WIRTSCHAFTS INFORMATIK

Call for Theses

(Bachelor, Master)

TECHNISCHE UNIVERSITÄT DARMSTADT

E-Mobility Services and Optimisation

Electric vehicles (EV) are seen as a promising technology to mitigate greenhouse gases, to increase energy efficiency and to decrease oil dependency of the transport sector as well as to relieve mega cities from local air emissions and smog. However, their market penetration is still at the very beginning and their market success unclear. This is mainly due to their limited range and their high purchase price [6,7]. Battery prices are currently declining significantly [5] and the variable costs of EV are considerably lower compared to conventional vehicles for most countries. This is why EV might succeed in the future market. However, the challenge of limited range remains so far - at least for battery electric vehicles (BEV).

According to current mobility data most trips by conventional vehicles are technically replaceable by EV if a recharge at home or at the working place (at usual household sockets) is possible [1]. However, at least once a year most of these vehicles are used for long distance trips (e.g., [2]). Therefore, the charging at household sockets (restricted to 3.5 kW, i.e., mode 1 or 2 according to IEC 61851) and even at public charging stations (usually restricted to 22 or 43 kW, i.e., mode 3) is too time consuming for these trips. Fast charging stations (restricted to about 100 kW direct current, i.e., mode 4) allow 80 % recharge of the battery within about 15–20 min [8] and are therefore almost comparable to conventional refuelling procedures [9]. As fast charging processes have stronger negative effects on battery lifetime, we assume that fast charging is mainly used during long distance trips. Therefore, they should be placed along highway corridors.

A rollout of fast charging stations has already begun in several states—also in Germany [4]. Unfortunately, these stations are currently not interoperable. In Germany, three competing technologies are in the market (e.g., superchargers, CHAdeMO [3], and combined charging system). The European Commission is supporting a rollout of fast charging stations with the combined charging system. The decision where fast charging stations should be allocated is serious, it has an influence on the allocation of further charging stations and it might be decisive for the market success of this technology. Furthermore, the charging infrastructure is expensive and its utilisation level is going to be low for the coming years. The decision for a location is most probably final as a change of location is costly. Hence, an optimal allocation seems to be inevitable.

Similar challenges occur when conventional trucks, taxis or even ambulances are to be replaced by EV or other alternative technologies.

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I. What We Seek for our Theses:

Our goal is to assess strategic, tactical and operational planning for different forms of e-mobility and e-mobility services. We are looking for theses that draw upon and contribute to the stock of knowledge on the design of these services and the optimisation of relevant planning problems and logistics. Can similar models and approaches be used for different technologies or services? What is different about e-mobility logistics and services? What is different in technology, product, and interface design and innovation in regard to AVs?

In sum, bachelor theses, student research projects (i.e., "Studienarbeiten"), or master theses on e-mobility should meet three criteria:

1	**Theses must target e-mobility and new forms of technology explicitly and theorize on the specific elements.** Direct applications of existing theory on mobility without differentiating e-mobility from traditional technologies are not suitable.
2	**Theses must provide novel contributions to knowledge about the design of e-mobility services, the logistics or related planning problems for e-mobility or other new technologies.** Any form of theoretical (conceptual or empirical) or practical contribution using any scholarly method is welcome.
3	**Theses can consider the social and/or technical aspect of e-mobility**. We encourage studies on e-mobility at and across a variety of levels of analysis, including individuals, organizations, environment, ecosystems, and societies.

Potential topics with applications in Germany, New Zealand or other countries include, but are not limited to:

- **Charging infrastructure for private cars**: The availability of charging infrastructure for private cars is crucial for the success of e-mobility. While fast-charging stations along the highway are important for long-distance trips (e.g. vacations) or commuters, charging possibilities at home and / or at work are prerequisites for users in order to buy EVs. While already a number of publications address the optimisation problem of locating charging stations, present approaches to forecast demand or schedule the charging processes, open questions remain and more thorough models and approaches can be developed.
- **E-taxis**: Many cities aim at using EVs as taxis, leading to a lot of different challenges and planning problems. Often, cars are owned by individuals who do not have access to charging infrastructure at home. Therefore, charging infrastructure must be available during the day. Related planning problems include the shift design, fleet design (i.e. number of conventional taxis and EVs), location planning of charging infrastructure, assignment or relocation of taxis to ranks with / without charging infrastructure, as well as the assignment of taxis to trips.
- **E-trucks:** Several companies like Deutsche Post DHL already use EVs in many cities to deliver letters or small packages, for example. For other use cases, especially long-distances trips, the decision for alternative technologies like batteries or hydrogen is not so easy. Routing of trucks must be adapted, charging infrastructure must be located, charging must be included into the routing etc. Several research problems arise that can be tackled by mathematical optimisation, for example.
- **E-ambulances:** In Borkum, an e-ambulance is already in use. Other regions and providers are investigating the options and the design of an e-ambulance. Besides legal regulations and organisational aspects, planning problems arise including the location of charging infrastructure. Theses could investigate the use of e-ambulances for patient transports and/or emergency rescues and address one or several planning problems.
- **VTOLs:** Companies like Volocopter work towards the goal to bring VTOLs into major cities worldwide. Singapore or Dubai have already performed live tests and hope to be able to integrate this new mobility service soon. From a logistics point of view, the topic has not been studied as much as other e-mobility topics. Questions about necessary and potential battery capacities / ranges, efficient networks for VTOL bases with charging infrastructure or battery exchanges, and routes within the networks arise.

- **Optimisation of other mobility services:** Students can also suggest other topics around the design and optimisation of mobility services and logistics using alternative technologies. Examples could include car-sharing, e-scoters

II. Possible Methodologies

Theses should cover one or more methodologies, such as:

- *Discrete Optimisation approaches*
- *Machine Learning approaches*
- *Discrete-event or agent-based simulations*
- *Structured literature reviews*
- *Quantitative online surveys*
- *Experiments*
- *Qualitative interviews*
- *…*

III. Application Requirements

Important: If you are interested in writing a thesis on E-Mobility, please send an email application that includes:

1. a **brief CV,**
2. a current **performance record** (can be downloaded in TUCaN),
3. a **short description** of your proposed topic including a **research question**, and
4. the **time period** in which you would like to work on the thesis

to: oppermann@is.tu-darmstadt.de.

References

[1] Babrowski S, Heinrichs H, Jochem P, Fichtner W (2014) Load shift potential of electric vehicles in Europe. J Power Sources 255:283–293.

[2] CHAdeMO's fast charging stations in the world. www.chademo.com. Accessed 02 Aug 2015

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[4] IEA (International Energy Agency) (2013) Global EV Outlook. IEA. http://www.iea.org/publications/globalevoutlook_2013.pdf. Accessed 02 Jan 2015

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[6] Plötz P, Gnann T, Wietschel M (2014a) Modelling market diffusion of electric vehicles with real world driving data—Part I: model structure and validation. Ecol Econ 107:411–421.

[7] Plötz P, Schneider U, Globisch J, Dütschke E (2014b) Who will buy electric vehicles? Identifying early adopters in Germany. Transp Res Part A 67:96–109.

[8] Qian K, Zhou C, Yuan Y (2015) Impacts of high penetration level of fully electric vehicles charging loads

on the thermal ageing of power transformers. Intern J of Electr Power and Energy Syst 65:102–112.
[9] Schroeder A, Traber T (2012) The economics of fast charging infrastructure for electric vehicles. Energy Policy 43:136–144.