Aerodynamic and Flexible Trucks for Next Generation of Long Distance Road Transport

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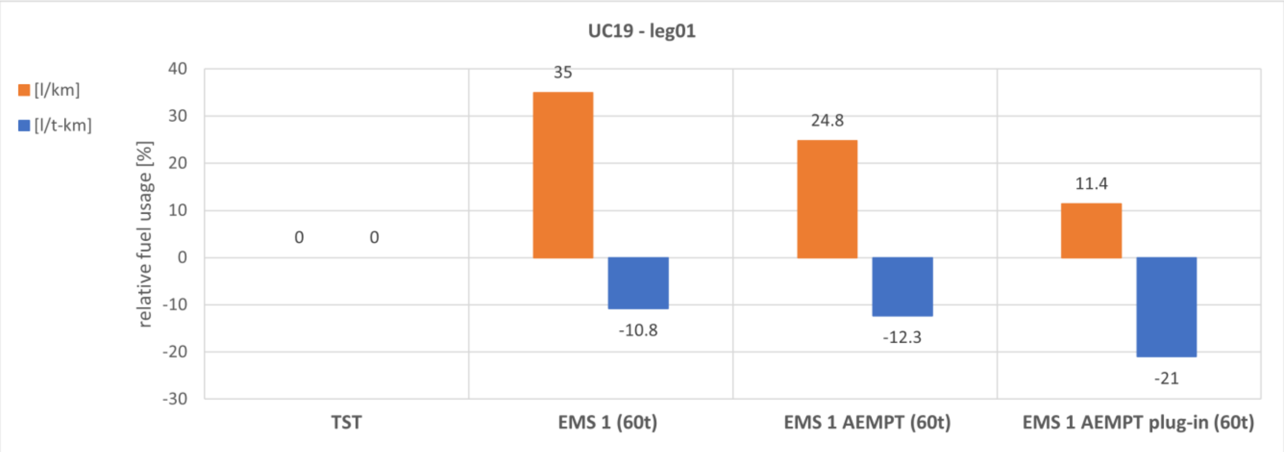
Publishable Executive Summary

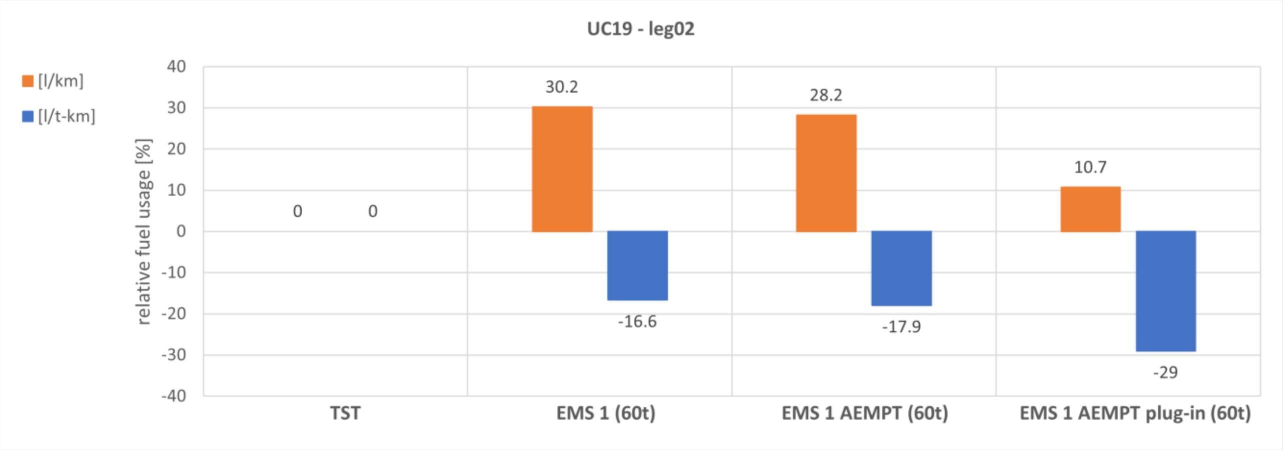
In AEROFLEX WP2 a powertrain architecture for vehicles as specified in the European Modular System (EMS) was developed, which include electric drives in multiple vehicle units. A sophisticated energy and torque management system allows for an efficient operation of this distributed powertrain. This powertrain architecture is referred to as Advanced Energy Management Powertrain (AEMPT).
The AEMPT is realized in a demonstrator vehicle consisting of

- a 6x2 MAN rigid Truck, which includes the newly developed Global Energy and Torque Management System (GETMS),
- the Smart Power Dolly (SPD), an electrically driven two-axle dolly, and
- a semitrailer with an electric drivetrain, originally developed in the TRANSFORMERS project.

