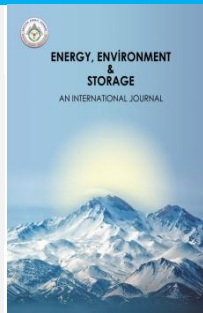


# Energy, Environment and Storage

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## The Relationship Between CO<sub>2</sub> Emissions and Economic Growth in Turkey

Rumeysa Ozden<sup>1\*</sup>, Selahaddin Orhan Akansu<sup>2</sup>, Bilge Albayrak Çeper<sup>3</sup>, Nafiz Kahraman<sup>4</sup>

<sup>1,2</sup> Erciyes University, Faculty of Engineering, Department of Mechanical Engineering, KAYSERİ, TURKEY

<sup>1</sup> [rumeysaozden01@gmail.com](mailto:rumeysaozden01@gmail.com), <sup>2</sup> [akansu@erciyes.edu.tr](mailto:akansu@erciyes.edu.tr), ORCID: 0000-0002-0085-7915

<sup>3,4</sup> Erciyes University Aeronautics and Astronautics Faculty, Department of Aerospace Engineering Kayseri, Turkey

<sup>3</sup> [balbayrak@erciyes.edu.tr](mailto:balbayrak@erciyes.edu.tr), ORCID: 0000-0001-5556-5170, <sup>4</sup> [nafiz@erciyes.edu.tr](mailto:nafiz@erciyes.edu.tr) ORCID: 0000-0002-8698-8632

**ABSTRACT.** The relationship between environmental pollution and economic growth has recently been the focus of discussion between policy makers and scientists around the world. The relationship between environmental pollution and economic growth has recently been the focus of discussion between policy makers and scientists around the world. In order to meet human needs, energy is needed in the activities to be carried out and the demand for this energy has increased exponentially over the years. Today, energy is produced from two sources: fossil fuels and renewable resources. Turkey renewable energy resources, particularly hydropower, wind energy, solar energy and is a country with significant potential for geothermal energy sources. Compared to fossil fuels, the carbon emissions from renewable energy sources are low. CO<sub>2</sub> emissions from the use of fossil fuels vary depending on the type of fossil fuel used. In this study, the energy sector between Turkey's 1990-2016 year, agricultural activities and carbon emissions per person from industrial processes and the per capita change in the manufacturing sector with the relationship between GDP energy imports, health care costs have been analysed.

**Keywords:** CO<sub>2</sub> emission, GDP, Energy production

**Article History:** Received:01.06.2021; Revised:16.08.2021; Accepted:22.08.2021; Availableonline: 26.08.2021

**Doi:** <https://doi.org/1052924/WOSD3037>

### 1. INTRODUCTION

The industrial revolution is a major and radical change in the production structure and economy, thanks to the use of new power sources such as steam and mechanization. This development, which is also expressed as the industrial revolution, started in Europe in the second half of the 18th century [1]. With the development of the industrial revolution, fossil fuel consumption has increased rapidly. Today, developed countries have increased their fossil fuel consumption with the industrial revolution, and environmental pollution has begun to increase by accelerating the destruction of forests, agricultural lands and similar natural resources. Until today, urbanization and industrialization are increasing. In this case, the amount of greenhouse gases, especially CO<sub>2</sub>, increases gradually.

Since the 19th century, the world's average air temperature has increased by 0.3 - 0.6 C°. It is estimated from researches that it will increase by 0.1 C° for every 10 years in the next 40 years [2].

Along with industrialization, the economic growth of countries has also increased. Gross Domestic Product (GDP) and Gross National Product (GNP) are the two main measures of economic growth [3]. In short, GDP (Gross Domestic National Product) is the sum of the monetary values of goods and services produced in a country in a year, in terms of current prices (market price). GNP (Gross National Product) is the sum of the monetary value of the final goods and services produced by a country's production factors in a year, in terms of current prices. GNP is obtained from the sum of GDP and foreign income [4].

There are many studies on environmental awareness, economic growth-income relationship and energy-related carbon emissions. The relationship between environmental pollution and per capita income is based on the Environmental Kuznets Curve (EKC) hypothesis. According to the Kuznets Curve shown in Figure 1., there is an inverted-U-shaped relationship between economic growth and income distribution inequality. In this theory, it is argued that income distribution will deteriorate first

\* Corresponding author: [rumeysaozden01@gmail.com](mailto:rumeysaozden01@gmail.com)

with economic growth and development, and income inequality will decrease as income increases continue [5].

