DETERMINING THE ENERGY BALANCE OF A BATTERY ELECTRIC CAR DURING NORMAL DRIVING

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worldwide DEWETRON

In collaboration with

Fachhochschul Studiengänge

FH Burgenland

and

ENERGIE STEIERMARK

Problem Definition

Energy requirements of electric vehicles?

Data from the manufacturer

Energy requirements are determined on the basis of standardized test cycles on vehicle test benches;
No reference to the daily driving experience;
Real energy demand in general differs greatly from test bench values;

Data from independent studies

Focus of the studies is not usually on the energy consumption of vehicles;

Measurement of energy consumption in real driving conditions places high requirements on the mobile measurement technology

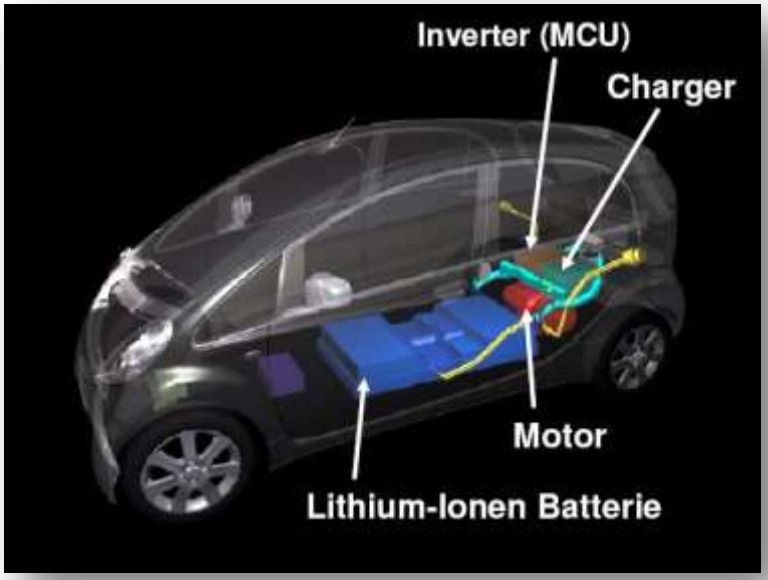
Objective

Determining the energy balance of an electric vehicle in real driving conditions

- Determination of the energy demand for typical driving situations
- Investigation of energy recovery by regenerative braking
- Analysis of user behavior
- Determination of the charging energy

Test vehicle

Mitsubishi i-MiEV



Specifications Mitsubishi i-MiEV	
Length / width / height	3475 / 1475 / 1610 mm
empty weight	1110 kg
Seats / doors	4 / 5
top speed	130 km/h
engine Type	3~ Synchronous motor, Permanent magnet
Max power	49 kW (67 PS)
Max torque	180 Nm
Maximum Speed	8000 rpm
Gear selection stages	P-R-N-D-B-C
Drive type	rear-wheel drive
Type of battery	Lithium-Ionen
battery voltage	330 V
total energy	16 kWh

Demands on the Measurement system

- Isolated inputs
- High precision power measurements
- High bandwidth
- Fast sampling rate
- Simultaneous sampling
- Direct voltage / sensor input
- SYNC-CLOCK™ technology enables synchronous recording of CAN bus, analog sensors, GPS, video, …
- Multiple power calculation modules (3 phase, DC, …)
- Efficiency and energy flow analyses
- For in-vehicle use, powered by hot-swappable batteries

Test Setup

Field test Mitsubishi i-MiEV

The combined cycle
Evaluation of the total energy requirement of the test vehicle, as well as assessment of sections consisting of 1/3 highway, 1/3 country roads and 1/3 city driving.

Uphill / downhill ride
Evaluation of the different energy recovery potential through selectable Recuperationsmodes when going downhill.

