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Research Article

**Sustainability and ESG Performance in Renewable Energy Companies: A
Comparative Multiple Case Study of Türkiye and Europe**

Mustafa Zeytin^a

Abstract

Introduction: This study provides a comparative analysis of sustainability performance between Turkish renewable energy companies Aydem, Smart Solar, Galata Wind and European counterparts for the 2020–2022 period. The research addresses the critical gap in understanding how sustainability practices differ between emerging and developed energy markets, and whether convergence trends exist despite structural disparities.

Method: The analysis focuses on three key dimensions of corporate sustainability (financial, environmental, and social indicators). Data was compiled from companies' sustainability and activity reports and analyzed using descriptive statistics, comparative indicator analysis, min-max normalization, and the creation of an equally weighted composite ESG index.

Results or Findings: The findings reveal significant differences between Turkish and European companies. While European companies demonstrate substantially higher financial capacity and installed power, Turkish companies exhibit rapid growth despite scale limitations. In environmental indicators, although European companies have higher absolute values, normalized data show more efficient carbon and water intensities compared to most Turkish companies. Social indicators reveal persistent gender imbalance across the entire sample, yet European companies demonstrate more systematic training practices and lower accident rates.

Discussion or Conclusion: The study highlights the importance of normalization in assessing inter-company ESG performance, emphasizes inconsistencies in reporting standards and data quality issues in emerging markets, and offers policy implications for Turkey's renewable energy sector alignment with international benchmarks.

Keywords: sustainability, ESG performance, sustainability accounting, renewable energy companies, Turkey–Europe comparative

JEL Codes: M14, M40, Q40.

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Araştırma Makalesi

**Yenilenebilir Enerji Şirketlerinde Sürdürülebilirlik ve ESG Performansı: Türkiye-
Avrupa Karşılaştırmalı Vaka Çalışması**

Mustafa Zeytin^a

Öz

Giriş: Bu çalışma, 2020-2022 dönemi için Türk yenilenebilir enerji şirketleri Aydem, Smart Solar ve Galata Wind ile Avrupalı muadilleri arasındaki sürdürülebilirlik performansının karşılaştırmalı bir analizini sunmaktadır. Araştırma, gelişmekte olan ve gelişmiş enerji pazarları arasında sürdürülebilirlik uygulamalarının nasıl farklılık gösterdiğini ve yapısal farklılıklara rağmen yakınsama eğilimlerinin olup olmadığını anlamadaki kritik boşluğu ele almaktadır.

Yöntem: Analiz, kurumsal sürdürülebilirliğin üç temel boyutuna (finansal, çevresel ve sosyal göstergeler) odaklanmaktadır. Veriler şirketlerin sürdürülebilirlik ve faaliyet raporlarından derlenmiş; tanımlayıcı istatistikler, karşılaştırmalı gösterge analizi, min-maks normalizasyonu ve eşit ağırlıklı bileşik ESG endeksi oluşturma yöntemi kullanılarak analiz edilmiştir.

Sonuçlar ya da Bulgular: Türk ve Avrupa şirketleri arasında önemli farklılıklar tespit edilmiştir. Avrupa şirketleri önemli ölçüde daha yüksek finansal kapasite ve kurulu güç gösterirken, Türk şirketleri ölçek sınırlamalarına rağmen hızlı büyüme sergiliyor. Çevresel göstergelerde, Avrupa şirketlerinin mutlak değerleri daha yüksek olsa da normalleştirilmiş veriler çoğu Türk şirketine kıyasla daha verimli karbon ve su yoğunlukları gösteriyor. Sosyal göstergeler, tüm örnekleme kalıcı bir cinsiyet dengesizliğini ortaya koyarken, Avrupa şirketleri daha sistematik eğitim uygulamaları ve daha düşük kaza oranları sergiliyor.

Tartışma ya da Yapılan Çıkarımlar: Çalışma, şirketler arası ESG performansını değerlendirmede normalleştirmenin önemini vurgulamakta, gelişmekte olan pazarlardaki raporlama standartlarındaki tutarsızlıkları ve veri kalitesi sorunlarını ortaya koymakta ve Türkiye'nin yenilenebilir enerji sektörünün uluslararası kıyaslamalarla uyum sağlaması için politika önerileri sunmaktadır.

Anahtar Kelimeler: sürdürülebilirlik, ESG performansı, sürdürülebilirlik muhasebesi, yenilenebilir enerji şirketleri, Türkiye-Avrupa karşılaştırması

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Introduction

The transition to a low-carbon economic structure on a global scale is possible through structural transformations in the energy sector and the alignment of these transformations with sustainability goals (Kozar & Sulich, 2023; Genc & Kosempel, 2023; Kamali Saraji & Streimikiene, 2023). Greenhouse gas emissions caused by fossil fuels increase climate change risks and price volatility (Romanello et al., 2022), while also reducing energy supply security and creating significant uncertainties in terms of environmental costs (Stepanov & Makarov, 2024). The role of renewable energy sources is of strategic importance not only in terms of environmental sustainability, but also in terms of economic development and social welfare (Omri & Belaid, 2021; Karimi Alavijeh et al., 2024; Lu et al., 2022). According to the International Energy Agency's projections, the share of renewable energy sources in global electricity production will continue to increase rapidly over the next decade; the European Union's 2030 and 2050 targets will make renewable energy investments mandatory for a carbon-neutral future (European Commission, 2020). The European Green Deal, which holds a central position in the European Union's energy transition strategy (Fetting, 2020), sets technical targets for greenhouse gas reduction and strengthens sustainable financing, corporate governance, and transparent reporting standards. Regulations now require energy companies to report their financial performance not only in terms of profit and investment levels, but also in conjunction with environmental and social responsibility indicators (Dathe et al., 2024; Chen et al., 2024). Companies' economic growth targets are pursued within a framework that is consistent with their climate change mitigation strategies (França et al., 2023; Khan et al., 2022). European energy companies such as Iberdrola (Alvarez-Meaza et al., 2020), Ørsted (Thomas, 2025), and EDP Renováveis are emerging as global leaders in the energy transition process not only through their financial capacity but also through their emission reduction strategies, circular economy practices, and social impact programs. Turkey has seen a significant increase in renewable energy investments over the past decade, and the share of renewable energy sources in the country's total installed capacity has approached 50% (Türkiye Elektrik İletim A.Ş., 2022). The development of renewable energy is important not only for ensuring energy security and reducing external dependency, but also for fulfilling Turkey's emission reduction commitments under the Paris Agreement (Erat et al., 2021; Budak, 2025; Kat, 2023). Aydem Renewable Energy Inc., Smart Solar Energy Technologies Inc., and Galata Wind Energy Inc., which are traded on the capital markets in Turkey, contribute to financial growth and the expansion of renewable energy capacity in the national energy market and conduct environmental and social performance reporting (Erdoğan et al., 2026; Sogukpinar et al., 2025). Although there is extensive literature on renewable energy companies, comparative findings regarding emerging markets remain limited. Using intensity-based normalization and a composite ESG (Environmental, Social, and Governance) index, this study compares three Turkish and three European renewable energy companies across financial, governance, environmental, and social indicators for the 2020–2022 period. Research on the sustainability performance of renewable energy companies is primarily based in Europe and the US, focusing particularly on the emission reduction strategies, investment dynamics, and corporate reporting practices of large-scale energy companies (Murugan et al., 2025; Cicchiello et al., 2023; Drago & Gatto, 2022; Hartmann et al., 2021; Crijns-Graus et al., 2022). There appears to be a limited number of comparative studies on the global positioning of energy companies in emerging markets such as Turkey. Given Turkey's rapid increase in renewable energy capacity and the growing importance of energy companies traded on the Istanbul Stock Exchange for international investors, this area stands out as a topic that should be considered in the context of sustainability and investment strategies. The main contribution of this study is that it analyzes renewable energy companies in Turkey and Europe not only in terms of financial performance

but also in a comprehensive manner, taking into account environmental and social indicators. The study examines Aydem, Smart Solar and Galata Wind from Turkey, listed on the BIST 30 index, and Iberdrola, Ørsted, and EDP Renováveis from Europe, listed on the EURO STOXX 50 index, for the 2020–2022 period. The study is designed as a comparative case study on a total of six renewable energy companies selected from Türkiye and Europe. The analysis comparatively evaluated the companies' financial governance indicators, such as net sales revenue, investment expenditures, installed capacity, and production volume; environmental indicators, such as energy consumption, water usage, waste management, and greenhouse gas emissions; and social indicators, such as the number of employees, female employment rates, occupational health and safety data, and training activities.

Method

Research Scope and Data Set

This study is based on a comparative case study of the financial, environmental, and social indicators of renewable energy companies in Türkiye and Europe for the period 2020–2022. The Turkish sample consists of Aydem Renewable Energy Inc. (Aydem), Smart Solar Energy Technologies Inc. (Smart Solar) and Galata Wind Energy Inc. (Galata Wind), which are traded on the Borsa Istanbul (BIST) 30 index. The European sample consists of Iberdrola S.A. (Spain), Ørsted A/S (Denmark) and EDP Renováveis S.A. (Portugal), which are listed on the EURO STOXX 50 index and are global leaders in the renewable energy sector. The data has been compiled from the companies' sustainability reports (Iberdrola, 2022b; Ørsted, 2022b; EDP Renováveis (EDPR), 2022b; Aydem, 2022b; Smart Solar, 2022b; Galata Wind, 2022b), annual activity reports (Iberdrola, 2022a; Ørsted, 2022a; EDPR, 2022a; Aydem, 2022a; Smart Solar, 2022a; Galata Wind, 2022a) and official statements published on their corporate websites. To minimise misleading effects arising from exchange rate differences in the comparisons, the financial indicators of European companies are presented in Euros, while those of Turkish companies are presented in Turkish Lira. However, the analysis focuses on revealing trends, growth rates and relative differences rather than size comparisons.

The coding system used in Table 1 was chosen to reduce repetition in the presentation of findings and to enhance comparability in the graphs. It has been used in the presentation of financial, environmental, and social indicators in the subsequent sections of the study. In the coding, the letter 'T' represents companies in the Turkish sample, while the letter 'E' represents companies in the European sample. This provides visual clarity in the tables and graphs, making the comparative analysis of the Turkish and European samples easier and more understandable.

Table 1

Companies Examined by Country and Serial Codes

Company Name	Series Code	Country
Aydem Renewables	T1	Turkey
Smart Solar Technologies	T2	Turkey
Galata Wind Energy	T3	Turkey
Iberdrola	E1	Spain
Ørsted	E2	Denmark
EDP Renováveis	E3	Portugal

Note. Created by the author. The companies included in this study were selected using purposive sampling based on market representation and data availability.

Indicators and Metrics

The study examined three main dimensions: Financial Governance indicators: Net sales revenue, investment expenditure, total installed capacity (MW) and total energy production (MWh/GWh). Environmental indicators: Direct and indirect energy consumption (kWh), water usage (m³), total waste volume (hazardous/non-hazardous), greenhouse gas emissions (Scope 1, 2, 3, tonnes CO₂e). Social indicators: Total number of employees, percentage of female employees, distribution by age group, gender balance in management positions, training activities (number of participants and hours), occupational health and safety indicators (TRC – total recorded accident frequency, LTIF – lost time injury frequency, employee turnover rate).

Method and Analysis Process

The indicators obtained in the study were evaluated using descriptive, comparative and focused analysis techniques. First, the values for each indicator were presented on an annual basis through tables and graphs, thus clearly revealing the differences between companies. Subsequently, the Turkish and European samples were evaluated internally, followed by comparisons between the two groups in terms of financial size, environmental performance, and social indicators. The trends of increase and decrease observed in the indicators during the 2020–2022 period were examined, with a particular focus on the post-pandemic recovery dynamics and the effects of increased investments being discussed contextually. Methodologically, the study is based on a qualitative comparative analysis approach. The ESG framework, unlike the traditional Environmental (E), Social (S), and Governance (G) dimensions, encompasses Environmental (E), Social (S), and Financial Governance (FG) dimensions. Financial Governance refers to the effectiveness of a company's financial decision-making processes, its resource allocation competence, and its long-term value creation capacity. Since direct governance data is limited, the term "ESG" is used in this study to refer to Environmental, Social, and Financial Governance performance. As the data set only covers the period 2020–2022 and the sample is limited to six companies, advanced statistical tests have not been applied; instead, descriptive findings and comparative assessments are highlighted. However, the consistency of trends and the relationships between indicators have been addressed and interpreted within the analytical framework.

Indicator Construction, Directional Alignment and Normalization

In order to enable comparison between companies and eliminate scale effects, the indicators were converted into intensity measures. Environmental load variables (e.g., total emissions, water withdrawal, and waste generation) were divided by an appropriate scale variable (total energy consumption) to obtain carbon, water, and waste intensity. The use of scale-adjusted indicators is widely adopted in sustainability comparisons between countries and companies to reduce size bias (D'Adamo et al., 2025; Desogus et al., 2024). All indicators have been directionally aligned, ensuring that higher values consistently represent better performance. Cost-type indicators (e.g., carbon intensity, water intensity, waste intensity, and TRC) have been reversed using a modified min–max transformation. This is consistent with the directional alignment principle commonly used in ESG rating methodologies (MSCI ESG Research LLC., 2022).

$$N_{ij}^{cost} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)} \quad (1)$$

Standard minimum-maximum normalization was applied to benefit type indicators:

$$N_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \quad (2)$$

All variables were normalized to a range of 0-1, yielding dimensionless and comparable measurements. This prevented any single indicator from dominating the composite index due to differences in measurement units or magnitudes (Qachach et al., 2025).

Sub-Indices, Composite ESG Score and Multi-Year Averaging

Following normalization, the indicators were grouped into three conceptual dimensions: Environmental (E), Social (S), and Financial (F). Within each dimension, the normalized indicators were summed using equally weighted arithmetic means:

$$E_{it} = \frac{1}{k} \sum_{j=1}^k N_{it,j}^* \quad (3)$$

$$S_{it} = \frac{1}{m} \sum_{j=1}^m N_{it,j}^* \quad (4)$$

$$F_{it} = \frac{1}{n} \sum_{j=1}^n N_{it,j}^* \quad (5)$$

k, m, and n denote the number of indicators assigned to each respective dimension, while N represents the directionally adjusted values for cost-type variables. To preserve methodological transparency and minimize subjective bias in the aggregation process, an equal-weighting scheme was adopted. The equal-weighting approach is frequently employed in the construction of composite sustainability indices to maintain normative neutrality and to avoid implicit value judgments regarding the relative importance of individual dimensions (D'Adamo et al., 2025; Desogus et al., 2024).

The composite ESG score was calculated as follows:

$$ESG_{it} = \frac{E_{it} + S_{it} + F_{it}}{3} \quad (6)$$

The use of a composite ESG structure is consistent with current literature that demonstrates that ESG performance cannot be explained by one-dimensional financial indicators and must be evaluated within a multidimensional framework (Yeh & Liao, 2026). To achieve more stable and long-term sustainability performance, a three-year average ESG score has been calculated:

$$\overline{ESG}_t = \frac{ESG_{i,2020} + ESG_{i,2021} + ESG_{i,2022}}{3} \quad (7)$$

The multi-year average approach is considered an effective method for revealing structural sustainability trends by mitigating the impact of cyclical shocks (Çalışkan, 2025). No data completion process was performed. Only the disclosed firm-year data was used to enhance

transparency and reproducibility. This approach is recommended, particularly in emerging markets, for data integrity and methodological reliability (Lavin & Montecinos-Pearce, 2021; Krueger et al., 2024; Dye et al., 2021).

Limitations of the Research

As the data used in this study is based on reports disclosed by companies to the public, differences in reporting standards may lead to limitations in comparisons. For example, while some companies report social indicators in detail, others provide more limited data. Furthermore, the disclosure of financial indicators in different currencies requires careful interpretation when comparing scales. One limitation of the study is that the governance dimension was measured through financial performance indicators rather than traditional indicators such as board structure, independence, supervisory board, and compensation policies. This limitation stems from the fact that corporate governance indicators were not systematically and comparably reported in the 2020-2022 reports of companies in Türkiye. While three companies selected from Türkiye and three from Europe represent the renewable energy sector in their respective markets, they do not cover the entire sector, and the sample size is limited to six companies. The data used is based on sustainability and activity reports that companies voluntarily share with the public. Due to differences in reporting standards and data quality issues in developing markets, some anomalous data may be observed. The lack of sensitivity analysis regarding alternative weighting techniques based on financial materiality, combined with the integration of ESG sub-dimensions using an equal-weighting method, limits the assessment of the robustness of composite ESG scores under different weighting assumptions; this limitation is considered an issue that should be addressed in future research.

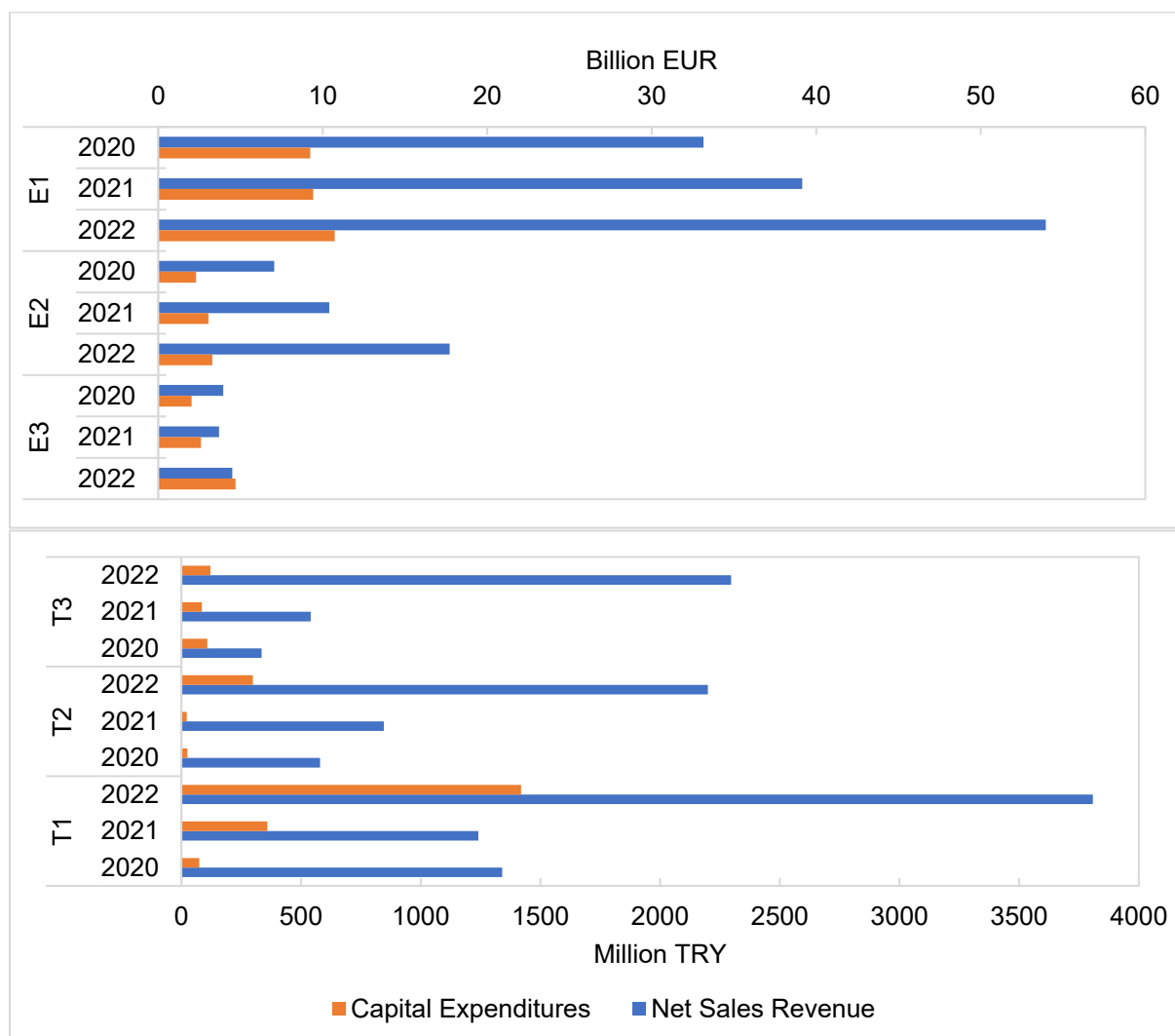
Findings

Financial Indicators

As presented in Figure 1., the net sales revenues of companies in Turkey (T series) have shown significant fluctuations over time. T1, which recorded revenues of 1,340 million TL in 2020, saw a 7.4% decline in 2021, but increased by approximately three times to 3,807 million TL in 2022. Similarly, T3 grew more than sixfold, reaching 2,296 million TL in 2022 from 335 million TL in 2020. T2 increased its revenue from 579 million TL in 2020 to 2,199 million TL in 2022, showing steady growth over the three-year period. It can be said that the expansion of the energy market in Turkey, the increasing investment volume and the global rise in energy prices in the 2021–2022 period played an important role behind these increases. It reveals that the renewable energy market in Turkey grew rapidly, particularly after the public offering, and that companies began to expand their capital bases.

Figure 1

Comparison of Companies' Net Sales Revenue and Capital Expenditures.



Note. This figure was created by the author using Microsoft Excel. The data were extracted from the companies' annual reports covering the period 2020–2022.

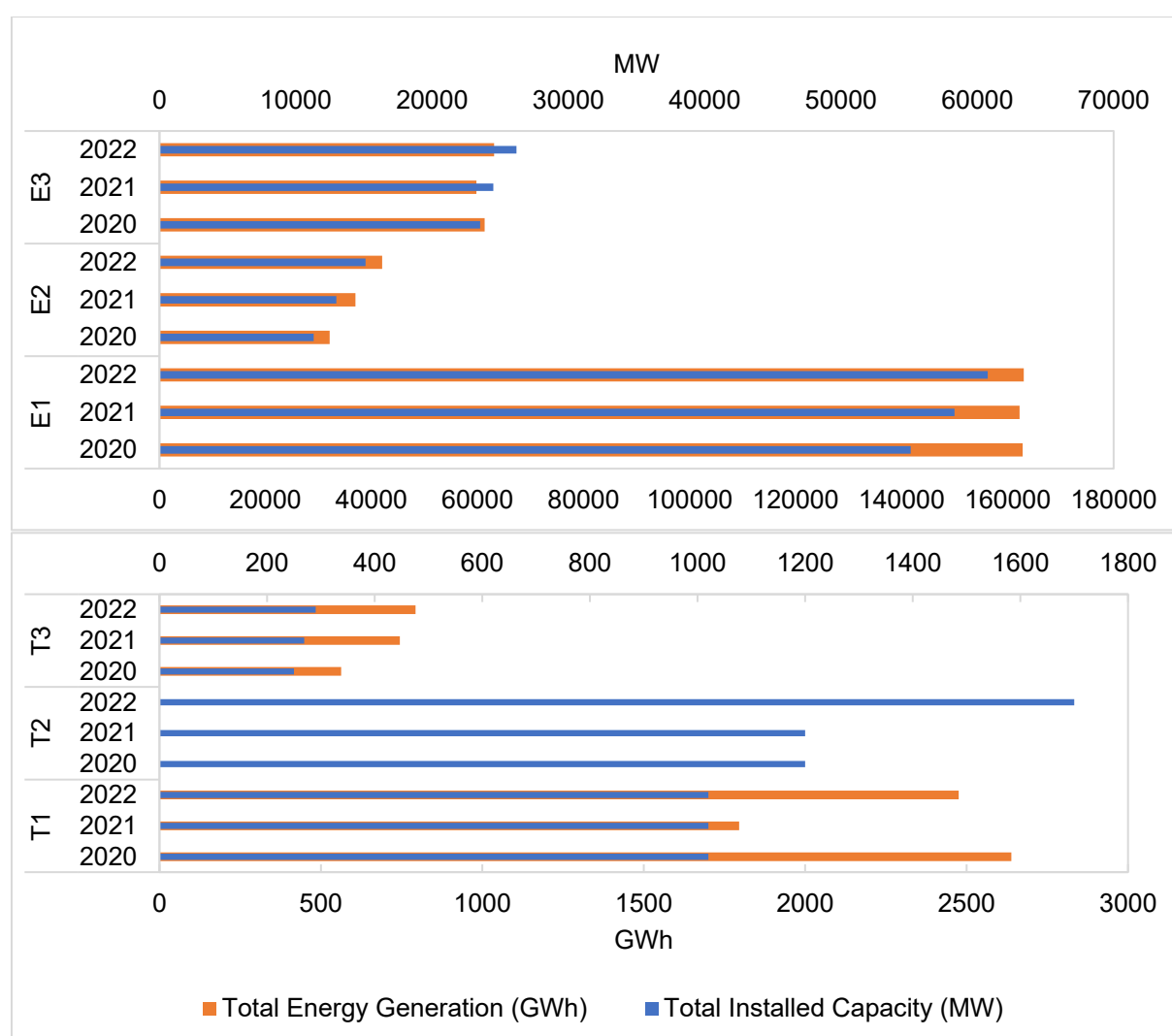
When examining European companies (E series), it is noteworthy that their net sales revenues are significantly higher in terms of scale. E1 increased its revenue from €33.15 billion in 2020 to €53.95 billion in 2022, recording a 62.8% increase during this period. E2 grew by approximately 151%, rising from €7.05 billion in 2020 to €17.72 billion in 2022. E3, on the other hand, saw a relatively more modest increase, raising its revenue from €3.95 billion in 2020 to €4.50 billion in 2022. A similar differentiation is also evident in terms of investment expenditure. In Turkey, T1 increased its investments from 74.6 million TL in 2020 to 1,418.9 million TL in 2022, representing an increase of approximately 19 times. T2 recorded growth of more than tenfold in 2022 with investments of 298.9 million TL compared to 2020. T3 investments saw a more limited increase from 108.2 million TL in 2020 to 121.7 million TL in 2022. European companies stand out with much higher absolute values. E1 made stable investments of approximately €9–11 billion annually between 2020 and 2022. E2 increased its investment from €2.30 billion in 2020 to €3.29 billion in 2022. E3 more than doubled its investment, rising from €2.03 billion in 2020 to €4.70 billion in 2022. These data reveal that

companies in Turkey are growing rapidly but still operate on a relatively limited scale compared to European companies in terms of absolute size.

As presented in Figure 2, in terms of installed capacity, companies in Turkey are relatively small in scale. T1 remained stable at 1,020 MW of installed capacity during the 2020–2022 period, while its production fell from 2,638 GWh in 2020 to 1,796 GWh in 2021, rising to 2,475 GWh in 2022. This fluctuation can be explained by climate-related variability in hydroelectric production. T2 increased its capacity from 1,200 MW in 2020 to 1,700 MW in 2022, but no production data was reported. T3 increased its capacity from 250 MW in 2020 to 290 MW in 2022; its production rose from 563 GWh to 793 GWh during the same period. European companies operate on a much larger scale.

Figure 2

Comparison of Companies' Total Installed Capacity and Total Energy Generation



Note. This figure was created by the author using Microsoft Excel. The data were extracted from the companies' sustainability and annual reports covering the period 2020–2022.

E1 increased its installed capacity from 55,111 MW in 2020 to 60,761 MW in 2022; its production remained above 160,000 GWh annually. E2 increased its capacity from 11,318 MW in 2020 to 15,121 MW in 2022 and increased its production from 32,095 GWh to 42,009 GWh

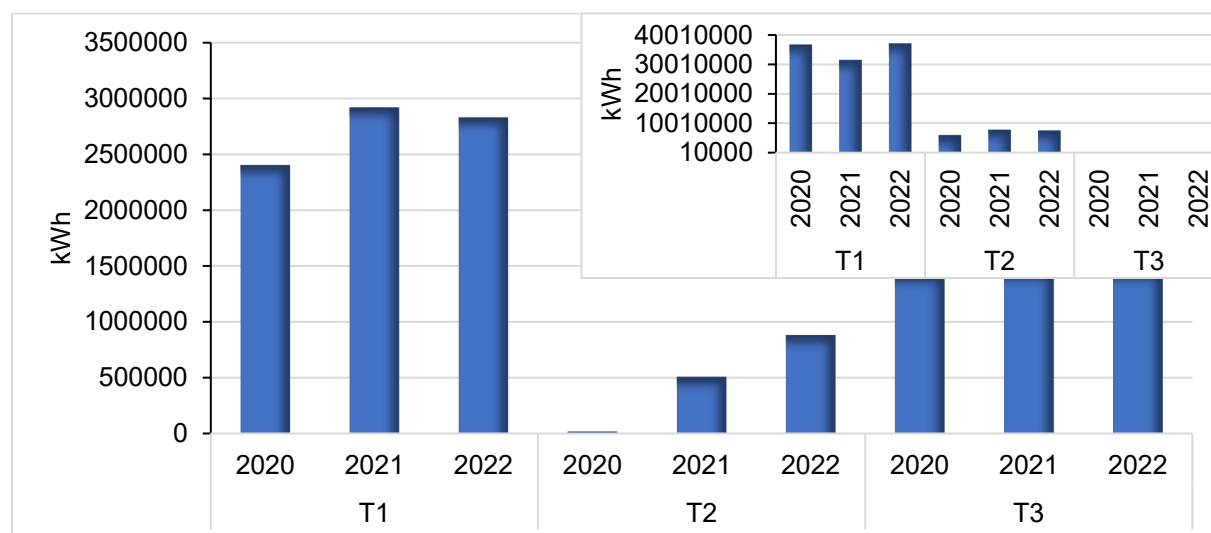
during the same period. E3 increased its capacity from 23,524 MW in 2020 to 26,187 MW in 2022, while its production reached 63,122 GWh from 61,351 GWh. This comparison reveals that European companies operate on a scale over a hundred times larger than Turkish companies in terms of installed power and production capacity. Although the increases in the Turkish sample are relatively more limited, they indicate that growth potential continues, particularly in capacity expansions. When financial indicators are assessed as a whole, it is clear that European companies have a much larger financial and operational capacity in absolute terms. Series E companies have reached billions of euros in revenue and investment volume, tens of thousands of MW of installed capacity, and hundreds of thousands of GWh of production capacity. In contrast, Series T companies are smaller in scale but have demonstrated remarkable performance, particularly in terms of revenue and investment growth rates, during the 2020–2022 period. Therefore, while European companies stand out with their economies of scale and market maturity, Turkish companies attract attention with their growth rates and ability to adapt to the market. This situation shows that Turkey is undergoing a dynamic development process in the renewable energy sector but is still at an early stage when compared to large-scale companies in Europe.

Environmental Indicators

When examining the energy consumption data for the 2020–2022 period between the renewable energy companies in Turkey (T1–T3) shown in Figure 3. and the companies in Europe (E1–E3) shown in Figure 4, differences are observed in terms of both scale and trend.

Figure 3

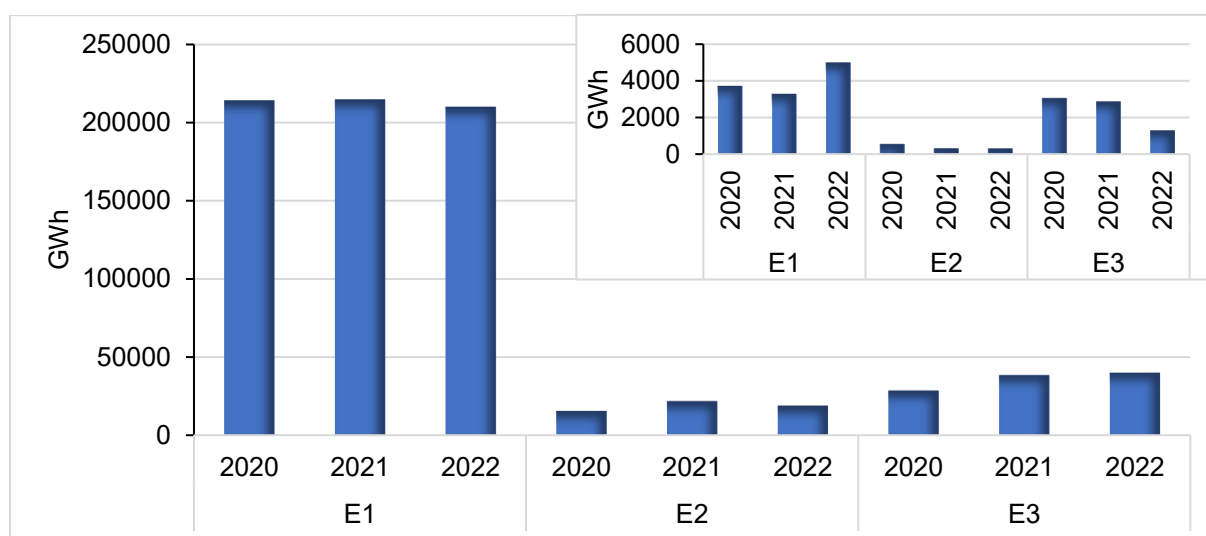
T Series Total Direct Energy Consumption (kWh) Total Indirect Energy Consumption (Electricity, kWh) Values



Note. This figure was created by the author using Microsoft Excel. The data were extracted from the companies' sustainability reports covering the period 2020–2022.

Figure 4

E Series Total Direct Energy Consumption (GWh) Total Indirect Energy Consumption (Electricity, GWh) Values



Note. This figure was created by the author using Microsoft Excel. The data were extracted from the companies' sustainability reports covering the period 2020–2022.

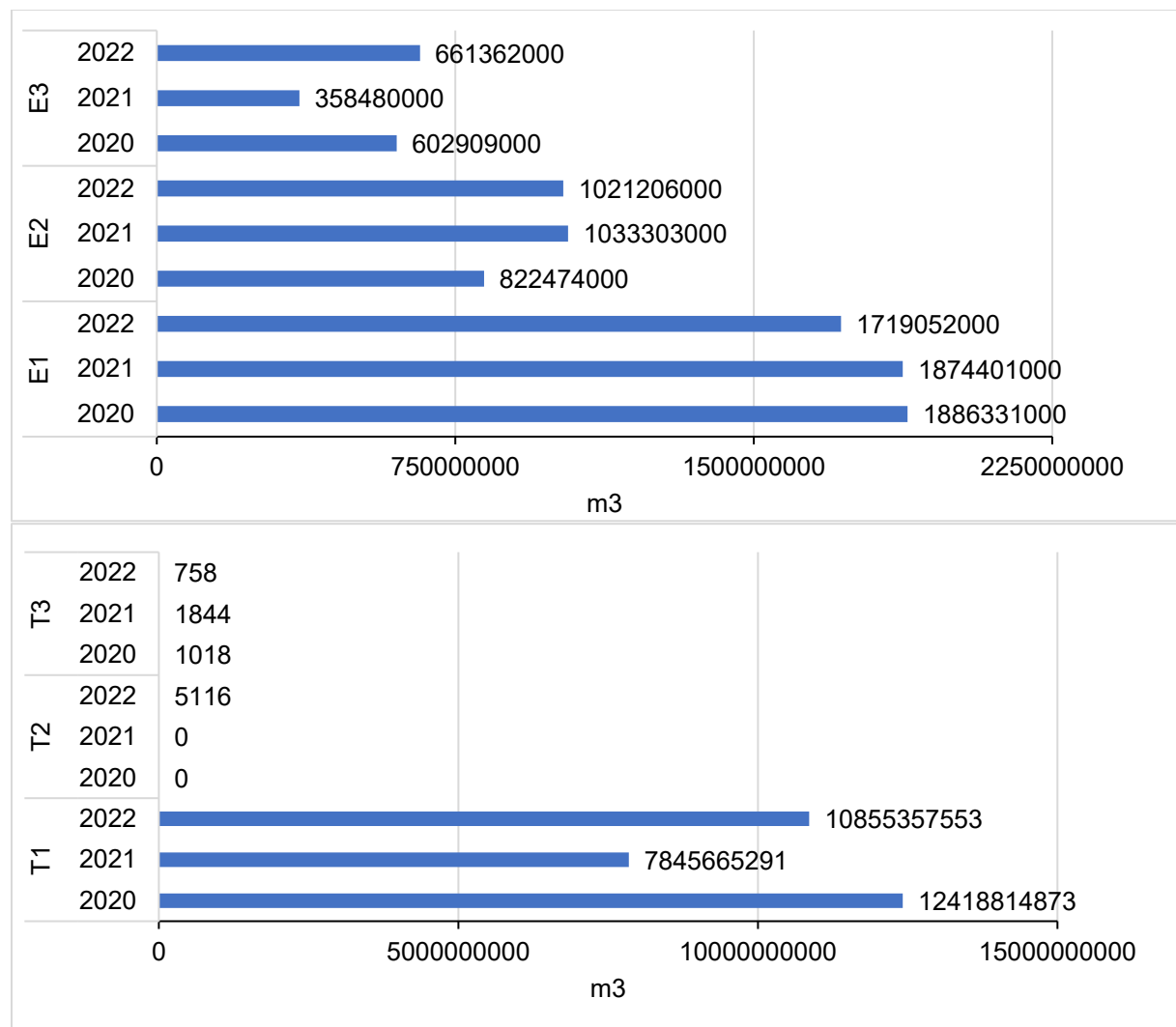
T1 showed a steady increase in direct energy consumption at the level of 2–3 million kWh, while indirect energy consumption fluctuated, falling to 30 million kWh in 2021 and rising again to 40 million kWh in 2022. T2 showed the most notable increase in direct energy consumption; consumption, which was only 20,000 kWh in 2020, reached 900,000 kWh in 2022. In contrast, indirect consumption remained stable in the 6–8 million kWh range. T3 maintained its direct energy consumption at 1 million kWh, while increasing its indirect consumption from 30,000 kWh to 60,000 kWh between 2020 and 2022. This figure shows that the absolute consumption levels of companies operating in Turkey are low, but T3 stands out in terms of growth rates. In Europe, high consumption levels are remarkable. E1 maintained a stable level of 210,000 GWh in direct energy consumption, while increasing its indirect consumption from 3,700 GWh in 2020 to 5,000 GWh in 2022. E2 increased its direct consumption from 15,000 GWh to 22,000 GWh and then reduced it to 19,000 GWh, while reducing its indirect consumption from 550 GWh to 310 GWh, achieving significant efficiency gains. Similarly, E3 increased its direct consumption from 29,000 GWh to 40,000 GWh, while reducing its indirect consumption from 3,100 GWh to 1,300 GWh. This trend shows that large companies in Europe are pursuing strategies to increase efficiency in indirect energy consumption despite their scale growth. When Turkey and Europe are compared overall, companies in Turkey have relatively low absolute energy consumption values but show a rapid growth trend. Companies in Europe, on the other hand, achieve very high absolute consumption levels thanks to their massive operational capacities, but are increasing their relative efficiency through energy efficiency and consumption reduction policies. This situation reveals that renewable energy companies in Turkey are undergoing a dynamic expansion process, while mature market structures in Europe prioritize stability and efficiency in energy management.

