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Total Cost of Ownership of Battery Electric Trucks – the KITE tool

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Executive Summary

Europe is currently in the process of transitioning its mainly diesel-powered trucking sector to low emission vehicles. However, challenges for fleet operators to adopt battery electric trucks (BETs) include the uncertainty around range and vehicle performance, lack of transparency on prices, requirements of charging infrastructure and associated costs. We present an open-access online webtool, called KITE (Key Infrastructure for Truck Electrification) that enables truck fleet operators to understand the BET vehicle capabilities, plan infrastructure, understand costs and calculate a business case for transition to BETs.

Keywords: Electric Vehicles, Heavy Duty electric Vehicles & Buses, Public policy & Promotion, Consumer demand, Smart charging

1 Introduction

Heavy duty vehicles (HDVs) have a disproportionally high impact on greenhouse gas emissions in Europe. These vehicles, of which trucks form the vast majority at around 90% [1], comprise about 2% of Europe's vehicle fleet but are responsible for around 25% of European emissions from road transport [2], [3].

The European Union is phasing out highly emitting vehicles in the HDV sector. Recently passed regulations aim to reduce emissions from trucks and buses by 45% between 2030 and 2034, 65% between 2035 and 2039 and 90% by 2040 [4].

Battery Electric Trucks (BETs) are a low emissions alternative for the European trucking sector, which is currently heavily reliant (96%) on diesel [1]. These trucks involve a drive train where all the truck's energy requirements, including mechanical drive, cabin heating and auxiliary services are provided through the discharge of the vehicle battery.

While the number of BETs in Europe is growing, in terms of fleet share, the numbers remain very low: only about 0.1% of trucks in the EU are battery electric [1]. Major challenges for truck fleet operators to convert to BETs are the uncertainty around range and vehicle performance, lack of transparency on prices, requirements of charging infrastructure and associated costs.

In this study, we present an open-access online tool called **KITE** (Key Infrastructure for Truck Electrification) that aims to address these challenges. It enables truck fleet operators to understand the BET vehicle capabilities, plan infrastructure, understand costs and calculate a business case for transition to BETs.

2 Methods

The calculation of the business case of BETs is presented through the total cost of ownership (TCO), defined as "an estimate of the comprehensive costs incurred by a vehicle or fleet owner over the expected vehicle lifetime" [5]. The tool provides the user with a large set of default inputs based on literature across several European countries: The Netherlands, Germany, France, Spain, Türkiye and the UK. The conversion of truck routes into energy requirements are based on measured values collected from a wide range of truck datasheets.

The TCO tool considers within its scope:

1) **Vehicle cost** including the cost of the initial purchase of the vehicle from which the residual value of the vehicle at the end of the analysis timeframe is deducted.

2) **Financing costs** associated with the payment of interest beyond the retail price of the vehicle.

3) **Charging costs** including both the cost of charging infrastructure as well as the costs of electricity over vehicle operational lifetime. Electricity costs are proportional to bus driven distance, route characteristics, vehicle efficiency, ancillary loads (like heating and cooling) and price of electricity.

4) **Maintenance and repair costs** including scheduled vehicle servicing (maintenance) and unscheduled vehicle servicing (repair).

The TCO is calculated as:

$$TCO = \sum_{i=1}^{N} \frac{C_i}{(1+d)^i} \quad (1)$$

where N is the total length of the analysis window in years,

i is the year of cash flow,

d is the discount rate accounting for opportunity cost in % and

C_i represents the cash flow in the i^{th} year in real inflation adjusted Euros (€).

The tool does not cover costs related to parking, vehicle registration, tolls or insurance. Although labour is an important and essential cost associated with truck operation in any commercial setting, the labour costs are considered out of scope of this tool. For an extended description of the method used for calculation of the TCO, refer [5].

3 Case study: Truck TCO in the Netherlands

The capabilities of the KITE tool are described through its application in a simple case study. Here, we consider the case of a single 18 ton truck for transport of dry goods (with no refrigeration or other power demand onboard the vehicle) in the Netherlands. The required inputs for running the calculation and their values are shown below in Table 1.

