



## Renewable energy for sustainable development in Turkey

C. Demirtaş\* ; T. Ayhan and O. Kaygusuz

Mechanical Engineering, Karadeniz Technical University, Trabzon, Turkey

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### Abstract

Energy has a pivotal role in every society, touching upon all aspects of life and creating, in particular, an accelerated sustainable economic and social development, which in turn enhances the welfare of people and consolidates the country's standing in the world. The new concepts of world energy require a shift of position in mind and strategic orientation. The coming decades are likely to bring about huge changes in the world's energy system. Future energy policy will be driven by the triple challenge of achieving substantial reductions in emissions of greenhouse gases while ensuring a secure supply of energy, all at reasonable cost to economies. 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. 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]. The seventh goal of the Sustainable Development Goals (SDGs) is dedicated to ensuring access to affordable, reliable, sustainable and modern energy for all by 2030 [5]. While energy was implicit in the Millennium Development Goals (MDGs), the SDGs explicitly recognise the direct linkage between energy access and consumption and poverty and development [6, 7]. This evolution of the development agenda is closely related to an expanded understanding of poverty, as it moves

beyond a monetary definition, to be seen as a more holistic measure of overall quality of life. Energy has thus become recognised as an important aspect of alleviating extreme poverty. However, what remains unclear is the impact that poverty reduction will have on worldwide energy consumption [8]. There is a significant concern concerning the connection between energy consumption (especially electricity) and development, ranging from engineering modelling to development policy. Nevertheless, there is a lack of attention given to the direct causal relationship between poverty reduction and energy consumption [9, 10].

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 [11]. The governments has continued this policy despite lower energy demand induced by the 2001 economic crisis [12]. This paper provides an overview of the clean energy utilization for climate change mitigation and energy sustainability in Turkey.

\*Corresponding author: [demirtas@ktu.edu.tr](mailto:demirtas@ktu.edu.tr)

## 2. Energy consumption in Turkey

Turkey is an energy importing country; more than half of the energy requirement has been supplied by imports [11, 12]. Oil, coal and gas have the biggest share in total primary energy consumption [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 [14]. 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 [15]. Turkey's electric energy demand is growing about 4-6% yearly due to fast economic growing (see Figs. 1-3)[13-17].

In 2020, primary energy production and consumption has reached 40 and 153 Mtoe as shown in Table 1 and 2 [15]. 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 [15]. 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 [13-20]. Figure 1 shows the power generation in Turkey by energy source [13-15].

Along with the economic growth and population increase, significant increases were observed both in primary energy and electricity consumption during the 10<sup>th</sup> Plan period [16]. 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 [15].

## 3. Renewable energy developments in Turkey

Clean 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 [20]. Total renewable energy supply declined from 1990 to 2008, due to a decrease in biomass supply [12, 18]. As a result, the composition of renewable energy supply has changed and wind power is beginning to claim market share [13]. 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. Figure 3 shows expected installed capacity by clean energies in Turkey. Table 3 also gives past and present renewable energy utilization.

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 [21-23]. At present, only about 35 % of the total hydroelectric power potential is in operation [21]. 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 to be % 5-10 [13-15]. 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 [13-15].

Among the renewable energy sources, biomass is important because its share of total energy consumption is still high in Turkey [14-16]. 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 [24]. The total recoverable bioenergy potential is estimated to be about 36 mtoe in 2008. On the other hand, using vegetable oils as fuel alternatives has economic, environmental, and energy benefits for Turkey. Animal wastes are mixed with straw to increase the calorific value, and are then dried for use [25].

Turkey is one of the countries with significant potential in geothermal energy and there may exist about 2000 MW<sub>e</sub> of geothermal energy usable for electrical power generation in high enthalpy zones. Turkey's total geothermal heating capacity is about 31,500 MW<sub>th</sub>. At present, heating capacity in the country runs at 1240 MW<sub>th</sub> equivalent to 150,000

households. These numbers can be heightened some seven-fold to 7,180 MW<sub>th</sub> 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<sub>th</sub> in 2020 [13-15]. 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/m<sup>2</sup>.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/m<sup>2</sup>.day and sunshine duration of 8.2 h/day and in the Black Sea region with an average solar radiation of 11.02 MJ/m<sup>2</sup>.day and sunshine duration of 5.4 hour per day, respectively [23]. The solar potential unconstrained by technical, economic or environmental requirements of Turkey is estimated at 90 Mtoe per year [13-15].