Figure 5 shows significant differences between renewable energy companies in Turkey and large-scale energy companies in Europe in terms of both absolute values and intensities in the water withdrawal data for the 2020–2022 period. T1 reports very highwater withdrawal due to its hydroelectric-dominated production structure: 12.4 billion m³ in 2020, 7.8 billion m³ in

2021, and 10.9 billion m³ in 2022. When normalized by production values, these figures correspond to a water intensity of 4,300–4,700 m³/MWh. In contrast, T2 and T3 reported almost negligible water withdrawal. Galata Wind’s reporting of only 758 m³ of water withdrawals for 793 GWh of production in 2022 demonstrates that the water footprint of wind and solar technologies is extremely low compared to hydroelectricity. Europe reports absolute water abstraction values in the billions of cubic meters. E1 reduced its abstraction from 1.89 billion cubic meters in 2020 to 1.72 billion cubic meters in 2022; E2 reported fluctuating values between 0.82 and 1.02 billion cubic meters during the same period. E3 increased its water withdrawal from 0.60 billion m³ in 2020 to 0.66 billion m³ in 2022.

Figure 5

Water Withdrawal (m³) Values for The Series



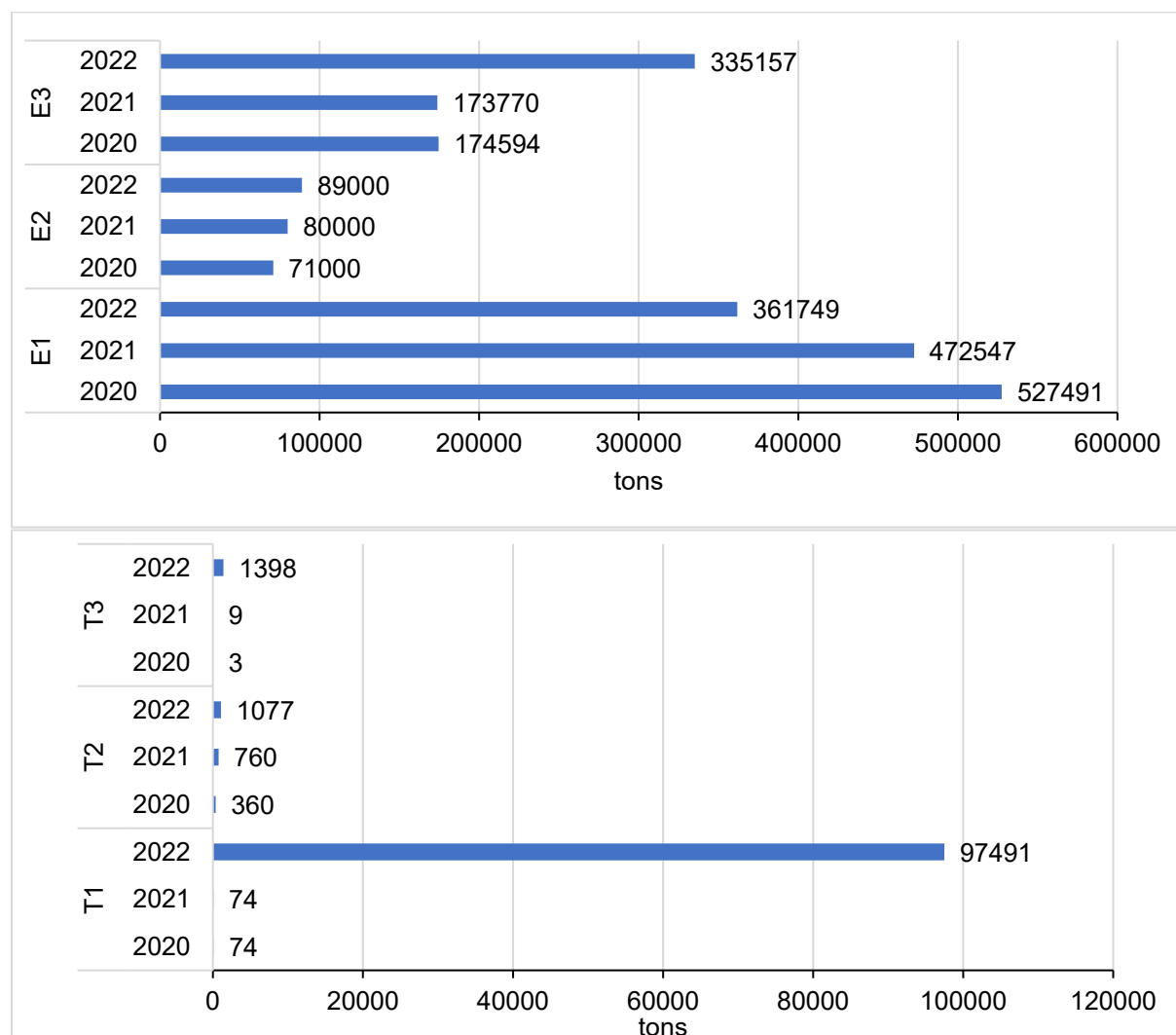
Note. This figure was created by the author using Microsoft Excel. The data were extracted from the companies' sustainability reports covering the period 2020–2022.

However, considering the production scale of these companies, their normalized water intensities are much lower than Aydem's: Ørsted remains at approximately 24–26 m³/MWh, and EDP Renováveis at 9–11 m³/MWh. This shows that despite their high absolute water withdrawals, European companies have relatively lower water intensities due to their scale. When considering the Turkey-Europe comparison holistically, the water withdrawal values of

companies producing hydroelectric power in Turkey exceed even those of major European companies. However, since the water withdrawal of Turkish companies focused on wind and solar power is negligible, the technology mix emerges as the most fundamental factor determining these differences. Although companies in Europe report high values in absolute terms, they appear to be more efficient in terms of water intensity; hydroelectric-heavy production in Turkey, on the other hand, creates a striking difference in terms of environmental sustainability with a much higher water withdrawal per unit.

Figure 6

Total Waste Amount (tons) Values for The Series



Note. This figure was created by the author using Microsoft Excel. The data were extracted from the companies' sustainability reports covering the period 2020–2022.

When examining total waste amounts for the 2020–2022 period given in Figure 6, a clear upward trend is observed in Turkish companies, while European companies show more stable or gradually decreasing trends. In Turkey, T1, which remained stable at around 74 tons in 2020 and 2021, increased dramatically to 97,490 tons in 2022. This sudden increase is said to be due to large-scale construction activities carried out during the physical investment process. Therefore, it is understood that this increase is not a reflection of a structural trend, but rather a temporary situation specific to the investment period; it is expected that waste levels

will return to normal after the investment process is completed. T2 recorded a gradual but significant increase, raising its waste from 360 tons in 2020 to 1,077 tons in 2022. Similarly, T3 increased its waste from only 2.9 tons in 2020 to 1,398 tons in 2022. This table shows that waste management is becoming increasingly critical in Turkish companies in parallel with their growth in scale. When examining large-scale companies in Europe, E1 achieved a significant reduction by decreasing its total waste from 527,491 tons in 2020 to 361,749 tons in 2022. E2, on the other hand, showed a limited but steady increase, rising from 71,000 tons to 89,000 tons. For E3, the waste amount, which was 174,594 tons in 2020, increased to 335,157 tons in 2022. European companies generally report much higher absolute waste volumes compared to Turkish companies. However, considering the scale difference, this is not surprising, as European companies have much larger installed capacity and production capacity.

E1 demonstrates that effective waste reduction policies can be implemented despite operational scale. When Turkey and Europe are compared holistically, Turkish companies remain small in terms of absolute waste volume but have shown a rapid upward trend over the past three years. Although companies in Europe report much higher absolute values, they are developing strategies for waste reduction, as in E1. Therefore, it can be said that waste management capacity and reporting standards need to be developed more systematically in Turkey, while sustainable waste reduction practices are relatively more strongly implemented in Europe despite the scale.

Table 2

Emission Values of The Series

Serial	Years	Scope 1 (tons CO ²)	Scope 2 (tons CO ²)	Scope 3 (tons CO ²)
T1	2020	775.5	4729.1	498.3
	2021	1364.7	3534.5	960.9
	2022	1587.9	3120.1	70482.5
T2	2020	N/A	N/A	N/A
	2021	146.7	3398.9	19204.2
	2022	257.6	3934.0	24512.8
T3	2020	73.8	597.7	62.3
	2021	82.9	646.4	76.3
	2022	78.9	611.9	149.8
E1	2020	12518864	1882654	47645574
	2021	12754162	2161984	44614613
	2022	11346356	1879381	42013975
E2	2020	1851000	111000	25333000
	2021	2142000	53000	18179000
	2022	2510000	45000	10983000
E3	2020	9304000	594000	11730000
	2021	9819000	791000	10304000

Note. Emission data were extracted from the companies' sustainability reports for the 2020–2022 period. Missing values (indicated as N/A) were not imputed to maintain transparency. The author used Microsoft Excel for data compilation and descriptive analysis.

