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Strategic Management of Clean Energy Investments: Financial Performance Insights by Using BWM-based VIKOR and TOPSIS Methods

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ABSTRACT

Market share of renewable energy companies increases with the increase in green-energy production. Companies increase their investments depending on the increase in energy production and can provide capital by offering the company to the public. Companies are traded in the exchange market in order to fund their increasing investments and access a large investor base. The increase in the market values of clean energy companies in recent years draws attention of investors. The study aims to identify key financial indicators that influence company growth and investment value by analyzing companies listed in the S&P North America and Europe Clean Energy Index. Therefore, the study evaluates the financial performance of clean energy companies using Best-Worst Method (BWM)-based VIKOR and TOPSIS methods to provide investors with a comprehensive assessment of investment opportunities in the clean energy sector. Also, the comparison of the two methods will contribute to the literature. The sample of this study consists of 10 big companies in S&P North America and Europe Clean Energy Index. Financial tables and exchange market data of the companies for the years 2019, 2020, and 2021 were used in this study. Remarkably, the analysis findings of the two methods differ from each other. The findings reveal significant insights into the financial health and growth potential of clean energy companies, offering valuable guidance for future.

Keywords: Clean Energy Companies, Financial Performance, Investor Decision Making, Best-Worst Method, TOPSIS, S&P
JEL Classifications: Q40, O13, G17, G32

1. INTRODUCTION

The global energy landscape is witnessing a major transformation regarding environmental protection and ensuring energy security. Escalating geopolitical conflicts and mounting agreement on climate change are driving the move toward renewable energy at an unprecedented pace. A recent International Energy Agency (IEA) (IEA, 2022) and KPMG reports state up to 70 million people could soon be without electricity (KPMG, 2022). To ensure a sustainable world, reducing reliance on fossil fuels and increasing renewable energy production is vital. Consequently, the increase in the share of green energy in the global energy supply accelerates the transition towards a new era.

The economic implications of renewable energy require scrutiny, especially for leading clean energy companies. Solar panels, wind turbines, and energy storage facilities are examples of technological innovations supporting renewable energy's efficiency and affordability. However, these technological developments need to be accompanied by a regulatory framework. Governments must provide clear regulations and appropriate incentives to attract investment and reduce risks in the renewable energy sector. Abandoning fossil fuels and switching directly to renewable energy sources requires complicated processes.

Switching from fossil fuels has various ramifications. For instance, it entails moving from areas dependent on established energy industries to ones that may face challenges and benefit from creating new jobs using renewable energy. Fair access to clean energy through workforce development strategies is essential for a proper technology, policy, and social equity transition. These are crucial for reducing risks from moving toward a clean energy future. Strengthening the companies' financial structures and initiating assets to achieve the expected return and investment performance will lead to a more sustainable energy sector.

Analysis of the financial performance of clean energy companies is crucial for anyone from potential entrepreneurs to stakeholders wishing to engage the public about a rapidly expanding sector. Indices such as the S&P North America and S&P Europe Clean Energy, among others, offer helpful windows into this field. While existing studies have examined the financial performance of clean energy companies, there still needs to be a gap in understanding how specific multi-criteria decision-making methods, such as the BWM-based VIKOR and TOPSIS, can provide a focused analysis of these companies' financial health. This study aims to fill this gap by applying these methods to evaluate the financial performance of companies listed in the S&P North America and Europe Clean Energy Index, aim to offer valuable insights for investors and contribute to the literature on financial analysis in the clean energy sector.

Numerous statistical and econometric methods exist to evaluate companies' financial performance. Multi-Criteria Decision Making Techniques are classified under two headings: Multi-Attribute Decision Making (MADM) and Multi-Objective Decision Making (MODM). Multi-Attribute Decision Making Techniques are the performance of variables according to the determined criterion weights (Dashti et al., 2010). The TOPSIS method, one of the methods in this group, aims to reach the most appropriate ideal solution by minimizing the cost criteria and maximizing the benefit criteria (Mohamed et al., 2020). The VIKOR method helps to find the best solution for ranking conflicting criteria. In case the criteria conflict with each other, it assists the decision maker by offering a compromise solution (Opricovic and Tzeng, 2004). The study evaluates the companies using both VIKOR and TOPSIS methods.

An efficient and impactful introduction of the intricate connection between clean energy transition and financial performance with a comprehensive analysis that could shed light on not only current market dynamics but also future research directions. As the world grapples with frequent energy crises, as the most viable pathway to long-term sustainability lies in the cleanest energy systems, and as the stability and security of governments around the globe are in jeopardy because of the impacts of energy's extraction, production, and consumption, it has never been more crucial that the globe's population have a clear and accurate understanding of the support of the emerging and evolving clean energy sector. From this perspective, renewable energy production can meet the increasing demand in the coming years by making new investments. Companies need financing to make new investments. Companies need new partners to provide financing. To invest in the company, partners examine the financial performance of the company and evaluate whether it has sustainable growth and return on investment.

In this context, the purpose of this study is to evaluate the financial performance of clean energy companies using BWM-based VIKOR and TOPSIS methods to provide investors and future researchers with a comprehensive assessment of the growth potential and investment value of the companies within the S&P North America and Europe Clean Energy Index.

2. LITERATURE REVIEW

There is a growing awareness of the potential for the energy sector to shift toward cleaner, renewable energy sources as sustainability and climate change mitigation gain more attention. For example, incumbent oil and gas firms, which are viewed as competitors of renewables, have gotten more involved in the renewable energy space by working on low-carbon projects all the way up the value chain and developing new technologies (Moncreiff et al., 2024).

In addition to contributing significantly to greenhouse gas emissions, energy-intensive industries underpin the economy by supplying the materials necessary for society. The entire supply chain should implement clean innovations in order to meet long-term emission targets (Wesseling and Vooren 2017). Particularly in the clean energy sector, where there are insufficient market incentives for clean technology innovation, entrepreneurial companies depend on government subsidies to lower expenses and mitigate risks (Peng and Liu, 2018). At this point, policy mixes, which refer to the combination of different policy instruments and strategies toward achieving specific goals, such as regulations, subsidies, and taxes, are also vital for sustainability (Johnstone et al., 2017).

Investment refers utilization of a source or value in order to achieve additional revenue (Feibel, 2003). Among the investment instruments, stocks offer dividends and capital gains. Before buying stock, investors investigate the financial status of the company. The whole process of interpreting the changes, trends, and inter-account relationships in financial tables by both general standards and a specific industry in order to reveal the financial status of a company is named financial performance analysis (Knight and Bertoneche, 2001). While the energy industry is of critical importance, it is necessary to examine the financial performance of companies and for investors to act rationally in order for the companies in this industry to survive. Non-rational investors might tend to achieve abnormal returns due to the motive of earning more. Various anomalies have been created in order to achieve abnormal return (Fama and French, 1992). For instance, it is thought that there was a negative relationship between the abnormal return and the Price/Book Value and Price/Earn ratios that investors use the most (Rouwenhorst, 1999). For investors to make accurate decisions, it is important to examine the financial data of companies and assess their financial performance.

Various financial analysis methods are used in order to assess the financial performance of companies. Among those methods, ratio analysis is the one used the most frequently. In addition to those main analysis methods, in literature, there are many studies in which financial performance was analyzed by making use of Multicriteria Decision-Making (MCDM) methods. DEA method

(Chen, 2008; Lim et al., 2014), TOPSIS (Feng and Wang, 2000; Wang and Hsu, 2004), GST (Feng and Wang, 2000), ELECTRE (Chen and Hung, 2009) and VIKOR (Lam et al., 2021; Rezaei et al., 2014) can be given as examples. MCDM is used in analyzing the decision-making problems such as selection, classification, and ranking (Vassilev et al., 2005). These methods can be used solely or by combining multiple methods. BWM method is used in determining the weights of variables to be used in decision-making problems. VIKOR and TOPSIS methods, however, ranks the alternatives by the weights of variables.

Decision-makers use MCDM methods for weighting, selection, and ranking purposes. It is precise that MCDM methods were used in many studies on performance management in the energy industry. By using pre-redetermined variables, MCDM methods allow for the analysis of alternatives. There is extensive literature on financial performance analysis in the energy sector, particularly on MCDM methods. These studies vary from assessing the impact of COVID-19 in the energy sector using a hybrid MCDM approach (Makki and Alqahtani, 2023) to proposing objective criteria for comparison of MCDM and weighting methods for financial analysis (Baydas and Elma, 2021). The literature also involves various studies such as utilizing Hesitant Fuzzy TOPSIS and trend analysis for energy companies on Borsa Istanbul (Dagistanli, 2023), assessment of manufacturing industries' financial performance using plithogenic MCDM models (Abdel-Basset et al., 2020), comparative analyses of renewable energy facilities (Lee and Chang, 2018), and evaluations of renewable energy development from a sustainability perspective (Li et al., 2020). Subsequently, these studies underscore the significance of adopting MCDM methods to navigate the complexities of financial performance analysis in the rapidly evolving energy sector, highlighting the need for innovative decision-making and policy formulation approaches.

