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APPLICATION OF MULTI CRITERIA DECISION MAKING USING WEIGHTED SUM METHOD IN TENDER PROCEDURES FOR THE PROCUREMENT OF RAIL VEHICLES WITH INNOVATIVE POWER SOURCES

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Public transport tendering procedures constitute a complex decision-making process that requires taking into account many technical, economic, environmental, and social factors. Traditional cost-minimization approaches are no longer sufficient, because supplier selection decisions must balance quality, innovation and long-term profitability of the investment. Multi-criteria decision making (MCDM) is therefore emerging as a valuable tool for effectively comparing different tender offers, based on a wide range of criteria.

The article presents the application of one of the MCDM methods, the weighted sum method, in the process of selecting a supplier of rail vehicles, taking into account specific technical and operational requirements, as well as the principles of sustainable development. The article aims to present the benefits of implementing multi-criteria decision support methods in tendering procedures, offering a tool that not only supports the supplier selection process but also ensures a transparent justification of the decision based on comprehensive, multi-faceted analyses. The aim of the article is to present and analyze the application of the weighted sum method as a multi-criteria decision support tool in four tender procedures conducted by Koleje Mazowieckie for the procurement of rail vehicles equipped with innovative power sources. The adopted research methodology, which involved analyzing the offer evaluation criteria, led to the conclusion that the weighted sum method enables the ordering party to adjust the weights assigned to individual criteria according to its needs and priorities.

Keywords: multi-criteria decision making, rail vehicles, tender procedure, weighted sum method

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1. INTRODUCTION

The use of conventional methods based solely on the lowest price criterion, despite their popularity, often proves insufficient for achieving the best results in terms of quality, reliability, and long-term adaptation to the strategic needs of the contracting authority. Given the growing role of sustainable development, the implementation of technological innovations, and efforts to increase energy efficiency and reduce emissions, decision-making processes in tender procedures must cover a wide range of criteria to ensure the selection of the most suitable offer. In response to these requirements, multi-criteria decision support methods are gaining increasing importance, as they enable the simultaneous analysis of numerous, often contradictory, criteria. Among these, the weighted sum method, as one of the MCDM tools, allows for precise adjustment of the evaluation process to the needs of the contracting authority by assigning appropriate weights to individual criteria. The use of the weighted sum method in tender procedures ensures the objectivity of the selection process, enabling the assessment of hard aspects, such as purchase costs, operating expenses, and technical specifications, as well as soft aspects, including environmental impact, passenger comfort, and the level of technological innovation in the offered solutions.

2. LITERATURE REVIEW

Public procurement procedures in Poland are regulated by the Public Procurement Law (PZP), which implements relevant EU directives. The precise regulation of contract conclusion processes under public procurement is intended to provide legal protection to both the ordering party and the contractor. The quality of tender documentation plays a key role not only in ensuring the accuracy, efficiency, and timeliness of the tender procedure, but also has a significant impact on determining the group of potential contractors interested in competing for the contract. In addition, this documentation defines the procedure for selecting the most advantageous offer and establishes the rules for implementing the public procurement contract. The issue of offer evaluation criteria and numerous decision support methods have been addressed by both domestic and foreign authors.

The review of multi-criteria decision support methods (Trzaskalik, 2014) indicated the possibilities of their potential applications and provided a concise overview of basic additive methods (such as the SAW – Simple Additive Weighting Method and SMART – Simple Multi-Attribute Ranking Technique Exploiting Ranks), analytical hierarchy methods (AHP – Analytical Hierarchy Process and ANP – Analytical Network Process), as well as verbal decision analysis methods. More extensive descriptions were provided for methods from the ELECTRE family (fr.: Elimination Et Choix Traduisant la Realia), the PROMETHEE family (Preference Ranking Organization

Method for Enrichment Evaluations), and methods using reference points. The study also included examples of practical applications of the described methods.

