Journal of Engineering Research and Applied Science
Available at www.journaleras.com
Volume 5(2), December 2016, pp 451-457
ISSN 2147-3471 © 2016

Renewable energy policies in Turkey: a case of bioenergy

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Accepted 18 October 2016

Abstract
Turkey has a limited amount of fossil fuel reserve, thus is dependent on foreign energy. Approximately 75% of current energy consumption is met by imports. However, Turkey has a high potential of renewables such as biomass, hydropower, wind, solar, geothermal energy, but the current utilization rate of these resources is very low. In recent years, in Turkey, hydraulic, solar, geothermal, and wind-based energy production has started to become widespread; producing energy out of biomass is widely used only via direct incineration. Turkey is rich in biomass and has adequate facilities and environmental conditions in terms of the development of this resource. In order to reduce the dependence of Turkey on foreign energy, transition to energy forestry and energy agriculture, development of obtaining biofuel from them and wastes, and biogas obtained from fertilizers, waste and garbage are required to be given importance. The present study gives renewable and sustainable energy policies in Turkey.

Keywords: Renewable energy; sustainable development; energy policies; bioenergy; Turkey

1. Introduction

Turkey has a limited amount of fossil fuel reserve, thus is dependent on foreign energy. Approximately 75% of current energy consumption is met by imports. However, Turkey has a high percentage of renewable energy resources including biomass, hydropower, wind, solar, and geothermal energy, but the current utilization rate of these resources is very low [1]. In recent years, in Turkey, hydraulic, solar, geothermal, and wind-based energy production has started to become widespread; producing energy out of biomass is widely used only via direct incineration. At present, due to declining fossil fuels, it is inevitable that energy shortage will occur in the near future [2]. In addition to this, when the environmental problems caused by the animal and vegetable-based wastes are considered, in terms of sustainable development, studies show that finding a solution to these two problems is very important [3-5]. For agricultural and animal wastes, one of the most effective solution practices, which is also environmentally acceptable, is biomass energy conversion systems. With these systems, out of the wastes, energy and organic fertilizer with high nutritional value are obtained [6-8]. Besides preventing the dissipation of resources, efforts to better the living standards and in order to reduce the negative effects of the resulting energy crisis, developed countries have investigated and developed methods to recycle various wastes [9-12].

Turkey uses the energy sources inefficiently and consumes more energy to produce a product. 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.

Oil and natural gas are an expensive energy sources and the consumption of these sources are high in Turkey. Also, energy production from renewables should be improved to reduce the dependency and environmental pollution. The author believes that Turkey does not use its renewable energy sources efficiently and should promote new technologies and use all its renewable energy potential. The present study gives renewable and sustainable energy policies in Turkey.

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2. Global energy demand

Global primary oil demand grew by a little more and to reach 87.4 million barrels per day in 2011 [13]. The trajectory that oil use over the coming decades differs considerably, reflecting the different assumptions about government policies to curb rising demand and emissions. According to the Scenarios, oil use increases in absolute terms to 2040, driven mainly by population and economic growth in the emerging economies, in response to strong policy action to curb fossil-energy use. The share of oil in total world energy demand falls and it reaches 27% in 2040 while 32% in 2011 [14]. The first of these fundamental trends is that the world's energy needs are set to rise. With the assumed expansion of the global economy of almost 140% and an increase of 1.7 billion in the world's population, more energy will be needed to satisfy growing demand for energy services, even though new policies and programs are put in place to encourage energy savings [14]. World primary energy demand increases by 35% between 2012 and 2040 in the New Policies Scenario as shown in Table 1 [14]. This represents a sharp slowdown in the energy demand growth experienced over the past two decades, testament to the anticipated effect that already implemented and planned policies would have on energy markets [13-16]. Table 2 shows the global renewable energy capacities in 2013 [15]. As shown in Table 1 and 2, the share of renewables in world primary energy demand reaches 18% in 2040, from 13% in 2012. This rapid increase is underpinned by incentives to overcome market barriers, falling technology costs, rising fossil fuel prices and in some cases carbon pricing. Most of the growth occurs in the power sector (1580 GW), where their share in total generation grows from 20% to 31%, a near tripling in actual generation. Hydro accounts 1018 GW capacity for power generation and its share is 64%. The second contribution is given by wind energy (319 GW). The amount of transport fuels is around 114 billion liters per year in 2013 [14, 15].

