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Towards a Greener Türkiye: Renewable Energy Perspectives and Future Directions

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Abstract

Many countries today rely heavily on fossil fuels such as coal and petroleum for electricity generation, and this dependence continues to grow as energy demands increase. However, transitioning to renewable energy sources like solar and wind is essential to mitigating the effects of climate change. This paper focuses on Türkiye, a country that remains dependent on fossil fuels but has been making significant strides in renewable energy development. Türkiye's renewable energy sector has become a key pillar in its pursuit of energy security and sustainable growth. This review examines the current state of renewable energy utilization in Türkiye, analyzing the key drivers, policies, and challenges shaping the sector. Considerable progress has been made in harnessing solar, wind, hydropower, and geothermal energy, helping to meet the country's rising energy demands while reducing fossil fuel dependence. However, challenges such as financial constraints, grid integration issues, and policy inconsistencies persist. Additionally, a survey conducted among Turkish high school students assessed their awareness of renewable energy. The results indicated that gender has no significant impact on their responses or their interest in pursuing careers in the renewable energy sector. By addressing these aspects, this paper provides a comprehensive overview of Türkiye's renewable energy landscape, offering insights into innovative technologies, policy recommendations, and strategic approaches to overcoming barriers. Ultimately, it highlights Türkiye's potential role in advancing global energy and climate goals.

Keywords: Renewable energy; sustainability; energy policy; energy transition.

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1. Introduction

As Ban Ki-moon, former secretary-general of the United Nations, points out, “Climate change is the defining challenge of our age” [1]. One of the major contributors of this phenomenon is greenhouse gas emissions, especially carbon dioxide (CO_2). Carbon levels in the atmosphere have increased dramatically over the years due to anthropogenic emissions. If no actions toward reaching carbon-neutral goals are made, CO_2 concentrations will climb up to the numbers seen between “Eocene and 2 million years ago”, which took natural processes 40 million years to lower, in slightly over 100 years [2]. In order to overcome the effects of greenhouse gases, many environmental agreements have been made. Kyoto Protocol, Paris Agreement and Sustainable Development Goals (SDG) are examples of such actions. Kyoto Protocol was adopted in 11 December 1997, and stated that “industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States” make sure their greenhouse gas emissions do not surpass their assigned amounts [3]. Also, those parties should be “reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012” [3]. The Paris Agreement was established in December 2015 and aimed at three main things: limiting the temperature increase at 1.5℃ since pre-industrial times, finding a way to limit emissions that doesn’t put food production into risk, and “making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development” [4]. Lastly, sustainable development goals (SDGs) that were proposed in 2015 aims to reach 17 goals encompassing “peace and prosperity for people and the planet” [5], [6]. Of those, goal 13 specifically addresses combating climate change. However, according to the 2024 report global temperatures rose 1.45℃, which is close to the lower boundary of 1.5, and the carbon dioxide concentration in the air is 150% above pre-industrial levels, emphasizing the urgency to take action [7].

Fossil fuels are undoubtedly the largest contributor to global climate change. They account for more than 75% of global greenhouse gas emissions and close to 90% of all carbon dioxide emissions [8], [9]. Therefore, continuing to use fossil fuels will exacerbate the current situation the world is facing. One of the ways of reducing carbon emissions is using renewable energy sources. Renewable energy is based on sources, ranging from sun to biomass, that will continue to exist, unlike fossil fuels. In addition, they either emit no CO_2 or very little compared to fossil fuels [10]. As a result, renewable energy sources stood out as an important solution to carbon emissions.

In this context, it was aimed to focus on utilization of renewable energy sources to overcome the effects of greenhouse gasses, especially in Türkiye by overviewing the current situation and its potential for utilizing the renewable energy sources and highlight the innovative solutions in this review.

2. Current Situation in Turkey

Compared to 2022, annual gross electricity consumption in 2023 increased to 335.2 terawatt-hour (TWh), a 1.2% increase. At the same time, electricity generation reached 331.1 TWh, a 0.8% increase compared to the previous year [11]. In 2023, allocation of the electricity generation sources was as follows: coal 36.2%, natural gas 21.0%, hydropower 19.3%, wind 10.3%, solar 6.7%, geothermal 3.4%, and other sources 3.2% [11]. When 2022 and 2023 are compared, coal sourced electricity production increased by 4% in 2023, reaching a very high level of 118 TWh [12]. This makes Türkiye the second largest coal-fired power generating country in Europe. Moreover, Türkiye is very close to taking the first place from Germany with an electricity generation from coal of 121 TWh. Due to that, it is possible that Türkiye can be the leader in Europe by 2025.

