

Nenad Ruškić¹
E-mail: nruskic@uns.ac.rs

Nataša Čačić¹
E-mail: ncacic@uns.ac.rs

Dragana Šarac¹
E-mail: dsarac@uns.ac.rs

¹ University of Novi Sad, Faculty of Technical Sciences
Trg Dositeja Obradovića 6, 21102 Novi Sad, Serbia

THE EFFECTS OF SWITCHING THE VEHICLE OF THE POST OF SERBIA TO ELECTRIC DRIVE IN NOVI SAD

Keywords

Ecological
postal operators
Transport
cost
Savings

Abstract

European Parliament Directive 94/2014 mandates the development of new technologies and innovations to improve air quality in densely populated areas, urban and suburban areas. Within this paper, the positive effects (savings) of switching to electric vehicles operated by Public Enterprise Post of Serbia in the working unit Novi Sad are considered. Taking into account the fact that with the expansion of e-commerce, the volume of postal items has increased significantly, the transition to greener modes of transport represents the environmentally responsible business of postal operators.

1. INTRODUCTION

Today's way of life causes a lot of noise and pollution, especially in large cities and urban environments. According to the World Health Organization's estimation, noise represents a significant environmental impact factor. The field of environmental noise is regulated by the Environmental Protection Act ("Official Gazette of the Republic of Serbia, No. 135/04, 36/09, 36/09 - amending law, 72/09 - amending law, and 43/11 – decision of the Constitutional Court"), as well as the Noise Protection Act ("Official Gazette of the Republic of Serbia, No. 36/09 and 88/10"), and other sublegal acts in accordance with European Union (EU) regulations [1]. Noise indicator values significantly exceed the permissible limits. Accordingly, improving the quality of life in urban areas is a top priority, as the population and vehicle numbers in the city of Novi Sad are constantly increasing. In the Vojvodina Region, the number of newly registered passenger cars is 9539 [2]. Based on Article 8 of the

Law on the Budget of the Republic of Serbia for 2023, the Government of the Republic of Serbia has issued a regulation on the conditions and procedures for subsidized purchases of new vehicles that are solely electric-powered, as well as vehicles powered by internal combustion engines and electric power (hybrid power) [3].

The world has been facing considerable populational growth rates, including an agglomeration in cities. Currently, more than 50% of the global population lives in cities, and by 2050 the percentage of people living in urban locations is expected to exceed 70% [4].

Overall, 15% of global CO₂ emissions are attributed to the transport sector, with the majority of these emissions caused by road transport. Urban transport accounts for a large share. In the EU, it is estimated to be responsible for 23% of greenhouse gas emissions [5]. Therefore, reducing transport emissions is key to meeting the EU's climate neutrality objectives. Recently proposed legislation sets targets to cut CO₂ emissions from cars by 55% and vans by 50% by 2030. 2021 saw a significant increase in the uptake of electric cars and vans in the EU-27. Electric car registrations for the year were close to 1,729,000, up from 1,061,000 in 2020. [6]. The European Green Deal set the blueprint for this transformational change. All 27 EU Member States committed to turning the EU into the first climate neutral continent by 2050. To get there, they pledged to reduce emissions by at least 55% by 2030, compared to 1990 levels [7].

In postal transportation, it is important to develop a good transportation plan and to efficiently manage the plan. Postal operators worldwide are considering the possibilities of transitioning to faster, safer, and more environment-friendly alternative postal delivery models. Authors analyzing the postal traffic field have conducted numerous analyses and studies that yielded results regarding alternative delivery methods and contemporary business models. Papers examining the benefits of eco-driving using electric vehicles are presented in Table 1.

Taking into account the fact that electronic commerce greatly affects the increase in the volume of traffic for CEP (Courier, Express and Parcel) operators and thus causes great pollution as a consequence of work, this paper provides an analysis of the possible positive effects of crossing the fleets of Public Enterprise Post of Serbia on electric drive. The analysis was carried out on the territory of the city of Novi Sad.