Total solar energy production of 965 Mtoe in 2020 and is projected to rise to 6.0 million toe (Mtoe) 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 2008, Turkey had 12 million m<sup>2</sup> of collector surface area installed with a heat output of 0.4 Mtoe contributing to energy production [23]. 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 [13-15]. The electricity requirement was reported as 194 000 GWh in 2008 [15]. 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 %. There are 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 [24-28].

There are a number of cities in Turkey with relatively high wind speeds. 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/(m<sup>2</sup>.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 [1-8].

### 3.1. Promoting renewable energy

In Turkey, there is a much more potential for renewables, but represent about 37% of total energy production and 10% of total energy consumption. This share is not enough for the country and the governments should be increase to this situation. More than half of the renewables used in Turkey are combustible fuels and waste, the rest being mainly hydro, solar and geothermal. Turkey is richly endowed with hydropower, wind and geothermal resources. Sectoral studies have indicated that small-scale hydropower is under developed, and a total potential production of 33 TWh of electricity per year [21]. It is estimated that Turkey has the potential for up to 48 000 MW of wind power capacity, capable of generating about 25 TWh of electricity per year [13-15].

## 4. Conclusions

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

There is also large potential for geothermal and solar thermal applications in Turkey. Solar collectors are already a significant, market-driven business. The government expects the use of geothermal and solar energy to double between 2014 and 2030. The organic component of waste incineration is also considered a renewable option in the future, using appropriate technology to meet high health and environmental standards. On the other hand, commercial use of renewable energy has not developed rapidly. Financial assistance is being provided for the development of renewable energy projects. In 2014, USD 800 million was made available; by 2020, about half had already been committed to finance 66 projects with several other projects under preparation [13-15].

government should support the domestic energy sources and use the installed power plants efficiently in Turkey. Coal is the most reliable domestic energy source in Turkey should be consumed more in the

industry and electricity production in order to reduce the energy production costs of Turkey and the dependency on other countries. Natural gas is an expensive energy source and the consumption is high in Turkey. Moreover, the share of natural gas in electricity generation is 46% in Turkey. Because of dramatically high dependency on natural gas, Turkey will be one of the most affected countries in a possible natural gas crisis in the world. In other words, consuming natural gas is a disadvantage for

Turkey in terms of development. 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. Therefore, Turkey has initiated a forward looking and innovative energy policy in which renewable energy plays a significant role.

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Table 1. Total energy production in Turkey (Mtoe)

Energy Sources	2020
Coal and Lignite	32.36
Oil	0.49
Gas	0.14
Hydropower	10.00
Geothermal	1.71
Wood and Biomass	4.96
Solar/Wind/Other	2.27
Total production	51.23

Table 2. Total energy consumption in Turkey (Mtoe)

Energy Sources	2020
Coal and Lignite	107.57
Oil	71.89
Gas	74.51
Hydropower	10.00
Geothermal	1.71
Wood and Biomass	4.96
Solar/Wind/Other	2.27
Total consumption	273.21

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	4864
Wood/wood waste	6541	4994	4322
Biogas	5	15	28
Biofuels	0	14	20
Wind energy	3	31	86
Solar energy	262	420	1264
Hydropower	2655	3083	5864
Geothermal energy	684	1048	2214

