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# HİDROJEN TEMELLİ ENERJİ VE TÜRKİYE

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## HYDROGEN-BASED ENERGY AND TURKEY

**ÖZ** *Enerji, keşfedildiğinden bu yana bir değişim ve dönüşüm içerisindedir. Yaşanılan dönüşüm ile birlikte yenilenebilir enerjiye yönelimin arttığı görülmekte, hidrojen enerjisi ise ön plana çıkmaktadır. Türkiye'nin mevcut enerji hedeflerinin en büyüğü olan enerjide merkez ülke olma ideali doğrultusunda hidrojen enerjisi potansiyel bir alternatif olarak düşünülmektedir. Bu düşünce ışığında makale, Türkiye hidrojen temelli enerjide merkez ülke olabilir mi sorusunun cevabını aramaktadır. Araştırma sorusunun cevaplanması adına Türkiye'nin mevcut durumu değerlendirilmiş, hidrojen enerjisinin dünyadaki ve Türkiye'deki mevcut ve potansiyel kullanım alanları incelenmiştir. Türkiye'nin mevcut avantajları göz önüne alındığında pil/batarya teknolojileri potansiyel kullanım alanları içerisinde en göze çarpan alan olarak belirlenmiştir. Makale kapsamında ABD, Rusya ve Çin'deki hidrojen politikaları incelenerek karşılaştırmalı bir analiz sunulmaya çalışılmıştır. Elde edilen bulgular doğrultusunda Türkiye'nin enerjide bağımsızlık hedeflerine ulaşması doğrultusunda hidrojen enerjisinin yüksek potansiyel vaat ettiği görülmüştür.*

***Anahtar Kelimeler: Enerji Politikaları, Enerji Güvenliği, Hidrojen Enerjisi, Pil/Batarya Teknolojileri, Türkiye***

**ABSTRACT** Energy *has been in a state of change and transformation since it was discovered. With the transformation experienced, it is seen that the tendency towards renewable energy has increased, and hydrogen energy has come to the fore. Hydrogen energy is considered as a potential alternative in line with Turkey's ideal of being a central country in energy, which is the largest of its current energy targets. In the light of this thought, the article seeks the answer to the question of whether Turkey can be a central country in hydrogen-based energy. In order to answer the research question, the current situation of Turkey has been evaluated and the current and potential uses of hydrogen energy in the world and in Turkey have been examined. Considering the existing advantages of Turkey, cell battery/ battery technologies have been identified as the most prominent area among the potential areas of use. Within the scope of the article, hydrogen policies in the USA, Russia and China were examined and a comparative analysis was tried to be presented. According to the findings obtained, it has been seen that hydrogen energy promises high potential in order for Turkey to achieve its energy independence goals.*

***Keywords: Cell Battery/Battery Technologies, Energy Policies, Energy Security, Hydrogen Energy, Turkey***

## INTRODUCTION

The concept of energy is defined in the literature as the ability to do work, and it can be found in various forms (ITU, 2007, p. 1). The spread of the concept of energy to daily life, which was first used in Ancient Greece, corresponds to the 18th century. The invention of electricity in this century and the transformative effects of the Industrial Revolution have brought a new dimension to the view on energy use and energy resources (Karagol et al., 2016, p. 9). Thus, the foundations of today's investments in the energy field have been established.

While energy resources are divided into two as renewable and non-renewable resources according to their use, they can be classified as primary and secondary resources according to their convertibility (Kaya et al., 2018, p. 220). Primary energy sources are listed as coal, oil, natural gas, solar, wind, hydraulic, nuclear, biomass and wave energy. The energy resources obtained from primary energy resources that are changed by exposure to external interventions are called secondary energy resources (Koc et al., 2018, p. 88), and these sources are divided into renewable (wind, hydraulic, solar, hydrogen, biomass, geothermal, wave) and non-renewable sources (coal, natural gas, oil) (U.S. Energy Information Administration, 2021).

The concept of energy, which has become increasingly important and grasped in the historical process, is in a position that policy makers cannot ignore today. Almost every country in the world has a policy on energy. The main issues of these policies, which are directly related to issues such as development levels, production levels and future targets of countries, are as follows,

- Ensuring the security of energy supply
- Diversify resources
- Competition conditions prevail
- To be able to offer the highest quality and lowest cost energy to the use of consumers (Kaya I. S., 2012, p. 271).

The direct and indirect relations established by countries with energy resources are among the most important factors determining their energy appearance, consumption practices and policies. However, the global Covid-19 pandemic that occurred in 2019 has led to the recent bankruptcy of these consumption practices and international energy policies. Similar to the 2008 crisis, oil prices have plummeted during the pandemic. Thus, for the first time in history, the price of American West Texas type crude oil saw negative levels in futures (TSKB, 2020, p. 26). In addition, the World Energy Outlook report published in October 2020 stated that the biggest energy demand decline after the Great Depression and World War II is expected (IEA, 2020, p. 30). In the data announced later, it was seen that the decrease was 4% (IEA, 2021, p. 6).

