Connected Electromobility –

Between CO_2 optimized energy management, user-centered design and cost effectiveness

Björn Born, Madlen Günther*, Benjamin Jähn, Sebastian Müller, Svenja Scherer, Aniko Temmler, Jens Teuscher, Uwe Götze, Ulrich Heinkel, Josef F. Krems, Wolfgang Schufft and Gerd Wanielik
Technische Universität Chemnitz, Chemnitz, D-09111, Germany
*Corresponding author: Madlen Günther; *E-mail address:* madlen.guenther@psychologie.tu-chemnitz.de

***Abstract*—In the present paper an innovative connected mobility concept with battery electric vehicles, pedelecs and the public transport is described. The project *ECoMobility* addresses the technical implementation of the mobility system and the intelligent charging system. Furthermore, the acceptance of electric mobility and incentives for an environmentally friendly behavior (e.g eco-driving) are examined. Analyzing the cost effectiveness of the connected mobility concepts and developing viable business models are the additional research aims.**

***Keywords*—ECoMobility, field-study; carsharing; pedelecs; usability; acceptance; travel mode choice; eco-driving**

I. INTRODUCTION

The reduction of greenhouse gasses and the efficient usage of fossil resources are major goals in the development of mobility systems for the future. One promising option to reach this goal is to increase the utilization of electric mobility.

Furthermore, carsharing systems can also make an important contribution to the reduction of emissions. The implementation of electric mobility in such a carsharing system seems to be a fruitful solution to achieve the maximum effect for a sustainable mobility system. The advantages are mostly the short distances of individual trips and the high utilization rate of the vehicles. A special application for such a carsharing system could be the usage of an in-house mobility system of a company, in which the mobility requirements are usually predictable.

The project *ECoMobility* considers such an in-house mobility system. In particular, connecting different mobility-systems (e.g. public transportation) and different individual vehicles (e.g. battery electric vehicles (BEVs), pedelecs) are the research aims of the project *ECoMobility*. In this paper we will outline the project and give an overview of first steps of the research agenda.

II. ECOMOBILITY

The project *ECoMobility* started in September 2015 funded by the European Union and the Free State of Saxony for the next three years. It is developed subsequent to the project of *fahrE* [1], which accomplished the charging infrastructure and the basic information system at the test site. Accordingly, results regarding system acceptance and usability are the base of the current research project.

The project is divided into four main parts (see. figure 1). The examination of user acceptance of electric mobility and the investigation of incentives (e.g. for an environmentally friendly behavior) are included in the *ECo-type adaptive* part. Further two parts (*ECological* and *E-Connected*) are based on the technical implementations. *ECological* considers the implementation and analyses of eco-driving and an intelligent charging system to use the most of renewable energies. The integration of server structure, data logging unit and booking system (i.e. Web-App) in a complete mobility-on-demand-system is the goal of *E-Connected*. Analyzing the cost effectiveness of the connected mobility concepts and developing viable business models are the research aims of the *EConomic* part.

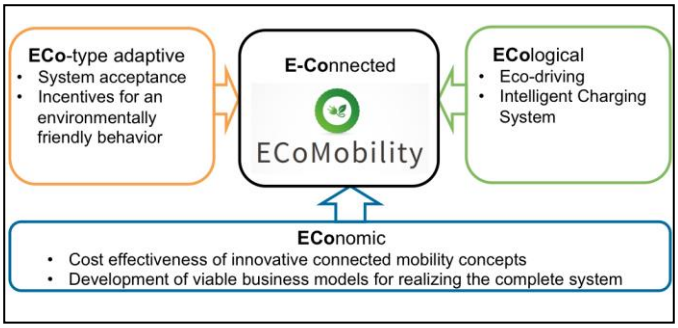

Fig. 1. Overview of *ECoMobility*.

III. PROJECT PART E-CONNECTED

A. *The Structure of Information Technology*

1) *Technical System Overview*

There are four major functional technical components for the *ECoMobility* project (see figure 2). These are, first of all, the backend server. This server is the central management unit of the whole system. Second, the user interface is realized as Web-App (i.e. booking system), which is the main interface between the user and the system. Third, the vehicle access control and logging unit are responsible for providing users with a valid reservation access to the car and uploading state updates to the server. Finally, the intelligent charging stations are responsible for optimizing the usage of renewable energy.

