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The 25th World Battery, Hybrid and Fuel Cell Electric Vehicle Symposium & Exhibition

ELECTRIC MOBILITY MODEL REGION VLOTTE IN AUSTRIA: SCIENTIFIC ACCOMPANYING RESEARCH

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Abstract— The project VLOTTE is situated in Vorarlberg and is a co-financed model region of the Climate and Energy Fund in Austria. The project's purposes are to reach companies for electric mobility with an all-in-one package, to build up necessary charging stations for users and last but not least to implement new renewable energy sources. The research is divided into following parts: 1) Single measurements of specific car values, 2) Series of measurements in practical use and 3) Continuous measurements of charging stations. The conclusion of this scientific accompanying research is that the current components of the electric cars should be enhanced in the future. The battery capacity of 28.2 kWh is more than enough for vehicle fleet with only one charging station at the firm. The peak of the household load profile for example is increased about 0.74 kW/car if the charging of the electric cars is not controlled. Therefore in future intelligent charging controls are necessary to guarantee a stable grid and more renewable energy for battery charging. *Copyright Form of EAEW / TU Vienna***.**

Keywords— Electro mobility, Model region, Driving consumption, Charging profile and Traffic analysis

1. Project VLOTTE

The project VLOTTE is situated in Vorarlberg and is a co-financed model region of the Climate and Energy Fund in Austria. The partners of this project are the utility company (VKW), federal state government, public transport system, Energy Institute and Insurance of Vorarlberg as well as Austrian Automobile Association, Raiffeisen Leasing and Vienna University of Technology.

Nearly 50 charging stations and 100 electric vehicles with so-calles ZEBRA-Batteries are applied in the field.

The project's purposes are to promote electric mobility for companies, municipalities and institutions for electric mobility with an all-in-one package, to build up necessary charging stations for users and last but not least to implement new renewable energy sources, especially photovoltaic, according to the energy demand of all electric cars.

This all-in-one-package is offered as leasing agreement, which includes energy from all public recharging stations, warranty insurance, service, tickets for public transportation and membership of Austrian Automobile Association.

The charging infrastructures are located at the most important public places and can be unlocked with a key. This system is called "Park & Charge" and is available in Austria, Germany and Switzerland.

For every electric vehicle the VKW installs approximately 20 m² photovoltaic plants. [1]

In Mai our Institute of Power Systems and Energy Economics finished the scientific accompanying research, which had the following main purposes:

- To define a metering concept for monitoring the cars, charging stations and customer behaviors.
- To analyze the total car consumptions, the overall charging processes and the client's driving behaviors.

2. Metering concept

Most of the cars are used by companies and different drivers. The most important charging station is therefore the regular parking place at the firm. Additionally some public charging stations can be used.

The key issue, however, is the electric car itself. Hence the measurements focus on the electric car itself. Figure 1 overviews all relevant partners and the installed measurement devices with its pros and cons.

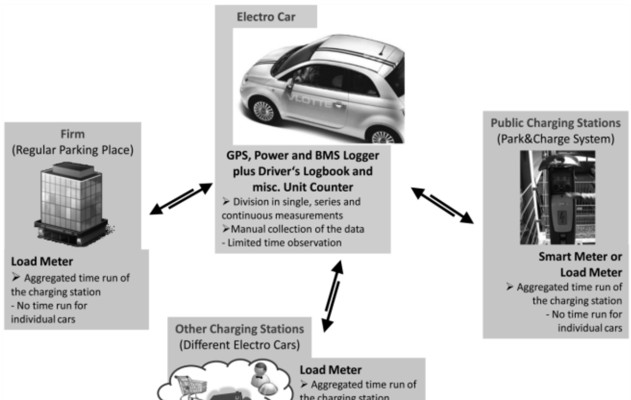

Figure 1: Overview of installed measurement devices and its pros and cons in VLOTTE.

The metering concept of our research is divided into following parts:

- Single measurements of specific car values: The most used car types, "TH!NK city" and converted "FIAT 500", are observed in detail. Data is collected from the whole car's power demand, the battery in detail, the charging station and also the GPS signal of the customer's ways.

- Series of measurements in practical use: Over a period of six weeks 19 “TH!NK cities” are monitored with power and GPS-loggers. So the whole power demand’s progress and the cars’ positions are aggregated.
- Continuous measurements of charging stations: In two charging stations load meters are installed. These meters log the energy demand every 10 minutes and so a real load profile of more than one car is concentrated.

