eHighway @ BreBeMi
Siemens Mobility – Ing. M. Bosi

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siemens.com/mobility
171 years of Siemens
Established in Italy as from 1899
Global megatrends will shape our lives in the coming decades...

Digitalization
By 2020, the digital universe will reach 44 zettabytes – a 10-fold increase from 2013

Demographic change
The earth's population will increase from 7.3 billion people today to 9.6 billion by 2050

Climate change
By 2050, a global temperature increase of 4°C is expected

Urbanization
By 2050, 70 percent of the world’s population will live in cities (2014: 54 percent)

Globalization
The volume of world trade nearly doubled between 2000 and 2014
Siemens Mobility

**Mobility Management**
Products, solutions and turnkey systems for rail and road automation and optimization

**Turnkey Projects and Electrification**
Complete rail and road solutions and rail and road electrification solutions

**Rolling Stock**
Short-distance, regional and long-distance rolling stock, and product and system solutions for passenger and freight transport

**Customer Services**
Innovative services for rolling stock and infrastructure throughout the entire lifecycle

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SIEMENS
Ingenuity for life

~2 mld €
giro d'affari

19
città italiane in cui siamo presenti

6
centri di competenza

1
centro tecnologico applicativo

2
stabilimenti produttivi

>3.100
collaboratori in Italia

1.700
smart worker

46
età media

25%
donne
We look back at an extraordinary journey
We have a global presence
eHighway
Electrified heavy duty road transport
Decarbonization of road freight transport
Requirements for the optimal solution

The solution

Compatible with existing infrastructure
System is safe, reliable and easy to maintain
Long lifecycle
High efficiency
Little to no impact on standard operation
Compatible with other alternative fuel technologies
Scalable
Able to achieve 100% decarbonization
Economical
Interoperable
# Zero emission trucks are possible with renewable energy, but efficiency varies greatly

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Range</th>
<th>Cost per km</th>
<th>Efficiency WTW</th>
<th>Example vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Road Systems</td>
<td>60 km</td>
<td>19 ct/km</td>
<td>77%</td>
<td></td>
</tr>
<tr>
<td>Battery</td>
<td>48 km</td>
<td>20 ct/km</td>
<td>62%</td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td>24 km</td>
<td>55 ct/km</td>
<td>29%</td>
<td></td>
</tr>
<tr>
<td>Power-to-Gas</td>
<td>17 km</td>
<td>70 ct/km</td>
<td>20%</td>
<td></td>
</tr>
</tbody>
</table>

1) Including storage
Source: German Ministry of Environment
Amongst the three external power supply technologies the pantograph concept is seen as the most cost efficient solution

Alternative eHighway concepts

- **Conductive Charging (ground based)**
  - The vehicles are supplied with electricity from conductor lines which are integrated in the surface of the road

- **Inductive Charging System**
  - Vehicles are supplied with electricity contactless via induction loops in the road pavement

- **Pantograph Concept**
  - The eHighway adapted hybrid trucks are supplied with electricity from overhead contact lines via an active pantograph

**Source:** Machbarkeitsstudie zur Ermittlung der Potentiale des Hybrid-Oberleitungs-Lkw, 2017 (BMVI); Electric Road Systems, KTH Sustainable Energy Engineering, 2016
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.

Image: HDV density on BAB-network ; Source: Verkehr in Zahlen 2012; TREMOD 2012
How the eHighway system works

https://www.youtube.com/watch?v=Z8l9ieoIazc
https://www.youtube.com/watch?v=zV2yZkRFBK0
The eHighway system is based on well proven Siemens technology and subsystems

The complete system

1. Vehicle
   - Pantograph
   - Drive System
   - Energy Storage
   - Control System

2. Power Supply
   - Substation
   - Contact Line

3. Drive Way
   - Infrastructure
   - Traffic Mgt.

4. Operation
   - Maintenance
   - SCADA
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 BCG and Prognos 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 (other sectors will need biomass more and out-bid transport)
- PtX only in 95% scenario (due to high expected costs of fuel)

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 DE 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.