Jalil and Mahmud analysed the relationship between carbon emissions, energy consumption, income and foreign trade for the 1975-2005 period for the Chinese economy. The result of the study confirms a relationship between carbon emissions and GDP per capita that supports second order EKC [6]. Artan et al. examined the relationship between environmental pollution and economic growth for Turkey data between 1981 and 2012. As a result of the findings obtained from the study, they determined a long-term relationship between economic growth and environmental pollution [7].

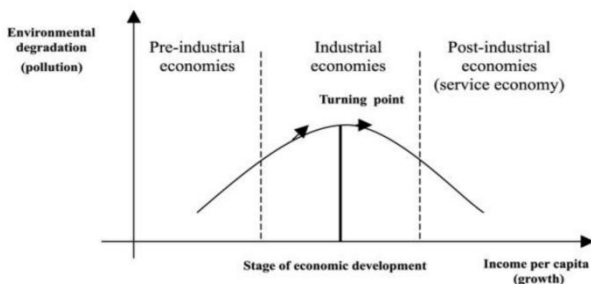


Figure 1. Environmental Kuznets Curve: Development Environment Relationship [8].

## 2. DEVELOPMENT AND COUNTRIES

The level of development in countries is mostly related to the economic structure of that country. Depending on the economic situation, social life and cultural structure are also among the criteria of development. Due to the differences in the economic, social and political structures of the countries, their development levels are also different from each other. Different criteria are used when determining the level of development of a country. The most important features of developed countries are that they use advanced technology and that a significant part of the employees work in the industry and service sector. According to these criteria, countries can be considered in two groups as developed and developing. The biggest criterion used to compare the development levels of countries is per capita income. Energy consumption is high in countries with developed industry and high living standards. Products exported abroad in developed countries are mostly industrial products. The raw material and food sector constitute the majority of the products imported into the country. The fact that the products sold bring high income to the country and the products purchased are low-priced products provide commercial income to the development. Developing countries buy high-income products and sell low-income products. For this reason, foreign trade deficits constantly occur. In such countries, the country's resources are not sufficient to utilize natural resources. Dependence on economically developed countries is high [9].

This industrialization, which has increased rapidly in the world, has led to global warming problems. Due to the increase in greenhouse gases sent to the air as a result of the use of fossil resources as fuel, gas rates per capita are

gradually increasing. This increase can be seen to decline as some countries start using renewable energy sources. The use of renewable energy is increasing in most countries compared to the first years. In our study, the data of Germany, France, the Netherlands, Turkey, India and Brazil, which were examined between 1990 and 2016, were collected. Energy production and consumption, renewable energy production amounts, GDP and CO<sub>2</sub> emission data from development levels were examined separately for each country [10].

### 2.1 Energy Production and Consumption

-Germany

Germany, which we have examined among the developed countries, is shown energy production in Figure 2. In 1990, it has advanced its total energy production of 508582 GWh in a way to continuously increase it without creating much fluctuations over the years. Looking at the year 2016, this value reached 614155 GWh with an increase of 17.19%. In Figure 3, the total energy consumption amounts of Germany are divided into sections in terms of coal, oil, geothermal, temperature, natural gas, biofuel and electricity, and the data is processed and combined into total values. In Figure 4, the energy consumption per capita of Germany is given in ktoe. When these figures are examined, it is seen that there is an annual increase in energy production, but a decrease in consumption, as well as a decrease in annual per capita consumption. This decrease between 1990 and 2016 is around 10%. The decrease in energy consumption is due to public awareness and more efficient use of systems.

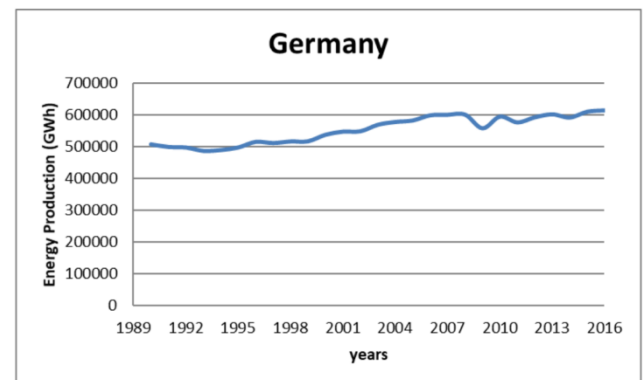


Figure 2. German Energy Production (OECD) [10]