The application of multi-criteria evaluation for variants of an integrated urban public transport system was presented using the example of Kraków (Solecka, 2013). Simulations were carried out for 8 variants of integrated urban public transport, with 10 evaluation criteria established. Computational experiments were carried out using four decision support methods: AHP, ANP, ELECTRE III and PROMETHEE II. As a result of the analyses, final recommendations were formulated.

The issue of multi-criteria contractor selection in public procurement was also raised by the author (Jadczak, 2014), who pointed out the essence of multi-criteria evaluation of contractors in the context of public procurement and the obligations of the contractor and the ordering party resulting from the need to comply with the provisions of the Public Procurement Law. The study discussed the subsequent stages of the contractor selection process for a public procurement. The author presented a simulation experiment based on an open tender procedure, evaluating bids using five criteria (price, order completion date, warranty period, payment date, and service duration) in the aspect of the Spearman rank correlation coefficient.

In the published (Kacprzak, 2018) work, the fuzzy SAW method was applied using weights derived from fuzzy entropy. The core idea of this method is to determine, for each decision variant, a linear combination of the elements from the normalized decision matrix and the corresponding elements of the weight vector. This approach allows for linear ordering of the considered decision variants and selection of the final variant in the light of the adopted criteria. Consequently, the use of objective weights in the presented method allows for reducing subjectivity and uncertainty arising from incomplete knowledge, personal judgments, opinions, and preferences of decision-makers or experts.

In the publication (Nurmalini, 2017), the author presented a study on the application of the SAW method within a decision support system. The author indicates the relatively simple SAW method as an effective and very useful in the decision-making process for modern managers. Based on the analysis, the author emphasizes that a decision support system using the SAW method can present the results of calculations based on criteria in an easy and transparent way. Importantly, it allows for quick and easy testing in various cases thanks to the simplicity of calculations.

A new model for determining the weighting factors of criteria in multi-criteria decision support models is presented (Pamučar, 2018) – the Full Consistency Method (FUCOM). This model assumes the definition of two sets of constraints that must be met by the values of the weighting coefficients. The first set of constraints ensures that the ratios of the weighting coefficients between criteria should be equal to the comparative priorities of the criteria. The second group of constraints is defined based on the principle of mathematical transitivity. After defining the constraints and solving the model, the results include not only the weight values but also the deviation from full consistency.

According to the authors, the main advantages of the FUCOM method compared to other multi-criteria decision-making approaches include: a significantly smaller number of pairwise comparisons, consistent pairwise comparison of criteria, and calculation of reliable weighting coefficient values that contribute to rational decision-making. In the work (Odu, 2019) on multi-criteria decision-making techniques, the author classified the methods into three categories: subjective, objective, and integrated (combined). The author indicates integrated methods as particularly valuable, as they allow decision-maker to more accurately assess the actual effectiveness of the tested solutions. An analysis of the specificity of services provided by transport companies operating along the New Silk Road was performed (Čarný, 2020) and a discussion of the multi-criteria methods used to evaluate offers in this market, as well as the criteria subject to evaluation.

The author presented the practical application of multi-criteria analysis methods in supporting decision-making, using examples from companies operating in the Slovak market. The summary emphasizes the importance of taking into account various evaluation criteria, enabling the ordering party to choose the most optimal offer from its perspective.

In the papers (Yannis, 2020; Karleuša, Dragičević, Deluka-Tibljaš, 2013), a review of the current state of knowledge on multi-criteria decision-making in the transport sector was conducted. The analysis indicates that the most commonly used method in this field is the analytic hierarchy process.

The author discusses in detail widely used MCDM techniques, emphasizing their advantages, such as the transparency and clarity of the decision-making process, the ability to manage large volumes of technical data, full control over the process (where results and weights are determined based on established parameters), as well as flexibility, allowing for modifications at later stages. The article also compares the most commonly used MCDM methods in the context of transport-related decision-making.

