Coaches as part of the eHighway system: A feasibility study

ERS – Electric Road Systems Conference 2019, Frankfurt am Main
Regina Linke, Kevin Rolko, Manfred Boltze, Technische Universität Darmstadt
Motivation and Research Scope

**Motivation**
- Improving the quality of life by electrifying vehicles in inner city areas
- Identifying further user groups of the eHighway system
- Equipping the first bus for long-distance travel with a pantograph system

**Research Scope**
- Feasibility of equipping a coach with required components
- Feasibility from a legal point of view to operate a coach on the eHighway system
- Simulation of an existing bus line schedule, the *Airliner*
Motivation and Research Questions

Methodology
- Identifying a reference bus based on operational and technical requirements
- Identifying an additional charging location
- Simulation of an existing bus line schedule from the Airliner to derive the necessary technical requirements
- Derivation of simulation scenarios

Basic assumptions
- Vehicle switches to an electric operation mode when entering the city center of Darmstadt or the airport area (Entry → electric, Exit → diesel)
- Speed while using the catenary system: 80 km/h
- Vehicles operating per day: 3 busses
Results
Scenario 1: Base Case

Mileage (km/d)

Total: 2,315,4 km/d

- Electric (inner city area): 1,508,5 km/d
- Electric (outside city area): 399,5 km/d
- Diesel (inner city area): 407,4 km/d
- Diesel (outside city area): 0,0 km/d

Consumption (kWh) und Costs (€)

- Diesel consumption: 4389,6 kWh
- Electric consumption: 1210,4 kWh
- Diesel costs: 566,00 €
- Electric costs: 182,00 €

Parameters

- Charging power surplus loading station: 120 kW/h
- Charging power surplus test track: 120 kW/h
- City borders: fixed
- Time under catenary: 3,8 min
- Battery capacity (gross/ net): 50/30 kWh
- Consumption rate:
  - Air-conditioning/heating: 0,75 kWh/km
  - Traction: 0,75 kWh/km

Results

- For the base case scenario an electric operation of the coach in the city center of Darmstadt and at the airport in both directions is possible
- No diesel operation within the city centre of Darmstadt
- The battery capacity and the charging power are sufficient to operate the busses fully electric within the necessary areas
- The unexploited capacity seems to be adequate
- Existing potential to reduce fuel costs
Results
Scenario 1: Base Case

Bus 1: Battery status over the driving distance (Track 1)
Results
Scenario 1: Base Case

Bus 1: Battery status over the driving distance (Total)

unexploited capacity: approx. 15 kWh
Results
Comparison of fixed and variable city borders

Base Case (km/d)

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<th>variable</th>
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Best Case (km/d)

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<tr>
<td>2a</td>
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<td>1808,7</td>
</tr>
</tbody>
</table>

Consumption rate (air-conditioning/ heating and traction)

<table>
<thead>
<tr>
<th></th>
<th>0,75 kWh/km</th>
<th>0,5 kWh/km</th>
</tr>
</thead>
</table>

Electric : green, Diesel : red
Final Remarks

Conclusion
- For the base case scenario a partially electric operation of the Airliner within the city center and at the airport is possible with an adequate battery buffer.
- For the best case scenario an operation of the Airliner with a relatively small battery is possible in the inner city area.

Further analysis
- Simulation results only apply within limits of the made assumptions and the parameter value intervals.
- Delays should be analyzed and considered as a stochastic element in the simulation.
- Pilot study for testing the Airliner operation under realistic conditions.
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