DOES IT PAY OFF? TOOL-SUPPORTED PROFITABILITY ANALYSIS OF ALTERNATIVE DRIVE TECHNOLOGIES

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Abstract The Corona crisis led to a variety of challenges in the logistics sector due to volatile demand and changes in demand behavior, as well as strong cost increases. In this respect, there is increasing pressure to reduce these costs in the future through innovative solutions. For road freight transport, the question arises as to whether alternative drives can achieve the goal of cost reductions and also have positive effects on climate protection. Logistics service providers are therefore not only faced with the problem of selecting a specific technology (e.g. Battery Electric Vehicles or Fuel Cell Vehicles) but above all with the problem of economic efficiency and evaluation of climate impacts. The aim of this project is to support the selection of alternative drives in corporate practice with a pragmatic practical approach. The Excel-based tool is characterized by the use of a direct costing based approach with fixed and variable costs as well as the structured collection of basic data (e.g. energy prices) and sample vehicle data for comparisons. As initial results of the case studies conducted shows, it can be stated that there are already use cases in which an alternative drive offers economic advantages over conventional combustion engine vehicles.

Keywords:
alternative drive technologies, calculation tool, case study, profitability analysis, logistics

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1 Introduction

The dramatic consequences of the COVID-19 crisis for the logistics sector are exemplified by a report that Amazon expected estimated increases in spending on shipping and fulfillment of over 53% in the year 2020 (Rösch, 2021). This reveals that the coronavirus pandemic has further exacerbated cost pressures in logistics. In addition to vehicle depreciation, the main cost driver in road freight transport is energy consumption.

The dominance of diesel-based forms of transport in the logistics sector remains high. Statistics show that as of the year 2021, there was a 93.7% share of diesel lorries in Germany (Kords, 2022). If the emission volume of road freight transport is assumed to be 50 metric tons (Mt) of CO_2 equivalent per year (Jöhrens et al., 2022), 46.9 Mt CO_2 of this per year are attributable to diesel-powered vehicles, which corresponds to a consumption of approximately 17.7 billion litres of diesel per year. The share of this consumption of diesel thus amounts to approximately 6.5% of the estimated total greenhouse gas (GHG) emissions in Germany for 2021 (BMWI, 2022). Against the backdrop of climate policy goals and the growing social awareness of environmental protection, it is essential that the share of alternative drive technologies must increase in the future as a part of CO_2 change management.

The aspect of economy has dramatically worsened since the beginning of the war in Ukraine (24 February 2022), as the price of diesel fuel has risen sharply over a short period of time since then. According to an evaluation by Europe's largest motoring association – the German Automobile Club (ADAC) – the price of diesel reached a peak of 229.2 Euro cents per liter on 15 May 2022 (ADAC, 2022b), an increase of 33% in the period since the start of the war in Ukraine. Comparing the average diesel price from 2018, 2019 and 2020 of 122.7 Euro cents (en2x, 2022) with the peak on 15 March 2022, this corresponds to almost a doubling – 86.8% to be precise. This considerable additional burden on freight transport amounting to several billion euro underlines that, in addition to climate protection, economic reasons are also strong drivers for the increased use of alternative drive technologies in logistics.

In recent years, viable alternatives to diesel motors have been brought to market maturity through research that is open to all technologies. In addition to the problem of selecting a specific technology (e.g. battery electric vehicle (BEV), hybrid or fuel cell), fleet operators are above all facing the problem of determining economic viability. This issue is particularly relevant on the one hand due to the application area of logistics, which can be characterised as highly competitive, while on the other due to the difficulties of carrying out a proper analysis of the economic viability. The authors of this paper are referring to a pragmatically practical approach that is intended to support the selection of alternative drive technologies in business practice.

