Analysis of different sector coupling paths for CO₂ mitigation in the German Transport sector

Source: Forschungszentrum Jülich/Tricklabor for the Kopernikus project “Power-to-X”
Outline

1. Introduction
2. TIMES Model
   - General modelling approach
   - Implementation of trolley trucks
   - E-Mobility
   - Scenario Analyses
3. Results
4. Conclusion
Motivation

German national targets for reducing the Greenhouse Gas emissions compared to 1990 [1]

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
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<tbody>
<tr>
<td>overall GHG emissions</td>
<td>-27.2%</td>
<td>-40%</td>
<td>-55%</td>
<td>-70%</td>
<td>-80% to -95%</td>
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- ambitious goals for GHG emission reductions
- almost complete decarbonisation of the entire German energy system necessary
- need of renewables in heat and transport sector
- potentials of renewables mostly in electricity sector
TIMES-D model
TIMES-D model
General modelling approach

- depiction of the entire German energy system
- derived from the TIMES-PanEU model
- **linear optimization**: total system costs minimized
- complete competition between different technologies assumed
- **GHG emissions** of the system are recorded
- division into **280 time segments of 3 hours** each
- model horizon: **2010-2050**
- determination of the **economically optimal energy supply structure** for a given target
TIMES-D model
Implementation of Trolley Trucks

Technology characteristics

- electrically powered trucks
- energy supply via pantograph and **overhead lines**
- construction of the necessary infrastructure over motorways (as discussed) **cost-intensive**

**Modelling**

- one of multiple technologies in transport sector
- selection of technologies in model dependent on process-costs (amongst other things) e.g. investment or maintenance costs
- contribution to meeting the freight traffic demand limited to **90%**
 costs for complete electrification of motorways distributed over assumed max. number of vehicles

problem: clear differences in the utilisation of motorways in Germany

overhead lines over heavily used motorways can power more vehicles than over low-frequented ones

new implementation
- infrastructure costs distributed unevenly over three stages
- stage 1: 1/3 of vehicles but 1/6 of infrastructure
- potential of one stage limited to 1/3 of the max. overall contribution from Trolley Trucks
• e-mobility: all electrically operated vehicles in transport sector (except for heavy goods traffic and trains)
• sufficient charging infrastructure has to be used to charge the batteries
• Power-to-grid possible
• one of multiple technology pathways in transport sector
TIMES-D model
scenario analyses

- gradual reduction of the system’s **GHG emissions**
- three scenarios with great **differences in the long-term reduction targets**
- Trolley Trucks: scenario S90 with and without **disaggregated infrastructure**
- analysis of the charging infrastructure’s influence
- **share of simultaneously usable infrastructure** limited to 10%, 50% and 90%

<table>
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<tr>
<th>scenario</th>
<th>2020</th>
<th>2030</th>
<th>2050</th>
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<tbody>
<tr>
<td>S80</td>
<td>-40%</td>
<td>-55%</td>
<td>-80%</td>
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<tr>
<td>S90</td>
<td>-40%</td>
<td>-55%</td>
<td>-90%</td>
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<tr>
<td>S95</td>
<td>-40%</td>
<td>-58%</td>
<td>-95%</td>
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</table>
Results
Results
Freight Traffic – potential of the Trolley Truck

Meeting the demand of freight transport

- huge discrepancy between the scenarios:
  - entire possible demand provided by Trolley Trucks in S95
  - no usage at all in S80
- deployment of trolley trucks highly dependent on the selection of GHG reduction targets
Results
Freight Traffic – influence of disaggregated infrastructure modelling

- share of electricity:
  - 30% (disaggregated infrastructure)
  - 21% (base)
- usage of Trolley Trucks depends strongly on the modelling of infrastructure
**Results**

**Freight Traffic**

Overall electrical load from trolley trucks in 2050

- **13.3 GW** additional load in S90
- **18 GW** additional load in S95
- load directly dependent on driving behaviour

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**Electrical load in GW**

**day of the week**

- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday
Results

E-Mobility

Meeting the personal transport demand

- no difference between the scenarios until 2035
- contribution of electric vehicles varies between 21% (scenario S80) and 75% (S95) in 2050
- choice of the long-term target has a major impact on the utilization of electric vehicles
Results

E-Mobility

- higher electricity consumption in 2050 due to electrification of all sectors
- in the S95 scenario e-mobility accounts for 10% of the total power consumption in 2050 (280 PJ)
- S95: 190 PJ more by e-mobility compared to S80
Results

E-Mobility – electrical load caused by charging

huge peaks for 50% availability
Results

E-Mobility – residual load and load by charging

![Diagram showing residual load and load by charging for 50% infrastructure availability in 2050](chart.png)
Conclusion
**Conclusion**

- contribution of the Trolley Truck **heavily dependent** on the choice of emission reduction targets with **no usage** at all in the S80 scenario
- maximal **electrical load of trolley trucks is 18 GW**, likely to vary significantly between different regions
- **significant influence of detailed modelling of infrastructures** on the results of Trolley Truck analyses
- **GHG emission reduction targets with major impact on the utilisation of e-mobility** (varying between 21% and 75%)
- the load caused by charging electric vehicles can be regulated by limiting the simultaneousness of the charging infrastructure
- by not limiting the simultaneousness e-mobility can serve as a **very useful flexibility option**, causing large **additional loads of around 40 GW** however
References


Thank you!

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