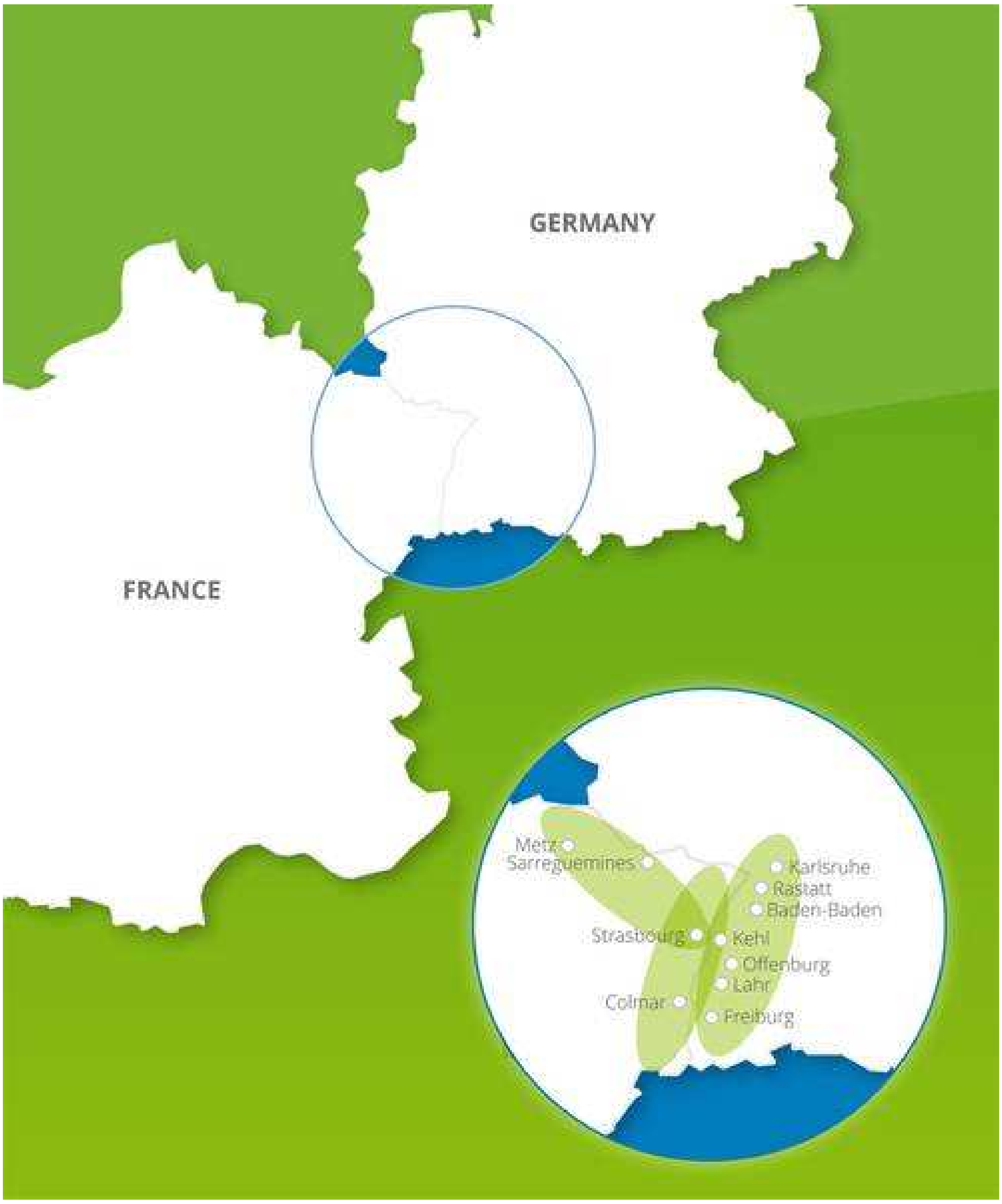
crome
cross-border mobility for EVs

FRENCH – GERMAN ELECTROMOBILITY



Report on the Research Project CROME

(for the period 2011-2013)

crome
cross-border mobility for EVs

REPORT ON PROJECT LEVEL

based on the joint French-German Project Outline

„D-F FOT - French-German eMobility Cross Border Field Operational Test“

PARTNERS

EDF, IFSTTAR, RENAULT, PSA PEUGEOT CITROËN, Schneider Electric

BOSCH, DAIMLER, EnBW, SIEMENS, PORSCHE, KIT

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Executive Summary

CROME – Vision and Objectives

Vision of the CROME (Cross-border Mobility for EVs) research project was *to create and test a safe, seamless, user-friendly and reliable mobility with EVs between France and Germany as a prefiguration of pan-european eMobility*; one of its major aims was to formulate answers and suggestions to contribute to the European Process of standardisation of the infrastructure for eMobility (connection to electric supply, cables and plugs, etc.) and of the services for eMobility (identification, billing, roaming, ...) and to provide stakeholders with an early customer feedback.

In this joint project with French and German industrial and research partners, the following overarching **objectives** have been followed:

- performing a wide-scale cross-border field demonstration of mobility with EVs;
- introducing fully public interoperable charging stations (EVSEs) ensuring easy access and charging of EVs all over the French and German CROME area;
- investigating customer acceptance of eMobility and user needs regarding charging in the context of cross border mobility;
- offering charging services enabling simplified identification and billing as well as charging spot availability and reservation;
- testing and giving recommendations on the European standardisation of the charging infrastructure (plug, cable, ...) and services (identification, billing, roaming, ...).

CROME – Project Consortium, Funding Ministries and Duration

The **CROME Project Consortium** has been composed by different French and German industry partners, energy suppliers and research organisations. They all brought in their competencies concerning different aspects of eMobility. The industry partners provided, besides electric cars (Daimler AG, Dr. Ing. h.c. F. Porsche AG, PSA Peugeot Citroën, Renault) and eMobility services (Energie Baden-Württemberg AG (EnBW), Électricité de France (EDF)), charging infrastructure solutions (Bosch Software Innovations GmbH, Siemens AG, Schneider Electric), also customer-oriented services on the respective side of the border. The research organisations (Institut français des sciences et technologies des transports, de l'aménagement et des réseaux (IFSTTAR) and Karlsruhe Institute of Technology (KIT)) carried out special analyses.

The consortium also included **Associated Partners**, most of which were regional partners from both sides of the border, but also Toyota and Nissan, which brought in electric cars.

Strategic Partners were different **French** and **German Ministries**. These Ministries have funded / are funding the project from January 2011 to December 2013 / 2014.

CROME – Is a Success !

The different stakeholders - industry partners, energy suppliers and research organisations – have been working closely together during the period 2011 – 2013 and paved the way towards interoperable cross-border eMobility.

CROME made possible a unique wide-scale field demonstration of cross-border eMobility:

- First field test with over 100 monitored EVs, covering a unique range of different EVs, among them some of the most recent models,
- First field test with the roll-out of interoperable dual-type socket public charging stations,
- First field test with involvement of private users having bought their EV according to real commercial conditions (over 150 private users each in France and in Germany subscribing to a CROME eMobility service)
- First field test making cross-border roaming possible. 87.000 journeys with 16.000 charging actions were logged. Thereof in 2013 330 roaming charging actions took place with 400 hours of charging time.

The project proved that eMobility and charging across borders is possible, user friendly and a reality already today. CROME paved the way and built the basis for commercial solutions like Hubject, GIREVE and others.

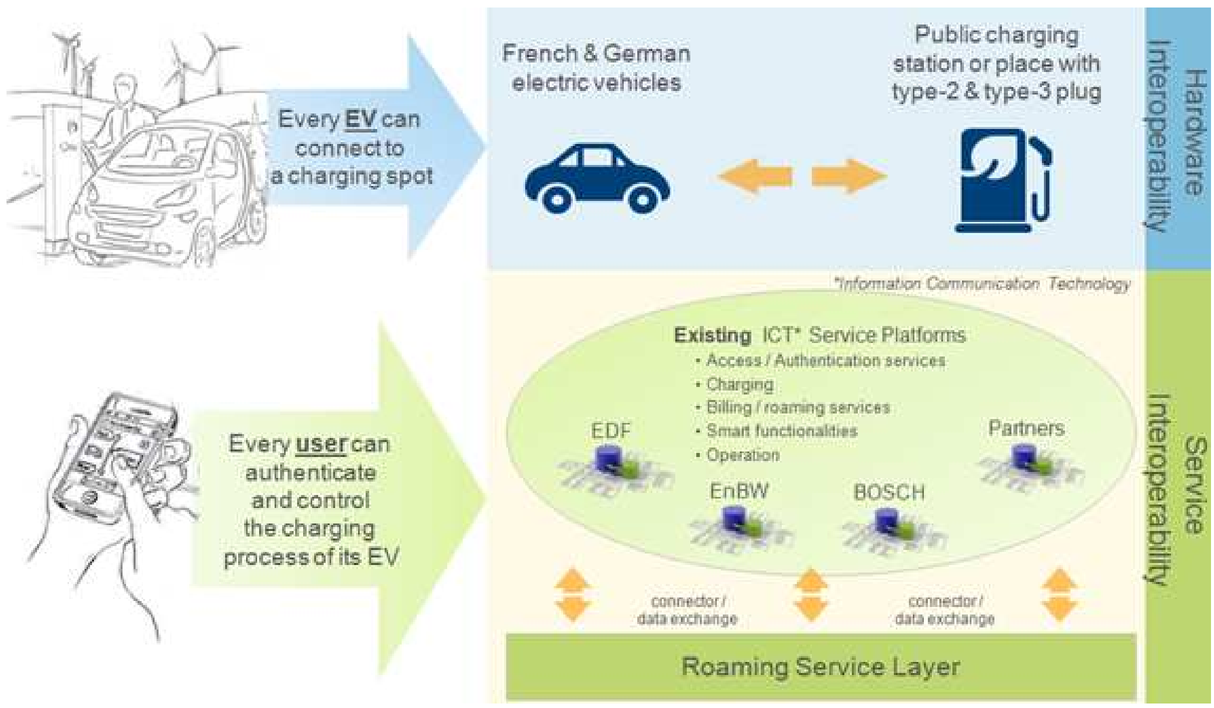
The project boosted visibility of eMobility in the concerned regions and demonstrated that concerns about cross border eMobility were not justified.

Learnings are already disseminated in France and used in public tenders for infrastructure deployment.

CROME Interoperability – Common Understanding

One of the core issues of the CROME Project is ***interoperability*** – in its different aspects:

1. ... hardware, i.e. charging modes and socket system;
2. ... software & service, i.e. roaming, billing, charging, smart functionalities as well as operation;
3. ... the specific issue of billing.



CROME Interoperability – Learnings and Recommendations

The major learnings with respect to the three aspects of interoperability addressed in CROME are:

Hardware Interoperability - Interoperable Public Charging Infrastructure

Interoperability is Technically Feasible – both Type 2 and Type 3 Plugs / Sockets have been proven successfully

The project has demonstrated that interoperability is feasible based on the existing technologies on both sides of the border:

It has been demonstrated in the CROME Project that both the type 2 and type 3 plugs / sockets can be implemented in one charging station according to the regulatory constraints on each side of the border in a way that easy retrofitting is ensured. Both types enables successfully charging of the EVs in the project. The initial objectives of the project were consequently achieved.

However, although technically feasible, this solution does not appear meaningful on the long term. In order to reduce the costs for the deployment of the infrastructure, the complexity of hardware, and increase the user acceptance, the CROME partners recommend an agreement at European level on one standard type of plug. In expectation of a European standard, the CROME partners recommend the deployment of charging stations which can be easily retrofitted if decided by the infrastructure owner, so that the costs for the adaptation to a future standard remain as low as possible. As developed above however the to-be-voted Directive should not require to retrofit existing installations.

Length of Process (DE, FR): Call for Tender, Decision on Location, …

The process for the rollout of public charging infrastructure worked differently in France and Germany:

- In France, the public charging infrastructure has been mainly bought and owned by local authorities in accordance with their managing role in the local transportation organisation, which need to go through public call for tenders and take into account the corresponding legal constraints.
- In Germany, the CROME charging stations are owned by EnBW, which discussed together with the respective municipalities and local energy suppliers the suitable locations for the CROME charging stations.

Thanks to the development of common specifications for charging in mode 3 for public charging stations and the preparation of an initial call for tender together with CUS, CROME contributed to simplify the process in France. The CROME terms of reference for the charging infrastructure have already been adopted by further border regions in France, e.g. Pas-de-Calais.

As a feedback roughly 9 months as a minimum are required from the specification definition to the start of operation in the street due the official constraints of the public tender regulation.

➔ European wide standards for the further development of eMobility is crucial.

Hardware Interoperability - Fast Charging

Fast Charging is used and meet EV Customer Needs

eMobility Corridors are an Appropriate Pattern in order to Structure Territories

Interoperable and Multistandard Fast Charging Facilities are required in order to Fast Charge the Different EV Types on the Market

CCS Charging and High Level Communication According to ISO / IEC 15118 work Properly

To keep up with the development on the eMobility market in Europe, charging using the new CCS plug and communication according to ISO / IEC 15118 should be analysed and tested within the CROME project. Therefore tests with the prototypes of a Siemens DC-Lab-Charger and a Daimler Smart ED with DC charging feature have been started in April 2013. Main focus of these tests was to set up, analyse and verify the communication between EV and EVSE according to DIN Spec. 70121 (as ISO / IEC 15118 is not normative at the moment).

It was proved that CCS-Charging and high level communication according to ISO / IEC 15118 works properly. Some open points within the standard (sometimes there´s still room for interpretation) were identified and will be forwarded to the responsible standardization committees.

Service Interoperability

CROME demonstrated service interoperability by roaming of services.

Communication Charging Station to Vehicle

The detailed definition added to the mode 3 specifications enabled a reliable cross-border charging. In this respect, no further developments are needed.

The adoption of the CROME terms of reference for charging in mode 3 have contributed to the development of an industrial offer in terms of infrastructure: several industrial providers now offer “CROME-like” charging stations.

RFID

The RFID card is a suitable media for ensuring roaming; within the project, the technology has proved to be user friendly and reliable. In addition, a live retrieval of the information needed between the backends avoids keeping data in all the systems. Consequently, e. g. in case a RFID-card gets lost, it is sufficient to disable it in one of the systems to have it immediately disabled in all the network of connected systems.

Communication Protocol of Charging Point to Backend System

OCPP allows a flexible connection of different charging stations to a backend system. It brings the advantage of being a de facto standard used by different providers. However, a connection requires the relevant partners to agree upon a common communication layer.

➔ **Standardization (RFID Card, Type 2 / 3 Plug, Mode 3 Charging, OCPP) is Key to Enable a Marketplace.**

Roaming Service Layer

It was demonstrated that the selected roaming architecture works and is accepted by all the partners connected, as it supports current as well as future business models.

- ➔ **The CROME partners recommend for a future marketplace to build a network of independent international partners (competitors) having their autonomous business and systems, the system design has to ensure that each partner keeps his independence (data).**
- ➔ It was proven, that realtime authorization between the partner systems linked via a roaming layer can be realized without any noticeable delay compared to the authorization within one partner system. This allows to respect the principle of minimized data storage and avoids large scale whitelist solutions.

Services

The search-service is essential for the market-success of eMobility.

Without legal framework conditions granting that a reserved spot is available upon arrival of the reserver, the introduction of such a service does not make much sense.

Linking vehicle data to backend systems makes innovative services possible; however, specific legal framework conditions are to be considered.

- ➔ **Roaming of services will be a key enabler for future mobility solutions.**

Billing Interoperability

Cross Border eMobility is Possible and Reality Today

Thanks to CROME, cross border eMobility is a reality already today. The implementation of the necessary requirements for the authentication of the users and the rollout of public charging stations compatible with both the type 2 and type 3 socket systems enabled to remove the major technical barriers for cross border eMobility

Customers Accept RFID Card for Authorisation and Payment

The RFID card has proved being a secure and user-friendly support for authentication and payment, well accepted by the users. Both in France and in Germany it is becoming a standard for the access to the charging infrastructure, so that the cross border eMobility is ensured for the coming years.

European wide Standards for Further Deployment of eMobility is Crucial

The definition of valid standards at European level is crucial for the success of cross border eMobility. This includes the measurement and payment modalities (kWh- or time-based) as well as common user authentication procedures.

Cross Border Billing of VAT

A clear legal framework is necessary for the actual implementation of cross-border billing, especially with respect to the billing of VAT.

Rollout and Operation of the Charging Infrastructure need to pay off in the Future

Considering that eMobility still is in its beginnings, the investment and operation costs for the charging infrastructure are quite high if compared to the rather restricted number of users. Future business models shall therefore plan a fair distribution of the costs among all market players in order to ensure a sustainable success of eMobility.

Costs Transparency for End Users

Showing a customised pricing table at the charging station of each provider may considerably increase the cost transparency for the end user. Similarly, transferring the pricing table also over the roaming service layer in connection with the authentication service also seems to make sense.

CROME Users – Learnings and Recommendations from the Acceptance Analysis

Respondents who had experienced EV at least during one or two test drives as a driver or passenger were evaluating EVs' characteristics, particularly driving characteristics, better than respondents who had not experienced EV so far.

French EV users show a higher degree of satisfaction with the EV's CO2 characteristics than German EV users.

It has been shown that the vehicles are mainly used for short trips in an urban environment and usually stay far below their maximum range.

The comparison between French and German use has shown that the considered French trips are statistically significantly longer in matters of distance but almost identical to the German trips in matters of time. This is caused by a larger share of rural use, which is probably due to the less dense settlement structure in the French part of the project region.

CROME – A Cornerstone for Cross Border Mobility for Electric Vehicles in the CROME Region for the Next Decades

The charging infrastructure remains in place.

The Bosch Roaming layer keeps on running in the framework of the Green eMotion Project and the Schaufenster-Projekte.

EVs are further used (either from current or new clients).

New series EVs (smart ed phase 3, Panamera S E-Hybrid ...) have entered the market which are completely compliant with the CROME infrastructure. We assume higher sales in the CROME region.

The experiences with the standards (type 2 and 3 plugs, mode 3...) are taken into account by the European standardisation process.

The knowledge gained is used in further projects through the involvement of the CROME partners in e.g. Green eMotion, RheinMobil, iZeus…

Interoperable eMobility services have been demonstrated and are continued (offers from Sodetrel and EnBW as eMobility service providers and interoperable charging infrastructure operators).

Outlook

Apart from the mere technical solutions which were accomplished in this project, we see further needs for action, e.g. in the different legal frameworks: differences in legal demands for calibrating energy measurement systems, open questions regarding parking signs for EV during charging and towing of other vehicles, cross-border billing of VAT, data protection, and missing standards how the cross-border exchange of data for EV services should be performed. Likewise, a continuation of the research activities covering new arising questions in the field of cross-border mobility (as multi-modality, intermodal mobility services) seems necessary and worthwhile (see chapter 13 for details)[1].

1 The variety of findings of crome and their relevance make allowance for the publication of a book band in 2015 in which results and findings from the project will be presented.

Content

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1 Introduction – Challenge, Vision, Objectives

Challenge

One major challenge to the worldwide diffusion of eMobility is the public awareness for electric (either battery electric (BEV) or plug-in hybrid (PHEV)) vehicles (EVs), their (future) users' acceptance and – last but not least – their appeal as practical and adequate alternative to conventional vehicles. Nevertheless, in the last years the charging infrastructures were mainly developed at national level and according to the local needs. This means that charging beyond the border might be a challenge for EV users. Though, national boundaries should not represent a hurdle to the introduction of eMobility in Europe, but allow accessible charging instead. Interoperability and security at affordable prices are the key to success.

Fig. 1: CROME – Project Region

And these key issues are the core challenges faced by the French-German cross-border fleet test in the Upper Rhine region. The project in the boundary region between France and Germany spreads over the Moselle and Alsace Region (with a focus on the cities of Sarreguemines, Strasbourg, and Colmar) in France and the Baden region including Karlsruhe, Baden-Baden and Freiburg in Germany. This area represents an ideal test field as a high share of cross border trips could be observed. Furthermore, drivers of vehicles from small commercial fleets build a significant target group and the local administrations on both sides are highly engaged in introducing eMobility. On both sides of the Rhine river many different eMobility projects were and are still carried out (Kléber, MeRegioMobil, iZeus, RheinMobil, …). Further projects are highly probable.

The project's approach envisaged exploiting closed and still running R&D projects with EVs in the French-German boundary region in order to establish a concrete cross-border experiment with an enlarged infrastructure and new mobility services.

Vision

Vision of the CROME research project was *to create and test a safe, seamless, user-friendly and reliable mobility with EVs between France and Germany*; one of its major aims was to formulate answers and suggestions to contribute to the European Process of standardisation of the infrastructure for eMobility (connection to the electric supply, cables and plugs, etc.) and of the services for eMobility.

Objectives

In this joint project with French and German industrial and research partners, the following overarching objectives were followed:

- performing a wide-scale cross-border field demonstration of mobility with EVs;
- introducing fully public interoperable charging stations (EVSEs) ensuring easy access and charging of EVs all over the French and German CROME area;
- investigating customer acceptance of eMobility and user needs regarding charging;
- offering charging services enabling simplified identification and billing as well as charging spot availability and reservation;
- testing and giving recommendations on the European standardisation of the charging infrastructure (plug, cable, ...) and services (identification, billing, roaming, ...).

Structure of the Report

Chapter 2 contains a description of the ***CROME Consortium*** – composed of different industry, energy supply, eMobility services, charging infrastructure and research partners from France and Germany. Here, each full and associated partner will be introduced with a short description. Furthermore, also the ***Ministries*** involved in the project during the first three-year-duration from January 2011 to December 2013 are mentioned.

Chapter 3 "Roadmap" gives an overview of the project timeline.

The project contents are described in this report together with the consortium understanding of ***Interoperability.*** First of all, **chapter 4** will offer a general introduction. All aspects introduced here will be deployed in detail within the **chapters** ***5, 6 and 7***. These refer to ***Hardware-, Services- and Billing Interoperability*** respectively.

Chapter 8 deals with the technical data of ***EVs*** involved ***in the project*** and offers a short introduction of the CROME vehicles in use on the French and on the German side of the Rhine.

Chapter 9 describes the research activities regarding the ***Acceptance Analysis***. Here an overview of the scientific research questions addressed in further publications indicated in the annex is offered.

CROME also addressed ***Special Research Questions***: in this context among others a Conformance Test Tool was developed and a fast charging network was established. The conformance test tool is a comprehensive testbed for testing ISO15118 communication between vehicles and charging infrastructure. The fast charging network has been established in order to gain first experiences with their acceptance and functionality. These achievements are described in ***chapter 10***.

Chapter 11 offers an overview on all project **Dissemination and Communication Activities**, while in ***chapter 12*** a pre-conclusive ***Project Outlook*** has been formulated.

2 CROME Consortium and Funding Ministries

Fig. 2: CROME Partners (Full and Associate)

The CROME project consortium has been composed by different French and German industry partners, energy suppliers and research organisations. They all brought in their competencies concerning different aspects of eMobility (cf. 2.1.1). The consortium also included Associated Partners, most of which were regional partners from both sides of the border (cf. 2.1.2). Strategic Partners were different French and German Ministries, who funded the project (cf. 2.2).

2.1 CROME Consortium

2.1.1 CROME Full Partners – Role in the Project

The industry partners provided electric cars (Daimler AG, Dr. Ing. h.c. F. Porsche AG, PSA Peugeot Citroën, Renault), eMobility services (Energie Baden-Württemberg AG (EnBW), Électricité de France (EDF)), charging infrastructure solutions (Bosch Software Innovations GmbH, Siemens AG, Schneider Electric), and customer-oriented services on the respective side of the border. The research organisations (Institut français des sciences et technologies des transports, de l'aménagement et des réseaux (IFSTTAR) and Karlsruhe Institute of Technology (KIT)) carried out special analyses.

BOSCH

Within CROME, Bosch Software Innovations provided and operated special Internet services for eMobility. These eMobility services allow the necessary communication among all parties involved: from the EV-driver, through the charging station and up to the energy supplier. Thanks to these services, users can search and find charging stations, authenticate themselves and charge their vehicle. Furthermore, Bosch addresses other added value services such as navigation and networked fleet management. Aim of the project was to verify the users' acceptance and investigate the possible need for further adaptations of the standards for cross-border eMobility.

Bosch Software Innovations brought another fundamental element into this research project: the possibility to provide and bill these services across the border – what in telecommunication is known as "roaming". Roaming is one of the core functions in CROME from the point of view of the infrastructure. The "Service Brokering" used for this purpose guarantees the mutual service billing. Concretely speaking, this means that the EV-driver has the possibility to access the services of both providers even if he is client of only one of them. This is how easy cross-border eMobility is performed.

DAIMLER

Daimler supports infrastructure and mobility initiatives

The success of eMobility's market penetration depends on many factors. It requires appealing and cost-effective business models to make emission-free driving a real alternative. Besides a suitable offer on the vehicle front, an infrastructure that meets the needs and adequate services, also creating a cross-border network and establishing international standards are important aspects to be considered.

Together with the project partners, in the framework of the CROME project Daimler experimented the cross-border infrastructure standardisation process. Besides plenty of experience, Daimler brought into the project also some specimens of its electric fleet. A total of 60 cars split between the models *smart fortwo electric drive* and Mercedes-Benz *A-Klasse E-CELL* took part to the project. So the company could gain some important insight on market research and customer acceptance. These aspects generate primarily from the challenge of a cross-border use of electric vehicles, as e.g. the different functioning of charging stations and several billing and payment systems as well as different plug types.

EDF

Project leader and coordinator of the French part of the CROME project.

Takes part to:

- Learning awareness from the former projects (Kléber in France)
- Design and definition studies of the CROME interoperable charging infrastructures and roaming platform
- Support to the local territories (Communauté urbaine de Strasbourg, Thionville, Forbach, Sarreguemines, Colmar) in order to deploy public CROME charging stations (upstream specifications, …)

- Through its subsidiary SODETREL:
  - o Upgrade of its operation backend in order to implement CROME interoperable specifications
  - o interoperable technical and commercial supervision and operation of the French charging stations in Alsace and Moselle (22 kVA and fast charging stations),
  - o customer-oriented eMobility services (cross-border access to the French and German crossborder charging stations, smart phone apps about availability of the charging spots, ...)
  - o introduction of pre-paid RFID card schemes
  - o interoperable access offer to DC / AC fast charging stations
  - o Test of the EV and PHEVs
- Creation and participation to the CROME service roaming platform set up between Sodetrel and EnBw through the Bosch platform in order to ensure a complete cross-border access to all the French and Geman CROME charging stations
- Implementation of actual business models compliant to the French organisation and CROME compliant (public tenders, billing, ...)
- Analysis of the customer acceptance feedback and CROME learnings dissemination.

EnBW

EnBW brought in the project its competencies on energy logistics and its experience deriving from different eMobility activities. In the framework of the CROME project, EnBW aimed at the following goals:

- installation and operation of an interoperable charging infrastructure along the French-German boundary in cooperation with associated local energy suppliers;
- development of innovative tariff and access concepts for public charging of electric vehicles;
- coordination of the charging infrastructure activities on German side (cooperation with local energy suppliers and other eMobility projects);
- creation of a common eMobility platform together with the cooperation partners for a sustainable eMobility in Baden-Württemberg;
- evaluation of users' behaviour.

KIT

The Karlsruhe Institute for Technology (KIT) cooperates with several industrial partners within the CROME project, acting as a scientific partner. In its activities the KIT analyses in particular the following aspects: (1) charging infrastructure, (2) use of electric vehicles, (3) services, (4) acceptance of electric vehicles, (5) legal evaluation, and (6) overall examination of eMobility:

1. To date, only few **charging infrastructure** is installed in distribution networks. Until 2020 this situation will change. Therefore, it is highly interesting to collect experiences with existing charging solutions and the related techniques in order to estimate the implications as e.g. the necessary network enlargement

and the effects on quality and stability of the energy supply. Increasing installations of decentralised electricity generation by of renewable energy sources already show that the absolute active power transfer critically affects the quality of the supplied energy. A similar development can be expected for the charging infrastructure.