The pandemic has opened the door to a new energy economy opportunity, in addition to the damage it has caused to the energy sector in the areas of production and consumption. As a result of the increasing interest in renewable energy sources during the pandemic period, signals have been given for the transition to an energy understanding based on electricity density, clean and efficiency (IEA, 2021, p. 15). During this period, the share of renewable energy in electricity generation reached an all-time high of 38% (Jones, 2022). As a matter of fact, in addition to the fact that fossil fuels used in the production of renewable energy

sources are not clean sources today, despite the advances in the fields of renewable energy and electric mobility, there is an increase in the demands of developing countries for fossil fuels especially with the effect of the economic recovery in the post-pandemic period (IEA, 2021, p. 2). It is seen that this transformation, which is trying to gain momentum with the pandemic, does not take place in a linear line. Despite the breakthroughs of renewable energy or other alternative energy sources in the sector, it is thought that fossil fuels will be used as the main energy sources in the near future.

Dependence on fossil fuels is directly related to national interests as well as production practices or energy independence. How the relationship with these resources will be shaped is still unclear, despite increasing sustainability and environmental pressure. As a matter of fact, in the period from 1971 to 2018, although the share of fossil fuels in the world energy supply decreased by only 6 points (81.2% in 2018), the share of oil decreased from 44.1%. The decline to 31.5% and the jump from 16.2% to 22.8% in natural gas, on the other hand, shows that fossil resource use has also undergone a transformation in terms of ecological destruction (Inat, 2021, pp. 16-17).

In order to reduce carbon emissions, the carbon neutral targets that countries have committed to achieve in 2050 also mark a transformation in the future of the energy sector. However, when we look at the current state of these policies, it is seen that they are quite far from the stated goal. The distance between the 2030 emission targets and the 2050 emission targets set by the countries before reaching the 2030 targets supports this argument (IEA, 2021, s. 17).

According to the 2020 Energy Outlook report prepared by BP, three different scenarios (Fast – Net 0 – Current Situation) have been created for the analysis of the world's 2018 emission levels and 2050 targets. Of these, for “the Fast Scenario”, it is expected that carbon emissions will decrease by 70% by 2050 compared to 2018 levels. According to “the Net Zero Emission Scenario”, this ratio has been estimated as 95%. In “the Current Situation Scenario”, this ratio is only It is thought that it will be 10% (BP, 2020, p. 13).

In the article, energy trends in the world were examined and new energy sources were analysed. While analysing, the reports of institutions that have an important place in this field in the world were examined. Turkey's energy outlook and energy policies were also examined, and a relationship was tried to be established considering the impact of new energy trends on Turkey's energy policies and their contribution to the success of the policies. A conclusion was reached by evaluating the policies followed on a global scale together with the published reports and the policies followed by Turkey in order to reach its goal.

## RELATIONS OF ENERGY WITH OTHER AREAS

It is essential to explain the relationship of energy with other fields, which is a basic necessity for survival and a critical factor affecting economic development and employment. These areas can be listed as environment, sustainable development, politics, society, technology and security. As is known, the environment is defined as our basic living space in the simplest sense. Energy use applications constitute a system in which the environment is also included. In this regard, the sustainability of the environment and energy correlates with the sustainability of the system created. Climate change, deforestation and agriculture in the general sense and more ecological catastrophe threatening the future of conventional energy sources and, at the same time increase the need for more efficient energy sources for sustainable development (Azam, 2014, p. 432). At this point, conventional energy sources are usually replaced by renewable energy sources. As a matter of fact, sustainable and renewable energy sources such as wind,

solar, hydraulic, geothermal, hydrogen, bioenergy and wave energy, which are claimed to reduce carbon emissions, come to the fore in order to reduce the damage caused by the use of energy resources to the environment and living things.

Energy has a very important place in the path of economic growth and sustainable development. However, given the relationship between energy consumption and growth, there is no consensus yet on whether economic growth can lead to energy consumption or whether energy consumption can be the determining force of economic growth. "According to authors such as Dunkerley (1982), Ebohon (1996) and Templet (1999), the main source of economic growth depends on energy consumption, but authors such as Yu and Choi (1985) also defend the idea that energy plays a minimal or neutral role in economic growth (as cited in: Ceker & as cited in: Seker, 2012, p. 86)".

Today, energy has become the basic building block in almost every sector and field. With its relationship with the economy, its ability to create jobs, its impact on the environment, security and its interaction with many other areas, energy also plays a decisive role in the decision-making process for policy makers (Daggett, 2019, pp. 193-194). The supply-demand phenomenon comes at the beginning of energy policies, which constitutes the basic elements of security and sustainability areas.

In addition to the relations of energy with ecology, economics and politics, its relationship with society also comes to the fore. Society is both active and passive in its relationship with the environment. The effects of the energy production practices used by the society as a subject on the environment also indirectly affect the society as an object. As a result of these simultaneous interactions, a dialectical relationship arises between society and the environment. To put it more clearly, society remains in a paradox.

