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ALTERNATIVE RENEWABLE ENERGY SOURCES IN THE CONTEXT OF GLOBAL ENERGY CRISES AND SUSTAINABLE ENVIRONMENT

KÜRESEL ENERJİ KRİZLERİ VE SÜRDÜRÜLEBİLİR ÇEVRE EKSENİNDE ALTERNATİF YENİLENEBİLİR ENERJİ KAYNAKLARI

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ABSTRACT

Energy is very important for individuals and countries as it is the basic input of production and consumption processes. Today, the energy crises faced by countries in the field of energy are increasing rapidly. The 19th-century energy crises centered on the unsustainability of the fossil fuels used to meet the global energy demand and the increasing damage to the environment. If greenhouse gas emissions from the burning of fossil fuels continue unabated, the need for a radical environmental transformation is indisputable. In addition, the threat of environmental problems such as global warming and climate change to the world ecosystem has brought about the search for different energy that can provide a sustainable environment. In addition, global energy crises make the transition to more sustainable and secure energy systems mandatory. At this point, renewable energy resources come to the fore as a solution to energy crises and environmental problems. This study examines the relationship between energy and the environment comprehensively based on a literature review on the axis of academic research, current data, and reports by focusing on the energy crises experienced in the global system on a historical axis. In this axis, the study also examines alternative energy sources that will contribute to the sustainable environment approach as a solution to the global energy crises. At this point, this study aims to provide innovative ideas for future studies in the field of energy by providing guiding implications for economic units and policymakers.

Keywords: Global Energy Crises, Energy Demand, Sustainable Environment, Renewable Energy

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ÖZ

Enerji, üretim ve tüketim süreçlerinin temel girdisi olduğundan bireyler ve ülkeler için oldukça önemlidir. Günümüzde ülkelerin enerji alanında karşılaştıkları krizler hızla artmaktadır. 19. yüzyılda yaşanan enerji krizlerinin odak noktasında, küresel enerji ihtiyacını karşılamak için kullanılan fosil yakıtların sürdürülebilir olmaması ve çevreye verdiği tahribatın gün geçtikçe artması yer almaktadır. Fosil yakıtların yakılmasından kaynaklanan sera gazı emisyonları durmaksızın devam ederse, köklü bir çevresel dönüşümün gerekliliği tartışılmazdır. Ayrıca küresel ısınma, iklim değişikliği gibi çevre sorunlarının dünya ekosistemini tehdit etmesi sürdürülebilir çevreyi sağlayabilecek farklı enerji arayışlarını beraberinde getirmiştir. Bununla birlikte küresel enerji krizleri, daha sürdürülebilir ve güvenli enerji sistemlerine geçişi zorunlu hale getirmektedir. Bu noktada enerji krizlerine ve çevre sorunlarına çözüm olarak yenilenebilir enerji kaynakları ön plana çıkmaktadır. Bu çalışma tarihsel eksende küresel sistem içerisinde yaşanan enerji krizlerine odaklanarak enerji ve çevre arasındaki ilişkiyi akademik araştırmalar, güncel veriler ve raporlar ekseninde bir literatür taramasına dayalı olarak kapsamlı şekilde incelemektedir. Bu eksende çalışmada ayrıca küresel enerji krizlerine çözüm olarak, sürdürülebilir çevre yaklaşımına katkı sağlayacak alternatif enerji kaynakları da ele alınmıştır. Bu noktada bu çalışma ekonomik birimler ve politika yapıcılara yol gösterici çıkarımlar sunarak enerji alanında gelecekte gerçekleştirilecek çalışmalara yenilikçi fikirler sunmayı amaçlamaktadır.

Anahtar Kelimeler: Küresel Enerji Krizleri, Enerji Talebi, Sürdürülebilir Çevre, Yenilenebilir Enerji

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Introduction

In the 18th century, the industrialization process and the increasing demand for energy resources elevated the importance of energy within the global economic and political system. Alongside industrialization, the continuous growth of the world population, the development goals of countries, and the changes in production and consumption patterns have resulted in an increasing need for energy every day. A country's access to energy resources is a significant power in the international system. In this context, countries that possess energy resources can wield this power, while countries lacking energy resources may become dependent on foreign energy sources.

