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Efficient and affordable Zero Emission logistics through **NEXT** generation **E**lectric **TRUCK**s

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D4.5 Report on online decarbonization strategy tool

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

Abbreviation	Meaning
AC	Alternating Current
API	Access Point Interface
AT	Austria
BE	Belgium
DC	Direct Current
DE	Germany
EEA	European Economic Area
EF	Emission Factor
ES	Spain
EU	European Union
EV	Electric Vehicle
FR	France
GHG	Greenhouse Gas
GVW	Gross Vehicle Weight
IC	Internal Combustion
LCC	Lifecycle Cost
MIA	Milieu-investeringsaftrek, a Dutch subsidy
MW	Mega Watt
NL	The Netherlands
NO	Nitrogen Oxide
NPV	Net Present Value
PHEV	Plug in Hybrid Electric Vehicle
PM	Particulate Matter
PV	Photovoltaic
PVGIS	Photovoltaic Geographical Information System
TCO	Total Cost of Ownership
TTW	Tank-To-Wheel
UK	The United Kingdom
USA	The United States of America
VAT	Value Added Tax
WP	Work Package
WTW	Well To Wheel
ZEV	Zero Emission Vehicle

EXECUTIVE SUMMARY

This deliverable describes the methods used within the online Fleet Decarbonisation Strategy tool developed as part of WP4 in the NextETRUCK project. The tool, which is to be openly available to the public, aims to assist fleet operators to transition to electric trucks by:

a) Providing information on the performance capabilities of electric trucks on the market
b) Estimating the amount of charging infrastructure required for a given fleet of electric trucks
c) Calculating the total cost of ownership of the trucks and charging infrastructure over their operational lifetime

Additionally, it also offers them an estimate of the reduction in greenhouse gas emissions and air pollution enabled through the electrification of the fleet.

This report provides the scope and methods for these calculations. Although the tool is meant as a stand-alone service, this report offers interested users of the tool to understand the procedure of calculation and interpret the results correctly. It is likely to be of interest to both practitioners: fleet operators, procurement and tendering departments as well as researchers in the field of electric mobility and logistics.

1 INTRODUCTION

NextETRUCK is a 3-year Horizon Europe project that develops ZEV concepts tailored for regional medium freight haulage, running from 1 July 2022 until 31 December 2025.

The project aims at playing a pioneering role in the decarbonisation of vehicle fleets, demonstrating next-generation e-mobility concepts. It also contributes to the development of zero-emission vehicles and ecosystems that are holistic, innovative, affordable, competitive, and synergetic.

NextETRUCK is expected to build concepts tailored for regional medium freight haulage with at least a 10% increase in energy efficiency compared to existing highest-end benchmark electric vehicles. In addition, it shall prepare concept and infrastructure demonstrators for fast charging and offer new business models to increase end-user acceptance and foster the market uptake of the project solutions.

The project's consortium consists of 19 partners from 8 countries: The Netherlands, Belgium, Germany, Spain, Greece, Austria, Turkey, United Kingdom[1]. The project's coordinator is TNO (Netherlands Organization for Applied Scientific Research).

NextETRUCK shall conduct demonstrations in Istanbul (TK), Barcelona (ES), and Utrecht (NL).

1.1 Purpose of the deliverable

As part of work package 4 subtask 4.3.2, a public facing digital tool was built with the following objectives:

1) To calculate the power rating and quantity of charging infrastructure required by electric trucks at a given depot
2) To calculate the total cost of ownership (TCO) of electric trucks and associated charging infrastructure
3) To calculate the reduction in tank-to-wheel (TTW) CO_2 emissions, NOx emissions and particulate matter emissions reduction caused by the shift to electric trucks from diesel trucks

This report accompanies the digital tool. It is meant as a guide to use the tool, discussing its purpose and scope and explaining the results and how to interpret them. It also provides the detailed methodologies for the various calculations for interested users of the web tool.

[1] The UK participants in this project are co-funded by the UK.

1.2 Intended audience

This report is targeted at the same audience as the public facing digital tool. It aims to serve as an operating manual for those using the online tools. The main intended audience is truck fleet operators and logistics providers interested in shifting from diesel to battery electric drive.

This tool is expected to be most helpful at the planning stage, to inform purchase and operational decisions and strategy. The tools can be applied either prospectively or retrospectively to learn more about electrified truck fleets.

Some interesting applications include:
a) identification of truck routes where the TCO of electric trucks is low enough to be competitive, and therefore prioritizing the order in which routes are electrified.
b) running simulations with several truck models to find which truck can be used with lowest TCO on a specified route.
c) estimating how well the truck infrastructure is sized for the given electric truck fleet
c) running a low-cost estimation study of the emission reduction and air pollution reduction enabled by an electrified truck fleet.

As such, this report and the corresponding tool are expected to be of interest to planners, researchers and other stakeholders in the trucking and logistics sectors. The public facing tool can been openly accessed via the nextetruck.eu website.

1.3 Structure of the report

The report is structured as follows: Section 2 initially defines the theoretical framework behind the digital tool: the total cost of ownership (TCO) as a financial metric for electric trucks and trucks fleets. It also describes the procedure used to estimate the TCO for a given electric truck fleet. Section 3 gives an overview of the procedure for calculation of charging infrastructure for a given truck fleet.

Section 4 describes the scope of emissions covered by the tool and how the reductions of greenhouse gas emissions in operation are calculated in comparison with diesel trucks. It also describes the types of air pollutants covered by the tool and describes the methods used to calculate the pollution reduction expected through operation of an electric truck fleet when compared with a diesel fleet. Finally, Section 5 summarises the report and concludes the study. A description of the tool is provided in Appendix A.

2 TCO OF ELECTRIC TRUCKS

To estimate the overall costs associated with a vehicle or vehicles fleet, working with a total cost of ownership (TCO) framework is common. This framework provides a comprehensive overview of costs over the vehicles or fleets' operational life. It is a robust method for evaluation over vehicles with different initial costs, different operational and maintenance costs, and is therefore well-suited for comparison of alternative powertrains over longer terms.

2.1 TCO definition

The total cost of ownership (TCO), sometimes known as lifetime cost or Life Cycle Cost (LCC), is broadly defined as *"the cost of an asset throughout its life cycle, from acquisition through operation to disposal, while fulfilling the performance requirements"*, based on (2021). It is commonly applied to vehicles and fleets, but has many wider applications across buildings, consumer goods and other assets.

In this study, we use a more specific definition, suitable for vehicles and fleets, *"The Total Cost of Ownership (TCO) provides an estimate of the comprehensive costs incurred by a vehicle or fleet owner over the expected vehicle lifetime"* (Burnham et al. 2021).

2.2 TCO Scope

The scopes of the TCO studies of vehicles depend on both the purpose of the analysis as well as the user of the vehicle. For example, analyses focusing on a single user of vehicle from point of purchase to point of sale may consider a fraction of the lifecycle of the vehicle. TCOs for non-commercial vehicles can safely neglect labour costs while studies for fleet managers must necessarily include costs of labour including wages and benefits.

For the tool developed in this study, the main objectives are:

1) To compare the TCO of electric trucks with an existing truck fleet of an operator
2) To identify the most important parameters affecting the TCO of electric trucks
3) To identify routes where the TCO of electric trucks is low enough to be competitive
4) To identify which trucks can be used with low TCO on given routes
5) To make estimates for financing of electric trucks

As such, the TCO tool considers within its scope:

1) **Vehicle cost:** This includes 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. We assume the vehicle to be driveable and in good condition at the end of the analysis horizon and thus implicitly assume maintenance and repairs. We also assume a depreciation of the vehicle value over this horizon.

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

3) **Charging costs:** Costs of charging cover the cost of charging infrastructure as well as the costs of electricity. Electricity costs are proportional to the driven distance, route characteristics, vehicle efficiency, ancillary loads (like heating and cooling) and electricity costs. In some cases, electricity costs may vary over the course of the day or year, leading to timing of charging rather than the scale of energy used for charging to also influence charging costs.

4) **Maintenance and repair costs**: These costs cover scheduled vehicle servicing (maintenance) and unscheduled vehicle servicing (repair).

The tool does not consider fees such as vehicle registration, parking, tolls, etc. 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. They are unlikely to change when compared with the labour costs associated with operating diesel vehicles in the long term[2].

Insurance costs covering both liability, and extra-ordinary replacement and repair are not considered. Further, we do not consider external costs (positive or negative) to society or the environment, such as urban congestion, air pollution, noise pollution, etc.

2.3 TCO calculation method

The TCO is calculated as:

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

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

i is the year of the 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 (€).

For an extended description of the methods, refer Burnham et al. (2021).

[2] Some studies report the ‘labour cost of charging’. This covers the costs associated with the time spent by the driver or other personnel on ensuring vehicles are adequately charged. We do not consider these costs here, and expect that as operators become more familiar with electric trucks, these costs will reduce.

2.3.1 Analysis timeframe and vehicle lifetime

The timeframe of analysis of heavy-duty vehicles is typically 10 years (Burnham et al. 2021). However, for trucks, especially battery electric trucks, the vehicle lifetime is often expressed in driven kilometres (or miles as the case may be).

Suzan and Mathieu (2021) use 15 years of vehicle lifetime for long haul electric trucks in Europe. Similarly, Sinha and Teja (2022) use 15 years of vehicle lifetime over a range of electric trucks including medium duty and heavy duty trucks for short regional and long haul applications in India. Basma et al. (2021) consider only the first purchaser/ user of new electric trucks and limit their analysis timeframe to 5 years, and consider a non-zero residual value of the truck at the end of this period. Tol et al. (2022) also consider only the initial purchaser of new trucks, and therefore limit the analysis timeframe to 5 years. Over 5 years, the vehicle is assumed to have driven 1.49 million km (1150 km per day for 265 days per year) with zero residual value at the end.

Hunter et al. (2021) uses the total life of the vehicle, rather than the initial purchaser (reporting a typical duration of use of 2 to 5 years by the first purchaser before resale), but define the lifetime based on vehicle-miles travelled before a major overhaul. Typical vehicle miles travelled are between 480,000 km and 1.6 million km[3]. Various scenarios with shifts determine the conversion of the driven distance into years of operation.

Here, we consider as default the entire vehicle lifetime rather than the initial purchaser of the electric truck. As such, similar to Suzan and Mathieu (2021) and Sinha and Teja (2022), we use 15 years of operation as the default timeframe of analysis.

We consider the truck to be used for its entire operational life with re-use rather than scrappage at the end of first life. We explicitly consider a second life of the battery, since 15 years from now, we expect a mature market for second life batteries to exist. Second life values of batteries are then expected to have a favourable influence on the TCO. For shorter time frames of analysis, as chosen by the user, we consider resale of the truck for mobility application – more details are provided in section 2.3.8.

2.3.2 Costs for electric trucks and charging infrastructure

The costs for electric trucks and charging infrastructure consist of the purchasing costs, from which any purchase subsidies are deducted. This section presents the data collected on purchase costs for trucks and charging infrastructure as well as associated subsidies for the countries of Germany, France, Spain, Türkiye, the Netherlands and the UK.

[3] Reported as 300,000 miles and 1 million miles in the original study.

The model database consists of 85 different electric truck configurations across weight, axle configuration, body type and battery size. A small overview is presented below. Electric truck purchase costs are presented per vehicle configuration (type – axles – GVW), with the range signifying the differences in battery capacity.