Digital technologies developed until today; It helps to improve energy systems and production processes, to increase technological developments and recovery of traditional fossil resources, to reduce costs and to maximize safety. Cybersecurity, data privacy, and digital technological advances capable of breaking down barriers between various demand and supply sectors and potentially leading to greater transformative effects are also accelerating the development of the sustainable and renewable energy sector.

The International Energy Agency defines energy security as “the continuous availability of uninterrupted affordable energy resources” (Hatipoglu, 2019). The most important examples of energy security are the oil crises in the 1970s (Ertas, 2014). When energy security is considered from a political perspective, a complex interdependence emerges. To put it more clearly, countries that are economically dependent on foreign energy are under the influence of this dependence in their political decision-making processes. Accordingly, it is clearly seen that energy-dependent countries are not effective in their foreign policies, that some energy-exporting countries use energy as a foreign policy tool, and this situation threatens the national sovereignty of energy-dependent countries (Milina, 2013, pp. 75-97).

## HYDROGEN BASED ENERGY

The simplest and most common form of hydrogen on earth consists of a proton and an electron (TSKB, 2021, p. 1). Hydrogen, the first element in the periodic table and atomic number 1, is not found in free form in nature, but is mostly found in molecular forms such as water or organic compounds. More than 90% of the visible matter on Earth consists of hydrogen (Aslan, 2006, p. 84). Hydrogen, which can act as a fuel and energy carrier, is abundant in nature. In addition, the storage of hydrogen, which can be produced

with a zero-emission target, can be done in different ways. This energy source, which can be transported over long distances with minimum loss, is an important energy source that has higher lower and higher thermal values compared to traditional fossil fuels and does not harm the environment in any way when produced from renewable energy sources (Dincer et al., 2021(a), p. 5).

In terms of production sources and forms, it is possible to classify hydrogen energy with different colors such as green, blue, yellow, turquoise, gray, red, purple, black and brown (Scita et al., 2020, p. 4). Green hydrogen is a completely sustainable and renewable energy, which is produced by electrolysis of water and separation of hydrogen atoms from oxygen atoms (IRENA, 2020, p. 9). Since only steam and water are produced as waste as a result of decomposition during production, it creates nearly zero greenhouse gas emissions. Blue hydrogen, whose production is based on natural gas, has low greenhouse gas emissions, and these gases are caught immediately before they reach the atmosphere and stored underground (Rokke, 2021). Yellow hydrogen obtained through thermochemical processes using electrolysis or nuclear energy represents an emerging alternative to steam-methane reformation (Scita et al., 2020, p. 4). The hydrogen obtained by thermal cracking of methane (methane pyrolysis) becomes turquoise hydrogen. In the process of obtaining turquoise hydrogen, solid carbon is produced instead of carbon dioxide (CO2). In addition, for carbon neutrality, there are prerequisites for generating the heat of the high-temperature reactor from renewable or carbon neutral energy sources and permanently binding the carbon (Gribova & Giese, 2021, p. 108). Today, turquoise hydrogen still has not completed its pilot phase (IRENA, 2020, p. 9). Gray hydrogen is produced with fossil hydrocarbons and steam structuring of natural gas. Depending on the raw material used, its production can result in significant carbon emissions (Gribova & Giese, 2021, p. 108). Another source of energy, red hydrogen, is produced by high temperature catalytic splitting of electrolysis water powered by nuclear energy as an energy source. Purple hydrogen is produced using nuclear power and heat through the chemothermal electrolysis splitting of water together (EEB, 2021, p. 4). Black or brown hydrogen is formed using coal material. Black and brown colors represent bituminous (black) and lignite (brown) coal types. Gasification of coal is highly damaging to the environment, as high levels of carbon dioxide and carbon monoxide are produced as by-products (Jensen et al., 2021, p. 3). However, it is one of the most common methods used to produce hydrogen.

## HYDROGEN USAGE AREAS AND SECTORS

The hydrogen energy sector, which is emphasized by the IEA that governments should lead the energy transformation, and on which the World Energy Council has published policy recommendations (World Energy Council Turkey, 2021), will be a sector that is expected to increase further. As mentioned in the article, hydrogen can be produced in different ways and has many types and wide usage areas. The main features that make hydrogen stand out compared to other energies are that it can be stored and easily transported. It is seen that hydrogen can be stored both in pure form as gas or liquid in tanks and physically in carbon materials or chemically in the form of various hydrides (TTGV Ideaport, 2022, pp. 18-20). The methods used for the storage of hydrogen can be divided into six classes: underground storage, liquid storage, gas storage (storage by compaction), metal hydrides, chemical hydrides, carbon materials and glass spheres (TTGV Ideaport, 2022, p. 20). Today, the most common hydrogen storage method is the storage method in pressurized tanks in the form of compressed gas (Ozdemir & Mutlubas, 2019, p. 29), which is emphasized as the most commercially important method (Dincer et al., 2021(b), p. 37). Two methods, cheap and expensive, can be used to store hydrogen in gaseous form. While natural gas and oil

