

Renewable and sustainable energy policies in Turkey

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Abstract

Energy is an essential factor to achieve sustainable development. Global energy production is growing fastly. As would be expected, the rapid expansion of energy production and consumption has brought with it a wide range of environmental issues at the local, regional and global levels. Renewable energy sources such as wind, biomass, hydropower, geothermal and solar are finally showing maturity. 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 fuels and electricity. Especially hydropower, biomass, solar and wind are very well. This paper provides an overview of the sustainable energy policies in Turkey.

Keywords: Renewable energy sources; sustainable energy development; energy

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].

Turkey is the 17th largest economy in the world and the 6th largest in Europe. With a growing economy and population, energy demand in Turkey has steeply risen, which has ranked security of supply at the top of the government's agenda, both for electricity and for other primary energy sources. The Turkish economy is heavily dependent on imported energy supplies, and its primary energy consumption is mainly based on fossil fuels, which was approximately 90% in 2012 where majority of this supply was imported from other countries. In the

upcoming years, it is forecasted that Turkey will continue with the major economic development, which will require an increase in the demand of energy supply [5].

According to current estimates, an increase of around 90% in primary energy demand will take place during the period of 2011-2023. Aside from investments for the creation of new capacity within the field, the source of energy and maximizing energy efficiency are also critical points for Turkey. In order to both avoid the risks linked to a high level of energy dependency and to develop a sustainable energy model, the Government is committed to promoting alternative solutions based mainly in renewable energy. Therefore, Turkey has initiated a forward-looking and innovative energy policy in which renewable energy plays a significant role.

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. This paper provides an overview of the sustainable energy policies in Turkey.

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2. Energy consumption in Turkey

Turkey is an energy importing country; more than half of the energy requirement has been supplied by imports [4, 5]. Oil, coal and gas have the biggest share in total primary energy consumption [2]. 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 [2, 3]. 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 [5]. Turkey's electric energy demand is growing about 4-6% yearly due to fast economic growing [1-10]. In 2014, primary energy production and consumption has reached 40 and 153

Mtoe as shown in Table 1 and 2 [3]. 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 [2]. However, the total share of renewable energy sources in total final energy consumption 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 [1-13]. Figure 1 shows the power generation in Turkey by energy source [13].

Table 1. Total energy production in Turkey (Mtoe)

Energy Sources	2015	2020	2030
Coal and Lignite	26.65	32.36	35.13
Oil	1.12	0.49	0.17
Gas	0.16	0.14	0.10
Nuclear	-	7.30	14.60
Hydropower	5.64	10.00	10.00
Geothermal	1.08	1.71	3.64
Wood and Biomass	5.10	4.96	4.64
Solar/Wind/Other	1.35	2.27	4.28
Total production	41.10	59.23	72.56

Mtoe. Million tons of oil equivalent

Table 2. Total energy consumption in Turkey (Mtoe)

Energy Sources	2015	2020	2030
Coal and Lignite	41.70	107.57	198.34
Oil	52.27	71.89	102.38
Gas	50.18	74.51	126.25
Nuclear	-	7.30	14.60
Hydropower	5.64	10.00	10.00
Geothermal	1.08	1.71	3.64
Wood and Biomass	5.10	4.96	4.64
Solar/Wind/Other	1.35	2.27	4.28
Total consumption	157.32	280.21	464.13

Along with the economic growth and population increase, significant increases were observed both in primary energy and electricity consumption during the 10th Plan period [6]. 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 [3, 4, 5]. Figure 2 shows Turkey's installed electricity capacity [13].

3. Renewable energy 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 [2]. Total renewable energy supply declined from 1990 to

2008, due to a decrease in biomass supply. As a result, the composition of renewables supply has changed and wind is beginning to claim market share [3-5].