Incorporating the MCDM methods in evaluating financial performance in the energy sector is a multifaceted decision-making process under uncertainty. Studies have highlighted the importance of using hybrid MCDM methods, such as for assessing the sustainability of solar sites in Iran (Kannan et al., 2021) and determining the sustainability of the alternatives for electricity generation in Türkiye, emphasizing the necessity of comprehensive policy formulation (Yilan et al., 2020).

A fuzzy TOPSIS was developed to select renewable energy and new divergence measures to handle total and combined uncertainties (Rani et al., 2020). The researchers modeled an integrated system in sustainable renewable energy systems problems with AHP, VIKOR, and TOPSIS, utilizing Triangular neutrosophic numbers (Abdel-Basset et al., 2021). In China, a comprehensive MCDM method that combines BOCR, AHP, and IT2 fuzzy TOPSIS was employed to evaluate 17 photovoltaic poverty alleviation projects, further emphasizing the importance of renewable energy in sustainable development (Wei, 2021). The challenges faced by the biofuel industry in India were addressed, utilizing ISM and DEMATEL to identify a total of 143 barriers across the ecological, social, technical, economic, and regulatory dimensions (Narwane et al., 2021).

Furthermore, using the entropy-based ARAS and GRI methods, Yasar and Terzioglu (2022) analyzed the financial performances of 8 companies operating in the energy industry. As a result of their analysis, the authors revealed that Enerjisa Enerji A.Ş. (Enerjisa Energy) had the highest performance and PAMEL Yenilenebilir Elektrik Üretim A.Ş. (PAMEL Renewable Electricity Production) had the lowest performance. Using SWARA and WASPAS methods, Erdogan et al. (2022) analyzed the financial performances of 4 companies operating in the renewable energy industry. The authors concluded that the financial leverage ratio had the highest weight. Also, companies producing electricity by utilizing one source were more successful than companies using multiple sources. By using Fuzzy-AHP and TOPSIS methods, Liu et al. (2021) examined the financial performances of 13 companies operating in the renewable energy industry. It was determined that Avrasya Oil, Turcas Petrol, and Akarsu Enerji companies had the highest financial performances. Using the DEA method, Halkos and Tzeremes (2012) analyzed the financial performances of 78 companies operating in the renewable energy industry. The authors revealed that high ROA and ROE ratios and low liability/equity ratios were beneficial in terms of financial performance.

The studies illustrate the importance of MCDM approaches in addressing financial analysis and project evaluation complexities in the energy sector. Therefore, better comprehension of the multiple criteria is vital for the sustainability of the energy sector.

On the other hand, there is no study that evaluate the financial performance of clean energy companies using BWM-based VIKOR and TOPSIS methods, within the S&P North America and Europe Clean Energy Index. Therefore, the use of BWM-based VIKOR and TOPSIS methods to evaluate the financial performance of clean energy companies within the context of the S&P North America and Europe Clean Energy Index, adds a unique angle to the research.

3. DATA AND ESTIMATION TECHNIQUES

3.1. Data

In the present study, in which it was aimed to examine the financial performances of companies operating in the renewable energy industry, the companies listed in S&P North America and Europe Clean Energy Index constituted the universe. The list created on 12 October 2021 includes 52 companies, market values of which ranged between 276 million USD and 74 billion USD on 30 November 2022. Ten companies having the highest market values on 30 December 2022 were involved in this study (S&P 2023). Financial table data of companies for the period 2019-2021 were used. The data were obtained from the consolidated financial tables from company web pages. Table 1 presents the list of companies in the sample, the exchange market codes, and origins.

It is thought that examining some financial accounts would be useful in order to assess the general financial status of companies. Constituting the material of this study, companies' total assets, sales revenues, and net profits accounts were consolidated and are presented in USD currency in Table 2. Cross exchange rates were used in combining the financial table data (Türkiye Republic Central Bank 2023).

When compared to the previous year, it was determined that the total assets of 10 companies increased by 7.39% in 2020 and 11.18% in year 2021. However, in comparison to the previous year, total sales revenues of 10 companies decreased by 6.5% in 2020 and increased by 14.09% in 2021. It is thought that the decrease in 2020 might have originated from the global decrease in the working hours of factories during the pandemic. It is estimated that there was a very high in 2021 due to the base effect. Moreover, when compared to the previous year, the total net profit of 10 companies increased by 10.52% in 2020 and by 2.57% in 2021.

Many variables are used in analyzing the financial performances of companies. While establishing the model in the present study, the variables that are widely used in the literature were utilized varies references. Variables are presented in Table 3.

Liquidity ratios help to evaluate companies' liquidity levels. Current Ratio and Quick Ratio are the most commonly used ratios. Operating ratios are useful for assessing the efficiency of companies' asset utilization. Accounts receivables turnover and asset turnover are the most commonly used ratios. The higher the turnover of accounts receivables, the faster the receivables are collected. The higher the Asset turnover, the more efficiently companies are considered to be using their assets. Profitability ratios are used to evaluate the profitability of companies as the final output of their operations. ROA and ROE are the most commonly used ratios. High ROA indicates efficient use of assets; high ROE indicates efficient use of equity. Financial structure ratios are used to assess firms' financial structures. Liability ratio and Debt to equity ratio are the most commonly used ratios. It is recommended that firms implement a borrowing policy that will ensure harmony between Debt and equity. Market ratios are used to evaluate the performance of a company's stocks, which are traded on the stock exchange. P/BV and P/E ratios are the most commonly used ratios. These ratios provide information to investors when determining the value of companies' stocks (Horne and Wachowicz, 2008; Koller et al., 2011).

Table 1: Companies list

Company name	Exchange market code	Country
Enphase Energy Inc.	ENPH	USA
Vestas Wind Systems As	VWDRY	Denmark
Consolidated Edison Inc.	ED	USA
Orsted A/S	DOGEF	Denmark
Solaredge Technologies Inc.	SEDG	Australia
Energias De Portugal Sa	ELCPF	Portugal
Iberdrola Sa	IBDRY	Spain
First Solar Inc.	FSLR	USA
Edison International	EIX	USA
Neste Corp.	NTOIF	Finland

Table 2: Companies list financial indicator data of companies (USD)

Year	Total assets	Sales revenues	Net profit
2019	371,546,257,232	116,917,984,060	11,725,086,287
2020	399,006,894,451	109,313,027,731	12,959,348,769
2021	443,637,364,764	124,722,870,243	13,293,116,782

The consolidated and independently audited financial tables of companies were obtained from the official websites of companies. Financial ratios were calculated with Microsoft Excel software by making use of the financial tables. Market ratios were obtained from YCHARTS database (Ycharts, 2023).

3.2. Method

MCDM is used in decision-making problems such as selection, classification, and ranking (Vassilev et al., 2005). Differing from the previous studies, the present study utilized three different methods in weighting and ranking. In this study, it is aimed to contribute to the literature in by using Best-Worst Method (BWM) and TOPSIS and VIKOR combined in the model.

3.2.1. Best-Worst method (BWM)

BWM, a criterion weighting method, was developed by Rezaei (2015). In this method, rather than comparing all the criteria to each other, the best and the worst criteria are compared to the other criteria in order to determine the criterion weights (Salimi and Rezai, 2018). The difficulty of comparing all the criteria to each other is eliminated in BWM and more consistent results are achieved. Application steps of BWM are presented below (Rezaei, 2015):

Table 3: Model variables, codes and references

Main variable	Sub-variable	Codes	References
Liquidity ratios	Current ratio	CR	(Yasar and Terzioglu, 2022; Erdogan et al., 2022; Paun, 2017; Zhao et al., 2022; Zimon et al., 2022)
	Quick ratio	QR	(Erdogan et al., 2022; Zimon et al., 2022)
Operating ratios	Accounts receivables turnover	ACT	(Erdogan et al., 2022; Zimon et al., 2022)
	Asset turnover	AT	(Yasar and Terzioglu, 2022; Erdogan et al., 2022; Zhao et al., 2022)
Profitability ratios	Return on assets	ROA	(Yasar and Terzioglu, 2022; Erdogan et al., 2022; Paun, 2017; Zhao et al., 2022; Zimon et al., 2022; Akthar et al., 2012; Moradi et al., 2021; Dopierala et al., 2022; Schabek, 2020; Wu and Huang, 2022)
	Return on equity	ROE	(Erdogan et al., 2022; Paun, 2017; Zhao et al., 2022; Zimon et al., 2022; Akthar et al., 2012; Moradi et al., 2021; Dopierala et al., 2022; Schabek, 2020; Wu and Huang, 2022)
Financial structure ratios	Liability ratio	LR	(Yasar and Terzioglu, 2022; Erdogan et al., 2022; Paun, 2017; Zhao et al., 2022; Akthar et al., 2012; Dopierala et al., 2022)
	Debt to equity ratio	DR	(Erdogan et al., 2022; Akthar et al., 2012)
Market ratios	Price to book value ratio	P/BV	(Srinivasan, 2012; Tandon and Malhotra, 2013; Bunea et al., 2019)
	Price-earnings ratio	P/E	(Srinivasan, 2012; Tandon and Malhotra, 2013; Bunea et al., 2019)

Step 1: Criteria set $\{C_1, C_2,\ldots, C_n\}$ is established.

Step 2: Among the criteria, the best (most important) and the worst (least important) ones are determined.

Step 3: Comparing the best criterion to the others, scores between 1 (equally important) and 9 (absolutely important) are assigned. Comparing to the scores given, best-others (A_B) vector is achieved.

$$A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn}) \tag{1}$$

Step 4: Comparing the worst criterion to the others, scores between 1 (equally important) and 9 (absolutely important) are assigned. Comparing to the scores given, best-Others (A_W) vector is achieved.

$$A_W = (a_{1W}, a_{2W}, \ldots\ldots, a_{nW})^T \tag{2}$$

Step 5: Optimum weights $\left(w_1^*, w_2^*, \ldots\ldots, w_n^*\right)$ are achieved for all criteria.

To determine the most suitable weights of criteria, the maximum absolute differences are obtained. Optimum weights of the criteria for w_B/w_j and w_j/w_w criterion pairs are $w_B/w_j = a_{Bj}$ and $w_j/w_w = a_{jw}$, respectively. A j value, with which the maximum absolute differences are minimized, $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_w} - a_{jw}\right|$ should be obtained.

This value is transformed into min - max model presented below:

On the condition that min max $\left\{\left|w_B - a_{Bj} w_j\right|, \left|w_j - a_{jw} w_w\right|\right\}, j$

$$\textstyle\sum_j wj = 1 \; w_j \geq 0, \text{ for all } j' \tag{3}$$

3.2.2. VIKOR

One of the multicriteria decision-making methods, VIKOR is a method, in which the alternatives to be analyzed are ranked by making use of the criteria specified by the researcher making the decision. VIKOR method was introduced to the literature by Opricovic and Tzeng (2004). The application steps are presented below (Opricovic and Tzeng, 2004):

Step 1: Decision matrix is established and the best f_j^* and the worst f_j^- values were determined for each criterion (j = 1, 2,…, n)

Step 2: Normalized decision matrix is obtained.

$$r_{ij} = \frac{f_j^* - x_{ij}}{f_j^* - f_j^-}\left(i = 1, \ldots, m \; ve \; j = 1, \ldots, n\right) \tag{4}$$

Step 3: Normalized decision matrix is weighted.

$$V_{ij} = r_{ij}\, w_j \,(i = 1,\ldots, m \; ve \; j = 1,\ldots, n). \tag{5}$$

Step 4: S_i and R_i values are calculated. The average and the worst group were obtained for i^{th} alternative.

$$S_i = \sum_{i=1}^{n} w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \tag{6}$$

$$R_i = \max_i \left[w_i (f_i^* - f_{ij}) / (f_i^* - f_i^- \right] \tag{7}$$

Step 5: Q_i values are calculated using S^*, S^-, R^*, R^- parameters (j = 1, 2,…, n).

$S^* = min_i\, S_i$, $S^- = max_i\, S_i$, $R^* = min_i\, R_i$, $R^- = max_i\, R_i$

$$Q_i = \frac{q.(S_i - S^*)}{S^- - S^*} + \frac{(1-q).(R_i - R^*)}{R^- - R^*} \tag{8}$$

Step 6: Alternatives are ranked and the conditions are examined. S_i, R_i, and Q_i are ranked from the lowest to the highest. Then, to test the accuracy of ranking, the alternative with the minimum Q_i value is supposed to meet the acceptable advantage and stability conditions. If the conditions are met, then the alternatives are ranked from the lowest to the highest by using Q_i values and the alternative with the lowest alternative value is considered as the best alternative.

3.2.3. TOPSIS

TOPSIS, developed by Hwang and Yoon in 1981, is a multi-criteria decision-making method that facilitates selection among alternatives based on specified criteria. TOPSIS has several stages (Opricovic and Tzeng, 2004):

Step 1. A normalized decision matrix is generated: a_{ij} shows the alternatives.

$$n_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}}\left(i = 1, \ldots, m \; and \; j = 1, \ldots, n\right) \tag{9}$$

Step 2. A weighted normalized decision matrix is generated.

$$V_{ij} = n_{ij}\, w_{ij} \,(i = 1,\ldots, m \text{ and } j = 1,\ldots, n) \tag{10}$$

Step 3. Positive ideal and negative ideal solution values are obtained.

$$A^+ = \left\{v_i^+, v_i^+, \ldots, v_n^+\right\} = \left\{\max{}_j v_{ij} \,\middle|\, j = 1, \ldots, p; i = 1, \ldots n\right\} \tag{11}$$

$$A^- = \left\{v_i^-, v_i^-, \ldots, v_n^-\right\} = \left\{\min{}_j v_{ij} \,\middle|\, j = 1, \ldots, p; i = 1, \ldots n\right\} \tag{12}$$

Step 4. Distances to the positive ideal and negative ideal values are determined.

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \tag{13}$$

$$S_0^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \tag{14}$$

Step 5. The relative closeness to the ideal solution is calculated.

$$C_0^* = \frac{S_i^-}{S_i^-, S_i^*} \tag{15}$$

Step 6. Alternatives are ranked according to the C_0^* value.

4. EMPIRICAL RESULTS

The variables in the model were weighted using the BWM method. The most commonly used ratios in financial performance evaluation are classified into 5 different ratio groups. Considering that sub-criteria had and equal level of importance, variable weights were obtained using BWM. Variables' weights are presented in Table 4. The weights of each ratio group and sub-ratios are calculated separately, and their shares in the total weight are given.

Given Table 4, a total of 10 variables in 5 main groups were weighted by using the BWM method. As a result of the analyses, it was determined that the main variable group having the highest weight was the market ratios (38.5%), whereas the main variable group with the lowest weight was the operating ratios (7.70%). Examining the weights of sub-criteria, it was found that the criterion having the highest weight was P/BV and P/E (19.25%), whereas the criteria with the lowest weight were the ACT (3.85%) and the AT (3.85%). After the market ratios, the highest weight is in the profitability ratios group at 23.00%. ROA and ROE are among the important indicators that are frequently used in financial performance evaluation. The weight of the two ratios is equal, and it has a weight ratio of 11.5% in the total weight. It can be seen that the weights of financial structure and liquidity ratios are the same (15.4%). Operating ratios are the ratio group that has the least priority in evaluating the financial performance of companies. Table 5 shows the results of analyses performed using the BWM-based VIKOR method. Table 6 presents the results of BWM-based TOPSIS methods. Finally, Table 7 shows the comparison of VIKOR and TOPSIS results. Companies are listed by their performances in 2021 by VIKOR findings.

Given the results for the year 2019, it was determined the best alternative was SolarEdge with a Q_i score of 0.180. Considering the variables in the model, this company was observed to have the best financial performance. Given the Q_i scores of other companies for the year 2019, Enphase (0.288) ranked second and followed by Orsted A/S (0.373). The worst alternative for the year 2019 was Energias de Portugal with a Q_i score of 0.916. Examining the results for the year 2020, it was determined that the best alternative was Enphase Energy with a Q_i score of 0.185. Considering variables in the model, this company was found to have the best financial performance. Assessing a Q_i scores of other companies in the year 2020, it was found that SolarEdge Technologies (0.461) ranked second and Neste Corp (0.645) ranked third. The worst alternative for the year 2020 was found to be Edison International with the Q_i score of 0.994. Analyzing the results for the year 2021, the best alternative was found to be Enphase Energy with a Q_i score of 0.190. Based on the variables in the model, this company was found to have the best financial performance. Considering the Q_i scores of other companies for the year 2021, SolarEdge Technologies (0.692) was found to rank second and Vestas Wind Systems (0.824) was found to rank third. The worst alternative for the year 2021 was found to be Iberdrola SA with a Q_i score of 1.000.

Given the results for the year 2019, it was determined the best alternative was Neste Corp. with a C_i score of 0.721. Considering the variables in the model, this company was observed to have the best financial performance. Given the C_i scores of other companies for the year 2019, Iberdrola SA (0.585) ranked second and followed by Energias de Portugal (0.578). The worst alternative for the year 2019 was First Solar Inc. with a C_i score of 0.451. Examining the results for the year 2020, it was determined that the best alternative was Enphase Energy with a C_i score of 0.825. Considering variables in the model, this company was found to have the best financial performance. Assessing a C_i scores of other companies in the year 2020, it was found that SolarEdge Technologies (0.450) ranked second and Neste Corp (0.268) ranked third. The worst alternative for the year 2020 was found to be Iberdrola SA with the C_i score of 0.090. Analyzing the results for the year 2021, the best alternative was found to be Neste Corp. with a C_i score of 0.807. Based on the variables in the model, this company was found to have the best financial performance. Considering the C_i scores of other companies for the year 2021, First Solar Inc. (0.741) was found to rank second and Orsted A/S (0.662) was found to rank third. The worst alternative for the year 2021 was found to be Enphase Energy with a C_i score of 0.313.

In 2019, SolarEdge (1), Enphase Energy Inc., in the VIKOR method. (2) and Orsted A/S (3) are the best-performing companies.

Table 4: Variable weights

Main variable	Weight	Sub-variable	Variable weight
Liquidity ratios	0.154	CR	0.0770
		QR	0.0770
Operating ratios	0.077	ACT	0.0385
		AT	0.0385
Profitability ratios	0.230	ROA	0.1150
		ROE	0.1150
Financial structure ratios	0.154	LR	0.0770
		DR	0.0770
Market ratios	0.385	P/BV	0.1925
		P/E	0.1925

Table 5: BWM-based VIKOR results

Companies	2019		2020		2021	
	Score	Rank	Score	Rank	Score	Rank
Enphase Energy Inc.	0.288	2	0.185	1	0.190	1
Vestas Wind Systems	0.838	4	0.755	5	0.824	3
Con. Edison Inc.	0.914	8	0.964	9	0.994	9
Orsted A/S	0.373	3	0.733	4	0.892	5
SolarEdge	0.180	1	0.461	2	0.696	2
Energias de Portugal	0.916	10	0.940	8	0.962	8
Iberdrola SA	0.898	9	0.917	7	1.000	10
First Solar Inc.	0.640	5	0.758	6	0.918	6
Edison International	0.835	7	0.994	10	0.948	7
Neste Corp.	0.715	6	0.645	3	0.848	4

Table 6: BWM-based TOPSIS results

Companies	2019		2020		2021	
	Score	Rank	Score	Rank	Score	Rank
Enphase Energy Inc.	0.569	5	0.825	1	0.313	10
Vestas Wind Systems	0.530	9	0.233	4	0.492	9
Con. Edison Inc.	0.577	4	0.110	9	0.643	5
Orsted A/S	0.531	8	0.229	5	0.662	3
SolarEdge	0.568	6	0.450	2	0.634	7
Energias de Portugal	0.578	3	0.150	8	0.642	6
Iberdrola SA	0.585	2	0.090	10	0.653	4
First Solar Inc.	0.451	10	0.219	6	0.741	2
Edison International	0.566	7	0.183	7	0.615	8
Neste Corp.	0.721	1	0.268	3	0.807	1

Table 7: Comparison of VIKOR and TOPSIS results

Companies	2019		2020		2021	
	VIKOR rank	TOPSIS rank	VIKOR rank	TOPSIS rank	VIKOR rank	TOPSIS rank
Enphase Energy Inc.	2	5	1	1	1	10
SolarEdge	1	6	2	2	2	7
Vestas Wind Systems	4	9	5	4	3	9
Neste Corp.	6	1	3	3	4	1
Orsted A/S	3	8	4	5	5	3
First Solar Inc.	5	10	6	6	6	2
Edison International	7	7	10	7	7	8
Energias de Portugal	10	3	8	8	8	6
Con. Edison Inc.	8	4	9	9	9	5
Iberdrola SA	9	2	7	10	10	4

In the TOPSIS method, Neste Corp. Companies (1), Iberdrola SA (2), and Energias de Portugal (3) showed the best performance. When the analysis results were compared, it was determined that the companies' performances differed according to the methods. The company that showed the best performance according to the VIKOR method was found to have a poor performance according to the TOPSIS method (6). When the 2019 results of the methods are compared, the results clearly differ. In this case, comparing the companies' financial statements with their financial ratios in decision-making processes is recommended.