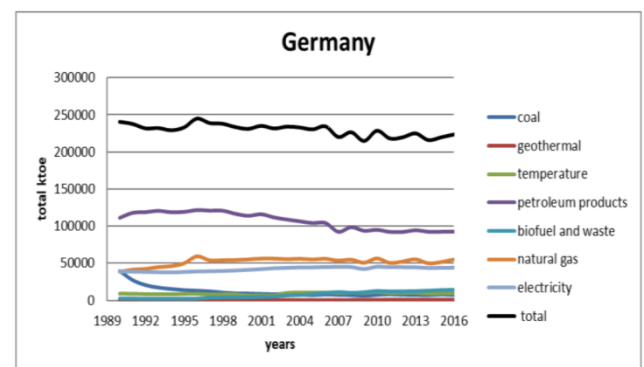


Figure 3. Germany Energy Consumption, Total ktoe (IEA 2019) [11]

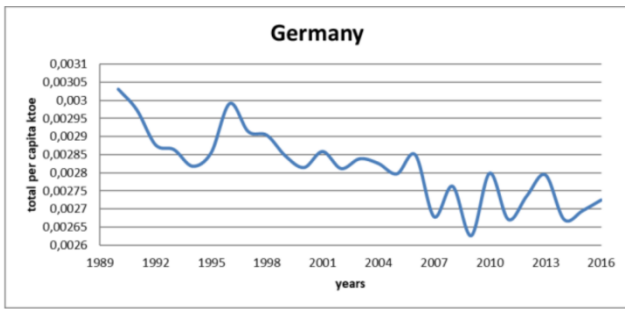


Figure 4. Energy Consumption in Germany, ktce per Capita (IEA 2019) [11]

- France

Energy production amounts are given in Figure 5 in the data of France, which is the other country we examined among the developed countries. When the year 1990 is examined, France, which produced 401151 GWh of energy, increased its energy production to 532943 GWh in 2016 with an increase of 24.73% between 1990 and 2016.

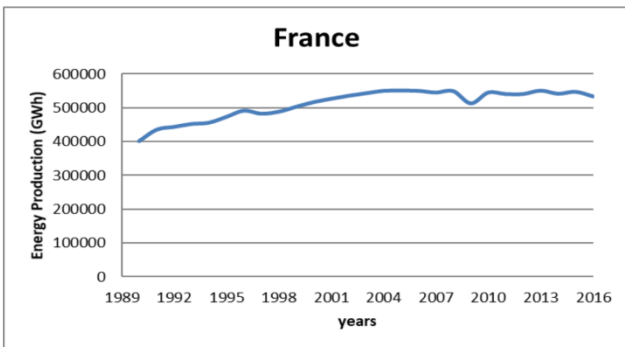


Figure 5. France Energy Production (OECD) [10]

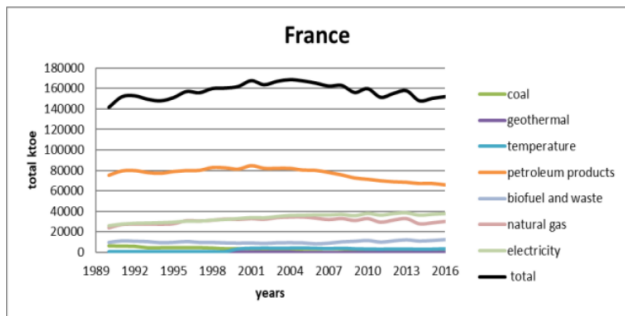


Figure 6. France Energy Consumption, Total ktce (IEA 2019) [11]

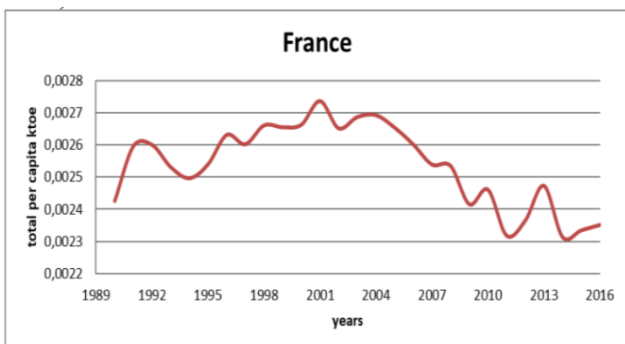


Figure 7. France Energy Consumption, ktce per Capita (IEA 2019) [11].

In Figure 6, energy consumption data are handled separately in coal, petroleum, geothermal, biofuel, natural gas, temperature and electricity categories and total data entries are processed. In Figure 7., the energy consumption of France is given in ktce per capita. While energy production increased by 24%, energy consumption started to decrease after 2002. While the per capita energy consumption reached its highest values in 2001, it started to decrease after this year. This decrease between 2002 and 2016 is around 11%. Compared to 1990, the decrease per person is around 3%.

