ROMANIAN JOURNAL OF INFORMATION SCIENCE AND TECHNOLOGY
Volume 29, Number 4, 2026, 287–298
doi: 10.59277/ROMJIST.2026.4.01

A STENOZA Method to Select Electric Vehicles for Waste Collection and Transport

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Abstract. Achieving sustainability while considering various sociological and technological factors represents a challenging task. Through this research, it is necessary to determine the feasibility of electrifying the vehicle fleet of a local utility company and its intention to place primary emphasis on the use of clean technologies and the achievement of greater technological sustainability. The aim of the research is to identify the most suitable electric vehicle for the collection and transport of non-hazardous municipal waste by applying a multi-criteria model, as support for the transition to carbon-neutral transport. The main methodological contribution of the paper is the development of a new STENOZA (STEvić NOvarlić ZAvadskas) method for the evaluation and ranking of potential solutions. The evaluation and selection of the electric vehicle were carried out using three MCDM (Multi-Criteria Decision-Making) methods: MEREC (MEthod Based on the Removal Effects of Criteria), FUCOM (FUll COnsistency Method), and STENOZA. The objective-subjective MEREC-FUCOM model was applied to determine the weights of nine influential criteria, while STENOZA was used to evaluate and rank the electric vehicles. The results indicate that EV2 is the best option, regardless of any changes in conditions, as confirmed by verification tests and additional analyses conducted in this paper.

Key-words: Electric vehicles; green transition and sustainability; MCDM; STENOZA method.

1. Introduction

Monitoring technological, informational, and innovative achievements across various fields is by no means an easy task, particularly in the context of developing countries. Consequently, maximum effort is required to ensure the sustainability of plans and strategies set by developed countries. The highly "ambitious" plan of the European Union (EU) on climate neutrality, with a particular focus on the Green Deal (GD), a low-carbon and sustainable economy by 2050 [1], represents a significant challenge for small, transitional countries. The role of the GD is precisely in transforming the EU towards a modern and prosperous society with a strong economy, with a focus on separating resource use from economic growth. The EU should support economic growth across all sectors by creating a strong and sustainable transition to new, advanced technologies, especially in the field of the circular economy and comprehensive waste management.

The transition of business activities from vehicles powered by internal combustion engines (ICE) to fully electric vehicles represents a particular opportunity for developing countries [2]. The challenges faced by small, transitional economies also provide them with the chance to integrate into global flows and trends in fleet electrification, as well as into systems aimed at strengthening the role of vehicle fleets in efficient waste management. The optimization of transport routes [3], combined with a specific e-mobility system, shows that the introduction of electric trucks can substantially reduce emissions and operational costs while generating profit for the company, provided that the length of the transport route and the scheduling of shifts for waste collection and transport are adequately arranged [4].

This paper examines the feasibility of transitioning the vehicle fleet of a local utility company from ICE vehicles to vehicles powered by 100% clean energy and zero emissions, providing an example of good practice for other local communities across the country as a potentially successful pilot project. Therefore, the aim of this paper is to apply an MCDM model to examine which electric vehicles for the collection and transport of municipal waste, available on the market, demonstrate optimal performance in terms of the operational efficiency of a utility company, and which of them would be considered for potential procurement by the company.

The main contribution of this paper lies in the development of a new MCDM method for ranking potential solutions, applicable to any problem with at least two influential factors and two alternatives. Advantages of new created STENOZA method are as follows: Triple normalization procedure that allows better processing of initial data and finds a compromise between different types of normalization. The determination of the distance of alternatives relative to the ideal and non-ideal solutions, has been developed. The aim of this step is to assign a value of 1 in the ideal matrix to the alternatives with the best preferred values according to the type of criteria, and a value of 0 in the non-ideal matrix to those with the worst characteristics. In such way we can determine precise values of variants. Possibility of the method to be stable in different conditions from the matrix size aspect, which means that STENOZA methods give very good and stable results in large matrix size.

Which criteria have the greatest influence on the ranking of electric vehicles under conditions of limited charging infrastructure and short daily routes, which are subject to significant challenges in waste collection and transport (such as inaccessible terrain with gradients above 10% and similar obstacles)? Do electric municipal vehicles have potential in transition countries for the collection and transport of non-hazardous municipal waste during night-time operations and in a constant start-stop system? To what extent are the results of MCDM ranking influenced by changes in the weights of criteria during the decision-making process regarding fleet electrification? These research questions represent a potential direction for the utility company, enabling it not only to comply with restrictive EU policies in the field of the green economy, but also to create all the prerequisites for integration into strong global trends in fleet decarbonization.