In the review of multi-criteria decision-making analysis in the context of sustainable production (Jamwal, Agrawal, 2021), the authors took into account such reference points as: social, economic, technical and environmental factors. The paper points out that various industries are currently facing increasing pressure from social non-governmental organizations to reduce the negative impact of production processes on both the environment and society, which, in consequence, can improve employee health and safety.

These problems can be solved by adopting environmentally conscious production practices within the industry. Adopting sustainable development practices enables organization to increase resource efficiency and reduce the amount of waste while saving energy. The authors note with satisfaction the growing importance of sustainable production aspects when planning production tasks.

The study (Stoilova, Martinov, 2022) analyzed four rail transport technologies intended for the transportation of road semi-trailers. The study developed

a methodology for assessing these technologies based on multi-criteria analysis. In the first stage, evaluation criteria were identified, covering both quantitative and qualitative aspects, which were divided into three main categories: technical, technological and economic. In the next step, the Shannon entropy method was used to objectively determine the weights of individual criteria. In the third stage, the importance of technologies was assessed using the PROMETHEE multi-criteria method, which allows for comparing variants and determining preferences for each criterion. The results of the analysis showed that economic criteria were the most important (50%), followed by technological criteria (45%), while technical criteria turned out to be the least important (5%).

3. TENDER PROCEDURES OF MAZOWIECKIE RAILWAYS FOR THE PROCUREMENT OF RAIL VEHICLES WITH INNOVATIVE POWER SOURCES

In recent years, the development of sustainable transport technologies has become one of the key priorities in the rail industry. In response to growing requirements for reduced greenhouse gas emissions and improved energy efficiency, rail vehicle manufacturers are increasingly implementing innovative power supply technologies that either replace traditional combustion engines or supplement electric drives. In this context, two alternative solutions are of particular interest: hydrogen fuel cell drives (Daszkiewicz et al., 2017) and vehicles equipped with high-capacity traction batteries (Maciołek, 2015). Battery-powered drives are particularly attractive for short- and medium-distance routes, as well as on non-electrified lines, where it is possible to recharge batteries on selected route sections. Batteries can be used as the sole power source or to be integrated into a hybrid system in combination with electric traction drives.

Koleje Mazowieckie (KM) is one of the largest regional rail carriers in Poland, providing passenger transport services in the Mazovian Voivodeship and select areas of neighboring voivodeships. The company was established in 2004 at the initiative of the Mazovian Voivodeship Government with the aim of providing Mazovian residents with convenient access to rail transport. Koleje Mazowieckie currently operates over 800 connections daily, carrying approximately 60 million passengers annually. The carrier has a modern rolling stock, consisting mainly of electric multiple units, and its development strategy focuses on improving service quality, modernizing its rolling stock, and introducing innovative technological solutions, such as vehicles powered by alternative power sources. Koleje Mazowieckie plays a key role in daily commuting to work, school, and institutions across the capital region and its outskirts, contributing to the improvement of mobility and integration of public transport in the Mazovia region.

Koleje Mazowieckie, as a key rail carrier in the Mazovian province, is currently facing various challenges and needs related to the modernization of its rolling stock. In the context of battery-powered vehicles, there are several key needs and tasks that can influence future decisions regarding their procurement and operation:

- Sustainable development. In response to growing environmental protection requirements, KM aims to reduce CO_2 and noise emissions. Battery-powered vehicles, which do not emit exhaust fumes during operation, are consistent with these goals.
- Operating costs. The implementation of battery-powered vehicles can lead to reduced operating costs, especially in the context of reducing fuel and maintenance costs. Electric vehicles often require less regular maintenance compared to traditional diesel locomotives.
- Adaptation to local conditions. Many railway lines in Mazovia, especially in areas with limited infrastructure, can be better served by battery-powered vehicles that do not require the expansion of the traction network. These vehicles can provide greater flexibility in operations on shorter routes.
- Efficiency and comfort. The growing competition in the public transport sector forces KM to invest in modern solutions that will provide passengers with comfort and reliability. Modern battery-powered vehicles offer not only quieter running, but also better quality of service.
- Charging infrastructure. The introduction of battery-powered vehicles requires the development of charging infrastructure. Koleje Mazowieckie will have to invest in appropriate charging stations and energy management systems to ensure efficient operation of the new rolling stock.
- Rolling stock management and integration with other systems. The introduction of new technologies also requires rethinking rolling stock management and integration with other public transport systems. Battery-powered vehicles can be part of a larger transport system, including cooperation with electric buses and other forms of public transport.
- Research and development. Koleje Mazowieckie can also take advantage of opportunities to cooperate with research institutions and vehicle manufacturers to develop and test new technologies, including different types of batteries and energy management systems.

