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Oreste Approach for Supplier Selection in a Power Plant Firm[1]

Bir Enerji Santrali Firmasında Tedarikçi Seçimi İçin Oreste Yaklaşımının Uygulanması

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ABSTRACT

In recent years, businesses are devoting enhanced attention to renewable energy sources due to the rapid depletion of fossil fuels, increased environmental awareness of society, and undesirable climate change results like the rise of atmospheric carbon dioxide, sharp increased temperature, and prolonged drought. Biomass is a relatively new renewable energy source, which is gathering the attention of firms. Biomass power is generated through the usage of organic materials to create energy. Crusher machines which, are used in biomass energy-generating processing, press the organic materials to reduce them into small size. In this paper, the ORESTE method are applied to find out the best crusher machine supplier. Firstly, criteria are essential to evaluate suppliers when purchasing a crusher machine are determined and ranked. Then, three crusher machine suppliers are assessed based on five criteria (moisture of material, tons/hour specification of crusher, electrical power of crusher, input-output properties of raw material, types of crusher) with ORESTE multi-criteria decision-making method to create a framework for decision-makers. The results show that third supplier is the best company to purchase the crusher machine.

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ÖZ

Son yıllarda işletmeler, fosil yakıtların hızla tükenmesi, toplumun çevre bilincinin artması, atmosferik karbondioksitin yükselmesi, hızla artan sıcaklık ve uzun süreli kuraklık gibi istenmeyen iklim değişikliği sonuçları nedeniyle yenilenebilir enerji kaynaklarına daha fazla önem vermektedir. Biyokütle, firmaların dikkatini çeken nispeten yeni bir yenilenebilir enerji kaynağıdır. Biyokütle enerjisi, enerji oluşturmak için organik maddelerin kullanılmasıyla üretilir. Bu çalışmada, en iyi kırıcı makine tedarikçisini bulmak için ORESTE yöntemi kullanılmıştır. Öncelikle bir kırıcı makinesi satın alırken tedarikçileri değerlendirmek için kriterler belirlenmiş ve sıralanmıştır. Daha sonra karar vericilere bir çerçeve oluşturmak için üç kırıcı makine tedarikçisi, ORESTE çok kriterli karar verme yöntemi ile beş kritere (malzemenin nemi, kırıcının ton / saat spesifikasyonu, kırıcının elektrik gücü, hammadde giriş-çıkış özellikleri, kırıcı çeşitleri) göre değerlendirilmiştir. Sonuçlar, üçüncü tedarikçinin, kırma makinesini satın almak için en iyi şirket olduğunu göstermektedir.

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INTRODUCTION

Nowadays, most managers face the problem of how to effectively and efficiently evaluate and consume their energy resources to manufacture products. Moreover, finite fossil energy resources make it hard to meet the company's production requirements. On the other hand, environmental issues and international policies about clean energy usage such as the Kyoto Protocol (Cai and Menegaki, 2019) increased awareness of consumers about climate change are the other reasons that push the company to use renewable energy resources.

Biomass energy is one of the renewable energy sources for companies as an alternative to fossil energy sources (Vassilev et al., 2010; Vassilev et al.,2012). The sources of the biomass energy can be waste of the wood, animal, human, agricultural and industrial products (Vassilev et al.,2010). Thus, they can be easily available all above world, which feature make it sustainable energy source, whereas this energy source is secure and environmental friendly (Sriram and Shahidehpour, 2005; Vassilev et al., 2010).The processing of the biomass to create bioenergy does not contribute to the greenhouse effect, acid rains or negative environmental impacts (Sriram and Shahidehpour, 2005). Therefore, this energy source is good opportunity for sustainable development as well as mitigation of the global warming problems.

The usage of MCDM method under renewable energy machine suppliers' evaluation and selection, assist managers through facilitation the information amount/complexity. Introduced in 1982 by Roubens, the ORESTE (Organization, Rangement Et Synthese De Donnees Relationnelles) method requires only ordinal data to evaluate alternatives and rank criteria. Therefore, it is a more attractive MCDM technique for managers when the numeric data are missing or impossible to find out or hard to calculate (Pastijn and Leysen, 1989; Chatterjee and Chakraborty, 2014). Using the ORESTE method under renewable energy machine suppliers' evaluation and selection assists managers by facilitation of the information amount/complexity. There is no unique optimal solution to evaluate suppliers, but the ORESTE method allows the creation of a model for a potential solution to a problem based on the preferences of managers.