- Netherlands

Energy production data of the Netherlands, which is among other developed countries, are shown in Figure 8. The Netherlands, which produced 69464 GWh of energy in 1990, produced 110984 GWh in 2016 and increased its production by 37.41% between these years.

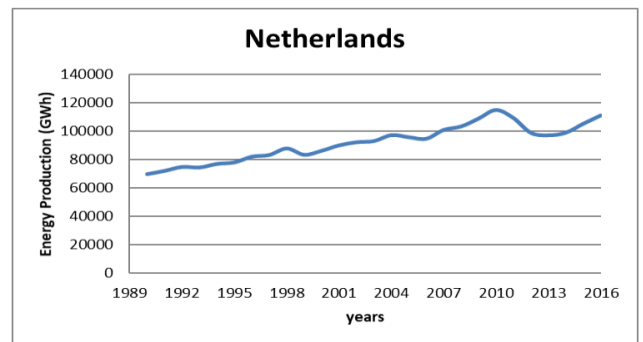


Figure 8. Netherlands Energy Production (OECD) [10]

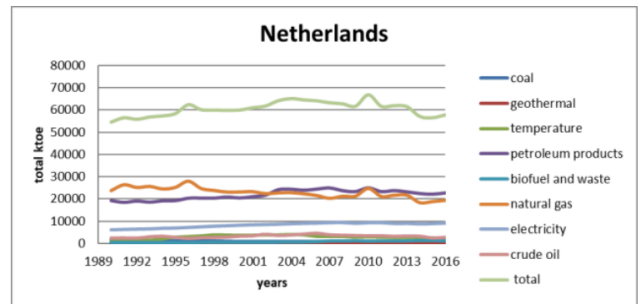


Figure 9. Netherlands Energy Consumption, Total ktce (IEA 2019) [11].

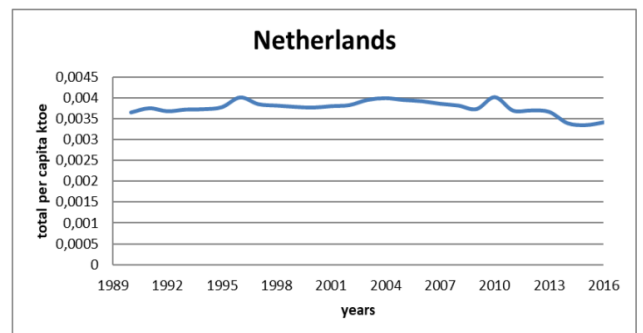


Figure 10. Netherlands Energy Consumption, ktce per Capita (IEA 2019) [11].

In Figure 9., coal, oil, geothermal, temperature, biofuel, natural gas and electricity data as energy consumption in the Netherlands country are handled in separate categories

and the total ktoe value is reached. Figure 10 shows the per capita energy consumption of the Netherlands. Although it reached the highest data in total energy consumption in 2004, it decreased by 11% between 2004 and 2016. When the period between 1990 and 2016 is examined, it is seen that there is an increase in energy consumption at the level of 5.7%.

- Turkey

Turkey is in the category of developing countries. The energy production amounts shown in Figure 11 were 54232 GWh in our country in 1990 and increased to 261937 GWh in 2016 with an increase of 79.3%.

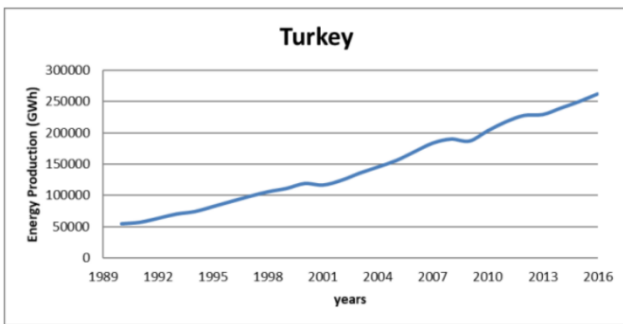


Figure 11. Turkey Energy Production (OECD) [10]

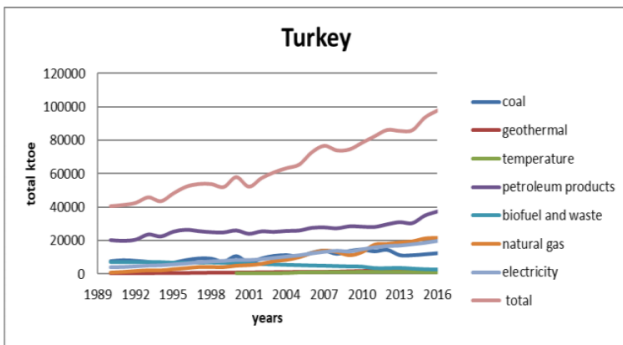


Figure 12. Turkey Energy Consumption, Total ktoe (IEA 2019) [11]