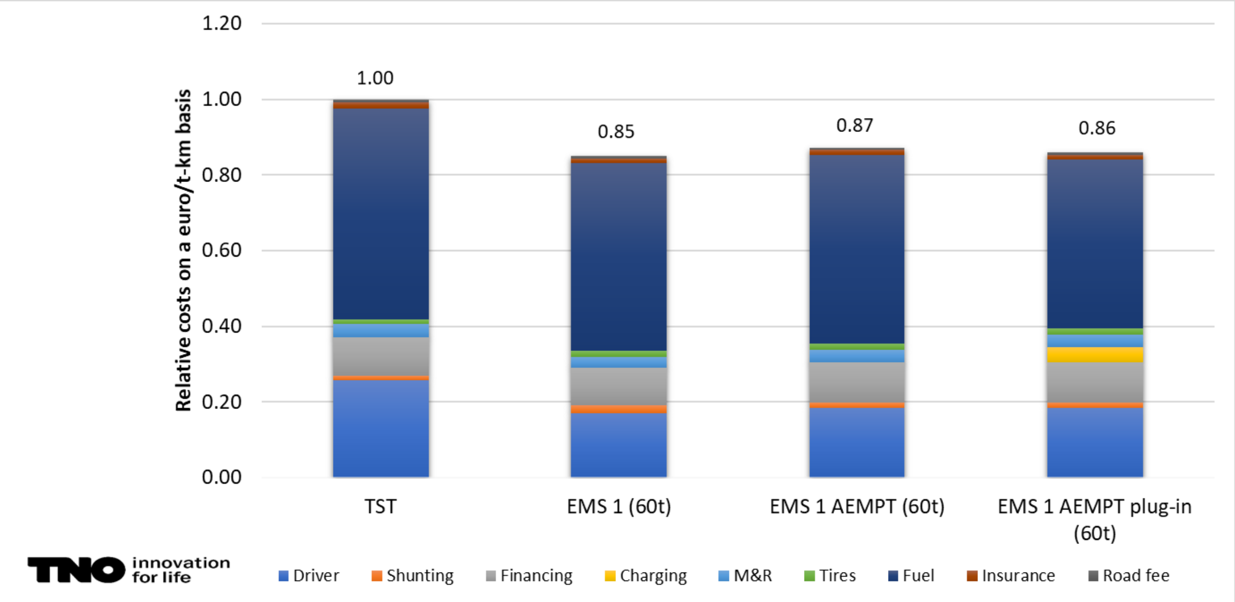
All vehicle units are exchanging relevant information of the electric drivetrains and control signal via a communication network based on Automotive Ethernet. Thus, the electric drivetrains of the trailer units are fully integrated in the tractor unit powertrain control strategy, which enables an optimal and efficient operation of the distributed drivetrain.
The demonstrator vehicle and a reference vehicle were subject to various on-road tests to demonstrate, validate and analyse the potential of the AEMPT concept to save fuel and decrease CO2 emissions under real-world conditions. The results, beyond others, are the input parameters for an assessment framework which applies the AEROFLEX vehicle combinations and innovations to certain customer use-cases.
To provide valid data to the cost-benefit analysis the measurement information of the field tests is verified by plausibility checks, analysis of the energy management behaviour and comparison to simulation results presented in deliverable D2.1.
The final assessment and cost-benefit analysis is conducted in WP6, tasks 6.5 and 6.6 respectively. One of the main conclusions is that future development of the AEMPT should include plug-in capability of the electric drivetrains in the e-dolly and e-trailer. Thus, the cost-benefit analysis presented in deliverable D6.6 is extended by an EMS1 AEMPT vehicle configuration including this functionality to outline the potential in terms of relative cost-savings compared to tractor-semitrailer or EMS1 reference vehicles.
The analysis includes one specific costumer use-case with a tractor – semitrailer used as reference vehicle combination. The figures below show that the impact of EMS1 vehicle combinations on fuel efficiency on a l/km basis and transport efficiency on a l/t-km basis can be significantly improved by using the AEMPT concept with plug-in capability.