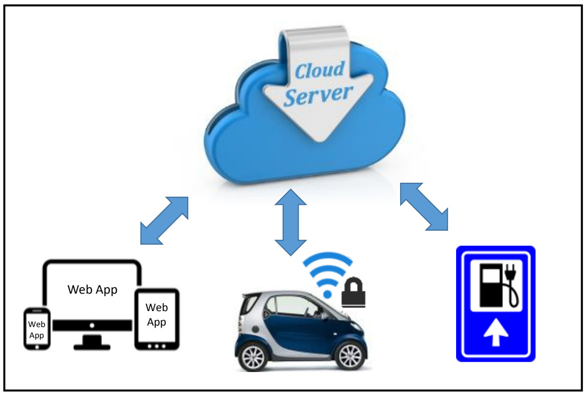

Fig. 2. The functional core components of *ECoMobility*.

2) Backend Server

The backend server consists of two functional parts. First, it contains a database, which stores all relevant user data, configuration, reservations, system events, and all necessary state information about the vehicles and charging stations. Second, it provides web services, which use all other components of the system via remote procedure call in order to interact with each other. These include user authentication, reservation and routing requests, state updates and maintenance commands. The intelligence of the whole system is behind these web services. The server saves where the vehicles should be, which battery level they have and who has access at a certain time.

With this simple centralized approach it is easily possible to maintain and improve the overall system without changing anything at the other components that are strewn at large in the whole city. Especially, the option of adding new management features to improve the availability and maintenance of the system without stopping its services is a huge advantage. Furthermore, this structure can be easily protected from external manipulation attempts by just providing transport security over the https protocol on the link between the components and the backend server.

In addition to electric cars and pedelecs, users will be able to use the public transport service. Currently, it is handled by providing previously purchased tickets to each user. For the future, it is intended that the server has an interface for the public transport schedule and an online ticket buying system such that the server can order tickets on demand and forward them to the user.

Furthermore, it is planned that the server statistically analyses users' choices of the different transport systems (BEV, bus, pedelec) and users' driving behavior with respect to BEVs' energy consumption. Thus, the user should be motivated to decide not on the most comfortable transportation platform but on the most environmentally friendly one (bus, pedelec). Furthermore, users should be motivated to develop an environmentally driving style (i.e. eco-driving, see section V) when using BEVs. Therefore, the user should be able to compare himself with the community by showing him certain charts and statistics (see section V).

3) User Interface

The user interface is realized as Web-App that runs in desktop as well as in mobile browsers. Therefore, it can be used on any mobile platform as well as on standard desktop operating systems. Hence, a wide range of possible users is reached and the amount of necessary development is reduced to the minimum. Furthermore, a unique user experience on all platforms can be provided.

With this app, the user is, at first, able to authenticate himself against the system. Afterwards, he will be able to manage his reservations. This includes the booking mechanism as well as the cancelation and modification of existing reservations.

The Web-App is realized using the jQueryMobile framework which creates the look and feel of a smartphone App but it is also capable of utilizing larger screens. With just this approach is not possible to make use of any sensors or communication capabilities of smartphones or other devices. Therefore, it is intended to embed the current Web-App into the Apache Cordova framework. Using this, in addition to other sensors and device functionality, the camera of the smartphone is accessible, which enables us to provide users an easy mechanism to create descriptive support requests. Besides, the localization mechanisms can be employed in order to help the user to find the vehicle by showing him the current position of the car and his own position on a map. It should be noted that just the first approach is currently supported.

B. Vehicle Access Control and Logging Unit

1) Concept of Access Control

To establish a car pool system with a large number of users, an access control is necessary. The next sub-chapter will figure out the basic ideas on this problem. Afterwards, the access control will be explained in more detail. In sub-chapter 4), a problem that can occur will be described and possible solutions will be given at the end of this chapter.

2) Basic Idea

The basic idea is that the user can book an electric car or a pedelec online. As soon as it has been booked, a message will be generated and sent to the access control in the vehicle. The message contains the booked time slot, the server timestamp and the user ID. For security reasons, an encryption message should be transmitted with AES-256. This ID is located on a RFID-Card using MIFARE-ID. The identification number is unique for each card. Thus, the driver can be securely identified and enter the car by using this card.

