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Renewable energy potential and utilization in Turkey

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Abstract
Energy is an essential factor to achieve sustainable development. Global energy production is growing fastly year by year. Renewable energy technologies such as wind, biomass, hydropower, geothermal and solar are finally showing maturity. 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, clean 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. The use of available renewable energy sources for a cleaner and greener energy production is crucial for a country like Turkey. For this reason, the Turkish government, within the scope of Vision 2023, aims to use renewable energy sources such as solar, wind, wave and geothermal in the most effective way. This study shows that there is enough renewable potential in Turkey for sustainable energy development. Especially hydropower, biomass, solar and wind energy are very well.

Keywords: Renewable energy; sustainable development; vision 2023 targets; Turkey

1. Introduction

Energy is essential to economic and social development and improved quality of life in all countries. 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. 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. 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 [1-4].

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 has continued this policy despite lower energy demand induced by the 2001 economic crisis. This paper provides an overview of the clean energy utilization for climate change mitigation and energy sustainability in Turkey [5-8].

The use of available renewable energy sources for a cleaner energy production is crucial for a country like Turkey. For this reason, the Turkish government, within the scope of Vision 2023, aims to use renewable energy sources such as solar, wind, wave and geothermal in the most effective way [7]. It aims to increase the share of renewable energy sources in electricity generation to 30% by the year 2023. In addition to Turkey having a great potential for wind energy, wind energy is the second most widely used, both actual and planned, energy source after hydro energy for electric generation all over the world [8]. Turkey had been late for studies in the field of wind energy, but it has progressed rapidly. Nevertheless, the 2023 targets are very optimistic and is a serious goal [9]. In order to achieve this goal, there are several requirements, such as identification of

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available potential, getting technological know-how, obtaining technical equipment, making policies and legal regulations, realizing domestic production and supplying finance as well as duly managing them as a whole. In this study, the renewable energy potential and utilization in Turkey was analyzed [9-11].

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 [8-13]. 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 [6]. 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 [6-8]. Turkey's electric energy demand is growing about 4-6% yearly due to fast economic growing [7].

In 2014, primary energy production and consumption has reached 40 and 153 Mtoe as shown in Table 1 and 2 [7].

Table 1.Total energy production in Turkey (Mtoe)

Energy Sources	2014	2023
Coal and Lignite	26.15	**33.13**
Oil	1.13	**0.17**
Gas	0.17	**0.10**
Nuclear	-	**10.20**
Hydropower	5.34	**9.00**
Geothermal	0.98	**3.24**
Wood and Biomass	5.12	**4.14**
Solar/Wind/Other	1.05	**4.30**
Total production	**39.94**	**64.28**

Table 2.Total energy consumption in Turkey (Mtoe)

Energy Sources	2014	2023
Coal and Lignite	39.70	**194.34**
Oil	51.17	**100.12**
Gas	49.58	**124.20**
Nuclear	-	**10.20**
Hydropower	5.34	**9.00**
Geothermal	0.97	**3.24**
Wood and Biomass	5.12	**4.14**
Solar/Wind/Other	1.05	**4.30**
Total consumption	**152.93**	**449.50**

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 [18-21]. 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 [6-13]. Figure 1 shows the power generation in Turkey by energy source.

Along with the economic growth and population increase, significant increases were observed both in primary energy and electricity consumption during the 10th Plan period [9]. Consumption of primary energy reached 153 Mtoe as of the end of 2014 with an annual average increase of 3.2% while electricity consumption reached 246 billion kWh with an annual average increase of 4.8% during this period. These increases are more evident in the period following 2014 [14, 15]. Figure 2 shows Turkey's installed electricity capacity.

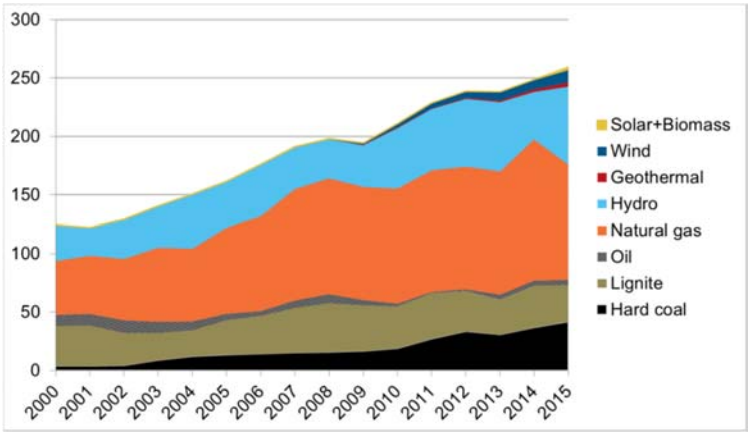

Figure 1. Power generation by energy source in Turkey (TWh)