With this in mind, KIT created a multifunctional fast charging station and used it as a demonstration system on which to analyse different charging modes – even at high charging power of up to 60 kW. This demonstration system has an open structure and allows integrating those results whilst analysing an efficient and network-optimised management of the charging station within the distribution network. Besides the possibility of transferring active power, which represents the charging of electric vehicle battery systems, also the demonstration system for a dynamic, network-supporting use is shown. Integrating network supporting and network optimising functions into charging stations reduces significantly impairments of the supply quality caused by the charging infrastructure. The integration of different optimisation processes, e.g. through provision of reactive power and harmonic elimination, the charging station represents a smart operating means within a smart grid, providing system services. The test functioning allows to formulate important findings on the requisites of (fast) charging stations.

2. Within the project framework many different vehicles and vehicle concepts, developed by different car manufacturers, were handed for use to selected clients. The data regarding the **vehicle use** were gathered and analysed from a technical point of view. The large amount of gathered measurement data was derived from different data sources and structures, which needed to be filtered, bundled, saved and evaluated. Additionally to the purely technical issues, customer satisfaction about the implemented eMobility solutions was observed in connection with the user acceptance analysis.

   On the basis of the different data gathering methods used by the different car manufacturers, a unified, significant data sample was agreed with all of them, which was then forwarded to the KIT for research purposes. Furthermore, this data sample was integrated with crucial parameters deriving from a parallel investigation with smartphones used as data loggers. To this aim, a specific application was programmed and developed. The whole of the data was then merged in a research data base ("data repository") developed by KIT for this purpose and standardised, in order to allow the KIT to carry out a data evaluation irrespective of their source.

3. **Services** offer comprehensive support for the use of electric vehicles and can contribute to enhance their acceptance. They supply the users with important and useful information (e.g. range, charging options, charging start time and charging duration) in the cross-border traffic. The visualisation and use of such services is performed through different interfaces like web applications or smartphones, which are already accessible to a large mass of users. Nevertheless, to date the user interfaces are rather static and cannot be easily and flexibly adapted to the needs of different users. In particular when considering the bilateral requisites of the CROME project, the possibility of flexible customising the interface to meet the individual users needs would be very important and a crucial factor for the acceptance of the services.

   To this aim the hitherto existing concepts of elaborated services were analysed and the usability of different interfaces with established processes was observed. After that, the users' features and the behaviour were identified, extrapolated and interpreted. On this new basis, new user profiles were derived.

4. Clients of fleet and commercial vehicles on both sides of the border drive electric vehicles. According to range and infrastructure, these clients use electric vehicles for different purposes. The use and **acceptance of electric vehicles** in the everyday use had not been analysed in depth so far. Further findings about the cross-border infrastructure of charging stations and services were also acquired.

Gathering of data on acceptance was performed through three coordinated online questionnaires, which were carried out at about 9 month distance to one another, building the basis for further findings. The questionnaire contents were developed considering the data gathered through other media (see 3. above). Furthermore, data on the use of e-bikes at KIT broaden these findings.

5. A lawful cross-border market communication (e.g. on billing) needs consistent data formats and normative provisions regarding communication processes and the definition of legal requisites on non-functional features (evidentiary value, contractual relationships, etc.). As the legal basis for the integration of eMobility into the energy market in France and Germany – exemplary for the whole of Europe – differ, there was and there is a need for a Europe-wide uniformation. In this respect, KIT carried out a **legal evaluation** of the business models and architectures of system and communication infrastructures used within the CROME project as well as of the different regulation requirements applying in France and Germany.
6. In order to perform an **overall examination of eMobility**, data from all processes needed to be gathered, including economic processes like pricing strategies and business cases, technical processes vehicle usage and charging procedure as well as sociological processes. A particular focus lay on data allowing the identification of national differences as well as their evaluation and dissemination.

   To this aim the following activities were performed: evaluation of the gathered data on driving and acceptance behaviour, content connection of data gathered through different sources and (repeated) extraction from the KIT data repository of the data needed for the evaluation of single aspects. The analysis of driving behaviour followed the implemented process chain to maintain a good data consistency within the analysis. The identification of national features and their effect on the user profile of the drivers was crucial for the analysis. Furthermore, an optional workshop with electric vehicle users was carried out with the aim of creating a forum for collecting feedback on use and users' satisfaction independent from the manufacturers. The results of the analysis were presented to the electric vehicle users and critically evaluated.

Porsche

eMobility in a sports car – drive your future today.

For a sports cars producer like Porsche, the application of forward-looking technologies is part and parcel of the development of new vehicles. This includes also the partial electrification or hybridisation of existing Porsche models as well as the direct fuel injection and light weight construction.

This is how Porsche could already successfully bring two models – the Panamera S E-Hybrid and the 918 Spyder – with an only-electric range of about 36 km to the streets. With a total performance of 380 hp, in NEDC the Panamera S E-Hybrid is satisfied with 3.1 l per 100 km, with emissions of only 71g / km. Also the 918 Spyder consumes in NEDC only 3.1 l per 100 km, with its emissions amounting to 72g / km – for an impressive performance of 652 kW (887 hp).

Thanks to the support of the German *Federal Ministry of Transport, Building and Urban Development* (BMVBS), this electrifying idea is carried on. The installation and the actual testing of battery-operated electric sports cars without combustion engine on the Porsche Boxster model as well as the testing of vehicles of the Panamera family with plug-in technologies and their use in cross-border traffic is a new real challenge. The different aspects put under test include the batteries' durability, charging and discharging cycles, the users' acceptance for electric vehicles as well as the safety in traffic under everyday conditions. All of which is measured to the particular features the users expect from a sports car: performance, engine output and efficiency – all in one concept.

PSA Peugeot Citroën

The brands Peugeot and Citroën participate in the CROME project with about 35 mass produced EVs. About 30 Peugeot *iOn* and Citroën *C-ZERO* as well as some Peugeot *Partner Origin* and Citroën *Berlingo First*, all equipped with electric motor, were used in normal conditions by private and commercial clients representing “typical users” of EVs. In cooperation with the research lab ***IFSTTAR***, the *French Institute of Science and Technology for Transport, Development and Networks*, ten Peugeot *iOn* and Citroën *C-ZERO* were equipped with data logger, which allowed gathering and analysing the users’ driving and charging habits. IFSTTAR ensured the data recording and interpretation of PSA vehicles.

The gathered data refer to power train (motor, battery, pedal support) and auxiliary equipment (air conditioning, heating …) and are aimed at characterising the car use. Links between potential ageing of the batteries and use features are investigated. The observation of commercial fleets will allow the evaluation of all usage modifications implied by the use of an electric vehicle (low usage costs, limited range, charging mode, etc.).

Renault

Renault’s contribution to the CROME project:

- 7 mass-produced *Kangoo Z.E.* are given in use to clients in Alsace and Moselle.
- Interested clients are delivered further electric cars – e.g. *ZOE* since October 2012.
- In cooperation with PSA and Daimler, additional specifications to the existing norms are formulated and the French “livre vert” for Strasbourg municipality’s public bidding of charging infrastructures is published.
- Measurement and gathering of car and driving data.
- Analysis of the users’ behaviour and satisfaction.
- Dissemination of project results and experiences.

Schneider Electric

Schneider Electric has entered the business of EV infrastructure 4 years ago and features a complete range of solutions : charge point for residential, public infrastructure, parkings, normal and fast charge stations as well as the complete set of solutions to manage energy, monitor and operate the infrastructure.

Within the framework of the CROME project, Schneider Electric was in charge of:

- Design charge stations to adapt the infrastructure deployed in France to CROME .
- Provide fast charge solutions, both AC / DC, and normal charge stations from 3 to 22 kW.
- Contribute to standardization work on charge interface and propose solutions to provide cross border interoperability.
- Design and develop advanced energy management on the charging spots.
- Contribute to the analysis on the use of infrastructures for cross border mobility.

SIEMENS

Ecology, energy efficiency and cost effectiveness: these three keywords perfectly describe the advantages of eMobility. In the future, energy consumption and the carbon footprint will be key factors to determine how affordable mobility is. For both criteria EVs are groundbreaking, as they represent an exceptional possibility to exploit energy from renewable sources.

Within the framework of the CROME project, Siemens had three overarching goals:

1. Diffusion of AC and DC fast charging systems
2. Analysis of the users' behaviour and of their preferences
3. Gain project experiences which can support the standardisation process (hardware, software and protocols)

Concretely speaking, these goals resulted in Siemens AG supporting the project partners particularly on the following themes:

- Interoperability of the AC charging infrastructure
- Testing of existing standards on charging plugs and of the interoperability of the communication between vehicle and charging station
- Security aspects during the charging process
- Users' behaviour and requisites for improvements
- Installation and testing of DC charging stations
- Integration of the infrastructure in backend systems.

2.1.2 CROME Associated Partners

During the project, the core Project Partners were supported by Associated Partners, mainly regional partners on both sides of the border.

On the **French side**, these were the **local administrative units:**

- Conseil Général de la Moselle,
- Communauté Urbaine de Strasbourg (CUS) and
- Région Alsace,

which launched the necessary public calls for tenders for the CROME dual-type charging stations and finally selected and awarded the provider of these stations.

On the **German side**, the Associated Partners were the **local energy suppliers**:

- E-Werk Mittelbaden,
- Stadtwerke Karlsruhe,
- Stadtwerke Baden-Baden,
- star.Energiewerke Rastatt.

These were contractors of EnBW. Together with them, EnBW installed and operated the interoperable CROME charging infrastructure along the Rhine.

EIFER

More than eight years ago, EDF and the University of Karlsruhe (now: Karlsruhe Institute of Technology, KIT) decided to establish a common research institute devoted to energy and the environment in Karlsruhe, called EIFER, European Institute for Energy Research.

EIFER is involved as a research partner in the Project CROME and works on the coordination between KIT and EDF R&D - ICAME as well as supports the research program on the French side.

The accompanying scientific research of CROME was driven by KIT and benefited from the support of EDF R&D - ICAME on both sides of the Rhine. Computer scientists, energy economists, automotive engineers, jurisprudents and electrical engineers have been working together in order to give responses to questions arising from different disciplinary origins. Notably, EDF R&D - ICAME contributed to the design of the questionnaires and has been in charge of the qualitative study, which was part of the acceptance analysis.

Further Partners were:

- **VDA -** Verband der Automobilindustrie (German Automotive Industry Association) and
- **deufrako**

  "DEUFRAKO is a technological-scientific cooperation in the field of transportation research between the German federal government research programme "Mobilität und Verkehrstechnologien" (mobility and transportation technologies), mainly conducted by the German Federal Ministry for Economy and Technology (BMWi) and Predit, the French counterpart to the German programme, which is jointly carried out by the French Ministry of Ecology, Research and Economy as well as the agency for energy management ADEME, the agency for innovation (OSEO innovation) and the national agency for research sponsoring (ANR)" (German original taken from http://deufrako.org/web/index.php ; own translation)

During the CROME project, the original group of Associated Partners has been enlarged to include **Toyota Europe SA** and **Nissan West Europe SAS**:

Toyota Motor Europe NV / SA

Toyota Motor Europe collaborated with EDF and CUS within the Kléber project (April 2010 to April 2013). The main objective of the Kléber project was to test 70 PHEVs Toyota Prius in a major city - Strasbourg (100 PHEV were tested in France out of the 200 PHEVs that were tested in 18 EU countries) where EDF deployed 145 charging stations (3KW, 16A, 230V) at home, companies' parking and on the curb side, among them 28 open to the public. On the other hand, this project was a first approach to French-German cross-border considerations and perspectives, EnBW tested 10 of the plug-in Prius on the German side, with a full compatibility and interoperability between vehicles and charging spots in France and Germany.

As stated in the *Storyline for Hardware Interoperability* (Part I - see chapter 5.1.1), the existing charging infrastructure available within the Kléber project was to a large extent maintained on both sides of the border, so that vehicles used in the project have access to an interoperable charging infrastructure on both side of the border.

Toyota's participation in the CROME project as Associated Partner was approved at the PMB meeting of 09.02.2012. By joining CROME, Toyota was interested to assess the compliancy of their present Kléber

PHEVs with the "mode 3" CROME infrastructure and to exchange on user's feedback between the two projects CROME and Kléber.

After an initial testing phase, some Prius PHEVs joined the CROME project and Toyota, together with CUS and EDF, agreed to the upgrade / retrofit (part of) the charging infrastructure used in the project Kléber according to the CROME specifications, i.e. replacing some of the 60309.2 sockets with E / F ("domestic") and mode 3 sockets, so as to enable charging for the CROME vehicles.

Nissan West Europe SAS

In Europe, Nissan West Europe SAS (Nissan) develops a fast charging infrastructure by offering free of charge to selected operators AC / DC fast charging stations. Nissan expects to deliver 400 fast charging stations The *Eastern France's Quick Charger Network ("Alsace Corridor Energétique")* project, which initially foresaw the deployment of six fast chargers in different cities all over the Alsace region, is part of this development (see chapter 5.2.2).

After deployment, the fast charging stations of the "Alsace Corridor Energétique" were connected to the CROME roaming platform, thus providing for all CROME users with compatible EVs an opportunity to charge at these stations.

In addition, Nissan has private users for its Nissan Leaf EV in Alsace, mainly located around Strasbourg. The involvement of Nissan enabled to involve some of them if the project and thus extend the target group of CROME users.

Nissan's participation in the CROME project as Associated Partner was approved at the PMB meeting of 12.07.2012.

Nissan installed in FRANCE more than 110 Quick Chargers and plans to expand this network in 2014.

2.2 CROME Funding Ministries

The CROME project has been a joint initiative of different **French and German Ministries**:

On the **French** side the partners EDF, Peugeot, IFSTTAR, Renault and Schneider-Electric have been and are funded by the ...

- ... *Ministry for Ecology, sustainable Development and Energy (Ministère de l'Ecologie, du Développement Durable et de l'Energie),*
- ... *Ministry of Industry (Ministère du Redressement Productif)* and
- ... *Ministry of Academic Education and Research (Ministère de l'Enseignement Supérieur et de la Recherche),*

Within the French funds "Investissement d'Avenir', managed by ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie).

On the **German** side the partners

- Daimler and KIT have been funded by the *Federal Ministry of Economics and Energy (Bundesministerium für Wirtschaft und Energie*), while the partners
- Bosch, EnBW, Porsche and Siemens by the *Federal Ministry of Transport and digital Infrastructure (Bundesministerium für Verkehr und digitale Infrastruktur).*

These Ministries have funded / are funding the project during its three-year-duration from January 2011 to December 2013 / 2014. This period represents the core project duration, as French and German partners had different project start and project end dates:

- for the German Partners CROME started in January 2011 (for some of them already in December 2010) and ended at the end of December 2013;
- the French Partners submitted their project application in March 2011. Therefore, the project officially started in April 2011 and ends on 24^{th} November 2014.

Independently from the project awarding, all partners started the content work in January 2011. Nevertheless, these different project durations triggered the French partners' request for a continuation of the fleet test and of its accompanying research – mainly the acceptance analysis, which will be continued by KIT and funded by *Federal Ministry of Economics and Energy* (see chapter 13).

3 CROME Roadmap

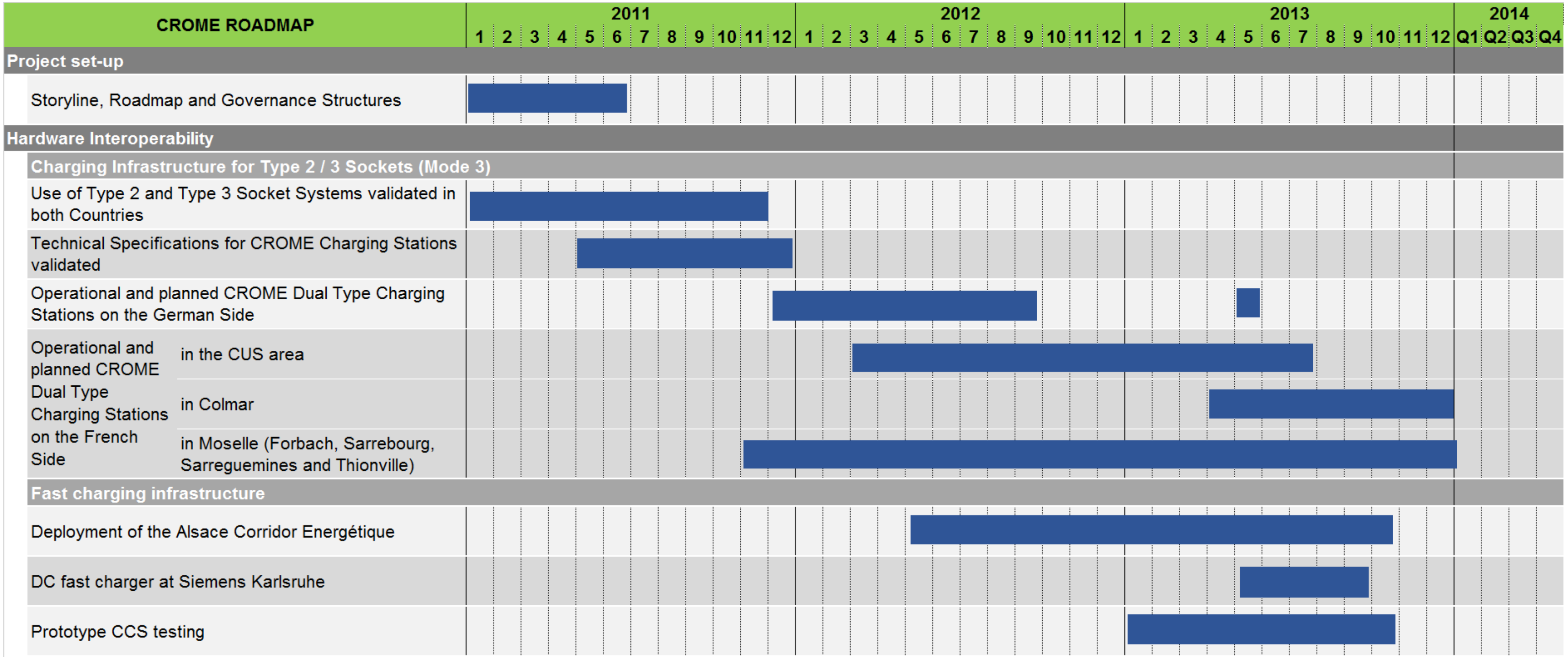
The following illustration gives a detailed overview over the project timeline for the core project duration from January 2011 to December 2013. As mentioned before, according to the different project starting and ending times the Project CROME itself is still running on the French side, whereas on the German side the accompanying research – mainly the acceptance analysis will be continued by KIT.

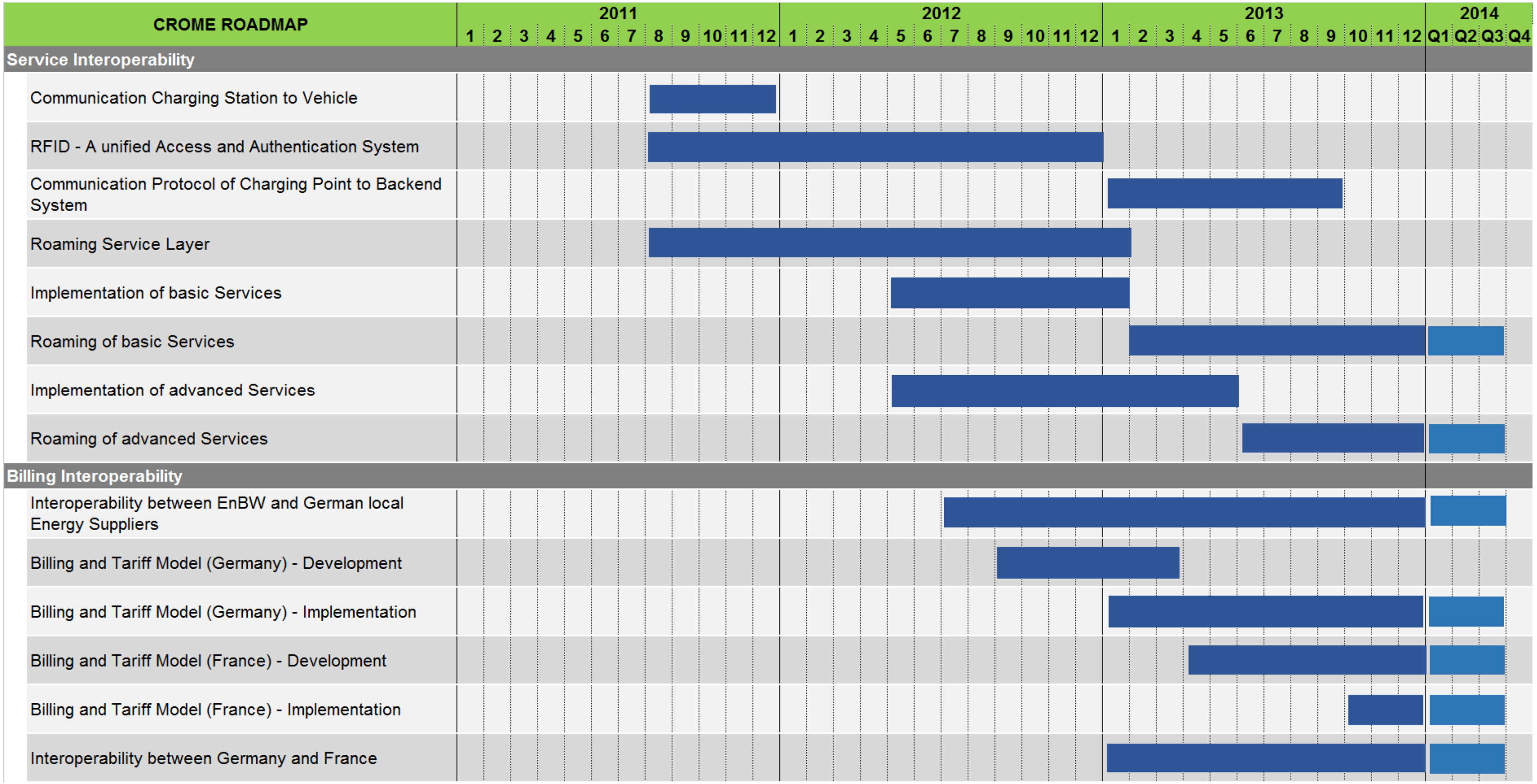
The timeline is segmented – to reflect the following chapters – into challenge, vision and objectives based on the common understanding of **interoperability**:

- *Hardware Interoperability*
  - *Public charging infrastructure for mode 3 charging*
  - *Fast charging infrastructure*
- *Services Interoperability*
- *Billing Interoperability*

After this section, the project activity *EVs in the Project* will be described in detail and the research block *Acceptance Analysis* will be depicted.

In the conclusive chapters 4 to 9 the project activities will be described in detail. Further contents complete the report.


CROME ROADMAP
2011
2012
2013
2014
1 2 3 4 5 6 7 8 9 10 11 12
Q1 Q2 Q3 Q4
Project set-up
Storyline, Roadmap and Governance Structures
Hardware Interoperability
Charging Infrastructure for Type 2 / 3 Sockets (Mode 3)
Use of Type 2 and Type 3 Socket Systems validated in both Countries
Technical Specifications for CROME Charging Stations validated
Operational and planned CROME Dual Type Charging Stations on the German Side
Operational and planned CROME Dual Type Charging Stations on the French Side
in the CUS area
in Colmar
in Moselle (Forbach, Sarrebourg, Sarreguemines and Thionville)
Fast charging infrastructure
Deployment of the Alsace Corridor Energétique
DC fast charger at Siemens Karlsruhe
Prototype CCS testing


CROME ROADMAP
2011
2012
2013
2014
1 2 3 4 5 6 7 8 9 10 11 12
Q1 Q2 Q3 Q4
Service Interoperability
Communication Charging Station to Vehicle
RFID - A unified Access and Authentication System
Communication Protocol of Charging Point to Backend System
Roaming Service Layer
Implementation of basic Services
Roaming of basic Services
Implementation of advanced Services
Roaming of advanced Services
Billing Interoperability
Interoperability between EnBW and German local Energy Suppliers
Billing and Tariff Model (Germany) - Development
Billing and Tariff Model (Germany) - Implementation
Billing and Tariff Model (France) - Development
Billing and Tariff Model (France) - Implementation
Interoperability between Germany and France

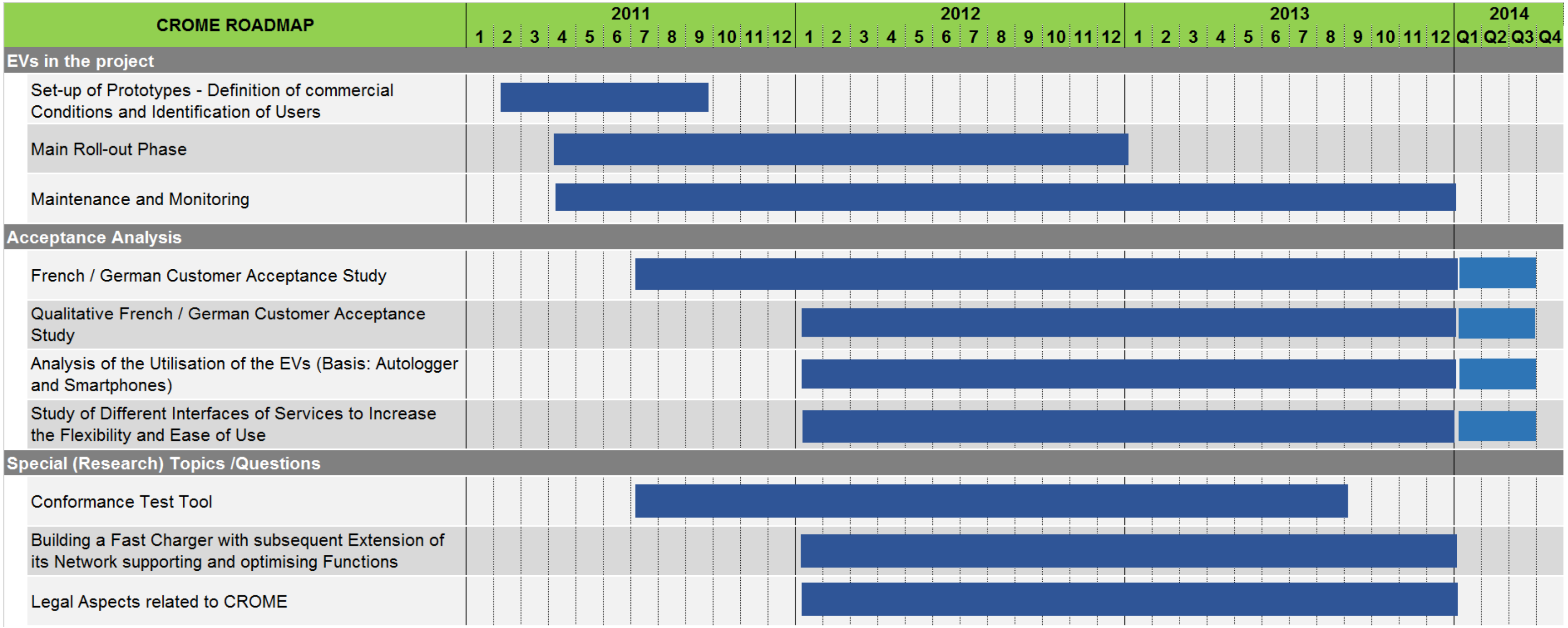


Fig. 3: CROME Roadmap – Overview

4 Interoperability – Common Understanding in CROME

One of the core issues of the CROME Project is ***interoperability***. In this respect, the partners started the project activities observing the different aspects of interoperability and defined the so-called CROME storylines for interoperability – as described in the following.

In general, the CROME project focuses on two main objectives:

- Every EV can connect to a charging spot (i.e. same socket system).
- Every user can authenticate (e.g. via RFID card) and control the charging process of his EV.