By the end of October 2024, total installed capacity reached 114,215.1 MW, annual electric energy generation reached 289.4 TWh, annual electricity energy consumption reached 289.4 TWh, total electricity export was 2.6 TWh, and total electricity import was 2.6 TWh [13]. For the first 6 months of 2024, electricity consumption by sector was 40.5% industry, 25.8% small businesses, 28.3% household, 3.3% agriculture, and 2.2% lighting [14]. As of the end of September 2024, the distribution of installed capacity by resources was 28.2% hydraulic, 21.6% natural gas, 19.2% coal, 10.8% wind, 16.4% solar, 1.5% geothermal, and 2.4% other sources [11].

3. Current Situation of Renewable Energy Usage in Turkey

As of 2025, Türkiye has been actively pursuing the expansion of renewable energy to reduce its dependence on imported fossil fuels and to address environmental concerns. The country's strategic initiatives and policy reforms have led to significant developments in renewable energy sectors, particularly in solar and wind power. A pivotal study by Mukhtarov, Yüksel, and Dinçer (2022) analyzed the relationship between financial development and renewable energy consumption in Türkiye from 1980 to 2019. Utilizing the Vector Error Correction Model (VECM) and Autoregressive Distributed Lag (ARDL) techniques, the study found that financial development has a positive and statistically significant impact on renewable energy consumption. Specifically, a 1% increase in financial development corresponds to a 0.21% rise in renewable energy consumption. This indicates that as Türkiye's financial sector grows, it facilitates greater investment and consumption in renewable energy projects [15]. Çeçen and his colleagues (2022) conducted an in-depth analysis of distributed photovoltaic power generation (DPPG) in Türkiye, highlighting both the potential and challenges associated with its integration into the national energy mix. The study emphasizes that while Türkiye possesses significant solar energy potential, the growth of DPPG is hindered by regulatory barriers, technical limitations, and financial constraints. The authors advocate for comprehensive policy reforms and incentives to promote the adoption of DPPG, which could play a crucial role in decentralizing energy production and enhancing energy security [16]. Türkiye has set ambitious targets to further increase its renewable energy capacity. The government aims to quadruple its wind and solar energy capacity to 120,000 MW by 2035, requiring an estimated $108 billion in investments from both public and private sectors. Efforts are underway to streamline the permitting process, reducing it from four to two years, and to encourage private sector participation through regulatory reforms and incentives. Telli, Erat, and Demir (2021) provide a comparative analysis of the energy transitions of Türkiye and Germany. Both countries are heavily reliant on fossil fuel imports, with Türkiye importing 93.2% of its oil and 99.2% of its natural gas, while Germany imports 99% of its oil and 96% of its natural gas. Germany has set more aggressive renewable energy targets, aiming for 65% renewable energy in its energy mix by 2030 and at least 80% by 2050. In contrast, Türkiye's targets are more modest, focusing on reducing foreign dependency and increasing the share of renewables in its energy mix through policies like "More Domestic, More Renewable."[17, 18] Türkiye's commitment to expanding renewable energy is evident in its strategic policies and investment plans. The positive correlation between financial development and renewable energy consumption highlights the critical role of the financial sector in achieving these energy goals. By fostering a conducive financial environment and implementing supportive regulations, Türkiye can continue to enhance its renewable energy capacity, contributing to energy security and environmental sustainability

3.1. Wind energy

Wind energy has become one of the fastest-growing renewable energy sectors in Türkiye, contributing significantly to the country's efforts to diversify its energy mix and reduce reliance on fossil fuels [19], [20]. The combination of favorable geographical conditions, supportive policies, and market incentives has enabled rapid expansion of wind power capacity in recent years. According to the comprehensive assessment provided by [21], Türkiye's wind energy sector has shown remarkable growth, reaching an installed capacity exceeding 11 GW by 2024. This growth is driven by the government's targeted incentive mechanisms, including feed-in tariffs (FITs), renewable energy auctions, and tax exemptions, which have created a favorable investment environment. The Renewable Energy Resource Areas (YEKA) program has also been instrumental in accelerating the development of large-scale wind projects by providing transparent tendering and support frameworks. Despite this progress, challenges remain, such as grid integration issues, regional disparities in wind resource distribution, and the need for improved forecasting technologies. Nonetheless, the Turkish wind energy market is poised for further expansion, supported by national energy plans aiming to increase wind capacity to 20 GW by 2030.

