Building Up Demand-Oriented Charging Infrastructure for Electric Vehicles in Germany

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on the basis of a decision by the German Bundestag
Objective:
  • Development of a systematically comprehensible and consistent strategy to build a charging infrastructure for E-Vehicles in Germany.
  • Main assumption: 1 Million registered E-Vehicles by 2020.

Projekt Partners:
  • DLR
    • Insitut für Fahrzeugkonzepte (FK)
    • Institut für Verkehrsforschung (VF)
  • KIT
    • Institute for Transport Studies (IfV)

Funding Institution:
  • Federal Ministry for Economic Affairs and Energy
Long-distance travel – Charging infrastructure
Long Distance Travel – Charging Infrastructure: Methodology

- Usage patterns of conventional vehicles
- Trip length distributions of long distance trips by car
- Calculation of different travel demand levels with respect to temporal effects (different days of the week, holidays etc.)

Car use model of conventional vehicles in LD-travel

- Spatial as well as temporal resolution and distribution of travel demand
- Network characteristics
- Assignment of the total demand for charging on the LD-network (no commuting)

Traffic Assignment on a network model

- Scenarios for the future fleet of electric vehicles (shares of BEVs / PHEVs, etc…)
- Vehicle and charging infrastructure characteristics (ranges, capacities of batteries, charging durations, charging currents, …)

Characteristics of future Electromobility

Estimation of the charging demand and spatial assignment of charging infrastructure
Car Usage Patterns and Long Distance Travel Demand

Network and Traffic Model

Data:

- VALIDATE (PTV Group) fine-scaled zone and network-model
  - about 10,000 traffic zones
  - about 2 Mio. nodes

- Demand on **workdays** (Tuesday – Thursday)
  - ca. 120 Mio. car-trips
  - ca. 8 Mio. O-D-relations
Car Usage Patterns and Long Distance Travel Demand

• Effects of seasonality on travel demand (Weekday vs. Weekend):

Input data for Travel Demand Modelling:
• Trip Length distributions from:
  • VALIDATE, MOP and CUMILE
• Different temporal resolution

Solution:
• Scaling factors for the demand on weekends and holiday seasons are calculated
Car Usage Patterns and Long Distance Travel Demand

- 1 Million EV within German car fleet - assuming a usage behaviour like „conventional cars“*.

* Based on the CUMILE- Model (Car Usage Model Integrating Long Distance Events) developed in KIT – IfV.
Determining Charging Demand and Allocation of Infrastructure

• **Input data:**
  • Assumption: 1 Mio. E-vehicles (1/3 BEV, 2/3 PHEV)

• **Assumptions:**
  • BEV: 200 km range
  • PHEV: 40 km electric range
  • State of Charge (SOC): 100 % at start
  • Recharging required at 20 % SOC
  • Fast charging up to 80 % of capacity within 30 minutes

- **BEV:**
  - 100% → 160 km (20%)
  - 80% → 120 km (20%)
  - 80% → 120 km (20%)
  - 80% →

- **PHEV:**
  - 30 km (20%)
  - 250 km
  - 80%

Electric Mode

Combustion Mode
Determining Charging Demand and Allocation of Infrastructure

- Simulation
Determining Charging Demand and Allocation of Infrastructure

- Translation of Charging Demand into Infrastructure Demand:

- Illustration of Charging Events as Charging Density:
  \[ CD = \frac{\# \text{Charging Events}}{100 \text{ km}} \]

Temporal Distribution of Network Utilization and Trip Lengths

\( \text{Red} = \text{Equally distributed demand (share of about 8\% of daily total demand over a duration of roughly 10 hours)} \)
Determining Charging Demand and Allocation of Infrastructure

- Effect of various BEV Ranges on infrastructure demand:

![Bar chart showing number of charging events on high- and federal ways.](chart.png)

- Continuous Count Stations and Annual Profiles

![Map showing continuous count stations.](map.png)
Daily travel – Charging infrastructure
Daily travel – Charging infrastructure: Methodology

Assumptions

- Mass market by 2020
- Charging occurs when cars park
- No change in activity and travel patterns
Daily travel – Charging infrastructure: Methodology

Assumptions

• Mass market by 2020
• Charging occurs when cars park
• No change in activity and travel patterns

16,000 x ICE
16,000 x PHEV
16,000 x BEV

(MiD 2008, KiD 2010)

Charging demand 1 million EVs Charging algorithm

Vehicle trip diary

Preference, location, accessibility, speed, daily travel
Results: Occupancy of charging infrastructure by EVs throughout the week
Results: Occupancy of charging infrastructure by EVs throughout the week – absent home charging
Scenario comparison: Reference scenario and sensitivity analysis

Number of charging points (values in 1,000)

<table>
<thead>
<tr>
<th>Speed</th>
<th>Location</th>
<th>Reference Scenario</th>
<th>667,000 BEVs 333,000 PHEVs</th>
<th>Charging at home &amp; work</th>
<th>Range +50%: BEV 300 km PHEV 60 km</th>
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