trolley:2.0 for smart cities

Trolley 2.0: Szeged use case and IMC legal framework recommendations

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SZEGEDI KÖZLEKEDÉSI TÁRSASÁG

Trolleybus roadmap to hybrid e-bus @ SZKT

2010. Conventional trolleybus

Convince public that trolleybus is a viable electric bus

2014. Battery mode

New trolleybuses with (7 km) auxilliary battery mode

50 % PT electrification in Szeged

2016. Diesel route test

Replacing an existing diesel bus route where there is long catenary section

2019. New hybrid trolley

Hybrid electric bus prototype development

Self driving possible?

2024. Hybrid trolley experimental operation

3-4 years operation, feasibility measurements

Hybrid trolley regular operation

Commercial operation

proposed 100 % PT electrification in Szeged

trolley

ebus the smart way

Új pályán

eLIPTIC electrification of public transport in cities

trolley:2.0 for smart cities

Szeged use case deliverables

trolley:2.0 for smart cities

- Finalizing composite framed midibus with IMC (done – sort of…)
- Authorization and testing of the vehicle (ran out of time)
- Testing automated rewiring system (done)

Electric Mobility Europe

Finalizing the Modulo EP095T

We finalized the assembly of the vehicle.
The DC-DC link was built in by August 2020

- The vehicle runs on batteries and charges from catenary. Around 63 km is the range when the vehicle is empty with AC (0,9 kWh/km). Recharging time: 2:12 at 50 % power output (48 A)
- Max. charging current: 96 A. Battery capacity: 56,8 kWh

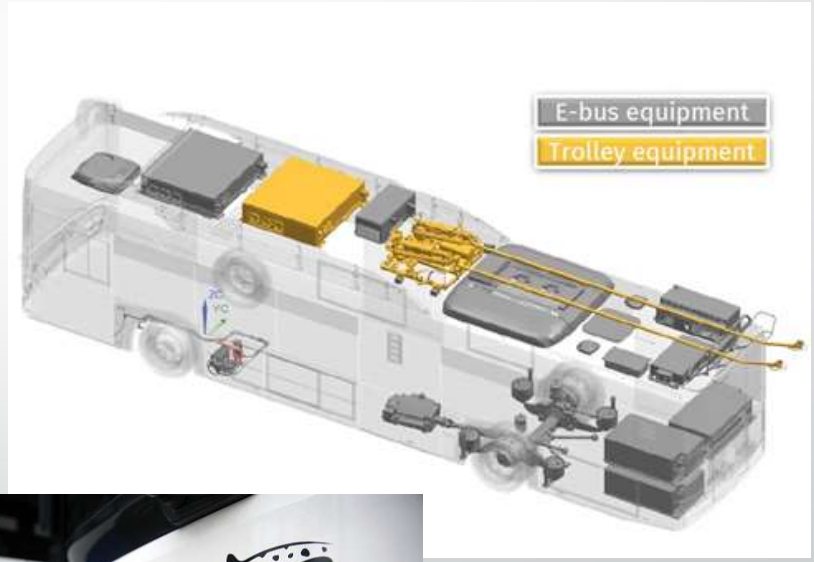
Initialization of the Siemens DC-DC link

Updates on Szeged's use case

- Run trials have started w/o catenary.
- However, we have problem with cooperating with Siemens
  - The DC-DC link (charger) shuts down on multiple isolations on the catenary. Software modifications is needed. Unfortunately the producer is not cooperative
  - The vehicle can only charge standing in a stable way.
  - Decided to examine as e-bus, but according to UN-ECE 100 POINT 5.3, in this case it is not allowed to charge in motion.
  - We are still working on examination
  - Trial is planned in December with passengers.

Electric bus or trolleybus?

- The difference between the electric buses and trolleybuses are blurring.
- (Some) Hybrid trolleybuses are electric buses, with a DC-DC link and a current collector.
- Electric bus equipment is high series, cheaper in the long run.



Solaris Trollino 12 Electric
Gdynia, „Gepard” project

Electric bus or trolleybus?

- **It is time that a separate trolleybus category disappears in the EU.**

Some countries in the EU trolleybuses are still considered **railway vehicle**. (Austria, Czech Republic, Slovakia; Hungary until 2011)

In many countries trolleybuses are **road vehicles** (Germany, Poland, Hungary from 2011).

However, partial trolleybuses, IMC trolleybuses do not fulfil the ENECE regulations.