Particularly, the 1973 Oil Crisis marked a significant shift in the global energy landscape. Today, wars, conflicts, disagreements between countries, economic crises, and the use of energy as a foreign policy tool have taken energy crises to a new level. The issues faced by states in the energy sector are increasing rapidly. Countries that are dependent on foreign energy sources are becoming vulnerable to sudden energy crises. In particular, fluctuations in energy prices and uncertainties in energy supply during the 2019 pandemic period and the 2022 Russia-Ukraine War triggered a new energy crisis, profoundly impacting global energy markets. Therefore, energy crises have a significant impact on shaping the economic balance, and internal, and external policies of countries globally. At this point, historical energy crises and the harm caused by energy consumption to the world, which is the only living space for individuals, have prompted countries to seek alternative energy sources (Aliyev et al., 2024). Energy and the environment are frequently discussed together due to the fact that the global economy has been fueled by fossil fuels that can alter the environment since the Industrial Revolution (Sing, 2021). Since energy supply is primarily based on fossil fuels, there is a need for a transition from a high-carbon energy system to a low-carbon one globally.

This study aims to comprehensively examine the relationship between energy and the environment by addressing historical energy crises within the global system. This work is based on a literature review, drawing on academic sources, current data, and reports. Additionally, the study will provide information and suggestions regarding alternative energy sources that contribute to a sustainable environmental approach as a solution to global energy crises. In this context, the study aims to provide guiding insights for economic units and policymakers, offering innovative ideas for future energy-related research. The study will first focus on the energy crises experienced worldwide in the historical context, discussing their causes, results, and impacts. In the subsequent stage, the relationship between energy and the environment will be evaluated. Finally, alternative energy sources, which both serve as alternatives to energy crises and contribute to a sustainable environment, will be examined.

1. Historical Energy Crises Worldwide

An energy crisis refers to problems that may arise in areas related to energy production, consumption, energy supply, and distribution. These problems have significant effects on the global energy market, energy prices, and the actors within the global system, namely the states. The need for energy in the world is increasing every day. The uneven distribution of energy resources across the globe and the potential depletion of these resources create uncertainties regarding the ability to meet future energy demand (Chatuverdi, 2017).

Today, the global energy system faces a critical set of issues. These include the rapidly growing energy demand in the face of the increasing geographical concentration of remaining conventional fuel reserves, the need to reduce the environmental impacts of energy systems, and the lack of access to modern energy for billions of people (Cherp et al., 2011). Furthermore, there are significant differences between past energy crises and those occurring today. Modern energy crises are more complex and have multifaceted impacts (Erden Kaya and Çaylak, 2024). Regional wars, power struggles, and instabilities affect global energy supply, demand, and prices, which in turn can shape national policies.

The Middle East, rich in oil resources, has always been at the center of global energy crises. The oil resources in the region have constantly increased the Middle East's international importance. The first major energy crisis of the 1970s occurred in 1973, due to the Arab-Israeli War. The U.S. support for Israel over an extended period greatly disturbed the oil producers in the region. The Organization of Arab Petroleum Exporting Countries (OAPEC) announced that they would not ship oil to countries supporting Israel (Özel Özcan and Öten, 2022: 182; Erden Kaya and Çaylak, 2024: 6).

The oil embargo imposed on the U.S., followed by OAPEC's decision to cut oil production, is reflected in oil prices. The 1970s was a challenging period marked by rising oil prices. Undoubtedly, the biggest rupture in international energy security and the relationship between energy supply and demand occurred with the 1973 Oil Crisis. This crisis led many countries, including European nations, to experience the negative consequences of energy dependence (Akın, 2020; Özel Özcan and Şahin, 2023: 30).

Energy crises have been recurring globally, starting with the oil crisis of the 1970s and continuing through various wars such as the Iran-Iraq War (1980-1988), the Gulf War (1990-1991), the Iraq War (2003), and the Russia-Ukraine War (2022) (Carlisle, 2017). Especially, wars and conflicts between countries, as well as economic and political relations, have been significant developments that prepare the ground for energy crises and influence energy policies. The 1980s marked another energy crisis, with the war between Iran and Iraq—two countries with significant oil reserves—resulting in a halt to oil exports (Özel Özcan and Öten, 2022: 181).

In the 1990s and 2000s, energy crises again erupted in the Middle East, driven by civil wars, instabilities, and power struggles targeting the region. In 1982, Saudi Arabia gradually reduced its oil production, and in 1990, Iraq's invasion of Kuwait led to a global energy crisis (Özel Özcan and Öten, 2022: 183). On the other hand, the COVID-19 pandemic that began in 2020 caused countries to close their borders, weakening economic ties and leading to a decline in oil consumption. This process resulted in a decrease in both oil prices and production. The effects of this crisis continued to be felt in 2021 and 2022 (Erden Kaya and Çaylak, 2024: 7).

The Russia-Ukraine War, which began in February 2022, is similarly a significant development impacting the global energy market. Russia, with its energy reserves, is a key global actor. A significant portion of the EU's energy needs is supplied by Russia. During the war, particularly after the EU imposed sanctions on Russia, Russia used its energy resources as a tool for retaliation, reducing its natural gas supply to European countries, thus triggering a new energy crisis (Wolowiec et al., 2022). The combination of the energy crisis caused by the Russia-Ukraine War and the food crisis has exacerbated financial problems in Europe (Moloney, 2023).

These developments led the EU to take measures regarding energy security, aiming to reduce dependence on foreign energy and diversify energy sources. In the long term, investments in additional natural gas projects and measures to increase energy security and meet climate targets were discussed within the European Commission (Wolowiec et al., 2022).

The energy crisis resulting from the Russia-Ukraine War is not solely due to Russia's use of its energy reserves as a sanctioning tool and the EU's dependency on Russia. Ukraine's failure to pay for the gas due to its economic conditions is another barrier to gas flow. Past instabilities in Ukraine have negatively affected energy flows to EU countries. Therefore, Ukraine is at the center of energy crises (Küçükkambak, 2024: 43).

Global energy crises lead to imbalances in the global energy market. These crises typically emerge from a combination of factors such as the limited nature of fossil fuel resources, environmental impacts, economic and political conflicts between countries, and increasing demand. Excessive reliance on fossil fuels causes environmental degradation, deepening the global climate change problem, while fluctuations in energy prices and supply shortages can threaten the economic stability of countries.

2. Energy and the Environment Relationship

As a result of the rapid increase in greenhouse gases in the Earth's atmosphere, human activities that add to the natural greenhouse effect and their impact on the environment are a major topic of discussion today. While the existence of a natural greenhouse effect on Earth is well known, anthropogenic changes in the composition and abundance of atmospheric greenhouse gases have become concerning (Stern, 2008). Greenhouse gas emissions from the burning of fossil fuels bring along many environmental problems, including global warming, climate change, rising sea levels, and water and soil pollution (He et al., 2021).

The primary human contribution to environmental degradation is the emission of greenhouse gases resulting from the burning of fossil fuels. Reducing this impact requires significant adjustments in energy production and consumption. Energy is a key input for all other consumption and production processes, making it a crucial issue. Therefore, energy is a significant parameter that controls growth and determines many aspects of human activities in general. The increasing growth and demand for the welfare of developed and developing countries are putting more pressure on energy resources (Bilgen, 2014: 891). In this context, the increasing demand for energy worldwide and its role as an essential component of the production process make the energy-environment relationship critical.

As the global population increases and countries grow, the need for energy and energy demand also rises. The increasing demand for energy and energy consumption results in higher emissions of carbon dioxide and other greenhouse gases due to the burning of fossil fuels (Akın and Akçayır, 2024). The environmental destruction caused by greenhouse gas emissions from energy consumption is growing day by day. The accumulation of carbon dioxide and other greenhouse gases leads to unpredictable environmental disasters (Omer, 2008).

On the other hand, non-renewable energy sources such as oil, coal, and gas, which meet a significant portion of global energy demand, are facing the threat of depletion in the future. Indeed, three-quarters of global greenhouse gas emissions come from the burning of fossil fuels for energy production (Our World in Data, 2024c). The intensive use of non-renewable energy

sources in the global energy system is causing many problems on the Earth, which is the living space for individuals (Ritchie et al., 2023). The use of non-renewable energy sources has a significant impact on climate, the stability of the natural environment, and ecology (Amjith and Bavanish, 2022).

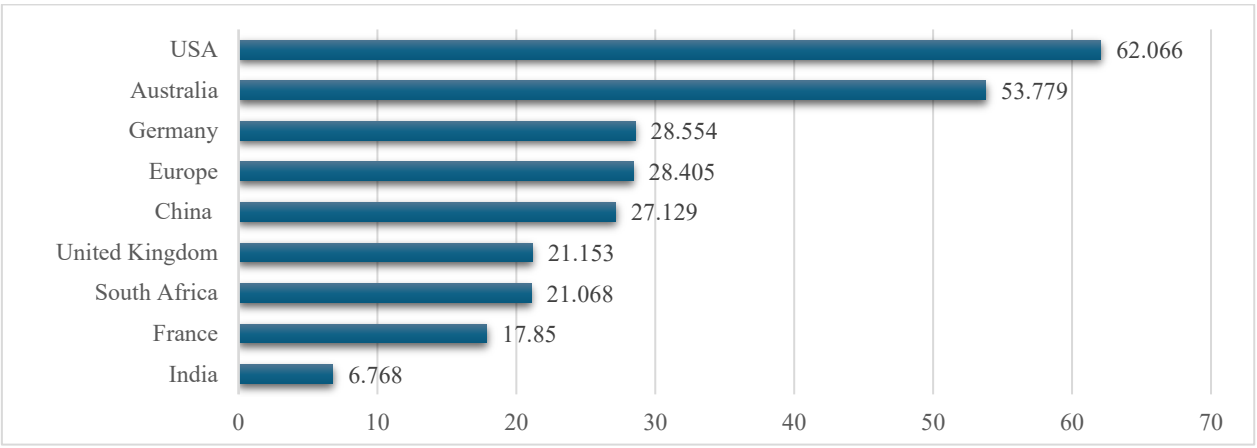
In this context, profound changes in global energy policies are required to reduce carbon emissions and combat environmental issues. The transition to sustainable energy production and consumption will not only provide environmental benefits but also economic and social advantages, creating a more livable world for future generations (Roser, 2020). This is because the focus of a sustainable environment is the need to preserve the ecosystem balance so that natural resources can be passed on to future generations without depletion or environmental degradation.

In 2023, global carbon emissions from fossil fuels and industry reached 37.79 billion tons (Our World in Data, 2024a). Since the Industrial Revolution, fossil fuel consumption for energy has increased significantly, reaching serious levels. The rapidly growing industrial production in the 20th century has triggered energy consumption. The industrial sector and the non-renewable energy sources used in this sector are the primary sources of global carbon emissions (Shen et al., 2023).

Total energy consumption varies by country based on population density and income growth. Countries with large populations inevitably consume more energy than smaller countries. Among the largest energy consumers are Iceland, Norway, Canada, the USA, and rich countries in the Middle East such as Oman, Saudi Arabia, and Qatar. An average person in these countries consumes 100 times more energy than individuals in the poorest countries (Ritchie et al., 2020). When examining the global status of fossil fuel consumption worldwide, in 1900 it was 5,973 TWh, in 1950 it was 20,139 TWh, in 2000 it was 95,548 TWh, and in 2023 it reached 140,231 TWh (Our World in Data, 2024a).