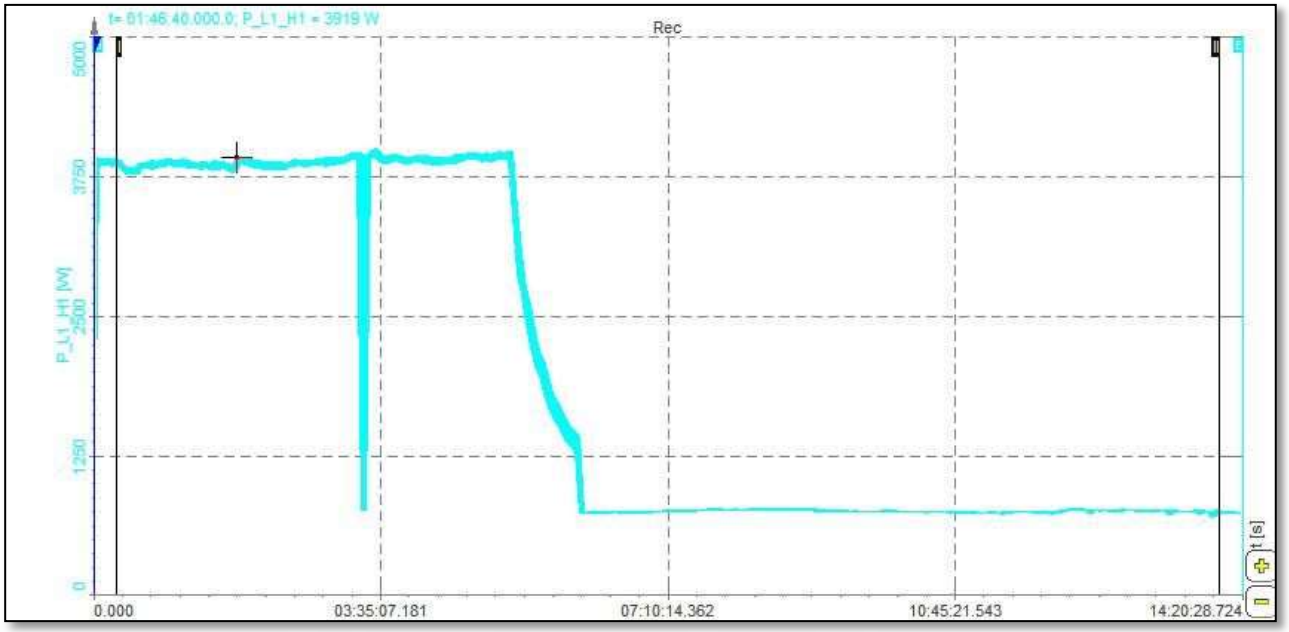
User behavior
Evaluation of the influence of different users / driving styles on the energy demand based on a test track.

Charging energy
Measurement of the charging energy for charging on the grid. Comparison to that of the battery power provided.

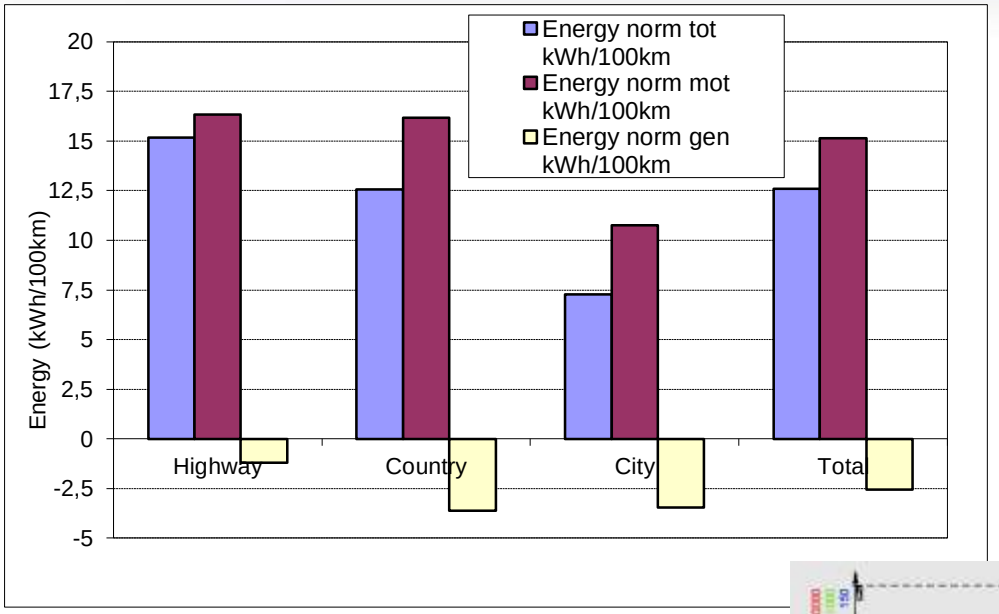
Charging energy

	Charge
Charging time (hh.min)	6,15
Rated charging power (W)	3840
Charging energy (kWh)	22,1
Charging power conservation (W)	2