Table 1 shows the purchase costs for electric trucks. All costs are indicative figures and are subject to change over time with market developments. Current purchase price data was sourced from the Cenex Fleet Advice Tool (Cenex 2024) and the Panteia TCO-ZET-Vracht model (Panteia 2024).

Table 1: Overview battery electric trucks purchase costs

Electric Truck Purchase Costs		
Configuration	**UK** (Cenex 2024)	**EU/Türkiye** (Panteia 2024)
Van - 4x2 - 3.5t	£ 67,000 - £ 95,000	€ 105,000 - € 125,000
Rigid Truck - 4x2 - 7.5t	£ 55,000 - £ 156,000	€ 169,000 - € 263,000
Rigid Truck - 4x2 - 18t	£ 220,000 - £ 320,000	€ 230,000 - € 125,000
Rigid Truck - 6x2 - 26t	£ 250,000 - £ 350,000	€ 280,000 - € 374,000
Articulated truck - 4x2 - 40t	£ 230,000 - £ 330,000	€ 333,000 - € 427,000
Articulated truck - 6x2 - 40t	£ 283,000 - £ 383,000	€ 352,000 - € 447,000

The data on vehicles and charging equipment costs collected by Lanz et al. (2022) reveals that vehicle and charging hardware costs do not vary widely across Europe, we therefore use similar value across countries. Users of the tool are given the option of inserting more accurate data based on recent tenders or market knowledge, if available.

Table 2 shows the available subsidies for electric trucks as of late 2024.

Table 2: Overview of electric truck subsidies

Electric Truck Purchase Subsidies			
Configuration	**UK** (Gov.uk 2024)	**Spain** (Ministerio de Transportes, Mobilidad y Agenda Urbana 2024)	**The Netherlands** (Panteia 2024)
Van - 4x2 - 3.5t	£ 16,000	€ 20,000	€ 14,700
Rigid Truck - 4x2 - 7.5t	£ 16,000	€ 50,000	€ 60,500
Rigid Truck - 4x2 - 18t	£ 25,000	€ 160,000	€ 60,500
Rigid Truck - 6x2 - 26t	£ 25,000	€ 160,000	€ 83,200
Articulated truck - 4x2 - 40t	£ 25,000	€ 160,000	€ 83,200
Articulated truck - 6x2 - 40t	£ 25,000	€ 160,000	€ 83,200

Purchase subsidies lowering the costs of electric trucks differ by country across Europe. France and Türkiye currently have no subsidies for electric trucks in late 2024, while Germany only provides subsidies on Bundesländer (sub-national or provincial) level (now-gmbh.de 2024). These are not included as the granularity of the tool is limited to the national level.

The UK gives subsidies based on vehicle type, with N2 and N3 trucks having different maximum subsidies (Gov.uk 2024). They further give only subsidies for vehicles on the eligible vehicle list, which is regularly updated. The model takes the vehicle category into account but does not check the eligible vehicle list. For both Spain and The Netherlands subsidies are based on vehicles weight and the size of the company requesting the subsidy (small, medium or large) (Ministerio de Transportes, Mobilidad y Agenda Urbana 2024; Panteia 2024). As a default, subsidies reported in the tool are applicable for medium sized companies, based on the weight of the selected vehicle. Table 3 and Table 4 show the costs and subsidies for charging infrastructure.

Table 3: Overview of charging infrastructure purchase costs

Charging Infrastructure Purchase Costs		
Configuration	**UK** (Cenex 2024)	**EU/Türkiye** (Panteia 2024)
AC 22 kW	£ 9,700	€ 3,700
DC 50 kW	£ 31,400	€ 32,100
DC 150 kW	£ 58,500	€ 93,200
DC 350 kW	**No data**	€ 208,500

The purchase costs for charging infrastructure are also sourced from the Cenex Fleet Advice Tool and the Panteia TCO model. The values include the purchase and installation costs of the chargers (Cenex 2024; Panteia 2024). As revealed by Lanz et al. (2022), charging hardware does not differ much across Europe. However, it should be noted that labour and installation costs do differ across Europe and the costs reported here, sourced from Western Europe, are likely to represent a higher value of labour costs.

Only a few European countries offer national subsidies for charging infrastructure for electric trucks as of late 2024, with the UK and Türkiye having no subsidies, France only has subsidies for home chargers (EAFO 2024). Germany only offers subsidies on the sub-national level (now-gmbh.de 2024), which we do not apply in this tool. The Netherlands has the SPRILA purchase subsidy (RVO 2024b), for which the allocated budget has been fully spent in 2024. However, a new round is planned for 2025. The Netherlands also offer non-purchase subsidies like the MIA where some costs for charging infrastructure are tax deductible (RVO 2024a). This type of subsidy has not been included in this tool.

Table 4: Overview of charging infrastructure purchase subsidies

Charging Infrastructure Purchase Subsidies		
Configuration	**Spain** (Ministerio de Transportes y Movilidad Sostenible 2024)	**The Netherlands** (RVO 2024b)
AC 22 kW	£ 9,700	€ 3,700
DC 50 kW	£ 31,400	€ 32,100
DC 150 kW	£ 58,500	€ 93,200
DC 350 kW	**No data**	€ 208,500

Spain has subsidies for charging infrastructure from 50 kW to 350 kW (Ministerio de Transportes y Movilidad Sostenible 2024), with the subsidy amount increasing with the charger power. Company size influences the maximum percentage of eligible costs, but the maximum subsidy level is the same for all companies. This tool uses the maximum subsidy levels.

2.3.3 Energy requirement of electric trucks

For calculating the energy required for the electric trucks, we use energy factors developed internally in Cenex, where the energy is calculated based on truck weight, battery size and route characteristics: congested, urban, rural and motorway.

These factors have been updated over several projects involving electric trucks, such as the Battery Electric Truck Trial. These factors are shown in
Table 5.

Table 5: Vehicle driving range per unit stored energy (km/kWh)

	Congested	Urban	Rural	Motorway
≥3.5 t Vans (N2 4x2)	3.50	3.36	2.36	2.05
≤7.5 t Rigid Truck (N2 4x2)	2.14	1.97	1.80	1.70
18 t Rigid Truck (N3 4x2)	1.25	1.15	1.06	0.99
18 t Refuse Collection Vehicle	0.45	0.51	0.73	0.73
26 t Rigid Truck (N3 6x2 or N3 6x4)	0.91	0.84	0.66	0.62
26 t Refuse Collection Vehicle	0.43	0.41	0.48	0.48
32 t Rigid Truck (N3 8x4)	0.82	0.76	0.67	0.64
40 t Articulated Truck (N3 4 x 2 tractor)	1.25	1.15	1.06	0.99
44 t Articulated Truck (N3 6 x 2 tractor)	0.66	0.60	0.59	0.78

2.3.4 Cost of electricity

We use the costs for industrial customers, annually consuming between 500 MWh and 2000 MWh per year[4], sourced from Eurostat (2024). For a truck fleet operator with 5 to 18 trucks driving around 350 km/day for around 265 days per year, this is a suitable category (Tol et al. 2022).

These costs, shown in Figure 1, show the split between electricity, taxes and value added tax (VAT). VAT is a recoverable expense for industrial consumers in all these countries, and is therefore excluded, as in Smith et al. (2024).

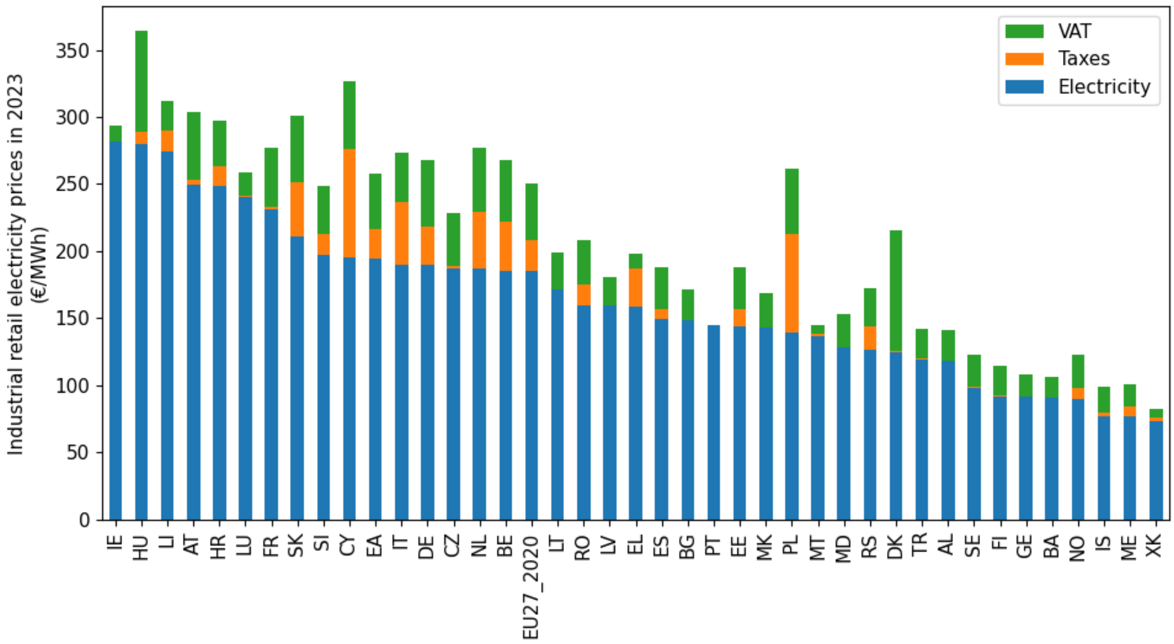


Figure 1: Cost of electricity for industrial customers (Eurostat band: IC) in each country within the EU27 in 2023

[4] Eurostat band: IC i.e. industrial customers consuming between 500 MWh and 2000 MWh annually.

2.3.5 Discount rate

The discount rate, *d*, is used to convert future cash flows into an equivalent present value. It represents the opportunity cost of cash flows at different times. For an upfront cost, the opportunity cost is typically the interest rate offered by a standard savings account or short-term investments.

A historic subset of discount rates for 2023 and 2024 for the countries investigated for application of the tool is shown in Table 6 (European Commission 2024b). In the tool, we use the most recent discount rates for end-2024 reported by the European Commission.

Table 6: Discount rates in select European countries as of end-2024

From	To	AT	BE	UK	ES	FR	DE	NL
1.12.2024	31.12.2024	4.45	4.45	6.65	4.45	4.45	4.45	4.45
1.11.2024	31.11.2024	4.45	4.45	6.65	4.45	4.45	4.45	4.45
1.10.2024	31.10.2024	4.45	4.45	6.65	4.45	4.45	4.45	4.45
1.9.2024	30.9.2024	5.11	5.11	6.65	5.11	5.11	5.11	5.11
1.7.2024	31.08.2024	5.11	5.11	6.65	5.11	5.11	5.11	5.11
1.4.2024	30.06.2024	5.11	5.11	6.65	5.11	5.11	5.11	5.11
1.1.2024	31.3.2024	5.11	5.11	6.65	5.11	5.11	5.11	5.11
1.11.2023	31.12.2023	4.64	4.64	6.09	4.64	4.64	4.64	4.64
1.9.2023	31.10.2023	4.64	4.64	6.09	4.64	4.64	4.64	4.64
1.8.2023	31.8.2023	4.64	4.64	5.24	4.64	4.64	4.64	4.64
1.7.2023	31.7.2023	4.64	4.64	5.24	4.64	4.64	4.64	4.64
1.6.2023	30.6.2023	4.64	4.64	5.24	4.64	4.64	4.64	4.64
1.5.2023	31.5.2023	4.06	4.06	5.24	4.06	4.06	4.06	4.06

2.3.6 Financing and loan repayment

If a loan is used to finance the vehicle purchase, the cost to the borrower is the cost of loan repayment. In case the discount rate is lower than the interest rate on the loan, it may be advantageous to finance the loan. However, interest rates on loans are typically higher than discount rates.

