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The Catenary ERS from the Truck Perspective

Dr. Armin Sue[1], Dr. Tobias Böhm[2]

[1]*Volkswagen AG, Brieffach 011/17780, 38436 Wolfsburg, Germany; armin.sue@volkswagen.de*

[2]*Volkswagen AG, Brieffach 011/17780, 38436 Wolfsburg, Germany; tobias.boehm@volkswagen.de*

Summary

Volkswagen AG Group Research and Siemens Mobility GmbH undertake together the national funded research project "Oberleitungs-LKW". Beside an extensive theoretical research program, practical drive tests with the newest generation of eHighway trucks on the three German test roads are planned. In the project two different strong electrified hybrid trucks will be tested. The presentation will inform about the content and the aim of the research project, will show the actual truck and results of simulations. At the end a strategic outlook to the evolution of the trucks and powertrains in parallel to a growing catenary infrastructure with the focus on the heavy duty trucks will be given.

1 Research Questions

The main question for electrified vehicle is how the sustainable produced electricity could come into the vehicle and how it can be stored. For the most passenger car applications a pure BEV or a fuel cell powertrain could be a good solution.

For commercial vehicles is the answer more complicate, because the requirements are mostly much harder. Due to the higher load and the longer distances between possible charging breaks, the necessary stored energy in the vehicle is so high that there will be a negative influence in the payload, space and/or TCO, if you want to reach a similar usability like a conventional diesel truck.

A solution could be the continuously supply of the electric power during driving – that's the basic idea of ERS.

The research project "Oberleitungs-LKW", funded by the German federal ministry of environment (BMU), is a joint project between the Volkswagen Group Research and the Siemens Mobility GmbH. The main research topics in the feasibility study are:

- Build up and validation of necessary simulation tools
- Optimisations of the pantograph (Siemens part)
- Analysis and optimisation of the heavy duty drivetrain components
- Understanding of drivetrain control and energy consumption in combination with the electrical infrastructure
- Environmental aspects like LCA and strategic outlook

Target of the project is to improve and develop the known systems to a robust and for real transport suitable vehicle system.

This presentation is focused on the vehicle related part of the project. So this presentation contains mainly the Volkswagen research part.

The main question from the vehicle side is not: How does a powertrain looks like that can drive pure electrical in any circumstances. That would reduce the technology to the too simple question: How big can the battery be in the truck?

The main question should be: How can we reach a maximum of CO_2 reduction with a minimum of components and cost in the truck and a minimum of catenary infrastructure? That means an optimum between TCO, LCA and costs for the society.

2 Methodology

The work in the research project is divided in two parts. One is the practical part.

In the project two hybrid eHighway trucks will be tested (**Figure 1**). The trucks are provided by the Volkswagen heavy duty commercial vehicle brand Scania. The first truck is based on an actual parallel hybrid truck. It has only a limited electric power and a relative small battery. This truck represents a low electrified vehicle with minimum additional costs and weight. The electric powertrain is strong enough to hold a constant speed when the truck is typically loaded. The battery can bridge a gap in the infrastructure of a few kilometres.

The second truck has a stronger electric machine and a 4 times larger battery. This truck will be able to drive only with the electric machine in the most situations. The battery is big enough to enable a pure electrical drive between the logistic centre and the eHighway infrastructure on the motorway. This truck is although equipped with a new DHT (dedicated hybrid transmission), an integrated system of gearbox and electric machines that enables new shifting functionality and improves the comfort of the transmission system.

Both hybrid trucks have as the base a conventional diesel ICE. That can of course be switched off in the most situations under the catenary and when the battery is full, but it can be used for boost and outside the eHighway regions. So both trucks have theoretical no limitations in their usage in comparison to conventional trucks. Under the catenary the battery can be charged with an onboard DC/DC converter. The power electronic of the e-motor is connected over a bypass switch and the pantograph with a high efficiency to the grid.

These trucks are used in the practical part of the project. They will drive frequently on all three German test areas until the end of the project. In the test drives typical transport jobs will be simulated under realistic condition. The trucks are equipped with a data logging system. The data are used to analyse and optimise the actual systems, and as input in the theoretical part of the research project.

