E-Mobility – Measurements under real driving conditions

Application Example

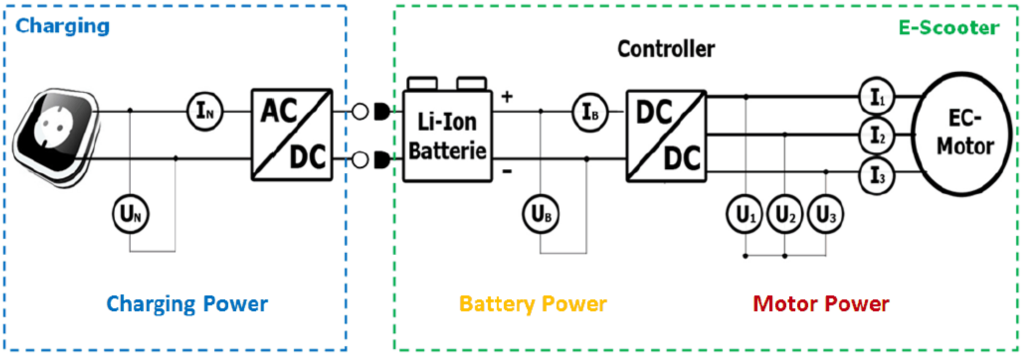
Customer: **University of applied science (Master thesis)**

Standardized driving cycles are used to measure the energy consumption of different vehicles. However, actual driving cycles are not suitable to measure the energy consumption of electric vehicles. The aim of two master theses at the University of Applied Science in Pinkafeld was to determine the energy balance under real driving conditions of electric vehicle - one for an electric car (Mitsubishi iMiev) and one for an electric two-wheeler (E-Scooter Emco Novum).
The field test consists of several road tests (city, freeway, uphill, downhill, etc…) under different conditions. Additional tests with different drivers accounts for the impact of personal driving behavior and ensures objective and significant results. The analysis of the charging cycle completes the measurements. Finally, the energy balance and the operational behavior of the E-Scooter are outlined. As a final point, some characteristic values are calculated and compared to other vehicles.

Challenges and Requirements

- Mobile measurement system with built-in battery pack
- Hot-swapable battery system to ensure a measurement period of 6 hours
- Synchronous acquisition of multiple channels (voltage, current, video, position, speed,…)
- High Bandwidth of whole measurement chain
- High Sampling rate (up to 1 MS/s)
- Online - Efficiency Determination and calculation of different parameters (Math)
- Post-Processing and Export functionality for detailed analysis

Measurement schematic



Software

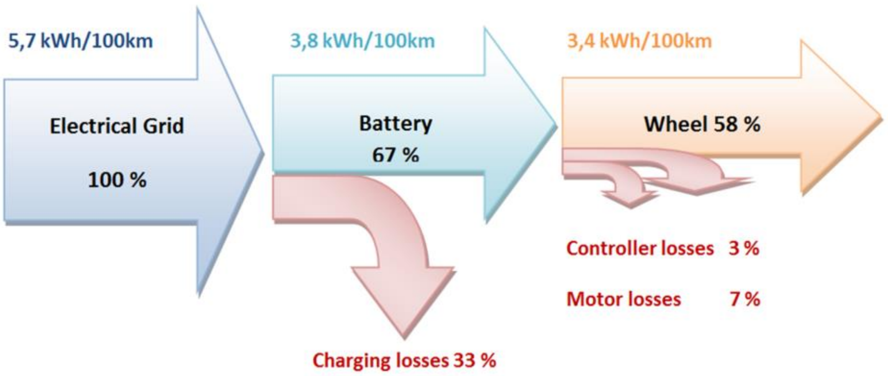
- Dewesoft

Hardware:

- *DEWE-2600 for measurement at electric vehicle*
- *DEWE-3020 for measurement at electric two-wheeler*
- *1 MS A/D card with 16 channels*
- *4 x Full-isolated high voltage Inputs (1400V)*
- *4 x Full-isolated low voltage Inputs (50V)*
- *4 x Clamp 150-DC*
- *VGPS 200C , USB Camera*

Results – Examples (Electric Two-Wheeler EMCO Novum):

- ***Energy balance***
  The first chart shows a Sankey diagramm for the energy flow, as well as a Grid-to-Wheel benchmark with other scooters.