The costs of loan repayment assuming monthly cashflows are calculated as follows:

$$\text{Monthly loan repayment} = Vehicle \text{ cost} \times \frac{r \times (1+r)^p}{(1+r)^p - 1}$$

where *r* is the monthly interest rate, which is 1/12th of the annual percentage interest rate,

p is the loan term in months, and

vehicle cost is the cost for the initial purchase of the vehicle from which the residual value of the vehicle at the end of the analysis timeframe is deducted.

A default down payment of 12% is assumed in case of financing truck purchase through a loan. All payments except the down payment need to be discounted to present value using the discounting factor.

2.3.7 Adjustment for inflation

The inflation rate describes the rise in prices over time and the corresponding fall in the purchasing power of a given currency. For this tool, we consider the base year to be 2023, the last year for which we have complete data. Thus, all future cashflows are converted to 2023-equivalents.

Due to inflation, future cashflows in currency amounts which are actually spent (nominal values) are adjusted to 2023-equivalent value of currency in terms of the purchasing power equivalence based on the expected interest rate, *i*.

For truck operations, the majority of costs are expected to be related to electricity[5]. Electricity prices in Europe differ considerably across the different countries in Europe, each of which has a different generation mix, trading partners and seasonality. Further, the electricity prices in Europe are also subject to price shocks from events such as the Russia-Ukraine war.

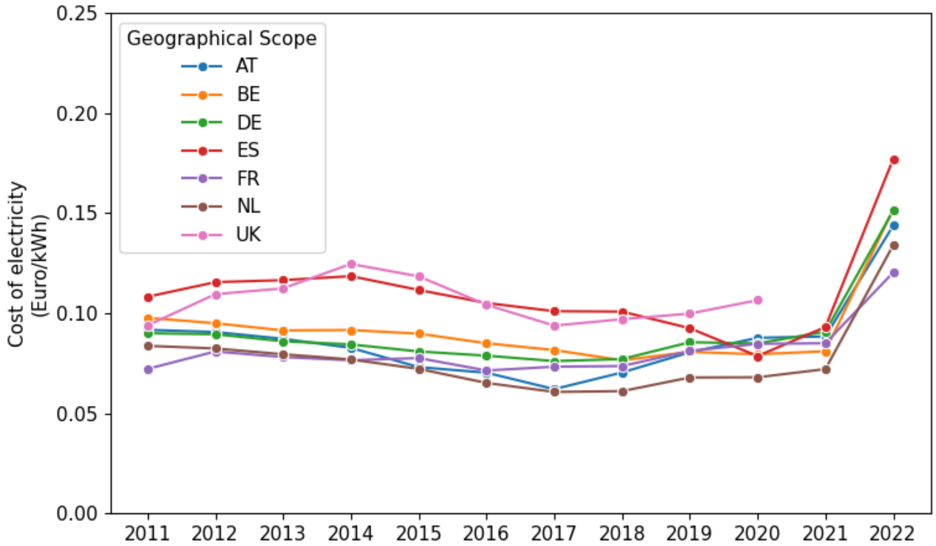


Figure 2: Cost of electricity in select European countries

Note: AT – Austria, BE – Belgium, DE - Germany, ES – Spain, FR – France, NL – the Netherlands, UK – United Kingdom. This dataset includes the UK in the EU28 until 2020 and neglects the UK after 2020.

[5] This assumes the exclusion of labour costs from the scope, refer Section 2.2: TCO Scope.

Figure 2 shows the average national price in Euro per kWh without taxes for medium size industrial consumers (Eurostat 2024). The large relative difference in costs across the countries as well as the large increases in 2022 are seen. Similar price changes in the future 15 years over the truck lifetime are largely unpredictable.

In this study, we take a simplified approach. A European Commission 2023 study on energy costs throughout the EU27 shows that electricity prices for industrial customers has increased at an average rate of 2% per year in the pre-war decade, from 96 €/MWh in 2010 to 124 €/MWh in 2021 (Smith et al. 2024, 35). This data is shown in Figure 3. We assume this rate of increase in prices to be extrapolated to the future, subject to discounting to present value.

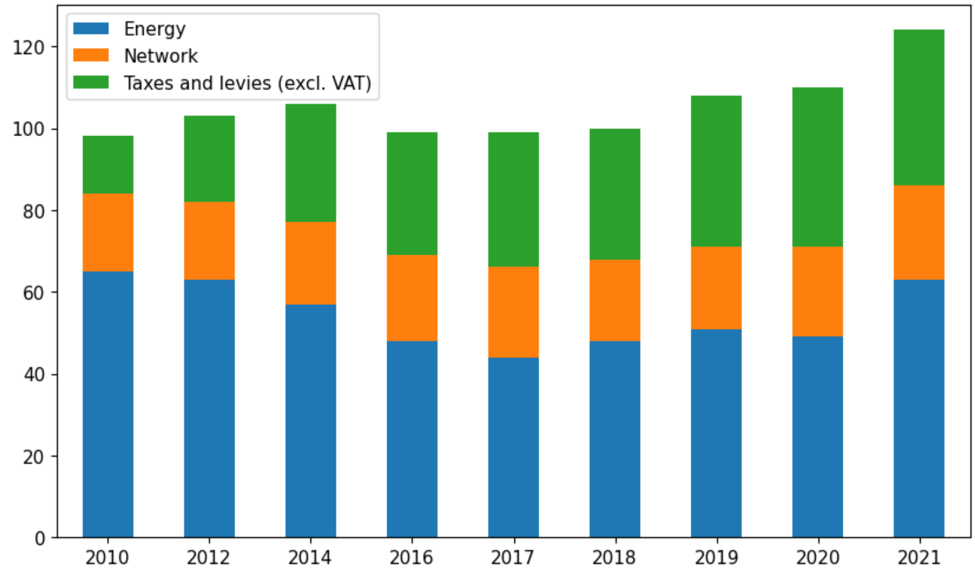


Figure 3: Cost of electricity for industrial customers in the EU

Further, the prices for industrial consumers have been converging over time as a result of the greater integration of wholesale markets, international competition and trading across borders. Though there still remain significant price differences between countries, with UK and Spanish prices far exceeding Dutch and Austrian ones (see Figure 2), we take the standard 2% increase per year across all countries in this study, neglecting individual variations in rate of change of electricity prices over time.

2.3.8 Vehicle depreciation, battery salvage and scrappage

In treatment of the vehicle depreciation, salvage value of batteries for repurposing and scrap value of the trucks, we follow methods outlined in (Burnham et al. 2021). Over the electric truck lifecycle, there are three options for an owner who wishes to discontinue the operation of the truck at any given moment:

1) Truck resale: The electric truck is sold for reuse as an e-truck for mobility purposes in another location.

2) Battery salvage: The vehicle body is scrapped, and the batteries reach their end-of-first-life, with around 80% state-of-health[6]. These batteries still have some value and can be sold independent of the vehicle body for repurposing or remanufacturing for second lifetime.
3) Scrappage: The truck including its batteries are scrapped. The batteries are expected to be recycled, as per the European Battery Directive (European Parliament 2023).

Figure 4 shows the trend in market value of the three options over the vehicle lifetime. The solid lines show the highest value option at any given moment, while the dotted lines show the other values.

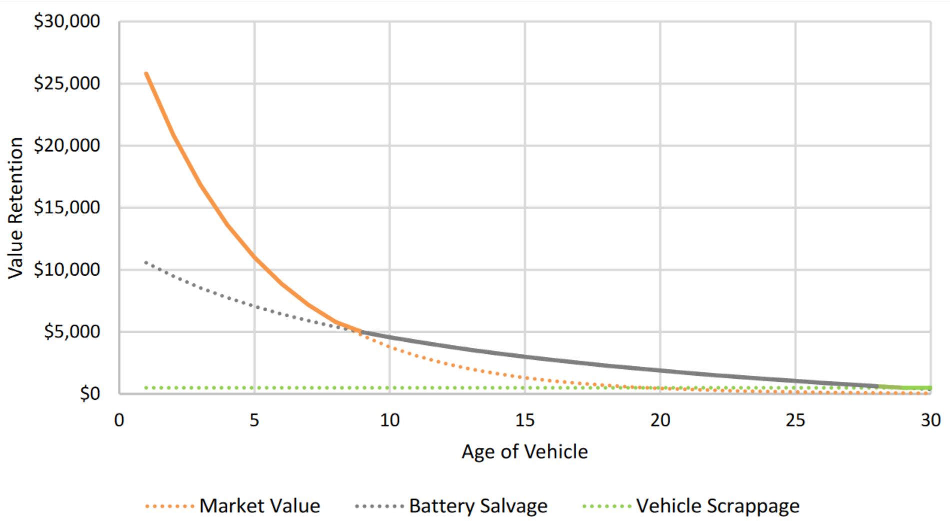


Figure 4: Changes in market value of an electric truck for resale as a truck, battery salvage and vehicle scrappage

Note: The numbers shown, related to passenger vehicles in the USA [Source: (Burnham et al. 2021)], are only for illustrative purposes. The orange line shows the resale value as a truck, the grey line shows the battery salvage value while the green line shows the scrap value. The highest value option for disposing of the truck at any given moment is shown as a solid line, while the dotted lines show the other options.

For most of the first decade of use, the truck is expected to have highest end-of-first-life value as a truck. After a certain period, in this figure shown around year 8, the resale value of the truck decreases below the salvage value of the batteries. Thus, the most profitable option is selling the batteries independently. This position remains for the rest of the vehicle life over which the battery salvage value keeps declining until the point where the only value is the scrap value of the materials.

However, this point is well beyond the vehicle lifetime of 15 to 20 years, suggesting that in most cases when vehicles are used for 15 to 20 years, salvaging value from the batteries is the best option for truck operators. In this study, given the long periods of truck ownership by

[6] While the 80% limit in battery state-of-health is commonly considered in academic works, in actual operations, the state-of-health is difficult to measure with certainty and can be improved through cell-level diagnosis and replacement or better battery management systems (BMS). Several innovative providers of battery monitoring systems have emerged (Volytica, Twaice, Voltaiq, etc.) to optimise battery performance through rapid diagnostics, corrective maintenance, predictive maintenance, thereby extending battery lifetime and reducing the TCO.

the first owner/operator, we mainly consider the salvage value of the battery as the end-of-first-life option. Truck resale for re-use in mobility are not explicitly considered, though the tool includes the option of adding a value by the user.

While this outlook on battery second lifetime remains promising from a circular economy perspective, the scale at which demand for new batteries is growing has led to expectations of very low future battery prices. Figure 5 shows the historic decline in lithium ion battery prices between 2013 and 2023 covering batteries for passenger vehicles, heavy duty vehicles and stationary storage (Catsaros 2023).