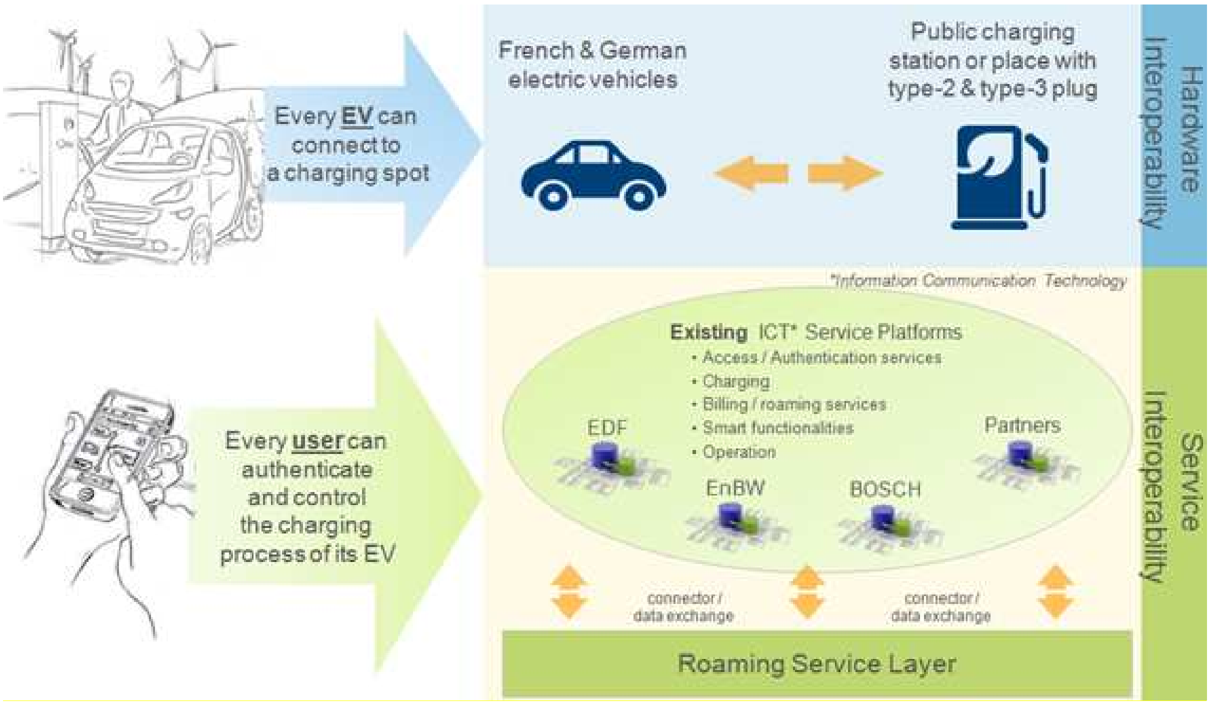


Fig. 4: Common Understanding of Interoperability in the CROME Project

According to the above figure the following aspects of interoperability are covered:

- Storyline – Part I focuses on hardware aspects of interoperability, i.e. charging modes and socket system.
- Storyline – Part II focuses on software & service aspects of interoperability, i.e. roaming, billing, charging, smart functionalities as well as operation.
- Storyline – Part III focuses on the specific issue of billing.

A specific issue is the topic fast charging. This is dealt with under Storyline - Part I.

Note: *The three storylines were developed and approved by all partners during the first project phase. They were not updated during the project and are reported in this document in their original form.*

5 Hardware Interoperability

5.1 Interoperable Public Charging Infrastructure

5.1.1 CROME Storyline for Interoperability (Part I)

A key objective of the CROME project is to experiment solutions that allow drivers to drive and connect their electric vehicles to charging spots throughout Europe. The goal is thus to provide users participating in the CROME experimental project with practical solutions for seamless eMobility between France and Germany and derive recommendations for European standardization from the project results.

The infrastructures deployed in France and Germany use different sockets for mode 3 charge (called respectively type 2 and type 3 sockets), and domestic charge (type E socket in France and type F ("Schuko") socket in Germany) on existing installations. One solution – not supporting interoperability on charging spots – would have been to provide users with at least one extra cord for cross-border mobility. Altogether, this would mean at least 3 different cords for every user, hence impacting customer convenience. The CROME project is looking for a less constraining solution for the users.

In a common binational adjustment process, a baseline scenario has been defined to offer a convenient solution in the scope of the field test.

Additional charging spots will be installed in public areas, at least 25 charging stations on each side of the border, with both type 2 and type 3 sockets at one charging place. They will allow for 3.5 kW charge up to 22 kW charge on both sides; these spots are to be called "dual type socket" spots. These at least 50 dual type socket charging stations will grant interoperability within CROME. The two sockets can mechanically be integrated into one charging station. But also solutions with satellite charging spots for type 2 or 3 charging could be taken into account. Thanks to the experimental nature of the CROME project it is expected to get a project-limited approval to use type 2 sockets (finger protection IPxxB) in France or type 3 (wire protection IPxxD) products in Germany. In case such an approval should not be obtained, the French and German partners will jointly look for a solution with the relevant authorities. The number of charging spots on each side will guarantee that drivers will always find a free public spot if they need to recharge on the other side of the border. The existing type E / F and / or IEC 60309-2 sockets, already deployed in France (the latter within the Kléber project) and Germany will be maintained as is. Also the IEC 60309-2 plug (finger protection IPxxB), which was adopted on the BOSCH charging spot of EnBW for the Kléber project will be taken into operation in Germany, so that vehicles currently used in the Kléber project (Prius PHEV) will still have an interoperable charging infrastructure, without any interruption on both side of the border.

From a driver perspective, using the infrastructure will be straightforward. Every vehicle will be delivered with a set of 2 cords: one cord for mode 2 charging on CEE 7 / 7 plug (which fits both in type E and F sockets) and one cord for mode 3 charging.

Mode 2 cord: The driver will be able to charge on existing charging spots equipped with domestic sockets when available and compliant with the safety regulations of France and Germany (upstream 30 mA RCD, earth protected, …) (e.g. MeRegioMobil) on the curbside, in parkings or even in homes or buildings.

Mode 3 cord: It comes with a type 2 plug in Germany or a type 3 plug in France; when travelling abroad, driver has to locate a "dual type socket" spot and plug on the right socket.

During the later CROME project phase 2 (as of 2012), these dual socket spots shall be retrofitted as needed to comply with any European standardisation decision which would have been taken by then.

5.1.2 Objectives

According to the *Storyline for Hardware Interoperability*, the major objective of CROME was:

- to install in public areas at least 25 additional charging stations on each side of the border,
- with both type 2 and type 3 sockets at one charging place, called "dual type socket" charging stations,
- allowing for 3.5 kW charge up to 22 kW charge and granting interoperability within CROME.

During the later CROME project phase 2 (as of 2012) it was foreseen to retrofit these dual socket spots as needed to comply with any European standardisation decision which would have been taken by then.

5.1.3 Achievements

a. Use of Type 2 and Type 3 Socket Systems Validated in Both Countries

The use of type 2 and type 3 Socket Systems has been validated in both countries:

Fig. 5: Type 2 Plug

By beginning of the project, the infrastructures deployed in France and Germany used different sockets for mode 3 charge (called respectively type 2 and type 3 sockets), which were not compatible with each other country's regulations:

- Type 2 sockets were not compliant with French regulation because of the absence of shutter,
- Type 3 sockets were not yet certified for a use in Germany.

Fig. 6: Type 3 Plug

In France, a specific design for including type 2 sockets (without shutter but with a locked flap released through RFID card authorization) in the dual mode charging spots was developed and submitted to the relevant certification organizations. The implementation in the public infrastructure for CROME of type 2 sockets without shutter in France has been formally approved by APAVE in October 2011, on the basis of the technical solution suggested, in the framework of CROME.

In Germany, EnBW and Bosch took the necessary steps in order to get the required certifications for the use of both type 2 and type sockets on EnBW CROME public charging stations.

b. Technical Specifications for CROME Charging Stations Validated

The technical specifications for CROME compatible charging stations have been validated.

A common *CROME Infrastructure Concept* has been defined by EDF and EnBW based on Storylines I, II and III:

➔ **The *CROME Charging Spots* will provide mode 3 sockets and some domestic (E / F, Schuko) ones.**

Fig. 7: CROME Dual Type Charging Station in France (Place du Schluthfeld, Strasbourg; left) and Germany (right)

The specifications for the mode 3 charging stations have been validated, addressing some of the gaps in the reference standard EN 61851-1 / 22. Additional specifications related to mode 3 charging for the public charging stations in France were agreed upon by PSA, Renault and Schneider-Electric. It was ensured that those additional specifications were not incompatible with the German EVs.

Together with the representatives of CUS a legal way has been elaborated in order to include the CROME specifications into a valid public call for tender. In Q4 2011 the final “upstream” technical specifications were delivered by EDF to CUS (open-to-the public charging infrastructures) and Conseil Général de la Moselle (B2C, B2B and open-to-the public charging infrastructures) in order to launch public calls for tenders when needed or to give these requirements to customers. This developed public call has been used also as a basis for the own ones by other institutions (e.g. Colmar City) and deals as a good blueprint for future call for tenders within Europe.

In Germany no call for tender is requested as EnBW is the owner of the public charging infrastructure and no contribution for investment is paid by customers.

c. Operational and Planned CROME Dual Type Charging Stations

The following CROME dual type charging stations are operational and planned in the project territory:

- **on the German Side**

Fig. 8: CROME Dual Type Charging Station (Kehl)

The timeline for the roll-out of the infrastructure in Germany foresaw 25 new charging stations equipped each with a type 2, a type 3 and an E / F domestic socket to be implemented by the end of 2011.

The delivery of the 25 charging stations by Bosch to EnBW started by mid of November and was successfully completed by beginning of December 2011.

Already by the end of January 2012, 13 charging stations had been installed. By September 2012, 24 charging stations had been installed and were in operation.

The last pending charging station, which was kept in EnBW's premises for test purposes has been installed end of May 2013 nearby the Europa Park in Rust.

- **on the French Side**

In Alsace as well as in Moselle, the specificity of the French business model for the deployment of the charging infrastructure, i.e. the purchase of the charging stations by local authorities via public tenders, as well as the delay in the delivery of the technical specifications for the CROME dual type charging stations, generated delays for the implementation of the CROME charging stations.

There are consequently 22 CROME charging stations installed and 17 in operation by the end of 2013 and over 20 still to be ordered or installed.

… in Alsace - *CUS (Strasbourg) Area*

The public call for tender for 8 brandnew CROME dual-type charging stations was launched by CUS by 9th March 2012. The selection of the provider had started by mid-April and has been concluded by mid of July 2012 and the awarding procedure launched by end of July. The delivery of the charging stations was expected in October 2012. 6 were in operation by end 2012, all 8 by end of January 2013.

Fig. 9: CROME Dual Type Charging Station (Place du Schluthfeld, Strasbourg)

In parallel, the retrofit of some Kléber project's public charging spots in open to the public areas towards CROME compliant ones had also been decided with CUS, EDF and Toyota. CUS initiated the retrofitting of 3 Kléber charging stations installed on the curbside to the CROME standard. The first one was in operation by September 2012, 2 additional ones by the end of July 2013.

By the end of June 2012 9 underground Kléber charging places had been additionally retrofitted with E / F sockets compatible with French and German EVs for charging in mode 2 with a CROME compliant customer access and supervision system.

… in Alsace - *Colmar Area*

The city of Colmar has completed its – initially not included in the project outline - call for tender and selected a provider for 5 CROME charging stations, which are now installed and expected to be in operation soon.

… in Moselle: Areas of Forbach, Sarrebourg, Sarreguemines and Thionville

The first dual-type charging station was available by the end of November 2011. By the end of 2012 there were 3 CROME charging station in operation, 5 by the end of April 2013. Five additional ones are still expected.

The following table provides an overview of the CROME compliant charging stations implemented in the project area by the end of December 2013:

Territory	Number of CROME public charging stations (charging spots) in operation	Number of planned additional CROME charging stations
German side[2]	25 (50)	Objective achieved
French side - Alsace		
• CUS[3]	11 (22)	7 (14, tbd)
• Colmar	5 (10)	
French side - Moselle[4]	6 (12)	5 (10)
Total	**47 (94)**	**12 (24)**

Fig. 10: Operational and Planned Dual Type Charging Stations in the Project Territory

2 See in detail: A - Fig. 1: Overview of the CROME Compliant Charging Stations on the German Side; p. 86.
3 See in detail: A - Fig. 2: Overview of the CROME Compliant Charging Stations in the CUS Area; p. 87.
4 See in detail: A - Fig. 3: Overview of the CROME Compliant Charging Stations in Moselle; p. 88.

Detailed information on the location and characteristics of the CROME charging stations are available in the annex.

The following map provides an overview of the geographical allocation of the new CROME charging stations:

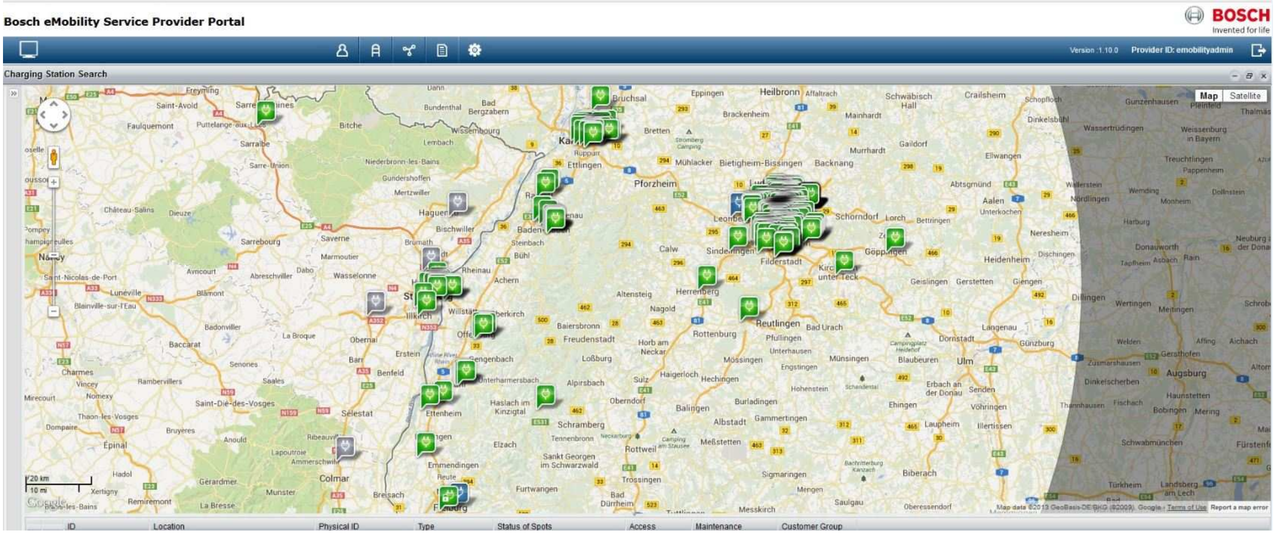


Fig. 11: Geographical Allocation of the new CROME Charging Stations

Further charging stations, although not “dual type”, are accessible to the CROME users and provide more charging possibilities on both sides of the border, mainly in Karlsruhe (25 charging stations in the Stadtwerke Karlsruhe area), the CUS area (9 charging stations retrofitted from projet Kléber) and in Moselle (12 charging stations).

d. Retroffiting to the European Standard

By the beginning of the project, the partners acknowledged that a decision on a common standard about the mode 3 socket-outlet was in preparation at European level. They agreed that if such a decision was made during the timing of CROME, they should apply it and possibly retrofit existing dual-type charging stations if required by the decision.

In the beginning of the project the situation was unclear as only very few mode 3 charging stations were in place. In 2012, the European situation split mainly in two parts. In France and Italy most mode 3 charging stations are equipped with Type 3 sockets, whereas in most other countries the Type 2 socket had been installed. Only some countries were still undecided.

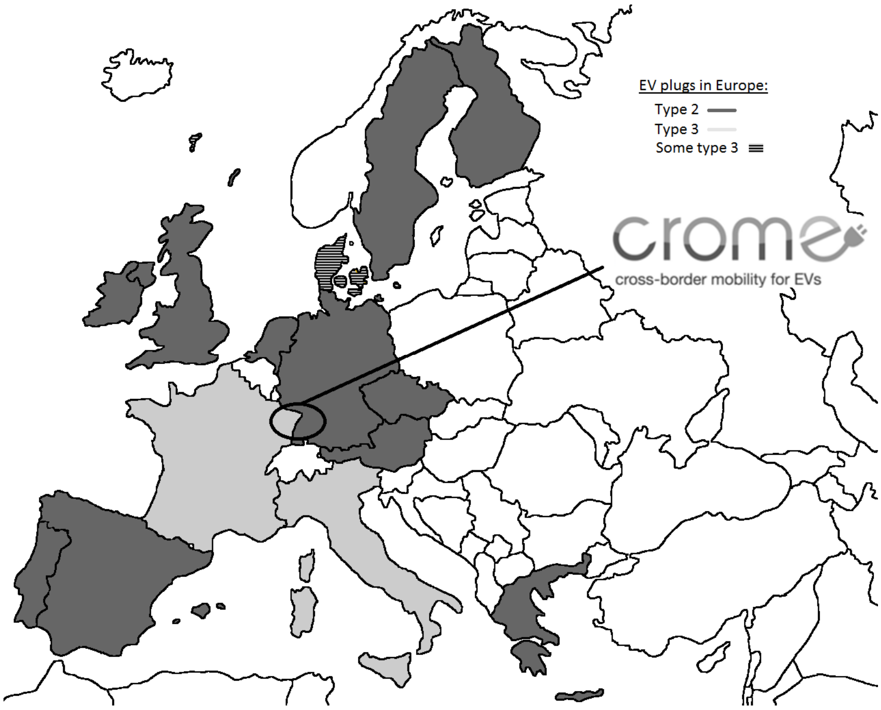


Fig. 12: EV Plug Types in Europe

(based on sources: LeGoy, Buckley 2012[5], van den Bossche et al. 2012[6], Theisen et al. 2012[7])

The European Commission effectively issued a draft Directive on the deployment of alternative fuels infrastructure on January 24th 2013, in which it announced that “Type 2” would be the selected standard. At the time of this CROME report, the Directive is in discussion between Commission, Parliament and Council; in its present writing, the Directive would not require to retrofit existing installations; hence, CROME will not need to retrofit its charging points.

5 LeGoy, P. R., Buckley, G. (2012): Low Voltage Grid Connections for Electric Vehicle Infrastructure in Europe, IEEE Power Engineering Society General Meeting, San Diego, CA.

6 Van den Bossche, Peter; Noshin, Omar; van Mierlo, Joeri (Eds.) (2012): A tale of three plugs: Infrastructure Standardization in Europe. EVS26, 06.05.2012 - 09.05.2012. Los Angeles.

7 Theisen, T., Marques, R. F. (2012): Facilitating e-mobility: EURELECTRIC views on charging infrastructure. Brussels.

5.1.4 Lessons Learned

- ***Interoperability is Technically Feasible – Both Type 2 and Type 3 Plugs / Sockets (Technology Fully Functioning)***

  The project has demonstrated that interoperability is feasible based on the existing technologies on both sides of the border:

  It has been demonstrated in the CROME Project that both the type 2 and type 3 plugs / sockets can be implemented in one charging station according to the regulatory constraints on each side of the border in a way that easy retrofitting is ensured. Both types enables successfully charging of the EVs in the project. The initial objectives of the project were consequently achieved.

  However, although technically feasible, this solution does not appear meaningful on the long term. In order to reduce the costs for the deployment of the infrastructure, the complexity of hardware, and increase the user acceptance, the CROME partners recommend an agreement at European level on one standard type of plug. In expectation of a European standard, the CROME partners recommend the deployment of charging stations which can be easily retrofitted if decided by the infrastructure owner,, so that the costs for the adaptation to a future standard remain as low as possible. As developed above however the to-be-voted Directive should not require to retrofit existing installations.

- ***Length of Process (DE, FR): Call for Tender, Decision on Location, …***

  The process for the rollout of public charging infrastructure worked differently in France and Germany:

  - In France, the public charging infrastructure has been mainly bought and owned by local authorities in accordance with their managing role in the local transportation organisation, which need to go through public call for tenders and take into account the corresponding legal constraints.
  - In Germany, the CROME charging stations are owned by EnBW, which discussed together with the respective municipalities and local energy suppliers the suitable locations for the CROME charging stations.

  Thanks to the development of common specifications for charging in mode 3 for public charging stations and the preparation of an initial call for tender together with CUS, CROME contributed to simplify the process in France. The CROME terms of reference for the charging infrastructure have already been adopted by further border regions in France, e.g. Pas-de-Calais.

  As a feedback roughly 9 months as a minimum are required from the specification definition to the start of operation in the street due the official constraints of the public tender regulation.

➔ **European wide standards for the further development of eMobility is crucial.**

5.2 Fast Charging

5.2.1 Context and Situation in CROME

Although likely to cover less than 5 to 10 % of the charging use cases fast charging is expected as necessary in some dedicated places for EV "customer reassurance" and specific needs. Nevertheless fast charging represents a great opportunity to extend EV's local territorial field when judiciously implemented in highways network or regional corridors for example.

Up to now, no unique solution is selected by EV carmakers for fast charging equipments. DC mode is the present choice for brand-new commercialised EVs with an external charger (eg. IMieV, Ion, C0, Leaf with CHAdeMO protocol) and future Europeans EVs (with CCS protocol, see ACEA Position Paper on EVs standardization, Sep. 14th 2011). But some European carmakers target 3-phase AC charging with on board chargers for EVs to be commercialised by the months or years to come (e.g. ZOE Renault as of October 2012 …).

As EVs with different fast charging modes are likely to be on road for the next decade, DC and AC fast charging should also stay actual alternative solutions.

Situation in CROME

Fast charging was also part of the CROME experimentation, but only to a minor extent and different expectations and understandings on both sides of the border.

The partners agreed on the following activities:

- On the French side, several DC CHAdeMO / AC triphase charging stations were implemented in order to support a field test on a regional corridor.
- In order to allow a cross-border field test, on the German side one DC CHAdeMO charging station has to be installed, so as to enable fast charging for the PSA, Renault and Nissan EVs in the project.
- Implement / test OCPP for connecting a charging station to the backend
- CROME does not promote any specific fast charging protocol.
- Daimler and Siemens tested communication according to ISO / IEC 15118 with CCS type 2 plug (using a smart ed prototype with DC fast charger and a Siemens prototype DC lab charger).

The partners explored especially thoroughly the necessary steps as well as concrete scenarios / options for making a field test on fast charging possible in CROME with the following objectives:

- Enable **EVs tested in CROME** to be fast charged (DC mode 4 / AC, …)
- Test and study **customer acceptance** and needs about fast charging of EVs and related services

5.2.2 Achievements

France

The *Eastern France's Quick Charger Network* (*"Alsace Corridor Energétique")* involving the partners Nissan, DBT-CEV, Alsace Regional Council, Sodetrel (EDF subsidiary) and Cora hypermarket chain allows fast charging within the whole Alsace Region (8.280 km²). The Cora markets are ideally located in the region, so most of Alsace inhabitants will indeed be no further than 40 km from a Fast Charger, no matter where they are in the Alsace Region.

Six AC / DC Fast Chargers have been installed in the following participating cities - Haguenau, Strasbourg, Illkirch-Graffenstaden, Colmar, Mulhouse in Alsace and another one in Sarrebourg (Moselle Department) and are operational since November 2012 creating an eMobillity corridor along the major regional roads ..

The stations are operated by Sodetrel and are connected to the CROME roaming layer; they are visible on the CROME App for the location of charging stations and accessible to the CROME users with their RFID cards.

Fig. 13: *Eastern France's Quick Charger Network*

After one year of operation a first feedback shows 3.5 charges a day for each station (4 studied sites). Charging is free of charge up to now. Introduction of a tariff is currently being studied.

An extension of the *"Alsace Corridor Energétique"* on the Moselle territory is currently under planning: four additional AC / DC Fast Chargers are expected to be installed in St-Avold, Metz-Borny, Metz-Moulins and Mondelange, close to the border of Luxemburg.

Germany

By the end 2012 Siemens provided a CHAdeMO fast charging station using the OCPP communication protocol. In addition Bosch agreed to provide an OCPP interface for charge spots to integrate the Siemens Fast-Charger in the CROME network.

In the meantime different on-site checks of potential sites at Michelin and KIT, as well as Siemens Karlsruhe took place with respect to the technical feasibility and the related costs. Finally mid of December 2012 the location Siemens Karlsruhe was chosen, because at that time they were looking for a Fast Charger in the context of the RheinMobil project, which started on January 1st 2013. In this project context Siemens is deploying an EV fleet in the framework of RheinMobil, and was interested in using the Siemens fast charging stations available in CROME.

The fast charger was installed on the premises of Siemens Karlsruhe by May 2013 and connected to the CROME roaming layer via an additional instance of Bosch eMobility Charging Services using the OCPP communication protocol as of June 2013. It is accessible to the CROME users via their RFID-cards.

5.2.3 Lessons Learned

- ***Fast Charging is used and meet EV Customer Needs***
- ***eMobility Corridors are an appropriate Pattern in order to structure Territories***
- ***Interoperable and Multistandard Fast Charging Facilities are required in order to Fast Charge the different EV Types on the Market***
- ***CCS Charging and High Level Communication according to ISO / IEC 15118 work properly***

To keep up with the development on the eMobility market in Europe, charging using the new CCS plug and communication according to ISO / IEC 15118 should be analysed and tested within the CROME project. Therefore tests with the prototypes of a Siemens DC-Lab-Charger and a Daimler Smart ED with DC charging feature have been started in April 2013. Main focus of these tests was to set up, analyse and verify the communication between EV and EVSE according to DIN Spec. 70121 (as ISO / IEC 15118 is not normative at the moment).

It was proved that CCS-Charging and high level communication according to ISO / IEC 15118 works properly. Some open points within the standard (sometimes there´s still room for interpretation) were identified and will be forwarded to the responsible standardization committees.

6 Service Interoperability

6.1 CROME Storyline for Service Interoperability (Part II)

Objectives

Primary objective and critical success factor of the CROME project is that every field test participant can authenticate and control his charging process individually, regardless of the charging station and / or EV.

The project will test several service interoperability scenarios based on the following objectives:

- Unified access and authentication concepts based on proofed systems like RFID, NFC….
- Cross border billing and roaming concepts based on different payment methods.
- Cross border smart charging concepts (lean against ISO / IEC 15118, communication via PLC…).
- Infrastructure management concepts to control & monitor the charging infrastructure.
- Unified ICT based connectors for data exchange between the partners. Basis for this concept is a unified roaming service layer which will be provide by the partners Bosch, EDF and others.
- Several smart functionalities (charging spot map, route optimizing, charging spot reservation…).
- Giving recommendations for unified service interoperability concepts.

Current Situation

On the French side EDF is currently running the Kléber project (up to 100 Toyota Prius Plug-In). In this project EDF is testing a charging spot access concept via RFID. Smart charging is planned but not in place. EDF also is running an ICT-based infrastructure management concept to control and monitor all relevant aspect of their charging infrastructure. Furthermore there is no billing service implemented: as of now the charging service is free of charge on the curbside; in parking lots open to the public, the charging service is included in the parking fee.

(Remark: The Kléber project ended in April 2013)

On the German side the MeRegioMobil project is testing some ICT based eMobility services. EnBW implemented a billing concept for the EV, which will be tested with up to 40 smart ed field test participants. Roaming will be tested with the partner Stadtwerke Karlsruhe. Some special equipped EVs have a bidirectional charger where the V2G concept will be tested (test at KIT Demolab).

(Remark: The MeRegioMobil ended in December 2011.)

On both sides a variety of specific services, fitting to the respective projects have been developed. Also several services especially for the vehicle have been developed by the OEMs.

Approach

- **Main Activities 2011 (Project Phase One)**

The existing user groups (participants of CROME, MeRegioMobil and Kléber project) are already equipped with RFID cards and will be granted access for all existing charging spots in Kléber project, MeRegioMobil and CROME. The currently used concepts for infrastructure management, billing, roaming and the established eMobility services will be used side-by-side. In parallel the concepts for the phase two will be established.