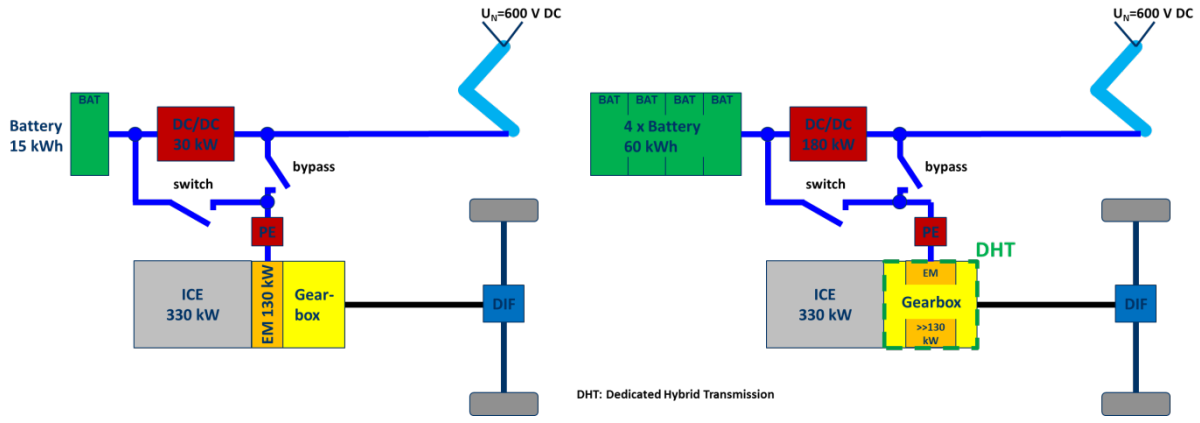

Figure 1: *Hybrid drive trains of the two eHighway trucks in the project*

The power flow on the hybrid system in eHighway truck is different to hybrid systems without electric power supply over the catenary. Especially the influence in the battery durability will be significant, because of the permanent charge and discharge. In addition to simulation results the measurement can improve the quality in durability forecasts.

3 Results

The research project started in 2018 and is ongoing until end of 2020.

The first new eHighway truck is developed and built-up by Scania (see **Figure 2**). He is already equipped with the newest pantograph generation from Siemens. This truck is running and was involved in the final test of the new eHighway test area on the motorway A5 in Hessen. The truck is passing the final test on the private test area of Siemens in Groß Dölln (north of Berlin).

Figure 2: *first Scania hybrid eHighway truck of the new generation*

The truck will be hand over to the Volkswagen/Siemens research project at beginning of April 2019. So actual are no measured data available.

But results from the theoretical investigations are available and shall be shown in the presentation. They are divided in two parts. For base calculations and general question a simulation tool was developed. That can calculate typical values like speed, torques, power, electric energy, fuel consumption for given drivetrain configuration in relation to the share and position of the infrastructure. This calculation can be done for all motorways and respects the topological situation, that is of course relevant for the slope off the road. The position of the catenary and the drivetrain components and their dimensions are fully variable. **Figure 3** shows a result of such a calculation.