All these factors indicate that KM is committed to implementing battery-powered vehicles as part of its development strategy, especially in the context of rolling stock modernization and the pursuit of sustainable public transport. This interest is expressed in the first tender procedure No. MWZ7.27.47.2023 announced by KM in June 2023 (INFORAIL, 2023). The subject of the order was the delivery of 6 brand-new, two-unit electric-battery traction units, together with a repair package. In addition to standard legal, economic, and technical information, the tender documentation also defined the criteria for awarding the order, including the weighting of these criteria and the method of evaluating bids. The analysis of the Specification

of Terms of Order indicates that the ordering party defined the following criteria for bid evaluation (fig. 1):

1) Cd – the price for delivery of 6 pcs. electric-battery traction units with a repair package – post-crash and employee training – weight 30%;
2) Cs – the price for providing service services for electric-battery traction units in maintenance levels P1, P2, P3 – weight 20%;
3) Cu – the price for repair P4 electric-battery traction units – weight 5%;
4) We – efficiency coefficient of electric-battery traction units – weight 20%;
5) Zta – range in battery mode of electric-battery traction units – weight 10%;
6) Człszst – stationary charging time from the traction network from 20% to 90% of the capacity of the batteries of electric-battery traction units – weight 5%;
7) Tdp – delivery date of vehicles – weight 10%.

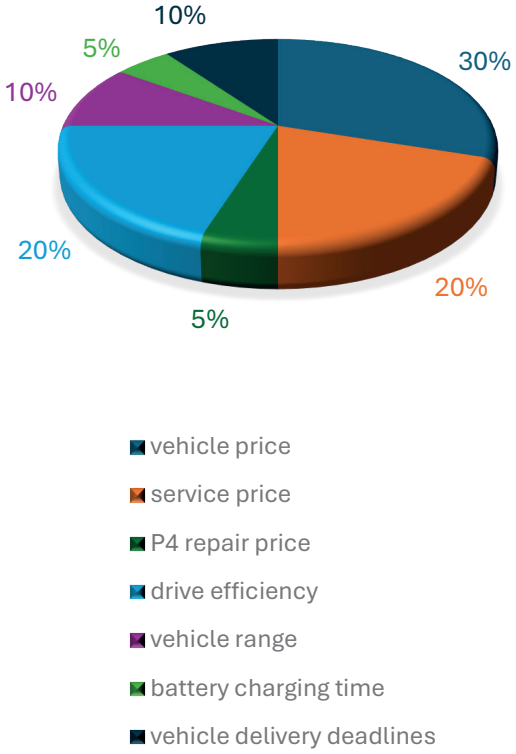

Fig. 1. Bid evaluation criteria. The first tender of Koleje Mazowieckie

The offers were evaluated as follows:

1) According to the Cd criterion – the price for the delivery of electric-battery multiple units together with a post-crash repair package and employee training. The Contractor who offers the lowest price will receive 100 points, while the other Contractors will receive correspondingly fewer points, according to the formula:

$$\text{Cd} = \frac{\text{Cd from the offer with the lowest gross price}}{\text{Cd from the gross offer examined}} \times 100 \text{ [pkt]} \quad (1)$$

The points obtained in this way will be multiplied by a coefficient of 0.3 corresponding to the weight of this criterion.

