



Energy utilization and policies in Turkey

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Abstract

Energy is an indispensable element for the survival and development of modern society. From the use of heat in industries to the heating of a house, from feeding a freighter to fueling a motorcycle, from automating an entire production process to lighting an office lamp, energy use is an essential part of our everyday life across different scales and forms of utilizing it. With the development of new technologies, coupled with the exorbitant growth of the world population and the emergence of new needs, one of the great challenges we currently face is the uncertainty of energy availability in the future given its current demand, primarily due to the extensive use of nonrenewable sources and the large-scale exploitation of the planet's natural resources. 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 renewable energy sources. This study shows that there is enough renewable energy potential in Turkey for heat and electricity generation. Especially hydropower, biomass, solar and wind are very well.

Keywords: energy utilization; sustainable development; renewable energy; Turkey

1. Introduction

Energy is an indispensable element for the survival and development of modern society. From the use of heat in industries to the heating of a house, from feeding a freighter to fueling a motorcycle, from automating an entire production process to lighting an office lamp, energy use is an essential part of our everyday life across different scales and forms of utilizing it. With the development of new technologies, coupled with the exorbitant growth of the world population and the emergence of new needs, one of the great challenges we currently face is the uncertainty of energy availability in the future given its current demand, primarily due to the extensive use of nonrenewable sources and the large-scale exploitation of the planet's natural resources [1].

Since the advent of the Industrial Revolution, energy has become intrinsically associated with the economic competitiveness of nations and their quality of life [2, 3]. In this context, economies with greater access to inexpensive energy resources, with low environmental impact, guarantee significant market advantages [4]. Therefore, the search for new renewable energy sources reflects not only the current need for diversifying the world energy matrix, but also the inevitability of developing alternatives that can

reduce the impacts caused by the generation, distribution, and consumption of energy [5]. It is from this perspective that discussions arise regarding technical, economic, environmental, and social feasibility for implementing renewable energy systems [2-5].

Energy in modern society is an essential ingredient for a wealth economy, like the blood circulating in our arteries. Since the beginning of civilization, humans have learned how to use biomass combustion for cooking and heating, the wind force for navigation, and the rivers flow to move mills [2]. With increasing world population, material progress in various parts of the world, and, especially, with the formation of large cities, new sources of energy have become necessary as coal, oil, and gas and more recently nuclear power [1].

In the early twentieth century, electricity production moved to the forefront as it can be converted to work with greater efficiency than coal, oil, and gas [1-3]. In this century, the electrification of the world economy is intensifying significantly, since electricity consumption is increasing about 4–5% per year while the energy consumption as a whole is only growing

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about 2% per year. Hydroelectric, wind, and photovoltaic energy—which are renewable in contrast to electricity produced by fossil fuels—have become a priority [4,5].

In 2017, the world investment in energy production was just over US\$ 1.7 trillion. US\$ 718 billion was invested in the production of electricity and the remainder in the production of oil, gas, coal, and energy efficiency. Of these US\$ 718 billion, US\$ 277 billion was invested in power grids, US\$ 193 billion in electricity generated from fossil fuels, and US\$ 297 billion in renewable energy, which in 2016 were distributed as follows: wind power (39%), photovoltaics (28%), hydroelectric (26%), and nuclear (7%) [1-5].

The usage of renewable energy resources shows a promising prospect in Turkey in the future as an alternative to the conventional energy. In the past decade, wind energy has become a valuable and dependable source of electricity worldwide. There is a promising potential in Turkey for both wind and solar

energy. In Turkey, several research institutions have initiated research at various stages on the applications of solar energy. The estimated wind and solar energy potentials: 48,000 MW for wind and 80 Million tons of oil equivalent (Mtoe) for solar. Turkey has a considerably high level of renewable energy resources that can be utilized to satisfy a part of the total energy demand in the country. Present applications have shown that renewable energy sources in Turkey are a promising alternative [6-10].

The aim of this study is to propose criteria that help public or private investors in prioritizing these investments for Turkey. As an example of the application of these criteria, the author evaluated existing energy situation. Turkey's geographical location has several advantages for extensive use of most of these renewable energy sources. This study shows that there is enough renewable energy potential in Turkey for heat and electricity generation. Especially hydropower, biomass, solar and wind are very well.