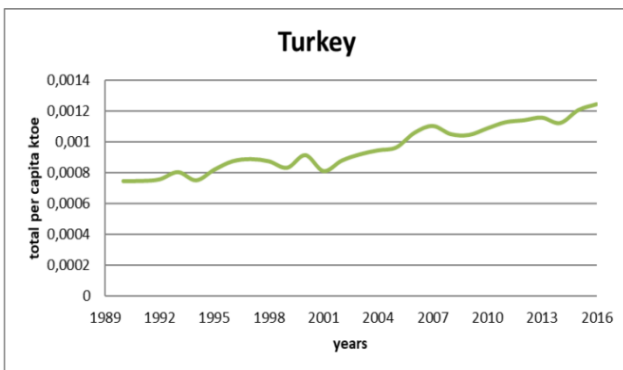


Figure 13. Turkey Energy Consumption, per capita ktoe (IEA 2019) [11].

In Figure 12., the coal, geothermal, temperature, oil, biofuel, natural gas and electricity data used in our country were collected from these data in the form of total consumption. In Figure 13, Turkey's per capita energy consumption amounts are given in ktoe. Turkey, which

has been increasing in energy consumption, shows an increase of 58.8% between 1990 and 2016.

- India

When the data of another developing country of India is examined, in Figure 14. the energy consumption amounts of coal, geothermal, oil, natural gas and electricity categories were collected, and total ktoe values were obtained. In Figure 15, the energy consumption per capita for the country of India is given in ktoe. When the energy consumption data of developing India is examined, it has increased in energy consumption by approximately 57.5% from a total value of 242881 ktoe in 1990 to 572289 ktoe in 2016.

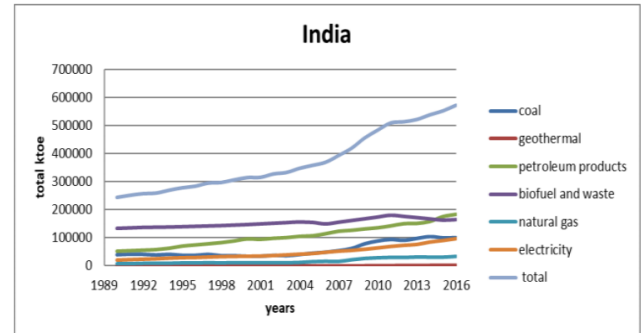


Figure 14. Indian Energy Consumption, Total ktoe (IEA 2019) [11]

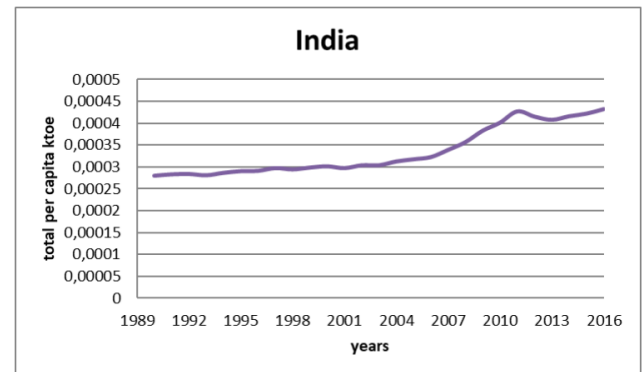


Figure 15. Energy Consumption in India, ktoe per Capita (IEA 2019) [11]

- Brazil

In the data of the last developing country Brazil examined, in Figure 16, the energy consumption data is evaluated separately for coal, geothermal, oil, biofuel, natural gas and electricity types and the total energy consumption is shown. In Figure 17, the amount of energy production per capita in Brazil is given in ktoe. Brazil increased its energy consumption by 50.4% from a total of 111338 ktoe in 1990 to 224269 ktoe in 2016.

As can be seen in Figure 18, where the energy production amounts changing by years and the countries examined are shown together, developed and developing countries exhibited ways that follow their own trends. In terms of energy status of the countries relative to each other, even though Turkey surpassed the Netherlands, it could not approach the energy production amounts of Germany and France. However, Turkey, which exhibits a linear slope in

growth, has shown a growth in energy production by increasing 79.3% over the years.

