BALKAN JOURNAL OF ELECTRICAL & COMPUTER ENGINEERING, Vol. 13, No. 3, September 2025
Research Article

Renewable Energy Transition in Türkiye: The Impact of Solar and Wind Based Capacity Growth on Market Prices and Cost Dynamics

Tamer Emre

***Abstract*— This study investigates the impact of solar and wind-based energy capacity expansion on electricity market prices and cost structures in Türkiye from 2020 to 2024. The rapid integration of renewable energy resources has significantly transformed Türkiye's electricity market, a key example due to the country's ambitious renewable energy goals. Using high-frequency data from the Turkish Electricity Market (EPİAŞ) and applying econometric methods such as time-series analysis and regression techniques, we demonstrate that the substantial growth in renewable energy capacity has resulted in a pronounced "duck curve" effect. This has led to significant midday price reductions, with solar based energy generation increasing over tenfold, contributing to a 20% drop in midday prices. Wind energy, though variable, also contributed to lower marginal prices during periods of high generation. Despite these benefits, the intermittency of renewable resources remains a challenge, highlighting the continued need for conventional energy resources such as imported coal and natural gas for grid stability. Market interventions, including price caps and renewable energy support mechanisms (YEKDEM), have mitigated extreme price volatility. However, they emphasize the need for improved grid flexibility, energy storage solutions, and more accurate forecasting. This study provides empirical evidence of the duck curve effect in Türkiye's electricity market, offering policy recommendations for optimizing renewable energy integration, enhancing forecasting precision, and reducing system costs. Our findings emphasize the dual role of renewables in driving price reductions while posing challenges for grid management, underscoring the importance of innovative market mechanisms and technological advancements for a sustainable energy transition.**

Index Terms—**Duck-curve, marginal price calculation PTF, renewable energy, solar capacity, Turkish energy market, wind capacity.**

I. Introduction

ENERGY SYSTEMS are one of the fundamental pillars of modern societies, playing a critical role in economic growth and sustainable development (UN, 2025). The increasing global demand for energy, combined with the limited reserves of fossil fuels and their environmental impacts, has heightened the interest in renewable energy resources for power generation (IEA, 2024). Among renewable energy resources, solar and wind-based power have gained prominence in recent years due to reduced costs and efficiency improvements driven by technological advancements (EMBER, 2024). This transformation is seen as a key strategy for ensuring energy security, reducing environmental impacts, and enhancing energy independence (MENR, 2017).

Türkiye, with its strategic location bridging Europe and Asia, is increasingly impacted by the global shift towards renewable energy due to its rising energy demands fueled by industrialization, urbanization, and population growth. These dynamics have not only escalated energy consumption but have also necessitated the adoption of sustainable energy generation strategies. In response, Türkiye's energy policies have prominently featured renewable energy investments aimed at enhancing energy security and minimizing external dependencies. The comparative lower operational costs and environmental advantages of solar and wind-based energy over traditional fossil fuel-based power plants have further propelled the adoption of these renewable resources.

With a population exceeding 80 million and a rapidly evolving socio-economic and technological landscape, Türkiye stands out in the energy economy due to its geopolitical position at the heart of regional energy resources. Despite the reflection of cultural norms and daily life practices in electricity consumption habits, longitudinal comparisons offer insights into the direction of these changing patterns. The renewable energy transition, which has been gaining momentum since the early 2000s when natural gas was the predominant price-setting resource, has significantly altered the dynamics of electricity markets designed during that era. Although non-market interventions were thought to prevent market disruptions during crises, such approaches proved insufficient during the energy crisis that began in 2021 and waned by 2023. During this turbulent period, Türkiye implemented unique measures such as price caps and reasonable profit methods to stabilize energy prices, despite rising costs. Situated in a geography prone to nearly all types of natural disasters, Türkiye, much like its resilient population, has rapidly adapted to challenging conditions. In these adaptive processes, it remains an open question whether the increased share of renewable energy has led to lower energy costs and whether the current market mechanisms support a more affordable and sustainable energy policy.

Tamer Emre, is the Director of Strategic Planning & Corporate Governance of Akenerji Elektrik Üretim A.Ş. Miralay Şefik Bey Sk., Akhan, No:15, Kat:4, 34437, Gümüşssuyu / Beyoğlu / İstanbul / Türkiye,(e-mail: tamer.emre@akenerji.com.tr), IEEE Senior Member
https://orcid.org/0000-0001-9354-8128

Manuscript received Jan 09, 2025; accepted Jul 12, 2025.
DOI: 10.17694/bajece.1636476

Studies on countries like Germany and the Netherlands indicate that while renewables lower market prices, they can also contribute to price volatility (Liebensteiner, 2025) (Wang, 2022). In Türkiye, the transition to renewable energy has been particularly impactful due to the country's strategic location and rising energy needs. Industrialization, urbanization, and population growth have continuously increased energy demand, necessitating the development of sustainable solutions.

This study hypothesizes that increasing wind and solar based energy capacities in Türkiye have significantly influenced electricity market prices by reducing peak-hour costs, creating a duck-curve effect, and introducing market volatility that requires further regulatory adjustments.

Türkiye's energy policies aim to ensure energy security and reduce dependence on imports by fostering renewable energy investments. Compared to conventional fossil-fuel power plants, solar and wind-based energy offer lower operational costs and environmental benefits, making them a preferred choice for expansion.

II. Renewable Energy Development in Türkiye

A. *The Role of Renewable Energy in Market Transition*

The integration of renewable energy resources plays a vital role in the transition to a low-carbon economy. Solar and wind-based energy contribute to reducing carbon emissions and lowering long-term energy costs. However, studies suggest that while renewables enhance sustainability, they can lead to increased price fluctuations in electricity markets (Pollitt.M., 2024). Similar trends are observed in Türkiye, where improving energy storage technologies and demand-side management mechanisms are crucial for mitigating such effects. Figure 1 illustrates the trends in installed energy capacities for solar based, wind based, thermal, and hydroelectric energy resources in Türkiye between 2020 and 2024, along with the average energy prices. The figure reveals a consistent upward trajectory in renewable energy capacities, particularly for solar and wind-based energy, underscoring the country's transition towards sustainable energy generation. The Market Clearing Price (MCP), which is PTF in Türkiye, depicted by the green line, shows a continuous decline after 2022, largely due to the tenfold increase in energy generation driven by the Global Energy Crisis. This reduction in prices can be attributed to the growing share of cost-efficient renewable energy resources in the energy mix. The figure offers valuable insights into the dynamic relationship between energy diversification and its economic implications over the observed period.

Türkiye has taken significant steps to diversify its energy portfolio through regulations and support mechanisms that promote the use of renewable energy resources. Particularly since the mid-2010s, initiatives such as the Renewable Energy Resources Support Scheme (YEKDEM) have accelerated investments in solar and wind-based energy. Technological advancements in efficiency and cost reductions have further enhanced the scalability of these resources, contributing to an increasing share of renewables in the country's energy generation. Large-scale tenders for Renewable Energy Resource Areas (YEKA), which are pre-permitted and auctioned, have been recognized as best practice examples globally. The Konya Karapınar 1 GW Solar based Power Plant, one of the largest solar based fields in Europe, is a prime example of this approach.

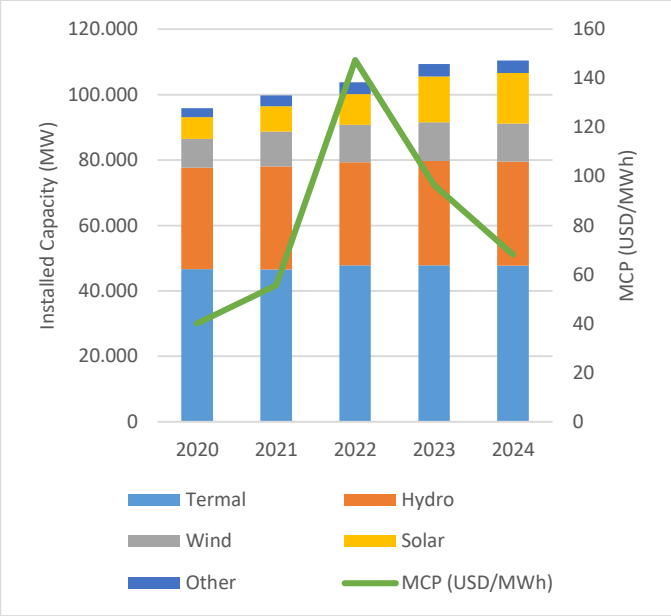

Fig.1. Trends in installed energy capacity and Market Clearing Prices (MCP) in Türkiye (2020–2024) (EMRA, 2020) (EMRA, 2021) (EMRA, 2022) (EMRA, 2023) (EMRA, 2024) (EXIST, 2025)

Figure 2 illustrates the growth trends of solar and wind-based energy from renewable resources in Türkiye. Notably, solar based energy experienced a rapid increase, particularly after 2020, while wind energy demonstrated a steady and continuous upward trajectory. According to the National Energy Plan of Türkiye, the targets for 2035 include 50 GW of wind energy capacity and 70 GW of solar based energy capacity (MENR, 2024).

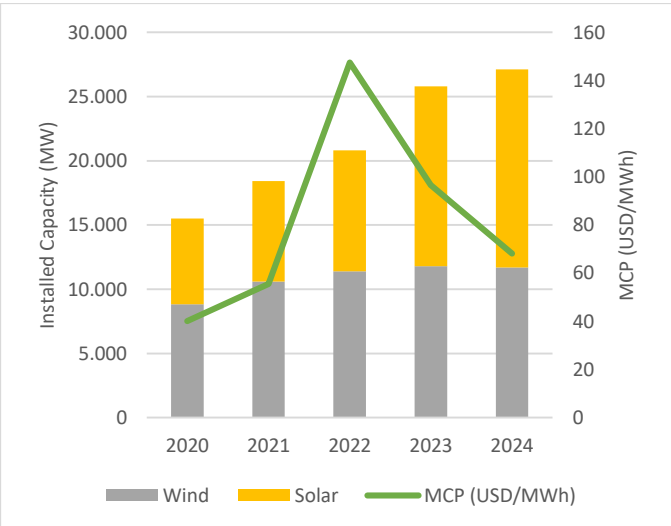

Fig.2. Change in renewable energy capacity in Türkiye

B. Technological Advancements in Solar and Wind based Energy

The last decade has witnessed remarkable advancements in solar based photovoltaics and wind turbine technologies. Lower costs and improved efficiencies have driven increased investments. However, renewables are subject to the cannibalization effect, where increased generation from solar and wind resources reduces wholesale electricity prices and subsequently diminishes their own profitability (Lopez Prol, 2020).

Similarly, wind energy technologies have seen increased generation capacity due to advancements in turbine design, the use of larger rotor diameters, and improvements in weather forecasting models. Wind energy, particularly during nighttime hours, contributes to electricity generation, offering the potential to enhance supply security through the establishment of hybrid energy systems when combined with solar based power. However, wind energy generation remains subject to seasonal variability and short-term weather conditions.

C. Impact on Market Prices and Policy Implications

Electricity market dynamics are significantly influenced by supply-demand balance. The expansion of renewables has led to lower electricity prices at certain hours while creating price instability. Studies show that solar and wind-based energy lower day-ahead market prices but can introduce imbalances in the system (Chava, 2024).

Furthermore, the integration of renewable energy resources into energy markets requires the development of various market mechanisms to ensure security of supply and price stability. The intermittent nature of renewable energy generation can increase system balancing costs and pose challenges to energy security. Therefore, the development of mechanisms such as energy storage solutions, smart grid systems, and demand-side management is critical to successfully implementing the renewable energy transition.

Since Türkiye's 2035 Road Map Plan has been announced as 120 GW - renewable energy capacity from wind and solar resources, to achieve this target, a variety of policies and strategies have been developed. Incentives for renewable energy investments, market regulations, and the promotion of private sector participation in renewable energy projects have contributed to the accelerated growth of this sector. However, in order to ensure the sustainability of the energy transition, further regulatory frameworks are needed to improve the effectiveness of market mechanisms. In particular, the integration of energy storage systems, the strengthening of grid infrastructure, and the development of renewable energy forecasting algorithms will allow Türkiye to more efficiently harness its renewable energy potential. Additionally, in line with the goals of reducing carbon emissions and decreasing dependence on fossil fuels, more innovative solutions in the energy sector need to be implemented.

III. Data Collection and Mathematical Framework

In this study, various data resources were utilized to examine the impact of the increase in renewable energy capacity on electricity prices in Türkiye. The data were obtained from official institutions such as TEİAŞ, EPİAŞ, EPDK, and TÜİK, and were supplemented with reports from international energy agencies and market analyses. Time series analysis, regression models, and optimization techniques were employed to assess the effects of solar and wind-based energy on market prices. As a result of these analyses, it was found that the increase in solar and wind-based energy generation between 2020 and 2024 in Türkiye led to a decrease in electricity prices, and the duck curve effect became more pronounced. Furthermore, it was concluded that new regulations are required to support the integration of renewable energy into market mechanisms.

The data obtained from the EPIAŞ Transparency Platform (2020, 2021, 2022, 2023, and 2024 data) were considered to represent a five-year period that accurately reflects the dynamics of the market. It was evaluated that a longer period would have a higher likelihood of containing misleading effects.

Various data cleaning and processing techniques were employed to ensure the reliability of the obtained data and their suitability for analysis:

Cleaning of Missing and Erroneous Data: Linear interpolation and average values from previous years were used for missing data. Erroneous or outlier values were identified using the IQR (Interquartile Range) method and excluded from the dataset.

Data Merging and Visualization: Data from different resources were merged on a common time scale. The data were processed and figures were created using Python (Pandas, NumPy) and MATLAB for time series analysis.

A. Methodology

Among the data used, consumption data, which is the primary driver of the price formation mechanism, was first analyzed. Hourly generation data for each resource-based power plant was also examined. In the price formation mechanism, data for independent purchases and independent sales quantities, as well as the curve gap between these two sets of data, were utilized.

$$\text{Curve gap} = \text{price independent sales} - \text{price independent purchases} \quad (1)$$

The curve gap is a fundamental component of the supply-demand curve, and an increase in this gap leads to a rise in prices. The increase in the share of independent sales (PIS) for power plants benefiting from renewable energy support mechanisms enables the curve to intersect at a lower price. This relationship can be observed through regression analysis. Using the established optimization model, it is possible to obtain the necessary parameters for the desired target. It is also known that national investment plans are based on the results of such analyses.

In markets where the theoretical maximum price is infinite, the actual value is derived by multiplying or approaching the theoretical maximum price in markets with price caps. This

ratio is referred to as the "saturation index." The correlation between the saturation index and the wind capacity generation curve will reveal the effect of this resource type on prices. Such an analysis, as applied in Türkiye's electricity market, cannot be implemented in European markets. Following the 2021 energy crisis, measures were introduced to set a new price cap once the saturation index reaches 70% of the theoretical maximum (which was 60% in previous version) (ACER, 2023).

$$\text{Saturation index} = \text{hourly marginal price (MCP)} / \text{theoretical maximum price} \quad (2)$$

To observe the effect of solar based capacity on prices, the correlation between generation levels and prices must be examined. To identify the structure and sensitivity of the duck curve in pricing, the maximum solar based generation and illumination values at noon (12:00 PM) were utilized. Even if the generation at this time does not meet the demand, the midday consumption pattern still generates a curve, providing a baseline price relative to the average price for this consumption. The downward trends of this baseline value with annual generation and a corresponding index reveal the duck-curve structure in the price curve.

B. *Mathematical Background*

In this study, various mathematical and statistical methods have been utilized to examine capacity increases, price changes, and market dynamics:

1) Time Series Analysis

The ARIMA (AutoRegressive Integrated Moving Average) model has been employed to investigate the temporal fluctuations in electricity prices and generation volumes. The Fourier transform has been applied to analyze the hourly variations in solar and wind-based energy generation.

A multiple regression analysis has been conducted to measure the impact of capacity increases in solar and wind-based energy on prices. Independent variables include solar and wind-based capacity (in megawatts, MW), and the prices of imported coal and natural gas (in USD per MWh). The dependent variable is the PTF (Market Clearing Price, in Turkish Lira per MWh). Regression model:

$$PTF=\beta0+\beta1\times SolarMW+\beta2\times WindMW+\beta3\times CoalUSD/MWh+\beta4\times GasUSD/MWh+\epsilon \quad (3)$$

2) Duck-Curve and Daily Price Change Model

Kernel Density Estimation (KDE) has been utilized to model the price drops caused by high solar based generation during midday hours. To demonstrate the duck-curve effect, the relationship between solar based energy generation at noon and market prices has been analyzed.

3) Optimization Models

Linear programming has been applied to analyze the impact of renewable energy generation on base-load power plants. The objective function is to minimize the total system costs. Constraints include demand-response limits, generation capacity limits, and emission restrictions.

These mathematical approaches allow for an assessment of the impact of renewable energy resources on the system from both economic and technical perspectives.

4) Limitations

This study utilized data from EPIAŞ, which lacks region-specific granularity. The methodology for calculating market prices in Türkiye aligns with the common optimization equation used in Europe, yet it retains unique characteristics. In this research, specifics concerning the optimization calculations were not examined, and interpretations were solely based on the observed outcomes. Therefore, results from different countries have been reviewed in the literature, but the analyses have focused on Türkiye.

IV. ANALYSIS

When examining the data from the Turkish electricity market, it cannot be said that consumption has continuously increased during the period between 2020 and 2025. According to Figure-3, the significant rise in consumption observed in 2023 is primarily due to the earthquake on February 6, 2023, which nearly erased three provinces from the map. Consumption, which had been showing a cautious increase until 2023, is notably above the normal trend in 2024. This can be attributed to a significantly higher air conditioning load during an unusually hot summer period and the increased use of devices in the advancing technological world contributing to this rise in consumption.

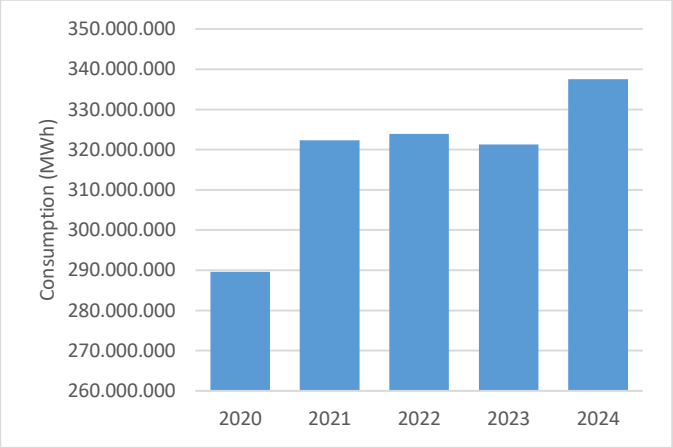

Fig.3. Change in consumption for 5 years period (EPİAŞ Data)

In recent years, heightened awareness of climate change has prompted a strategic shift from traditional portfolio balancing to a focus on diversifying energy resources through a green transformation agenda, prioritizing renewable energy resources. This shift is particularly evident in the increased investments in wind and solar based energy sectors, driven by technological advancements and declining costs. Figure 4 and 5 depict the evolution of energy generation between 2020 and 2025, incorporating the impact of additional capacity introduced during this period.

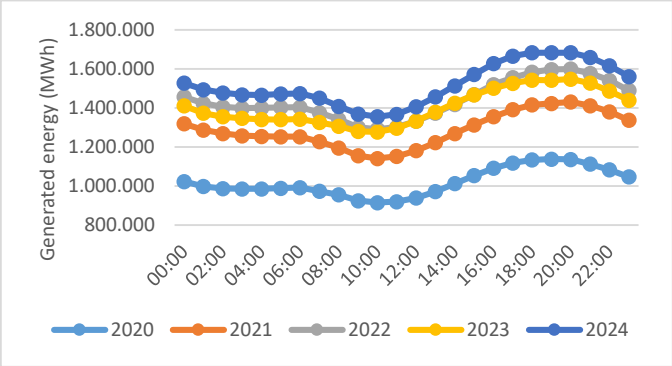

Fig.4. Annual generation volumes of wind power plants (EPİAŞ data)

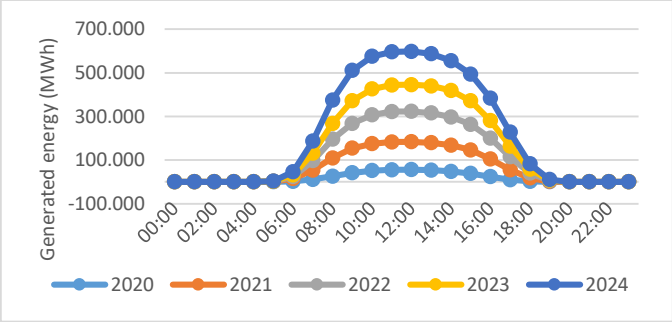

Fig.5. Annual generation volumes of solar power plants (EPİAŞ data)

As investments in these resources increase, there is also an observable rise in generation volumes. For instance, the continual increase in wind generation over the years, except for 2022, indicates that the year-to-year variability in wind conditions remains below the level of investment. In 2022, a less favorable year for wind saw generation occasionally drop below the levels of the previous year.

Regarding the regression analysis of the relationship between curve gap and saturation index for the year 2024, which aims to exclude the effects of the 2021-2023 energy crisis, the r-squared value is 0.61. Despite other drivers, this value indicates a strong correlation.

Solar based generation exhibits a consistent year-over-year increase. The illumination that starts after 6 AM continues until 7 PM, peaking at noon. The generation at noon between 2020 and 2024 has shown an increase of more than tenfold.

As for the dynamics of conventional energy resources without additional investments, what are the trends? In Türkiye, market pricing is predominantly influenced by two conventional resources: imported coal and natural gas. These resources are distinguishable by their operational flexibility in terms of activation and deactivation times. Given that the accuracy of wind forecasts hovers around 15%, these fuels continue to play a critical role as base-load suppliers in the energy market. An analysis of Figure-6 reveals that, except for the supply crisis in 2021, there has been a consistent upward trend in the utilization of imported coal, solidifying its essential role as a base-load resource.

Figure-7 indicates that during the crisis period marked by shortages in imported coal supply, the generation from natural gas resources was exceptionally high, particularly noting a decline in consumption in 2023 and 2024. From a market perspective, the underutilization of natural gas resources, which can be rapidly ramped up and down, implies that the marginal price did not reach its highest possible level and that the required energy was instead met through alternative resources (in this case, additional wind and solar based capacity). The fact that these resources are compensated through YEKDEM via a non-market method creates a zero-priced supply in terms of market dynamics.

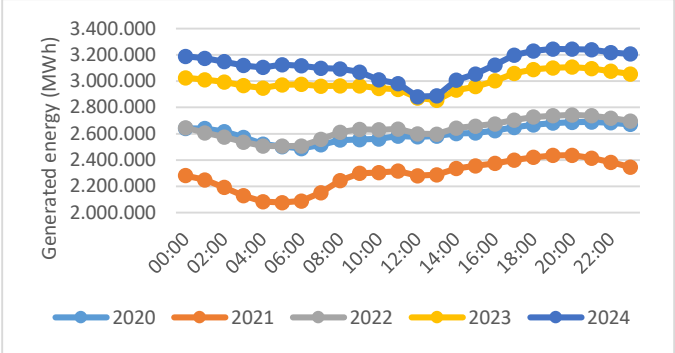

Fig.6. Annual generation volumes of imported coal power plants (EPİAŞ data)

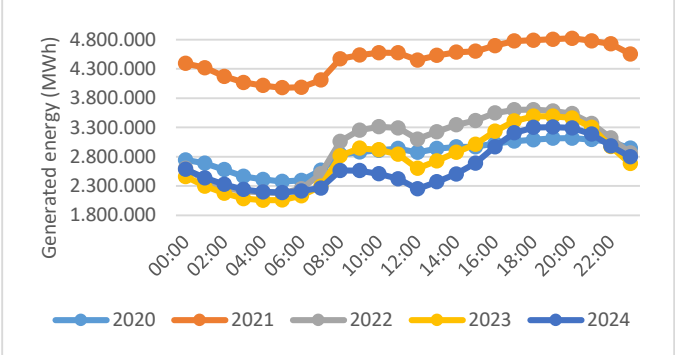

Fig.7. Annual generation volumes of natural gas power plants (EPİAŞ data)

Figure-8 displays the trajectory of price-independent sales offers over the years. According to the figure, the increases in 2022 and 2023 remained below the levels of 2021. This could be due to a decrease in generation from various resources (such as wind and hydroelectric power). In 2024, an increase in price-independent capacity is observed, influenced by both wind and solar based capacities. Another important aspect to note is the surplus of capacity in 2021 and 2022 that opted not to participate in the support mechanism. This capacity is not zero-cost in terms of market dynamics and does impact the marginal price.

Figure-9 shows the trajectory of the reference price over the years. During 2022 and 2023, the global energy crisis led to increased costs, which, in turn, caused marginal prices to rise; however, these increases were kept within certain limits through market regulations. During this period, the market was supported by non-market mechanisms in line with the literature. Assuming a traditional load curve for 2020 and 2021, a limited price drop during midday hours can be observed. In contrast, a significant decline in marginal prices at midday is noted for the years 2022, 2023, and 2024. This decline is attributed to the relaxation of supply and demand dynamics in the market. The

alleviation is markedly demonstrated by the consistent influence of wind energy on prices throughout the day.

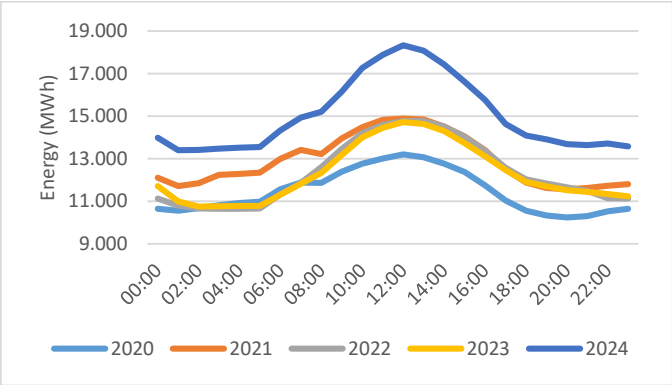

Fig.8. Price-independent sales offers (EPİAŞ data)

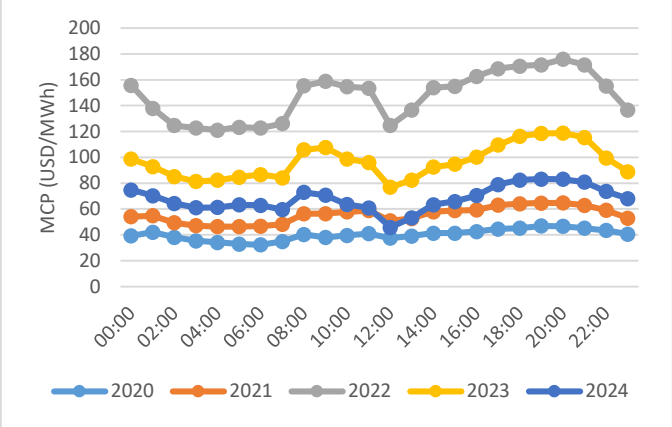

Fig.9. Annual changes in MCP (EPİAŞ data)

Figure-10 employs a different approach, displaying the ratio of solar based generation at its peak generation hour, noon, to the daily average generation. This comparison allows for a clearer observation of how high solar based energy generation at noon influences the downward trend in prices. The figure shows that in 2020, generation at noon was 94% of the daily average, but this percentage subsequently decreases to 92%, 85%, 80%, and 67% over the years. This trend clearly indicates the formation of a duck-curve pattern in the price curve.

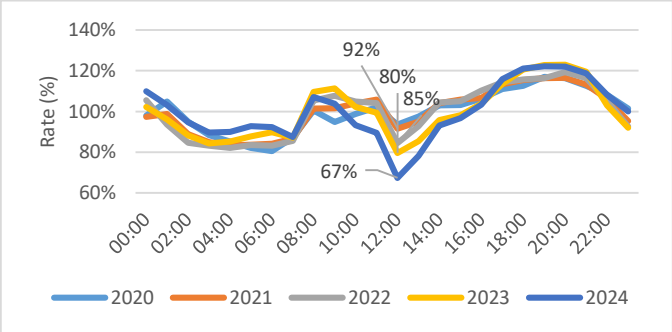

Fig.10. Ratio of noon-prices to daily average

The integration of renewable energy resources into the system often results in imbalances due to the inadequacy of forecast data. Figure-11 displays the quantities of 0 and 1 coded YAL (upward regulation) and YAT (downward regulation) instructions, which reflect the costs in the balancing markets as the system operator faces an increasing share of renewable energy resources and a decreasing generation of conventional fuels over the years. When evaluated independently of price, a regular decrease in these quantities is observed following the crisis period. The reason for not including the costs of the capacity mechanism in these calculations is that this mechanism inherently requires reserves to be held under all circumstances.