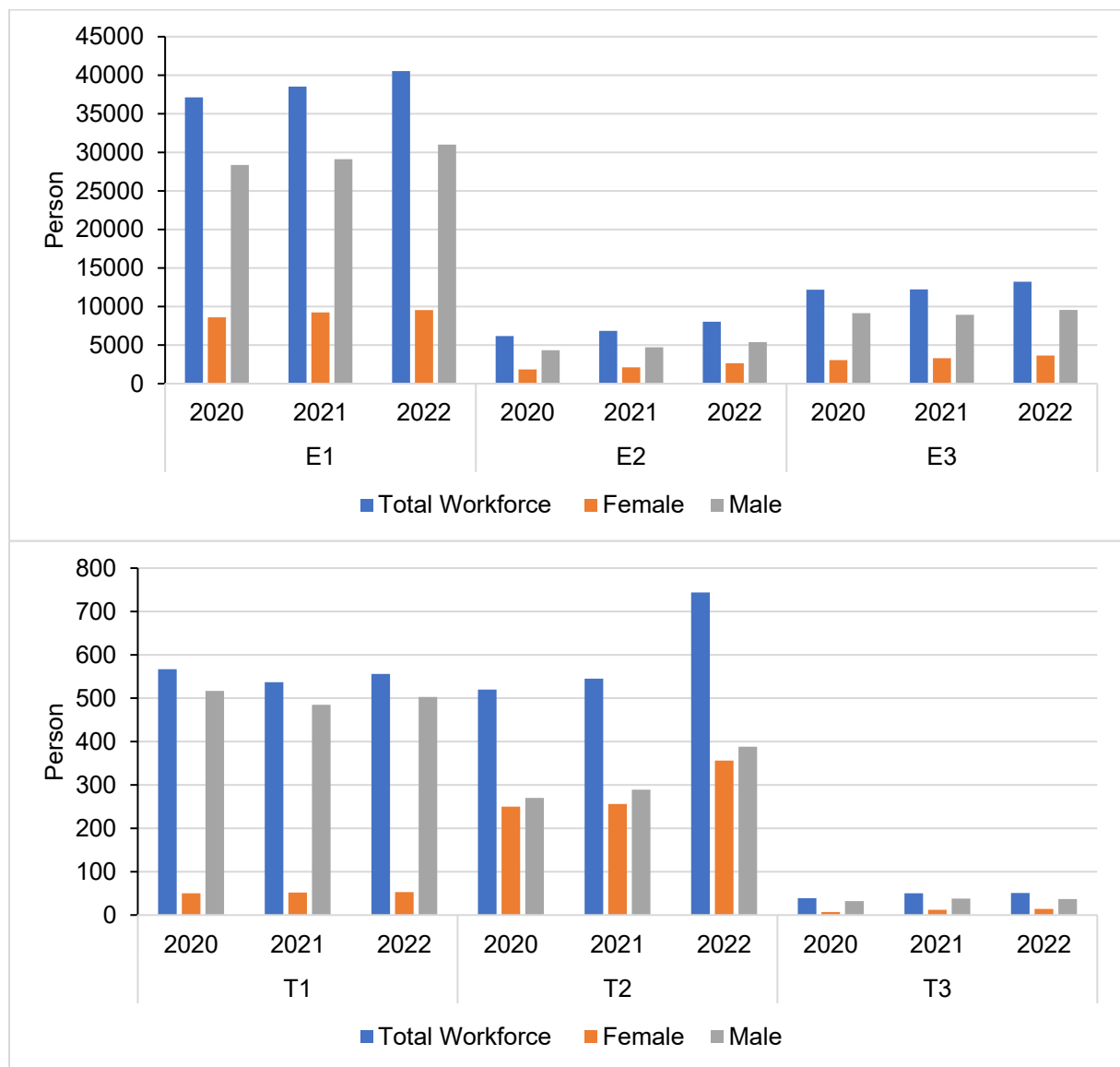
Similarly, the greenhouse gas emission data for the 2020–2022 period provided in Table 2 reveal significant differences between companies in Turkey and large-scale energy companies in Europe in terms of absolute levels, trends, and reporting scope. In Turkey, T1 increased its Scope 1 emissions from 775 tons of CO₂ in 2020 to 1,588 tons of CO₂ in 2022. Scope 2 emissions fell from 4,729 tons to 3,120 tons during the same period, while Scope 3 emissions skyrocketed to 70,482 tons in 2022. This extraordinary increase is considered to be a reflection of temporary circumstances rather than a permanent trend, stemming from construction activities carried out during the investment process and supply chain-related operations. Scope 3 emissions are expected to return to a lower and more stable level once the physical investment process is completed. T2 did not report any emissions in 2020, but reported 147 tons in Scope 1, 3,399 tons in Scope 2, and 19,204 tons in Scope 3 in 2021. In 2022, these values increased to 258 tons, 3,934 tons, and 24,513 tons, respectively. T3, on the other hand, has very low emission levels; Scope 1 emissions are in the 70–80-ton range, Scope 2 emissions are around 600 tons, and Scope 3 emissions are at most 150 tons. In European companies, absolute emissions are in the millions of tons. E1 achieved a partial reduction by lowering Scope 1 emissions from 12.5 million tons in 2020 to 11.3 million tons in 2022. Scope 2 emissions remained stable at 1.88 million tons, while Scope 3 emissions fell from 47.6 million tons to 42 million tons. E2 increased its Scope 1 emissions from 1.85 million tons to 2.51 million tons, but reduced its Scope 2 emissions from 111,000 tons to 45,000 tons; Scope 3 emissions also showed a notable decrease, falling from 25.3 million tons to 10.9 million tons during the same period. E3 kept its Scope 1 emissions steady at 9.3 million tons, reduced its Scope 2 emissions from 594,000 tons to 469,000 tons, and lowered its Scope 3 emissions from 11.7 million tons to 9.3 million tons. The absolute emissions of Turkish companies are extremely low compared to large-scale energy companies in Europe. However, these low levels are largely due to limited production scale and technology preferences (emphasis on wind and solar). In contrast, the extraordinary increase in T1's Scope 3 emissions in 2022 being a temporary situation driven by investments highlights the importance of contextual factors in assessing environmental indicators. Although companies in Europe have much larger absolute emissions, they show clear reduction trends, particularly in Scope 2 and Scope 3 categories, demonstrating the effectiveness of advanced reporting systems and carbon reduction strategies. Therefore, while companies in Turkey appear to have a relative advantage due to their low-scale emissions, their carbon management capacity has not yet been institutionalized due to fluctuations arising from investment processes. European companies, on the other hand, despite their high absolute emission profiles, are in a more advanced position in terms of environmental sustainability with their more stable reduction strategies.

Social Indicators

When examining employee data for the 2020–2022 period in Figure 7, significant differences are observed between renewable energy companies in Turkey and companies in Europe in terms of scale and gender balance.

Figure 7

Companies' Total Workforce, Female and Male Employees



Note. This figure was created by the author using Microsoft Excel. The data were extracted from the companies' sustainability and annual reports covering the period 2020–2022.

In Turkey, T1 reduced its total number of employees from 567 in 2020 to 537 in 2021, then increased it to 556 in 2022. The number of female employees remained stable between 50 and 53 over the three years, with the ratio remaining at around 9–10%. T2 showed the most notable increase in both total number of employees and female employment: starting with 520 employees (48% female) in 2020, it reached 743 employees (48% female) in 2022. T3 has a small-scale employment structure, with the number of employees rising from 42 to 57; the number of female employees increased from 7 to 14, with the female ratio ranging between 18% and 27%. This table shows that only T3 stands out in terms of female employment in Turkey, while the other two companies have low female ratios. Large-scale companies in Europe have a much greater employment capacity. E1 started with 36,965 employees in 2020

and reached 40,550 in 2022; the number of female employees increased from 8,599 to 9,545 during the same period. The female employment rate remained at around 23–24%. E2 started with 6,179 employees in 2020 and increased to 8,027 in 2022; the female employee rate varied between 30–33%. E3 increased its number of employees from 11,610 in 2020 to 13,211 in 2022, while increasing female employment from 3,045 to 3,651, maintaining the ratio at 25–27%.

All companies in Europe have seen a steady increase in their total number of employees, with female employment at more balanced rates compared to companies in Turkey. When Turkey and Europe are compared overall, companies in Turkey are limited in terms of employee numbers, but they show remarkable success in terms of female employment, as seen particularly in the T2 example. T1 and T3, on the other hand, remain smaller in terms of total employee numbers and have low levels of female employees. Companies in Europe (E1, E2, E3), on the other hand, have much higher absolute employment levels and present a relatively more balanced picture in terms of female employee ratios, ranging from 23% to 33%. This situation reveals that gender equality policies are implemented more systematically at the corporate level in Europe, whereas in Turkey, the structure varies from company to company and is fragmented and unstable.

When examining female employee ratios in Figure 8, there are notable differences between renewable energy companies in Turkey and companies in Europe in terms of both scale and gender balance. In Turkey, T1 has kept its female employee ratio within the 8.8–9.7% range for three years, remaining at a very low level. This ratio indicates that female employment in the sector is marginal and that gender imbalance continues at the corporate level. T3 increased its female ratio from 15.4% in 2020 to 24% in 2021 and maintained it at 23.5% in 2022.

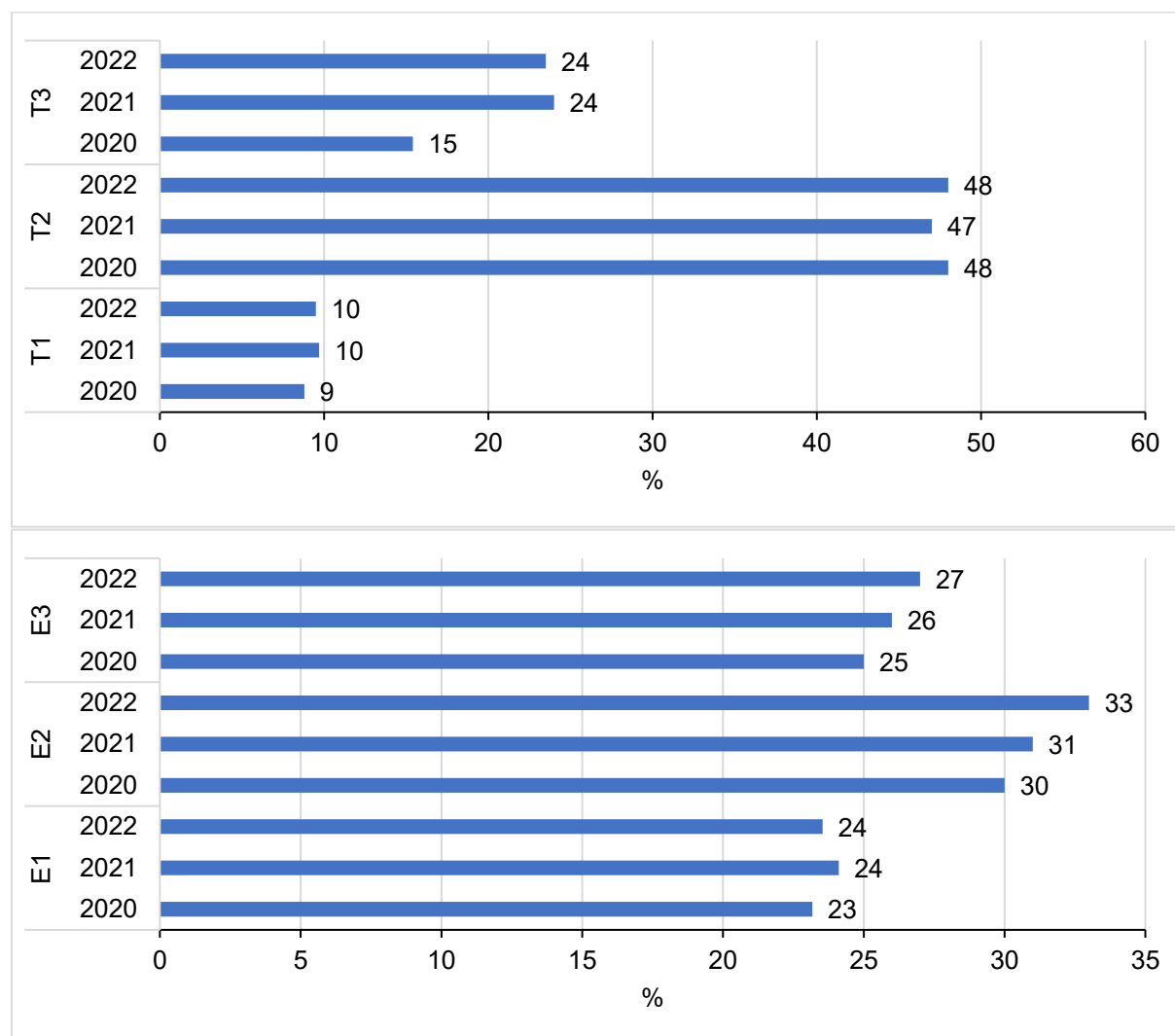
Although these values are higher than Aydem's, they show a fluctuating trend rather than a sustainable increase. In contrast, T2 is the company with the strongest performance in terms of female employment in Turkey. During the 2020–2022 period, the female ratio remained stable at 47–48%, achieving near gender balance. This situation reveals that the employment structure in the solar energy sector may be more inclusive compared to other areas. When companies in Europe are examined, it is seen that female employee ratios are more balanced and based on corporate policies compared to Turkey. E1 maintained female employment at a steady rate of 23–24%, E2 increased female employment from 30% to 33% and performed above the sector average. E3 showed a steady increase, rising from 25% to 27%. These rates in Europe show that companies take gender equality into account in their employment policies and adopt an approach supported by corporate practices at the sector level.

When the Turkey-Europe comparison is evaluated overall, female employment in Turkey shows significant differences between companies. While T2 exhibits an almost equal structure, T1 and T3 remain well below the European average with low rates. Companies in Europe, on the other hand, offer relatively balanced rates in the range of 23–33%; in particular, E2's rise to 33% demonstrates that gender equality policies are yielding results at the corporate level. These findings show that there is a fragmented picture regarding gender equality in Turkish companies, while a more consistent and systematic approach has taken root in European companies. When evaluating training activities within the scope of social indicators, the scale difference becomes even more pronounced. While T1's total training hours were 13,192 in 2022, T2's were 7,311, and T3's were only around 85 hours. In contrast, E1 conducted 2.7 million hours of training in the same year, and E3 conducted approximately 310,000 hours. These figures clearly show that European companies allocate significantly more resources to

employee development, while companies in Turkey are still in the early stages of development in this area.

Figure 8

Female Employee Ratios in Companies



Note. This figure was created by the author using Microsoft Excel. The data were extracted from the companies' sustainability and annual reports covering the period 2020–2022.

Table 3

Companies' Direct Labor Force by Age Groups, Senior Management Structure (persons), Middle Management Structure (persons), Gender Distribution of Employees

Serial	Years	Direct Labor Force by Age Groups			Senior Management Structure (person)		Middle Management Structure (person)	
		18-30	30-40	40+	Female	Male	Female	Male
T1	2020	94	217	256	0	4	8	43
	2021	94	207	236	0	4	7	43
	2022	85	219	252	0	4	7	46

T2	2020	157	235	128	3	4	4	15
	2021	146	235	164	5	12	9	21
	2022	228	283	232	6	11	13	29
T3	2020	3	33	6	0	2	1	0
	2021	7	39	9	0	3	2	0
	2022	12	35	10	0	3	2	1
E1	2020	6377	21860	8728	58	1649	627	10816
	2021	7158	24063	8537	41	1649	676	9816
	2022	7442	25068	8040	58	1647	537	10844
E2	2020	N/A	N/A	N/A	30	115	237	675
	2021	N/A	N/A	N/A	33	131	253	590
	2022	N/A	N/A	N/A	43	146	291	647
E3	2020	1937	6556	3117	405	1235	1773	2934
	2021	2052	7213	2971	451	1376	1983	3281
	2022	2328	7973	2910	484	1220	2417	4027

Note. Workforce data by age groups, senior and middle management structures, and gender distribution were compiled from the companies' annual activity reports. Calculations and tabulation were performed by the author using Microsoft Excel.