Figure 1 shows per capita fossil fuel consumption derived from the combination of coal, oil, and gas as part of the total primary energy. Looking at energy consumption at the country level, it is generally a strong reflection of population size rather than actual per capita fossil fuel consumption. In 2023, per capita fossil fuel consumption in the USA was 62,066 kWh, in Australia 53,779 kWh, and in Germany 28,554 kWh. The USA maintains a significant share of global energy demand and is one of the world's major polluters.

Figure 1: *Per Capita Fossil Fuel Consumption in Selected Countries (2023 / kWh)*



Source: World Bank, 2024; Our World in Data (2024a)

Carbon emissions associated with energy and industrial production can originate from various types of fuels. The contribution of each of these sources has significantly changed over time. The use of coal as a fuel on an industrial scale first emerged in Europe and North America in the 1700s. Growth in emissions from oil and gas production occurred around the late 1800s (Our World in Data, 2024b). Table 1 provides data on carbon emissions by fuel type over the years globally. Upon examining Table 1, it is observed that carbon emissions from the use of coal, oil, and gas as fuels have steadily increased from 1900 to the present. These data indicate that the environmental damage caused by fossil fuels has been increasing every day and will continue to do so.

Table 1: *CO_2 Emissions by Fuel Type in the World*

Year	Coal	Oil	Gas	Other Industries
1900	1,88 billion tonnes	67,31 million tonnes	11,54 million tonnes	-
1950	3,88 billion tonnes	1,55 billion tonnes	353,15 million tonnes	4,99 billion tonnes
1960	5,16 billion tonnes	3,12 billion tonnes	834,56 million tonnes	27,51 billion tonnes
1970	5,70 billion tonnes	6,80 billion tonnes	1,79 billion tonnes	44,35 billion tonnes
1980	7.01 billion tonnes	8,95 billion tonnes	2,76 billion tonnes	48,20 billion tonnes
1990	8,70 billion tonnes	9,24 billion tonnes	3,81 billion tonnes	223,05 billion tonnes
2000	9,20 billion tonnes	10,27 billion tonnes	4,75 billion tonnes	216,33 billion tonnes
2010	13,95 billion tonnes	11,32 billion tonnes	6,23 billion tonnes	246,16 billion tonnes
2020	14,27 billion tonnes	10,96 billion tonnes	7,56 billion tonnes	295,06 billion tonnes
2023	15,40 billion tonnes	12,21 billion tonnes	7,90 billion tonnes	301,13 billion tonnes

Source: Our World in Data (2024b)

3. Alternative Renewable Energy Sources in the Axis of Sustainable Environment as a Solution to Energy Crises

Today, energy systems are highly dependent on rapidly depleting fossil fuels. This dependence brings uncertainties regarding the future trajectory of energy markets. Globally, ensuring the sustainability of energy resources has become an urgent issue for countries. The world lacks low-carbon, cheap, secure, and large-scale energy infrastructure. Without the growth of energy infrastructure, energy crises will continue to occur worldwide. To prevent global environmental issues, countries are focusing on the 'zero emissions' target. The zero-emissions goal influences many global energy policy decisions (Berahab, 2022). Leading developed countries such as Germany, France, and Japan have set a target of zero carbon emissions by 2050 in order to overcome climate and environmental challenges (Doğan et al., 2022). Furthermore, countries have set targets to reduce fossil fuel consumption by 2030 within the framework of the Sustainable Development Goals (SDGs) (Roser, 2021). However, dependence on fossil fuels in the global energy market is one of the major barriers to achieving these goals.