Table 1. Previous research

Ref.	Problem	Method	Results
[8]	Estimation the delivery time and energy cost of e scooter vehicles in postal sector	Machine learning, considering 15 different input parameters	The delivery time of a package to short-distance delivery addresses using e-scooter vehicles is 20.21% shorter than other traditional delivery vehicles.
[9]	"This paper proposes a methodology that combines routing optimization and large-scale distribution planning algorithms, to perform a realistic assessment of the electrification of parcels' transportation"	A Route Optimization Model (ROM) and Reference Network Model (RNM)	The estimated absolute emissions of the electrified fleet for a decentralized scenario are up to 50% lower compared to a centralized one. the results reveal that smart charging strategies also contribute to lessen the incremental costs and significantly reducing the cost of energy supply.
[10]	A comprehensive analysis of Electric vehicles charging station usage at the University of Georgia	The data collection method is time- and cost-effective	The results from this study can be used as a reference for possible expectations of EV charging station usage on other college campuses.
[11]	This work evaluated the use of electric vehicles of smaller dimensions, tricycle and LDV in the last mile of parcel deliveries	Economic assessment, Social assessment	"The analysis showed that the electric tricycle alternative is feasible in the economic, environmental and social aspects, as well as in the maintenance of the level of service".
[12]	This work analyzing the effects that eco-driving has on fuel consumption and GHG emissions on courier deliveries in Spain	Statistical Analysis (A Sequential Method), Interview and Observation	Eco-driving with courier delivery does not lead to average fuel savings per vehicle.
[13]	The Proton Exchange Membrane Fuel Cell (PEMFC) health monitoring and management	Model-driven method Unscented Kalman filter	"The results show that the proposed model-driven method is able to accurately estimate the voltage degradation trend of PEMFC in the FCEV".
[14]	Conducted a cradle-to-grave life cycle greenhouse gas (GHG) assessment for two scenarios	Life-cycle analysis (LCA) tool	"The BEV NGDV has almost double the vehicle cycle emissions as the ICEV NGDV due to the production emissions of the Li-ion battery".
[15]	A comparison between the EVs and the ICEVs used to perform last-mile deliveries in business-to-consumers (B2C) e-commerce	The life cycle assessment method	EVs turned out to be the best option in all the scenarios assumed.
[16]	"This paper identifies and reviews, from an OR/CS perspective, several open research challenges related to the introduction of EVs in L&T activities"	Use of metaheuristics and simheuristics to deal with optimization problems	"This paper has reviewed some of the existing literature related to the introduction of electric vehicles in road transportation, paying special attention to environmental issues".

2. ELECTRIC VEHICLE MARKET

The transport sector accounts for 25% of total greenhouse gas (GHG) emissions. By categories of transport, road transport represents almost 95% of emissions [12]. The report of electric vehicles market provides a peek into this fast-growing industry. This market is currently focusing on battery electric vehicles, plug-in hybrid electric vehicles and electric vehicles infrastructure which includes information about public charging stations. Compared to 2020, sales of new electric vehicles more than doubled in 2021 with an increase of 51.8%. The volume weighted average price of electric vehicles market in 2023 is expected to amount to US\$51.98k. China conveniently topped the global sales charts in 2021 with more electric vehicles sold

than the rest of the world combined and almost five times more than Germany, which was in second place. Europe recorded an increase between 2020 and 2021, reaching about 66%, with the plug-in hybrid share of all electric vehicle sales being the biggest in the world. Driven by the availability of more models, as well as the market expansion and purchase incentives, the European market is expected to continue along this trend as countries within the EU adopt stricter CO2 emission standards and move toward zero-emissions vehicle mandates [17]. At COP-25 in Madrid 73 States have committed to being carbon neutral by 2050 [12,18].

