CROME: the French and German Field Demonstration of the Interoperable Mobility with EVs

Patrick GAGNOL[1], *Patrick JOCHEM*[2], Magali PIERRE[3], Wolf FICHTNER[2]

[1] *(corresponding author) EDF, EDF DME 10, Avenue de l'Arche 92419 Courbevoie cedex France, patrick.gagnol@edf.fr*
[2] *Institute for Industrial Production (IIP) at the Karlsruhe Institute of Technology (KIT), Germany*
[3] *EDF – R&D, ICAME, Paris, France*

Abstract

The project CROME – cross-border mobility for electric vehicles – is the first European field demonstration introducing a standardised and interoperable cross-border charging infrastructure network in the French-German Upper Rhine region. The main aim of the project, funded by different Ministries on both sides of the border, is to create and test a safe, seamless, user-friendly and reliable mobility with electric vehicles between France and Germany. Fully public interoperable charging stations have been implemented ensuring easy access and charging of EVs all over the French and German CROME area. Solutions are developed and tested about charging services enabling simplified authentication, identification, billing as well as charging spot availability and reservation. The achieved CROME market place enables data exchanges and roaming between different operators ICT back-end systems based on the Bosch service brokering platform. Feedback on customer acceptance of e-mobility and user needs with regard to charging is carried out.

Keywords: policy, standardisation, communication, infrastructure,

1 Introduction

Most industrialised countries set ambitious targets for electric vehicle (EV) shares in the near future. E.g. Chinas target is half a million by 2015 and 5 million by 2020 and India even 6 million by 2020. France's target amounts to 2 million (about 6.7 % of the fleet) by 2020 and Germany's to 1 million by 2020 rising to 6 million (about 14 % of the fleet) by 2030. The objectives of these targets are mainly motivated by decreasing oil dependency and cutting CO_2 emissions in road transport [1].

So far hardly any (reasonable) EV has been offered in the market. This year, however, a wide range of EV is becoming available on the market. Many countries have already reached effective charging infrastructure and interface standards. The next challenge is now to reach cross-border standards allowing e-mobility beyond any boundaries.

This is where the CROME-project comes into play: As the market for EV is growing successively, it is necessary to implement across-the-border solutions for driving and charging on both sides. Introducing a standardised easy-to-use, reliable, safe and interoperable charging station network in the French-German Upper Rhine region; the project CROME is making this scenario become reality.

2 Project description

The CROME project area spreads over the region Alsace and the departement Moselle in France (with a focus on the cities of Strasbourg, Thionville, Sarreguemines, Forbach and Colmar) and in Baden-Württemberg from Karlsruhe southwards to Freiburg in Germany (see Figure 1).

Especially on the French part of the border, mobility is an important challenge where the EV could find a favourable ground, because of two characteristics:

first, the predominance of the car; as a matter of fact, car possession and usage are quite high in Moselle and Bas-Rhin[1]. And second, the question of crossborder commuting; Germany and Luxembourg are attractive areas for French border dwellers, leading to a daily substantial automobile traffic[2].
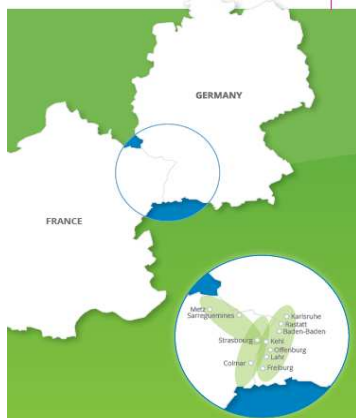

Figure 1 : CROME French and German area

The CROME project consortium consists of major carmakers (Daimler, Porsche, PSA, Renault), energy suppliers as eMobility service providers (EDF, EnBW), tier suppliers (Schneider Electric, Siemens, Bosch) and research institutions (Karlsruhe Institute of Technology (KIT), EDF R&D and IFSTTAR) from France and Germany. Associated partners including Nissan and Toyota as well as Local Authorities (Communauté Urbaine de Strasbourg, Région Alsace, Conseil Général de la Moselle) in France and energy suppliers (E-Werk Mittelbaden, Stadtwerke Karlsruhe, Stadtwerke Baden-Baden, Star.Energiewerke Rastatt) on the German side of the border also take part.