can be stored cheaply in caves, mineral deposits that are not used more costly can be used as hydrogen storage (Dincer et al., 2021(b), p. 38). The transportation of the produced and stored hydrogen is another important issue, at this point, we come across the types of transportation by pipelines and transportation by tankers (Tutar & Eren, 2015, p. 9). In the report prepared by the IEA, it was explained that the fact that hydrogen is a low-density gas would increase the cost in long-distance transportation, but it was also emphasized that the cheapest method related to this would vary according to geography, distance, scale and the required end use of hydrogen (IEA, 2019, p. 70). Hydrogen, which can be produced, stored and transferred, can be used in two ways (as fuel and in batteries). Hydrogen, which can be used as fuel in vehicles, can also be used by mixing it into natural gas networks in certain proportions. In addition to increasing the efficiency of hydrogen used by mixing into natural gas networks, it is not yet fully decarbonized and is seen as an intermediate process in transition to decarbonization (Saygın et al., 2021, p. 33). As a matter of fact, this situation is important when considering the trend towards sustainable energy in the world. In addition, combi boilers operating with hydrogen are also produced by some companies, creating an alternative fuel source for individual use.[1]

Hydrogen batteries, which take their place in the growing battery sector, show how important hydrogen is in energy. Batteries appear as systems that store electrical energy by converting it and that can return the stored energy as electrical energy when it needs to be used, and systems created by connecting batteries to each other are called batteries (Dincer & Ezan, 2020, pp. 63-68). It is clearly seen that the use of batteries, which are energy carriers, is increasing day by day and its place among the researches in the literature is increasing. The batteries generally used in the world are lithium-ion batteries and are among the secondary battery types. In the technical article on battery technologies published by the Union of Chambers of Turkish Engineers and Architects, Chamber of Metallurgical Engineers, lithium-ion batteries were compared with other secondary batteries (silver-zinc, nickel-zinc, nickel-hydrogen), and a report was published comparing the advantages and disadvantages (Polat & Keles, 2012, p. 42). In another study, when comparing lithium-ion batteries and nickel metal hydride-based batteries using hydrogen, it was emphasized that hydrogen-containing batteries are more environmentally friendly, more tolerant and more reliable (Kucukdeveci, 2018, p. 454). In addition, hydrogen energy offers an alternative with many advantages for batteries, and this advantage has an important place in the developing battery sector. Today, studies on the use of alternative materials for batteries are also continuing. Boron, on the other hand, which has been studied on the use of both lithium-ion batteries and hydrogen-based batteries in battery production, stands out in this regard (BOREN, n.d.). At this point, studies in the literature focus on the use of (Atmaca & Sevim, 2007, pp. 29-30) borohydride and borohydride in hydrogen batteries. As a result, while the battery sector continues to grow in the light of the above information, the importance of hydrogen batteries, which strengthens its place in the sector, is increasing day by day.

The increasing development of hydrogen batteries positively affects the use of hydrogen energy. Today, it is seen that hydrogen energy is increasingly used in areas such as housing, transportation and defense industry, especially in industry. Hydrogen energy is not yet at a major point in the world energy scale. As a matter of fact, both the efficient storage and transportation of hydrogen and the fact that it is an actor that can fulfill the emission commitments of countries for 2050 constitute the general reasons for the investments made in the future of hydrogen energy. In researches on the potential use of hydrogen energy,

[1] There are combi boilers using hydrogen energy. For detailed information, see https://lotusisitma.com/shop/

it is seen that only 4% of the world's energy consumption is met by hydrogen energy in 2019, and it is estimated that this rate will increase to the band of 18-22% in 2050 (TTGV Ideaport, 2022, p. 30). In addition, it has been clearly observed that the global hydrogen demand has grown by around (IEA, 2021, p. 43) 50% since the beginning of the millennium and reached 90 million tons (Mt) in 2020. As of 2021, it is known to exceed 100 (TTGV Ideaport, 2022, p. 5) Mt. In addition to its increasing role in meeting the global energy demand, the use of hydrogen energy is also supported at sectoral dimensions. The concrete response of this support is clearly seen in the national hydrogen projects realized until (Hydrogen Council, McKinsey & Company, 2021, p. 6) January 2021 and the number of them reached 228. The planned projects are progressing in a similar direction with the current use and incentives of hydrogen energy. Today, the industrial sector dominates the hydrogen demand and the transportation sector is the sector that receives the most incentives (IEA, 2019, p. 89). The fact that 90 of the 228 national projects planned in this regard focuses on industry, and 53 on the transportation sector reveals the quality of investments made in hydrogen energy (Hydrogen Council, McKinsey & Company, 2021, p. 6).

The industrial sector's demand for hydrogen is led by oil refineries. In addition to refineries, chemical use (ammonia and methanol production) and iron and steel production are among the industrial sectors that use hydrogen. The hydrogen usage demands of these areas can be listed as follows (IEA, 2019, p. 89).

- Oil refinery (33%)
- Ammonia production (27%)
- Methanol production (11%)
- Steel production by direct reduction of iron ore (3%)

Hydrogenation of vegetable oils, iron reduction processes in steel production, ammonia (fertilizer, medicine, paint making), automotive, fuel, electronics and building materials areas can be shown as examples of the usage areas of hydrogen energy in the industrial sector (Oral, 2020, pp. 1140-1141).

One of the areas with high potential for the future of hydrogen energy is the transportation sector. The role of hydrogen in transportation is paralleled by the reduction of carbon ratios. Today, 95% of global hydrogen production is provided by fossil fuels, which are rich in carbon emissions. However, hydrogen has the potential to be produced by electrolysis without negative environmental consequences and to replace fossil fuels in transportation (Hydrogen Europe, Revolve, 2021, p. 24). However, this transformation is dependent on developments in battery technology. In particular, it is expected that developments in FCEV (Fuel Cell Electric Vehicular) technology will be one of the main factors determining the role of hydrogen energy in the field of transportation. In addition to FCEV technology, BEV (Battery Electric Vehicle) is also known as a clean energy alternative that is often used today (IRENA, 2018, p.15). According to the data of June 2021, it was seen that more than 40.000 FCEV technology cars were actively used. However, this situation, which is a positive development for the hydrogen economy, has remained well below the use of electric cars, the number of which is about 11 million (IEA, 2021, p. 6). As another indicator of the increasing use of hydrogen in transportation, hydrogen supply stations, which have increased linearly since 2014 and the number of which is 685 in 2021, are also appearing (H2Stations, 2022). The activities of hydrogen energy in the field of transportation are mostly focused on land transport and passenger cars, but in addition to this, it is also used for transportation methods other than cars (truck, truck, bus, etc.) and the

railway (train, tram), sea (ships, ferries, roll-on/roll-off ships) or traditional methods, such as studies on airway transportation (IEA, 2021, pp. 71-72).

In addition to the industry and transportation sectors, hydrogen energy is also used in the residential sector, albeit at a minimal level. Today, there are four potential methods of using hydrogen in buildings: mixing, methane produced from clean hydrogen, the use of 100% hydrogen and fuel cells, and cogeneration (Saygın et al., 2021, p. 33). Realizing the potential of hydrogen use in buildings and transitioning to low carbon hydrogen use does not seem possible in the short term, but sectoral communication and interaction should be increased in order for this transformation to take place (IEA, 2019, p. 150). Hydrogen energy has a promising potential for countries to fulfill their emission reduction commitments and ensure their energy security. This potential of hydrogen energy has made it an increasing investment area and an energy source on which policy is established.

## HYDROGEN POLICIES OF ENERGY DEVELOPED COUNTRIES

Today, most of the developed or developing countries have a hydrogen strategy and policy. According to 2021 data, 17 governments have published hydrogen strategies, while more than 20 countries are working on publicly disclosed strategies (IEA, 2021, p. 5). Within the scope of the article, the hydrogen policies of the USA, Russia and China will be taken as a basis. The reason for choosing these three countries is their policies and potentials in production or consumption in the field of energy today.

According to the hydrogen program published by the US Department of Energy (DOE) in 2020, the ministry's goal in hydrogen energy is to research, develop, verify technologies related to hydrogen and fuel cells, as well as eliminate corporate or market barriers and ensure the adoption of hydrogen applications in industries. In October, Dec is also funding R&D studies that will provide the basis for the near, medium and long-term production, distribution, storage and use of hydrogen obtained from various energy sources. (U.S. Department of Energy, 2020, pp. 8-14). It is possible to divide the US hydrogen policy into three sheet pillars. These can be listed as strengthening the US's energy leadership position, reducing the cost of clean energy resources and reducing emissions. Jul. June Jul 2021, the United States has created the initiative “Hydrogen Energy Earthshot”, the first of which was published in this regard, and through this initiative aims to reduce the cost of clean energy produced from hydrogen by 80% (U.S. Department of Energy, 2021). On the other hand, according to the world energy problem graph presented by the World Energy Council in its 2022 report, hydrogen energy is emerging as a critical issue for the United States, increasing the level of uncertainty in 2022 compared to 2021 (World Energy Council, 2022, p. 25).

Russia is trying to embody its hydrogen energy policies in the light of three different reports, the first of which was published in June 2020. These reports are listed in chronological order as “Energy Strategy until 2035”, “Hydrogen Development Roadmap until 2024” and “Concept for the Development of Hydrogen Energy in Russia” (Barlow, 2021). Russia aims to obtain hydrogen from nuclear energy and renewable sources, but natural gas is expected to be the largest factor in hydrogen production due to Russia's large gas reserves (Griffin & Dmitrieva, 2022). According to Russia's hydrogen strategy, the main sectors are industry, power and export sectors, and the secondary sectors are the construction and transportation sectors (Albrecht et al., 2020, p. 13). Today, the industrial use of hydrogen in Russia and their competence in the field of energy both scientifically and financially (production, distribution tools, etc.) coincide with their desire to become one of the leading hydrogen energy producers and exporters in the world, which

they set as their target (Barlow, 2021). In this regard, in the reports we have listed above, the export targets have been determined as 0.2 million tons in 2024 and 2 million tons in 2035 (Albrecht et al., 2020, p. 119). In its projection for 2050, it aims to increase its exports to the range of 15-50 million tons (Lynn, 2022).

Today, China is the world's largest producer and consumer of hydrogen. Despite its enormous size in hydrogen production, the Chinese government has just released its long-term hydrogen plans on March 22, 2022, called “the 14th Five-Year Plan for the Modern Energy System" and the "Medium- and Long-Term Plan for the Development of the Hydrogen Energy Industry (2021-2035)" published on 23 March 2022 (Koty, 2022). These plans are mainly related to decarbonization policies and energy supply security, and are in line with the hydrogen strategies that the Chinese government has previously implemented. According to the “International Hydrogen Strategies Report” published in 2020, reducing carbon emissions, diversifying energy supply and accelerating economic growth have been adopted as the main goals of China's hydrogen strategy (Albrecht et al., 2020, p. 9). In order to achieve these goals, the transportation and energy sectors have been brought to the forefront. In addition to the increasing number of FCEV-based cars and hydrogen refueling stations in China, the fleet target of 50,000 hydrogen-fueled vehicles set for October 2025 indicates that this policy is being implemented (Nakano, 2022). In the field of energy production, the Chinese government plans to produce 100,000-200,000 Mt of green hydrogen annually from renewable sources by 2025, as well as switch to the use of a 124 MW (Megawatt) electrolyzer to produce hydrogen in China in 2021 (Lin, 2022). Finally, the Chinese state has stated that it will support the logistics infrastructure, set quality and safety standards, promote the use of green hydrogen, and support refueling stations with a daily hydrogen distribution capacity of more than 1,000 kilograms in the published plan (Lin, 2022).

## TURKEY ON THE PATH TO BE THE HUB COUNTRY IN ENERGY

The current and increasing importance of energy on a global scale has become both a political and an economic issue for countries. So much so that a parallel connection can be established between energy consumption and development (Yurdakul, 2018, p. 67). In this direction, as a developing country, Turkey is a country where energy demand and supply increase every year. Turkey , which is located both on important energy transfer routes and in a region adjacent to approximately (TRTHABER, 2022) 60% of the world's proven oil and natural gas reserves , is dependent on foreign sources at a rate of 74% to meet its energy demand (MFA, n.d.). Turkey, which meets its energy demand mainly by using fossil fuels such as oil, natural gas and coal, is adding renewable energy sources to its energy supply day by day.

When we look at Turkey's energy profile, foreign dependency in fossil fuels comes to the fore. According to the latest data, foreign dependency in oil is 93.9%, and (Kavaz, 2021, p. 42) the search for new domestic resources continues (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, n.d.). Foreign dependency is also high in natural gas, the production of which is (Kavaz, 2021, p. 47) 1% of its consumption. In coal, another fossil fuel, both production and consumption are increasing (Kavaz, 2021, pp. 50-54). Therefore, Turkey's foreign dependency continues. Renewable energy, on the other hand, stands out as a growing energy sector for Turkey. In Turkey, which has a high geographically renewable energy potential, renewable energy installed power is increasing every year. According to January 2022 data, 54% of the total installed power consists of renewable resources (MFA, n.d.). Especially solar energy and geothermal energy are used from renewable sources. In addition to these resources, Turkey continues to invest in nuclear energy. Having basic minerals used in nuclear energy, Turkey ranks first in the world, especially in thorium reserves (Eroglu

& Sahiner, 2017, p. 22). However, Turkey does not yet produce and trade uranium and thorium, and concentrates on nuclear power plant projects. To put it more clearly, the construction of the Akkuyu Nuclear Power Plant is continuing, while the works for the Sinop Nuclear Power Plant are continuing. With the establishment of nuclear power plants, these mines, especially uranium, are expected to come to the fore. Although thorium has the potential to be used in nuclear energy, it is not used yet, but studies on the use of thorium in nuclear energy continue throughout the world. Boron stands out as another important mineral reserve. Boron mine is used in many fields such as security equipment and space exploration, as well as taking its place as a supporting element in the energy sector (Kavaz, 2021, pp. 65-66). Boron in the energy field; energy saving, reduction of carbon emissions, production of solar panels, support of lithium batteries and realization of energy transfer with minimum loss (ETIMADEN, 2019). As a matter of fact, boron has an important potential in terms of zero carbon policies in energy and energy transfer with batteries.

