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MANAGEMENT OF MUNICIPAL WASTE COLLECTION AND MANAGEMENT SERVICES

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Purpose: This article aims to present the theoretical solution to the problem of waste management.
Design/methodology/approach: This model is a proposal for the assessment of bids, which enables the unification of assessments against the criteria expressed in various measures, includes determining the importance of individual criteria, and thus the simulation of assessments when changing the criteria weight values.
Findings: The article presents the theoretical optimization model of waste collection and management, which may be helpful in solving the problem of waste more effectively.
Research limitations/implications: The article is limited to presenting only the basic model of waste management optimization. Due to the fact that in individual administrative units of the country solving the problem of waste is a local issue, it was impossible to present a solution that would be adequate for each region of the country.
Practical implications: The article presents a theoretical model that can form the basis of a practical optimal solution to the problem of waste in individual administrative units of the country.
Social implications: Optimal waste management is an extremely important social issue. In addition to efficient waste management, increasing public awareness of the impact of precipitation segregation and recycling on the environment is an extremely important issue.
Originality/value The presented model is a flexible model that can be used by individual administrative units, taking into account the specificities of waste management possibilities and restrictions in a given region.

Keywords: waste management, selective waste collection, ecology, optimisation, multi-criteria analysis.

Category of the paper: construction model, literature research.

1. Introduction

According to the Act of 5 July 2018 and art. 6d. 1. the head of the municipality, mayor or city president is obliged to award a public procurement for the collection of municipal waste from property owners referred to in art. 6c or a public procurement for the collection and management of this waste. In the case of preparing the specification of the essential terms of the procurement, the head of the municipality, mayor or city president specifies the requirements within it, regarding, among others, the forwarding of collected mixed municipal waste and green waste to regional municipal waste treatment installations, types of municipal waste collected selectively from property owners, sanitary standard of service provision and environmental protection, obligation to keep documentation related to the activities covered by the procurement, installations, in particular regional installations for processing of municipal waste, to which the entity collecting municipal waste from property owners is obliged to hand over the received waste – in the case of a tender for the collection of waste from property owners – or obliges to indicate such installations in the bid, in the case of a tender for the collection and management of such waste (prawo.sejm.gov.pl/…).

Pursuant to art. 91 para. 1 and 2 of the Public Procurement Law, the ordering party selects the most favourable bid, based on a set of criteria for the assessment of bids specified in the bid specifications. The criteria for assessing bids for municipal waste collection and management services may be the price or the cost, as well as other criteria related to the subject matter of the contract. In this paper, a multi-criteria model of assessments of bids was proposed, taking into account broader criteria, not only the price and cost. It is up to the customer, as to which criteria will be taken into account when assessing the bids. Due to the different specifications defined by the governing authorities in different municipalities, there were no artificially defined threshold values of the criteria and the scoring scheme – this can be done when initialising the model assuming specific values as threshold variables. In the absence of threshold values, these values will be the highest values that one of the bids receives. On the basis of municipality contracts regarding waste management, a hierarchical structure of criteria was developed (www.uzp.gov.pl/…; www.um.kielce.pl/…; bip.gdansk.pl/…; www.przetargi.egospodarka.pl/…; www.uokik_raport_odpady_komunalne.pdf).

1) financial aspect – price (PLN),
2) social aspect,
    a. taking into account the needs of people with disabilities (point),
    b. ecological education – carrying out information and educational activities in the field of proper management of municipal waste, in particular in the field of selective collection of municipal waste (point),

3) ecological (environmental) aspect,
   a. types of solutions beneficial for the environment – impact on the natural environment due to the exhaust emissions of vehicles used by the contractor in the performance of the service. The bid should include a list of vehicles used to perform the contract: vehicles adapted to collect individual parts of waste, excluding the mixing of waste, vehicles with a hydraulic crane, vehicles with dynamic weight certification, flatbed vehicles adapted to collect waste using the bin bag system, vehicles adapted to transport containers, vehicles equipped with devices with the function of bin washing, flatbed vehicles for the transport of bulk waste, smaller vehicles intended for collecting waste from places with difficult access, European emission standards vehicles meeting the Euro 3, Euro 4, Euro 5 or Euro 6 standards. The model will specify the percentage use of individual vehicles. For individual vehicle groups, weights will be assigned in accordance with the customer's expectations,
   b. the distance of the storage and transport base from the borders of the municipality – the smaller the distance, the smaller the amount of exhaust fumes produced at shorter journeys and the lower the road wear,
   c. applicability of waste separation (point),
   d. the use of biodegradable bags – the contractor bids to provide and equip property owners with biodegradable bags for biodegradable waste instead of traditional bags (point),
   e. having a certified environmental management system, compatible with, e.g. the international ISO 14001 standard, the European Eco-Management system or the EMAS audit scheme (point),
   f. inclusion of waste selection (point):
      - plastics and plastic packaging,
      - metals and metal packaging,
      - composite packaging,
      - mixed packaging waste,
      - paper and cardboard, paper and cardboard packaging,
      - glass and glass packaging,
      - biodegradable waste,
   g. equipping bins/containers with RFID transponders (%),
      - recycling (including organic recycling) (point),
   h. energy recovery – thermal waste treatment for energy recovery (point),
4) professional qualifications and experience of persons designated to perform the contract (point),

5) technical aspect,
   a. delivery conditions (point),
   b. distance of the storage and transport base from the municipality borders – the smaller the distance, the shorter the time to supply a replacement vehicle in the event of a breakdown (km),
   c. The deadline for filing complaints (number of days),
   d. disposal of bins – the period, for which the Contractor undertakes to leave bins at the disposal of the Ordering Party, after the completion of the service of collecting and transporting waste, over a minimum 30-day period required (number of days),
   e. Equipping property with containers and bags for collecting waste (point),
   f. Deadline for bin delivery, within which the contractor undertakes to provide a municipal waste bin, newly declared by the property owner, after receiving the notification from the ordering party (number of days),
   g. Additional bin washing – a declaration for carrying out additional washing and disinfection of bins, which the contractor undertakes to perform during the provision of waste collection and transport services, beyond the specified minimum (point),
   h. the possibility of collecting other waste (point):
      - bulk waste,
      - electrical and electronic equipment waste,
      - used tyres from passenger cars,
      - construction and demolition waste from multi-family buildings,
      - collection of expired medicines from pharmacies.

The purpose of this paper is to present a multi-criteria model that can form the basis for analysing bids of waste management services. This model can be modified, e.g. extended with additional criteria as expected by the Ordering Party. The proposed solution allows to go beyond the artificial adherence to restrictions, compare the value of criteria expressed in different units of measurement, as well as gives the possibility to simulate the obtained results, depending on the specified weight of criteria.

2. A multi-criteria model for assessing waste management bids

Searching for the optimal solution, the problem is analysed and a solution adequate to the problem is sought. When analysing waste management bids, it is based on many criteria, which is expressed in different units of measurement. Therefore, it seems reasonable to use multi-criteria programming, together with the data normalisation process (Trzaskalik, 2006, Stadnicki, 2006). This paper presents a hierarchical structure of criteria compiled on the basis

of the requirements set by various cities and municipalities in Poland, taking into account the freedom to choose these criteria and the importance of criteria.

The presented model assumes the analysis of I – bids, consisting of a finite set O:

$$O = \{O_1, O_2, ..., O_i, ..., O_I\}, \qquad i = 1, ..., I, \tag{1}$$

The criteria presented in point 1 of the work form a three-level hierarchical structure. The paper adopts the W_o variable that determines the validity of *Level 1* criteria (price, social aspect, ecology, professional qualifications and experience of the persons appointed to perform the contract, technical aspect):

$$\sum_{j=1}^{5} W_j = 1 \tag{2}$$

Level 2 criteria consist of sub-criteria of *Level 1* criteria. The validity of these criteria is described by the variable W_{jk} (k – *Level 2* criterion).

$$\sum_{k} W_{jk} = 1 \tag{3}$$

Level 3 criteria include sub-criteria of criteria, such as: types of beneficial solutions for the environment, as well as consideration of the selection of waste from the third criterion – the ecological aspect and the possibility of receiving other waste from the criterion in the technical aspect. The validity of *Level 3 criteria is described by the* W_{jkl} *variable*(l – *Level 3* criterion).

$$\sum_{l} W_{jkl} = 1 \tag{4}$$

Due to the fact that the criteria, against which the bids are subject to assessment, are expressed in different measurements, the grades are normalised according to the formula:

$$N'_{O_i} = \frac{N_{O_i}}{\max N_{O_i}}, \tag{5}$$

where:

N – the value of the bid assessment in relation to a given criterion,

max N – the maximum bid assessment within a given criterion. The received N value is the new binding value of the bid assessment in relation to a given criterion.

