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Costs of the energy supply infrastructure for trucks with alternative driving system from a user and macroeconomic perspective in Germany

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Summary

The urgency to take action to reduce greenhouse gas emissions in the transport sector is particularly high due to the fact that there has been no reduction in this sector to date and that demand for transport is likely to continue to rise. The question of the economic viability of alternative propulsion systems in freight transport is relevant from both a user and a macroeconomic perspective. The construction and costs of the necessary energy supply infrastructure are of central importance. Before this background, cost analyses were carried out from both perspectives.

On the one hand, TCO (total cost of ownership) calculations were carried out from the user's point of view, taking into account possible infrastructure costs, and on the other hand macroeconomic costs for different decarbonisation paths were carried out, taking infrastructure costs into account. The calculations show that 1) the direct use of electricity in battery-electric and catenary vehicles can already lead to lower TCO costs for users in the mid-term and also to lower transformation costs for society as a whole than, for example, the use of synthetic fuels or hydrogen in fuel cell vehicles. 2) the costs of the infrastructure make up only a small part of the total transformation costs, but due to the low utilization in the market ramp-up phase they could represent an obstacle if they were fully allocated to the early users.

1 Research Questions

The decarbonisation of long-distance road freight transport is a major challenge in achieving European climate protection targets. A technological decision has not yet been taken.

Existing scenarios and studies on alternative propulsion concepts indicate that ERS technologies such as overhead catenary vehicles can represent a sensible and cost-effective option for reducing greenhouse gas emissions in long-distance road haulage [4].

Economic efficiency plays a decisive role in freight transport in particular. Therefore, the question arises how the user costs of overhead line vehicles could develop in comparison to other drive concepts and what impact the costs of providing the energy supply infrastructure could have on the economic operation of the vehicle.

At the same time, the question arises which energy supply path, taking into account the costs of energy sources, energy supply infrastructure and vehicles, leads to the lowest transformation costs in the long term from the perspective of society as a whole, and what significance infrastructure costs have in this context.

In order to deduce obstacles, it is also crucial when these costs will be incurred and how they could develop in the long term, even after a market ramp-up, and how costs of the energy supply infrastructure can be allocated.

2 Methodology

As part of the "StratON" project, TCO calculations were made from a user perspective for various years in Germany [1]. In addition to fuel costs, costs for vehicle acquisition, costs for operation and maintenance and the truck toll were considered. The total costs were determined on the basis of a typical use profile of a truck in long-distance freight transport with an annual mileage of 120,000 km and a holding period of 5 years. In addition to diesel trucks (ICEV), the TCO was determined for overhead diesel hybrid trucks (OC-HEV), overhead battery electric trucks (OC-BEV), pure battery electric trucks (BEV) and H_2 fuel cell trucks (FCEV) for the years 2025 and 2030.

In the calculations, vehicle costs for conventional diesel vehicles and for alternative drives (OC-HEV, OC-BEV, BEV, FCEV) were modelled taking into account a degression of the specific component costs. The acquisition costs therefore depend on the year of acquisition. Particularly efficient vehicles were used for diesel trucks and a further increase in efficiency was assumed. These TCO considerations were supplemented by costs caused by the use of the infrastructure. Due to the assumed market ramp-up, low infrastructure utilisation in the early years was assumed. The truck toll was also taken into account, from which electric trucks are exempt according to the current decision in Germany.

This overview of possible user costs of the various drive technologies is compared with scenario results from the perspective of society as a whole. These scenarios were developed in the context of the projects "Sensitivities to the cost assessment of various energy supply options for transport up to the year 2050" [2] and "Determining an expert strategy for the energy supply of the transport sector up to 2050" [3]. Different energy scenarios and options for a greenhouse gas-neutral transport sector in 2050 were compared with respect to the costs for energy supply, infrastructure adaptation and vehicle production. In addition to the direct use of electricity in OC-HEV, electricity-generated synthetic fuels were also considered for long-distance freight transport. In addition to PtL (Power-to-liquid) diesel and PtG methane (liquid) in internal combustion engine vehicles, hydrogen was also investigated in FCEV.

For the derivation of the accumulated total costs, projections were derived with regard to the costs of the energy sources, whereby for the PtX fuels an import from regions with low electricity production costs was assumed. Furthermore, plausible infrastructure scenarios were derived on the basis of the market penetration of the vehicles with alternative drive concepts and a degression of the additional vehicle costs was derived. The results were the accumulated total costs compared to a fossil reference scenario for the entire period up to 2050 and accumulated for five-year steps.

3 Results

The results of the TCO analyses from a user perspective show that the economic efficiency of trucks for the direct use of electricity (OC-HEV, OC-BEV and BEV) could be the best. However, this depends on the one hand on the extent to which the toll exemption is maintained in the long term, and on the other hand on whether the users have to bear the full costs of the infrastructure. In the market ramp-up phase, the costs of building and operating the infrastructure are high due to low utilisation and could constitute a barrier to market ramp-up. Without these costs, vehicles with alternative drive concepts can be operated in the medium term at lower user costs than conventional diesel trucks.

