POWER UP - HOW E-MOBILITY WILL SUPPORT THE TRANSITION TO RENEWABLE ENERGIES.

ENERGY STORAGE IN GERMANY – R&D FOR THE ENERGY SYSTEMS TRANSFORMATION

1. MÄRZ 2015

BMW GROUP
ENERGY TRANSITION AND ELECTRIC-MOBILITY AS WELL ARE UNDER DISCUSSION.

**Energy transition**

- Electricity becomes too expensive
- Resistance against new power lines
- Resistance against new pump hydro power plants
- Resistance against new wind power plants

- Does the energy transition really help against the climatic change?

**Electric mobility**

- Batteries too expensive, poor range
- E-mobiles reasonable, but boring
- No sufficient charging infrastructure
- Electricity supply already without E-mobility more and more critical

- Is E-mobility really sustainable?
WITHIN A CHANGING WORLD E-MOBILITY BECOMES A VERY INTERESTING SOLUTION.

Environment
Climatic change and damages

Urbanisation
2030 more than 60% of the worldwide population will live in cities

Customer
Change of values

Pushing E-Mobility

Culture
Sustainable mobility as an element of a modern urban lifestyle, take-over of social responsibility.

Economy
Limited resources, increasing prices for fossil fuels

Politics
CO₂ – taxes, Fleet regulation, Limited access, congestion charge
THE BMW GROUP HAS THE ACEA COMMITMENT MORE THAN FULFILLED.

- 39 Models unter 120g/km
- 2015 EU fleet target: 130g CO₂/km
- 2020 EU fleet target: 95g CO₂/km
- 2025 EU fleet target: 75g CO₂/km

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E-VEHICLES ARE BEST CHOICE IN TERMS OF CO₂- AND EFFICIENCY COMPARED TO ALL POWERTRAIN CONCEPTS.

Energy consumption per km (relative to Diesel)

- Energy

+ Energy

CO₂ – Equivalent per km (relative to Diesel)

CO₂

Energy consumption per km (relative to Diesel)

Windpower
PEV
EU-Electricitymix
H₂ from Wind
FuelCell
PEV

Gasoline
CNG
Biodiesel
Biogas
Ethanol

Source: own slide according to EUCAR/Concawe/JRC Well-to-Wheels-Report
BMW IS CONSEQUENTLY PROCEEDING THIS PATH - E-MOBILITY IS A MAJOR PATH.

E-Mobility opens a new approach to the Ultimate Driving Machine.
Beyond less than 50,000 km the higher amounts of CO2 emissions are already compensated.
ENERGY TRANSITION AND E-MOBILITY.
A STRONG INTERFERENCE.

1 Electric vehicles as consumers of green energy

+ Sustainable, emission-free mobility

2 Strongly volatile feed-in of RE

Electric vehicles as flexible loads

Flexible loads (functional storage)
Storage (physical)

Required storage capacity

3 Electric vehicles as storage devices

4 Batteries from Electric vehicles in 2nd use

Source: Research project „Merit Order Energiespeicher 2030“

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Required energy for E-Mobility is quite low. Enough RE available.

Chance: Intelligent power and load management by controlled charging.

Chance: Sell capacity in wholesale markets or ancillary services.

Quellen: Bundesministerium für Wirtschaft, Zahlen und Fakten Energiedaten (Bruttostromverbrauch), 02/2013
BDEW: installierte Kraftwerksleistung 2014
Prämissen E-Fzg: Lade(anschluß)leistung 3,7kW; Energierverbrauch p.a.1920kWh (12.000km); Annahme nutzbarer Speicherkapazität für untertägige Ausgleichsdienste ~ 20kWh bei sich weiterentwickelnden Batt.-Kapazitäten 2020ff
BMW’S APPROACH OF GRID INTEGRATION.
TWO WAYS CHARGING PEV’S.

• Controlled charging in the grid
• ancillary services
• Markets: EU, US, J, CN

• Local, energy-autarcy
• Integrated Energy-Management vehicle ←→ local facility
• Markets: EU, US, J, CN

• Intelligent functions and services enabling access for renewable energy
• Experience of sustainable mobility
• New business opportunities

• vehicle enabled for intelligent energy services
• Standard interfaces
• Meeting worldwide specs.

• from local generation

… renewable energy from the grid

… from local generation
GRID INTEGRATION – SHOWCASE IN GERMANY.  
CONTROLLED CHARGING 3.0.

Gov. funded research project
- 2013 – 2015 duration
- 10 BMW Active E fleet test with 30 customers (3 phases)
- Start March 2013 in Berlin
- Business model: incentives for grid friendly charging behaviour
- Challenge: meet SRL spec (German TSO transmission code
## CONTROLLED CHARGING V3.0.
### FIRST RESULTS.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>System services to be met by EV`s?</td>
<td>DE: SRL neg.</td>
</tr>
<tr>
<td></td>
<td>US: D/R</td>
</tr>
<tr>
<td>Concept meets requirements</td>
<td>Timing &amp; dynamic requirements fulfilled</td>
</tr>
<tr>
<td>Potential and Profitability?</td>
<td>Revenue around 55€ p.vehicle/year</td>
</tr>
<tr>
<td>➞ Businessmodel</td>
<td>No positive business case today (2014)</td>
</tr>
<tr>
<td></td>
<td>Perspective with V2G</td>
</tr>
<tr>
<td>Competing technologies and business models?</td>
<td>Growing number of research and pilot projects.</td>
</tr>
<tr>
<td>Usability and customer acceptance?</td>
<td>85% interested in participation</td>
</tr>
<tr>
<td></td>
<td>Positive feedback from test users</td>
</tr>
<tr>
<td>Grid load with growing EV-fleets</td>
<td>Distribution grids have to be prepared for E-Mobility rollout</td>
</tr>
</tbody>
</table>
CUSTOMER RESEARCH: MAIN MESSAGES.