The potential of the eHighway technology ranges from closed shuttle applications to open highways solutions

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**eHighway application cases**

**Shuttle transport**
- Solution for high frequency shuttle transport over short and medium distances (<50km), i.e. in ports or industrial areas
- Lower fuel consumption and longer lifetime
- Reduction of air and noise pollution

**Electrified mine transport**
- Connection of pits and mines to storage or transit locations
- Minimization of harmful emissions
- Sustainable, clean and economical mine operation

**Electrified long-haul traffic**
- Economical and sustainable alternative for road freight transport
- Significant reduction of CO\(_2\) emissions
- Substantial cost savings for freight carriers
The Siemens pantograph solution is currently evaluated in 3 pilots which will serve as basis for upcoming projects

- Since 2010 **proof of concept** on test track (private road) outside Berlin
- Three research and development **projects successfully executed** Projects partly funded by German Federal Ministry of Environment, Nature Conservation, Building and Nuclear Safety (BMUB) – Pjets ENUBA, ENUBA2, ELANO
- Development **cooperation** with global truck manufacturer Scania
- Currently project ideas for **field trial** in evaluation

**Germany**

- June 2016 opening of world’s first eHighway on public road in Sweden
- Two year **test phase** of Siemens catenary system (E16 highway; 2 km)
- Two Scania diesel hybrid test **vehicles adapted** in collaboration with Siemens
- **Project funded** by the Swedish Transport Administration (Trafikverket)
- **Evaluation** of options for Electric Road Systems prior to introduction on Swedish road network

**Sweden**

- Public road demonstration (1.6 km) of eHighway system in Southern California
- **Several test hybrid trucks** (e.g. Mack, Volvo Group) with various alternative fuel technologies (e.g. LNG-hybrid, fully electric truck)
- **Reducing local air pollution** is major motivator for realizing the project
- **Evaluation of eHighway operations** esp. intensely used road freight operations connecting nearby ports of LA and Long Beach with local rail yards

**United States**

- Southern California

Source: eHighway: Electrified heavy duty road transport, Siemens, 2018; eHighway: Innovative electric road freight transport, Siemens, 2017; Siemens eHighways, Siemens, 2017
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
Divers stakeholders need to be involved to establish the eHighway solution in Italy and execute projects successfully.

### Decision Maker

<table>
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<tr>
<th>eHighway customers</th>
<th>Regulatory bodies/Italian Government</th>
<th>End customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway owners/operators</td>
<td>Ministry of Transport</td>
<td>Logistic companies, Carrier companies, Online mail order companies, Supermarket chains</td>
</tr>
<tr>
<td>Airport owner incl. concession partner for cargo</td>
<td>Airport authority</td>
<td>Airlines operating in the cargo sector</td>
</tr>
<tr>
<td>Port owners incl. concession partner</td>
<td>Port authority</td>
<td>Logistic companies, container shipping companies (e.g. ZIM)</td>
</tr>
<tr>
<td>Mine owners</td>
<td>Mining association</td>
<td>Mining companies (e.g. Marcegaglia S.p.A.)</td>
</tr>
</tbody>
</table>

### Components supplier

- Multi sources from small manufacturers in Europe
- Conductive charging components suppliers
- Inductive charging components suppliers
- Microwave charging components suppliers

### Technology provider

- Siemens: Pantograph Concept
- Alstom, Elways: Conductive Charging ground based
- Bombardier, Enel, Kaist: Inductive Charging System
- WiTricity (MIT): Microwave Charging System

### Vehicle manufacturer

- Scania
- Renault
- Volvo
- Fiat Chrysler Automobiles

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- Clarity regarding the stakeholder situation in the eHighway market is important to:
  a) pave the way and establish the **pantograph solution** as the ultimate eHighway solution in the **Italian market**
  b) plan and execute concrete eHighway projects successfully

- **Regulatory bodies** and the Italian **government** need to have clear information about the **advantages** of the pantograph solution

- **Vehicle manufacturers** need to be persuaded to be part of the **development** to get the pantograph solution into practice

- The doings of **competitive solutions** need to be closely observed esp. who is investing in the different technologies

- The stakeholder situation at **airports, ports and mines** is considered less complex as these are closed systems with clear calculable factors

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**Customers and Stakeholders**

**Divers stakeholders need to be involved to establish the eHighway solution in Italy and execute projects successfully**

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Relevant stakeholders expressed their interests for investigating road electrification for heavy duty vehicles.
Grazie.
Ing. Marco Bosi – CEO Siemens Mobility