eHighway – Status of the art
Ing. Marco Bosi – CEO Siemens Mobility
### Siemens Mobility @ a glance

#### Business Units

<table>
<thead>
<tr>
<th>Turnkey Projects &amp; Electrification</th>
<th>Rolling Stock Mainline &amp; Urban Transport</th>
<th>Mobility Management</th>
<th>Customer Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete rail &amp; road solutions (including eBuses &amp; eHighway) Rail electrification solutions</td>
<td>Short-distance, regional and long-distance rolling stock Product and system solutions for passenger and freight transport Railbound urban public transport vehicles, and passenger coaches</td>
<td>Products, solutions and turnkey systems for rail and road signaling, intelligent traffic systems, automation and optimization. Integrated Mobility</td>
<td>Services and tools for road and rail infrastructure, rolling stock, mobility management</td>
</tr>
</tbody>
</table>

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From 1882 to 2019
Same concept, but looking at the future

Siemens 1882
Berlin

Scania & Siemens 2018
Sweden

Filocarro AEM 1938 – 1962
Valtellina - Italy
Road freight emissions trends make it clear: Solutions for decarbonization are needed

Based on latest policy announcements, global heavy road freight is forecast to emit 3 Gt CO₂ by 2050.

Transport will increasingly be the biggest challenge for decarbonization in Europe.

Source: IEA - The Future of Trucks (2017) page 117
Source: European Commission reference scenario for 2050 (2013) page 53
Measures to reduce road freight CO₂ emissions

Source: International Road Transport Union – Commercial Vehicle of the Future (2017); EU Reference Scenario 2016- Energy, transport und GHG emissions
Heavily use roads
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

**Legend:**
- **BAB:** Federal freeways (12,394 km)
- **BS:** Federal roads (40,400 km)
- **LS:** State roads (86,600 km)
- **KS:** District roads (91,600 km)
- **GS:** Municipal roads (>420,000 km)

**Key messages:**

- **Focusing first on the main freight transport routes, a significant decarbonization step can be achieved.**
- This approach can be applied all over the world.
Decarbonization of road freight transport
Requirements for the optimal 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

The solution
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

100 kWh
6.0 ct/kWh
PUN – Prezzo Unico Nazionale
Catenary electrification is compatible with and complementary to other alternative fuel technologies

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>H₂</td>
</tr>
<tr>
<td>Rigid truck (4 axles)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Alternative eHighway concepts [external power supply]
Pantograph concept seen as the most cost efficient solution

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

- Least cost intensive eHighway solution; established technology; little/no impact on standard operation
- Infrastructure of pantograph solution esp. the catenaries are an intervention in the environment

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

- Other vehicles e.g. passenger cars can be integrated in the charging system and supplied with electricity as well
- Higher safety requirements; considerable impact on traffic flow during construction/repair works; higher installation cost

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

- Other vehicles e.g. passenger cars can be integrated in the charging system and supplied with electricity as well
- Most cost intensive solution (e.g. needed highway reconstruction); low efficiency factor hence higher energy consumption

Source: Machbarkeitsstudie zur Ermittlung der Potentiale des Hybrid-Oberleitung-Lkw, 2017 (BMVI); Electric Road Systems, KTH Sustainable Energy Engineering, 2016
How the eHighway system works
Proven technologies, in a new application

https://www.youtube.com/watch?v=Z8l9ieoIazc
https://www.youtube.com/watch?v=zV2yZkRFBK0
eHighway
Proven Siemens technology and subsystems

The complete system

… and its subsystems

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

**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 CO₂ emissions
- Substantial cost savings for freight carriers
The Siemens pantograph solution
3 pilots serving as basis for upcoming projects

Germany
Berlin

- 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) – Pjts ENUBA, ENUBA2, ELANO
- Development **cooperation** with global truck manufacturer Scania
- Currently project ideas for **field trial** in **evaluation**

Sweden
Stockholm

- 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

United States
Southern California

- **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

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
- Construction ended 2018

**Federal State of Baden-Württemberg**
- Tender not published yet (expected 2018)
- Track length / Amount of trucks: 5-6km / 5
- Start of Construction/Demonstration: June 2018
Project Elisa – Construction phase in Essen
La Brebemi sarà la prima autostrada elettrica italiana

INFRASTRUTTURE
Analisi Agici: l’opera ha fatto risparmiare 577 milioni e 11 milioni di ore di traffico
Bazol: Importanti investitori internazionali interessati al progetto
Sara Monaci

Milano
E’ stata per anni l’autostrada della discordia. Sostenuta dagli industriali del territorio lombardo ma avversata da Autostrade per l’Italia, la Brebemi dopo quattro anni le ricadute economiche della strada, per anni criticata dagli ambientalisti con l’accusa di essere inutile, e per il fatto di avere un piano industriale non sostenibile. È stata costruita con un progetto finanziato da circa 2 miliardi ai tempi in cui il gruppo Gavasa l’interessa potenziale, poi la proprietà è passata poi di mano a banca Intesa Sanpaolo, che, in una volta, ha contribuito a lo.
Grazie.
Ing. Marco Bosi – CEO Siemens Mobility