2) According to criterion Cs – the price for the provision of maintenance services of electrical-battery multiple units in maintenance levels P1, P2, P3. The Contractor who offers the lowest price will receive 100 points, while the other Contractors will receive correspondingly fewer points, according to the formula:

$$\text{Cs} = \frac{\text{Cs from the offer with the lowest gross price}}{\text{Cs from the gross offer examined}} \times 100 \text{ [pkt]} \quad (2)$$

The points obtained in this way will be multiplied by a coefficient of 0.2 corresponding to the weight of this criterion.

3) According to the Cu criterion – the price for the repair of P4 electric-battery multiple units. The Contractor who offers the lowest price will receive 100 points, while the other Contractors will receive correspondingly fewer points, according to the formula:

$$\text{Cu} = \frac{\text{Cu from the offer with the lowest gross price}}{\text{Cu from the gross offer examined}} \times 100 \text{ [pkt]} \quad (3)$$

The points obtained in this way will be multiplied by a coefficient of 0.05 corresponding to the weight of this criterion.

4) According to criterion We – Coefficient of performance of electric-battery multiple units. The Contractor who proposes the lowest value of the coefficient will receive 100 points, while the other Contractors will receive correspondingly fewer points, according to the formula:

$$\text{We} = \frac{\text{We from the offer with the lowest gross price}}{\text{We from the gross offer examined}} \times 100 \text{ [pkt]} \quad (4)$$

The points obtained in this way will be multiplied by a coefficient of 0.2 corresponding to the weight of this criterion. The method of calculating the coefficient of performance of battery-electric multiple units – EC is described in detail in the relevant annex to the Terms of Reference (it is the ratio of the declared energy consumption to the number of fixed seats in the vehicle).

5) According to the Zta criterion – battery range of battery-electric multiple units. Offers will be evaluated according to the rules set out in table 1.

Table 1. Score for the criterion: Range

Range offered in battery mode	Number of points
120 km	10
110 km	5
100 km	2
90 km	0

6) According to the criterion Człszst – time of stationary charging from the overhead contact line from 20% to 90% of the capacity of the batteries of electric-battery multiple units. Offers will be evaluated according to the rules set out in table 2.

Table 2. Score for the charging time criterion

Charging time from the traction network from 20% to 90% of battery capacity	Number of points
30 minutes	5
40 minutes	4
50 minutes	3
60 minutes	0

7) According to the Tdp criterion – delivery date of vehicles. Offers will be evaluated according to the rules set out in table 3.

Table 3. Scoring for the criterion: Delivery date

Offered delivery date for vehicles	Number of points
up to 29 months	10
up to 30 months	9
up to 31 months	8
up to 36 months	0

To select the most advantageous offer, the contracting authority used one of the most common algorithms of multi-criteria analysis – the method of weighted sums calculated according to the formula:

$$O = (\text{Pp for Cd} * 0{,}3) + (\text{Pp for Cs} * 0{,}2) + (\text{Pp for Cu} * 0{,}05) + (\text{Pp for We} * 0{,}25) + \text{Pp for Zta} + \text{Pp for Człszst} + \text{Pp for Tdp} \quad (5)$$

where:

O – overall evaluation of the offer (number of points);

Pp for Cd – points awarded for the price for the delivery of electric-battery multiple units together with a repair package - post-crash and employee training;

Pp for Cs – points awarded for the price for the provision of maintenance services of electric-battery multiple units in maintenance levels P1, P2, P3;

Pp for Cu – points awarded for the price for the repair of P4 electric-battery multiple units;

Pp for We – points awarded for the coefficient of efficiency of battery-electric multiple units;

Pp for Zta – points awarded for the range in battery mode of electric-battery multiple units;

Pp for Człszst – points awarded for stationary charging time from the overhead contact line from 20% to 90% of the battery capacity of electric-battery multiple units;

PP for Tdp – points awarded for the delivery date of vehicles.