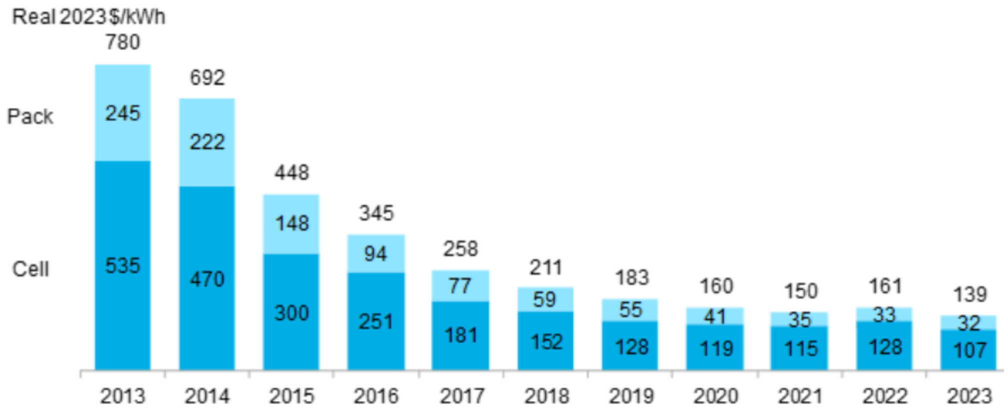


Figure 5: Battery prices at the cell and pack level in the decade from 2013 to 2023

Battery prices are expected to drop further in the future (Kuhn, Bubna, and Anculle 2021), with several forecasted trends shown in Figure 6. These include forecasts for battery packs from Bloomberg New Energy Finance (BNEF), IHS Markit (now part of S&P Global) and the UK's Advanced Propulsion Centre (APC).

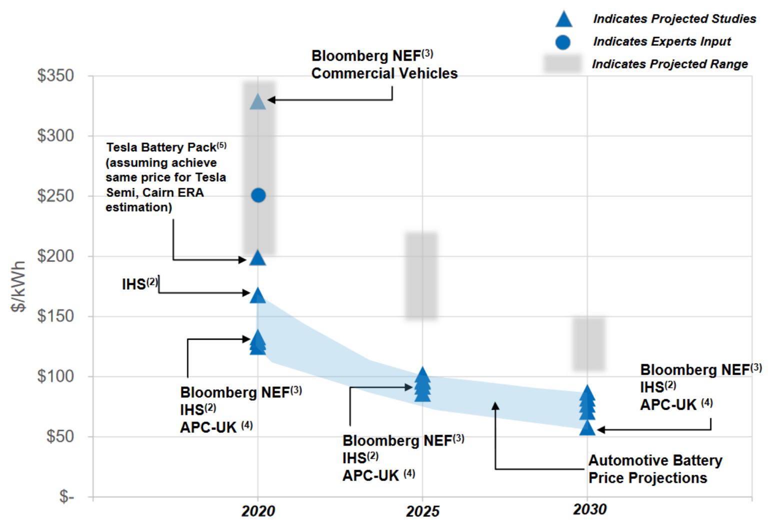


Figure 6: Battery pack price forecasts

Note: (1) Ricardo analysis, (2) IHS Next Generation Battery Technologies and Market Trends NAATBatt Annual Conference 9 February 2021, (3) Passenger Electric Vehicle Outlook, NaatBatt 2021, February 2021, (4) APC UK Electrical Energy Storage Roadmap 2020, (5) Cairn ERA estimation $187/kWh, https://www.cnbc.com/2021/03/10/teslas-lead-in-batteries-will-last-through-decade-while-gm-closes-in-.html

On comparing, the initial period of the forecast (2021 to 2023), we see that the battery pack prices are dropping fast, close to the lower limits of the Automotive Battery Price Projections, shown in light blue. For this reason, we choose the APC battery price forecasts in this study (Greenwood 2021).

Following Burnham et al. (2021a), we calculate the battery salvage value at end-of-life as:

$$V_{salvage} = (1 - K_r - K_u)(1 - K_h) \times C_{new} \times F_{RPE}$$

where $V_{salvage}$ is the salvage value of the battery pack,

K_r is the refurbishment cost factor of 15%,

K_u is the used product discount factor of 15%,

K_h is the battery health factor, beginning with 0% in the first year and increasing by 3% per year,

C_{new} is the cost per usable kWh of battery pack capacity for a new battery in the year the pack is salvaged, sourced from (Greenwood 2021), and

F_{RPE} is the ratio of the retail price to manufacturing cost, taken as 1.5 retail price equivalent.

Details on the original model for salvage value of the battery pack may be referenced at Neubauer and Pesaran (2010).

2.4 TCO and cash flow curves

Finally, the total cost of ownership (TCO) of electric trucks purchased are presented both as net present value (NPV) and as a cash flow curve, over the lifetime of the truck (with a default value of 15 years). An example of such a cash flow curve is shown in Figure 7. The down payment in the first year, the repayment of the loan used to finance the vehicle purchase in 5 years, the annual payments for electricity, operation and maintenance (O&M) over the 15-year vehicle lifecycle and the final scrap value through vehicle sale are all marked.

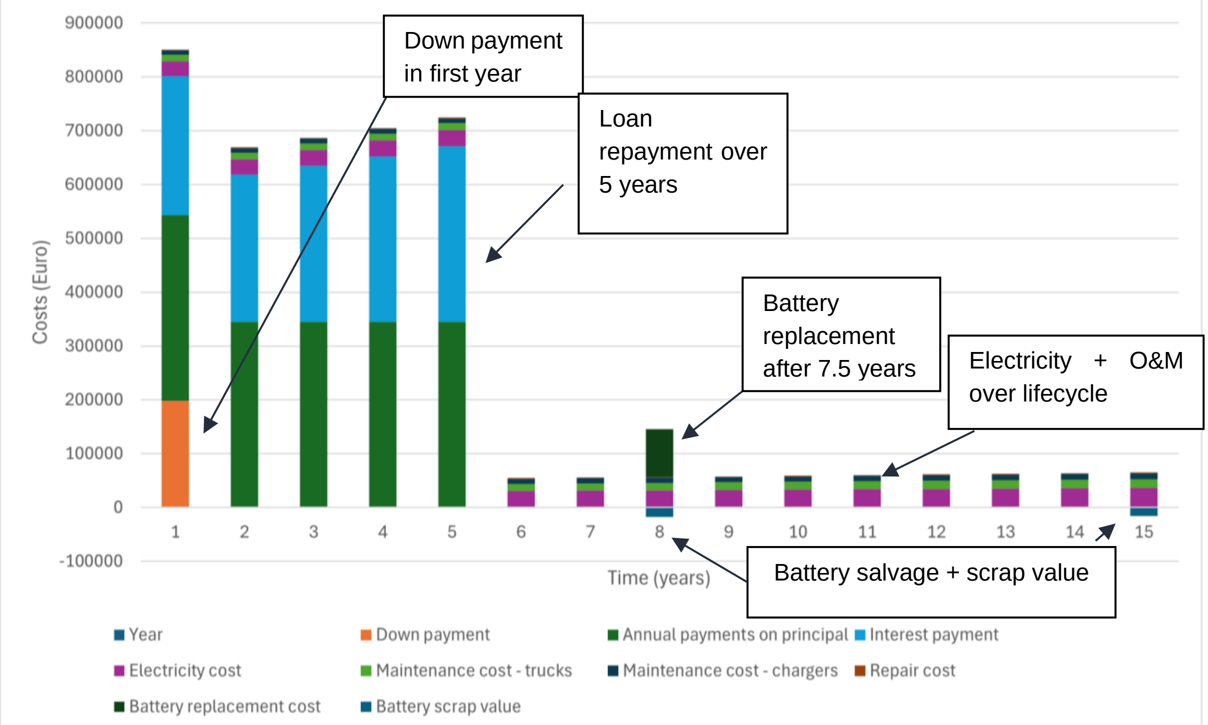


Figure 7: Illustrative example of an annual cash flow curve for a single electric truck

As shown in the example in Figure 7, the down payment results in larger outward cash flow (shown as positive) in the first year. The financing loan is paid off over a 5-year period, with payment for both the vehicle (in blue) and the interest associated with the loan (in orange). Throughout the entire lifecycle, there are payments for electricity (in green) and maintenance and repair (in red). In the 15th year, the batteries are sold for salvage value while the vehicle body is scrapped, leading to revenue (shown as negative).

The values of the cash flow from the cash flow curve, or their conversion through discounting to a net present value represent the total cost of ownership of the tool. For truck fleet operators, this information when combined with revenue streams provides the business case for an electric truck or the entire fleet of trucks. Assuming that out-of-scope costs such as insurance and labour, as well as ticket and non-ticket based revenues do not change with electrification of trucks, the TCO as calculated in this tool provides key financial information on the costs of electrification of truck fleets.

3 ESTIMATION OF CHARGING INFRASTRUCTURE

As the user inputs information on their fleet and its operations, the typical energy consumption per vehicle is estimated as described in Section 2.3.3. This section describes the methods used to estimate the type and quantity of charging infrastructure required on the parking site of the electrified fleet.

3.1 Scope

The process to establish the best configuration of chargers at a particular site is a complex problem. The best solution depends on a number of factors, including: operational needs of the fleet, limitations on import power at the site, existing energy loads at the site, onsite energy generation, physical/space limitations of the site, existing infrastructure, and availability of charging at other sites.

The online tool provides a simplified first estimate of the impact of charging the fleet at a single site. Users are able to input different configurations of charger equipment and view the impact of charging their fleet with this equipment on:

- The percentage of required energy by the fleet that can be supplied by the given equipment.
- The maximum grid import power required over a typical 24-hour time period.
- The ability of the fleet to increase self-consumption of onsite generated energy.

The tool does not replace a full site review, and will not consider: physical limitations, charging at other sites visited by the fleet, or existing charger infrastructure.

3.2 Infrastructure Calculation method

The daily charging needs of the fleet are calculated in several sub-stages based on inputs from the user.

3.2.1 Existing Site Baseload

The user is prompted to input a typical 24-hour power profile of the existing load at their depot site. The site baseload should include any existing sources that import power on the site, most notably nearby buildings. This can be input as a custom profile or can be constructed from one of two default profile shapes. A typical office profile is provided based on (HOMER Pro 2024) and shown in Figure 8.