Thus, this study aims to apply the ORESTE method in a power plant firm for assessing the three various crusher machine suppliers and determining the best one based on five criteria. These criteria are determined by a sales executive employee who responsible for buying the crusher machine. Then, these criteria are ranked based on the importance level, and suppliers are evaluating. This study contributes to the biomass energy source literature by prioritizing the five criteria used to assess the crusher machine suppliers. The paper is organized as follows, the next section presents the current literature on ORESTE, and then the third section gives information ORESTE (Organization, Rangement Et Synthese De Donnees Relationnelles) method. The fourth section covers the application of the model in a firm, whereas the fifth section concludes.

1. LITERATURE REVIEW

In the literature, there are lots of the multi criteria decision making methods such as Analytic Hierarch Process (Saaty, 1990; that create a hierarchical structure and make pairwise comparisons to solve problem), TOPSIS (order preference based on the similarity to ideal solution cluster) and PROMETHEE (rank preference depending on enrichment evaluations) to evaluate suppliers. For example, Ghodsupour and O'Brion (1998) integrated AHP and linear programming model to assess the suppliers' tangible and intangible variables to select best one. Furthermore, Akarta (2001) used product development, manufacturing, quality capability and cost and delivery main attributes to appraise casting suppliers, whereas Tahriri et al. (2008) used AHP method to determine best supplier for a steel manufacturing firm. On the other hand, Hwang and Yoon (1995) have developed the TOPSIS method to assess and order the alternatives whose have the shortest interval from positive ideal solution and the farthest from negative ideal solution set. Boran et al. (2009) used intuitionistic fuzzy set and TOPSIS approach to show how multi-criteria group decision making can be used to select most suitable supplier

for an automobile firm. In 2012, Bhutia and Phipon appraised 30 suppliers based on the four criteria (product quality, service quality, delivery time and price), and weight of criteria had been calculated with AHP method and suppliers evaluated with TOPSIS.

Moreover, fuzzy set have used in the problem solving and combined various MCDM methods, such as Fuzzy AHP, Fuzzy TOPSIS, Fuzzy PROMETHEE so on. For example, Fuzzy AHP method are used by Kahraman et al. (2003) to appraise domestic supplier performance based on three main, 11 sub-criteira. Moreover, Chan et al. (2008) use Fuzzy-AHP method to select best global supplier through both evaluating quantitative and qualitative decision factors, whereas Kilincci and Onal (2011) work with well-known washing machine company to identify best supplier based on the 3 main (supplier, product performance and service performance criteria) and 14 sub-criteria. In addition to this, Chen (2000) employed the TOPSIS method with using fuzzy data set for team decision making process. Junior et al. (2014) applied Fuzzy AHP and Fuzzy TOPSIS methods separately to same supplier selection problem to compare results to determine which one is suitable to solve the problem, and result showed that each method can be appropriate and applied to supplier selection case. Moreover, Graham et al. (2015) used AHP, Entropy and TOPSIS methods to create of green supplier selection model, whereas, Gupta and Barua (2017) evaluated suppliers based on their green innovation ability by utilizing Best Worst Method (BWM) and TOPSIS.

However, researchers and managers must deal with data such as weights of the criteria or preference functions to solve a case when used those MCDM methods. ORESTE is one of the multi criteria decision making (MCDM) method was developed by Roubens (1982), and first case study had been done in 1982 (Pastijn and Leysen, 1989). ORESTE is very useful approach when the researchers have been suffering from lack of numerical data, criteria weights, or doubtless evaluation (Pastijn and Leysen, 1989; Chatterjee and Chakraborty, 2014). Thereby, it is an excellent decision-making method, which only use ordinal assessment when construct the alternatives, that enhance decision making process.

When the literature is examined, ORESTE method has been used by the researchers to solve problems and enhance decision-making process of the managers. Some articles only use this method; on the other hand, the others prefer to use a hybrid method and combine the ORESTE and the other MCDM method to solve problems. For example, in 1991, nuclear waste management problem had been solved by ORESTE method (Delhaye et al., 1991), whereas in 2002, ORESTE method is applied to find best land mine detection strategies (De Leeneer and Pastijn, 2002). Moreover, this method is applied in various problems by the researchers to help managers selecting the best personnel for job (Eroglu et al.,2014), ranking departments of Information and Communication Technology Research Centers (Fasanghari and Pour, 2008), deciding best concept of a rotary switch component (Raj and Vinodh, 2016), aligning the web design firms (Adali and Işık, 2017) and prioritize the patients (Zhang et al., 2018).

Besides that, various MCDM methods are preferred by the managers and researchers to deal with renewable energy problems. The existing methods were categorized based on the MCDM type/s, decision problem and country, which are available in Table 1.