3.2. Geothermal Energy

In Türkiye, there are 2000 natural geothermal sites with varying temperatures spread over the country [22]. Türkiye's whole geothermal potential is estimated to be roughly 38,000 MW, with approximately 4,500 MW suitable for power production and the remainder for direct use applications such as heating. Türkiye has only used roughly 2–4% of its geothermal potential, according to contemporary estimations. There is about 992 MWt of installed capacity for direct usage and 20.4 MWe for power production. District heating, greenhouse heating, industrial operations, and thermal tourism all make substantial use of geothermal energy. Geothermal energy provides heating for over 61,000 homes and 565,000 square meters of greenhouses. Greenhouse gas emissions can be considerably decreased by using geothermal energy. For example, 48 million tons of CO_2 might be avoided each year if the geothermal heating capacity is fully utilized. But if not properly handled, Türkiye's highly mineralized geothermal waters could cause environmental problems like soil and water poisoning [23, 24, 25, 26].

3.3. Solar energy

Türkiye is geographically placed between 36° and 42° north latitudes; therefore, it gets more radiation compared to the USA, China, and many European countries, and, as a result, solar energy generation per meter square is high compared to many countries [27]. Kalyon Karapınar Solar Power Plant in Konya is Europe's largest and one of the top five power plants in the world; The power plant is worth $1 billion, has 3.2 million solar panels, and can power 3 million kilowatt hours (kWh) of electricity per year [28]. In 2023, the first three regions with licensed solar plants with the most total capacity were Central Anatolia (1,352 MW), Mediterranean Region (136 MW), and East Anatolia (121 MW) [14]. In February 2025, total installed capacity for solar power plants was 20,378 MW and compared to the previous month, both unlicensed solar installed power and licensed solar installed power increased, reaching 18,371 MW and 2,008 MW respectively [29].

3.4. Hydraulic energy

Of the 114,215 MW installed capacity at the end of September 2024, 28.2% of it was hydraulic. Also, hydraulic energy generation plants with a number of 765, including unlicensed ones, was 2.42% of all energy generation plants. From February 2024 to March 2024, there had been an increase of 14.8 MW installed capacity increase. When February and March 2024 figures are compared, the contribution of hydraulic plants in electricity generation decreased from 28.1% to 24% [11].

Renewable energy sources, which encompassed 37.7% of the total electricity generation in September 2024, tapped 38.3% in October 2024. Specifically, in that period, dam type hydroelectric power plants allocated 12.4% and river type hydraulic power plants allocated 3.0% of total electricity generation [30]. Atatürk Dam and Hydraulic Power Plant, Türkiye's one of the biggest hydraulic power plants, has got total installed capacity of 2400 MW, and since its inauguration in 1992, it has produced 210 billion kilowatt-hour (kWh) electric energy, contributing 500 billion TL to Türkiye's economy by just electric energy generation [31], [32]. Moreover, Türkiye placed in first place in Europe in terms of new capacity installation by installing 399 MW of new hydraulic power plants in 2023 [33].