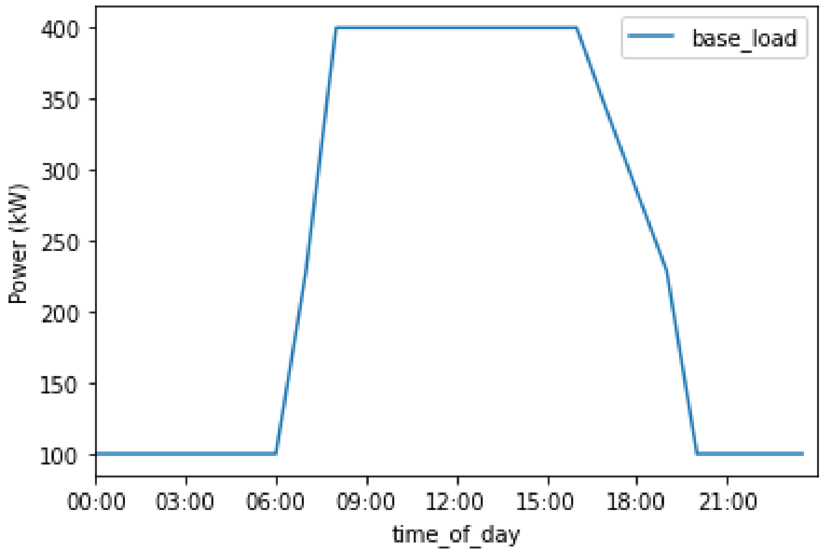


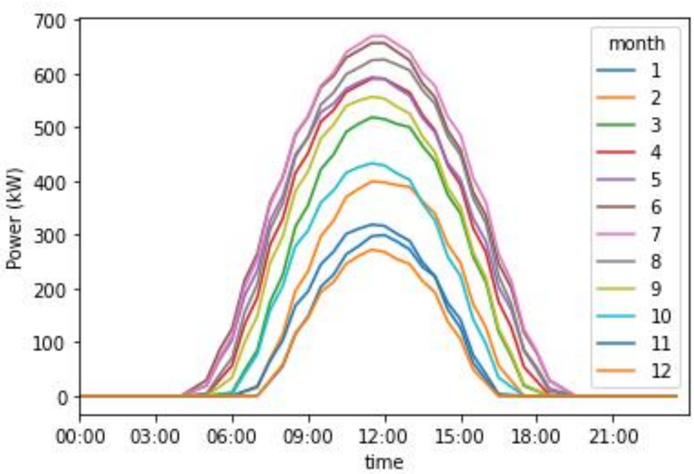
Figure 8: Example office load profile

3.2.2 Onsite Solar Energy Generation

Energy generated onsite can offset the charging load of the vehicles or baseload. The user can optionally input details of an existing or new photovoltaic (PV) installation to generate energy at their depot site.

Details of the generated power over the 24-hour charging period are retrieved from the European Commission Photovoltaic Geographical Information System (PVGIS) API (European Commission 2024a). With an input location, orientation and installed PV peak power, the PVGIS service provides a yearly record of solar energy provided by a PV array with the given specifications.

The user can choose to display a typical daily power profile for Summer, Winter or Year Average. In the tool, an average profile is made for each month as illustrated in Figure 9. The summer/winter profiles are selected based on the highest and lowest average daily generation respectively. Similarly, the year-average profile is based on all received data from the API.



The PVGIS service provides historical data based on actual received solar power at the chosen location, and so includes the average effects of cloud cover over each month of data.

Figure 9: Example of month-average solar generation 24-hour profiles from PVGIS data

3.2.3 First Estimate of Chargers Required

The tool considers four different charger types:

- Fast AC charging 22 kW
- Fast DC charging 50 kW
- Level 1 Ultra-Fast DC charging 150 kW
- Level 2 Ultra-Fast DC charging 350 kW

When the user navigates to the "Depot" screen, the tool will automatically populate a first estimate of the number of chargers required. It will assign one charger per vehicle with an energy consumption *E* and available charge time T_{Charge}, with a charger power *P* defined by:

$$P_{min} = \frac{E_{Winter}}{T_{Charge}}$$

Assuming that the vehicle uses the most energy during winter, this will provide a minimum power required to fully charge the vehicle during its available charging time. The vehicle will be assigned the smallest charger type that exceeds this minimum power requirement.

3.2.4 Resolution of Daily Charging

Charging is a complex process to optimise as both the needs of the fleet and the available onsite generation will change from day to day. This tool provides a simplified case based on a hypothetical single day within the chosen season (summer, winter, or year-average). It is assumed that all vehicles within the fleet operate on this day and will all need to fully recharge at the end of their shift. It is also assumed that the fleet completed exactly the same charging behaviour on the previous day, e.g. where a vehicle's time at the depot runs overnight, the available time to charge will wrap around to the morning of the displayed 24-hour profile.

Users can choose whether or not to apply smart charging to their fleet. Unconstrained or non-smart charging will charge each vehicle at the full power of its connected charger as soon as it arrives on site, until the battery is full. Smart charging will attempt to spread the load of fleet charging through all available time to minimise the peak charging power import, and maximise self-consumption of any onsite generation.

The tool does not offer a fully optimised charging strategy, as this is a computationally slow to process. Instead, it applies a processing-light estimate of smart charging algorithm based upon an existing tool within the Cenex portfolio. An example of the results from this smart charging estimate is shown in Figure 10.

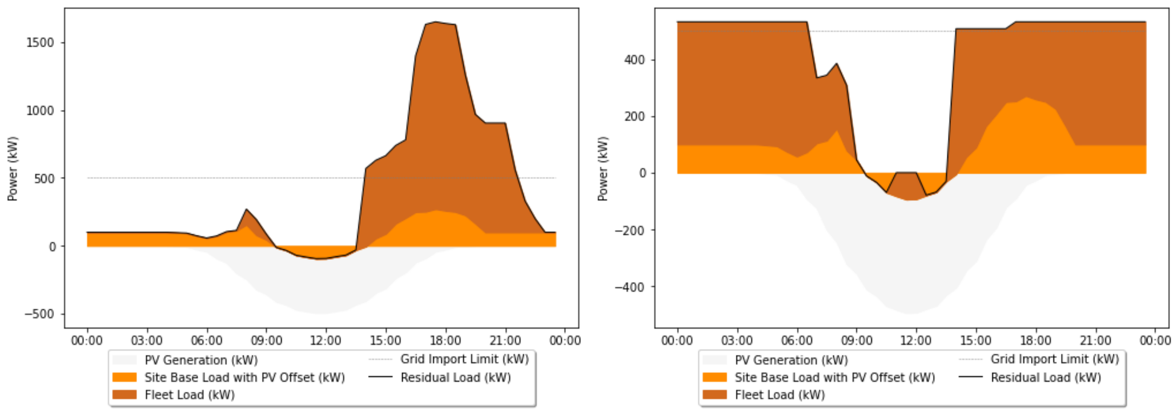


Figure 10: Example of a) Unconstrained and b) Smart Charging of fleet with base load and onsite generation

3.2.5 Success Metrics

Once the daily charging profile for the fleet has been calculated, the tool will generate a set of success metrics.

EV to charger ratio is defined in the equation below. The tool will default to a ratio of 1 charger per vehicle in the input fleet, but the user can alter the number of chargers to see if a more efficient solution can be found. Generally, if the fleet can be supplied with sufficient charge using a smaller number of chargers than vehicles (e.g. with an EV to charger ratio > 1), this would represent a greater saving on the overall infrastructure cost.

$$EVratio = \frac{Number\ of\ Electric\ Vehicles}{Number\ of\ Chargers}$$

Grid capacity deficit shows the shortfall (if any) of the existing electrical grid import limit to allow for charging of the input fleet under the chosen charging conditions. This is calculated based on the peak charging power during the chosen season (summer, winter, or year-average). In the ideal situation, the charging load of the fleet will not cause the site's overall power demand to exceed existing grid limits. In some cases, the site will require electrical grid infrastructural upgrades to allow sufficient import power for the additional load of fleet charging.

The percentage of range requirement met by the chosen chargers is calculated as in the equation below. The ideal value for this metric is 100%. If lower than 100%, this indicates one of the following issues:

a) The user has not selected enough chargers
b) The user has selected chargers with power ratings that are too low
c) The fleet cannot be sufficiently charged with the available charger types within the tool

$$Range\ Requirement\ Met = \frac{Estimated\ Charge\ Energy\ Supplied}{Total\ Fleet\ Energy\ Demand}$$

The percentage of electrical demand met by the existing infrastructure shows how much of the fleet's overall calculated load falls within the existing grid limitations as specified by the user. Once again, the ideal value for this metric is 100%. A value lower than 100% indicates that an upgrade to grid import capacity would be required to charge the fleet under the chosen charging conditions and season. For timesteps *t* with Site Residual Load *R*, base load *B* and PV generation *PV*, the electrical demand met is calculated using the equation below.

$$Elec\ Demand\ Met = \frac{Hours\ in\ Timestep * \sum_{t=0}^{n}(\min\,(Grid\ Import\ Limit, R_t) - B_t + PV_t)}{Total\ Fleet\ Energy\ Demand}$$

4 CALCULATION OF GHG EMISSION AND AIR POLLUTION REDUCTION

The digital tool can be used to calculate the reduction in greenhouse gases (GHGs) which contribute to climate change and the reduction in air pollution caused by vehicle exhaust as a result of transitioning from a diesel truck to an electric truck.

4.1 Scope of GHG emission reduction of electric trucks

The reduction in greenhouse gas (GHG) emissions attributed to electric trucks is expressed as a comparison with the trucks they are expected to substitute – diesel trucks of a similar size.

Within greenhouse gas emissions, a comprehensive approach would consider the well-to-wheel (WTW) emissions i.e. the emissions involved in the production of fuel and its delivery to the vehicle (well-to-tank emissions) and use in operation (tank-to-wheel or tailpipe emissions). As a reference, the representative well-to-wheel emission of heavy goods vehicles in the EU are around 137 gCO_2-eq. per tonne-km based on average loading (European Environment Agency. 2022).

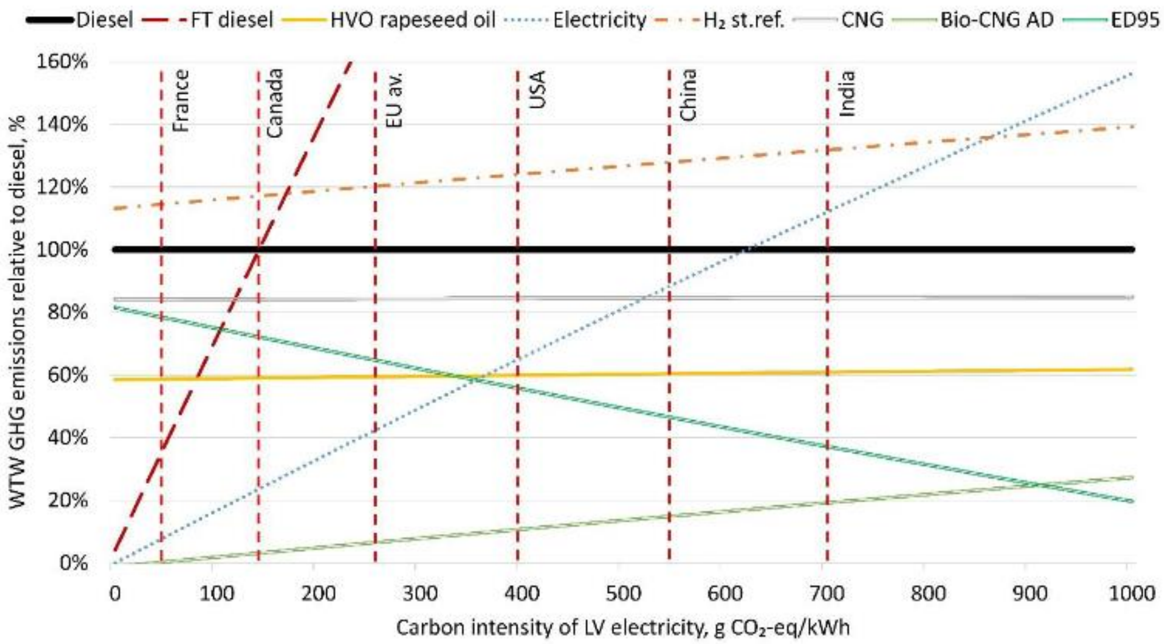


Figure 11: WTW greenhouse gas emissions of a 40 ton long haulage truck as a function of carbon intensity of electricity (Source: Gustafsson et al. 2021)

However, the well-to-wheel emissions are sensitive to the carbon intensity of electricity used for charging and therefore to the location (Gustafsson et al. 2021). With the mix of electricity sources within the countries in the NextETruck project differing from each other and also expected to change over the coming years, the estimation of emission factors associated with carbon intensity of electricity in each country's electricity grid is complex to calculate and also subject to considerable uncertainty. Further, since the geographical focus of this tool is the cities where the trucks run, rather than the powerplants where the electricity is generated, the scope of this tool is limited to tank-to-wheel (TTW) or tailpipe emissions.