Table 1: Overview of existing MCDM models for Renewable Energy Problems

Author/s (Year)	**MCDM Method/s**	**Decision Problems**	**Country**
Maleki-Ghelichi and Sharifi, (2017)	AHP	Anaerobic digestion system (create energy from biomass) selection	Iran

Kheybari et al. (2019)	AHP	Assessing energy production technologies converting biomass to biofuels	Iran
Wang et al. (2015)	AHP and GRA (Grey Relational Analysis)	Selecting a biomass briquette fuel system	China
Wang et al. (2020)	SWOT (Strengths, Weaknesses, Opportunities, and Threats) and Fuzzy AHP	Selecting among renewable energy alternatives	Pakistan
Saelee et al. (2014)	TOPSIS	Selecting biomass type	Thailand
Solangi et al. (2019)	Delphi-AHP and Fuzzy TOPSIS	Choosing among renewable energy resources	Pakistan
Şengül et al. (2015)	Fuzzy TOPSIS	Ordering renewable energy supply systems	Turkey
Afsordegan et al. (2016)	Fuzzy AHP and Q-TOPSIS (Qualitative TOPSIS)	Selecting sustainable energy alternatives	Spain
Lee and Chang (2018)	WSM (Weighted Sum Method), VIKOR (visekriterijumsko kompromisno rangiranje) , TOPSIS, and ELECTRE (elimination et choicetranslating reality)	Ranking renewable energy sources	Taiwan

In the following literature, the researchers combine the ORESTE method with other various MCDM methods. For instance, Feyzi et al., (2017) implemented an integrated approach which applies DEMATEL (The Decision-Making Trial and Evaluation Technique) method to determine weights of criteria and ORESTE method to assess knowledge management. Furthermore, Günay and Kaya (2017) compared the performance of the firms traded in Borsa İstanbul based on their some financial ratios by using ELECTRE, ORESTE and TOPSIS methods. On the other hand, Arslan (2018) used ARAS (Additive Ratio Assesment) and ORESTE methodology to find best solar water heating systems for a hotel. Wu and Liao (2018) propose a hybrid method to deal with the innovative product design selection case. The researchers expanded Quality Function Deployment (QFD) method and later combine it with the probabilistic linguistic term set (PLTS) and ORESTE. Moreover, researchers combined ORESTE with the traditional qualitative flexible (QUALIFLEX) method to solve the case, such as, Işık (2016) combined QUALIFLEX and ORESTE methods to select best insurance company, whereas, Liang et al. (2019) applied ORESTE–QUALIFLEX methods to appraise the performance of green mines. Liao et

al. (2018) extended the ORESTE method within hesitant fuzzy linguistic (HFL) context, and they applied this method in a supplier selection case study. Although the application area of this method is comprehensive, it has not been widely used in the solution of renewable energy and supplier selection problems which is the main motivation of this study.

2. ORESTE

ORESTE is an efficient multi criteria decision making method which require only the ordinal data and ranking for alternatives and criteria. The procedure of the method is as follows (Chatterjee and Chakraborty, 2012: 387):

$$i: criterion, i = 1,2,3, \dots, m$$

$$j: alternative, j = 1,2,3, \dots, n$$

$$a_i: i.alternative$$

$$c_j: j.criterion$$

In the first step of ORESTE method, the criteria in the evaluation problem are sorted from the most important to the least important. Two terms can be used when sorting. These terms are presented below.

$$P: an\ alternative\ or\ criterion\ is\ preferred\ over\ another$$

$$I: two\ criteria\ or\ alternatives\ share\ the\ same\ rank$$

Then, the alternatives are sorted from the best to the worst for each criterion. After that, Besson's ranks are calculated by the preference relations. If two criteria or alternatives are both in the same rank, then they would both receive an average rank of the places they occupy.

$$rc_j: Besson\ rank\ of\ criterion\ j$$

$$r_j(a_i): Besson\ rank\ of\ alternative\ i\ with\ respect\ to\ criterion\ j$$

Next step is to calculate the projection distances. The projection distance is the relative positions of an alternative with respect to an arbitrary origin. The projection distance can be calculated by using Equation 1.

$$d_j(0, a_i): projection\ distance\ of\ alternative\ i\ with\ respect\ to\ criterion\ j$$

$$d_j(0, a_i) = \frac{rc_j + r_j(a_i)}{2} \qquad \text{Equation 1}$$

Next step is to calculate global Besson ranks. The sum of these ranks show the mean rank of the alternatives. The mean rank of the alternatives can be calculated by using Equation 2.

