Advanced Logistic Systems – Theory and Practice, Vol. 17, No. 1 (2023), pp. 21-26
https://doi.org/10.32971/als.2023.002

THE INDUSTRIAL REVOLUTION OF OUR AGE: THE OPPORTUNITIES IN THE ELECTRIFICATION OF PUBLIC TRANSPORT BUSES

VINCE KRUCHINA[1]

Abstract: For operators of public transport companies the increasing use of battery electric buses for their services is not only motivated by the need to support the green transition or to reduce general noise levels: purely economic considerations also justify the need for a technological shift. Volánbusz Zrt., which has the most significant bus fleet in Hungary, carried out a large series of tests and measurements in order to prove the efficiency of electrification and its environmental sustainability and energy advantages with reliable economic calculations based on its own data sources. The article presents the data and calculations that form the basis of the analysis in detail. Taking all of this into account, it can be stated that electrification can revolutionize the operating model of the company, which has a great impact on supply chain management that is more sustainable than before.

Key words: *electrification, public transport, battery electric bus, energy, V2G, TCO, decarbonisation.*

1. INTRODUCTION

"Thanks to advances in technology, in 2023 the introduction of electric buses in public transport is nowadays no longer an engineer's fantasy dreamed up on the drawing board, but an accomplished reality" [1].

Figure 1. In 2022, Volánbusz Zrt. introduced Ikarus 120e electric buses in the local traffic of Székesfehérvár, Source: Volánbusz Zrt.

Operators of public transport bus services around the world (from Shenzhen to Philadelphia and from Izmir to Delhi) are increasingly using electric buses. Their choice is not only motivated by the need to support the green transition or to reduce general noise levels: purely economic considerations also justify the need for a technological shift. This is particularly true where energy demand is extremely import-intensive. The energy crisis of recent years has highlighted the apparently clichéd – but all the more crucial – observation that a country can be economically successful and stable if it can supply its own energy needs and adapt its economic structure to reduce the level of its energy imports as much as possible.

[1] CEO, Volánbusz Zrt., Hungary
Vince.Kruchina@volanbusz.hu

The revolution in battery technology emerging at the dawn of the 21st century is fundamentally transforming the manufacture of cars and buses. Electrification can significantly reduce the need for energy imports in countries which – like our own – have extremely limited fossil fuel resources, and it can also increase such countries' economic stability and independence [2].

2. ECONOMIC COMPARISON OF BUSES WITH DIFFERENT DRIVETRAINS

The comparison of the buses operating with different drivetrains that make up the vehicle fleet can be done on the basis of the total lifetime cost. The financial estimate intended to help buyers and owners determine the direct and indirect costs of a product or service is called total cost of ownership (TCO). A TCO analysis includes total cost of acquisition and operating costs, as well as costs related to replacement or upgrades at the end of the life cycle. A TCO analysis is used to gauge the viability of any capital investment. Capital expenditures (CAPEX) are a company's major, long-term expenses while operating expenses (OPEX) are a company's day-to-day expenses [3].

Fig. 2 shows a comparison that compares the TCO of electric buses with diesel buses as a function of travel distances.

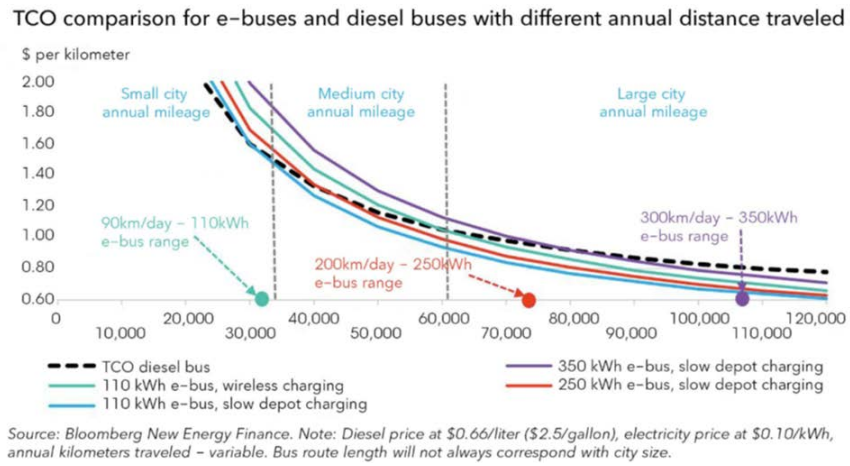

Figure 2. TCO comparison for e-buses and diesel buses (Source: Bloomberg New Energy Finance) [4]

Since the publication of the report [4] in 2018, the TCO of electric buses has improved significantly. Continuous monitoring of TCO is facilitated by tests and measurements carried out at Volánbusz Zrt.