The results of the greenhouse gas emissions calculated by this tool should therefore be interpreted with the caveat that they do not represent a comprehensive overview of the lifecycle of the vehicles under consideration, but only the tank-to-wheel phase. This is particularly important to note for the comparison between electric and fossil-based drivetrain. As shown in Figure 11, the well-to-wheel (WTW) emissions associated with 40 ton haulage trucks are around 40% of similar diesel powered trucks (Gustafsson et al. 2021). In comparison with diesel, electric drive has lower emissions on average throughout most place in the world – only the extent varies with location. Figure 12 shows the ratio of diesel and non-diesel trucks in the selected European countries as well as in the EU.

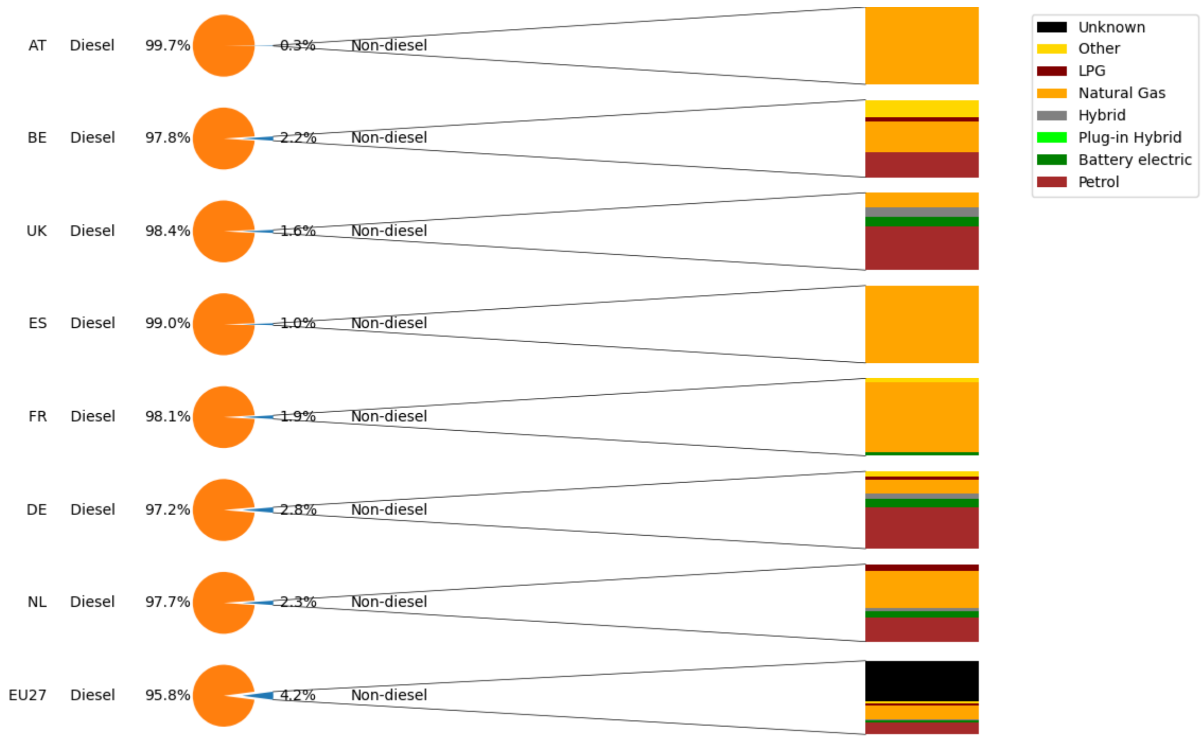


Figure 12: Share of diesel and non-diesel powered trucks in the selected European countries and the EU27 in 2022 [based on data from (ACEA 2024)]

Note: The authors were unable to find statistics on the split of trucks in Türkiye by power source, but it is expected that, similar to European countries, over 97% of Turkish trucks are powered by diesel.

It is clear from Figure 12 that nearly all the existing trucks in operation are powered by diesel, with over 97% of trucks powered by diesel in each of the studied countries (AT, BE, UK, ES, FR, DE, NL) and over 95% at the EU level[7]. In this report, we therefore focus on diesel substitution. This tool aims to provide an extent of GHG emission reduction at the tailpipe through the transition from diesel to electric trucks.

[7] Information on the split of truck in Türkiye by power source was not available.

4.2 Scope of air pollution reduction

The reduction in air pollution attributed to electric trucks is expressed as a comparison with the trucks they are expected to substitute – diesel trucks of a similar size. As a broader concept, air pollution covers ozone precursors, acidifying substances, greenhouse gases, particulate matter and heavy metals among others. Within air pollution, particulate matter with diameter of 2.5 micrometre or smaller ($PM_{2.5}$) and nitrogen oxide (NO_x) emissions are the categories that cause the highest mortality (premature deaths) in Europe (European Environmental Agency 2023). Heavy duty vehicles running on fossil fuels contribute to the production of these pollutants, and are amongst the main sources of pollution in urban areas (Bloemen et al. 2008; Camilleri et al. 2023). Hence, electrification of these vehicles has the largest health benefits in these categories.

For this reason, in this study, we limit our scope within air pollution to $PM_{2.5}$ and NO_x emissions. Only exhaust-based emissions are considered. Non-exhaust emissions such as evaporation of fuel from vehicles, brake and tyre wear and road wear are not considered. Non-exhaust emissions remain with the use of electric vehicles, and any change in these emissions as compared with diesel drive are not considered here[8].

For this study, we use definition and methods from the COPERT Guidebook - version 5.7 (Ntziachristos and Samaras 2023), which is the EU's standard vehicle emissions calculator.

4.2.1 $PM_{2.5}$ emissions

Particulate matter refers to fine inhalable particles where the diameter of each particle is 2.5 micrometres and smaller. Coarser fractions (PM2.5-10) are negligible in vehicular exhaust (ibid., p.3) and are not considered in this report. The values reported are the mass of particles collected on a filter kept below 52℃ during diluted exhaust sampling. This corresponds to total (filterable and condensable) $PM_{2.5}$.

4.2.2 NO_x emissions

The NO_x emissions cover nitric oxide (NO) and nitrogen dioxide (NO_2) and are reported as NO_2 equivalent mass.

[8] For a detailed and up-to-date report on the contribution of brake emissions at depots, refer the Horizon2020 funded AeroSolfD project report (Moreno et al. 2024).

4.3 GHG and Air pollution reduction calculation

The methods used here are derived from the COPERT Guidebook - version 5.7, which is the EU standard vehicle emissions calculator. It is globally recognised, used by many European countries for official reporting, peer reviewed and openly accessible. For further elaboration, the original guidebook can be referenced (Ntziachristos and Samaras 2023). This methodology calculates emissions and pollution based on estimations of the type and quantity of fuel consumed by standardised vehicle categories.

Within the COPERT framework, there are several methodologies which can be applied depending data availability. The decision tree for choosing the suitable methodology is shown in Figure 13.

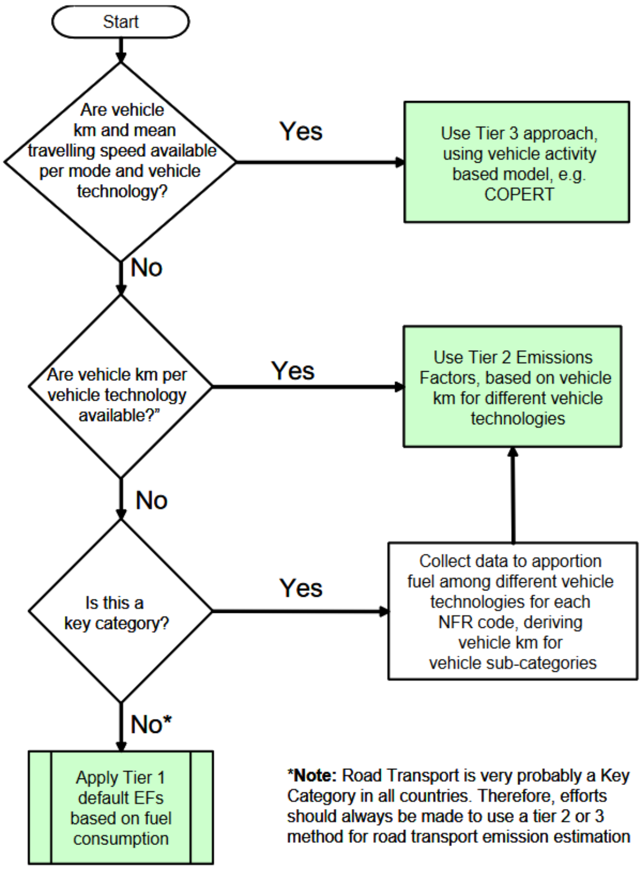


Figure 13: Decision tree for choosing a method for calculating emissions from road transport (Source: COPERT Guidebook - version 5.7)

Within the NextETRUCK project, where the method is applied to prospective truck routes to be deployed at a later stage in the project, there is currently no measured data on the vehicle kilometres driven and mean travelling speed.

At this stage, the number of trucks and their vehicle category are known, along with an estimate of the kilometres that they will drive in anticipated operation. For this reason, the Tier 2 emission factors are used. These Tier 2 emissions factors are provided in units of grams per vehicle-kilometre for each type of truck.

4.3.1 Truck fleet-level calculation

The general formula used for calculation of annual air pollution of type *p* through the COPERT Tier 2 method is:

$$E_p = \sum_{i=1}^{n} (M \times EF_p)$$

where *n* is the total number of trucks of the technology/ powertrain under consideration,
i is the index of any given truck ranging from 1 to *n*,
M is the average annual distance driven per vehicle (in km/vehicle), and
EF_p is the technology-specific emission factor of pollutant *p* for the truck.

4.3.2 Technology specific Emission Factors

We compare electric trucks with diesel trucks, which can use various types of fuels based on the Euro standards. The diesel VI D/E is the latest diesel standard with vehicles already on the road. We aim to compare the newly introduced electric trucks with the technology which a new diesel truck would use rather than older diesel technologies, and therefore use diesel VI D/E as the diesel benchmark.

New legislation passed in April 2024 pushed for more stringent Euro VII standards for N2 and N3 vehicles. Four years after publication (2028), this will apply to all new M3 vehicle models while 5 years after publication (2029), this will apply to all vehicle models. The timeline for Euro VII is beyond the NextETRUCK timeline, and therefore not considered here.

The emission factors used are presented in

Table 7. NO_x and $PM_{2.5}$ are directly calculated on the basis of kilometres driven. For CO_2, which is more sensitive to the fuel type, an additional step of using standard fuel use per km and then the factor for CO_2 content based on complete combustion is applied.

In our tool, we further make a division between driven cycles on the fuel consumption per driven km, shown in Table 8.