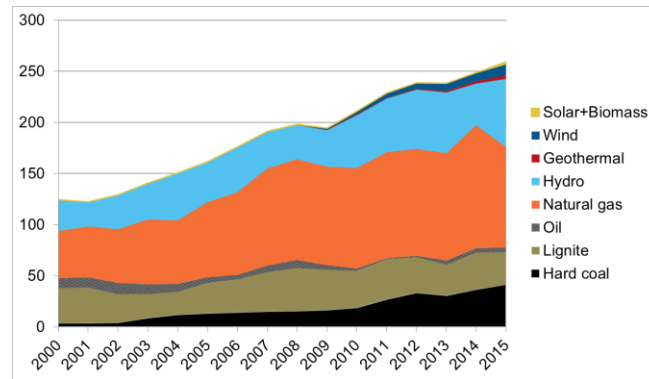


Figure 1. Power generation by energy source in Turkey (TWh).

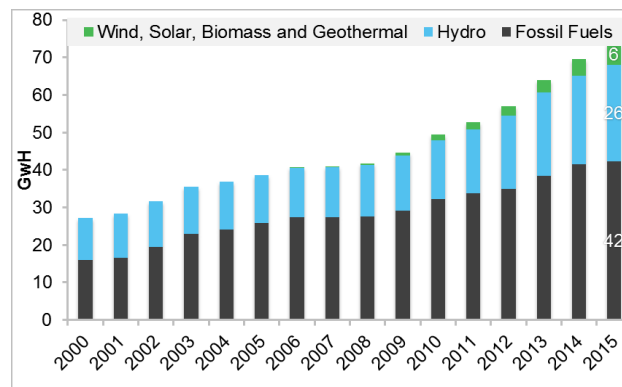


Figure 2. Turkey's Installed capacity (GWH).

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 [3]. Figure 3 shows expected installed capacity by clean energies in Turkey [13].

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

	2005	2010	2014
Total energy demand	85340	101510	131214
Total energy production	23626	27279	34650
Supply by renewables	10131	9604	10426
Biomass and waste	5332	5023	4864
Wood/wood waste	5325	4994	4322
Biogas	7	15	28
Biofuels	0	14	20
Wind energy	5	31	46
Solar energy	385	420	964
Hydropower	3402	3083	4864
Geothermal energy	1007	1048	1214
Share (%)	11.87	9.46	10.2
Biomass and waste	6.25	4.95	5.10
Wood/wood waste	6.24	4.92	4.96
Biogas	0.01	0.01	0.02
Biofuels	0.00	0.01	0.01
Wind energy	0.01	0.03	0.06
Solar energy	0.45	0.41	0.52
Hydropower	3.99	3.04	3.46
Geothermal energy	1.18	1.03	1.24

toe: tons of oil equivalent

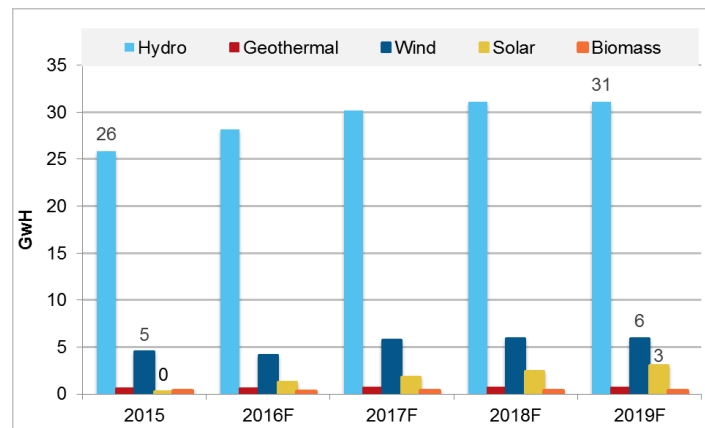


Figure 3. Expected installed capacity by renewables between 2015-2019 (GW)

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 [11-13]. At present, only about 35 % of the total hydroelectric power potential is in operation [11]. The national development plan aims to harvest all of the hydroelectric potential by 2023 [5]. 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. This is over 10 % of the cultivable land in Turkey; the land to be irrigated is more than half of the presently irrigated are 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 [11-15].