- **Main Activities 2012 and 2013 (Project Phase Two)**

In project phase two a unified authentication concept has been introduced and will be tested. It has been decided that the primary authentication will be enabled with the use of RFID cards. The RFID cards are deployed to EDF and EnBW / local energy suppliers customers. The EDF and EnBW differences of the MIFARE card types in use have been accounted for and either card type is now supported. In addition, a second authentication method using a mobile application is currently being discussed and different solutions will be evaluated.[8]

Also in the second project phase a cross border billing / roaming concept will be tested, based on different payment methods.

Smart functionalities for charging will be tested (leaning against IEC / ISO 15118 standard). Additional smart functionalities like charging spot map or route optimizing will be developed and tested. All of these services will be realised through the roaming service layer. The partners commit to a common service layer framework with standardised ICT protocols and connectors. Therefore a unified data connector protocol will be developed by Bosch, EDF and other potential partners through which the partners can connect their IT systems to the roaming service layer.

6.2 Objectives

According to the Storyline for Service Interoperability, the major objectives of CROME were to develop and implement:

- a unified authentication concept, enabling all CROME users to access to the public charging infrastructure;
- a roaming concept and a common service layer framework enabling delivery and roaming of services across operators and borders;
- smart functionalities / services for charging.

8 This paragraph of the storyline has been modified. The former version was:

"In project phase two a unified authentication concept will be introduced and tested, right now it is open to discussion if this will be realised by RFID, NFC or other access concepts. Also in the second project phase a cross border billing / roaming concept will be tested, based on different payment methods."

6.3 *Achievements / Implementation*

6.3.1 Communication Charging Station to Vehicle

The specifications for the mode 3 charging stations have been validated by the partners, addressing some of the gaps in the reference standard EN 61851-1 / 22. In Germany the control-software of the charging spots has been reviewed to avoid malfunction related to the gaps in the standard. A common extra specification for charging in mode 3 has been defined for the (3 kVA and 0 / 22 kVA) charging stations in France, taking into account the OEM's requests. Together with the representatives of CUS a legal way has been elaborated in order to include the CROME specifications into a valid public call for tender, so that the specifications for the CROME charging infrastructure could be completed. End of 2011 the final specifications were delivered by EDF to CUS and Conseil Général de Moselle. These have been integrated in the requirements for the respective public calls for tenders.

As a result of the described activities the CROME project mode 3 charging can now be considered as ensuring an interoperable charging possibility. All the tested BEVs / PHEVs from the partners can successfully connect and run a mode3 charging process with the CROME charging infrastructures.

6.3.2 RFID - A unified Access and Authentication System

- **Technical Aspects**

For the purpose of the project it was agreed to use the unique ID (U-ID) of the RFID card for the identification of the customer. The U-ID is a code on the RFID card that is unique for the card, no second RFID card with this code does exist. This is valid although different RFID standards exist. Nevertheless, an interoperability test of Siemens, EDF, Bosch and EnBW with CROME RFID cards showed that some chargers need an update of their firmware to be able to read the U-ID. After the implementation all cards could finally be read.

For the start it was agreed that the partners exchange lists of the valid U-ID of their customers (white list). These lists were then added to the white lists of the corresponding electro mobility solutions of the partners EnBW and EDF. This approach has to deal with many drawbacks. A full bilateral exchange of whitelists between related organisations within Europe is not realistic (e.g. exchange of the list between a small German utility (Stadtwerke) and a municipality in Portugal). It will always be a nonexistent synchronicity between the partner whitelists and a difficulty of banning users coincident at all partners. Even a central European whitelist solution would be in contradiction to the principle of minimized data storage. With the introduction of the roaming layer the authorization is verified automatically to avoid the limitations of a white list exchange.

The limitation of this approach is the insufficient security of the unique ID. This ID can easily be read. The creation of cards with a copied unique ID must be considered as technically possible. Furthermore with the further introduction of NFC (near field communication) this will probably be possible by a software download. But the partners considered this limitation as acceptable for the purpose of the project, as the numbers of partners as well as customers that are part of the experiment as well as the related financial risks are limited.

Further authentication methods such as SMS charging, NFC, QR-Codes and App have been evaluated but not selected for an implementation within CROME. The implementation of the necessary remote operation functionalities on the charging spot is technically feasible but cost intensive.

- **Delivery of the RFID Cards to the Users / Clients**

EnBW and the local energy suppliers have distributed RFID cards to their customers in Germany.

On behalf of the French local authorities, which own of the public CROME charging infrastructures EDF / Sodetrel is in charge of the business operation of the public charging stations. In this framework EDF / Sodetrel has been delivering more than 150 CROME RFID cards to private customers. Previous “Kléber” cards are also accepted by the brandnew CROME stations.

For more information, see chapter 7 billing interoperability

6.3.3 Backend Connection

a. Communication Protocol of Charging Point to Backend System

Up-to now, proprietary communication protocols are usually implemented at charging points and backend systems. EDF, EnBW and Bosch use for instance such proprietary communication protocols on the charging stations. Connecting different charging points and backends using such proprietary protocols in a common system can result in a lot of efforts, time and costs. On the other hand, such protocols present the advantage, compared to non-proprietary protocols, to integrate elaborated functionalities with respect to maintenance, service and billing.

As Open Charge Point Protocol (OCPP) has been introduced and was becoming more and more a de-facto standard, it was decided to evaluate and test it in CROME.

The testing consisted mainly in establishing an OCPP V1.2 based connection between the Bosch eMobility Charging Services backend and a DC-Charger provided by Siemens and located at Siemens’ premises in Karlsruhe. The connection was realised successfully in June 2013. Charging tests were realised. Within OCPP it is not defined how a secure communication between the charging spot and the backend system can be established.

The problem with such a connection lies in the fact that the communication layer is not defined. While first connecting the Siemens fast charger to the Bosch backend, it was noticed that Siemens grants a secure communication by using a closed range of numbers supplied by the telecommunication provider while Bosch uses an open range of numbers but uses a certificate-based encrypted communication. Both procedures are effective, but they are not compatible to each other.

For the integration in the CROME system Bosch and Siemens have developed a sufficiently secure workaround without adapting the charge-spot or the backend software.

b. Roaming Service Layer

- **An Interoperable Roaming / Service Layer was successfully taken in Operation**

To realise the interoperable eMobility services within the CROME project the partners have agreed to create a dynamic network of independent international partners, which maintain their autonomous business and systems. Thus roaming can accelerate the development of Ecosystems by providing a brokering platform to connect services between partners individually (marketplace) without being a bottleneck for the individual further development. The partners can extend their service portfolio to the benefit of the end customers. Smaller partners can instead of developing their own system be integrated in the system of another partner.

This leads to the following main design principles for the connection of the independent systems:

- Each partner can operate and develop his system independently; he is still master of his business (B2C) and data.
- Minimised data storage on roaming service platform (B2B); focus on transaction brokering with high transaction rates and workflow management.
- Partners can negotiate different roaming frameworks / agreements with different partners within the roaming service platform, doing business with high flexibility.

Based on this the overall system integration architecture has been defined.

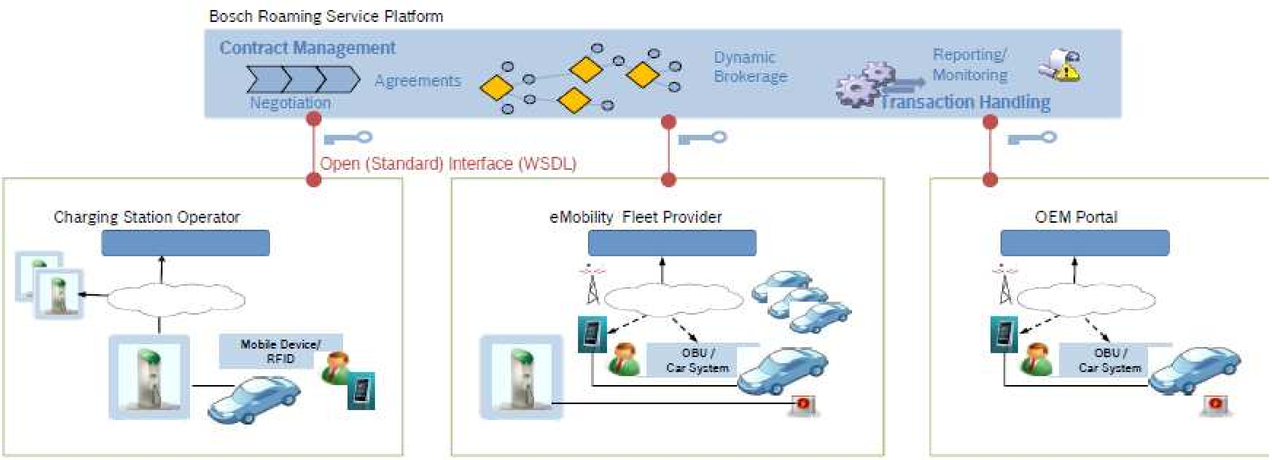


Fig. 14: Bosch Roaming Concept

The **contracting component** is used to manage contracts for services between the different partners connected to the roaming system. E.g. an Electric Vehicle Supply Equipment (EVSE) can offer his charging spots, he can require a specific price, restrict the offer to specific partners or for a period in time. An Electric Vehicle Service Provider (EVSP) can agree to the offer, thus use the service and provide it to his customers.

The figure below shows a screen shot of the contracting component. In this screen a partner can manage his offers.

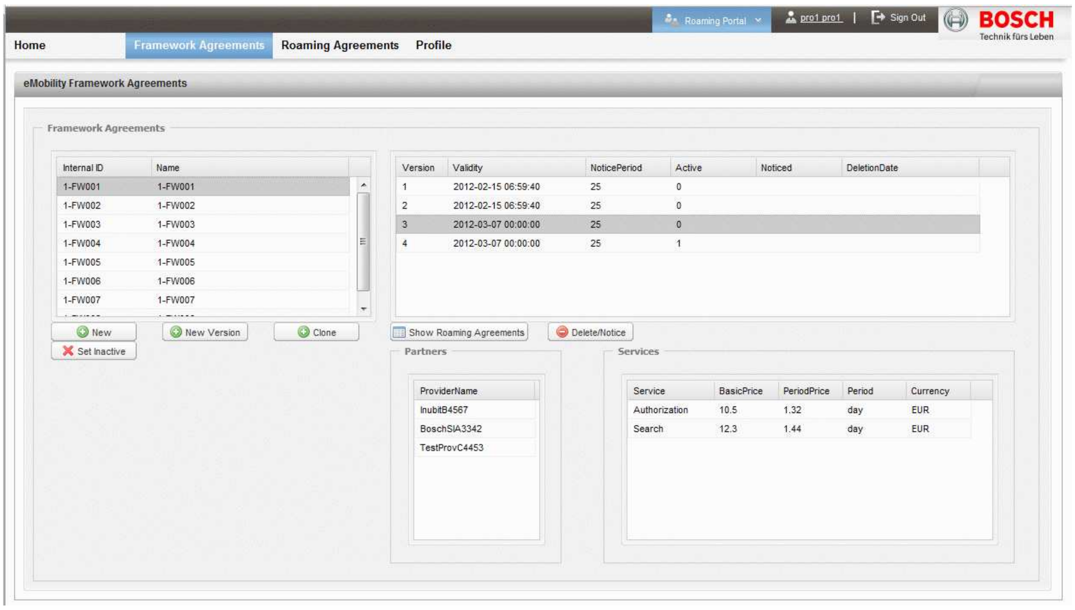


Fig. 15: Roaming System - Contracting Component

In the routing component the services request are forwarded from one partner to the other corresponding to the agreed contracts. Moreover the interactions are monitored and documented (see Figure below). This can be used for a contractual clearing of the provided services.

To provide the interoperable services a common specification of the interfaces between Bosch, EDF / Sodetrel, EnBW and Siemens was required. For the basic services a corresponding specification has been aligned including the Web Service Description Language (WSDL) description.

Bosch provided a roaming system that connects the backend-systems of EnBW, EDF / Sodetrel,and Bosch (Porsche, Siemens). This roaming system consists of two main parts, a contracting and a routing component.

The productive EDF / Sodetrel and EnBW backend systems have been successfully connected to the Bosch CROME Roaming Layer since January 2013.

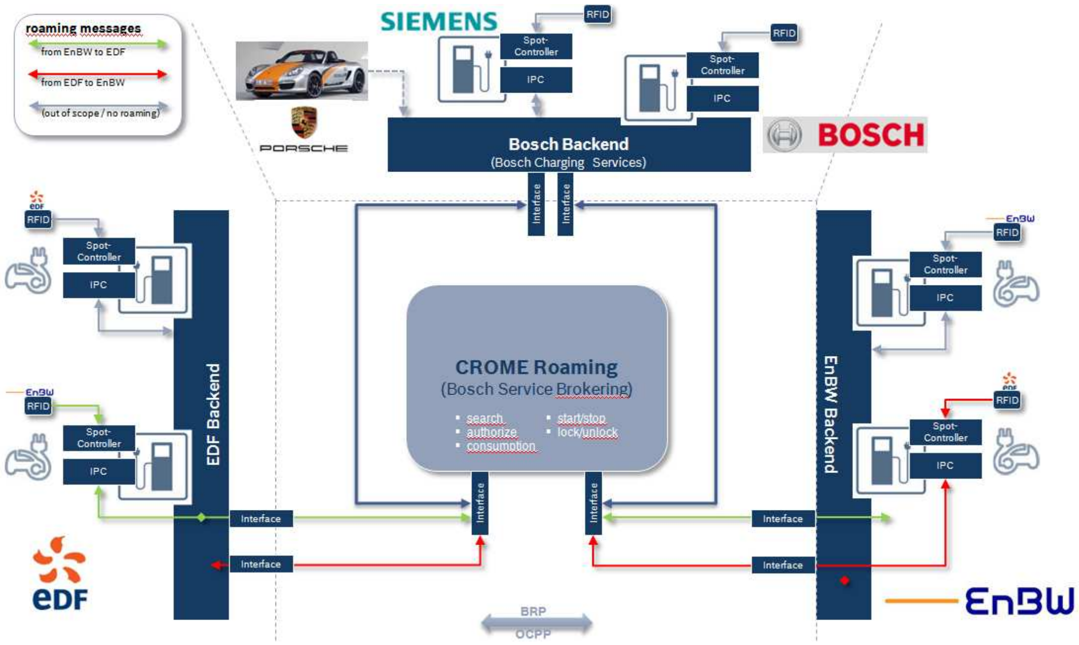


Fig. 16: CROME Roaming Layer Architecture

The overall software system contains the different backend systems of the involved partners and the roaming system that connects the backend solutions. The system is open for all possible participants using an EV, users of the CROME EV and all other existing and future EV owners.

In cooperation with the Green eMotion (GeM) project Bosch connects the CROME roaming layer to the GeM-system provided by IBM. Main differences of the interfaces are that CROME addresses charging stations (typically with two charge spots) and GeM addresses directly charging spots. Moreover GeM has a different session handling concept. The OICP interface (Open Intercharge Protocol) that is used within Hubject uses a similar concept as GeM. For the connection of the CROME roaming layer to the GeM-system Bosch has developed an extension to its system. This connection will be used to interconnect EDF / Sodetrel to GeM as soon as the corresponding GeM-Systems are productive.

c. Implementation and Roaming of (Basic) Services

The following basic services have been implemented:

- Search, including mobile App
- authorization
- consumption

The specified basic services have been implemented on the central Bosch roaming system. Also, the basic services, except for the remote operation functions, have been implemented within the EDF / Sodetrel and EnBW backend systems. The remote operations, Start / Stop Charging and Lock / Unlock Charging Station will not be implemented within the EnBW backend but in the EDF / Sodetrel one. This is due to the implementation within the control unit (IPC) of the EnBW charging stations not enabling such services.

- **Search, including mobile App**

The roaming layer allows sending position and availability queries from the backend to the charging station. The results of the query can be visualised in the different systems and output media (web interface, Smartphone-App) delivered by EnBW, EDF / Sodetrel and Bosch. The information can be updated on regular intervals or live on request.

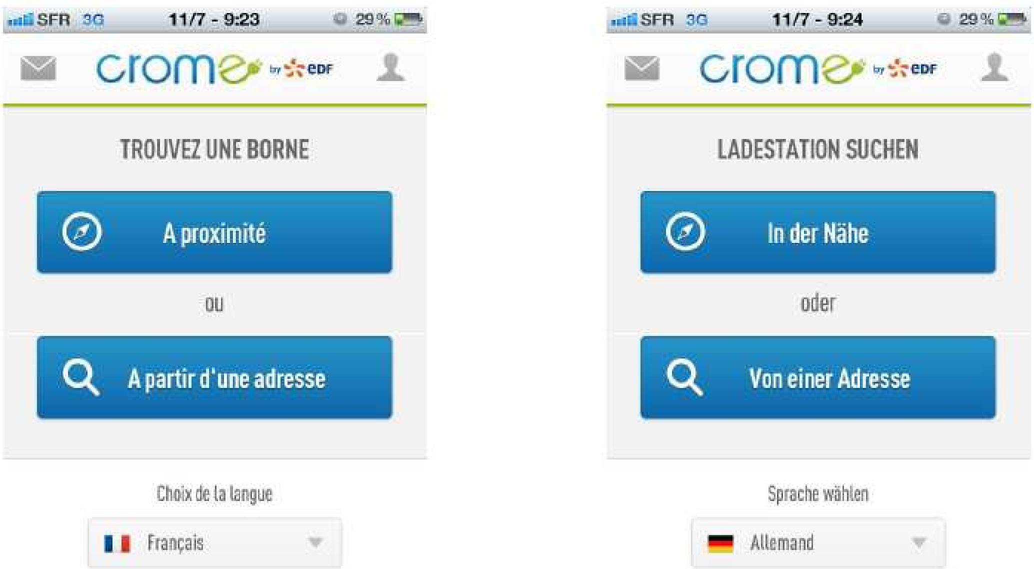


Fig. 17: EDF - CROME Mobile App

- **Authorisation (see RFID)**

For the purpose of authentication, the U-ID of the user‘s RFID-card is transferred from the charging station to the backend of station operator. In case the station is operated by the same operator providing the eMobility services to the user, an authorisation can be carried out directly. Otherwise, the charging station backend checks the identity and access rights of the user through the roaming layer before giving the authorisation. This process takes a fraction of a second to be carried out, without the user taking notice.

- **Consumption**

At the end of the charging process, all information needed for billing is exchanged between the relevant backends (for instance between EDF / Sodetrel and EnBW in case of a EnBW client charging at a station operated by EDF / Sodetrel).

d. Implementation and Roaming of (advanced) Services

The following advanced services were developed and implemented to the extent of the given legal possibilities:

- Availability / Reservation
- Billing (see Storyline III – billing interoperability)
- Fleet services

- **Reservation**

The value added service “reservation” has already been implemented in the Bosch backend system and the roaming layer. Due to the fact that a reservation of a charge spot can not guarantee the availability of the corresponding parking lot it has been decided in the project that this functionality will not be provided to the end user to avoid user-dissatisfaction.

- **Fleet Services**

Functional prototype

The goal of the development of fleet services was to provide an integrated view on vehicle and chargespot information. This view should be available inside the vehicle, on a mobile device of the driver as well as for the fleet operator. To demonstrate the functionality Bosch and Porsche specified and implemented a functional prototype based on a tablet application (see Fig.17). The advantage of this solution was that it could be used in the vehicle as well as mobile device, without changes in the vehicle hmi-system (human machine interface).

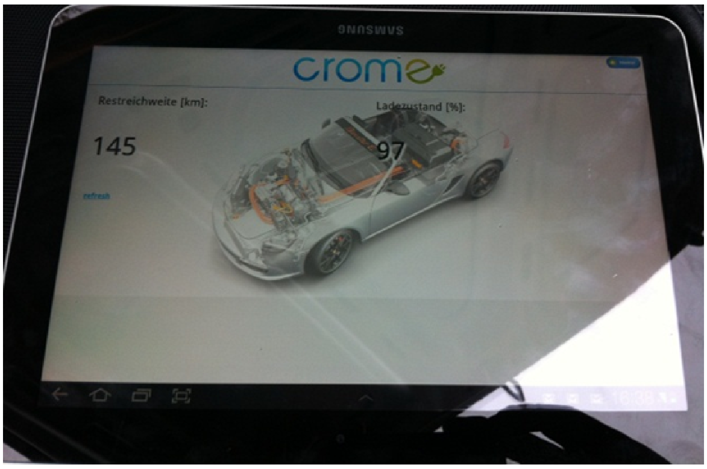


Fig. 18: Porsche in-Vehicle Roaming

For the purpose of the functional prototype the vehicle data was transferred via a hardware unit connected to the vehicle and GSM to a Bosch server. The server was able to buffer the data of one vehicle and send it to the tablet application.

Based on the experience made with the functional prototype it was shown that an integrated view of vehicle and chargepoint information is a valid service for drivers and fleet managers.

Multi Vehicle Services

With the Bosch (e)Mobility Fleet Services, EV Data of several fleet vehicles can be evaluated; driver- and vehicle-statistics can be created. For example consumption information can be compared, maintenances planned and vehicles can be reserved flexibly. To extend the functional prototype to a connected fleet service, Bosch replaced the vehicle data server that could handle only information of one vehicle by its Bosch (e)Mobility Fleet Services solution.

It was necessary to develop a communication between the vehicle and the Bosch (e)Mobility Fleet Services backend to achieve a connected service. Therefore, Bosch needed to ensure the prerequisites for the communication between the vehicle and the Bosch (e)Mobility Fleet-Services backend. Information such as e.g. mileage and state of charge was considered as especially relevant here. The communication was made possible through a piece of hardware connected to the CAN-bus of the vehicle, which sends the information to the backend and could be resorted to the CCU-value unit, already available at Bosch. The CCU-value unit is an intelligent gateway for the connection of USB-, CAN- and GSM interfaces; in addition, it is equipped with temperature and speed sensors.

Fig. 19: CCU-Value

Together with Porsche, Bosch implemented the CAN-matrix in the CCU-Value unit. The relevant data are communicated via GSM to the Bosch (e)Mobility Fleet Services backend, where they are processed and displayed.

During a test, a Porsche Boxster e was linked to the Bosch (e)Mobility Fleet Services backend via the CCU value unit. During several days, data were logged and received by the backend. The data could be processed and displayed by the (e)Mobility Fleet Services frontend.

Due to employee co-determination issues, the fleet-functionality could not be tested within the standard usage of the vehicles. This is why the demonstration and testing described above had to be limited to a certain period of time with a specified number of developers involved. A test with the vehicles of some Bosch directors was carried out. The stability of the solution was proven.

6.4 Lessons Learned

CROME demonstrated service interoperability by roaming of services.

The major learnings with respect to service interoperability and roaming are:

- **Communication Charging Station to Vehicle**

  The detailed definition added to the mode 3 specifications enabled a reliable cross-border charging. In this respect, no further developments are needed.

  The adoption of the CROME terms of reference for charging in mode 3 have contributed to the development of an industrial offer in terms of infrastructure: several industrial providers now offer “CROME-like” charging stations.

- **RFID**

  The RFID card is a suitable media for ensuring roaming; within the project, the technology has proved to be user friendly and reliable. In addition, a live retrieval of the information needed between the backends avoids keeping data in all the systems. Consequently, e. g. in case a RFID-card gets lost, it is sufficient to disable it in one of the systems to have it immediately disabled in all the network of connected systems.

- **Communication Protocol of Charging Point to Backend System**

  OCPP allows a flexible connection of different charging stations to a backend system. It brings the advantage of being a de facto standard used by different providers. However, a connection requires the relevant partners to agree upon a common communication layer.

  ➔ **Standardization (RFID card, Type 2 / 3 plug, mode 3 charging, OCPP) is key to enable a marketplace.**

- **Roaming Service Layer**

  It was demonstrated that the selected roaming architecture works and is accepted by all the partners connected, as it supports current as well as future business models.

  ➔ **The CROME partners recommend for a future marketplace to build a network of independent international partners (competitors) having their autonomous business and systems, the system design has to ensure that each partner keeps his independence (data).**

- **Services**

  The search-service is essential for the market-success of eMobility.

  Without legal framework conditions granting that a reserved spot is available upon arrival of the reserver, the introduction of such a service does not make much sense.

  Linking vehicle data to backend systems makes innovative services possible; however, specific legal framework conditions are to be considered.

  ➔ **Roaming of Services will be a Key Enabler for future Mobility Solutions.**

7 Billing Interoperability

7.1 CROME Storyline for Interoperability (Part III)

Objective

The CROME project aims to allow and analyse save, seamless, user friendly and reliable use of eMobility between France and Germany and to give recommendations for the European standardization process for eMobility infrastructure (plug, cable, etc.) and services (authentication, authorization, accounting, roaming, reservation, etc.), i.e. to introduce interoperable charging facilities with interoperable and user friendly identification (authentication), authorization and accounting ("triple-A-concept") as well as value added services like reservation, smart charging, etc..

Current Situation

On each side of the border several public charging spots with different types of sockets are already installed. Currently, EV users can charge and are billed in their regions – either on the French or on the German side. The authentication and authorization process is handled on both sides (FR: Projet Kléber / DE: MeRegioMobil) via RFID technology. In order to charge abroad the customer currently needs – besides the technical requirements addressed in Storyline I and II – an additional RFID card for authentication and authorization. However, the accounting is different in both projects. Projet Kléber and local authorities in France follow the strategy that customers pay for a service, respectively charge for free, whereas MeRegioMobil in Germany focuses on billing for power consumption (kWh).

Technical background

Public charging infrastructure in the Projet Kléber is controlled and monitored by an ICT-based infrastructure management. This concept does not implement any kind of accounting for power consumption. Instead, it favors direct payment for local services (like parking fees). The price for power consumption is implicitly included in the price for using the service, respectively is free, i.e. the customer is not directly involved in the transfer of funds between the service provider and the power provider.

The MeRegioMobil project participants have a contract with EnBW, which specifies the conditions for consuming electricity. Due to the utility based regulatory framework ("measures laws") in Germany, MeRegioMobil has only an approval for the MeRegioMobil participants to bill the customers via kWh based consumption model.

Therefore, the current difference between the two accounting forms is that on the French side, the Projet Kléber participant is paying directly for the use of services, while on the German side the MeRegioMobil project participant gets an accumulated bill for power consumption (kWh).

Planned Accounting / Billing Concept for CROME

It is important to mention that a cross border billing concept will be complex and a time intensive approach. Nevertheless the goal of CROME is to demonstrate some practical accounting concepts within the context "international roaming".

In this context in various projects (Clearing House, Green Emotion, etc.) different concepts are currently discussed (roaming, clearing house, marketplace). With respect to its schedule CROME is in a lead position and will contribute with practical experience to these (and other) projects.

Within CROME, the project participant will be charged for services e.g. time-based, charging, charge and park or reservation etc. An accumulated bill as well as direct payment (cash, card etc.) is also in discussion. The mode of payment will be changed or extended during the project.

In **phase 1** (see storyline I, II) only hardware interoperability is available. The customer will be charged and billed in their home country. Cross border charging will not be considered in the accumulated bill. An invoicing between the project partners will not be made. Where direct payment is requested it will be applied for all project participants.

Starting with **phase 2** (mid 2012) the basic software services will be available. Based on this, the “triple-A-concept” will be extended to allow cross boarder charging.

The full billing functionality will be introduced with the introduction of the value added services starting in January 2013.

7.2 Objectives

The major objectives were:

- The design and demonstration of a billing model for the use of the charging infrastructure,
- The demonstration of national and cross-border roaming models integrating different market players, such as energy providers, municipal utilities as well as end users.

7.3 Achievements / Implementation

7.3.1 Interoperability between EnBW and German Local Energy Suppliers

The interoperability between the German local energy suppliers implies the possibility for each specific user – independently of its mobility provider / energy supplier - to access the complete charging infrastructure on the German side (CROME + MeRegio Mobil + Modellregion Stuttgart + Kléber + Schaufensterprojekt).