$$r(a_i): mean\ rank\ of\ alternative\ i$$

$$r(a_i) = \sum_{j=1}^{n} r_j(a_i) \qquad \text{Equation 2}$$

3. APPLICATION

A case have been conducted within a power plant firm to find out the best crusher machine supplier among the three different suppliers based on five evaluation criteria. The authors have asked the industrial executive questions to determine which criteria are essential to evaluate suppliers when purchasing a crusher machine. Based on the answers, five supplier evaluation criteria are determined. This firm use biomass renewable energy sources to produce and sell energy, as well as it is a waste disposal facility. Waste of wood and wood shavings and any biomass resulting from forest and agricultural activities have been converted into dust, later those are used as a main ingredients of the energy generated system. Thus, main source of the energy generation is dust biomass. Moreover, waste of the wood and other waste should be converted to suitable form to process them to create energy. Crusher machine is used to break into materials to pieces by compression them with knives. However, managers should take into consideration many criteria when buying a crusher machine, that is the main focus point of this article. The researchers had interviewed an industrial executive to appraise and rank criteria for enhancing supplier selection decision-making process using the ORESTE optimization technique. Industrial executive who responsible buying the crusher machine has been interviewed for evaluating and ranking crusher machine suppliers from the five perspectives.

Moisture of material (amount of the water content of the materials) is first criteria, that manager consider when select a machine. The next criteria is tons/hour specification of crusher (how many tons in a hour a machine to crush waste), whereas third criteria is input-output properties of raw material (raw wood, recycled wood or recycled agricultural waste). The other important criteria for selecting cruster machine is electrical power of crusher and the last one is types of crushers (mobile and fixed . Mobile crusher machine is used when the raw material moisture level is 50%, output's size is 30-50 mm and machine production capacity is 70-80 tons/ hour. On the other hand, fixed crusher machine is suitable when the produce smaller than 30-50 mm output's size, and it works the same situation as a mobile crusher does. The ranks of the criteria can be seen in Table 2.

Table 2: The Ranks of the Criteria

Criterion Code	Criterion Name	rc_j
Criterion 1	moisture of the material	1
Criterion 2	tons/hour specification of crusher	2
Criterion 3	electrical power of crusher	4
Criterion 4	input-output properties of raw material	3
Criterion 5	types of crushers (mobile or fixed types)	5

The expert in the company ranks the alternatives with respect to all criteria in the second part of the same form. The answers can be seen in Table 3.

Table 3: The Ranks of the Alternatives

	Alternative 1	Alternative 2	Alternative 3
Criterion 1	3	1	2

Criterion 2	1	1	1
Criterion 3	2	3	1
Criterion 4	2	1	1
Criterion 5	1	1	1

The rows of Table 3 can be shown with symbols:

$$c_1: a_2 \; P \; a_3 \; P \; a_1$$
$$c_2: a_1 \; I \; a_2 \; I \; a_3$$
$$c_3: a_3 \; P \; a_2 \; P \; a_1$$
$$c_4: a_2 \; I \; a_3 \; P \; a_1$$
$$c_5: a_1 \; I \; a_2 \; I \; a_3$$

According to these answers, alternative 2 is the best alternative from the viewpoint of criterion 1. Alternative 1 is the worst alternative from the viewpoint of criterion 1. Some ranks are same in Table 3. In this case, the data set should be revized. The revised version of the data set can be seen in Table 4.

Table 4: Revised Version of the Dataset

	Alternative 1	**Alternative 2**	**Alternative 3**
Criterion 1	3	1	2
Criterion 2	2	2	2
Criterion 3	2	3	1
Criterion 4	3	1,5	1,5
Criterion 5	2	2	2

Next step is to calculate the projection distances. The projection distance is the relative positions of an alternative with respect to an arbitrary origin. The projection distance can be calculated by using Equation 1. The values can be seen in Table 5.

Table 5: The Projection Distances

	Alternative 1	**Alternative 2**	**Alternative 3**
Criterion 1	2	1	1,5
Criterion 2	2	2	2
Criterion 3	3	3,5	2,5

Criterion 4	3	2,25	2,25
Criterion 5	3,5	3,5	3,5

Next step is to calculate global Besson ranks. The global Besson ranks can be seen in Table 6.

Table 6: Global Besson Ranks

	Alternative 1	**Alternative 2**	**Alternative 3**
Criterion 1	4,5	1	2
Criterion 2	4,5	4,5	4,5
Criterion 3	10,5	13,5	9
Criterion 4	10,5	7,5	7,5
Criterion 5	13,5	13,5	13,5

In the last step of ORESTE method, mean ranks are calculated by using Equation 2. The values can be seen in Table 7.