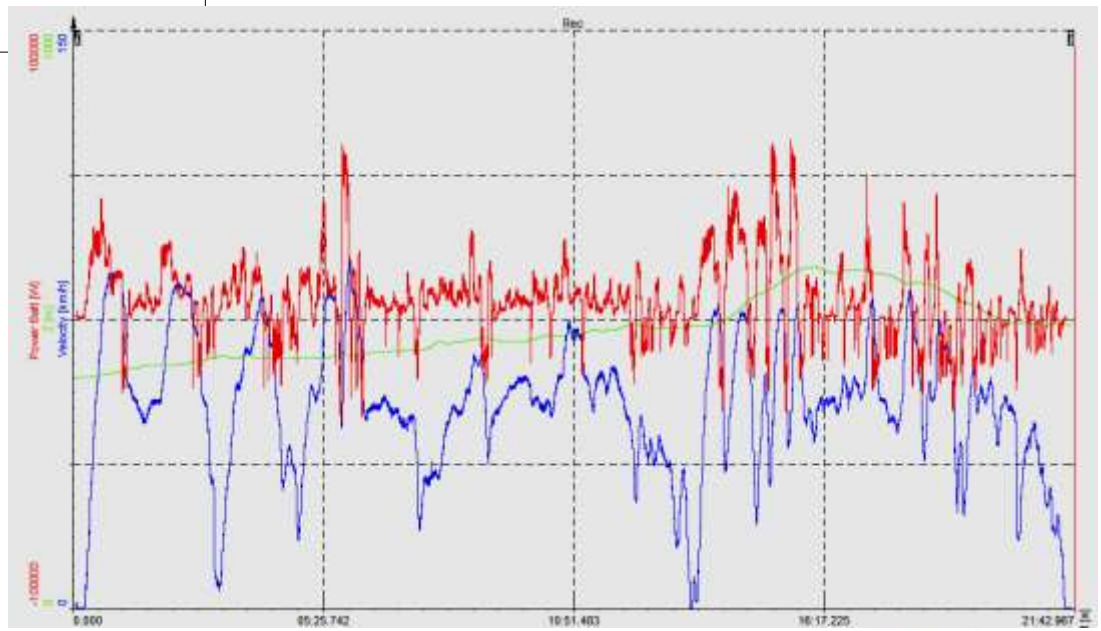
	Discharge
Discharging time (h)	3,52
Discharge avg (W)	3994,8
Discharge energy (kWh)	15,3
Charge efficiency (%)	69,3



