Charging infrastructure for electric vehicles: demand, cost and impact on the energy supply in Austria by 2030

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Motivation

- The improvement of **air quality** and **climate protection** is the motivation for **legal regulations** to reduce pollutant (**Euro classes**) and greenhouse gas emissions (**CO₂ fleet consumption**).
- **Electromobility** is understood as **one of the solutions** and requires **appropriate market penetration**.
- However, this also requires a **sufficient charging infrastructure**.

Aim

- Tool-based identification of the required charging infrastructure and its impact on energy supply by 2030 in Austria.

- Key questions:
  - **How many** charging points are needed?
  - **When** are these required?
  - **Where** are they needed?
  - **Which** charging power should be installed?
  - **What** costs can be expected for the construction of the infrastructure?
  - **What** effects are there on the grid?

- This results in the main topics:
  - Forecast of **new registrations and fleet** of pure battery electric vehicles
  - Analysis of **mobility behavior**
  - Derivation of the **number of charging points** per **charging power** and their **distribution** (city/country-side)
  - Determination of the **additional electrical power and energy requirements** for e-mobility
  - **Costs** for the construction of charging infrastructure
  - **Impact on local grids**
Methodology

fleet of vehicles, energy consumption, mileage driven, …

Austria

fleet mileage & energy requirement

Regional distribution

demography, mobility behavior, charging behavior, …

needed charging stations, energy and power

grid data, transformer, distribution, …

Costs
New registrations and fleet development

- Based on an expert assessment regarding the development of new registrations of pure electric vehicles up to 2030, **26 % new passenger cars (PC) and 16 % new light duty truck (LDT) registrations** are expected **in 2030 in Austria**.

- This leads to a **stock of 11 % passenger cars (PC) and 6,5 % light duty truck (LDT)** of pure electric vehicles **in 2030**.

Methodology

- fleet of vehicles, energy consumption, mileage driven, ...
- demography, mobility behavior, charging behavior, ...
- grid data, transformer, distribution, ...

Austria Regional distribution

fleet mileage & energy requirement

needed charging stations, energy and power

Costs
Mobility behavior
to define the charging behavior by time and duration

- A highly detailed austrian-wide survey on individual mobility behavior was used.
- Main data of a single trip
  - arrival time
  - trip length
  - weighting factor
- Differentiated according →
- Assumption:
  - charging after every trip

Leads to more than 18,000 combinations.

Charging behavior
Assumption for the distribution of charging power according to place of charging

- **Expected charging power** for PC Home, PC Destination and LDT Home

<table>
<thead>
<tr>
<th>Charging Power [kW]</th>
<th>PC Home</th>
<th>PC Destination</th>
<th>LDT Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,3</td>
<td>27%</td>
<td>6%</td>
<td>10%</td>
</tr>
<tr>
<td>11</td>
<td>27%</td>
<td>21%</td>
<td>10%</td>
</tr>
<tr>
<td>22</td>
<td>40%</td>
<td>17%</td>
<td>10%</td>
</tr>
<tr>
<td>44</td>
<td>65%</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>52%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 kW and higher</td>
<td>6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PC Home:**
PC charging at home or their home charging place (own parking spaces or roadside)

**PC Destination**
PC charging at their destination (public)

**LDT Home:**
LDT charging at home at their own parking spaces
Calculation scheme to determine the simultaneity and load profile

- Based on the input data and assumptions shown above, the simultaneity and load profile were calculated, respecting
  - 93,000 different single trips; statistically recorded
  - an average yearly mileage of 12,900 km (PC) and 18,600 km (LDT)
  - an average energy consumption of 25.6 kWh/100km (PC) and 55 kWh/100km (LDT)
Charging power demand for pure electric vehicles (PC and LDT) in 2030
Maximum power in calendar week 3

- Energy demand: **2,23 TWh** (equals **3,2 %** of the energy demand in 2018)
- Maximum power demand: **1,1 GW** (equals **10,8 %** of power demand in 2018)
By 2030, Austria will require **857,000 charging points** for 623,000 PC and LDT.

This corresponds to **1,38 charging points per vehicle**.

39% of them in **public space**.

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### Required number of charging stations until 2030

**Distribution according to place of loading**

- **Total**: 857,000
- **Home charging road side**: 154,000
- **Home charging personal parking space**: 490,000
- **Destination charging road side**: 32,000
- **Destination charging parking space**: 86,000
- **Light-duty trucks**: 33,000
- **Highway**: 6,000

This corresponds to **1.38 charging points per vehicle**.

39% of them are in **public space**.
Costs for the construction of charging stations until 2030
Distribution according to charging power

- Cost estimate of various energy provider and operators.
- Consideration of the costs of:
  - Hardware
  - Grid fees
  - Building measures
- Distinction according to:
  - Charging power (2,3 - 50 kW)
  - Loading location (urban / rural)
  - Loading type (roadside/parking space)
- In total **6,1 Mrd. € until 2030**.
- This corresponds to **9,800 €/vehicle** in the scenario described.
Methodology

- fleet of vehicles, energy consumption, mileage driven, ...
- demography, mobility behavior, charging behavior, ...
- grid data, transformer, distribution, ...

Austria

fleet mileage & energy requirement

Regional distribution

needed charging stations, energy and power

Grid model

Costs
Impact on the grid
Consideration of various local grid models

- Considering a model for a
  - Rural grid (59 households)
  - Small town grid (87 households)
  - Metropolitan grid (168 households)

- Random distribution of the required charging points in the grid model
- Using the calculated load profile
- Determining the impact on the local grid
- Derivation of possible corrective measures

Part of a rural distribution grid

...charging spot
Impact on the grid
Results by 2030

- In the analyzed rural, small town and metropolitan grids, there has been **no inadmissible resource utilization and voltage range deviations occurred**.

- The grid models considered in the study **reach their limits** at a fleet share of
  - Rural grid: 30 % PC and 18 % LDT pure electric vehicles
  - Small town grid: 56 % PC and 33 % LDT pure electric vehicles
  - Metropolitan grid: 48 % PC and 28 % LDT pure electric vehicles

- **The limits of the considered grids are achieved by the maximum utilization of the transformers** and not by voltage band violations or line overloads.

- In unfavorable cases (e.g. old or higher loaded grids) an inadmissible operation can not be excluded even before 2030.

- **Due to the long planning phases** in grid expansion, the start of **extensions** for higher fleet shares of pure electric vehicles may already be **appropriate before 2030**.

- To **protect the grid** in a first step, **intelligent charging management** (e.g. smart meter) controls the charging power (e.g. $P_{\text{max}}$, $P_{(U)}$) and/or the charging time (start, end, duration).
Summary

- With the methodology developed, a tool was created to assess the requirements and consequences of electromobility with regard to the charging infrastructure and energy supply of a country under free selectable boundary conditions.

Based on the parameters shown, for Austria in 2030:

- Pure electric vehicle stock of 11% passenger cars (PC) and 6.5% light duty truck (LDT).
- For most journeys, low charging power is sufficient.
- The additional annual energy demand amounts to 3.2% of the energy demand in 2018.
- The additional power requirement amounts to 10.8% of the maximum power level in 2018.
- 857,000 charging points for 623,000 PC and LDT needed.
- The construction of charging infrastructure will incur cumulated costs of 6.1 Mrd. € or 9,800 €/vehicle.
- The analyzed grids show no problems with inadmissible resource utilization and voltage range deviations.
Thank you for your attention!

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