Table 3 shows that there are differences in terms of scale, diversity and gender representation between renewable energy companies in Turkey and Europe in terms of the distribution of employees by age group and gender balance at management level. In Turkey, T1 concentrated the majority of its employees in the 30–40 and 40+ age groups (a total of 471 people in 2022), while the 18–30 age group remained at a lower level with 85 people. T2 provided more employment opportunities for young workers, employing 228 people in the 18–30 age group in 2022; this ratio reflects the company's growth dynamics and its tendency towards young labour. T3, on the other hand, has a small workforce and increased the number of young employees from only 3 in 2020 to 12 in 2022. Overall, the proportion of young employees in Turkish companies remains limited, with middle-aged and older employees predominating, particularly at Aydem and Galata Wind. In terms of gender balance at management levels, it is evident that there is no equal distribution in Turkish companies. All T1 senior management positions are concentrated among men, with no female managers present. At the middle management level, women are represented by 7–8 individuals, while men dominate with 43–46 individuals. T2 started with 3 women and 4 men in senior management in 2020 and achieved a more balanced gender distribution in 2022 with 6 women and 11 men. In middle management, the number of women rose from 4 in 2020 to 13 in 2022, but with the number of men increasing from 15 to 29, the proportion of women remained low. T3 has a very limited number of managers; between 2020 and 2022, there were no female managers in senior management, while at most 2 female managers served in middle management. This picture shows that women are systematically underrepresented in senior management positions in Turkey. In European companies, however, a more advanced picture emerges in terms of both scale and gender representation. E1 employed 7,442 people aged 18–30 out of a total workforce of 40,550 in 2022, indicating that young employees represent a much higher absolute value compared to companies in Turkey. Female representation in senior management remained stable at between 41 and 58 individuals, while men were concentrated at around 1,647. In middle management, there were 537–676 female employees compared to 9,816–10,844 male managers. Although E2 did not report data on age groups, it increased the number of women in senior management from 30 in 2020 to 43 in 2022, while the number of

men rose from 115 to 146 during the same period. In middle management, the number of women increased from 237 to 291, while the number of men decreased from 675 to 647. This indicates that gender balance is moving towards a relatively more balanced structure. E3 increased the number of young employees from 1,937 to 2,328 between 2020 and 2022, while increasing the number of women in senior management from 405 to 484. At the middle management level, the number of female managers rose from 1,773 to 2,417, while the number of men increased from 2,934 to 4,027. When Turkey and Europe are compared overall, companies in Europe have a more inclusive structure in terms of both employing young workers and the participation of women in management positions. In Turkey, however, the proportion of young workers remains limited, and women are underrepresented in senior management positions. Although it is noteworthy that Smart Solar has moved towards a relatively more balanced structure in terms of the proportion of female managers, the overall picture shows that companies in Europe implement their gender equality policies in a more institutional and systematic manner. When occupational health and safety indicators are examined, the decrease in T1's TRC value from 5.77 in 2020 to 1.6 in 2022 indicates a significant improvement. T2's TRC value rose from 5.16 in 2020 to 18.9 in 2022, indicating an increase in occupational safety risks. T3's accident frequency remained close to zero. In European companies, TRC values are generally in the range of 1–3, with E1 reported at 1.02, E2 at 3.1, and E3 at 1.13. This indicates that European companies have standardised practices in the field of occupational safety.

Table 4

Companies' Recorded Accident Frequency, Lost Time Accident Frequency, Employee Turnover Rate (%) Values

Serial	Years	TRC	LTIF	Turnover Rate (%)
T1	2020	5.77	0.82	4.03
	2021	3.36	0.84	3.53
	2022	1.6	0	5.2
T2	2020	5.16	0.63	29.4
	2021	17.31	0.92	38.16
	2022	18.89	0.63	24.05
T3	2020	0	0	7
	2021	0	0	10
	2022	0	0	15
E1	2020	1.20	0.06	7.53
	2021	1.06	0.06	8.86
	2022	1.02	0.07	12.39
E2	2020	3.60	1.70	8.40
	2021	3.00	1.30	10.60
	2022	3.1	1.60	11.70
E3	2020	1.04	2.07	11.47
	2021	1.4	2.09	13.00
	2022	1.13	2.18	11.80

Note. Occupational health and safety indicators and employee turnover rates were derived from the companies' official sustainability and activity reports for the 2020–2022 period. The author used Microsoft Excel for data processing and rate calculations.

The differences in occupational health, safety and worker mobility in Turkey and Europe are shown in Table 4. The European examples (E1, E2, E3) generally show that accident frequencies remain at low levels. In particular, lost-time accident frequencies ranged from 0.06 to 2.18 during the 2020–2022 period, indicating that the minimum risk in terms of lost working days has been maintained. However, employee turnover rates in European companies ranged from 7–12 per cent in 2020, reaching around 11–12 per cent in 2022 with a slight increase, and remained stable in some examples. This indicates that employee loyalty is relatively high in the European labour market and that occupational safety is managed effectively. The Turkish examples (T1, T2, T3) present a more volatile and high-risk picture. The accident frequencies recorded in the T1 and T2 groups were 5.16–5.77 in 2020, while in 2022, a significant decrease (1.6) was observed in the T1 group, and a serious increase to 18.89 was observed in the T2 group. This situation indicates that occupational health and safety practices in some sectors in Turkey are irregular or inadequate. Furthermore, employee turnover rates ranged from 24 to 38 per cent in the T2 group, while in the T3 group, they rose steadily from 7 per cent in 2020 to 15 per cent in 2022. These high turnover rates suggest that employee loyalty and motivation in

Turkish workplaces are lower than in Europe. Generally speaking, while social indicators in European companies paint a more positive picture in terms of both occupational safety and employee stability, serious fluctuations are observed in accident risks and employee turnover rates in Turkey, pointing to a need for improvement in occupational health and human resources management practices. A comparison between Europe and Turkey clearly shows that Turkey has higher risks and greater variability in terms of social indicators.

Composite ESG Performance and Regional Comparative Analysis

Environmental (E), social (S), financial (F), and composite ESG scores calculated for the 2020–2022 period are presented and analyzed comparatively at the regional level. The values in Table 5 were obtained as a result of a three-stage pre-processing and aggregation process. Environmental indicators (carbon, water, and waste) were converted to intensity metrics to reduce bias stemming from firm scale. The relevant load indicators were scale-corrected by dividing them by total energy consumption. Cost-type variables (carbon intensity, water intensity, waste intensity, and TRC) were transformed using the inverse form of min–max normalization; benefit-type indicators (female employee ratio and financial growth rates) were normalized to the 0–1 range using the standard min–max method.

The sub-indices were constructed using the equally weighted arithmetic mean method. The environmental sub-index was calculated as the average of three intensity indicators; the social sub-index as the average of the female ratio and TRC; and the financial sub-index as the average of net sales revenue growth and capital expenditure growth. The composite ESG score was defined as the equally weighted average of the three sub-dimensions. Since the financial growth rate could not be calculated in 2020, the financial sub-index was taken as a neutral value (0.500) to ensure methodological consistency. This approach prevents the base year from artificially inflating or lowering the composite score.

Table 5

Environmental, Social, Financial and Composite ESG Scores

Serial	Years	E	S	F	ESG
T1	2020	0.565	0.000	0.500	0.355
	2021	0.609	0.403	0.500	0.504
	2022	0.290	0.458	0.424	0.390
T2	2020	0.667	0.553	0.500	0.573
	2021	0.391	0.500	0.404	0.431
	2022	0.649	0.500	0.728	0.626
T3	2020	0.666	0.584	0.500	0.583
	2021	0.651	0.692	0.500	0.614
	2022	0.567	0.682	0.514	0.588
E1	2020	0.949	0.579	0.500	0.676
	2021	1.000	0.663	0.215	0.626
	2022	1.000	0.655	0.029	0.561
E2	2020	0.897	0.458	0.500	0.618

	2021	0.970	0.699	0.467	0.712
	2022	0.944	0.723	0.080	0.583
E3	2020	0.753	0.617	0.500	0.623
	2021	0.845	0.678	0.069	0.531
	2022	0.862	0.697	0.030	0.530

Note. Environmental, social, and financial sub-indices were constructed by the author using min–max normalization and equal-weighted aggregation. The composite ESG score is the arithmetic mean of the three sub-dimensions. The "G" in ESG stands for Financial Governance, which is functionalized through net sales revenue growth and capital expenditure growth as indicators of financial decision-making efficiency and resource allocation ability. All calculations were performed in Microsoft Excel based on raw data from the companies' 2020–2022 integrated reports.

Table 5 presents the normalized Environmental (E), Social (S), Financial (F), and composite ESG scores at the firm-year level. The average environmental sub-index for European-based firms is approximately 0.91, while the average for Turkish firms is approximately 0.56. This difference of approximately 0.35 points indicates that intensity-based environmental performance is more institutionalized and stable in European firms. In the social dimension, European firms also exhibit a more balanced distribution (average 0.64), while Turkish firms show a more wide-band and fluctuating structure (average 0.49). In contrast, the average financial sub-index for the Turkish group (0.51) is higher than that of the European group (0.27). This situation is particularly related to the decline observed in the financial sub-index for European firms in 2021 and 2022.

Considering the composite ESG scores, the average for the European group is approximately 0.61, while that of the Turkish group is approximately 0.52. Therefore, the overall difference is approximately 0.09 points. However, a remarkable convergence is observed when examining the trend over time. While the Europe-Turkey difference was approximately 0.13 points in 2020, this difference decreased to approximately 0.02 points in 2022. The improvement of Turkish firms, especially in social and financial dimensions, supports this convergence process.

When examining the impact of sub-dimensions on composite ESG, it is observed that environmental and social dimensions carry the ESG score more strongly at the overall sample level. In the European group, due to the high and relatively saturated environmental scores, fluctuations in the financial dimension during the 2021–2022 period negatively affected composite ESG. In the Turkish group, ESG performance is more affected by changes in environmental and social dimensions. This result shows that sustainability performance exhibits a multi-dimensional structure that is sensitive to the regional context, rather than a one-dimensional one.

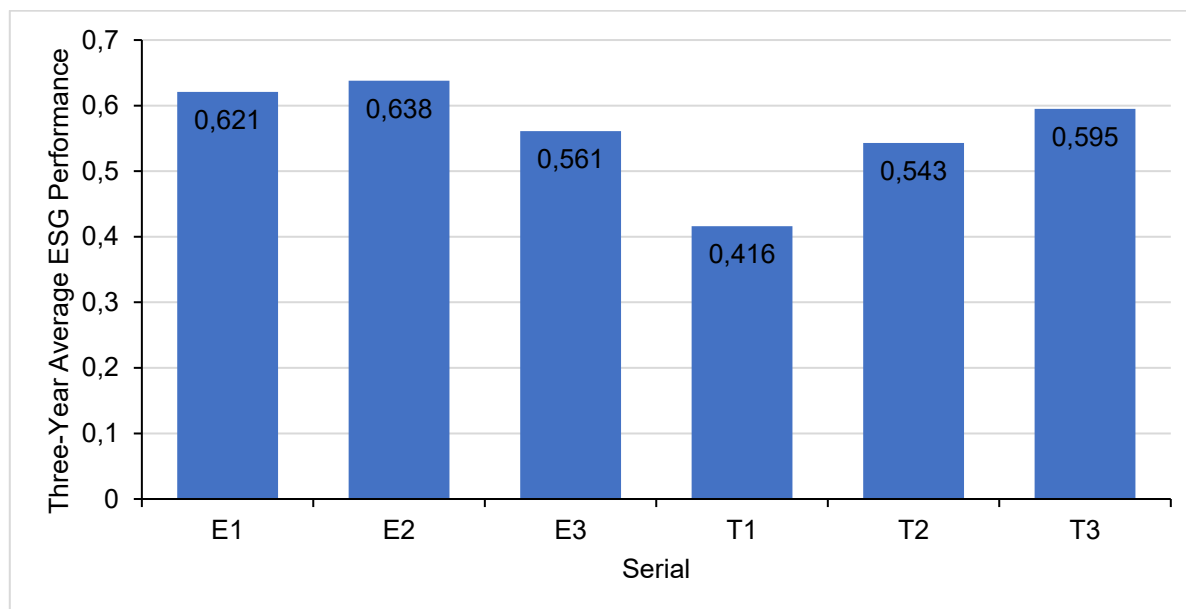
Intra-firm volatility analysis reveals that volatility is relatively higher in the Turkish group. While Turkish firms show wider range of movement in their three-year ESG scores, European firms appear to have more stable environmental and social scores. The volatility observed in the European group stems primarily from financial factors.

