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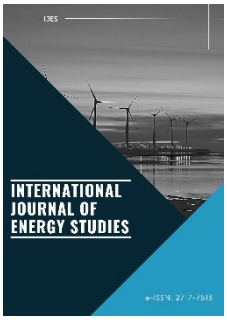

Research Article
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The impact of the establishment of the cross-border balancing market on the integration of RES into the regional electricity grid

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Highlights

- Examining the establishment of regional energy markets and cross-border electricity cooperation.
- Developing a model for the integration of discrete renewable energy capacity into the system.
- Establishing a regional balancing market in the electricity sector will provide access to a broad renewable portfolio.

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ABSTRACT

Nowadays, it has become of great importance to obtain electricity from renewable, clean sources that do not pollute the nature. Wind power plants and photovoltaic-based solar power plants, which are among the leading renewable energy technologies, pose difficulties in monitoring the system for transmission system operators because their production is intermittent and not always continuous. Production from these sources varies with changing weather conditions and can be difficult to predict. Although new renewable capacities are available, including in the power system, the problem of intermittency of meteorological uncertainty is a major problem for the system stability of the power grid. The electricity obtained from RES based on intermittent wind and solar energy can vary significantly in a short time depending on changing weather conditions. The greater the share of these intermittent power supplies connected to the grid, the greater the risk of instability in the system. In this sense, integrating Turkey's large capacity in wind, solar and hydroelectric energy with the energy system of neighboring countries will greatly increase system reliability. Establishing regional energy markets and cross-border electricity collaborations are of great importance for the integration of this discrete renewable energy capacity into the system. In this study, Turkey's contribution to the integration of renewable resources into the cross-border power balancing market and regional load transfer is investigated. The electrical load transfer potential was examined in the light of the current capacity and planned future capacity increases, and the benefits and necessity of the system to be installed were revealed.

Keywords: Sustainable energy, Renewable resources, Balancing market, Electricity grid

1. INTRODUCTION

Today, electrical energy has become an indispensable concept with the changes in modern society structure and developments in technology. It brings with it the management of all resources in order to meet the demand for electrical energy at the desired quality. To meet this energy demand, it is seen as an aim to maximize the use of renewable energy sources that are harmless to the environment. It is possible to face new challenges due to the variability and intermittent nature of renewable energy sources such as wind and solar energy, which are proposed as solutions to the difficulties experienced. The electricity from some renewable energy technologies is both stable and flexible. In this sense, hydroelectric power plants can provide reliable and clean electricity based on seasonal variations in the water level. On the contrary, electricity from renewable energy sources (RES) based on discontinuous wind and solar energy can vary significantly in a short time due to changed weather conditions. When the share of these intermittent power supplies connected to the mains is greater, the risk of instability in the system increases.

Cross-border cooperation in the electricity sector will contribute positively to solving the problem of variability in electricity frequency, and can help overcome the difficulties brought by the renewable resources to the system. In order to create a cross-border market in electricity, eliminating the problems that prevent growth in cross-border trade, smooth operation of regional electricity markets, will help increase the potential of electricity trade to facilitate growth in renewable energy.In this way, regional collaborations are inevitable in order to prevent voltage instability and system crashes and to meet system needs in growing and complex systems. Cross-border cooperation in the electricity sector will help solve the problem of frequency instability and besides, will also help overcome the difficulties that renewable resources bring to the electricity network.To develop a cross-border electricity market, it is necessary to overcome the obstacles that prevent the market from growing larger, to operate the regional markets without creating problems, to increase the potential of renewable resources in electricity trade between neighboring countries [1].

Several methods are used to address this problem of discontinuity. Cross-border trade in the electricity sector is considered one of these methods, as it allows countries to access a more diversified power plant portfolio across a wider geographical area. In this way, regional collaborations are inevitable in order to prevent voltage instability and system collapse. Cross-border cooperation in the electricity sector will help solve the problem of frequency instability and

besides, will also help overcome the difficulties that renewable resources bring to the electricity network. On the other hand, in some circumstances, the discrete renewable energy sources that cover a wider geographical region can be used to compensate for the energy variability of regional power plants or the sudden increase in demand in interdependent countries. Therefore, the cross-border collaboration in electricity can reduce the cost of balancing the power deriving from greater penetration of RES, allowing countries to access flexible power plants in an area wider geographical area.

To the extent that this collaboration will help to reduce frequency variability, energy exchanges will between countries, therefore, allow the integration of intermittent renewable power plants in multiple markets. Meanwhile, Türkiye has a large amount of capacity in wind, solar and hydroelectric power [2]. For the integration of this discrete renewable energy capacity into the system, the establishment of regional energy markets and the establishment of cross-border electricity cooperation are of great importance. In this study, firstly Türkiye's electricity production potential from renewable resources as wind, solar and hydropower has been examined, and secondly, for RES integration to the electrical system, the contribution of Türkiye's to cross-border balancing market and regional integration networks have been investigated. For this, The capacity of regional transmission lines with neighboring countries has been examined.

2. RENEWABLE CAPACITY AND INTEGRATION OF RES POTENTIAL

Türkiye Electricity Generation Installed Capacity in 2020 is 5,0% annually; 4,1% in 2021; It increased by 4,0% in 2022 and 2,7% in 2023. As of the end of February 2024, the Turkish Electricity Generation Installed power increased by 1.194,7 MW, compared to the value of 106.634,9 MW at the end of 2023, and became 107.829,6 MW, with an increase of 1,12% as shown in Figure 1 [3].

Contribution of resources to Türkiye's Electricity Generation Installed Power: HEPPs are 31.991 MW and their share is 29,7%; Natural gas is 25.401 MW and its share is 23,6%; Solar Power Plant 12.296 MW and its share is 11,4%; RES 11.961 MW and its share is 11,1%; Imported Coal 10.374 MW and its share is 9,6%; Lignite was 10.194 MW and its share was 9,5%. While 66,6% of Türkiye's Electricity Generation Installed Power comes from domestic resources; 33,4% is based on external resources (Natural gas, Imported coal, Fuel Oil). 55,7% of Türkiye's Electricity Installed Power comes from renewable sources; 44,3% consists of other fuels.