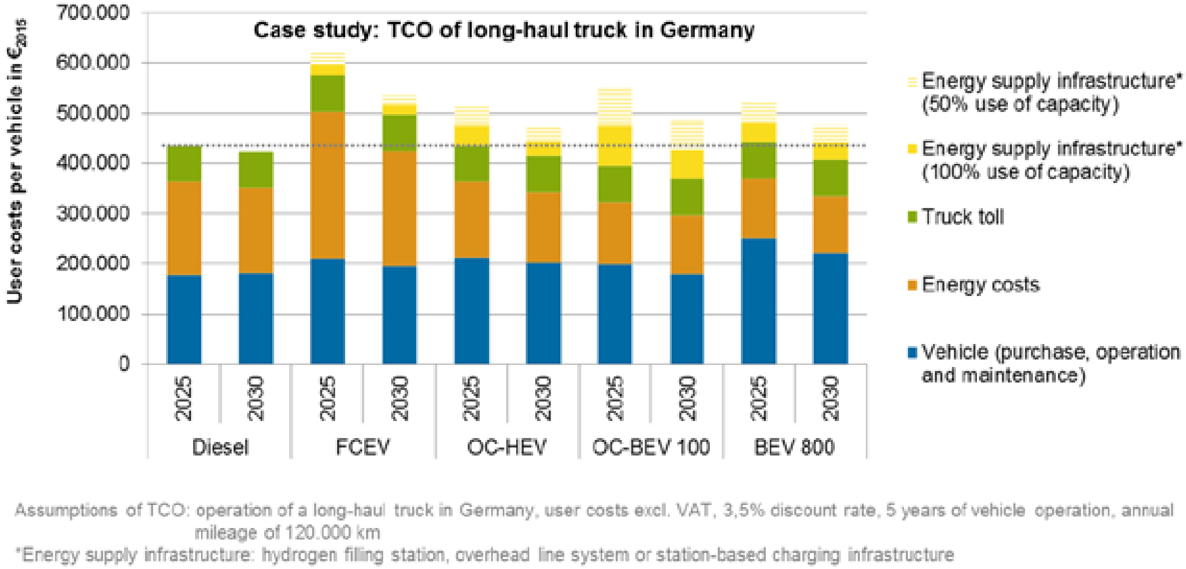

Figure 1: TCO of long-haul trucks with different propulsion systems and including costs of energy supply infrastructure for the year 2025 and 2030.

In terms of the total costs of transforming road freight transport from the perspective of society as a whole, direct electricity use is the most cost-effective option. Systemic barriers (as illustrated in Figure 1) and low acceptance could, however, prevent a widespread introduction. Power-to-gas-methane (PtG-CH_4) and Power-to-Liquid diesel (PtL) have similar costs in road freight, while the use of power-to-gas-hydrogens (PtG-H_2) in fuel cell vehicles is the most expensive option.

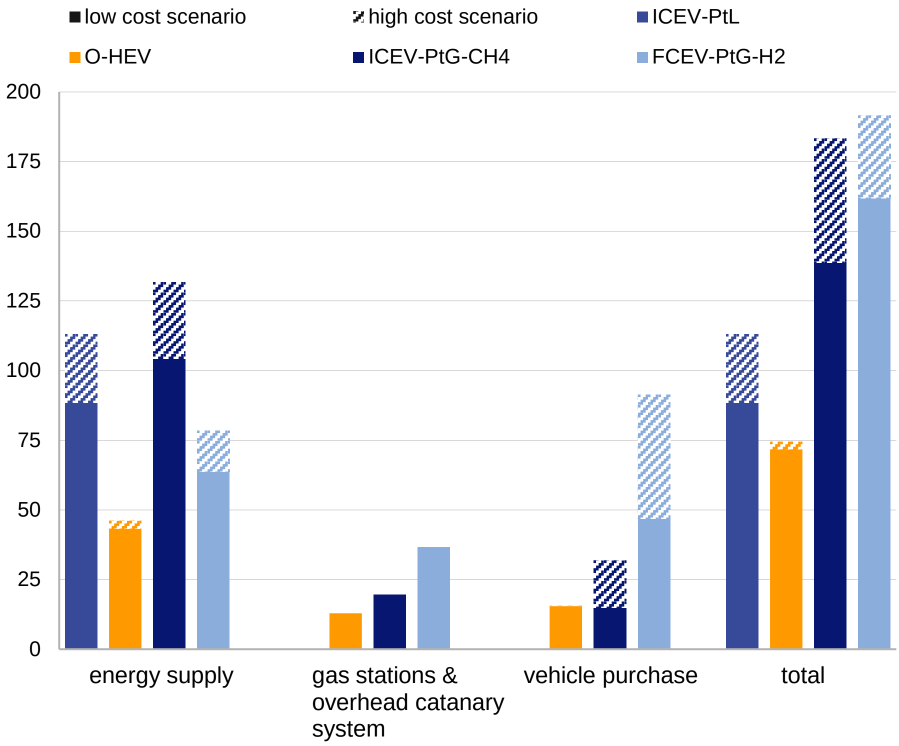

Figure 2: Long-haul road freight transport: Accumulated differential costs of different energy supply scenarios compared to the reference scenario for the period 2020 to 2050 (positive: additional costs) in billion €

The results show that the additional costs are to a large extent caused by the costs of the energy supply and partly by the vehicles from a long term perspective, whereas the costs of the necessary energy supply infrastructure play a more minor role. The analysis of the accumulated costs in five-year slices also makes it clear that the conversion of the transport system to direct electrical use initially results in higher system costs than with other reduction technologies. However, depending on cost assumptions, the direct electric path is already cheaper than the other options around the year 2030 or 2035.

Against the background of the complete decarbonisation of the transport sector - and thus also of road freight transport - which is necessary in perspective, the different perspectives of the analyses carried out show the existing conflict area. A lack of pre-financing of the necessary energy supply infrastructure could prevent the economic viability and thus the market entry of overhead catenary line trucks, although in perspective the overhead catenary line truck system is characterised by particularly favourable overall social costs in comparison with the technology alternatives and the infrastructure costs are of secondary importance in the long term.

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