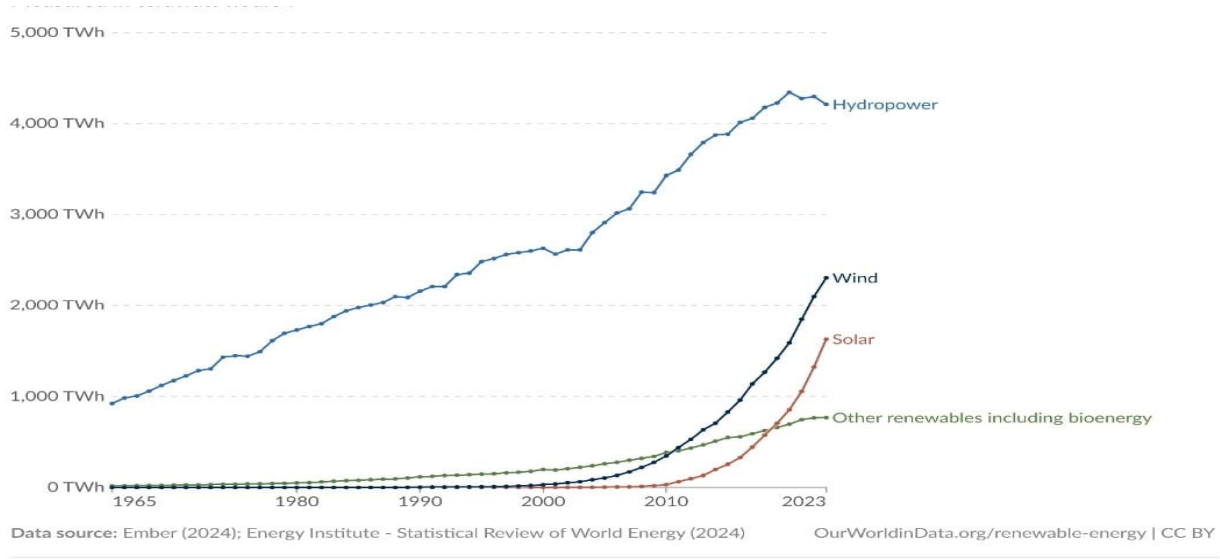
On the other hand, improving energy efficiency to consume less energy is a crucial factor that could help improve global environmental quality (Heryadi and Hartono, 2016). Energy efficiency can offer an effective solution to energy crises by reducing excessive demand for energy consumption. The alternatives developed for the future aim to address complex issues such as the growing energy demands of the rapidly expanding global population and global environmental pollution. Therefore, options for long-term and environmentally friendly energy supply should be developed. This requires the use of renewable resources (water, solar, wind, biomass, geothermal, hydrogen). Renewable energies can protect a country from negative

effects related to energy supply, prices, and environmental issues (Omer, 2008: 2268). As an alternative to the search for new sources to reduce environmental degradation, renewable energy is a very important development for global transformation (Şahinler et al., 2024).

Renewable energy is used to describe energy sources that occur naturally in nature and are self-renewing (Omer, 2008: 2271). The global energy crises that began with the extraordinary economic recovery after the pandemic in 2021 and intensified after Russia's invasion of Ukraine in February 2022 highlighted the importance of investments in renewable energy sources. This process initiated the integration of regional markets, the development of energy efficiency, and the promotion of renewable energy sources (Gajdzik et al., 2024). All these developments emphasize the urgent need for new technologies, systems, social organizations, and policies for energy conservation (Farghali et al., 2023).

Over the past few decades, the profile of renewable energy sources has significantly diversified. While hydroelectric energy continues to provide a large portion of electricity production, variable renewable energy sources have continuously increased their share in the global electricity mix, rising from 1.1% of renewable energy production in 2000 to 40.2% in 2022 (IRENA, 2024). The distribution of global renewable energy production by components (hydroelectric, solar, wind, and others) is shown in Figure 2. This data allows us to see the changes in renewable energy production over time. Hydroelectric production, which was 3,428.38 TWh in 2010, increased to 4,211.01 TWh in 2023. Hydroelectric energy stands out as a low-carbon renewable energy source (Ritchie et al., 2020; Our World in Data, 2024c). Similarly, wind energy production, which was 345.92 TWh in 2010, increased to 2,304.44 TWh in 2023. In 2023, the Asia-Pacific region leads hydroelectric production with 1,788.22 TWh, followed by South and Central America with 749.94 TWh, and Europe with 638.70 TWh (Energy Institute, 2024).