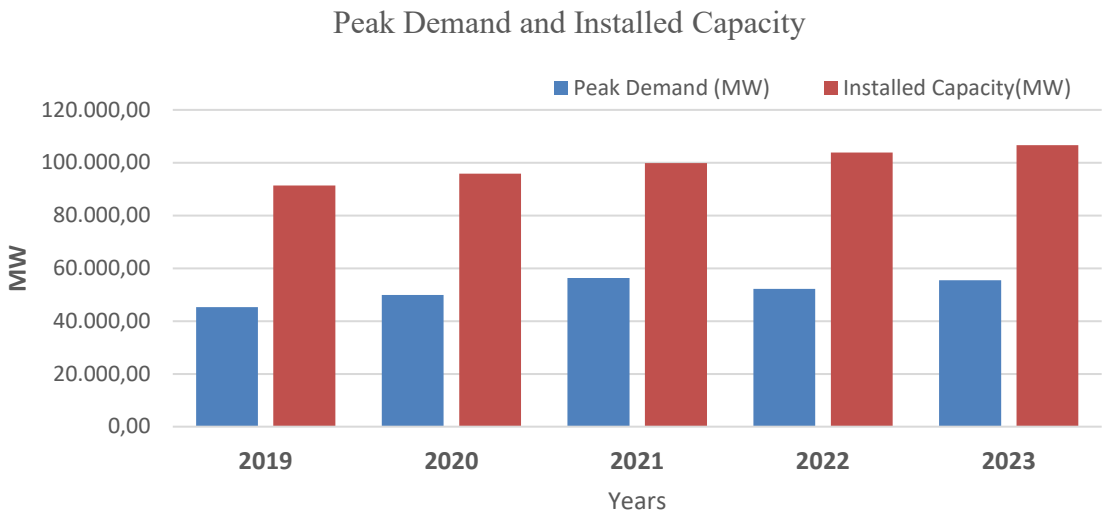


Figure 1. Peak Demand and Installed Capacity of electricity in Türkiye

The highest peak of all time in electricity demand in Türkiye was 56.304,2 MW on August 5, 2021. Peak demand peak: decreased by -1,8% in 2019; While it increased by 10,0% in 2020 and 12,9% in 2021, it decreased by -7,4% in 2022 and increased again by 6,3% in 2023.

Türkiye's electrical energy consumption decreased by 0,2% compared to the previous year, reaching 330,3 TWh in 2023, and electricity production decreased by 0,6% compared to the previous year, reaching 326,3 TWh (Figure 3.). According to the results of the Türkiye National Energy Plan study, electricity consumption is expected to reach 380,2 TWh in 2025, 455,3 TWh in 2030 and 510,5 TWh in 2035. In 2023, Türkiye's 36,3% of electricity production will come from coal, 21,4% from natural gas, 19,6% from hydraulic energy, 10,4% from wind, 5,7% from solar, 4% was obtained from geothermal energy and 3,2% from other sources [4] .

When the installed power values on the basis of resources are analyzed, The share of renewable power plants in installed power is 54%, and the type of solar power plants with the highest increase in installed power is solar power plants. Distribution of Türkiye's installed capacity by resources as of the end of 2023 is 29,7% hydraulic energy, 23,3% natural gas, 20,3% coal, 11,1% wind, 11,5% solar, 1,6% geothermal and 2.5% is from other sources. In addition, the number of electrical energy production plants in our country increased to 17.866 (including unlicensed power plants) as of the end of February 2024. Of the existing power plants, 760 are hydroelectric, 69 are coal, 364 are wind, 63 are geothermal, 357 are natural gas, 15.780 are solar, and 473 are other power plants [5].

According to estimates, although Türkiye's electricity production potential from solar energy is estimated to be 380 TWh annually and its installed power potential is 56 GW, the installed solar power capacity so far is around 12,3 GW. In Türkiye, 50 meters above ground level and 7 m/s over the accepted wind power plant can be established at 5 MW per square kilometer in areas with wind speed and Türkiye's wind energy potential was determined to be 48 GW. According to one study, Türkiye's potential wind energy technically is determined as 275 GW, despite the current installed wind capacity is currently around 11,9 GW (Figure 2).

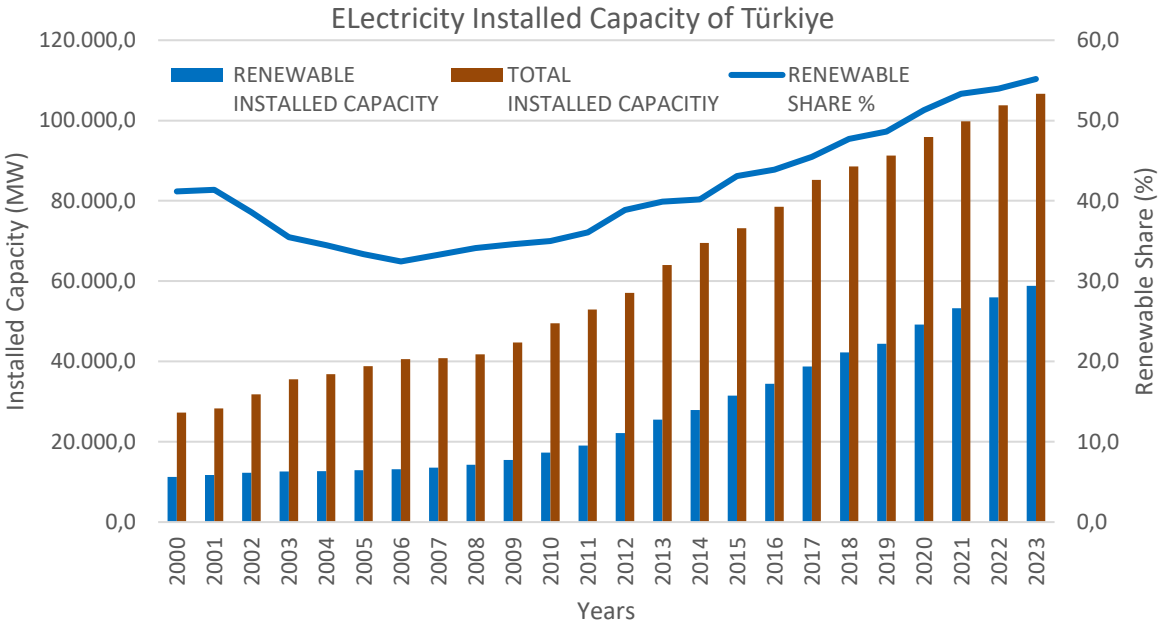


Figure 2. Electricity installed capacity and share of renewable in Türkiye [3]

There is a steady increase in electricity production from renewable energy sources in Türkiye, especially wind and solar energy production. Türkiye with approximately 11% wind share in Turkish electricity production; It ranks ahead of G20 countries such as France (8%) and Italy (7%). However, in terms of the share of solar energy, it is at similar levels with countries such as Poland and Ukraine, whose solar energy potential is much lower than Türkiye [6].