The paper has been structured into six sections in total. The second shows the background of research with a focus on justification of such studies. The third section represents a detailed algorithm of the newly developed STENOZA method for alternative ranking, while the next one shows a case study with a detailed explanation of the application created methodology. In order to prove obtained results in the fifth section, verification tests have been performed, and the last two sections describes discussion and the main conclusions, limitations, and future research.

2. Literature Review

Changes regarding sustainability cannot be confined solely to the European Union, as they do not recognize such boundaries; therefore, the implementation of the Green Agenda extends to the Western Balkans as well. The path to achieving climate neutrality and the effective implementation of circular economy principles indicates that nearly three decades are required for one generation to "transform" the entire supply chain and industrial sector [5]. Accordingly, 2026 represents a key year in the transformation process if the benefits of the Green Agenda (GA) 2050 strategy are to be realized. On the other hand, a key factor in mobility is the choice of an alternative, environmentally friendly model, such as transitioning from vehicles with exhaust gases to electric vehicles, or to walking, cycling, and similar modes. Innovation and the advancement of technologically modern business principles, adapted to restrictive EU directives, contribute to long-term successful sustainability [6]. Research has shown [7] that particular attention is given to economic and technical sustainability in the field of electrification of municipal vehicles for the collection of non-hazardous municipal waste. On the other hand, the lack or insufficient capacity of smart charging stations, stable connections, and battery range [8] during the operation of municipal vehicles along transport routes occupies a central role [9]. Winter conditions pose a particular challenge for electric trucks (extremely low temperatures hindering optimal truck performance) when operating on transport routes with slopes, inclines and hard-to-access locations for waste collection. Additionally, the potential lack of service support and the limited short-term availability of spare parts further complicate their deployment [10]. The success of fleet electrification in the observed utility company depends on several key factors: the availability of financial instruments (such as incentives for the procurement of electric vehicles), the developed infrastructure (network) of charging stations with particular emphasis on fast charging, the lifespan and health of batteries [11] during daily vehicle operation, and the rapid responsiveness of service centers in providing spare parts in the short term. The introduction of electric vehicles should be systematic and well-planned. In the first three years after the purchase of an electric vehicle, maintenance costs are between 30% and 40% lower than those of their diesel counterparts [12], while the operational costs of electric vehicles are almost 50% lower than those of diesel or gasoline vehicles, provided that charging stations for electric vehicles are readily accessible and electricity prices during vehicle charging are optimal. As the production of electric trucks and battery costs decrease, the competitiveness of electric vehicles compared to ICE trucks continues to grow. Accordingly, electric vehicles are becoming an economically sustainable alternative to their diesel-powered counterparts, based on the latest total cost models, i.e., taking into account infrastructure, maintenance, electricity, procurement subsidies, and similar factors [13]. On the other hand, a significant increase in electricity prices is expected in EU countries, alongside even greater and more pronounced consumption [14]. The decarbonization process may potentially be slowed by the energy crisis, particularly in member states that must import significantly more expensive electricity. Therefore, yet another motivation arises to intensify efforts today toward the transition to electric vehicles, whose ultimate adoption in the foreseeable future is unquestionable. The selection of the optimal electric vehicle for municipal waste management represents a highly complex problem, depending on a range of factors, most frequently technical and economic performance, as well as operational, environmental, and infrastructural constraints. One of the most commonly used approaches to support such a selection is the MCDM methodology, but the number of research studies applying the MCDM methodology in the field of waste management is not extensive. Even fewer studies are designed for transitional countries such as Bosnia and Herzegovina, where utility companies operate under limited budgets while also facing constant EU pressure related to decarbonization alignment policies. Research shows that electric trucks [15], despite their higher purchase cost compared to ICE vehicles, can provide significant, and potentially even crucial, benefits. These include lower annual operational costs, sufficient battery life to cover the entire daily transport route, extremely low noise levels during night-time operations, and, ultimately, comprehensive protection of the environment and human health. The application of MCDM is particularly important when comparing the selection of electric vehicles according to the optimal characteristics of utility companies, where transport routes are relatively short, waste collection and transport operate on a night schedule, and a constant "door-to-door" waste collection method is employed, resulting in a start-stop vehicle operation system.