In the information published by Koleje Mazowieckie in August 2023, it was reported that due to the procedure for the "Purchase of railway vehicles with service" was canceled due to the absence of submitted bids.

However, a month later, KM relaunched the tender and announced a second procedure (marked MWZ7.27.95.2023) for the purchase of 6 electric-battery traction units, together with a post-accident repair package and employee training. To the surprise of potential tender participants, the procedure was canceled by KM and on the very same day it was announced in the Supplement to the Official Journal of the EU, i.e., the bulletin informing about tenders in the EU.

The ordering party informed that circumstances had arisen causing a change in the needs for the supply of vehicles, which significantly changes the nature of the order and in the light of the provisions of the Public Procurement Law is a circumstance causing that further conduct of the procedure is unjustified. The contracting authority stated that circumstances had arisen which altered the requirements for the vehicle supply, significantly changing the nature of the order. According to the provisions of the Public Procurement Law, this constitutes grounds rendering the continuation of the procedure unjustified.

The analysis of the tender documentation shows that KM modified the provisions in terms of the criteria for selecting offers. Compared to the first tender, in the second one, the ordering party removed one of the criteria: the vehicle delivery date. Therefore, the evaluation criteria are as follows:

1) Cd – price for delivery of 6 pcs. electric-battery multiple units with a post-crash repair package and employee training – weight 30%;
2) Cs – price for the provision of maintenance services of electric-battery multiple units in maintenance levels P1, P2, P3 – weight 20%;
3) Cu – price for repair P4 of battery-electric multiple units – weight 5%;

4) We – battery electric multiple unit coefficient of performance – weight 25%;
5) Zta – battery range of battery-electric multiple units – weight 10%;
6) Man – time of stationary charging from the overhead contact line from 20% to 90% of the battery capacity of electric-battery multiple units – weight 10%.

Therefore, the formula (5) took the form:

$$O = (\text{Pp for Cd} * 0{,}3) + (\text{Pp for Cs} * 0{,}2) + (\text{Pp for Cu} * 0{,}05) + (\text{Pp for We} * 0{,}25) + \text{Pp for Zta} + \text{Pp for Człszst} \quad (6)$$

The criteria with their corresponding weights are presented in the graph below (fig. 2):

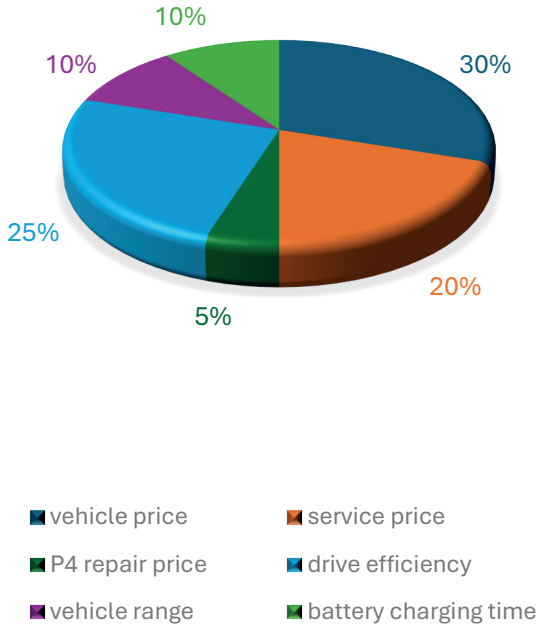

Fig. 2. Bid evaluation criteria. The second tender procedure of Koleje Mazowieckie

Due to the removal of the vehicle delivery date criterion, the weights of two other criteria were also changed: drive efficiency and battery charging time. In the case of drive efficiency, the weight of the criterion increased from 20% to 25%. In the case of charging time, the weight of the criterion increased from 5% to 10%, i.e., by as much as 100%. In the next – third tender (reference number: MWZ7.27.103.2023), the ordering party maintained the previous scope of delivery in the form of 6 vehicles, but supplemented the order with the possibility of using the option to deliver additional maximum 3 vehicles of the same type. However, there were no changes in the criteria for evaluating the offers in relation to the criteria presented in the second tender. In this procedure, two contractors submitted bids. However, since both

exceeded the amount that the ordering party intended to allocate to finance the order, the procedure was canceled (Madrjas, 2023).