2. Energy consumption in Turkey

Turkey is an energy importing country; more than half of the energy requirement has been supplied by imports [6, 7]. Oil, coal and gas have the biggest share in total primary energy consumption [7-10]. 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 [11]. 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 [12-16]. Turkey's electric energy demand is growing about 4-6% yearly due to fast economic growing [17-28].

In 2017, primary energy production and consumption

has reached 36 and 145 Mtoe as shown in Table 1 and 2 [12]. 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 [12-14]. 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. Turkey has recently announced that it will reopen its nuclear programme in order to respond to the growing electricity demand while avoiding increasing dependence on energy imports [29-35]. Figure 1 shows the installed power capacity in Turkey by energy source.

Table 1. Total energy supply in Turkey (Mtoe).

Energy Sources	2017
Coal and Lignite	14.47
Oil	2.68
Gas	0.29
Nuclear	0.00
Hydropower	5.00
Geothermal	7.12
Wood and Biomass	2.53
Solar/Wind/Other	2.75
Total production	35.36

Mtoe: Million tons of oil equivalent

Table 2. Total energy demand in Turkey (Mtoe).

Energy Sources	2017
Coal and Lignite	38.82
Oil	44.53
Gas	45.87
Nuclear	0.00
Hydropower	5.00
Geothermal	7.12
Wood and Biomass	2.53
Solar/Wind/Other	2.75
Total consumption	145.30

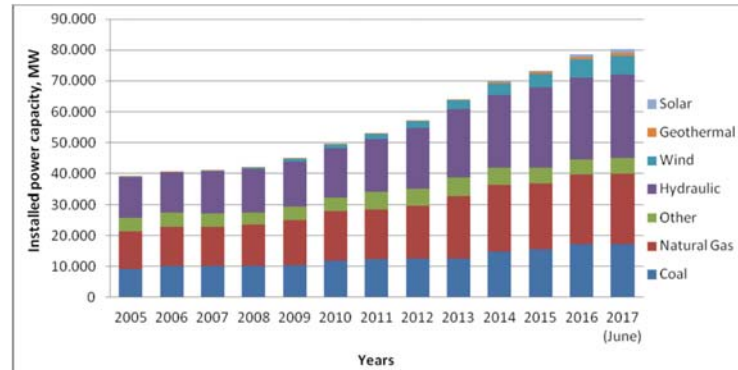


Figure 1. Turkey's Installed capacity (MW)

In Turkey, electricity is mainly produced by thermal power plants, by consuming coal, lignite, natural gas, fuel-oil and geothermal energy, wind energy (recently) and hydropower plants [20-22]. The electricity requirement was reported as 194 000 GWh in 2008 [21]. The electricity is mainly produced by thermal power plants and accounted for 74,82 % of the total, while hydro power energy was 25,11 % and the wind power energy was 0,07 %. In the thermal electricity production, the lignite part was 18,37 % and natural gas was 44 %. Compared to other energy sources, PV systems don't have sufficient contributions to gross electricity demand. There are no sufficient governmental driving forces to support PV systems in Turkey yet. Turkey's annual solar energy

potential is estimated to be 1015 kWh, which is more than 5 700 times of the present electricity consumption [12-15].

Along with the economic growth and population increase, significant increases were observed both in primary energy and electricity consumption [14]. Consumption of primary energy reached 146 Mtoe as of the end of 2017 with an annual average increase of 3.1% while electricity consumption reached 276 billion kWh with an annual average increase of 5.2% during this period. Figure 2 shows Turkey's electricity power generation (GWh). Table 3 also shows breakdown of installed capacity in Turkey (MW) [12-14]

Table 3. Installed power capacity of Turkey in 2017.

Power resources	Installed capacity (MW)
Thermal power plants	46,926.5
Hydroelectric	27,273.1
Wind	6,516.2
Solar PV	3,420.7
Geothermal	1,063.7
Total	85,200.2

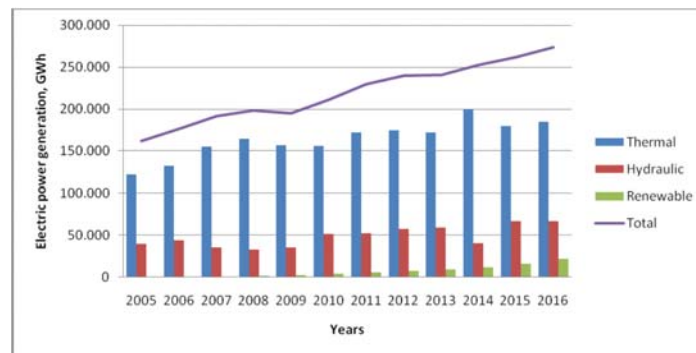


Figure 2. Turkey's electric power generation (GWh)

