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Renewable energy during Covid-19 pandemic in Turkey

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Abstract
Global renewable energy power including solar, wind, biomass, hydropower, and geothermal are increasing very fastly. With respect to global environmental issues, Turkey's carbon dioxide emissions have grown along with its energy consumption. States have played a leading role in protecting the environment by reducing emissions of greenhouse gases. In this regard, renewable energy resources appear to be the one of the most efficient and effective solutions for sustainable energy development in Turkey. Turkey's geographical location has several advantages for extensive use of most of these clean energy sources. Electricity demand of the country has experienced great fluctuations due to the measures taken to prevent the Covid-19 pandemic. The effect of the measures taken in this context to slow down the economic activity was also seen in electricity demand as of the end of the year. Turkey has been one of the countries that was least affected by the pandemic with an increase of 0.8% in electricity demand. Structural arrangements that we have made in recent years to encourage the use of renewable energy sources instead of imported sources in electricity production continued to show their results despite the developments experienced during and as a result of the Covid-19 pandemic in the markets. In this context, the share of renewable energy sources was 55.4% in total electricity installed power in 2020, increased to 53% in 2021. This study shows that there is enough renewable energy potential in Turkey for electricity generation. Especially hydropower, biomass, solar and wind are very well.

Keywords: Energy issues, renewable energy, sustainable development, Turkey.

1. Introduction

Energy is essential to economic and social development and improved quality of life in all countries [1]. Much of the world's energy, however, is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to increase substantially [2]. The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution and consumption in the country [3]. Electricity supply infrastructures in many developing countries are being rapidly expanded as policymakers and investors around the world increasingly recognize electricity's pivotal role in improving living standards and sustaining economic growth [4].

There is a growing concern that sustainable development may be compromised unless measures are taken to achieve balance between economic and environmental outcomes. Since the early 1980s, Turkish energy policy has concentrated on market liberalization in an effort to stimulate investment in response to increasing internal energy demand. The governments have continued this policy despite lower energy demand induced by the 2001 economic crisis. This paper provides an overview of the renewable energy utilization for climate change mitigation and energy sustainability in Turkey.

2. Energy consumption in Turkey

Turkey is an energy importing country; more than half of the energy requirement has been supplied by imports [5]. Oil, coal and gas have the biggest share in total primary energy consumption [6]. Turkey, with its young population and growing energy demand per person, its fast-growing urbanization, and its economic development, has been one of the fast growing power markets of the world for the last two decades [7]. It is expected that the demand for electric energy in Turkey will be 573 billion kWh by the year 2020 and 760 billion kWh by the year 2030 [8]. Turkey's electric energy demand is growing

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about 4-6% yearly due to fast economic growing [9-20].

In 2020, primary energy production and consumption has reached 40 and 153 Mtoe as shown in Table 1 and 2 [4]. The most significant developments in production are observed in hydropower, geothermal, solar energy and coal production. Turkey's use of hydropower, geothermal and solar thermal energy has increased since 1990. However, the total share of renewable energy sources in total final energy consumption (TFEC) has declined, owing to the declining use of non-commercial biomass and the growing role of natural gas in the system (Fig. 1). Figure 2 shows the power generation in Turkey by energy source [1-5].

Along with the economic growth and population increase, significant increases were observed both in primary energy and electricity consumption during the 11th Plan period [6]. Consumption of primary energy reached 153 Mtoe as of the end of 2020 with an annual average increase of 3.2% while electricity consumption reached 286 billion kWh with an annual average increase of 4.8% during this period. These increases are more evident in the period following 2014 [1-9].

Table 1. Total energy production in Turkey (Mtoe)

Energy Sources	**2020**
Hard coal & Lignite	14.8
Oil	3.4
Gas	0.4
Hydropower	6.7
Geothermal	10.6
Wood and Biomass	3.4
Solar/Wind/Other	4.2
Total production	**43.5**

Source. Refs. [1-5]

Table 2. Total energy consumption in Turkey (Mtoe)

Energy Sources	**2020**
Coal and Lignite	40.1
Oil	34.2
Gas	40.1
Hydropower	6.7
Geothermal	10.6
Wood and Biomass	3.4
Solar/Wind/Other	4.2
Total consumption	**140.1**

Source. Refs. [1-5]

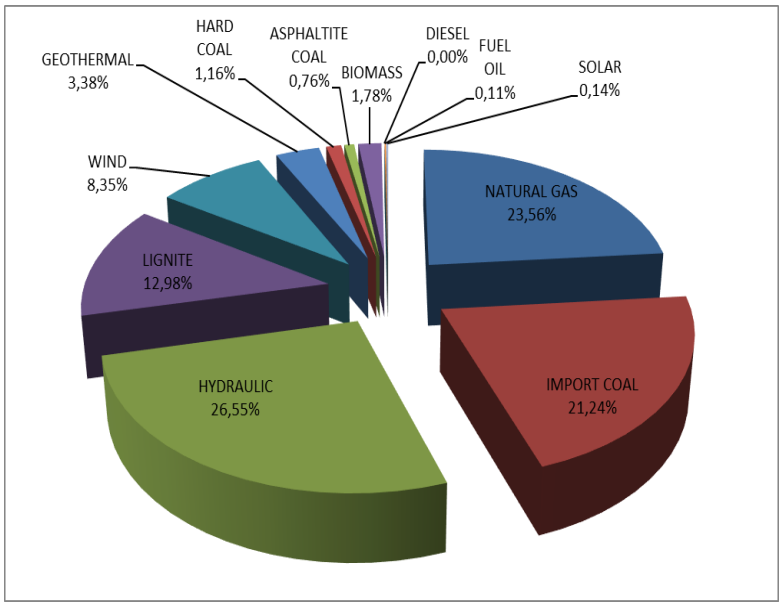

Figure 1. The distribution of licensed Electricity Generation by Sources in 2020 (%) [1]

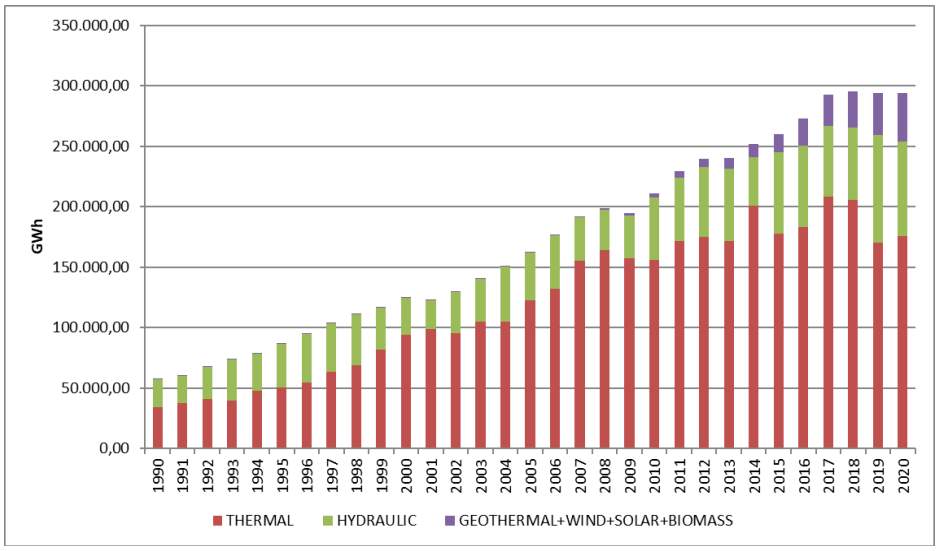

Figure 2. Source-based development of licensed electricity generation by years (GWh) [1]

3. Renewable heat and power in Turkey

In Turkey, the composition of renewable energy supply has changed and wind and solar power is beginning to claim market share. As a contributor of air pollution and deforestation, the share of biomass in the renewable energy share is expected to decrease with the expansion of other renewable energy sources. Table 3 shows renewable energy resources in Turkey. [4].

Total gross hydropower potential and total energy production capacity of Turkey are nearly 70 GW and 142 TWh/yr, respectively and about 30% of the total gross potential may be economically exploitable [1-5]. At present, only about 35 % of the total hydroelectric power potential is in operation [14]. The national development plan aims to harvest all of the hydroelectric potential by 2020 [16]. The contribution of small hydroelectric plants to total electricity generation is estimated as 8-12% [1-5].

Among the renewable energy sources, biomass is important because its share of total energy consumption is still high in Turkey [8-12]. Since 1990, the contribution of the biomass resources in the total energy consumption dropped from 15 to 4 % in 2014 [13-15]. Biomass in the forms of fuelwood and animal wastes is the main fuel for heating and cooking in many urban and rural areas [14]. The total recoverable bioenergy potential is estimated to be about 34 mtoe in 2016 [14]. On the other hand, using

vegetable oils as fuel alternatives has economic, environmental, and energy benefits for Turkey [30]. Animal wastes are mixed with straw to increase the calorific value, and are then dried for use [1-20].

Turkey's total geothermal heating capacity is about 31,500 MW_{th}. At present, heating capacity in the country runs at 1240 MW_{th} equivalent to 150,000 households. These numbers can be heightened some seven-fold to 7,180 MW_{th} equal to 800, 000 households through a proven and exhaustible potential in 2012. Turkey must target 1.2 million house holds equivalent 7,700 MW_{th} in 2020 [3-7].

Total solar energy production of 0.465 Mtoe in 2008 increased to 2.2 Mtoe in 2020 and is projected to rise to 5.5 million toe (Mtoe) by 2030 [14]. Flat plate solar collectors are the most widespread solar thermal application in Turkey, which are generally used for the production of commercial and domestic hot water, especially throughout the coastal regions. In 2020, Turkey had 16 million m^2 of collector surface area installed [20].

In Turkey, electricity is mainly produced by consuming coal, lignite, natural gas, solar, wind, geothermal and hydropower plants [13-15]. The electricity requirement was reported as 280 000 GWh in 2020 [9]. The electric generation accounted for 55 % of the total by coal and gas, while hydropower was 21 % and other renewables were 24% [8-10].

Table 3. Renewable energy resources in Turkey (1000 TOE/year)

	2000	**2010**	**2020**
Total energy demand	77624	101510	133214
Total energy production	26808	27279	36650
Supply by renewables	10149	9604	14426
Biomass and waste	6546	5023	3396
Wood/wood waste	6541	4994	3346
Biogas	5	15	28
Biofuels	0	14	20
Wind energy	3	31	2135
Solar energy	262	420	1784
Hydropower	2655	3083	6716
Geothermal energy	**684**	**1048**	**10576**

Source. Refs. [1-5]

4. Renewable energy resources support mechanism

The YEK Law No. 5346 on the Use of Renewable Energy Resources for Electricity Generation, wind, solar, geothermal, biomass, wave, current and tidal power plants as well as hydropower plants with a canal or river or reservoir area of less than fifteen square kilometers can benefit YEKDEM for ten years. Power plants commissioned the effective date for YEK Law, until December 31, 2020 will be covered by YEKDEM. On the other hand, YEKDEM unit prices are US$73/MWh for hydroelectric and wind power plants, US$ 105/MWh for geothermal power plants and US$133/MWh for biomass and solar power plants [1-7].

It is stated by the Ministry officials that they are working on a support mechanism encompassing new conditions for the power plants to be commissioned after December 31, 2020. It is also stated that this prospective support mechanism will be TL-denominated and priced based on an escalation system but no official statement has been issued yet. In addition, as per the Presidential Resolution published in the Official Gazette on September 18, 2020, the condition for the commissioning of the generation plants eligible for YEKDEM by December 31, 2020 was extended to June 30, 20217. According to the resolution, the price support eligible for the YEK-certified generation plants subject to YEKDEM to be commissioned from January 1, 2021 to June 30, 2021 will apply until December 31, 2030 [7].

Due to the aforementioned feed-in tariffs and the increase in foreign exchange rates, the number of renewable energy power plants that wish to benefit from the USD-based feed-in tariffs under YEKDEM has increased. As specified in the Electricity Outlook Section, the number of power plants to benefit from YEKDEM in 2020 rose to 817, and the total installed capacity increased to 21,860 MW. In addition to

licensed power plants, unlicensed power plants with a total installed capacity of 6,600 MW also benefit from YEKDEM [7].

4.1. YEKDEM developments

Failure to achieve targeted levels for the use of renewable energy resources and high initial investment costs paved the way for incentivizing these resources at a higher level. YEKDEM is a mechanism backed by government guarantee for power plants aiming to generate electricity from renewable energy resources in the early 2000s. Built upon two main laws and various regulations, YEKDEM covers a USD-denominated feed-in-tariff under YEK for the first ten years following the initiation of generation at renewable energy power plants. Furthermore, a domestic equipment incentive applies for the first five years in addition to the feed-in-tariff depending on the quantity and type of the domestic equipment used in the power plant. Expectations regarding the announcement of a new mechanism prevailed in 2020, based on the information that YEKDEM, one of the major factors in the growth of the share of renewables in the electricity mix, would be terminated as of December 31, 2020 [1-7].

Supply chain delays concerning renewable energy-based power plant investments with a high requirement for imported equipment triggered by the Covid-19 pandemic posed the risk of failure to fulfill the conditions of YEKDEM and renewable energy investments lagged behind their respective targets for 2020. In this respect, the sector expected an extension of time of 6-8 months since the pandemic constituted a force majeure. Published in the Official Gazette on September 18, 2020, the Presidential Resolution of September 17, 2020 stipulated that the YEK power plants subject to YEKDEM to be commissioned between January 1 and June 30, 2021 could benefit from the YEKDEM prices listed in Schedule I attached to the Law until December 31, 2030 [1-7].

According to the resolution, the YEK power plants that are commissioned between January 1 and June 30, 2021 and file their applications to EMRA until October 31, 2021 can sell the electricity generated thereby between January 1, 2022 and December 31, 2030 over the YEKDEM prices. In line with the same resolution, equipment support will be added into the price of the electricity sold for five years from the date of commissioning of generation plants in the event that the mechanical and/or electromechanical equipment used in the YEK power plants to be commissioned between January 1 and June 30, 2021 are manufactured within the country. In 2020, 817 licensed power plants with a total installed capacity of 21,050 MW are currently covered by YEKDEM. If it is foreseen that a certain additional installed capacity will be covered by YEKDEM with the extension of time for six months, it is expected that the total installed capacity of YEK power plants that will benefit from YEKDEM after 2021 and 2022 will gradually decrease [1-7].

4.2. Renewable energy resource area (YEKA)

YEKA projects in Turkey support the country's strategy for supply security, domestic and renewable energy resources, but also are of great importance in terms of sustainable energy objectives. Tenders help attract foreign investors. The production of domestic energy equipment and incentives intended for R&D centers are also considered positive in terms of creating added value for the country's economy, reducing the current account deficit and creating employment opportunities [7-9].

On the other hand, the MENR developed YEKA model in 2016 for large-scale investments. The first YEKA tender was organized for Karapınar SPP in 2017, and Kalyon and its South Korean partner Hanwha were awarded with the tender. However, Hanwha decided to withdraw from the joint venture in January 2019 due to financial issues. In October 2019, Kalyon Energy and China Electronics Technology Group Corporation (CETC) closed a deal for a 500-MW solar panel factory, which was commissioned in August 2020. In September 2020, 4 MW of the 1,000-MW SPP was commissioned and the SPP started generating electricity. The first 1,000-MW WPP YEKA tender held in 2017 was awarded to Siemens-Türkerler-Kalyon joint venture over a bid of 3.48 US$-cents/kWh. Siemens Gamesa Renewable Energy company started manufacturing nacelles in the newly-established company at the end of November 2019 [1-9].

It was announced in 2018 that January 2019 would be the deadline for applications regarding Turkey's second largest solar power plant tender. This tender incorporated three separate contests, one for an installed capacity of 500 MW in Viranşehir, Şanlıurfa, one for 200 MW in Erzin, Hatay and one for 300 MW in Bor, Niğde. However, it was

announced in January 2019 that the tender was cancelled. YEKA tenders continued in 2018 as well. On June 21, 2018, a tender for a 1,200-MW offshore wind farm project was announced but this tender was postponed since the tender failed to attract a sufficient demand [7].

YEKA WPP-2 tender was held on May 30, 2019. The tenders covered WPPs with an installed capacity of 250 MW in Balıkesir, Çanakkale, Aydın and Muğla. Enercon and EnerjiSA were each awarded two of these tenders. Enercon's bid of 4.00 USD cents /kWh enabled the company to win the Muğla tender while a bid of 3.53 USD cents /kWh secured the Balıkesir tender. EnerjiSA, on the other hand, was awarded the Aydın tender with a bid of 4.56 USD cents /kWh and the Çanakkale tender with a bid of 3.67 USD cents /kWh. The applications for 74 YEKA tenders, also known as Mini YEKA and targeting a total installed capacity of 1,000 MW, were postponed from October 5-9, 2020 to January 18-21, 2021. In addition, pre-license applications for 2,000-MW wind power plants to be received on October 5-9, 2020 were also postponed [7].

5. Conclusions

The renewable energy sources in Turkey became the only source of energy generation recording a 5% growth during the first quarter of 2021. Reduction in electricity consumption and, accordingly, electricity generation following the measures taken against the Covid-19 pandemic resulted in a decline concerning the generation of electricity based on thermal power plants. The share of renewables in electricity generation was over 60% in April and May. While the share of renewables in total electricity generation stood at 66.1% and 62.2% in April and May, respectively. Upon the introduction of normalization steps, thermal power plants became operational again. Standing at 44.2% in June, the share of renewables in electricity generation was 42.2% and 40.5% in July and August, respectively.

The electricity generation sector was affected the most in terms of pricing by the pandemic process in which many sectors came to a standstill. Although there was a decline in the generation of electricity based on natural gas and coal throughout this period dominated by depressed industrial demand and elevated household demand, the share of renewables within electricity mix increased owing to YEKDEM incentives. The Covid-19 pandemic also directly affects renewable energy investments. Since most of the equipment intended for wind and solar power plants was imported, supply difficulties were experienced in ongoing investments.

Therefore, the period for fulfilling the condition for the commissioning of the generation plants eligible for YEKDEM by December 31, 2020 was extended to June 30, 2021. It is observed that another impact of the Covid-19 pandemic was relevant to pre-license applications based on wind energy. According to the announcement by EMRA on September 17, 2020, the wind-based pre-license applications to be filed between October 5-10, 2020 were postponed until another announcement.

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References

[1] EPDK, Republic of Turkey Energy Market Regulatrory Authorıty. Electricity market sector report 2020. EPDK, Ankara, Turkey, 2020.
[2] IEA, International Energy Agency. Energy Policies of IEA Countries: Turkey 2021 Review, OECD/IEA, Paris, 2021.
[3] International Energy Agency (IEA). Energy Policies of IEA Countries: Turkey 2016 Review, OECD/IEA, Paris, 2016.
[4] Ministry of Energy and Natural Resources (MENR). Energy Statistics in Turkey. available from http://www.enerji.gov.tr (accessed date 06 July 2021).
[5] WECTNC, World Energy Council Turkish National Committee. Energy report of Turkey for 2019. WECTNC, Ankara, Turkey, 2019.
[6] DPT, State Planning Organization. Eleventh Development plan 2019-2023, DPT, Ankara, Turkey, 2018.
[7] TSKB, Türkiye Sinai Kalkınma Bankası. Energy Outlook 2020. TSKB, İstanbul, 2020.

[8] MENR, Ministry of Energy and Natural Resources. National Renewable Energy Strategy December 2014, MENR, Ankara, Turkey, 2014.
[9] TEIAS, Turkish Electricity Transmission Corporation. Electricity production statistics in Turkey, TEIAS, Ankara,, www.teias.gov.tr (accessed date 04.02.2020).
[10] Geothermal energy in Turkey, www.jeotermaldernegi.org.tr (access date 14 Jun 2021).
[11] Coskun Avci, A., Kaygusuz, O., Kaygusuz, K. Geothermal energy for sustainable development. J. of Engineering Research and Applied Science 2020; 9(1): 1414-1426
[12] Güney, MS., Kaygusuz, O. Sustainable energy in Turkey: aspiration and endurance. Journal of Engineering Research and Applied Science 2020; 9(1): 427-1434.
[13] Kaygusuz, K. Clean energy policies for sustainable development in Turkey. Journal of Engineering Research and Applied Science 2012; 1(2): 1-10.
[14] Kaygusuz, K. Hydropower as clean and renewable energy source for electricity generation. Journal of Engineering Research and Applied Science 2016; 5(1): 359-369.
[15] Bilgen, S., Keleş, S., Sarıkaya, I., Kaygusuz, K. A perspective for potential and technology of bioenergy in Turkey: present case and future view. Renewable and Sustainable Energy Reviews 2015; 48: 228-239.
[16] Kaygusuz, K., Güney, M.S., Kaygusuz, O. Renewable energy for rural development in Turkey. Journal of Engineering Research and Applied Science 2018; 7(2): 886-895
[17] Kaygusuz, K. Prospect of concentrating solar power in Turkey: the sustainable future. Renewable and Sustainable Energy Reviews 2011; 15: 808-814.
[18] Kaygusuz, K. Global energy issues, climate chnage and wind power for clean and sustainable energy development. Journal of Engineering Research and Applied
[19] Science 2015; 4(2): 317-327. [19] Alboyaci B, Dursun B. Electricity restructuring in Turkey and the share of wind energy production. Renew Energy 2008; 33: 2499–505.
[20] Cicek BN, Ozturk M, Ozek N. Renewable energy market conditions and barriers in Turkey. Renew Sustain Energy Rev 2009; 13: 1428–36.
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