The project is funded by French and German Ministries with a strategic orientation role (in France: Ministère du Redressement Productif and Agence de l'Environnement et de la Maîtrise de l'Energie; in Germany: Bundesministerium für Wirtschaft und Technologie, Bundesministerium für Verkehr, Bau und Stadtentwicklung) and

started officially in 2011 – and it is even based on the experiences since 2009 from the Kléber Projekt in France [4] and MeRegioMobil in Germany [5].

The CROME project now offers seamless charging opportunities on both sides of the borders to all cars involved in the project (currently over 100 battery electric vehicles (BEV) from Daimler Mercedes, Smart, Porsche, Peugeot, Citroën, Renault, Nissan and Toyota (PHEV) involved in the CROME quantitative feedback and several hundreds of targeted EV users in France).
The objective of CROME competes therefore with other concepts for seamless charging throughout European countries, e.g. [6,7,8].

3   Main achievements
During the last months, the project partners have implemented all necessary conditions to ensure a cross-border charging functionality between France and Germany, including both hardware and software.
Introduced interoperability of the CROME public charging spot networks ensures that whatever the EV model from CROME, whatever the charging spot location in the CROME area in France and Germany and whatever the charging station operator, EV users can connect their vehicle, charge and pay when needed.

3.1   Hardware interoperability
In the framework of CROME, 25 new CROME public charging stations in Germany and 16 new charging stations in France () have been installed up to July 2013. 6 further stations are going to be operated in October 2013. Each of these are equipped with two charging spots respectively with type 2 and type 3 socket-outlets in ISO 61851 "mode 3" charging (see Figure 2). Operation of at least 50 CROME charging stations is targeted.
Each CROME public charging spot can deliver up to 22 kW (400 V, 32 A, AC triphase) in "mode 3" charging. Household E/F socket-outlets are also available for "mode 2" charging in 230 V single phase (up to 3.5 kW).

Interoperable connection to the fast charging station network (6 locations : Hagenau, Sarrebourg, Strasbourg, Illkirch-Graffenstaden, Colmar, Mulhouse) introduced in Alsace by Nissan, EDF and Cora (supermarket chain) was also implemented in 2012. These fast charging spots offer 43 kW DC CHAdeMO (compliant with Ion/C0, iMiev, Leaf, ...)

---

[1] The part of people possessing at least one car is 84% in Moselle and 81,3% in Bas-Rhin (and 80,4% in average in France). In Bas-Rhin, 60% of the trips are done by car [2], including short distances.
[2] The modal split of border workers is highly car dominated (88% of their trips in 2007) [3].

and AC triphase by "type 2" socket-outlet (compliant to ZOE) charging. Another CHAdeMO compliant charging station is installed in Karlsruhe, Germany. Furthermore, a study comparing the Combo2 and CHAdeMO is accomplished by KIT [9]. All these public charging stations are in actual operation and compliant to the CROME interoperability specifications.

Figure 2: CROME interoperable public charging stations: 2 x "mode 3" (type 2 and 3) in Strasbourg (left), 2 x "mode 3" (type 2 and 3) in Kehl (middle), and 43 kW DC fast charging mode 4 in France (right).

Technical overlayers to the mode 3 IEC 61581 standard were set up with the carmakers taking part in CROME in order to ensure a proper charging process with the "mode 3"-compliant EVs. Therefore all the EV/PHEV models currently available on the French and German markets or the tested EV/PHEV prototypes can be charged on the CROME charging stations (Smart ed, Ion/Co, Leaf, ZOE, PHEV Prius, PHEV Panamera, e A Class, ...) (see Figure 3).

Access to all the CROME charging spots are allowed through contactless cards using RFID technology (Mifare Desfire, Mifare Ultralite) in France and Germany. Round 200 EV users have already ordered CROME cards.

NFC cellphone identification will also be investigated. All the CROME charging spots are remotely monitored and controlled by the charging spots operators (e.g. EDF and EnBW).

3.2   Tested business models

Actual business models are assessed within CROME taking into account peculiarities of both countries.

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. Due to the marginal impact of consumed electricity[3] 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 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.

Figure 3: German Smart ed and French ZOE charging in Strasbourg on a CROME 22 kW station.

On the German side the stations have been implemented by EnBW which is also the infrastructure owner and operator. EnBW has set up partnerships with local German utilities in order

---

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

to help them provide eMobility services to their own customers.

This implies the possibility for each specific EV user – independent of their mobility provider / utility to have access to the complete charging infrastructure   on   the   German   side. The concept includes also the distribution of RFID-Cards. The customer receives one monthly bill for all charging sessions.