3. Results

This research’s main results reflect the typical car properties of such electric vehicles. Most of the used cars in VLOTTE are equipped with older battery types such a ZEBRA. Those batteries must be heated, because their operation temperature lies above 260°C. [2]

Therefore these car types show very high Stand-by-Losses. These and all other losses as well as the driving consumptions are illustrated in the following section.

3.1 Driving consumption and car losses

The driving consumption is the electric energy recharged at a power socket after a drive. This consumption is measured in kWh/100km and includes all charging losses of every components in the car as well as the restoration of the battery’s energy level.

In Figure 2 the driving consumptions of two real testing drives in Vorarlberg are shown. It allows a direct comparison between the “TH!NK city’s” and the “FIAT 500’s” energy demand.

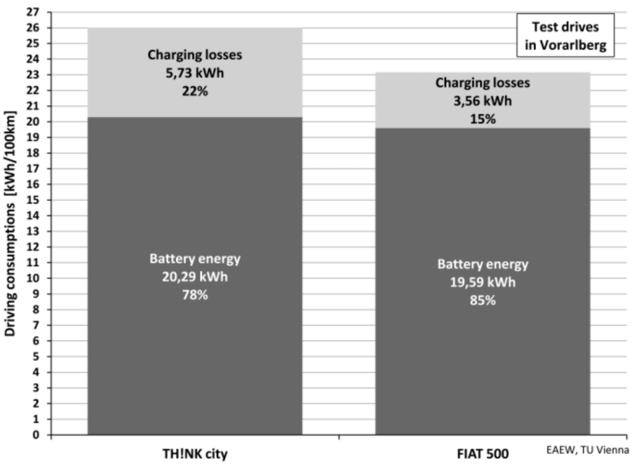

Figure 2: Driving consumptions of the two vehicle types.

As you can see, the charging losses of the “TH!NK city” are very high and may cause from not good designed components. The driving consumption of 23.2 kWh/100km is a realistic value for today’s electric vehicles.

The next important steps to take for cars with ZEBRA-Batteries are the Stand-by-Losses – as described above. These losses take effects only at standstill, because if the car is in motion, the discharging losses heat the battery. Therefore the Stand-by-Losses have the unit kWh/h (= dwell time).

In Figure 3 the two vehicle types’ Stand-by-Losses are compared. It shows that the “TH!NK city” also presents high additional losses, which cause from many additional devices in the car. At an average the “FIAT 500” needs about 107 W from the grid without been moved.

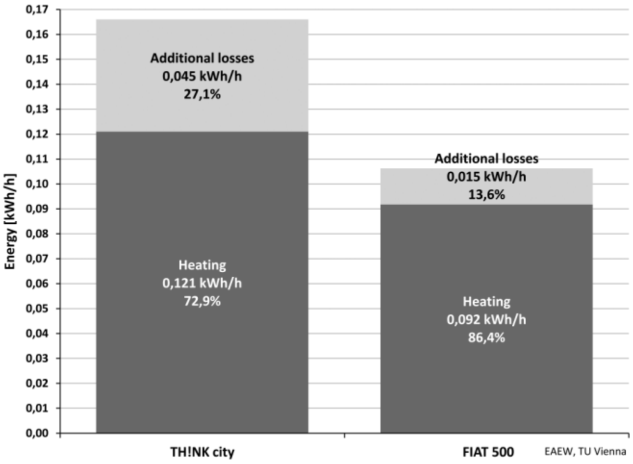

Figure 3: Stand-by-Losses of the two vehicle types.

New battery technologies, such as Li-Ion-Batteries, reduce the Stand-by-Losses to an absolute minimum and therefore future electric cars will offer lower energy demands. [3]

3.2 Charging process of all cars

In the following analysis 19 “TH!NK cities” over six weeks are monitored. This car type comes with a battery capacity of 28.2 kWh (= approx. 140 km). The focus of this section lies on the distribution of the depth of discharge (DOD) and the charging profiles of all vehicles.

The depth of discharge after a drive is the battery energy which was used by the car, in percentage, compared to the total battery capacity. With this value you can see how much of the battery’s capacity is really needed and how long the charging periods take place.