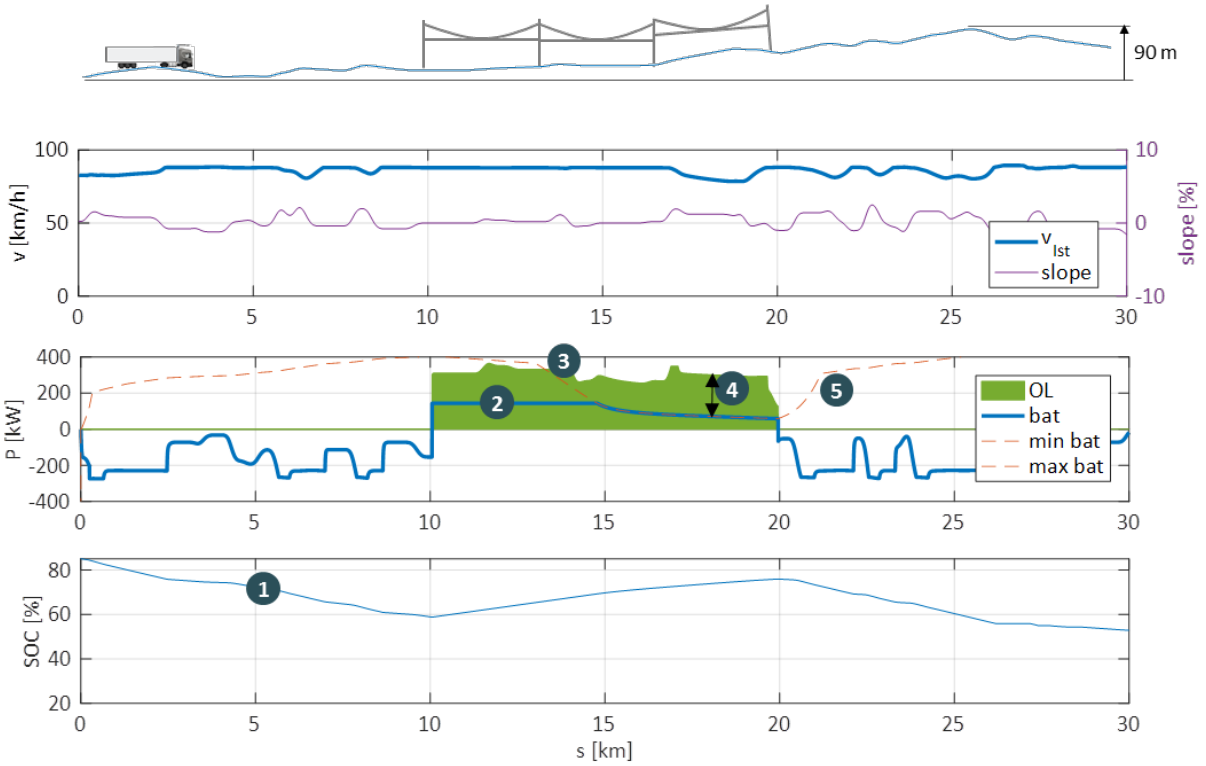

Figure 3: *Example calculation of the simulation tool for eHighway trucks and infrastructure*

By varying the position and the share of the infrastructure is possible to find an optimum for a given certain road. A result for the motorway A2 between Hannover and is shown in **Figure 4**.

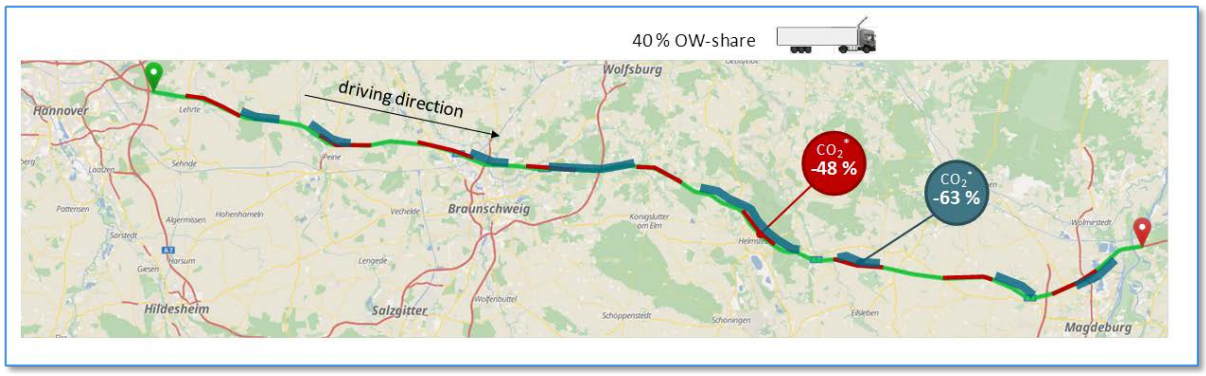

Figure 4: *impact of the catenary positioning on the CO2-benefit*

The tool is although able to optimize and compare different drivetrain configurations in relation from catenary share or transport requirements. **Figure 5** illustrates the CO_2 reduction potential of two different hybrid powertrains.