The EnBW billing and tariff approach is based on "quality" of parking zones (Zone 1 to 4) and on a time based billing model (see Figure 4). Each involved partner utility has however the possibility to design its own tariff model independent from the EnBW price plan. EnBW, Stadtwerke Baden-Baden, E-Werk Mittelbaden and star.energiewerk are using the time based pricing model. Stadtwerke Karlsruhe has chosen an exclusive flatrate model for their own customers.

Figure 4: Example of EnBW's charging tariff.

3.3   Service Interoperability

Within the CROME-project, EV users benefit from advanced e-mobility services enabling a full and user-friendly access to all of CROME's public charging stations in France and Germany:

- uniform access to charging stations with contactless RFID card for user identification,
- simplified cross-border billing for payment and roaming between e-mobility operators,
- customer-oriented web and smartphone applications[4] (availability of the charging stations and optimiser route navigation, cf. Figure 5), and

---

[4] EDF's CROME smart phone application can be freely downloaded at the following URL : http://m.sodetrel/crome

- access to the fast charging network..

Uniform and simplified access, identification and authorisation of the EV user to the CROME charging stations are made possible through the CROME market place between the French and German operators, respectively EDF and EnBW.

This organisation enables data exchanges and roaming between different operators ICT back-end platforms (cf. Figure 6) based on the Bosch service brokering. In fact, no data is stored in the developed market place but exchanged through a broadcast inquiry. Customer account data remain only known by the related operator. Data routing and brokering are controlled by defined agreements between the different operators on the market place.
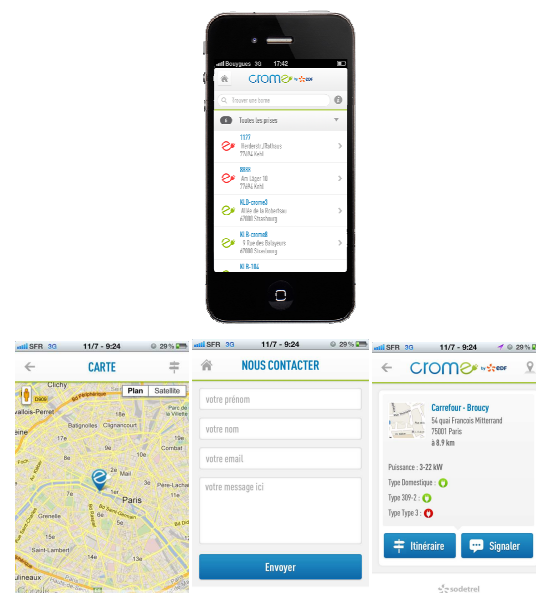

Figure 5: EDF's CROME smart phone apps about charging spot information
(availability, direction, type, …).

Such a roaming organisation can be used for billing. In France however, usage of contactless pre-paid cards like the Kiwhi Pass will be also experienced as a complement for non-registered customers.

CROME market place helps connect eMobility service Providers. The Bosch eMobility Service Brokering Platform forms within CROME a reliable interconnected network of the partners of different countries and industries, thus it integrates them in a barrier-free Ecosystem. The strength of the approach within CROME is that each partner stays the owner of his system and customer data and can run his business still autonomously. In

---

addition each partner can accelerate his business growth by sharing integrated services with other partners. Moreover each partner can negotiate different service agreements with one, several or all other partners. Through the interaction with other eMobility projects like GreenEmotion CROME is also going to demonstrate how connection between different eMobility market places can be organized and performed in order to offer to EV/PHEV users access numerous charging infrastructure networks in Europe.
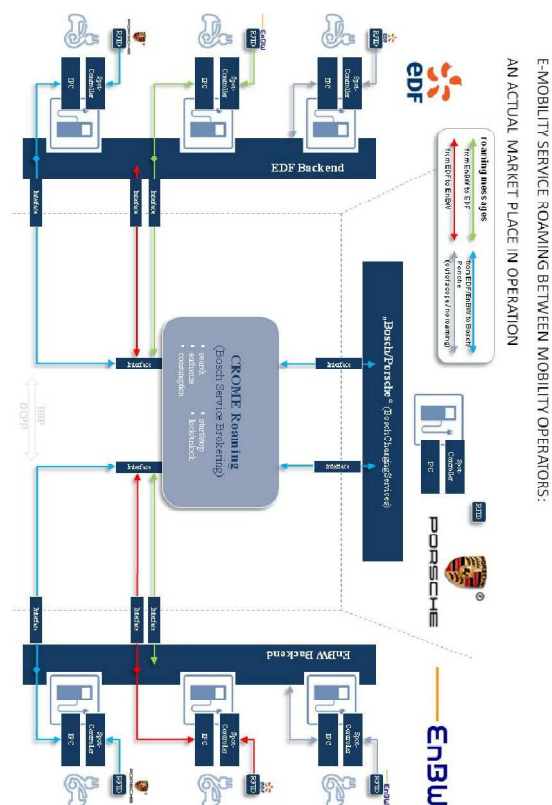

Figure 6: Charging service "roaming" organisation between CROME operators.