In Figure 4 the distribution of the depth of discharge is shown. On the vertical axis the numbers of full charges in percentage of all charges are plotted. On the horizontal axis the depth of discharge divided into 10 percentage steps is drawn.

About 44 % of all full charges, as you can see, need maximal 10 % of the nominal battery capacity. 80 % of all full charges are charged with less than 30 % DOD or in 5 hours. Therefore these modes of usage don’t demand a high level battery capacity.

The next important aspects are the charging profiles of all vehicles combined. Similar to the load profile of households, information about the drafted power of all electric vehicles on working days is collected. Finally, this collection is related to one working day and one car.

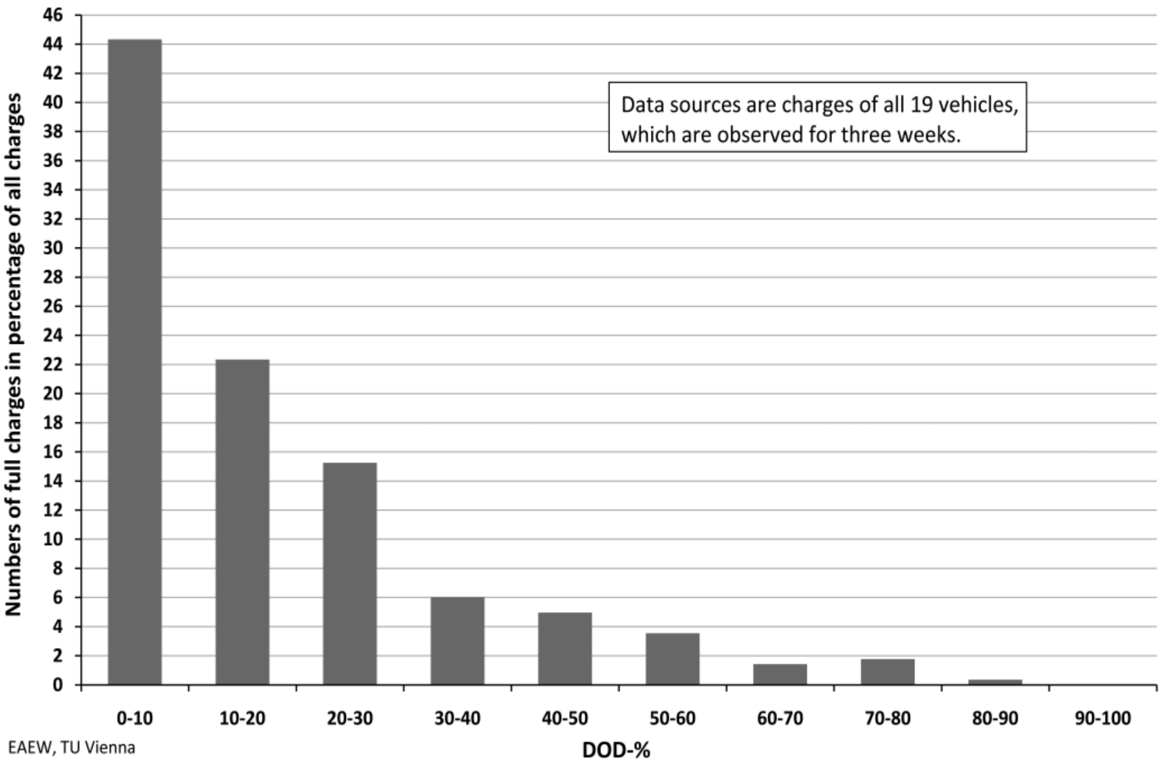

Figure 4: Distribution of depth of discharge (DOD) of all full charges.