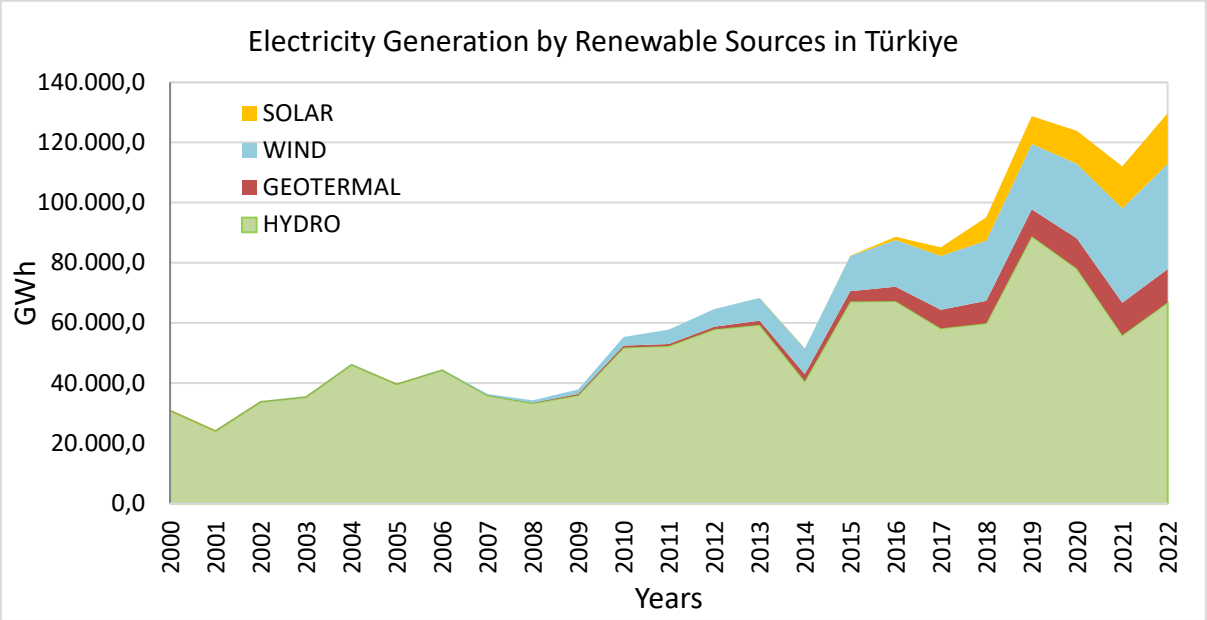


Figure 3. Türkiye's electricity generation from Renewable Energy Sources

Through Renewable Energy Resource Area (RERA), planned that add an additional 20.000 MW of electricity to energy basket in the following 10 years. The related offshore RERA will be the Türkiye's first and the world's largest offshore wind farm.

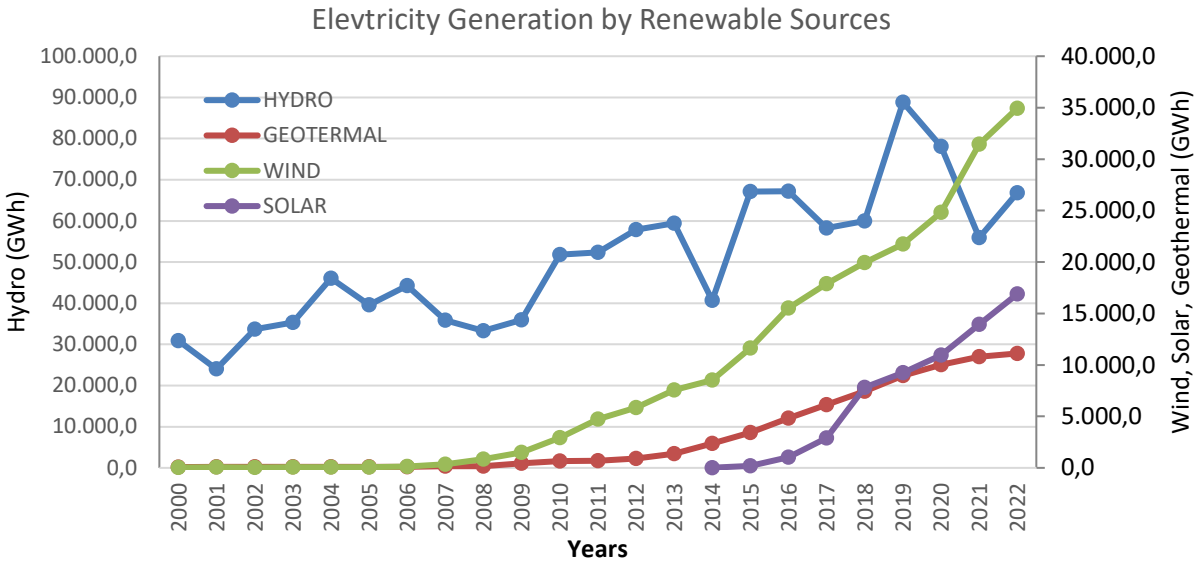


Figure 4. Türkiye's electricity generation comparison from different renewable sources

It is predicted that electricity production from total wind + sun will grow to hydrolytic production in the coming years, as shown in Figure 3, 4. Türkiye's offshore wind potential is evident with the possibility of reaching 32 GW amid the huge progress in recent years that has been made globally

according to a representive of the eurepean wind industry. But, Türkiye's offshore (offshore) wind energy potential is estimated that totally can be near to 11.000 MW [7]. More than 50% of the electricity used in Türkiye is anticipated that obtained from renewable resources, which is currently one year corresponding to 165 billion kWh of electricity.

3. SOUTH-EASTERN EUROPEAN ELECTRICITY BALANCING MECHANISM

The establishment of a common electricity balancing market and mechanism between Türkiye and its neighboring countries, particularly those in South-Eastern Europe, holds significant importance for several reasons.

A shared balancing market allows for efficient distribution of electricity across borders. In times of supply shortages or imbalances, neighboring countries can assist each other, enhancing overall energy security. Collaborative mechanisms ensure a reliable power supply by minimizing the risk of blackouts or disruptions. Renewable energy sources, such as wind, solar, and hydropower, play a crucial role in achieving sustainable energy goals. A common balancing market enables better integration of intermittent renewables. When one country experiences excess renewable generation, it can export the surplus to neighboring countries, reducing curtailment and maximizing utilization.

Coordinated balancing also facilitates demand-response management, allowing flexibility in adjusting consumption patterns based on renewable availability. By sharing resources and balancing services, countries can reduce operational costs associated with managing imbalances. A regional approach enhances grid stability by smoothing out fluctuations caused by variable renewable generation. A common balancing market fosters regional cooperation and market integration. It encourages cross-border trading and competition among participants. Efficient balancing mechanisms promote price convergence, benefiting consumers and encouraging investment in renewable projects. Coordinated balancing supports the transition to a low-carbon energy system. It allows countries to collectively reduce reliance on fossil fuels and decrease greenhouse gas emissions. By optimizing renewable energy utilization, the region can contribute to global climate goals. In summary, establishing a common electricity balancing market with neighboring countries enhances energy security, promotes renewable energy integration, and contributes to a more sustainable and resilient energy landscape for Türkiye and the South-Eastern European region.