The determination of KM in acquiring vehicles with innovative power sources was so great that another tender was announced – the fourth one (designation MWZ7.27.134.2023) with a similar scope of delivery as the third tender (Szymajda, 2024). However, there was a change in the evaluation criteria. For this tender, the criteria were as follows (fig. 3):

1) Cd – price for the delivery of all battery-electric multiple units with a post-crash repair package and employee training – weight 40%;
2) Cs – total price for the provision of maintenance services of all battery-electric multiple units in maintenance levels P1, P2, P3 – weight 25%;
3) Cu – price for P4 repair of all battery-electric multiple units – weight 5%;
4) We – battery electric multiple unit coefficient of performance – weight 20%;
5) Zta – battery range of electric-battery multiple units – weight 10%.

Therefore, the formula (5) was expressed as follows:

$$O = (\text{Pp for Cd} * 0{,}4) + (\text{Pp for Cs} * 0{,}25) + (\text{Pp for Cu} * 0{,}05) + (\text{Pp for We} * 0{,}2) + \text{Pp for Zta} \quad (7)$$

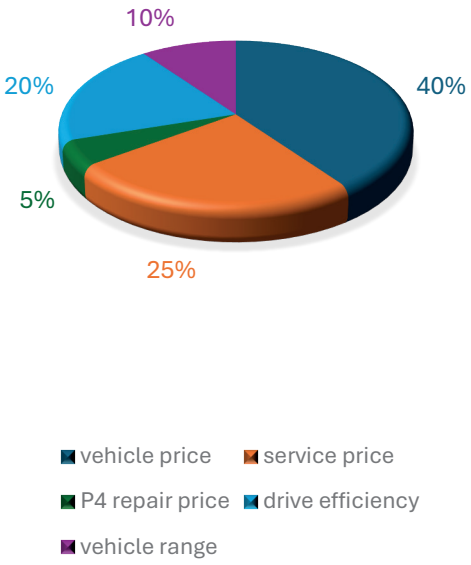

Fig. 3. Bid evaluation criteria. The fourth tender procedure of Koleje Mazowieckie

This indicates that, compared to the third tender, the battery charging time criterion was completely removed. In addition, greater emphasis was placed on the vehicle price criterion, with its weight increasing by 33% (from 30% to 40%). The service price criterion was also increased by 25% (from 20% to 25%). However, the

weight of the drive efficiency criterion was reduced from 25% to 20%. In this procedure, three contractors submitted bids. However, as in the previous case, the procedure was invalidated because all bids exceeded the amount that the ordering party intended to allocate to finance the order, which in the light of the provisions of the Public Procurement Law is a valid justification for annulling the procedure.

4. SUMMARY

The use of multi-criteria decision making through the weighted sum method is an effective and formally justified procedure in tender processes for the supply of rail vehicles. It allows for a comprehensive assessment of proposed solutions by considering various technical, economic, and environmental criteria. This is particularly important in the context of the increasing emphasis on quality and sustainable development in public transport. The analyses carried out confirm that the weighted sum method enables the ordering party to precisely adjust the weights assigned to individual criteria according to its specific needs and priorities, thereby enhancing the accuracy of decision-making. Implementing this method in tender procedures helps to increase the level of transparency and rationalization of the decision-making process, while also supporting more effective risk management in the context of long-term infrastructure investments. In the context of dynamic technological changes and growing requirements for sustainable development, multi-criteria decision support methods, including the weighted sum method, are gaining importance as essential analytical tools. The development of advanced decision models and optimization of assessment procedures will be an important area for further research, ultimately contributing to enhanced quality and efficiency in tender procedures within the public transport sector.