Based on standardised bid assessments against *Level 3* criteria, one can determine weighted bid assessments according to the formula:

$$N_{O_{i-jk}} = \frac{\sum W_{jkl} \cdot N'_{O_{i-jkl}}}{\sum W_{jkl}} \tag{6}$$

The next stage is normalisation of bid assessments against *Level 2* criterion using the formula (5). Based on standardised assessments, we determine the total assessment, taking into account the validity of individual criteria according to the formula:

$$N_{O_{i-j}} = \frac{\sum W_{jk} \cdot N'_{O_{i-jk}}}{\sum W_{jk}} \tag{7}$$

The cumulative assessments of *Level 1* criteria are then subject to standardisation (5). Normalised assessments against *Level 1* criteria, taking into account the validity of these criteria, form final assessments according to the formula:

$$N_{O_i} = \frac{\sum W_j \cdot N'_{O_{i-j}}}{\sum W_j} \tag{8}$$

After analysing the bids, the contract will be awarded to the contractor who bids the most favourable bid, i.e. receives the highest score based on the adopted criteria. Therefore, after defining the final accumulative scores, maximising the assessment can be used to determine which bids best meet the employer's expectations:

$$N_i \rightarrow MAX \tag{9}$$

Based on the above formula, it is possible to select the contractor with the most favourable bid – *i.*

3. Summary

This article presents a multi-criteria model for assessing bids for the collection and management of municipal waste. The choice of solution was guided by the ordering of the criteria for the assessment of bids, the solution of the issue of various measurements of individual criteria and the possibility of changing the validity of the criteria, which, in turn, enables a full overview of various options of the results of the assessment of the bids. This model can be the basis for the assessment of bids, but it is not artificial – it can be modified according to the requirements or preferences of the Ordering Party.

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References

1. Bilitewski, B., Hardtle, G., Marek, K. (2008). *Podręcznik gospodarki odpadami. Teoria i praktyka*. Warszawa: Wydawnictwo Seidel-Przywecki.
2. http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20180001454/T/D20181454L.pdf.
3. http://www.przetargi.egospodarka.pl/510553_Sukcesywny-odbior-i-zagospodarowanie-odpadow-o-kodzie-19-12-12_2019_2.html.
4. http://www.uokik_raport_odpady_komunalne.pdf.
5. https://bip.gdansk.pl/zamowienia-publiczne/odbior-i-transport-odpadow-komun-z-nieruchomosci-zlokalizowanych-w-granicach-admin-gminy-miasta-gdanska-sektory-i-v,a,142654.
6. https://www.uzp.gov.pl/__data/assets/pdf_file/0028/36982/MZNK_Jaworzno.pdf.
7. Kesra, N. (2017). *Metody analizy wielokryterialnej i wielowymiarowej w podejmowaniu decyzji*. Warszawa: PWN.
8. Marcinkowski, T. (2011). *Kompleksowe zarządzanie gospodarką odpadami*. Poznań: Wydawnictwo Polskie Zrzeszenie Inżynierów i Techników Sanitarnych.
9. Rosik-Dulewska, Cz. (2015). *Podstawy gospodarki odpadami.* Warszawa: PWN.
10. Stadnicki, J. (2006). *Teoria i praktyka rozwiazywania zadań optymalizacyjnych*. Warszawa: WNT.
11. Trzaskalik, T. (2006). *Metody wielokryterialne na polskim rynku finansowym*. Warszawa: PWE.
12. www.um.kielce.pl › kielce2 › files › przetargi › 2017_08_02_odpady › siwz.