Benchmark Efficiency:

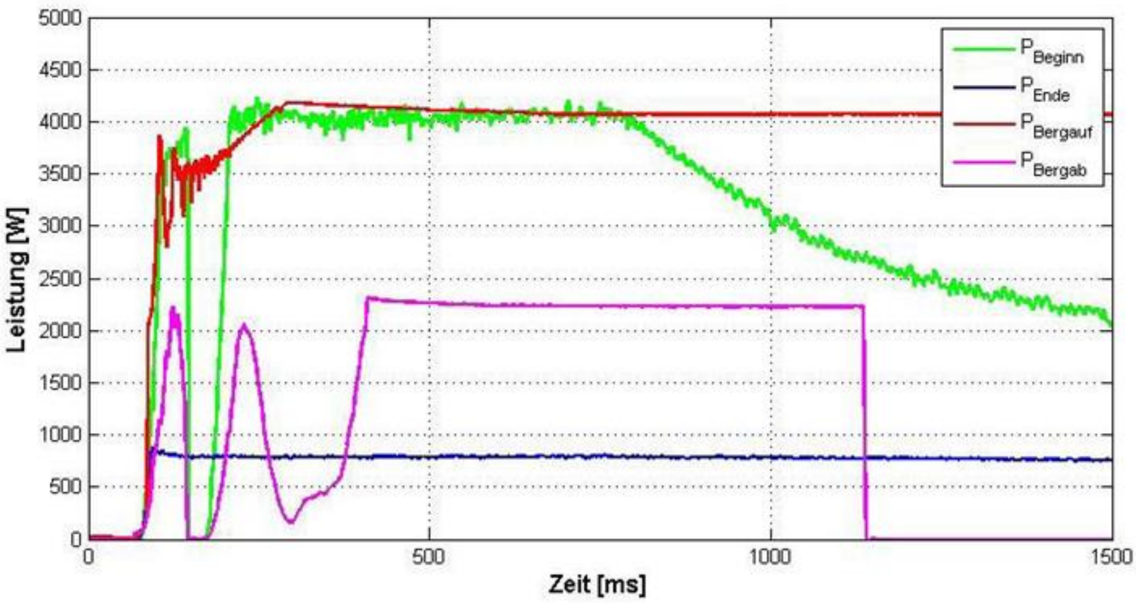
- Modern E-Scooter with Lithium Ionen - Battery[1] 71 %
- Cheap E-Scooter with Lead Acid Battery[1] 31 %

[1] Widmer R. & Gauch M. (2010) Umweltnutzen von E-Scooter – Vergleich mit Personenwagen, EMPA, Schweiz

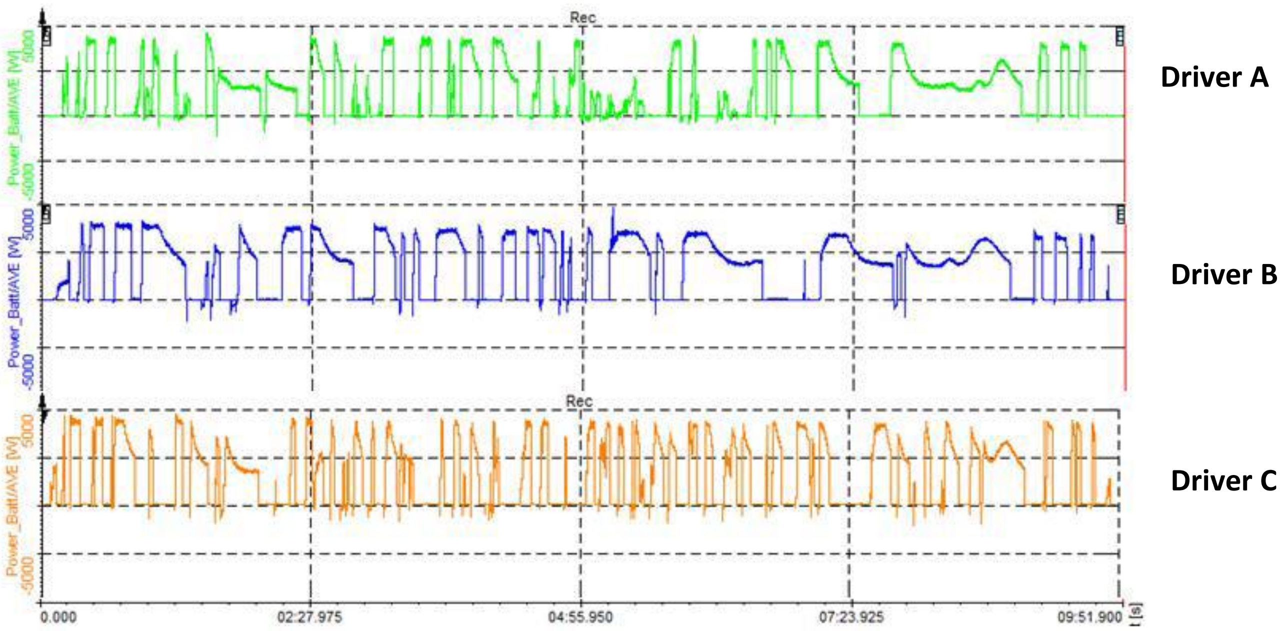
- ***Averaged values***
  This table shows the averaged values of the electric two-wheeler.