3. Renewable energy in Turkey

Turkey is one of the fastest growing energy markets in the world. Turkey's total energy demand has been increasing rapidly. Imported fossil fuels dominate Turkey's total primary energy consumption by 75%. However, one of the government's priorities is to increase the ratio of renewable energy resources to 30 % of total energy generation by 2023. As seen in Table 3, Turkey had 85.2 GW of installed electricity generation capacity end of 2017. The breakdown by generation sources is as follows: 55.08% fossil fuels (natural gas, coal, liquid fuels etc.), 32.01% hydro, 7.65% wind, 4.01% solar and 1.25% geothermal. Almost all natural gas and around 40% of coal were imported. Therefore, Turkey needs to boost its power self-sufficiency by handling its rich potential of renewable energy sources [10-16].

Renewable energy supply in Turkey is dominated by hydro and biomass, but environmental and scarcity-of-supply concerns have led to a decline in biomass use, mainly for residential heating [5, 19]. Total renewable energy supply declined from 1990 to 2017, due to a decrease in biomass supply [18, 19]. As a result, the composition of renewable energy supply has changed and wind power is beginning to claim market share [12-15]. 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 4 also shows the potentials for investment of the renewable energies in Turkey. Figure 3 shows expected installed capacity by renewable energies in Turkey [31-35].

Table 4. Potentials for investment for renewable energy technologies in Turkey.

Sectors	Million \$	Remarks
Hydroelectric	120	Economical development potential of 28,400 MW, Corresponding 100,000 GWh/a
Wind power	72	Economical development potential of 48,000 MW With wind speed > 7 m/s
Solar thermal	170	Economical development potential of 131,000 GWh/a, Corresponding to approx. 300 million m ² collector area
Bioenergy	15	Agricultural residual material and dung, when used for electricity generation, 1,000 MWe and 7,000 GWh/a

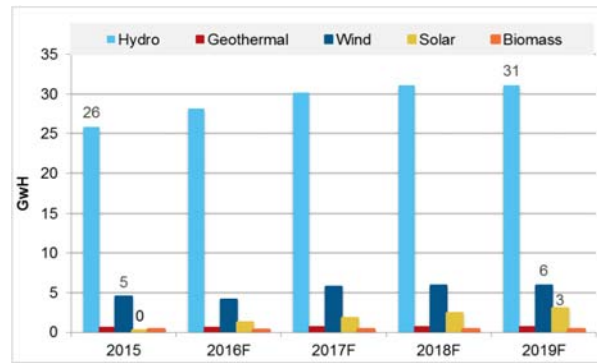


Figure 3. Turkey's expected installed capacity by renewables (GW)

3.1. Hydropower

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 [13, 14]. At present, only about 35 % of the total hydroelectric power potential is in operation [19]. The national development plan aims to harvest all of the hydroelectric potential by 2020 [20]. The contribution of small hydroelectric plants to total electricity generation is estimated to be % 5-10 [22]. On the other hand, the Southeastern Anatolia Project (GAP) is one of the largest power generating, irrigation, and development projects of its kind in the world, covering 3.0 million ha of agricultural land [27]. This is over 10 % of the cultivable land in Turkey; the land to be irrigated is more than half of the presently irrigated area in Turkey. The GAP project on the Euphrates and Tigris Rivers encompasses 22 dams and 19 hydroelectric power plants. Once completed, 27 billion kWh of electricity will be generated and irrigating 1.7 million hectares [13, 14, 19, 20, 22].

3.2. Biomass

Biomass is the major source of energy in rural Turkey. Among the biomass energy sources, woody biomass seems to be the most interesting because its share of the total energy production of Turkey is high at 11 %. Turkey's annual biomass potential is about 120 million tons and the total biomass energy potential is about 36 Mtoe [5]. The amount of usable biomass potential of Turkey is approximately 18 Mtoe. Turkey has the potential to produce 4.0 million tons of wood pellet has approximately 780 million dollars of market value by the help of existing woody biomass [12]. Producing wood pellet could account to 1.4% of total primary energy consumption in 2014 and 1.38% of imported energy. If Turkey utilized existing woody biomass as wood pellet, this would represent a saving

of 340 million dollars from energy imported in 2014. The capacity for wood pellet production in Turkey is quite low, due to its high cost [13]. Therefore, relevant institutions should launch more projects to promote the production and consumption of wood pellet. International pellet standards should be adopted, and private sector should be encouraged by government [14].