3. A New STENOZA Method

The new STENOZA (STEvić NOvarlić ZAvadskas) method consists of the following algorithm:

Step 1. Define the MCDM model A_{ij} with the required number of potential alternatives n and influential criteria m.

Step 2. Perform multi-phase normalization n_{ij}, which includes three types: vector (1), nonlinear (2) and Type II linear normalization (3), in order to treat the MCDM model as objectively as possible:

$$n_{ij}^{v} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{n} a_{ij}^{2}}}\ \textit{for B}, \qquad n_{ij}^{v} = 1 - \frac{a_{ij}}{\sqrt{\sum_{i=1}^{n} a_{ij}^{2}}}\ \textit{for C} \tag{1}$$

$$n_{ij}^{nl} = \left(\frac{a_{ij}}{a_{j}^{\max}}\right)^{2}\ \textit{for B}, \qquad n_{ij}^{nl} = \left(\frac{a_{j}^{\min}}{a_{ij}}\right)^{3}\ \textit{for C} \tag{2}$$

$$n_{ij}^{l} = \frac{a_{ij}}{a_{j}^{\max}}\ \textit{for B}, \qquad n_{ij}^{l} = \frac{a_{j}^{\min}}{a_{ij}}\ \textit{for C} \tag{3}$$

Step 3. Apply weighting to each normalized matrix separately, calculating the weighted vector matrix v_{ij}, the weighted nonlinear matrix nl_{ij}, and the weighted linear matrix l_{ij}:

$$v_{ij} = n_{ij}^{v} \times w_{j}, \qquad nl_{ij} = n_{ij}^{nl} \times w_{j}, \qquad l_{ij} = n_{ij}^{l} \times w_{j} \tag{4}$$

Step 4. Define the ideal solution t_j (5) and the non-ideal solution k_j (6) for each weighted matrix separately:

$$t_{j}^{v} = \max v_{ij}, \qquad t_{j}^{nl} = \max nl_{ij}, \qquad t_{j}^{l} = \max l_{ij}, \qquad j = 1, 2, \ldots, m \tag{5}$$

$$k_{j}^{v} = \min v_{ij}, \qquad k_{j}^{nl} = \min nl_{ij}, \qquad k_{j}^{l} = \min l_{ij}, \qquad j = 1, 2, \ldots, m \tag{6}$$

Step 5. Calculate the distance from the ideal solution dt_{ij} and from the non-ideal solution dk_{ij}. The aim is to assign a value of 1 in the dt_{ij} matrix to the alternatives with the best preferred values according to the type of criteria, and a value of 0 in the dk_{ij} matrix to those with the worst characteristics. Use Eq. (7) for dt_{ij} and Eq. (8) for dk_{ij}:

$$dt_{ij}^{v} = v_{ij} + (1 - t_j^{v}), \qquad dt_{ij}^{nl} = nl_{ij} + (1 - t_j^{nl}), \qquad dt_{ij}^{l} = l_{ij} + (1 - t_j^{l}) \tag{7}$$

$$dk_{ij}^{v} = v_{ij} + (0 - k_j^{v}), \qquad dk_{ij}^{nl} = nl_{ij} + (0 - k_j^{nl}), \qquad dk_{ij}^{l} = l_{ij} + (0 - k_j^{l}) \tag{8}$$

Step 6. Aggregate the previous matrices from the perspective of the ideal solution st_{ij} and from the perspective of the non-ideal solution sk_{ij} in order to obtain a unified matrix as follows:

$$st_{ij} = \frac{dt_{ij}^{v} + dt_{ij}^{nl} + dt_{ij}^{l}}{3}, \qquad sk_{ij} = \frac{dk_{ij}^{v} + dk_{ij}^{nl} + dk_{ij}^{l}}{3} \tag{9}$$

Step 7. Calculate the coefficients gt_i and gk_i as follows:

$$gt_i = \frac{\sum_{j=1}^{m} st_{ij}}{m}, \qquad gk_i = \sum_{j=1}^{m} k_{ij} \tag{10}$$