Table 7: Mean Rank Values and Ranks

Alternative	**Mean Rank Value**	**Rank**
Alternative 1	43,5	3
Alternative 2	40	2
Alternative 3	36,5	1

The lowest mean rank shows the best alternative when analyzed all criteria together in the multi criteria decision making problem. According to the results in Table 7, alternative 3 is the best option for machine selection problem with 36,5 value.

CONCLUSION

Appraising and selecting suppliers, which is one of the crucial decision-making activities, has gained significance recently. Cost of the raw materials, information/ amount complexity, and the time of evaluating options are some of the critical factors that affect managers' decision-making process. Moreover, selecting suppliers include several qualitative and quantitative criteria. Therefore, MCDM methods have been used by the researchers to deal with the problems and enhance the decision-making process. For example, Ghodsypour and O'Brion (1998) evaluate tangible and intangible variables of the suppliers' to select the best one with AHP, whereas, Akarta (2001) assess casting suppliers by using the AHP approach.

Furthermore, various MCDM methods can be combined to solve the problems, such as AHP, Entropy, and TOPSIS methods are used to select the best green supplier by Graham et al. (2015), whereas Boran et al. (2009) used intuitionistic fuzzy set and TOPSIS approach to assess suppliers. Even so, MCDM methods require some complex data collection and evaluating process. The ORESTE method is desirable for the researchers as it has only needed ordinal data, and criteria can be easily ordered based on their importance.

Depletion of fossil energy sources, as well as their impact on global warming, international attempts to decrease greenhouse gas emissions, and people's environmental awareness are the factors to push the companies to increase usage of renewable energy sources. Biomass energy source is an excellent renewable energy alternative to firms to reduce the need for fossil fuels and hazardous emission, biomass waste into the environment, and a cheap and colossal source to create energy (Vassilev et al.,2015). Thus, in this research, a case has been conducted within a power plant firm in Turkey to find out the best crusher machine supplier among three different suppliers based on five evaluation criteria (the moisture of material, tons/hour specification of crusher, input-output properties of raw material, electrical power of crusher and types of crushers). So, crusher machine supplier selection is formulated as a multi-criteria decision-making problem and solved used the ORESTE method, which aids managers in providing a comprehensive evaluation of all criteria and suppliers as a whole. Results demonstrate that the third alternative (supplier) has the highest ranking when appraising the five evaluation criteria as a whole, followed by the second supplier and first supplier, respectively.

In this study, criteria weights are calculated based on the Besson's rank, which is used in the ORESTE method. However, information about criteria weight is limited when the Besson's rank is used. So, researchers can obtain criteria weights with other methods such as AHP or Analytic Network Process (ANP) in the future study. Moreover, many researchers show great interest in combining the ORESTE method with other MCDM methods such as TOPSIS, ELECTRE, and ARAS. Thus, researchers can apply hybrid MCDM methods when to solve supplier decision making problem in the future.

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Etik Beyanı	**:**	Bu çalışmanın tüm hazırlanma süreçlerinde etik kurallara uyulduğunu yazarlar beyan eder. Aksi durumun tespiti halinde NÖHÜSOSBİL Dergisinin hiçbir sorumluluğu olmayıp, tüm sorumluluk çalışmanın yazar(ları)ına aittir. İlgili çalışmada kullanılan veriler 2019 yılında toplanmış ve veriler analiz edilmiştir. Veriler 2020 yılı öncesi toplandığından etik kurul kararı gerekmemektedir.
Yazar Katkılar	**:**	Kevser Yılmaz (1.yazar), çalışmada giriş, literatür taraması, uygulama ve sonuç bölümlerinde katkı sağlamıştır. Aşkın Özdağoğlu (2.yazar) , çalışmada giriş, ORESTE ve uygulama bölümlerinde katkı sağlamıştır. 1. yazarın katkı oranı %50, 2. yazarın katkı oranı %50.
Çıkar Beyanı	**:**	Yazarlar arasında çıkar çatışması yoktur.
Ethics Statement	**:**	The authors declare that ethical rules were followed in all preparation processes of this study. In case of detection of the opposite situation, NÖHÜSOSBİL Journal has no responsibility and all responsibility belongs to the author(s) of the study. The data used in the related study were collected in 2019 and the data were analyzed. Since the data were collected before 2020, an ethics committee decision is not required.
Author Contributions	**:**	Kevser Yılmaz (1st author) contributed in the introduction, literature review, application and conclusion sections of the study. Aşkın Özdağoğlu (2nd author) contributed in the introduction, ORESTE and application sections of the study. The contribution rate of the 1st author is 50%, the contribution rate of the 2nd author is 50%.
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