Table 7: Truck emission factors for diesel Euro VI D/E fuel based on COPERT Tier 2 methods

Vehicle category	Gross Vehicle Weight (tonne)	NO_x[9] (gNO_2-eq/km)	$PM_{2.5}$[10] (g/km)	Fuel consumed[11] (g/km)	CO_2[12] (g CO_2/ g diesel)
N2 or N3	<=7.5t	0.18	0.0005	101	3.169
N2 or N3	7.5 to 16t	0.291	0.0008	155	
N3	16 to 32t	0.422	0.0012	210	
N3	>32t	0.507	0.0013	251	

Note: N2 vehicles are vehicles used for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes. N3 vehicles are vehicles used for the carriage of goods and having a maximum mass exceeding 12 tonnes.

Table 8: Diesel consumed per kilometre driven per truck type differentiated by drive cycle

Vehicle category	Congested	Urban	Rural	Motorway
≥3.5 t Vans (N2 4x2)	0.102	0.082	0.089	0.089
≤7.5 t Rigid Truck (N2 4x2)	0.166	0.140	0.117	0.108
18 t Rigid Truck (N3 4x2)	0.283	0.238	0.199	0.184
18 t Refuse Collection Vehicle	0.388	0.326	0.318	0.295
26 t Rigid Truck (N3 6x2 or N3 6x4)	0.431	0.363	0.315	0.286
26 t Refuse Collection Vehicle	0.530	0.478	0.329	0.329
32 t Rigid Truck (N3 8x4)	0.770	0.515	0.483	0.483
40 t Articulated Truck (N3 4 x 2 tractor)	0.483	0.408	0.312	0.279
44 t Articulated Truck (N3 6 x 2 tractor)	0.541	0.455	0.355	0.235

[9] Ntziachristos and Samaras (2023), Table 3-21: Tier 2 exhaust emission factors for heavy-duty vehicles

[10] Ntziachristos and Samaras (2023), Table 3-22: Tier 2 exhaust emission factors for heavy-duty vehicles

[11] Ntziachristos and Samaras (2023), Table 3-27: Tier 2 average fuel/energy consumption values)

[12] CO2 emission factors are based on an assumed 100% oxidation of the fuel carbon (ultimate CO2)

5 CONCLUSIONS

This report describes the methods used to develop a digital tool for planning for deployment of electric trucks and preparing a strategy for it. It enables users to:

1) Calculate the power rating and quantity of charging infrastructure required for charging a given electric trucks at a depot
2) Calculate the total cost of ownership (TCO) of the electric truck fleet and associated charging infrastructure
3) Calculate the reduction in tank-to-wheel (TTW) greenhouse gas emissions and air pollution reduction caused by the shift to electric trucks from diesel trucks

The tool is expected to provide clarity related to the TCO of electric trucks for fleet operators considering electrification in the upcoming years. Several key areas of investment, including the vehicle, the charging infrastructure and the extent of grid upgrade required are all calculated in the tool, thereby providing the inputs for making a business case. However, certain aspects of the business case such as the cost of public charging along highways and the cost of labour in running logistic operations are missing in the tool, since these are location- and case-specific.

The report is expected to be of interest to truck fleet operators and logistics providers as well as researchers, planners and other stakeholders in the trucking and logistics sectors.

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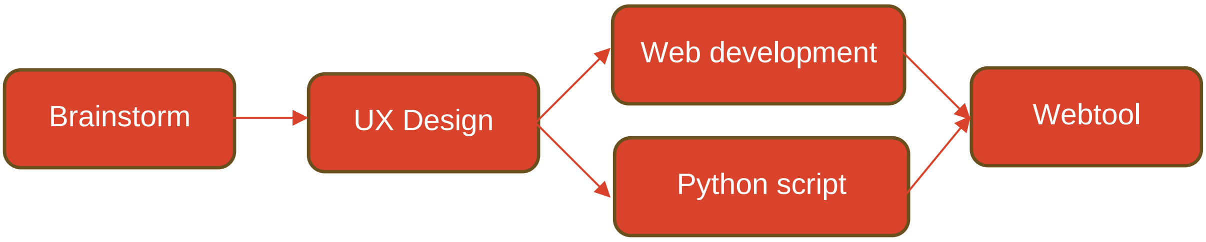
7 APPENDIX A

The NextETruck Fleet Decarbonisation Strategy tool is a free to use public webtool. To access the tool online, it will need to run on a server and accessible via a URL. The proces to get to the end result followed a number of steps. In the brainstorming phase, the required functions were discussed up to a conceptual design. The external and subcontracted party (Bootmine) turned the conceptual design in to a professional UX design. The functions were developed in to a Python script while in parallel Bootmine built the back-end and front-end of the tool. The end result is the online webtool.



7.1 User interface design

To be of value for the end user, the development team brainstormed what functions the webtool should include and to what level this needs to provide information. The purpose is to provide a comprehensive overview without making the information output too complex. The end-user may not be an expert in this topic, a factor that should be taken into account. Various design concepts were proposed, where one design was chosen to continue the development.

The chosen conceptual design revolves around four main sections for in- and outputs:

1. Fleets
2. Depot
3. Finance
4. Results

In the following subsections, the four main sections are elaborated on how and what the end-user will come across during the use of the tool to get a picture of the impact on the financial and electric implications when transitioning its fleet to electric.

7.1.1 Fleets

The Fleets section offers support for up to five groups of vehicles of a certain class and/or type of use. These include vans, rigid trucks and articulated trucks. For each group, the number of axles (when applicable) can be configured, and the trucks function, either for regular operation or for waste disposal, can be specified as input. To get a good understanding of the operational activities, the duty cycle, daily distance (per week) and the shift hours are inputs for each group. Vehicles are fitted with different sizes of batteries, of which the option are provided from small (80 kWh) up to large (300 kWh). In addition, the preferred charging power from 22 kW up to 350 kW are options to choose from. Lastly, the ownership period should be provided, which is relevant for the financial calculations. Bootmine turned the conceptual design in to a professional UX design, as shown in Figure 14.

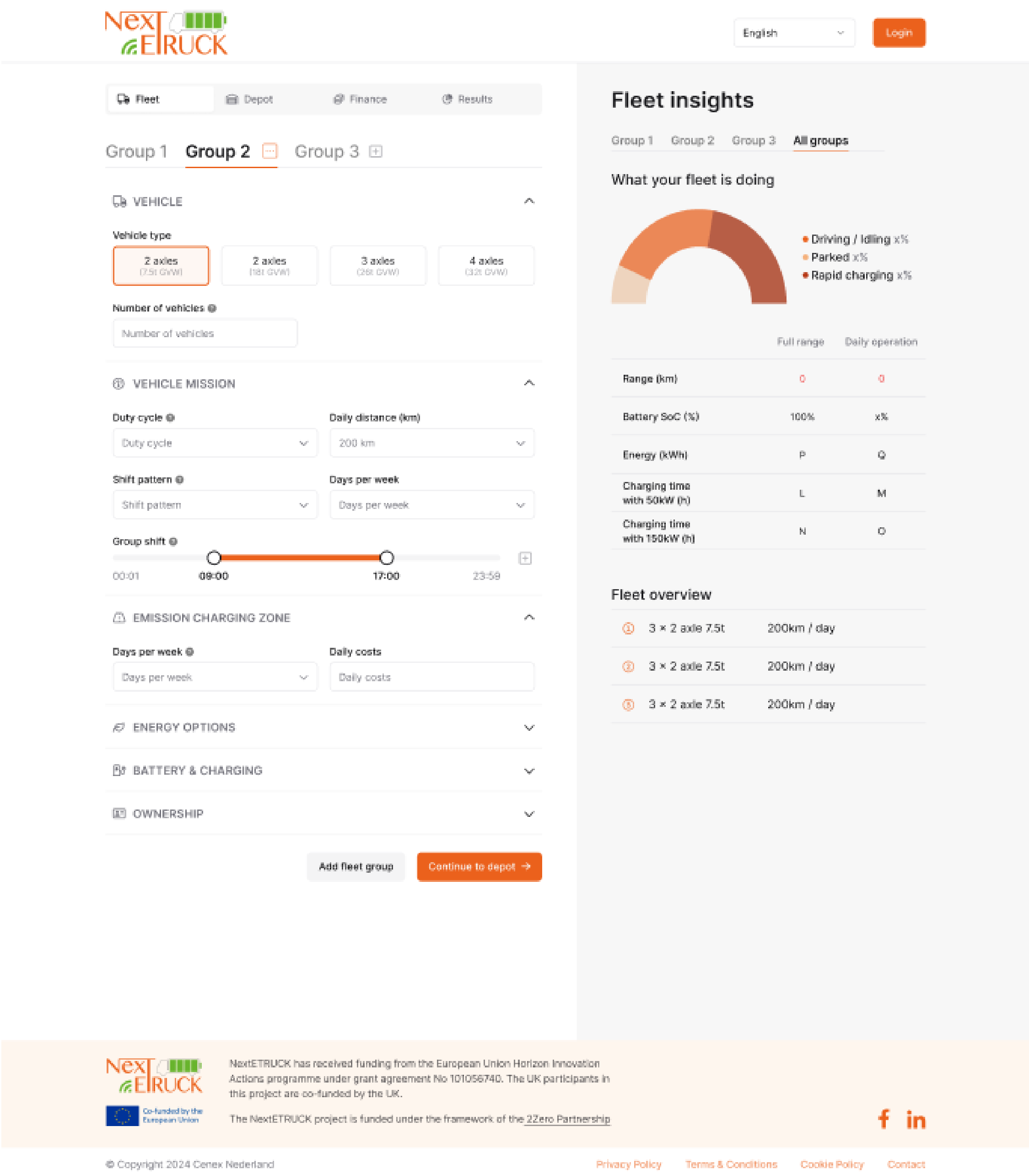


Figure 14 UX design of the Fleets section by Bootmine

7.1.2 Depot

The depot section (see Figure 15) is referred to as the base location of the end-user's fleet, where vehicles load their goods and often stay overnight. When parked at the depot, the electric truck could be charged on-site. To get a good understanding of the limitations of the site, the user is asked to provide the grid connection limits and its peak load value (kW). Standard load patterns are provided to choose from, such as: office, continuous and custom.

The required charging infrastructure, based on the inputs of the fleet, is displayed, but can be altered manually if needed. The location of the depot can be entered, which is relevant for any solar installation (especially as the tool can be applied for different countries in Europe with different solar intensities). Additional information of this solar installation, such as the peak power value should be provided as well. The energy costs are important for the financial calculations.

