Perspectives for Electric Road Traffic

Chances an Challenges

Prof. Dr.-Ing. Arnd Stephan

3rd ERS Conference, 2019-05-07
Chair of Electric Railways

Power Generation and Transmission
Power Distribution and Supply
Electric Vehicles and Drives
Return Current and Interaction
Vehicle and Facility Operation

More than 100 years experience in Electric Transportation
Electric railways are our daily and lovely business ...
Initial Statement

Yes, of course …

• ... *long distance freight transport belongs onto rail*
• ... *rail freight transport should be fully electrical*
• ... *rail network to be extended and further electrified*

But, what if …

• ... *railway will not be capable to manage this basically?*
• ... *the extension of the rail network will last for decades?*
• ... *massive local resistances to rail network extensions occur?*
So, one answer could be:

Road Electrification
Strategic Options: What is possible on roads?

### Onboard energy supply
- Alternative Fuels
  - Bio Fuels
  - Synthetic Fuels
- Electric Energy
  - Battery
  - Capacitor
  - Fuel cell

### External energy supply
- Contactless Transmission
  - Inductive Transmission
  - Linear Synchronous Motor
- Conductive Transmission
  - Ground Power Rail
  - Overhead Contact Line

**New installation of charging / fueling infrastructure**
- low power
- limited range
- no standards

**New construction of track (!)**
- most expensive subsystem
- highly sensitive element
- functional integration !!!

**New installation of traction power supply**
- well known
- standardized
- long term approved
Overhead contact lines already exist - even above roads.

Tramway Contact Line
Trolley Bus
Trolley Bus Contact Line

... it’s not on!
New contact line for electrified roads …

… using know how and experience from railways
… not everywhere necessary
Contact Line System – designed for Road’s Application

- **Bipolar** DC current overhead contact line up to 100 kph
- Nominal Voltage DC 600 V (ref. to EN 50163)
- Regular contact wire height 5,10 m (minimum 4,70 m)
- Regular pole distance 65 m
- Highly solid copper wires - 150 mm² each (magnesium alloy)
- Double chain overhead contact line with separate messenger wire, **dropper distance 3 m**
- Elastic tensioning for low sagging and temperature compensation
- Centre-track guidance of contact wire also in slopes → „askew catenary system“
Bipolar Contact Line
Askew Catenary System
Traction Power Supply System – Railway Standard

- DC power supply with Traction Power Substations along the track
- Substation output power 2 ... 4 MW
- Grid Connection to 10 / 20 / 30 kV medium voltage cable traces or overhead lines
- Substation distances 2 ... 3 km
- Passive Diode Rectifiers or Active Controlled Converters
- Electric Protection Equipment based on Railway Standards - with specific further developments

This exists equally for trolley bus, tramway and subway systems.
Traction Power Substation
This should be avoided, of course ...

Photos: A. Stephan
Vehicle and Drive Technology

- Electric-/ Diesel-**Hybrid-Truck with pantograph**
- **Fully electric drive chain** with Permanent Synchronous Motor
- Provision of traction power from contact line or onboard Diesel
- Supplementing of a battery storage possible
- **Automated power system change:** Contac Line / Diesel / Battery
- Power and energy management within the drive control
- **New developed bipolar pantograph**
- Automated contacting and lowering during maximum speed
- **Switchable car body isolation**
Research Projects: What was already done up to now?

- **ENUBA (Germany)**
  - First Research Project of BMUB
  - 05/2010 – 09/2011

- **ENUBA II (Germany)**
  - Second Research Project of BMUB
  - 05/2012 – 12/2015

- **ELANO (Germany)**
  - Third Research Project of BMUB
  - 01/2016 – 09/2019
What was already developed and investigated?

- (Further) Development of system technology and components
- Erection / rebuilding of the Groß Dölln Test Track (2.3 km)
- Manufacturing of preliminary Hybrid eTrucks (Paul, Scania)
- Development of safety and protection concepts
- Proof of concept for system technology and operation
- Extensive test runs in “protected areas”
- Economic and ecologic evaluation studies
- Power grid integration studies
- Planning manual / compendium for road traffic integration
- Technology Assessment with German Federal Roads Authority (BASt)
Example: Sign Bridge Visibility...

Simulator by DLR

Field of view evaluation by TU Dresden
Does the system fulfills safety and effort requirements?

**Electrical Safety**
- Low voltage DC 600 V DC (as for tramway or trolley bus ...)
- Passive protection by clearance and insulation
- Electrical protection and earthing concept following on railway principles
- Specific lightning protection
- Proved electromagnetic compatibility

**Mechanical Safety**
- Fundamentally tried and tested contact line construction
- Highly solid copper wires CuMg 150 mm²
- Computed added design of catenary, poles and foundations including wind and ice loads
- Dynamic simulation of pantograph / contact wire interaction
- Installation of additional crash barriers
What is going on in Germany? – 3 Field Tests

- Hessen
  - Projekt: ELISA
  - A5 Zeppelinheim-Weiterstadt

- Schleswig-Holstein
  - Projekt: FESH
  - A1 Reinfeld - Lübeck

- Baden-Württemberg
  - Projekt: eWay-BW
  - B462 Kuppenheim-Gaggenau
Field Tests: System’s Behavior under Real Conditions

Integration and Migration Requirements

- Planning and tender procedures
- Design process and documentation requirements
- Construction process and phases
- Permission, commissioning, approval and acceptance tests
- Maintainability under traffic conditions
- Operation and business models
- ...

Traffic Suitability

- Applicability and stability
- Lane use and overtaking procedures
- Visibility of signposting
- Psychologic effects for drivers and users
- Emergency and rescue concepts
- ...

Outlook: What is to expect?

- Highway electrification could be a **potential module** for decarbonization of road transport. *It should work.*

- At present is seems to be the only approach in long distance road transport to meet the climate goals of the transport sector.

- The system could be economically successful. *This will be decided by the boundary conditions – not by the technology.*

- **Technology development is not finished yet.**
  Some core components (such as pantograph, hybrid drive system, power supply arrangement) are still under further development.

- **Research projects and field tests are absolutely necessary.**
  *Otherwise we only chat about it and do not learn anything.*

- The idea behind the ongoing field tests in Germany is to experience the **integration** in roadside environment, power supply networks an traffic flow.
Important Notices:

• **Electric traffic / transportation always will be an infrastructure topic.**
  (... no matter whether done with contact lines, batteries and charging systems, fuels cells and refueling / distribution).

• Infrastructure must fit to existing installations and environments (and should require only **minimum interventions**).

• Infrastructure means: **long term** planning, approval and financing pre-processes. And mostly **public participation**, too.

• **The one will be successful, who have mastered the migration into the existing stock** (roads, grids, fleets, traffic and maintenance procedures, business models).