R & D at the University of Applied Sciences Kempten

Bavarian pilot region for electromobility since 2009

Within several projects funded at Federal State, National and European level and conducted by the University of Applied Sciences Kempten (UAS Kempten), the regional energy provider Allgäuer Überlandwerk GmbH (AÜW) as well as the e-car developer ABT Sportsline GmbH (ABT), the Allgäu region managed to establish itself as pilot region for electric mobility since 2009.

As early as in 2009, in the context of the project “eE-Tour Allgäu” which was promoted by the programme “ICT for electric mobility” of the Federal Ministry for Economic Affairs and Energy (BMWi), tourists and locals could rent 50 different electric vehicles to discover the Allgäu in an ecofriendly manner. In the project “IRENE” starting in 2011, the UAS Kempten, the AÜW, the Siemens AG and the RWTH Aachen could analyse the integration of renewable energies and electric mobility on behalf of the BMWi. Therefore, the distribution grid of a municipality was equipped with measurement equipment and stabilized with a stationary battery with a peak performance of 300 kVA and a capacity of 170kWh. The successful implementation and the good visibility were continued in the lighthouse project “econnect-Germany” of the BMWi in 2012. A network of seven German municipal utilities developed and tested sustainable and intelligent electric mobility with focus on municipalities and companies. Diverse issues in the research field electric mobility are additionally sponsored by the Free State of Bavaria since 2011 via the technology network Allgäu TNA for electric mobility.

Allgäu EVs of the ABT Sportsline GmbH

Based on extensive methodical analyses and the acquired knowledge, the setup of a small-series production of 40 battery-powered vehicles for the delivery traffic by ABT was initiated in the showcase project “E-Lieferungen im Allgäu”. The vehicles were designed for the delivery traffic of the Deutsche Post DHL Group and employed and tested in their distribution fleets as well as in regional companies. The UAS Kempten essentially contributed to the advancement and the qualification of the batteries and provided crucial inputs regarding the acquisition and analysis of the usage and load conditions of the vehicles. Moreover, it acquired knowledge concerning the user acceptance. ABT gained expertise and developed plants for the small-series production of purely electric light commercial vehicles in 3 segments: the ABT eCaddy, the ABT eT5 and the ABT eBox on the basis of a VW T6 with long wheelbase, 4,25 t admissible total weight and a loading space of 20 m³ (fig. 1).

Fig. 1 eBox (on the basis of a VW T6) for delivery traffics of the ABT Sportsline GmbH

Battery research

By measurements and trials on new and aged batteries, in the laboratory as well as during operation (fig. 2), appropriate simulation models for the entire electric powertrain were developed and verified in the Institute for Electrical Energy Systems (IEES) of the UAS Kempten. Thereby, a reliable electric dimensioning of powertrains with lithium ion batteries for various application profiles was permitted.

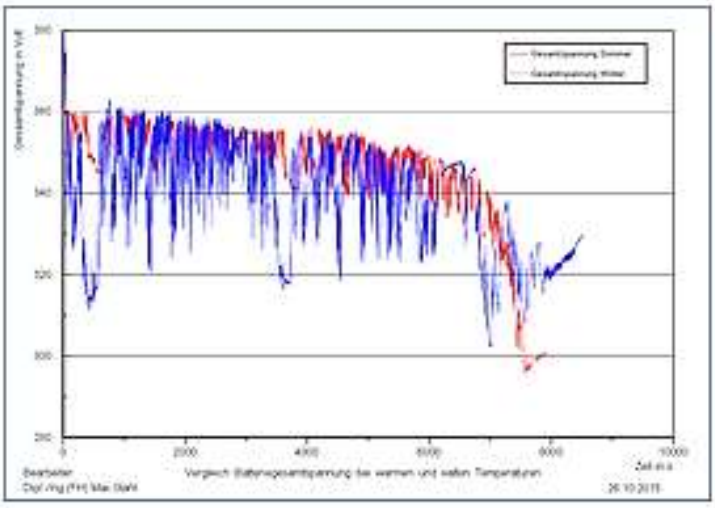

Fig. 2 Battery voltage at driving until discharge in summer/winter

Usage and load analysis

Over the course of several projects, the UAS Kempten developed and refined an ICT infrastructure to test the usage and load conditions of electric vehicles in different use cases (fig. 3). Specific data loggers in the vehicles are directly connected to the CAN bus and gather relevant data such as the electric current and voltage of the battery, the state of charge (SOC), different temperatures and position data via GPS. The data are transferred once per minute telemetrically via UMTS to the server of the UAS Kempten where they are checked on plausibility, corrected and written into a database by an automatic importer.

