
Analysis of the Total Cost of Ownership of Electric and Combustion Engine Trucks Used in Poland

Submitted 15/08/25, 1st revision 29/08/25, 2nd revision 11/09/25, accepted 30/09/25

Paweł Miązek¹, Lei Lei Zhang²

Abstract:

Purpose: This article focuses on analyzing the automotive market and comparing the economics of combustion engine and electric vehicles. Separate cost models were created to compare the two types of transportation.

Design/Methodology/Approach: The article analyzes one-time, recurring, and variable costs for both models. In addition, the cost model for electric cars has been enriched with avoided costs that will not be incurred when operating electric vehicles. The analysis included an economic comparison and addressed non-cost issues that cannot be clearly quantified.

Findings: When comparing the total cost of ownership of electric vehicles and combustion engine vehicles over a five-year period, the most economical solution is to choose electric vehicles and invest in private charging infrastructure.

Practical Implications: The global automotive market is changing dynamically. In recent years, there has been a noticeable trend towards the electrification of cars, which has led to a significant increase in the number of electric vehicles on the roads.

Originality/Value: Currently, most car manufacturers have electric vehicles in their range.

Keywords: Electromobility, electric vehicles, TCO.

JEL Codes: O30, O32, O33.

Paper Type: Research article.

Acknowledgement: This research was co-financed by the Minister of Science under the "Regional Excellence Initiative."



Regionalna
Inicjatywa
Doskonałości



Ministerstwo Nauki
i Szkolnictwa Wyższego

¹University of Szczecin, Institute of Management, Research Center for Management of Energy Sector, Poland, ORCID: 0000-0002-5202-8406

e-mail: pawel.miazek@usz.edu.pl;

²Jiangxi University of Science and Technology, Jiangxi Province, Grodno State University, Belarus, e-mail: 328386133@qq.com;

1. Introduction

Electric cars are increasingly able to successfully replace standard combustion engine vehicles. The range of electric vehicles, both trucks and passenger cars, can reach up to 1,000 km. This means that for most users, an electric car will be fully functional when compared to a combustion engine car. Since limited range will not be a problem for most users, the article compares the two types of transport in economic terms. In order to compare the vehicles, a TCO (total cost of ownership) analysis was carried out for both electric and combustion engine vehicles.

All costs of owning a car, both combustion engine and electric, over a period of 5 years were analyzed. The highest costs generated during car use are those incurred for fuel or electricity. Given the importance of this issue, three options for charging electric vehicles were analyzed.

The article compares three options: charging vehicles using private charging infrastructure, using publicly available DC charging stations, and using publicly available AC charging stations. Depending on the power of the charging station, the fee per kWh may vary, which is why three variants were calculated. As a result, the article not only answers the question of whether an electric or combustion engine car is a more economical choice, but also indicates the most advantageous solution for charging electric vehicles.

2. Literature Review

Scientists believe that the ever-increasing number of electric vehicles can significantly contribute to improving air quality. This improvement can be achieved by reducing CO₂ and NO_x emissions (Lewicki, Drożdż, Wróblewski, and Żarna, 2021). Therefore, many countries across Europe are introducing policies to promote electric vehicles (Lebeau, Macharis, and Van Mierlo, 2019). At the same time, the implementation of transport based on solutions using electricity has become part of the development of European Union countries (Lewicki and Drożdż, 2021).

The constantly developing infrastructure of charging networks for electric vehicles also has a positive impact on encouraging users to switch to electric vehicles (Pawłowski and Miązek, 2024). However, the increase in electricity demand associated with the spread of electric vehicles requires innovative solutions from electricity distribution system operators (Jaworski, Miskiewicz, Miązek, Drożdż, Rzepka, and Karnowski, 2024). Electric vehicles are increasingly becoming the subject of research due to falling battery prices and ever-increasing operational capabilities.

Battery capacities are constantly increasing, and as a result, the range of vehicles is also increasing (Coban, Lewicki, Sendek-Matysiak, Łosiewicz, Drożdż, and Miśkiewicz, 2022). Articles describing TCO very often cover only passenger

vehicles (Champeechoensuk, Saisirirat, Chollacoop, Vithean, Thapmanee, Silva, and Champeechoensuk, 2025; De Clerck, van Lier, Messagie, Macharis, Van Mierlo, and Vanhaverbeke, 2018). There are also articles in the literature that cover a broader comparison of electric trucks with combustion engine trucks (Davis, and Figliozzi, 2013; Feng and Figliozzi, 2013; Taefi, Stütz, and Fink, 2017).