3.4 Feedback and dissemination

The CROME project represents a unique opportunity to test and collect information on these extensive cross-border functionalities with fully interoperable public charging stations and a huge number of EVs from different car manufacturers crossing the border.

A qualitative and quantitative feedback is being carried out and assessed both on the customer acceptance of EVs and the customer use and satisfaction with the CROME interoperable public infrastructure. More than 100 EVs of different car segments from the CROME carmakers are monitored with on-board data loggers which allow to analyse the user acceptance and behaviour of more than hundred users and several fleet managers. The CROME charging infrastructure is open for all EVs and PHEVs in the French and German CROME area. E.g. for Alsace, more than 800 actual and "normal" EV users who bought their cars from end 2012 are also likely to connect and charge at the CROME charging station network. Over 150 EV users have already ordered CROME cards in France from March up to June 2013. Quite a lot of them are private EV customers (B2C) but also B2B ones as a carsharing company in Strasbourg.

At the KIT the accompanying scientific research of CROME is based on an interdisciplinary analysis and benefits from the support of EDF R&D on both sides of the Rhine. Computer scientists, energy economists, automotive engineers, jurisprudents and electrical engineers are working together in order to give responses to questions arising from different disciplinary origins.

The acceptance analysis, as part of the evaluation concept (cf. Fig. 7), consists of repeatedly questioning the users and fleet managers of the EVs by online surveys with different focuses (expectations, first experiences and adoption of EVs), as well as of face-to-face interviews with some users and workshops with fleet managers; this qualitative study aims to understand the rationale of the individuals (ways of thinking and behaving) concerning EVs and the charging infrastructure, to consider their original questions, and to collect data from the observation of their mobility routines in professional sites. Additionally, technical data on trips such as speed and acceleration is collected by using data loggers within the car and smartphones additionally. The latter allows to track the GPS signal and make it possible to conduct a short survey before each trip, asking e.g. for purpose, number of passengers, etc. So far more than 4,650 trips and 50,000 km have been tracked.
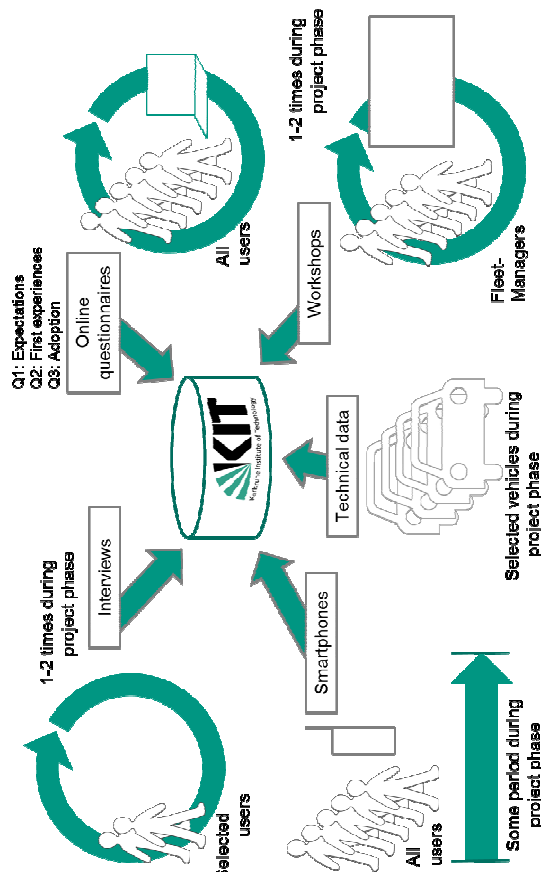
Figure 7: Evaluation concept for EV user acceptance in the CROME project.