3) Control System in Detail

Our Control system consists of two parts. The first part is a microcontroller, which is able to manage all low level tasks. The second part is an embedded system operating on a Linux OS. This platform handles all higher-level communication like GPS, receiving GPS coordinates and communication with the *ECoMobility* backend system. For the access control system, a controller is used based on an ARM® Cortex®-M3 Core. The Microcontroller manages all incoming and outgoing signals and the RFID Card reader is managed by this system as well. Another task of the controller platform is to handle the power management system for the embedded system. In order to save as much energy as possible, the known IDs, which have access to the car, are cached on and thereupon, the embedded system is turned off for the time, at which the car is not moved. A Bluetooth module has been added to the platform to ensure that the access control grants also access to the car if there is a spontaneous booking nearby the vehicle. By using Bluetooth and a smartphone, the credentials can be exchanged, even if the embedded system has no valid connection established to the server. In figure 3 all components of the Access Control System are shown. The block diagram depicts all interconnections between the single blocks.

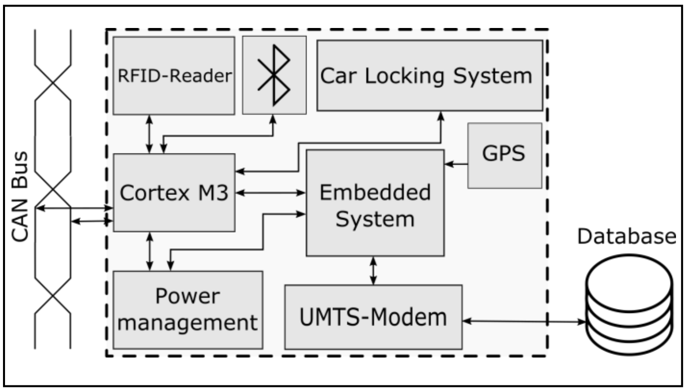

Fig. 3. Block diagram of the access control system.

4) Possible Challenge

One of the biggest challenge is the limited charge of the car battery system. All electric devices connected to the power supply decrease the operating time of the whole system. To come up with this problem, the power consumption of the access control and the attached embedded system has been reduced as much as possible. The Cortex®-M3 provides several sleep states, where the power consumption is significantly reduced. The embedded system will be turned off as mentioned before.

IV. Project Part Ecological

A. State of Charge Estimation

For a CO_2 optimized charge management, a reliable State of Charge (SoC) of the used batteries in the vehicles has to be provided. On the condition that this SoC has correctly been estimated, the renewable energies for the charging can be used in the intended way.

1) Prerequisites

To set up a reliable estimation, the behavior of the user has to be recorded. Based on this dataset, it is aimed to predict the SoC after the trip. The data, which are available on the system bus (CAN) of the car are being used in order to analyze the driver's attitude in the traffic. The starting point and the destination are required as well.

2) How it Works

Based on the user profile that is generated by the measured data, the (explained) algorithm estimates the power consumption during the trip. If the result of the estimation shows that the battery charge will be too low for the trip, the information will be sent to the charge station.

3) Further Steps

In the next steps, the hardware will be set up and tested. In addition, research on basic estimation algorithms has to be carried out in order to find a mathematical model for the electric car. There are various approaches to provide estimation. One possible solution can be found in the fuzzy classification and prediction. Another approach could be seen in the prediction-based algorithms. The last part of the estimation algorithm should take current traffic situation in account. This information can be obtained by using local traffic information systems or services like Google Maps.

B. Intelligent Charging System

1) Current System Restrictions

The charging system for the electrical vehicles in *ECoMobility* has to fulfill several conditions. First of all, it must be assimilable to the electrical grid. Secondly, the vehicles have to be provided with enough electrical power to reach the users destination. Thirdly, the charging energy should produce as less CO_2 emission as possible. The previous project named *fahrE* and its developments serve as a basis for these goals.

The current solution for the charging process is to designate the charge of the vehicles directly from the electrical grid. To enhance the proportion of ecological renewable energy, the intelligent charging system uses an analysis of the forecast of the renewable energy production. Combined with the advance booking data of the vehicles, the algorithm determines the best timeframes for the charging process. The charging power is limited to the charging station and the power is directly taken from the electrical grid. The process of charging with a consideration of the forecast of renewable energy decreases the strain of the electrical grid. This points out that the strain of the grid is even higher if there is renewable energy supply in proximity of the connection point.

