technical an commercial aspects

WP 3000 addressed the external ICT for EV service provision, charge infrastructure management and balancing energy demand and supply for the users

WP 4000 developed the EV Communication Device and the OEM-neural universal on-board communication and service platform

WP 5000 conducted usability tests and the overall end-to-end system validation

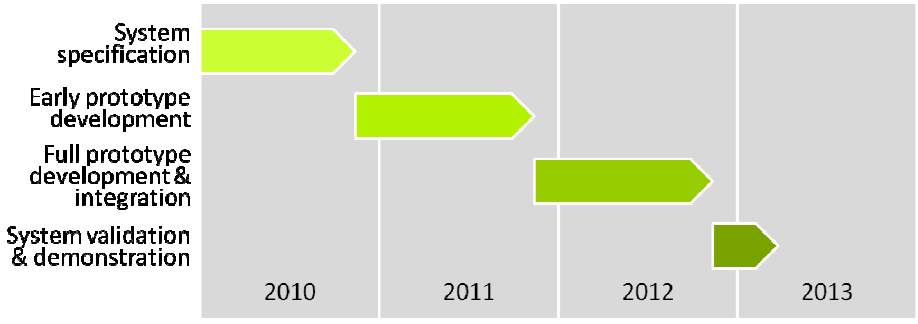


Fig. 1: Project Distribution over 39 months

The ELVIRE system was developed within the three core RTD work packages.

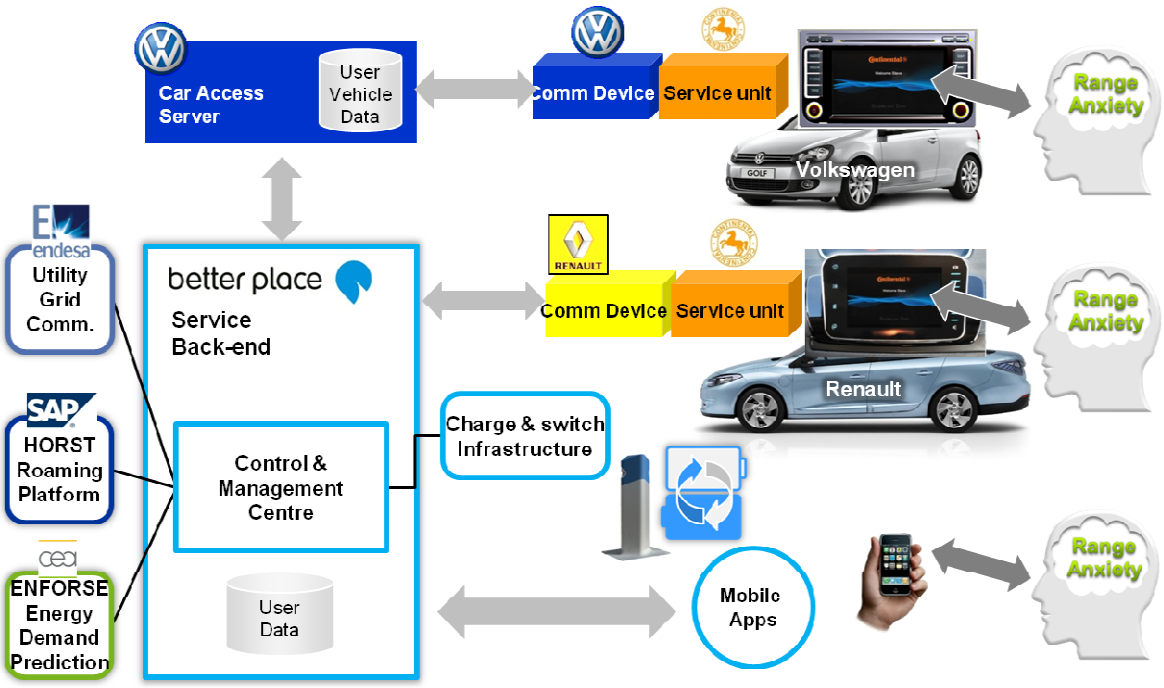


Fig. 2: ELVIRE System Diagram

The ELVIRE system is comprised of a number of sub-systems. In order to minimize Range Anxiety the EV users have access to service terminals built into the dashboards of the demo vehicles. These terminals provide reliable information, esp. about the feasibility of driving trips. There are two principal solutions to the service communication. However, both service terminals obtain their service communication from the same service provider back-end system. The main difference between the two communication channels is that one is directly communicating with the service provider and the other is linking exclusively to an OEM back-end which functions as a car access server for the service provision and which also offers telemetry services directly to their customers.

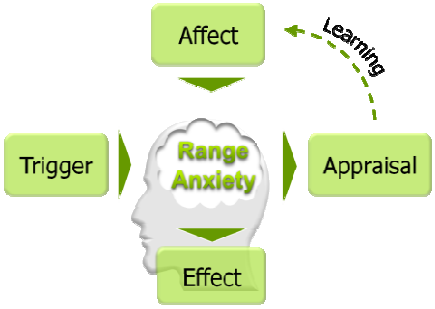
The service provider back-end has at its core the control and management centre (CMC), which secures communication and functions as a gateway. Behind the CMC there are several connected subsystems. The charge infrastructure is reporting on current occupancy and availability levels, the ENFORSE system is predicting energy demand from the field and it forecasts the availability of charge infrastructure. HORST is a system for the realization of roaming between service providers which improves infrastructure utilization and the utility grid communication provides information about actual and planned grid limitations and it allows service providers to warrant higher service levels to their customers.

3 Project Results and Achievements

The main project results in chronological order are:

1. Definition of the use cases which provided a framework for the RTD work packages to further specify their sub-systems. The use cases described the user experience of driving an EV in a typical day. The most prominent included:
    a. "initial activation", the set-up routine when a car is purchased;
    b. "frequent update" which is performed every time a vehicle is switched on and which checks for data updates, i.e. driver vehicle assignments;
    c. "planning drive" which checks if a planned trip is feasible, and if not, which countermeasures provide remedy;
    d. "driving without a plan", which is a typical scenario for daily commutes;
    e. "charging" which requires authentication, etc.

    Other use cases dealt with emergencies, driver exchanges during a trip or other exceptional situations.
2. Analysis and definition of the "Range Anxiety" phenomenon. Range Anxiety was identified as one of the potential constraints to the marketability of EVs. The cognitive model of Range Anxiety was developed which indicated that it is dynamic, subjective, temporal, emotional and object oriented. The following strategies were identified to avoid Range Anxiety:
    a. availability of reliable information sources for the user which clarify any uncertainty;
    b. capability for immediate monitoring;
    c. active interference possibilities when a destination is out of reach;
    d. ability to double check or drill down information;
    e. flexibility of the information presentation



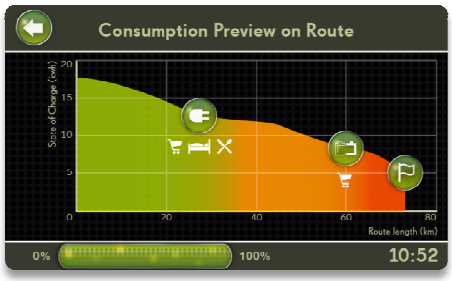
Anxiety Cognitive Model

3. Development of the Early Prototype, which was the first running system on the bench with a reduced set of use cases implemented. The Early Prototype enabled first tests, incl. usability testing of the system as presented on the user terminal, which was at that time a PC. The Early Prototype consisted of the following sub-systems:
    a. Control and Management Centre (CMC), which manages the service provider process and generates service responses to remote requests;
    b. Communication Platform (CMP), which safeguards the backend data communication and authenticates the communication partners;
    c. The working interfaces to remote systems such as Utility Energy Management, HORST roaming platform, ENFORSE energy demand prediction and all the connected charge and battery switch infrastructure.

d. OEM Back-end for service clearing and telemetry

e. Communication Device (EVCD) for secure data communication in the vehicle;

f. Service Unit, which is the touch screen operated user terminal in the vehicle dashboard, which represents services and provides users with the required information to minimize Range Anxiety. This device contains a navigation map and besides guidance services it also estimates the expected energy consumption for a given route considering topography, driving behaviour and vehicle status information. With this information it analyses the feasibility of a planned trip and it also produces suggestions in case of a driving range conflicts i.e. by searching for available energy outlets and offering reservation, etc.

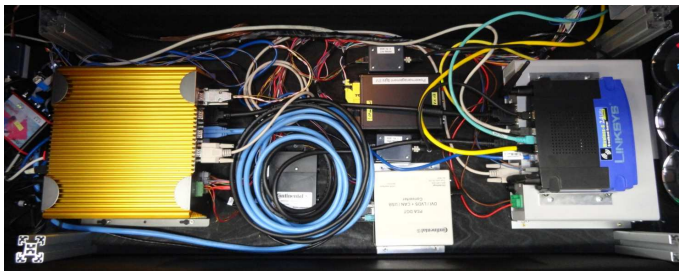


Consumption Preview

4. Analysis and recommendations regarding a business model for e-mobility. All stakeholders along the value chain were interviewed and their views mapped on the so called Business Model Canvas. The derived business model is centred around the question of how to realize a full coverage charge infrastructure, when selling energy to EV users seems not a major revenue opportunity. Generation of value has to reach beyond energy retail. The usage of infrastructure, battery leasing and inner city parking are of higher value and they could be bundled with energy retail to be offered combined. In addition, battery switch is an interesting option which supports the business model and at the same time further reduces Range Anxiety.

5. Development of the Full Prototype which completed the implementation of the remaining use cases. The results of the Early Prototype testing were analysed and improvements were defined and implemented. Also the vehicle on-board equipment was now completed and the systems were integrated to their final configuration. The devices were installed into vehicles and embedded software was calibrated to meet car specifications

VW Dash



in Renault Trunk

6. Verification and validation of the full prototype included open road testing with unbiased test subjects. These subjects were driving the demo cars accompanied by test moderators who were tasking them to perform standardised system interactions. In addition answers to a number of questions were noted and the whole driving was recorded with video cameras. The analysis of the materials showed that 92% of the participants believed that the application is a useful tool for EVs. They trusted the system and the information presented to a large degree.

4 Potential Impact

ELVIRE was at the forefront of the EV related European research projects. It addressed the main technical challenges for a vehicle-grid-integration and produced solutions for unlimited and unconcerned e-mobility. The project also spent effort on defining a possible business plan which showed e-mobility could actually become a viable business. Over the three year period the public perception about EVs as reflected in the media underwent a transformation. In the beginning the EV was seen as a saviour and the media in a state of hype was producing exaggerated expectations regarding the EV market adoption. Today, three years later the media is drawing a different picture by stating that the customers don't want to buy EVs yet, due to high purchase prices and limited driving range. Batteries are portrayed as not advanced enough. So the former exaggerated expectations could not be met. EVs did not come to the market in the promised quantities and their production costs and sales prices are much higher than predicted. Also the parallel development of smart grids and renewable energy sources stalled. Germany i.e. reduced the subsidies on private solar panel installations. The economic downturn of the banking industry which is now followed by financial instabilities in southern Europe is consuming vast amounts of capital. From this point of view the political discussion about investments for the needed energy turnaround towards alternative sources seems no longer opportune.

So the market development of e-mobility and the introduction of EVs have been slow. There are just a few EV models coming to the market and the adoption rate has been low and will likely remain low, mainly due to the price barrier and the lack of infrastructure. The perceived range limitation of EVs can be solved with smart ICT solutions as this project successfully demonstrated. Not the battery technology is the limiting factor, the missing critical mass of EVs in the market is the reason that e-mobility is not jump started as expected. If the market is not getting up to speed by itself and the car industry is not realising good profit margins then society has only one power left to accelerate the change, political power. At a point in time when the human race understands its impact on the biosphere and needs to take measures to drastically reduce green house gas emissions the governments are asked to take necessary actions, even against interests of some lobby groups. Unfortunately so far not much has happened. The political discussions around these topics always seem to end with the conclusion that our local economy has a still higher priority than global ecology.

ELVIRE has produced a principal solution in terms of technology as well as economy for realising the EV mass market. If governments are not adjusting the general conditions in favour of EVs then the market will not take off until oil prices leave no alternative. When will that be? The answer is uncertain. Probably the crude oil reserves have to be further exhausted

before it takes place. The damage to our global climate system will have worsened by then and future generations will not just struggle with their economies.

Tangible impacts of ELVIRE have been slowed in different areas. Since the beginning of the project no Pan-European service providers have been established. Some national activities, were started, but they are not tightly aligned nor interoperable yet. Political will is not formed to support the dense distribution of charge infrastructure. Car manufacturers are not requested to support battery switch as a solution. So, the impact could have been much higher yet. What remains is the excellent international collaboration which took place in this project and which is continuing in subsequent research projects. The developed technologies will find their individual ways into exploitation, although probably with lesser impacts. As hybrid cars seem to enjoy a better market adoption (by the way: steered through emission legislation) some of the on-board solutions will be likely to be used in this context.

The potential impacts are remaining true. The technology developed in ELVIRE is ready for utilization and it would help to make an impact in many areas, such as: competitiveness of the European industry, CO2 emission reduction, energy security and personal data security. Of course the entire consortium is wishing that the EV market is accelerating nevertheless and that the project results will also produce monetary results soon.

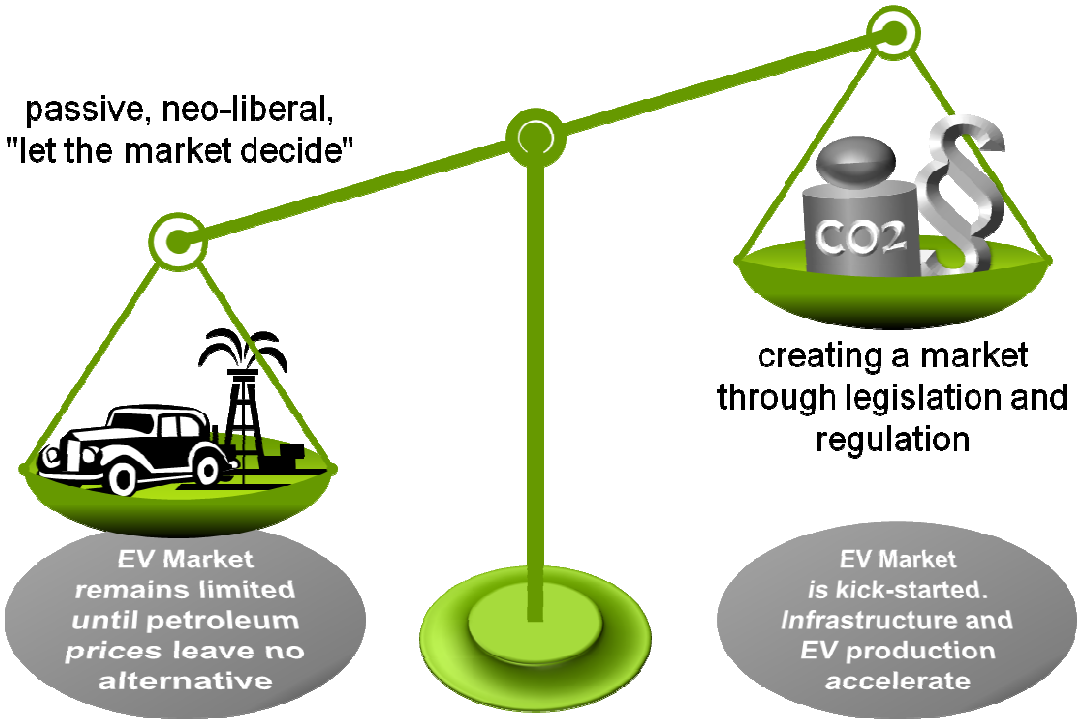


Fig. 7: Political Power is needed to give EVs more weight

5 Project Website

The address of the project public website is **http://www.elvire.eu/**

This website contains all formal data regarding the project and the consortium. It also provides a high level description of the project purpose, structure and outcomes. More importantly, is allows open access to the public deliverables of the project, the scientific & technical publications as well as the released communication materials. More generally, dissemination activities are listed and related documents (slides, posters, papers) are available for download.

6 Contacts

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