2.1. The use of electric vehicles in postal traffic

CEP (Courier, Express, and Parcel) operators, through their business programs and development strategies, aim to reduce CO2 emissions. The European Parliament Directive 94/2014 (access to European Union law) mandates the development of new technologies and innovations to improve air quality in densely populated areas, both in urban and suburban environments [19]. The introduction of electric vehicles provides CEP operators with the opportunity for enhanced mobility in city centers and a reduction in the number of fossil fuel-powered vehicles. According to the Business Program of the Public Enterprise "Post of Serbia," environmental protection measures and fleet renewal are planned for the year 2023 [20]. The Public Enterprise "Post of Serbia" has adopted a public procurement plan for 2023, which includes open procurement procedures for electric bicycles in the first quarter of 2023 and electric vehicles in the fourth quarter of 2023 [21]. According to data from 2022, the United States Postal Service announced that it expects to acquire at least 66,000 battery electric delivery vehicles as part of its 106, 000 vehicle acquisition plan for deliveries between now and 2028. [22]. Since 2015, the Croatian Post has included 180 electric bicycles in its vehicle fleet, which have reduced CO2 emissions by 100.31 tons annually, along with 26 electric mopeds that contribute to a yearly CO2 emission reduction of nearly 20 tons [23, 24] (Figure 2). The electric vehicles of the Public Enterprise "Post of Serbia," are shown in Figure 1.



Figure 1. Electric vehicles of the Public Enterprise "Post of Serbia" [25]



Figure 2. Electric mopeds and electric quadricycles of Croatian Post [24]

In 2021, Swiss Post operated 6,000 electric scooters and 260 electric delivery vans for emission-free delivery of letters and parcels. In 2022, Austrian Post operated the largest fleet of EVs within Austria (2462 EVs) and is committing to switch its entire fleet of more than 8,500 vehicles to EVs by 2030, resulting in a carbon-free delivery

process [26]. Using the Green Strategy, Royal Mail has so far reduced greenhouse gas emissions by 31.9%. Bio-CNG vehicles cut carbon emissions by 85%. Royal Mail has introduced 295 zero-emission electric vehicles. Effectively, Royal Mail is reducing greenhouse gas emissions by 459 tons of CO₂ through eco-driving. DHL's mission is to achieve net-zero emissions by 2050. The plan is for DHL to have more than 80,000 electric vehicles on the roads by 2030 [27]. Many of the largest private fleet operators, including FedEx, UPS, Amazon, and Walmart, have begun electrifying their fleets [14].

3. ASSESSMENT OF CO₂ EMISSION REDUCTION IN THE CITY OF NOVI SAD

According to the data obtained from the Public Enterprise Post of Serbia, it has been determined that a total of 78 vehicles operate daily in the city of Novi Sad to provide services to customers. The vehicles are of different categories and carrying capacities. Table 2 provides the adopted factors for estimating CO₂ emissions depending on the type of fuel used by the vehicles.

Table 2. Factors of CO₂ emission

Type of fuel	kgCO ₂ /kg fuel
Petrol	3,18
Diesel	3,14
LPG*	3,02
CNG**	2,75

*liquefied petroleum gas; ** compressed natural gas

Table 3 provides an overview of the number of vehicles and vehicle types owned by the observed postal operator. Average daily distances traveled and average fuel consumption per day are also provided. Based on available data, CO₂ emissions on an annual basis have been calculated for the territory of Novi Sad for the observed postal operator.

Table 3. Postal Service vehicles

S. N.	Type of vehicle	Amount of fuel (L)	Average daily mileage (km)	Number of working days	Fuel	Average spending	Total annual consumption per vehicle	Number of vehicles in the group	Emission CO ₂ on an annual basis (kg)
1	A passenger vehicle	141	49	23	ED	6	1692	6	31.877
2	Cargo vehicle	142	38	25	ED	11	1704	58	310.332
3	Cargo vehicle	586	247	27	ED	8,9	7032	10	220.805
4	Cargo vehicle	1330	187	27	ED	25,39	15960	4	200.458
Total							29.289	78	763.472