The challenges of an economic analysis of alternative drive technologies are manifold. In addition to the main problem of selecting one or more calculation methods based on business economics, there is also a need to take a dynamic approach. The focus of this period-related analysis is, among other things, the development of energy prices and the estimation of residual values at the end of an asset's economic lifetime. In addition, there are economic policy framework conditions, which include, for example, the granting of subsidies. Transaction costs must also be taken into account. Depending on the selection of a technology, the search for a charging facility, e.g. for BEVs, can be counted among these costs. Profitability analyses are simplistically limited to paid costs or quantitative aspects, although alternative drive technologies require a broader perspective. First and foremost, there are qualitative factors that defy precise valuation. One example is the quality of a workshop that can carry out professional repairs or maintenance on vehicles with alternative drive systems. This point becomes relevant for logistics companies that are not located in the immediate vicinity of conurbations.

An Excel tool is used to support the profitability analysis of alternative drive technologies. This tool is characterised by the use of a direct costing approach with a distinction between fixed and variable costs, the consideration of a maximum planning period of fifteen years, the structured collection of basic data (e.g. fuel and other energy prices), environmentally relevant data such as CO_2 conversion factors (Tank-to-Wheel (TtW) and Well-to-Wheel (WtW)), and numerous example vehicle data for vehicle comparisons. The benefits of the tool lie in the automatic generation of a cost comparison with graphical support (e.g. break-even chart), the short training period, and the possibility of extending or modifying the tool with little effort, e.g. by integrating different scenarios for energy prices. This functionality distinguishes the tool from the main economic efficiency calculators available on the internet (e.g. ADAC 2022a; Kostenrechner 2022; Stromdrive 2022); it thus represents a universal template. A major advantage over other studies on economic efficiency (e.g. Hacker, F., von Waldenfels R., Mottschall, M., 2015) is the possibility of entering up-to-date data (e.g. vehicle acquisition values), general conditions (e.g. the granting of subsidies) and planning data for energy prices. In order to broaden the perspective to include qualitative aspects, the tool includes a scoring model (Bertram and Bongard, 2014).

The applicability of this tool is continuously tested within the Master's Degree in Logistics course at the Ludwigshafen University of Business and Society by using it as a template for case studies. In addition to the short training period, the possibility of mapping and analysing different scenarios (e.g. with regard to energy price development) with little effort has proven to be particularly advantageous. The vehicle models and data used in the case studies can be accessed in an integrated database of the tool. As the initial results of the case studies conducted show, it can be stated that there are indeed already use cases in which an alternative drive technology offers economic advantages over a diesel vehicle. This confirms the expectations relating to the cost advantage of e.g. battery trucks compared to diesel trucks (Jöhrens et al., 2022).

2 Parameters of the economic analysis

Data for certain parameters are required for the profitability analysis. The tool differentiates between basic data, which is independent of the vehicle, and vehicle data. The basic data includes the start year of the analysis, the analysis period (economic life), the annual mileage and the respective energy prices in the analysis period. In the case of the vehicle data, in addition to recording the manufacturer, drive technology designation and model name/type designation, the cost parameters are divided into fixed and variable costs according to the direct costing principle. The total costs as an addition of these cost parameters are also referred to as total costs of ownership (TCO) in existing literature (Jöhrens et al., 2021; Wietschel et al., 2019).

The selection of parameters for the economic efficiency analysis is largely based on relevant sources (Hacker, F., von Waldenfels R., Mottschall, M., 2015; Jöhrens et al., 2022; Jöhrens et al., 2021; Wietschel et al., 2019). Committed to the approach of the pragmatic-practical use of the tool, the number of parameters were limited to a manageable level. Therefore, cost items with a low value were omitted, e.g. lubricants. From the point of view of cost relevance, an attempt was made to concentrate on costs that are as relevant to decision-making as possible. For this reason, financing costs, costs for drivers (personnel costs), trailers, lorry trailers and fleet management are not included. Discounting of future costs using an economic interest rate was also omitted. This concerns the current status of the tool and does not exclude any later extensions. The processing of case studies resulted in additional cost components that are taken into account in the tool. In concrete terms, taken into account means that the corresponding collection of basic and vehicle data (e.g. vehicle performance in km per year, diesel price per litre and average diesel consumption of a vehicle) leads to the automatic calculation of costs (in the example case, fuel consumption in euro per year). To simplify the data collection, lump sum values for variable and fixed costs can also be recorded. In addition, the authors of this paper developed a proposal to give a uniform definition to the parameters of an economic efficiency analysis in terms of their naming (parameter name) and dimensioning (parameter unit). This would make it easier to compare results of different economic efficiency calculations. The respective calculation of cost values is performed in various calculation modules, each of which is created as a separate worksheet tab of the Excel tool.