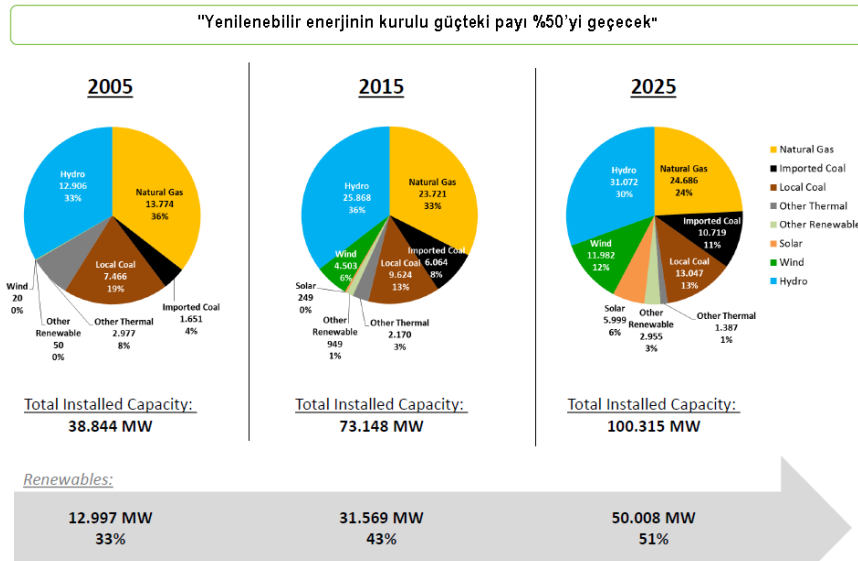


Figure 1. Percentage of Turkey's total installed capacity from 2005 to 2025.

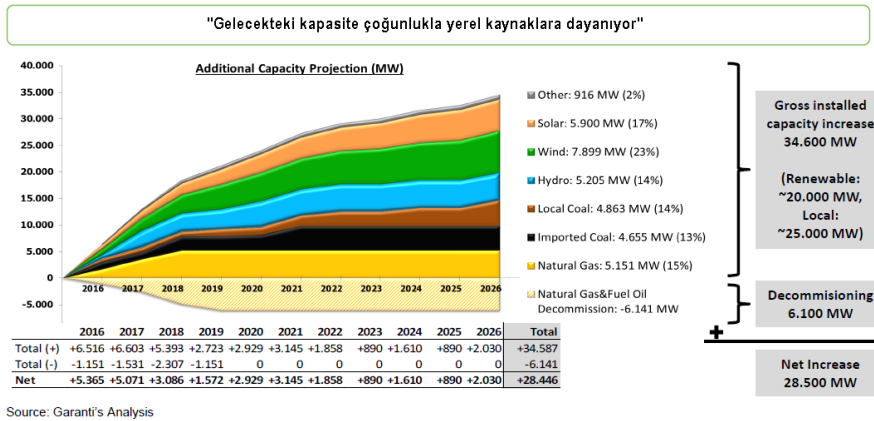


Figure 2. Turkey's present and future installed power capacity by energy sources.

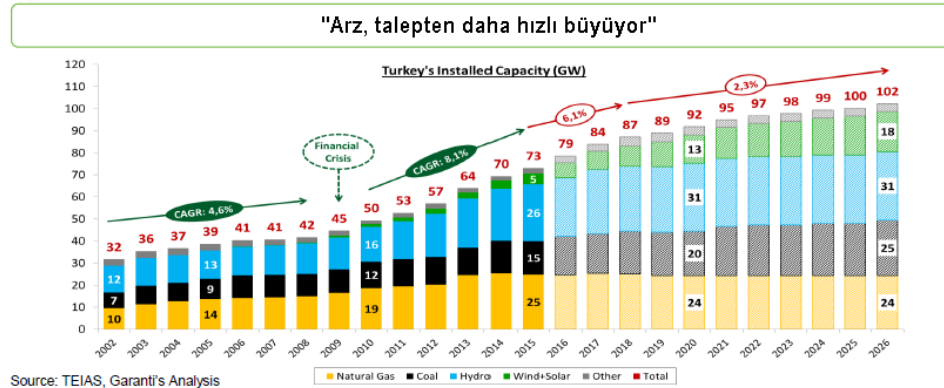


Figure 3. Turkey's energy demand and capacity developments by the year.