The obtained CO₂ emission values per vehicle type are given on an annual basis. It has been determined that the observed postal operator emits a total of 763,472 kg within the territory of Novi Sad city. It should be noted that in the observed area, in addition to the observed postal operator, around 15 postal operators provide services, and their CO₂ emission analysis has not been considered. As there is a drive to reduce CO₂ emissions, a large number of CEP operators are considering the possibility and effects of transitioning to electric-powered vehicles, encouraged by state incentives for eco-driving, especially in urban city environments. Taking into account that the price of 1 ton of CO₂ is €101.16 in the EU [28], the costs incurred solely from the observed postal operator's CO₂ emissions amount to €77,233.

4. CONCLUSION

The trend of transition to electric vehicles is present all around the world. Local pollution reduction is imperative for larger cities, and one of the ways to achieve this is by having a greater number of vehicles use electric power for propulsion. While it's currently challenging for vehicles that travel longer distances to utilize electric energy, vehicles that operate within cities and for shorter distances can be electric. Electric vehicles, as well as public transport vehicles, have proven to be ideal for transitioning to electric propulsion, especially with the option of overnight battery charging in their company garages.

In the context of this study, a preliminary analysis was conducted regarding the transition to electric propulsion for vehicles operated by the Public Enterprise Post of Serbia in the Novi Sad branch. According to the analysis, if all vehicles in this branch were to switch to electric propulsion, a reduction of approximately 764 tons of CO₂ emissions, equivalent to around €77,000 annually, would be achieved solely through pollution reduction. The study did not analyze other benefits of transitioning to electric vehicles (reduced consumption, maintenance costs, depreciation, etc.), nor did it examine the reduction of other pollutants originating from the combustion of fossil fuels within the territory of Novi Sad city and its surroundings.

ACKNOWLEDGMENT

This research (paper) has been supported by the Ministry of Education, Science and Technological Development through the project no. 451-03-47/2023-01/200156: "Innovative scientific and artistic research from the FTS (activity) domain".

REFERENCES

- [1] Gradska uprava, "Program zaštite životne sredine Grada Novog Sada za period 2015.-2024. godine", Gradska uprava za zaštitu životne sredine - Grad Novi Sad, 2015.
- [2] RZS, Republički zavod za statistiku, 2023. Available at: [https:// www. Stat . gov.rs/](https://www.Stat.gov.rs/)
- [3] RS, ""Sl. glasnik RS", br. 18/2023, Uredba o uslovima i načinu sprovođenja subvencionisane kupovine novih vozila koja imaju isključivo električni pogon, kao i

vozila koja uz motor sa unutrašnjim sagorevanjem pogreće i električni pogon“, Republika Srbija, 2023.

