Exploration of the impact of electric vehicle policies on vehicle registrations, emissions and cost-benefit-analysis

ETC Frankfurt 2015

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Background

• EU Roadmap: 60% less transport induced GHG emissions in 2050 vs. 1990 (EC White Paper 2011)

• Electric vehicles are seen as one key component of GHG reduction strategies, e.g. in Germany: 1 million EV in 2020 as a national goal

• However, market diffusion pathways of EV depend on different factors such as
  • EU-wide and national policy settings,
  • technological and
  • economical developments

• ...and are yet open - analysing electromobility scenarios and their socio-economic impacts is needed
Electromobility scenarios: set-up

Research questions
• Business as Usual (BaU): What will the market penetration of electrified vehicles be with current policies and technologies until 2030?
• Politically Driven (PoD): Which impact do alternative policies at national and at EU-level have to enable a faster and more pronounced market penetration of electrified vehicles?

Markets
• Finland, France, Germany, Italy, Poland, the United Kingdom and EU-28

Methods and Tools
• Scenario analysis using a passenger car market model
• Cost-benefit analysis (CBA)
• Wider economic analysis (WEA)
VECTOR21 – a passenger car market model

- **Energy consumption**
- **Technology costs**
- **Fuel prices, taxes, ...**

**Computer model**
- Fuel economy packages
- Powertrain concept
- Type of fuel
- Vehicle size
- Technical parts
- Customer (900 types)
- Annual mileage
- Willingness-to-pay

**Selection**

**Sales / market shares**

**Final energy consumption CO₂ emissions**
## Scenario – key characteristics

<table>
<thead>
<tr>
<th></th>
<th>BaU</th>
<th>PoD-GER</th>
<th>PoD-EU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle design</strong></td>
<td>6 powertrain concepts, 5 electrified; 3 sizes; 9%-30% increase in vehicle energy efficiency up to 2025[^1^]</td>
<td>As in BaU</td>
<td>As in BaU</td>
</tr>
<tr>
<td><strong>Traction battery costs</strong></td>
<td>2010-2015: 450 €/kWh; floor costs reached in 2029 (230 €/kWh)[^2^]</td>
<td>As in BaU</td>
<td>As in BaU</td>
</tr>
<tr>
<td><strong>Charging infrastructure</strong></td>
<td>Coverage according to EC proposal COM(2013) 18 final, e.g. Germany 2020: 25%; 2030: 50%</td>
<td>Germany: increasing coverage by 10% p.a.[^3^]</td>
<td>As in BaU</td>
</tr>
<tr>
<td><strong>CO₂ targets</strong></td>
<td>2015: 130 g/km; 2021: 95 g/km; 2030: 75 g/km, incl. phase-in &amp; super credits</td>
<td>As in BaU</td>
<td>2015: 130 g/km; 2021: 95 g/km; 2030: 60 g/km</td>
</tr>
<tr>
<td><strong>Taxes &amp; subsidies</strong></td>
<td>As current legislation</td>
<td>Germany: 1,500 €/EV (2016-2020)[^4^]; exemption from renewable energy levy</td>
<td>As in BaU</td>
</tr>
<tr>
<td><strong>Willingness-to-Pay</strong></td>
<td>Adapted per country according to PPP[^5^]</td>
<td>Germany: increasing WTP by 10%[^3^]</td>
<td>As in BaU</td>
</tr>
</tbody>
</table>

[^1^] engine-based measures, lightweight construction, improvements in aerodynamic drag
[^2^] based on sold units using learning curves
[^3^] in relative terms
[^4^] e.g. by purchase premiums or tax exemptions
Germany - New passenger car sales

**Business as Usual scenario**

- Share of conventional **diesel vehicles** increases towards 2020 but shrinks afterwards due to more stringent CO₂ emission limits
- **Hybrid EV** gain market shares from 2015 on
- Almost no **BEV** as high purchase costs and high electricity prices prevent a pay-off over vehicle usage
- Increasing sales of **PHEV** after 2020: economically favorable vs. **BEV**

**Politically Driven scenario**

- Through measures to enhance electromobility, the share of **EV** increases
- Already in 2020 almost 10% of new vehicle sales are **PHEV**
- In 2030 40% of vehicles have a **charging device** of which <5% are **BEV**
- Only 20% of vehicles are **conventional**, not-electrified vehicles in 2030
EU28 - New passenger car sales

Business as Usual scenario

- Market shares over time are comparable to the German market
- PHEV are the most favorite EV
- CNG shares are mostly due to sales in Italy

Politically Driven scenario

- By tightening EU CO2 limits from 2021 on, market penetration of EV is faster and more pronounced
- In 2030 30% of vehicles have a charging device of which <5% are BEV
- 40% of vehicles are conventional, not-electrified vehicles in 2030
Cost Benefit Analysis

- costs (resource use) and benefits (resource savings) of EV diffusion from a societal point of view
- 2010-2030, 1% annual discount rate, net costs (taxes and subsidies not included)
- Aspects considered:
  - Infrastructure and production
  - Owning and operation
  - CO₂ emissions
  - Air pollutants
  - Noise

Wider Economic Analysis

- Macroeconomic effects such as
  - Employment
  - Gross value added
  - Fiscal revenues
Higher market diffusion of EV causes higher costs for infrastructure and car production (EV technology costs).