3.3. Wind energy

There are a number of cities in Turkey with relatively high wind speeds [27]. These have been classified into six wind regions, with a low of about 3.5 m/s and a high of 5 m/s at 10 m altitude, corresponding to a theoretical power production between 1000-3000 kWh/(m².yr) . The most attractive sites are the Marmara Sea region, Mediterranean Coast, Aegean Sea Coast, and the Anatolia inland. Capacity is likely to grow rapidly, as plans have been submitted for just under a further 600 MW of independent facilities. At start 2014, total installed wind energy capacity of Turkey is only 1900 MW [12-14].

Turkey added 766 MW in 2017, bringing the country's total wind power capacity to 6,857MW. 2017 marked a turning point for Turkey's wind industry: in December, 2.11 GW were issued preliminary licences for 67 wind projects by Turkey's electricity transmission operator TEİAŞ. This completed a round which had started in June 2017 with the assignment of 710 MW of so called pre-licences, issued to projects meeting specific criteria and participating in grid capacity auctions. In addition, the country's first wind tender was held in August, where 2.0 GW of onshore wind capacity was allocated under Turkey's YEKA renewable energy programme. Recently Turkey's energy and natural resources ministry also announced its plans to start offshore wind development to boost the country's renewable

energy capacity. The ministry has identified potential zones for the country's first offshore wind tender [12-14].

3.4. Solar energy

Total solar energy production of 0.465 million tons of oil equivalent (Mtoe) in 2008 increased to 0.827 Mtoe in 2016 and is projected to rise to 5.5 Mtoe (5.5% of primary energy production) by 2025 [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 2017, Turkey had 14 million m² of collector surface area installed with a heat output of 0.4 Mtoe contributing to energy production [13].

According to a study by the MENR, in its high demand scenario, Turkey's energy demand will increase by 7% per year by 2030 and will reach 680 TWh. In order to meet these energy demand, the country must be used all domestic energy sources at

maximum capacity, especially hydropower, lignite, wind and solar power. On the other hand, solar energy is one of the most valuable renewable energy sources, which is still untapped in Turkey, with an expected potential of at least 500 GW. In 2017, Turkey's installed solar PV capacity was 3421 MW (see Table 3).

3.5. Geothermal energy

Turkey is one of the countries with significant potential in geothermal energy and there may exist about 2000 MW_e of geothermal energy usable for electrical power generation in high enthalpy zones. 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 2014. Turkey must target 1.2 million households equivalent 7,700 MW_{th} in 2020 [12, 13, 25].

4. Conclusions

Energy production from renewables should be improved in Turkey to reduce the dependency and environmental pollution and increase the development level of the country by increasing the economic level of the country. The author believes that Turkey does not use its clean energy sources efficiently and should promote new technologies and use all its renewable energy potential. According to the government policies, new capacity investments, supply diversity and maximizing energy efficiency are critical points for Turkey in conjunction with the increasing primary energy demand. In order to avoid the risks linked to both energy dependence and developing a sustainable energy model, the government is committed to promoting alternative solutions based mainly on local and renewable energy sources. Therefore, Turkey has initiated a forward looking and innovative energy policy in which renewable energy plays a significant role.

After examining and analyzing renewable energy

potential and its current utilization of Turkey, it can be briefly concluded that renewable energy has been more popular. In Turkey, the share of renewable energy in the total electricity generation was 9% while it was over 10% for installed power capacity in 2017. Added to them, essentially wind energy from the available renewables in Turkey has showed significant increase. Wind energy occupies about 82% of the total renewable based installed power capacity of Turkey as of July 2018. Solar and geothermal based installed power capacities take the remaining 30% with the shares of about 18% and 12%, respectively. Turkish governments should be give more and more attention to develop the renewable energy utilization for achieving the 2023 renewable targets. Turkish governments must give more importance to the utilization of its renewable energy resources with the assistance of useful laws and amendments as well as major incentives which can all remove the available barriers to renewable energy investments

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