Transition to renewable energy is an important issue both within the scope of Turkey's compliance with environmental policies within the scope of the European Union membership process and its dependence on foreign energy. In this context, Turkey's Automobile Initiative Group/Türkiye'nin Otomobili Girişim Grubu (TOGG) branded automobile, whose electric vehicle is based on lithium-ion batteries, is an important initiative, especially in Turkey. Lithium-ion battery-based TOGG automobiles are produced in the factory established in Gemlik, Bursa, and TOGG, which is progressing within the plans, will be ready for mass production in the last quarter of this year. In this context, lithium battery factories were established with initiatives, especially ASPILSAN, and charging supply stations were started to be established. Currently, there are approximately 3,500 charging unit sockets in Turkey. The number of charging sockets is targeted to reach 12,500 in 2023, 30,000 in 2025, and 160,000 in 2030 (Aras, 2022). Today, it carries out serious investments and R&D studies related to the production of fuel cell vehicles.

In addition to the advantages of using the boron mine in the field of hydrogen, the potential to obtain hydrogen from hydrogen sulfide, which is found in high amounts in the deep waters of the Black Sea, creates an advantageous situation for Turkey.

"Hydrogen sulfide was formed as a result of excessive pollution in the Black Sea deep waters. The deep waters of the Black Sea, where hydrogen sulfide (H2S) is found, are very poor in terms of oxygen. Since there is no oxygen in the parts where hydrogen sulfide is present, there are no living creatures in these parts. The most important feature to be mentioned for hydrogen sulfide is that hydrogen sulfide contains a high level of toxic and has a heavy odor. To reduce the environmental damage of hydrogen sulfide, this substance must be broken down into its components. The components resulting from the decomposition are sulfur and hydrogen in gaseous form" (Ozturk et al., 2005, p. 267).

Considering Turkey's current high foreign dependency, it is clear that it has developed important strategies to ensure energy supply security and reduce this dependency. Turkey's energy policies have focused on being a central country in energy diplomacy, especially in energy. With this policy, diversification of resources and routes is the main strategic goal to ensure energy supply security. In addition, contributing to regional and global energy security and being a regional trade center are among these goals (MFA, n.d.). In this context, the Ministry of Energy and Natural Resources introduced the "National Energy and Mining Policy" to the public in 2017. This policy has been established on three main pillars as (Kavaz, 2021, p. 67) localization, energy supply security and a predictable energy market. With these pillars, it is aimed both to

reduce foreign dependency and to have a decisive role in prices as a regional energy center. In order to reduce foreign dependency through localization, studies are carried out to extract new fossil resource reserves and it is planned to increase the number of installed renewable energy resources day by day. In addition, the installation of nuclear power plants is continuing, and international negotiations are continuing for new power plants.

There is a harmony between the long-standing energy policies and the current situation in Turkey. It is seen that the installed capacity is tried to be increased in order to meet the increasing energy demand. As a matter of fact, Turkey is rich in renewable energy potential and continues to increase its existing power. Studies in this area are important in terms of self-sufficiency policy, which is one of Turkey's main energy targets. The issue of energy storage should not be ignored. The fact that Turkey is not rich in fossil resources does not make it possible to be a price determinant in resources such as oil, natural gas and coal, although production is increasing. Turkey, which has an important role in the transfer processes of fossil resources due to its geographical location, has the potential to be a transfer center in this field. However, the fact that it does not have enough resources to become the center poses a major obstacle. In the light of this information, Turkey needs new energy resources in addition to its existing resources in order to become a central country in energy. At this point, three main objectives that EU countries have determined for themselves as energy policy come to the fore. These objectives are mainly based on competition, safety and more choice and cheaper price (EU Presidency, 2022). The main objectives of the EU's energy policy, in which sustainability also plays an important role, are important determinants of Turkey's goal of becoming a center in energy. Here, two main energy sources emerge that can be applied both for EU policies and regional policies, which have a high share in world politics, and for Turkey's national goals. One of them is the nuclear energy source, whose current investments continue. Nuclear energy is a great source of energy for the region where it is established. After some nuclear accidents in the world, although some countries have decided to close their installed nuclear power plants due to the abstention from nuclear energy, nuclear energy is a resource that is used on a high scale in developed countries and has an important place in providing energy supply. In addition to the risks involved, nuclear energy is seen as the key to sustainable development in the long term due to the capacity to produce large amounts of energy uninterruptedly from a low amount of primary sources. As a matter of fact, in addition to the use of nuclear energy in the field of electricity generation, the use of nuclear energy in many areas such as military, medicine, industry and agriculture reveals its direct relationship with development. In addition to these, unlike fossil fuels, the fact that it is an energy source that does not emit greenhouse gases and does not pollute the environment in this regard contributes to the use of nuclear energy by considering the risk of accidents, waste and terrorism (Harunogulları, 2019, s. 132,133). Turkey also develops policies regarding the use of this resource and uses advanced security systems in the power plants it has established in accordance with the standards set by the International Atomic Energy Agency (MFA, n.d.). The second energy source that Turkey can use is hydrogen energy. Hydrogen energy, in line with the European Green Consensus, was adopted as the “Hydrogen Strategy” in 2020 (EU Presidency, 2022). This situation has increased the interest in hydrogen energy and has led to the intensification of studies in this direction. In the light of the above information, it is thought that Turkey will strengthen its hand. Considering that in addition to the important role of hydrogen in carbon policies, its use in energy transfers and its high energy storage potential (Saygın et al., 2021), it is clear that pioneering investments in the field of hydrogen energy have an important place in Turkey's energy strategy. In addition, the opportunities for Turkey to use green

hydrogen energy, which is a clean energy type, were investigated (Saygın et al., 2021, p. 29) and it was announced that there is a high potential for the use of hydrogen energy in the manufacturing, transportation and housing sectors (Saygın et al., 2021).