Sidenote: **In Hungary** trolleybus catenary is still considered railway infrastructure. It may sound weird (no railway vehicle is using the railway infrastructure), but with special regulations it might be an acceptable legal framework.

Electric bus or trolleybus? Case study: Modulo EP095T

The Hungarian road regulations (1/1975. (II.5.) KPM-BM joint order: "*on road traffic rules*") know two separate categories (Appendix 1. chapter II.: "*Definitions regarding road vehicles*"):

- e) „*Bus: a motorcar designed for the carriage of passengers, not connected to an electric overhead contact line, with more than nine permanent seats, including the driver's seat*"
- f) „*Trolleybus: a car connected to an electric overhead line.*"

In Hungarian legal framework this two categories do not have intersection.

Which is the IMC electric bus/battery hybrid trolleybus? The authority decided in 2005 that battery trolleybuses are in the „trolleybus" category (at the time railway vehicle).

The first battery trolleybuses in service in Budapest, in 2005

Electric bus or trolleybus?
Case study: Modulo EP095T

In the authorization process initially (May 2018.) the Hungarian authority accepted the Modulo EP095T as an electric **bus** (vehicle category M3, environment protection class 5E bus*)

M3 category refers: "*Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tonnes.*" according to the United Nations Economic Commission for Europe (UNECE) regulations

This would have meant, that the authority accepted the IMC ebus as part of the ebus class which was alrady authorized with all its „bus" papers.

* environment protection class according to Hungarian regulations

Electric bus or trolleybus?
Case study: Modulo EP095T

However, in the Hungarian authority clarified its communication (March 2020), that the the Modulo EP095T is a **trolleybus** (still vehicle category M3, environment protection class 5E)

Reason: UNECE 100 5.3., buses are not allowed to move while charging

UNECE 100 1.:

*„The following prescriptions apply to safety requirements with respect to the electric power train of **road vehicles** **of categories M and N**, with a maximum design speed exceeding 25 km/h, equipped with one or more traction motor(s) **operated by electric power and not permanently connected to the grid**, as well as their high voltage components and systems which are galvanically connected to the high voltage bus of the electric power train."*

UNECE 100 5.3.:

*„(…) If the on-board RESS** can be externally charged by the user, **vehicle movement by its own propulsion system shall be impossible as long as the connector of the external electric power supply is physically connected to the vehicle inlet. (…)"*

The Hungarian authority bypassed UNECE 100 by putting the vehicle to trolleybus category.
(I.e. pretending, that it is permanently connected to the grid.)

* High voltage bus = the electrical circuit, including the coupling system for charging the RESS that operates on high voltage

** RESS = rechargable electric storage system

Electric bus or trolleybus? Recommendations

UNECE 100 5.3. has to be modified:

- an exception should be possible from banning the movement during charging for IMC e-buses/trolleybuses.

UNECE 100 should also clarify the electric insulation safety requirements. Today it writes (5.1.2.3):

„In the case of motor vehicles which are intended to be connected to the grounded external electric power supply through the conductive connection, a device to enable the galvanical connection of the electrical chassis to the earth ground shall be provided.(…)"

This text shows, that galvanic chargers are either grounded or ground independent. In both cases single insulation is enough (with or without grounding).

Trolleybus catenaries are neither grounded, nor ground independent. This is why double insulation is required. Proposed regulation:

- IMC e-buses/trolleybuses must have double insulation, but this should be also achievable through galvanic separation device in the high voltage bus (i.e. usage of DC-DC link, which provides one insulation level all the on board high voltage electric circuit on its output side).

How to change UNECE? One member country has to take the lead.

Electric bus or trolleybus? Recommendations

By merging the ebus and trolleybus categories the following results could be achieved:

- **More lenient trolleybus driver education**: with a category D (+ extra, more simple education about the trolleybus network) one should drive trolleybuses

(today in Hungary buses and trolleybuses are two separate category causing shortage of trolleybus drivers)

- **Encouraging a choice and combination in charging infrastructure:** today heavy duty electric buses usually combine overnight and opportunity charging (range extender). **How about using IMC as a range extension (max. 10 % of the route under catenary)?**
- **Simplicity for the manufacturers:** no separate testing, authorization requirements for trolleybuses, one family of electric vehicles.
- **Unified market for IMC and trolleybus vehicles** (no country-by-country rules). Enabling second hand market.

Poznan, 18 m overnight charging ebus with range extender charger.

(Charging time > 20 min.)

Thank you for the attention!

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