Prologue

Against the background of climate change and the limited resources of fossil fuels the governments of France and Germany both have supported an accelerated market penetration of electric vehicles (EV) for several years. When using electricity from low-carbon power generation, the substitution of internal combustion engine vehicles (ICEV) by EV will not only reduce CO_2 emissions in the transport sector, but also the dependency on fossil fuels. Nowadays, the use of EV goes still along with certain disadvantages compared to ICEV which inhibit a larger market penetration of EV. Next to high costs of EV, range limitations and a relatively long battery charging duration imply flexibility losses for EV users (cf. chapter 8). In order to reduce these drawbacks, technological advances on the vehicle side as well as a user-friendly charging infrastructure and mobility services that fulfil the users' needs are required (BMVI 2014 p.45). As vast efforts were and still are made in both countries to fulfil these requirements the need for cooperation on these concerns were eminent. Therefore, the vision of the CROME (CROss-border Mobility for Electric vehicles) research project was to create and test a safe, seamless, user-friendly and reliable mobility with EV between France and Germany as a prefiguration of pan-European electromobility. One of its major aims was to formulate answers and suggestions to contribute to the European standardisation process of charging infrastructure for electromobility (such as electric supply, cables and plugs) and of corresponding services (e.g. identification, billing, and roaming) and to provide stakeholders with an early customer feedback. Several significant milestones have been achieved during the project:

- A wide-scale cross-border field demonstration of mobility with more than 100 EV was performed in 2011, introducing fully public interoperable charging stations (EVSE), ensuring easy access and charging of EV all over the French and German CROME area.

- The customer acceptance of electromobility as well as the users' needs regarding charging in the context of cross-border mobility were investigated.
- Charging services enabling simplified identification and cross-border billing and charging spot availability as well as reservation was developed, implemented and tested. This serves as a cornerstone of the European roaming concept.
- The project contributed significantly to the European standardisation process of charging infrastructure and corresponding services.
- Besides these achievements, this book provides our main findings of the accompanying research.

In the first chapter the **editors** give a brief overview on the projects context and its main characteristics presenting the involved partners, their performed tasks, the concept of interoperability, the fleet test schedule, the involved EV and the installed infrastructure.

In the second chapter **Daniel Ried** presents the data repository of the fleet test, i.e. data collection, transfer and storage. The design and architecture of the data repository is focused on a secure and reliable operation of all transfers and storage. The heterogeneity of datasets was high: Technical data with a very high timely resolution came from the vehicle (via internet from vehicle manufacturers), geo-positions and other trip related data (recorded by smartphones) were sent by data-streams, and other data from the vehicle users were merged with a unique ID system. Additionally, various interfaces, tools and services for the data repository were developed in order to improve the usability of data imports and processing of raw data as well as for querying, accessing and exporting aggregated business objects for further analytical processes.

In the third chapter **Peter Krasselt** gives an insight into public EV fast charging infrastructure and their reactive voltage support for the grid. Therefore he depicts standards and technical rules for their network connection as well as how network disturbance can be assessed, and he proposes a fast charging infrastructure topology. Finally a detailed analysis

of reactive power voltage control schemes is performed and its results are highlighted.

In the fourth chapter **Magali Pierre** and **Anne-Sophie Fulda** present the results from 45 interviews performed during the fleet test, all respondents are EV users – some are employees using the EV of their company and others are private EV owners: First they take a deeper look into EV usage in a professional context, before they refer to interviews with EV users which influenced the EV purchase decision. Finally, changes in mobility patterns and experiences of EV usage during the first year are highlighted.

In the fifth chapter **Felix Vogel** and **Hartmut Schmeck** give an overview on the development of electromobility services within the fleet test and in general. Furthermore, they describe an analysis of the users' mobility behaviour with EV as well as the usability of e-services in France and in Germany and expose its results.

In chapter six **Eva Weis** and **Silvia Balaban** take a look at the harmonisation process of European legislation in the context of electromobility. They explicate the framework conditions and analyse the general ways of attaining a European harmonisation within its limits. The chapter shows the harmonisation approach of the European Commission on the example of fast charging infrastructure. Further aspects connected to the use of EV regarding their need of being harmonized are equally outlined.

In chapter seven **Mathias Pfriem, Frank Gauterin** and **Thomas Meyer** give an overview of the analysed usage of the EV on the basis of recorded trips during the field test. The authors present the data sample and their developed and applied data collection methods. Subsequently key figures of the observed mobility are presented. The charging behaviour is analysed additionally and reveals a mostly daily recharging from high states of charge to a full battery. Finally, national idiosyncrasies are presented by comparing characteristic mobility aspects of France and Germany.

In chapter eight **Axel Ensslen, Patrick Jochem, Martin Rometsch** and **Wolf Fichtner** analyse purchase intentions of EV users and fleet managers who experienced EV during a period of about two years in a professional context. Therefore, after presenting a brief literature review, they characterize the sample of an online questionnaire. A binary logistic regression model is derived from the survey data providing information on private EV purchase intentions.

In chapter nine **Elise Nimal** and **Anne-Sophie Fulda** analyse the collected data during the operation of charging stations installed in France in consideration of frequency, location and user characteristics. Additionally they have a deeper look into the user behaviour related to the use of charging infrastructure.

Tim Hilgert, Martin Kagerbauer, Christine Weiss and **Peter Vortisch** pursue the question of how EV can be used in people's everyday life in chapter ten. After a brief presentation of the underlying data, models and methods they analyse the usage of EV in the field test and give a short comparison of vehicle usage in France and Germany. Using the national household travel survey data (German Mobility Panel (MOP)) they estimate the share of German car trips that can be substituted by EV and compare this with the situation in company fleets.

Condensed key findings of the accompanying studies in the fields of charging infrastructure, electric vehicle usage, user acceptance and demand for mobility within the fleet test are described briefly in the following:

Charging infrastructure: Fast charging systems have a high influence on the voltage quality in the low-voltage network. The effect on the change in voltage is particularly high. Boundary value violations are observed in typical low-voltage networks for a distance of over 250 meters between the fast charging unit and the local substation. Active network supporting fast charge units may be operated in long branches exceeding 250 m. Here, the voltage band is stabilized by reactive power support and the maximum distance can be increased by 30%. When comparing different regulatory

approaches for voltage support a hysteresis-based regulatory approach has achieved the best results in rural, suburban and urban grid area. In compliance with the normative requirements for the voltage quality the additional power losses were in this case in the range of 1-5% during the loading operation due to the additional reactive power load flow. Additional fast charging systems may attenuate fast voltage changes. Here, the control parameters of all connected consumers who provide active voltage stabilizing are to be chosen with care to avoid control oscillations and instabilities.

Vehicle use: In the field test, EV are applied mainly in commercial fleets of local focused institutions and are mainly used in urban areas within a radius of 40 km maximum. The rides are mostly short (<10 km) and also in combination of all day trips well below the maximum possible range. Nevertheless, the vehicles are charged almost daily, so the battery is used almost exclusively in the upper half of its capacity. The share of journeys over 15 km in length is significantly higher in France, because more overland trips are made, resulting in relatively faster velocity profiles.

User acceptance: EV in the context of CROME are perceived more environmentally friendly by the French respondents than by the German users. In particular, the characteristic of EV to cause low CO_2 emissions is evaluated significantly better by the French respondents. The German field test participants evaluate the factor that EV are perceived as innovative and environmentally friendly, both inside and outside their organization by third parties, significantly better than the French field test participants. CROME field test participants, who already drove a few trips with EV, are more likely to purchase an EV than those who had no experience with EV. The multi-modal data repository with user acceptance, mobility and technical data provides a good basis for analysing the applicability of EV in commercial fleets.

Replaceability of ICEV by EV: CROME survey participants have a significant consumer preference for EV and high annual mileage. Nevertheless, for the replacement of an ICEV by an EV behavioural changes are mostly

necessary. Due to the car choices within a vehicle fleet the use of EV as a supplement in company vehicle fleets is a realistic scenario, as for every ride a reach optimal vehicle is available. However, we still see the requirement to harmonize and adjust the national legislation for EV.

Karlsruhe, October 2015

Johannes Schäuble, Patrick Jochem, Wolf Fichtner