Regardless of the type of transport, the total cost of ownership is defined as all expenses incurred by a specific user, starting with the purchase of the vehicle and ending with its final disposal or sale (Miśkiewicz, Lewiński, Drożdż, Dowejko, and Miązek, 2024). This article enriches the currently available literature with additional aspects, taking into account the exact values of subsidies for the purchase of electric vehicles, which in Poland reach up to PLN 40,000. This is a significant amount that can positively influence the decision to choose a specific type of vehicle.

Another aspect that enriches the current literature is the presentation of avoided costs incurred by users of combustion engine vehicles but not by users of electric vehicles. Avoided costs were taken into account both in quantifiable terms, i.e., not having to pay for parking in large cities in Poland, and in non-quantifiable terms. The non-quantifiable costs included, among others, time savings resulting from the possibility of using bus lanes or the ease of finding a parking space reserved exclusively for electric vehicles. Opinions on the cost-effectiveness of using an electric car are divided, depending on the type of charging infrastructure used (Lebeau, Lebeau, Macharis, and Van Mierlo, 2013; Huber, De Clerck, De Cauwer, Sapountzoglou, Coosemans, and Messagie, 2021).

Therefore, this article analyzes three forms of vehicle charging. The first form is charging a vehicle using private charging infrastructure, the second form is using publicly available AC charging stations, and the last is using publicly available DC charging stations. The analysis of the costs incurred in each case not only allows for a comparison of the total cost of ownership of electric vehicles with that of internal combustion engine vehicles, but also answers the question of which form of charging electric vehicles will be the most economically advantageous over the analyzed 5-year period of operation.

3. Research Methodology

A comparative analysis of the profitability of purchasing and operating electric and combustion engine vehicles was based on two separate models. The model describing the TCO (Total Cost of Ownership) for combustion engine vehicles included the following components: one-off costs, recurring costs, and variable costs. The basic one-off costs included the costs of purchasing vehicles, registering vehicles, and adapting them for use. Another component is recurring costs, which include insurance costs, periodic inspection costs, parking zone subscription fees, motorway tolls, etc. The third group of costs analyzed are variable costs. These include fuel, servicing, and spare parts. The final value to be deducted from the total

costs is the residual value. The residual value is the estimated amount for which the vehicle can be sold after its useful life. The model used to calculate the TCO for combustion engine vehicles is shown in the table below.

Table 1. TCO model - combustion engine vehicles

TCO model - combustion engine vehicles		
One-off costs (OC)	Recurring costs (RC)	Variable costs (VC)
Vehicle purchase	Vehicle insurance	Fuel
Vehicle registration	Cost of periodic inspections	Service
Adaptations for use	Parking zone subscription, motorway tolls, etc.	Spare parts
Residual value (RV)		

Source: Own study.

The model used to calculate the total cost of ownership of electric vehicles has been expanded to include another cost group, namely: avoided costs. This means that the model includes four cost groups. The first group consists of one-off costs, which include vehicle purchase costs, registration costs, adaptation to use costs, and the purchase of a charging station. The next group consists of recurring costs, which include vehicle insurance, the cost of periodic inspections, motorway tolls, car washes, etc.

The third group, which was also present in the previous model, is the group containing variable costs. This group includes costs incurred for electricity, vehicle servicing, spare parts, and charging station servicing. The fourth group of costs, which occurs in the case of the model for electric vehicles but not in the case of the model for combustion engine cars, is avoided costs. This group includes the costs of paid public parking, which is free for electric cars, time savings due to the possibility of using bus lanes, and no need to pay fees for entering clean transport zones in city centers. The model showing the total cost of ownership of electric vehicles is presented in Table 2.

Table 1. TCO model - electric vehicles

TCO model - electric vehicles			
One-off costs (UC)	Recurring costs (RC)	Variable costs (VC)	Avoided costs (AC)
Vehicle purchase	Vehicle insurance	Electricity	Paid public parking
Vehicle registration	Cost of periodic inspections	Vehicle servicing	Time savings
Adaptations for use	Highway travel, car wash, etc.	Spare parts	Clean transportation zone entry fees
Purchase of charging stations		Charging station service	
Residual value (RV)			

Source: Own study.

The biggest cost incurred during vehicle operation is, of course, fuel expenses (in the case of combustion engine cars) and electricity expenses (in the case of electric cars). Therefore, three versions of charging electric vehicles were calculated for comparison.

The first involved the purchase of proprietary charging infrastructure and subsequent charging of vehicles on one's own.

The second version involved charging vehicles using publicly available alternating current (AC) charging infrastructure with a power of up to 22 kW.