At the same time, there are savings due to lower

- energy costs
- CO\textsubscript{2} emissions
- Air pollutants/Noise

One important obstacle for EV market penetration is charging infrastructure that needs building up and is cost-intensive.
Wider Economic Analysis – Germany PoD vs BaU

Employment

- Industry
- Trade
- Manufacturing
- Trade
- Electricity generation
- Charging infrastructure

72,000 person years gained

Gross value added (net present value)

- Industry
- Trade
- Manufacturing
- Trade
- Electricity generation
- Charging infrastructure

8 million € gross value added

Taxes (net present value)

- Purchase Tax (VAT)
- Subsidies
- Energy taxes
- Other taxes (Income, ...)

4 million € tax losses
Conclusion

• Market penetration of EV is feasible from 2020 on, but depending on
  • Technological and infrastructure costs
  • Political support (e.g. strengthening of EU CO₂ limits)
• The share of BEV stays low in all scenarios
• EV are one important component to lower transport induced emissions and noise, although those benefits are not automatically higher than EV market penetration costs
• EV Policies can have a positive effect on employment and gross value added but, if financial incentives are given, could lead to tax losses
Our research work was funded by the Electromobility+ project eMAP (electromobility – scenario based Market potential, Assessment and Policy options, 2012-2015)

http://www.project-emap.eu/
VECTOR21
Customer specification

- 3 vehicle segments: small, medium, large
- Based on historical data and forecasts for each country

- Different annual mileage for each segment and country
- Based on surveys and publications

- Five different adopter groups
- Influence on customers’ willingness to pay
VECT0R21
Decision process

- Vehicle type (technology / fuel combination)
- **0** Step 0: Availability of vehicle
- **1** Step 1: Vehicle segment and basic requirements
- **2** Step 2: least RCO (Relevant cost of ownership) + willingness to pay
- **3** Step 3: least WTW CO2-Emissions (Assumption: costumer knows about WTW)
Powertrain concepts

- 10 Powertrains per vehicle segment (G, D, CNG, G_HEV, D_HEV, CNG_HEV, PHEV, REEV, BEV and FCEV)

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<thead>
<tr>
<th></th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
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<tbody>
<tr>
<td>HEV</td>
<td>15</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>REEV</td>
<td>65</td>
<td>10</td>
<td>65</td>
</tr>
<tr>
<td>PHEV</td>
<td>40</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>FCEV</td>
<td>65</td>
<td>2</td>
<td>65</td>
</tr>
<tr>
<td>BEV</td>
<td>65</td>
<td>20</td>
<td>65</td>
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Scenario parameters

• Moderate increase of oil price assumed.
• As foreseen in the current regulation, an EU-wide CO2-limit is taken as well as a continued development until 2030.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>Source</th>
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<tbody>
<tr>
<td>Energy and resource prices</td>
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<tr>
<td>Energy supply and emissions</td>
<td></td>
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<tr>
<td>CO₂ intensity H₂</td>
<td>g CO₂/MJ</td>
<td>100</td>
<td>73</td>
<td>21</td>
<td>McKinsey (2011)</td>
</tr>
<tr>
<td>CO₂ intensity CNG</td>
<td>g CO₂/MJ</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>JRC (2013)</td>
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<tr>
<td>CO₂ regulation</td>
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</tr>
<tr>
<td>EU CO₂ limit</td>
<td>g CO₂/km</td>
<td>2015: 130</td>
<td>2021: 95</td>
<td>75</td>
<td>EU law</td>
</tr>
</tbody>
</table>

• The eMAP countries cover approx. 28% of the new vehicle sales in the EU.
• To cover more than 70%, the United Kingdom, France and Italy are additionally simulated within the eMAP project.
• The market shares (size of segment and share of drivetrain) of these 6 countries correspond to those of the EU15 (93% of entire EU28 market size).
Germany - Stock

Business as Usual scenario

- Share of EV in stock is 35% in 2030
- WtW CO₂ emissions and energy consumption are decreasing by 30% in 2030 vs. 2010 due to
  - increasing efficiencies of conventional powertrains
  - an increasing number of electrified powertrains
  - An increasing share of renewables in electricity production

Politically Driven scenario

- Share of EV in stock is 40% in 2030
- WtW CO₂ emissions and energy consumption are further reduced (<5% in 2030 vs. BaU)
EU28 - Stock

Business as Usual scenario

- Share of EV in stock is 20% in 2030
- **WtW CO₂ emissions** and **energy consumption** are decreasing by 30% in 2030 vs. 2010 due to increasing efficiencies of conventional powertrains and an increasing number of electrified powertrains

Politically Driven scenario

- Share of EV in stock is ¼ in 2030
- **WtW CO₂ emissions** and **energy consumption** are further reduced (<5% in 2030 vs. BaU)
Stock