With *ECoMobility* the current system should be improved in two ways. First, the proportion of ecological energy for the charging process should be increased. Second, the expense of the integration of the charging system in the electrical grid has to be reduced. The attempt to achieve the two goals is the integration of stationary energy storage into the charging system.

2) Advantages of a Stationary Energy Storage

The current charging process for the electrical vehicles does not react to the power situation in the corresponding electrical grid. Therefore, the charging processes strain the lines of the grid above average. The process of fast charging with a high load is, especially, an unusual strain for low voltage grids. It could be the reason to forbid additional charging stations in special parts of several electrical grids in the future. Moreover, the current charging process does not include the current state of renewable energy production optimally. The charging process developed in *fahrE* includes the data of the forecast power. However, the system can only use the power of the renewable sources if the vehicles are at the charging station. This restricts the possible charging times in a way which leads to the state that particular timeframes with high renewable energy output are often not available. Furthermore, the algorithm uses the booking data to determine the ideal timeframes for the charging process. The data of the project *fahrE* shows that most users tend to book the vehicles spontaneously. These incidents disturb the optimization of the charging process. If the determined timeframes for the charging process are not available, the system has to charge at other times which have no optimal proportion of renewable energy. Moreover, the optimization faces restrictions if the utilization of the vehicles is very high. It is possible that the vehicles are so seldom at the charging stations, that the system has to charge the vehicles whenever they are at the charging station to prevent them from the state of discharge. Both aspects will lead to the situation that the use of an optimization of the charging timeframe will not work optimal.

The integration of energy storage in the charging infrastructure provides several benefits for the current charging system. First of all, the resulting charging system would be capable of decreasing the strain of the electrical grid. The system could charge the storage in all timeframes when there is a high supply of energy generation in the proximity. With this capacity, it is possible to demand power to lighten the strain of the electrical grid by preventing the grid from transporting the decentralized generated energy to the higher voltage grids. Furthermore, the storage does not have to be charged with the highest possible power. The result is a direct easing of the electrical strain for the corresponding electrical grid. Regarding the optimal consumption of renewable energy, the storage improves the charging system as well. The stationary energy storage could be charged whenever the energy supply of renewable energy is high or even too high. A consumption which depends on the supply of the renewable energy could prevent some renewable energy systems from shutting down during a period of too much energy production. With the storage, it is possible to separate the charging with high proportion of renewable energy from the presence of the vehicles at the charging station. This leads to an improved proportion of renewable energy in the charging energy and reduces the dependence of an accurate booking data and the user behavior.

3) Implementation

At first, it has to be determined which stationary storage type will be implemented. Because of several reasons, it will be most likely battery storage. After the analysis of the data from the project *fahrE* is finished, it is possible to determine the battery type and the capacity as well. Moreover, the location for the storage has to be selected. There are several aspects of functionality and restrictions that have to be considered during this process. After the integration of the hardware, the charging optimization algorithm has to be adapted to the storage and the new functionality. At the end of the test period the data of the charging processes have to be analyzed systematically in order to improve the optimization of the charging and the storage.

V. Project Part ECo-type Adaptive

Alternative mobility systems (BEVs, public transportation and pedelecs) have the potential to make an important contribution to the reduction of greenhouse gases. Therefore, human factors research focused more intensively on the interaction between humans and different transport- and mobility-systems (e.g. travel mode choice [2]), humans and their learning and adoption behavior (e.g. BEVs and eco-driving; [3]) and their user experience and usability [4] when interacting with new driving concepts and systems.

The first main focus of *ECo-type adaptive* lies on the investigation of incentives, which are adapted to users' requirements. Our goal is to encourage users to change their conventional travel mode choices (e.g. higher usage frequencies of public transport systems and pedelecs), to use new modes of transport (e.g. BEVs instead of combustion engineering vehicles), to adapt their usage behavior and to develop new strategies for interacting with limited BEV-range (e.g. eco-driving strategies). Based on the implementation of the innovative connected mobility concepts, described in section III, several challenges have to be faced to provide high levels of user behavior (adoption and usage) and user experience (acceptance) [5]. To address these challenges, a user-centered design with a comprehensible, user-friendly and usability-optimized interface should be conducted. This is the second main focus of our work. Both, the investigation of incentives and usability, are essential parts to influence the user behavior and experience.

Usability as a quality feature comprises a plurality of factors. These include an intuitive design for error reduction, easy learnability and high effectiveness [6], efficient usability and perceived satisfaction [7] when dealing with software projects and graphic user interfaces [8]. Non-consideration of one or more of these factors can ultimately lead to a dissatisfaction of the product. The early application of usability methods can reduce the user dissatisfaction [9]. In conclusion, it is necessary to address usability problems even after the introduction to the market.

To implement a well-designed and well-accepted system, it is necessary to better understand and to address the user's requirements on innovative connected mobility concepts [10]. Nowadays, user requirements on mobility services are high; individual and made-to-measure trips via the shortest connection between A and B and a flexible, straightforward and easy booking system [11] are examples. Another requirements on carsharing systems are the option for one-way trips and open-end bookings. Thus, the time of vehicle return and the drop off are not fixed [12]. Furthermore, users expect a uniform ticket- and reservation system for all transport systems and all providers [13], [14] and the possibility to use a portable computing device [15] such as a smartphone or tablet computer.

Based on user requirements (investigated from literature and form expert interviews) and technically possible system parameters (see section III and IV) the innovative connected mobility concepts will be implemented. Users will be able to reserve and book their trips using a booking system provided by a smartphone app or a website. Websites, apps, operating systems and application software are also frequently affected with usability problems even after their introduction to the market. To prevent this, a unified software basis will be used to integrate the booking system into a usability management system. Usability problems will be addressed quickly during different test stages in order to develop the system continuously to enhance user satisfaction. As the problem solving occurs using an iterative process loop, it is appropriate to consider modern software development approaches such as agile software development [16]. These are able to respond to changes and problems quickly [17].

To ensure that the booking system has no major usability failures at the beginning of the test phase, usability tests with experts (i.e. cognitive walkthrough) and typical users will be conducted. Major and even minor problems could be resolved this way. Even if the booking system is integrated into a usability management system, in which ongoing product update cycles occur, problems can be eliminated at any stage. This should result in a higher acceptance, product attractiveness and thus, in a higher utilization rate of the mobility concept in general.

Hence, the booking system should consider different options for recording, categorizing and weighting the usability problems of the software to manage and edit them. Within the main study, there will be two different opportunities to detect usability problems. First, the inclusion of the problems as well as specific user demands that occur during the test phase while using the interface will be collected via direct input option in the booking system. Second, general usability problems will be collected through the logging of mouse clicks on specific icons. Users might have specific and recurring problems that can be determined this way in the test phase. The categorization and weighting of the problems will be done systematically by the developers together with usability experts and will be integrated in ongoing update processes as far as possible.

After system conceptualization and certain test phases for all implemented features (i.e. software functions as well as hardware components), the multimodal mobility-on-demand system will be available for all employees at Technische Universität Chemnitz. We will use a field study research design to investigate user behavior and experience. Major objectives of *ECo-type adaptive* are to examine: (1) user acceptance of the multimodal mobility-on-demand system, (2) user interaction with different transport modes in everyday use, (3) user mobility demands and mobility profiles, (4) influence of different incentives on user's travel mode choice, (5) user adaptation and learning effects in driving a BEV (i.e., related to range management), (6) user's eco-driving strategies to cope with range and (7) influence of different incentives on user's eco-driving behavior.

Eco-driving is defined as the environmentally friendly driving behavior that minimizes energy consumption and therefore CO_2-emissions [18]. Eco-driving includes practices (i.e. strategies) such as moderate acceleration, avoiding abrupt acceleration or breaking, driving exactly at or even under the speed limit and floating with the traffic flow to reduce energy consumption [19]. The successful usage of eco-driving strategies has the potential to reduce energy consumption of a BEV by more than 25% [20]. Therefore, emissions can be reduced and the BEV range can be extended [3]. Previous research has shown that eco-driving behavior could be successfully motivated by extrinsic driving conditions (e.g. instructions due to a driving test [3] and a critical range situation paradigm [21]). Also feedback of financial (Euros) and environmental savings (CO_2-emissions) resulted in a higher eco-driving behavior [22]. In the present study, participants will be intrinsically motivated due to gamification elements ("Be the one, who saved most of the energy and CO_2-emissions!") as well as extrinsically motivated due to financial savings.