Table 1.World primary energy demand by fuel in the New policies Scenario (Mtoe)

	1990	2012	2020	2030	2040
Coal	2 231	3 879	4 211	4 342	4 448
Oil	3 232	4 194	4 487	4 689	4 761
Gas	1 668	2 844	3 182	3 797	4 418
Nuclear	526	642	845	1 047	1 210
Hydropower	184	316	392	469	535
Bioenergy	905	1 344	1 554	1 796	2 002
Other renewables	36	142	308	581	918
Total	8 782	13 361	14 978	16 720	18 293

Source: Ref.[14]

Table 2. Global renewable energy capacities in 2012

Renewable energy	Capacity
Power generation (GW)	
Wind power	319
Biomass power	88
Solar PV	138
Geothermal power	12
Concentrating solar power (CSP)	3.4
Hydropower	1 018
Ocean power	0.5
Hot water/heating (GW_{th})	
Modern biomass heating	320
Solar colectors for hot water/space heating	373
Geothermal heating	66
Transport fuels (billion liters/year)	
Ethanol production	87.8
Biodiesel production	26.3

Source: Ref. [15]

3. Energy situation in Turkey

3.1. General overview

As a developing country, due to its fast growing economy and population Turkey's energy consumption has increased rapidly as shown in Figure 1. For example, while total primary energy consumption in 1996 was 71 Million tons of oil equivalent (Mtoe) in 2013 it raised 120 Mtoe and total energy production in 1996 was 28 and 32 Mtoe in 2013 [17-19].

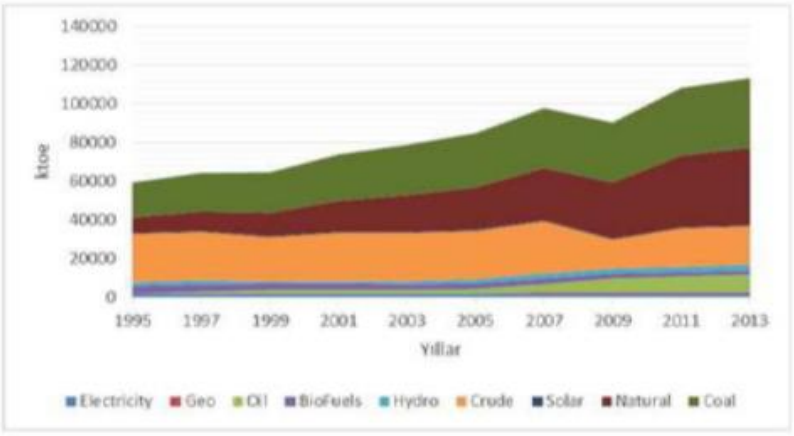

Figure 1. Energy consumption in Turkey (ktoe: kilo tons of oil equivalent).

Turkey is an energy importing country and dependent on the imported energy sources as given in Table 3 [17, 18]. Furthermore this trend seems to be continuing in the future. Energy sources in Turkey are hard coal, lignite, asphalt, oil, natural gas, hydropower, geothermal, wood, animal and plant wastes, solar and wind energy [17]. The proven reserves of lignite, the most abundant domestic energy source, is 7300 million ton and found in almost all of the country's regions. Lignite has the largest percentage in total energy production with its 43% share. After lignite, wood has the greatest share in total energy production with its 20% and oil accounts for 13%, 12.4% hydro and the final 15% includes animal wastes, solar, hard coal, natural gas, geothermal electricity and geothermal heat [17-20]. Turkey's various renewable energy sources represent its second largest energy source after coal [17]. Wood and animal waste account 32 %, hydropower 37 %, geothermal 19 % and wind and solar account for 10.6 % each of total renewable energy production [18]. Table 4 shows Turkey's total installed power capacity in 2013. In Turkey, 24 % of electricity generation was provided by hydropower in 2013, and will be increased to 36 % in 2020 [19]. The largest hydro power project in Turkey is the Southeastern Anatolia Project (GAP). Upon competition, GAP will have an installed capacity of 7476 MW and 22% of Turkey's total estimated economic potential [1-5; 8-10; 17-20].

