Challenge for Germany

Integration of e-Mobility In German Grid

**Gains**
- Increase of renewable resources
- CO2 saving
- Saving on costs for energy storage
- New business model

**Importance**
- Decarbonization of transport system
- Grid flexibility
- Raising customer demand for EV
- Change in demand behavior
Integration of e-Mobility In German Grid

Country challenge-provider: Germany
Forecast number of EV in Germany

Statistics for Germany

- 2013: 7,114
- 2014: 12,156
- 2015: 18,948
- 2016: 25,502
- 2017: 34,022
- 2018: 53,861
- 2019: 1,000,000
- 2020: 50,000

# of EVs in use in 2017

- NRW: 52,833
- HE: 2,582
- BY: 8,175
- BW: 6,657
- other states: varying numbers
Current energy system interconnection

Grid = 4 TSO + 883 DSO

Maintenance areas of TSO
Daily prices of energy

- Daily energy prices are changed every hour
- Prices can even been negative
- We propose charging EV at definite period with low prices
- We improve the load graph and reduce costs for energy system
Structure of electrical power supply

380 kV

TSO

0.23 kV

DSO
Structure of electrical power supply

- TSO
- Energy market
- Smart system
- DSO
- Money
- Measurements
- Power Flow
- Cashback
- Control
Business model of project

Cashback for EV owner: 200 €/year

<table>
<thead>
<tr>
<th>Discount rate, ct/kWh</th>
<th>0,05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of EV</td>
<td>0,001k</td>
</tr>
<tr>
<td>CAPEX, €</td>
<td>5 000k</td>
</tr>
<tr>
<td>TOTAL OPEX, €</td>
<td>100k</td>
</tr>
<tr>
<td>PROFIT per year, €</td>
<td>-100k</td>
</tr>
<tr>
<td>Payback period, year</td>
<td>NO</td>
</tr>
</tbody>
</table>

Breakeven point

# of EV in Germany, EVs
## Stakeholders

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Key Interests</th>
<th>What to do?</th>
</tr>
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<tbody>
<tr>
<td>EV owner</td>
<td>Cashback 200 €</td>
<td>4 System maintenance</td>
</tr>
<tr>
<td>EV producer</td>
<td>Sales growth</td>
<td>3 Connection of cars (contracts with car owners)</td>
</tr>
<tr>
<td>DSO</td>
<td>Load optimization</td>
<td>2 Technical part implementation</td>
</tr>
<tr>
<td>TSO</td>
<td>Load optimization</td>
<td>1 Contract with car producers (standardization of the charging station)</td>
</tr>
</tbody>
</table>

**Baden-Württemberg**
What's new?

Intelligent Energy System
Intelligent buildings
Intelligent transport
«Life Is On» – EUREF-Campus
Intelligent datacenter

100 EV

200 000 EV
Business model 2.0

Full charge/discharge once a day

1. Battery cost = 200 €/kWh
   - Discount rate of electricity cost = 9 ct/kWh
   - Charge/discharge cycles:
     - required number = 2,222 cycles
     - max allowable number = 1,500 cycles

   Not working now

2. Battery cost = 110 €/kWh
   - Discount rate of electricity cost = 9 ct/kWh
   - Charge/discharge cycles:
     - required number = 1,263 cycles
     - max allowable number = 1,500 cycles

Interesting Business Model
Profit = 18% of battery coast in 4 years
### Values

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Difference in the cost of electricity market, ct/kWh</strong></td>
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<td></td>
<td>0,05</td>
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<tr>
<td><strong>Number of EV</strong></td>
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<td>50000</td>
<td>1000000</td>
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<tr>
<td><strong>Total price of consumption, €</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>per day</td>
<td>0,625</td>
<td>31 250</td>
<td>625 000</td>
</tr>
<tr>
<td>per year</td>
<td>228,13</td>
<td>11 406 250</td>
<td>228 125 000</td>
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<tr>
<td><strong>CAPEX</strong></td>
<td>5 000 000</td>
<td>5 000 000</td>
<td>5 000 000</td>
</tr>
<tr>
<td><strong>Data center OPEX, €</strong></td>
<td>100 000</td>
<td>100 000</td>
<td>100 000</td>
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<tr>
<td><strong>Cost communication channel OPEX, €</strong></td>
<td>24</td>
<td>1 080 000</td>
<td>19 200 000</td>
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<tr>
<td><strong>Cashback for EV owner, €</strong></td>
<td>200</td>
<td>10 000 000</td>
<td>200 000 000</td>
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<tr>
<td><strong>TOTAL OPEX, €</strong></td>
<td>100 224</td>
<td>11 180 000</td>
<td>219 300 000</td>
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<tr>
<td><strong>Profit per year, €</strong></td>
<td>-99996</td>
<td>226 250</td>
<td>8 825 000</td>
</tr>
<tr>
<td><strong>Payback period, year</strong></td>
<td>NO</td>
<td>22,1</td>
<td>0,6</td>
</tr>
</tbody>
</table>
## Charging time

<table>
<thead>
<tr>
<th>Index</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power of the charging station, kW</td>
<td>3,5</td>
</tr>
<tr>
<td>Minimum required time for charging, h</td>
<td>3,6</td>
</tr>
<tr>
<td>Average available charging time at Home at night, h</td>
<td>9</td>
</tr>
<tr>
<td>Average available charging time at Office in the parking lot, h</td>
<td>7</td>
</tr>
<tr>
<td>Total Average available charging time, h</td>
<td>16</td>
</tr>
</tbody>
</table>
Power price in ct/kWh for German household
- PHEV battery costs:
  -73% in the past 7 years
  -58% to go in the next 7 years
- ICE cost parity for 2020-2022?
Components of Car Cost

- **Engine/Battery**
- **Other Components**

x1000 Euro

- **Mass Market**
- **BMW 5-Series**
- **BMW 7-Series**
- **Tesla**
Global average unsubsidized total cost of ownership outlook of BEVs compared with internal combustion engine vehicles ($/mile)

Between 2020 and 2030, EVs will become cheaper to own than ICE cars on an unsubsidized basis.

Source: Bloomberg New Energy Finance. Note: Fuel costs use EIA’s “low” reference crude oil price, rising from $50/barrel in 2015 to $75 in 2040.