Gamification is the use of traditional gaming mechanisms and tools outside of games with the aim to influence the user behavior [23]. Mechanisms that are often used as gamification incentives are ranking lists to compare with other players. Further elements are tasks, that need to be done and the pursuit of the own progress referring to the community of players. The financial incentives include benefits of any kind that affect the user behavior (e.g. higher usage frequencies of public transport systems, higher level of eco-driving strategies). The combination of different incentives seems to be very effective and has the greatest impact on behavioral changes [24].

The field trial will be designed as a longitudinal study with a duration of six months that involves three main points of data collection: First, before users have the opportunity to use the mobility system (T0) including a short additional data collection event after users gained their first experience with the new vehicles after approximately one week of use (T0+1), second, after two months of use (T1) and third, at the end of the trial after six months (T2). At each point of data collection, users will complete a one-hour questionnaire. Additionally, participants' mobility behavior will be assessed via diaries. Data loggers will automatically record several parameters (e.g. SOC, driven kilometer, speed, energy consumption; see also IV). The general study design is based on structural elements that had already proved fruitful in earlier BEV field trials [25].

During the field trial we will apply a combination of two different types of incentives: gamification and financial components, which address an environmentally friendly mobility behavior in two stages. First, the users will have the possibility to achieve several points for every trip done with public transport systems or pedelecs instead of BEVs (motivation of travel mode choice). And second, independent of the motivation of the travel mode choice, the users could achieve points for the lowest energy consumption level when using the BEVs (high usage of eco-driving strategies and hence, motivation of driving behavior).

VI. PROJECT PART ECONOMIC

In addition to technical functionality and acceptance research, the development of functional value chains is an indispensable presupposition for the enforcement and implementation of mobility concepts characterized by intelligent connected mobility providers. This requires that economic efficiency is maintained or expected from the perspective of all value added required market participants [26].

Ensuring the economic efficiency therefore is the third emphasis of the project *ECoMobility*. The objective of the Professorship of Management Accounting and Controlling, which is responsible for the research field *EConomic*, is to examine the economic efficiency of innovative connected mobility concepts from the point of view of all involved market actors (especially public transportation companies, infrastructure service providers, OEMs and public institutions) as well as to develop viable business models for realizing the complete system. For achieving these objectives, primarily a broad overview of potential concepts of connected mobility and existing solutions for interconnecting mobility providers (e.g. fleets of vehicles, pedelecs and public transport), traffic participants (such as public transport users and car sharers) and infrastructures of energy generation and distribution (charging infrastructure, regenerative energy generation) must be acquired. Subsequently, the particularly – in terms of economic efficiency – relevant or critical value adding elements have to be identified. Based on these insights potential value adding structures of market participants involved in a connected mobility concept will be modelled, focusing on value adding relationships between the participants of electricity, information and transport networks.

For the subsequent economic assessment of business models additionally the requirements for an appropriate valuation and modeling instrument have to be formulated. In particular, the existing approaches for assessment and creation of economic efficiency (notably Life Cycle and Target Costing) will be specified concerning their applicability for the relevant subject matter and their fulfilling the previously defined requirements. A (further) development of the selected instrument is necessary for verifying the economic efficiency of value designs including their mobility goods and services (e.g. in combination with intelligent charge control, energy consumption forecasts in electrically-driven transportations and providing mobility data). Furthermore, the extended instrument can provide impulses for raising the economic profitability (e.g. by creating innovative service performance and realization concepts and business models) and, ultimately, enables a specific and successful implementation of concepts for connected mobility. In this context, based on the Life Cycle Costing, an appropriate instrument will be advanced in such a manner that it is suitable for a long-term economic evaluation of connected mobility concepts.

The created instrument will then – as part of case studies – be applied to selected decision alternatives for designing the mobility concept and individual elements thereof. Thus, the generated business models of connected mobility can be verified in terms of their viability and recommendations on shaping individual elements can be given.