Recuperation	%	2
Motor efficiency	%	90,0
Controller efficiency	%	97,2
Vehicle efficiency	%	87,5
Specific battery energy consumption	Wh/km	38,2
Specific battery energy consumption cum.	kWh/100km	3,8
Charging efficiency	%	67,0
Total efficiency	%	58,7
Specific total energy consumption	Wh/km	56,9
Specific total energy consumption cum.	kWh/100km	5,7
Diesel-equivalent	l/km	0,6
Gas-equivalent	l/km	0,7

- ***Acceleration behaviour at different driving situations***
  This chart shows the acceleration of the scooter at different driving situations. The green chart is the acceleration with full-charged battery, the blue one when the battery was nearly empty, the red one for uphill and the magenta one for downhill driving.

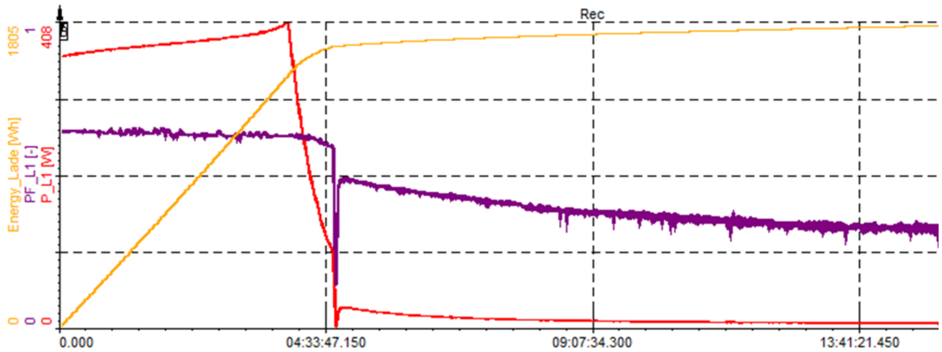


- ***Acceleration behaviour of different drivers***
  This chart shows the acceleration behaviour of different test drivers on the same test-track. The acceleration behaviour can influence the energy consumption of up to 10%.



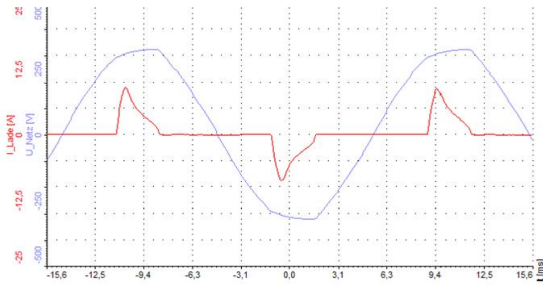
- ***Charging profile, time and efficiency***
  In the table you see the energy consumption and efficiency for full charging and a shor charge process. In the chart you see the charging profile.