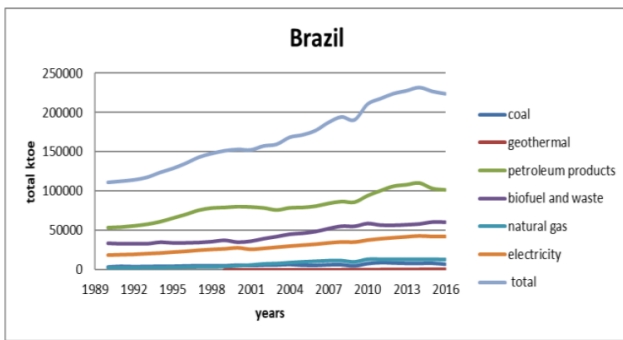


Figure 16. Brazilian Energy Consumption, Total ktOE (IEA 2019) [11]

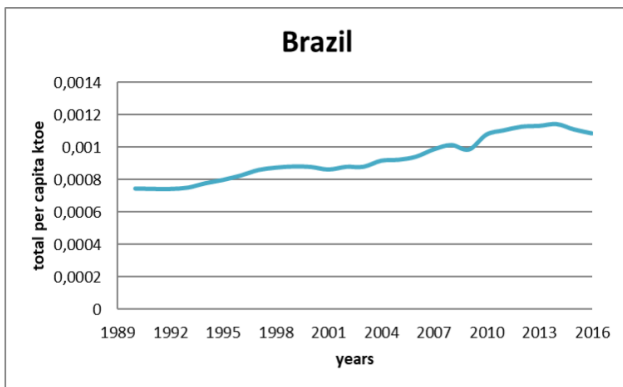


Figure 17. Brazilian Energy Consumption, ktOE Per Capita (IEA 2019) [11].

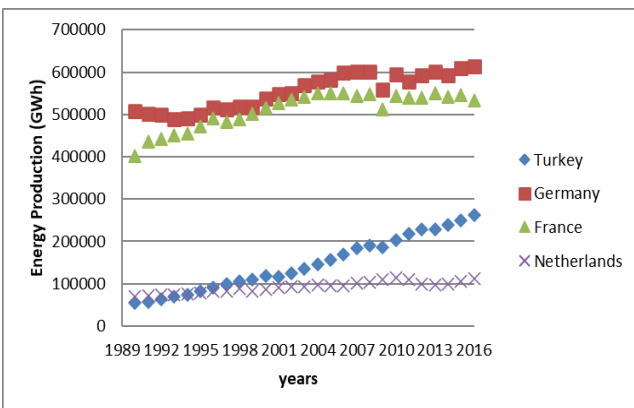


Figure 18. Energy Production (OECD) varying by years [10].

### 2.2 Renewable Energy Production Amounts

The total renewable energy generation values in GWh of hydroelectric, wind, solar, geothermal and tidal wave energies in Germany, France, the Netherlands, Turkey, India and Brazil between 1990 and 2016 are given in Figure 19. As it can be seen from the figure, it is seen that all countries have increased continuously, even if there are fluctuations when the year 1990 is taken as a basis. Brazil, the country that exhibits the most renewable energy production, increased its total value of 206708 GWh in 1990 by 50.13% between these years and reached 414484 GWh in 2016. Hydroelectric power plants have the biggest role. Looking at Germany, these values increased from 19863 GWh in 1990 to 144006 GWh in 2016, with an

increase of 86.21%. In Turkey, on the other hand, this situation increased the total energy production of 23228 GWh in 1990 by 73.79% to 88610 GWh in 2016.

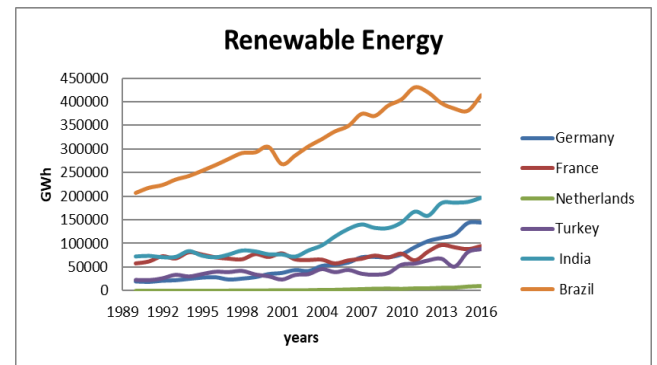


Figure 19. Change by years Renewable Energy Production (IEA 2019) [11].

### 2.3. Gross Domestic Product (GDP)

There is a relationship between the gross annual product per capita and CO<sub>2</sub> emissions. Both the developed countries and the developing countries, the GDP and per capita CO<sub>2</sub> emissions of the flue gases consisting of greenhouse gases of the fuel-based production sectors operating for all energy production have been analysed. The changes in GDP between 1990 and 2016 for Turkey, Germany, France, Netherlands, India and Brazil countries that we have examined are shown in Figure 20. As can be seen from the figure, developed countries and developing countries have gradually displayed growth rates, showing approximately the same distributions as if they express themselves in separate communities. It is seen that the GDP per capita has increased with the economic growth of Germany, France and the Netherlands, which are developed countries over the years. Likewise, this is the case in developing countries such as Turkey, India and Brazil.