In 2020, the results of VIKOR and TOPSIS methods are the same. Enphase Energy Inc. (1), SolarEdge (2), and Neste Corp. (3) are the best-performing companies. In 2020, six of the 10 companies' ranking predictions were the same, and only the performance rankings of 4 companies differed. According to 2020 data, it was determined that the results of the methods were close to each other. It is possible to use one of two methods in financial performance evaluation.

By using VIKOR method for 2021, Enphase Energy Inc. (1), SolarEdge (2), and Vestas Wind Systems (3) are the top performers. In the TOPSIS method, Neste Corp. (1), First Solar Inc. Companies (2), and Orsted A/S (3) showed the best performance. The company that showed the best performance according to the VIKOR method had the worst performance according to the TOPSIS method (10). The results for 2021 differ similarly to 2019. In general, when the 3-year analysis results were compared, it was found that there were similar results in 2020, but the results were completely different in other years.

5. CONCLUSION

In the present study, the financial performances of companies listed in S&P Nort America and Europe Clean Energy Index and ranked in Top 10 Highest Market Value Companies were analyzed using the BWM-based VIKOR and BWM-based TOPSIS methods. As a result of the financial performance analysis performed on the renewable energy industry, the main variable group having the highest weight was found to be the market ratios (38.5%) and the main variable group having the lowest weight was the operating ratios (7.70%).

At the end of the BWM-based VIKOR analyses covering a 3-year period, Enphase Energy was found to have the highest financial performance. It is thought that company's high profitability and market performance values were effective for its good financial performance. Iberdrola SA was found to have the worst financial performance (ranked 9th in 2019 and 9th and 10th in years 2020 and 2021). It is thought that the factors playing role in Iberdrola SA's poor performance were low liquidity, low profitability, and high financial structure ratios. When the results of the analysis with the BWM-based VIKOR method are analyzed by years, it can be seen that financial performance ranking of companies didn't remarkably change in this 3-year period.

At the end of BWM-based TOPSIS analyses covering a 3-year period, Neste Corp. was found to have the highest financial performance (ranked 1st in 2019, 3rd in 2020 and 1st in 2021). It is thought that company's high profitability and market performance values and low financial structure ratios were effective for its good financial performance. Vestas Wind Systems has the worst financial performance (9th in 2019, 4th in 2020 and 9th in 2021). Low liquidity, low profitability and high financial structure ratios are thought to be the factors that play a role in Vestas Wind System's poor performance.

An analysis has been conducted using BWM-based VIKOR and BWM-based TOPSIS methods, spanning 3 years. Rankings obtained through the two methods differ in the years 2019 and 2021. However, the analysis conducted with 2020 data reveals similar rankings. It is known that in the year 2020, which was most affected by the Covid-19 pandemic, companies underwent changes in their capital structures, experienced a decrease in profitability, and encountered disruptions in their operational structures. In addition to the negative impact of the pandemic, since the analysis results of the methods differ, investors should decide when choosing the methods by taking into account the advantages and disadvantages of both methods. Comparing the financial statement calculations and ratio analysis findings is vital. It is advisable that companies make investment decisions by comparing their positions in the sector and the situations of their competitors.

Market ratios of companies are important for the preferences of investors. Especially in studies on the behavioral finance (Rosenberg et al., 1985; Fama and French, 1992; Rouwenhorst, 1999) determined that there was an inverse relationship between low P/BV and abnormal returns. In studies using P/E variable, it was reported that there was an inverse relationship between low

P/E ratio and abnormal returns (Halkos and Tzeremes, 2012; Rouwenhorst, 1999; Basu, 1977). In the present study, it can be seen that Enphase Energy and SolarEdge Technologies having the highest financial performances had high P/BV and P/E ratios.

The present study focused on the companies listed in S&P North America and Europe Clean Energy Index and ranked in top 10 in market value. The financial performances of the companies in study sample were comparatively examined. Researchers are recommended to analyze financial performance of different renewable energy companies by using the BWM-based VIKOR method or other methods.

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