The third version involved charging vehicles using publicly available direct current (DC) charging infrastructure with a power output of over 50 kW.

The average electricity and fuel consumption for each vehicle model was determined based on information from vehicle manufacturers.

4. Research Results and Discussion

A significant cost incurred even before the start of operation is the purchase of vehicles. This cost is significantly higher for electric cars, despite the subsidies offered. Table 3 shows the purchase costs of the analyzed combustion engine vehicles.

Table 3. *Prices of combustion engine vehicles*

Make and model	Net price	Gross price
Opel Vivaro	PLN 143,700.00	PLN 176,751.00
Peugeot Expert	PLN 143,700.00	PLN 176,751.00
Renault Trafic	PLN 137,700.00	PLN 169,371.00
Ford Transit Custom	PLN 128,732.00	PLN 158,340.36
Fiat Scudo	PLN 142,887.00	PLN 175,751.01

Source: *Own study based on information from car manufacturers.*

For comparison purposes, Table 4 shows the purchase costs of twin vehicles, but with electric drive.

Table 4. *Prices of electric vehicles*

Make and model	Net price	Gross price
Opel e-Vivaro	PLN 207,900	PLN 255,717.00
Peugeot e-Expert	PLN 207,900	PLN 255,717
Renault Trafic e-tech electric	PLN 197,500	PLN 242,925
Ford Transit Custom	PLN 181,549	PLN 223,305.27
Fiat e-Scudo	PLN 207,087	PLN 254,717.01

Source: *Own study based on information from car manufacturers.*

At first glance, there is a significant difference in the purchase price of vehicles, depending on the type of drive used. In order to offset the price difference and encourage users to purchase electric vehicles, subsidies have been introduced in Poland. The maximum subsidy amount under the "NaszeAuto" program is PLN 40,000 (Naszeauto.gov.pl), so this amount will be deducted from the purchase price later in this article.

According to information on city council websites, the cost of registration in 2025 is PLN 160 (eurzad.szczecin.pl). According to information received from vehicle dealers, comprehensive insurance and third-party liability insurance for new vehicles amounts to approximately 2% of the value of the car. That is why this amount has been taken as the estimated cost of insurance.

A comprehensive package including periodic inspections, free replacement of defective parts, a replacement vehicle, and replacement of wear parts is priced by dealers at PLN 1,799 for combustion engine vehicles and PLN 1,161 for electric vehicles (peugeot.pl). An additional cost is city parking, which in one of the cities in Poland costs PLN 300 per month (spp.szczecin.pl).

The cost of purchasing a wallbox for private use is approximately PLN 3,899, while extending the warranty to 5 years (total analysis period) costs an additional PLN 699 (greenwallbox.pl). Table 5 shows the WLTP combined cycle fuel consumption of combustion engine vehicles. The fuel purchase price was determined based on the average price for the first month of 2025 and amounted to PLN 6.14/l (orlen.pl).

The price per kWh when using a private charging station was determined based on the price list of one of the distribution system operators and amounted to PLN 0.6213/kWh (enea.pl). When using publicly available charging stations, the costs are as follows: AC – PLN 1.43/kWh and DC – PLN 2.39/kWh (orlen.pl).

Table 5. WLTP combined cycle fuel consumption (l/100km)

Make and model	WLTP combined cycle fuel consumption (l/100 km)	Engine power (HP)	Engine displacement (cm ³)
Opel Vivaro	7.3	144	1997
Peugeot Expert	8.2	144	1997
Renault Trafic	7.1	150	1997
Ford Transit Custom	8.1	136	1996
Fiat Scudo	8.2	144	1997
Average fuel consumption	7.78	143.6	1996.8

Source: Own study based on information from car manufacturers.

For comparison, Table 6 shows the WLTP combined cycle electricity consumption.

Table 6. Combined cycle energy consumption (kWh/100 km) WLTP

Make and model	Vehicle range in the WLTP combined cycle (km)	Energy consumption in the WLTP combined cycle (kWh/100 km)	Battery capacity	Engine power (hp)
Opel e-Vivaro	352	237	75	136
Peugeot e-Expert	313	289	75	136
Renault Trafic e-tech electric	318	221	52	122
Ford Transit Custom	327	230	64	136
Fiat e-Scudo	313	289	75	136
Average	324.6	253.2	68.2	133.2

Source: Own study based on information from car manufacturers.

Combustion engine:

$$TCO = UC + RC + VC - RV$$

UC – Unit costs

RC – Recurring costs

VC – Variable costs

RV – Residual value

$$TCO = (171,392.87 + 160) + (2\% * 171,392.87) + (7.78 * 1000 * 6.14 + 1799 * 5) - 87,000 = 171,552.87 + 3,427.86 + 56,764.2 - 87,000 = \text{PLN } 144,744.93$$

Electric drive:

$$TCO = UC + RC + VC + AC - RV$$

KJ – Unit costs

RC – Recurring costs

VC – Variable costs

AC – Avoided costs

RV – Residual value

Charging at public AC charging stations with a power of up to 22 kW.

$$TCO = (246,476.26 - 40,000 + 160) + (2\% * 246,476.26) + (25.3 * 1,000 * 1.43 + 1,161 * 5) - 92,250 = 206,636.26 + 4,929.5 + 41,984 - 18,000 - 92,250 = \text{PLN } 143,299.76$$

Charging at public DC charging stations with a power output of over 50 kW.

$$TCO = (246,476.26 - 40,000 + 160) + (2\% * 246,476.26) + (25.3 * 1000 * 2.39 + 1161 * 5) - 92,250 = 206,636.26 + 4,929.5 + 66,272 - 18,000 - 92,250 = \text{PLN } 167,587.76$$

Charging using private charging infrastructure (wallbox) with a power of 7.4 kW.

$$\text{TCO} = (246,476.26 + 3,899 - 40,000 + 160) + (2\% * 246,476.26 + 699) + (25.3 * 1000 * 0.6212 + 1,161 * 5) - 92,250 = 210,535.26 + 5,628.5 + 21,521.36 - 18,000 - 92,250 = \text{PLN } 125,435.12$$

5. Conclusions, Proposals, Recommendations

Considering purely economic aspects, owning an electric car proves to be the best solution over a 5-year period of use. Both types of vehicle power have their pros and cons, so it is important to take a personalized approach that takes specific needs into account.

The most cost-effective solution is to purchase an electric vehicle (taking advantage of the subsidies currently offered in Poland) together with the charging infrastructure.

The infrastructure costs are quickly recouped, generating lower total costs over a 5-year period of PLN 17,864.64 compared to charging at publicly available alternating current (AC) charging stations and PLN 42,152.64 compared to charging at publicly available direct current (DC) charging stations.

The total operating costs of cars with conventional combustion engines over the 5-year analysis period amount to PLN 144,744.93, which puts them in third place in the presented ranking.

The article includes the total operating costs of combustion engine and electric cars. However, not all costs will be quantifiable. In the case of electric cars, avoided costs, which cannot be clearly quantified, play an important role. Avoided costs include, among others, time savings resulting from the possibility of driving in bus lanes. This privilege is particularly important when driving in very large and congested cities.

However, it is difficult to clearly calculate the savings generated by this privilege. Another privilege is the ability to park at public charging stations for electric vehicles. This option is particularly valuable when traveling in very congested cities where it is difficult to find a parking space in the center.

Currently, the network of public charging stations for electric vehicles is constantly expanding, which means that there are more parking spaces for electric cars and, at the same time, fewer parking spaces for conventional combustion engine vehicles.

Considering the above, when analyzing two different types of vehicles, in terms of economic criteria and during the period when vehicles are covered by the manufacturer's warranty, the purchase of an electric vehicle will be the more advantageous solution.

References:

- Champeechoarensuk, T., Saisirirat, P., Chollacoop, N., Vithean, K., Thapmanee, K., Silva, K., Champeecharoensuk, A. 2025. Total cost of ownership (TCO) analysis of electric vehicles in ASEAN. *Energy for Sustainable Development*, Volume 85, 101650. DOI:10.1016/j.esd.2024.101650.
- Coban, H.H., Lewicki, W., Sendek-Matysiak, E., Łosiewicz, Z., Drożdż, W., Miśkiewicz, R. 2022. Electric Vehicles and Vehicle–Grid Interaction in the Turkish Electricity System. *Energies*, 15, 8218. <https://doi.org/10.3390/en15218218>.
- Davis, B.A., Figliozzi, M.A. 2013. A methodology to evaluate the competitiveness of electric delivery trucks. *Transp. Res. Part E Logist. Transp. Rev.*, 49, 8-23. <https://doi.org/10.1016/j.tre.2012.07.003>.
- De Clerck, Q., van Lier, T., Messagie, M., Macharis, C., Van Mierlo, J., Vanhaverbeke, L. 2018. Total Cost for Society: A persona-based analysis of electric and conventional vehicles. *Transp. Res. Part D Transp. Environ.*, 64, 90-110. <https://doi.org/10.1016/j.trd.2018.02.017>.
- EEA. *Appropriate Taxes and Incentives Do Affect Purchases of New Cars*. EEA: Oshkosh, WI, USA, 2018.
- Electricity price list: <https://www.enea.pl/dla-domu/zamrozenie-cen>.
- Feng, W., Figliozzi, M. 2013. An economic and technological analysis of the key factors affecting the competitiveness of electric commercial vehicles: A case study from the USA market. *Transp. Res. Part C Emerg. Technol.*, 26, 135-145. <https://doi.org/10.1016/j.trc.2012.06.007>.
- Fuel price list: <https://www.orklen.pl/pl/dla-biznesu/hurtowe-ceny-paliw#paliwa>.
- Huber, D., De Clerck, Q., De Cauwer, C., Sapountzoglou, N., Coosemans, T., Messagie, M. 2021. Vehicle to Grid Impacts on the Total Cost of Ownership for Electric Vehicle Drivers. *World Electr. Veh. J.*, 12, 236. <https://doi.org/10.3390/wevj12040236>.
- Jaworski, J., Miskiewicz, R., Miasek, P., Drozd, W., Rzepka, A., Karnowski, J. 2024. Challenges and Solutions for Grid Penetration Caused by EV Charging Stations in Urban Areas. In: Alareeni, B., Hamdan, A. (eds) *Technology: Toward Business Sustainability*. ICBT 2023. *Lecture Notes in Networks and Systems*, vol. 925. Springer, Cham. https://doi.org/10.1007/978-3-031-54019-6_41.
- Lebeau, K., Lebeau, P., Macharis, C., Van Mierlo, J. 2013. How expensive are electric vehicles? A total cost of ownership analysis. *World Electr. Veh. J.*, 6, 996-1007. <https://doi.org/10.3390/wevj6040996>.
- Lebeau, P., Macharis, C., Van Mierlo, J. 2019. How to Improve the Total Cost of Ownership of Electric Vehicles: An Analysis of the Light Commercial Vehicle Segment. *World Electr. Veh. J.*, 10, 90. <https://doi.org/10.3390/wevj10040090>.
- Lewicki, W., Drożdż, W. 2021. Electromobility and its Development Prospects in the Context of Industry 4.0: A Comparative Study of Poland and the European Union. *European Research Studies Journal*, Volume XXIV, Issue 2 -Part 2, 135-144. DOI: 10.35808/ersj/2207
- Lewicki, W., Drożdż, W., Wróblewski, P., Żarna, K. 2021. The road to electromobility in Poland: consumer attitude assessment. *European Research Studies Journal*, 24(s1), 28-39.
- Miśkiewicz, R., Lewiński, M., Drożdż, W., Dowejko, J., Miązek, P. 2024. TCO Analysis of Conventional and Electric Vehicles on the Example of Operations of the Polish Enterprise. In: Alareeni, B., Hamdan, A. (eds) *Technology: Toward Business*

- Sustainability. ICBT 2023. Lecture Notes in Networks and Systems, vol. 925. Springer, Cham. https://doi.org/10.1007/978-3-031-54019-6_43.
- Parking zone price list: <https://spp.szczecin.pl/informacja/abonamenty-miesieczne>.
- Pawłowski, M., Miązek, P. 2024. Trends in EV Charging Stations Infrastructure Development in Poland. In: Alareeni, B., Hamdan, A. (eds) Technology: Toward Business Sustainability. ICBT 2023. Lecture Notes in Networks and Systems, vol. 925. Springer, Cham. https://doi.org/10.1007/978-3-031-54019-6_32.
- Price list for publicly accessible charging stations:
<https://www.orklen.pl/content/dam/internet/orklen/pl/pl/o-firmie/media/komunikaty-prasowe/dokumenty/orklencharge-cennik.pdf.coredownload.pdf>.
- Private charging point price list: <https://greenwallbox.pl/products/green-wallbox-2-pro-slim-7-4kw?variant=47574104408411>.
- Registration fee:
https://eurzad.szczecin.pl/chapter_51228.asp?soid=ADCADBC8A9F24A8DB25B9DC84B686F42.
- Service package prices:
https://www.peugeot.pl/content/dam/peugeot/poland/cenniki/rm_2025/Cennik_Expert_RM_2025_RP_2025.pdf.
- Subsidies: [Naszeauto.gov.pl/o-programie/](https://naszeauto.gov.pl/o-programie/).
- Taefi, T.T., Stütz, S., Fink, A. 2017. Assessing the cost-optimal mileage of medium-duty electric vehicles with a numeric simulation approach. *Transp. Res. Part D Transp. Environ.*, 56, 271-285. <https://doi.org/10.1016/j.trd.2017.08.015>.