Step 8. Perform the final calculation of the values fc_i and rank the alternative solutions in descending order:

$$fc_i = \frac{gt_i + gk_i}{2} \tag{11}$$

4. Selection of an Electric Vehicle for Waste Collection and Transport

4.1. Study description, research sample, and data collection process

This paper analyzes the potential procurement of one or more electric vehicles by the local utility company Progres JSC Doboj, one of the leaders in comprehensive waste management in Bosnia and Herzegovina, based on needs that are explained in detail below. Although the company operates 10 ICE vehicles for the collection and transport of non-hazardous municipal waste, all aged 15 years or more, its management is embarking on an ambitious fleet renewal project with modern, carbon-neutral vehicles, planned for a 10-year period. Data were collected through the analysis of information available on the websites of European manufacturers of electric municipal vehicles with distribution and service centers in Bosnia and Herzegovina, i.e., within the Western Balkans region. In addition, importers and distributors were contacted by phone and email to obtain accurate information. In the first round of data collection, the analysis included 11 potential electric vehicles that met the needs of the utility company Progres JSC Doboj. However, a detailed analysis revealed that four vehicles were of Asian origin and lacked logistical support in the Western Balkans region, with spare parts taking up to 90 days to be delivered, making them technically unacceptable. One vehicle initially considered in the analysis, did not meet the technical specifications required for the company's operations. The data collection and analysis period covered the interval from November 21, 2025 to January 12, 2026.

4.2. Calculation of criterion weights

The procedure for determining the weights of criteria is based on the application of an objective-subjective model, which consists of the MEREC [16] and the FUCOM method [17]. The obtained values of the criterion weights for both methods are as follows: MEREC: (0.159, 0.053, 0.089, 0.172, 0.159, 0.037, 0.117, 0.097, 0.118), FUCOM: (0.142, 0.100, 0.120, 0.115, 0.129, 0.098, 0.106, 0.095, 0.095). The final weights, obtained by averaging the values are (0.150, 0.076, 0.105, 0.144, 0.144, 0.067, 0.111, 0.096, 0.107). The most significant criteria relate to vehicle price, energy consumption, and battery charging time.

4.3. Evaluation of electric vehicles using the STENOZA method

The following section presents the results of selecting an electric vehicle for waste collection and transport using new STENOZA method. The initial matrix is shown in Table 1.

Table 1. Initial STENOZA matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
EV_1	310000	6.6	336	12	1.45	9000	80	12	5
EV_2	260000	6.0	264	10	1.25	8250	71	12	5
EV_3	290000	6.3	300	14	1.35	9000	75	12	5
EV_4	240000	5.7	265	12	1.15	9000	63	10	4
EV_5	255000	5.7	282	11	1.15	9000	65	10	4
EV_6	260000	5.7	280	13	1.20	8000	69	10	4

Criteria C_1, C_4, C_5 and C_6 belong to the cost group, while the remaining criteria are benefit. The normalized matrix for all types of normalization, using Eqs. (1)-(3) is presented in Table 2.

Table 2. STENOZA normalized matrix

	n_{ij}^{v}				n_{ij}^{nl}				n_{ij}^{l}			
	C_1	C_2	·	C_9	C_1	C_2	·	C_9	C_1	C_2	·	C_9
EV_1	0.532	0.448	·	0.451	0.464	1.000	·	1.000	0.774	1.000	·	1.000
EV_2	0.607	0.408	·	0.451	0.787	0.826	·	1.000	0.923	0.909	·	1.000
EV_3	0.562	0.428	·	0.451	0.567	0.911	·	1.000	0.828	0.955	·	1.000
EV_4	0.637	0.387	·	0.361	1.000	0.746	·	0.640	1.000	0.864	·	0.800
EV_5	0.615	0.387	·	0.361	0.834	0.746	·	0.640	0.941	0.864	·	0.800
EV_6	0.607	0.387	·	0.361	0.787	0.746	·	0.640	0.923	0.864	·	0.800

In the third and fourth steps of the STENOZA method, the normalized matrix (4) was weighted and the ideal t_j (5) and non-ideal solution k_j (6) were defined, as shown in Table 3.

In the fifth step, the distance from the ideal solution dt_{ij} and the non-ideal solution dk_{ij} was calculated using Eqs. (7) and (8), respectively, as shown in Table 4.

By applying Eqs. (9)-(11) in the final three steps of the STENOZA method, the final values and rankings of the electric vehicles were obtained (Table 5). The results obtained using the new STENOZA method indicate that the best electric vehicle among those considered is the second alternative, which is the Mercedes-Benz eEconic.