3 Case study

The application of the tool is continuously tested with case studies within the Master's Degree in Logistics course at the Ludwigshafen University of Business and Society. The case studies are based on practical tasks and allow the use of lorries of all vehicle classes. In the 'craftsman case study', the annual mileage adds up to 17,480 kilometres. The starting year is 2020, and the period under consideration is six years. Citroën vehicles serve as comparison vehicles, once as Jumpy in the diesel version (Vehicle 1) and as ë-Jumpy in the BEV version (Vehicle 2). Both the diesel and electricity prices are expected to rise steadily, with a stronger increase in the diesel price.

Table 1: Case study energy prices

Energy		2020	2021	2022	2023	2024	2025
Diesel	Euro/litre	1.12	1.17	1.20	1.23	1.26	1.30
AdBlue	Euro/litre	0.70	0.70	0.70	0.70	0.70	0.70
Power	Euro/kWh	0.22	0.23	0.25	0.25	0.26	0.26

The following vehicle-related values were taken into account for the economic efficiency comparison:

Table 2: Case study cost components

Cost components	Parameter name	Parameter unit	Vehicle 1	Vehicle 2
Vehicle				
Loss in value as a residual variable	P_depreciation	Euro/p.a.	3,212.50	3,635.67
Net list price	P_list_price	Euro	25,700.00	40,250.00
Activatable extras/accessories	P_cap_extras	Euro		2,310.00
Grants/subsidies	P_grant_subsidy	Euro		9,000.00
Loss in value in %	P_residual_value	%	25 %	35%
Resources				
Energy:				
Fuel consumption diesel	P_fuel_consumption	Litre/100km	4.90	
AdBlue	P_AdBlue_consumption	Litre/100km	0.20	
Power	P_electricity_consumption	kWh/100km		27.00
Vehicle inspection, tax and insurance				
Main/exhaust gas inspection, safety inspection	P_veh_gen_inspection	Euro/p.a.	120.00	53.50
Vehicle tax	P_veh_tax	Euro/p.a.	290.00	
Vehicle insurance	P_veh_insurance	Euro/p.a.	1,450.00	1,659.00
Maintenance				
Maintenance, service and care	P_veh_maintenance_repair_care	Euro/100km	5.50	4.40

After the data has been entered, all the further calculations are performed automatically. Various charts are available for visualising the results. The 'TCO' chart shows the comparison of the average total costs per km.

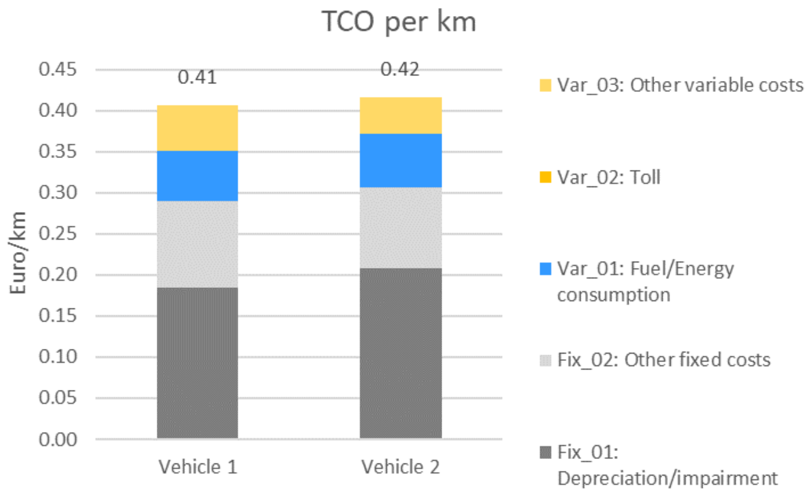

Figure 1: TCO case study

On the one hand, the disproportionately large share of fixed costs can be seen resulting from the relatively low mileage per year, while on the other, the TCO for both vehicles is virtually on a par with 0.41 Euro/km for Vehicle 1 and 0.42 Euro/km for Vehicle 2.