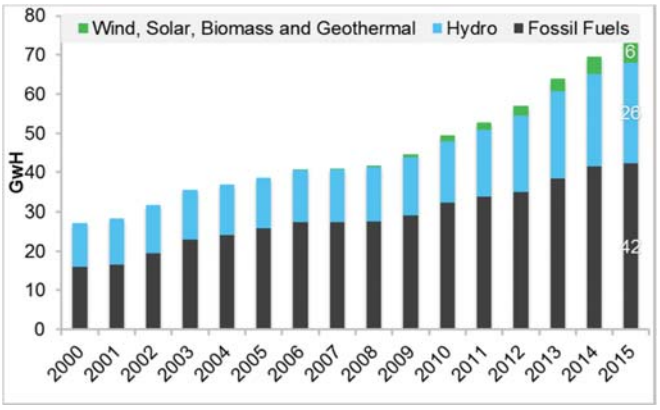

Figure 2. Turkey's Installed capacity (GWH)

3. Renewable energy utilization in Turkey

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 [6-8]. Total renewable energy supply declined from 1990 to 2014, due to a decrease in biomass supply. As a result, the composition of renewable energy supply has changed and wind 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. Table 4 also shows the potentials for investment of the clean energies in Turkey.

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 [16-18]. 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 [9]. The contribution of small hydroelectric plants to total electricity generation is estimated to be % 5-10 [14-18]. 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 [18]. The GAP project on the Euphrates and Tıgris 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 [18]. Figure 3 shows Turkey's renewable energy capacity.

Table 3.Turkey's present and targeted renewable energy capacities in 2015 (MW)

Renewables	In operation	In development	Target 2023
Hydropower	25 900	12 640	34 000
Wind	4 694	7 166	20 000
Solar	44	N/A	5 000
Geothermal	414	364	1 000
Biomass	246	35	1 000
TOTAL	31 298	20 205	61 000

Table 4. Potentials for investment for clean energies in Turkey

Sectors	Million $	Remarks
Hydroelectric	118	Economical development potential of 28,400 MW, Corresponding 100,000 GWh/a
Wind power	62	Economical development potential of 48,000 MW With wind speed > 7 m/s
Solar thermal	168	Economical development potential of 131,000 GWh/a, Corresponding to approx. 300 million m^2 collector area
Biogas	5	Agricultural residual material and dung, when used for electricity generation, 1,000 MWe and 7,000 GWh/a
Total	353	

Among the renewable energy sources, biomass is important because its share of total energy consumption is still high in Turkey [19, 23]. 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 [23]. The total recoverable bioenergy potential is estimated to be about 30 mtoe in 2012 [23]. On the other hand, using vegetable oils as fuel alternatives has economic, environmental, and energy benefits for Turkey [6-9]. Animal wastes are mixed with straw to increase the calorific value, and are then dried for use [19-23].

Turkey is one of the countries with significant potential in geothermal energy and there may exist about 2000 MWe of geothermal energy usable for electrical power generation in high enthalpy zones. Turkey's total geothermal heating capacity is about 31,500 MWth. At present, heating capacity in the country runs at 1240 MWth equivalent to 150,000 households. These numbers can be heightened some seven-fold to 7,180 MWth equal to 800, 000 households through a proven and exhaustible potential in 2012. Turkey must target 1.2 million house holds equivalent 7,700 MWth in 2020 [24, 25].

Turkey receives a high level of solar radiation throughout the year with mean daily sunshine duration of about 7.2 h and solar energy intensity of 12.96 MJ/m2.day. The highest and lowest solar energy potential of Turkey is in the Southeast Anatolian region with an average solar radiation of 14.37 MJ/m2.day and sunshine duration of 8.2 h/day and in the Black Sea region with an average solar radiation of 11.02 MJ/m2.day and sunshine duration of 5.4 hour per day, respectively [26]. The solar potential unconstrained by technical, economic or environmental requirements of Turkey is estimated at 90 Mtoe per year [6-8].

Total solar energy production of 5 Mtoe in 1986 increased to 465 Mtoe in 2008 and is projected to rise to 5.5 million toe (Mtoe) (5.5% of primary energy production) by 2025 [7]. 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 2014, Turkey had 13 million m2 of collector surface area installed with a heat output of 0.4 Mtoe contributing to energy production [6-8].

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 [6, 8, 16]. The electricity requirement was reported as 212 000 GWh in 2014 [16]. 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 [27-34].

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, Agean 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 [6-8; 31-33].

4. Conclusions

R Turkey uses the energy sources inefficiently and consumes more energy to produce a product. So, the production costs in this country are higher than the world's average. Energy policies of Turkish government should support the domestic energy sources and use the installed power plants efficiently in Turkey. 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.

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