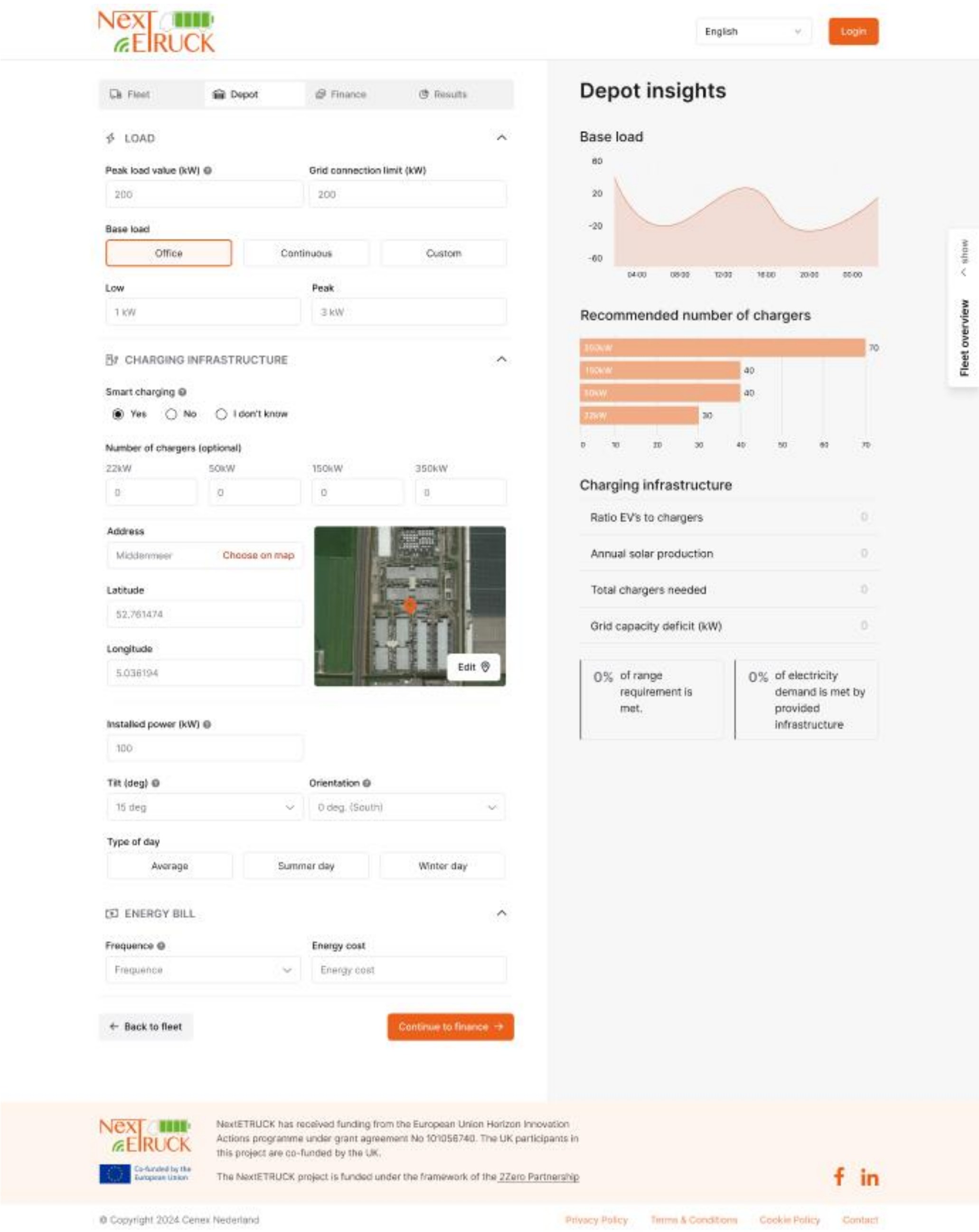


Figure 15 UX design of the Depot section by Bootmine

7.1.3 Finance

The third section is called Finance (see Figure 16), focussing on the CAPEX and OPEX of the end user's fleet and installations. To start, a country should be selected from the list, which consists of a selection of European countries for which the subsidy values have been researched and entered as a preset. If the country is not listed, the values can be entered manually to facilitate the other European countries. The subsidies and costs may apply to either the fleets per group, the charging infrastructure or the solar installation.

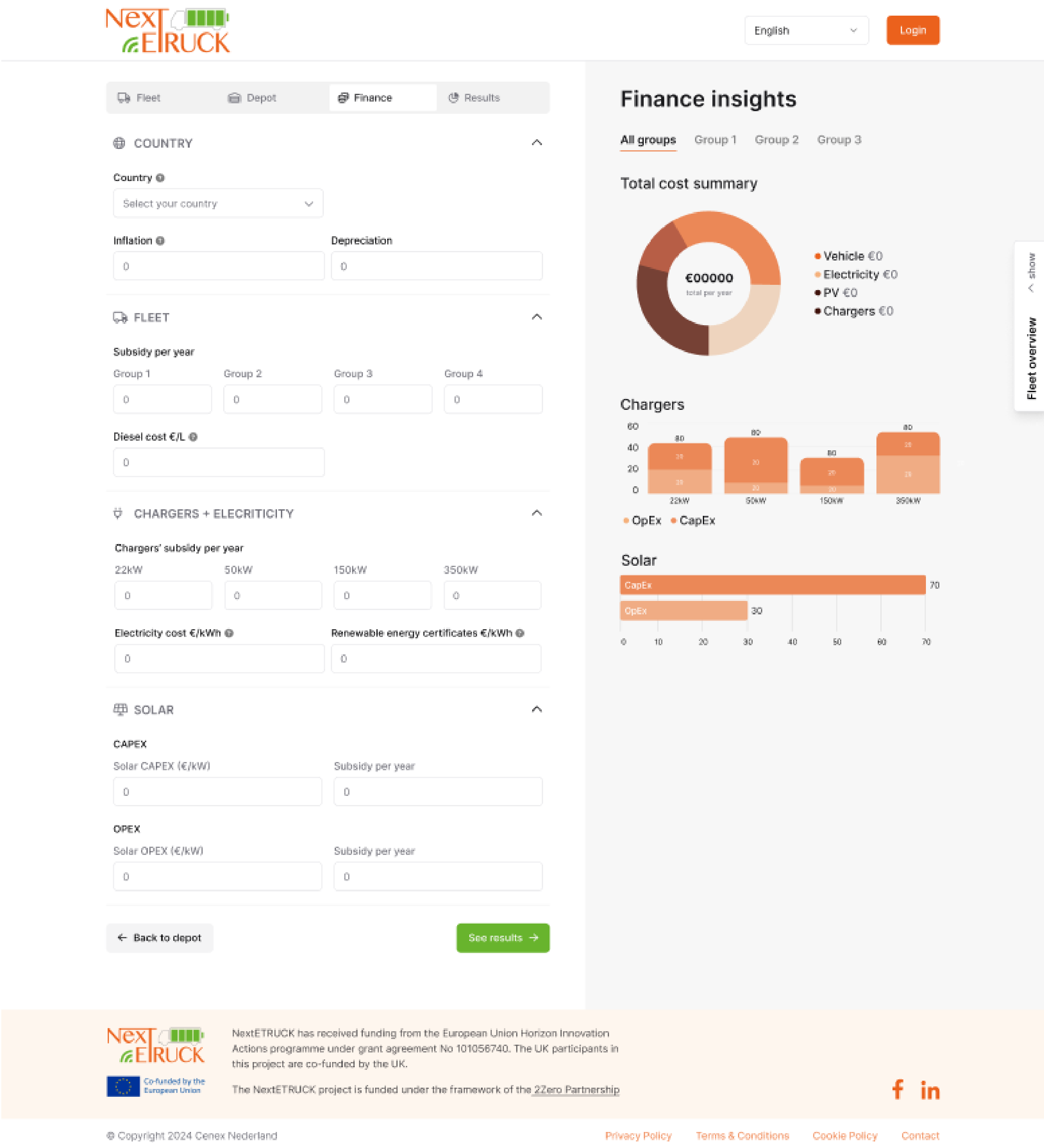


Figure 16 UX design of the Finance section by Bootmine

7.1.4 Results

The final section of the webtool is the Results section (see Figure 17), providing an overview of the in- and outputs in values and infographics. More detailed information can be found by clicking on the sub-tabs. Besides the overview, the subtabs include the fleet, charging infrastructure, costs, environmental and vehicles suggestion.

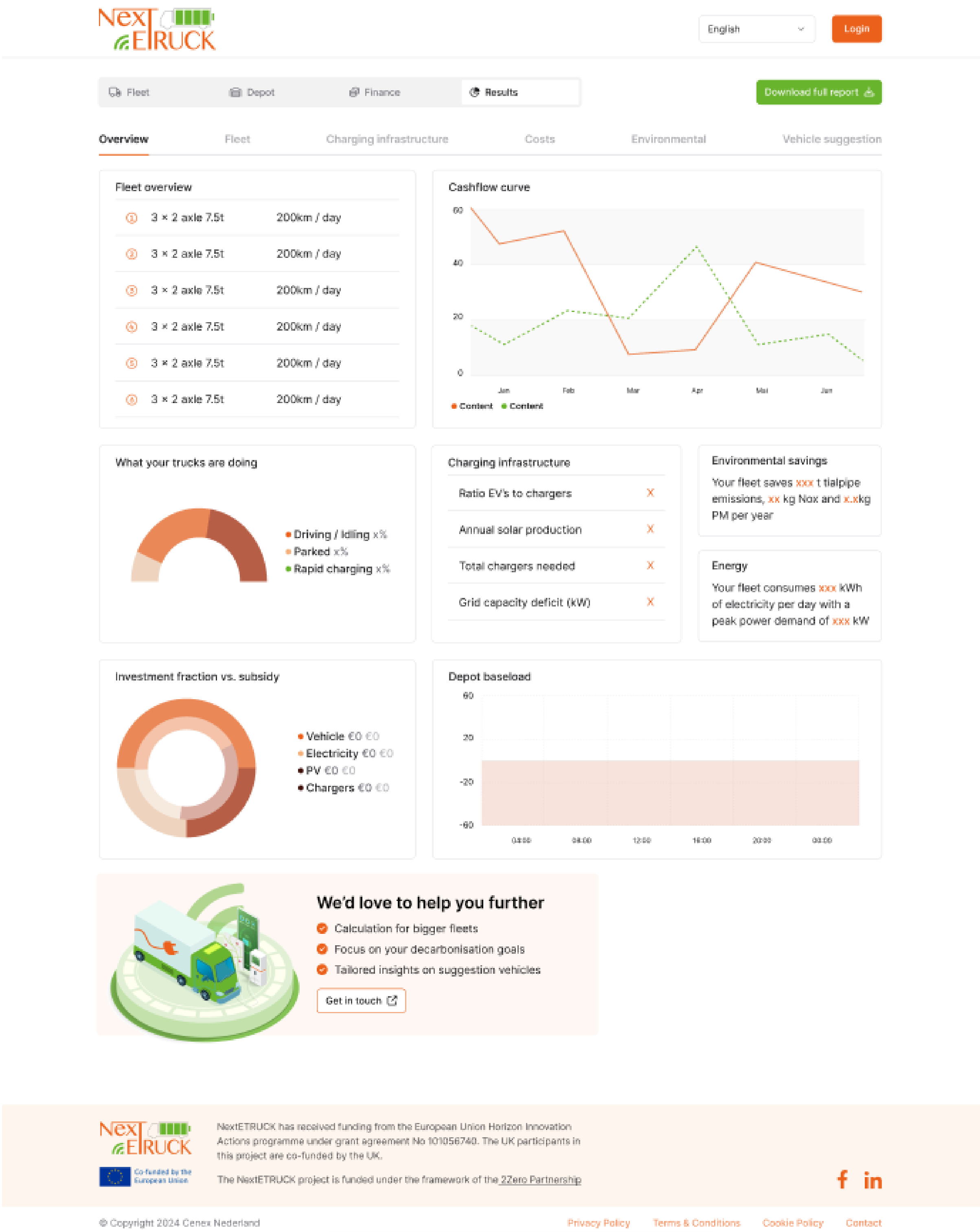


Figure 17 UX design of the Results section by Bootmine

The end-user is given the option to export the results to a PDF as a download for later reference.

7.2 Webtool features

To facilitate the end-user, the tool is fitted with features such as a language selector. Bootmine built a module on the back-end which allows to translate the webtool in different languages, making the tool more accessible and convenient for multiple countries. Also, the units and currencies can be changed, which is convenient for countries such as the United Kingdom and Turkey.