All these data samples can be reunited anonymously by a unique user ID which allows a comprehensive impression on first user experiences with EV and potential anxieties concerning cross-border trips. Economic issues like prices and the profitability for users of EVs are considered as well as sociological and cultural aspects that permit to identify national particularities concerning user acceptance of EVs.

About 170 fleet managers and users already responded to the first online questionnaire (survey period September 2011 until April 2013). The following results refer to the end of July 2012, more recent results can be found in [10]. Whereas the nationality of respondents does represent the assumed population properly (each about 80), males are significantly overrepresented, with 72 % of the respondents. Furthermore, compared to the national average, respondents between 40 and 60 are overrepresented, whereas respondents younger than 30 and older than 60 are underrepresented.

The household income within our sample seem to be above the national averages (French participants: 3,588 €; German participants: 3,766 €) [11]. Nearly all vehicles are used in company fleets and can be used only for business trips and commuting (about 94 %). Nevertheless, a third of the respondents do not exclude to potentially charge the EV at home. This refers to a crucial point within the CROME project: Less than half of the respondents planned in 2012 to recharge the EV on public charging infrastructure (in the street and off-street), and this proportion was specifically low among German people. It must also be taken into account in this analysis that only a few cross-border charging infrastructures were really available at that first inquiry period of time in the geographical inquiry area.

Therefore, the CROME project focuses currently more on the other half of the EV users, which plan to charge at public charging stations. However, users, which already made experiences with EV, are much more confident about their suitability for daily use and, therefore, all users might increase their electrified mileage. This could lead to an increase in the usage of the public charging infrastructure also by pessimistic users. Furthermore, an implemented overview (a simple table on the homepage and the application by EDF)of charging stations might help to motivate users to use them more frequently. Interestingly, the knowledge about available charging stations seems to reduce the range anxiety significantly. The results from the questionnaire provide an optimistic forecast about EV penetration: only $\frac{1}{5}$ could not imagine buying an EV for personal use in the following years. [10,11,12]

With respect to the city size, which is often said to influence the acceptance of EV, no real dependencies could be confirmed by our first survey. French respondents tend to live in communities with less than 5,000 or more than 100,000 citizens (over 60% of the French respondents) whereas the German respondents are heavily overrepresented in towns with between 5,000 and 100,000 citizens (over 80% of the German respondents). This might, however, depend on the local conditions of the CROME regions and the participating companies [10,11]. A comprehensive overview on the results from the online questionnaire on EV users' experiences can be found in [10,11,12] and for the results from the smartphones in [13].

In this context several questions appear which are focused by the ongoing questionnaire. For

instance, is the limited range a constraint for these professional users? If they are familiar with border travelling, is cross-border recharging a fear for them? Are there measurable dissimilarities between French and German people, considering their positions on energy and environmental issues and their relation to cars?

The qualitative study intends to address these topics by following the same methodology in France and in Germany (face-to-face interviews, sample of approximately 20-25 users and fleet managers on each country, with a common guideline, etc.). The interviews conducted in 2012 underline the following results: the cars have been provisioned in the companies and institutions like conventional cars, i.e. allocated by a fleet manager considering short and medium distance trips. Some companies even use the EV as a reward (e.g. for a successful project completion employees get the EV for a few days). Nevertheless, it is frequent that users are allowed to commute by EV, and this flexibility intends to encourage the employees to use the new car. Most of the companies and institutions involved in the project are interested in the success of the EV deployment. Consequently, a part of them install customized charging infrastructure at the entrance of their sites. Although the users appreciate a lot the driving with an EV and the charging in familiar places, they declare to miss an easy access to the specifications of public charging infrastructure (location, processes, available sockets, etc.).

New campaigns of interviews and questionnaires are going to be carried out from Q4 2013 on. In fact major changes have now to be taken into account both due to the increase of available CROME cross-border charging stations (at least 50 stations by end 2013 + 7 fast charging facilities) and of the amount of sold EVs and of new users in Alsace (800 EV users likely to charge, important ZOE sales with 22 kW charging capabilities) .

Quantitative feedback on the use of the CROME charging infrastructures is also going to be assessed by 2013 as all the public charging spots are monitored.

4 Conclusions

A seamless mobility with EVs between European countries is an undeniable requirement for the future car market. The CROME project identified this challenge already in 2010 and focused on the interoperability of hardware (e.g. plug and socket for mode 3 charging) and software (e.g. authentication, billing, and services) in the border region of France and Germany and has been therefore the first project to discuss this issue.