3.5. Biomass energy

There are different ways for producing energy from biomass, and these methods fall into three main categories: biochemical, thermochemical, physiochemical [34], [35]. Some examples of biomass energy are biogas (a natural gas alternative made by the fermentation of microorganisms in airless atmosphere), biodiesel (a diesel alternative made by esterification of oily seeds or plant/animal sourced waste oils), and bioethanol (a gasoline alternative made by fermentation of organic material consisting of carbohydrate) [34, 36, 37, 38, 39]. Biomass energy plays an increasingly vital role in Turkey's renewable energy portfolio, offering a sustainable alternative to conventional fossil fuels while contributing to waste management solutions. Turkey possesses significant biomass potential, largely derived from agricultural residues, forest by-products, and organic waste. The country's diverse agricultural sector produces a wide variety of feedstocks, including crop residues like wheat straw, corn stalks, and sunflower husks, as well as animal manure. Additionally, Turkey has been focusing on energy recovery from municipal solid waste (MSW) and wastewater sludge, aligning with its goals for circular economy practices. The total biomass potential is estimated to exceed 8 million tons of oil equivalent (TOE) annually, providing an untapped opportunity for energy generation (Table 1). Despite its potential, biomass energy utilization in Türkiye faces several challenges, including technological limitations, lack of awareness, and insufficient incentives for large-scale projects. In recent years, however, the government has implemented supportive policies, such as feed-in tariffs under the Renewable Energy Support Mechanism (YEKDEM), to encourage investments in biomass energy projects [40]. Several biogas and biomass power plants have been established across the country, primarily in regions with high agricultural output. Moreover, the integration of biomass energy into Türkiye's overall energy strategy aligns with its commitments to reduce greenhouse gas emissions and promote sustainable development. By addressing policy and infrastructure gaps, Türkiye can fully exploit its biomass energy potential, creating a pathway toward enhanced energy security and environmental sustainability [41]. There were 386 biomass power plants and 2,109 MW installed capacity in October 2024 [29]. There are biomass power plants all over Türkiye; however, most of them are in Central Anatolia, Marmara Region, and Aegean Region. Furthermore, the biomass power plants with the highest installed capacity are located in the Marmara Region, and the reason for them to accumulate there is the high population density [42]. Bioethanol can be mixed with petroleum and can be categorized from E5 (5% ethanol and 95% gasoline).

Table 1: Waste Potential of Türkiye [43]

Type of Waste	Amount of Waste (tons/year)	Theoretical Energy Equivalent of Waste (TEP/year)	Economical Energy Equivalent of Waste (TEP/year)
Animal	193,878,079	4,385,371	1,084,506
Plant	62,206,754	25,384,268	1,462,159
Municipality Waste	32,170,975	3,373,011	485,858

3.6. Legal Regulations

Türkiye plans to increase its GHG emissions until 2038 and announced 2053 as its net-zero target date [44] . The CCPI country experts emphasize that the main shortcoming of the policy to reduce GHG emissions is that it is calculated within a business-as-usual scenario (BAU) and therefore does not aim to reduce net greenhouse gas (GHG) emissions [44] Türkiye updated its Nationally Determined Contribution (NDC) in April 2023, but the experts indicate it is not in line with the country's net-zero vision and the Paris Agreement's 1.5℃ target [45]. Legislation and policies regarding biofuel use in Türkiye are shaped within the framework of renewable energy targets and environmental sustainability. There are some main legislation and policies regarding biofuels such as the Energy Market Regulatory Authority (EMRA) Regulations which consist of Petroleum Market Licensing Regulation and Fuel Quality Regulation. The first regulation includes provisions on the blending of biofuels with petroleum products and the licensing of biofuel production facilities [46]. Biofuel producers must obtain a license and comply with certain technical and administrative requirements. As for the Fuel Quality Regulation, this regulation sets technical standards and quality criteria for blending biofuels with fossil fuels. It ensures that biofuels meet environmental and performance standards [47]. Another legislation is Renewable Energy Law (YEK) coded 5346, aims to promote the use of renewable energy sources, including bioenergy, in electricity generation. This law provides incentives and support mechanisms for energy production from biomass [48], [49].