Table 1: Truck TCO in the Netherlands – Required inputs (optional inputs are not shown)

	Value	Unit
Truck type	18 ton Rigid 4x2 for dry goods transport	-
Number of vehicles	1	-
Daily driven distance	100	km
Grid connection limit	50	kW
Existing electrical load on same connection	Office profile varying from 5 kW to 15 kW	kW timeseries
Smart charging	No	-

The KITE tool enables a large variety of optional inputs. These include

1) Battery size for the given vehicle type, predefined as small, medium and large
2) Purchase price of vehicles, chargers and solar photovoltaic systems
3) Vehicle duty cycle across urban, rural, mixed and congested
4) Truck shift times and number of working days per year
5) Number of chargers of each power rating in 22 kW, 50 kW, 150 kW and 350 Kw
6) Duration of vehicle ownership, defaulting to 15 years based on current best practice [6], [7]
7) Customisable existing load profiles
8) Solar photovoltaic generation on site
9) Smart charging of the vehicles during charging with the objective of flattening peaks and increasing solar self-consumption (if any)
10) Financing and loan parameters and down payment
11) Inflation of electricity and discount rates for the countries of the Netherlands, the UK, Germany, Spain, France, Belgium, Turkey
12) Subsidies on vehicle purchase, charger purchase, solar purchase and solar feed-in

These parameters all have pre-populated default values, avoiding the necessity for the user to search and input values. However, the tool also enables the interested user to customise the inputs according to the required case for calculations.

The resulting cash flow curve for inputs in Table 1, with all other parameters set to default is shown below in Figure 1.

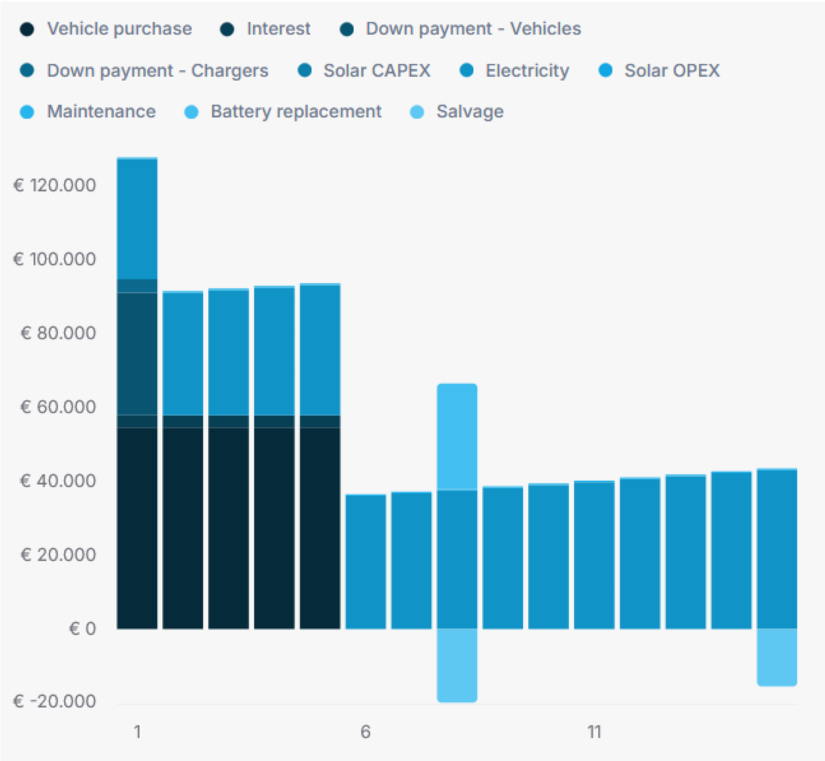

Figure 1: Cash flow curve for the simple case of a single 18t 4x2 rigid truck in the Netherlands

The cash flow curve displays the down payment (12%) for the truck, the down payment for the charger (100%), the principal and interest payments made for a 5-year financing loan, the costs per year for electricity, maintenance and repairs and the costs for battery replacement. KITE assumes a future existence of a second life battery market and uses the model developed by Neubauer and Sekaran [8] together with Lithium Ion Battery cost forecasts from Bloomberg New Energy Finance [9] to estimate the salvage value of the battery from its sale for second hand application.

4 Comparison of Truck TCOs across Europe

The tool can also be used for more elaborate studies. Here, we present the application of the developed backend to perform an evaluation of Battery Electric Truck TCOs across Europe. Data on vehicle purchase costs and charging equipment suggests that these do not vary widely across Europe [10]. However, the costs of electricity, costs of diesel, availability of public charging infrastructure, willingness and capability to invest in new technologies and availability of favourable governmental subsidies lead to differing conditions.

