Integration of electric vehicles and power grids (VGI)

Vision 2030 for Germany:
Reduction of CO₂ without subsidies: up to 39 mtpa

10 million emission-free cars in 2030

September 2019
Make EVs cheaper than conventional cars through creating value from provision of battery energy services

**TMH VGI-Initiative**

<table>
<thead>
<tr>
<th>TMH Approach</th>
<th>2030</th>
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<tbody>
<tr>
<td>• EV + bidirectional charger should become cheaper than ICE regarding initial cash investment.</td>
<td>• 10 million EVs in Germany in 2030 are ambitious but possible*.</td>
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<tr>
<td>• This will enable mass adoption of EVs on socially equitable basis.</td>
<td>• Norway – more than 50% of new sales are EVs as soon as all-in cash costs are lower than ICEs.</td>
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<td>• It can be achieved by factoring-in the value of VGI.</td>
<td>• German grid volatility provides unique opportunity to do the same with no additional burden on taxpayers.</td>
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<tr>
<td>• For this we need VGI with equal legal framework for EVs and stationary storage regarding levies.</td>
<td>• Just regulatory changes and VAT treatment of the battery and the charger as business are needed, to achieve value of €6000 per car without subsidies – higher than the current subsidy of €4000 in Germany.</td>
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<td>• €4300 per car – VGI present value over 10 years.</td>
<td></td>
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<tr>
<td>• €1700 per battery + charger – VAT reimbursement.</td>
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</tbody>
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* NPM (Report by WG1 of the ‘Future of Mobility’ National Platform, March 2019)  
Source: The Mobility House, NPM
Germany can have 10 million EVs on the road in 2030 if cash costs of EVs are lower than ICE sooner rather than later

€6000 per car will allow reaching parity between EVs and ICEs as soon as the regulatory changes are made

**Value of VGI (home case 2025, €/a/EV)**

<table>
<thead>
<tr>
<th>Revenue</th>
<th>OPEX</th>
<th>Aggregation &amp; commercialization</th>
<th>Margin for EV owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
<td>110</td>
<td>135</td>
<td>655</td>
</tr>
</tbody>
</table>

**VGI will help to reduce the initial cash outlay in EVs**

*Source: The Mobility House, BNEF*
VGI can contribute significantly to the emission reduction targets of the German government as well as address curtailment on local level

Prize of VGI – enable Verkehrswende with 10m EVs in 2030 and increase CO₂ reduction per EV

<table>
<thead>
<tr>
<th>GHG emission reduction (tCO₂eq/a/EV)</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICE</td>
<td>-2,2</td>
</tr>
<tr>
<td>EV</td>
<td>-1,7</td>
</tr>
<tr>
<td>VGI</td>
<td></td>
</tr>
</tbody>
</table>

7,0-10,5 million EVs reduce 15-23 MtCO₂eq/a according to NPM¹

60 VGI-cycles p.a. with 60 kWh battery, \( \frac{1}{3} \) of which avoided curtailment and \( \frac{2}{3} \) of which arbitrage

** Contribution to emission reduction target**

DIE SEKTORZIELE IM KLIAMASCHUTZPLAN 2050

<table>
<thead>
<tr>
<th>Sektion</th>
<th>2030</th>
<th>2014</th>
<th>1990</th>
</tr>
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<tbody>
<tr>
<td>Energie</td>
<td>-16%</td>
<td>-14%</td>
<td>-15%</td>
</tr>
<tr>
<td>Industrie</td>
<td>-14%</td>
<td>-11%</td>
<td>-13%</td>
</tr>
<tr>
<td>Gebäude</td>
<td>-11%</td>
<td>-5%</td>
<td>-6%</td>
</tr>
<tr>
<td>Verkehr</td>
<td>-16%</td>
<td>-14%</td>
<td>-13%</td>
</tr>
<tr>
<td>Landwirtschaft</td>
<td>-15%</td>
<td>-12%</td>
<td>-14%</td>
</tr>
</tbody>
</table>

* NPM (Report by WG1 of the 'Future of Mobility' National Platform, March 2019)
** Assuming 50-50 allocation to Transportation and Energy sectors
Source: The Mobility House, NPM
Curtailment occurs currently primarily in northern Germany and grew annually by 71% on average since 2009, with 5.5 TWh curtailed in 2017.

Curtailment growth will continue as renewables increase from 38% in 2018 to 65% in 2030.

Source: The Mobility House, Umweltbundesamt
10 Million EVs with VGI in Germany would be a key element for achieving German 2030 CO₂ reduction targets

Call for action – what is needed?

• Equal footing of EV swarm batteries on vehicle-grid-integration technology with other sources governed by the German Renewable Energy Act (EEG)
  • Apply grid and renewables’ levies only to energy consumed for driving, not the temporarily stored energy.

• Commitment to using decentralized storage to avoid curtailment of renewable energy and to supply system services to relieve pressure on the grid
  • Create unlimited access to ancillary services and short-term energy markets for EV swarms by reducing the commitment periods and power thresholds.
  • Use the features of battery storage such as precision, fast reaction & ramping times and their distributed nature with corresponding grid service products – as already successfully in place in some US regions.

• Cooperation of stakeholders (BNetzA, DSOs and TSOs, car manufacturers, car leasing companies, lenders, KfW and aggregators like TMH) to work together to develop new models for funding VGI
  • TMH has systems and processes in place and the model’s technical feasibility has been verified with leading car manufacturers and successfully tested in pilot projects in Germany and Europe.
TMH has proven track record in VGI
First EV stabilizing German electricity grid

FCR with EVs

> Generation of revenues through supply of FCR (Frequency Containment Reserve)
> Prequalification for FCR following TSO directives identical to a large-scale power plant
Audi opens battery storage on Berlin EUREF Campus

Multi-use Stationary Storage with Volkswagen Group

Source: The Mobility House
Impressions inside of battery storage

Stationary Storage with Daimler

Spare part batteries

Second life batteries

Inverter and DC cabinets

Source: The Mobility House
Porto Santo is the first island powered by Renault EVs managed by TMH

Marketplace on Island

Utility

Aggregation platform

Smart Charging
- 20 unidirectional EVs (Renault Zoe, Kangoo)
- 40 charging stations

Vehicle to Grid
- 2 bidirectional EVs (Renault)

Stationary Storage
- 2nd-use Renault batteries
- Storage systems (132 kW / 121 kWh)


Source: The Mobility House
EV-battery based multi-use storage system generates revenues through various services

ESS Amsterdam

- Optimized PV Integration
- Peak Shaving & Backup Power
- Grid Services
- Vehicle-to-Grid
- EV Car Sharing

3 MW / 2.8 MWh storage system made of 148 Nissan Leaf batteries