Among the renewable energy sources, biomass is important because its share of total energy consumption is still high in Turkey [16-19]. Since 1990, the contribution of the biomass resources in the total energy consumption dropped from 15 to 4 % in 2014 [2, 3]. Biomass in the forms of fuelwood and animal wastes is the main fuel for heating and cooking in many urban and rural areas [16]. The total recoverable bioenergy potential is estimated to be about 36 mtoe and 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 [16-19].

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 160,000 households. These numbers can be heightened some seven-fold to 7,380 MWth equal to 800, 000 households through a proven and exhaustible potential in 2012. Turkey must target 1.2 million households equivalent 8,700 MWth in 2023 [20].

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. The solar potential unconstrained by technical, economic or environmental requirements of Turkey is estimated at 90 Mtoe per year [2, 3, 21, 22, 23].

Total solar energy production is 987 toe in 2015 and is projected to rise to 5100 toe by 2023 [5]. 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 2015, Turkey had 14 million m² of collector surface area installed [2-6].

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]. The electricity requirement was reported as 294 000 GWh in 2015 [13]. The electricity is mainly produced by thermal power plants and accounted for 74 % of the total, while hydro power energy was 24 % and the

wind power energy was 1.2 %. 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 [3, 5, 24].

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/(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 [3, 4, 5].

4. Dynamics of energy patterns in Turkey

4.1. Introduction

Turkey is a rapidly growing country whose income level is moving towards that of the rest of the OECD area. This catch-up process has been associated with a rapid growth of greenhouse gas emissions. Nonetheless, carbon emissions from any country contribute equally to the pressure on the global climate. Consequently, the major issue facing policy makers is how to contribute to reducing the burden on global resources at a low cost and without jeopardizing the rapid growth of the economy [2].

The Turkish government is now in the process of developing a strategy to reduce the growth of greenhouse gases [5]. Turkey will have the obligation to implement measures and policies to mitigate greenhouse gas emissions but will not be required to meet a specific greenhouse gas emission target [6]. At present, demand for electricity is boosted by a high level of what is called "non-technical" system losses. In practice, this phrase refers both to electricity that is consumed through illegal connections to the network and non-payment of bills. The problem may be difficult to settle, in that the new distribution companies have different profiles of losses, with illegal consumption rising to 50% in some areas. Enforcing normal contract discipline, though, would further add to the de-coupling of carbon emissions from GDP growth [2-6].

5. Conclusions

Turkey is the 17th largest economy in the world and the 6th largest in Europe. With a growing economy and population, energy demand in Turkey has steeply risen, which has ranked security of supply at the top of the government's agenda, both for electricity and for other primary energy sources. The Turkish economy is heavily dependent on imported energy supplies, and its primary energy consumption is mainly based on fossil fuels. In the upcoming years, it is forecasted that Turkey will continue with the

4.2. Assisting 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 [25]. 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 [13]. 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 [2-6].

major economic development, which will require an increase in the demand of energy supply.

According to current estimates, an increase of around 90% in primary energy demand will take place during the period of 2014-2030. Aside from investments for the creation of new capacity within the field, the source of energy and maximizing energy efficiency are also critical points for Turkey. In order to both avoid the risks linked to a high level

of energy dependency and to develop a sustainable energy model, the Government is committed to promoting alternative solutions based mainly in renewable energy. Therefore, Turkey has initiated a forward-looking and innovative energy policy in which renewable energy plays a significant role.

On the other hand, by 2030 Turkey plans to have an electricity generation mix in which the share of renewable energy accounts for 30% of overall need, as well as, having 10% of the requirements of the

transportation sector met by renewables. There is also a commitment to reduce by at least 20% the amount of energy consumed per unit GDP in the year 2030. The Government has established ambitious objectives for 2030 regarding electricity generation based on the high availability of renewable energy resources such as hydropower, bioenergy, wind, solar and geothermal which would increase the share of renewable energy in electricity generation to at least 30% and 189 TWh in 2030.

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