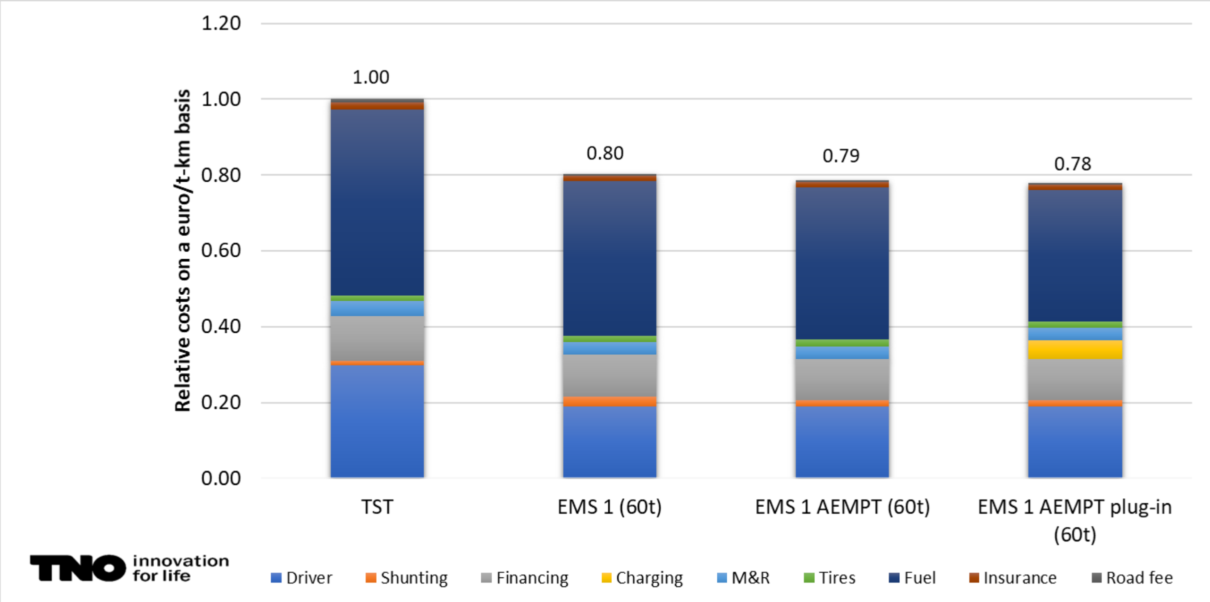
The concept can mitigate the increased fuel consumption of EMS1 vehicles by 19.5% - 23.6% depending on the leg of the use case. The transport efficiency gains can be improved up to 29%.



For customer use case 19, the cost-benefit analysis does not show a clear benefit for an AEMPT drivetrain including an e-Dolly. For the normal hybrid operation without plug-in capability, the effect is even negative for mass limited leg 1. This is because the penalty on weight surpasses the gains in fuel consumption. For the volume limited leg 2, only a small benefit can be seen. A far larger fuel saving effect of additional 10% can be achieved by assuming a plug-in operation with intermediate charging. However, for the assumed diesel price of about 1€/l (See also D6.6), the saved fuel costs are more than outweighed by the additional electricity costs. For that reason, we have been looking also at a scenario with twice the diesel costs as of the basic scenario. With this assumption there can be seen a small benefit of the plug-in case with respect to the normal hybrid operation. However, the total costs for leg 1 still exceed the basis EMS1 vehicle due to the reduced payload, as can be seen in the figure below.



For leg 2 there is a small benefit (see next figure). The analysis shows that by far the biggest effect on €/t-km of about 20% comes from using an EMS1 vehicle instead of a conventional tractor semitrailer combination. The additional effect of the AEMPT concept even under optimistic assumptions is small at least for customer use-case 19. This use-case represents a typical multi day long haul trip. A more substantial benefit of the AEMPT concept might be seen for shorter trips where plug-in operation is realized by charging at low costs at the customers depot. However, benefits regarding reduction of CO2 emissions or the usage of the e-dolly for shunting in terminals or hubs are still existing, although not obvious in the figures.



For the overall AEMPT concept realized in AEROFLEX, future development has to address the transition towards an CO2-neutral world. Therefore, it is clear that only zero emission vehicles can be part of the transport future. The hybrid powertrain approach of AEROFLEX must be seen as an intermediate step. It has to be further developed into a zero-emission concept. That means being compatible with battery electric or fuel cell vehicles. An e-dolly or an e-trailer could enable long ranges also for emission free EMS vehicles. Further development is necessary to investigate such an approach.