85% of the test group are willing to participate. Main reason:
Cost savings, but non-monetary reasons as well.

Availability of customer vehicles in the target time-window increases on 70% and more.

95% of the test-customers like to use the system in their daily life.
USING THE FLEXIBILITY WITHIN CHARGING ONLY, NO POSITIVE BUSINESS CASE IS IN SIGHT. V2G MAY HELP.

For V2G operation of EV's there are two restrictions evident:
- Limited charging/discharging cycles of the battery
- Limited operational lifetime of the E/E components and charging system

Next generation of system components and BMW-PEV models will be prepared, if there is demand and significant advantage.
Gov. funded research project
- 2012 – 2016 duration
- 60 Mini E in stationary and mobile service
- Start February 2013 in Newark, Del., USA
- Bi-directional EV charging
- Business model: revenues from grid services
- Challenge: meet frequency regulation specs.
V2G: TYPICAL REQUEST (FREQUENCY REGULATION). V2G-ENABLED MINI E MEETS REQUIREMENTS.

Discharge
Charge

RL am 01.04.2014 00:00-03:00h, Fzg. 652

FRS, 01.04.2014, 01:20-01:50h, EV 652

V2G: TYPICAL REQUEST (FREQUENCY REGULATION). V2G-ENABLED MINI E MEETS REQUIREMENTS.

FRS, 01.04.2014, 00:00-03:00h, EV 652

TYPICAL REQUEST (FREQUENCY REGULATION).

V2G-ENABLED MINI E MEETS REQUIREMENTS.

ca. 30s
POTENTIAL REVENUES SEEM TO BE PROMISING.

<table>
<thead>
<tr>
<th>Market</th>
<th>Charging power</th>
<th>Type of ancillary service</th>
<th>Payment by ISO / a / EV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany „Only charging“ GL V3.0</td>
<td>3,70 kW</td>
<td>SRL negativ</td>
<td>55 €³</td>
</tr>
<tr>
<td>Germany (2008)</td>
<td>3,50 kW</td>
<td>SRL negativ &amp; positiv</td>
<td>960 €¹,³</td>
</tr>
<tr>
<td>Germany (2008)</td>
<td>15,00 kW</td>
<td>SRL negativ &amp; positiv</td>
<td>4680 €¹,³</td>
</tr>
<tr>
<td>Austria (2012 → 2020)</td>
<td>10,50 kW</td>
<td>SRL negativ &amp; positiv</td>
<td>215 €¹,²,³</td>
</tr>
<tr>
<td>Smart Grid Project Modelregion Salzburg (7/2011)</td>
<td>-</td>
<td>SRL negativ &amp; positiv</td>
<td>465 €³</td>
</tr>
<tr>
<td>France (2011)</td>
<td>3,00 kW</td>
<td>PRL negativ &amp; positiv</td>
<td>232 €³</td>
</tr>
<tr>
<td>USA (ISO, 2000-2003)</td>
<td>2,90 kW</td>
<td>Frequency regulation (~ PRL)</td>
<td>$ 600³</td>
</tr>
<tr>
<td>USA (ISO, 2000-2003)</td>
<td>6,60 kW</td>
<td>Frequency regulation (~ PRL)</td>
<td>$ 1290³</td>
</tr>
<tr>
<td>USA (ISO, 2014)</td>
<td>19,00 kW</td>
<td>Frequency regulation (~ PRL)</td>
<td>$ 1670⁴,⁵</td>
</tr>
<tr>
<td>USA (CAISO, 2000-2003)</td>
<td>6,60 kW</td>
<td>Frequency regulation (~PRL)</td>
<td>$ 2640³</td>
</tr>
<tr>
<td>USA (CAISO, 2000-2003)</td>
<td>15,00 kW</td>
<td>Frequency regulation (~PRL)</td>
<td>$ 6000³</td>
</tr>
</tbody>
</table>

¹Battery wear considered  
²Request probability considered  
³Theoretical value  
⁴Real market participation  
⁵V2G-Project in Delaware with MINI E

Sources: [Link](#)
... BUT THE COMPLETE COST STRUCTURE HAS TO BE CONSIDERED.

Cost & benefit [$/a/EV]

1.670 *

Revenue?

Operational costs

Increased EV production costs

Invest

Revenue?

Revenue?

Revenue?

Cost & benefit [$/a/EV]

Payment by ISO  Aggregator  BMW  Customer

Operational costs

Increased EV production costs

Invest

Wear costs

Operational costs

Wallbox

Increased EV costs

Business case & customer`s TCO under work.

Source: University of Delaware
*Participation 22 h/d
BMW I CHARGE FORWARD. OVERLOOK.

- Pool with 100 BMW i3 customers
- 7/2015 – 12/2016
- Stationary storage as backup
- Business model: Incentive for customer participation:
  1000$ „Up-front“
  1$ / day @ DR Event-participation

San Francisco-Peninsula: Highest EV-population worldwide

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Quite simple:

- Charging status
- Revenue, savings
- Customer keeps control: can opt-out

Incentive: 1$ / day if opted-in

Revenue for D/R – Service: 3,000 $ / month (from PG&E to BMW)
CONCLUSION.

– Electric vehicles as flexible loads or storage devices will have significant potentials in future smart homes and smart grids.

– Therefore, a reliable, safe and cost effective communication between electric vehicles and backend systems will be mandatory - with respect to OEM liability responsibilities!

– Electric vehicle grid integration has to be in line with customers interests.

– Given markets and regulatory conditions assumed - BMW Group will develop electric vehicles and systems to support grid integration.
MANY THANKS FOR YOUR ATTENTION.