4. Future prospects of the world

4.1. Jellyfish

It is important to substitute fossil fuel-based energy sources with renewable ones; however, what is also as important is “unused energy recovery”. There is motion in every part of nature, and motion means energy. Therefore, discovering ways to convert all the energy around us is a crucial step to satisfying the ever-increasing energy demand of humanity. One of those energies is mechanical vibration energy, which is omnipresent and easy to produce “like river flowing, vehicle motion, subway shaking, and mechanical oscillations” [50]. Among those, sea wave energy is a candidate for renewable energy as sea waves have an energy density that is 1000 times that of air flow [51]. This section focuses on two approaches that use principles of biomimicry to mimic jellyfish to take advantage of the energy availability of the sea waves. There have been attempts to convert vibration energy to electrical energy; however, “traditional linear vibration energy harvesters are constrained by their effective operational range, which is confined to the vicinity of resonance, significantly limiting the extraction of high output power” [52]. This means that even the slightest change in the wave frequency and amplitude will result in considerable inefficiency in electricity production. To address this limitation, a low-barrier nonlinear oscillator has been proposed. “Jellyfish move in the ocean by compressing and contracting the internal cavity of the umbrella through dense muscle nerves. During the movement, the umbrella can be abstracted as an oscillator. The muscles of the umbrella can be simplified into springs and links. Since bridges experience multifaceted and low-frequency vibrations, it is proposed that this model can be used to supply energy for self-powered bridge sensors used for monitoring [53]. Another method is the utilization of piezoelectric polymers to convert wave energy to electric energy. Piezoelectricity is “the generation of electrical polarization in a material in response to a mechanical stress” [54]. This model was inspired by the fact that jellyfish’s tentacles vibrate when waves pass through. The simulations showed that as the tentacle gets longer and the wave amplitude increases, the voltage increases. It is found out that “each tentacle can generate 0.01 ~ 0.03 volts; if there are 330 tentacles on a jellyfish generator, it can supply up to about 5 volts on average,” and the energy produced from this source could be used to provide electricity to on-sea fish farms, some ocean monitor devices [50].

4.2. Hydrogen

Hydrogen is an element that can be found widely in nature from cellulose in plants to hydrogen in water. While it is abundant in nature, it also has lots of benefits if used as an energy source. For example, it has a high energy density by mass, can help make economy-wide decarbonization in transportation and industrial sectors, and is a clean energy carrier [55]. There are many different methods for producing hydrogen: “steam methane reforming, electrolysis, biomass gasification, photoelectrochemical water splitting, and thermochemical water splitting” [56]. Of those, steam reforming and electrolysis are the most common [57]. While electrolysis has advantages due to factors like integration with fuel cells and zero carbon emissions, it has drawbacks due to factors such as low system efficiencies and high capital costs; for the steam reforming, it has developed technology and avoids the costly upgrading of the bio-oil but produces carbon co-products [55]. Other than energy issues, there are problems related to waste. To mitigate the wastes and produce energy, different methods for hydrogen production are used. Lee and his colleagues valorized waste tea bags via pyrolysis with CO_2 [58].

They found out that non-biomass part of the waste contained (96.5 wt.%), an indicator that it is suitable for hydrogen production. Also, CO_2 increased hydrogen yield and higher temperatures yielded more non-condensable gas. Another study tried to address the waste due to the coffee industry and focused on hydrogen production from coffee mucilage combined with other organic wastes with dark fermentation method [59]. They had many trials, and they found out that conditions of 30°C, pH 7.0, chemical oxygen demand 60 g O_2/L in the presence of 20% (w/w) organic waste resulted in an optimum of 25.9 L hydrogen yield and considered it to be a potential source for practical hydrogen fermentation with the requirement of further research. Lastly, it is expected that in 2050 Türkiye has the potential to export up to 1.9 metric ton (Mt) of hydrogen, proving hydrogen to be not only beneficial for the environment but also for the economy [60].

4.3. Artificial photosynthesis

Natural photosynthesis is a process in which green plants, certain bacteria, such as cyanobacteria and heliobacteria, and algae turn carbon dioxide and water, by using light energy that comes mostly from the sun, into energy in the form of glucose and oxygen. Artificial photosynthesis is the process that aims to mimic natural photosynthesis to convert sunlight into energy forms that can be stored, like hydrogen, to create eco-friendly energy sources. Photochemical cells are important parts of artificial photosynthesis systems because they perform the direct conversion of solar energy into chemical energy [61]. They contain light-absorbing material, catalysts, and redox mediators that expedite the process of converting absorbed photons into chemical reactions with examples like water splitting and carbon dioxide reduction [61]. When the artificial and natural photosynthesis are to be compared, natural photosynthesis is comparably more efficient due billions of years of evolution: 3-6% conversion efficiency of sunlight into storable chemical energy [62]. On the other hand, artificial photosynthesis is not close to reaching similar efficiency rates. Moreover, it is much more costly [61]. However, while natural photosynthesis produces glucose as an energy source, artificial photosynthesis can produce energy-dense fuels. Artificial photosynthesis’s ability to generate energy-dense fuels is of paramount importance, even though it still has to be developed to get closer to nature’s efficiency rates [62].

