Modelling a cost-efficient rollout Scenario for Germany

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Background

- Sector target for transport CO$_2$ emissions in Germany:
  - - 40 % compared to 1990 until 2030
  - Heavy duty trucks* account for 25 % of road CO$_2$ emissions

- CO$_2$ target for new trucks: - 30 % till 2030 (reference 2019)

  - Both targets difficult to meet with combustion engines
  - ERS trucks are an efficient alternative

- Currently several pilot projects in Germany

- Results from the research project: „Road Map OC truck“

* > 26 t GVW
Goal of the study

- Evaluation of road sections which are suitable for electrification from a cost and logistical perspective
- Focus on overhead catenary (OC) systems and diesel hybrid articulated trucks > 26 t GVW
- Main questions:
  - Which strategy for an OC deployment is advantageous in terms of costs and logistics?
  - Which conditions can be set by the state in order to promote the OC technology in a cost-efficient manner?
- Linear programming is used to answer those questions
Approach: Overview

Road transport data

All road transport trips in Germany (from PTV Validate)

Exclusion criteria:
- certain goods
- trips with unsuitable characteristic (length, road type)
- small trucks (<26 t)

Trips with a high affinity towards the OC-technology

Routing (transferring origin-destination data to detailed route information)

Trips with detailed route information

Allocation of routes to usage profiles of vehicles

Vehicle usage profiles for potentially suitable routes

TCO calculation

Energy prices

TCO of conventional

Energy consumption calculation

Energy consumption of

Vehicle data:
- weight

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Approach: Overview

TCO calculation
- Energy prices
- Vehicle costs:
  - CAPEX
  - OPEX

Energy consumption calculation
- TCO of conventional and OC-trucks, separately for each highway and off-highway section
- Vehicle data:
  - weight
  - drag coefficient
  - transmission
  - power etc.

Optimization phase
- Linear optimization

Answers delivered by the optimization model:
- Which vehicles will be electrified due to cost advantages of operators?
- Which highway sections should be electrified in order to minimize system costs?

Additional results:
- Energy consumption and GHG emissions
- Net Public costs infrastructure, taxes, Subsidies (if applicable)
- Savings for trucking companies

Infrastructure costs
Approach: Optimization Model

Objective function (cost minimization):

\[
\min \left( \sum_{j,t} x_{j,t} \cdot (k_{j,t}^{\text{fix}}) + \sum_{i,j,t} d_{i,j,t} \cdot k_{i,j,t}^{D,\text{var}} + \sum_{i,j,t} s_{i,j,t} \cdot k_{i,j,t}^{S,\text{var}} + \sum_{i,t} z_{i,t} \cdot k_{i,t}^{\text{fix}} \right)
\]

- **Annual fixed costs of the trucks**
  - Finance costs
  - Vehicle tax etc.

- **Variable costs for hybrid mode**
  - Depreciation
  - Tyres
  - Diesel etc.

- **Variable costs for electric drive**
  - Depreciation
  - Tyres
  - Electricity etc.

- **Infrastructure costs**
  - Investment
  - Maintenance
Results: Scenario definition

All costs are differential costs between conventional and OC trucks

Cost minimum implies a TCO advantage for all the shifted relations/trucks

A maximal annual grid deployment is assumed in both scenarios, 1.400 km until 2030

Policy scenarios for initial phase 10 years (here: 2020-2030)

- S1) only infrastructure funding
- S2) infrastructure funding+toll exemption\(^1\)

\(^1\) toll exemption only on electrified highways
Results: Grid deployment

Grid deployment

S1 - Only infrastructure funding

S2 - Infrastructure funding + toll exemption
Results: Suitable highway stretches

In this figure two additional scenarios are considered:

1) infrastructure funding + high electricity price;
2) infrastructure funding + low OC vehicle price.
Results: Vehicel mileage of OC trucks

Mileage OC trucks

Infrastructure+toll exemption:
- Mileage in 2030: 10.6% of all HDV\(^1\)
- Electric mileage in 2030: 7.9% of all HDV (share: 75%)

Only infrastructure funding:
- Mileage in 2030: 6.2% of all HDV
- Electric mileage in 2030: 5.7% of all HDV (share: 92%)

\(^1\) >26t; data from TREMOD
Results: CO₂ emissions

Mitigated annual TTW-CO₂-emissions compared to emissions in 2018 *

CO₂ emissions HDV (>26t): 36.8 Mio. t/a (currently)
Reduction in 2030:
- **Scenario 1**: 12% (TTW) and 7% (WTW)
- **Scenario 2**: 14% (TTW) and 11% (WTW)

*Percentage refer only to HDV >26t
Results: Costs and savings

Costs and savings 2020-2030 - only infrastructure funding

- Public indirect (energy tax losses) and direct costs (infrastructure) become comparable towards 2030
- Savings of freight forwarders could contribute significantly to coverage of infrastructure expenses in 2030

Assumption: 1,5 mio. €/km depends on capacity and local characteristics...
Results: Costs and savings

- Indirect costs (tax and toll losses) dominate total public costs
- Savings of freighters exceed the infrastructure costs in 2030 significantly
Conclusion

- Suitable highway sections have been identified, mainly in the North-West of Germany
- Vehicle stock of OC trucks depends on framework conditions (toll exemption, energy/vehicle prices etc.)
- The policy might also have an impact on the optimised infrastructure deployment, e.g. toll exemption
  - Some freight forwarders benefit significantly
  - Large indirect costs emerge (especially until 2030)
- Already in 2030 considerable TtW CO₂ emission savings of 12-14 % possible
Thank you on behalf of the team!
Results: Financial advantage of forwarders

- Savings of freight forwarder in 2030

Only infrastructure funding - 2030

- 14 \(^1\) of all freight forwarder (using HDV) benefit from the OC technology
- 3 % save more than 9 ct/km

Infrastructure funding+toll exemption - 2030

- 26 \(^1\) of all freight forwarder (using HDV) benefit from the OC technology
- 16 % save more than 9 ct/km

\(^1\)Total stock of HDV >26t in 2030: 334.000 (TREMOD)