Fig. 3 ICT infrastructure and data acquisition in the Allgäu e-mobility projects

The web portal Fleetalyzer is a tool for the administration, visualization and the analysis of data acquired of the vehicles registered in the database. Every partner obtains access to their data and hence the possibility to supervise their vehicles online.

The questions pursued in the context of different projects as well as the required data analyses for the evaluation were automated. Frequently, information are based on one tour (e.g. the course of the road, the route length, meters in altitude, energy consumption, number of stops, course of the performance, the start and end times, loaded, consumed and recovered energy, SOC, percentage of motorways, urban and rural roads, evaluation of the driving style considering the road type, outdoor temperature).

Examples of successful applications of electric vehicles: For the delivery of letters and parcels, but also for the usage in various use cases involving craft businesses, the application of electric vehicles is recommendable as they frequently drive along similar route profiles. However, due to the many starts and stops the energy demand is considerably higher (fig. 4).

	Delivery traffic	Test drive
Standing time	~ 76%	4%
Stops	125	9
Energy consumption	7,75 kW/h	5,25 kW/h

Fig. 4 Example of a delivery tour of 25 kilometers

Fig. 5 displays the analysis of the SOC over the course of a day that illustrates the potential of the development of an intelligent charge management for fleets.

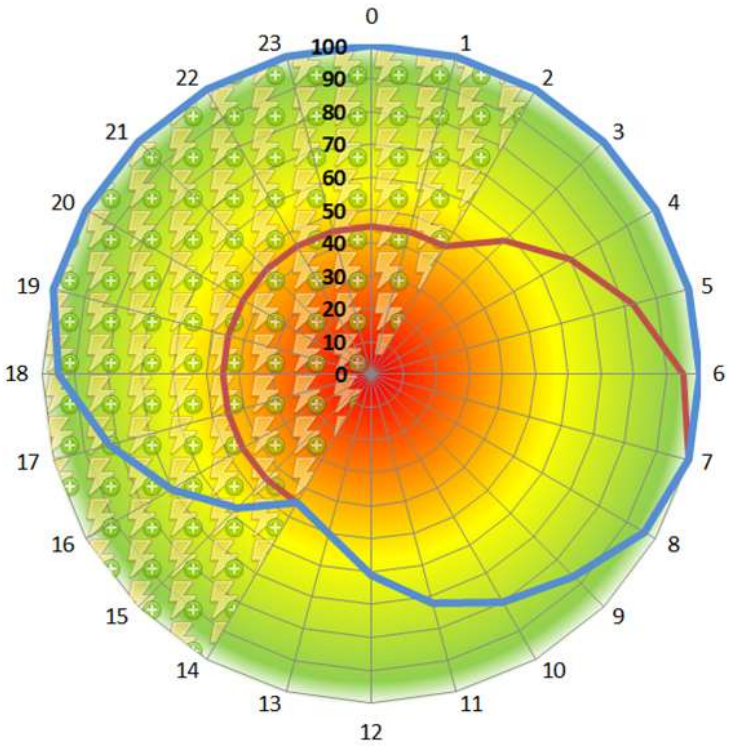

Fig. 5 SOC history over the course of a day; blue: recorded data, red: possibility of later charging

Another example of the analyses refers to the specific energy consumption per kilometer (here: for a selected car within a year, fig. 6). In the case of this car, the average specific energy consumption was:

winter: 424 Wh/km

summer: 259 Wh/km

The energy demand of the vehicles highly depends on the individual driving style and has major effects on the potential range of the electric vehicle. In comparing test drives on mixed routes the energy consumption doubled in case of a sportive driving style towards a very reserved driving style. To support the driver, a gamified range app including the evaluation of the current driving style was developed. Resultant, recommendations for the alteration of the driving style and thereby an increase of the range can be derived.