Figure 2: *Global Modern Renewable Energy Production by Source (Terawatt-hours)*



Source: Our World in Data (2024c)

Large-scale wind energy production, compared to hydroelectric energy, is a relatively modern renewable energy source but is rapidly growing worldwide (Ritchie et al., 2020; Our World in Data, 2024c). Similarly, solar energy has emerged as a new and increasingly important renewable energy source compared to hydroelectric energy. Solar energy is an important,

inexhaustible, easily convertible, and zero-carbon energy source (Duffie and Beckman, 2013). In 2023, the global installed solar energy capacity was recorded at 1,418.97 GW. A significant portion of the installed solar capacity (609.92 GW) occurred in China (IRENA, 2024). Solar energy is considered a clean energy source that should be explored as an alternative solution to future energy crises.

Wind energy, considered a secondary form of solar energy, is also categorized among clean energy sources. Today, many countries, including China, the United States, and Germany, are rapidly increasing their installed wind energy capacities. In 2023, the global installed wind energy capacity was recorded at 1,017.20 GW. Countries with high installed wind energy capacities include Germany (69.46 GW), India (44.74 GW), and Spain (31.03 GW) (IRENA, 2024).

The direction of future energy consumption is crucial for analyzing economy, energy, and environmental policies. A forecast of future energy consumption helps make decisions about future energy investments. Global energy demand will continue to rise, but traditional energy sources are depleting over time and becoming environmentally hazardous (Bilgen, 2014: 891). Renewable energy production and consumption offer alternative solutions to global energy crises and environmental degradation (Eylasov et al., 2023). However, incentives and discount systems should be established for using renewable energy systems, and various investment supports, such as research funding and support from policymakers and decision-makers in the energy sector, should be provided. Renewable energy sources present an environmentally friendly solution and serve as a significant alternative to traditional energy (Küçükkambak, 2024: 45).

4. Conclusion

Recent energy crises have focused on the unsustainability of fossil fuels used to meet global energy demand and the increasing environmental damage they cause. Additionally, the slow transition to sustainable energy sources and the inadequacy of energy infrastructures are making energy crises more complex. Global energy crises are forcing the transition to more sustainable and secure energy systems. Renewable energy stands out as a solution to energy crises. Although the share of renewable energy in global and national energy supply and demand is relatively small compared to fossil fuels, the depletion of fossil fuels and their environmental damage is increasing the importance and future role of renewable energy sources.

Today, the main cause of environmental issues is the carbon emissions resulting from the intensive use of fossil fuels to meet global energy demand. Carbon emissions lead to environmental problems threatening ecosystems, such as climate change, air pollution, and global warming. Replacing fossil fuels with renewable energy sources helps reduce carbon emissions and mitigate global environmental issues. Furthermore, countries around the world have varying access to energy and energy resources. Some countries have access to energy resources due to their geographical location, while others depend on foreign energy resources. This inequality affects the economic and political balances between countries, leading to energy crises and deeply impacting global energy markets. In this regard, the transition to renewable energy sources can be a solution to reduce countries' dependence on foreign energy.

There are deficiencies in energy systems in the transition from fossil fuels to renewable energy sources. Developed countries can benefit from renewable energy sources by making more

investments in renewable energy systems. In developing countries, the establishment of renewable energy infrastructures is slower due to economic challenges and technological shortcomings. To ensure the widespread use of renewable energy sources in all countries, various strategies and policies involving local, national, and international collaborations are required. Governments should provide incentives to entrepreneurs and private companies for the transition to renewable energy systems. Additionally, technological investments should be made, and long-term energy strategies should be developed for the widespread use of renewable energy systems.

In conclusion, effective policies against global energy crises are vital to ensure the security of energy supply and promote environmental sustainability. To this end, investments in renewable energy sources should be increased, energy efficiency measures should be strengthened and dependence on fossil fuels should be reduced. In addition, diversification of energy supply chains, strengthening international cooperation, and the use of innovative technologies to reduce carbon emissions should be encouraged. Smart grids and energy storage solutions can create a more resilient structure against crises by enabling more efficient management of energy supply and demand. Furthermore, social support programs for low-income households and consumer awareness campaigns can mitigate the impacts of global energy crises by ensuring a just transition.

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