Modelling market uptake of ERS in Germany

ERS Conference 2019
Scientific Session „Large Scale Implementation“

Ruth Blanck, Wolf Görz

Frankfurt, 08.05.2019
Project StratON – a short overview

- funded by the German Federal Ministry for the Environment
- Oeko Institut (lead), Heilbronn University, Intraplan Consult, Fhg-IAO
- Stakeholder involvement (4 workshops)
- Research topics:
  - Comparison of technologies,
  - development of an e-highway network,
  - modelling of market uptake
  - evaluation of economic and environmental effects
Market uptake of ERS: main influencing factors

Model scope

- Global trends (e.g. oil price, battery prices)
- Regulatory framework (taxes, tolls, standards)
- Availability of ERS infrastructure
- Vehicle use profiles, (business models)
- Risk aversion (preferences) in the transport market

Market uptake of ERS

- Availability of vehicles
- Acceptance
Within the StratON project, a „core network“ for a future ERS infrastructure on German highways was developed by Intraplan.

Database: traffic flows according to BVWP 2030

Criteria for selection of corridors for the core network:

- High traffic volumes of HDV
- High share of long-haul transport
- Length of at least around 200 km

Core network of around 4,200 km
# Assumptions on ERS network growth

<table>
<thead>
<tr>
<th></th>
<th>2020 „Pilots“</th>
<th>2025 „Star“</th>
<th>2035</th>
<th>2040 „Core network“</th>
</tr>
</thead>
<tbody>
<tr>
<td>km electrified</td>
<td>18</td>
<td>523</td>
<td>2969</td>
<td>3817</td>
</tr>
<tr>
<td>km total and electrified share</td>
<td>18 (100%)</td>
<td>747 (70%)</td>
<td>4242 (70%)</td>
<td>4242 (90%)</td>
</tr>
<tr>
<td>Network growth p.a. (km)</td>
<td>102</td>
<td>245</td>
<td>170</td>
<td></td>
</tr>
</tbody>
</table>

Availability of ERS infrastructure

plus sensitivity analysis (5 years faster)
Model description

- Truck registration model as part of Oeko-Institutes existing model TEMPS (Transport Emissions and Policy Scenarios)
- Agent-based optimization with around 1200 truck user profiles
- User profiles are based on trip data by Intraplan
  - **vehicle filter**: min. 4-axis
  - **trip filter**: long-haul transport (>100 km on ERS network) – trip filter excludes around 50% of mileage of 4-axis-vehicles (in case of core network)
- Each agent chooses vehicle with minimum TCO among available powertrains (diesel, O-HEV, and O-BEV)
- ERS network determines the (maximum) share of electric driving for each trip
## Assumptions on economic parameters

### Vehicle purchase prices 2030

<table>
<thead>
<tr>
<th></th>
<th>diesel</th>
<th>ohev</th>
<th>ohev100</th>
<th>ohev200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC truck + diesel engine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC truck + battery with 100 km reach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC truck + battery with 200 km reach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Investment 2030</strong></td>
<td>110.000</td>
<td>144.000</td>
<td>116.000</td>
<td>138.000</td>
</tr>
<tr>
<td>(Euro 2010)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Fuel prices 2030

- diesel price similar to current prices
- electricity price: 60% of domestic electricity price

<table>
<thead>
<tr>
<th></th>
<th>diesel</th>
<th>electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ct/kWh (2030)</td>
<td>11.11</td>
<td>13.02</td>
</tr>
</tbody>
</table>

---

Global trends
OBEV can achieve significant comparative economic advantages over diesel trucks

**TCO comparison of powertrains (2030)**

*illustrative user profile: 100,000 km p.a., 5 years, 50% electric mode*

![Bar chart showing TCO comparison of powertrains for different scenarios (die, ohev, obev100, obev200). The chart illustrates the breakdown of costs into road toll, maintenance, energy costs, and investment.]
Model runs

Model runs with variations of relevant assumptions:

- Availability of ERS network (faster network growth rates)
- Availability of fast charging infrastructure for oebev
- Economic parameters (Fuel prices, road toll, vehicle prices)
- Assumptions on risk aversion of vehicle users (payback periods)
Scenarios with varying assumptions on truck toll

Truck toll represents an essential lever for market uptake of OC trucks. The following scenarios were considered:

- **M0**: no toll exemption for electric trucks
- **MB**: complete toll exemption for electric trucks (according to the current regulation in Germany)
- **ME**: Truck toll exemption in electric driving mode
- **M80**: no exemption for electric trucks, but CO$_2$ price of 80 euro/t (from 2023)
- **M200**: no exemption for electric trucks, but CO$_2$ price of 80 euro/t for truck toll from 2023 and 200 euro/t from 2026
Truck toll represents an essential lever for the economic advantage of OC trucks

**TCO difference of ohev and diesel truck (2030)**

Illustrative user profile: 100,000 km p.a., 5 years, 50% electric mode
By introducing a CO2 price, the proportion of OC trucks can be significantly increased.

In the case of complete toll exemption (MB), an O-HEV is also profitable if it runs only or mainly in diesel mode.
Electric mileage varies significantly depending on road toll framework conditions

Share of electric mileage for 4-axis vehicles (2030)

Not a maximum potential (regional trips are excluded by a-priori trip filter)
Electric mileage varies significantly depending on road toll framework conditions

Share of electric mileage for 4-axis vehicles (2040)

Not a maximum potential (regional trips are excluded by a-priori trip filter)
Road toll exemptions for electric trucks could result in considerable revenue losses

**Difference of revenues from road toll and fueltax**
Compared to diesel scenario, cumulated 2020-2040

-9  25  68  -130
-11  36  80  -15
-12  -145

**Estimated costs for ERS infrastructure:**
10-12 bn Euro
By 2030, GHG reductions of 3 Mt or more can be achieved

Reduction of GHG emissions compared to diesel scenario (2030)
ERS system shows even higher benefits in the post-2030 timeframe

Reduction of GHG emissions compared to diesel scenario (2040)
The share of OC trucks varies significantly depending on assumption of payback periods

- **M0**: standard assumption: 20% of agents calculate with payback periods of 1, ..., 5 yrs respectively
- **M0_A5**: payback period of 5 yrs for all agents
- **M0_A1**: payback period of 1 yr for all agents

Long payback periods can be a relevant barrier for deployment of new technologies – especially in case of short-term contracts in the logistic market.
Real-world conditions vs. model simplifications

- The model does not differentiate cost-components with high uncertainty (e.g. resale value of trucks, oil price) from cost-components with lower uncertainty (e.g. fuel taxes) – but: risk aversion may be crucial for investment decisions

- There may be hidden costs for freight operators when changing to OC trucks – but also additional benefits (=> green logistics)

- Ex-ante filter on long haul transport excludes regional traffic flows from estimated potentials

- Reduced flexibility of OBEV is not assumed to be a limiting factor for vehicle purchase decisions => results represent „maximum OBEV potential“ under given battery capacities. Higher shares of electrification would be possible e.g. with OBEV300 etc.
Summary

- In the case of a **full road toll exemption for electric trucks**, OHEV are cost-competitive even if they are used only or almost exclusively in diesel mode (=> **false incentive, high revenue losses**). Adding a **CO₂ price component** to the truck toll is a better solution and results in high electric driving shares.

- The market’s willingness to accept longer **payback periods** has a **considerable influence** on the vehicle choice.

- GHG reduction potential for long-haul transport in 2030 is around **4-5 million tonnes CO₂** and can be increased to **up to 10-15 million** tonnes by 2040 (plus: additional reduction potential for electification of regional transport).