We use the KITE tool to compare the TCO of electric trucks across Europe. The parameters selected inTable 1: Truck TCO in the Netherlands – Required inputs (optional inputs are not shown)Table 1 remain the same and the variations are only in the electricity and discount rates per country. No subsidies of any kind have been considered.

The electricity prices were sourced from Eurostat (including Türkiye in Euro) using data for Eurostat band IC i.e. industrial customers consuming between 500 MWh and 2000 MWh annually. This is the category expected for a truck fleet operator with 5 to 18 trucks driving around 350 km/day for around 265 days per year [11], and include taxes including Value Added Tax (VAT). The electricity costs for the UK, which were not available from Eurostat were taken from the Uk government [12], for electricity band Small/Medium for non-domestic consumers, which consume between 500 and 1999 MWh annually. These prices include the Climate Change Levy and were converted to Euro at the current rate of 1 GBP = 1.18 Euro. The discount rates were taken from the European Commission, updated to May 2025 (including UK) [13] and for Türkiye from the Central Bank of the Republic of Türkiye [14].

The results are shown below in Figure 2, where the net present values of the TCO across the different countries of Europe are shown, together with the electricity costs which are highly correlated. The TCO in Türkiye is much lower than the others largely due to the very high discount rate (40%) offered by the Turkish Central Bank as compared to the discount rates in Europe and the UK (well below 10%). Within Europe, the results reveal a very favourable case in Sweden and Finland, where costs are amongst the lowest in Europe as compared to Cyprus and the UK, where the costs are among the highest. Our results reveal that the TCO of such a truck in Finland is around 83% of the TCO of the same truck in the UK.

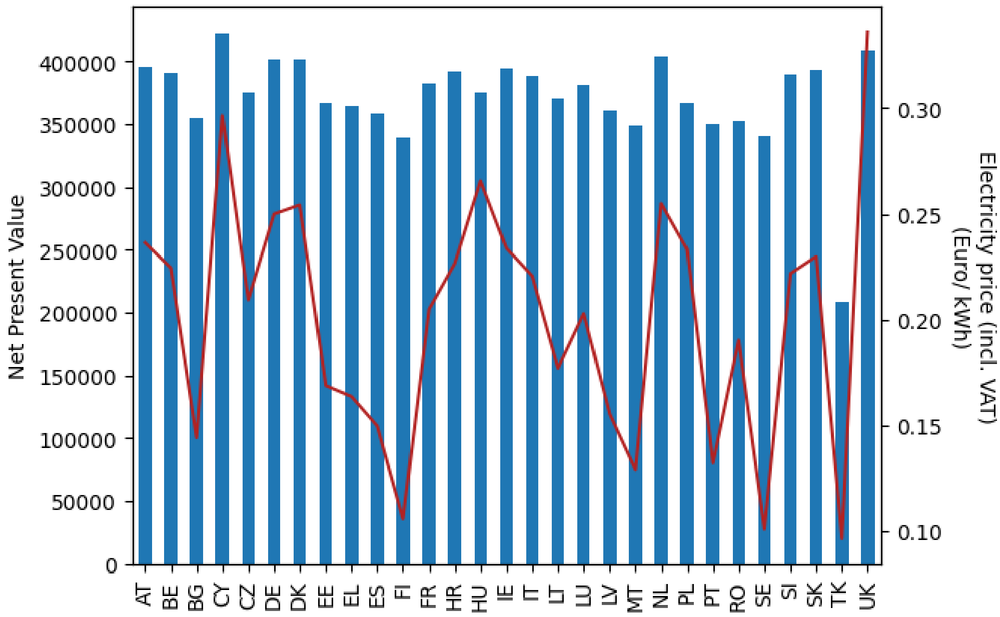

Figure 2: Net Present Value of the Total Cost of Ownership of a single 18t 4x2 rigid truck including 22 kW charging infrastructure across the countries of Europe

In order to further identify locations which are favourable for rapid electrification of trucks, we compare the TCO per country with diesel, the most common alternative fuel for trucks, on which 96% of the European truck fleet operates [1]. The diesel costs were sourced from [15] for the UK, from [16] for Türkiye and from [17] for all remaining countries. The results are shown in Figure 3.