3.1. Türkiye's SEE Region Neighbour Country Electricity Capacities

The South East Europe (SEE) region has the greatest undiscovered hydroelectric potential in the European continent. Besides hydroelectric Türkiye has a great potential hydroelectric capacity at this time it is increasing dramatically. On the other hand, although a promising potential alternative, renewable energy sources have experienced a rising trend in only a few South East Europe countries (Figure 5). With the exception of Türkiye, most SEE countries the focus of energy policy, wind, solar and biomass instead of still shows on hydropower. Türkiye has made a great leap forward in the wind and solar energy.

Figure 5. The southeastern Europe countries and Türkiye's neighbor countries

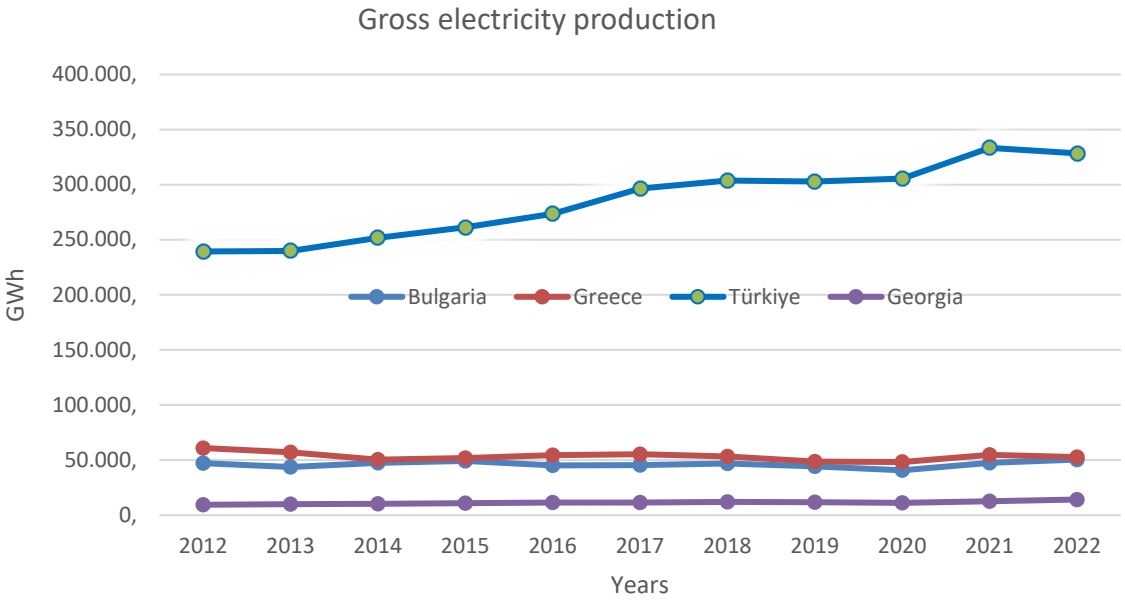


Figure 6. Türkiye's and neighbors countries comparison of total electricity generation (Source: Eurostat)

Compared with the countries of the synchronous interconnection of Türkiye where she worked as the monthly net electricity generation and transmission lines, Greece, Bulgaria and compared with Goergia it seems to be more than about 5 times, as shown in Figures 6, 7, 8 . This shows that, Türkiye could take an important role in the integration of renewable energy sources such as solar.

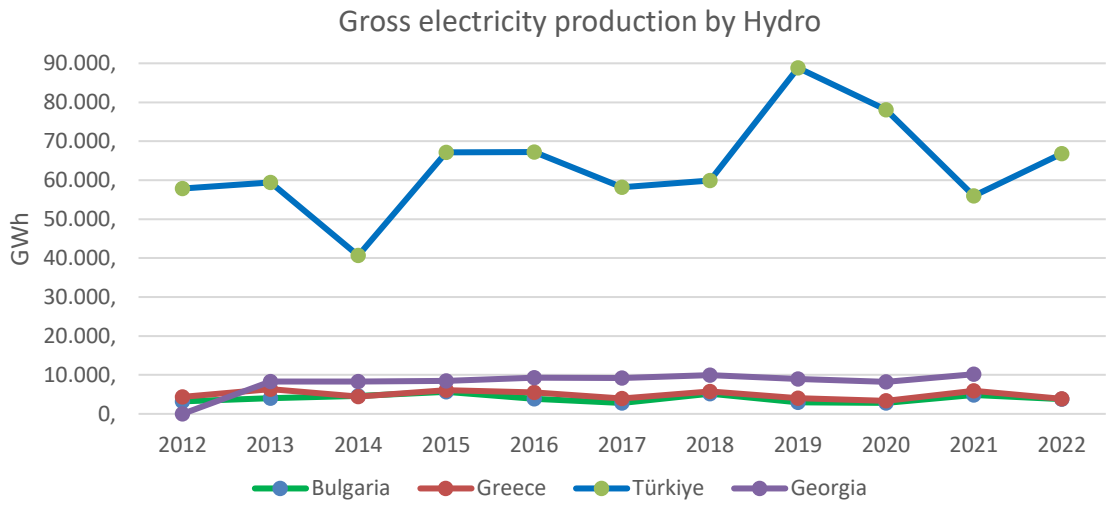
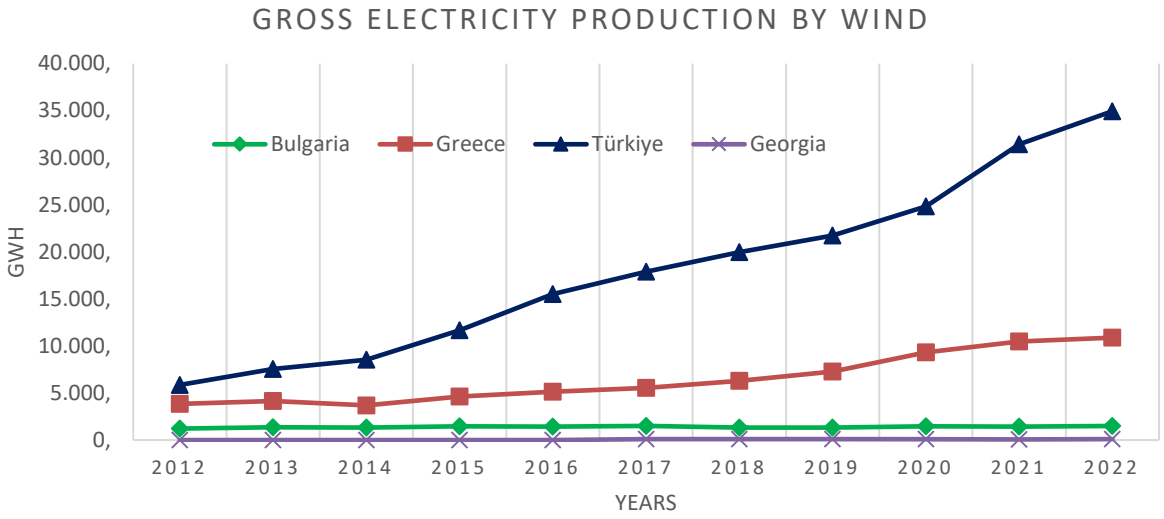
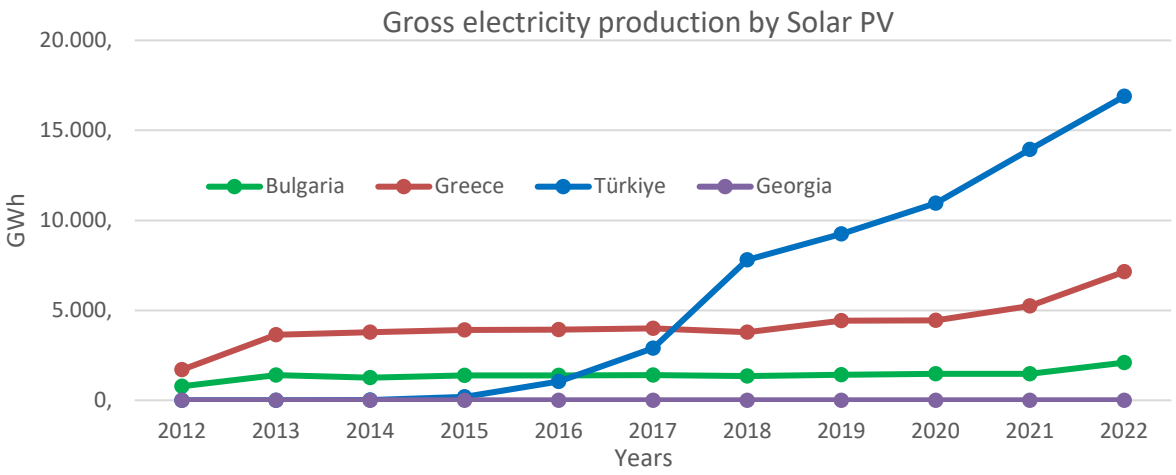


Figure 7. Türkiye's neighbors countries hydroelectric generation.(Source: Eurostat)



(a)



(b)

Figure 8. Türkiye's neighbors countries a) wind and b) solar PV generation (Source: Eurostat)

Seven SEE countries, including Bulgaria, Macedonia, Greece, Montenegro, Albania, Bosnia-Herzegovina and Serbia, produce approximately 34 TWh (billion kWh) of electricity annually with an installed hydroelectric capacity of 12,5 GW. This production amount corresponds to around 21% of annual electricity consumption. However, due to the fact that hydroelectric electricity production depends on rainfall over the years, the contribution of hydroelectric energy to electricity production was between 16% and 25% in 2011-2017 [7].

South East Europe is a diverse region with respect to its electricity sector development One of the most important predicaments facing the countries of Southeastern Europe is that more than 30% of the current installed fossil fuel production capacity in the SEE region must be replaced by renewables by the end of 2030, including more than 95% by 2050 [7]. Cross-border interconnections will develop with the expansion and improvement of the electricity network in the region. This will enable the establishment of a market integration across the region of the currently fragmented market. The electricity transmission system is expected to be expanded with additional investments in the future to cope with the planned RES production integration [8].

According to 2017 data, Bulgaria has a total installed power of 1200 MW, of which 4500 MW is coal, 2000 MW is nuclear, 0,6 GW is natural gas, 3100 MW is pumped storage hydroelectric power plants, and 6300 MW is hydroelectric power plants. and 1800 MW consists of other renewable energy sources. While the share of renewable energies in total electricity production is still relatively low, they also have significant hydraulic storage capacity. Greece has a total installed

capacity of 16.400 MW, of which 3900 MW consists of lignite, 4300 MW of natural gas, 34000 MW of hydroelectricity including pumped storage hydroelectricity and 4800 MW of other energy resources. As of the end of 2017, Greece's wind, solar and biomass capacity is 5100 MW (including NII), exceeding the total hydroelectric capacity. Greece has been a net importer of electricity for several years [9].

Electricity production in Georgia is mainly produced by hydroelectric power plants, but during periods of peak demand electricity is also produced by thermal power plants (TPP). Georgia has not yet used most of its hydroelectric potential, this rate is around 75%. More than 60 potential hydroelectric projects in the country are at the pre-feasibility study stage. The country's total installed power is 3.724 MW and there are more than 70 power plants, and approximately 852 MW of the total installed power consists of four thermal power plants (TPP), and more than 75% of the installed power consists of hydroelectric power plants. Georgia will be able to produce an additional 24 TWh per year with its currently untapped hydroelectric resources. The country's total solar energy potential is estimated to be around 108 MW [10].

Analysis of the electricity sector in Southeast Europe represents the most important energy sources for electricity generation of hydroelectricity and coal. Hydroelectric provides the necessary flexibility and storage capacity to ensure the stability and supply security of a transmission system and supports the integration of increasing amounts of renewable energy, especially wind. More than 50% of the total electricity installed capacity in Albania, Montenegro, Croatia and Bosnia-Herzegovina consists of Hydroelectric power plants. This hydroelectric capacity is of great importance in providing the necessary flexibility and storage capacity to ensure the stability of the transmission system and security of supply [11].

SEE economies have an installed hydroelectric capacity of 8,5 gigawatts (GW), approximately 0.6 GW in small hydroelectric power plants (ECS, 2017b). In addition to the significantly larger hydroelectric capacity, some economies plan to build more hydroelectric power plants at both low and high capacities. However, despite the contribution of hydroelectric power, large amounts of coal and lignites burned across the region mean that greenhouse gas emissions per unit of national income are relatively high. Southeastern European countries have important opportunities for the development of the electricity sector with the diversity of resources they have. One of the most important challenges that the region will face in the energy transition will be the renewal of more

than 30% of the current installed fossil fuel production capacity by the end of 2030 and more than 95% by 2050 [12].

3.2. Türkiye's Cross-Border Interconnection Capacity

Türkiye's Electricity System ENTSO-E CESA (former UCTE synchronous zone) result of work on connecting parallel synchronous system, on January 14 with the Observer Membership Agreement signed in 2016 Türkiye became a member of the first observers of ENTSO-E and import and export terms of the Net Transfer Capacity, annual started to be allocated as monthly and daily auctions.Türkiye synchronous parallel operation with other countries outside western neighbors with the integration of the Electrical System of ENTSO-E system, it allows these countries to fulfill certain standards and procedures, and it is possible within the framework of ENTSO-E's approval. Back-to-Back, DC connection, unit routing and isolated zone feeding method are the methods used in energy exchange with third countries of a country that started to work in parallel with the ENTSO-E system. Energy exchanges to be made with these methods are subject to the permission of ENTSO-E. The integration of the Turkish electricity system and market with those of Europe has hence been taken to a higher level (Figure 9, 10). Here, Türkiye's eastern and western borders with neighboring countries in working conditions only existing synchronous parallel electric transmission lines are investigated [3].

Table 1. Türkiye Western-Side Interconnection Energy Transmission Line Capacity

Country	Line Capacity	Total Conductor Area (mm2)	Line Length (km)	Current Carrying Capacity (A)	Summer Capacity (MVA)	Spring / Autumn Capacity (MVA)	Thermal Capacity (MVA)
Hamitabat(Türkiye) - Maritsa East(Bulgaria)- I	400 kV	2x517	158.45	2x755	832	1360	995
Hamitabat(Türkiye) - Maritsa-East(Bulgaria)-II	400 kV	3x547	148,76	3x765	1268	2070	1510
Babaeski(Türkiye) – Nea Santa (Greece**)**	400 kV	3x547	127,85	3x765	1268	2070	1510

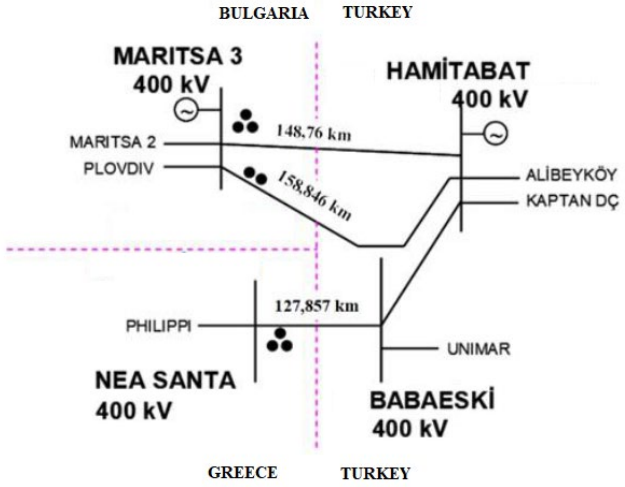


Figure 9. Türkiye's Interconnection lines with Bulgaria and Greece

Table 2. Türkiye Eastern Side Interconnection Energy Transmission Line Capacity

Country	Line Capacity	Total Conductor Area (mm2)	Line Length (km)	Current Carrying Capacity (A	Summer Capacity (MVA)	Spring / Autumn Capacity (MVA)	Thermal Capacity (MVA)
Hopa (Türkiye) - Batum (Georgia)	220 kV*	517	28,85	755	240	393	287
Borçka (Türkiye) - Akhaltsikhe (Georgia)	400 kV **	3x547	152.154	3x765	1268	2070	1510

* 220 kV Hopa-Batum Interconnection Line is used only for emergencies and it has been decided not to engage in electrical energy import / export.
** The line is operated by asynchronous parallel operation method.

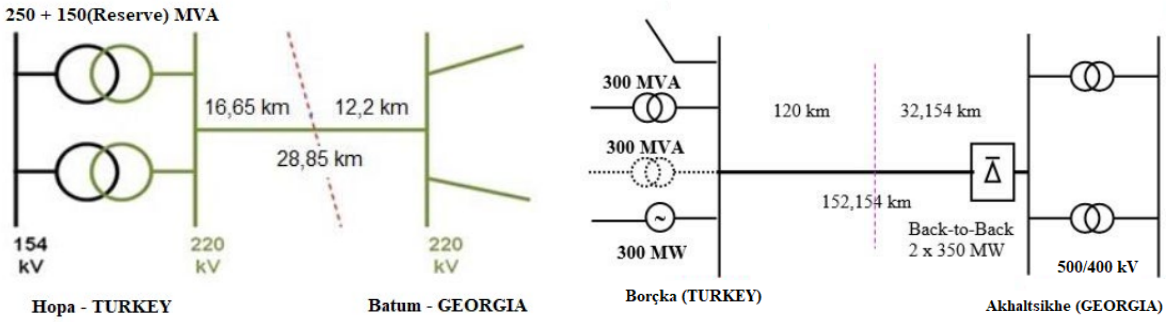


Figure 10. Türkiye's Interconnection lines with Georgia

Turkey exported 4.1 billion kilowatt-hours of electricity last 2021, an increase of 68 percent compared to the previous year. This figure was at 2.4 billion kilowatt-hours in 2020. Electricity imports also increased by 23 percent in 2021 compared to the previous year, from 1,8 billion kilowatt-hours to 2.3 billion kilowatt-hours. Looking at the Transmission System of Turkey, as of

June 2023, the total transmission line length in the country is 73.806 km and there are 789 substations. There are 15 connection lines with neighboring countries. In electricity trade through the Transmission System, Turkey's electricity exports reached 2.647 GWh by 2023, while total electricity imports amounted to 7.012 GWh. While Greece had the highest share in electricity exports with 69,6%, 53,8% of the total electricity in 2022 was imported from Bulgaria (Figure 11,12,13).

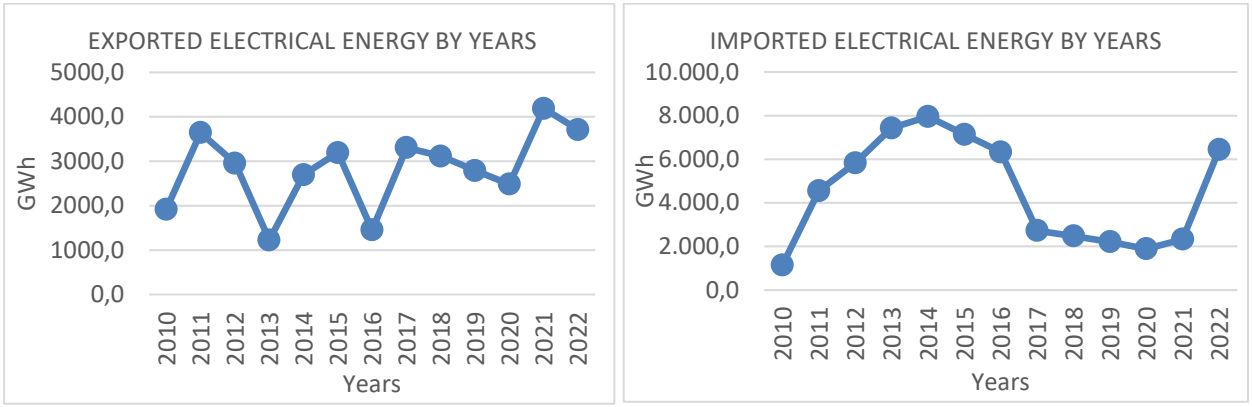


Figure 11. Türkiye's Exported/Imported electrical energy by years

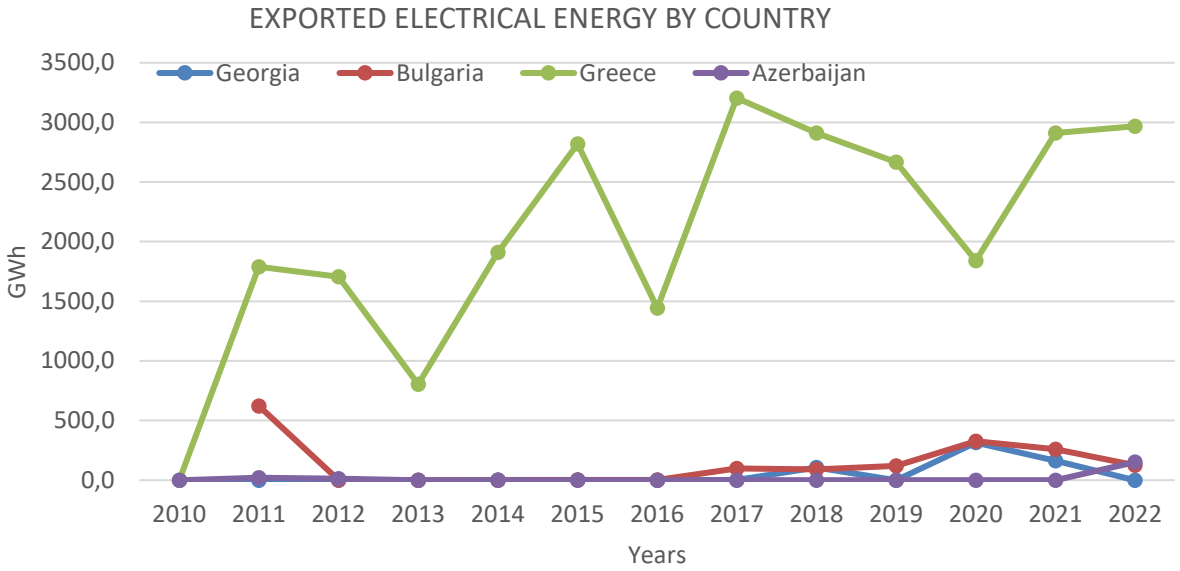


Figure 12. Türkiye's Exported electrical energy from Cross-Border Countries by years

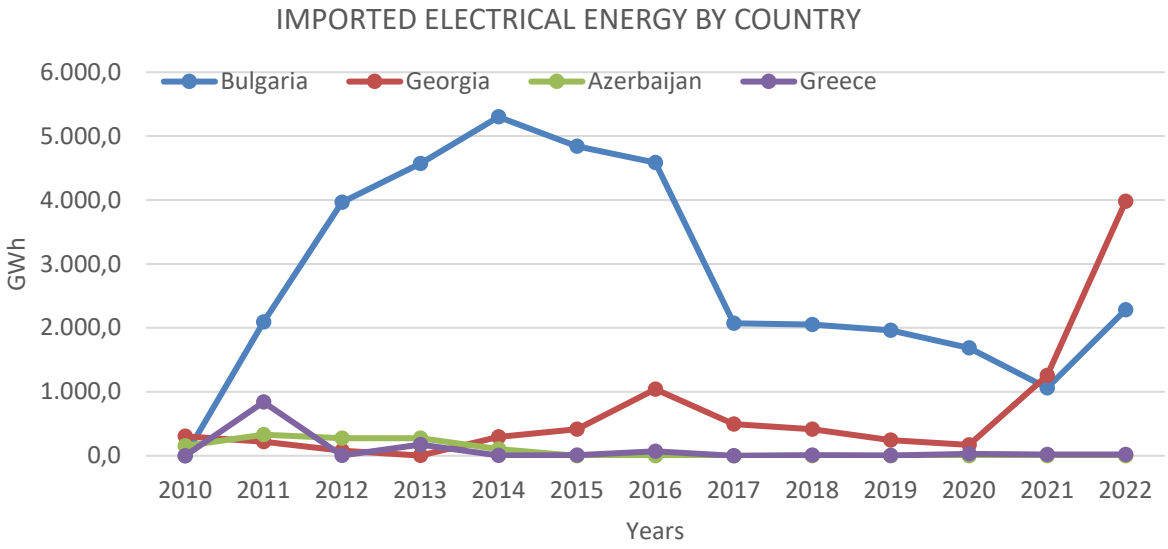


Figure 13. Türkiye's Imported electrical energy from Cross-Border Countries by years

4. INDICATORS FOR REGIONAL ELECTRICITY BALANCING MARKET

Cross-zonal transmission capacity (CZC) present not used for balancing markets is one of the essential preconditions for integration. Exchange and sharing of reserves of electricity capacity depend on the availability of CZC at long term perspective. CZC is a term defined in ENTSO-E's Capacity Allocation and Congestion Management Draft. Bulgaria and Greece Electrical Systems work synchronously with the European Electricity Transmission System Operators Network European Continent Synchronous Zone (ENTSO-E CESA). TEİAŞ (Türkiye Transmission System Operator) for capacity allocation will be carried out by Bulgaria party in the capacity allocation "Bidding Method" is offered to market participants. As of 2016, annual and daily tenders have started to be made in addition to monthly tenders for Bulgaria [13].

With the Southeastern Europe Coordinated Tender Office (SEE CAO) established between Greece, Montenegro, Croatia, Bosnia and Herzegovina, Albania, Kosovo and our country's electricity transmission system operators, it is aimed to tender the interconnection capacities between these countries from a single center. In this context, since October 2015 Türkiye - Greece interconnection capacity allocation started to be monthly and daily capacity allocation auctions by SEE CAO, by the year 2016 in addition to the monthly and daily auctions has started to conduct annual auctions.Limit terms to facilitate the cross-border electricity load transfer Greece, Montenegro, Croatia, Bosnia and Herzegovina, Albania, regional of the interconnection capacity

between the countries concerned with Kosovo and Türkiye aimed to be tendered from a single center [14].

Turkey, which acts as a natural center between Asia and Europe, will be effective in diversifying the energy supply of Southeastern European countries with alternative sources from the Caspian Basin and the Middle East. Integrating the Turkish electricity system into the ENTSO-E system has the potential to help stabilize the electricity markets of the countries in the region. Southeastern European (SEE) countries are largely dependent on lignite-fired electricity generation, but it is expected to undergo a significant change towards 2030. According to the foreseen plans, In 2030, approximately 50% of electricity production in the SEE region will be provided by renewable energy sources, and approximately 70% of this is expected to be obtained from wind and solar. However, since production patterns of wind and solar are variable due to weather conditions, power systems in SEE need to become much more flexible and have to cope with this variable generation.

4.1. Electricity Capacity Development in Future Projections

According to the forecast results obtained, looking at the gross consumption estimates of consumers connected to the distribution system, the gross consumption of consumers connected to the distribution system is expected to be approximately 257 billion kWh in 2028. According to MENR's covering the years 2019-2039 "Türkiye Electricity Demand Projections Report", electricity demand is expected to increase by 2.4 percent to 284 billion kWh in the low scenario, and to exceed 315 billion kWh with an average increase of 4 percent according to the high scenario. (Figure 14) [16].

The highest annual average electricity demand growth rate in Europe is expected to be in the western Balkan countries. In the scenarios, it is predicted that the final electricity consumption may more than double by 2040. Considering the resource situation in the electricity production of the Western Balkan countries, lignite dominates. It appears that Kosovo has significant lignite reserves. Hydroelectric production has a significant potential in some Balkan countries, but it is not evenly distributed among countries, and hydroelectric production is expected to maintain its importance in electricity generation. In Southeastern Europe, renewable energy for electricity generation, other than hydropower, is at a strong stage of development, with the share of electricity supply in total electricity supply being less than 1%. However, the potential for electricity

generation from both wind and solar energy is high in Southeastern Europe, and solar and wind capacities are predicted to increase significantly in the future.

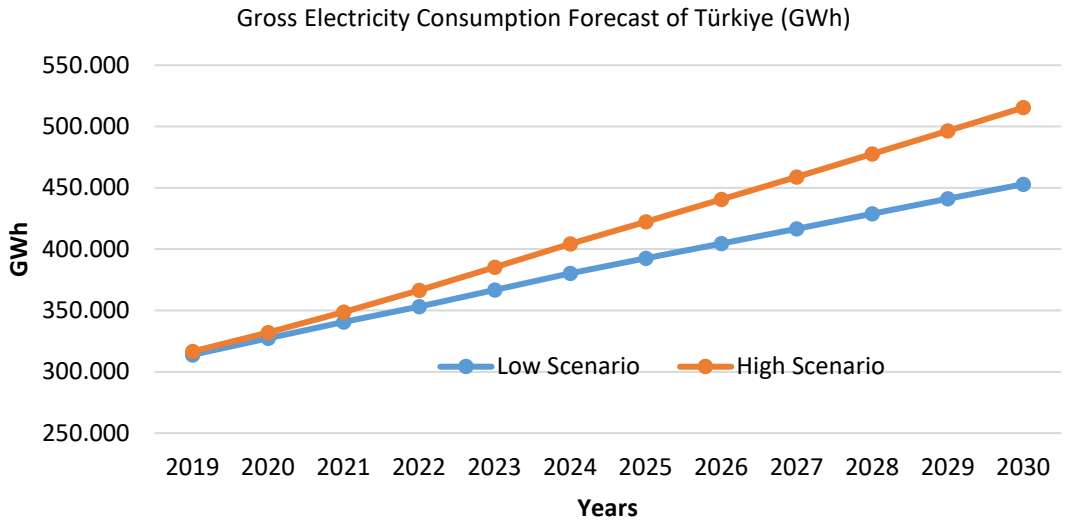


Figure 14. It prepared by MENR, covering the years 2019-2039 "Türkiye Electricity Demand Projections Report"

Cross-border interconnections are developed with the expansion and improvement of the electricity network.These will enable the integration of the already fragmented market. The electricity transmission system is expected to require additional reinforcement in the future to cope with the planned RES generation distribution [17]. According to studies, in the high growth scenario in 2015, an average growth of 1,3% is expected for SEE countries other than Türkiye, and when Türkiye is added, this growth rate is expected to be 3,9%. In the SEE region, which includes Türkiye, the balance position of the region becomes positive in 2025 according to the reference scenario [18].

If a regional power system is established between countries in the SEE region, the need for flexibility in the integration of renewable resources can be minimized. Because the transition from a national electricity balancing market to regional balancing will significantly reduce national flexibility needs in all countries. Therefore, there is a need for increased cross-border connections and regional cooperation to integrate higher wind power and solar PV production. This will require flexible operation of conventional power plants. Accordingly, conventional power plants will need to reflect renewable energy production flexibly: When renewable energy production is high, conventional power plants will produce less, and when renewable energy production is low, fossil

power plants production will increase. Achieving security of supply with 50% renewable energy sources in the SEE region can only be achieved through a mixture of traditional power plants and establishing a balance with cross-border cooperation.

Regional cooperation will be significantly beneficial to maximize national security of supply and minimize energy system costs. Providing regional integration will help prevent RES restrictions in countries and will be an element in ensuring the continuity of production by ensuring the geographical correction of RES.

5. CONCLUSION

Turkey draws attention with its focus on renewable energy resources in recent years. According to the Turkish Electricity Market Overview Report published in December 2023, Turkey stands out as one of the countries with the 12th largest renewable energy capacity in the world. This potential can make a significant contribution to Turkey's goals of reducing energy dependency.
Turkey has a great potential in solar energy and other renewable energy resources. In particular, solar energy is expected to have a significant share in installed capacity. The National Energy Plan, which determines the targets that must be met by 2035 in order to realize Turkey's 2053 Net Zero Emission vision, clearly reveals its commitment to renewable energy. In recent years, significant investments have been made in the field of renewable energy in Turkey. Projects such as solar panel cell production facilities, hybrid power plants and storage power plant investments can help Turkey use its energy potential at the highest level.

The population of SEE countries is more than 150 million and has great potential for rapid development of the energy sector. The close cooperation of South East European countries offers better opportunities for future power network and market development. Close cooperation between Southeast European countries offers better opportunities for future energy network and market development. Türkiye has a large capacity in wind and solar. Establishing regional energy markets and cross-border electricity collaborations are of great importance for the integration of this discrete renewable energy capacity into the system. All these factors highlight Turkey's critical role in the SEE region.

In this study, Turkey's contribution to the integration of renewable resources into the cross-border power balancing market and regional load transfer is investigated. Electrical load transfer potential

is examined in light of current capacity and planned future capacity increases. Turkey's geographical location positions the country as one of the main transit points of future energy routes. Turkey's natural role as a hub between Asia and Europe will be effective in diversifying SEE's energy supply with regional and alternative sources in the Caspian Basin and the Middle East. The Turkish Electricity System of the ENTSO-E system contributes to the integration of the region and the SEE capacity contributes to the stabilization of the country's electricity market. By promoting cooperation, Türkiye and its neighbors can benefit from the full potential of renewable resources, increase energy security and thus contribute to a sustainable energy future for the entire region.

NOMENCLATURE

CZC: Cross-zonal Transmission Capacity
CESA : Continent Synchronous Zone
ENTSO-E: European Network of Transmission System Operators for Electricity
HEPP : Hydroelectric Power Plant
MENR: Ministry of Energy and Natural Resources
NII : Non-Interconnected Islands
RERA: Renewable Energy Resource Area
RES : Renewable Energy Sources
SEE : Southeastern European
SEE CAO: Southeastern Europe Coordinated Tender Office
TEİAŞ : Türkiye Transmission System Operator
TSO : Transmission System Operator
TPP: Thermal Power Plant

DECLARATION OF ETHICAL STANDARDS

The author of the paper submitted declares that nothing which is necessary for achieving the paper requires ethical committee and/or legal-special permissions.

CONTRIBUTION OF THE AUTHORS

Mehmet Bulut: Design of the article, evaluation of data, preparation of graphics and writing of the entire article.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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