In conclusion, considering the scarcity of fossil fuels in Turkey and the increase in the use of renewable energy all over the world, nuclear energy and hydrogen energy come to the fore for Turkey both in its target of being the center of energy and in its energy independence target. In addition to nuclear energy, the hydrogen energy sector's current tendency to grow, the initiation of initiatives in the near future and the ability to store hydrogen provide an advantage for Turkey.

## DISCUSSION

In the historical process, which started with the use of oil as an energy source and continued with the inclusion of different energy sources in the system by transforming over time, energy has become an indispensable element for countries with technological developments and it has been seen that countries have established some relations for energy supply. Considering the effects of energy on the economies of countries and its indispensability, its place in international relations and diplomacy is clearly understood. For this reason, the energy policies of the countries and the diplomatic relations they have established in the field of energy are of great importance. As emphasized in the text, both the diplomatic relations and commercial agreements Turkey has developed with countries due to its dependence on foreign energy are important factors for Turkey's position and situation in the world. Considering the policies developed by Turkey to reduce foreign dependency in energy, diversify resources and become an energy center, it is inevitable that studies in the field of energy diplomacy will increase. It is seen that Turkey also acts in this direction and shapes its policies. Thanks to the investments to be made in hydrogen energy, Turkey might be one of the leading countries in energy in the world and even strengthen its place in the international arena with the multiple relations it will establish. What stands out at this point is Turkey's geopolitical position as a natural bridge (Kocaslan, 2014, p. 741). Even in the current situation, Turkey's development in the field of hydrogen energy, which has relations with many countries on wide energy platforms, especially energy transfer with hydrogen batteries, will increase its relations around the world.

It is thought that hydrogen sulfide (H2S) and boron mines, which are of great importance for hydrogen energy and are abundant in Turkey, will provide an advantage to Turkey at this point. At the same time, the TOGG brand electric vehicle, which is currently being invested in and which is domestically produced in Turkey, stands out. It is also seen that investments are made in battery factories for TOGG in Turkey in this field. As explained in the article, the use of hydrogen in batteries as well as the use of boron in hydrogen energy supply and instead of lithium in batteries are important considerations for battery-powered cars. It is aimed that Turkey will take a leading position in the international arena in this regard. It seems possible that the energy power that will increase with the active use of hydrogen energy will positively affect not only international relations but also domestic politics. In today's conditions, where energy is indispensable, it is an undeniable fact that the uninterrupted and sustainable energy supply of states to their people will strengthen the central authority. Uninterrupted access of energy, especially to rural and urban areas, will not only increase the quality of life, but also increase the loyalty of the people to the state and increase the rate of fulfilling their responsibilities such as taxes. Ensuring resource diversity through the use of hydrogen energy and storing energy through batteries strengthens the goals of being both the central country and the price determinant in energy. Another possible contribution that Turkey can make with hydrogen energy

is that green hydrogen production with renewable energy is in line with the "zero carbon" policies in the world and therefore strengthens relations with international and supranational organizations. For this reason, it is foreseen that hydrogen will make great contributions to domestic and foreign policies and shape diplomacy positively.

## CONCLUSION

Research shows that developing technology and energy supply security lead to the search for alternative energy. The greenhouse gases caused by fossil fuels causing global warming and climate change have increased the use of renewable energy. Today, almost energy consumption indices and development indices follow each other in parallel. Considering all these issues, the potential of hydrogen energy in renewable energy to be a zero-harmful energy source for the environment and society reveals the importance of hydrogen energy.

It is thought that the next stage of the transformation from traditional energy sources to renewable energy sources will be hydrogen energy. To put it more clearly, it is thought that the 21st century will be an era in which the " carbon age " will end and the transition to the " hydrogen age " will be experienced, but Turkey needs to make investments in the following areas in order to be a pioneer in the field of hydrogen and to achieve its goal of becoming a central country in energy, which is one of its main strategies. which they are,

- Production
- Distribution
- Storage
- Usage
- Training human resources (Dincer et al., 2021(b), pp. 5, 66-68)

Investments to be made especially in the fields of education and human resources increase the potential of Turkey to be in an advantageous position in hydrogen energy. It is envisaged that qualified experts to be trained in the field of hydrogen energy and batteries will represent Turkey in the international arena.

Based on the findings presented in this study and expanding it, it is thought that carrying out studies on the potential of Turkey in the field of hydrogen energy, especially in the battery sector, may yield important results.

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