Electric road systems: Challenging the established road system and business models

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Agenda

1. Background and definition of ERS
2. ERS demo projects in Sweden
3. Business model challenge of ERS
The History of ERS

Conductive rail, 1881

Overhead lines, 1882

Electric car, 1884

Inductive power transfer, 1891

Sundelin, 2016
Evolution of filling-up regime
Diesel engine development

Minimum specific fuel consumption

ECE R49 -20%  Euro 1  Euro 2  Euro 3  Euro 4  Euro 5  Euro 6

Charge-cooling  Turbocompounding  Unit injectors  EGR  SCR
Background for change
Global oil consumption per sector

* Passenger vehicles include buses and two- and three-wheelers.

Source: EIA, 2016
Freight sector expected to grow with economic growth

Source EIA, 2017
Impact of alternatives

<table>
<thead>
<tr>
<th>Energy efficiency</th>
<th>Systemic improvements</th>
<th>Alternative fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Substantial potential to contribute indirectly (through reducing aggregate energy use)</td>
<td>Natural gas</td>
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<td>20% lower tank-to-wheel emissions offset by methane slip and leakage</td>
<td>Biofuels</td>
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<td>Need for low well-to-wheel emissions and minimization of land use change</td>
<td>Requires low-carbon fuel supply pathways</td>
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<tr>
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<td>Assumes use of high quality drop-in fuels</td>
<td>Electricity</td>
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<td></td>
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<td>Hydrogen</td>
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**Key**

- **Green**: Highest
- **Yellow**: Positive
- **Orange**: Neutral / no improvement

**Impact**

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<th>Energy supply diversification</th>
<th>Climate change</th>
<th>Air pollution</th>
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Requires low-carbon fuel supply pathways

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IEA, 2017
Transition towards ERS
The Electric Road System
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Two national projects awarded funding in a pre-commercial procurement
eRoadArlanda
The facility

• Existing infra of 400 m.
• Electrifying 2 km between Airport and Freight Terminal.
• Civil works beside the road finalized in Sept 2017.
• Ongoing production of rails.
• Focusing on safety and system verification.
• Waiting for "GO" to start mounting the rails into the road.
Technical solution of Elways

View from above

Sections are energized one by one as the car passes

Elways, 2017
The Truck

Brand: DAF
Converted by: E-traction
Motors: Two motors built into the rear axle. Total power of 226 kilowatts (300 hp). They weigh 500 kilo each.
Battery: 80 kWh, weight 600 kilos. (Battery Tesla Model 6 close to 550 Kg.)
What does not weigh: Engine, power train and a full diesel tank
Weight: 18 tons
Load: 6.5 tons
Emissions: –
Electric Road – E16 Sandviken
The Facility

- 2 km long facility on the E16
- Region Gävleborg is project owner and builder
- Infrastructure/facility owner Siemens
- Catenary system – Built without legal dispensations
- Siemens innovative pantograph
- Power supply Sandviken Energi
- 10 kV AC
- After conversion 650-800V DC
The technical solution

The complete system ...

... and its subsystems.

1. Electric Infrastructure
   - Substation
   - Contact Line System

2. Hybrid Vehicle
   - Pantograph
   - Drive System
   - Energy Storage
   - Control System
   - Passive Protection
   - Pavement

3. Driveway
   - Maintenance
   - ITS & Signalling

4. Operation

Åkerman et al., 2015
The Truck

Scania, Euro6 Class
Parallel hybrid power train
264kW diesel, 139kW electric engine, 100kW battery
Still a test vehicle
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“Not a technology problem, a business model challenge”

What we know:
• New business models are needed to commercialize sustainable technologies; a firm-user relationship

What we don’t know:
• The “right” business models for new socio-technical systems
A business model opportunity?

Comparing energy use, emissions and costs

From the perspective of the user:
- ERS
- Methane (57% bio gas)
- HVO
- Diesel

Possibility for investment in vehicles and infrastructure

Including taxes and subsidies. Based on average data and specification of fuels sold in Sweden.

Trafikverket, 2017
Utility of the new infrastructure is critical
Analyzing the emergent phase of transition through a BM perspective

Policy makers

Socio-technical change
New business models

Subsystem suppliers

System Users
Transition towards ERS

Extent of use

R&D

Demonstration projects

Technological niche

Closed system

Niche and mass market

Open system

ElonRoad, SAET, Qualcomm, Utah State University, Bombardier, Alstom, Highways England, Project Victoria, Elyways, Siemens, OLEV

Tongur & Sundelin, 2016
Thank you! Questions?

Electrified road transport

- a contribution to a transport sector independent of fossil fuels.

Double efficiency = Considerable energy cost savings!

GERMANY: Potential of 6,000,000 tons of CO₂ savings per year if 30% of truck traffic is electrified.

SWEDEN: Total potential of 1,500,000 tons of CO₂ savings per year of the main highways.