Table 3.Turkey's energy production and consumption in 2013 (Mtoe)

Energy source	Production	Consumption
Hard coal	990	17 692
Lignite	13 973	13 182
Asphaltite	488	416
Oil	2 485	33 896
Natural gas	443	37 628
Hydropower	5 110	5 110
Geothermal (electric)	1 173	1 173
Geothermal (heat)	1 463	1 463
Animal & plant wastes	1 666	1 666
Wood	2 707	2 707
Wind	650	650
Solar	795	795
Total	31 944	120 290

Source: Ref. [18]

Table 4.Turkey's total installed power in 2013 (MW)

Energy source	Amount	Percent (%)
Natural gas	20 854	% 31.7
Coal	12 828	% 19.5
Other thermal	5 711	% 9.1
Hydropower	22 898	% 34.8
Wind	2 930	% 4.4
Geothermal	317	% 0.5

Source: Ref. [18]

3.2. The role of renewables

Renewable supply in Turkey is dominated by hydropower and biomass, but environmental and scarcity-of-supply concerns have led to a decline in biomass use, mainly for residential heating [17]. Total renewable energy supply declined from 1990 to 2012, due to a decrease in biomass supply [18]. On the other hand, the composition of renewable energy supply has changed and wind power is beginning to claim market share [19]. The share of biomass in the renewable share is expected to decrease with the expansion of other renewable sources as shown in Table 5 and 6 [18]. These tables show that there is an important renewable energy potential in Turkey [17-19].

Table 5. Renewable energy potential in Turkey (2013)

Energy source	Potential (MW)	Power plants With licence (MW)
Hydropower	45 000	20 218
Wind	48 000	9 244
Geothermal	600	636
Solar	33	-
Biomass	9.0	54
Biogas	2.0	190

Source: Ref. [18]

Table 6. Potentials for investment for renewable energies in Turkey

Sectors	Million €	Remarks
Hydroelectric	114	Economical development potential of 28,600 MW, Corresponding 100,000 GWh/a
Wind power	57	Economical development potential of 48,000 MW With wind speed > 7 m/s
Solar thermal	165	Economical development potential of 131,000 GWh/a, Corresponding to approx. 300 million m^2 collector area
Biogas	4	Agricultural residual material and dung, when used for electricity generation, 1,000 MW_e and 7,000 GWh/yr
Total	340	

Source: Ref. [18, 19, 22]

3.2.1. Hydropower

Turkey's theoretical hydroelectric potential is 1% of that of the World and 16% of Europe [21]. The gross theoretical viable hydroelectric potential in Turkey is 433 billion kWh and the technically viable potential is 216 billion kWh [17]. The economically viable potential, however, is 140 billion kWh. Annual energy consumption per capita in Turkey has reached 2.900 kWh which is above world average of 2.500 kWh [18]. Currently, Turkey has 178 hydroelectric power plants in operation with total installed capacity of 16 160 MW generating an average of 48.000 GWh/year, which is 35% of the economically viable hydro potential [19]. In 2013, 150 hydroelectric power plants are under construction 8.600 MW of installed capacity to generate average annual 20.000 GWh representing 14% of the economically viable potential [10]. In the future, 1.418 more hydroelectric power plants will be constructed in order to make use of additional 22 700 MW installed capacity. As a result of these works, a total of 1.738 hydroelectric power plants with 45.000 MW will tame rivers to harness the economically viable hydropower of

Turkey [17-21].

Approximately 50% of the additional potential of 38 TWh (that is, 19 TWh) could be realized as small hydroelectric plants (SHP), with installed capacities of less than 10 MW [17]. The share of SHP potential in the total, which is 3% at present, would be 14% [18]. On the other hand, in accordance with the results obtained from the pre-evaluation study, about 15% of the increase in 126 TWh/year exploitable energy potential might be achieved by developing additional SHP potential [19]. However, this study gives only rough results about the additional SHP potential of the country and the potential must be evaluated more precisely, with comprehensive master plan studies for each hydrological basin [19-22].

3.2.2. Bioenergy

Bioenergy is a very complex field; concerns associated with the sustainability of its production and use require a case-by-case assessment, considering feedstock, location, production methods, land use, conversion pathways, infrastructure, and so on [1]. These concerns span all types of bioenergy, from traditional uses of biomass in the residential sector to bioenergy used in the transport sector and power generation, across the three pillars of sustainability [2]. For example, the greenhouse gas (GHG) balance needs to be carefully evaluated on a case-by-case basis with proper assessment of the full life cycle of GHG emissions, from land use conversion to end use. There are some unresolved methodological issues, such as how to account for the indirect impacts of bioenergy production on land use. Potential economic and social impacts, including on food security, must also be carefully considered. While the inclusion of sustainability considerations for bioenergy is still under development in the legal and regulatory regimes of many countries, improved frameworks are beginning to emerge [3].