The 'break-even analysis' chart shows when a vehicle represents a better alternative in terms of cost.

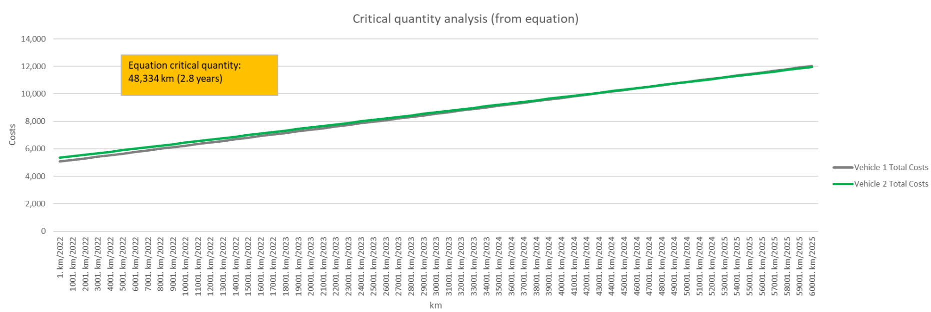

Figure 2: Break-even analysis case study

The linear function equations are derived from the average values, from which the break-even point is calculated at 48,334 kilometres; a mileage that is reached after approximately 2.8 years. From this point on, Vehicle 2 has a cost advantage over Vehicle 1. The tool also calculates a break-even point based on the actual annual costs. This calculation results in a slightly higher mileage value of 54,001 kilometres (approximately 3.1 years) for the present case.

A particular advantage of the tool is that the recorded data can be changed to reflect changing framework conditions. As an example for the present case, the assumption is made that the subsidy halves to EUR 4,500 for the BEV and the diesel price would remain constant at EUR 2.30 per litre.

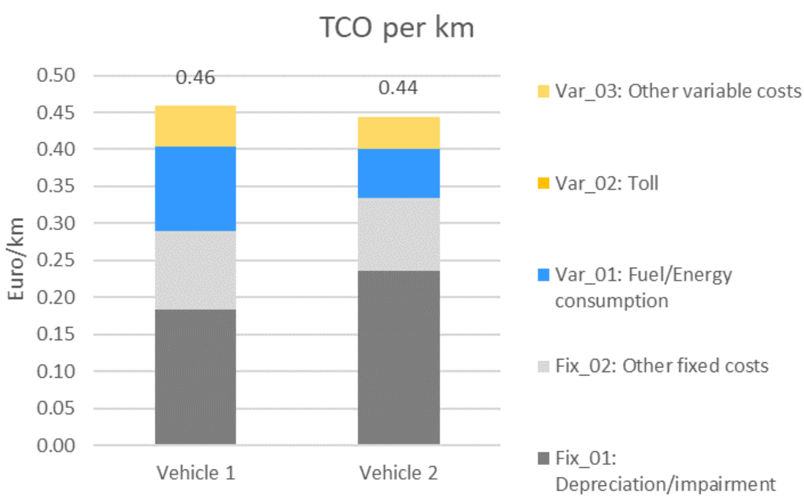

Figure 3: TCO case study with changed framework conditions

Due to the changed framework conditions, Vehicle 2 is now the more economical alternative.

4 Summary and outlook

Using the tool presented in this study, it is possible to subject two vehicles to a practice-oriented economic comparison without much effort. The primary purpose is to identify when vehicles with alternative drive technologies offer economic advantages over conventional combustion vehicles. Furthermore, the GHG emissions are determined to also enable a sustainability comparison. In addition to quantitative factors, qualitative factors can also be used for evaluation purposes as part of a scoring model. Against the background of the current political and economic policy developments at the beginning of 2022, it can be assumed that it will be much more difficult to plan essential framework conditions in the future. In this respect, this tool offers numerous opportunities to use data from alternative scenarios and to examine their effects. Energy price scenarios are likely to play a particularly prominent role in this respect.

The goals for further expansion of the tool are extended functionalities for the processing of scenarios, the expansion of the GHG section in the direction of lifecycle analysis and the inclusion of further vehicles in the vehicle database.

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