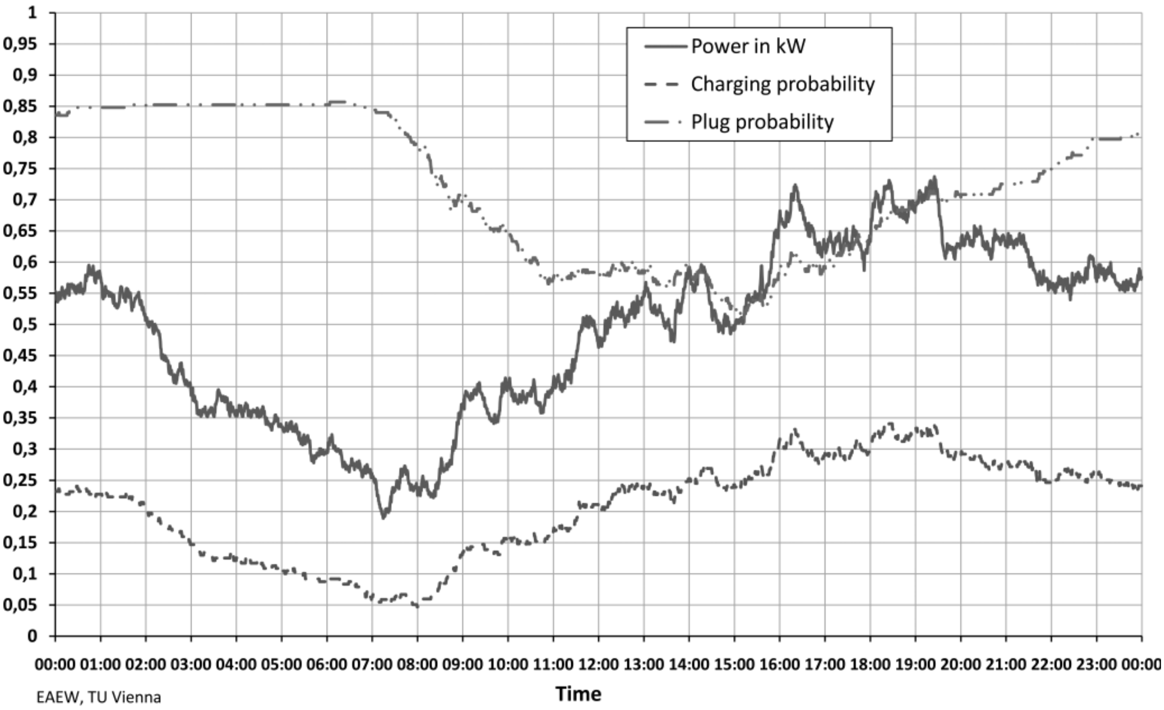

Figure 5: Mean charging profile as well as the probabilities of charging and plugging at a working day for one electric vehicle.

The charging profile is represented in Figure 5 by the solid line. The unit of the vertical axis for this line is kW. The dashed line in the diagram demonstrates the charging probability. This line shows the probability that the electric vehicle is charging at the current time.

The alternating dotted and dashed line is the plug probability. This line shows the probability that the electric vehicle is plugged in at the current time.

Between 4:00 pm and 7:30 pm on working days most of the electric cars are charging and the maximum power demand is 0.74 kW/car. At 3:00 am nearly all cars are finished with the charge and are plugged in until 7:00 am. During the off-peak hours (3:00 pm until 6:00 pm) 50 % of all plugged in vehicles doesn't charge at all. Thus these cars are in stand-by-mode and could supply the grid with energy (V2G).

3.3 Traffic analysis

Using the GPS-Data from the costumer's ways, all stops can be analyzed in detail, also unplugged stops are recognized. The dwell time and place are the important facts for the future charging infrastructures.

Figure 6 shows the total dwell time of four observed vehicles divided into plugged and unplugged times. Only 8 % of the complete dwell time the cars are not connected to the grid.

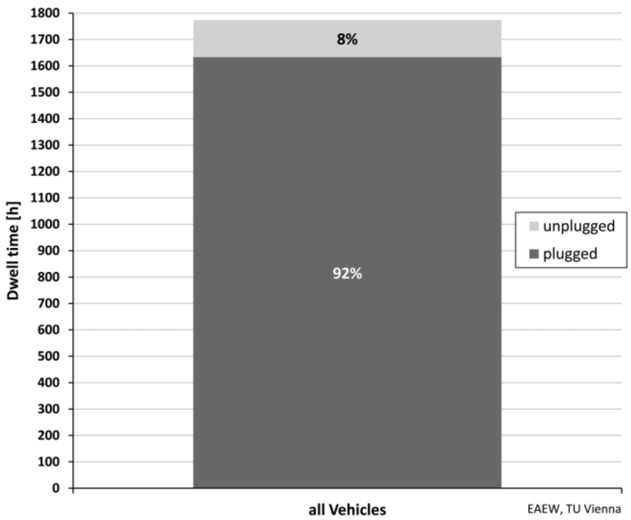

Figure 6: Total dwell time of four vehicles divided into plugged and unplugged time.