For reaching long-term economic decisions on the basis of cost information the life cycle perspective should be incorporated into an early cost management [27]. Thus, based on Life Cycle Costing in the research field *EConomic* a specific electric mobility Target Costing concept will be developed, which enables determining target prices and target costs of goods and services from the user's perspective and providing advices for its shaping.

After evaluating the research results of the project *ECoMobility*, finally concrete recommendations for the economical creation of innovative service performance and realization concepts and connected mobility elements will be derived.

VII. Conclusion

The *EcoMobility* project is a comprehend mobility concept for in-house mobility requirements in enterprises. The challenge to address an innovative mobility concept is divided in four main research fields. First, *E-Connected* includes the logging and the connection of all used mobility systems and the information technology. Second, *ECological* contains the implementation of an intelligent charging system of electric vehicles with mostly renewable energies and the usage of a stationary energy storage system. In addition to this charging system, the prediction of energy consumption is also analyzed in this part. Third, these technical solutions are completed with a human-factors-part, which is called *ECo-type adaptive*. The aims of this research field are to better understand users' acceptance of electric mobility and to analyze the effects of incentives (e.g. for environmental friendly driving). The last part (*EConomic*) considers the cost effectiveness of innovative mobility systems and the development and evaluation of viable business models for mobility systems. Until 2018 the interdisciplinary research team will implement, test and evaluate this innovative in-house mobility concept at Technische Universität Chemnitz.

Acknowledgments

The study is funded by the European Union (Europäischer Sozialfond; ESF) and the Free State of Saxony. Any views expressed herein are those of the authors and do not necessarily reflect those of the funding bodies or partners involved in the project.

Europäische Union

Europa fördert Sachsen.

ESF

Europäischer Sozialfonds

References

[1] D. Langer, S. Bauer, A. Dettmann and D. Kühnert, „Nachwuchsforschergruppe fahrE: Konzepte für Multimodale

Mikromobilität unter Nutzung lokaler regenerativer Energien“, Abschlussbericht TU Chemnitz., 2015, Chemnitz, Germany.

[2] C. A. Klöckner and A. Blöbaum, „A comprehensive action determination model: Toward a broader understanding of ecological behaviour using the example of travel mode choice” Journal of Environmental Psychology, 2010, vol. 30(4), pp. 574-586.

[3] I. Neumann, T. Franke, P. Cocron, F. Bühler and J. F. Krems, „Eco-driving strategies in battery electric vehicle use–how do drivers adapt over time?”, Intelligent Transport Systems, IET, 2015, vol. 9(7), pp. 746-753.

[4] J. M. Robert and A. Lesage, “From usability to user experience with interactive systems”, G. A. Boy (Ed.), Handbook of Human-Machine Interaction, 2010, pp. 303-332, Ashgate, U.K.

[5] A. Dettmann, D. Langer, A. C. Bullinger and J. F. Krems, „Introducing electric vehicle-based mobility solutions – impact of user expectations to long and short term usage”, D. de Waard et al., Eds., Proceedings of the Human Factors and Ergonomics Society Europe Chapter 2014 Annual Conference, pp. 1-12, 2015, available from: http://hfes-europe.org

[6] M. Maguire, “Methods to support human-centred design” International Journal of Human-Computer Studies, 2001, vol. 55(4), pp. 587-634, doi:10.1006/ijhc.2001.0503

[7] M. Burmester, „Usability-Engineering“, W. Weber (Ed.), Kompendium Informationsdesign, pp. 321-358, 2008, Springer Berlin Heidelberg.

[8] A. Holzinger, “Usability engineering methods for software developers. Communications of the ACM”, vol. 48(1), pp. 71-74, 2005, doi:10.1145/1039539.1039541

[9] C. Rudlof, “Handbuch Software-Ergonomie: Usability Engineering”, 2nd ed., 2006, Tübingen, Germany: Unfallkasse Post und Telekom.

[10] S. Beul-Leusmann, E.-M Jakobs and M. Ziefle, „User-centered design of passenger information systems”, IEEE International Professional Communication Conference, pp. 1–8, 2013, doi:10.1109/IPCC.2013.6623931

[11] A. Picot and R. Neuburger, „Mobilitätskonzepte von morgen – Erwartungen der Nutzer und ihre Implikationen für zukünftige Marktstrukturen“, C. Linnhoff-Popien, M. Zaddach, & A. Grahl, Eds., Xpert.press. Marktplätze im Umbruch, pp. 613–624, 2015, Berlin, Heidelberg: Springer Berlin Heidelberg, doi:10.1007/978-3-662-43782-7_65

[12] D. Steding, A. Herrmann and M. Lange, „Car-Sharing–sozialinnovativ und kulturell selektiv? Möglichkeiten und Grenzen einer nachhaltigen Mobilität“, Zentrum für Umweltforschung, Ed., ZUFO-Berichte, Band 3, 2004, Münster, Germany.