The combined cycle

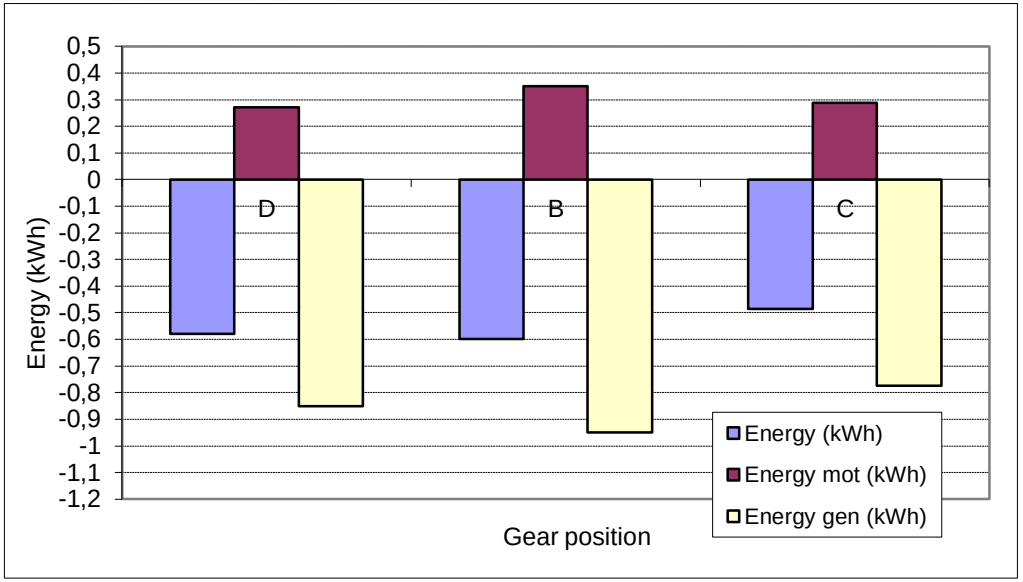


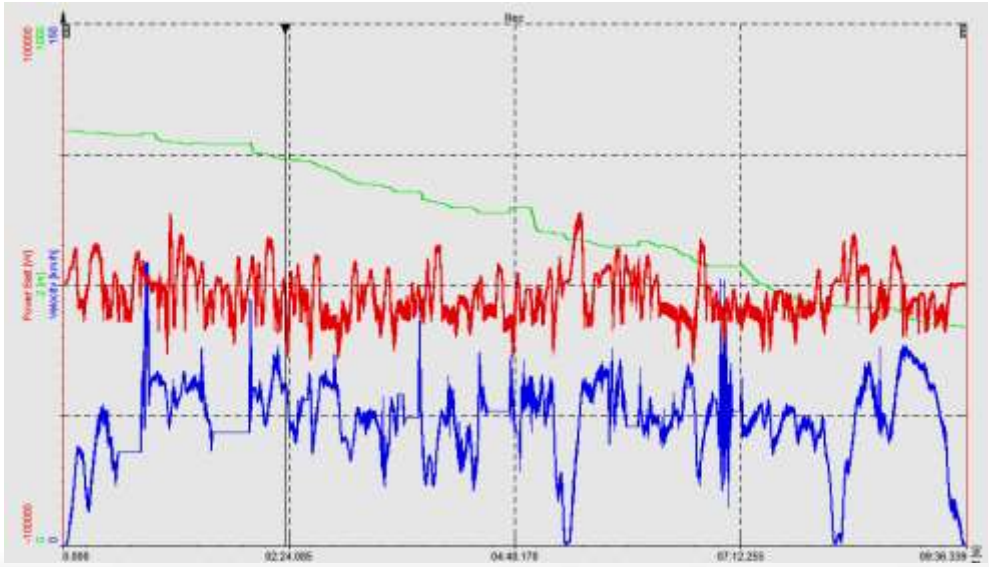
	Highway	Country	City	Total
Battery Energy norm corr (kWh/100km)	21,9	18,1	10,5	18,2
Energy demand corr (l Diesel/100km)	2,20	1,82	1,05	1,83
Energy demand corr (mpg (US-Galllone))	106,8	129,12	223,8	128,4

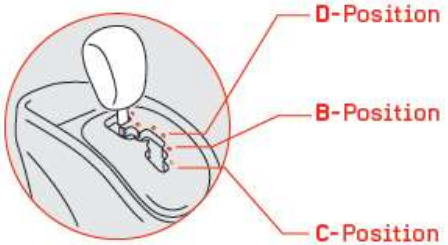


Energy recovery

	D-Position	B-Position	C-Position
Distance (km)	5,75	5,95	5,74
Driving time (min)	11,06	9,60	9,63
Battery Power avg (W)	-3142	-3742	-3027
Battery Energy (kWh)	-0,58	-0,60	-0,49
Battery Power pos avg (W)	1467	2194	1797
Battery Power neg avg (W)	-4609	-5936	-4824

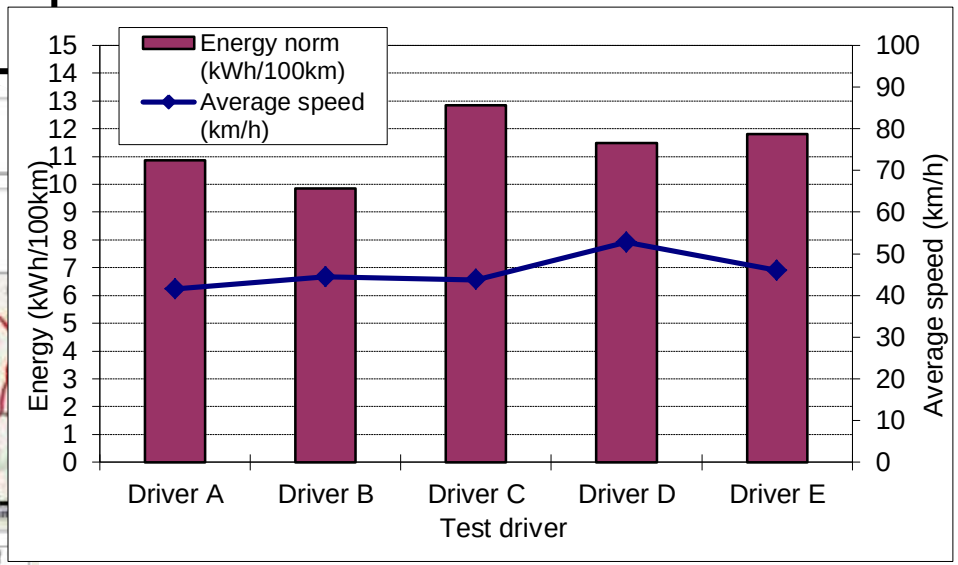






Test track user behaviour

	Driver A	Driver B	Driver C	Driver D	Driver E
Distance (km)	22,2	22,2	21,1	22,2	22,1
Driving time (min)	32,1	30,0	29	25,1	28,5
Battery Power avg (W)	4518	4382	5615	6056	5436
Battery Energy (kWh)	2,4	2,2	2,7	2,6	2,6
Battery Energy norm (kWh/100km)	10,9	9,9	12,8	11,5	11,8
Average Speed (km/h)	41,6	44,4	43,8	52,8	46



Summary

- Energy consumption in the combined by a factor of 2-3 lower than comparable vehicles with internal combustion engine
- Energy recovery by about 17% in the combined (total) at a high level
- "Economical" driving also shows an effect on electric vehicles

Thank you for your attention!

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