The CROME project has been developing and implementing an interoperable charging station system which allows charging within the project's region by a unique authentication and billing process, services and plugs – no matter in which country. This concept includes:

- Installation of at least 50 interoperable 22 kW "mode 3" charging stations and 7 fast charging installations
- Implementation of a service roaming layer for billing and service provision between eMobility service providers
- Furthermore, a comprehensive user acceptance analysis has been carried out and will be completed in 2013-2014. The next questionnaire will deal with long-term adoption intentions of the participants, and the next qualitative study will address the usage of public infrastructure and give a specific attention to the off-work users (people having personally purchased an EV).

Actual business models are assessed within CROME taking into account peculiarities of both countries. In Germany billing scheme are based on a time-based tariff (pay per hour). In France charging on public charging station is free of charge but could be priced by the end of 2014.

Therefore, the CROME project delivers very useful findings for other projects in this field. Dissemination of main achievements, learnings and recommendations is one of the main CROME goals. Further complementary information can be found on the CROME web site WWW.crome-project.eu.

Acknowledgments

of electric vehicles in commercial fleets in proceedings of EVS27, Barcelona, Spain.

References

[1] Gomez Vilchez, J.J.; P. Jochem; W. Fichtner (2013): The Impact of Electric Vehicles on the Global Oil Demand and CO_2 Emissions, in proceedings of World Conference of Transport Research Society, Rio de Janeiro, Brasil.

[2] INSEE, Recensement de la Population 2008

[3] CEPS/INSTEAD, Enquête Frontaliers 2007.

[4] Kléber Projet: http://www.greenunivers.com/wp-content/uploads/2011/05/PPP-projet-Kleber-Toyota-EDf-9-mai.pdf accessed on 2013-06-10

[5] MeRegioMobil: http://meregiomobil.forschung.kit.edu accessed on 2013-06-10

[6] HUBJECT, http://www.hubject.com, accessed on 2013-06-10.

[7] Green eMotion, http://www.greenemotion-project.eu, accessed on 2013-06-10.

[8] e-clearing.net, http://www.e-clearing.net, accessed on 2013-06-10.

[9] Schäuble, J.; P. Jochem; W. Fichtner; S. Balaban; F. Schellhas-Mende; P. Krasselt (2013): Vergleichsstudie von Systemansätzen für das Schnellladen von Elektrofahrzeugen, Project Report, Karlsruhe.

[10] Ensslen, A.; P. Jochem; W. Fichtner (2013): Experiences of EV users in the French-German context, Proceedings of EVS27.

[11] Ensslen, A.; P. Jochem, P.; J. Schäuble; S. Babrowski; W. Fichtner (2013): User Acceptance of Electric Vehicles in the French-German Transnational Context, Proceedings of World Conference of Transport Research Society, Rio de Janeiro, Brasil.

[12] Ensslen, A.; S. Babrowski; P. Jochem; W. Fichtner, W. (2012): Existe-il des différences d'acceptation des véhicules électriques entre la France et l'Allemagne? – Premiers résultats de l'analyse scientifique du test de flotte Cross Border Mobility for Electric Vehicles (CROME), 11ème séminaire francophone est-ouest de socio-économie des transports, Karlsruhe, Germany

[13] Pfriem, M.; F. Gauterin (2013): Less range as a possible solution for the market success

Authors

Patrick GAGNOL is in charge of operational partnerships with major EV-markers in Europe at EDF's Electric Mobility Division. French project leader of the CROME project and EDF manager of eMobility demonstrations as "SAVE".. Head of the EDF R&D's research team on materials and energy storage for transportation and stationary applications up to 2000. Project manager from 2001 to 2005 for the development of electric urban transportation.

Patrick Jochem is the leader of the research group "transport and Energy" at the chair of energy economics and senior researcher at the Karlsruhe Service Research Institute (KSRI) at KIT. He received his PhD in transport economics about CO_2 emissions in road transport and holds a Diploma of economics from the university of Heidelberg, Germany.

Magali Pierre is a sociologist working on households' energy uses at EDF R&D. She focuses on individual mobility, and more specifically on the emerging electric vehicle in France since 2007. Her recent work has consisted in bringing in a sociological support to trials rolling out electric vehicles and charging infrastructure in France.

Wolf Fichtner is Director of the Institute for Industrial Production and the French-German Institute for Environmental Research. He is full professor and holder of the Chair of Energy Economics at KIT. His main areas of research are Energy System Modelling and the Techno-economic Analysis of Energy Technologies.