Enzymes are biological catalysts that have specific active sites with accurately arranged metal centers, amino acids, and cofactors. More than one-third of all known enzymes are classified as metalloenzymes, a prevalent group of enzymes that include structurally and/or functionally significant metal ions for bioactivity, structural, signaling, or other purposes [63]. A complex arrangement of metal ions coordinated to amino acid (AA) side chains and prosthetic groups, as well as a secondary coordination sphere of extra proximal AA side chains and cofactors (such as pigments, NAD(P)H, and ATP), are what give metalloenzymes their reactivity and selectivity [63]. Crucially, cofactors supply electrons, hydride equivalents, and other species to support reactive pathways, while the secondary coordination sphere uses non-covalent contacts to maintain transition states and reactive intermediates. There have been many artificial systems proposed including metal and metal oxide nanoparticles and metal-organic frameworks (MOFs) in order to imitate enzymes. However, they mostly mimic enzymes’ active metal centers without secondary coordination or additional cofactors [61]. Therefore, artificial enzyme systems are restricted to catalyzing relatively rudimentary reactions and lack the systematic tunability to widen their range. One study done by Lan and his colleagues to improve the efficiency of artificial photosynthesis included the addition of amino acids. They suggested a metal–organic framework-based artificial enzyme (metal–organic–zyme, MOZ) with specific arrangement of metal centers, amino acids and pigments on one MOF monolayer to produce well-defined and complex active sites. They designed two libraries of MOZs to perform photocatalytic CO_2 reduction and water oxidation reactions. By tuning the incorporated amino acids in the MOZs, they methodically optimize the activity and selectivity of these libraries. Merging these optimized MOZs into a single system achieves complete artificial photosynthesis in the reaction of $(1 + n) CO_2 + 2H_2O \rightarrow CH_4 + nCO + (2 + n/2)O_2$. As a result, with the help of the amino acids, increased methane production will not only help with the increasing energy demands of humanity but also the principle of the system can be applied to other complex chemical reactions [64].

5. Turkish Teens' Awareness Towards Renewable Energy

Recent studies emphasize the pivotal role of youth in driving climate action, highlighting how effective communication and early engagement shape environmental consciousness. According to Karacaoğlu and Akbaba, accessible and targeted messaging significantly influences young people's understanding of complex environmental issues like renewable energy. Also, the potential of teens to act as catalysts for change when empowered with knowledge and platforms for expression is significant. In Turkey, raising awareness among teenagers about renewable energy can thus be instrumental, not only in fostering environmentally responsible behaviors but also in building a generation capable of influencing broader societal transitions towards sustainability [65], [66]. A survey has been conducted on 112 Turkish high school students to learn about students' awareness towards renewable energy (Table 2). For the statistic to better represent Türkiye, the survey was conducted on students from multiple different cities and different backgrounds. 20 Likert survey questions were asked related to the awareness of the teens towards renewable energy and the students gave a response from 1 (highly disagree) to 5 (highly agree). The questions and the percentage of the given answer is as follows:

Table 2: Questions and the Statistics of the Answer by Gender [67]

Questions	Female Mean	Female Standard Deviation	Male Mean	Male Standard Deviation
1) They always involve energy sources whose availability is unlimited	2.83	1.18	2.83	1.18
2) The renewable energy means energy that does not increase pollution and that does not deplete resources	2.29	1.36	2.29	1.36
3) Solar energy is only applied in warm regions	3.79	1.19	3.79	1.19
4) The technology of renewable energy does not work unless it reaches sources of energy	2.71	1.14	2.71	1.14
5) Turkey is a rich country about renewable energy sources	2.58	1.14	2.58	1.14
6) The renewable energy is always cheaper than	3.36	1.22	3.36	1.22