These 8 % of time, as you can see in Figure 7, is otherwise about 64 % of all stops. In the diagram stated below the numbers of stops, divided in plugged and unplugged, are drawn over categories of dwell time.

Herefrom you can reason:

- At a dwell time over 30 minutes about 50 % of all stops are executed with plugged cars and the electric vehicles are recharged at this time.
- As soon as the dwell time lasts more than two hours, more than 75 % of the drivers plugged their car in.

The analyze of the different location shows, that apart from only one stop, all drivers charged their cars in the regular parking place at the firm. This disproves the general prejudice, that E-Mobility is only possible with a multitude of charging stations.

4. Conclusions

The conclusion of this scientific accompanying research is, that the current components of electric cars should be further enhanced in the future. The driving consumption of a test drive including the charging losses with the "TH!NK city" is 26.0 kWh/100km and for the "FIAT 500" is 23.2 kWh/100km.

The charging losses range between 13 and 27 % of the total charging energy. The Stand-by-Losses, which are typically for ZEBRA-Batteries, lie in between 0.107 and 0.165 kWh/h. The "FIAT 500" shows in every category the better performance.

The battery capacity of 28.2 kWh is more than enough for these vehicle fleets with only one charging station at every firm, because only 20 % of all full charges needed more than 30 % of the total battery capacity and more than

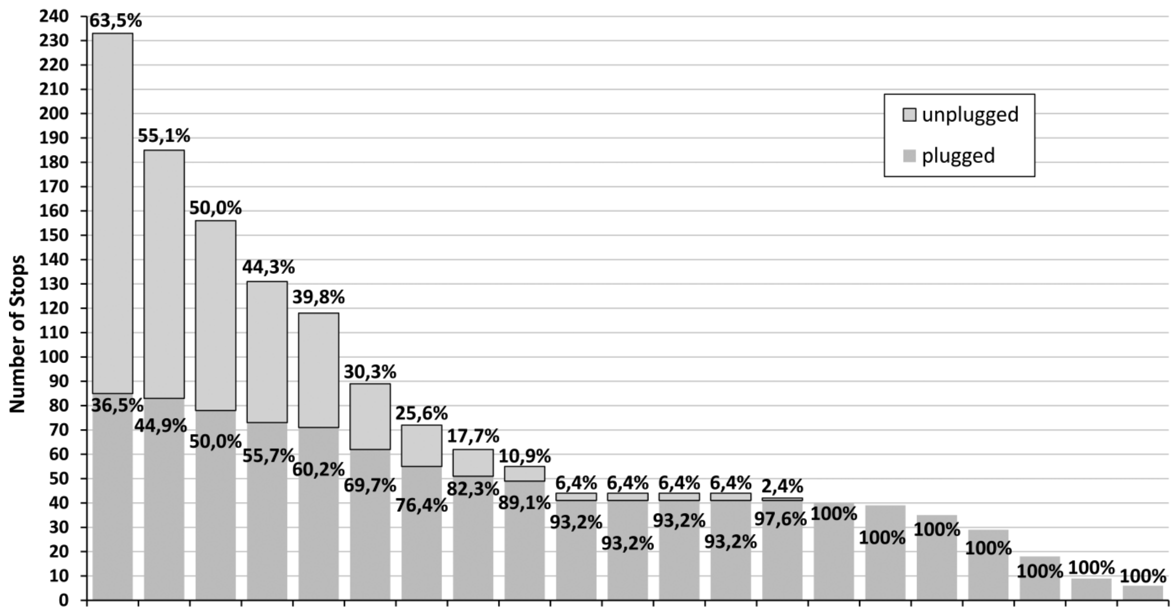

Figure 7: Mean charging profile as well as the probabilities of charging and plugging at a working day for one electric vehicle.

5 hours. Therefore many vehicle batteries are plugged and fully charged and could deliver energy to the grid.

The peak of the household load profile for example is increased at about 0.74 kW/car if the charging of the electric cars is not controlled by outside systems. Therefore in future intelligent charging controls are necessary to guarantee a stable grid and more renewable energy for battery charging.

5. References

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