The robustness of the findings was evaluated within the framework of methodological assumptions. While min-max normalization is a method sensitive to outliers, calculating the three-year average reduces the impact of periodic jumps. The equal weighting assumption

eliminates the problem of subjective weighting, but it is acknowledged that the contributions of sub-dimensions may change in different weighting scenarios. Nevertheless, European dominance in the environmental and social dimensions and the convergence trend observed as of 2022 are findings that are expected to be structurally preserved in different weighting approaches. The average ESG scores over three years are presented in Figure 9.

Figure 9

Comparative Three-Year Average ESG Performance



Note. This figure was created by the author using Microsoft Excel. The data were extracted from the companies' sustainability reports covering the period 2020–2022.

Figure 9 reveals a filtered long-term performance view of short-term fluctuations. Examining the average values, European firms are seen to have a higher and more stable ESG performance. However, the improving trend shown by Turkish firms as of 2022 indicates a potential for gradual convergence in sustainability integration. The three-year average approach reveals the structural sustainability position of firms more clearly by mitigating the impact of investment cycle-related financial volatilities and periodic environmental spikes.

Discussion

This study compares the environmental and social performance indicators of renewable energy companies in Turkey (T1–T3) and Europe (E1–E3). It reveals that European firms have higher absolute Scope 1–3 emission levels, a difference largely attributed to variations in operational scale and production capacity. The literature emphasizes that ESG performance is closely related to firm size and operational scale (Alareeni & Hamdan, 2020; Gillan et al., 2021), after a comprehensive review of the ESG and corporate social responsibility literature, demonstrate that firm size and corporate maturity play a decisive role in ESG practices (Khan et al., 2016). The high absolute emission levels observed in European firms reflect scale differences rather than poor performance, and comparisons made using normalized indicators yield more meaningful results. The data used in this study is obtained from reports that companies have publicly disclosed. Differences in reporting standards in developing countries bring about problems such as scope inconsistencies and the risk of greenwashing. The 2,000% jump in Scope 3 emissions by T1 and T2's failure to report its 2020 data are concrete examples

of this. Voluntary disclosure regimes limit the reliability of comparative analyses. Although the normalization and multi-year averaging methods applied in this study reduce the impact of these deviations, independent auditing of the data will increase reliability.

According to the findings, differences were identified in Scope 3 emission reporting. The incomplete or limited reporting of some Scope 3 data in Turkish companies makes comparability difficult. This is consistent with the literature showing that voluntary disclosure regimes in ESG reporting can lead to heterogeneous results. It is stated that ESG statements are shaped by institutional structure, regulatory pressure, and investor demand (Christensen et al., 2021; Gillan et al., 2021). The more institutionalized sustainability framework in Europe encourages more comprehensive reporting, including Scope 3. Therefore, the data gaps observed in our study are not a methodological weakness, but a natural consequence of differences in reporting practices between countries. A more balanced gender distribution and organizational diversity have been observed in European firms in terms of social indicators and governance structure (Birindelli et al., 2018), who examined the effect of board composition on ESG performance, showed that the structure and activity intensity of the board are significantly related to ESG performance (Manita et al., 2018). The more institutionalized governance structure observed in European firms can be attributed to the more systematic integration of sustainability performance. The difference in management diversity between groups T and E in our study supports the governance-ESG link emphasized in the literature.

One of the study's notable findings is that European firms are reporting their social and governance indicators in a more holistic manner. This aligns with the literature showing that ESG is not only an area of environmental performance but also closely related to corporate strategy and risk management (Gillan et al., 2021; Krueger et al., 2020). It is emphasized that ESG practices have now become central to the corporate finance literature and are becoming decisive in investor decision-making processes (Boubaker et al., 2022; Broadstock et al., 2021). The comprehensive reporting approach of European firms is relevant not only to regulatory requirements but also to capital market expectations.

This study parallels the literature showing that ESG performance is related to firm resilience during crisis periods (Broadstock et al., 2021; Albuquerque et al., 2020), found that firms with high ESG performance were more resilient to the COVID-19 market shock. In this context, the more holistic ESG integration observed in European firms can be considered an indicator not only of reporting practices but also of corporate resilience potential.

In conclusion, the findings of this study reveal certain structural differences in environmental and social performance between Turkish and European renewable energy companies. However, a significant portion of these differences stem from scale, regulatory framework, and level of corporate maturity (Christensen et al., 2021; Gillan et al., 2021). When considered alongside the literature, our study does not claim statistical generalization but provides a structured comparative analysis explaining how country-based ESG performance differences manifest at the indicator level.

Conclusion

This study presents a comparative case study based on financial governance, environmental, and social indicators between renewable energy companies operating in Türkiye (Aydem, Smart Solar, and Galata Wind) and leading European companies (Iberdrola, Ørsted, and EDP Renováveis) for the period 2020-2022. The findings show differences between the two regions regarding the scale, reporting standards and corporate maturity. In terms of

financial governance, European companies have higher net sales revenues, investment volumes and installed capacities than Turkish companies. Therefore, the European companies possess economies of scale in the global energy market. In 2022, Iberdrola generated revenues of €53.9 billion and had an installed capacity of 60,761 MW, whereas Aydem's revenues in 2022 stood at TL 3.8 billion with a capacity of 1,020 MW. These results are consistent with previous research showing that large, well-established firms in the renewable energy industry tend to have stronger financial capabilities and more advanced sustainability management systems. The impressive growth that Turkish companies showed in the years 2020-2022 is remarkable. The sixfold increase in revenue of Galata Wind in 3 years, Smart Solar's gender balance approach in female employment and the nineteenfold increase in Aydem's investment volume prove that Turkey is in a dynamic development process although the scale is limited in the renewable energy sector. Emerging renewable energy markets are making big strides toward sustainability with constant investment and capacity growth. Sustainability performance should be evaluated in terms of the level of current performance and the processes by which firms integrate sustainability with long-term corporate development.

Environmental indicators also highlight structural differences in the two regions. European companies, despite very high levels of absolute energy consumption, waste generation and emissions, display a more stable and systematic performance when observing normalized intensity indicators. Ørsted's reduction in Scope 3 emissions from 25.3 million tons of CO₂ in 2020 to 10.9 million tons in 2022 reflects significant institutional progress in carbon management and supply-chain sustainability practices. Turkish companies have lower absolute emissions, which can be attributed mainly to their smaller scale and technology choices, particularly the emphasis on wind and solar power systems. So lower emissions are not automatically a sign of better environmental performance. Aydem's increase of Scope 3 emissions by over 70,000 tons in 2022 should be viewed as a temporary situation during the investment period, not a structural trend. Aydem's water intensity is significantly higher than European companies (10–25 m³/MWh) with its hydroelectric-based production structure (4,300–4,700 m³/MWh) creating a large difference in terms of environmental sustainability. The results show that renewable energy technologies have very different environmental footprints and that sustainability assessments should not be based on aggregated indicators but on technology-specific impacts. It is stressed that intensity-based environmental indicators provide a meaningful basis for comparing companies operating at different scales and under different production conditions.

Regarding social indicators, European businesses have a more institutionalized and balanced framework. While high training hours show great business capacity and human capital growth, the percentage of female workers stays constant at 23–33% at Iberdrola, Ørsted, and EDP Renováveis. These results corroborate earlier research underlining how diversity and workforce development help to guarantee long-term sustainability. Only Smart Solar in Türkiye has reached a comparable balance to Europe—that with roughly 48% women employees; Aydem is still at 9–10% and Galata Wind is in the 18–27% range. Indicators of occupational health and safety also reveal a like divergence. Although the frequency of lost-time accidents in European businesses varied from 0.06 to 2.18 between 2020 and 2022, the rise in the TRC value to 18.9 at Smart Solar points to possible flaws in occupational safety procedures during times of fast organizational growth. Employee turnover rates in Turkish businesses—which range from 15 to 38 percent—suggest less corporate stability than the 7–12% range seen in European businesses. These variations show that the Turkish renewable energy industry still has to be much more socially sustainable. Long-term sustainability success also relies on

environmental accomplishments, good governance systems, human capital growth, and sensible social policies.

Given these results, the study's original contribution is the analysis of sustainability performance not only in terms of absolute values but also inside a multidimensional framework employing normalized intensity indicators (per MW, per MWh, and per employee). The intensity-based transformation and minimum–maximum normalization technique used to remove scale bias has helped to make emerging-market companies structurally similar to those in mature Europe. Hence, it has been feasible to examine comparative performance instead of just absolute size. The suggested structure helps with sustainability evaluations by offering a fair basis for comparison of businesses working under varied organizational sizes and market situations.

The study additionally developed an overall ESG performance index combining sub-dimensions for environmental (E), social (S), and Financial Governance (FG). Using the minimum-maximum technique, these sub-dimensions were normalized then combined with equal weighting. Correlation analysis shows that environmental ($r = 0.688$) and social ($r = 0.656$) factors mostly drive ESG performance; financial ($r = 0.117$) aspects have a comparatively weak correlation. This finding points to a structural higher sensitivity of sustainability performance in the renewable energy industry to social institutionalization and environmental efficiency than to short-term financial development. The claim that financial indicators mostly show short-term corporate dynamics calls for a multidimensional ESG assessment of corporate sustainability.

During the years 2020–2022, regional analysis based on composite ESG ratings reveals that European businesses have a greater average ESG performance (0.607) than Turkish companies (0.518). But over time the ESG gap is narrowing, which suggests a convergence rather than a static structural separation. This demonstrates how Turkish renewable energy businesses are progressively including sustainability policies into their strategic management processes and matching their reporting techniques with worldwide norms. The noted variations point to various levels of sustainability maturity rather than as permanent structural flaws. The narrowing of the ESG gap in 2022 reflects a temporary decline in the financial sub-index of European companies due to macro-shocks; it should not be interpreted as a permanent convergence dynamic. While the findings point to the partial resilience of Turkish firms, they do not offer evidence of a lasting leap in corporate maturity.

Still, the study has some restrictions notwithstanding these contributions. Only six renewable energy businesses are included in the study, which runs just 2020–2022. Furthermore, changes in sustainability reporting standards and data availability could affect the comparability of certain indicators. Future research could increase the sample size, cover more nations' renewable energy companies, and use different weighting techniques for ESG index building. Moreover, looking at the cause-and-effect link between ESG performance and long-term financial performance could offer more thorough understanding of sustainability management in the renewable energy industry.

The results show that although European renewable energy companies now have higher sustainability maturity levels, Turkish companies have shown great improvement across several ESG areas during the study period. Gradual narrowing of the ESG gap points to the great potential of the Turkish renewable energy industry to reach sustainability criteria like those of top European businesses in the next years. These results could help corporate executives and

legislators to create better ESG plans, raise the caliber of sustainability reporting, and strengthen institutional sustainability initiatives inside the renewable energy industry from a practical standpoint.

References

- Alareeni, B. A. & Hamdan, A. (2020). ESG impact on performance of US S\&P 500-listed firms. *Corporate Governance*, 20(7), 1409–1428. <https://doi.org/10.1108/CG-06-2020-0258>
- Albuquerque, R., Koskinen, Y., Yang, S. & Zhang, C. (2020). Resiliency of environmental and social stocks: An analysis of the exogenous COVID-19 market crash. *The Review of Corporate Finance Studies*, 9(3), 593–621. <https://doi.org/10.1093/rcfs/cfaa011>
- Alvarez-Meaza, I., Pikatza-Gorrotxategi, N. & Rio-Belver, R. M. (2020). Sustainable business model based on open innovation: Case study of Iberdrola. *Sustainability*, 12(24), Article 10645. <https://doi.org/10.3390/su122410645>
- Aydem Renewables (2022a). *Annual Reports*. Retrieved May 18, 2026, from https://www.aydemrenewablesinvestorrelations.com.tr/media/activityreports/AYD_FR_AE_2022_1708511207.pdf
- Aydem Renewables (2022b). *Sustainability Report*. Retrieved May 18, 2026, from https://www.aydemyenilenebilir.com.tr/upload/raporlardosya/97/dosya/Aydem-Renewables-Sustainability-Report---2022_compressed.pdf
- Birindelli, G., Dell’Atti, S., Iannuzzi, A. P. & Savioli, M. (2018). Composition and activity of the board of directors: Impact on ESG performance in the banking system. *Sustainability*, 10(12), Article 4699. <https://doi.org/10.3390/su10124699>
- Boubaker, S., Cellier, A. & Manita, R. (2022). Does corporate social responsibility reduce financial distress risk? *Economic Modelling*, 91, 835-851. Article 102143. <https://doi.org/10.1016/j.econmod.2020.05.012>
- Broadstock, D. C., Chan, K., Cheng, L. T. W. & Wang, X. (2021). The role of ESG performance during times of financial crisis: Evidence from COVID-19. *Finance Research Letters*, 38, Article 101716. <https://doi.org/10.1016/j.frl.2020.101716>
- Budak, Y. (2025). Climate law: Necessity or opportunity for Türkiye? *International Journal of Energy Studies*, 10(3), 1229–1258. <https://doi.org/10.58559/ijes.1685452>
- Çalışkan, M. M. T. (2025). Measuring environmental sustainability in the Turkish banking sector: Composite scoring of ESG-e performance (2022-2024). *Erciyes University Journal of the Faculty of Economics and Administrative Sciences*, 72, 185–196. <https://doi.org/10.18070/erciyesiibd.1708220>
- Chen, X., Li, W., Torsin, W. & Tsang, A. (2024). Dividend policy under mandatory ESG reporting. *Journal of International Financial Markets, Institutions and Money*, 93, Article 101986. <https://doi.org/10.1016/j.intfin.2024.101986>
- Christensen, H. B., Hail, L. & Leuz, C. (2021). Mandatory CSR and sustainability reporting: Economic analysis and literature review. *Review of Accounting Studies*, 26(3), 1176–1248. <https://doi.org/10.1007/s11142-021-09609-5>
- Cicchiello, A. F., Marrazza, F. & Perdichizzi, S. (2023). Non-financial disclosure regulation and ESG performance. *Corporate Social Responsibility and Environmental Management*, 30(3), 1121–1128. <https://doi.org/10.1002/csr.2408>
- Crijns-Graus, W., Wild, P., Amineh, M. P., Hu, J. & Yue, H. (2022). International comparison