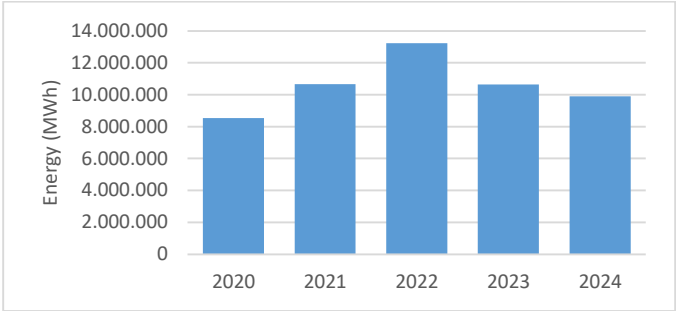

Fig.11. Annual changes of upward and downward regulation volumes (EPİAŞ data)

Figure-12 displays YEKDEM prices. Despite significant fluctuations during the crisis period, these prices have remained steadily close to and below market prices. In this context, it can be said that the capacity affecting price formation through price-independent sales, being compensated at prices below the formed marginal prices, contributes to reducing the overall costs.

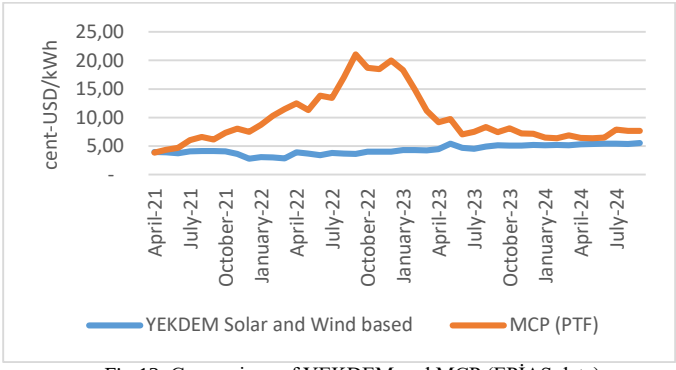

Fig.12. Comparison of YEKDEM and MCP (EPİAŞ data)

V. Results and Discussion

Solar and wind-based energy have significantly reduced peak electricity prices. Between 2020 and 2024, noon-time electricity generation from solar based increased tenfold, leading to an evident duck-curve effect. Moreover, the simultaneous observation of the duck-curve effect in both market prices and load profiles implies the growing role of distributed generation in meeting local demand, particularly through rooftop solar systems and behind-the-meter consumption.

Intermittency challenges persist, necessitating the continued use of natural gas for grid stability. Market mechanisms such as price caps have helped mitigate volatility, but long-term

stability requires storage solutions and improved forecasting models.

VI. Policiy Recomendations

To ensure a sustainable transition to renewables, this study proposes:

-Investment in Energy Storage: Battery storage and pumped hydro should be expanded to counteract price fluctuations.

-Improved Forecasting Models: AI-driven predictions should enhance grid balancing strategies.

-Market Design Adjustments: Revisiting the YEKDEM subsidy mechanism to align incentives with long-term market stability.

-International Benchmarking: Comparing Türkiye's market interventions with successful global examples, such as California's and Germany's capacity market designs.

VII. Conclusion

This study has thoroughly examined the impact of Türkiye's renewable energy transition on the electricity market. Recent capacity expansions in wind and solar-based power have significantly increased their contribution to total electricity generation, with solar-based energy generation during midday rising more than tenfold. This surge has resulted in a substantial decline in electricity prices during peak solar-based hours, visibly altering the market's supply-demand balance. Graphical analyses, particularly from 2022 to 2024, reveal that marginal prices have consistently dropped during midday, confirming the emergence of a pronounced duck curve in the Turkish electricity market. Furthermore, the analysis indicates that when wind generation is high, the depth of the price curve is reduced, reflecting a lower saturation index and decreased marginal prices. Both renewable energy resources have demonstrated a price-suppressing effect on the market.

However, the unpredictability of renewable energy remains a challenge. The relatively low forecasting accuracy of wind generation, in particular, underscores the continued necessity for baseload power resources. Imported coal and natural gas-based power plants remain critical in ensuring system reliability. During periods of crisis, increased natural gas-based generation has helped meet the system's flexibility requirements. Meanwhile, regulatory interventions and price control mechanisms have helped mitigate extreme price fluctuations; however, long-term sustainability requires further structural reforms.