Table 3. Weighted STENOZA normalized matrix with ideal and non-ideal solutions

	n_{ij}^{v}				n_{ij}^{nl}				n_{ij}^{l}			
	C_1	C_2	·	C_9	C_1	C_2	·	C_9	C_1	C_2	·	C_9
EV_1	0.080	0.034	·	0.048	0.070	0.076	·	0.107	0.116	0.076	·	0.107
EV_2	0.091	0.031	·	0.048	0.118	0.063	·	0.107	0.139	0.069	·	0.107
EV_3	0.084	0.033	·	0.048	0.085	0.070	·	0.107	0.124	0.073	·	0.107
EV_4	0.096	0.030	·	0.038	0.150	0.057	·	0.068	0.150	0.066	·	0.085
EV_5	0.092	0.030	·	0.038	0.125	0.057	·	0.068	0.141	0.066	·	0.085
EV_6	0.091	0.030	·	0.038	0.118	0.057	·	0.068	0.139	0.066	·	0.085
	t_j^{v}				t_j^{nl}				t_j^{l}			
t_j	0.096	0.034	·	0.048	0.150	0.076	·	0.107	0.150	0.076	·	0.107
	k_j^{v}				k_j^{nl}				k_j^{l}			
k_j	0.080	0.030	·	0.038	0.070	0.057	·	0.068	0.116	0.066	·	0.085

Table 4. Distances from the ideal and non-ideal solutions

	dt_{ij}^{v}				dt_{ij}^{nl}				dt_{ij}^{l}			
	C_1	C_2	·	C_9	C_1	C_2	·	C_9	C_1	C_2	·	C_9
EV_1	0.984	1.000	·	1.000	0.919	1.000	·	1.000	0.966	1.000	·	1.000
EV_2	0.995	0.997	·	1.000	0.968	0.987	·	1.000	0.988	0.993	·	1.000
EV_3	0.989	0.998	·	1.000	0.935	0.993	·	1.000	0.974	0.997	·	1.000
EV_4	1.000	0.995	·	0.990	1.000	0.981	·	0.962	1.000	0.990	·	0.979
EV_5	0.997	0.995	·	0.990	0.975	0.981	·	0.962	0.991	0.990	·	0.979
EV_6	0.995	0.995	·	0.990	0.968	0.981	·	0.962	0.988	0.990	·	0.979
	dk_{ij}^{v}				dk_{ij}^{nl}				dk_{ij}^{l}			
	C_1	C_2	·	C_9	C_1	C_2	·	C_9	C_1	C_2	·	C_9
EV_1	0.000	0.005	·	0.010	0.000	0.019	·	0.038	0.000	0.010	·	0.021
EV_2	0.011	0.002	·	0.010	0.048	0.006	·	0.038	0.022	0.003	·	0.021
EV_3	0.005	0.003	·	0.010	0.015	0.013	·	0.038	0.008	0.007	·	0.021
EV_4	0.016	0.000	·	0.000	0.081	0.000	·	0.000	0.034	0.000	·	0.000
EV_5	0.012	0.000	·	0.000	0.056	0.000	·	0.000	0.025	0.000	·	0.000
EV_6	0.011	0.000	·	0.000	0.048	0.000	·	0.000	0.022	0.000	·	0.000

Table 5. Evaluation results of electric vehicles using the STENOZA method

	st_{ij}				sk_{ij}				gt_i	gk_i	fc_i	Rank
	C_1	C_2	·	C_9	C_1	C_2	·	C_9				
EV_1	0.957	1.000	·	1.000	0.000	0.011	·	0.023	0.986	0.121	0.554	2
EV_2	0.984	0.992	·	1.000	0.027	0.004	·	0.023	0.991	0.164	0.577	1
EV_3	0.966	0.996	·	1.000	0.009	0.008	·	0.023	0.984	0.097	0.540	5
EV_4	1.000	0.989	·	0.977	0.043	0.000	·	0.000	0.984	0.102	0.543	4
EV_5	0.988	0.989	·	0.977	0.031	0.000	·	0.000	0.985	0.111	0.548	3
EV_6	0.984	0.989	·	0.977	0.027	0.000	·	0.000	0.983	0.090	0.536	6

5. Verification Tests

This section defines additional verification tests to assess the stability and reliability of the new STENOZA method. A comparative analysis was conducted with a large number of other

MCDM methods (Fig. 1), a sensitivity analysis whose results are presented in Fig. 2, and the calculation of statistical rank correlations (Fig. 3). These analyses are of great importance for verifying the stability of both the method and the obtained solutions, as confirmed by numerous studies [18,19].