- [4] J. Calão, D. Lemos Marques, A. Godinho Completo, and M. Cabrita Coelho, “Life Cycle Thinking Approach Applied to a Novel Micromobility Vehicle”, *Transportation Research Record.*, vol. 2676(8), pp. 514-529, 2022.
- [5] J. Buko, M. Bulsa, and A. Makowski, “Spatial premises and key conditions for the use of UAVs for delivery of items on the example of the polish courier and postal services market”, *Energies.*, vol. 15(4), pp. 1403, 2022.
- [6] EEA, “New registrations of electric vehicles in Europe”, European Environment Agency, 2022.
- [7] EC, “The European Green Deal”, European Commission, 2023.
- [8] H. İnaç, Y.E. Ayözen, A. Atalan, and C. Ç. Dönmez, “Estimation of Postal Service Delivery Time and Energy Cost with E-Scooter by Machine Learning Algorithms”, *Applied Sciences.*, vol. 12(23), pp. 12266, 2022.
- [9] M. Martínez, A. Moreno, I. Angulo, C. Mateo, A. D. Masegosa, A. Perallos, and P. Frías, “Assessment of the impact of a fully electrified postal fleet for urban freight transportation”, *International Journal of Electrical Power & Energy Systems.*, vol. 129, pp. 106770, 2021.
- [10] S. Hovet, B. Farley, J. Perry, K. Kirsche, M. Jerue and T. H. Tse, “Introduction of electric vehicle charging stations to university campuses: A case study for the university of Georgia from 2014 to 2017”, *Batteries.*, vol. 4(2), pp. 27, 2018.
- [11] R. A. de Mello Bandeira, G. V. Goes, D. N. S. Gonçalves, D. A. Márcio de Almeida, and C. M. de Oliveira, “Electric vehicles in the last mile of urban freight transportation: A sustainability assessment of postal deliveries in Rio de Janeiro-Brazil”, *Transportation Research Part D: Transport and Environment.*, vol. 67, pp. 491-502, 2019.
- [12] J. F. Coloma, M. García, G. Fernández, and A. Monzón, „Environmental effects of eco-driving on courier delivery“, *Sustainability.*, vol. 13(3), pp. 1415, 2021.
- [13] K. Chen, S. Laghrouche, and A. Djerdir, “Fuel cell health prognosis using Unscented Kalman Filter: Postal fuel cell electric vehicles case study”, *International Journal of Hydrogen Energy.*, vol. 44(3), pp. 1930-1939, 2019.
- [14] M. Woody, P. Vaishnav, M. T. Craig, and G. A. Keoleian, “Life Cycle Greenhouse Gas Emissions of the USPS Next-Generation Delivery Vehicle Fleet”, *Environmental Science & Technology.*, vol. 56(18), pp. 13391-13397, 2022.
- [15] T. Erdelić, and T. Carić, “Goods delivery with electric vehicles: Electric vehicle routing optimization with time windows and partial or full recharge”, *Energies.*, vol. 15(1), pp. 285, 2022.
- [16] A. A. Juan, C. A. Mendez, J. Faulin, J. De Armas, and S. E. Grasman, “Electric vehicles in logistics and transportation: A survey on emerging environmental, strategic, and operational challenges”, *Energies.*, vol. 9(2), pp. 86, 2016.
- [17] Statista Market Insights, „Electric Vehicles-Serbia”, Statista, 2023.
- [18] EP, „COP25: MEPs push for CO2 neutrality by 2050“, European Parliament, 2019.
- [19] EU, „Directive 2014/94/EU of the European Parliament and of the council of 22 October 2014 on the deployment of alternative fuels infrastructure“, European Union, 2014.

- [20] JP. Pošta Srbije, „Program poslovanja javnog preduzeća Pošte Srbije, Beograd za 2023. godinu“, 2023.
- [21] JP. Pošta Srbije, „Plan javnih nabavki javnog preduzeća Pošte Srbije, Beograd za 2023. godinu“, 2023.
- [22] USPS, USPS National News, United States Postal Service, 2022. Available at: <https://about.usps.com/newsroom/national-releases/2022/1220-usps-intends-to-deploy-over-66000-electric-vehicles-by-2028.htm>
- [23] Š. Bakula, „Stanje i trendovi zelene javne nabave u Republici Hrvatskoj“, *Doctoral dissertation*, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, 2021.
- [24] L. Klarić, „Dekarbonizacija voznog parka“, *Doctoral dissertation*, University of Rijeka, Faculty of Engineering, 2022.
- [25] JP. Pošta Srbije, „Vesti - Prvi električni automobili stigli u Poštinu flotu“, Pošta Srbije, 2020. Available at: <https://www.posta.rs/lat/info/vest-deta-ljni-je.aspx?ID=4567>
- [26] Climate Group, Top companies signal major demand for EVs as automakers gather in Geneva, 2019.
- [27] A. Antunović, „Analiza emisija stakleničkih plinova u poštanskom prometu“, *Doctoral dissertation*, University of Zagreb, Faculty of Transport and Traffic Sciences. Division of Transport, Department of Postal Transport, 2022.
- [28] Balkan green energy news, 2023. Available at: <https://balkanenergynews.com/rs/cene-co2-u-eu-prvi-put-premasile-100-evra-za-tonu/>