[13] G. Ambrosino, F. Logi and P. Sassoli, “eBusiness Applications to flexible transport and mobility services”, Eunite Einite conference, 2001, Tenerife, Spain.

[14] W. Canzler and S. Franke, „Mit cash car zum intermodalen Verkehrsangebot: Bericht 3 der Choice-Forschung“, WZB Discussion Paper, No. FS II 02-104, 2002, available from: http://hdl.handle.net/10419/49786

[15] F. Beutler, „Intermodalität, Multimodalität und Urbanibility: Vision für einen nachhaltigen Stadtverkehr“, Wissenschaftszentrum Berlin für Sozialforschung gGmbH (Ed.), WZB Discussion Paper, No. SP III 2004-10, 2004, Berlin, Germany, available from: http://nbn-resolving.de/urn:nbn:de:0168-ssoar-117495

[16] D. Cohen, M. Lindwall and P. Costa, “Agile Software Development”, DACS State-of-the-Art/Practice Report, 2003.

[17] A. M. M. Hamed and H. Abushama, “Popular agile approaches in software development: Review and analysis”, International Conference on Computing, Electrical and Electronics Engineering (ICCEEE), 2013, 160-166.

[18] F. Mensing, E. Bideaux, R. Trigui, J. Ribet and B. Jeanneret, “Eco-driving: An economic or ecologic driving style?”, Transportation Research Part C, 2014, vol. 38, pp. 110–121.

[19] J. N. Barkenbus, “Eco-driving: An overlooked climate change initiative”, Energy Policy, 2010, vol. 38, pp. 762–769.

[20] M. Helmbrecht, K. Bengler, R. Vilimek, „Strategies for Efficient Driving with Electric Vehicles”, Brandenburg E, Doria L, Gross A, Günzler T, Smieszek H, (Eds.), Grundlagen und Anwendungen der Mensch-Maschine-Interaktion – Foundations and applications of human-machine interaction, 10. Berliner Werkstatt Mensch-Maschine-Systeme 10.–12. Oktober 2013, ZMMS, Technische Universität Berlin, prometei graduiertenkolleg, pp. 83–91

[21] M. Günther, N. Rauh and J. F. Krems, „Conducting a study in the field of electric vehicle use approach, methodology design and analysis”, Proceedings of the 14th World Conference on Transport Research, 2016, Shanghai, China.

[22] E. B Dogan, “Driving Feedback - Psychological factors influencing the effectiveness of feedback”, Published PhD thesis, 2012, University of Groningen, available from: http://www.rug.nl/research/portal/en/publications/pub%28c6b19b9b-4651-4255-b02e-0cf73fbccb9c%29.html.

[23] S. Deterding, D. Dixon, R. Khaled and L. Nacke, „From game design elements to gamefulness: defining gamification“, Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments, pp. 9-15, ACM, September 2011,.

[24] M. Wardman, M. Tight and M. Page, “Factors influencing the propensity to cycle to work”, Transportation Research Part A: Policy and Practice, 2007, vol. 41(4), pp. 339-350.

[25] T. Franke, M. Günther, M. Trantow, J. F. Krems, R. Vilimek and A. Keinath, „Examining user-range interaction in battery electric vehicles - a field study approach”, T. Ahram, W. Karwowski, & T. Marek (Eds.), Proceedings of the 5th international conference on applied human factors and ergonomics AHFE, pp. 334-344, 2014, Krakow, Poland

[26] U. Götze and M. Rehme, „Karten neu gemischt – Neue Wertschöpfungsarchitekturen durch Elektromobilität“, η green, 2011, pp. 16-19.

[27] F. Schmidt, „Life Cycle Target Costing: Ein Konzept zur Integration der Lebenszyklusorientierung in das Target Costing“, 2000, Aachen, Germany.