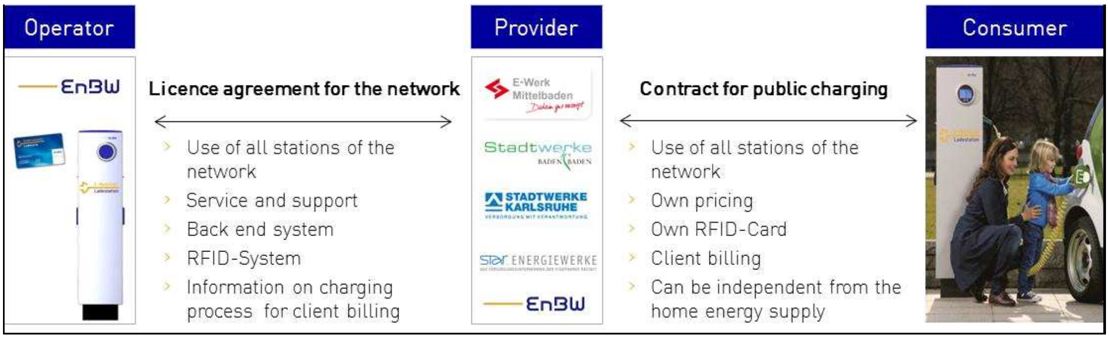


Fig. 20: Operator – Provider - Consumer

EnBW and each energy supplier subscribe a license agreement. Each energy supplier also has an exclusive contract relationship to the client and invoices its own clients (EnBW makes charging information available).

Stati… EXAMPLE	…rt/ Tarifzone	Stecker	Tarif	Beginn	Ende	Anschluss-dauer	Ladekosten (netto)	Ladekarten Nr.
	EWM Freiburgerstr. 23a, / Wasserstr.Betriebsverwaltung des E-Werk Mittelbaden 77652 Offenburg Zone: Basis-Zone	Turbo-stecker	1,68 €/h	08.08.2012 09:54	08.08.2012 15:41	05:46	9,69 €	98
	Anzahl der Ladevorgänge	**1**			**gesamt**	**05:46**	**9,69 €**	

Fig. 21: License Agreement - Example

The concept includes also the distribution of RFID-Cards from each local energy supplier to its customer base (new clients are also provided with a RFID-card). The RFID card grants independence and security: it allows accessing currently about 370 charging stations in Baden-Württemberg. The card is used both to access and pay for the charging. The client receives one monthly bill for all charging sessions.

Fig. 22: RFID cards – German Utilities

The concept is also open for all possible participants using an EV - Users of the over 100 CROME-EVs as well as all other existing and future EV-Owners. The potential users have free choice from which eMobility provider they want to receive the RFID card (EnBW or other local energy suppliers involved in CROME).

Additionally, EnBW has finalised the redesigned maintenance and service concept including the requirements of the local energy suppliers. The operation of the charging infrastructure is ensured beyond December 2013.

7.3.2 Billing & Tariff Model (Germany)

While designing the tariff concept, the objective was to develop a market-oriented and competitive model for the future. Possible tariff models were investigated and evaluated against several assessment criteria:

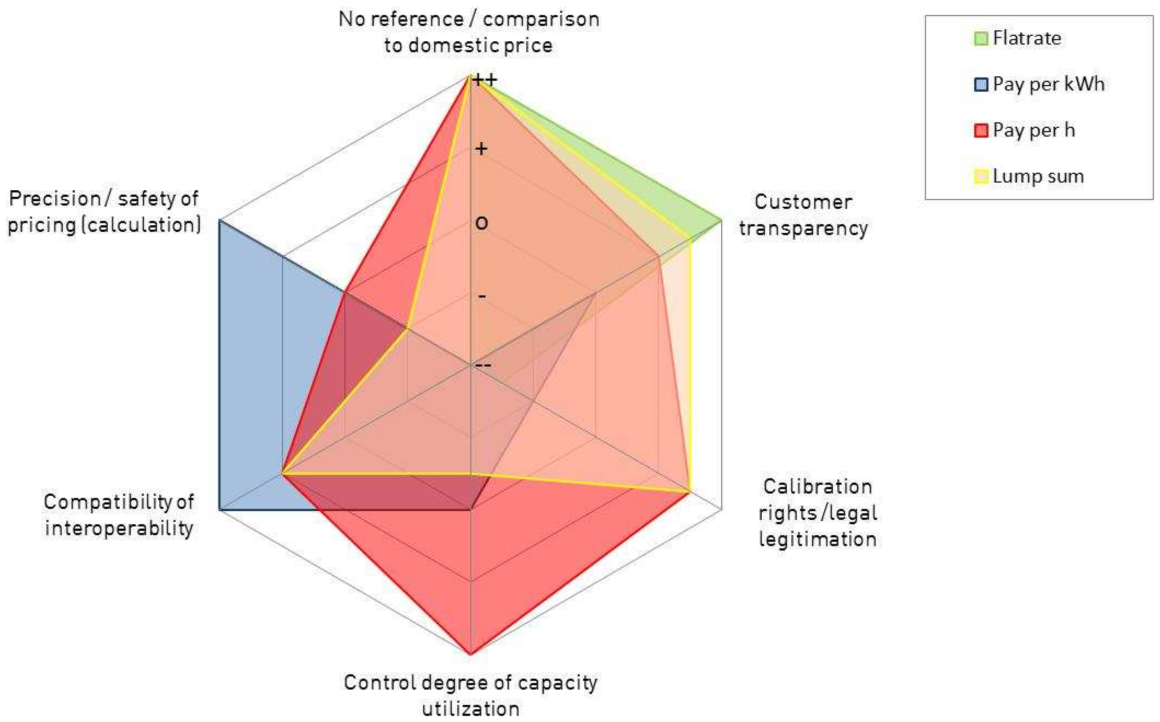
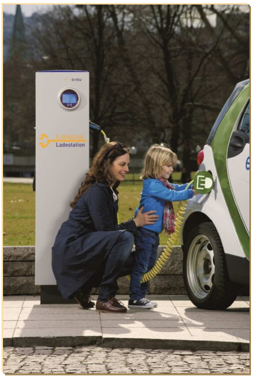


Fig. 23: Assessment Criteria for Tariff Models

The assessment criteria chosen for the tariff models selection are:

- Transparency and control:
  - Billing on a time basis of the charging time is transparent for the user, which remains in full control of the charging time.
- Occupancy steering mechanism
  - A user occupies a charging station during the whole connection time, preventing any other user from accessing it.
  - The target is to keep the occupancy time as short as possible, in order to allow making as many charging stations as possible available to the users. A charging station use control can only be achieved through a time steering mechanism.
- Innovative, sustainable model
  - The tariff model shall be innovative and sustainable. In case of strongly frequented areas, a price increase constitutes a strong incentive for short occupancy of the charging stations. The user is supposed to use the station only as long as necessary.

The EnBW approach is based on "quality" of parking zones (Zone 1 to 3) and a time based billing model. Currently, the charging stations are all classified in the "Basis Zone".



Grundpreis		9,90 €/Monat
Ladekosten		
Spar-Zone	max. 1 €/h	max. 15 Cent/h
Basis-Zone	2 €/h	50 Cent/h
Hot-Spot-Zone	3 €/h	75 Cent/h

Fig. 24: Tariff Model Details

Every customer closes a contract with the energy supplier of his choice. The tariff agreed upon in the contract is valid for all charging locations, independently from the energy supplier running the charging station. Each charging station is equipped with the functionality to display only the valid tariff for this specific customer. The latter gets an accumulated bill from his provider for all charging processes in the period of the bill.

Each energy supplier has the possibility to design its own tariff model, (nearly) independently from the EnBW price plan. To ensure an interoperable billing system, some constraints have to be considered by the partners' tariff design, among them e.g. the use of a time-based billing (no billing on the base of kWh consumption due to calibration regulations (Deutsches Eichrecht)). Currently, EnBW, Stadtwerke Baden-Baden, E-Werk Mittelbaden and star.energiewerke are using the time based pricing model. Stadtwerke Karlsruhe has chosen an exclusive flatrate model for their own power customers.

The valid pricing is displayed on the charging station. This guarantees a complete cost transparency:

Fig. 25: Charging station _ Display Pricing

During the period 2011-2013, a pre-paid RFID-card was developed and implemented in the framework of the iZeus project and made available to the CROME users.

The interoperability between France and Germany had been taken into account during the conception of the card, so that these can be used on both sides of the border.

7.3.3 Billing & Tariff Model (France)

In France, the CROME public charging stations have been provided through actual public calls for tender from the local territories (towns) based on the CROME interoperability specifications. These public charging infrastructures are owned by these cities.

The charging infrastructure service is currently offered for free by these local territories. Non-free-of-charge schemes are however being determined for potential implementation by end 2014 for the global charging service. The 2014 customer acceptance feedback will be used in „ tariff“ study.

Due to the marginal impact of consumed electricity[9] in the Total Cost of Ownership and Use of the charging infrastructure electricity will be integrated as a cost in the global price of the charging service offer.

EDF through its subsidiary SODETREL operates this global CROME charging infrastructure network in France and the CROME-connected fast charging infrastructure financed by Nissan, Cora and EDF.

CROME RFID cards issued by Sodetrel are to be bought by the EV users. The use of the Kiwhi Pass which is a national eMobility pre-paid card has also been introduced as a possible interoperable access and payment tool to the CROME charging infrastructures (compliant ID).

Fig. 26: CROME RFID Card by EDF / Sodetrel with Kiwhi Pass compliant ID

7.3.4 Interoperability between Germany and France

CROME has laid the technological corner stone for future roaming models. All partners are connected to each other and can quickly and securely exchange all data required for authentication and billing. These data are necessary both for national and international roaming.

Due to the different billing systems on the two sides of the border (charging is currently free of charge in France but not in Germany) and in order to foster cross border eMobility, until the end of 2013 cross border charging was free of charge.

9 In France, the electricity cost of a charge is between 1.5 and 2.5 € per 100 km

7.4 Lessons Learned

- ***Cross Border eMobility is possible and Reality today***

  Thanks to CROME, cross border eMobility is a reality .already today. The implementation of the necessary requirements for the authentication of the users and the rollout of public charging stations compatible with both the type 2 and type 3 socket systems enabled to remove the major technical barriers for cross border eMobility.

- ***Customers accept RFID Card for Authorisation and Payment***

  The RFID card has proved being a secure and user-friendly support for authentication and payment, well accepted by the users. Both in France and in Germany it is becoming a standard for the access to the charging infrastructure, so that the cross border e- mobility is ensured for the coming years.

- ***European wide Standards for Further Deployment of eMobility is Crucial***

  The definition of valid standards at European level is crucial for the success of cross border eMobility. This includes the measurement and payment modalities (kWh- or time-based) as well as common user authentication procedures.

- ***Cross Border Billing of VAT***

  A clear legal framework is necessary for the actual implementation of cross-border billing, especially with respect to the billing of VAT.

- ***Rollout and Operation of the Charging Infrastructure need to pay off in the Future***

  Considering that eMobility still is in its beginnings, the investment and operation costs for the charging infrastructure are quite high if compared to the rather restricted number of users. Future business models shall therefore plan a fair distribution of the costs among all market players in order to ensure a sustainable success of eMobility.

- ***Costs Transparency for End Users***

  Showing a customised pricing table at the charging station of each provider may considerably increase the cost transparency for the end user. In the same way, transferring the pricing table also over the roaming service layer in connection with the authentication service also seems to make sense.

8 EVs in the Project

8.1 Objectives

One of the major objectives of the CROME project was to perform a wide-scale cross-border field demonstration of mobility with EVs.

The target number of cars to be brought into the project was set to a minimum of **100** (mainly BEVs as well as plug-in hybrids EVs (PHEVs)).

8.2 Characteristics of the EVs in the Project

Fig. 27: Cars in CROME

The CROME fleet included a number of vehicles ranging from small cars to sports cars and utility vehicles. These are either series vehicles which are offered for sale to final customers or small series vehicles which can be leased by the customers. Within the project framework also some prototypes were tested.

These vehicles can charge in mode 2 (domestic sockets) and in mode 3 (with plugs of the type 2 or type 3). Some vehicles support fast charging (43 kW), i.e. an 80% recharge in 25 minutes instead of several hours for a normal stop.

A short description of each EV in the project are given in the following:

	Mercedes Benz A-Klasse E-CELL	
Model	*Category*	Battery EV
	Readyness level	Series production
	Commercial launch	End 2010
Battery	*Battery type*	Lithium-Ion
	Battery energy	36 kWh
Charge	*Normal charge*	2 X 3,3 KW mode 2 / 3
	Plug (EV side)	Type 2
	Fast charge	-
Misc.	*Range (ZEV mode)*	255 km
	ICE engine	-
	Max. speed	150 km / h
	0-100 km / h	14 s

The five-seater with battery-powered electric drive meets all the requirements for a family car for everyday use and features a generously dimensioned interior and luggage compartment for maximum versatility, setting no compromises in terms of space and variability. Both high-performance lithium-ion batteries are located well-protected and in a space-saving way in the vehicle underbase and allow a range of 255km (NEDC). The car is powered by a quiet, locally emission-free electric drive with peak output of 70 kW (95 hp), developing a high torque of 290 Nm.

The limited series of 500 Mercedes-Benz A-Class E-CELL is already in everyday operation of selected private and fleet customers since 2010.

	Peugeot iOn / Citroën C-ZERO	
Model	*Category*	Battery EV
	Readyness level	Mass production
	Commercial launch	End 2010
Battery	*Battery type*	Lithium-Ion
	Battery energy	16,3 kWh
Charge	*Normal charge*	3,3 kW mode 2 / 3
	Plug (EV side)	Type 1
	Fast charge	43 kW DC mode 4
Misc.	*Range (ZEV mode)*	150 km
	ICE engine	-
	Max. speed	130 km / h
	0-100 km / h	16 s

Generated from a partnership between PSA Peugeot Citroën and Mitsubishi Motors, at the end of 2010 the two car models Peugeot iOn and Citroën C-ZERO were the first new generation electric vehicles (equipped with lithium-ion batteries and a permanent magnet synchronous electric motor) marketed in Europe.

Thanks to a range of 150 km (normal cycle) and their up to 30-minutes fast charging feature, these cars satisfy most needs of urban traffic.

	Peugeot Partner Origin / Citroën Berlingo First	
Model	*Category*	Battery EV
	Readyness level	Mass production
	Commercial launch	End 2010
Battery	*Battery type*	Lithium-Ion
	Battery energy	23,5 kWh
Charge	*Normal charge*	2,3 KW mode 1
	Plug (EV side)	Maréchal
	Fast charge	-
Misc.	*Range (ZEV mode)*	120 km
	ICE engine	-
	Max. speed	110 km / h
	0-100 km / h	

At the End of 2009, the French mail service provider La Poste decided to provide its employees with 250 electric Citroën Berlingo First, developed by Venturi Automobiles on the basis of the thermic version.

This utility vehicle, which was brought to the market at the same time as its „sibling“, the electric Peugeot Partner Origin, features a loading capacity of 500 kg and a loading volume of 3 m³.

	Porsche Boxster e	
Model	*Category*	Battery EV
	Readyness level	Prototype
	Commercial launch	n / a
Battery	*Battery type*	Lithium-Ion
	Battery energy	26 kWh
Charge	*Normal charge*	3,3 kW mode 2 / 3
	Plug (EV side)	Type 2
	Fast charge	22 kW mode 3
Misc.	*Range (ZEV mode)*	170 km
	ICE engine	-
	Max. speed	2WD: 150 km / h 4WD: 200 km / h
	0-100 km / h	2WD : 9,8 s 4WD : 5,5 s

The Boxster e, equipped with an electric motor on the front and rear axles, is a purely electric four-wheel drive vehicle featuring the same driving dynamics as a Boxster S. Together with further two Boxster e equipped with a rear axles electric motor, this prototype is used for investigating how suitable purely electric vehicles are in everyday use as well as their drivers' behaviour in terms of driving and charging. Researchers aim at gathering findings about technical requirements of future models, the further development of Porsche Intelligent Performance and the integration of electric vehicles to the infrastructure.

Porsche Panamera S E-Hybrid

Model	*Category*	Plug-in Hybrid
Model	*Readyness level*	Prototype
Model	*Commercial launch*	end 2013
Battery	*Battery type*	Lithium-Ion
Battery	*Battery energy*	9,4 kWh
Charge	*Normal charge*	3,3 kW mode 2 / 3
Charge	*Plug (EV side)*	Type 2
Charge	*Fast charge*	-
Misc.	*Range (ZEV mode)*	36 km
Misc.	*ICE engine*	3,0l V6 (245 kW)
Misc.	*Max. speed*	270 km / h
Misc.	*0-100 km / h*	5,5 s

Already the market introduction of the Porsche Panamera S hybrid back in 2011 was an exceptional success. Thanks to its parallel full hybrid technology, this model won the Intercity Rallye on the 11th Michelin Challenge Bibendum – an international forum for sustainable mobility which took place in Berlin in 2011.

Now Porsche goes farther: while testing the Panamera S E-Hybrid cars with plug-in technic in the context of the CROME project, the first car prototypes are used for cross-border drives long before entering the market.

With the second Gran Turismo generation, Porsche introduces the first plug-in-hybrid luxury car worldwide. The Panamera S E-Hybrid represents a consistent enhancement of a parallel full hybrid technology with electric motor, a battery with enhanced performance and capacity and the possibility of external charging from the energy supply network. Its electric drive performs 95 hp (70 kW) and takes the power from a newly developed Lithium-Ion-battery performing 9.4 kWh. The electric range of the Panamera S E-Hybrid was calculated in 36 km (NEDC).

Renault Kangoo Z. E.

Model	*Category*	Battery EV
Model	*Readyness level*	Mass production
Model	*Commercial launch*	End 2011
Battery	*Battery type*	Lithium-Ion
Battery	*Battery energy*	44 KWh 226 Nm
Charge	*Normal charge*	6 to 9 hours
Charge	*Plug (EV side)*	-
Charge	*Fast charge*	80% within 30 min

The Kangoo Z.E. is the pioneer for the Renault Zero Emission range and the first affordable commercial vehicle completely running on electricity.

Misc.	*Range (ZEV mode)*	170 km
	ICE engine	-
	Max. speed	130 km / h
	0-100 km / h	5,1 s

With a loading capacity of 650kg and a loading volume of 2.4 to 4.6 m³ depending on the vehicle type (Kangoo Z.E. or Kangoo Maxi Z.E.) this is the perfect car for commercial users. The Kangoo Z.E. provides a strong acceleration and a conventional range of 80 up to 125km (at cold or moderate temperatures respectively) and thus can cover usual everyday needs - All of this without causing noise or emissions.

The Kangoo Z.E. was awarded "International van of the years 2012." In France 19 of the largest companies and local authorities will purchase more than 15,000 Kangoo Z.E. within the next 4 years.

	smart fortwo electric drive (phase 2)	
Model	*Category*	Battery EV
	Readyness level	Series production
	Commercial launch	End 2009
Battery	*Battery type*	Lithium-Ion
	Battery energy	16,5 kWh
Charge	*Normal charge*	3,3 kW mode 2 / 3
	Plug (EV side)	Type 2
	Fast charge	-
Misc.	*Range (ZEV mode)*	135 km
	ICE engine	-
	Max. speed	100 km / h
	0-60 km / h	6,5 s

The innovative concept of the smart fortwo has been combining modern technologies and individual, urban mobility for more than 10 years now. The production of the smart fortwo electric drive under series-production-like conditions started as early as the end of 2009 and at the moment selected customers are driving the electric vehicle in 18 different countries around the world.

The vehicle may be charged at any conventional domestic socket as well as on public charging stations with a fully charged battery allowing for a range of about 135km (NEDC).

In the fall of 2012, Daimler AG introduced the new electric smart (phase 3) to the market thus offering eMobility for everyone.

		Toyota Prius
Model	*Category*	Plug-in Hybrid
	Readyness level	Series production
	Commercial launch	2012
Battery	*Battery type*	Lithium-ion
	Battery energy	4.4 kWh
Charge	*Normal charge*	< 3 kW mode 2 / 3
	Plug (EV side)	Type 1
	Fast charge	-
Misc.	*Range (ZEV mode)*	25 km
	ICE engine	1.8L gasoline Atkinson cycle
	Max. speed	180 km / h
	0-100 km / h	11,4 s

The introduction of the Prius Plug-in Hybrid to the European market in the fall of 2012 was part of a specific long term rental program including 600 vehicles around the world, 200 of them located in 18 European countries.

The European part of this large scale test was started in Strasbourg in late April 2010 with the objective to show the advantages the Prius Plug-in Hybrid offers when used for inner-city rides. Around 100 prototypes of the Prius Plug-in Hybrid were rented out to selected partners over the course of three years. Some of these prototypes were included in the CROME project.

The Prius Plug-in Hybrid raises the bar in the field of sustainable mobility and, above all, it fulfils the needs of city customers with the range of the electrical motor increased to 25km and the heat engine's overall range of more than 1,200 km.

With a combined maximum performance of 136 hp, the Prius Rechargeable has a very attractive and extremely low fuel consumption of 2.1 l per 100 km in the European Driving Cycle and emission of 49g Co2 / km.

8.3 Number and Geographic Distribution of the EVs in the Project

Between summer 2011 and summer 2013, the "monitored" EVs have been delivered to the customers. In total 121 EVs took part in CROME, of which 79 in France and 42 in Germany.

However many more EV users are using the CROME French and German charging infrastructures as over 800 EVs were sold by the two last years in Alsace. EDF / Sodetrel has been delivering over 150 CROME access cards to private EV owners, whose EVs are among these "100 monitored" EVs.

The following table indicates the distribution of the various monitored EVs and also shows the data logger and smartphones used:

	Situation 30.06.2013						
	Daimler	Porsche	PSA	Renault	Toyota	Nissan	Total
Involvement in CROME signed	64	5	35	7	3	7	121
Datalogger sending data	61	5	10	7		-	83
Active smartphones	49				3		52

Fig. 28: EVs in the Project – Absolute Figures

The next picture provides a detailed overview of the different EV models involved in the project:

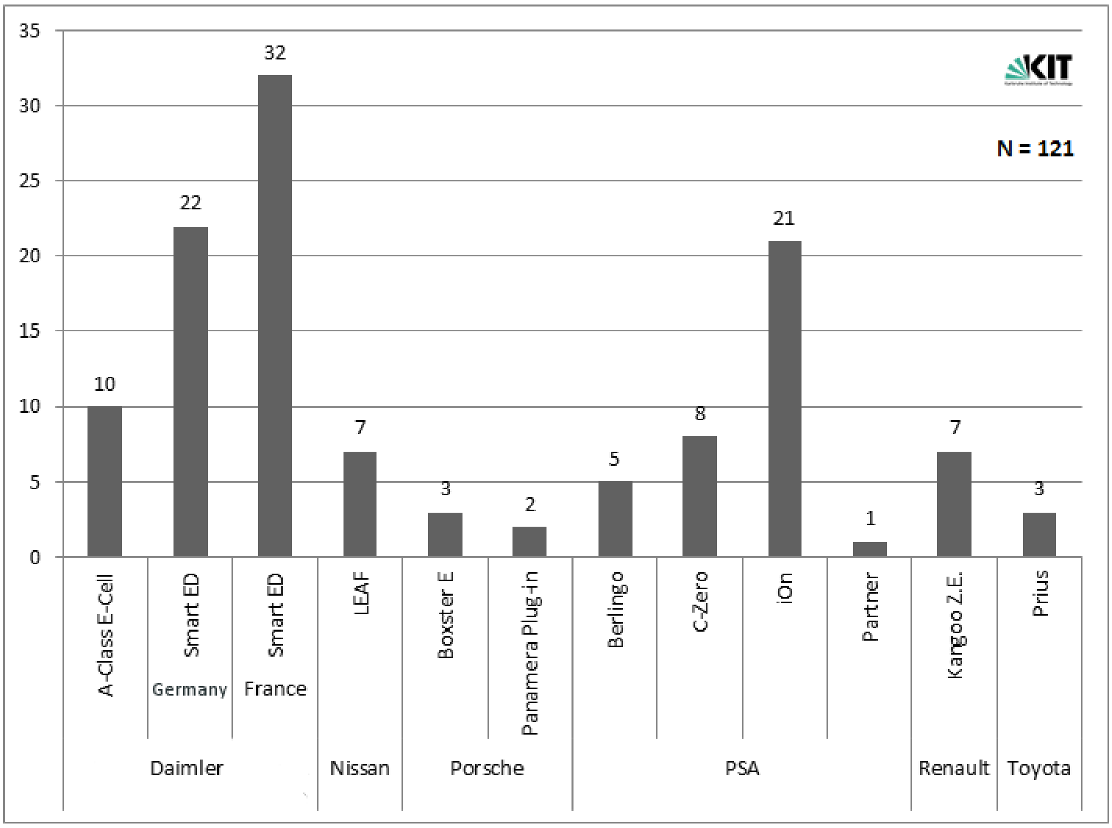


Fig. 29: EVs in the Project – Absolute Figures detailed

The following figure shows the geographic distribution of the EVs on a map of the project territory:

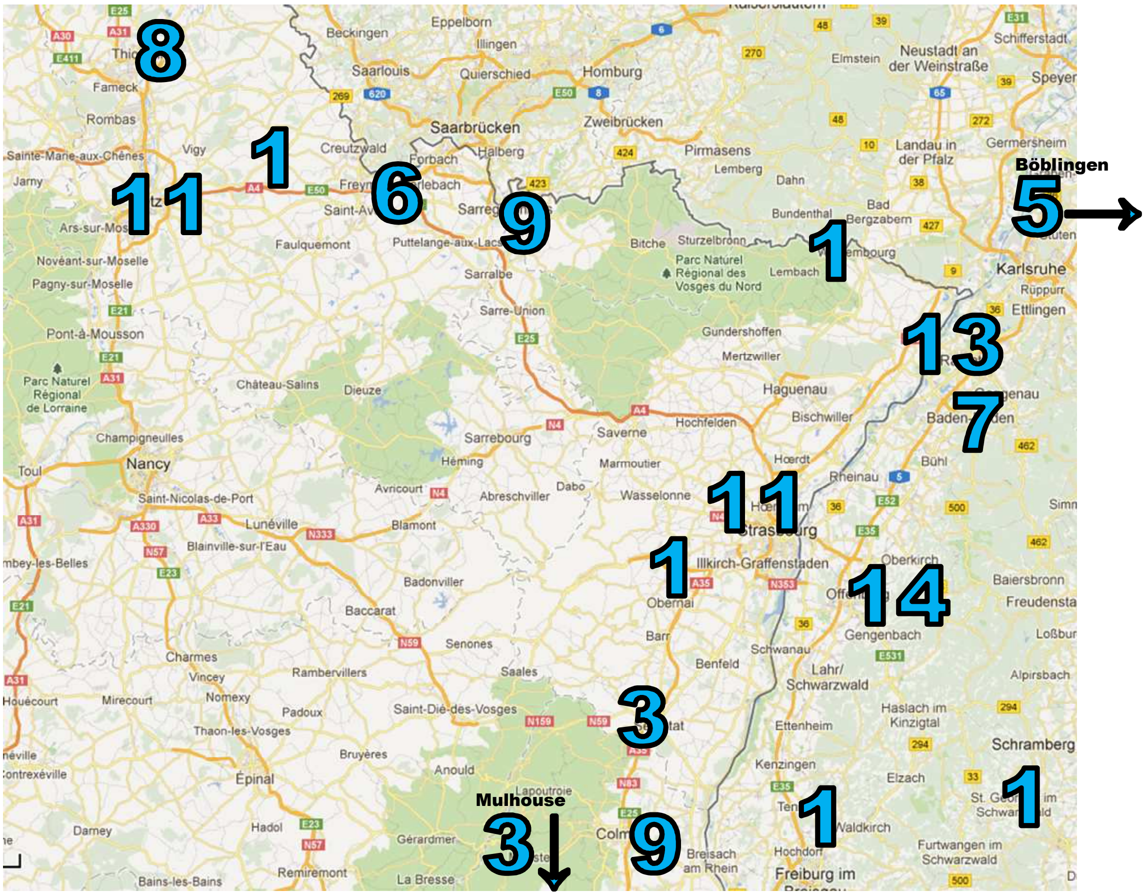


Fig. 30: Geographical Distribution of the EVs (Involvement in CROME Signed)

9 Acceptance Analysis – Results

To get a comprehensive overview on eMobility in the border region the users in both countries had to be surveyed in detail. This chapter explains the approach, which was implemented in the project to gather, store and analyse data about French and German EV users. Therefore an insight into the empirical and qualitative acceptance study is given as well as into technical utilization of the vehicles and the need for eMobility services.