3. TESTING AND MEASUREMENTS

As confirmed by the tests and measurements carried out at Volánbusz Zrt., economic calculations and operational efficiency considerations play an increasingly important role in the adoption of electric buses. Our company's electric bus test periods in recent years have provided us with indispensable experiences and lessons that will allow us to continue the

task of building with the necessary courage. Based on the analysis of the test measurements, I think it is important to highlight the following findings:

1. In 2022 the power consumption of the electric buses used by Volánbusz Zrt. was about 1 kWh/km, with a minimal increase in winter (+0.3 kWh) and a decrease in summer (-0.2 kWh).
2. From the consumption data it follows that, depending on the size of the battery pack used to store the electrical energy, a bus can reliably cover a daily distance of 300 km (for an electric bus, a battery capacity of 320–350 kWh is completely normal).
3. With fast-charging capability, a 300-kWh battery can be fully charged in about two hours, ensuring the rapid availability and turnaround of each electric bus.
4. For Volánbusz Zrt., a daily range of 300 km means that nearly one sixth of the current fleet (about 1,000 buses) could be replaced by electric buses.
5. In terms of maintenance costs, experience of the operation of trolleybuses indicates that the operating costs of electric buses are one third of those of diesel buses; electric buses have low OPEX, but high CAPEX [5].
6. The price of batteries is continuously falling, while their lifespan is continuously rising: in 2022 some manufacturers were already offering an eight-year full warranty (Fig. 3) [6].
7. Another advantage of the substitution of diesel by electricity is that the latter's potential for generating its own electrical power makes it significantly cheaper than diesel – and indeed almost free. Even without its own generating capability, one can expect significant long-term reductions in the price of electricity relative to diesel fuel.
8. Finally, from an operational point of view, the potential for the efficient production of electricity at company level and national level is particularly important for Volánbusz Zrt., and also – due to the size of the company – for the national economy. In the long term, this can ensure security of supply and reduce energy imports.

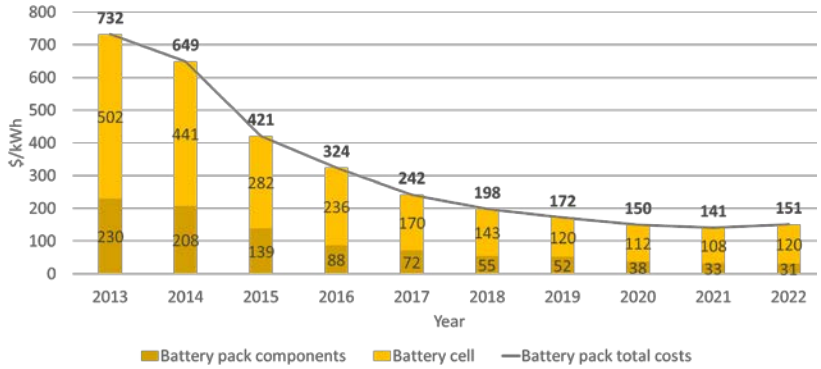

Figure 3. Development of lithium-ion battery costs [5]

Fig. 4 shows that for bus services operating in "standard" time periods the best option is advanced, fuel-efficient, low-emission diesel buses. Meanwhile during "peak" periods (over distances of less than 300 km per day), electric buses can provide the perfect solution.