The offer of rail vehicle manufacturers in the field of battery-powered vehicles is developing dynamically, driven by the growing interest of public transport operators in more sustainable and flexible solutions.

Vehicles such as Stadler Flirt Akku (Przybylski, 2023), Siemens Mireo Plus B (Horpeniakova, 2024), Alstom Coradia Continental (Preston, 2023), Bombardier Talent 3 BEMU (Laperrière, 2019) or Škoda RegioPanther BEMU (Plesko, 2024) are becoming increasingly popular across European Union member states, offering advanced technologies that enable efficient operation of partially non-electrified lines.

Their success results from the possibility of reducing emissions, improving energy efficiency, and increasing operational flexibility compared to traditional combustion-powered vehicles. In the context of the Polish rail market, it seems inevitable that domestic carriers will show growing interest in such solutions in the near future, especially in the face of increasing environmental and regulatory requirements, as well as the need to modernize both infrastructure and rolling stock. The

key challenge will be the systematic monitoring of the latest technical solutions and assessing their potential application within the Polish context, which will allow for the optimization of the decision-making process and adaptation of the rolling stock to the expectations of passengers and regulatory requirements. At the same time, it is essential to conduct tender procedures in a way that enables the selection of the most advantageous offer from a full life cycle perspective of the entire life cycle of the vehicle, taking into account both economic aspects, such as purchase. This included not only operating costs, but also technical and environmental parameters. A multi-criteria approach to offer evaluation will allow carriers to make rational decisions consistent with long-term strategic goals and current technological trends.

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ZASTOSOWANIE WIELOKRYTERIALNEGO WSPOMAGANIA DECYZJI Z WYKORZYSTANIEM SUM WAŻONYCH W POSTĘPOWANIACH PRZETARGOWYCH NA DOSTAWĘ POJAZDÓW SZYNOWYCH Z INNOWACYJNYMI ŹRÓDŁAMI ZASILANIA

Streszczenie

Postępowania przetargowe w sektorze transportu publicznego, a szczególnie te dotyczące dostawy pojazdów szynowych, stanowią złożony proces decyzyjny, który wymaga uwzględnienia wielu czynników technicznych, ekonomicznych, środowiskowych i społecznych. Tradycyjne podejścia oparte na minimalizacji kosztów przestają być wystarczające, ponieważ decyzje o wyborze dostawcy muszą równoważyć jakość, innowacyjność oraz długoterminową opłacalność inwestycji. Wielokryterialne wspomaganie decyzji (ang. Multi Criteria Decision Making – MCDM) staje się zatem narzędziem, które pozwala na efektywne porównanie różnych ofert przetargowych na podstawie szerokiego spektrum kryteriów. W artykule przedstawiono zastosowanie jednej z metod MCDM – metody sum ważonych w procesie wyboru dostawcy pojazdów szynowych, uwzględniając specyficzne

wymagania techniczne i operacyjne oraz potrzeby zrównoważonego rozwoju. W ten sposób w pracy zaprezentowano korzyści płynące z implementacji wielokryterialnych metod wspomagania decyzji w postępowaniach przetargowych, oferując narzędzie, które nie tylko wspiera proces wyboru dostawcy, ale również umożliwia przejrzyste uzasadnienie podjętej decyzji na podstawie kompleksowych analiz wieloaspektowych. Celem artykułu są przedstawienie i analiza zastosowania metody sum ważonych jako narzędzia wielokryterialnego wspomagania decyzji w czterech postępowaniach przetargowych Kolei Mazowieckich na dostawę pojazdów szynowych z innowacyjnymi źródłami zasilania. Przyjęta metodyka badań polegająca na analizie kryteriów oceny ofert doprowadziła do konkluzji, że metoda sum ważonych umożliwia zamawiającemu dopasowanie wag przypisanych poszczególnym kryteriom do jego indywidualnych potrzeb i priorytetów.

Słowa kluczowe: analiza wielokryterialna, pojazdy szynowe, postępowanie przetargowe, metoda sum ważonych