- of research and investments in new renewable electricity technologies: A focus on the European Union and China. *Energies*, 15(17), Article 6383. <https://doi.org/10.3390/en15176383>
- D'Adamo, I., Di Leo, S., Gastaldi, M. & Paris, A. (2025). Evaluating sustainability in Europe with composite indicators. *Discover Sustainability*, 6(1), Article 1251. <https://doi.org/10.1007/s43621-025-02129-1>
- Dathe, T., Helmold, M., Dathe, R., & Dathe, I. (2024). ESG reporting rules. In *Implementing environmental, social and governance (ESG) principles for sustainable businesses* (pp. 147–158). Springer. https://doi.org/10.1007/978-3-031-52734-0_11
- Desogus, E., Bompard, E. & Grosso, D. (2024). A composite index for tracking the evolution towards energy transition at urban scale: The Turin case study. *Energies*, 17(6), Article 1281. <https://doi.org/10.3390/en17061281>
- Drago, C. & Gatto, A. (2022). Policy, regulation effectiveness, and sustainability in the energy sector: A worldwide interval-based composite indicator. *Energy Policy*, 167, Article 112889. <https://doi.org/10.1016/j.enpol.2022.112889>
- Dye, J., McKinnon, M. & der Byl, C. (2021). Green gaps: Firm ESG disclosure and financial institutions' reporting requirements. *Journal of Sustainability Research*, 3(1), Article e210006. <https://doi.org/10.20900/jsr20210006>
- EDP Renováveis, S.A. (2022a). *Annual Report 2022*. Retrieved May 18, 2026, from https://www.edp.com/sites/default/files/document/2025-04/Relat%25C3%25B3rio%2520CGS%25202022_EN.pdf
- EDP Renováveis, S.A. (2022b). *Sustainable Supply Chain Report 2022*. Retrieved May 18, 2026, from https://www.edp.com/sites/default/files/document/2025-04/Sustainable%2520Supply%2520Chain%2520Report%25202022_0.pdf
- Erat, S., Telli, A., Ozkendir, O. M. & Demir, B. (2021). Turkey's energy transition from fossil-based to renewable up to 2030: Milestones, challenges and opportunities. *Clean Technologies and Environmental Policy*, 23(2), 401–412. <https://doi.org/10.1007/s10098-020-01949-1>
- Erdoğan, H., Tutcu, B., Talaş, H., & Terzioğlu, M. (2026). Performance analysis in renewable energy companies: Application of SWARA and WASPAS methods. *Journal of Sustainable Finance & Investment*, 16(1), 188-209. <https://doi.org/10.1080/20430795.2022.2144107>
- European Commission. (2020, November 19). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: An EU strategy to harness the potential of offshore renewable energy for a climate-neutral future* (COM(2020) 741 final). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0741>
- Fetting, C. (2020, December). *The European Green Deal* (ESDN Report). ESDN Office. Retrieved May 18, 2026, from https://www.esdn.eu/fileadmin/ESDN_Reports/ESDN_Report_2_2020.pdf
- França, A., López-Manuel, L., Sartal, A. & Vázquez, X. H. (2023). Adapting corporations to climate change: How decarbonization impacts the business strategy–performance

- nexus. *Business Strategy and the Environment*, 32(8), 5615–5632. <https://doi.org/10.1002/bse.3439>
- Galata Wind Energy (2022a). *Clean energy for a clean future 2022 annual report*. Retrieved May 18, 2026, from <https://www.galatawindenerji.com/files/sayfalar/dosya-en/galata-wind-fr-2022-en-web.pdf>
- Galata Wind Energy (2022b). *Clean energy for a clean future Galata Wind 2022 sustainability report*. Retrieved May 18, 2026, from <https://www.galatawindenerji.com/files/sayfalar/dosya-en/sustainability-reports.pdf>
- Genc, T. S. & Kosempel, S. (2023). Energy transition and the economy: A review article. *Energies*, 16(7), Article 2965. <https://doi.org/10.3390/en16072965>
- Gillan, S. L., Koch, A. & Starks, L. T. (2021). Firms and social responsibility: A review of ESG and CSR research in corporate finance. *Journal of Corporate Finance*, 66, Article 101889. <https://doi.org/10.1016/j.jcorpfin.2021.101889>
- Hartmann, J., Inkpen, A. C. & Ramaswamy, K. (2021). Different shades of green. *Journal of International Business Studies*, 52(5), 879–903. <https://doi.org/10.1057/s41267-020-00326-w>
- Iberdrola, S.A. (2022a). *Annual Report*. Retrieved May 18, 2026, from https://www.iberdrola.com/documents/20125/2931678/gsm23_FinancialStatements_AuditorsReport_Consolidated2022.pdf
- Iberdrola, S.A. (2022b). *Sustainability Report*. Retrieved May 18, 2026, from https://www.iberdrola.com/documents/20125/2931678/gsm23_IA_SustainabilityReport2022.pdf
- Kamali Saraji, M. & Streimikiene, D. (2023). Challenges to the low carbon energy transition: A systematic literature review and research agenda. *Energy Strategy Reviews*, 49, Article 101163. <https://doi.org/10.1016/j.esr.2023.101163>
- Karimi Alavijeh, N., Ahmadi Shadmehri, M. T., Esmaeili, P. & Dehdar, F. (2024). Asymmetric impacts of renewable energy on human development: Exploring the role of carbon emissions, economic growth, and urbanization in European Union countries. *Journal of the Knowledge Economy*, 15(4), 17188–17212. <https://doi.org/10.1007/s13132-024-01811-5>
- Kat, B. (2023). Clean energy transition in the Turkish power sector: A techno-economic analysis with a high-resolution power expansion model. *Utilities Policy*, 82, Article 101538. <https://doi.org/10.1016/j.jup.2023.101538>
- Khan, M. K., Trinh, H. H., Khan, I. U. & Ullah, S. (2022). Sustainable economic activities, climate change, and carbon risk: An international evidence. *Environment, Development and Sustainability*, 24(7), 9642–9664. <https://doi.org/10.1007/s10668-021-01842-x>
- Khan, M., Serafeim, G., & Yoon, A. (2016). Corporate sustainability: First evidence on materiality. *The Accounting Review*, 91(6), 1697–1724. <https://doi.org/10.2308/accr-51383>
- Kozar, Ł. J. & Sulich, A. (2023). Energy sector's green transformation towards sustainable development: A review and future directions. *Sustainability*, 15(15), Article 11628. <https://doi.org/10.3390/su151511628>

- Krueger, P., Sautner, Z. & Starks, L. (2020). The importance of climate risks for institutional investors. *The Review of Financial Studies*, 33(3), 1067–1111. <https://doi.org/10.1093/rfs/hhz137>
- Krueger, P., Sautner, Z., Tang, D. Y. & Zhong, R. (2024). The effects of mandatory ESG disclosure around the world. *Journal of Accounting Research*, 62(5), 1795–1847. <https://doi.org/10.1111/1475-679X.12548>
- Lavin, J. F. & Montecinos-Pearce, A. A. (2021). ESG disclosure in an emerging market: An empirical analysis of the influence of board characteristics and ownership structure. *Sustainability*, 13(19), Article 10498. <https://doi.org/10.3390/su131910498>
- Lu, Z., Gozgor, G., Mahalik, M. K., Padhan, H. & Yan, C. (2022). Welfare gains from international trade and renewable energy demand : Evidence from the OECD countries. *Energy Economics*, 112, Article 106153. <https://doi.org/10.1016/j.eneco.2022.106153>
- Manita, R., Bruna, M. G., Dang, R., & Houanti, L. (2018). Board gender diversity and ESG disclosure: Evidence from the USA. *Journal of Applied Accounting Research*, 19(2), 206–224. <https://doi.org/10.1108/JAAR-01-2017-0024>
- MSCI ESG Research LLC. (2022, June). *MSCI ESG Ratings methodology: Executive summary*. Retrieved May 18, 2026, from https://esg-library.mgimo.ru/upload/iblock/eb0/8amwem7t2szh2380p5kpd3thiao6dx2f/ESG_Ratings_Methodology_Exec_Summary.pdf
- Murugan, S. K., Kumari, P., Baskaran, T. L., Dimen, L. & Nuta, A. C. (2025). Comparative economic impact of green energy investments: Evidence from India, USA, Germany, and Denmark. *Energies*, 18(14), Article 3626. <https://doi.org/10.3390/en18143626>
- Omri, A. & Belaid, F. (2021). Does renewable energy modulate the negative effect of environmental issues on the socio-economic welfare? *Journal of Environmental Management*, 278, Article 111483. <https://doi.org/10.1016/j.jenvman.2020.111483>
- Ørsted, A/S. (2022b). *Annual Report*. Retrieved May 18, 2026, from <https://cdn.orsted.com/-/media/2022-annual-report/orsted-annual-report-2022.pdf>
- Ørsted, A/S. (2022a). *Green energy to power lasting positive impact: Ørsted sustainability report 2022*. Retrieved May 18, 2026, from <https://cdn.orsted.com/-/media/2022-annual-report/orsted-sustainability-report-2022.pdf>
- Qachach, A. R., El Mahrar, B., Kharbouch, O., Moumen, A., El Aoufi, S., El Gueddari, M. & Abdallah-Ou-Moussa, S. (2025). Bridging the ESG data gap: Transparent metrics and rankings for emerging financial markets. *International Journal of Financial Studies*, 13(4), Article 198. <https://doi.org/10.3390/ijfs13040198>
- Romanello, M., Di Napoli, C., Drummond, P., Green, C., Kennard, H., Lampard, P., Scamman, D., et al. (2022). The 2022 report of the Lancet Countdown on health and climate change: Health at the mercy of fossil fuels. *The Lancet*, 400(10363), 1619–1654. [https://doi.org/10.1016/S0140-6736\(22\)01540-9](https://doi.org/10.1016/S0140-6736(22)01540-9)
- Smart Solar Technologies (2022a). *The century of the sun is beginning: Annual report 2022*. Retrieved May 18, 2026, from <https://smartsolar.com.tr/images/2022-Annual-Report.pdf>
- Smart Solar Technologies (2022b). *2022 Sustainability Report*. Retrieved May 18, 2026, from

<https://smartsolar.com.tr/pdf/Sustainability-Report-Interactive.pdf>

- Sogukpinar, H., Bozkurt, I., Oyucu, S. & Aksoz, A. (2025). Unveiling the wind energy future of Türkiye with policies technologies and potential. *Heliyon*, 11(4), Article e42592. <https://doi.org/10.1016/j.heliyon.2025.e42592>
- Stepanov, I. A., & Makarov, I. A. (2024). Greenhouse gas emissions regulation in fossil fuels exporting countries: Opportunities and challenges for Russia. In A. Obydenkova (Ed.), *Strategies and challenges of sustainable development in Eurasia* (pp. 82–109). Routledge.
- Türkiye Elektrik İletim A.Ş. (2022). *Aralık 2022 kurulu güç raporu*. Retrieved May 18, 2026, from <https://www.teias.gov.tr/kurulu-guc-raporlari>
- Thomas, M. (2025). Ørsted’s strategic transformation and renewable energy revolution: The art of timing, kairos and speed in change management. *Strategic HR Review*, 25 (1): 17–22. <https://doi.org/10.1108/SHR-07-2025-0069>
- Yeh, Y. H. & Liao, C. C. (2026). Does ESG performance mitigate ESG-negative events? Examining the insurance-like vs. greenwashing effect. *Energy Economics*, 155, Article 109163. <https://doi.org/10.1016/j.eneco.2026.109163>

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