nonsustainable energy sources				
7) Solar energy is too expensive and is not technologically ready to mass use	3.31	1.15	3.31	1.15
8) When the renewable energy is used, it never produces environmental pollution	3.23	1.14	3.23	1.14
9) Turkey uses renewable energy sources to meet its necessity for energy	2.89	1.18	2.89	1.18
10) Renewable energy sources will replace non-renewable energy sources in the future	2.36	1.22	2.36	1.22
11) Solar energy panels are not actually environmentally friendly because energy consumed during manufacturing is larger than energy generated	3.26	0.98	3.26	0.98
12) Turkey uses technologies of renewable energy effectively	3.5	0.99	3.5	0.99
13) After installing solar energy panels, you will still need fossil fuel as a back-up energy source in cloudy and rainy days	3.01	1.01	3.01	1.01
14) Turkey is at the top of Europe rankings with respect to solar energy sources	3.17	1.13	3.17	1.13
15) Turkey should give great importance on renewable energy technologies and use	2.42	1.51	2.42	1.51
16) When only solar energy is used at home, our life quality can decrease due to necessity of huge power for modern instruments	3.02	1.19	3.02	1.19
17) I believe that I have enough information on renewable energy	2.83	1.02	2.83	1.02
18) I think that there are no adequate courses about renewable energy	2.23	1.24	2.23	1.24
19) I think that there should be more courses about renewable energy in our curriculum	2.41	1.31	2.41	1.31
20) I want to work on renewable energy field in the future	3.38	1.31	3.38	1.31

In all the tests, a significance level of α=0.05 is used. This is a simple random sample because all the individuals in the population had an equal chance of being included. The distributions seem to be approximately normally distributed. Variance in each group can be assumed to be same and the subjects were independent of each other. Therefore, the conditions has been met for the tests.

A Two-Tailed T-Test was conducted to see weather the mean of the responses to the questions differ by gender.

H_0: $\mu_d=0$

H_a: $\mu_d\neq0$

-t-value=-0.07
-p-value = 0.944

Because the p-value is 0.944>0.05, we fail to reject the null hypothesis. There isn't statistically significant difference to assume that there is a difference in the answers given to the questions due to gender.

Regarding the question "I want to work on renewable energy field in the future", Chi-Square Test for Independence was used to determine whether there is an association between gender and inclination to work in renewable energy field.

H_0= There is no association between gender and inclination to work in the renewable energy field.

H_a= There is an association between gender and inclination to work in the renewable energy field.

The contingency table for the data is as follows:

Table 3: The contingency table for the data

Gender	**Answers**					**Total**
	1	2	3	4	5	
Male	5	4	8	10	9	36
Expected	3.86	5.79	8.04	9.32	9	
Female	7	14	17	19	19	76
Expected	8.14	12.21	16.96	19.68	19	
Total	12	18	25	29	28	112

Degrees of Freedom= (#rows-1)(#columns-1)=(2-1)(5-1)=4

$$\chi^2=\sum\frac{(Observed-Expected)^2}{Expected}$$

Sample calculations for female with answer 5:

Expected value=$\frac{(row\ total)(column\ total)}{total\ people\ surveyed}$

$=\frac{(76)(28)}{112}$

Expected value=19

$\chi^2 = \frac{(19-19)^2}{19} = 0$

Therefore, $\chi^2 \approx 1.384$, $p \approx 0.847$, and df=4.

Since, $p \approx 0.847 > 0.05$, we fail to reject the null hypothesis. Therefore, there isn't statistically significant evidence to reject that there is no association between gender and inclination to work in the renewable energy field for the teenagers going to high school in Türkiye.

6. Conclusion

This review demonstrated that even though Türkiye still has shortcomings, there have been noticeable improvements with its renewable energy utilization. As it was mentioned, Türkiye is in a very important geographical area that provides lots of potential for the renewable energy that is based on natural energy sources like sun, wind, and geothermal sites. Therefore, integrating more installed capacity for the natural sources that Türkiye has in abundance will be crucial to meet 2053 net zero goals and increase the utilization of renewable energy sources. However, there are still more steps to be taken with the current legislations and technological infrastructure to make sustainable energy sources, like biomass, to be ubiquitous. The paper explains three recent energy production methods (jellyfish, hydrogen, artificial photosynthesis) to showcase that there are different alternative energy production methods available that might support or even take over the traditional energy sources to assist Türkiye in its journey to become a sustainable country. Lastly, a survey of 20 questions was conducted on a sample of 112 high school students from Türkiye to get an understanding of the Turkish teens' awareness towards renewable energy. It was found through Two-Tailed T-Test that gender does not affect the teens answer. Moreover, Chi-Squares Test for Independence showed that gender does not affect students' desire to work in the renewable energy field.

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