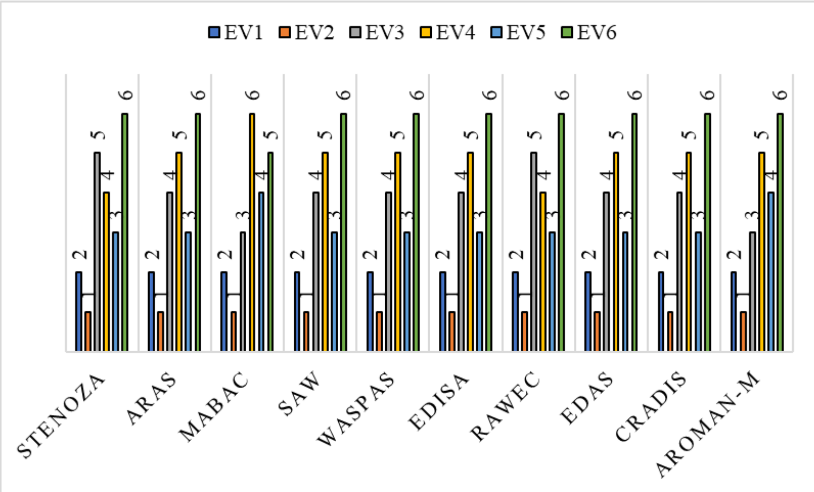

Fig. 1. Comparative analysis.

The comparative analysis shows a sufficient alignment of the STENOZA method with nine other methods, confirming both the originality and reliability of the new method. In the complete comparative analysis, the two electric vehicles with the best performances retained their positions.

Fig. 2 shows the new rankings of electric vehicles for waste collection and transport based on changes in the importance of the criteria. The key point is that the highest-ranked electric vehicle retains the first position across all newly formed scenarios, thereby confirming the selection made using the STENOZA method. Certain criteria influence other alternatives, and depending on the criterion considered, the vehicle rankings vary.

Statistical correlation tests, SCC [20,21] and WS [22], in the comparative analysis range from 0.714 to 1.000 for SCC, and from 0.898 to 1.000 for the WS coefficient. In the sensitivity analysis, the lowest correlation coefficient value is SCC=0.600, which is due to a 90% reduction in the significance of the fourth criterion relative to its original value. Overall, the average values of both coefficients for both types of analysis indicate high or very high correlation: SCC(SA)=0.919, WS(SA)=0.944, SCC(CA)=0.920, WS(CA)=0.965.

The STENOZA method has been checked through application in the MCDM model within 16 alternatives and shows very stable results and correlation with other studies. Depending on the type of the problem, this method can provide precise results in a way to check whether alternatives tend toward ideal or non-ideal solutions.

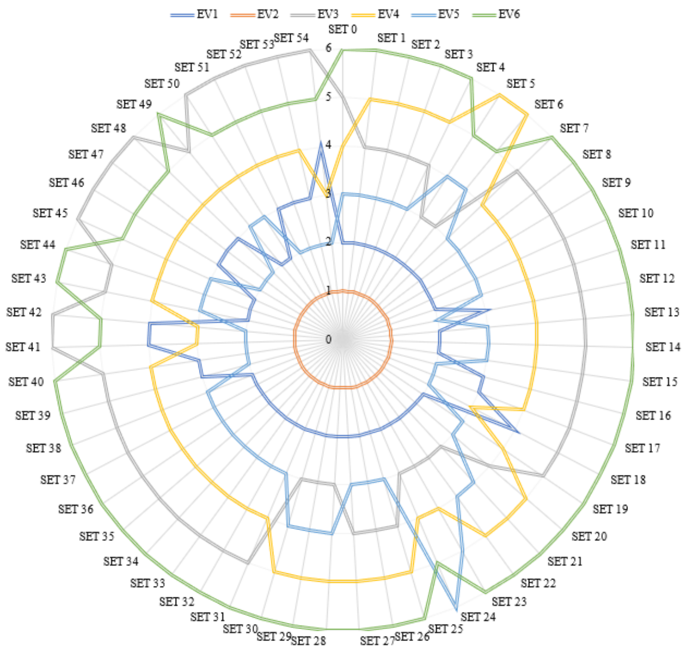

Fig. 2. New sensitivity analysis results.