To gain more experiences, especially user feedback, Siemens has delivered 3 AC charging stations to EnBW. One of these was used for testing purpose at EnBW. The others have been installed with the support of Siemens in the premises of KIT (Karlsruhe) and DLR (Stuttgart).

9.1 French / German Customer Acceptance Study

During the binational evaluation of the CROME operational EV field test the vehicles, their users and fleet managers have been monitored. Users and fleet managers participated in surveys focusing on their expectations, their first experiences and their long-term adoption intentions of EV. Furthermore, 22 qualitative interviews of fleet managers and users of EV have been carried out in the French and 23 in the German part of the model region in 2012 in order to get a holistic impression about EV usage in the French-German border area. Additionally, a workshop with fleet managers has taken place. Technical data (e.g. speed, acceleration, GPS signals) from the vehicles' data loggers and smartphones (provided to selected vehicle users) have been tracked. Technical data originating from the smartphones enriched by a short survey before each trip, asking e.g. for purpose, number of passengers, etc.. All data (except from the interviews and workshops) can be anonymously reunited by an unique personal code.

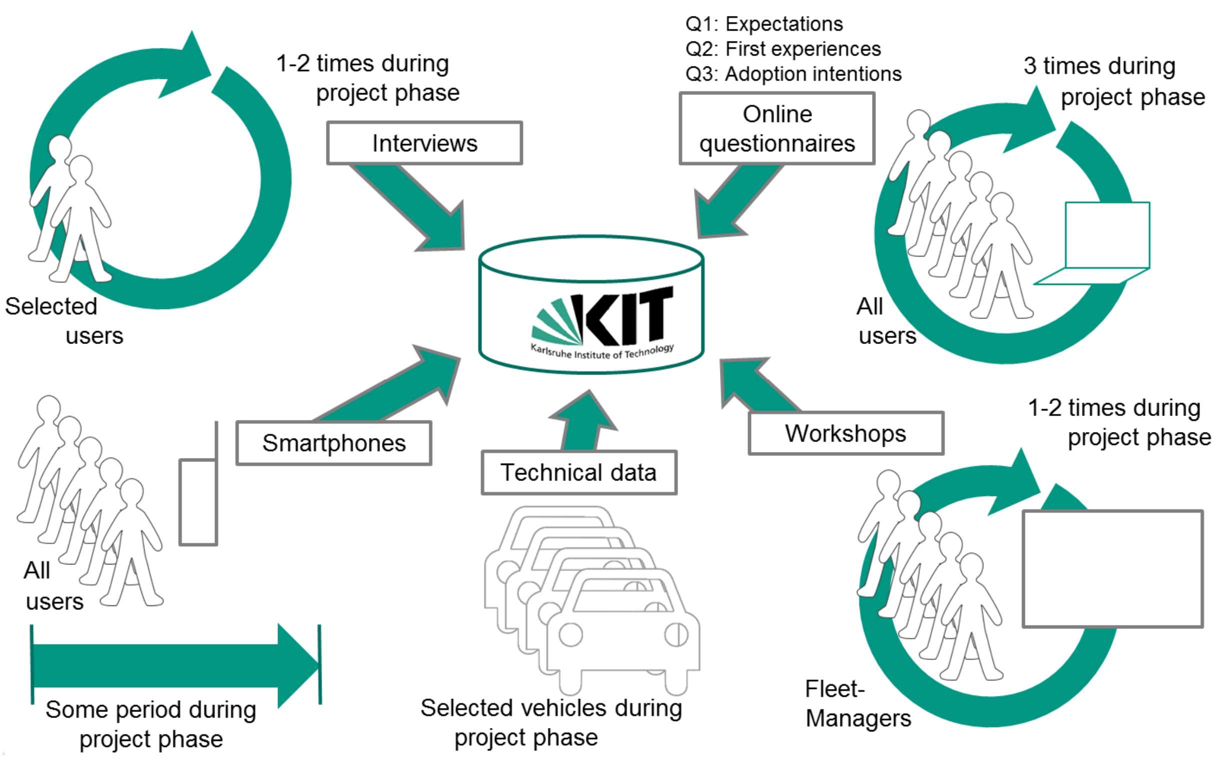
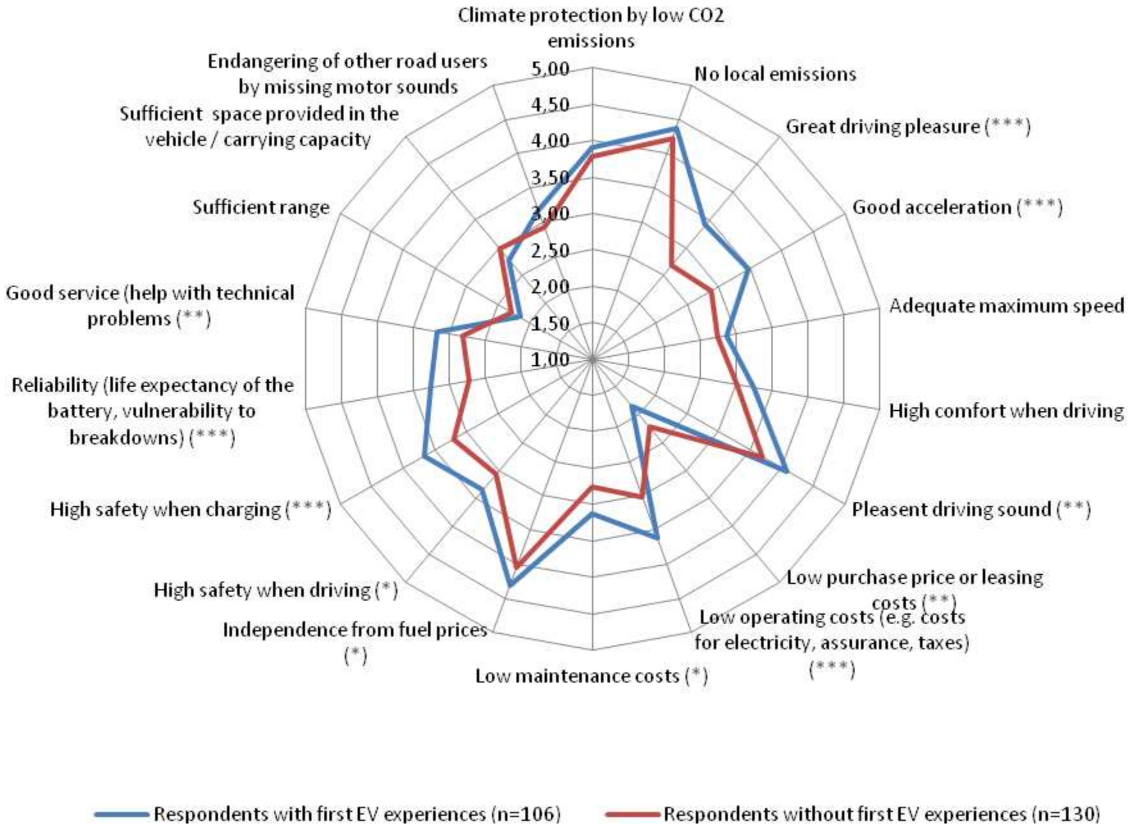


Fig. 31: Evaluation Concept for EV User Acceptance in CROME

The first online questionnaire focusing on EV users' expectations has been collected between September 2011 and March 2013. It can be observed that respondents who had experienced EV at least during one or two test drives as a driver or passenger were evaluating EVs' characteristics, particularly driving characteristics, better than respondents who had not experienced EV so far. An overview about CROME and first results based on the survey concerning EV users' expectations was presented at the 11ème séminaire francophone est-ouest de socio-économie des transports, in Karlsruhe (Ensslen et al. 2012) and at the WCTRS Ensslen et al. (2013a).



Mann-Whitney-Test results:
° : p < 0.1 * : p < 0.05
** : p < 0.01 *** : p < 0.001
n.s. : not significant

Original scale:
Items have been measured on the following scale:
1: Not at all … 5: Completely

Fig. 32: Arithmetic Averages of Respondents' Evaluations about the Degree to which they think that the EV will meet their Expectations (Ensslen et al. 2013b)

Results concerning EV users' experiences after an average usage period of about one year was presented at the Electric Vehicle Symposium in Barcelona (cf. Ensslen et al. 2013b). Differences concerning EV users' attitudes, values and norms as well as differences concerning degrees of satisfaction with the EVs' characteristics depending on country and size of the EV users' home municipality have been analysed. The respondents' overall degree of satisfaction with the EV is very high (97% of the respondents answered being completely or predominantly satisfied). Furthermore, 76% of the respondents agreed to the statement to prefer driving an EV over driving a conventional car. Based on the respondents' evaluations on satisfaction with different characteristics of the EV, a cluster analysis has been performed and the respondents have been classified in two clusters representing respondents showing higher and lower degrees of satisfaction. Mann-Whitney Tests between the two clusters and EV users' evaluations on satisfaction with EVs' different characteristics show significant differences for all characteristics, but for sufficient range. French users are more satisfied with EVs' characteristic to protect the climate by lower CO2 emissions to a highly significant degree ($p < 1\%$) (cf Ensslen et al. 2013b). The respondents seem to be aware of the electricity mix and corresponding CO_2 emissions from fossil fuels consumed for electricity generation in France (79g CO_2 per kWh in 2010) and Germany (about 461 g CO_2 per kWh in 2010) (IEA 2012).

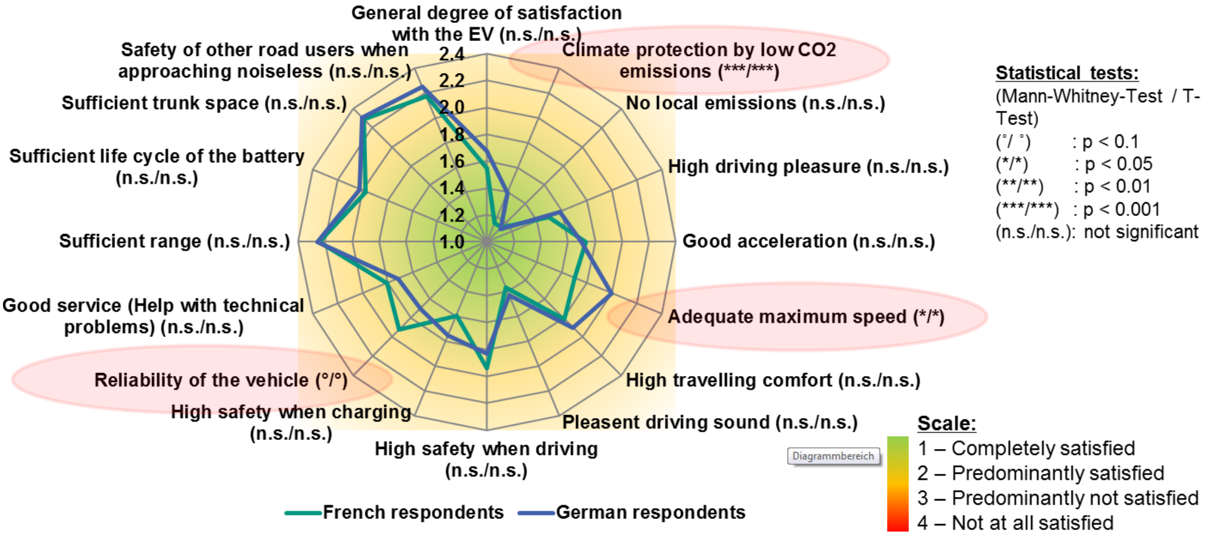


Fig. 33: Degree of Satisfaction with different Characteristics of the EV according to the Respondents' Country (Ensslen et al. 2013b)

Users' satisfaction has furthermore been analysed according to residential municipality size. Respondents living in municipalities with more than 20,000 citizens are to a highly significant degree ($p < 1\%$) satisfied more with EVs' characteristic to emit no local emissions. Respondents who live in municipalities with more than 20,000 citizens are to a marginally significant degree ($p < 10\%$) satisfied more with EVs' range as well as the life cycle of their batteries as respondents living in municipalities with less than 20,000 citizens.

Furthermore, observable dependencies between the respondents' country and their attitudes have been analysed more profoundly. French respondents are in our sample to a highly significant degree ($p < 0.1\%$) more worried about climate change impacts and show to a significant level a higher affinity towards innovations ($p < 5\%$). Respondents' evaluations of items concerning EVs' corporate public image on the other hand indicate to a significant degree that the EVs are more beneficial to the companies' public image in Germany than in France, so EVs' external image effect in the corporate context seems to be more crucial in Germany than in France. This is further supported by findings of the first online survey where fleet managers have been asked about the reasons why their companies have decided to purchase the EV (data collection period from September 2011 until April 2013). Prestige has to a significant degree been more likely to be mentioned by the German fleet managers being one of the three most important reasons to purchase an EV than by the French ($n=55$; $\chi^2=3.841$; $df=1$; $p=0.05$).

Additionally, respondents classified in the cluster representing rather satisfied users tend to have a higher affinity towards innovations ($p < 10\%$) and tend to attach a higher degree of importance on the factor representing individuals' evaluations concerning the external image effect of EV ($p < 10\%$) than the users who have been classified in the cluster with respondents who are less satisfied with the EV.

Furthermore fleet test participants in CROME have been asked where they charge the EVs, at what kind of sockets they charge them and when the charging processes usually takes place. It could have been observed that the charging processes predominantly takes place at the organisations premises, whereas charging the EVs at public charging spots seems to be taking place only exceptionally.

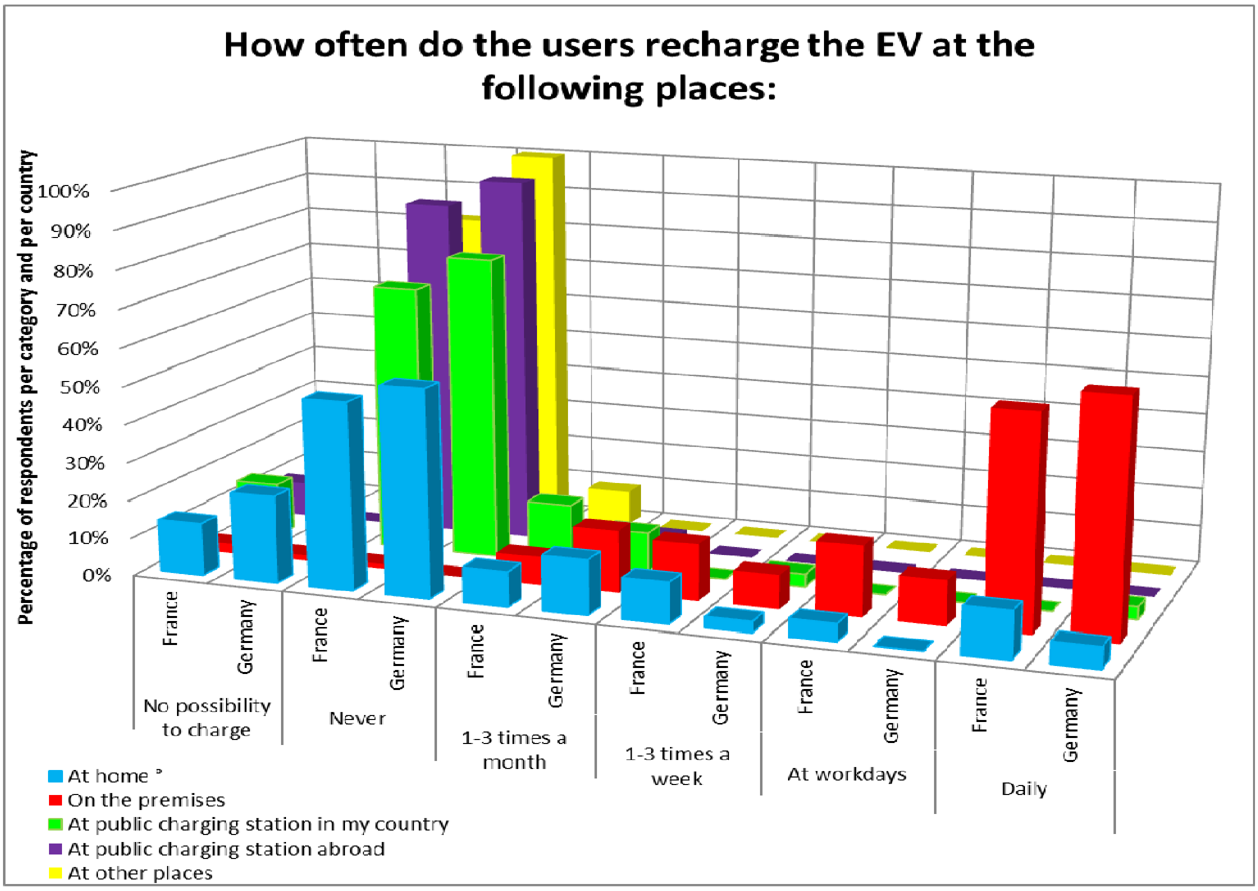


Fig. 34: Places where the EV are charged by the EV users (81 French and 89 German respondents)

Most of the respondents charge their EVs after each trip (51%). 23% stated to charge the EVs when a certain state of charge (SOC) level has been reached and 18% stated to charge after the last trip of a day. The EVs are most frequently charged at domestic sockets. 63% of the French and 71% of the German respondents stated to charge the EVs at domestic sockets regularly. Only about 10% of the respondents stated to never charge the EVs there. On the other hand the respondents also stated how often they charge the EVs at special sockets for EVs (type 2 and type 3 sockets). 45% of French and 61% of the German respondents stated to charge the EVs with type 2 and type 3 plugs regularly whereas somewhat below 30% of the respondents said they never do so.

Although domestic power sockets are most frequently used to charge the EVs, the type 2 and type 3 plug-and-socket system has been used regularly by a major part of the respondents.

The field trial participants have been asked whether they prefer plugging in the EVs to charge or filling up a car at the filling station. The major part of the respondents prefers charging to refueling.

Hence, today mode 2 charging is slightly dominating the number of charging processes. And the charging takes mainly place at the premises for the CROME fleet vehicles.

Further survey results as well as results of the Workshop are provided in the KIT reports of the CROME project to the German Federal Ministry of Economics and further publications (cf. Ensslen et al. 2013a, Ensslen et al. 2013b and Ensslen et al. 2013c).

The core component of the developed CROME vehicle fleet evaluation concept is a database for the storage and the management of heterogeneous data sets (e.g. technical and geographical) in different time resolutions (static vehicle data and dynamic data measured in time resolutions from less than a second to several minutes) and from different sources (e.g. online questionnaires and smartphones). To comply with the security and privacy requirements of the data owners (OEMs, users) it was set up within the KIT intranet infrastructure with physical and logical access control and encrypted data transfer.

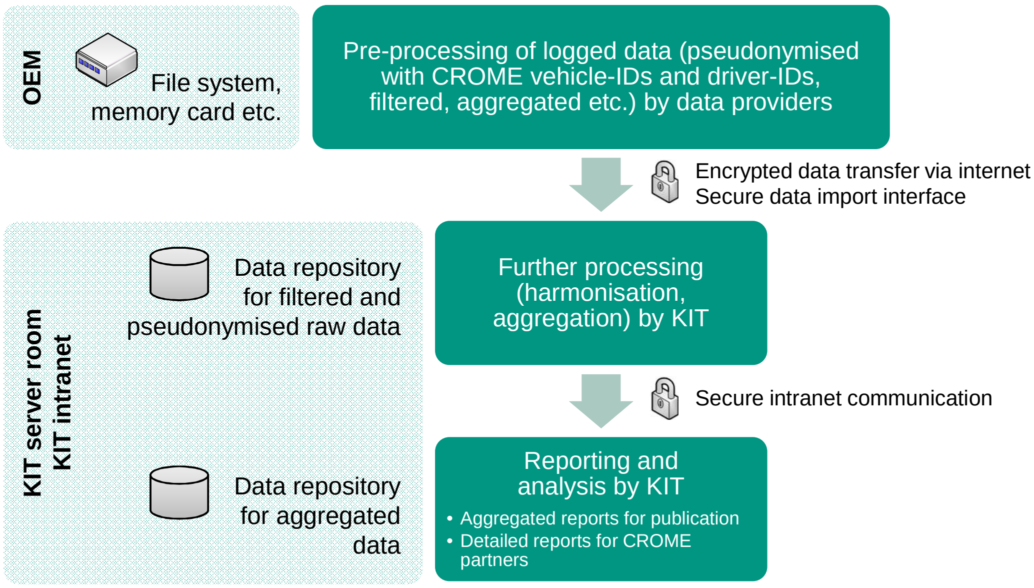


Fig. 35: Developed KIT Data Repository: Security of Data Transfer and Processing

Additionally, various interfaces, tools and services were developed that provide for the import and further processing of raw data (cleaning, harmonization, aggregation) and the analysis and the export of aggregated data based on a unified data model and commonly used data and file formats, such as CSV, XML, and JSON.

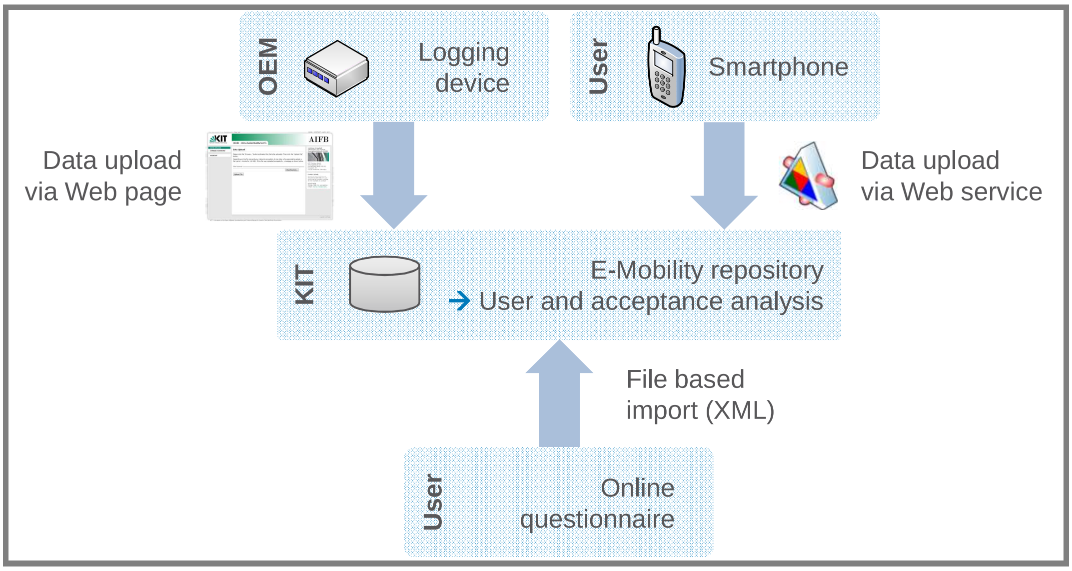


Fig. 36: Data Import – Interfaces and Formats

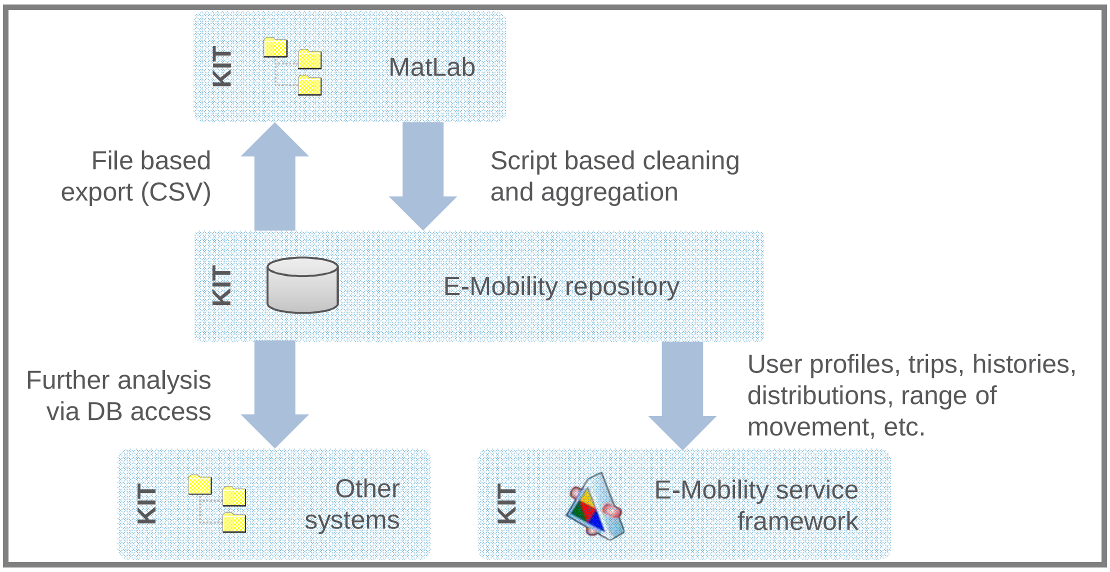


Fig. 37: Developed KIT Data Repository: Interfaces and Formats of Data Processing and Export

The unified data model, in particular, is the basis of the eMobility service framework that consists of specific interfaces and services that enable the composition of data-centric, value-added services based on core business objects, e.g. “User”, “Trip”, “Charging”, and “Location”.

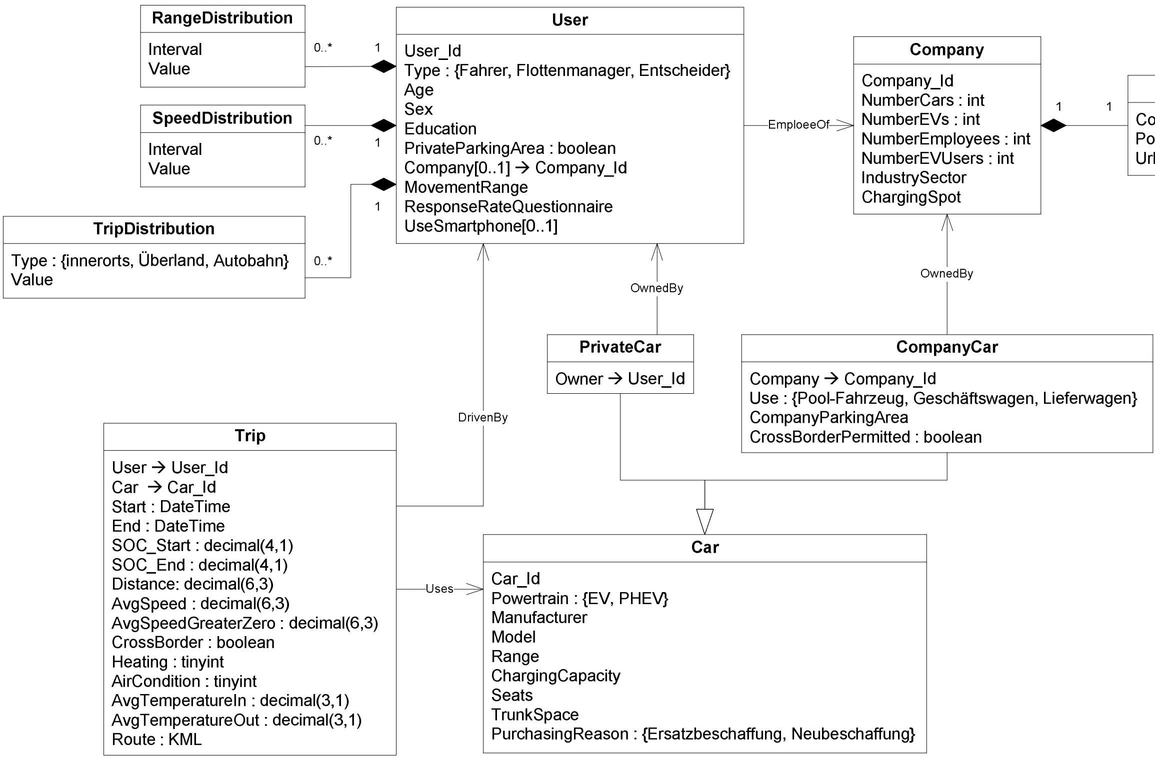


Fig. 38: Developed KIT Data Repository: Unified Data Model (Excerpt)

In future scenarios such composite services can be offered to provide information that is not available so far. Therefore, users can have personalised access to a chronological overview of their trips (e.g. a history or a logbook), an overview of their usage and consumption profiles (based on speed, SOC, range, acceleration, etc.), and an overview of their range of movement including reachable charging spots. Possible integration scenarios of such services are (mobile) web applications with text- and table-based representations, including customizable query and filter functions and a graph- and map-based representation, e.g. by means of Google Maps or Open Street Map. A prototype was developed for evaluation and demonstration purposes using Open Street Map in order to show the range of movement of a certain user and a trip history filterable by attributes such as date, time, range, and average speed.

9.2 *The Qualitative French / German Customer Acceptance Study*

Context

A qualitative study to evaluate the acceptance of EVs and charging process by French and German car users was conducted during 2012-2013 (cf. Gagnol et al.).

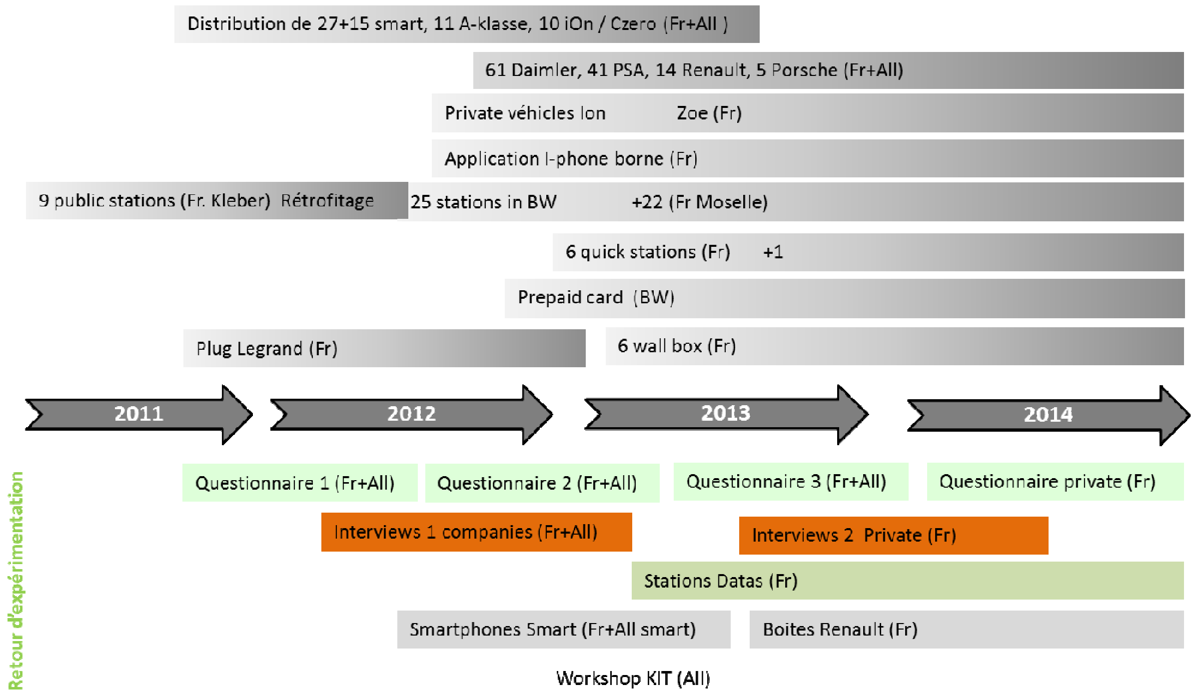


Fig. 39: Timeline of the Qualitative Study to Evaluate the Acceptance of EVs and Charging Process by French and German Car Users

The qualitative study consisted of face-to-face interviews, i.e., a bottom-up method, presenting the users' interests, problems, needs and experiences. The guideline of the interviews focused on advantages and weaknesses of the vehicle, initial driving impressions, any possible changes to travel patterns or fleet management and any other subject concerning the project. The interviews also addressed charging practices (when, where, who, how often, what difficulties were encountered), compatibility, charging cards, expectations, price, location, use of public / private charging infrastructure, parking issues, etc.

This chapter only reports the first part of the study in Germany and France. Therefore it only deals with users in a professional context (and not with private individuals, who were interviewed more recently). The data gathering (interviews) took place during the summer and autumn of 2012.
This study will be continued in 2014.

Sample

Most of the cars were distributed among local authorities, administrations, services (hotel, radio, sanitary), energy providers, car manufacturer suppliers, etc.. Whereas most of the companies and administrations are located along the French-German border, only a few use them regularly for cross border trips.

25 French persons (11 users, 11 fleet managers and 3 project members) were interviewed in the Moselle region and 24 German persons (12 users and 12 managers) in Baden Württemberg. Three quarters of the interviewees were men, with an average age of 44. The interviews were generally conducted at the work place, which offered an opportunity to see the car, the electric installation, and sometimes to observe the users' behaviour with their EVs. All cars were used for professional purposes. Some of them were also used to commute (work / home). Fleet managers encouraged the employees to borrow EVs and to achieve more battery range by recharging them at home. In the Moselle region, half of the EVs (most were Smart ED, Ion or Berlingo) were "car pool" vehicles and the other half were shared between one or two people (very rarely, an executive car assigned to only one person). In Baden Württemberg, the different types of cars (A-Klasse E-CELL, Ion, Prius, Opel Ampera, Smart ED) were only used for professional purposes, and almost never for commuting. Some cars were test cars for company clients. As the public charging infrastructure was still in the early stages of development, and not interoperable at the time of the study, this report does not address the need for public infrastructure.

Motivation

Most firms participating in CROME are involved in the development of eMobility, in fields such as technology development, innovation, energy, sustainability and car manufacturing. Therefore, their primary motivations to participate to the trial were:

- Let their customers and the public know about their involvement in sustainable mobility (communication). In France, the specific advantages of EVs are: silence when driving, fewer CO_2 emissions and less local pollution.
- Pioneer the testing of new vehicles.
- Participate in local economic development - it is very important for local authorities to support local business development.

Most of the companies and administrations in the Moselle region came to the trial through the Regional Council, which provided rebates for EVs and provided charging points at the beginning of the trial. Some city councils invested in one or more EVs and a charging infrastructure as a way to demonstrate their commitment to sustainable development.

The EV within a Company Fleet

EVs are well suited to use in a company's transportation fleet due to three main reasons (see also Globich et al., 2013): 1. Fleet vehicles are used mainly in routine trips; 2. The vehicle has a fixed and dedicated parking place at work where the charging infrastructure can be installed; 3. Most employees can benefit from the flexibility of a car pool and compensate for the EVs range limitation with a conventional vehicle if necessary. At the same time, most employees work under pressure and do not want to increase their stress levels because of anxiety about limited battery range.

Nevertheless, companies have specific needs that most of the German participants mentioned. They have to ensure the security of their employees. They care about their return on investment in the car and they are concerned with their economic risk, which is why leasing is considered a positive option.

The Smart ED (Moselle) is seen as appropriate for daily professional use but only for short trips (if one leg of the journey is less than 40 km) and for trips without luggage. Some service trips are regular and can be assigned a vehicle based on size and range. Battery range is an accepted limitation but not really a problem because of the choice of vehicles.

The trips are organised and managed either by the user (if the EV is allocated to one or 2 persons) or by the fleet manager (if the EV is shared by several users). In the first case, the charging of the car is considered to be easy: as the destination is well known, the user anticipates the distance to travel and return and assess whether battery range is sufficient.

When the EV is shared by 1 or 2 users there are no constraints on its use and there doesn't appear to be any problem with established mobility. But when the EV is shared in a car pool, fleet management becomes more complicated. The vehicle is sometimes integrated into overall fleet management in the same way as a normal car (most of the time in Germany via a central reservations system) or the fleet manager encourages use of the EV by lending it as a perk, or by authorizing the user to take the EV home. Furthermore, the fleet manager offers an introduction to the new technology and helps if a problem should occur. Some firms sent out Emails and had flyers to inform their employees about their participation in the CROME project.

Different charging strategies were used. Half of the users charged every time they parked (especially in case of a high number of users per EV). In situations where the car is shared among a small group (1 or 2 persons), it is charged at the end of the day or when the battery charge is between 30% and 50%.

Acceptance of the Car

The cars met the expectations of both French and German users and most of the people considered that it was a successful innovation. Special mention was made of the lack of noise during driving and driving comfort. Users particularly appreciated the acceleration and the internal communication options. Users mention that they are more noticeable in the city, and that they like the visibility of the car. Some of them mention as well, that they had no parking problem and that they personally appreciated reducing their energy consumption.

Some negative aspects were limits on speed, constrains on range and that the boot space is too small.

The electric car does not fundamentally change the travelling pattern (in Moselle and BW).

Acceptance of the Charging Process

The users and managers interviewed were satisfied with the charging process in their own facilities. Everyone mentioned the simple process, which was easy to do and to manage. They liked the fact that they did not have to go to a gasoline pump and that they avoid bad smells and billing procedures.

Sometimes, the charging infrastructure was used as part of company marketing. A charging station was installed for the clients in front of their entrance which supports the image of the company as an innovative firm. Even though this charging station was not used very often, there was a significant reaction from clients. In addition to this charging station, a charging point was built in the company garage and was the most frequently used charging point.

Users both in France and Germany mention a need for information about the battery and also about the standards of plugs at public infrastructure. At home, in France, users got great satisfaction from "Legrand" plugs[10] because of the easy use; sometimes they are not identifying the difference between a "normal plug" and the "Legrand" (which is securised) and they charge at a standard plugs even though the point may not have been properly installed.

10 http://www.legrand.fr/professionnels/economies-durables-et-securite-absolue_2663.html

Private Charging Infrastructures in Moselle

Private Charging Infrastructures in Baden-Württemberg

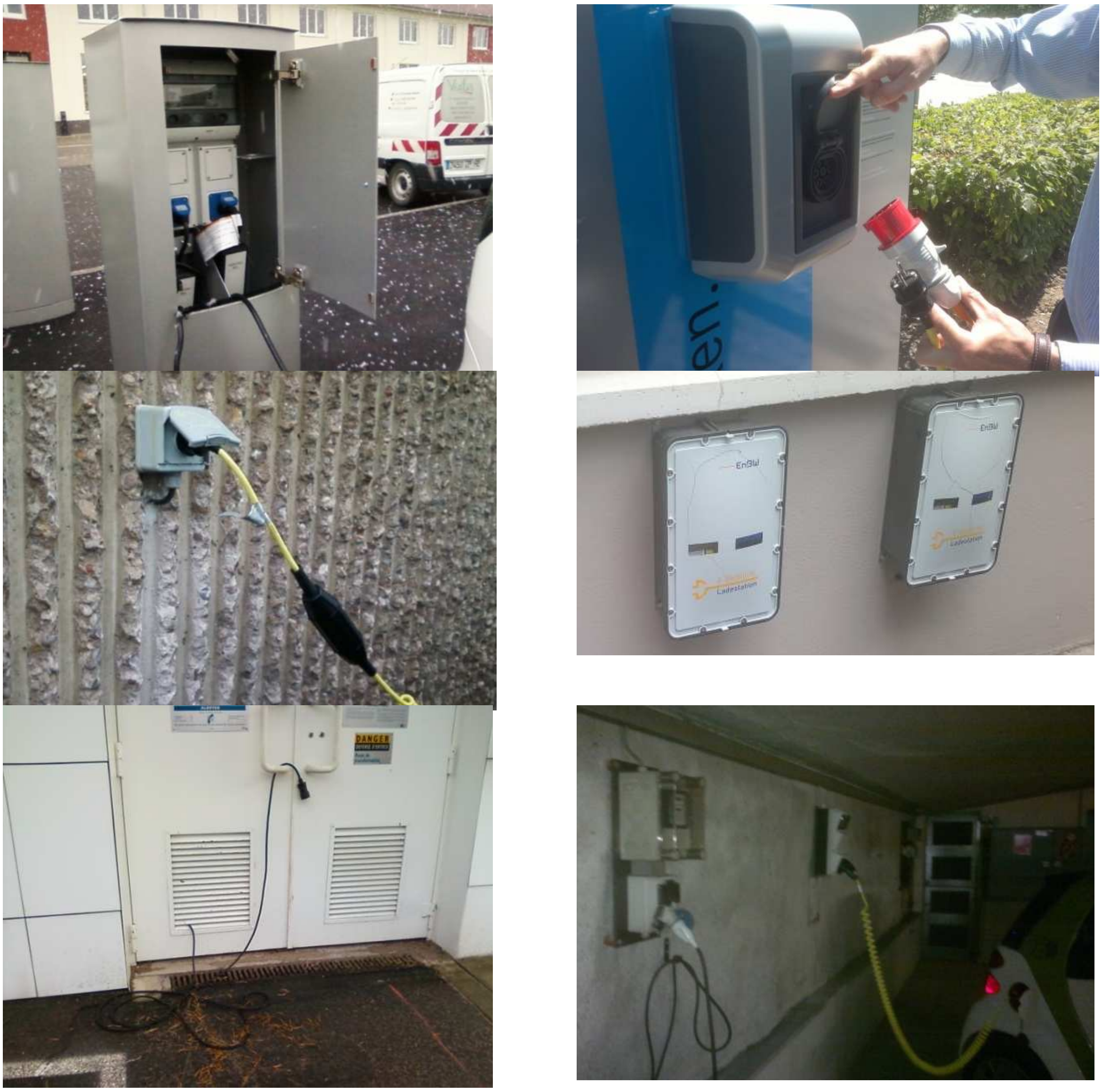


Fig. 40: Private Charging Infrastructures in Moselle and Baden-Württemberg

German Interest in Renewable Energy

All interviewees in Baden Württemberg were concerned with energy and electrical issues. Some of them were able to build their own charging points which they welcomed as a positive talking point with their clients. Some users would like to see other charging options such as fast charging, induction, and battery change. They were interested in the calibration of the battery capacity, not only for mobility needs but also in terms of energy needs (i.e., storage for other purposes).

Many users tried to integrate the EV into a self-sufficient energy system. Some German firms are equipped with photovoltaic panels for local production and wondered about including storage and possible financial benefit in the future.

Some of them mentioned their concern about the energy change in Germany. Most of them use green energy and some of the interviewees were not sure about the development of electricity prices and were concerned about possible taxes on electricity used for transport.

This analysis will be developed further in the final report on the qualitative studies (see chapter 13). At the time of the interviews, there were few public charging points (on-street or off-street). The second phase of the study, which took place in Alsace (mainly Bas-Rhin) will give more information about the use and acceptance of public charging. Furthermore, the interviews in Alsace (data gathered during the summer and autumn of 2013 and analysis at the beginning of 2014) will focus on private users, who purchased or leased a car for private purposes. The report will give us an opportunity to compare professional and private use of EVs (cf. Pierre M., 2013).

9.3 Analysis of the Utilisation of the EVs (Basis: Autologger and Smartphones)

Another cornerstone of the acceptance analysis is the continuous acquisition and analysis of mobility data from CROME EVs. All fleet vehicles were equipped with different kinds of data logging devices by the vehicle manufacturers or their subcontractors. In a first step, a list of research questions to get a clear insight in the use of the electric vehicles has been worked out. From this list a request form of necessary data has been derived and brought into the negotiation with the vehicle manufacturers. Following all technical and secrecy constraints a common data sample could be agreed that is delivered to KIT for analysis (cf. section 9.1).

Due to technical constraints, a major part of the fleet is not capable of recording GPS-data for the trips. As GPS-data is seen as a crucial input for the analysis of cross-border mobility, a mobile measurement system had to be developed for the retrofit of vehicles that had already been delivered to customers. Android smartphone with a custom-built application have been chosen for this task. They could be acquired at very low costs (<100 € per unit), have sensors to measure GPS and accelerations, are capable of storing and transmitting data wireless via GSM-networks and provide with the touchscreen an easy user interface for the input of valuable additional data like the trip purpose or the payload. After the development of the app and an intensive test campaign of the measurement system it has been rolled out to all customers that agreed on using it. Almost 60 vehicles could be equipped with smart phones – the attendance (e.g. number of tracked trips) exceeds all our expectations.

Fig. 41: Smartphone with KIT App as Vehicle Data Logger (Pfriem 2013b)

In agreement with the vehicle manufacturers, different processes have been built up for the transfer of data to KIT. The smartphones automatically transfer data after each trip to a server (via GSM) and the vehicle data is transferred at several points of time as a bulk on different ways during the project by the vehicle manufacturers or their subcontractors. This data is in a first step imported to the data repository where it is stored in an SQL-database (cf. section 9.1). Based on different export specifications depending on the data sources, the datasets are exported in csv-files for the import into the software environment Matlab, which is used to store and analyse the vehicle trip data.

At the same time, an extensive tool kit has been built up in Matlab for all different needs of data processing for the analysis. A main challenge hereby is to deal with five different measurement systems – four from the different vehicle manufacturers – and the smartphones, that all have different peculiarities in the data structure. Therefore, significant effort has to be made in the pre-processing of the datasets to get a clean basis for the further mobility analysis. Based on the data basis that has been built up during the project, various aspects of the use of the EV could be analysed in detail.

It has been shown that the vehicles are mainly used for short trips in an urban environment and usually stay far below their maximum range.

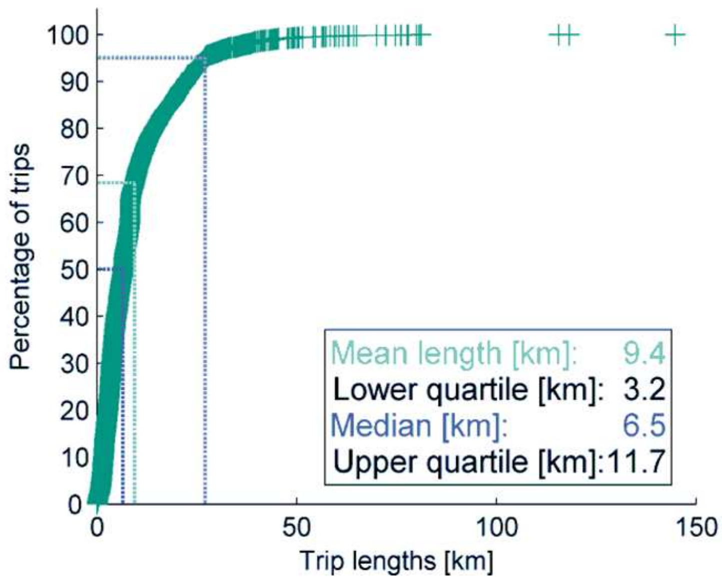


Fig. 42: Length Analysis per Trip Logger (Pfriem 2013b)

In combination with a mostly daily recharging through the users this leads to a situation where many vehicles are very dominantly used in high SOC classes.

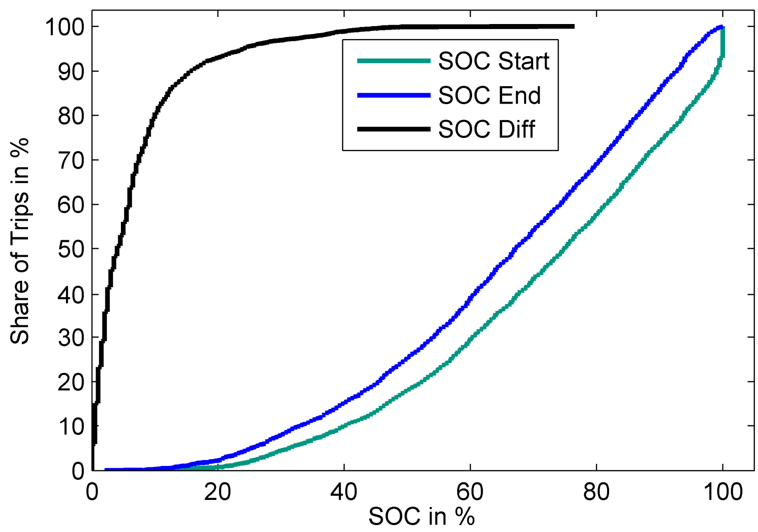


Fig. 43: SOC Consumption Analysis per Trip Logger (Pfriem 2013b)

Furthermore, the analysis of speed and GPS position has shown that most vehicles of the CROME fleet are used with a strong local focus and predominantly in low speed ranges as they are typical for in-city use. Nevertheless, the untypical accumulation of speed records at 100 km / h, which is the maximum speed of these vehicles, suggests that this maximum speed is not sufficient. This might be interpreted by drivers as a car constraint and hinder acceptance It could also be pointed out that cross-border traffic happens seldom for the GPS tracked trips (only about 1 %). This is mainly due to the local focus of the CROME users (i.e. local authorities, municipalities).

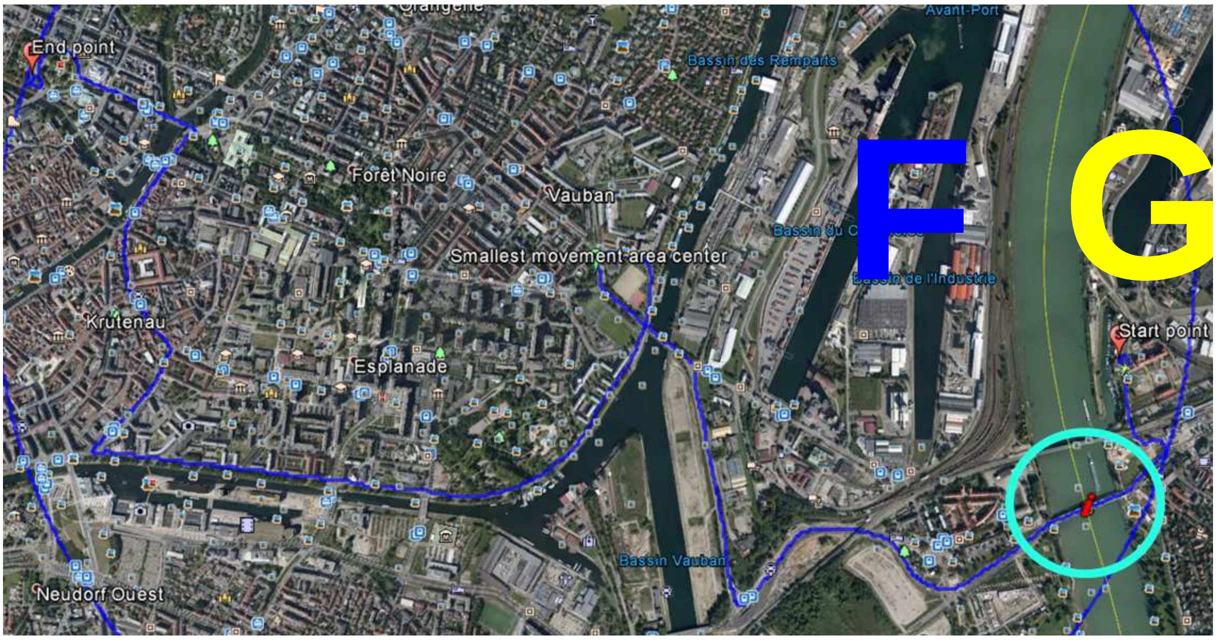


Fig. 44: Example of GPS Track for Cross-Border Trip from Germany to France (Pfriem 2013b)

The comparison between French and German use has shown that the considered French trips are statistically significantly longer in matters of distance but almost identical to the German trips in matters of time.

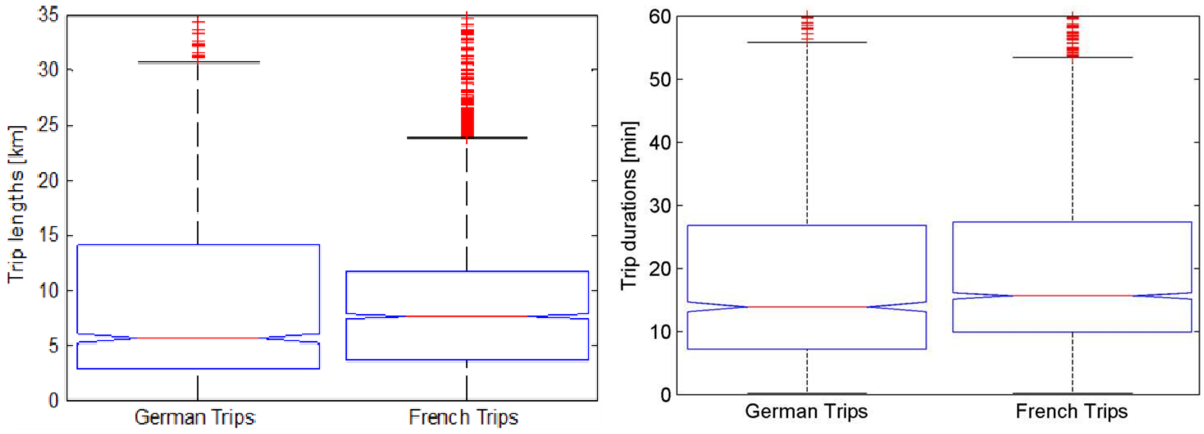


Fig. 45: Comparison of Trip Lengths and Durations (Pfriem 2013b)

This is caused by a larger share of rural use which is probably due to the less dense settlement structure in the French part of the project region. Basically, the data suggests that the performance of the EVs is on most days (more than) sufficient for the users' mobility needs on both sides of the border.

9.4 Study of Different Interfaces of Services to Increase the Flexibility and Ease of Use

Another focus of the CROME project was to find and develop possible eMobility services in a cross-border context based on the results of the user acceptance analysis. In cooperation with industry partners, association partners and research institutes from Germany and France, brain-storming meetings were organised to define desired and practicable services. The services should include access to charging stations, data exchange between the partners and countries by a communication platform, a tool for finding all installed charging stations in the CROME area and other additional services. The developed services should reduce the anxiety of participants for charging abroad and help the fleet test users finding the corresponding foreign EVSE. An important requirement was an effective administration of private user data by using a secure interoperable system.

Many suggestions for different types of services have been discussed and a list of important services has been created. The list has been divided into two groups:

1. Basic services. These services concern the search of EVSE, simple interoperable charging, time based charging, emergency solutions (e.g. in the case of a lost RIFD card), personal usage information, delivery and cancellation of identifications cards, reporting of spot utilisation and customer behaviour.
2. Value-added services. The major services from this group include preconditioning, advanced time-based charging (using additional communication), reservation of EVSE, direct payment, fleet management (EV pick up procedure and EV return procedure).

Interoperable charging has been realised with the help of a roaming service layer developed by the project partner Bosch. The access for charging an EV at a CROME EVSE is accomplished by an RFID-card. This is possible due to the data exchange between the EVSE operators (i.e. EDF, EnBW and Bosch) via the communication platform. Pictures of a demonstration test of interoperable charging can be seen in Fig 26 (a, b, e, f). There, two EVSE in Germany and France have been used to charge several e-cars, providing access by a single RFID-card. The tests included statistical measurements such as the charging time, and overall the demonstration was completed successfully without revealing major problems.

A major value-added service is the reservation of EVSE within the CROME area. In cooperation with industry partners, a collection of use cases for different charging scenarios has been worked out including car sharing, private ownership and fleets. An analysis concerning the confirmation of available parking spots and reservation of EVSE has been performed. As a next step, a web interface has been developed and implemented which has a connection with the CROME communication platform via web services. Using this platform, people on both sides of the border can access their charging data in a web browser. The software platform has been successfully evaluated using a broad set of test cases (cf. section 6).

Fig. 46: Services in the CROME Project:
A demonstration of interoperable charging in Germany and France in a), b), e) and f).
A EDF web-application to find CROME public EVSE in c).
A prototype web application for the reservation of available EVSE in d).
Service specific results of an online survey with CROME participants in g).

In cooperation with several KIT institutes, a large set of questions has been created to evaluate the major CROME hypotheses regarding eMobility, use of services, use of charging stations and cross-border activities (cf. section 9.1). The questionnaires are available in German and in French. The part of the questionnaire dealing with services was completed by 30 CROME participants on both sides of the border (most of which are fleet managers). Results concerning the process of finding and searching public EVSE and the usage of charging spots show a heterogeneous picture. 50% of the participants, cf. Fig. 26 g, state to prefer a smartphone or the web to find the closest public charging station, 15% prefer their GPS navigation system, and others prefer to ask friends or calling a service centre. About 30% of the participants wish to be informed about the closest charging station before starting a trip. There is a general desire for fast public EVSE at supermarkets, shopping centres, motorways and main roads. According to these demands, a light-weight web-application has been developed by EDF to find CROME public EVSE and look up their technical data and current status. The corresponding information (EVSE positions, socket systems and charging rates) are taken in real time from the CROME communication platform. The connection is allowed within a secure line between the partners (e.g. EDF, EnBW, KIT, Bosch) only.