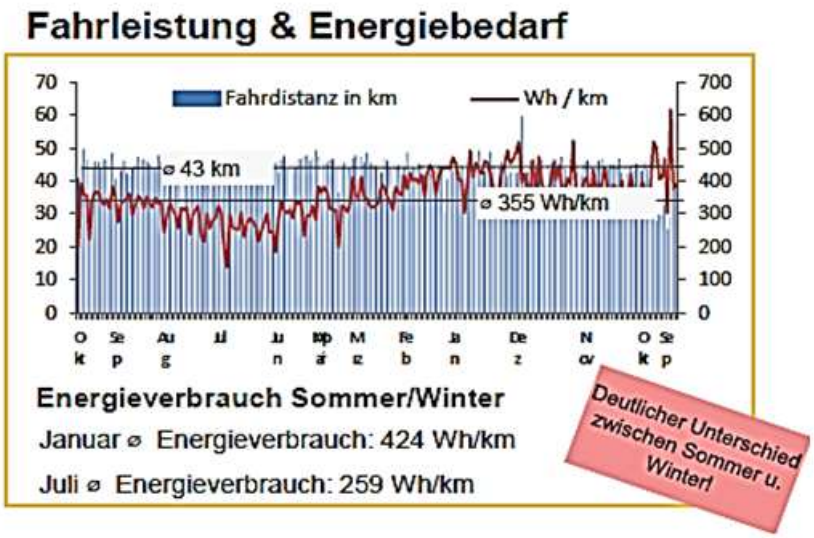

Fig. 6 Driving performance and energy demand (DPDHL)

E-mobility coaching

One of the main obstacles in the context of the implementation of electric vehicles is the insecurity concerning the compliance of the range demands. Based on its expertise, the UAS Kempten offers an “e-mobility coaching” that provides interested fleet operators and private users with sound data and thereby supports an appropriate decision making regarding the switch to electric mobility.

Mobility check

Over a period of 6 weeks, the tours of existing conventional vehicles are recorded to describe the current mobility demands. These tours are then simulated with virtual models of electric vehicles and evaluated respectively the required range, the suitable charging infrastructure, costs and potential CO_2 savings. The capacity of the fleet vehicles and the integration of electric vehicles with due regard to the charging times are also analysed.

Experience electric mobility

The UAS Kempten offers potential purchasers of EVs the possibility to experience the favored electric mobility beforehand by testing electric vehicles of its own fleet.

Fleetalyzer app

The electric mobility app with the web portal Fleetalyzer supports users of EVs with a reliable indication of the existing range, an evaluation of the current driving style, an anticipatory indication of the necessary charging demand and a cost analysis (fig. 7).

Fig. 7 Reliable range indication with driving style evaluation

Acceptance studies

The implementation of electric vehicles accompanied continuous in-depth interviews with all users to identify their specific requirements and motives as well as their behaviour and decision-making processes. It became apparent that a multilevel survey on experiences promoted the contemplation of the drivers regarding their work and likewise the acceptance of the new technological requirements. Moreover, an increased identification with and enthusiasm for the new technology could be noted.

Conclusion

- Electric mobility works for commercial and delivery traffic, particularly due to predictable operating times and deployment routes.
- Reliable information concerning the favored mobility are important to enable fleet operators to take an appropriate decision regarding a switch to electric vehicles – *e-mobility coaching*.
- There is market demand for delivery vehicles of different sizes, but no series offered from manufacturers.
- The operation of electric vehicles, particularly in fleets, requires instruments for the planning of the range and the charging – *Fleetalyzer*.
- The gamification of the workflow and the operating procedures in the car can enhance the attraction of electric vehicles and facilitate the usage – *Drivalyzer*.
- The acceptance of the new technology increases with the inclusion and education of the target group.

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