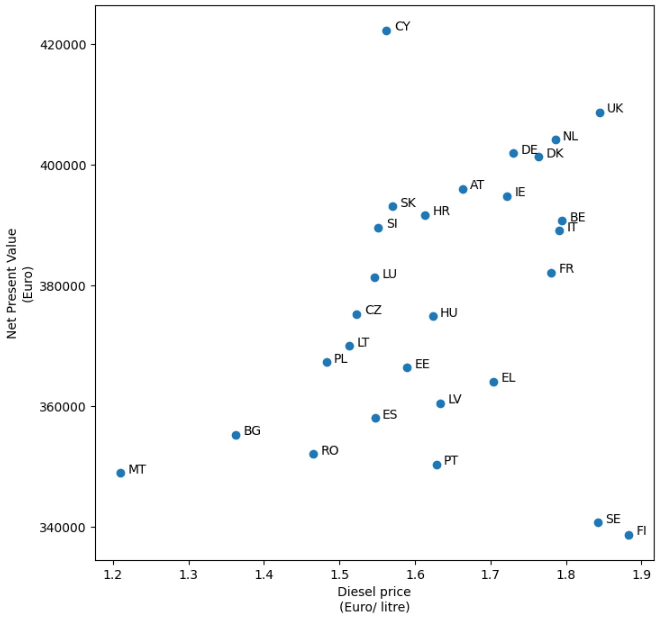

Figure 3: Comparison of the Net Present Value of the TCO of a single truck with diesel costs per litre across Europe

The results show an interesting split across the countries analysed. The most favourable cases are to be found in the bottom right of the figure, with low TCO of electric drive and high diesel prices. Sweden and Finland are clearly best suited for this. In the top right, diesel costs remain high, but the TCO of electric trucks is also expected to be high in comparison with other European countries – as is the case in the UK, the Netherlands, Germany and Denmark among others.

Cyprus, with the highest TCO for electric trucks and relatively moderate costs of diesel presents a poor financial case for electrification. No countries are found in the region with high electric TCO and low diesel costs. In the region with low TCO of electric trucks and relatively low diesel costs are Malta, Bulgaria and Romania.

There are some limitations of the KITE tool which affects this analysis. KITE does not consider the availability of public charging infrastructure, national and regional subsidies (though they can be input by the user), availability of hardware, availability of grid connection and the willingness and capability of fleet operators in different countries to invest in new technologies. However, we expect the tool to provide an accurate picture of the broad fundamentals of the business case for electric trucking.

5 Conclusion

We present the KITE (Key Infrastructure for Truck Electrification) tool for estimating the total cost of ownership (TCO) of battery electric trucks. Open and free access to such an open-source tool is expected to provide financial clarity for logistics fleet operators before planning investment in electric fleets. In comparison with existing tools, it provides ease of interface, a high degree of customisation, a large number of pre-filled default values for many European countries, is completely free to use and includes advanced features like smart charging, inclusion of solar photovoltaics, smart charging, charging infrastructure sizing, battery replacement and salvage value cost calculation and estimation of CO2, NOx and particulate matter reduction.

We show the inputs and briefly describe the methodology used for the operation of the KITE tool. An example of the TCO calculation is provided for a single truck and charger in the Netherlands, with the resulting cash flow curve. We then use the KITE tool to analyse the case for truck electrification across Europe, including the UK and Türkiye. While many factors such as favourable governmental policy and availability of hardware and grid connections, we expect the analysis to provide a general understanding of the comparative business case for electric trucking across the countries of Europe.

We hope that the KITE tool is widely used by fleet operators, planners, infrastructure developers and other stakeholders to plan, assess and prepare for the deployment of zero emission electric vehicles in the heavy-duty sector.

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Presenter Biography

Rishabh Ghotge is a researcher with a technical background in energy systems and charging infrastructure for electric transport. He obtained his PhD at the Delft University of Technology for his dissertation on the use of solar energy for charging electric vehicles. Rishabh has been working at Cenex NL since 2023 as an Energy and Infrastructure specialist and consultant.

Jorden van der Hoogt Jorden is a researcher and consultant with a background in Mechanical Engineering and Science-to-Business Innovation. He has worked at Cenex NL since 2019 on consultancy and research projects focused on electric vehicles and charging infrastructure. Jorden is currently the team lead for Energy and Infrastructure at Cenex NL.