Besides the web application by EDF, the KIT developed a prototype web application for the (hypothetical) reservation of available EVSE, too. The easy-to-use web application is suitable for tablets, smart phones and regular computers (cf. Fig. 26 d). Additionally, an agent based simulation environment with vehicle users and EVSE has been developed within the scope of a student research project. Various realistic reservation scenarios have been evaluated with respect to the ability of detecting shortest and fastest routes to different distant EVSE.

10 Special (Research) Topics / Questions

Besides the field tests of fast charging with actual users (see chapter 5.2), during the project fast charging had been equally analysed in detail in laboratories. Thereby a conformance test tool for the charging process was implemented as well as an demonstrator charger to show the potential of Network Supporting and Optimising Functions of EVSE.

10.1 Conformance Test Tool

One of the major goals in eMobility is to ensure that PHEVs and BEVs are enabled to recharge at all charging spots (e.g. according to ISO / IEC 15118). In the context of CROME, Daimler AG developed a Conformance Test Tool. While implementing the tool, the latest developments in standardisation have been monitored and used as additional input for the tool development as well as experiences from tool development have been used as input for the standardisation work. The tool is intended to be used for verifying if an ISO / IEC 15118 implementation complies with the standard.

10.2 Analysing the Impact of Dense Fast Charging Facilities in Urban Grids and Convincing Solutions

Fast charging of EV has a significant impact on power quality in low voltage grids. In order to quantify the effects of high power EVSE, a fast charging demonstrator system capable of charging powers up to 60 kW has been built at the KIT.

The system has been integrated in a grid simulation environment, which has been configured for typical rural and urban grid environments. A real-time load flow calculation allows determination of the impact on power quality and development of methods to achieve a better grid integration of EVSE.

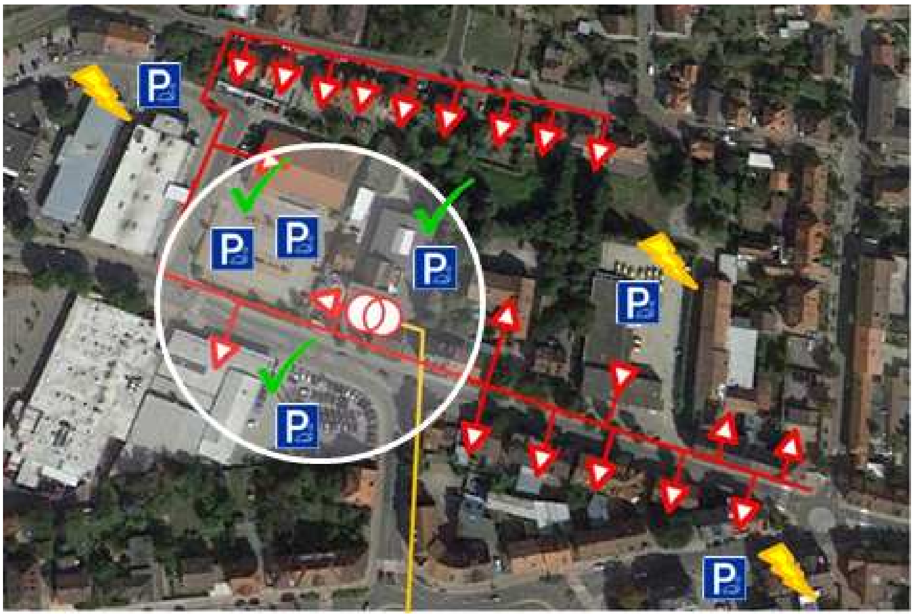


Fig. 47: Suburb EVSE Scenario

The figure before shows a suburb scenario including several high power EVSE. The simulation model shows significant voltage band deviations due to the increased load flow for EV charging at peak times. Strategies to minimise the voltage drop have been developed and tested using the fast charging demonstrator system. Therefore, different reactive power compensation schemes have been applied in different grid environments. These schemes improve gird stability of the whole grid environment in the considered district.

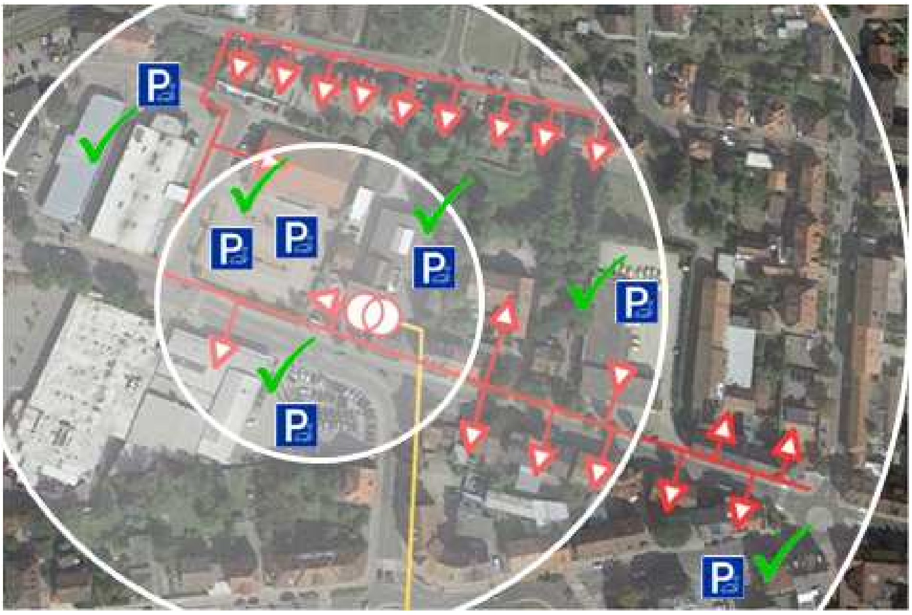


Fig. 48: Extended EVSE Scenario

In the analysis of the generated test data, mainly two compensation schemes convinced for high power EVSE applications. In suburb and urban low voltage grids, the best results have been achieved using power factor correction with a capacitive power factor in the range of 0.90 to 0.95. This allows high parallel charging activities (Figure 48). In rural grids with high photovoltaic generation, a voltage controlled reactive power compensation Q(U) scheme seems to be more suitable.

10.3 A Study on Fast Charging Socket Systems in Europe

During the CROME project period, KIT examined the regulations for fast charging in Germany and in France. This also included considering the possibility of a European harmonisation, especially for economic and practical purposes in order to facilitate a seamless mobility of EV across borders. So far there have been several different plugs used for fast charging in the European countries, the most prominent ones being the CHAdeMO and the CCS systems. Desirable for the cross-border use of EVs is that users do not need to deal with different socket systems. With national objectives aiming at the circulation of 1.000.000 EV until 2020 in Germany and 2.000.000 EV until 2020 in France, it was necessary to analyse how and when a European harmonisation could take place in order to work against deterrents. Furthermore, the fast charging stations would need to safely comply with the norm for CE-marking (indicating that the product does not violate any directive specifically formulated for this kind of merchandise). The CE marking indicates that a product can freely circulate within Europe as it complies with all applicable directives on safety and health. Generally speaking, these directives indicate that the product is safe and the technical norms established by a standardisation body – like the international ISO norms, the European CEN or the German DIN – have been considered. Although these technical norms are not legally binding, they are ascribed major binding effects.

The possibilities of a standardised product have been examined and three possibilities were recognised for that context: firstly, a simple agreement between the producers, as it was the case for mobile phone chargers back in 2009; secondly, a simple technical norm established by a standardisation body and thirdly, the European harmonization. As a technical norm is not legally binding, the best would be indeed the European harmonisation. This one is only possible, as indicated in Art. 26 TFEU, if the establishment of an internal European market occurs. As different legal systems are a barrier for a common European market, the EU can, according to Art. 114 TFEU, rely on their given instruments, namely a directive (which has to be implemented into national law) or a regulation (directly valid in all European countries the day it comes into force). As no limits of the European harmonisation like the encroachment of fundamental rights, or fundamental freedoms as well as the principle of subsidiarity and proportionality are violated, plug systems require the legal harmonisation.

Different charging stations and plugs hinder the EV commerce and – as a consequence – the achievement of national environmental objectives which could be achieved by having a certain amount of EVs. As the EU also considers the protection of the environment as a European objective, according to Art. 3 TFEU, a European harmonisation seems to be the best way to achieve these goals. The EU commission recognised the urgency of the matter and established a proposal for the directive: COM (2013) 18 final, recommending a legal harmonisation and the definition of a single plug system, justifying it especially with interoperability purposes.

These harmonisation aspects are also necessary for other issues which were also examined within CROME. Especially the field of billing systems is lacking specific regulations both in Germany and in France. In this respect, different systems existing in the two countries were compared. It was observed that, for the time being, simple accounting is preferred (e. g. paying for the parking time). Nevertheless, in order to integrate the EV in the grid, also other charging aspects need to be observed. Without this step, the pursued objective of resource-saving behaviour can hardly be attained.

Furthermore, also emerging new functions (like charging station provider, roaming system provider, etc.), which has been raised up within the CROME-model, need to be legally integrated. Moreover, it is not clear for Germany how the charging station should be legally classified: as a possible client facility or a facility sui generis, or a segment of the grid itself. However, also in France the introduction of a so-called mobility provider is not legally clear.

Roaming systems are clearly preferable but need to guarantee that a discrimination free access to the charging station is given. This is necessary not only on a national basis, but should also allow in the future to choose any foreign (European) provider. As German and French legislations are suffering a lack of electric vehicle specific regulations, a unified European provision would help simplify the integration of the electric vehicle within the grid.

11 Dissemination and Communication

The website CROME - http://crome-project.eu/ - informs in a French and German version about the project.

CROME was presented at the following events:

CROME Presentations			
Date	**Location**	**Event**	**Participants**
19-20.01.2012	Paris	3ème réunion annuelle – Véhicules Electriques 2012	Moselle
23.03.2012	Bühl	Deutsch-Französische Tagung	KIT
06-09.05.2012	Los Angeles	EVS26 - Integrating Electric Vehicles into the German Electricity Grid – an Interdisciplinary Analysis	KIT
21.05.2012	Karlsruhe	11ème séminaire francophone est-ouest de socio-économie des transports	KIT
11.09.2012	Venice	IAEE 2012, Smart Charging – Results From an On-Road Test With Electric Scooters	KIT
30.11.2012	Bremen	User Acceptance of Electric Vehicles in the French-German Context Workshop Future Mobility	KIT
21.02.2013	Lauterbourg	CROME Presentation at the Committee for Spatial Development and Transport (Ausschuss für Raumentwicklung und Verkehr) of the PAMINA Region	KIT
28.02.2013	Strasbourg	Inauguration of the CROME charging stations by CUS	CUS, Daimler, EDF, PSA, Renault
19.03.2013	Karlsruhe	CROME Event at KIT during the French-German Week	KIT, Bosch, EDF
11.–14.04.2013	Stuttgart	Exhibition at iMobility fair	EnBW
05 / 06.12.2013	Bremen	User Acceptance of Electric Vehicles in the French-German Context Workshop Future Mobility	KIT
28.06.2013	Strasbourg	Advanced Automotive Battery Conference Europe	EDF

15.- 18.07.2013	**Rio de Janeiro**	**World Conference of Transport** User acceptance of electric vehicles in the French-German transnational context	KIT
30.09- 02.10.2013	Stuttgart	Exhibition at World of Energy Solutions fair	EnBW
17.- 20.11.2013	**Barcelona**	**EVS 27**	
19.11.2013		*Session 4E: Project dissemination* CROME Cross-Border Mobility for EVs	Bosch, EDF, EIFER, EnBW, KIT, Renault
19.11.2013		*Session 6D: Public policy* CROME: The French and German Field Demonstration of the interoperable eMobility with EVs	EDF
20.11.2013		*Session 8D: Driving patterns & Behaviour* Experiences of EV Users in the French-German Context	KIT
		Dialogue Session: Less range as a possible solution for the market success of electric vehicles in commercial fleets	KIT
03.12.2013	Hagenau	Visit of Spitzencluster “Elektromobilität Süd-West” to Pôle Véhicule du Futur	KIT
11.- 12.12.2013	Lille	Congrès des Collectivités Électromobiles de l’Avere-France	EDF, Hagenau, Moselle, Ministry of Industry

Fig. 49: Presentations and Communications at Public Events

12 Learnings and Recommendations

12.1 Main Achievements at that Stage (to be completed in 2014)

The interoperable CROME charging infrastructure remains in place and keeps on being operated in 2014.

The Bosch Roaming layer keeps on running for CROME in the framework of the Green eMotion Project and the Schaufenster-Projekte.

EVs are further used (either from current or new clients). More than 800 EVs are likely to be targeted in Alsace.

New series EVs (smart ed phase 3, Panamera S E-Hybrid, ...) have entered the market.

The experiences with the standards (type 2 and 3 plugs, mode 3...) are being considered in the European standardisation process.

The knowledge gained is used in further projects through the involvement of the CROME Partners in e.g. Green eMotion, RheinMobil, iZeus, Stuttgart Services… .

12.2 Interoperability

The major learnings with respect to the three aspects of interoperability addressed in CROME are:

Hardware Interoperability - Interoperable Public Charging Infrastructure

Interoperability is technically feasible – both Type 2 and Type 3 Plugs / Sockets work well

The project has demonstrated that interoperability is feasible based on the existing technologies on both sides of the border:

It has been demonstrated in the CROME Project that both the type 2 and type 3 plugs / sockets can be implemented in one charging station according to the regulatory constraints on each side of the border in a way that easy retrofitting is ensured. Both types enables successfully charging of the EVs in the project. The initial objectives of the project were consequently achieved.

However, although technically feasible, this solution does not appear meaningful on the long term. In order to reduce the costs for the deployment of the infrastructure, the complexity of hardware, and increase the user acceptance, the CROME partners recommend an agreement at European level on one standard type of plug. In expectation of a European standard, the CROME partners recommend the deployment of charging stations which can be easily retrofitted if decided by the infrastructure owner, so that the costs for the adaptation to a future standard remain as low as possible. As developed above however the to-be-voted Directive should not require to retrofit existing installations.

Length of Process (DE, FR): Call for Tender, Decision on Location, …

The process for the rollout of public charging infrastructure worked differently in France and Germany:

- In France, the public charging infrastructure has been mainly bought and owned by local authorities in accordance with their managing role in the local transportation organisation, which need to go through public call for tenders and take into account the corresponding legal constraints.

- In Germany, the CROME charging stations are owned by EnBW, which discussed together with the respective municipalities and local energy suppliers the suitable locations for the CROME charging stations.

Thanks to the development of common specifications for charging in mode 3 for public charging stations and the preparation of an initial call for tender together with CUS, CROME contributed to simplify the process in France. The CROME terms of reference for the charging infrastructure have already been adopted by further border regions in France, e.g. Pas-de-Calais.

As a feedback roughly 9 months as a minimum are required from the specification definition to the start of operation in the street due the official constraints of the public tender regulation.

➔ **European wide Standards for the Further Development of eMobility is crucial.**

Hardware Interoperability - Fast Charging

Fast Charging is used and meet EV Customer Needs

eMobility Corridors are an appropriate Pattern in order to structure Territories

Interoperable and Multistandard Fast Charging Facilities are required in order to Fast Charge the Different EV Types on the Market

CCS charging and high level Communication according to ISO / IEC 15118 works properly

To keep up with the development on the eMobility market in Europe, charging using the new CCS plug and communication according to ISO / IEC 15118 should be analysed and tested within the CROME project. Therefore tests with the prototypes of a Siemens DC-Lab-Charger and a Daimler Smart ED with DC charging feature have been started in April 2013. Main focus of these tests was to set up, analyse and verify the communication between EV and EVSE according to DIN Spec. 70121 (as ISO / IEC 15118 is not normative at the moment).

It was proved that CCS-Charging and high level communication according to ISO / IEC 15118 works properly. Some open points within the standard (sometimes there´s still room for interpretation) were identified and will be forwarded to the responsible standardization committees.

Service Interoperability

CROME demonstrated service interoperability by roaming of services.

Communication Charging Station to Vehicle

The detailed definition added to the mode 3 specifications enabled a reliable cross-border charging. In this respect, no further developments are needed.

The adoption of the CROME terms of reference for charging in mode 3 have contributed to the development of an industrial offer in terms of infrastructure: several industrial providers now offer “CROME-like” charging stations.

RFID

The RFID card is a suitable media for ensuring roaming; within the project, the technology has proved to be user friendly and reliable. In addition, a live retrieval of the information needed between the backends avoids keeping data in all the systems. Consequently, e. g. in case a RFID-card gets lost, it is sufficient to disable it in one of the systems to have it immediately disabled in all the network of connected systems.

Communication Protocol of Charging Point to Backend System

OCPP allows a flexible connection of different charging stations to a backend system. It brings the advantage of being a de facto standard used by different providers. However, a connection requires the relevant partners to agree upon a common communication layer.

➔ **Standardization (RFID card, Type 2 / 3 plug, mode 3 charging, OCPP) is key to enable a marketplace.**

Roaming Service Layer

It was demonstrated that the selected roaming architecture works and is accepted by all the partners connected, as it supports current as well as future business models.

➔ **The CROME partners recommend for a future marketplace to build a network of independent international partners (competitors) having their autonomous business and systems, the system design has to ensure that each partner keeps his independence (data).**

Services

The search-service is essential for the market-success of eMobility.

Without legal framework conditions granting that a reserved spot is available upon arrival of the reserver, the introduction of such a service does not make much sense.

Linking vehicle data to backend systems makes innovative services possible; however, specific legal framework conditions are to be considered.

➔ **Roaming of services will be a key enabler for future mobility solutions.**

Billing Interoperability

Cross Border eMobility is possible and Reality today

Thanks to CROME, cross border eMobility is a reality .already today. The implementation of the necessary requirements for the authentication of the users and the rollout of public charging stations compatible with both the type 2 and type 3 socket systems enabled to remove the major technical barriers for cross border eMobility

Customers accept RFID Card for Authorisation and Payment

The RFID card has proved being a secure and user-friendly support for authentication and payment, well accepted by the users. Both in France and in Germany it is becoming a standard for the access to the charging infrastructure, so that the cross border e- mobility is ensured for the coming years.

European wide Standards for further Deployment of eMobility is crucial

The definition of valid standards at European level is crucial for the success of cross border eMobility. This includes the measurement and payment modalities (kWh- or time-based) as well as common user authentication procedures.

Cross Border Billing of VAT

A clear legal framework is necessary for the actual implementation of cross-border billing, especially with respect to the billing of VAT.

Rollout and Operation of the Charging Infrastructure need to pay off in the Future

Considering that eMobility still is in its beginnings, the investment and operation costs for the charging infrastructure are quite high if compared to the rather restricted number of users. Future business models shall therefore plan a fair distribution of the costs among all market players in order to ensure a sustainable success of eMobility.

Costs Transparency for End Users

Showing a customised pricing table at the charging station of each provider may considerably increase the cost transparency for the end user. In the same way, transferring the pricing table also over the roaming service layer in connection with the authentication service also seems to make sense.

CROME Users – Learnings and Recommendations from the Acceptance Analysis

Respondents who had experienced EV at least during one or two test drives as a driver or passenger were evaluating EVs' characteristics, particularly driving characteristics, better than respondents who had not experienced EV so far.

The French EV users are more satisfied with EVs' characteristic to protect the climate by lower CO_2 emissions at a highly significant degree.

For the French and German users the EV was a nice surprise and an enjoyable experience.

It has been shown that the vehicles are mainly used for short trips in an urban environment and usually stay far below their maximum range.

The comparison between French and German use has shown that the considered French trips are statistically significantly longer in matters of distance but almost identical to the German trips in matters of time. This is caused by a larger share of rural use, which is probably due to the less dense settlement structure in the French part of the project region.

13 Outlook on Research Activities in the Context of CROME

The idea of a continuation and expansion of the research activities within CROME arose for several reasons:

- The funding period of the French partners exceeds the German partners funding period. On the French side, the project will continue until November 2014. A continuation of the fleet tests, of the BEV / PHEV customer acceptance feedback and its accompanying scientific research was encouraged and desired by the French partners.
- The potential of research opportunities and knowledge gain from the already developed concepts, structures, and the bi-national user base is estimated to be very large. However, a relatively small amount of funds is required to activate this potential.
- In the diversified field of eMobility new research questions arise (such as multi-modality and intermodal mobility services) that can be explored comprehensively with relatively little effort by means of the already developed basis.

This results in five additional work packages (WP 901, 902, 903, 904 and 905), in which further research activities are carried out constitutively related to cross -border mobility with electric vehicles in the German-French context.

The main part of the WP901 is the integration of mobility data of the project in the overall demand for mobility with special consideration of current topics of mobility research (such as multimodal behaviour). Therefore, the data collection will be continued in WP902 and expanded to include the collection of reference data and their comparison, as well as capturing the overall mobility of individual users of all modes of transport. In WP903 the user survey will be continued with a focus on intermodal mobility services including data from WP902. WP905 accommodates the emerging and increasing importance of fast charging EV and therefore addresses this issue in detail. Though contact to experts in this area will be set up to exchanged gained knowledge. WP904 primarily serves as a comprehensive interpretation of the new findings (including impacts on energy economy) in cooperation with the French and German partners. The variety of findings and their relevance make allowance for the publication of a book band in which results and findings from the project will be presented. In addition to the scheduled publications additional results will be published and discussed at trade shows or conferences.

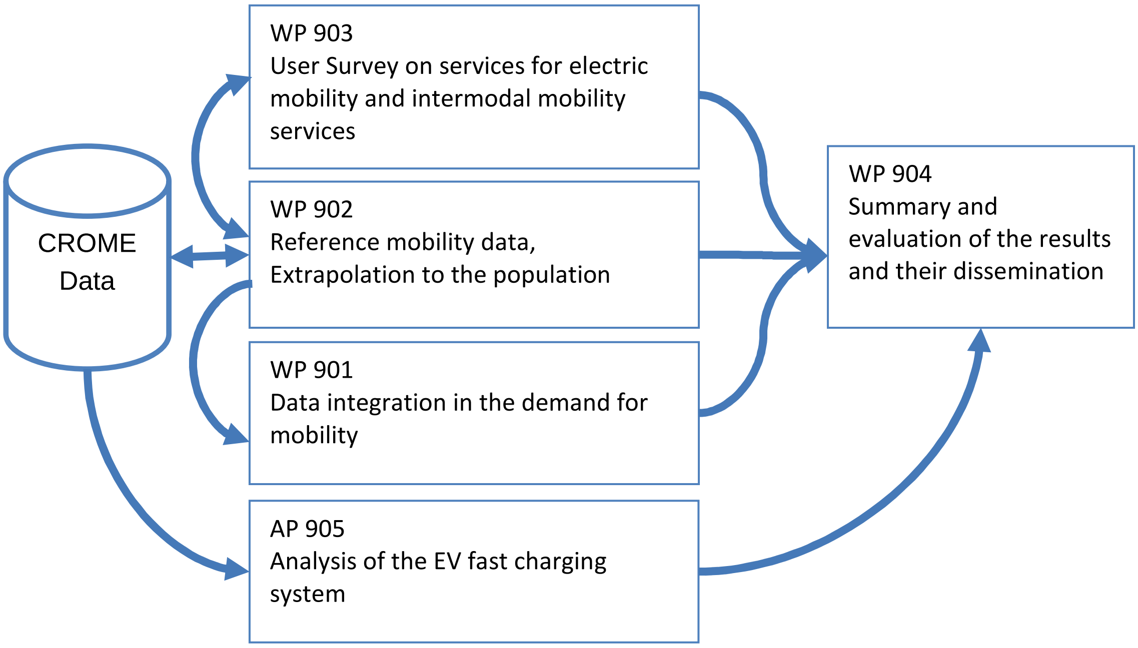


Fig. 50: Outlook on Research Activities of KIT in the Context of CROME

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15 Annex

Overview – CROME Compliant Charging Stations in the Project Area

… on the German Side

CROME stations in Germany	Charging stations	Charging spots	Sockets	Charging mode	Availability
E-Werk Mittelbaden	10	20	T2 + E / F on one side T3 on the other side	Mode 2 & Mode 3 3 – 22 kW	9 in June 2012 1 in July 2012
Stadtwerke Baden-Baden	10	20	T2 + E / F on one side T3 on the other side	Mode 2 & Mode 3 3 – 22 kW	10 in June 2012
star.Energiewerke Rastatt	2	4	T2 + E / F on one side T3 on the other side	Mode 2 & Mode 3 3 – 22 kW	July 2012
EnBW: • Endingen • Freiburg • Europa-Park	3	6	T2 + E / F on one side T3 on the other side	Mode 2 & Mode 3 3 – 22 kW	Sept. 2012 June 2012 May 2013
Stadtwerke Karlsruhe (existing infrastructure)	25	50	T2 and E / F	Mode 2 & Mode 3 3 – 22 kW	Already available by project beginning
	50	**100**			

A - Fig. 1: Overview of the CROME Compliant Charging Stations on the German Side

… in Alsace - *CUS (Strasbourg) area*

CROME stations in Strasbourg area		Charging stations	Charging spots	Sockets	Charging mode	Availability
New ones	CUS	8	16	T2 + E / F on one side T3 on the other side	Mode 2 & Mode 3 3-22 kW	6 in operation by end 2012. All 8 in operation by end of January 2013
	CTS	7	14			tbc
Retrofit from projet Kléber	Curbside	3	6	T2 + E / F on one side T3 + 309-2 on the other side	Mode 2 & Mode 3 3 kW	1 by September 2012 2 additional by the end of July 2013
	Underground parking lots	9	9	E / F + 309-2	Mode 2 3 kW	9 by end of June 2012
		27	**45**			

A - Fig. 2: Overview of the CROME Compliant Charging Stations in the CUS Area

… in Alsace - Colmar area

The city of Colmar has completed its – initially not included in the project outline - call for tender and selected a provider for 5 CROME charging stations, which are now installed and expected to be in operation soon.

… in Moselle

CROME stations in Moselle	Charging stations	Charging spots	Sockets	Charging mode	Availability
P&R Fameck	1	2	T2 + E / F on one side T3 + E / F on the other side	Mode 2 & Mode 3 3 kW	October 2012
Leclerc supermarket between Metz and Thionville (Hauconcourt)	2	4	T3 + E / F on each side	Mode 2 & Mode 3 3 kW	April 2012
Leroy Merlin store park in Forbach	1	2	T3 + E / F on one side T2 + E / F on other side	Mode 2 & Mode 3 3 -22 kW	November 2012
	1	2	T3 + E / F	Mode 2 & Mode 3 3 -22 kW	June 2012
Smartville Hambach	1	2	T3 + E / F on one side T2 + E / F on other side	Mode 2 & Mode 3 3 – 22 kW	October 2012
P&R Thionville-Veyremange	1	2	T3 + T2 + 2 E / F	Mode 2 & Mode 3 3 kW	November 2013
Sarreguemines area	4	8	T3 + E / F on one side T2 + E / F on other side	Mode 2 & Mode 3 3 – 22 kW	Expected March 2014
Faulquemont	1	2	T3 + T2 + 2 E / F	Mode 2 & Mode 3 3 – 22 kW	September 2013
City of Cattenom	1	2	T3 + E / F on one side T2 + E / F on other side	Mode 2 & Mode 3 3 kW	Expected February 2014
Leclerc Fameck	2	4	T3 + E / F on each side	Mode 2 & Mode 3 3 – 22 kW	September 2013
Leclerc Thionville	2	4	T3 + E / F on each side	Mode 2 & Mode 3 3 – 22 kW	September 2013
Leclerc Sarrebourg	1	2	T3 + T2 + 2 E / F	Mode 2 & Mode 3 3 kW	December 2013
	18	36			

A - Fig. 3: Overview of the CROME Compliant Charging Stations in Moselle