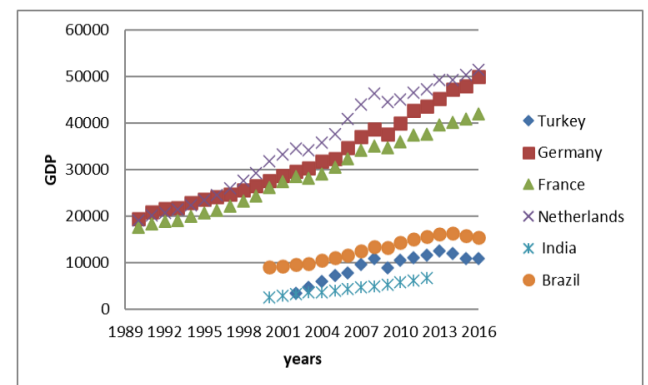


Figure 20. GDP that varies by years (OECD) [10].

In Figure 21. GDP growth rates are given. In the economic crisis that started in the last quarter of 2008 and passed as the 2009 crisis, all countries were affected by the crisis. Although it did not take long for countries to recover after 2009, this crisis in Turkey declined sharply and rose sharply.

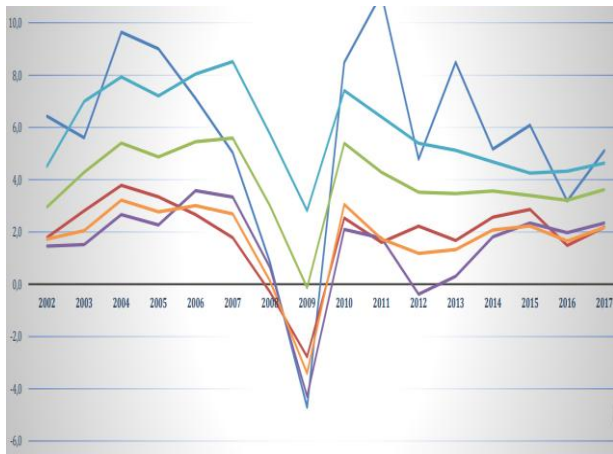


Figure 21. Comparison of GDP Growth Rates [12]

— Turkey; — ABD; — World; — AB-28; — Developing countries; — Developed countries

### 2.4. CO<sub>2</sub> Emissions

One of the negative effects of economic growth on the environment is CO<sub>2</sub> emissions. Rapidly increasing industrialization has increased the global warming problems and the per capita gas rates of the increase in greenhouse gases. It has been concluded that the relationship between CO<sub>2</sub> emissions and economic growth is realized by the fact that developing countries mostly increase their energy consumption and maintain their high growth rates at the expense of neglecting effective technologies [13]. CO<sub>2</sub>, which is formed by the burning of primary fossil fuels containing carbon, accumulates in the atmosphere and causes global warming triggers such as biodiversity losses, ocean level rise, and climatic disturbances. In the countries where CO<sub>2</sub> emissions were measured, growth was initially considered without environmental awareness.

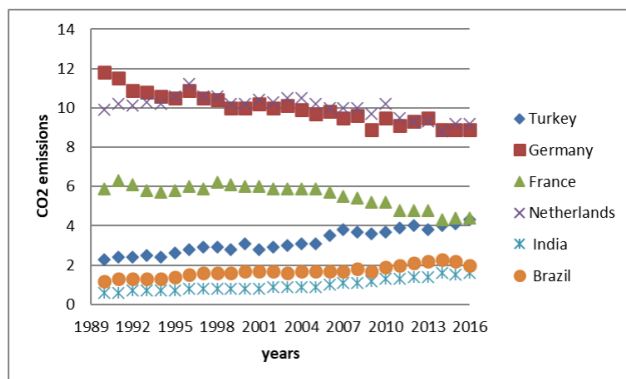


Figure 22. CO<sub>2</sub> emissions (OECD), [10].

In Figure 22, the CO<sub>2</sub> emission values with which the countries are compared are given in terms of tons/person. Developed countries such as Germany, France, and the Netherlands increased their income level at first, and later showed trends that led to environmental awareness and decreased CO<sub>2</sub> emissions. Turkey, India and Brazil countries, that is, these developing countries ignore environmental pollution in order to increase their income levels first. This causes the CO<sub>2</sub> emission rates of developing countries to increase gradually. The figure confirming the Kuznets curve, which is the hypothesis that

environmental pollution will increase as the income levels of countries increase, but when a higher income level is reached, environmental awareness is created and environmental pollution decreases, CO<sub>2</sub> emissions decrease in Germany, France and the Netherlands.

### 3. CONCLUSION

In this study, energy production and consumption values of developed and developing countries, production amounts of renewable energy, GDP values and CO<sub>2</sub> emission amounts are explained with numerical data in the form of graphics. Developed countries initially ignored the environmental pollution caused by greenhouse gases emitted as a result of excessive use of energy consumption by raising their economic levels. As the income levels of these countries increase, considering the sensitivity to environmental awareness, the use of energy with more efficient systems has brought a conscious decrease in energy consumption. Developed countries such as Germany, France and the Netherlands, which give results close to the Kuznets curve, showed the same characteristics by showing a decrease in the slope of the per capita CO<sub>2</sub> emission curves with the per capita energy consumption curves. The main reasons for the decrease in greenhouse gases are the increase in the economic values of the developed countries, mostly from the software sectors within their own country borders, and the production of manpower in foreign countries or the fact that approximately 70% of the energy production is provided by nuclear energy, as in France. European countries have set different targets in various sectors for 2020. These targets are 20% reduction in CO<sub>2</sub> emissions, 20% increase in renewable energy production, 20% increase in emissions and energy efficiency. According to the data interpreted in the graphics, the desired increase and decrease values in the targets set between 1990-2016 were achieved before reaching 2020.

Looking at the developing countries, they are in the part of the Kuznets curve with economic growth. Developing countries such as Turkey, India and Brazil, which attach importance to economic growth values regardless of global warming, air pollution and CO<sub>2</sub> emission values, show a continuous increase in energy consumption per capita and the use of fossil fuels. Looking at the CO<sub>2</sub> emission values in Turkey, it was seen in Figure 22 that greenhouse gas emissions constantly increased with the demand of economic growth. It should not be overlooked that the CO<sub>2</sub> emission values in Turkey, which show a continuous increase in the graph, have caught the CO<sub>2</sub> emission values of France. Although the data we have belongs to the years 1990-2016, it can be thought that CO<sub>2</sub> emission values will decrease with the

### 4. REFERENCES

[1] IndustrialRevolution <https://www.wikitarih.com/sanayi-devrimi-nedenlerisonuclari/>, 2016.  
 [2] Özmen, M.T., 009, Greenhouse Gas – Global Warming and the Kyoto Protocol, IMO e-library, TMH-453– 2009/1, 2009.

- [3] Koç, E., Şenel M.C., Kaya, K., Industrialization I – Strategy and Basic Industrialization Problems in the World and Turkey, *Engineer and Machinery*, 59 (690), 1-26,2018.
- [4] <https://ekonomihukuk.com/makroiktisat/gsmh-gsyih-nedir-nasil-hesaplanir/>, 2017.
- [5] Bayramoğlu, A.T., Yurtkur, A.K, The Relationship between Carbon Emission and Economic Growth in Turkey: Nonlinear Cointegration Analysis, *Bolu Abant İzzet Baysal University Journal of Social Sciences Institute*, 16(4), 31-46, 2016.
- [6] Jalil, A., Mahmud, S. F., Environment Kuznets curve for CO2 emissions: a cointegration analysis for China, *Energy policy*, 37(12), 5167-5172,2009.
- [7] Artan, S., Hayaloğlu, P., Seyhan, B., The Relationship Between Environmental Pollution, Trade Openness and Economic Growth in Turkey, *Yönetim ve Ekonomi Araştırmaları Dergisi*, 13(1), 308-325, 2015.
- [8] Tanger S.M., Zeng P., Morse W., Laband D.N., Macroeconomic conditions in the U.S. and congressional voting on environmental policy: 1970–2008, *Ecological Economics*, 70,1109-1120, 2011.
- [9] *Geography Science*, <http://www.cografyabilimi.gen.tr>, 2018.
- [10] OECD reports, <http://www.oecd.org/> , 2019.
- [11] IEA reports, <https://www.iea.org/> , 2019.
- [12] T.R. Ministry of Customs and Trade [www.gtb.gov.tr](http://www.gtb.gov.tr) , 2017
- [13] Altintas H., The relationship between primary energy consumption, carbon dioxide emissions and economic growth in Turkey: cointegration and causality analysis, *EskişehirOsmangazi University Journal of Economics and Administrative Sciences*, 8(1), 263-294, 2013.