In conclusion, renewable energy investments in Türkiye have substantially influenced the electricity market, especially through their impact on price mechanisms. Nonetheless, improving system reliability and enhancing renewable energy forecasting accuracy remain essential. Future developments such as smart grid systems, energy storage solutions, and refined market mechanisms will enable more efficient utilization of renewable energy resources, ultimately reducing costs and enhancing market stability.

References

[1] ACER. (2023, 01 10). Harmonised maximum and minimum clearing prices for single day-ahead coupling. Guideline on capacity allocation and congestion management (CACM Regulation) for EU 2015/1222. ACER.

[2] Chava, J. (2024). Impacts of energy price cap system on electricity and gas prices in the era of energy crisis. California State University, Dissertation Graduate Thesis. San Bernardino: California State University.

[3] EMBER. (2024). Türkiye Elektrik Görünümü. EMBER.

[4] ACER. (2023, 01 10). Harmonised maximum and minimum clearing prices for single day-ahead coupling. Guideline on capacity allocation and congestion management (CACM Regulation) for EU 2015/1222. ACER.

[5] Chava, J. (2024). Impacts of energy price cap system on electricity and gas prices in the era of energy crisis. California State University, Dissertation Graduate Thesis. San Bernardino: California State University.

[6] EMBER. (2024). Türkiye Elektrik Görünümü. EMBER.

[7] EMRA. (2020). Market Annual Report. Ankara: Energy Market Regulatory Authority (EMRA).

[8] EMRA. (2021). Market Annual Report. Ankara: Energy MArkets Regulatory Authority.

[9] EMRA. (2022). Market Annual Report. Ankara: Energy Markets Regulatory Authority.

[10] EMRA. (2023). Market Annual Report. Ankara: Energy Markets Regulatory Authority.

[11] EMRA. (2024). Monthly Report. Ankara: Energy Markets Regulatory Authority.

[12] EXIST. (2025, 01). Transparency Platform. EXIST: https://seffaflik.epias.com.tr/home

[13] IEA. (2024). World Energy Outlook. Paris: International Energy Agency.

[14] Liebensteiner, M. (2025). High electricity price despite expansion in renewables: How market trends shape Germany's power market in the coming years. Energy Policy, 198, 114448.

[15] Lopez Prol, J. (2020). The cannibalization effect of wind and solar in the California wholesale electricity market. Energy Economics, 85, 104552, https://doi.org/10.1016/j.eneco.2019.104552.

[16] MENR. (2017). National Energy Efficiency Implementation Plan 2017-2023. Ankara: Ministry of Energy and Natural Resources.

[17] MENR. (2024). 2035 Road Map in Renewable Energy Launch Presentation. (s. 7). İstanbul: MENR.

[18] Pollitt.M., G. d.-H. (2024). Recommendations for a future-proof electricity market design in Europe in light of the 2021-2023 energy crisis. Energy Policy, 188, 114051, https://doi.org/10.1016/j.enpol.2024.114051.

[19] UN. (2025, 01). The Sustainable Development Goals. United Natıons Official Page: https://turkiye.un.org/en/sdgs adresinden alındı

[20] Wang, D. (2022). Electricity price instability over time: Time series analysis and forecasting. Sustainability, 14,9081 https://doi.org/10.3390/su14159081.

BIOGRAPHIES

Tamer Emre Ankara, Türkiye, in 1978. He completed his B.Sc. in Electrical and Electronics Engineering at Gazi University in 2001, holds M.Sc. degrees in Electrical and Electronics Engineering (Power Systems) from Gazi University in 2004, and Business Administration (Production Management and Quantitative Methods) from Hacettepe University in 2014 and his PhD in Energy Systems Engineering from Gazi University in 2022.

Dr. Emre began his career in the energy sector in 2004 as a Foreign Trade Specialist at GAMA Holding, where he was responsible for procuring equipment for its affiliated companies. From 2005 to 2014, he held engineering and mid-level management positions at TEDAŞ and TEİAŞ, which are public enterprises. During this period, he was part of a small team that undertook the establishment activities of the Turkish

Electricity Market. He continued his career as the Coordinator of Electricity Market Services at PwC Turkey from 2014 to 2019. Between November 2019 and May 2021, he served as the Central Coordination Director at Kazancı Holding, where he was responsible for coordinating between the Management and the Electric Distribution Companies. Since May 2021, he has been working at EPİAŞ for about two and a half years as the Director of Energy Market Operations, managing operations of electricity and gas markets, environmental markets, and eligable consumer markets, as well as financial settlement operations. He has overseen the launch of the Futures Electricity Market, Futures Gas Market, and Renewable Energy Guarantees of Origin Markets, and has been involved in the design of numerous innovative projects. Since May 2024, he has been serving as the Director of Strategic Planning and Corporate Governance at Akenerji. Throughout his over 20 years of professional life in the energy field, Dr. Emre has also continued his academic work, currently teaching "Energy Economics and Environment" to undergraduate students at Gazi University's Faculty of Technology. He speaks English, Russian, and Japanese. He is married and a father of one daughter.