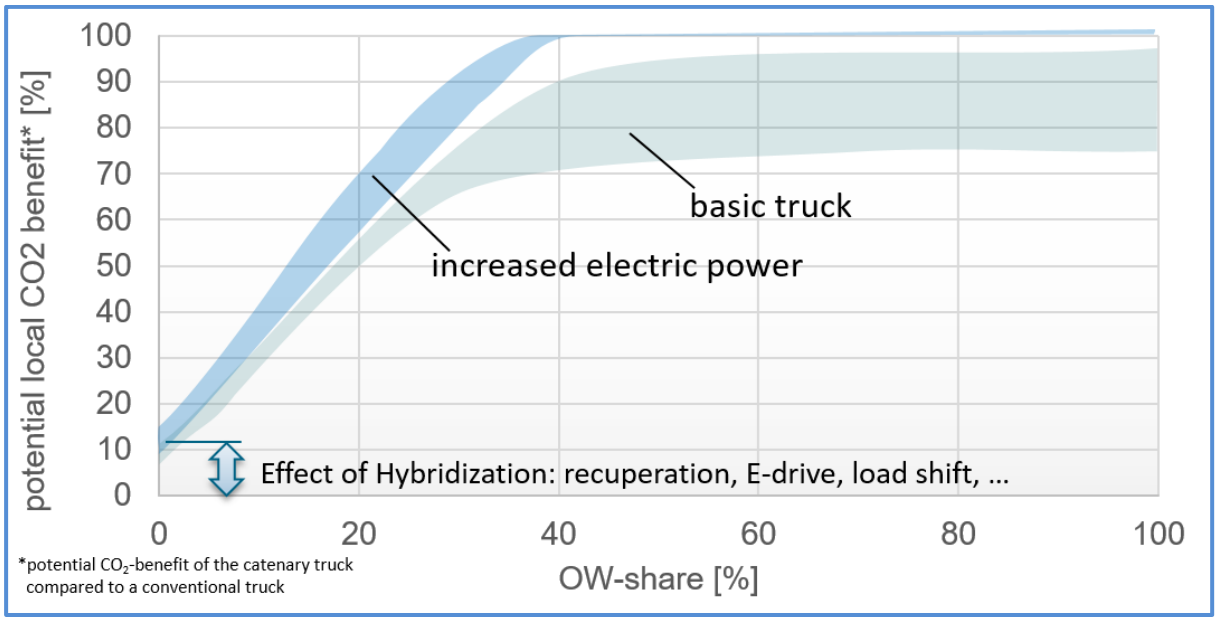

Figure 5: *Simulation results for the potential of CO_2 reduction in relation to the infrastructure share and the grade of electrification of the hybrid drivetrain*

Another usage area for this tool is to calculate the expected energy consumption and the related reduction of emissions for concrete transport drives. With relative few data about the driven speed, e.g. from the drives card, and some information about the route and payload, it is possible to calculate the relevant data that are interesting for further investigations.

The CO_2 reduction potential is not the only relevant value for commercial applications. For this use case the optimum of TCO, the results of a LCA, the costs for the society and CO_2 reduction is the right value for the powertrain configuration and the infrastructure dimension for the eHighway technology.

At the end of the presentation the authors will give also a strategic outlook into evolution of the catenary ERS and the development steps of eHighway trucks from the perspective of the truck builder.

Authors

Dr.-Ing. Armin Sue:

1966 born in Alfeld (Leine), Germany; 1991 study of mechanical engineering at Leibniz Universität Hannover; 1997 scientific assistant at the institute for mechanical engineering, IMKT; 2003 dissertation in the field of continuously variable transmissions; 2003 Volkswagen Group Research, department for transmission research; since 2008 project manager for several electric and fuel cell passenger research vehicles; since 2015 electrification of commercial vehicles; actual project manager for the research project “Oberleitungs-LKW”.

Dr.-Ing. Tobias Böhm:

1963 born in Braunschweig, Germany; study of mechanical and chemical engineering at University Hamburg and Clausthal, dissertation in the field of combustion engine; 1991 Volkswagen Group Research, 1996 different functions and responsibilities in Volkswagen commercial vehicles, 2004 head of powertrain systems in Volkswagen Group Research, since 2017 head of electrified drivetrain in Volkswagen Group Research.