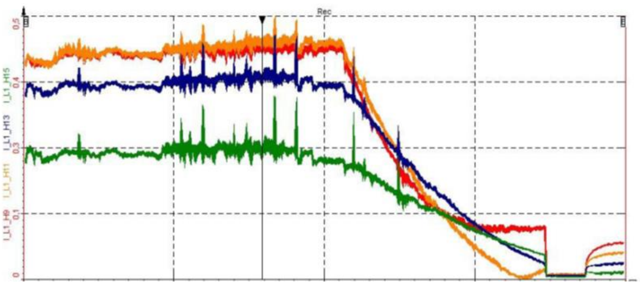
	Energy consumption [Wh]	Charged Energy [Wh]	Efficiency [%]	Duration
Full charging	1211	1805	67,1	14 hours
Short-charging	203	301	67,4	55 minutes

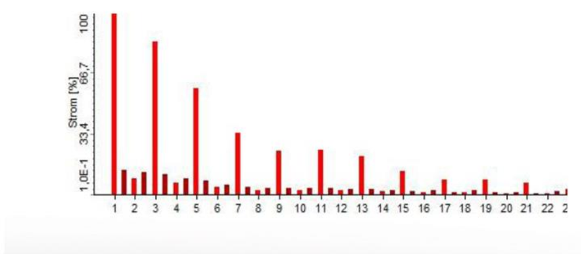


- ***Charging device - EMC tests according to EN61000-3-2***
  This charts describes the Harmonics emission of the charging device. The table shows the values as well as the maximum value, and the charts the profile of the harmonics as well as the harmonics in time and frequency domain.

Ordnungszahl der Harmonischen	Frequenz [Hz]	Strom [A]	Maximal zulässiger Strom [A]
1	50	1,82	-
3	150	1,42	2,3
5	250	0,95	1,14
7	350	0,58	0,77
9	450	0,45	0,4
11	550	0,44	0,33
13	650	0,36	0,21
15	750	0,22	0,15

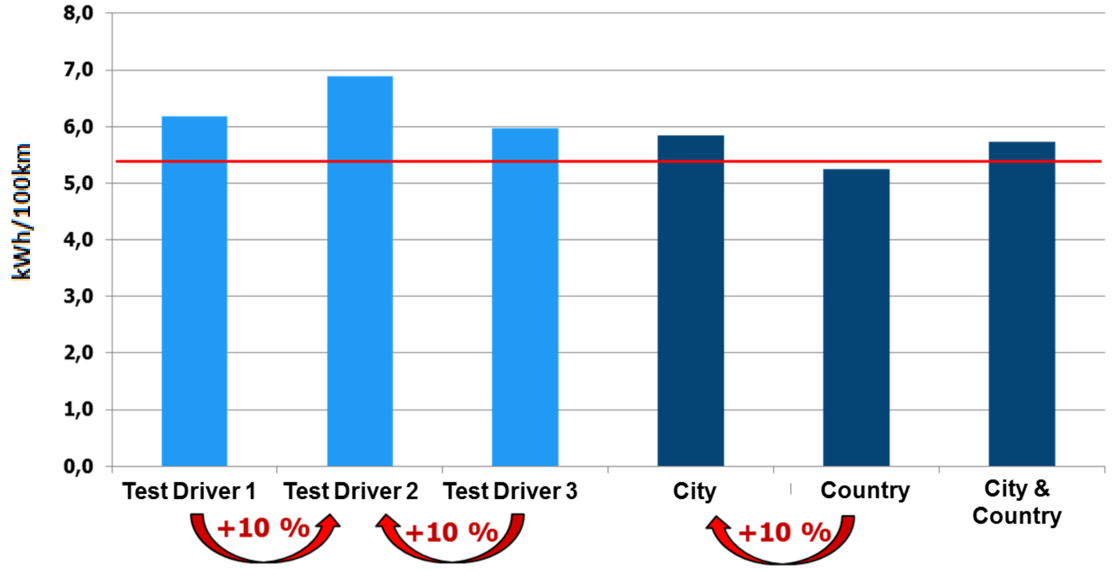






- ***Energy consumption of different drivers at the same test track***

This chart describes the energy consumption of different test drivers and different test tracks.



- **Uphill:** 8 times more energy consumption