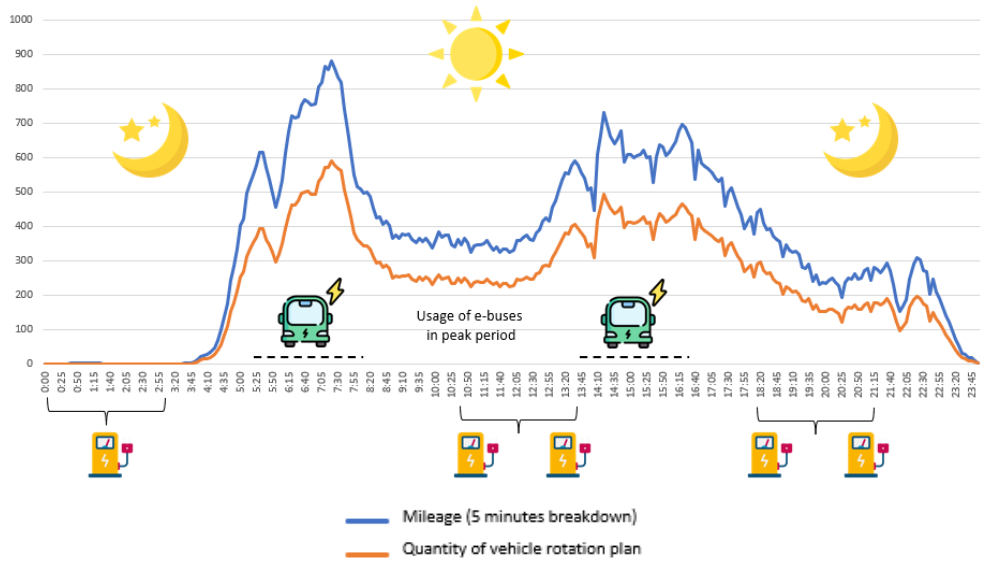

Figure 4. Effective solutions for the different time periods

The latter can even be charged from solar panels at certain times of the day in "valley" periods, weather permitting. As shown in the figure above, charging outside the valley and peak periods can also lead to further savings, with the cost of charging electric buses at night being possibly even more economical.

The data in Fig. 5 shows that – during both daytime and night-time periods – the cost of electricity is significantly less than that of diesel or natural gas. It can also be seen that, from an operational point of view (OPEX), taking into account both fuel and maintenance costs, electric buses are much more economical to operate than their diesel or compressed natural gas counterparts.

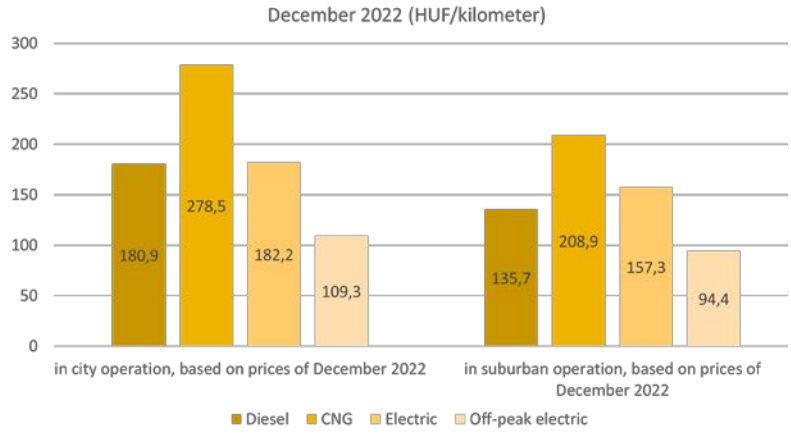

Figure 5. The cost of fuel types

4. TECHNOLOGICAL CHANGE AND RE-EVALUATION OF BUS OPERATORS' CLASSIC ROLE

Given the significant size of the fleet and the considerations outlined above, the question arises as to whether Volánbusz Zrt. could be more than simply a public transport operator. Taking into account today's technological advances and our company's vehicle operating practices, from the above figures it can be seen that with 1,000 electric buses and a battery capacity of 300 kWh per bus, the daily electricity demand of the total electric bus fleet would be 300 MWh. The scale of this could also revolutionise our operations: with this level of storage capacity, further business opportunities would open up. On the one hand, we could become a community service provider, intermittently supplying balancing power to the Hungarian electricity transmission system operator MAVIR (Vehicle-to-grid, or V2G) or a virtual power plant service for the operators of photovoltaic power plants. Our bus company could also become a stand-alone generator with independent generating capacity, which could sell its surplus capacity on the market – possibly also to the public. (There would be the potential to sell electricity to the owners of electric cars at charging stations set up at the more than sixty sites across the country belonging to Volánbusz Zrt.) Last but not least, there is a further business opportunity in the circular economy, with batteries with reduced but still usable capacity being resold as uninterruptible power sources for storage or other secondary uses (Fig. 6).

