eHighway
Electrified heavy duty road transport
Opening questions (posed by Jari)

• Where are we today?

• CO2-mitigation potential?

• Cost-effectiveness?

• Feasibility, timeline, Adoption rates?
Context for Electrified Roads for HDVs

Important points from yesterday’s workshop sessions
• Focus on profile of emission reductions getting us to the emissions goal („at least 60% by 2050“)
• HDVs operating outside cities constitute a large majority of diesel consumption
• Emissions from HDVs is expected to grow from 1.5 Gt to 3 Gt by 2050
• Fully implementing traditional tool box cannot get us close to reaching climate goals
→ Need to think about new solutions and a systemic transition, especially for non-urban HDVs

Additional context
• Power sector decarbonization
• ERS and grid synergies
• Compatible with industry trends
What are electrified roads for HDVs

- Development of eHighway
- The potential benefits
- Possible road map from initial deployment to system
How eHighway works

https://www.youtube.com/watch?v=Z8l9ieoIazc
https://www.youtube.com/watch?v=zV2yZkRFBK0
## The eHighway hybrid truck can be configured to suit specific applications

<table>
<thead>
<tr>
<th>Truck types</th>
<th>Drive system</th>
<th>On-board source of electricity</th>
<th>Combustion engine</th>
<th>Non-electrical source of energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractor truck (2 axles)</td>
<td>Parallel-hybrid</td>
<td>Battery (small)</td>
<td>Engine (small)</td>
<td>Diesel</td>
</tr>
<tr>
<td>Tractor truck (3 axles)</td>
<td>Serial-hybrid</td>
<td>Battery (medium)</td>
<td>Engine (medium)</td>
<td>Bio-fuel</td>
</tr>
<tr>
<td>Rigid truck (2 axles)</td>
<td>Full electric</td>
<td>Battery (large)</td>
<td>Engine (large)</td>
<td>CNG/LNG</td>
</tr>
<tr>
<td>Rigid truck (3 axles)</td>
<td></td>
<td>Fuel cell</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rigid truck (4 axles)</td>
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<td>H₂</td>
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</tbody>
</table>
Alternative concepts for climate-friendly road freight transport

Investigated concepts comprise external power supply and on-board storage systems

**On-board storage**

<table>
<thead>
<tr>
<th>Alternative fuels</th>
<th>Electricity</th>
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</thead>
<tbody>
<tr>
<td>CNG / LNG</td>
<td>Battery</td>
</tr>
<tr>
<td>Bio fuels</td>
<td>Capacitors</td>
</tr>
<tr>
<td>Fuel cell</td>
<td></td>
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</tbody>
</table>

**External power supply**

<table>
<thead>
<tr>
<th>Contactless</th>
<th>Conductive</th>
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</thead>
<tbody>
<tr>
<td>Inductive power supply</td>
<td>Ground-based contact line</td>
</tr>
<tr>
<td>Linear s. motor concepts</td>
<td>Overhead contact line</td>
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**Alternative fuels**

- CNG / LNG
- Bio fuels

**Electricity**

- Battery
- Capacitors

**Contactless**

- Inductive power supply
- Linear s. motor concepts

**Conductive**

- Ground-based contact line
- Overhead contact line
What are electrified roads for HDVs

Development of eHighway

The potential benefits

Possible road map from initial deployment to system
Funded research projects supplement the currently executed projects on public roads in Los Angeles and Sweden

### Research Projects

- **ENUBA (Germany)**
  - First research project with BMUB
  - Duration: 05/2010 – 09/2011

- **ENUBA 2 (Germany)**
  - Second research project with BMUB
  - Duration: 05/2012 – 12/2015

- **ELANO (Germany)**
  - Third research project with BMUB
  - Duration: 01/2016 – 09/2019

### Projects on Public Roads

#### Los Angeles – Port Application

- One mile demonstration as connection to near-dock rail terminals for cargo vehicles for 6 months
- Primary goal is to promote the implementation of zero emission goods movement technologies
- Cooperation with Volvo trucks and local truck converter

#### Sweden – Highway Application

- Two kilometer demonstration on a public road between industrial area and port for 2.5 years
- Overall aim is to evaluate Electric Road System options prior to introduction on road network
- Cooperation with Scania trucks
How it works – in reality

California: [https://www.youtube.com/watch?v=3s1Vopg3vUc](https://www.youtube.com/watch?v=3s1Vopg3vUc)

Sweden: [https://www.youtube.com/watch?v=fmcMmYdF6lA](https://www.youtube.com/watch?v=fmcMmYdF6lA)
Field Trials in Germany are a necessary next step for the development of the system

Information and routing

Federal State of Schleswig Holstein
- Tender recently published
- Track length / Amount of trucks: 5-6km / 5
- Start of Construction/Demonstration: 2018/2019

Federal State of Hesse
- Project awarded to Siemens
- Track length / Amount of trucks: 5km / 5
- Start of Construction/Demonstration: 2018/2019

Federal State of Baden-Wuerttemberg
- Tender not published yet (expected 2018)
- Track length / Amount of trucks: 5-6km / 5
- Start of Construction/Demonstration: 2018/2019
Field Trials in Germany are a necessary next step for the development of the system

Information and routing

Source: https://mobil.hessen.de/verkehr/elisa/baustellen-news
Swedish government has allocated EUR 30m for a semi-commercial pilot to take electric roads to the next level by 2021

Swedish policy actions

• 85% of Swedish parliament voted for climate law with goal of 70% reduction of domestic transport GHG emissions by 2030

• Swedish Transport Administration developing road map for electrified roads for next long term transportation plan (by 2022)

• As preparation for the road map a pilot project before 2022 is planned, with government co-funding of up to EUR 30m available.

• Major trucking companies calling for ambitious pilots of new technologies

• Existing demonstration project has performed above expectations and has strong stakeholders in place
Agenda

What are electrified roads for HDVs

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Possible road map from initial deployment to system
Zero emission trucks are possible with renewable energy, but efficiency varies greatly.

### Electric Road Systems
- **Range:** 60 km
- **Cost per km:** 19 ct/km
- **Efficiency (WTW):** 77%
- **Example vehicle:**

### Battery
- **Range:** 48 km
- **Cost per km:** 20 ct/km
- **Efficiency (WTW):** 62%

### Hydrogen
- **Range:** 24 km
- **Cost per km:** 55 ct/km
- **Efficiency (WTW):** 29%

### Power-to-Gas
- **Range:** 17 km
- **Cost per km:** 70 ct/km
- **Efficiency (WTW):** 20%

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1) Including storage

Source: German Ministry of Environment

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100 kWh
6.0 ct/kWh

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1) Including storage

Source: German Ministry of Environment

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Akerman / MO TI EH
System cost assessment, needs to include cost of energy supply as well as vehicle and infrastructure costs

- Business case for zero emission need to assess several factors, in addition to vehicles
- It is equally important to assess cost of refueling (quickly).
- Especially cost of energy appear to impact total system cost significantly

![Graph showing additional cost for different greenhouse gas reduction scenarios compared to the reference case (all fossil fuel use) for the long-haul heavy-duty freight transport sector in Germany (based on Kasten et al., 2016).](image)

Figure 5. Additional cost for four different greenhouse gas reduction scenarios compared to the reference case (all fossil fuel use) for the long-haul heavy-duty freight transport sector in Germany (based on Kasten et al., 2016).

Source: ICCT - Transitioning to zero-emission heavy-duty freight vehicles (2017) page 23
German industry association BDI recommends 4,000 to 8,000 km of overhead catenary lines as a cost-effective climate action for HDVs

Background
- BDI commissioned an independent report looking at all sectors of the economy
- Investigated the most cost effective ways to reach German climate goals: -80% and -95% GHG
- Involved 68 BDI-member associations and companies, 200 industry experts and 40 workshops

Major findings
- Reaching the 80% reduction is possible by pushing existing technologies to the max. Has economically positive effects, even if Germany acts alone.
- Reaching the 95% reduction goal touches the limit of what can be expected from technology and citizens. Only in joint action with G20 economies would this be economically manageable

Transport highlights
- Shift to rail leads to an increase by 88% of ton-km of freight activity on rail by 2050
- No additional biofuels for transport, because other sectors will be prepared to pay more
- PtX only in 95% scenario. Imported from Middle East & North Africa, and it will still be very pricey

eHighway
- Building overhead catenary is the cheapest solution for HDVs, despite high infrastructure costs.
- Recommends building 4,000 km overhead contact line in the 80% scenario and 8,000 km in 95%
- Based on GER perspective. EU solution brings large synergies and is even more cost-effective
- Investment decision needs to be made by 2025, leading to first 400 km in operation by 2028.
Germany electrified 6.000 km railway track in 12 years

Abbildung 15: Ausbau raten der Streckenelektrifizierung in Deutschland (1945-1989)

Infrastructure on heavily use roads addresses significant part of heavy duty vehicle (HDV) emissions

The analysis of the German road network leads to the following key messages:

1. 60% of the HDV emissions occur on 2% of the road network (BAB = 12,394 km)

2. The most intensely used 3,966 km handle 60% of all ton-km on the BAB

Focusing first on the main freight transport routes, a significant decarbonization step can be achieved.

This approach can be applied all over the world.
Surface freight density: 2010

Source: ITF - Transport Infrastructure Needs for Future Trade Growth (2016) page 31
Surface freight density: 2050

Source: ITF - Transport Infrastructure Needs for Future Trade Growth (2016) page 31
Agenda

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Possible road map from initial deployment to system
The path forward focuses on the electrification of highly frequented routes

**eHighway application fields**

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<thead>
<tr>
<th>Near term</th>
<th>Long term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shuttle transport</td>
<td>Mine transport</td>
</tr>
<tr>
<td>Mine transport</td>
<td>Long haul traffic</td>
</tr>
</tbody>
</table>

The development path of road electrification can echo that of rail electrification a century ago
## Maturation of eHighway

<table>
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<tr>
<th>Installation</th>
<th>Characteristical operation</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gävle demonstration</td>
<td>A few vehicles run by purposely hired personnel on short pieces of infrastructure</td>
<td>Technical demonstration and development of vehicle and infrastructure.</td>
</tr>
<tr>
<td>German field trials</td>
<td>5-10 vehicles with short yearly milage utilized by logistics operators replacing conventional vehicles</td>
<td>Technical and functional verification of vehicles and infrastructure ready for series production</td>
</tr>
<tr>
<td>Gävle extension</td>
<td>150-200 vehicles with high yearly mileage</td>
<td>Validation of concept at end customer with low volume series produced vehicles and stable infrastructure design</td>
</tr>
</tbody>
</table>
Private data on truck flows and energy consumption

- Can tell us what an **optimal ERS network** should look like

- And can **pinpoint the clusters** where the deployment should begin. This is of crucial importance.
ERS target Sweden: 2021

- Infrastructure erected and commissioned for first cluster having 20 vehicles in operation
- Economic and functional market need for cluster installation verified
- Experience from several installation, funding and operating schemes available for other cluster establishments to use
- Vehicle volume increase to 200 vehicles in 2 years initiated
ERS target Sweden:
2025

• The first established cluster has been in operation for 5 years and has been using 150-200 vehicles from different vehicle suppliers for several years

• National rollout plan, including necessary funding, approved by Swedish government

• Conditions known for
  − ERS installations providing net value for society
  − Profitable vehicle investments by private actors

2030

• The ERS ecosystem mature and growing

• Benefit analysis of ERS installation routinely evaluated by Regional and National entities

• Four to five clusters in operation

• Installation of ERS-infrastructure between clusters ongoing to form national network

• (Several interoperable clusters in operation throughout EU)
eHighway
Elektrisch in die Zukunft
Thank you for your attention

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