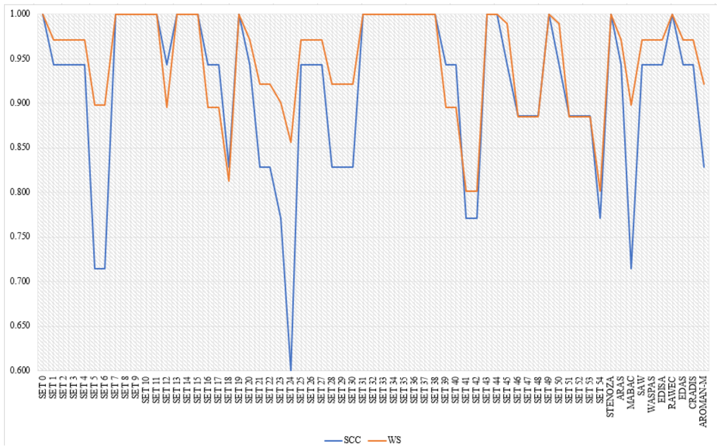

Fig. 3. Correlation coefficients for sensitivity analysis and comparative analysis.

6. Discussion

Studies have shown that the optimization of transport routes and the efficient planning of electric vehicle charging significantly increase the operational efficiency of an electric vehicle fleet [23]. Research [24] confirms that diesel-powered municipal vehicles, after ten years of active service, exhibit an exponential increase in nitrogen monoxide and nitrogen dioxide emissions. According to the same study, older internal combustion engine trucks potentially generate up to

25% higher energy losses due to periodic malfunctions and engine degradation over extended periods of operation. On the other hand, it has been demonstrated that electric vehicles achieve more favorable outcomes for utility companies following their integration into the fleet, with benefits realized within a period of four to seven years, compared to municipal vehicles powered by internal combustion engines. By transitioning to electric-powered municipal vehicles, energy costs can be reduced by up to 70% compared to internal combustion engine vehicles, while maintenance costs decrease by up to 40%, depending on the operating cycle. Since municipal waste collection in urban areas often involves a high frequency of stops [3] to empty waste containers, another advantage of electric vehicles lies in their ability to recover a relatively significant amount of energy during braking, resulting in minimal energy losses during route servicing [25]. The age of the vehicle fleet also increases maintenance costs and reduces the operational efficiency of municipal vehicles in transitional countries [26]. It has been proven that incentives and subsidies for the procurement of electric vehicles contribute to positive management decisions [27]. Therefore, although electric vehicles are more expensive than conventional diesel-powered vehicles, with government-approved incentives, the investment can become cost-effective within a period of three to five years [28].

7. Conclusions

Unlike the developed world, transitional countries unfortunately still rely on linear waste disposal practices without intermediate treatment (such as the utilization of secondary raw materials and their reintegration into a circular economy model, generating new usable value from waste). In this research, an optimistic analysis was conducted to select the optimal electric vehicle for waste collection and transport in the city of Doboj using the newly developed STENOZA method, with a specific analysis of input and output criteria encompassing technical, economic, operational and infrastructural aspects. The scientific contribution of this study lies in the fact that the paper offers a newly created MCDM method for ranking alternatives, which can be applied in any field of decision-making. Professional contribution can be manifested in fact that the proposed model for selecting the optimal electric vehicle in this paper can serve as a practical tool for decision-makers in utility companies, as well as a starting point for future research in the field of sustainable transport.

This research belongs to the very limited body of studies on the sustainability of utility enterprise electrification in Bosnia and Herzegovina, particularly given that this sector is considered a low-capital branch of the economy, similar to other enterprises of this type in the country. Its primary contribution lies in "broadening perspectives" in the field of clean transport and in enhancing environmental protection and public health for all other countries in the Western Balkans. A breakthrough in vehicle fleet modernization also represents a potential opportunity to connect with global, technologically advanced trends in the European Union and worldwide. The research results have shown that electric municipal vehicles can meet the requirements set out in this paper. Moreover, although the purchase costs of a new electric truck are significantly higher than those of conventional vehicles, it has been confirmed that, when equipped with an appropriate charger of up to 22 kW, an operationally sustainable and technically reliable system for waste collection can be established, directly contributing to the achievement of sustainable objectives.

Future research from aspect of this case study should be related to the procurement of electric vehicles and the monitoring of their exploration performances and influence on company business. From the aspect of decision-making processes, many extensions of the STENOZA method should be created with the theory of uncertainties.

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