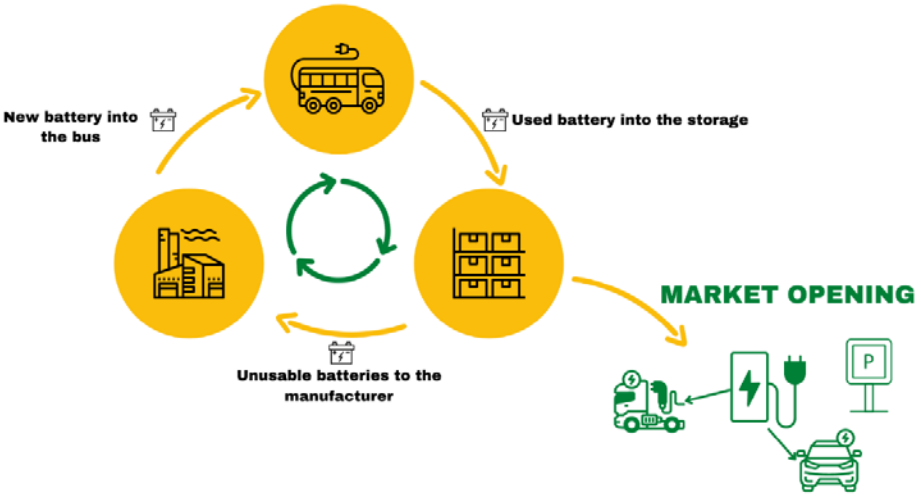

Figure 6. Life cycle of the batteries

The technological change outlined in this article and the re-evaluation of bus operators' classic role could be facilitated by synthesising the contributions of the major Hungarian-owned bus manufacturers present on the domestic market, battery manufacturers which have arrived more recently, and the professional and operational experience of Volánbusz Zrt. – which is unique in both domestic and international terms. Using these three pillars, in my view rapid changes in technology now make it possible to create a new operational structure – a new business model – for public transport bus services, while at the same time taking into account the specific geographical characteristics of our country (the potential for

development of solar parks and geothermal power plant capacities, as well as a lack of fossil fuels). In this new structure the bus company can – in addition to its activities as a transport operator – perform energy trading and production tasks, and thus become a catalyst for the electric bus industry.

5. CONCLUSIONS

Global changes and emerging technological trends in the world, as well as the depletion of fossil energy sources, present new challenges for public transport companies as well. Operators of public transport bus services around the world are increasingly using electric buses. The revolution in battery technology is fundamentally transforming the manufacture of cars and buses. Electrification can significantly reduce the need for energy imports in countries have extremely limited fossil fuel resources.

As confirmed by the tests and measurements carried out at Volánbusz Zrt., economic calculations and operational efficiency considerations play an increasingly important role in the adoption of electric buses. All this confirms the conclusion that the technological change and the reinterpretation of the classic role of the transport service provider is not only possible, but an urgent task.

REFERENCES

[1] Kruchina, V. (2023). *Hatalmas lehetőség van az elektromos buszos közlekedésben Magyarországon*, Retrieved from https://www.portfolio.hu/gazdasag/20230210/hatalmas-lehetoseg-van-az-elektromos-buszos-kozlekedesben-magyarorszagon-595966

[2] Chauhan, S., Hans, M., Rittstieg, M. & Zafar, S. (2022). *Fleet decarbonization: Operationalizing the transition*, McKinsey & Company, Automotive & Assembly Practice,

[3] Christensen, D. K. (2016). What is TCO? Why TCO?. *Facilities Manager* **32**(4). 21-23, Retrieved from https://www.appa.org/wp-content/uploads/2019/03/TCOArticleJun-Jul2016.pdf

[4] *Electric Buses in Cities: Driving Towards Cleaner Air and Lower CO2*, Bloomberg NEF, Retrieved from https://about.bnef.com/blog/electric-buses-cities-driving-towards-cleaner-air-lower-co2/

[5] Jefferies, D. & Göhlich, D. (2020). A Comprehensive TCO Evaluation Method for Electric Bus Systems Based on Discrete-Event Simulation Including Bus Scheduling and Charging Infrastructure Optimisation, *World Electric Vehicle Journal* **11**, 56, Technische Universität Berlin, https://doi.org/10.20944/preprints202007.0691.v1

[6] *Lithium-ion Battery Pack Prices Rise for First Time to an Average of $151/kWh*, (2022). Bloomber NEF, Retrieved from: https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/)

[7] *Lithium-ion Battery Pack Prices Rise for First Time to an Average of $151/kWh*. Retrieved from https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh