REPUBLIC OF TÜRKİYE
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCE AND ENGINEERING

EFFECTS OF ENERGY POLICIES IN THE CONTEXT OF REGIONAL DEVELOPMENT: A REVIEW ON TÜRKİYE NUTS1 REGIONS

Büşra SAĞLAM

MASTER OF SCIENCE THESIS
Department of Urban and Regional Planning
Regional Planning Program

Supervisor
Prof. Dr. Senay OĞUZTİMUR

Co-Supervisor
Dr. Hartmut DUMKE

August, 2023

REPUBLIC OF TURKEY

YILDIZ TECHNICAL UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCE AND ENGINEERING

EFFECTS OF ENERGY POLICIES IN THE CONTEXT OF REGIONAL DEVELOPMENT: A REVIEW ON TÜRKİYE NUTS1 REGIONS

A thesis submitted by Büşra SAĞLAM in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE is approved by the committee on 10.08.2023 in Department of Urban and Regional Planning, Regional Planning Program.

Prof. Dr. Senay OĞUZTİMUR Yıldız Technical University Supervisor	Dr. Hartmut Dumke Technical University of Vienna Co- supervisor

Approveds By the Examining Committee

Prof. Dr. Senay OĞUZTİMUR, Supervisor

Yildiz Technical University _____

Prof. Dr. Adem Erdem ERBAŞ, Member

Mimar Sinan Fine Art University _____

Assoc. Dr. Adem SAKARYA, Member

Yildiz Technical University _____

I hereby declare that I have obtained the required legal permissions during data collection and exploitation procedures, that I have made the in-text citations and cited the references properly, that I haven't falsified and/or fabricated research data and results of the study and that I have abided by the principles of the scientific research and ethics during my Thesis Study under the title of Effects of Energy Policies in the Context of Regional Development: A Review on Türkiye NUTS1 Regions supervised by my supervisor, Prof. Dr. Senay OĞUZTİMUR. In the case of a discovery of false statement, I am to acknowledge any legal consequence.

Büşra SAĞLAM

Signature

Dedicated to my lovely father….

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my advisor, Prof. Dr. Senay Oğuztimur, for her invaluable guidance and support throughout my master's program. Her expertise and encouragement helped me to complete this research and write this thesis. She is always supporting, encouraging, and never lacking in self-sacrifice to me.

I am grateful to Dr. Hartmut Dumke for providing me with opportunity to conduct my research at Erasmus Program, and for all the resources and support they provided. I feel so lucky to selected dear Hartmut Dumke as a co-supervisor since he had been with me in every question during that process and assisted me gain new perspectives.

Besides, I would like to thank the following people.

Dear Yaşar Acar provides me with moral and material support and always keeps his shadow on me as a tree.

My dear family, they always make me feel strong.

And my precious spiritual brother, Latif Çırak, who always helped me to find my way.

I wish to extend my special thanks to my beloved soulmate M. Emin Çırak, whose existence I thank daily, and I am so glad to have you. Without him, this journey would not have been possible.

Büşra SAĞLAM

TABLE OF CONTENTS

LIST OF ABBREVIATIONS viii

LIST OF FIGURES x

LIST OF TABLES xiii

LIST OF MAPS xiiii

ABSTRACT xv

ÖZET xvii

1 INTRODUCTION **1**

1.1 Literature Review **1**

1.2 Objective of Thesis **2**

1.3 Hypothesis **3**

2 RELATION OF SUSTAINABLE ENERGY POLICIES AND REGIONAL DEVELOPMENT THEORIES **5**

2.1 Relationship between Energy and Development **5**

2.2 Europe Sustainable Development and Energy Policies **8**

3 DEVELOPMENT OF ENERGY POLICIES **14**

3.1 Energy policies in Türkiye and the situation in energy today in Türkiye **14**

3.2 Change of primary energy supply in Türkiye **21**

4 REGIONAL ECONOMIC POLICIES IN TÜRKİYE AND CURRENT SITUATION **53**

4.1 The reason of unbalanced regional development in Türkiye **53**

4.2 Regional economic development policies in Türkiye **54**

4.3 Türkiye Regional Economic Development Status at NUTS 1 (2020) **66**

5 THE EMPIRICAL RELATIONSHIP BETWEEN TÜRKİYE'S NATIONAL SCALE ENERGY DATA AND ECONOMIC GROWTH **88**

5.1 Energy Consumption Forecast Models for 2030 with Support Vector Regression and Multiple Regression Models **90**

5.2 Production Forecasting Model by Energy Sources **103**

5.3 Energy Dependency Prediction Model **108**

6 CONCLUSION 111

REFERENCES 121

PUBLICATION FROM THE THESIS 129

LIST OF SYMBOLS

Gw	Gross Weight – Gigawatt
Gw/h	Gross Weight - Gigawatt/ hour
Kw	Kilowatt
Kw/h	Kilowatt/hour
Mw	Mega-watt
Mw/h	Mega-watt/hour
Thousand TEP	Thousand Ton Equal Petroleum
TEP	Ton Equal Petroleum

LIST OF ABBREVIATIONS

BP	British Petrol
ÇNAEM	Çekmece Nuclear Resources Training Center
DAP	East Anatolian Project
DOKAP	East Anatolian Development Project
DPT	State Planning Organization
EIEI	Electrical Works Survey Administration
EMRA	Energy Market Supervision Agency
EPIAŞ	Energy Market Operation Inc
EU	European Union
EUROSTAT	European Union Statistical Office
GAP	Southeast Anatolian Project
GDP	Gross Domestic Product
GVA	Gross Added Value
KOY	Development Priority Regions
LPG	Liquid Petroleum Gasses
MAPE	Mean Absolute Percent Error
MENR	Ministry of Energy and Natural Resources
MMO	Chamber of Mechanical Engineer
MTA	Mineral Research Exploration
NPP	Nuclear Power Plant
OIZ	Organized Industrial Zone
OLS	Ordinary Least Squares
PCC	Pearson Correlation Coefficient
R&D	Research & Development
SCADA	Supervisory Control and Data Acquisition
SOE	Special Operations Executive
SVR	Support Vector Regression
SWOT	Strengths-Weaknesses-Opportunities-Threats
TAEK	Turkish Atomic Energy Institute
TANAP	Trans Anatolian Natural Gas Pipeline
TEDAŞ	Türkiye Electricity Distribution Inc.

TEİAŞ	Türkiye Electricity Transmission Inc.
TEK	Turkish Electricity Institute
TR	Turkish Republic
TUIK	Turkish Statistical Institute
UN	United Nations
UNEP	United Nations Environment Program
WUF	World Urban Fo

LIST OF FIGURES

Figure 3.1 Alteration of Türkiye's population and GDP per capita from 1923 to 2020 …..... **22**

Figure 3.2 1923-2020 amount of electricity generation and consumption ……..... **23**

Figure 3.3 2020 Türkiye primary energy supply ……..……..…… **25**

Figure 3.4 Share of energy resources in primary energy in Türkiye ……..…..….. **25**

Figure 3.5 Population sizes of NUTS 1 regions of Türkiye …….……...…**30**

Figure 3.6 GDP per capita in NUTS 1 regions of Türkiye…….....…… **30**

Figure 3.7 Distribution of Türkiye's 2000-2021 primary energy supply by areas of use….. **33**

Figure 3.8 Distribution of Türkiye's 2015-2021 primary energy supply by areas of use..…. **33**

Figure 3.9 Distribution of Türkiye's 2000-2021 primary energy supply by areas of use….. **34**

Figure 3.10 Installed capacity in Türkiye NUTS 1 regions (Mw) ……..…….….. **37**

Figure 3.11 Energy generation/consumption rate in Türkiye NUTS 1 regions …….....… **38**

Figure 3.12 Türkiye installed power rate by resources ……..…… **38**

Figure 3.13 Türkiye NUTS 1 regions installed power ratio by resources……..……. **39**

Figure 3.14 Distribution of energy consumption in TR1 region between 2000-2020 by usage ……..……. **44**

Figure 3.15 Distribution of energy consumption in TR2 region between 2000-2020 by usage ……..….. **45**

Figure 3.16 Distribution of energy consumption in TR 3 region between 2000-2020 by usage ……..……..**46**

Figure 3.17 Distribution of energy consumption in TR 4 region between 2000-2020 by usage ……..……..……**46**

Figure 3.18 Distribution of energy consumption in TR 5 region between 2000-2020 by usage ……..…….…**47**

Figure 3.19 Distribution of energy consumption in TR 6 region between 2000-2020 by usage ……..…….…**47**

Figure 3.20 Distribution of energy consumption in TR 7 region between 2000-2020 by usage ……..…….…**48**

Figure 3.21 Distribution of energy consumption in TR 8 region between 2000-2020 by usage ……..…**48**

Figure 3.22 Distribution of energy consumption in TR9 region between 2000-2020 by usage ……....**49**

Figure 3.23 Distribution of energy consumption in TR region A between the years 2000-2020 by usage …….…….. **49**

Figure 3.24 Distribution of energy consumption in TR region B between the years 2000-2020 by usage …….……... **50**

Figure 3.25 Distribution of energy consumption in TRC region between 2000-2020 by usage ……..…..….**51**
Figure 3.26 Distribution of energy consumption data of all regions by usage ….…...…….. **52**
Figure 5.1 Correlation analysis between variables…….……..... **89**
Figure 5.2 Total energy consumption in Türkiye by years (x10^{8})…….…. **90**
Figure 5.3 Change graphs of variables by years……..... **92**
Figure 5.4 Predictive power of total energy consumption model for SVR model (x10^{6}) ….. **93**
Figure 5.5 Predictive power of total energy consumption model for multiple regression model (OLS) (x10^{6}) ……...… **100**
Figure 5.6 Comparison of SVR and OLS models with actual amounts …….…….……..... **100**
Figure 5.7 Total energy consumption forecast to 2030 (x10^{8}) by SVR and OLS models ... **102**
Figure 5.8 Energy Production Graph Between 2000-2021 by Energy Sources …….…..…. **105**
Figure 5.9 Distribution of energy production by resources as of 2021 (ThousandTEP) **106**
Figure 5.10 Production forecasts of energy resources based on time series forecasts …..... **107**
Figure 5.11 Correlation between variables ……..... **110**
Figure 5.12 Graph of change in the relationship between total energy supply and dependency ……. **110**
Figure 6.1 Türkiye planning hierarchy system …….……...……**118**

LIST OF TABLES

Table 3.1 Classification of energy resources in terms of type ……..…….. **21**

Table 3.2 2000-2020 Türkiye Total Primary Energy Data ……..…...……**26**

Table 3.3 Main Indicators of NUTS 1 Regions ……..…… **31**

Table 3.5 Annual Change of Total Installed Capacity by Resources in Türkiye ….……...**36**

Table 4.1 Regional Development Tools Based on Traditional and New Economy ….……...**61**

Table 4.2 Regional development goals …….…….**64**

Table 5.1 Multiple Regression Analysis Model …….…..…..**94**

Table 5.8 Transportation Energy Usage- Enegy Consumption Regresion Analysis …….**98**

Table 5.9 Residential, Commercial, Service Sector Energy Usage- Energy Consumption Regression Analysis ……..……**99**

Table 5.10 Agricultural Energy Usage – Energy Consumption Regression Analysis…….…**99**

Table 5.11 Time Series Estimates of Independent Variables …….……...**101**

Table 5.12 Energy Consumption Estimates by Models (MW) ……...…….**102**

Table 5.13 Total Energy Production by Resources (Thousand TEP) Between 2000-2020...**103**

Table 5.14 MAPE Percentages of Energy Resources with Forecast Models …….…...**107**

Table 5.15 Production Forecasts Based on Time Series Analysis 2023-2030 (Thousand TEP)…….……...**108**

Table 5.16 Energy Dependence Based on Import and Export Quantities for 2030….……..**109**

Table 6.1 Fundamental Socio-Economic and Energy Indicators of Türkiye NUTS1 Regions…….……...……..……..1**21**

Table 6.2 Energy Sources Rate By NUTS1 Regions …….…….…....**121**

LIST OF MAPS

Map 3.1 Distribution of Türkiye's Population and GDP Values by Level 1 Regions……..**29**

Map 3.2 Energy Consumption and Installed Capacity in NUTS 1 Regions of Türkiye ….. **35**

Map 3.3 Installed Capacity Rate by Resources in Türkiye NUTS 1 Regions ……...…… **41**

Map 4.1 Türkiye and Germany Solar Energy Potential Map …….……... **83**

Map 4.2 Türkiye Wind Energy Potential Map ……..…..…… **86**

Map 4.3 Türkiye Geothermal Resources Map …….…….. **87**

Map 6.1 Spatial Relation of Renewable Energy Potential in Türkiye …….…. **120**

ABSTRACT

Effects of Energy Policies in The Context of Regional Development: A Review on Türkiye NUTS1 Regions

Department of Urban and Regional Planning

Master of Science Thesis

Supervisor: Prof. Dr. Senay OĞUZTIMUR

Co- supervisor: Assoc. Dr. Hartmut DUMKE

Energy is a vital issue that affects the functioning of individual and social life, regional and national development, and national and international policies. Energy is one of the essential needs, especially in the 21st century, when it is considered together with what the technology era brings. The increase in energy consumption daily necessitates an increase in energy production. However, only some countries have equal energy resource potential. For this reason, there is an energy crisis in the world. Countries with insufficient energy sources and production meet their necessary energy needs by importing, which creates an economic burden in the development processes of countries. The ability of each country to provide energy security, independence, and financial stability is a fundamental element for national liberation.

In the 21st century, the first step was taken in the United Nations Framework Convention on Climate Change in 1992 to reduce the use of fossil resources due to problems such as environmental pollution, global warming, and climate change and to turn to renewable energy resources instead of fossil resources. Changing traditional resource use and reducing carbon emissions are among the main goals of all countries that have ratified the Paris Agreement, which entered into force in 2016.

In this study, based on the literature research, energy policies were primarily examined, and the change in energy policies from the establishment of Türkiye to the present day was analyzed. First, the importance of the energy issue in the 21st century and the sustainable energy policies of the European Union countries have been evaluated. Then, energy consumption, production, and dependency demand forecasts for 2030 were developed by considering the spatial and socio-economic effects of Türkiye's energy policies and projects in the context of regional development, a global energy and development issue. Finally, the study was concluded with the regional development policy recommendations and evaluation section based on the future forecast.

Keywords: Sustainable development, balanced regional planning, energy policy, energy-economy scenarios, forecast demanding

ÖZET

Bölgesel Kalkınma Bağlamında Enerji Politikalarının Etkileri: Türkiye İBBS Düzey 1 Bölgeleri Üzerine Bir Değerlendirme

Şehir ve Bölge Planlama Bölümü

Yüksek Lisans Tezi

Danışman: Prof. Dr. Senay OĞUZTİMUR

Eş- Danışman: Dr. Hartmut DUMKE

Enerji; bireysel ve toplumsal yaşamın işleyiş şeklini, bölgesel ve ulusal kalkınmayı, ulusal ve uluslararası politikaları etkileyen hayati bir konudur. Özellikle 21. yy'da teknoloji çağının getirdikleriyle beraber düşünüldüğünde enerji en önemli ihtiyaçlardan birisidir. Enerji tüketiminin her geçen gün artması enerji üretiminin de artmasını gerekli kılmaktadır. Ancak her ülke eşit enerji kaynağı potansiyeline sahip değildir. Bu sebeple de dünya üzerinde enerji krizleri yaşanmaktadır. Enerji kaynağı ve üretimi yetersiz olan ülkeler gerekli enerji ihtiyaçlarını ithal ederek karşılamaktadırlar ve bu durum ülkelerin kalkınma süreçlerinde ekonomik bir yük oluşturmaktadır. Her ülkenin enerji güvenliğini, bağımsızlığını ve ekonomik stabiliteyi sağlayabilmesi, ulusal bağımsızlık için temel bir unsurdur.

21.yy'da çevresel kirlilik, küresel ısınma ve iklim değişikliği gibi problemler sebebiyle fosil kaynak kullanımının azaltmak, fosil kaynaklar yerine yenilenebilir enerji kaynaklarına yönelmek amacıyla ilk adım 1992 yılında Birleşmiş Milletler İklim Değişikliği Çerçeve Sözleşmesi'nde atılmıştır. Geleneksel kaynak kullanımını değiştirmek ve karbon emisyonunu azaltmak 2016 yılında yürürlüğe girmiş olan Paris Anlaşmasını onaylayan tüm ülkelerin temel hedefleri arasındadır.

Yapılmış olan literatür araştırmalarından yola çıkılarak bu çalışmada öncelikli olarak enerji politikaları incelenmiş olup Türkiye'nin kuruluşundan günümüze kadar geçen sürede enerji

politikalarında yaşanan değişim analiz edilmiştir. 21. yy'de enerji konusunun önemi ve Avrupa birliği ülkelerinin sürdürülebilir enerji politikaları değerlendirilmiştir. Daha sonra küresel bir öneme sahip olan enerji ve kalkınma konusu bölgesel kalkınma bağlamında Türkiye enerji politikalarının ve projelerinin mekânsal ve sosyo-ekonomik etkileri değerlendirilerek 2030 yılı için enerji tüketim, üretim ve bağımlılık talep tahminleri geliştirilmiştir. Yapılmış olan gelecek tahmini üzerinden bölgesel gelişme politika önerileri ve değerlendirme bölümü ile çalışma sonlandırılmıştır.

Anahtar Kelimeler: Sürdürülebilir kalkınma, dengeli bölgesel kalkınma, enerji politikaları, enerji-ekonomi senaryoları, enerji talep tahmini

1
INTRODUCTION

1.1 Literature Review

Energy is an essential element of daily life at the individual and national levels. It is one of the elements that help people meet their basic needs that enable them to survive. For countries, it forms the basis of progress in technology and industry, meeting social needs and development. Governments aim to strengthen their energy resources locally to reduce their share in household expenses and because of their national strategic value.

One of the conditions of a strong economy is the production of safe energy that is not dependent on foreign sources and is safe. However, for nations' economic and social development, it is necessary to produce cheap, reliable, and clean energy. The security of energy brings with it its continuous and uninterrupted being. In addition to the alternative energy issue that comes to mind when the clean energy source is mentioned, this is directly related to the accurate site selection of the clean energy to be produced, affecting the energy production from a clean source. Therefore, the energy issue has multifaceted political, economic, and environmental elements. In this context, in the literature, it is seen that many studies are proving a bilateral causality relationship between energy production and economic development.

Since fossil resources can be extracted in certain places worldwide, many countries have to meet their energy needs by importing. That means a significant burden for the economies of energy-importing countries. On the other hand, developed countries are energy exporters; it is experiencing a paradigm shift in their energy production and consumption policies, considering the energy-based global warming and climate change issues.

Türkiye is a developing country, investments in technology and industry are constantly increasing; in this case, the need for energy increases daily. The increase in energy requirement makes reaching clean, reliable, and cheap energy necessary. Currently, energy imports constitute ¼ of the total imports. On the Ministry of Foreign Affairs website, the rate of foreign dependency on energy is 74%. According to this ratio, ¾ of the energy consumed by Türkiye is imported. This situation creates a severe economic burden and negatively affects development.

Countries are looking for local alternatives for energy production since energy imports pose a development threat for nations, and the tendency towards renewable energy is increasing daily

due to the global climate crisis. While increasing energy production, they also work on energy efficiency projects to reduce the energy consumption rate because it is stated in the literature that achieving regional development and national development goals will be possible only by maintaining a generation-consumption balance.

1.2 Objective of Thesis

Unbalanced regional development is an unsolved problem for Türkiye and the world. In the case of Türkiye, the eastern part of the country has a meager impact on development. When evaluated within the country, it can be said that eastern part lags compared to the western region. Can the energy sector, especially the renewable energy potential, be an opportunity in line with the national development and balanced regional development goals to prevent this regional inequality? This question is the main research question of this study.

The literature has many studies on the relationship between energy and development, sustainable development, and renewable energy. However, most of these studies only offer economic evaluation. In addition to the existing literature, this thesis discusses the subject from the regional planning perspective and provides a different perspective.

The first aim of this study; is to draw attention to the importance of energy for regional development by examining the energy policies, investments, and current energy data in Türkiye and Europe's sustainable energy and balanced regional development policies. The second purpose is to make an energy demand forecast for the year 2030 for energy supply and demand in Türkiye. Finally, based on global data, it evaluates spatial and socio-economic implications in the context of balanced regional development to reduce energy dependence.

Within the scope of the thesis, exploratory research was conducted. After the literature review, necessary quantitative data were collected from the relevant institutions. The data and findings collected within the scope of the study evaluate the energy potential of Turkey's land borders. Also, the study used NUTS 1 regions from the Statistical Regional Unit Classification. Using NUTS1 Regions is because it creates spatial integrity in terms of geography and has a size close to the surface area of European countries in terms of area size so that more convenient data can be compared. Time was handled in two different ways in the study. First, the process and results from the past to the present were revealed by making a process analysis. Then a demand forecast was made for 2030 using regression and time series methods, giving weight to recent data.

1.3 Hypothesis

Energy is one of the elements that help people meet their basic needs and survive. It forms the basis of progress in technology and industry, meeting social needs and development. Countries aim to strengthen their energy resources locally to reduce their share in household expenses because of their national strategic value. One of the conditions of a strong economy is the production of safe energy that is not dependent on foreign sources and is safe. In this context, in the literature, it is seen that many studies are proving a bilateral causality relationship between energy production and economic development.

Two research questions were determined in this study. These are,

1. Can national and regional development policies support the balance between energy consumption and energy potential?

2. Can energy policies be a solution/suggestion for unbalanced regional development?

In the literature's economic studies that reveal the causal relationship between development and energy production/consumption, population, per capita national income, and export and import rates are considered independent variables. In this study, in addition to the economic analyses, an approach from the perspective of urbanism was added, and the rate of urbanization and the energy consumption of the sectors were counted among the indicators of the hypothesis. Sectoral consumption amounts have been considered essential variables since it is also a part of the research that what amount of energy consumption is realized in which sector in which region within the scope of NUTS 1 region of Türkiye.

As a result of all research and data, hypotheses and sub-hypotheses were developed as follows:

H0: The change in socio-economic indicators for 2000-2020 in Türkiye has no effect on energy consumption.

HA: The change in socio-economic indicators for 2000-2020 in Türkiye affects energy consumption.

The sub-hypotheses formed within the scope of this central hypothesis are presented below:

H1: Population size affects energy consumption in Türkiye.

H2: GDP per capita affects energy consumption in Türkiye.

H3: The number of exports in Türkiye affects energy consumption.

H4: Import amount affects energy consumption in Türkiye.

H5: Urbanization rate affects energy consumption in Türkiye.

H6: Energy use in the industrial sector in Türkiye affects energy consumption.

H7: Energy use in the transportation sector in Türkiye affects energy consumption.

H8: Energy use in residential, commercial, and service areas in Türkiye affects energy consumption.

H9: Energy use in the agricultural sector in Türkiye affects energy consumption.

In this context, with exploratory research, firstly, literature research and then analyses were made using support vector, multiple regression, and time series methods to answer the research questions and test the hypotheses.

2

RELATION OF SUSTAINABLE ENERGY POLICIES AND REGIONAL DEVELOPMENT THEORIES

2.1 Relationship between Energy and Development

The effect of energy on society and the economy comes to the fore with specific events. The main reasons were the Industrial Revolution, World War II, and the oil crisis in the 1970s. The transition to mass production has led to the concentration of the population in cities and cyclically more energy consumption. Pioneering studies investigating the relationship between energy consumption and economic growth are Kraft and Kraft (1978) and Akarca and Long (1980). The relationship between energy consumption/production and economic growth is a global research topic. When we look at the studies that have been done, it has been observed that similar studies have been carried out worldwide from the Far East to America. Especially in China, these studies are a subject of investigation not only for urban areas but also for rural areas. With the ecological economics approach, energy has been evaluated as a third factor of production in addition to labor and capital, which are factors of production [1].

Energy resources, which are of fundamental importance in all areas of life, especially for national development strategies, are unevenly distributed worldwide. For this reason, many countries import the resources they need. However, this situation creates an economic burden for governments. Looking at B.P. World Statistics, fossil fuels have a share of 82% of the primary energy supply in the world. Russia is by far the world's leading exporter of fossil fuels [2]. According to the European Union Statistical Office (EUROSTAT) data, E.U. countries imported 58% of the energy they used in 2020. On the other hand, Türkiye's dependence on foreign energy is 71%. Being dependent on foreign energy reduces national competitiveness. For this reason, countries develop sustainable development policies. Sustainable energy policies are directly related to using renewable and local energy sources.

The most basic way that countries use to achieve their goals of reducing carbon emissions and fossil fuel use, as well as ensuring national energy security and energy efficiency, within the scope of combating climate change, is to use local and renewable energy sources. Diversifying energy resources, being independent in energy, and increasing national competitiveness are the main goals of nations [3].

According to the search results on the Web of Science site, when "energy policies" and "sustainable energy policies" are written as keywords, it is seen that there was a total of 40.100 publications between 1975-2022. When the time is changed to 2018-2022, it is seen that 29.000 of these publications were published in the last four years. When the keywords are updated as "energy" and "regional development," it is noticed that there are 10,276 articles in total between 1980-2022, but 5,223 of them were published between 2018-2022. As a result of this analysis, the subject of energy and development has a rising trend soon.

In the study by Usama Al-mulali in 2014, the relationship between GDP growth and renewable and non-renewable energy consumption in 82 developing countries classified by region was investigated. Using the data between 1990 and 2009, panel analysis and cointegration test results methods were used. As a result of the test, it was revealed that the consumption of renewable and non-renewable energy has a long-term positive relationship with the economic sectors in the whole region. However, the results showed that non-renewable energy consumption has a more significant impact on economic sectors. According to the study, the main reason for this situation is that the primary energy consumption of these regions is fossil fuels. Therefore, the study advises increasing renewable energy projects and investments to increase renewable energy consumption in energy consumption [4].

The study of Adrienne Ohler and Ian Fetters in 2014 is on the causality relationship between renewable energy production and GDP development. The study examined the causality between electricity generation from renewable sources and economic growth in 20 OECD countries from 1990 to 2008. According to the results obtained from the panel error correction model, there is a bidirectional causality relationship between total renewable energy production and GDP, and biomass, hydropower, waste, and wind energy show a long-term positive relationship with GDP. Hydropower and waste generation show a short-term positive bidirectional relationship. Biomass, hydropower, and waste electricity generation significantly impact real GDP in the long run. He states that in the short run, biomass and waste production increases negatively affect GDP, while renewable and hydroelectric energy increases GDP. And the study indicated that current policies cause a decrease in biomass and waste energy. Still, increasing electricity production from hydroelectric, wind energy, and energy-saving policies will positively affect GDP [5].

According to the study prepared by David I. Stern in 2015, energy consumption is positively related to GDP. However, the energy density decreased over time. Many factors affect the energy intensity of economies. Energy efficiency is one of the most important of these.

According to the statement in the study, Ecological economists and some economic historians argue that increased energy supply is the primary driver of growth. Energy intensity is rising in many developing countries, but the reasons for this have yet to be explored. Few guides exist on energy efficiency policies' real energy-saving potential [6].

The article was written by Caraiani C. et al. in 2015; It covers the period 1980-2013 and is about the causality relationship between energy consumption and GDP in the context of developing European countries. It details energy consumption according to sources and refers to five European developing countries. Unlike previous studies, it analyzed long- and short-term bidirectional relationships. A three-stage analysis was carried out regarding the effect of energy consumption on economic growth. Stability, cointegration, and causality tests were performed [7].

The article by Selay Giray Yakut et al., published in 2021, shows that the study's primary purpose is to examine the relationship between the variables determined in the literature. Afterward, the study was completed using multivariate analysis techniques to understand Türkiye's place in the world in the context of variables. Correlation, factor, and cluster analysis were used, and as a result of these analyses, Brazil, Uruguay, and Chile were shown to be similar to Türkiye. GDP per capita, carbon dioxide emissions, inflation, and foreign trade was determined as energy use variables. Achieving economic growth and increasing GDP per capita bring about an increase in energy use. With the rise in energy use, carbon dioxide emissions increase. The increase in GDP per capita increases energy production and consumption. When examining inflation and foreign trade variables, since most of the energy needed in Türkiye is imported, economic growth increases the energy supply and a foreign trade deficit. Due to the increasing current account deficit and rising exchange rate naturally triggers the inflation process [8].

While examining global resources, another approach that has been particularly emphasized in recent years in connection with sustainable resource use and the climate crisis in European countries is integrated spatial energy planning. Countries related to this issue prepare national and regional integrated spatial plans and develop strategies. Considering that the areas where energy is used most intensively are cities and especially metropolitan areas, urban planning and energy are intertwined. Therefore, under specific headings such as energy systems, mobility, carbon-free zones, and building construction systems, decarbonization strategies are developed and implemented under these data.

Gernot Stoeglehner emphasizes the importance of the transition to sustainable energy systems in connection with the climate protection goals in his article published in 2020. He stated that most local and regional spatial strategies are essential in energy strategies. He emphasized the importance of energy saving in urban areas and the potential of renewable energy in rural areas. He explains the importance of integrated spatial energy planning in achieving sustainable development goals based on the research results obtained from his experiences in Austria [9].

On the other hand, Hartmut Dumke and his colleagues conducted a case study on balanced renewable energy scenarios in conjunction with integrated spatial energy plans in their article published in 2018. This study aims to respond to the increasing renewable energy increase with a balanced land use planning. This study shows how much energy plans are related to land use decisions and regional development. While the energy targets are taken at the national development scale, the effects of these decisions at the regional and local scale in the spatial scope are emphasized. It has been stated that the national energy demand and the objectives of increasing renewable energy production cannot be solved only by municipalities at the local level and the need for cooperation and coordination at the regional level. This study, which predicts the future of 2030, has established a relationship between requirements and targets. The examination organized a workshop with the determined stakeholders, acting on the principle of "participation in planning." The workshop prepared an assessment between the energy forecast scenario and land use using geographic information systems. [10]

2.2 Europe Sustainable Development and Energy Policies

The concept of sustainability was first included in the World Nature Charter document, which was accepted in 1982. The idea of sustainability has recently emerged as a rising value at local, regional, national, and global levels. On the other hand, sustainable development aims to meet the needs of individuals in settlements of all scales, taking into account the environmental dimension, without compromising the ability to meet the needs of future individuals.

The concept of sustainability is one of the fundamental issues in cities, as it is related to almost every subject. Cities, which are the centers of economic and social development, are areas where more than half of the world's population live and therefore have some environmental issues. The sustainable city concept aims to protect and improve natural resources, consider ecological values in economic activities, consider development differences between cities, and minimize the difference in welfare levels within the same city [11].

Considering the concept of sustainability within the framework of European Union policies, developing a sustainable city is a new phenomenon. Local and global measures are taken to ensure sustainable development, and this issue is discussed in more than one international platform. It is aimed to contribute to sustainable urban policies in the long term by making international agreements [12].

At the 1972 Stockholm Conference, environmental problems as a problem and the concepts of development and development were discussed for the first time. As a result of this conference, the United Nations Environment Program (UNEP) was established. This organization aimed to increase all societies' environmental awareness worldwide and coordinate with other United Nations units to transform environmental goals into action. After this conference, on November 22, 1973, the First Environment Action Program was approved by the European Union Council and the representatives of the member countries and turned into a community statement. The primary objectives of this program are:

- Protection and strengthening of natural capital,
- Ensuring the transition to a resource-efficient, green, competitive low, carbon economy,
- Protecting the health and well-being of citizens against environmental risks,
- Ensuring the necessary investments for environmental and climate policies,
- Strengthening the sustainability of cities,
- Establishing consistency by ensuring the integration of all policy areas of the environment,
- Strengthening the Union's effectiveness on global environmental and climate problems [13].

At the Habitat I Conference held in Canada in 1976, the main objective was to solve the urbanization problems of developing countries and provide international cooperation on urban sustainability.

In the Rio Declaration made in 1992 to create new levels of cooperation between key sectors of society and people, working towards international treaties that protect the global system of environment and development that considers the interests of all societies, A statement was published recognizing the intimate and unified nature of the world.

Habitat II Conference in 1996; has an important place in sustainable development. At this conference, the scope of sustainable development was expanded, the relationship of the concept

with different disciplines was emphasized, and the concept of sustainable development was associated with many fields of study, from economy to management.

The World Urban Forum (WUF) was established in 2001 by the United Nations to examine the world's most pressing problems. Its objectives are to increase awareness of sustainable urbanization among constituencies and stakeholders, including the public, and to increase coordination and cooperation between stakeholders and constituencies to advance and implement sustainable urbanization [14].

The Kyoto Protocol is an international agreement to combat global warming and climate change in 1997. Countries that have signed the protocol have promised to reduce their emissions of carbon dioxide and five other greenhouse gases, or to increase their rights through carbon trading if they cannot. According to the contract:

- The amount of greenhouse gas released into the atmosphere will be reduced to 5%,
- Legislation to reduce the amount of greenhouse gases originating from industry, motor vehicles, and heating will be rearranged,
- Heating with less energy, traveling long distances with less energy-consuming vehicles, and placing less energy-consuming technology systems in the industry will be ensured,
- It will be directed to alternative energy sources to reduce the rate of methane and carbon dioxide released into the atmosphere,
- For example, biodiesel fuel will be used instead of fossil fuels,
- Waste processes will be rearranged in enterprises that consume high energy, such as cement, iron-steel, and lime factories,
- Systems and technologies that emit less carbon in thermal power plants will be put into use,
- Solar energy will be paved the way; since nuclear energy is carbon-zero, this energy will be brought to the fore in the world,
- Countries that consume more fuel and produce more carbon will be taxed more. [15]

Kyoto Protocol was adopted in the General Assembly of the Grand National Assembly of Türkiye in 2009 and became a law. The National Climate Change Strategy Document, which will cover 2010-2020, has been adopted. The action plan based on this document was completed in 2011. [16]

Europe is enthusiastically working on energy policies. It aims to maintain its role as a global leader in renewable energy production until 2030 and contribute within the scope of combating

climate targets. The European Union has set sustainable development goals with agreements such as the Green and the Paris Agreements. Among these targets, the issue of renewable energy is also supported. It aims to protect the environment and reduce air pollution in cities with policies. It enables households and businesses to become clean energy producers. It reduces foreign dependency on energy and increases energy security. In this way, it creates more employment and attracts new investments to the European economy.

- New policies for renewable energy sources,
- Provides a long-term safe and risk-free environment for investors and accelerates the procedures for obtaining permits for projects,
- Puts the consumer at the center of the energy transition, with the right to produce renewable energy,
- Increases the competition and market integration of renewable electricity,
- Accelerates the use of renewable energy in the heating/cooling and transportation sectors,
- Strengthens the sustainability of bioenergy and promotes innovative technologies.

It has been stated that economies of scale can be achieved by acting at the European Union level. Moreover, by sharing best practices, we aim to have a more profound impact across the continent. Thus, it is claimed that a reasonable approach will be provided for consumers thanks to sustainability, growth, and increased employment.

Looking at the European Union's 2030 action plan, transformation in the energy system, buildings, transportation, and industry is one of the main goals. The main objective of the developed policies is:

- To reduce greenhouse gas emissions by 55%,
- Increasing the share of renewable electricity generation from 32% to 65% or more by 2030
- To increase employment with localization by providing the opportunity to encourage local investments in renewable resources, especially for rural areas [17].

The Paris agreement is a guiding agreement for the whole world for the transition to clean energy on a global scale. It is the first global climate change agreement covering almost all global carbon emissions. It is enough to guide the world to transition to clean energy worldwide. It necessitates changes in all political decisions, business, and investment behaviors. The

agreement sends a clear message to stakeholders, investors, corporations, non-governmental organizations, and policymakers about the need for a global clean energy transition [18].

The sustainable development goals of the Paris Agreement, which entered into force in 2016, include access to affordable, reliable, sustainable, and modern energy for all. Within this main target, sub-targets are given. These are as follows:

- Provide universal access to affordable, reliable energy services by 2030,
- To significantly increase the share of renewable energy in global energy,
- Doubling the rate of improvement in energy efficiency,
- To cooperate internationally to facilitate access to energy research and technology, including renewable energy, energy efficiency, and clean energy, and to encourage investment in energy infrastructure in the context of renewable energy technology,
- Expanding infrastructure and upgrading technologies to provide modern and sustainable energy services in developing countries, especially underdeveloped ones.

Based on this agreement, Türkiye has stated that it will voluntarily reduce its greenhouse gas emissions to below 21% by 2030. It has been observed that Türkiye's economic growth has slowed since 2012, and per capita income has started to stagnate and decline in the last 12 years. For Türkiye to develop further, switching to a low-carbon development model with technological innovation and strategic policy options is necessary rather than existing carbon-based, low-value-added production sectors. Türkiye has determined its targets for using renewable energy, especially in the energy field, and the transition to nuclear energy. In addition, it foresees low-carbon investments that will provide energy efficiency in industry, the transportation sector, and urbanization and declares that it will reduce greenhouse gas emissions. A severe transformation is required in all energy usage areas, especially in energy-intensive sectors. The Paris Agreement gave a clear signal to the whole world for this transformation. Today, when renewable energy has become competitive, it is crucial for the relevant sectors to make the necessary plans and investments for the transition to clean energy [19].

Energy security is an essential element for Türkiye in its current geopolitical position. For this reason, it is vital to find sustainable solutions with renewable energy policies. It is seen that some Central European countries have succeeded in increasing their energy consumption from renewable sources by following a green procedure, even if they do not have suitable conditions for renewable energy consumption (Austria 33.77%, Croatia 31.6%). These examples show that

the implementation of sustainable energy policies that support the goals of the 2030 sustainable development agenda can be achieved with developable targets [3].

Today, the world; is faced with the global epidemic and the Ukraine-Russia War, economic crisis, global warming, climate crisis, and rising energy prices. The energy crisis due to the war between Ukraine and Russia; has highlighted Europe's dependence on fossil fuels and has raised the need, more than ever, for a rapid transition to clean, renewable energy and energy savings. The strategy proposed by the European Commission in response to the energy crisis and war in Ukraine; is aimed at taking measures for a sustainable future. These measures are; increasing energy efficiency and savings, giving up fossil fuel purchases, using alternative energy sources as a temporary solution to the energy crisis, using renewable energy sources, and transitioning to sustainable public transportation based on clean sources [3].

3
DEVELOPMENT OF ENERGY POLICIES

3.1 Energy policies in Türkiye and the situation in energy today in Türkiye

Since fossil resources can be extracted in certain places worldwide, many countries meet their energy needs by importing. It means a significant burden for the economies of energy-importing countries. On the other hand, countries that are energy exporters are experiencing a paradigm shift in its policies in energy production and consumption policies, considering the energy-based global warming and climate change issues.

As Türkiye is a developing country, investments in technology and industry are constantly increasing. For this reason, the need for energy is increasing day by day. Growing energy needs; brings with it the necessity of reaching clean, reliable, and cheap energy. Currently, energy imports constitute ¼ of the total imports. Imports meet 70.6% of the primary energy supply. This situation harms national and regional development.

The increasing population, sectoral diversification, and growing country's economy have increased the demand for energy supply in Türkiye since 1923. As indicated in the graph of gross electricity production amount (GWh) and net electricity consumption amount (GWh) given in Figure 3.2, there is a proportional increase between supply and demand. Considering the change in the data provided in this graph, it is seen that the amount of energy production and consumption between 1923-1960 was meager, A particular movement between 1961-1980. There was a breaking point in 1980. In the period after 1981, the amount of electricity production and consumption accelerated in the graph. After 2001, the acceleration in this increase reached its highest level. For this reason, to understand and evaluate the strategies and policies that Türkiye has developed to meet its energy needs, this section, the ninety-nine-year period, has been divided into four periods.

- **1923-1960 Early Republican Period Energy Policies**

Policies and strategies developed regarding energy are related to economic changes and developments. With the establishment of the Republic of Türkiye, the Izmir Economy Congress was held in the same year. The prevailing view on energy in this congress is to meet the energy

need with domestic resources, especially coal, except in obligatory situations. These decisions formed the basis of the energy policies adopted until the 1950s. Since it is a process where the industry is not intense, energy is mainly consumed for heating and lighting purposes in residences.

In 1926, the Petroleum Law was enacted. With this law, all oil exploration rights within the country's borders were given directly to the government per the law. The state has taken its first steps towards becoming an actor in the energy field. One of the duties of the Industry and Mining Bank of Türkiye, which was established this year, has been determined to provide loans to Turkish industrialists and miners. [20]

The main subject of the Industry Incentive Law (1927) was to provide various exemptions, concessions, and incentives to enterprises that would make industrial investments in every field. Until the 1930s, the state's view of the economy, investments, and policies was regulated according to liberal economic rules. It remained in force with various changes for about 15 years until the adoption of the principle of statism, which would dominate after this date [21]. The Republic's first years were when electricity was available only in some provinces, and the annual electricity consumption per capita was 5KWh [22]. In the Republic, importance was given to electricity production, but the lack of operation and capital required the establishment of production activities with foreign capital partnerships. As a result, concessionary electricity companies have been established in cities such as Ankara, Urfa, Adana, Konya, Malatya, Bursa, Mersin, Balıkesir, Gaziantep, Tekirdağ, Edirne, İzmir, Antalya, Trabzon. [20]

During the economic depression in 1930, statist policies dominated Türkiye. It aimed to protect coal, Türkiye's most essential energy source, from foreign competition and to meet its energy consumption with domestic resources. In this period, the share of mining and energy investments in total investments is approximately 27%. Etibank / MTA and other national energy companies were established in 1935. Many national companies have been found to implement energy policies whose basic policy is statism [20]. The state bought these companies from the end of 1930 until the middle of 1940, and their authorities were transferred to the municipalities. The period between 1940-1950 II. It is the period of World War II. For this reason, in this period, as in the whole world, it is seen that the economic shrinkage experienced in Türkiye, the electricity consumption decreased, and statist policies were implemented.

After 1950, it transitioned to a multi-party and economically more liberal period. In this period, urbanization, industrialization, and economic growth were faster. For this reason, studies on the

diversification of energy sources have started (Demir, 1980As a result, energy consumption in Türkiye increased by an average of 4.3 percent per year from 1950 to 1960 [23].

- **1961-1980 Planned Development and Statist Policies Period Energy Policies**

With the preparation of the First Development Plan in 1963, an economic process was started in which planned and statist policies were developed. In the period between 1960-1980, three development plans were prepared. When we look at the targets and strategies set on energy in the development plans, it is stated that almost all energy and water facilities are under state control.

Considering the energy policies produced in this period, it aimed to use energy resources effectively and minimize production costs. Savings in energy were encouraged, pricing was determined according to the cost and local-imported nature of energy prices, and the nature of local resource use was emphasized. In this period of increasing industrialization and urbanization, the primary energy supply issue has gained more importance. The Turkish Electricity Authority (TEK) was established in 1970. With national growth, increasing urban population, and industrial development, energy consumption demands have also increased. Against this situation, the search for local resources has been raised to increase the supply. The fact that energy consumption increases during periods of economic leap and decreases during periods of stagnation reveals the relationship between economic growth and energy.

After the establishment of the Turkish Atomic Energy Agency (TAEK) in 1956 within the scope of uranium and thorium energy resources research in the context of nuclear energy, the Çekmece Nuclear Research Training Center (ÇNAEM) was established in Istanbul in 1962, and the Nuclear Research Center in Ankara in 1967. However, there is no government policy on nuclear energy in Türkiye. They are seen as promising as domestic production, and export may be questioned when future uranium and thorium reserves are used [23]

- **Energy Policies in the 1981-2000 Liberalization Period**

In this period, there need to be more inadequacies in the energy sector, rural-urban, inter-regional and intra-regional imbalances brought about by rapid urbanization. For this reason, it is aimed to eliminate the deficiencies and follow the balanced development method. In the primary energy supply, domestic demand has increased by an average of 16.4% per year, and 40.9% of the total investments include oil and 59.1% coal investments. Nuclear energy is mentioned in the fourth development plan for the first time. Considering the development

potential of nuclear power, it has been stated that exploration and investigation studies will be initiated to determine the presence of radioactive mineral resources in the country. The General Secretariat of the Atomic Energy Commission, established in 1956 with the law numbered 6821, was restructured under the name of TAEK under the Prime Ministry with the law numbered 2690 in 1982.

- The management of known reserves of national energy resources will be essentially; will be developed, and programs to find new reserves will be accelerated.
- Necessary research will be continued to benefit from new energy sources,
- It will be ensured that the known energy resources are connected to their reserves and reach economic operating conditions in a way that will support the development of the country,
- It has been stated that necessary improvements and arrangements will be made in the established laws of TEK and EIE Administration.

After 1985, energy production is predicted to increase by an average of 7.7% per year. It is aimed to provide this increase mainly due to lignite and natural gas. Therefore, when the shares of resources in primary energy production are analyzed, it is estimated that lignite production, whose share was 29.8% at the beginning of the V. Plan period, will approach 38 percent at the end of the period, the share of hydraulic energy will rise to 20%, and the share of crude oil will decrease.

The energy sector is planned to have a structure that supports economic development. Therefore, it was stated that energy investments would continue to be emphasized, and private sector and foreign capital initiatives would be kept in the exploration/production of energy raw materials.

For the first time, in the V. Development Plan, under the priority of giving priority to reliable and cheap energy sources, the issue of supporting initiatives related to alternative energy sources has come into question. And for the first time in this plan period, the preparation of the "Energy Master Plan" is mentioned. The primary purpose is to provide reliable, cheap, and quality energy to all user segments, on-site and on time, to support economic and social development. It is observed that the tendency to import resources has increased due to the need for a more and higher quality of local resources.

In this period, it was aimed to commission hydroelectric power plants and a thermal power plant based on imported coal, and this target was achieved. It was emphasized that a

comprehensive study is necessary to determine the long-term position of natural gas imports, new natural gas pipelines, city distribution networks and connection line investments, and the place of natural gas in Türkiye's general energy balance. It was stated that to reduce environmental pollution in energy production, technology transfer will be made by the characteristics of existing and newly established facilities, and R&D programs will be supported to benefit from the potential of renewable alternative energy resources.

In the 1990s, energy imports reached 49%. Build-operate-transfer models were introduced while establishing the power plant, which created financial difficulties. As a result, the domestic oil supply has reached 20% of the total share, and joint production initiatives have been made in oil abroad. Establishing a reliable and low-cost energy supply system in the long term is essential. In this direction, it is aimed to develop domestic energy resources and start the necessary projects for the supply of imported resources, whose share in consumption will increase over time.

In this period, when foreign expansion and liberal policies were adopted, it was observed that energy imports increased by moving away from being self-sufficient statist policies. While natural gas imports started for the first time in this period, alternative energy sources were also mentioned for the first time, and R&D studies were started. As a result, the primary energy supply, especially from the hydraulic energy source, increased in this period.

- **Energy Policies in the Sustainable Policies Period after 2001**

  It has been mentioned that necessary measures will be taken to meet the energy demand reliably and continuously at a low cost in 2000 and beyond. It has been stated that the liberalization in the energy sector will continue, and the arrangements to ensure private sector participation will continue. In this context, it has continued its existence by being subject to regulations that prevent the build-operate, build-operate-transfer models from leading to anti-competitive practices. It was deemed necessary to transform the energy sector market into a competitive structure and to implement regulatory audits in this context. A study has been conducted on energy availability in the world. The energy assets of the countries were evaluated, and the networks to be established were emphasized. As of 2014, energy imports constitute ¼ of the total imports, and it is necessary to reduce this foreign dependency on energy, so it is planned to create alternative energy policies. As a result, the market shares of the private sector have increased. For this purpose, renewable energy production continued to be supported to increase energy supply security. Domestic coal

resources were opened to the private sector for electricity generation, studies on constructing nuclear power plants were started, regulations were made to increase energy efficiency, and various programs were implemented. For the year 2023, it is aimed to provide energy continuously, with high quality, sustainable, safe, and bearable costs.

Looking at the projects developed in this period, importance is given to cooperation projects in the fields of transportation, communication, and energy. It aims to bring Türkiye to the position of a country where the region's most crucial energy transmission lines intersect, especially with the projects related to the Baku-Ceyhan Oil Pipeline and the Caspian transit Turkmen Natural Gas to European countries via Türkiye. Within the scope of E.U. regional targets, it aims to establish a Trans-European energy network within the scope of E.U. regional targets, connect the unit to the central regions of the peripheral areas, and establish an integrated system. Within the content of the GAP, ten projects for irrigation and energy have been completed. R&D studies on the search for raw materials for geothermal and nuclear energy continued in this period. In 2004, the Electricity Energy Sector Reform and Privatization Strategy Document was prepared and implemented. In a "transition period" proposed within the framework of this document, the necessary works, especially the measures to be taken regarding the privatization of electricity distribution and generation facilities and the security of supply, have been linked to a program, and responsible and responsible relevant institutions have been determined. Baku-Tbilisi26 Ceyhan Main Export Pipeline project was completed in 2006. With the agreement made with the Russian Federation, the Samsun-Ankara Natural Gas Transmission Line was completed, and gas purchases from this line began in 2003.

An agreement was signed with the Russian Federation to construct the Akkuyu Nuclear Power Plant. In addition, Japan signed an agreement to establish a second NPP with a power of 4,480 MW in Sinop. Furthermore, a bilateral cooperation agreement was signed with the United Arab Emirates (UAE) to utilize Afşin-Elbistan lignite deposits in electricity generation. An intergovernmental agreement was signed with Azerbaijan to realize the Trans-Anatolian Natural Gas Pipeline (TANAP) project.

A sustainable development approach aims to consume and supply energy at a minimum amount and cost to support economic and social development, destroying the environment at the minimum level. In 2001, the Energy Markets Supervision Agency (EMRA) was established. To increase the share of renewable energy resources in electricity generation, Law No. 5346 on the Use of Renewable Energy Resources for Electricity Generation was

enacted in this period. In 2014, Türkiye's high dependence on oil and natural gas resources, mainly supplied from abroad, continued in its primary energy supply. In particular, the share of natural gas in electricity generation continues to be high. High dependence on a limited number of fossil fuel exporting countries is considered a risk factor regarding supply security. It has been stated that it is necessary to reduce foreign dependency on energy, and therefore alternative energy policies should be established. For this purpose, renewable energy production continued to be supported to increase energy supply security, and domestic coal resources were opened to the private sector for electricity generation, studies on the construction of nuclear power plants were started, regulations were made to increase energy efficiency, and various programs were put into practice. The Energy Efficiency Law introduced regulations encouraging and mandating the efficient use of energy. The Energy Efficiency Strategy Document published in 2012 aims to reduce energy intensity by at least 20 percent by 2023.

- Inclusion of energy supply from NPP in the portfolio,

- Activation of Nuclear Technical Support Joint Stock Company,

- Increasing the use of lignite reserves in electrical energy production by environmental standards,

- Supporting R&D projects related to clean coal technologies,

- Increasing the total underground natural gas storage capacity by completing the Tuz Gölü Underground Natural Gas Storage Project and the Northern Marmara Natural Gas Storage Expansion Project,

- Increasing the share of renewable energy resources in production, realizing plans and investments in this direction,

- Promoting energy efficiency, spreading more efficient buildings that can produce their energy,

- Completion of Tortum – Georgia energy transmission line project,

- Energy Market Operations Inc. (EPİAŞ) effectively maintains activities for the development of electricity and natural gas trading platforms with new market products,

- Completion of Turkish Stream Onshore Section-1 Natural Gas Pipeline Project,

- Carrying out studies on the development of the National Smart Grid Management System (National SCADA) for use in energy SOEs,

are stated as the energy policies for the year 2019-2023.

3.2 Change of primary energy supply in Türkiye

Energy supply is the provision of energy flow from energy sources to meet the demand in economic conditions. An energy economy can be expressed as the amount of energy offered to the market for consumption. When the energy resources are classified according to their use, they are renewable and non-renewable; When classified according to their recyclability, they are expressed as primary and secondary energy sources. The state of energy that has not undergone any change or transformation is described as direct energy (Table 3.1). [24]

Energy is an essential element and one of the basic requirements of countries' economic and social development. The presence of energy in the world has become an indicator of the level of development. The state of having an energy source and the amount of energy production affect growth. It is seen that most of the developing countries import energy. Therefore, it is an essential issue for developing countries to be able to meet their energy needs to make their development sustainable.

In this section, which will address the primary energy supply in Türkiye, energy resources will be discussed as conventional (fossil) and alternative.

Table 3.1 Classification of energy resources in terms of type

Energy Sources	
Energy Sources According to Their Uses	**Energy Sources According to Their Convertibility**
1. Non-Renewable	**1. Primary**
a. Fosil Kaynaklı	Coal
Coal	Petroleum
Petroleum	Natural Gas
Natural Gas	Nuclear
b. Çekirdek Kaynaklı	Biomass
Uranium	Hyraulics
Thorium	Solar
	Wind
2. Renewable	Wave
Hyraulics	
Solar	**2. Secondary**
Biomass	Electricity, Fuel Oil, Diesel

Table 3.1 Classification of energy resources in terms of type (Continuation)

Wind	Secondary Coal
Geothermal	Petroleum Coke
Wave	Air Gas
Hydrogen	Liquid Petrolium Gas (LPG)

The country's increasing population since 1923, sectoral diversification, and the developing country's economy increased energy consumption. (Figure3.1) The energy supply is also increasing with the growing population, the country's economy, and the development of industry and services sectors.

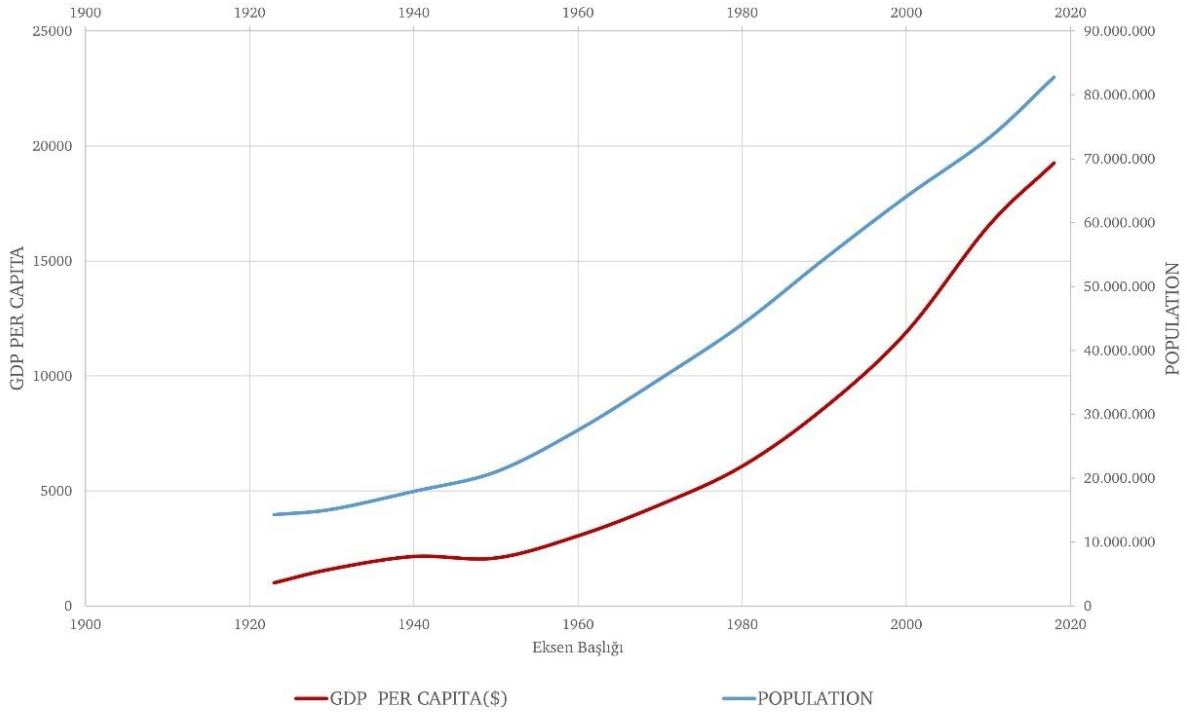


Figure 3.1 Alteration of Türkiye's population and GDP per capita from 1923 to 2020 [25]

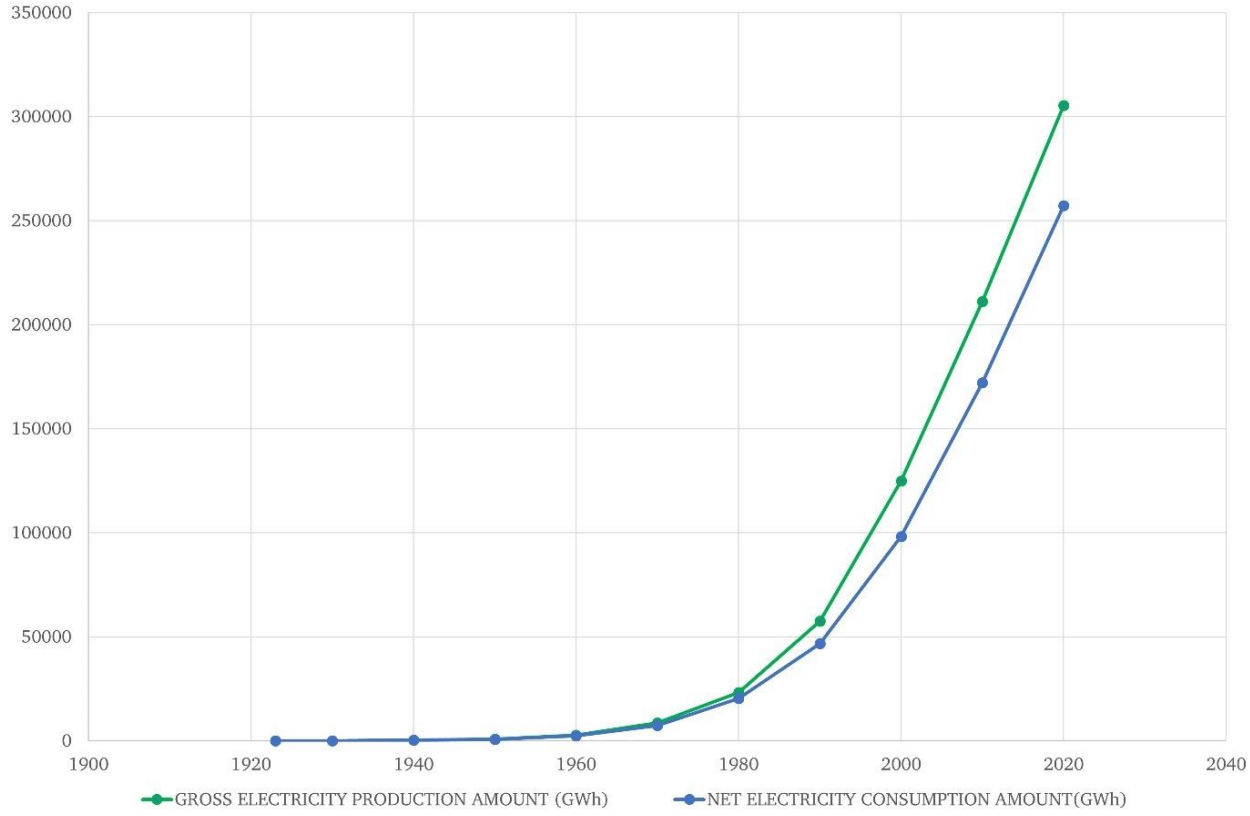


Figure 3.2 1923-2020 amount of electricity generation and consumption [26]

Türkiye is a developing country and is directly or indirectly affected by the economic fluctuations in the world. It has emerged due to the literature and secondary data analyses that have been searching for resources to provide energy supply since 1923 and that they are in the development targets for this need. In this study, in which the change of primary energy supply in terms of quantity and type over the years and the energy policies developed from 1923 to the present are discussed in the context of development plans, it is seen that urbanization, industrialization, and development goals and energy are in a direct relationship.

The development plans stated that during the Early Republican Period, coal, lignite, and non-commercial energy sources were intensively used from conventional energy sources. Petroleum reserves were explored after the 1950s with the increase in urbanization and industrialization, and oil imports were made. With the start of economic growth and development, there has been a period in which the energy demand has increased intensively, and the country's resources are not enough to meet this demand. As seen in Figure 3.2, energy production and consumption have been overgrown, especially after 1980. In the 1980s, the globalization process started in Türkiye with liberal policies. With the country's globalization, upward momentum is observed in economic growth.

Economic growth is the most crucial reason for the increase in energy demand. Other reasons for the rise in energy demand are; high birth rates (population growth), higher living standards, industrialization, and an increase in the rate of the young population [27]. Factors such as urbanization, the increase and diversification of machines and vehicles used by new technologies, and the change in consumption habits are other factors that increase energy demand [28]. As in the world, Türkiye's energy demand is rising rapidly. Industrialization and urbanization gained upward momentum in this period. Conventional resources such as coal and oil were used intensively in Türkiye until 1980, and after 1980, the use of natural gas started, and thus the tendency towards oil and coal decreased [25].

Today, 18.6% of Türkiye's total imports in 2021 are energy imports, and 70.7% of Türkiye's primary energy supply consists of imported energy resources [26]. Fluctuations in energy prices also trigger inflation, unemployment, economic recession, and recession in Türkiye. The country's energy dependency is increasing day by day. According to EUROSTAT 2020 data, Türkiye's dependence on foreign energy is 71%. This rate is given as an average of 58% in European countries [29].

T.R. According to the Ministry of Energy and Natural Resources data, Türkiye's total energy supply in 2020 was 147.17 million toes. When we look at how this supply is distributed to the resources, 28.66% of the total supply is oil, 27.67% is coal; 27.05% is natural gas, and 9.85% is geothermal, wind, and solar; It is seen that 4.56% is hydraulic and 2.31% is bioenergy, waste, and other resources (Figure 3.3).

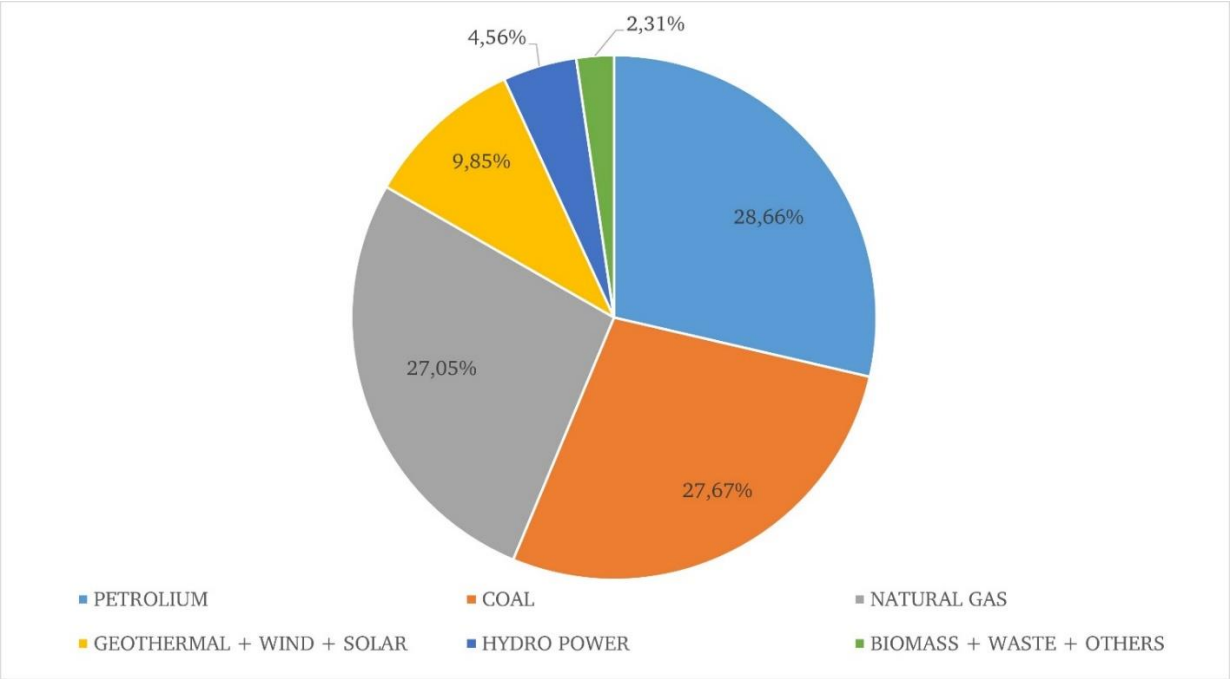


Figure 3.3 2020 Türkiye primary energy supply [30]

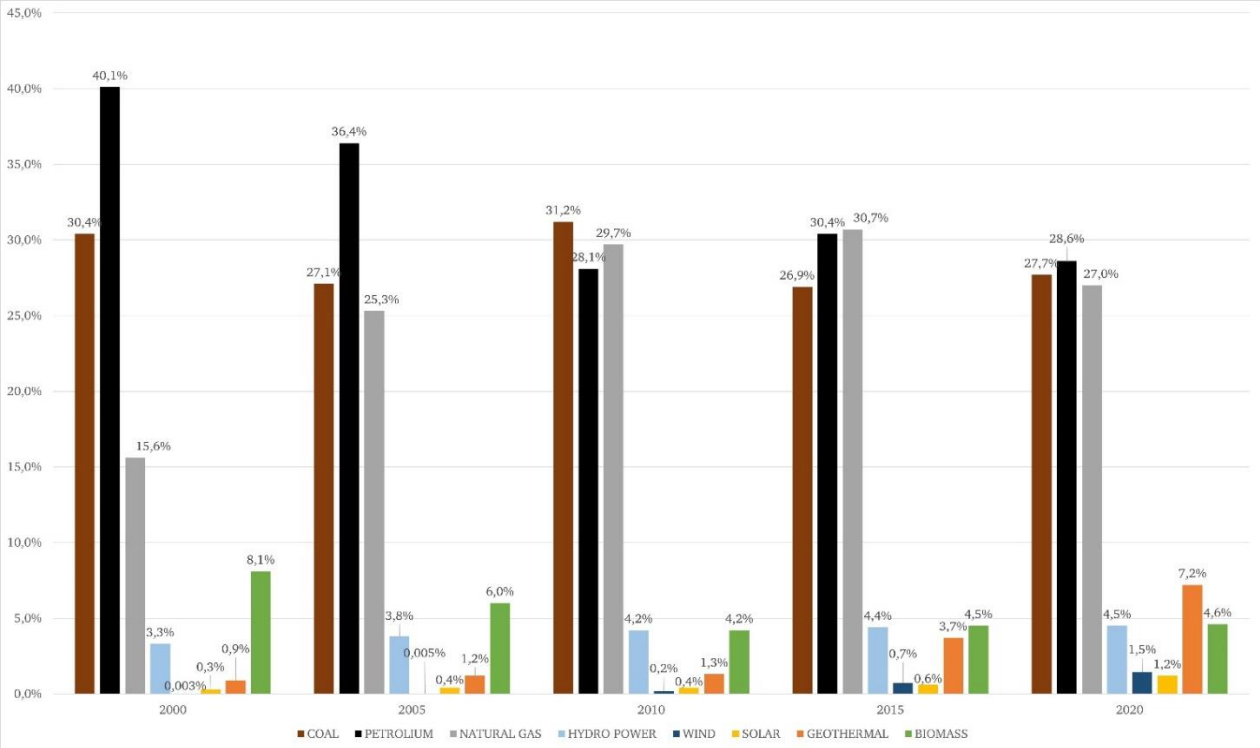


Figure 3.4 Share of energy resources in primary energy in Türkiye [30]

In the last 20 years between 2000 and 2020, Türkiye's total energy supply has increased by 85.3%, while oil has risen by 25.4%; the share of coal is 77.3%; the share of natural gas is 219.8%; share of hydraulic energy is 152.8%; the share of geothermal, solar, and wind increased

by 1386%; it was observed that the total share of bioenergy, wood, garbage, and waste decreased by 52.2% (Figure 3.4). Crude oil and natural gas resources comprise Türkiye's energy imports the most. [31]. It is observed that the use of alternative energy sources in energy supply started to increase, especially after 2015 (Figure 3.4).

- **Türkiye Primary Energy Production**

While the total energy production in Türkiye was 26.46 MTEP in 2000, it increased by only 17.67 MTEP (66.9%) in 20 years. While Türkiye's total primary energy production has risen by 17.67 MTEP in 20 years, 7.9 MTEP of this increase has been realized in the last five years, of which solar, wind, and geothermal energy production. On the other hand, while the total energy production increased by 66.9% in the 20 years between 2000 and 2020, the energy supply increased by 85.3%. As a result, the total primary energy supply increased from 79,428 thousand TEP to 147,168 thousand TEP in this period [31].

Table 3.2 2000-2020 Türkiye total primary energy data [31]

2000-2020 TÜRKİYE TOTAL PRIMARY ENERGY SUPPLY, GENERATION, IMPORTS, EXPORTS (MTEP) AND PRODUCTION CONSUMPTION SUPPLY CHANGES (%)							
	2000	**2002**	**2010**	**2015**	**2018**	**2020**	**2000-2020 INCREASE**
TOTAL PRIMARY ENERGY SUPPLY	79,4	77,1	105,9	129,2	143,6	147,2	86
ENERGY GENERATION	26,4	24,4	31,5	30,9	39,7	44,07	66,9
ENERGY IMPORT	55,1	57,2	84,6	112,8	115,8	114,29	107,4
ENERGY EXPORT	1,6	3,2	7,9	8,1	6,1	8,8	450
ENERGY GENERATION/TOTAL ENERGY**	33,2	31,6	29,7	23,9	27,6	29,8	-3,3
**RATIO OF TOTAL PRIMARY ENERGY PRODUCTION TO MEET TOTAL ENERGY SUPPLY							

In the 20 years between 2000 and 2020, energy imports increased by 107.4% and rose from 55,081 thousand TEP to 114,286 thousand TEP. On the other hand, total energy exports in this period increased from 2,104 thousand TEP to 8,842 thousand TEP, increasing by 319% [31] (Table 3.2).

Considering the ratio of total energy production to meet the entire energy supply, it is seen that it has decreased from 33% to 29.8% in the last 20 years. As a result, the rate of foreign dependency on energy, which was 67% in 2000, increased to 76% in 2015. However, national production increased with the tendency to use renewable energy sources after 2015. Thus, the foreign dependency rate on energy decreased to 70% in 2020. [31]

- **Türkiye NUTS1 Regions Main Indicators**

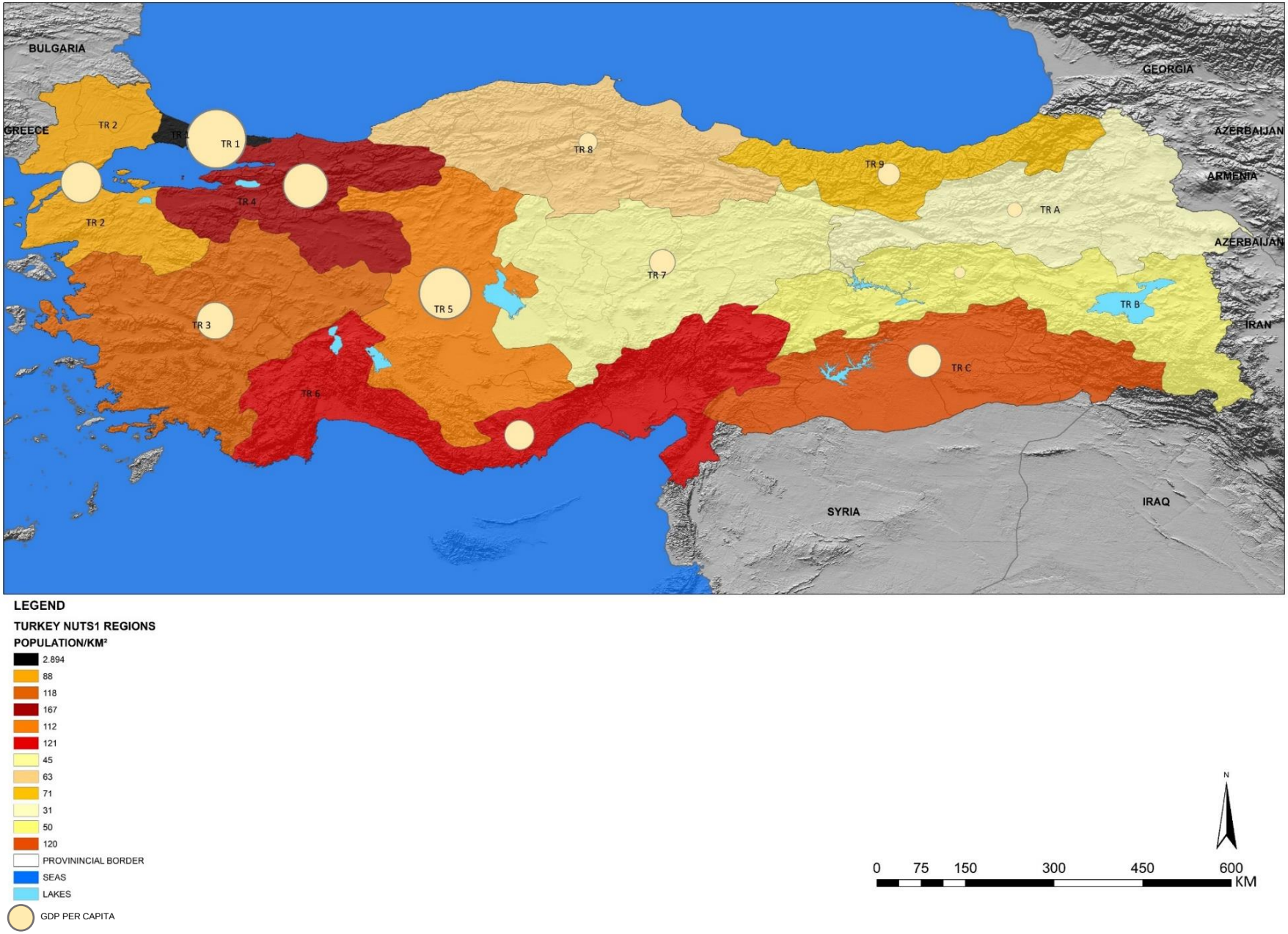
The classification of regional statistical units emerges as a criterion that Türkiye must fulfill in the European Union membership process. The application's aim is defined as the determination of the regional policy framework, the socio-economic analysis of the regions, and the production of regional statistical data comparable at the European level [32] While creating a three-stage regional system, 81 provinces were defined as Level 3, and "Neighboring provinces with economic, social and geographical similarities, taking into account their regional development plans and population sizes" were determined as Level 2 (26 units) and Level 1 (12) regions.

Within the scope of this study, firstly, the population of the regions and their per capita GDP values and then the energy consumption data of the installed power capacities were evaluated in Level 1 scale to have similar areal sizes with the developed European countries and to be more efficient to be able to make comparisons.

As seen in the literature review, it has been revealed by many studies that there is a bidirectional or unidirectional causality between countries' development levels, economic development status (which many studies have considered as the GDP of countries), and energy production/consumption values. For this reason, in this study, population size, population density, area size, and GDP per capita values, the leading indicators for each NUTS 1 region, were primarily examined. Afterward, energy data were considered, and an evaluation was made for the regions. Thus, the current situation of the areas for 2020 is presented.

Looking at the Map3.1, the population density of 12 regions at NUTS 1 in Türkiye is expressed with colors. Population sizes of the regions are shown in the graph in Figure 3.5 TR1 Istanbul region has been the most densely populated area with 2.894 persons/km². TR1 region is followed by TR4 Region (Kocaeli, Sakarya, Düzce, Yalova, Bursa Bilecik, Eskişehir) with 167 persons/km². TR3 İzmir and its surroundings are in third place, with 118 persons/km². It is seen

that the population density decreases as you go eastward in the country. 44% of the total population, almost half of them, live in the TR1, TR3, and TR6 regions, but these three regions only cover 21% of the country in the area.



Map 3.1 Distribution of Türkiye's population and GDP values by NUTS 1 regions [33]

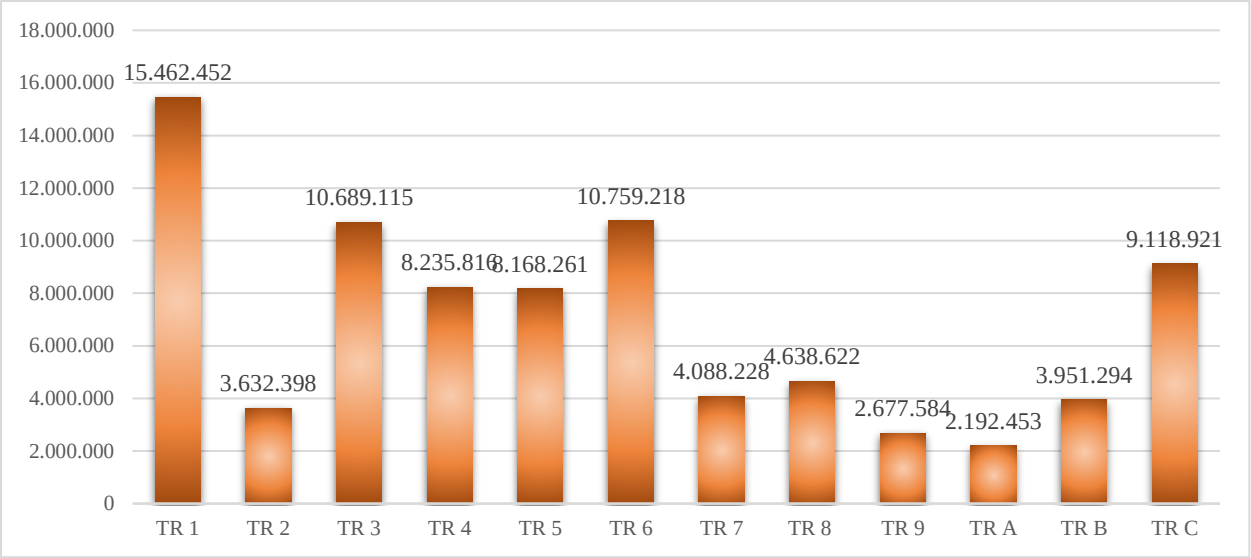


Figure 3.5 Population sizes of NUTS 1 regions of Türkiye [33]

When the GDP per capita in the regions is analyzed, it is seen that only TR1, TR3, and TR5 out of 12 areas have 67% of the total GDP (Figure 3.6). Therefore, in terms of area size, these regions have only 23% of the country.

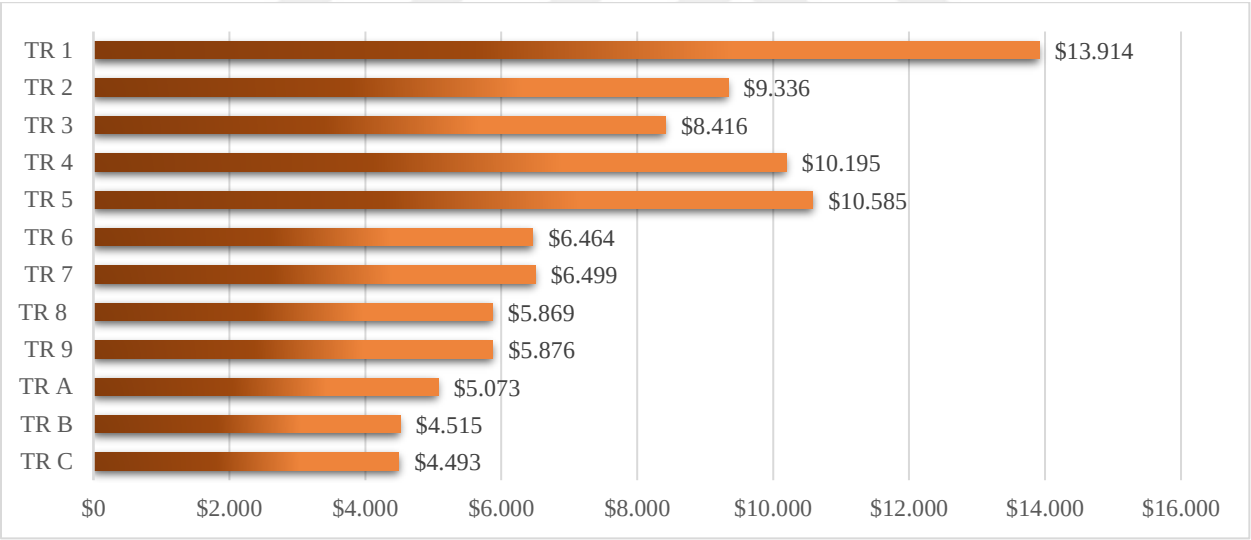


Figure 3.6 GDP per capita in NUTS 1 regions of Türkiye [34]

Area sizes, populations, population densities, GDP, and GDP per capita values of the regions are shown in Table 3.3.

Table 3.3 Main indicators of NUTS 1 regions [34]

	AREA (KM²)	POPULATION 2020	POPULATION DENSITY (KİŞİ/KM²)	GDP 2020 (TL)	GDP PER CAPITA (TL)	GDP PER CAPITA ($) 2020
TR 1	5.343	15.462.452	2.894	1.517.323.616	₺97.950	$13.914
TR 2	41.280	3.632.398	88	237.727.696	₺65.722	$9.336
TR 3	90.456	10.689.115	118	631.233.668	₺59.250	$8.416
TR 4	49.404	8.235.816	167	587.116.362	₺71.771	$10.195
TR 5	73.126	8.168.261	112	607.034.808	₺74.515	$10.585
TR 6	89.983	10.759.218	121	486.606.355	₺45.505	$6.464
TR 7	91.709	4.088.228	45	186.752.399	₺45.750	$6.499
TR 8	73.946	4.638.622	63	192.219.982	₺41.316	$5.869
TR 9	37.551	2.677.584	71	111.030.662	₺41.369	$5.876
TR A	71.035	2.192.453	31	78.440.604	₺35.716	$5.073
TR B	78.458	3.951.294	50	125.260.838	₺31.785	$4.515
TR C	75.938	9.118.921	120	286.136.317	₺31.627	$4.493

- **Türkiye Level 1 Regions Installed Power and Energy Production / Consumption Values**

As a concept and production factor, energy has taken its place in the economy in a modern sense with the ecological economics approach. The cycle between labor and capital, expressed as neoclassical activity flow, has been seen as a sub-system of the global ecosystem in environmental economics until the understanding of ecological economics. In ecological economics, solar energy is the only energy source in the worldwide ecosystem. Solar energy is used either directly or indirectly in the ecosystem and is thrown away as low heat. Accordingly, in ecological economics, energy is the only primary factor of production [1].

The use and impact of energy, which is a factor that directly affects development, is increasing day by day in all areas of life. Energy, which is an input in production and a cost element in consumption, has become an economic value, and energy has become one of the leading roles in developing countries; therefore, in development. For this reason, the energy consumption amounts of the regions and the installed capacity in these regions were examined at NUTS 1.

Considering the order of usage areas of energy consumption from the national energy balance tables throughout Türkiye; industry, transportation, housing, services – trade, and agriculture.

The fact that the industrial sector ranks first indicates that the most energy use is in the industry, and as production increases, energy consumption increases (Figure 3.7). As stated in the 2.1. Energy Policies and Development Relations section, the bidirectional causality relationship between development and energy consumption has been proven by causality analyses conducted in many studies around the world. The increase in production brings with it economic growth. The area with the lowest energy consumption in agriculture. [35]

The amount of energy used in transportation is in second place, under the heading of the vehicle; railways, seaways, airways, pipelines, and highways. While energy consumption was given together under housing and services until 2015, data were divided into two headings: housing, commerce, and services in 2015 and beyond (Figure 3.8). Since the energy consumption data used in the housing area before 2015 were not given separately, the data on housing, trade, and services were considered as a single data within the scope of the study to make a correct comparison of all data between 2000-2021. From this point of view, as seen in Figure 8, the first usage area is housing, commerce, and services; It can be stated that industry is in the second place, transportation is in the third place, and agriculture is in the fourth place.

The national energy tables have the cycle and energy sector titles among the energy consumption areas. The data under this heading represent the losses experienced during the conversion, transmission, and distribution process from primary to electrical energy (secondary energy). These amounts almost go hand in hand with the amount of energy consumed in the industrial sector (Figure 3.9).

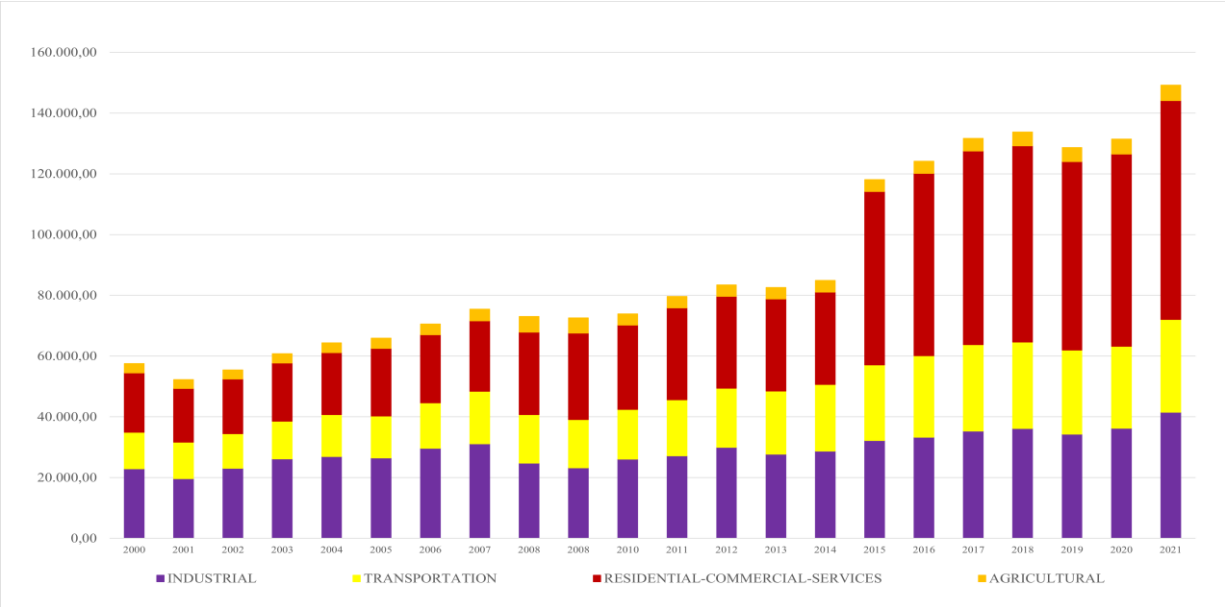


Figure 3.7 Distribution of Türkiye's 2000-2021 primary energy supply by areas of use [35]

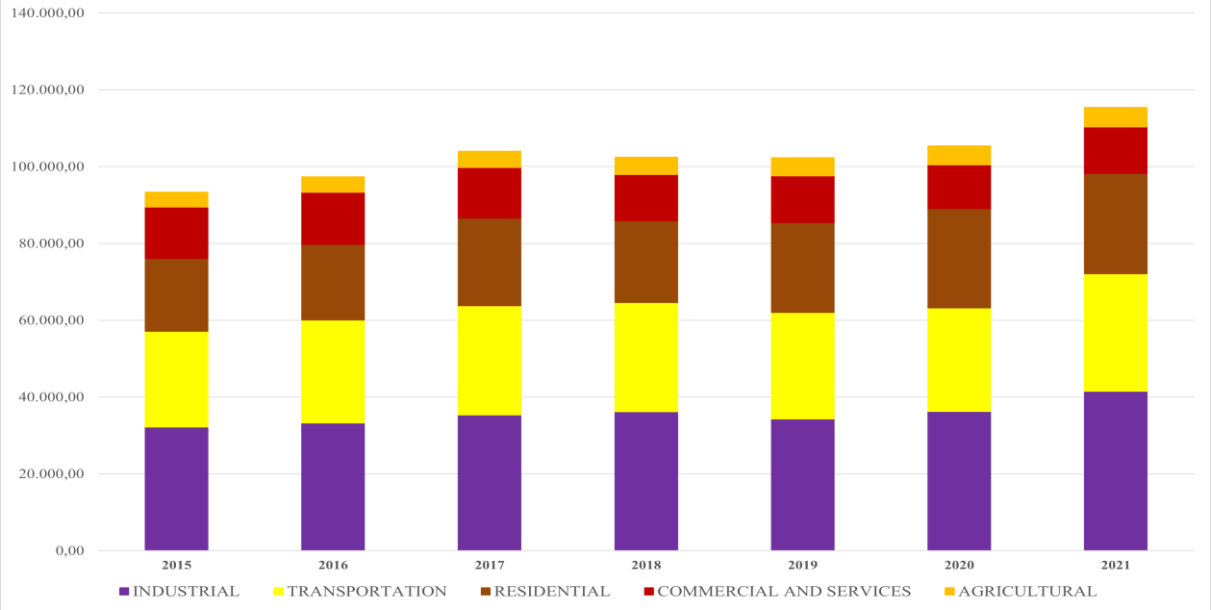


Figure 3.8 Distribution of Türkiye's 2015-2021 primary energy supply by areas of use [35]

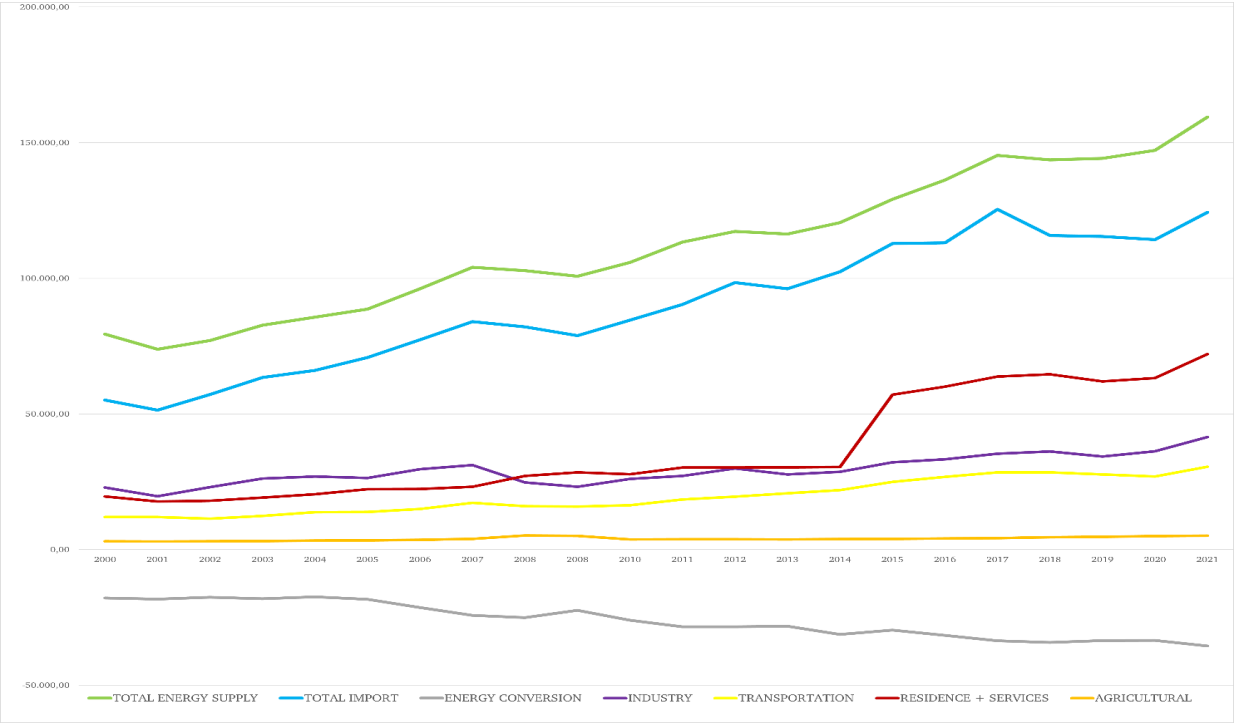
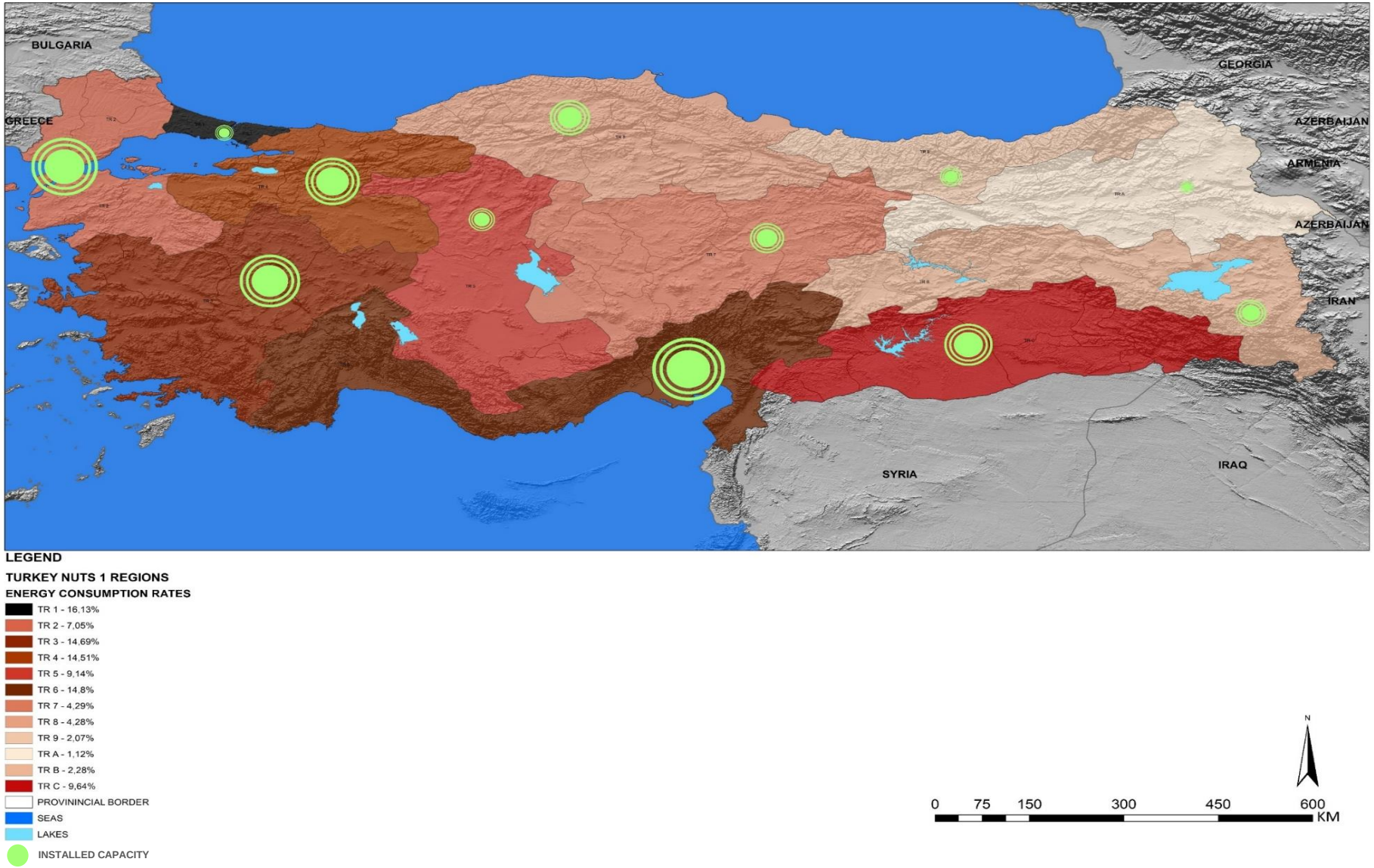


Figure 3.9 Distribution of Türkiye's 2000-2021 primary energy supply by areas of use [35]

On the map in Figure 3.11, the colors represent the energy consumption of the regions. The enormous energy consumption amount belongs to TR1 Istanbul with a share of 6.13%. Istanbul is Türkiye's commercial, tourism, investment, and financial center, and approximately 20% of Türkiye’s population lives here. The fact that Istanbul ranks first in energy consumption is an expected situation under these conditions. The TR6 region, which includes the provinces of Antalya, Isparta, Burdur, Mersin, Adana, Hatay, and Osmaniye, comes second in energy consumption. In third place; There is the TR3 region, which includes İzmir, Aydın, Denizli, Muğla, Manisa, Afyon, Kütahya, and Uşak. The energy consumed in TR1, TR6, and TR3 regions corresponds to 45.62% of all consumption. Half of the energy consumption takes place in the area covering 23% of the country's surface area. If we look at Istanbul specifically, 16% of energy consumption is realized in 0.7% of the country's territory. The regions' detailed energy consumption, installed capacity, and energy production/consumption rates are given in Table 3.3.



Map 3.2 Energy consumption and installed capacity in NUTS 1 regions of Türkiye [34]

Table 3.4 NUTS 1 regions basic energy data [34]

NUTS 1 REGIONS	ENERGY CONSUMPTION	INSTALLED CAPACITY	PRODUCTION/CONSUMPTION RATE
TR 1	16,13%	3,44%	22,00%
TR 2	7,05%	11,25%	251,58%
TR 3	14,69%	16,65%	329%
TR 4	14,51%	9,80%	70,47%
TR 5	9,14%	5,43%	49,59%
TR 6	14,80%	16,80%	103,26%
TR 7	4,29%	5,10%	128,35%
TR 8	4,28%	9,24%	229,99%
TR 9	2,07%	4,96%	126,23%
TR A	1,12%	1,93%	87,65%
TR B	2,28%	5,18%	137%
TR C	9,64%	10,19%	64,72%

The installed power (capacity) is expressed with the point representation expressed on the map. Installed power is the name given to a power plant's maximum ability to meet, an installation system can handle, and an electrical network can carry. Installed power, also known as connection power, is essential in ensuring the continuity of electricity [36]. The change in the installed power in Türkiye between the years 2000-2020 is given in Table 3.5.

Table 3.5 Annual change of total installed capacity by resources in Türkiye [26]

YEARS	COAL		PETROLIUM		NATURAL GAS		TOTAL FOSSIL	WASTE		HYRO		WIND/SOLAR/GEOTHERMAL		TOTAL RENEWABLE
	MW	%	MW	%	MW	%	%	MW	%	MW	%	MW	%	%
2000	7.399,00	27,1	3.725,00	13,7	4.905,00	18	58,8	24,00	0,1	11.175,00	41	36,00	0,1	41,2
2005	9.588,00	24,7	5.303,00	13,7	10.976,00	28,3	66,6	35,00	0,1	12.906,00	33,2	35,00	0,1	33,4
2010	12.403,00	25	6.466,00	13,1	13.302,00	26,9	65	107,00	0,2	15.831,00	32	1.414,00	2,9	35
2015	16.104,00	21,7	6.901,00	9,3	18.528,00	25	56	370,00	0,5	26.868,00	36,2	5.376,00	7,3	44
2020	20.323,00	21,2	312,00	0,3	25.675,00	26,8	48,3	1.485,00	1,5	30.984,00	32,3	17.113,00	17,8	51,7

In this period between 2000-2020, besides the acceleration of renewable energy power plant investments, With the continuation of thermal power plant investments, annual installed power increase rates have always been higher than the annual production increase rate. When the development of the installed power according to the resources is examined, it is seen that there has been a decrease in the established power due to petroleum products in recent years and an increase in all of the other resources, including more wind, solar and geothermal resources [31].

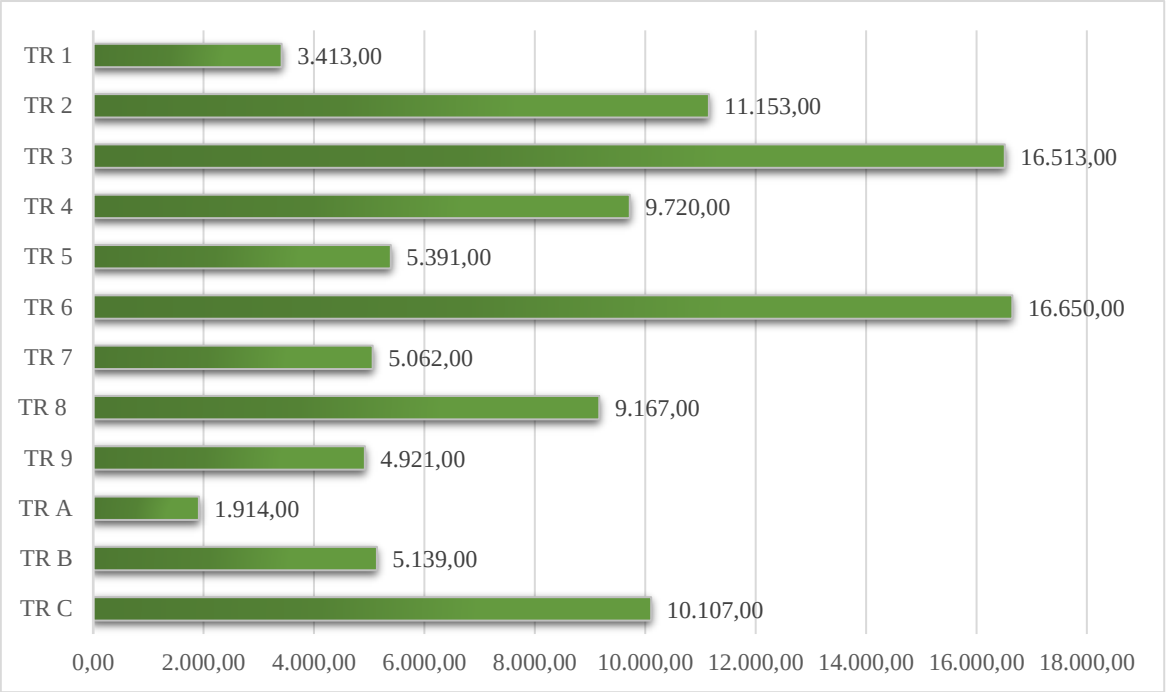


Figure 3.10 Installed capacity in Türkiye NUTS 1 regions (Mw) [37]

TR6 is the region with the highest installed capacity in Türkiye. 16.8% of the total installed power in the country is in this region. T.R. 6 region is followed by TR3 region with 16.65% and TR2 region with 11.25% installed power ratio. TR2, TR3, and TR6 regions have 44.7% of the total installed capacity. Looking at Table 3.4, the area where the production and consumption balance is seen is the TR6 region. Notably, production is much higher in the TR2, TR3, and TR8 regions than in the energy consumed (Figure 3.11). Although Istanbul is the region with the highest amount of energy consumed, the amount of energy produced in the area is only 22% of its consumption.

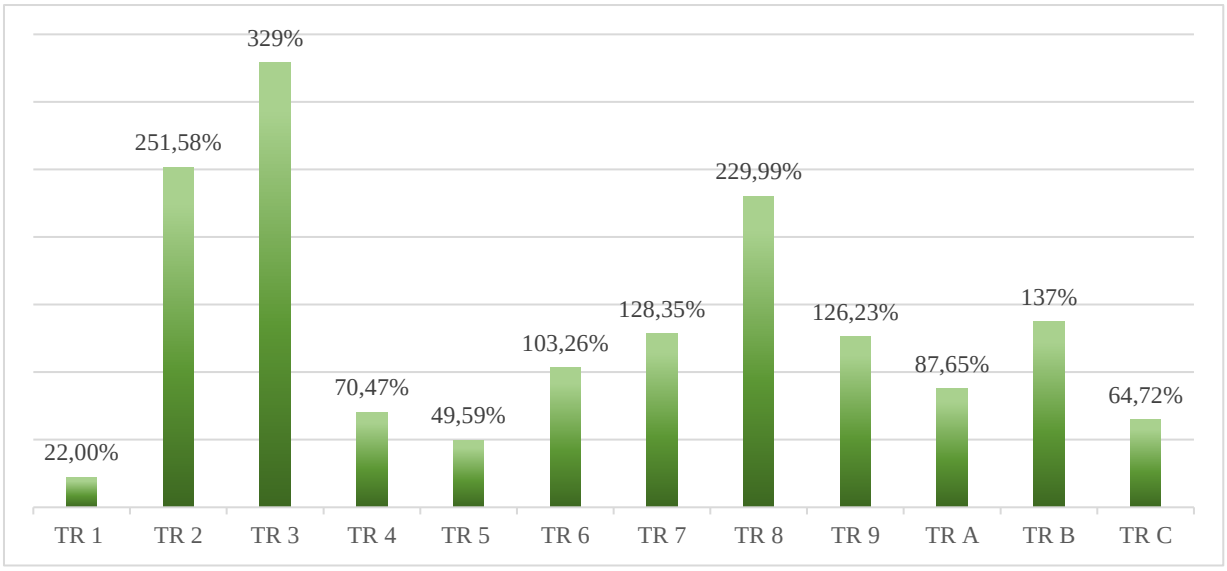


Figure 3.11 Energy generation/consumption rate in Türkiye NUTS 1 regions [37]

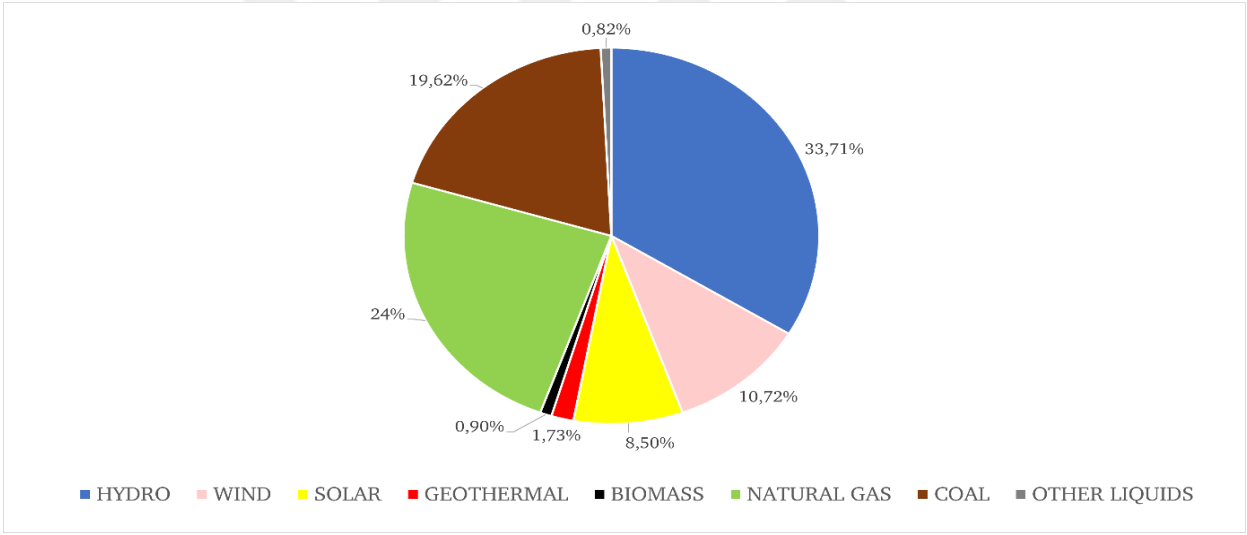


Figure 3.12 Türkiye installed power rate by resources [37]

Considering which energy types have more installed power in which areas, wind power plants are located on the Aegean coasts and the east of the Mediterranean, hydroelectric power plants are in the Euphrates-Tigris basin and Çoruh basin, domestic coal plants are in areas with coal mines, imported coal plants are in coastal cities, natural gas power plants are in high electricity levels.

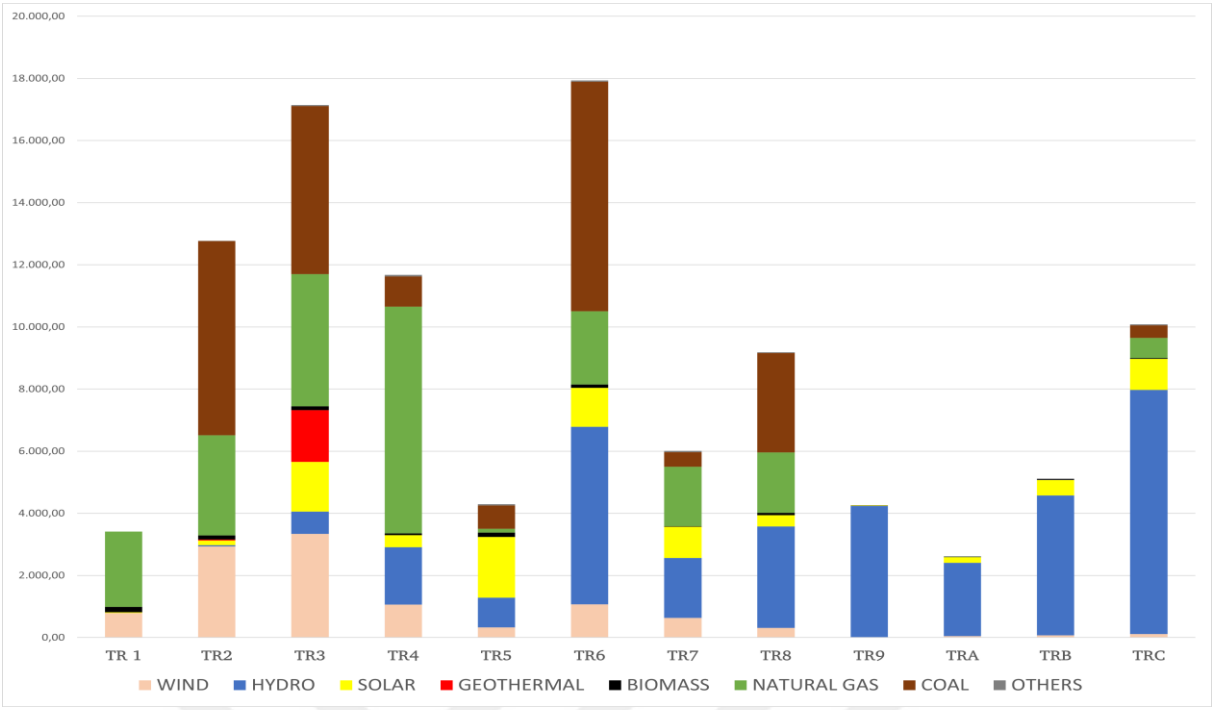


Figure 3.13 Türkiye NUTS 1 regions installed power ratio by resources [37]

Looking at the installed power in Level 1 regions according to the sources, the maps and graphics that reveal which type of installed power is concentrated in which region are given in Figures 3.13 and Map 3.3.

If evaluated in terms of renewable energy:

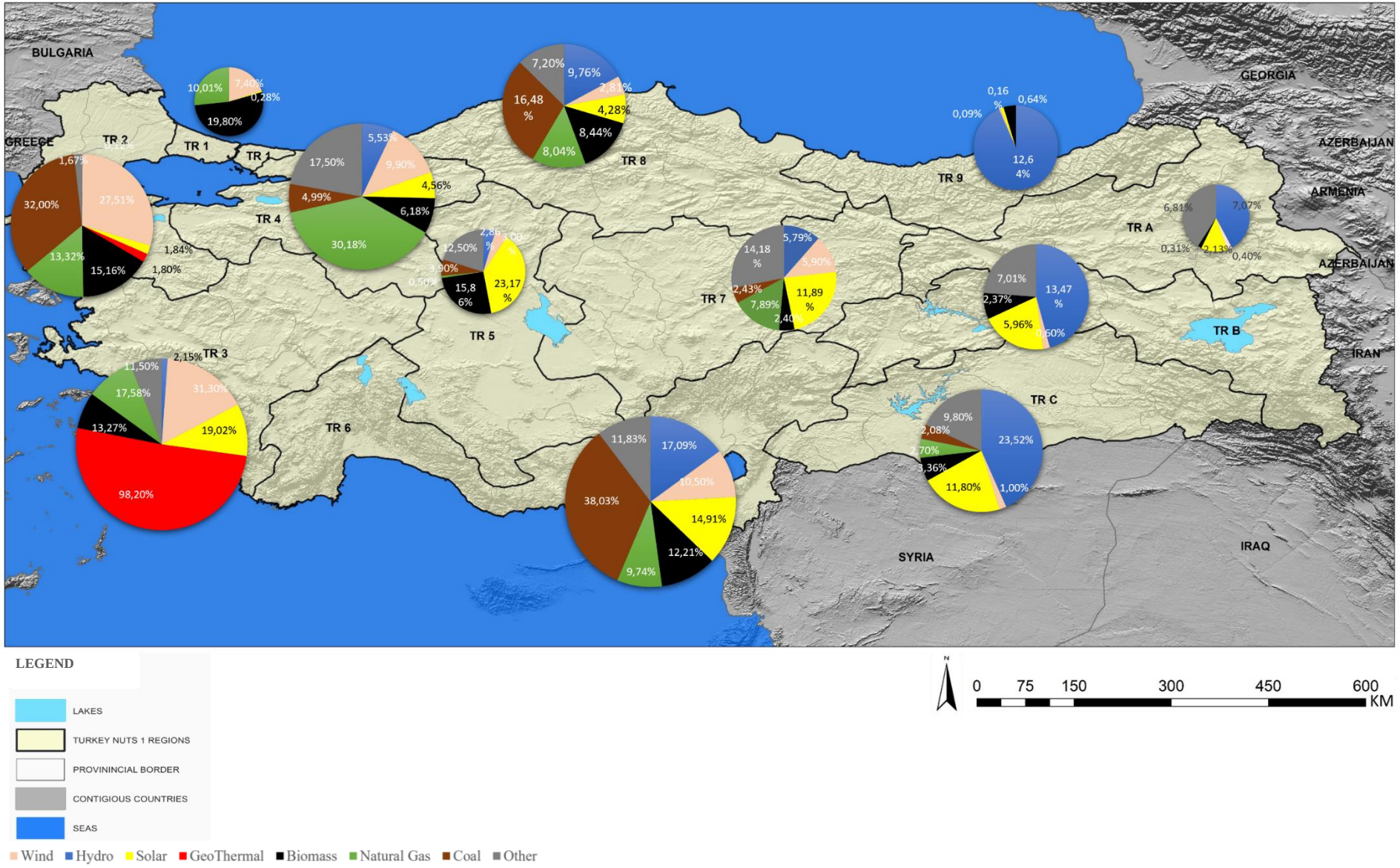
- 54.08% of the total installed hydraulic power is in the TRC, TR6, and TRB regions, and the TRC region has the largest share with 23.52%.
- 58.51% of the wind energy installed capacity is located only in the TR2 and T.R. 3 regions, and the TR3 region has the largest share, with 31.3%.
- TR5 Region has the largest share in solar energy installed power, with a share of 23.17%. TR5 region is followed by TR3 region with 19.02% and TR6 region with 14.91%.
- 98.2% of the geothermal energy installed capacity is in the TR3 region; It is stated that there is no geothermal energy installed capacity in the other areas except TR2 and TR3 regions.
- It is seen that the installed capacity of biomass is in regions where large cities such as TR1, TR5, and TR2 are located.

In terms of fossil fuels:

- TR4 region has the largest share in natural gas installed power with 30.18%; 61.08% of total natural gas installed power is in TR2, TR3, and TR4 regions. Still, natural gas-installed power is not included in TR9 and TRB regions.

- In terms of coal, the installed power is concentrated in TR2 (32%), TR6 (38.03%), and TR8 (16.48) regions since domestic coal power plants are in regions with coal mines and imported coal power plants are in coastal cities, TR1, TR3, TR9 It is stated that there is no installed capacity in the, TRA and TRB regions.

When we examine the regions in general, TR3 and TR6 regions have the most significant share in the installed power, and they have almost all the resources; In terms of production-consumption balance (Table 3.4), the TR6 region is in balance, and the production is three times more than consumption in the TR3 region; It is seen that the TR1 region, where the consumption is most intense, remains very low in installed power share and production. All these data reveal the spatially uneven distribution of energy policies. At the same time, these data, while arousing curiosity about Türkiye's energy potential, "Is it possible to provide spatial production/consumption balance and to produce an integrated, balanced spatial energy plan?" It also brings the question to mind.



Map 3.3 Installed capacity rate by resources in Türkiye NUTS 1 regions [37]

In the Map 3.3, it is stated that the regions in Türkiye at the NUTS1 level and the % of each energy type are produced in these regions. According to the Ministry of Energy and Natural Resources data, as of 2021, 55.56% of the installed power in Türkiye consists of renewable energy sources and 44.44% of fossil fuels. If we look at the shares of energy resources in detail, 33.71% hydraulic, 10.72% wind, 8.5% solar, 1.73% geothermal, 0.9% biomass, 24% ü consists of natural gas, 19.62% coal, and 0.82% other liquid fuels. Considering the shares of installed power capacities in the regions respectively:

In TR1 (Istanbul) region; 10.01% of natural gas, 7.40% of wind, 0.28 of solar energy, 19.80% of biomass;

In TR2 (Tekirdağ, Edirne, Kırklareli, Balıkesir, Çanakkale) region; 32% of coal, 27.51% of wind, 15.16% of the biomass, 13.32% of natural gas, 1.84% of solar, 1.8% of geothermal, and % of other liquid fuels 1.67 of them;

In TR3 (İzmir, Manisa, Kütahya, Afyonkarahisar, Uşak, Aydın, Muğla, Denizli) region; 98.2% of geothermal, 31.3% of wind, 19.02% of solar, 17.58% of natural gas, 13.27% of the biomass, 11.50% of other liquid fuels and 2.15% of hydraulics;

In TR4 (Bursa, Eskişehir, Bilecik, Kocaeli, Sakarya, Düzce, Bolu, Yalova); 30.18% of natural gas, 17.5% of other liquid fuels, 9.9% of wind, 6.18% of the biomass, 5.5% of hydraulics, 4.99% of coal, 4.56% of the sun;

In the TR5 (Ankara, Konya, Karaman) region; 23.17% of the sun, 15.86% of the biomass, 12.5% of other liquid fuels, 3.9% of coal, 3% of wind, 2.86% of hydraulics, 2% of natural gas 0.5;

In TR6 (Antalya, Isparta, Burdur, Mersin, Adana, Osmaniye, Hatay, Kahramanmaraş), 38.03% of coal, 17.09% of hydraulics, 14.91% of solar, 12.21%, 11.83% of other liquid fuels, biomass, 10.50% of wind, 9.74% of natural gas;

In the TR7 (Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir, Kayseri, Sivas, Yozgat) region; 14.18% of other liquid fuels, sun; 11.89%, 7.89% of natural gas, 5.9% of wind, 5.79% of hydraulics, 2.43% of coal, 2.4% of biomass;

In TR8 (Zonguldak, Karabuk, Bartin, Kastamonu, Sinop, Çankırı, Samsun, Çorum, Amasya, Tokat); 16.48% of coal, 9.76% of hydraulics, 8.44% of the biomass, 8.04% of natural gas, 7.2% of other liquid fuels, 4.28% of solar and 2.81% of the wind,

In TR9 (Trabzon, Ordu, Rize, Giresun, Gümüşhane, Artvin) region, 12.64% of hydraulics,

In the TRA (Erzurum, Erzincan, Bayburt, Ağrı, Kars, Iğdır, Ardahan) region, 7.07% of hydraulics, 6.81% of other liquid fuels, 2.13% of solar.

In the TRB (Malatya, Elazig, Bingol, Tunceli, Van, Muş, Bitlis, Hakkari) region, 13.47% of hydraulics, 7.01% of other liquid fuels, 5.96% of the sun, 2.37% of biomass;

In the TRC (Gaziantep, Adıyaman, Kilis, Şanlıurfa, Diyarbakır, Mardin, Batman, Şırnak, Siirt) region, 23.52% of hydraulics, 11.8% of solar, 9.8% of other liquid fuels, 3.36% of culture, 2.7% of natural gas, 2.08% of coal and wind has 1% installed power capacity.

When we look at the NUTS1 level regions, which are in the first three places in terms of installed power capacity, respectively.

In hydraulic energy, TRC, TR6, and TRB (54.08% of total hydraulic installed capacity);

In wind energy, TR3, TR2, TR6 (69.31% of total wind installed capacity);

In solar energy; TR5, TR3, TR6 (57.1% of total solar installed power);

In geothermal energy, TR3, TR2 (100% of total geothermal installed power);

In biomass energy, TR1, TR5, TR2 (50.82% of total biomass installed capacity);

In natural gas, TR4, TR3, and TR2 (61.08% of total natural gas installed capacity)

In coal, TT6, TR2, and TR8 (86.51% of total coal installed power)

In other liquids, TR4, TR7, and TR6 (30.51% of total other liquid fuel installed capacity)

It is observed that the regions come to the fore.

- **Electricity Consumption Values According to Usage Areas in NUTS 1 Regions**

The relationship between energy production consumption and the economic development levels of countries has been explained in the literature with many causality analyses. At the same time, the energy issue and energy dependency are among the critical indicators of the country's economies [38]. Energy production and consumption are directly proportional in countries. As industrialization and urbanization increase, the energy consumption of countries and regions also increases. For this reason, the distribution of the energy consumption of the regions to the

sectors in the NUTS 1 scale in Türkiye between the years 2000-2020 has been analyzed with TUIK data. In this way, the changes in electricity consumption rates in which regions and their sectoral uses are also revealed.

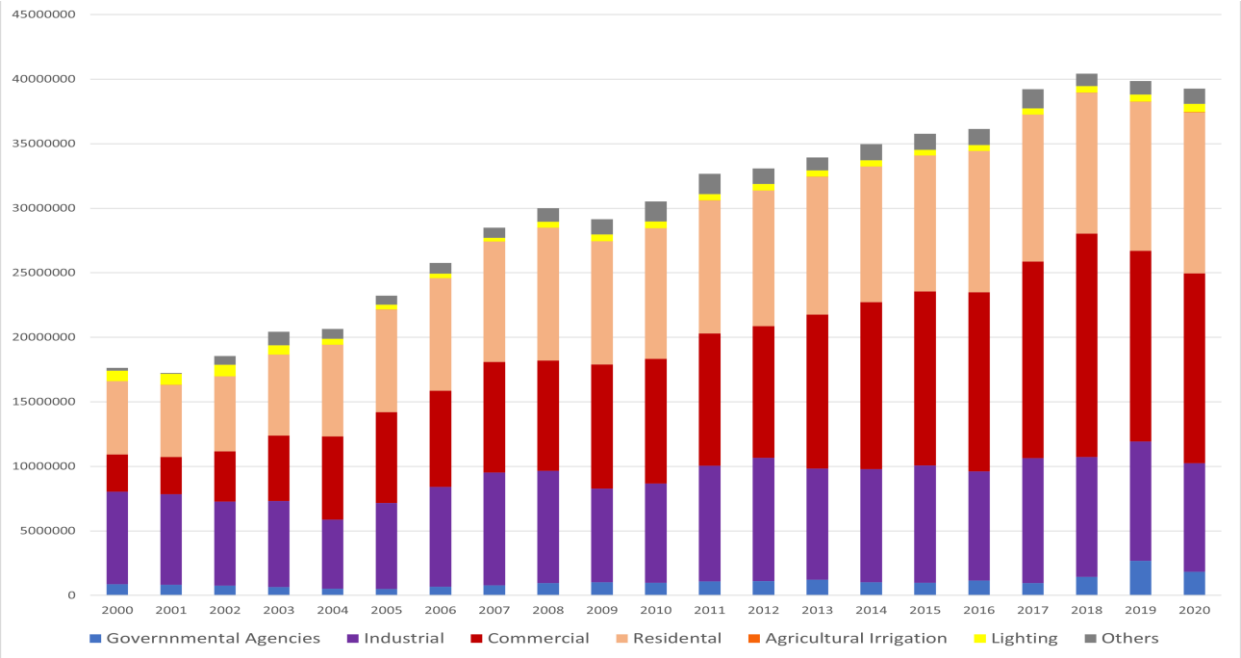


Figure 3.14 Distribution of energy consumption in TR1 region between 2000-2020 by usage

Looking the sectoral distribution of energy consumption in the TR1 Region, it is seen that industry had the largest share in 2000, while in 2020, trade took first place, second place, and industry took third place (Figure 3.14).

As seen in Figure 3.15, the industrial sector consistently ranks first in energy consumption in the TR2 region and tends to increase in quantity. In 20 years, the amount of consumption has nearly quadrupled.

The TR3 region is given in Figure 3.16, and as can be seen, the industrial sector always maintains its first place. It is seen that the amount of energy consumption has increased by approximately 2,5 times.

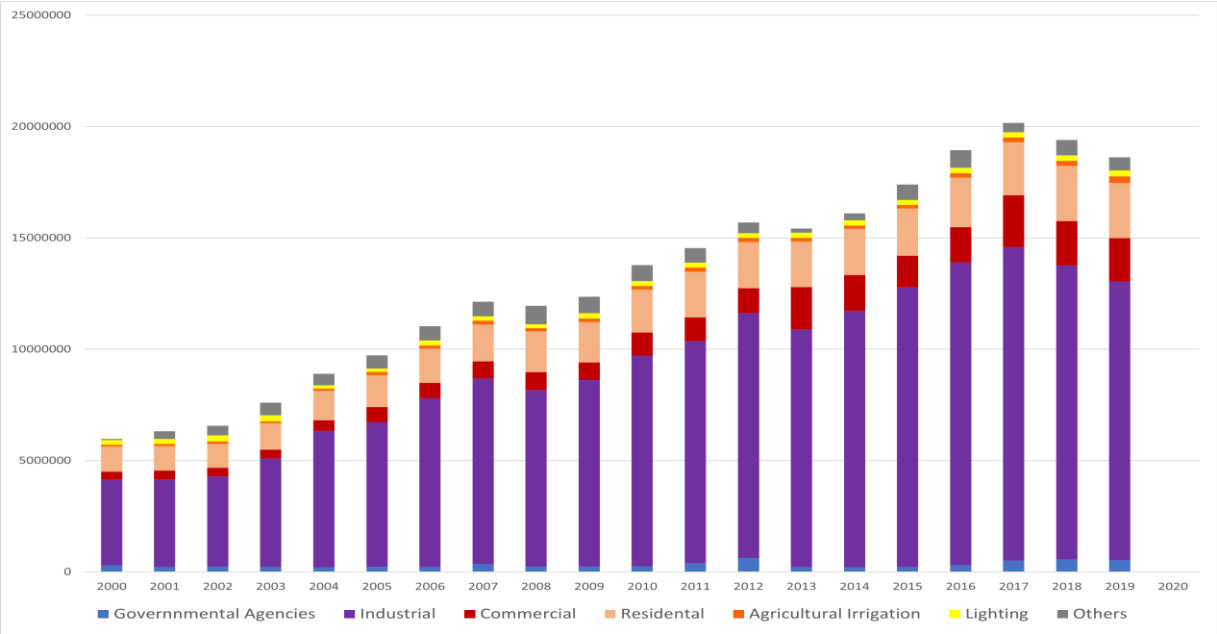


Figure 3.15 Distribution of energy consumption in TR2 region between 2000-2020 by usage

Considering the TR4 region, more than 60% of the energy consumption belongs to the industry sector. Housing comes second, and trade comes third (Figure 3.17).

As seen in TR5 region Figure 3.18 and TR6 region Figure 3.18, although there has been an increase over the years, there is no change in the balance of sectoral uses. In the 20-year process, the industry is always in the first place, housing in second place, and commerce in third place.

In TR5, TR7, and TRC regions, unlike other areas, the share of agricultural irrigation has a significant percentage. The graphs in Figures 3.20 and 3.21 show that the industry has the largest share in T.R. 7 and 8 regions. Unlike other areas in TR9 and TR A regions (Figure 22-23), the largest energy consumption share is residential use.

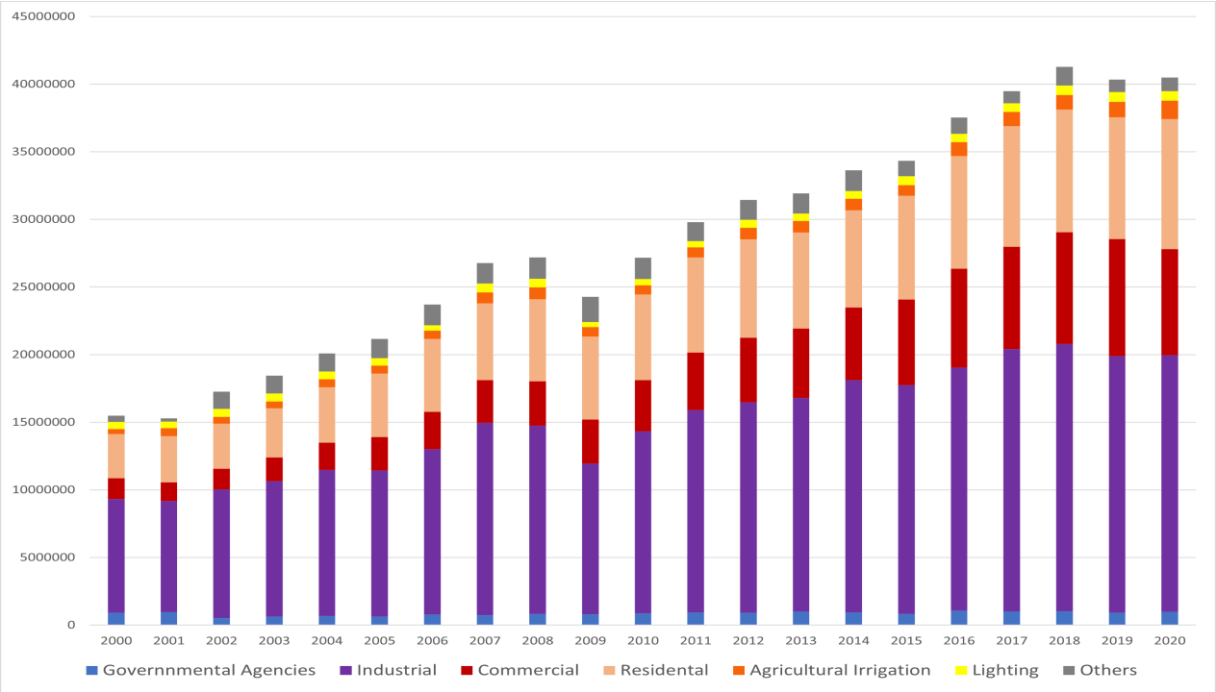


Figure 3.16 Distribution of energy consumption in TR 3 region between 2000-2020 by usage

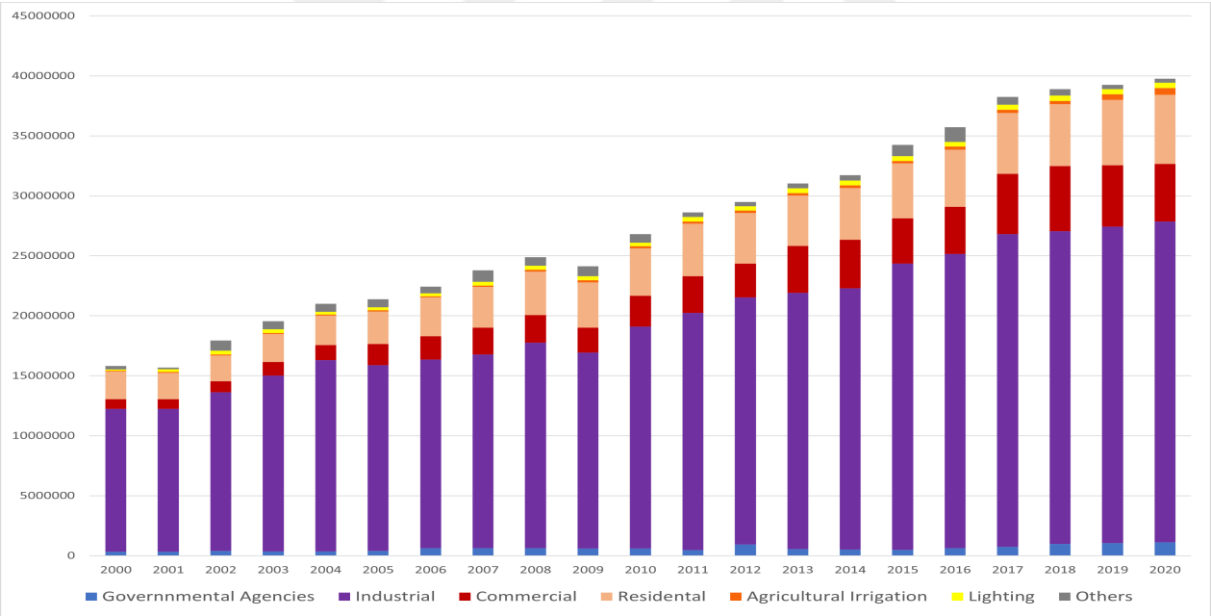


Figure 3.17 Distribution of energy consumption in TR 4 region between 2000-2020 by usage

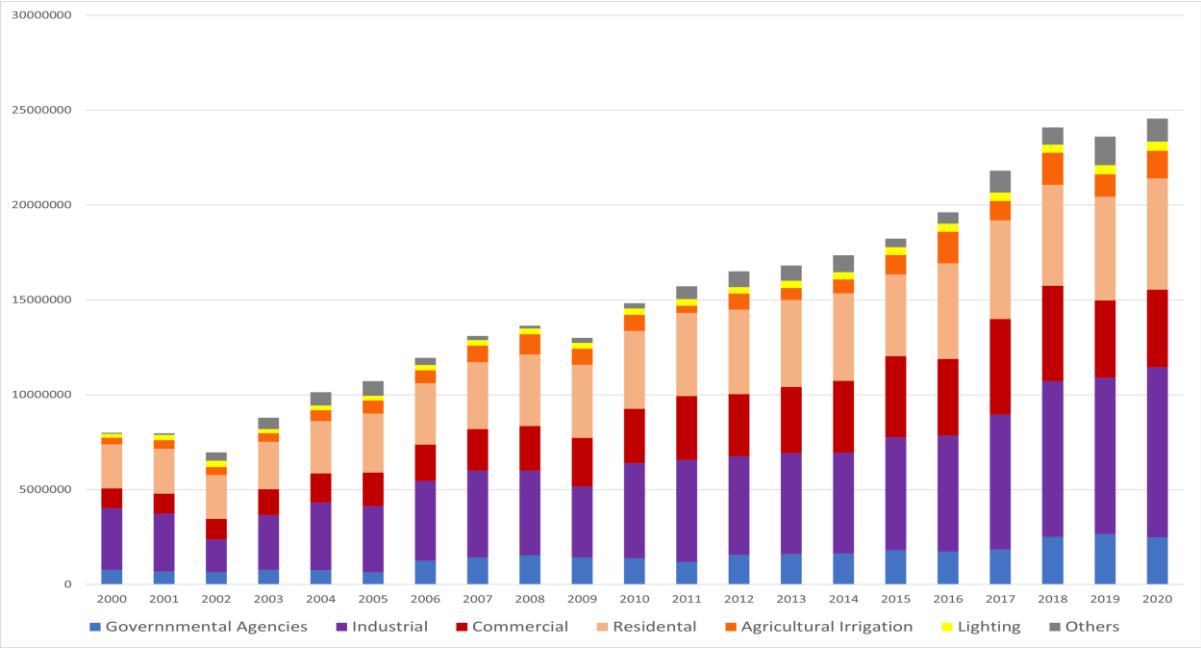


Figure 3.18 Distribution of energy consumption in TR 5 region between 2000-2020 by usage

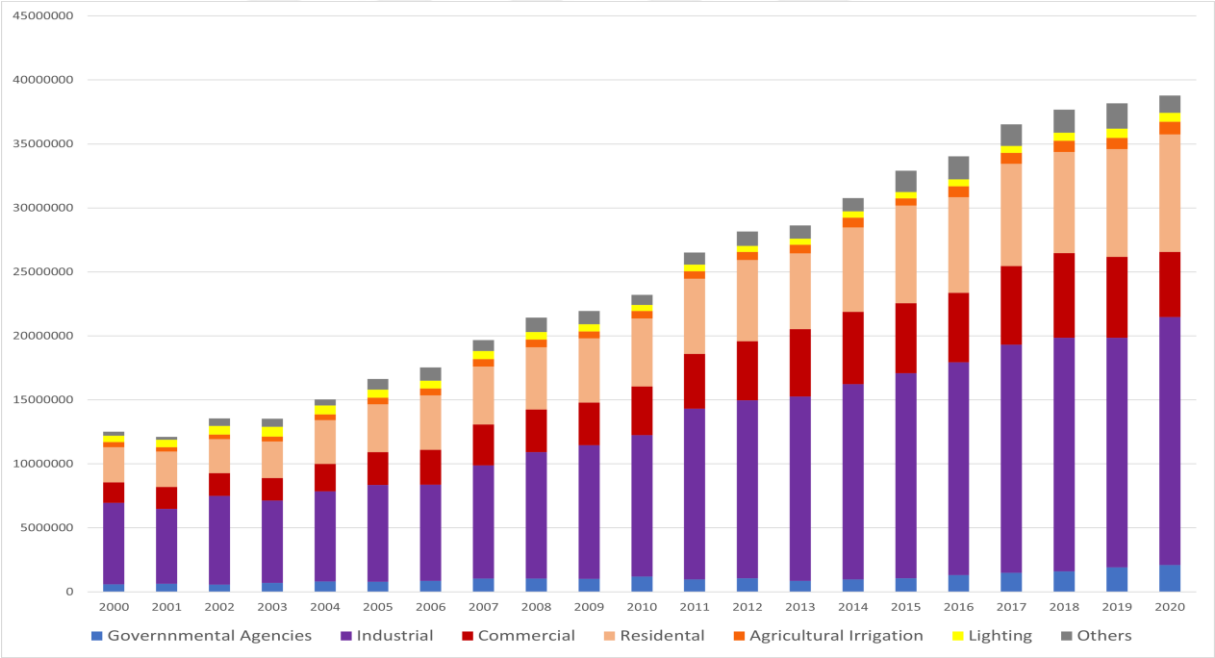


Figure 3.19 Distribution of energy consumption in TR 6 region between 2000-2020 by usage

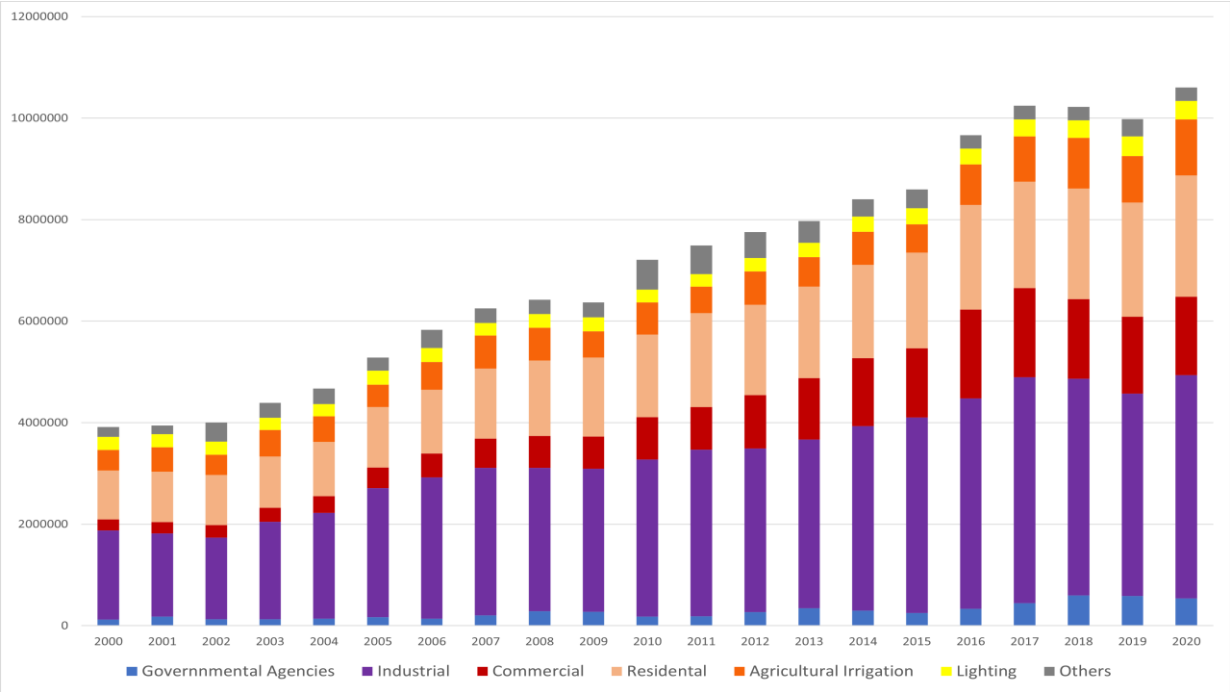


Figure 3.20 Distribution of energy consumption in TR 7 region between 2000-2020 by usage

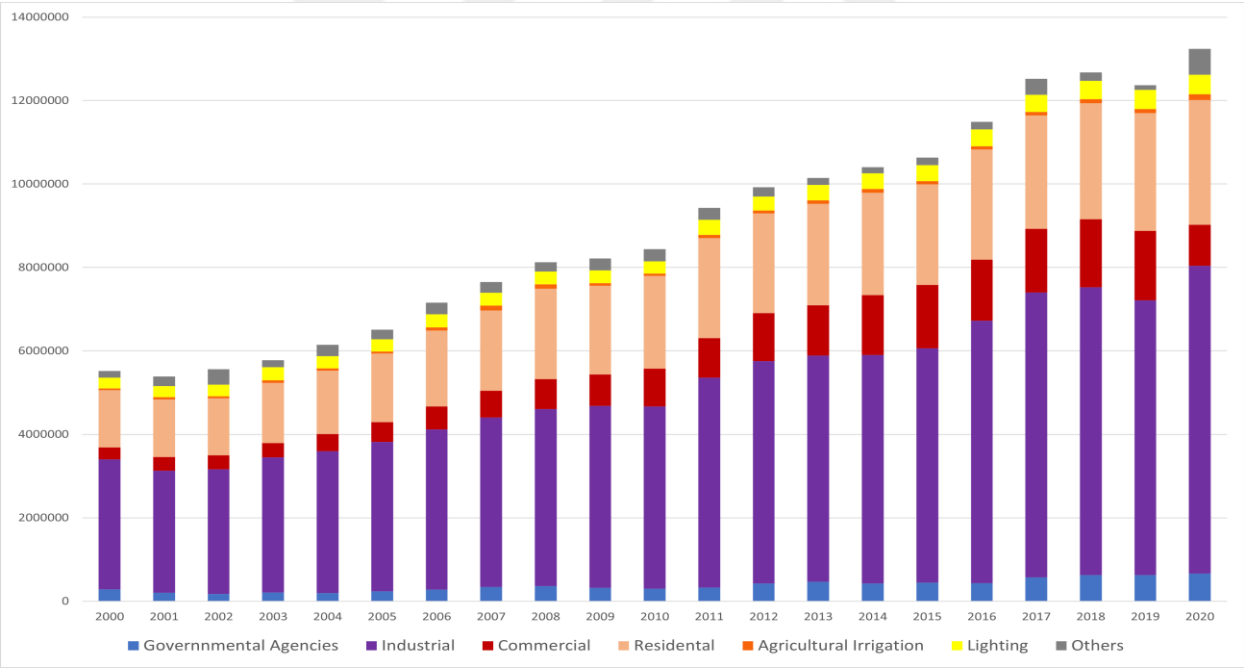


Figure 3.21 Distribution of energy consumption in TR 8 region between 2000-2020 by usage

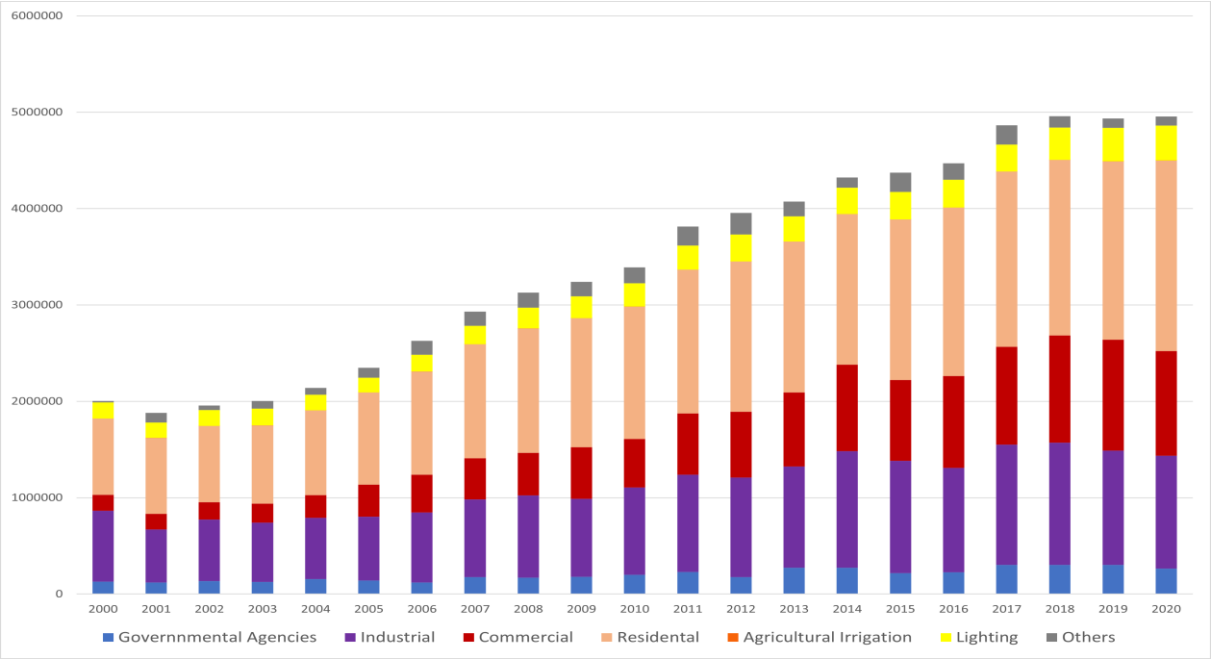


Figure 3.22 Distribution of energy consumption in TR9 region between 2000-2020 by usage

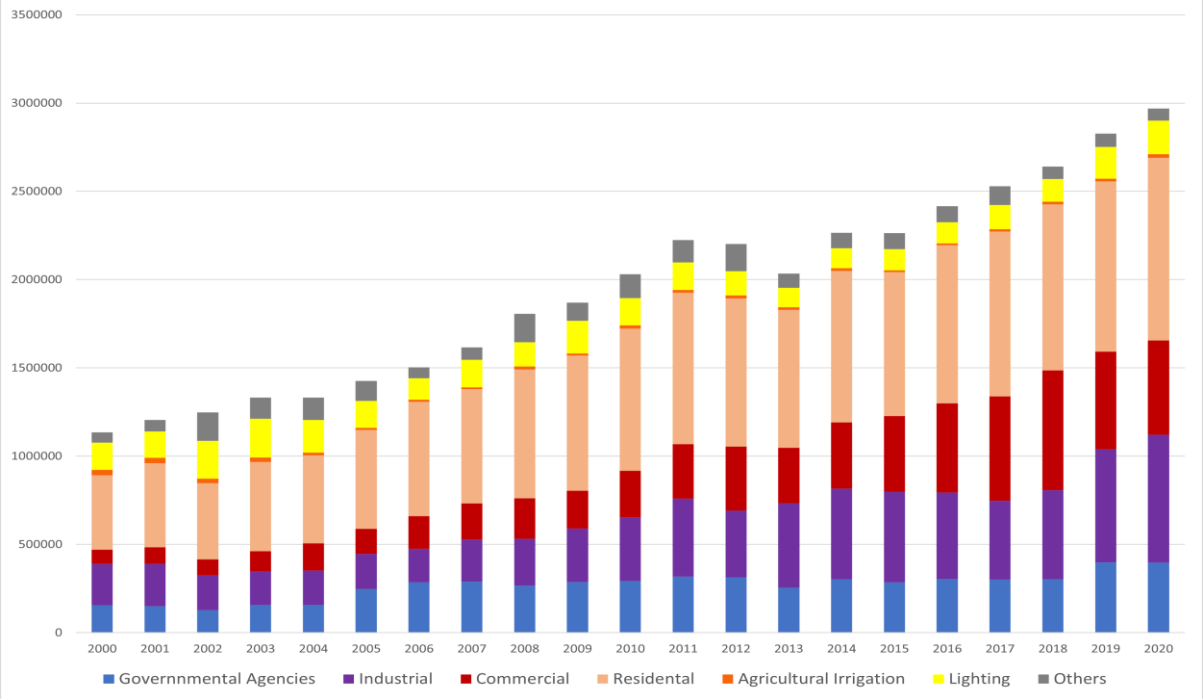


Figure 3.23 Distribution of energy consumption in TR region A between the years 2000-2020 by usage

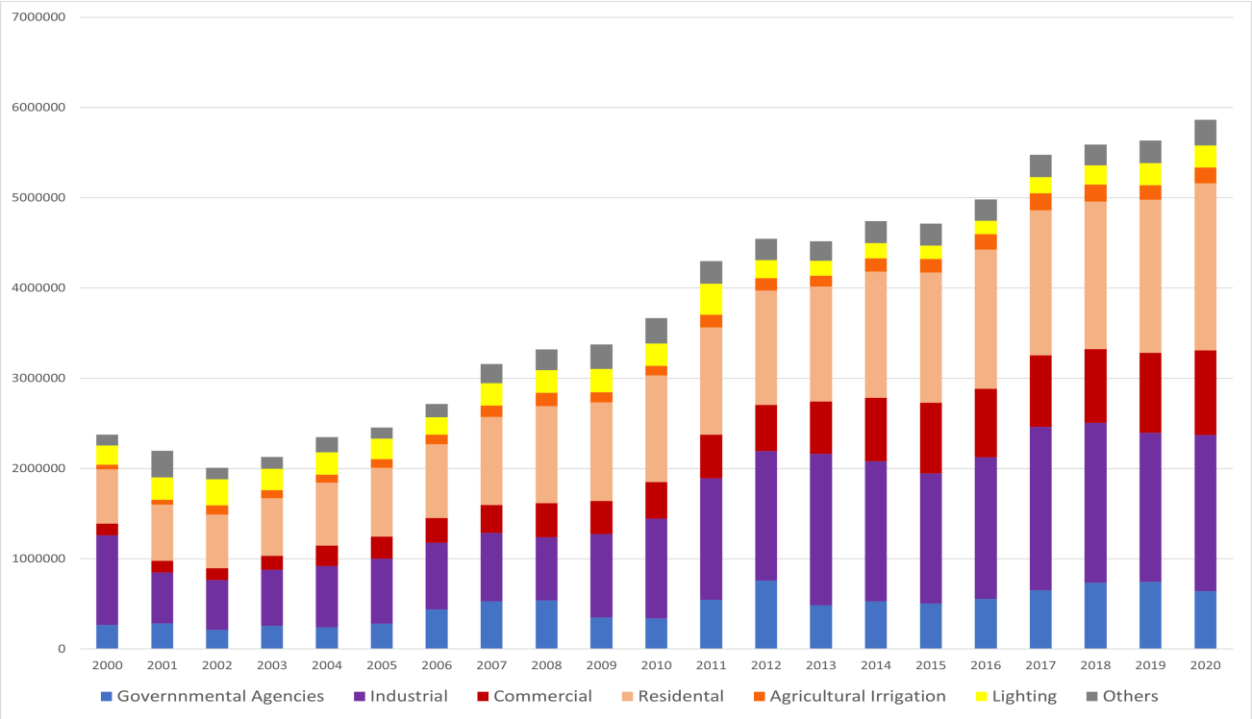


Figure 3.24 Distribution of energy consumption in TR region B between the years 2000-2020 by usage

As can be seen, when the graph of the TRB region is analyzed, the energy consumption of residential and industrial areas is much higher than the others (Figure 3.24). On the other hand, the T.R. C region has an intense use of industry. It is seen that the industry has had a larger share than residential and trade, and agricultural irrigation for the last three years (2018,2019,2020). Among all regions, the region with the highest percentage of energy consumption in agricultural irrigation stands out as the TRC region (Figure 3.25).

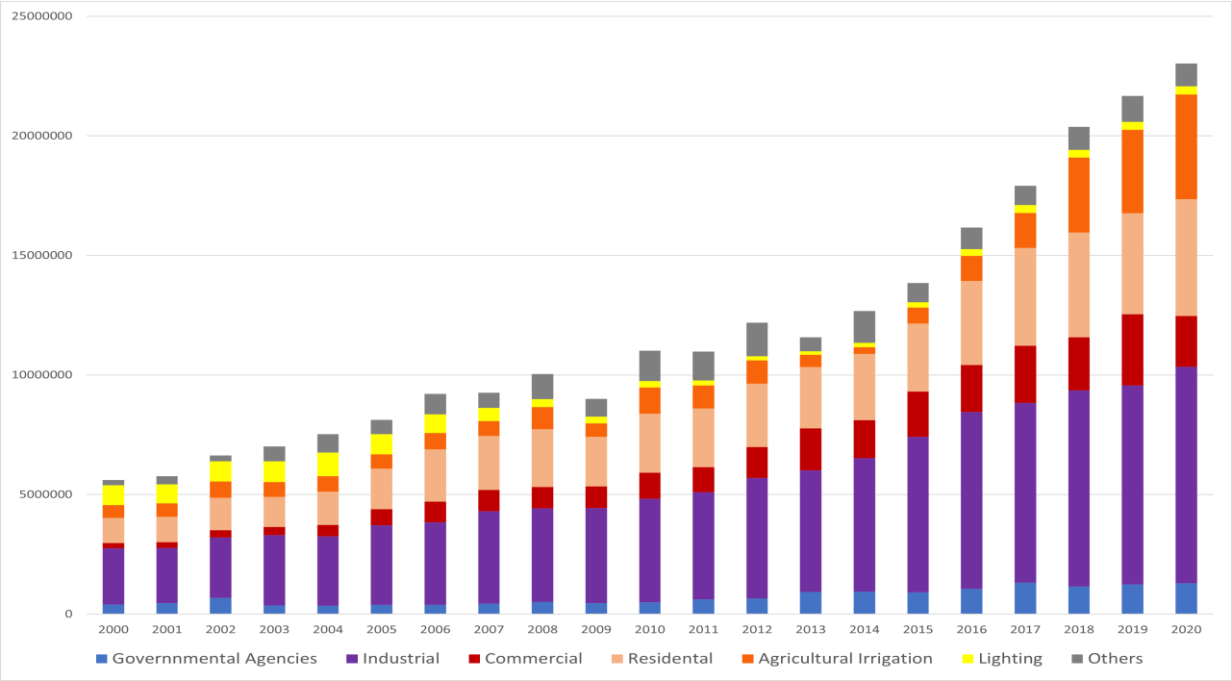


Figure 3.25 Distribution of energy consumption in TRC region between 2000-2020 by usage

When all regions are considered together for 2020, the regions with the highest energy consumption are TR3, TR4, TR1, and TR6, respectively. The region with the lowest energy consumption is the TRA region. It is observed that the energy consumption rate in TRA, TR9, TRB, TR7, and TR8 regions is meager compared to other regions. Considering the production-consumption balance given in Table 3.3 and the energy consumption data of the regions for 2020 in Figure 3.29, considering the causality between energy consumption and regional/national development, this situation also reveals the regional unbalanced development in Türkiye (Figure 3.26).

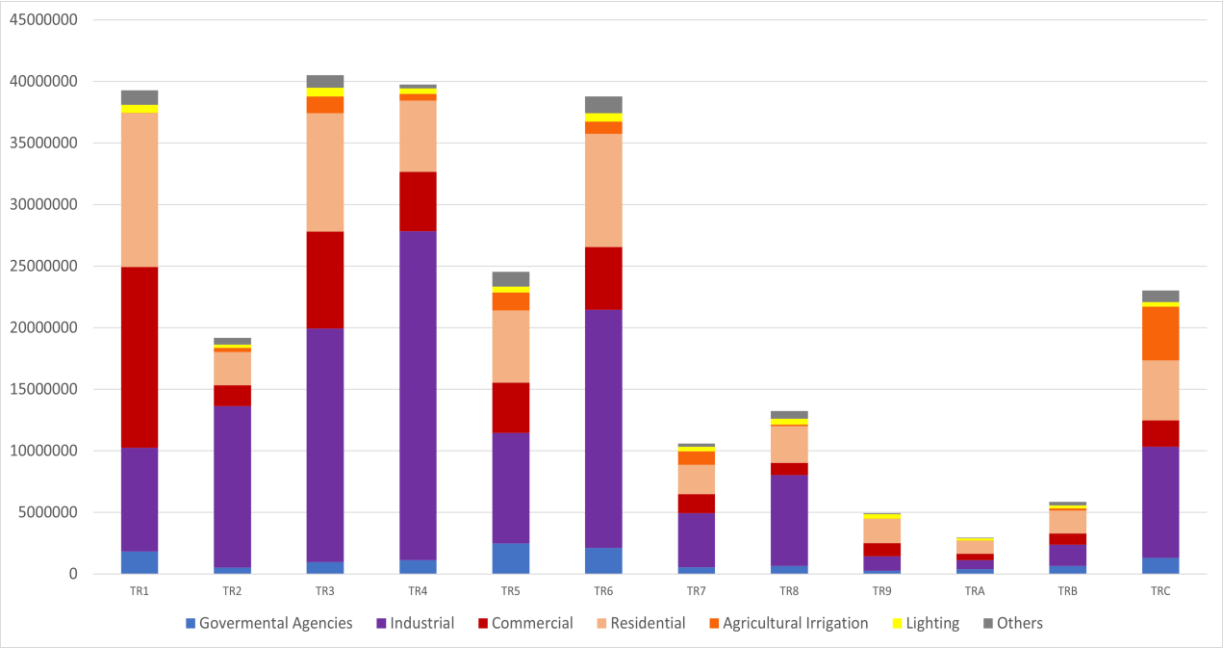


Figure 3.26 Distribution of energy consumption data of all regions by usage

The sectoral distribution of energy consumption data published by the Turkish Statistical Institute for 2020 has been examined in this section. It is seen that energy is consumed primarily in industry, housing, and trade-service areas, respectively. TR1 (Istanbul), TR3 (İzmir, Aydın, Muğla, Manisa, Afyonkarahisar, Kütahya, Uşak), TR4 (Bursa, Eskişehir, Bilecik, Kocaeli, Sakarya, Düzce, Bolu, Yalova) and TR6 (Antalya, Isparta, Burdur, Mersin, Adana, Osmaniye, Kahramanmaraş) regions appear as the areas with the highest energy consumption. These areas are also where population density, GDP per capita, industrial production, and services sector are intense. TRC region ranks first in terms of energy consumed for agricultural irrigation. As a result of regional development projects (GAP), it can be evaluated that agricultural production has increased in this area, and the agricultural sector has an essential share in energy consumption.

On the other hand, there is a severe decrease in energy consumption of TR7, TR8, TR9, TRA, and TRB regions compared to other regions. In this low consumption, the largest share in terms of sectoral classification belongs to residential use. The graph that expresses this table in Figure 3.26 clearly shows that there is no sectoral diversification and production in these regions, and therefore the uneven development between regions and regional backwardness.

4

REGIONAL ECONOMIC POLICIES IN TÜRKİYE AND CURRENT SITUATION

4.1 The reason of unbalanced regional development in Türkiye

The problem of regional inequality is defined as follows, according to Tekkanat and Mermer: "The resources that will allow the development of the regions are not evenly distributed on the earth. While some regions develop because they are rich in resources, others cannot develop and lag because resources are limited and difficult to reach."

The problem of imbalance between regions appears to be a problem that needs to be resolved worldwide. There is regional inequality in Türkiye, as seen in almost every country worldwide. The rapid industrialization and urbanization process started with the industrial revolution II. It accelerated after World War II. II. Although the economic and political changes and globalization process after World War II have integrated cities and regions globally, the problem of regional imbalance continues.

In Türkiye, due to the uneven distribution of investments within the country, the distribution of labor, capital, and, accordingly, the diversity and density of urban facilities have been the main reason for regional inequality [39]. In Türkiye, especially after 1980, it is seen that regional differences gradually increased. The social, cultural, infrastructural, economic, and geographical differences of the regions also cause differentiation in regional development. From a geographical point of view, it is seen that there is a tremendous developmental difference between the east and West of Türkiye. In this case, climate and physical geography conditions are affected. However, because of inadequate infrastructure conditions, unplanned development, and uneven distribution of investments, the potential of the regions cannot be evaluated correctly and effectively; In terms of primary public assets such as population, sectoral diversification, income distribution, transportation, and communication, health, and education, unbalanced development prevailed throughout the country.

In most studies conducted as another measure of regional imbalance, GDP values were taken as an indicator of development. Based on this situation, when we look at 12 regions in terms of GDP by analyzing the NUTS scale in Türkiye, It is seen that TR1, TR3, and TR5 regions have 54.6% of Türkiye's total GDP.

All over the world, a solution is sought for interregional imbalance. In order to eliminate this imbalance, countries are directing more public investments to the underdeveloped regions and trying to send sector representatives to the underdeveloped regions with special incentives. [40]

The development of Istanbul and its hinterland due to the historical missions imposed on the regions and provinces; Since Ankara was the capital city, the rapid development process after 1923; geographically, coastal towns have a transportation hinterland and develop as port cities; plays a positive role in the development of the regions. However, when we look at the eastern part of the country, it is seen that the inter-regional development gap in Türkiye has increased rapidly due to the topographic structure, difficult climatic conditions, distance to domestic and foreign markets, scattered settlement structure and insufficient and unbalanced investments [41].

4.2 Regional economic development policies in Türkiye

To prevent unbalanced regional development, which is a global problem, and to find a solution to this problem of inequality, solutions are sought, and policies are produced in every country. In this section, the regional development process in Türkiye and the policies developed in this process will be examined periodically.

The foundations of the regional imbalance in Türkiye date back to the Ottoman Empire. Trade agreements signed in the 19th century led to decreased production within the country; The fact that industrial products from the West were offered for sale without restrictions caused the economic activities in the Ottoman cities to lose their importance. Due to these developments, economic value has been lost in the interior, especially in the Eastern and Southeastern Anatolian parts. On the other hand, in the western cities on the coasts, the revival in trade relations brought about rapid development by increasing the population [41].

High inflation, high unemployment rates, and low and unevenly distributed gross domestic product per capita are the leading causes of interregional inequality. In addition to income, interregional inequality prevails in many areas, such as population structure, physical and social infrastructure, entrepreneurship, human resources, education level, access to health services, environmental quality, and employment in connection with economic development [42]. After explaining the causes of unbalanced regional development and the effects of the period before the establishment of the Republic, the developments in Türkiye after 1923 and the regional economic development policies produced are grouped under four headings in terms of their periodic similarities.

- **1923-1960 Period**

When the Republic of Türkiye was established, due to all the developments experienced, the problem of regional inequality was one of the existing problems. However, until 1950, it is seen that no comprehensive regional development plan or policy could be implemented to solve this problem. When the regional development policies in this period are examined, as the most important of the practices to reduce the regional development**:**

- Ankara is the capital. With Ankara becoming the capital, a modern city was established in Anatolia, and an attempt was made to prevent the further growth of a city like Istanbul with heavy investments. Istanbul - Ankara transportation networks were tried to be strengthened.
- It is seen that industrial areas have started to be established in Anatolian cities with a population of at most 10,000, except for coastal cities such as Marmara and Aegean. It is aimed to provide transportation to these regions, which are in the inner parts where the factory is established, by the railway network.
- Supporting national development with private sector initiatives with the Izmir Economy Congress held in 1923. The congress aims to ensure national development and development. [39]
- With the Encouragement-i Industry Law enacted by the Ottoman State in 1913, it was realized that the developments experienced after the industrial revolution were lagging, and it was aimed to support industrialization. Within the scope of the Encouragement Industry Law in 1927, it is desired to develop the country's economy and reduce foreign dependency. It has been stated that the industrial areas are concentrated in the West of the country, while the east of the country lags in infrastructure and investment. With this law, the state-supported private companies sought to meet citizens' compulsory needs through state institutions with the national capital. The Government has enacted the First Industry Program to enable the state-sponsored establishment of large companies. [43]
- Due to the global economic crisis in 1929, the state intervened in the economy within the scope of the "principle of statism".
- The period between 1950-1960 II. It is the post-World War II period, and although there was no war in this period, the effects of the war are seen in the country. It has become a necessity for the regions to develop based on their internal dynamics. After 1945, due to the transition to the multi-party period and the change in political power, there were

changes in the state's intervention in the economy. In this period, infrastructure investments gained importance. Public investments were made outside of large settlements, but private sector investments were concentrated in the country's West [44]. Although spreading the assets throughout the country with public investments was desired, the East could not get enough shares [45]. Due to the private sector investments concentrated in the western regions, the problem of unbalanced development between the country's East and the West has increased even more.

After World War II, planned development was supported worldwide, and organizations such as the OECD, which provided financial support, presented the planned model as a prerequisite. This situation brought the planned model discussions to the agenda, and studies were carried out to establish a planning organization in the 1960s. [39]

- **1961-1980 Period**

To accelerate Türkiye's social and economic development, the State Planning Organization was established on September 30, 1960, and served the country until 2011. After 1960, a comprehensive planning approach was adopted to accelerate social, cultural, and economic developments [42]. In 1963, five-year development plans started to be prepared to ensure social and economic balance. Reducing inequality between regions is among the priority objectives of development plans. During this period;

- Increasing public service opportunities,
- It is planned to provide discounts and credit opportunities for those who will invest in the underdeveloped regions and to establish an organized industrial zone in these regions,
- Development regions have been determined throughout the country, and specific sectoral characteristics have been assigned to the regions (for example, East Marmara industry, Çukurova agriculture and industry, Antalya region agriculture and tourism),
- Growth centers, which are accepted to spread economic and social development around them, have been proposed. It aims to intensify public investments and complete the infrastructure in these centers, considering that private sector investments will also be attracted to these regions.
- At the end of the term, the "Development Priority Regions (KÖY)" project, which will enable regional resources to be activated and to work effectively with local governments, has been developed [45].

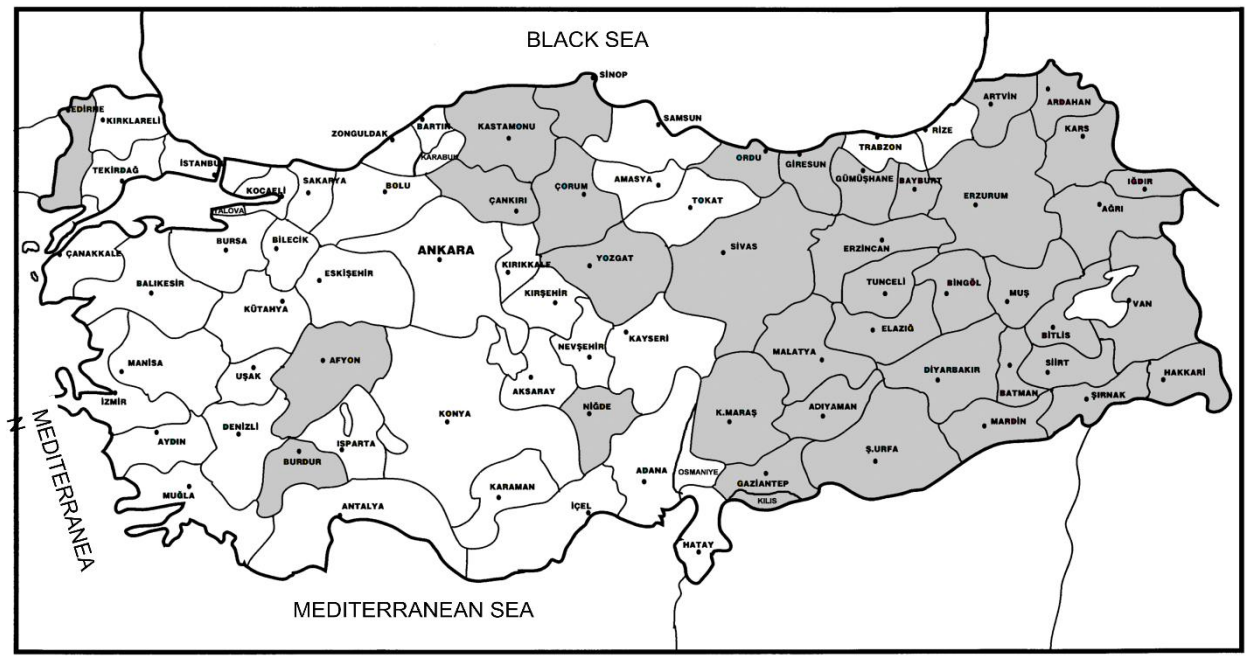
- **1981-2000 Period**

To ensure economic development in this period:

- Dividing labor,
- Reducing the planning decisions to the spatial dimension,
- Ensuring a balanced distribution of services, industry, and infrastructure at the country level,
- It has been proposed to reorganize the incentives applied in a way that will highlight the regional resources and potentials and activate them.
- The importance of regional development in development and planning has increased, and the necessity of making regional plans has been expressed. To accelerate the development of the regions and use the resources effectively, "Regional Planning" is envisaged in the regions that are developing and have development potential in specific sectors. DPT determined 16 regions. The concept of an independent region from administrative borders is based on. Furthermore, creating "Functional Regions" with the highest mutual relations between settlements on different subjects is envisaged.
- An urban development project has been initiated for the rapidly developing Çukurova Region. In addition, a legal framework for regional planning has been established for the Southeastern Anatolia region, one of the country's underdeveloped regions.
- Since 1990, the "Regional Planning" concept has been replaced by "Regional Development."
- It is envisaged to prepare a new settlement stratification to provide a balance in the grading of the settlements, reduce the population and industry density towards metropolitan cities, and control inter-regional and intra-regional migrations.
- As of 1990, E.U. regional policies started to be considered.
- To give priority to the "environment" issue in economic and physical planning while creating plans and policies,
- Reducing interregional development disparities by providing sustainable development,
- It is among the basic principles of this period to prepare special projects for the underdeveloped regions of the country, considering their resource and development potentials, with priority given to the southeastern and eastern regions.

Priority provinces within the scope of “KÖY” with the decision of the Council of Ministers dated 1998:

Adiyaman, Agri, Aksaray, Amasya, Ardahan, Artvin, Bartin, Batman, Bayburt, Bingol, Bitlis, Cankiri, Corum, Diyarbakir, Elazig, Erzincan, Erzurum, Giresun, Gümüshane, Hakkari, Igdir, Kahramanmaras, Karabuk, Karaman, Kars, Kastamonu, Kırıkkale, Kırşehir, Kilis, Malatya, Mardin, Muş, Nevşehir, Niğde, Ordu, Osmaniye, Rize, Samsun,



Map 4.1 Priority regions in development 2000 [45]

Siirt, Sinop, Sivas, Şanlıurfa, Şırnak, Tokat, Trabzon, Tunceli, Van, Yozgat, Zonguldak. Counties; Gökçeada, Bozcaada. **(**Figure 4.1) [45]

- **Post 2001 Period**

To reduce the development differences between countries, within the country, between regions and sub-regions, the European Union and OECD countries, in order to reduce economic and social disparities, the regional development fund, which constitutes half of the Structural funds, has been used for the development of the underdeveloped regions and to support the initiatives in these areas. The main targets are:

- Ensuring social, economic, and spatial integration,
- Protection of the environment,
- Strengthening local governments,

- Establishment of an integrated socio-economic and geographical information system,
- Creating development axes that will strengthen the functional connection of medium-sized cities with each other and address the problems and potentials of the regions,
- Ensuring effective institutionalization,
- Strengthening the state-private sector bond,
- Sustainable land use is aimed at ensuring social balance.

When we look at the regional development in Türkiye for the year 2000 and after, it is seen that the regional development gap continues as a problem. However, progress has yet to be made. The partial importance of the central regions where the industry is concentrated in the country has decreased. The share of provinces such as Istanbul, Izmir, Adana, and Ankara in the Turkish manufacturing industry has reduced. The main reason is the spread of industrial activities from these provinces to the surrounding provinces and the concentration of service sectors such as finance, banking, marketing, trade, and tourism in these centers. As a result, while the characteristics of these provinces as centers increase, it has been stated that some provinces, such as Mersin Kırklareli, Sakarya, and Tekirdağ, are new industrial centers.

Infrastructure investments, essential in reducing regional development disparities and ensuring the development of underdeveloped regions, are completed after a period of time due to inadequate cash flow and appropriations, negatively affecting regional development.

The high population growth rate complicates living conditions, leads to a lack of employment, and increases the lack of public services. For this reason, "Action Plans" and "Emergency Support Programs" were implemented in the 7th Five-Year Development Plan period (1996-2000) to meet the deficiencies in the eastern and southeastern regions. Eastern, southeastern, and eastern Black Sea projects such as GAP, DAP, and DOKAP draw attention. These plans aim to develop national resources for the highest economic and social benefit and minimize interregional imbalances. These applications are specially integrated projects aimed at providing development both in the region where they are applied and throughout the country [42]. Since the agriculture sector is the primary sector in these regions, it is aimed to increase the added value, production, and productivity in the food, agriculture, and livestock sectors, to solve environmental problems by improving public infrastructure services, to reduce migration out of the region by increasing the welfare level in rural and urban areas.

Goals of regional development policies; ensuring sustainability, interregional integration, social and economic balance, improving the quality of life, providing equal opportunities throughout the country, and increasing cultural development and participation.

Within the scope of Türkiye's harmonization process with the E.U., in addition to the seven geographical regions used locally, the Statistical Regional Units Classification (NUTS) was created in 2002. There are regions of three different levels: Level 1, Level 2, and Level 3. This classification; consists of units consisting of 12 regions within the scope of Level 1, 26 regions at Level 2, and 81 provinces at Level 3. In 2006, the Development Agencies, which are autonomous public institutions, were established in coordination with the Ministry of Industry and Technology, primarily aiming to reduce regional inequalities and carry out studies to ensure regional development. They were found to improve cooperation between the public, non-governmental organizations, and the private sector, based on the Level 2 regions, under Law No. 5449, and to reduce the intra-regional and inter-regional development differences by ensuring the effective use of resources to activate the local potential of the regions. [46]

With the eighth development plan, it is stated that the regional approach requires a holistic evaluation. Participatory planning, sustainability, resource use efficiency, and harmonization with European Union policies are fundamental principles in regional development. Therefore, regional strategies and policies focused on strategic regional planning, the importance of clustering, and provincial development plans. These policies it was aimed to increase the competitiveness level of the regions and to increase entrepreneurship by highlighting the local potential. E.U. funds were used to realize SMEs were supported, and the first comprehensive regional plans and green river basin development project were prepared. Thus, it is seen that regional development tools and policies have begun to be analyzed and implemented in a multidisciplinary framework. [47]

In the Ninth Development Plan, different from the regional development practices implemented in the previous plans, the regional development tools based on the new economy are mentioned (Table 4.1).

Table 4.1 Regional development tools based on traditional and new economy [47]

General Concepts	**Traditional Economy**	**New Economy**
Fundamental Infrastructure	Energy, Water, Road, Railway, Port, Airport	Telecommunication, multi-functional platforms, broadband internet
Local Infrastructure	Industrial parks. business incubators, Techno parks	logistics areas, internet incubators, Virtual networks for best practices development
Human Resources	Education and training Adaptation of people with disabilities, vocational training	Information, continuous learning, Predetermination of trade requirements,
Business Support Policy	subsidies, tax breaks, Special supports, (consulting services), Audit, consultancy services	Financial engineering, joint support, Expert support/custom supports,
Potential Region Investment Attractiveness	job creation, Variable investment research, competitive advantages,	Entrepreneurship, Cooperation business to business, clustering
Role of Public Administration	business support pricing of local resources, Public service, Evaluation, priorities recognition, making deals,	partnership, governance, regional research, Technological monitoring, economic intelligence, sustainable development Public-private partnerships sampling, Benefit/cost ratio of public expenditures, Integration strategies, innovation

Regional development tools in nine development plans regional development specialization report.

- Institutional Qualified,

Development agencies, Investment support offices, regional plans, operational programs, and SWOT Analysis

- Economic Qualified

Organized industrial zones, regional aid practices, venture capital, joint regional development practices.

- Culturally Qualified

Conference, exhibition, fair centers, recreation, and amusement parks, alternative tourism, regional nature parks, cultural centers

- Social Networking Qualified

Regional innovation systems, technology centers, innovation transfer centers, business/business clusters, public-private partnerships, intermediary (catalyst) institutions, trade associations, intra-regional sectoral industry networks, techno parks, incubation centers, business seeding/core capital centers, business /business angels, entrepreneurship development programs

grouped under four main headings.

Regional development tools are expected to contribute to competitiveness, provide support from the actors, provide coordination, and help in what scale and kind of regions they can be applied [47]. During the ninth development plan period (2007-2013), efforts were made to activate regional development policies at the central level, and programs and strategies for evaluating the potential of regions were put into practice. Institutional capacity has been tried to be developed, and rural development has been emphasized. However, the social-economic development gap between the West and the East is still at a severe level; In terms of contribution to GVA, the contribution of the first five regions among the NUTS 2 regions consisting of 26 regions is 55.5%, and the share of the last five regions is at the level of 4.4%; It has been stated

in the Tenth Development Plan that the tendency of the population to concentrate in metropolitan cities continues [48].

When we look at the tenth development plan (2014-2018), it is seen that there is no specific program or application mentioned. Only goals, objectives, and policies are developed. The target is balanced development and increasing the competitiveness of regions by evaluating their potential. Developed policies:

- Strengthening the harmony between lower and upper-scale plans, spatial developments, and socio-economic policies,
- Diversifying economic activities, especially in low-income regions, developing SMEs, increasing agricultural productivity, strengthening human and social capital,
- Increasing the accessibility of public services and transportation
- Strengthening transportation corridors to ensure the integration of regions/provinces with each other,
- Improving the living conditions of the regions by improving the infrastructure and superstructure and increasing their attractiveness for investments.
- Development of cross-border socio-economic relations of border regions
- Ensuring effective use of information and communication technologies, especially in the development of low-income and geographically disadvantaged regions
- Strengthening and globalizing inter-cluster collaborations
- Increasing the production and export capacities of OIZs,
- Giving importance to branding in terms of the potential they have in cities, the opportunities they offer, the goods and services they produce,
- Strengthening the link between development agencies, activating resource management, especially EU funds

is in the form [49].

As in the tenth development plan, there is no special expert commission report within the scope of the eleventh development plan (2019-2023), and there is no mention of a newly developed application. Regional development targets are shown in Table 4.2.

Table 4.2 Regional development goals [50]

	2018	**2023**
Ratio of Per Capita Income of the Highest Income Region to the Per Capita Income of the Lowest Income Region (%)	4,28	3,85
Ratio of Graduates from College and Above in the Five Regions with the Lowest Education Level (%)	10,9	16
The Average of the Five Regions with the Lowest Share of Industry and Services in the Regional Economy (%)	77,4	80

However, in the "Regional Development National Strategy 2014-2023" report prepared by the Ministry of Development in 2014, visions and strategies were developed by revealing the trends and current structure of the regions. An integrated spatial development perspective with the European Union is aimed at, and six priorities have been determined. These are:

- Supporting multi-centered and balanced spatial development,
- Supporting integrated development in urban and rural areas,
- Spatial integration between cross-border and transnational functional regions,
- Global competitiveness of regions with strong local economies,
- Improvement of spatial accessibility,

It is the management of ecological, cultural, and natural values. [51]

In the regional development national strategy, objectives have been determined for 2023. Under the heading of general purposes:

- Spreading welfare in a balanced way across country borders and reducing regional development disparities
- Evaluating the existing potentials of all regions and increasing their contribution to national growth and development by increasing their competitiveness,
- Strengthening economic and social integration
- Establishing a more balanced settlement throughout the country

These general objectives are divided into two and constitute spatial and horizontal objectives. Spatial objectives:

- Increasing the global competitiveness of metropolitan centers and spheres of influence,
- Strengthening the openness of growth centers and increasing competitiveness,
- Triggering development in low-income regions with regional centers of attraction,
- Diversifying economic activities and reviving the economy in the provinces of structural transformation,
- Convergence of priority development provinces across the country,
- Accelerating development in rural areas.

Horizontal objectives:

- Improving the governance of regional development and building institutional capacity,
- Alignment of public investment and support practices with regional development goals,
- Improving the competitiveness of regions,
- Developing cross-border and interregional cooperation,
- Improving the transport network and accessibility,
- Supporting the sustainable environment and green economy.

Strategies were determined by explaining what needs to be done to implement these articles.

When we look at all the plans prepared, all the policies developed, and all the projects implemented throughout the periods, it is seen that the main aim is always to eliminate regional inequality. In the period before 2000, while it was aimed to develop policies on the development of the existing sectors of the regions, sectoral diversification was expressed as of the 10th Development Plan. However, when we look at the actuality of these goals and targets, it is seen that they cannot provide the expected benefit when we look at the available data. As stated in the title of "Türkiye Level 1 Regions Basic Indicators" in the study, when the 2020 data are examined, only the TR1, TR3, and TR5 regions have 67% of the total GDP out of 12 regions (Figure 7). However, these regions cover only 23% of the country in terms of area size and contain 41% of the entire country's population.

An economy based on only one sector in a region brings economic risk to that region. Sectoral diversity brings empowerment. As production increases in countries, energy consumption increases, and the energy sector plays an essential role in development today. When the international literature and the policies of European countries are examined, it is evident that

the energy potential of the regions should be emphasized more. When we look at the Regional Development National Strategy, which has been prepared recently, it is seen that the title "Energy" is included. Particularly, renewable energy, energy efficiency, and energy supply security are the prominent expressions.

4.3 Türkiye Regional Economic Development Status at NUTS 1 (2020)

All countries experience changes and transformations in the economic and social structure over time. The rapid changes in the 21st century bring an increase in energy consumption. Rapid changes in population change in political and political decisions have also caused a transformation in the historically different concept of "development". The success of nations worldwide is related to how quickly and to what extent they can adapt to these global transformation processes. While a top-down system was applied in the concept of development in the 20th century, as of the 21st century, together with the concept of sustainable development, it is seen that national development consists of a regional balanced development process. Therefore, the emphasis on the importance of the local has increased. It has been realized that in addition to reducing the development differences between regions, increasing the global competitiveness of regions by using their potential has an important place in national development.

Regional development agencies prepare regional plans to understand better the potentials and problems of the regions in Türkiye and determine the regions' socio-economic development trends and sectoral targets. In this section, the energy situation in the NUTS1 regions of Türkiye will be examined within the scope of the current regional plans prepared at NUTS 2. The energy potentials of the regions and the planned energy corridors will be considered.

- **TR 1 Region**

When we look at the TR1 Region, it is seen that only Istanbul is located, and it has the smallest surface area with 5,343 km² in area. Istanbul is a city under the pressure of intense construction. It is exposed to intense immigration because it is the most developed city in the country in terms of economic, social, and cultural aspects. The 2014-2023 regional plan for Istanbul emphasized that adopting environmentally friendly energy use and sustainable waste management is essential. In the "Environmentally Friendly Energy Management," "Quality and Sustainable Environment," and "Environmentally Friendly Energy" sections of the plan, it is stated that it has energy-related targets in the context of sustainable development.

Due to its location as a mega city, the region has a high population. It has been considered the primary consumer of natural resources and the main producer of pollution and waste. In Istanbul, within the framework of combating climate change, it is essential to use suitable land, increase forest and agricultural areas, protect natural resources with sustainable waste management, and reduce greenhouse gas emissions. Although some studies are carried out in Istanbul on producing energy from garbage and reusing wastewater and solid waste, existing studies need to be expanded and improved due to insufficient infrastructure and services. TR1 Region has some potential in energy production, but it is expressed as a large market in energy consumption due to the intense population and economic activities. As seen in Table 3.4 in energy consumption, although it had a significant share of 16.13% of the country's consumption in 2020, it does not have sufficient energy resources for energy production. Therefore, ensuring energy efficiency in energy usage areas such as transportation, industry, housing, and service and expanding the use of clean energy is vital for the TR1 Region.

When examined in terms of renewable resources, it is seen that wind energy has an important place in Istanbul. However, it needs more potential in terms of solar energy. At the same time, it was stated that Istanbul lacks sufficient and utilizable waterpower and a geothermal field. When the wind speed at 50 m altitude and the areas where a wind power plant can be established in Istanbul are evaluated, it is stated that there is a total installed power capacity of 4,177 MW in a total area of 855 m^2. However, according to the Ministry of Energy data for 2021, the total installed power of the wind power plants in operation in Istanbul is only 790 MW.

The energy targets given within the scope of the 2014 - 2023 Regional Plan are as follows:

Increasing renewable energy production to reduce the share of energy imports.

- Expanding wind power plants and increasing their capacities, especially in the northern parts of the European Side,
- To provide energy efficiency and to create programs for the dissemination of clean energy use to reduce the greenhouse gas emission rate,
- To raise awareness and raise public awareness to increase efficiency in energy resources and energy use,
- Establishing energy efficiency and clean energy centers on both sides of Istanbul to support R&D studies for clean energy applications in companies,
- To support studies and consultancy services for the use of renewable energy sources in the industry and increasing efficiency in production

- To increase institutional capacities on green buildings and to expand practices,
- Sheathing, central system, etc., to increase applications, to expand energy conservation in existing buildings by using technology,
- Using efficient energy-consuming technologies and renewable energy sources in public application areas such as urban lighting, traffic lights, billboards,
- To do transportation planning to ensure energy efficiency in transportation,
- To support the use of engines and fuel systems that use clean energy sources,
- To expand intelligent grid applications that will provide energy efficiency,
- To expand the use of electric vehicles, primarily public transportation, and to provide related infrastructure services.

It is stated that the services sector in Istanbul is at the forefront and produces more added value, while the industrial sector is in a structure that produces labor-intensive and low-medium technologies and low-added value simultaneously, so there are adverse effects on foreign trade performance. It was stated that this situation increased Türkiye's macroeconomic risk and negatively affected its growth performance. [52]

- **TR2 Region**

TR2 region includes TR21 (Tekirdağ-Edirne-Kırklareli) and TR22 (Balıkesir-Çanakkale) regions. For this reason, 2 separate regional plans will be examined for the TR2 region. When the regional plans are examined, it is seen that the region is rich in terms of both renewable and fossil resources.

Renewable energy sources in the region has significant potential. Especially the TR22 South Marmara Region is rich in renewable energy resources such as wind, solar, geothermal, and biogas, and energy production is carried out in many districts in the region. Among the primary energy sources, it is seen that the resources that contribute locally to the energy supply in Türkiye are hydraulic and renewable. For this reason, it is essential to expand the use of renewable resources and the production of energy from them. [53]

It is predicted that cattle, sheep, and poultry manures, other organic wastes, and food industry wastes arising from agriculture and livestock activities, which are intensively carried out in Türkiye, are processed in the region, and can meet the energy need of 5.9-11.6 percent of the country's total electricity production.

Regarding geothermal resources, it has been stated that the resources are spread throughout the region and that residence heating studies are carried out with geothermal energy.

As an exciting statement for the solar energy source, in the TR22 Regional Plan, with an average of 2430 hours of sunshine per year, in Türkiye, applications of the Southern Marmara Region, which receives one and a half times the solar energy potential of Germany (max 1241MW/year), one of the European Union countries, which is at the advanced level in solar energy production. It has been stated that it is expected to improve the legislation because it is out of the regions that can get a license.

It has been mentioned that the source that will make the immense contribution to electricity production in the Thrace region is coal, but it is harmful in terms of carbon emissions. In addition, Türkiye's oil and natural gas reserves are concentrated in Thrace and Southern Anatolia. [54]

Renewable energy technologies should also be developed to increase the use of renewable energy sources. It is seen in the regional plans that this issue is emphasized in the TR2 Region. It has been stated that the Region aims to get the highest share of this added value by specializing in a place where renewable energy technologies are developed. For this purpose, it has been stated that it is necessary to disseminate renewable energy research in a multi-disciplinary manner by establishing energy institutes and energy systems engineering departments at universities in the Region to train human resources. Furthermore, in vocational schools and vocational high schools, it has been started to work on training qualified intermediate staff needed by the energy technologies sector and the production of added value that will arise from factors such as machinery-equipment production, maintenance and repair, logistics, construction, design, consultancy, R&D and human resources with the resources in the Region is aimed at regional development, highlighted as important.

The policies to be implemented within the scope of priority are listed as follows.

- Diversifying resources in energy production by giving priority to domestic resources,

- Increasing the share of renewable energy sources in the energy supply,

- To effectively evaluate the advantage of the energy transit corridor, which is shaped within the framework of national policies,

- Increasing efficiency in energy use,

- Developing high-tech vocational training capacity

- Reducing the use of poor-quality fuel within the scope of combating air pollution

- To inform the producers about sustainable agricultural practices in order to prevent pollution caused by agricultural activities and to encourage livestock enterprises to produce their energy in regions where the amount of biomass waste is high,

- By giving priority to the public sector, to promote environmentally friendly, heat-insulated, and energy-efficient building systems, to encourage the construction of green buildings based on feasibility,

- To research the development of clean production and energy efficiency methods that can be applied for sub-sectors where industrial enterprises are concentrated and to support innovative approaches in this direction,

- Greenhouse and greenhouse cultivation will be expanded, and to encourage the establishment of greenhouse facilities that benefit from geothermal energy resources,

- To raise awareness about energy efficiency and clean production in public and industrial organizations and to encourage energy saving,

- To conduct studies to develop and increase the number of companies interested in producing renewable energy systems, attract investors to the Region in this field, and create a cluster in the sector.

- **TR3 Region**

TR 3 region consists of 3 regions within itself when viewed at the NUTS2. These; TR31 (İzmir), TR32 (Aydın, Denizli, Muğla), TR33 (Manisa, Afyonkarahisar, Kütahya, Uşak) regions.

To ensure sustainable development in the region, the main objectives are to expand the production and use of renewable energy, to increase efficiency and capacity in traditional energy production, to expand the use of modern technology, and to save in consumption. Increasing the production efficiency allows us to benefit from the inputs in the longer term. In energy use, the increase in efficiency ensures that the energy consumed is utilized to the maximum extent and time while reducing energy losses and using less energy per unit of work. Renewable resources that come to the fore in the region; are solar, wind, geothermal, and biomass. The installed wind energy capacity in the region corresponds to 31.3% of Türkiye's total wind energy capacity. The total wind energy installed power in this region is 3333.77 MW

as of 2021, and 2970 installed power is provided only from İzmir. According to the theoretical information in the TR31 regional plan, the wind energy capacity of İzmir is 11,854 MW. Therefore, the amount of energy to be produced by evaluating this potential is greater than the total electricity consumption of the Aegean region. [55]

- The region is one of the most advantageous areas in terms of the potential to benefit from solar energy. For example, in the Antalya region, which has the highest solar capacity ratio in Türkiye, the rate is 20%; In İzmir, this rate is around 15-18%.
- 98.2% of Türkiye's geothermal energy installed power belongs to the TR3 region. Much of the energy produced from geothermal energy is used for residential heating and some for-greenhouse heating and tourism purposes.
- The main targets set for the development of renewable energy efficiency are as follows:
- Extending energy efficiency practices and renewable energy use in all sectors
- Increasing renewable energy production.
- To provide more production with the same amount of energy in energy-intensive industrial facilities.
- Strengthening university-industry cooperation for the development of R&D and innovation capacity in the field of eco-efficiency.
- Green buildings provide significant energy savings of 30% compared to non-green buildings, therefore making it mandatory to comply with green building legislation in all new buildings.
- To provide intelligent grid applications that enable residential, commercial, service, and industrial areas to be included in the grid as energy-consuming producers.
- Strengthening public transportation in the context of transportation, encouraging non-motorized transportation, and supporting it through public institutions.
- Reducing energy losses by improving traditional energy generation and distribution infrastructure.

- **TR4 Region**

The region consists of two regions in NUTS2, namely TR41 (Bursa, Eskişehir, Bilecik) and TR42 (Kocaeli, Düzce, Sakarya, Bolu, Yalova). Increasing efficiency in energy use and expanding the use of renewable resources are important, but resources cannot be used effectively. Although it has a large share in electricity consumption due to industry and population density, it is a region that also produces energy (14.5% of Türkiye). [56] The region is under the influence of the Istanbul metropolitan area. The region, which is rich in above-

ground and soil resources, is also under intense economic pressure due to the metropolitan effect. Establishing a balance between these two different dynamics and making land use decisions scientifically and rationally creates a situation that will ensure sustainable development [57]. It is understood from the regional plans that the potentials for renewable biogas resources exist in areas where wind, partial solar, hydraulics, agriculture, and livestock are intense.

In this context.

- By the legislation, energy efficiency centers are opened in organized industrial zones, and the use of heat insulation and heat meters in buildings is increasing.
- It is planned to establish thermal power plants to utilize the coal reserves in Bursa and Eskişehir.
- Identifying energy efficiency needs, expanding energy management, and reducing energy intensity.
- Developing R&D studies in the field of renewable energy and producing energy technologies
- To conduct feasibility studies to determine renewable energy production potential areas and encourage their use.
- To increase the use of local resources to the maximum level to reduce foreign dependency on energy and keep the environmental damage at the lowest level while meeting the energy demand.
- Supporting project design and implementation activities in all potential areas

Application recommendations have been developed.

- **TR5 Region**

TR5 region includes TR51 (Ankara), TR52 (Konya, Karaman) regions in NUTS2. When the regional plans are examined, it is seen that the energy sector is among the priority sectors for the region. It is aimed to increase renewable energy in energy production and use with the aim of ensuring green growth within the protection-use balance [58]. For this purpose, the targets set in the TR51 and TR52 regional plans to maximize the use of existing potentials, support technological developments and increase efficiency are as follows:

- To carry out actions in line with the transportation master plan strategies for the use of energy-efficient transportation methods and to increase the share of environmentally friendly systems in urban transportation.

- Developing applications such as energy efficiency certification for buildings, integration of renewable energy systems into buildings.
- To increase the quality of energy supply and infrastructure for the manufacturing industry, especially OIZs.
- Supporting the use of renewable energy and technology production
- To support solar energy potential.
- To improve the energy and environmental infrastructure (such as the establishment of distribution lines that can meet the electricity and natural gas demand, the establishment of wastewater treatment plants, and industrial solid waste separation and disposal systems), meeting the increasing demand for space, the transportation connection between the living spaces of the citizens who make up the relevant workforce and the industrial zone. Pay attention to the effectiveness.
- To prepare a strategy and action plan for Ankara to become an international energy market administrative center.
- To increase the installed power to meet the increasing energy demand most efficiently, to serve the needs of the electricity supply security, the manufacturing industry, and the quality of life of the citizens in the most efficient way, while providing renewable clean energy sources (to make maximum use of wind, solar, hydroelectric and biomass energies.
- To intensify geothermal energy investments in the determined sub-regions
- To carry out feasibility and application studies by considering the use of thermal resources in residential heating in combination with solar energy.
- To support specialization, clustering, technology transfer, technology development, and R&D activities in this field so that the region becomes an essential center in producing energy systems and energy production.
- To carry out information on energy efficiencies, such as using energy systems, passive heating, cooling, and lighting mechanisms.
- Establishment of green buildings will be encouraged, requiring energy efficiency certification in new constructions.
- Applications for the use of hot water will be expanded; start activities to use solar energy in residential heating.

- To intensify the establishment of biogas facilities to prevent environmental damage and to recover the excessive amount of animal waste produced in the region with rural areas in terms of the number of cattle and small cattle.
- Costs will be reduced by using solar energy in agricultural irrigation.
- Dissemination of energy efficiency practices in all institutions and organizations, especially in manufacturing industry enterprises.

  Although it is lower than Çanakkale Region, it provides an advantage to the region regarding wind energy investment due to the continuity of the wind.
- To encourage such activities by developing models and partnerships regarding making significant solar energy investments of strategic importance with private sector-public cooperation.

- **TR6 Region**

TR6 region; It consists of TR61 (Antalya, Isparta, Burdur) TR62 (Adana, Mersin), TR63 (Hatay, Osmaniye, Kahramanmaraş) regions. It is important to evaluate the potential of alternative energy resources in the region to protect the quality of life in the region, to protect the agriculture, tourism, energy, and industrial sectors, which are important for the region, to ensure sustainable green growth and to reduce energy dependence. [59]. Another fundamental role assigned to the region in national plans and programs is that the region is one of the world's most critical energy distribution bases with its existing and planned pipelines. Using the region's location, it is mentioned in the development plans that Türkiye aims to be a transit and terminal country between energy producers and consumer countries. In line with the strategic goal of "becoming an international center of attraction and production base" in the plan, "being an energy generation and distribution center" for the TR6 Region is one of the priority areas. [60] Approximately 50% of Türkiye’s lignite reserve, which is calculated as approximately 10 million tons, is in this region. [61]

Renewable energy measures and measures developed to ensure sustainability are listed as follows.

- Increasing the share of alternative energy sources in production
- By evaluating the favorable position of the region in terms of solar radiation value and sunshine duration, studies on electricity generation from solar energy will be supported.

- Studies on the production of biomass energy from the vegetable wastes generated during the production activities of the greenhouses, the wastes belonging to the forest assets, and the wastes generated after the livestock activities will be supported.
- Scientific studies to reveal the region's wind energy potential will be supported, and wind power plants will be established in areas with potential.
- Initiatives for the domestic production of parts used in the renewable energy sector will be supported.
- Efforts to increase energy efficiency through using environmentally friendly facilities and technology in production will be supported.
- Legal arrangements will be continued to improve the investment environment to realize new investments in energy production in the TR63 Region.
- Research, analysis, and feasibility studies will be carried out, and the results will be shared with the investors. In these studies, cooperation with regional universities will be considered a priority.
- An R&D center based on university and private sector cooperation will be established for renewable energy systems.
- Training and application programs will be developed to train a qualified workforce for the energy sector, especially in the field of renewable energy resources.
- Investment Support Offices will be actively involved in the process to facilitate new investment processes.
- Investments for modernizing electricity transmission and distribution lines in the TR63 Region will be increased and continued.
- The development and use of innovative production and consumption systems that increase energy production efficiency and energy consumption savings will be supported.

- **TR7 Region**

TR7 region has been evaluated within the scope of TR71 (Kırıkkale- Aksaray- Niğde- Nevşehir - Kırşehir) and TR72 (Kayseri - Sivas - Yozgat) regional plans, and it is seen that the leading sectors in the region are agriculture and industry. Inadequacies and deficiencies in the infrastructure of existing OIZs negatively affect the production process. The most important of these deficiencies is energy. Therefore, increasing efficiency in production, prioritizing energy

efficiency, developing marketing and promotional activities, and using resources effectively are the primary targets determined in the regional plan.

The settlements' planning process aims to adopt approaches that consider the sustainable use of natural resources, the protection of ecological balance, the prevention of pollution, energy efficiency, and environmental awareness.

The most basic measure taken to increase added value is to increase production efficiency, especially energy efficiency in agriculture, industry, and services sectors, and to develop the production of industrial products for renewable energy production systems.

- Supporting specialization centers, clustering, and entrepreneurship activities to support the production of necessary equipment for renewable energy production and power generation technology.
- Solar energy potential is high in the region, especially in Niğde and its surroundings, and it is aimed to utilize it to the maximum extent and to support investments.
- It aims to increase the region's energy production obtained from wind, geothermal, landfill gas, and biofuels.
- Due to the intensive livestock breeding in the region, the production volume of the region is exceptionally suitable for energy production from biofuels. Therefore, the dissemination of such facilities will be encouraged and encouraged.
- Another natural wealth of the region is its geothermal wealth. It will be ensured and supported to carry out the necessary feasibility studies so that this resource can be used in heating (greenhouse and housing) and energy production.
- In the TR72 region, which includes the provinces of Kayseri, Sivas, and Yozgat, wind and solar energy stand out among the energy resources, and there is a strong potential waiting to be evaluated in terms of the supply of materials to be used in the production process of these energy industries.
- Sustainable environment and energy axis has been determined, and in this axis, improving the energy infrastructure for efficient use is among the main targets.
- It is aimed to carry out studies on the production of materials and equipment to be used in energy production facilities in the region. Among these, projects will be developed that reduce consumption and encourage savings (such as producing heat pumps and heat insulation materials and panels, turbines, and materials used in solar-wind energy production).

- Construction of green buildings for improving energy efficiency, awareness raising activities, raising awareness at all levels, and developing cooperation among institutions and related groups have been determined as another target. [62] [63]

- **TR8 Region**

TR8 Region Zonguldak, Karabuk, Bartin (TR81); It is an area that covers Kastamonu, Çankırı, Sinop (TR82) and Samsun, Tokat, Amasya, Çorum provinces. Suggestions, targets, and measures developed to understand how the energy issue is evaluated in the three regional plans at Level 2 have been examined. Although the bioenergy, wind, and solar energy potential is high in the region, the energy needed by the region cannot be produced in the area. The region has significant potential in terms of mineral resources, and the development of mining in the region is essential for its economy as it is linked to areas such as transportation, energy, and employment. [64]

- Studies will be carried out on generating energy, steam, and heat from waste; necessary support will be provided for companies to invest in the region and cooperation between relevant institutions will be provided, and the establishment of biogas production facilities will be encouraged.
- Wind energy investments will be encouraged. (The region's wind energy potential of only Çankırı, Sinop, and Kastamonu has been determined as 2,321.4 MW.) The installed wind energy capacity of the TR 8 region in 202 is 314MW.
- Solar energy investments will be supported.
- There is also a high hydraulic energy potential in the region.
- To promote clean energy sources such as natural gas and biogas in industrial areas.
- To increase the P&D and R&D capacities of SMEs by using clean technology to increase their energy efficiency.
- To carry out feasibility studies on maximizing mechanization and reducing costs in the region, which has a resource in terms of hard coal.
- To carry out rehabilitation and modernization studies to ensure energy efficiency.
- Promoting environmentally friendly buildings using renewable energy sources, encouraging the use of environmentally friendly vehicles
- Reducing the public transport share of railways by reducing fossil fuel consumption and reducing harmful emissions to the environment by preventing unnecessary fuel use are basic transportation policies.

- **TR9 Region**

TR9 Region, which indicates the Eastern Black Sea region, covers the area where the provinces of Trabzon, Ordu, Giresun, Rize, Artvin, and Gümüşhane are located. The region has high hydroelectric energy potential with the availability of altitude and stream flow and high biomass energy potential due to the excess of plants and residues that can be converted into biomass energy. As a result, the TR9 region more than meets its energy demand and significantly contributes to the national energy supply. Within the region's renewable energy scope, there is also a good level of installable wind energy potential, especially in Ordu. On the other hand, considering current technologies, TR90 Region is not considered suitable for production in solar, geothermal, and sea wave energies. [65]

Under the innovative and competitive economy axis title, mobilize regional energy and mineral resources within the scope of efficiency and environmental awareness.

- Carrying out awareness-raising activities and taking necessary measures to increase efficiency in energy consumption

- Increasing the variety of resources in the energy portfolio of the Region

- Taking and implementing environmental sustainability measures in energy production and mining activities

developed as a strategy.

- **TRA Region**

TRA Region is the area with the lowest share in the installed power ratio in Türkiye. It consists of TRA1 and TRA2 NUTS2 regions, which include Erzurum- Erzincan - Bayburt-Ağrı- Kars - Iğdır - Ardahan provinces. It is located on the central energy axis in the east-west direction. It is a transition region for transporting rich energy resources in Central Asia and the Caucasus to global markets. Baku-Tbilisi-Ceyhan Crude Oil Pipeline and Baku-Tbilisi-Erzurum and Eastern Anatolian Natural Gas Pipe Main Transmission Line and the Trans-Anatolian Natural Gas Pipeline to be constructed pass through the Region. [66] Hydroelectric power plants are generally used in the Region, and it has a geostrategic location due to its location on the transit route of energy transmission lines. However, the advantages of its position could not be utilized. Regarding solar energy, Ağrı stands out with its 1700 kWh/m²-yearly radiation values throughout the Region and Türkiye. Apart

from solar energy, some areas provide high potential in biomass energy and geothermal energy in the Region. [67]

- To carry out feasibility studies on alternative energy sources and production opportunities, especially wind, solar, and biogas throughout the Region, to provide investments within the scope of grant supports.
- Ensuring inter-institutional cooperation to use energy more efficiently.
- Providing 50% financial support in agricultural irrigation by installing solar-powered irrigation systems
- To provide support to projects carried out by industrial organizations in the fields of energy efficiency and renewable energy.
- To implement investments for the construction of new greenhouses using alternative energy sources.
- To eliminate the deficiencies and infrastructure problems in the infrastructure of OIZs
- Ensuring the continuity of energy supply by improving the infrastructure of energy transmission and distribution facilities
- Disseminating insulation systems in buildings and promoting energy-efficient heating/lighting systems

These are the strategies developed within the scope of regional plans.

- **TRB Region**

The share of the TRB region, which consists of two regions, TRB1 and TRB2, and eight provinces (Malatya- Elâzığ- Bingöl- Tunceli / Van- Muş- Bitlis - Hakkari), in the total installed power is 5.17% as of 2021. As in the TRA region, renewable resources are not used in this region, except for hydroelectric power plants. However, it has emerged from the analysis that there is an excellent solar energy potential. On the other hand, it is stated that there is no specific potential in wind energy except for Malatya and Elazığ provinces. Therefore, the region contributes to national development by producing more than its energy demand, even with intensive hydroelectric production. [68] To attract renewable energy investments to the Region, it is necessary to make promotions in national and international arenas and organize symposiums, fairs, and congresses in the Region's provinces to promote the Region's renewable energy resources. [69]

- The strategies developed are given in the plans as follows:
- - Improving energy infrastructures
- - To support and encourage investment in renewable energy resources, to identify resources
- - To prevent energy losses and leaks
- - Ensuring the modernization of existing irrigation facilities, which are out of order due to energy insufficiency, and supporting energy production with renewable energy sources (especially disseminating solar energy systems in irrigation systems)
- - Developing projects for applications that increase energy efficiency
- - Developing the electromechanical industry
- - Supporting applications for those with suitable fluid temperatures for industrial and residential heating of geothermal resources in the region
- - To increase the amount of greenhouse area heated with geothermal energy
- - To improve energy transmission and distribution infrastructure systems and to reduce leakage/loss rates.

- **TRC Region**

The region is the area located in the southeast of Türkiye, formed by the provinces of Gaziantep, Adıyaman, Kilis, Şanlıurfa, Diyarbakır, Mardin, Batman, Şırnak, and Siirt. 10% of the energy installed power in Türkiye is produced in this region. However, due to the inadequacies in the transmission infrastructure and high loss-leakage rates, an uninterrupted energy supply cannot be provided. Therefore, it aims to create a "Green Energy Zone" image by expanding the use of renewable energy sources and environmentally friendly technology. [70]. The amount of energy produced remains below that consumed. Industrial enterprises use more than half of the energy consumed. As a result, the sunbathing potential in the region is above the country average. In general, the wind energy potential in the region is low. However, some regions in the northwest of Gaziantep and northeast of Adıyaman have sufficient potential to obtain wind energy. [71]

- To prevent raw material and energy losses
- To expand the use and production of solar and wind energy
- To promote the use of renewable energy in the heating and cooling of public buildings and environmentally friendly and energy-efficient residential applications such as the "greenhouse" example in the housing sector.

- To prevent loss and leakage by supporting the energy distribution structure by strengthening the infrastructure of rural areas in the region
- To increase the use of solar-powered irrigation pumps in the agricultural sector
- To support the establishment of an energy production facility for the evaluation of organic wastes as biofuels.
- To implement projects that will ensure the separation of domestic solid wastes at source, their use for recycling, and energy production.
- Efforts will be made to increase renewable energy investments in the region, which is rich in solar, wind, and bioenergy resources. In this context, the private sector will expand the use of the "Energy Efficiency Consultancy (EVD) Incubation Center" to be established in the GAP Region.
- Improving energy efficiency in the Turkish industry by encouraging industrial establishments to create effective energy management using energy efficiency measures and technologies.
- To reduce energy consumption and, therefore, greenhouse gas emissions in buildings in Türkiye by raising building energy performance standards, supporting and strengthening the implementation of relevant legislation, developing building energy management standards, and exhibiting, promoting, and disseminating integrated building design approach applications with the Project for Increasing Energy Efficiency in Buildings.

- **Türkiye Potential Renewable Energy Potential**

The increase in the foreign dependency ratio in energy, security of supply and the fight against climate change direct the energy policies in Türkiye. Looking at the World Energy Outlook 2022 report of the International Energy Agency, it is seen that clean energy investments are shown as the key to energy efficiency. If we look at the basic policies on energy in Türkiye, which have been developed in the current development plans and regional plans.

- To increase resource diversity in energy by giving priority to domestic resources,
- Increasing the share of renewable energy sources in the supply
- Increasing energy efficiency
- Turning the country into an energy corridor,
- Ensuring continuity and security in energy needs can be summarized as primary objectives.

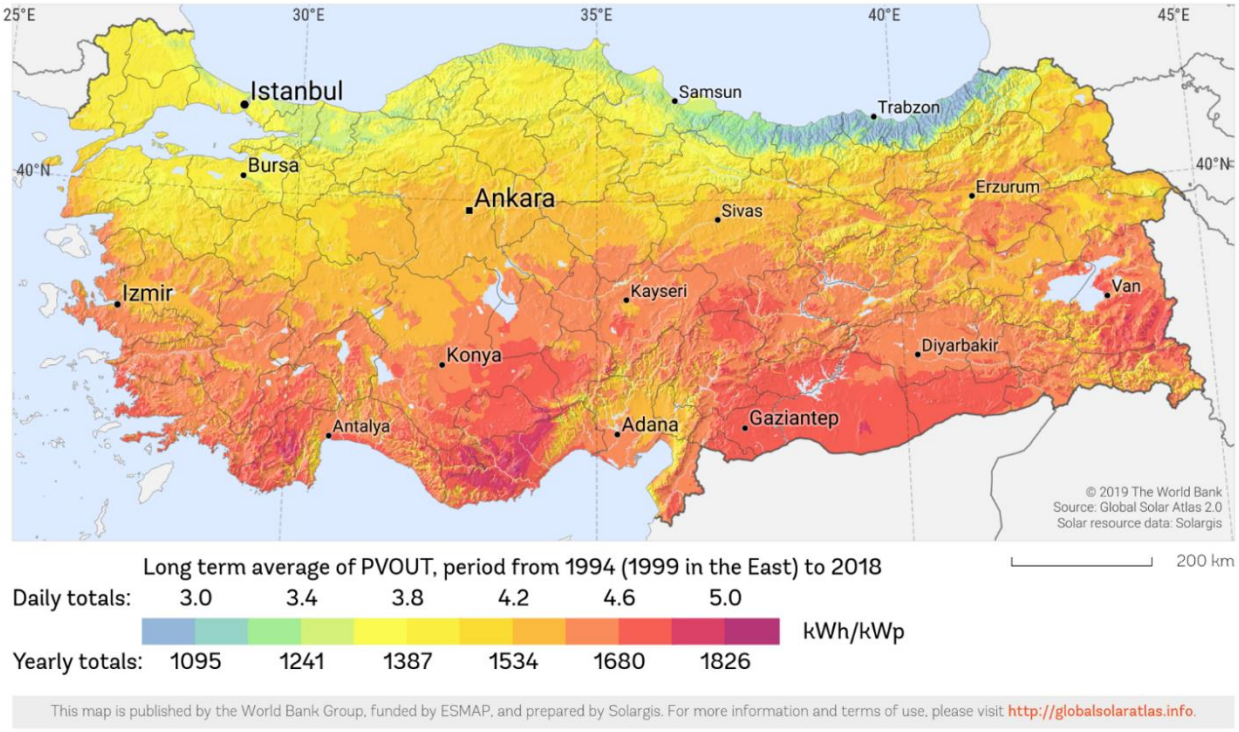
Considering the current values on the Ministry of Energy and Natural Resources website, Türkiye's installed power has reached 103,541MW as of the end of November 2022. Distribution of installed power by resources: 30.5% hydraulic energy, 24.4% natural gas, 21.1% coal, 11% wind, 9% solar, 1.6% geothermal, and 2.4% other sources.

As of 2021, Türkiye imports 91.02% of the oil it consumes. Looking at the countries that import crude oil and petroleum products, Russia ranks first with 36%, Iraq ranks second with 21%, and Kazakhstan and India are ranked third and fourth with 7%. The share of coal in the total installed power in Türkiye is 19.61% in 2021. Türkiye's share in the world coal reserves is seen as 1%. Looking at the national energy balance table of the Ministry of Energy, the hard coal import rate for 2021 is stated as 97.74%. To ensure resource diversity in terms of natural gas supply security, exploration and production opportunities, and reserve exploration activities have accelerated with the developments in offshore drilling technology in recent years. As a result, as of 2021, 98.37% of the natural gas used in Türkiye is imported. The share of fossil resources in the primary energy supply is approximately 82%; the fact that more than 90% of all fossil rocks are imported creates a tremendous economic burden for Türkiye. For this reason, the use of local resources is essential.

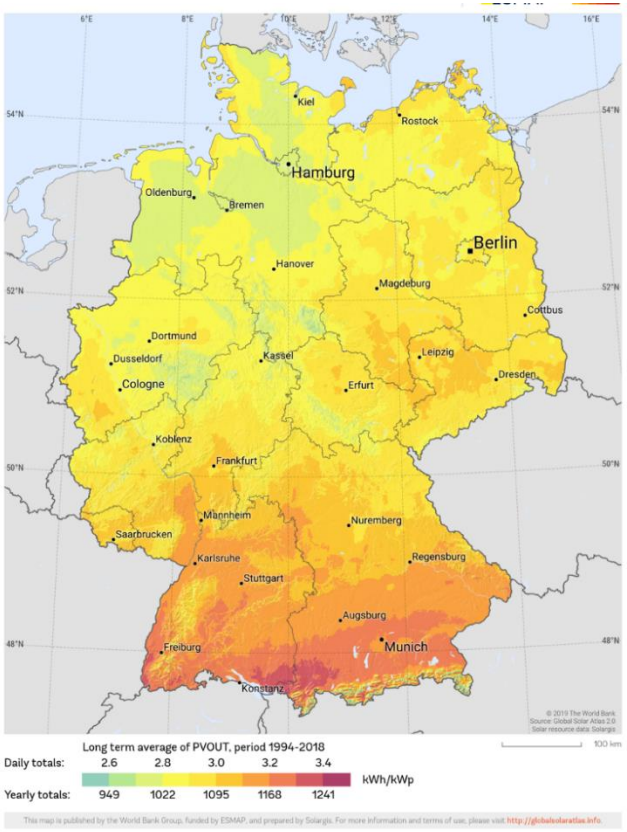
It is stated in the development plans that some studies have been carried out since the 1950s to install nuclear energy, which is one of the alternative energy sources that aim to increase local production. For example, with the Mersin Akkuyu Nuclear Power Plant project, signed in 2010, Türkiye aims to provide an installed power capacity of 4800MW in addition to its current capacity.

When examined in terms of solar energy potential, it is seen that Türkiye is high due to its geographical location. Solar energy installed power in Türkiye in 2021 is 8.425,73MW. Its share in the installed capacity is 8.5%. In 2021, 13.294.280.970 kilowatt-hours of electricity were produced. In most of the regional plans, although the regions are not found suitable for solar energy production in Türkiye, it is stated that they have more than the solar energy potential of Germany. Germany's solar power installed capacity in 2021 was given as 58,728 MW. [72] For this reason, the solar energy potential maps of Türkiye and Germany are given together in Map 4.2. As can be seen from the maps, while the annual maximum solar energy potential value is 1241kWh in Germany, this value is in the low-value range in Türkiye. This situation clearly shows that feasibility studies should be carried out effectively and efficiently to reveal the existing local potential.

SOLAR POTENTIAL MAP OF TURKIYE



SOLAR POTENTIAL MAP OF GERMANY



Map 4.2 Türkiye and Germany solar energy potential map [90]

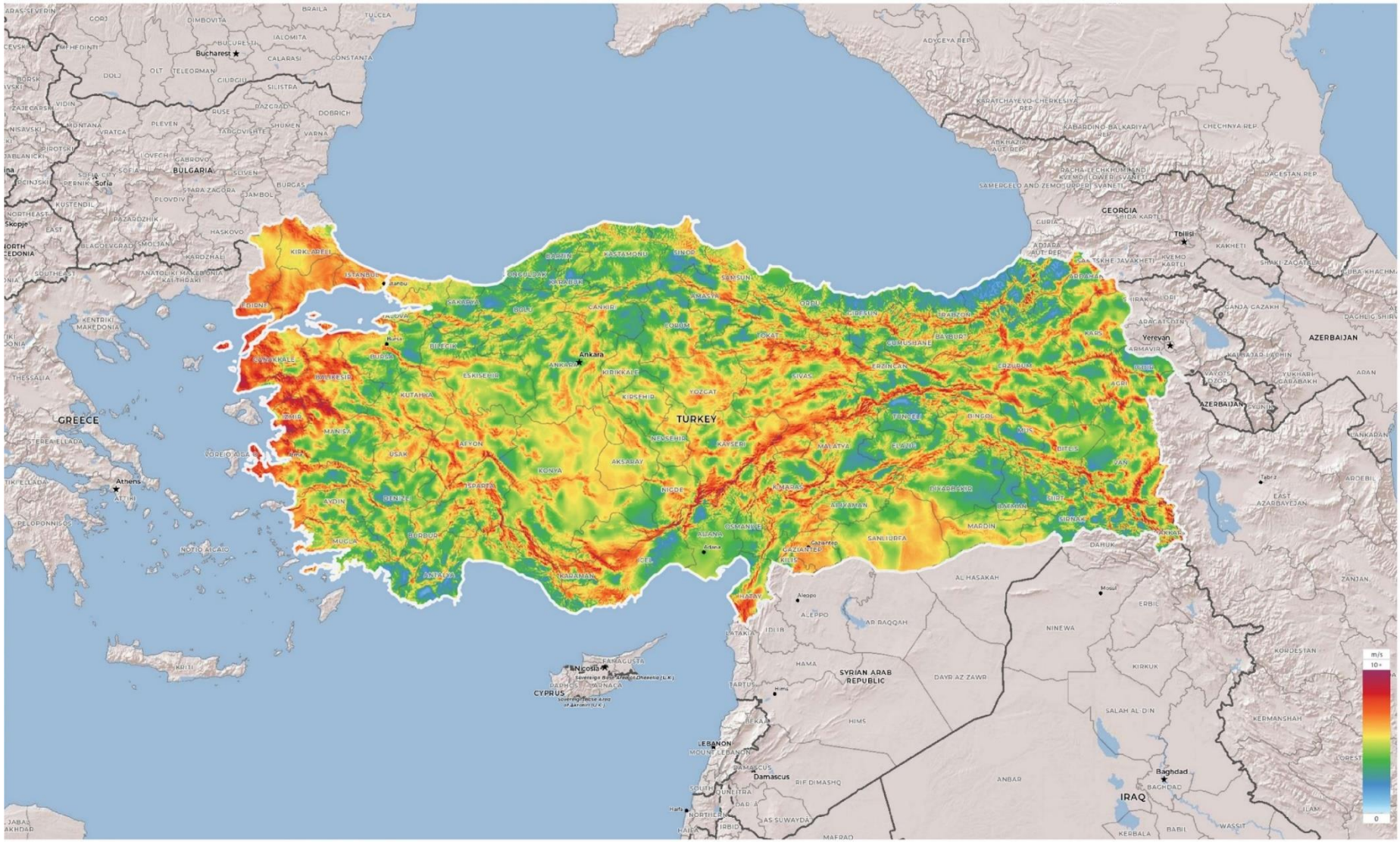
Wind energy in Türkiye has an installed power of 10,629.42MW, and its share in the installed power is 10.72%. In 2021, 31,137,427,230 kilowatt-hours of electricity were produced. The amount of power that can be obtained from the wind depends on the size of the turbine and the length of its blades. Output is proportional to its dimensions and the cube of the wind speed. Theoretically, when the wind speed doubles, the wind power potential increases eightfold. [73]

The five cities of Türkiye with tremendous wind potential are Balıkesir 13 827 MW, 13,013 MW Çanakkale, İzmir 11,854 MW, and 5,222 Manisa and Samsun, 5302 MW. [74] According to Türkiye's wind energy potential map in Figure 4.3, TR1, TR2, and TR3 regions, which are densely located on the Aegean coast, have the highest potential in Türkiye. However, it is seen that there are areas with high potential in the TR6, TR5, TR7, TRA, TRB, and TRC Regions in the interior.

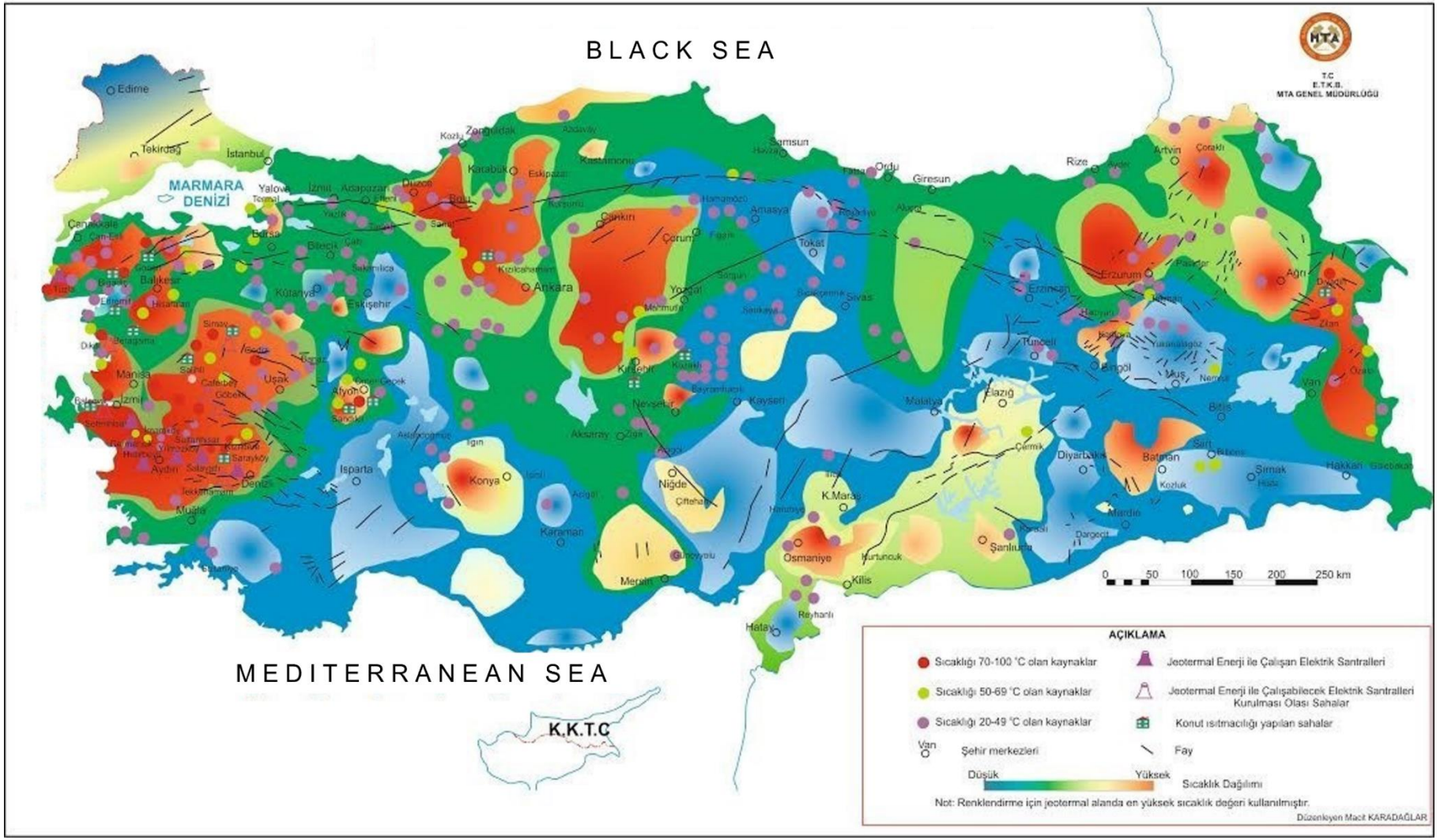
Hydroelectric energy is one of the most used energy types in the world. Hydroelectric power plants are preferred among various energy sources due to their environmental friendliness and low potential risk. [75] In 2021, the installed power in Türkiye was 33,427,23MW, and its share in the installed power is 33.71%, and 55.695.231.650 kilowatt-hours of electricity has been produced from hydroelectric power plants (Map 4.3).

Geothermal energy is a domestic underground resource that is renewable, clean, inexpensive, and environmentally friendly. Since our country is located on an active tectonic belt due to its geological and geographical location, it is in a wealthy position among the world's countries in terms of geothermal. 78% of potential areas are in Western Anatolia, 9% in Central Anatolia, 7% in Marmara Region, 5% in Eastern Anatolia, and 1% in other regions. Moreover, 90% of our geothermal resources are at low and medium temperatures and are suitable for direct applications (heating, thermal tourism, various industrial applications) and 10% for indirect applications (electric power generation). Its installed power in Türkiye is 1.701,07 MW, its share in the installed power is 1.73%, and 10.770.879.810 kilowatt-hours of electricity has been produced from hydroelectric power plants. [75] (Map 4.4).

According to Law No. 5346, biomass; Provided that it is not imported; is defined as municipal waste (including landfill gas) as well as vegetable oil wastes, agricultural wastes with no food and feed value, forest products other than industrial wood and resources obtained from the by-products of the processing of waste tires, industrial waste sludge, and treatment sludge. Resources are classified as forest and forest products, animal, urban, and industrial biomass resources. For this reason, biomass energy can be produced in rural and urban areas. Its installed power in Türkiye is 886.69 MW, and its share in the installed power is 0.9%, and in 2021, 7.371.770.000 kilowatt-hours of electricity were produced from biomass [75].



Map 4.3 Türkiye wind energy potential map [91]



Map 4.4 Türkiye geothermal resources map [75]

5

THE EMPIRICAL RELATIONSHIP BETWEEN TÜRKİYE'S NATIONAL SCALE ENERGY DATA AND ECONOMIC GROWTH

In this part of the study, energy consumption forecasts for 2030 were made using annual data between 2000 and 2020. For this purpose, annual electricity consumption as the dependent variable (explained variable), population, per capita national income, energy import amount, energy export amount, and urbanization rate as the independent variable (explanatory variable); Energy consumption amounts in the industry, transportation, housing-services-commerce, and agriculture were used. Support vector regression and multiple regression (least squares method) models have been established to estimate energy consumption for 2030. Time series analysis was applied to calculate the values the independent variables will reach for 2030. For the accuracy and comparison of the regression models, the coefficient of determination R2 and the mean absolute percentage error rates were used. In addition, correlation analysis was applied to determine the relationship between the independent variables in both models, with each other and with the dependent variable, and to strengthen the structure of the model. Afterward, For the year 2030, the forecast model was developed by applying the time series method for the change in energy dependence depending on the number of imports and exports.

First, correlation analysis was applied to reveal the relationship between dependent and independent variables in the model. Correlation analysis is a statistical method that measures the relationship between two or more variables. This relationship is measured by the Pearson Correlation Coefficient (PCC) value and takes a value between -1 and 1. If the relationship between the two variables is positive (higher values correlate with each other), the PCC takes a positive value. PCC takes a negative value if the connection is negative (high values diverge).

If there is no relationship (variables are not dependent), PCC takes the value 0. Figure 5.1 shows the co-change relationship between the variables.

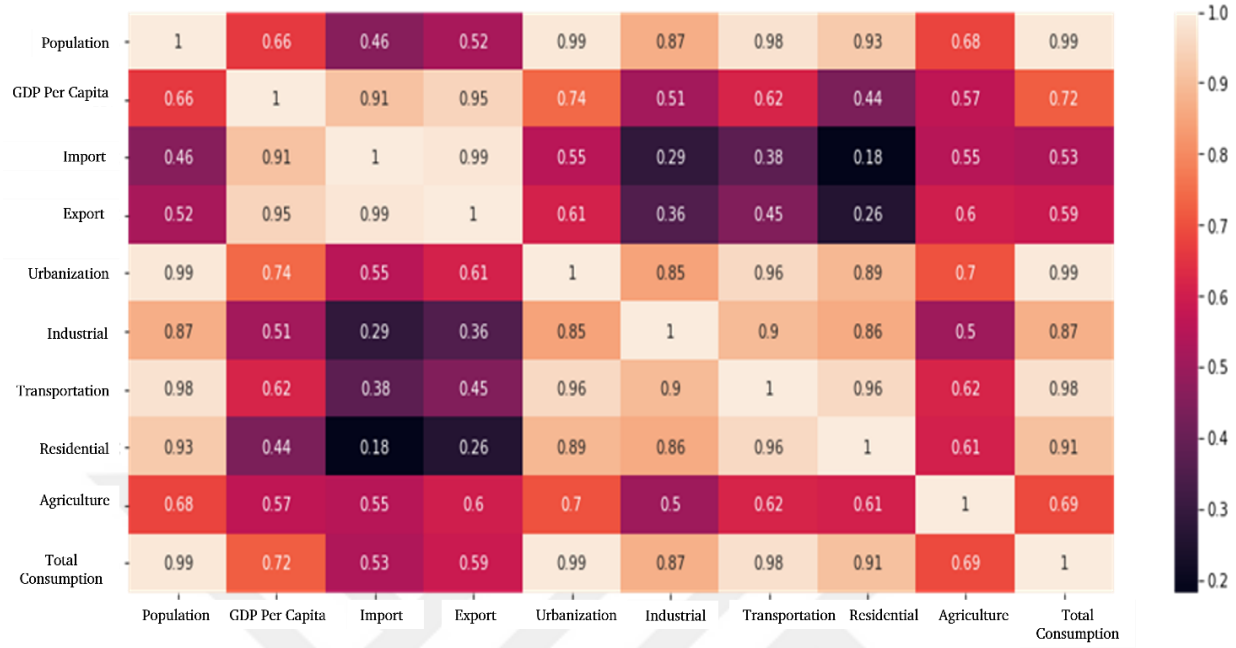


Figure 5.1 Correlation analysis between variables

As seen in Figure 5.1, the total consumption and population, per capita income, imports, exports, urbanization, the amount of energy used in industry, the amount of energy used in transportation, the amount of energy used in residences, and finally, the amount of energy used in agriculture have a high and positive direction. There is a co-exchange relationship. In addition, it is seen that the independent variables are highly correlated with each other. So that

this situation does not create any multicollinearity problem in the regression model, the variables were normalized.

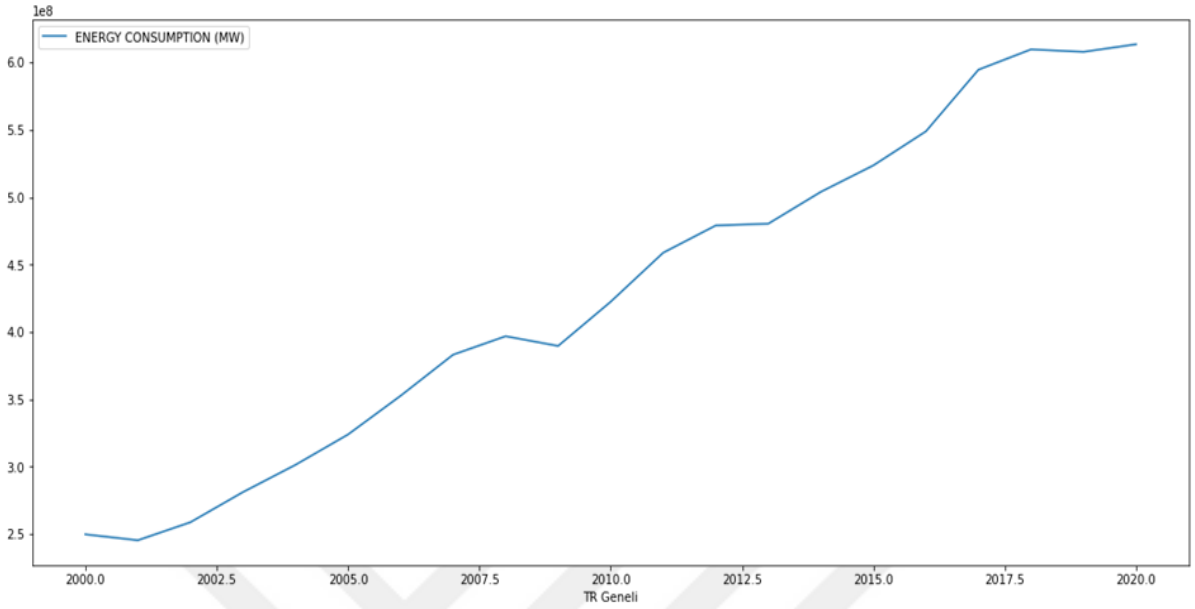


Figure 5.2 Total energy consumption in Türkiye by years (x10^8)

5.1 Energy Consumption Forecast Models for 2030 with Support Vector Regression and Multiple Regression Models

- **Support Vector Regression (SVR) Model**

There are many different approaches in the literature to determine the independent variables to be included in the model. Although some studies have used univariate, generally, multivariate models are established. In this study, a multivariate model was constructed. After the result of the correlation analysis applied for the compatibility of the variables to be included in the model, the support vector regression (SVR) was first constructed. The following formula can express the SVR model:

$y = w*x + b$

Here:

y: Estimated output variable

w: Parameters that determine the weights of input variables (weights)

x: Input variables

b: The parameter that determines the shift of the line relative to the y-axis (bias)

is expressed as.

For the model to work correctly, the variables in the SVR must be normalized. Therefore, the dependent and independent variables were normalized first. Then, as can be seen in Figure 5.2, the total energy consumption has a linear structure. Therefore, for the SVR model, the linear function is preferred as the kernel function since it gives the highest accuracy rate. Among the other variables in the model, figures showing the rate of urbanization, per capita income, amount of imported energy, amount of exported energy, population, and total energy consumption according to years are presented in Figure 5.3.

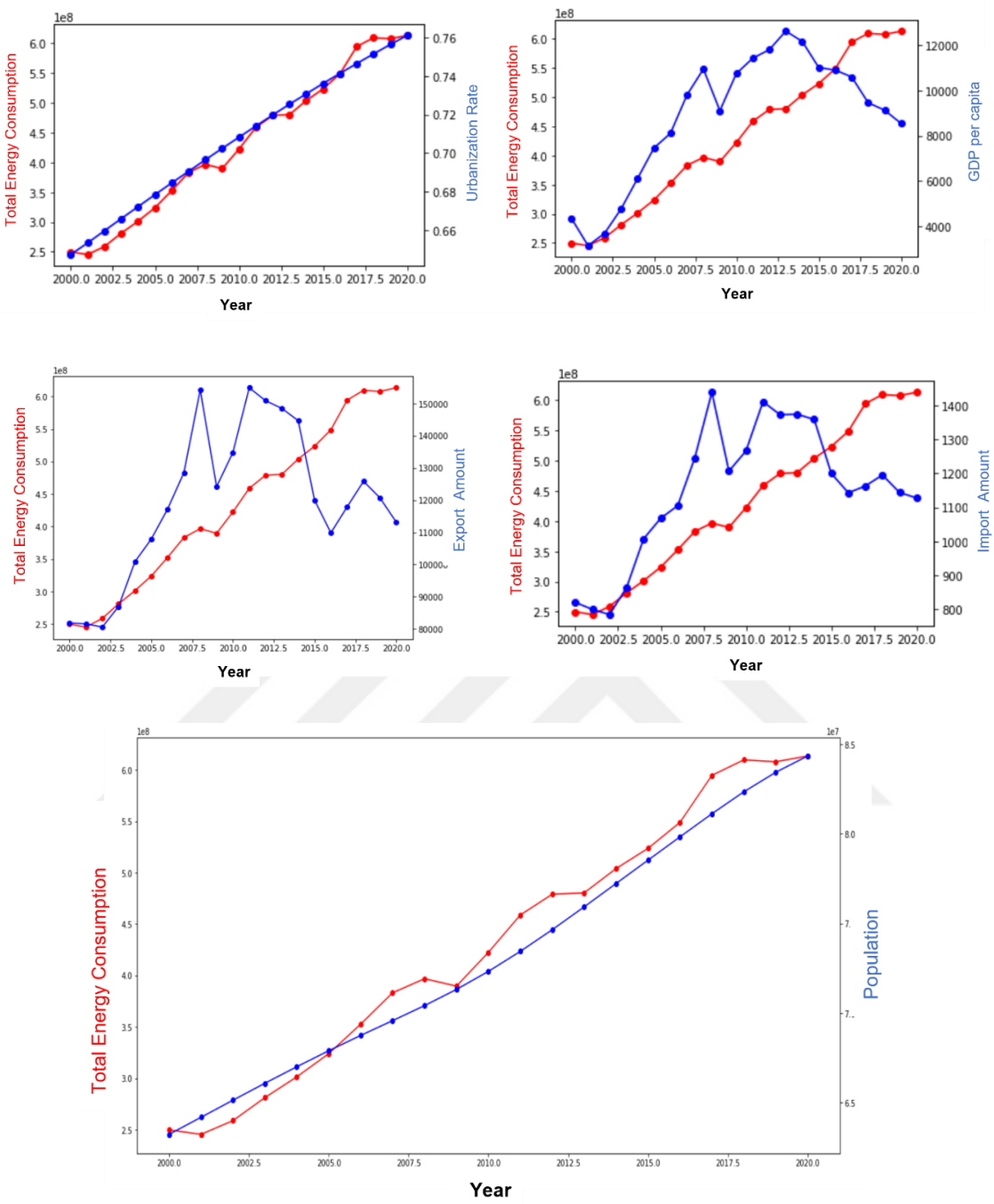


Figure 5.3 Change graphs of variables by years

After the model fit was achieved, the accuracy score of the model was found, accordingly the R2 score of the SVR model was found to be 99.25%. This shows that the variables in the model are suitable for the estimation of the dependent variable and the explanatory power is quite high. The mean absolute percentage error was calculated to determine the predictive power of

the model. The formula for the mean absolute percent error, which is abbreviated as MAPE, is as follows:

$$\text{MAPE} = \frac{100\%}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|$$

Here, Ft is the predicted value, At is the actual value, and n is the estimated time length. In this model, annual intervals are taken as the t value. Accordingly, the MAPE ratio of the SVR model was found to be 1.793%. Figure 5.4 shows the total energy consumption between 2000 and 2020 and the total energy consumption predicted by the model. As seen from this, the model was expected with great accuracy.

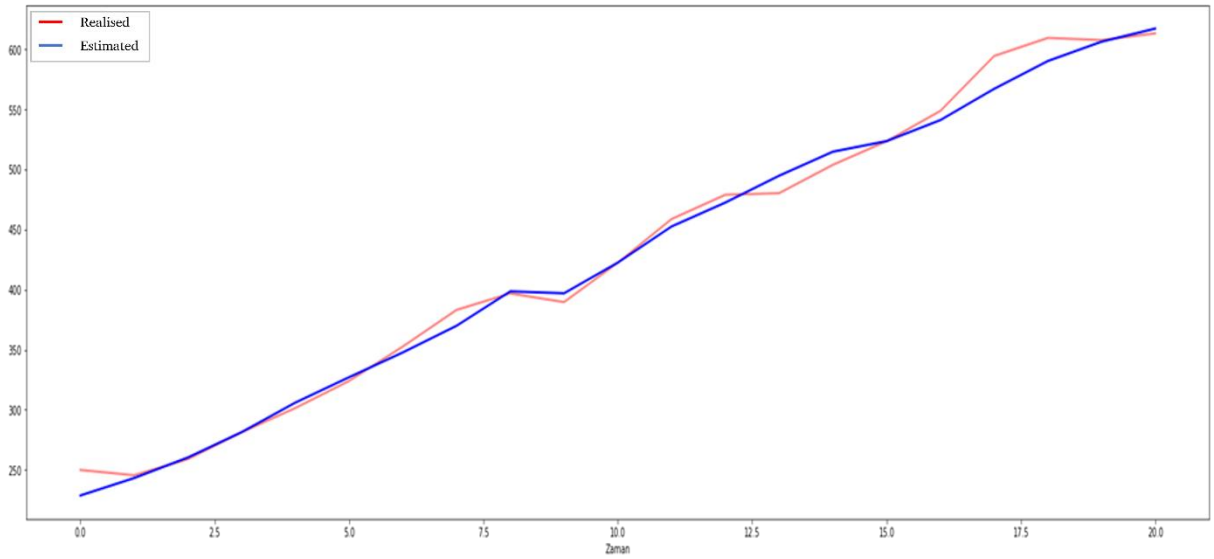


Figure 5.4 Predictive power of total energy consumption model for SVR model (x10^6)

- Multiple Regression Model

After the SVR model, multiple regression analysis was conducted using the least squares method.

The formula of multiple regression is as follow:

Y = b0 + b1X1 + b2X2 + ... + bn*Xn

Variables are;

Y: tahmin edilen değişken (bağımlı değişken)

X1, X2, ..., Xn: explanatory variables (independent variables)

b0: constant term

b1, b2, ..., bn: are represented as regression coefficients (they are parameters used to explain the model's predictions).

In this study, the model was created using the independent variables used in the SVR model. The outputs of the model created by the least squares method are shown in Table 5.1.

Table 5.1 Multiple regression analysis model

Variables	**β**	**Standard Error**	**t**	**P**
Constant	-7.45e+08	4.37e+08	-1.706	0.116
Population	7,12e+08	7.897	0.902	0.386
GDP	2,72e+11	4372.753	0.622	0.547
Import	2,21e+11	656.792	3.369	0.006
Export	-2,20e+13	1.11e+05	-1.976	0.074
Urbanization	6,30e+16	1.41e+09	0.446	0.664
Industry	1,45e+11	741.961	1.961	0.076
Transportation	4,59e+11	2606.492	1.762	0.106
Residential	8,46e+10	513.548	1.648	0.128
Agriculture	3,62e+11	5228.039	0.692	0.503
Adjusted R^2= 0.997, F=811.2, df=9, p<0.001				
Durbin-Watson: 2.042				

As can be seen in Table 5.1, the corrected R^2 is based on the explanatory power of the model. Considering that the relevant value is 99.7%, it is seen that the established multiple regression model is highly explanatory. In addition, the model is significant at the rate of 0.001. Accordingly, it can be said that the established multiple regression model is suitable for estimating the total energy consumption. Behind the significance of the model, the mean absolute percent error was calculated. The ratio of MAPE, whose formula is given above, for the relevant model was found to be 1.598%. In line with these explanations, the estimation graph of the model is shown in Figure 5 below.

In this case, "**HA: The change in socio-economic indicators for the years 2000-2020 in Türkiye affects energy consumption.**" hypothesis was accepted.

The P (probability) value is a value used to determine the presence of statistical significance and the level of evidence, if any, of difference [69]. The smaller the P-value, the higher the evidence we have to reject the H0 hypothesis. [76].

0.01<=p<0.05 The interpretation of the value is statistical significance.

0.001<=p<0.01 The interpretation of the value is of high statistical significance.

P<0.001 The interpretation of the value is very high statistical significance.

The significance value for the entire regression analysis for this study is high.

Table 5.2 Population – energy consumption regression analysis

Variables	**β**	**Standart Error**	**t**	**P**
Constant	-946226438,414	37608005,325	-25,160	0.001
Population	18,803	0,512	36,732	0.000
Adjusted R^2= 0.985, F=1349,232, df=1, p<0.001				

In the model where the relationship between population and energy consumption is analyzed, the adjusted R^2 value is 0.985. This value shows that approximately 98.5% of the change in energy consumption is explained by the population size, which is the independent variable in the model. (Table 5.2.) It is seen that the established regression model is highly explanatory. In addition, the model is statistically significant at a rate of 0.001. When the related table is examined, it is seen that a one-unit increase in the population causes an 18.80-unit rise in energy consumption (p<0.001). The hypothesis **"H1: Population size affects energy consumption in Türkiye"** was accepted in this case.

Table 5.3 GDP per capita- energy consumption regression analysis

Variables	**β**	**Standart Error**	**t**	**P**
Constant	152806121,294	63804626,064	2,395	0,027
GDP Per Capita	31315,534	6870,278	4,558	0,000
Adjusted R^2= 0,497, F=20,776, df=1, p<0.001				

In the model in which the relationship between per capita income and energy consumption is analyzed, the adjusted R^2 value is 0.497. This value shows that approximately 49.7% of the

change in energy consumption is explained by the independent variable in the model, per capita income. (Table 5.3.) It is seen that the established regression model is highly explanatory. In addition, the model is statistically significant at a rate of 0.001. When the related table is examined, it is seen that a one-unit increase in national income causes an increase of 31315.53 units in energy consumption ($p<0.001$). The hypothesis "**H2: GDP per capita in Türkiye affects energy consumption**" was accepted in this case.

Table 5.4 Import- energy consumption regression analysis

Variables	**β**	**Standart Error**	**t**	**P**
Constant	94302493,856	124301047,698	0,759	0,457
Import ($)	2812,164	1022,608	2,750	0,013

Adjusted R^2= 0,247, F=7,562, df=1, p<0,001

In the model where the relationship between the total import amount and the energy consumption is analyzed, the adjusted R^2 value is 0.247. This value shows that approximately 24.7% of the change in energy consumption is explained by imports, which is the independent variable in the model. (Table 5.4.) It is seen that the established regression model is highly explanatory. When the related table is examined, it is seen that a one-unit increase in imports causes a rise of 2812,164 units in energy consumption ($p<0.05$). The "**H3: Import amount affects energy consumption in Türkiye**" hypothesis was accepted in this case.

Table 5.5 Export- energy consumption regression analysis

Variables	**β**	**Standart Error**	**t**	**P**
Constant	5660758,595	135231819,143	0,042	0,967
Export ($)	369655,921	116182,274	3,182	0,005

Adjusted R^2= 0,313, F=10,123, df=1, p<0,001

In the model where the relationship between total export amount and energy consumption is analyzed, the adjusted R^2 value is 0.313. This value shows that approximately 31.3% of the change in energy consumption is explained by the independent variable in the model, exports. (Table 5.5.) It is seen that the established regression model is highly explanatory. When the related table is examined, it is seen that a one-unit increase in exports causes an increase of

369655.92 units in energy consumption (p<0.05). In this case, **"H4: The amount of exports in Türkiye affects energy consumption**." hypothesis was accepted.

Table 5.6 Urbanization- energy consumption regression analysis

Variables	**β**	**Standart Error**	**t**	**P**
Constant	-205284572,069	60774643,562	-33,778	0,000
Urbanization Rate	3512867016,531	85890288,101	40,899	0,000

Adjusted R^2= 0,988, F=1672,766, df=1, p<0,001

In the model where the relationship between urbanization rate and energy consumption is analyzed, the adjusted R^2 value is 0.988. This value shows that approximately 98.8% of the change in energy consumption is explained by the urbanization rate, which is the independent variable in the model. (Table 5.6.) It is seen that the established regression model is highly explanatory. In addition, the model is statistically significant at a rate of 0.001. When the related table is examined, it is seen that a one-unit increase in urbanization rate causes a rise of 3512867016.53 units in energy consumption (p<0.001). Considering the urbanization rate as 1%, it corresponds to 850,000 people in a population of 85,000,000, which can be considered as the energy consumption of 850,000 people. In this case, the "**H5: Urbanization rate affects energy consumption in Türkiye**." hypothesis accepted.

Table 5.7 Industrial energy usage- energy consumption regression analysis

Variables	β	Standart Error	t	P
Constant	-232826869,960	86284111,701	-2,698	0,014
Industrial Energy Usage	23163,488	2977,653	7,779	0,000

Adjusted R^2= 0,748 F=60,515, df=1, p<0,001

In the model where the relationship between industrial energy use and energy consumption is analyzed, the adjusted R^2 value is 0.748. This value shows that approximately 74.8% of the change in energy consumption is explained by industrial energy use, which is the independent variable in the model. (Table 5.7.) It is seen that the established regression model is highly explanatory. In addition, the model is statistically significant at a rate of 0.001. In this case, the "**H6: Energy use in the industrial sector in Türkiye affects energy consumption.**" hypothesis accepted.

Table 5.8 Transportation energy usage- energy consumption regression analysis

Variables	β	Standart Error	t	P
Constant	41991587,306	20887288,088	2,010	0,059
Transportation Energy Usage	20373,777	1048,556	19,430	0,000

Adjusted R^2= 0,950 F=377,537, df=1, p<0,001

In the model in which the relationship between the energy used in transportation and energy consumption is analyzed, the corrected R^2 value is 0.95. This value shows that approximately 95% of the change in energy consumption is explained by the energy use in the transportation sector, which is the independent variable in the model. (Table 5.8.) It is seen that the established regression model is highly explanatory. In addition, the model is statistically significant at a rate of 0.001. In this case, the "**H7: Energy use in the transportation sector in Türkiye affects energy consumption**." hypothesis is accepted.

Table 5.9 Residential, commercial, service sector Energy usage- energy consumption regression analysis

Variables	β	Standart Error	t	P
Constant	204150409,761	26268498,765	7,772	0,000
Residantial+Commercial+ Service Sector Energy Usage	6421,528	670,067	9,583	0,000

Adjusted R^2= 0,820 F=91,842, df=1, p<0,001

In the model where the relationship between energy used in housing, commerce, and services and the energy consumption is analyzed, the adjusted R^2 value is 0.82. This value shows that approximately 82% of the change in energy consumption is explained by the independent variable in the model, energy use in the fields of housing, commerce, and services. (Table 5.9.) It is seen that the established regression model is highly explanatory. In addition, the model is statistically significant at a rate of 0.001. In this case, the "**H8: Energy use in residential, commercial and services areas in Türkiye affects energy consumption**." hypothesis was accepted.

Table 5.10 Agricultural energy usage – energy consumption regression analysis

Variables	β	Standart Error	t	P
Constant	-72250764,979	121485698,078	-0,595	0,559
Agricultural Energy Usage	128446,057	30644,693	4,191	0,000

Adjusted R^2= 0,453 F=17,568, df=1, p<0,001

In the model in which the relationship between the energy used in the agricultural field and the energy consumption is analyzed, the adjusted R^2 value is 0.45.3. This value shows that approximately 45.3% of the change in energy consumption is explained by the independent variable in the model, energy use in the agricultural field. (Table 5.10.) It is seen that the established regression model is highly explanatory. In addition, the model is statistically significant at a rate of 0.001. In this case, "**H9: Energy use in the agricultural sector in Türkiye affects energy consumption**." hypothesis was accepted.

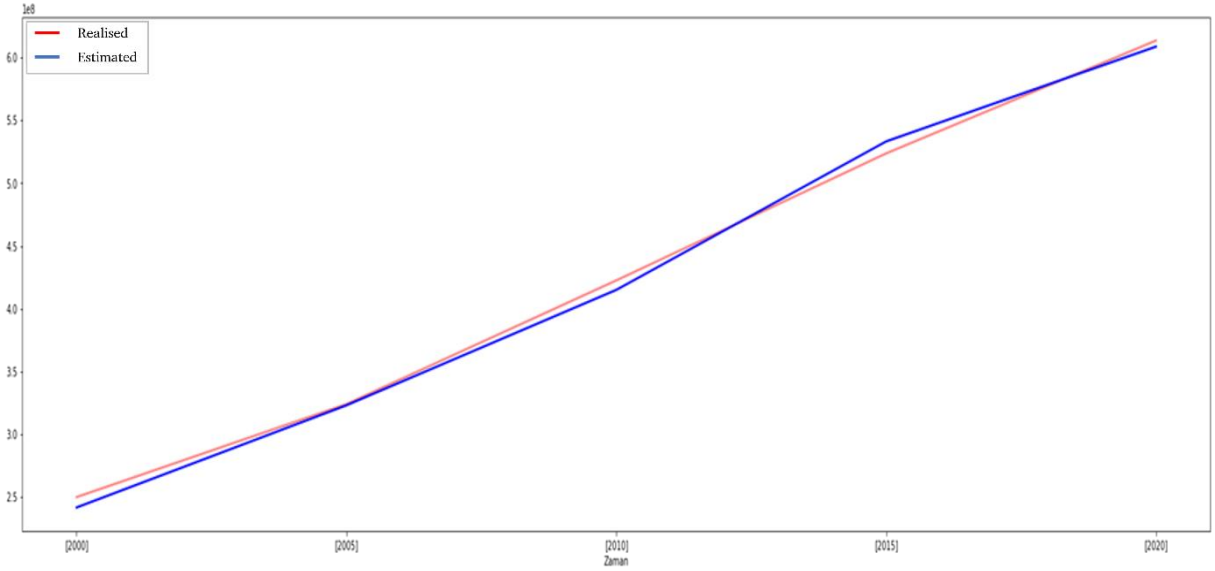


Figure 5.5 Predictive power of total energy consumption model for multiple regression model (OLS) (x10⁶)

- **Comparison of Models and Time Series Analysis of Independent Variables**

The predictive power of both models is compared in Figure 5.6 below. As can be seen from the figure, the predictive power of both models is very close to the actual energy consumption. Therefore, both models have high predictive power.

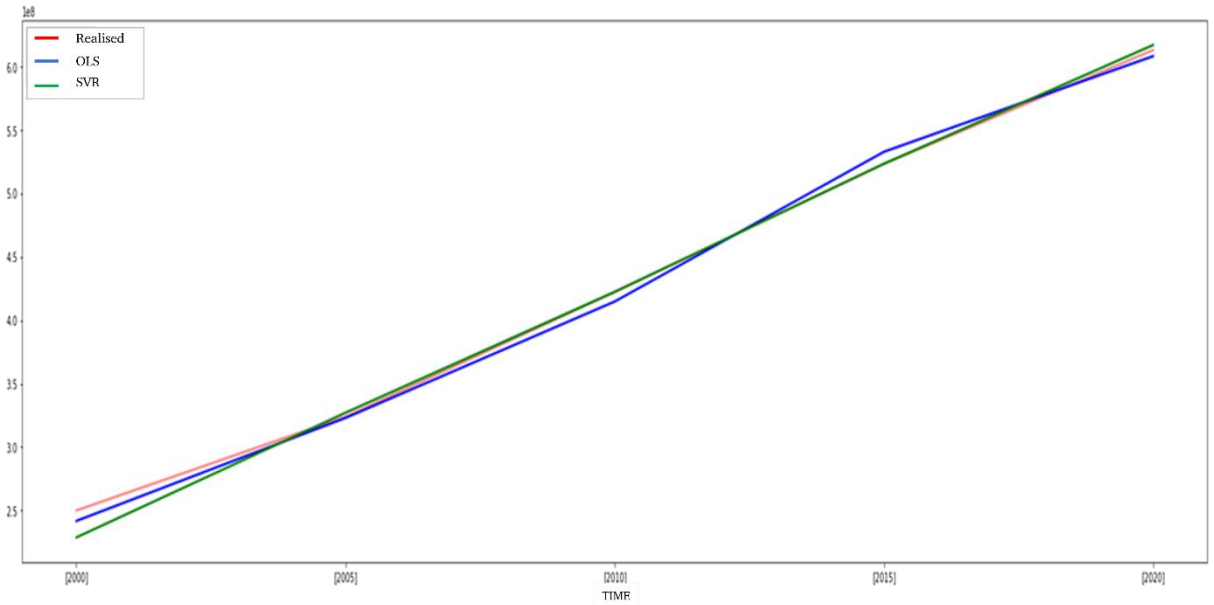


Figure 5.6 Comparison of SVR and OLS models with actual amounts

After the support vector regression and multiple regression models were established, the time series was used to predict the values that the independent variables in the model will take until 2030. Table 5.2 below shows the values of the results for each variable over the years.

Table 5.11 Time series estimates of independent variables

Year	Population	Per Capita ($)	Import ($)	Export ($)	Urbanization Rate	Industry (MW)	Transportation (Mw)	Residential (Mw)	Agriculture (Mw)
2023	87222777	8962,8	98059,6	1074,3	0,77	35600,6	27900,3	63218,1	4980,
2024	87886375	8995,6	91961,2	1053,9	0,78	35567,3	29400,2	62762,0	4950,7
2025	88477067	9023,4	85188,0	1032	0,78	35559,5	31153,2	62583,6	4931,6
2026	89003267	8904,8	78151,2	1005,3	0,79	35568,3	32843,0	62281,9	4940,3
2027	89480935	8809,6	70895,2	978,4	0,80	35555,8	34293,4	61966,4	4975,5
2028	89918806	8689,7	63295,3	952,4	0,80	35555,6	35370,8	61661,7	5032,2
2029	90323493	8573,1	55311,0	925,1	0,81	35555,0	36093,1	61340,8	5104,7
2030	90700237	8461,	46986,3	896,6	0,81	35552,8	36570,3	61061,01	5185,4

Based on the population mentioned above, per capita income, import, export, urbanization rate, energy used in industry, transportation, housing + trade + services, and agriculture, the total energy consumption amounts for the models until 2030 have been calculated. Values for the relevant calculations are presented in Table 5.3.

Table 5.12 Energy consumption estimates by models (Mw)

YEAR	SVR	OLS	Difference
MAPE	**%1,793**	**% 1.598**	
2023	660.890.236	622.838.082,00	38.052.154
2024	669.442.647	628.388.248,00	41.054.399
2025	676.372.497	633.729.246,00	42.643.251
2026	681.818.961	638.481.279,00	43.337.682
2027	686.347.298	641.454.944,00	44.892.354
2028	689.948.636	641.430.965,00	48.517.671
2029	692.786.642	639.063.037,00	53.723.605
2030	694.975.886	634.988.934,00	59.986.952

In addition, the graph of the estimated total energy consumption amounts for the eight years until 2030 for both models is shown in Figure 5.7.

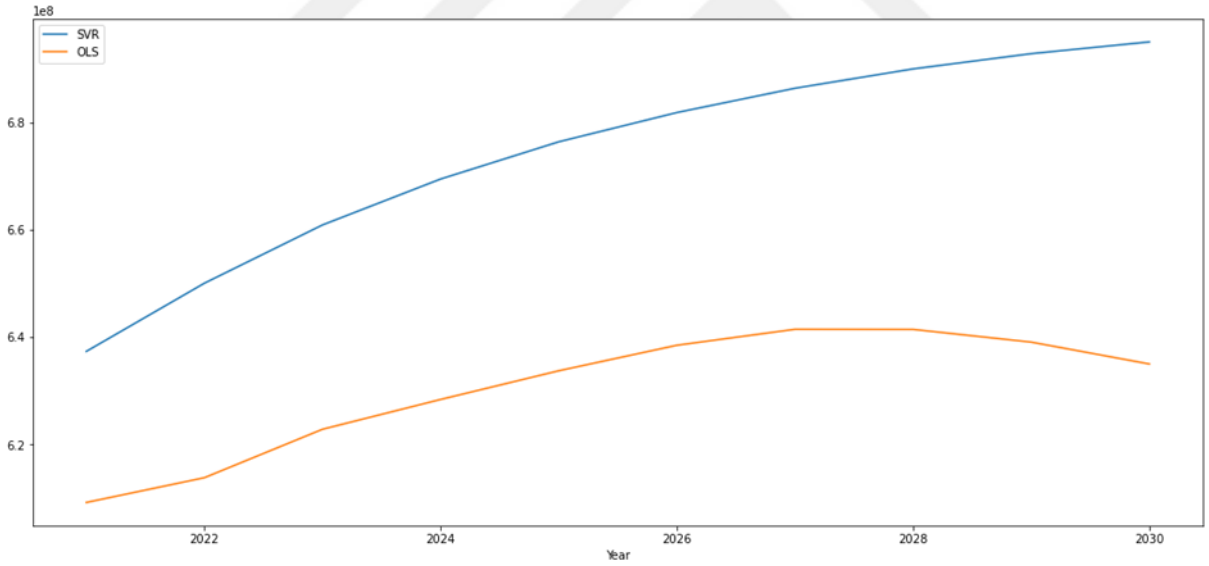


Figure 5.7 Total energy consumption forecast to 2030 (x10^8) by SVR and OLS models

As can be seen from Figure 5.7 above, according to the SVR model estimation, even if the rate of increase in total energy consumption slows down, it will continue to rise; On the other hand, according to the OLS model, it is seen that the total energy consumption will decrease as of 2027.

5.2 Production Forecasting Model by Energy Sources

After estimating Türkiye's total energy demand for 2030 with support vector regression and multiple regression methods, it aims to evaluate the total energy our country will produce in 2030. In this direction, energy production data are classified as coal, oil, natural gas, hydroelectric, biomass, geothermal, wind, and solar according to their sources, and the total amount of energy produced between 2000-2021 in line with these sources is tabulated in TEP (Ton Equivalent Petroleum). The relevant data were obtained from the statistics published by the Ministry of Energy and Natural Resources. In Table 5.4 below, production information for each energy source is given.

Table 5.13 Total energy production by resources (Thousand TEP) between 2000-2021

Year	Coal	Petrolium	Natural Gas	Hydro	Biomass	Geothermal	Wind	Solar
2000	24140,00	32463,00	12446,00	2656,00	6457,00	713,00	3,00	262,00
2001	20006,00	30676,00	13479,00	2065,00	6211,00	764,00	5,00	287,00
2002	21144,00	31049,00	14598,00	2897,00	5974,00	820,00	4,00	318,00
2003	23316,00	31719,00	17633,00	3038,00	5748,00	860,00	5,00	350,00
2004	23662,00	32778,00	18518,00	3963,00	5532,00	891,00	5,00	375,00
2005	24033,00	32199,00	22416,00	3402,00	5325,00	1007,00	5,00	385,00
2006	27978,00	32304,00	25730,00	3813,00	5169,00	898,00	11,00	403,00
2007	31144,00	33326,00	30263,00	3097,00	5008,00	914,00	31,00	420,00
2008	31120,00	31992,00	30465,00	2861,00	4771,00	1151,00	73,00	420,00
2009	32228,00	29091,00	29535,00	3092,00	4674,00	1625,00	129,00	429,00
2010	33114,00	29794,00	31456,00	4454,00	4489,00	1965,00	251,00	432,00
2011	34897,00	30430,00	36861,00	4501,00	3508,00	2060,00	406,00	630,00
2012	37197,00	30168,00	37338,00	4976,00	3427,00	2236,00	504,00	768,00
2013	33433,00	32130,00	37628,00	5110,00	3399,00	2636,00	650,00	795,00

Table 5.13 Total energy production by resources (Thousand TEP) between 2000-2021 (Continuation)

2014	36426,00	31625,00	40201,00	3495,00	3246,00	3524,00	733,00	803,00
2015	34751,00	39209,00	39651,00	5775,00	5876,00	4805,00	1002,00	828,00
2016	38558,00	42204,00	38338,00	5782,00	5685,00	6034,00	1334,00	917,00
2017	39655,00	44278,00	44319,00	5007,00	5063,00	7128,00	1540,00	1091,00
2018	41089,00	41913,00	41171,00	5155,00	6027,00	8343,00	1716,00	1547,00
2019	42111,00	41269,00	37128,00	7639,00	6314,00	9651,00	1869,00	1622,00
2020	40826,00	42190,00	39806,00	6716,00	6793,00	10576,00	2135,00	1784,00
2021	41662,00	63983,00	49231,00	4810,00	8197,00	11234,00	2704,00	2059,00

In line with the information above, descriptive statistical analyses were made for each data, and mean, standard deviation, maximum and minimum values were calculated. During the preprocessing, outliers in the data were detected, and these values were corrected by limiting them. Figure 5.8 below shows the change graph of the production data obtained from energy sources over the years.

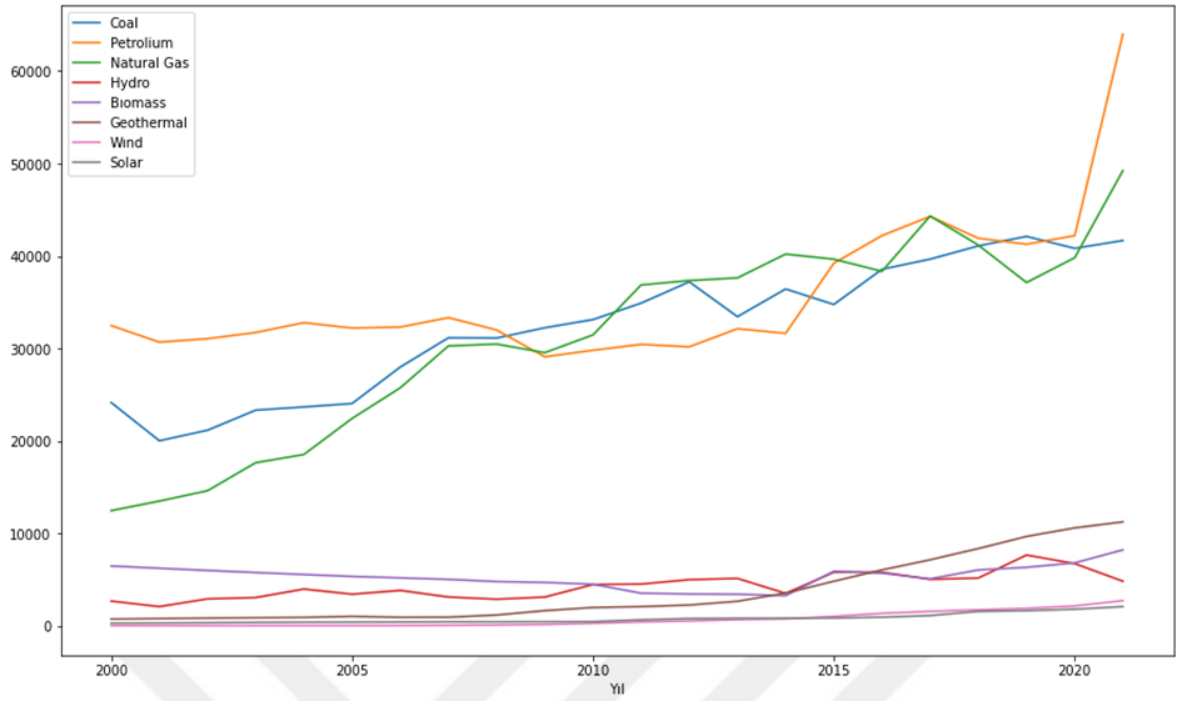


Figure 5.8 Energy Production Graph Between 2000-2021 by Energy Sources

As can be seen from Table 5.4 and Figure 5.8, while the most used resources for energy production were oil, coal, and natural gas in 2000, respectively, in 2021, it is seen that the energy produced from natural gas exceeds the energy produced from coal. The order is in the form of oil, natural gas, and coal. Figure 5.9 below shows the distribution of energy resources used in production as of 2021.

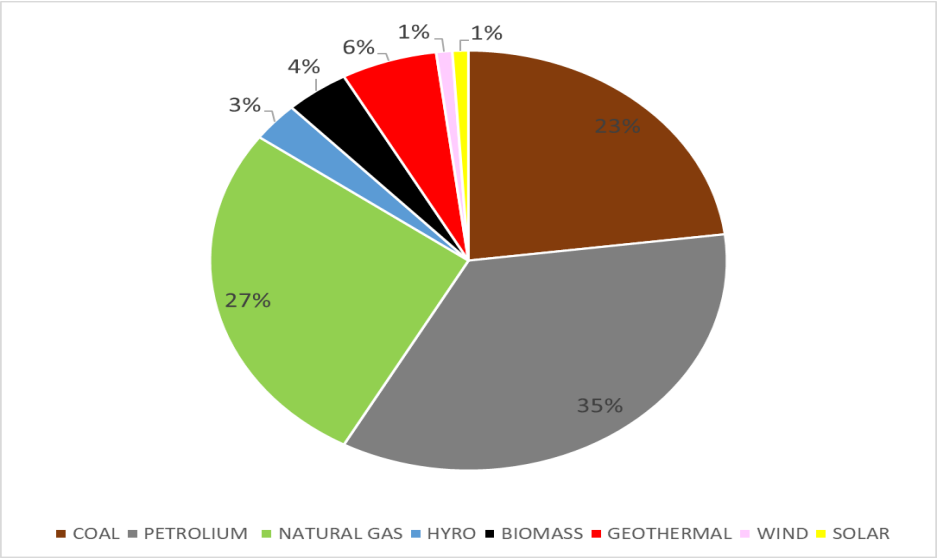


Figure 5.9 Distribution of energy production by resources as of 2021 (Thousand TEP) [35]

In line with this information, it is desired to estimate energy production until 2030 based on the changes in the resources used in energy production between 2000-2021. In this direction, time series analyses were carried out based on the relevant years' data. Autoregressive Integrated Moving Average Model (ARIMA), Artificial Neural Network Model, and Support Vector Regression were used for related analyses. However, ARIMA gave each production source a higher error rate than other models. For this reason, Artificial Neural Networks and Support Vector Regression were preferred for the related time series analysis, the lowest mean absolute percentage error rate (MAPE) was used for both models, and the prediction model was developed. Table 5.5 below shows the MAPE of the time series model used for each power generation source.

Table 5.14 MAPE percentages of energy resources with forecast models

Resources	MAPE
Coal	3,24
Petrolium	5,57
Natural Gas	4,99
Hydroelectric	0,76
Biomass	3,30
Geothermal	5,76
Wind	1,59
Solar	6,05

As shown in the table above, the average absolute percentage error rate of energy generation sources varies between 0.76% and 6.05%. Although there is no threshold value for MAPE in the literature, it is considered acceptable to be below 10%. Therefore, from this point of view, each resource's MAPE ratio is acceptable. In line with this information, the predictive power of the applied time series analyses is high. Figure 5.10 shows the estimated production amounts of each energy source until 2030.

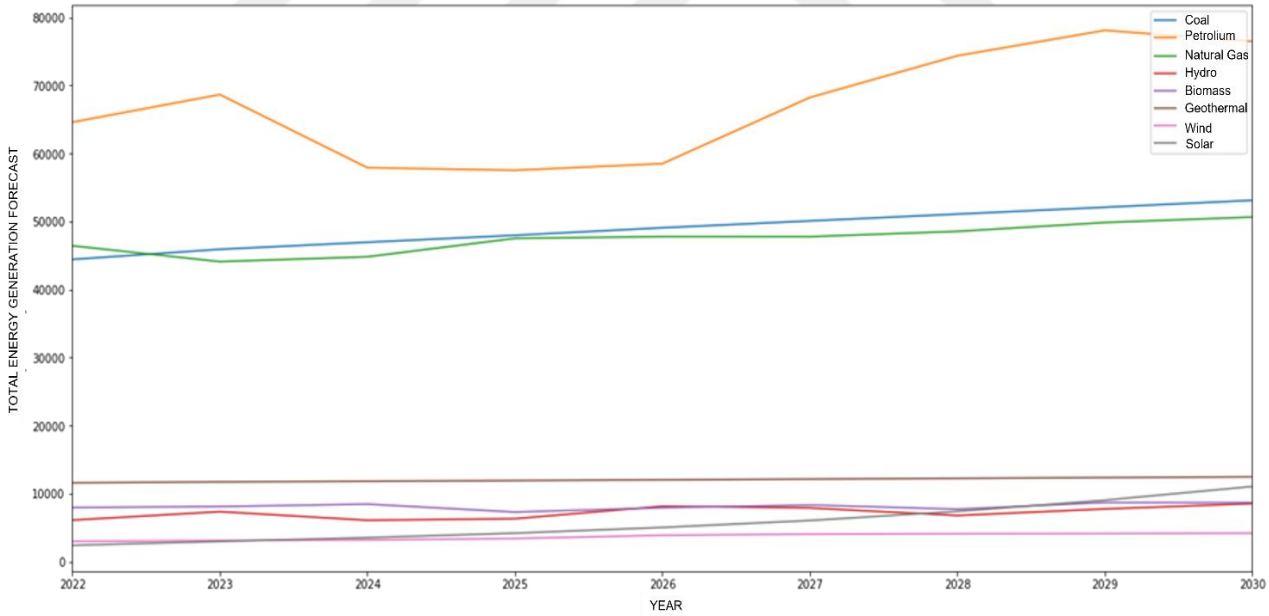


Figure 5.10 Production forecasts of energy resources based on time series forecasts.

In addition to Figure 10, detailed energy production estimates for each source for 2030 and the total amount of energy production are shown in Table 5.6. In addition, the percentage differences in energy production by year are also shown in the table.

Table 5.15 Production forecasts based on time series analysis 2023-2030 (Thousand TEP)

Year	Coal	Petroliu m	Naatural Gas	Hydr o	Biom ass	Geother mal	Wind	Solar	Total	Differ ence
2023	45901, 86	68647, 71	44090,93	7328, 93	8082, 49	11706,80	3095,46	2950, 89	191805 ,07	
2024	46940, 45	57903, 56	44803,31	6068, 16	8441, 61	11795,67	3178,09	3512, 99	182643 ,83	-4,78 %
2025	47961, 94	57522, 43	47511,32	6293, 51	7272, 13	11904,07	3382,22	4168, 63	186016 ,25	1,85 %
2026	49065, 49	58494, 90	47770,13	8133, 80	7904, 37	12011,81	3859,20	5010, 22	192249 ,93	3,35 %
2027	50076, 64	68223, 53	47764,32	7875, 18	8309, 77	12118,71	4031,58	6031, 64	204431 ,36	6,34 %
2028	51078, 71	74356, 68	48536,40	6767, 27	7693, 79	12228,46	4088,41	7372, 06	212121 ,77	3,76 %
2029	52085, 43	78092, 92	49840,43	7731, 74	8675, 68	12339,91	4110,82	9017, 50	221894 ,43	4,61 %
2030	53102, 19	76461, 78	50644,84	8507, 31	8661, 11	12448,64	4171,48	1103 1,61	225028 ,97	1,41 %

5.3 Energy Dependency Prediction Model

Following this information, it is desired to develop an estimation model based on the amount of imported and exported energy to calculate Türkiye's energy dependence. The related model was tried to be estimated with the time series. For both variables, MAPE was found as Import: 3.18% and Export: 3.17%, respectively. In this direction, it can be said that it predicts with high accuracy in both models and has a high predictive power. In the calculation of the dependency ratio, the net imports divided by the total supply method was used. The formulas used in this sense are given below.

Net Imports = Imports – Exports

Energy Dependency = Net Imports / Total Energy Supply

The import and export rates resulting from the model and the energy dependency percentage obtained in line with these rates are shown in Table 5.7.

Table 5.16 Energy dependence based on import and export quantities for 2030

Year	Import (Thousand TEP)	Export (Thousand TEP)	Total Primary Energy Supply (Thousand TEP)	Dependency
2023	130236,675	9805,9758	191805,066	0,6278807
2024	133344,733	8155,9682	182643,831	0,68542564
2025	137409,892	9048,6611	186016,251	0,69005385
2026	140229,095	9343,5951	192249,928	0,6808091
2027	143450,819	10028,1893	204431,363	0,65265245
2028	146707,348	9850,1673	212121,773	0,64518215
2029	150095,641	10823,0271	221894,434	0,62765258
2030	153329,821	10807,9526	225028,967	0,63334899

Correlation analysis was carried out to examine the co-variation of the values shown in the table above. Figure 5.11 below shows the co-exchange relationships of the variables.

As can be seen in Figure 5.11, there is an entirely linear and positive relationship between the year and imports. In this case, imports also supplement with a linear proportion as the year increases. On the other hand, there is a negative relationship between year and dependency. In this respect, the dependence decreases as the year increases. Also, as expected, imports and dependency have a negative relationship. The change graph of the total primary energy supply and its dependence is given in Figure 5.12 as biaxial to understand the exchange relations better.

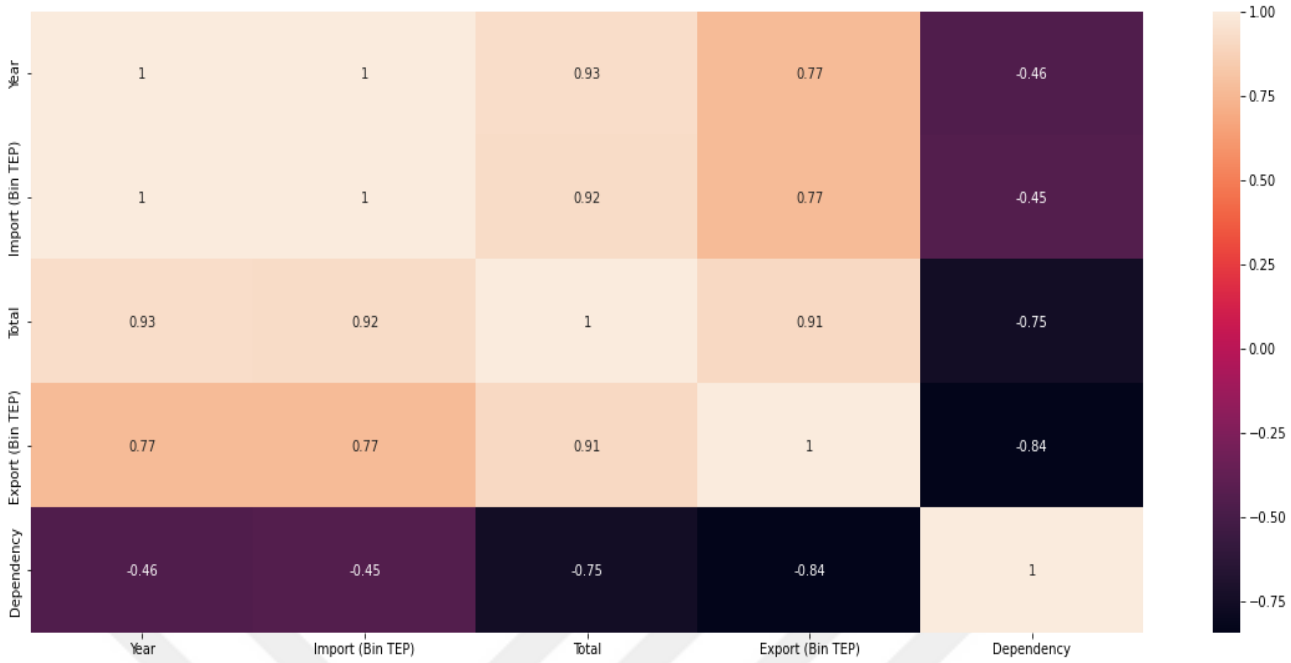


Figure 5.11 Correlation between variables

It is seen that while the total supply increases, the dependency decreases relatively. The reason for this is the increase in domestic production in the energy supply. (The data in the National Energy Balance Table of the Ministry of Energy and Natural Resources were used, and the "Electricity" values were not included in the data because it is not a primary energy source.

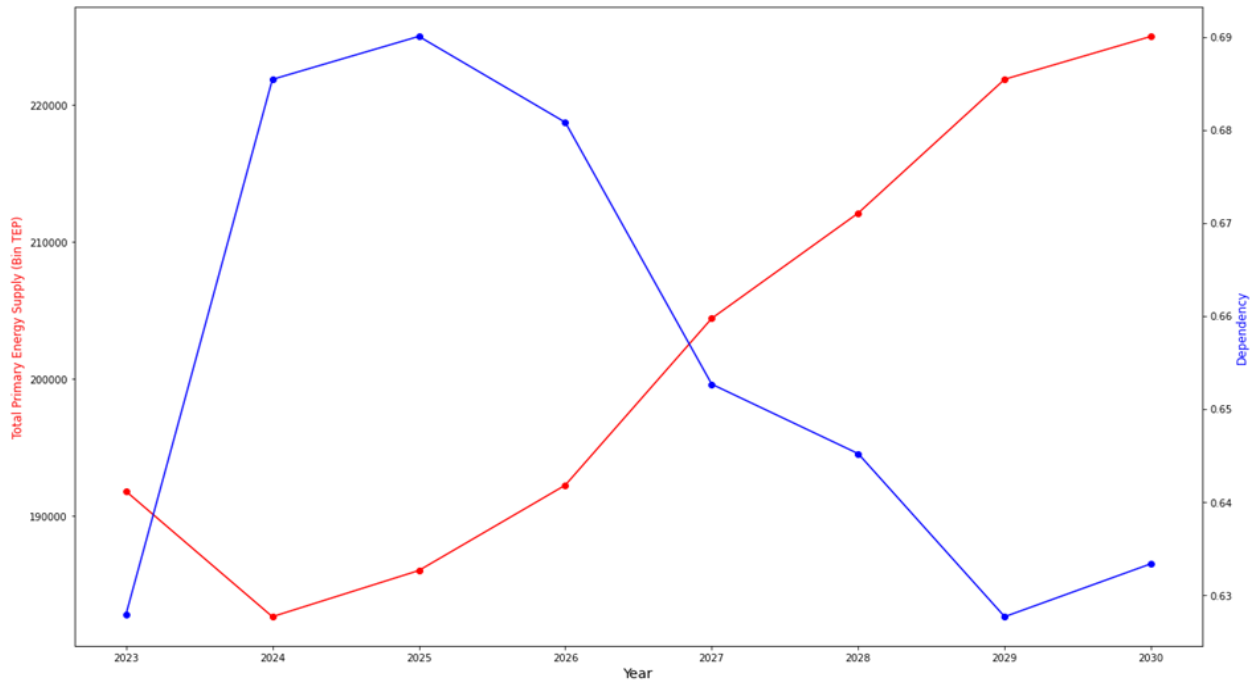


Figure 5.12 Graph of change in the relationship between total energy supply and dependency

6
CONCULUSION

In the ecological economics approach, energy is considered the third production factor in addition to labor and capital. In addition, energy is of fundamental importance for national development strategies because many countries import energy. Türkiye is one of these countries, and its foreign dependency ratio is 74% in meeting its energy demand [77].

When the international literature is examined, as seen in section 2.1., the importance of the energy issue and the number of research on it are increasing daily. The causality between nations' economic growth and development and the energy issue has been explained with similar indicators in many studies. As of the 21st century, the concept of sustainability and the subject of energy have come together under the title of renewable energy. The importance of renewable energy for sustainable cities and the issue of energy efficiency are frequently discussed within the scope of combating global warming and climate change. Many conferences were held, reports were published, and agreements were signed between countries. In the last ten years, integrated spatial energy plans have been on the agenda.

In this context, primarily in this study, the development and change of policies in Türkiye in the historical process were examined. Between 1923 and 1950, we see that the country, governed by Statist policies, tended to use domestic resources. The transition to the multi-party period in the 1950s brought along more liberal policies. Liberal policies were followed by growth in urbanization and industrialization. Thus, the need for energy has increased, and the energy resources have diversified to meet the increasing energy need. Policies were developed under state control in the years 1960-1980. As a result, efficient use of energy resources, minimizing production costs, and searching for local resources have come to the fore. The first breaking point in electricity production consumption amounts is after 1980.

The change between 1980-2000 brought about the liberal economy approach. With the liberal economy, the country experienced an increased population, rapid industrialization, and urbanization. As a result of this situation, unbalanced developments were observed between regions and within regions. As a result, local resources in energy began to need to be increased. In this period, when globalization became widespread and liberal policies were implemented, energy imports increased severely. After 2000, neoliberal policies were put into practice, and

the increasing energy demand due to the increase in the fields of industry, technology, and science accelerated the increase in energy imports. Since 2010, more emphasis has been placed on renewable energy sources, and it is understood from the increasing solar and wind energy production that there are developments in this direction for the evaluation of local potential.

The main difference between this study from other studies and its value to the literature is that it handles energy data on a national scale and provides a regional evaluation according to the Level 1 scale of the Classification of Statistical Regional Units. When fundamental economic indicators such as population density and GDP per capita are examined at the Level 1 scale, it is seen how the result of unbalanced regional development is reflected today. For example, TR1 (Istanbul), TR3 (Izmir, Manisa, Afyonkarahisar, Kütahya, Aydın, Denizli, Muğla, Uşak), and TR5 (Ankara, Konya, Karaman), which are only three of the twelve regions on the Level 1 scale, account for 67% of the total GDP. It is seen that almost 1/5 of the total country population resides in the TR1 region, which consists of the province of Istanbul.

How much energy is used in which sectors is published annually in the "National Energy Balance Sheets" reports on the Ministry of Energy and Natural Resources website. Sectoral usage includes industry, transportation, housing, trade, and services, respectively. As stated in many international sources, national growth – that is, an increase in production and GDP – brings with it an increase in energy consumption. There is a bidirectional causality relationship between energy and national development. The increase in energy use triggers national development, and national development triggers an increase in energy consumption.

In order to correlate fundamental economic indicators with primary energy data, Chapter 3 examines installed power (capacity), energy production, and consumption values in 12 NUTS 1 Regions. The region with the highest installed energy power in Türkiye is the TR6 Region, which consists of Antalya, Isparta, Burdur, Mersin, Adana, Hatay, Osmaniye, and Kahramanmaraş. This region has 16.8% of the total energy capacity in Türkiye. Regarding energy production and consumption balance, Istanbul is the weakest region regarding production-consumption balance, where the densest population in Türkiye and the services and industry sectors are located. On the other hand, the energy production/consumption ratio is very high in Central Anatolia and northern regions such as TR7,8,9 Regions. Therefore, these regions can be described as relatively underdeveloped areas. Detailed explanations for each region are included in the section.

In Figure 3.29, where the sectoral distribution of energy consumption of NUTS 1 regions is shown, the uneven regional development in the country is visualized. There is a severe socio-economic development gap between the country's east and west. In addition to physical conditions, the most fundamental problem in these areas is the difference in income level and living standards. Urban areas are developing more rapidly in the west of the country, but rural areas continue to exist in the east and north. The inability to achieve development in rural areas due to inadequacy in investment and production creates a migration movement in the population towards urban areas. While the aggregation in urban areas due to migration creates new problems in these areas, it causes a decline in population and socio-economic development in rural areas. There are 12 regions in total on the Level 1 scale. When the energy consumption amounts of 7 of these regions, TR2, TR7, TR8, TR9, TRA, TRB, and TRC, and the other five areas are compared, more than half is encountered between regions.

Within the scope of the study, eleven development plans and regional plans of 26 regions at Level 2 prepared for the years 2014-2023 were examined. The most crucial issue mentioned in the projects is that it is impossible to solve the problems with the policies developed in the form of implementing the decisions from the center, which are traditionally implemented. For this reason, regional development programs were started to be implemented in cooperation with the European Union, and Regional Development Agencies were established to find solutions to the problems for the needs of the locals. It aims to develop policies based on local development in the context of regional internal dynamics, demands, and potentials. In the regional development plans, the energy potentials of all regions are mentioned one by one. For example, it is stated in the plans that "Türkiye is in a powerful position in terms of renewable energy potential." A particularly emphasized situation is that Türkiye's renewable energy resources potential and the relevant expert evaluations are not used. Table 6.1 and Table 6.2 give status summaries of fundamental socio-economic indicators and energy data by NUTS 1 Regions.

Table 6.1 Fundamental socio-economic and energy indicators of Türkiye NUTS1 regions

	AREA (KM²)	2021 POPULATION	2020 GDP PER CAPITA ($)	2021 TOTAL ENERGY CAPACITY (MW)	2021 ENERGY CONSUMPTION (MW/H)	GENERATION / CONSUMPTION RATE (%)
TR1	5.343	15.840.900	$13.914	3.413,00	53.170.472	22,00%
TR2	41.280	3.699.764	$9.336	11.153,00	23.242.198	251,58%
TR3	90.456	10.784.645	$8.416	16.513,00	48.425.497	329%
TR4	49.404	8.380.829	$10.195	9.720,00	47.840.766	70,47%
TR5	73.126	8.283.180	$10.585	5.391,00	30.140.407	49,59%
TR6	89.983	10.888.766	$6.464	16.650,00	48.784.381	103,26%
TR7	91.709	4.108.687	$6.499	5.062,00	14.132.515	128,35%
TR8	73.946	4.666.651	$5.869	9.167,00	14.098.765	229,99%
TR9	37.551	2.693.034	$5.876	4.921,00	6.817.178	126,23%
TRA	71.035	2.183.098	$5.073	1.914,00	3.678.543	87,65%
TRB	78.458	3.940.275	$4.515	5.139,00	7.526.180	137%
TRC	75.938	9.210.444	$4.493	10.107,00	31.777.093	64,72%

Table 6.2 Energy sources rate by NUTS1 regions (%)

	RENEWABLE ENERGY SOURCES RATE					FOSSIL FUEL RATE		
	Hydro	Wind	Solar	GeoThermal	Biomass	Natural Gas	Coal	Other
TR1	0,00%	7,40%	0,28%	0,00%	19,80%	10,01%	0,00%	0,00%
TR2	0,12%	27,51%	1,84%	1,80%	15,16%	13,32%	32,00%	1,67%
TR3	2,15%	31,30%	19,02%	98,20%	13,27%	17,58%	0,00%	11,50%
TR4	5,53%	9,90%	4,56%	0,00%	6,18%	30,18%	4,99%	17,50%
TR5	2,86%	3,00%	23,17%	0,00%	15,86%	0,50%	3,90%	12,50%
TR6	17,09%	10,50%	14,91%	0,00%	12,21%	9,74%	38,03%	11,83%
TR7	5,79%	5,90%	11,89%	0,00%	2,40%	7,89%	2,43%	14,18%
TR8	9,76%	2,81%	4,28%	0,00%	8,44%	8,04%	16,48%	7,20%
TR9	12,64%	0,09%	0,16%	0,00%	0,64%	0,00%	0,00%	0,00%
TRA	7,07%	0,40%	2,13%	0,00%	0,31%	0,04%	0,00%	6,81%
TRB	13,47%	0,60%	5,96%	0,00%	2,37%	0,00%	0,00%	7,01%
TRC	23,52%	1,00%	11,80%	0,00%	3,36%	2,70%	2,08%	9,80%

In this study, which focuses on the effects of energy policies in the context of balanced regional development, a quantitative measurement was made, and analysis was made using support vector, multiple regression, and time series methods. Demand forecasts for 2030 were made using annual data between the recent years 2000-2021. The energy consumption estimation was made by determining the population, GDP per capita, imports, exports, urbanization rate, the amount of energy consumed in industry-transportation-housing and agriculture as the independent variable and the energy consumption as the dependent variable. Then, the values to be reached by the independent variables were calculated using the time series method and an estimate was developed to see the change in the energy dependence.

Established in the study "H0: The change in socio-economic indicators for the years 2000-2020 in Türkiye does not affect energy consumption." The hypothesis was rejected as a result of the established model. "HA: The change in socio-economic indicators for 2000-2020 in Türkiye affects energy consumption." The hypothesis was accepted. The based multiple regression model was found to be explanatory at a rate of 99.7%. In addition, the model is significant at the rate of 0.001. Accordingly, the established multiple regression model is suitable for estimating the total energy consumption.

- Approximately 98.5% of the change in energy consumption is with the population size, which is the independent variable in the model,
- With the national income per capita, which is the independent variable in the model, approximately 49.7%,
- With imports, which is the independent variable in the model, approximately 24.7%,
- With exports, which is the independent variable in the model, approximately 31.3%,
- With the urbanization rate of approximately 98.8% as the independent variable in the model,
- With industrial energy use, which is the independent variable in the model, approximately 74.8%,
- With approximately 95% energy use in the transport sector, which is the independent variable in the model,
- With approximately 82% of energy use in the fields of housing, commerce, and services, which is the independent variable in the model,
- With approximately 45.3% of energy use in the agricultural field, which is the independent variable in the model,

has been disclosed.

As a result of the numerical analysis, it has been determined that the increase in population size, national income, import and export, urbanization rate, and sectoral energy use in a place increase the total energy consumption, albeit at different rates. As the explanatory power of each variable was determined one by one, the corrected R^2 was taken as the explanatory power of the model in which all variables were considered, and considering that this value was 99.7%, it is seen that the established multiple regression model is highly explanatory. In addition, the model is significant at the rate of 0.001. Accordingly, it can be said that the based multiple regression model is suitable for estimating the total energy consumption. Behind the significance of the model, the mean absolute percent error was calculated. The ratio of MAPE, whose formula is given above, for the relevant model was 1.598%. In this case, **the "HA: The change in socio-economic indicators for 2000-2020 in Türkiye affects energy consumption"** hypothesis was accepted.

Based on the data taken from the national energy balance tables published by the Ministry of Energy and Natural Resources, fossil, and renewable energy sources were handled individually, and the demand forecast for 2030 in primary energy supply was analyzed by time series method. According to the time series analysis, when all conditions are kept constant, it is predicted that there will be a 27% increase in coal, 19% in oil, 2% in natural gas, 76% in hydroelectric, 5% in biomass, 10% in geothermal, 54% in wind and 435% in solar energy production.

Reducing foreign dependency on energy is very important for national and regional development. On the website of the Ministry of Foreign Affairs, the rate of foreign dependency in energy is given as 74%. According to this ratio, ¾ of the energy consumed by Türkiye is imported. This situation creates a serious economic burden and negatively affects development. Looking at the quantitative study, the key point here is the change in the dependency ratio because of all the estimations. Energy dependency is estimated at 63% for 2030 when all conditions are constant. Reducing energy dependence can be considered as a reduction in economic burden and ensuring national development.

The increase in energy demand causes Türkiye to develop its energy policies and seek new solutions. With the Russia-Ukraine war that started in 2022, it was once again seen how important it is for nations to produce their energy. Furthermore, due to the gas crisis in the European countries facing Russia, which is a global energy importer, the search for local resources has become a priority to ensure national economic independence.

Another issue that has been increasing its seriousness every day since the end of the 20th century is global warming and climate crisis. Reducing carbon emissions, targets and objectives are determined for 2030 and 2050, and relevant practices are carried out. It continues its efforts to produce policies aiming to create zero-carbon city centers for the year 2050. Türkiye is also a signatory to the Green Deal and the Paris Climate Agreement. Türkiye's clean energy policies are developing to fulfill the promises made in these agreements and ensure national energy independence.

It is possible to reduce foreign dependency on energy with integrated energy policies. As a result of the demand estimation analysis, it is possible to reduce the 63% energy dependency ratio predicted for 2030 with the energy policies to be developed. The "Integrated National Energy and Climate Plan 2021-2030" [72] study, which has come to the fore in the last ten years and has been prepared separately for each European country, should also be conducted for Türkiye. In this way, preparing a spatial energy plan that shows a holistic and balanced development may be possible. The main question of this research is, "Can energy policies be a solution for unbalanced regional development?" The answer to the question can be answered positively with this plan.

The planning hierarchy in Türkiye is given in Figure 6.1. Considering this hierarchy, the National/Regional Integrated Spatial Energy Plan can be positioned between the National Spatial Strategy Plan and the Regional Plan. This plan: is of great importance as it provides a base for national development, indicates site selection at a spatial scale, has a sectoral qualification, and is a solution proposal for unbalanced regional development.



Figure 6.1 Türkiye planning hierarchy system

Integrated spatial energy plans; is a set of policies that consider decarbonization, energy security, energy efficiency, R&D and innovation, and production from local and renewable energy sources. Considering the potential in the country in terms of renewable energy sources, biomass energy has potential for 12 regions on NUTS1 as it has different production options in both rural and urban areas. Facility installations can be carried out by conducting joint studies with relevant R&D centers and relevant departments of universities.

When spatially renewable energy resources are evaluated for Türkiye, TR3 (İzmir, Aydın, Denizli, Manisa, Muğla, Afkyonkarahisar, Uşak, Kütahya) and TR4 (Eskişehir, Bursa, Bilecik, Yalova, Kocaeli, Sakarya, Düzce, Bolu) regions are high for geothermal facilities. Stand out as potential areas. Nuclear power plants are included in current government policies. I have two facilities set up in Mersin and Sinop. When we look at the energy potential map in terms of solar energy, the production seems to be appropriate in the whole country, except for a part of the TR9 (Trabzon, Ordu, Rize, Artvin, Giresun, Gümüşhane) region. For wind energy, a wind energy corridor was created based on the potential map. An area that provides a transition

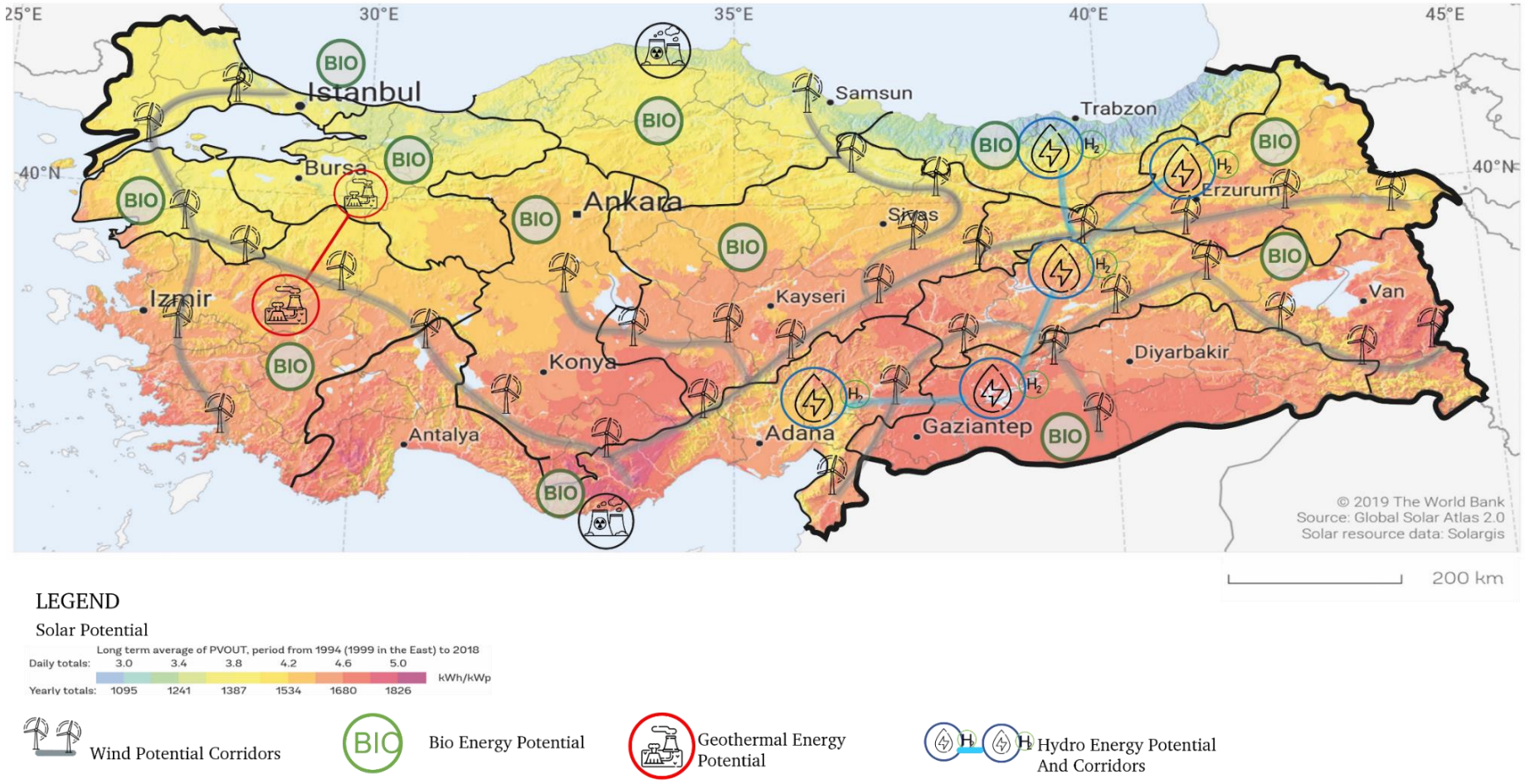
between the western coasts of the country, the Taurus Mountains in the south, and the high parts of Eastern Anatolia has been shown as having high potential (Figure 6.1.).

In the news titled Bringing the treasury lands to the economy, published by the Ministry of Environment, Urbanization, and Climate Change on January 12, 2023, it is in question whether the unused treasury lands are put into use for investments in solar and wind energy production, which are renewable energy sources. However, detailed feasibility studies and site selection decisions in the presence of experts can significantly increase renewable energy production without causing environmental damage.

Türkiye can be considered relatively rich in terms of water resources. Improvements should be made in hydroelectric power plants' construction and energy production processes. At the same time, Hydrogen (fusion) energy research, which provides the world's highest amount of energy production in areas suitable for HEPPs, should be followed closely. The places where HEPPs are concentrated are mostly TR9, TRA, TRB, and TRC regions, and these areas are areas that can be defined as underdeveloped, unable to achieve regional development, emigrant, low population, and rural. In these areas, university R&D, industry, and energy sectors may be suitable for working in cooperation. To ensure balanced regional development, the energy sector should be considered a steppingstone. Energy production facilities should be established in the regions according to their energy potentials. Local and central government incentives and support should be provided at the investment stage and throughout the process. Inter-regional and intra-regional energy corridors should be established. Storage areas are essential because renewable energy sources show a variable production rather than a fixed one. Decisions regarding the location and size of storage facilities should be taken by performing feasibility studies.

Renewable energy facilities and R&D centers to be established will also play a role in increasing employment. For this reason, the areas where they are based are of profound importance. Urban and regional planners should be involved in site selection decisions. How will the employment created by renewable energy policies affect regional development? How should site selection decisions be made on a regional or even urban scale? These new questions that emerged at the end of the study, such as these, may serve as research questions for future studies.

Considering only the recommendations outlined above, it may be possible to talk about sustainable regional development policies to prevent unbalanced regional development and reduce energy imports, significantly burdening the economy in national development.



Map 6.1 Spatial Relation of Renewable Energy Potential in Türkiye

REFERENCES

[1] C. Usta, «Regional Analysis of Relationship between Energy Consumption and Economic Growth in Turkey,» *International Journal of Economics and Innovation,* pp. 181-201, 2016.

[2] International Energy Agency, «World Energy Outlook,» 2022.

[3] R.-V. Ionescu, M. L. Zlati, V.-M. Antohi, I. O. Susanu ve N. Cristache, «A new approach on renewable energy as a support for regional economic development among the European Union,» *Technological Forecasting and Social Change,* 2022.

[4] U. Al-mulalini, «GDP Growth - Energy consumption relationship revisited,» *International Journal of Energy Sector Management,* pp. 356-379, 2014.

[5] A. Ohler ve I. Fetters, «The causal relationship between renewable electricity generation and GDP growth: Astudy of energy sources,» *Enrgy Economics,* pp. 125-139, 2014.

[6] D. I. Stern, «Economic Growth and Energy,» *The New Palgrave Dictionary of Economics,* 2015.

[7] C. Caraiani, C. I. Lungu ve C. Dascalu, «Energy consumption and GDP causality: A three-step analysis for emerging European countries,» *Renewable and Sustainable Energy Reviews,* pp. 198-210, 2015.

[8] S. Giray Yakut, S. D. Özdemir Yazgan, N. E. Bacaksız ve H. Fikir, «Enerji kullanımı ve başlıca makraoekonomik göstergeler etkileşimi ve bu etkileşim bağlamında Türkiye'nin dünya içindeki yeri,» *Journal of Life Economics,* pp. 247-261, 2021.

[9] G. Stoeglehner, «Integrated Spatial and Energy Planning: A Means to Reach Sustainable Development Goals,» *Evolutionary and Institutional Economics Review,* pp. 473-486, 2020.

[10] P. Nabielek, H. Dumke ve K. Weninger, «Balanced renewable energy scenarios: a method for making spatial decisions despite insufficient data, illustrated by a case study of the

Vorderland-Feldkirch Region, Vorarlberg, Austria,» *Energy, Sustainability and Society,* 2018.

[11] E. Karakurt Tosun, «Sürdürülebilirlik Bağlamında Ekolojik Kent Söylemşi,» *AİBÜ Sosyal Bilimler Enstitüsü Dergisi,* pp. 169-189, 2017.

[12] S. Ökten ve A. Ökten , «Avrupa Birliği Politikaları Perspektifinde Sürdürülebilir Kent,» *Academia Journal of Social Sciences,* pp. 408-425, 2018.

[13] 23 12 2022. Available: https://www.bmuv.de/en/topics/europe-international/europe/environment-action-programmes.

[14] 23 12 2021. Available: https://unhabitat.org/.

[15] United Nations, «United Nations Climate Change,» Available: https://unfccc.int/kyoto_protocol. [Accessed in: 13 08 2023].

[16] Devlet Su İşleri, «Sera Gazı Salımları ve Türkiye'de İklim Değişikliği ile Mücadele Konusunda Yapılan Çalışmalar,» 10 2014. Available: dsi.gov.tr. [Accessed in: 08 2023].

[17] European Comission, «Communıication From The Commission to The European Parliament, The Council, The European Economic and Social Committee and the Committee Of The Regions,» 17 9 2020. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562.

[18] Avrupa Birliği Türkiye Deklerasyonu, «Geleceğe Dair: Paris İklim Anlaşması,» Ankara, 2016.

[19] E. Karakaya, «Paris Climate Agreement: An Evaluation of Its Content and Impact on Turkish Economy,» *Adnan Menderes University, Journal of Institute of Social Sciences,* pp. 1-12, 2016.

[20] B. Çetinkaya, *Erken Cumhuriyet Dönemi Enerji Politikaları,* Karabük, 2019.

[21] A. G. Ökçün, «Teşvik-i Sanayi Kanun-ı Muvakkatı 1913,» *Ankara Üniversitesi Siyasal Bilgiler Fakültesi Dergisi,* pp. 25-44, 1975.

[22] N. Yurtoğlu, «Cumhuriyet Türkiyesinde Elektrik Enerjisi Üretimi ve Enerji Politikaları,» *Atatürk Araştırma Merkezi Dergisi,* pp. 227-280, 2017.

[23] State Planning Organization, «First Five-Year Organization Plan,» 1963.

[24] E. Koç ve K. Kaya, «Enerji Kaynakları - Yenilenebilir Enerji Durumu,» *Mühendis ve Makina,* pp. 36-47, 2015.

[25] «Our World in Data,» 2022. Available: https://ourworldindata.org/grapher/gas-share-energy?tab=chart&country=~TUR.

[26] «TEİAŞ,» 2022. Available: https://www.teias.gov.tr/turkiye-elektrik-uretim-iletim-istatistikleri.

[27] H. K. Öztürk, A. Yılancı ve Ö. Atalay, «Past, present and future status of electricity in Turkey and the share of energy sources,» *Renewable and Sustainable Energy*, pp. 184-202, 2007.

[28] A. Gürbüz, «Enerji Piyasası İçerisinde Yenilenebilir (Temiz) Enerji Kaynaklarının Yeri ve Önemi,» %1 içinde *5. Uluslararası İleri Teknolojiler Sempozyumu*, Karabük, 2009.

[29] «Eurostat Statistics Explained,» 2022. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Enlargement_countries_-_energy_statistics.

[30] Republic of Türkiye Ministry of Energy and Natural Resources , 24 4 2023. Available: https://enerji.gov.tr/haber-detay?id=21143.

[31] T. MMO, «Türkiye'nin Enerji Görünümü 2022,» Makine Mühendisleri Odası, Ankara, 2022.

[32] Kalkınma Ajansları, «Kalkınma Planlamasında İstatistiki Bölge Birimleri Sınıflandırması,» Available: https://ka.gov.tr/en/pages/kalkinma-planlamasinda-istatistiki-bolge-birimleri-siniflandirmasi--24. [Accessed in: 2022].

[33] Türkiye İstatistik Kurumu (TUIK), 2021. Available: https://biruni.tuik.gov.tr/medas/?locale=tr. [Accessed in: 2022].

[34] Türkiye İstatistik Kurumu (TUIK), 2020. Available: https://biruni.tuik.gov.tr/medas/?locale=tr. [Accessed in: 2022].

[35] T.R. Ministry of Energy and Natural Resources, «EİGM Reports,» 30 12 2022. Available: https://enerji.gov.tr/eigm-raporlari.

[36] «Maabir,» 25 11 2022. Available: https://maabir.com/kurulu-guc-nedir/.

[37] Turkish Republic Ministry of Energy and Natural Resources, «Enerji Atlası,» [Çevrimiçi]. Available: https://www.enerjiatlasi.com/. [Accessed in: 2022].

[38] D. Ç. Yıldırım, S. Erdoğan ve E. İ. Çevik, «Regime-Dependent Effect of Crude Oil Price on BRICS Stock Markets,» *Emerging Markets Finance and Trade,* pp. 1706-1719, 2018.

[39] S. S. Tekkanat ve H. Mermer, «Inter-Regional Inequalities as a Planning Problem: The example of Turkey,» *Journal of Aksaray University Faculty of Economics and Administrative Sciences* , pp. 91-132, 2018.

[40] M. Bakkal, S. Bakkal ve H. Yıldırım, «Regional Economic Instabilities in Turkey and Ways of Solution,» *Social Sciences Studies Journal,* pp. 799-809, 2018.

[41] G. Erzi, *Türkiye'nin Bölgesel Gelişim Süreci ve Yeni Bölgeselcilik,* 2004.

[42] H. Sevinç, «Bölgesel Kalkınma Sorunsalı: Türkiye'de Uygulanan Bölgesel Kalkınma Politikaları,» *Girişimcilik ve Kalkınma Dergisi,* pp. 35-54, 2011.

[43] «Atatürk Ansiklopedisi,» 7 12 2022. Available: https://ataturkansiklopedisi.gov.tr/bilgi/sanayi-tesvik-kanunu/.

[44] N. Ertaş, *Bölgesel Kalkınma Politikası Aracı Olarak Kalkınma Ajansları: Türkiye'de Bölgesel Potansiyelin Değerlendirilmesi Açısından "Mevlana Kalkınma Ajansı" Örneği,* Konya: Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Yüksek Lisans Tezi, 2013.

[45] DPT, «Bölgesel Gelişme Özel İhtisas Komisyonu Raporu,» Ankara, 2000.

[46] «Güney Marmara Kalkınma Ajansı,» 10 12 2022. Available: https://www.gmka.gov.tr/kalkinma-ajansi-nedir-gorevleri-nelerdir.

[47] DPT, «Bölgesel Gelişme Özel İhtisas Komisyon Raporu,» Ankara, 2008.

[48] Kalkınma Bakanlığı, «Onuncu Kalkınma Planı 2014-2018,» Ankara, 2013.

[49] Kalkınma Bakanlığı, «Onuncu Kalkınma Planı 2014-2018,» Ankara, 2013.

[50] TC Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı, «On Birinci Kalkınma Planı (2019-2023),» Ankara, 2019.

[51] T.C. Kalkınma Bakanlığı, «Bölgesel Gelişme Ulusal Stratejisi 2014-2023,» Ankara, 2014.

[52] İstanbul Kalkınma Ajansı, «2014 - 2023 İstanbul Bögle Planı,» İstanbul, 2014.

[53] Güney Marmara Kalkınma Ajansı, «TR 22 Güney Marmara Bölgesi 2014-2023 Bölge Planı,» Balıkesir, 2014.

[54] Trakya Kalkınma Ajansı, «Trakya 2014-2023 Bölge Planı,» Tekirdağ, 2014.

[55] İzmir Kalkınma Ajansı, «2014-2023 İzmir Bölge Planı,» İzmir, 2014.

[56] BEBKA, «2014-2023 TR41 Bölge Planı,» Bursa, 2014.

[57] Doğu Marmara Kalkınma Ajansı, «2014-2023 TR42 Bölge Planı,» Kocaeli, 2014.

[58] Mevlana Kalkınma Ajansı, «Karaman Konya 2014-2023 Bölge Planı,» Konya, 2014.

[59] Batı Akdeniz Kalkınma Ajansı, «TR 61 Bölge Planı 2014-2023,» Isparta, 2014.

[60] Çukurova Kalkınma Ajansı, «2014-2023 Çukurova Bölge Planı,» Adana, 2014.

[61] Doğu Akdeniz Kalkınma Ajansı, «TR63 Bölge Planı 2014-2023,» Hatay, 2014.

[62] Ahiler Kalkınma Ajansı, «2014-2023 TR71 Düzey 2 Bölgesi Bölge Planı,» Available: https://www.kalkinmakutuphanesi.gov.tr/dokuman/2014-2023-tr71-duzey-2-bolgesi-bolge-plani/1393. [Accessed in: 01 2023].

[63] Orta Anadolu Kalkınma Ajansı, «2014-2023 TR72 Bölgesi Bölge Planı,» Available: https://www.oran.org.tr/images/dosyalar/111.pdf. [Accessed in: 01 2023].

[64] Kuzey Anadolu Kalkınma Ajansı, «TR82 Düzey 2 Bölgesi Bölge Planı,» Ankara, 2014.

[65] Doğu Karadeniz Kalkınma Ajansı, «Doğu KAradeniz Bölge Planı 2014-2023,» Trabzon, 2014.

[66] Kuzeydoğu Anadolu Kalkınma Ajansı, «Kuzeydoğu Anadolu Bölge Planı 2014-2023,» Erzurum, 2014.

[67] Serhat Kalkınma Ajansı, «TRA2 Bölgesi 2014-2023 Bölge Planı,» Kars, 2014.

[68] Fırat Kalkınma Ajansı, «2014-2023 TRB1 Bölge Planı,» Malatya, 2014.

[69] Doğu Anadolu Kalkınma Ajansı, «TRB2 Bölgesi 2014-2023 Bölge Planı,» Van, 2013.

[70] Karacadağ Kalkınma Ajansı, «TRC2 Bölge Planı 2014-2023,» Diyarbakır, 2014.

[71] İpekyolu Kalkınma Ajansı, «TRC1 Bölge Planı 2014-2023,» Gaziantep, 2015.

[72] «Türkiye Raporu,» 06 01 2023. Available: turkiyeraporu.com/arastirma/herkesin-enerjisi-kendine-gunes-enerjisi-kullanimi-artiyor-mu-10523/#:~:text=Almanya'da%20güneş%20enerjisinin%20kurulu,GW'ye%20kadar%20ulaşmış%20durumda..

[73] IRENA, «Wind Energy,» Available: https://www.irena.org/Energy-Transition/Technology/Wind-energy. [Accessed in: 01 2023].

[74] O. Özuğurlu, *Yenilenebilir Enerjinin Türkiye'deki Gelişimi,* Niğde: Niğde Ömer Halisdemir Üniversitesi Sosyal Bilimler Enstitüsü İktisat Anabilim Dalı, 2019.

[75] Enerji ve Tabi Kaynaklar Bakanlığı, «Enerji ve Tabi Kaynaklar Bakanlığı,» 06 01 2023. [Çevrimiçi]. Available: https://enerji.gov.tr/bilgi-merkezi-enerji.

[76] S. Kul, «Klinik Araştırmalarda Örnek Genişliği Belirleme.,» *Plevra ,* pp. 129-132, 2011.

[77] «Republic of Türkıye Ministry of Foreign Affairs,» 13 04 2023. Available: https://www.mfa.gov.tr/turkeys-energy-strategy.en.mfa.

[78] S. Carmalt, The Economics of Oil A Primer Including Geology, Energy, Economics, Politics, Cham: Springer, 2017.

[79] G. R. P. E. C. P. M. A. P. C. B. T. J. .. &. B. Walther, «Ecological responses to recent climate change,» *Nature,* pp. 389-395, 2002.

[80] M. S. J. D. Z. J. Alex O. Acheampong, «Effects of income inequality and governance on energy poverty alleviation: Implications for sustainable development policy,» *Utilities Policy,* 2022.

[81] L. W. L. Z. M. Y. Yu Hao, «The dynamic relationship between energy consumption, investment and economic growth in China's rural area: New evidence based on provinincial panel data,» *Energy,* pp. 374-382, 2018.

[82] G. Stoeglehner, «Integrated spatial and energy planning: a means to reach sustainable development goals,» *Evolutionary and Institutional Economics Review,* 2020.

[83] B. P. (BP), «BP Statistical Review of World Energy.,» London, 2021.

[84] «IRENA,» 06 01 2023. Available:https://www.irena.org/Energy-Transition/Technology/Wind-energy#:~:text=Onshore%20wind%20capacity%20grew%20from,2019%20to%20reach%201412%20TWh..

[85] Republic of Türkiye Ministry of Energy and Natural Resources, «Türkiye hydrogen technologies strategy and roadmap,» 2023.

[86] Republic of Türkiye Ministry of Environment, Urbanization and Climate Change, 12 01 2023. Available: https://csb.gov.tr/hazine-arazileri-ekonomiye-kazandiriliyor-bakanlik-faaliyetleri-37378.

[87] Republic of Türkiye Ministry of Energy and Natural Resources, 1 2023. Available: https://enerji.gov.tr/Media/Dizin/SGB/tr/Kurumsal_Politikalar/HSP/ETKB_Hidrojen_Stratejik_Plan2023.pdf.

[88] B. Dawson ve R. G. Trapp, Basic & Clinical Biostatistics (LANGE Basic Science), McGraw-Hill Medical, 2004.

[89] European Comission, «European Comission,» An official website of European Comission, 2021-2030. Available: https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en. [Accessed in: 14 05 2023].

[90] «Global Solar Atlas,» Available: https://www.globalsolaratlas.info/map. [Accessed in 2022].

[91] «Global Wind Atlas,» Available: www.globalwindatlas.info/en/area/Turkey. [Accessed in: 2022].

PUBLICATIONS FROM THE THESIS

Article

[1] B. Sağlam and S. Oğuztimur, «Development in Energy Policies in Türkiye and Investigation of Primary Energy Supply Within NUTS 1 Regions» *Pamukkale Journal of Eurasian Socioeconomic Studies,* pp. 34-56, 2023.