Bioenergy provides around 14% of global energy consumption. Some 70% of this biomass energy is believed to be consumed in developing countries for cooking and heating with open fires and very inefficient stoves, the traditional uses of biomass [3]. It is widely recognized that these uses, including the inefficient production and use of charcoal, lead to deforestation and are closely linked to indoor air pollution. But biomass can also be used to produce household-level energy more efficiently via improved cooking and heating appliances. It can also be used to produce heat efficiently for commercial and industrial needs, as well as electricity and transport fuels. Ambitious renewable energy scenarios rely heavily on these “modern” forms of bioenergy use to meet their goals, but some also recognize that traditional uses of biomass will continue to be an important energy source for many people for some time to come. Indeed, it is not possible to distinguish, using available data, the extent to which bioenergy is used by modern or traditional conversion methods, at least as far as the residential sector is concerned [1, 2, 3, 9].

Turkey has a great potential of biomass and bio-energy production [17]. The total annual recoverable bio-energy potential in Turkey was estimated to be around 30 Mtoe, based on the recoverable energy potential from agricultural residues, livestock farming wastes, forestry and wood processing residues and municipal wastes [1, 2, 11]. The contribution of energy production share of animal wastes and plant residues to primary energy consumption in Turkey ranged from 6 % in 2000 to 4 % in 2013 [22]. Despite Turkey has a great potential of biomass to produce renewable energy, but the share of renewable energy in energy production is still low. Biogas production potential in Turkey was estimated to be around 1.5 to 2.0 Mtoe. However, since the share of renewable energy in energy production is so low, the possible contribution of biogas to this share can also be ignored [17-21].

3.2.3. Geothermal energy

Among the renewable energy alternatives, geothermal energy in Turkey has become very attractive [17]. The reason for this interest is features of geothermal energy in direct and indirect use. It is unfortunate that geothermal energy in direct use can only be utilized locally. But, firing fossil fuels at 1500 oC, and using the generated heat at only 50-60 oC is obviously a thermodynamic waste. Turkey has a significant potential in geothermal energy and there may exist about 2000 MWe for electrical power generation. Turkey’s total geothermal heating capacity is about 31,500 MWth. At present, heating capacity in the country runs at 1220 MWth equivalent to 147,000 households. These numbers can be heightened some sevenfold to 7,080 MWth equal to 760 000 households through a proven and exhaustible potential in 2016. Turkey must target 1.2 million households equivalent 7,900 MWth in 2020 [17, 19, 22].

3.2.4. Solar energy

Turkey is so lucky about solar energy potentials that it has 4.2 hours insulation time average per day and 1514 kWh/year.m2 solar radiation level. Only available rooftop area for PV modules is 611 km2 and energy gain from this area will be 90 billion kWh/year. Apart from this area it is determined that the area which has more than 1650 kWh/m2

irradiation level is about 4600 m2 in Turkey. That means this solar energy potential equals to a natural gas plant with a power of 54,300 MW [4, 17, 19, 22]. Except some special applications PV installation is almost none existing in Turkey. However, solar energy is widely used for heating water [17]. The hot water heating system installations cover about 10 million m2 surface in 2013. Turkey is the second big country at hot water heating systems all over the world. Apart from this, PV installations are not so much up to now because of the economic issues [4]. While the existing feed in tariff is about 6.5 €cent/kWh, it is foreseen that it will be about 26 €cent/kWh for PV and 22 €cent/kWh for CSP in 2013. Moreover, there will be no license need for systems up to 500 kW. There are some goals about PV installations in Turkey due to these regulations. It is expected that there will be 3 million installations of private homes which has totally power of 3.000 MW. In addition, the target of installed PV power plant by 2020 is 20.000 MW [17, 19, 22].

3.2.5. Wind power

Surrounded by the Black Sea to the north, the Marmara and the Aegean Sea to the west and the Mediterranean Sea to the south, Turkey has huge potential for wind power generation. Turkey has a theoretical wind energy potential of nearly 90,000 MW [17]. So far only about 1,000 MW capacity wind farms are in operation in Turkey, generating less than 0.5% of total electricity consumed [17]. 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 [19]. 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 1 900 MW [17, 19, 22]. It has estimated that Turkey could meet 20% of its electricity demand from wind power with a target capacity of 20,000 megawatts, even assuming an average 8% annual growth in power consumption. Three sides of Turkey is surrounded by Mediterranean, Black and Aegean sea with the warm and nice weather and good amount of stable wind speeds. However, to use all these advantages, Turkey needs energy [19, 22].

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 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. Moreover, Turkish government should improve the coal burning technologies in the thermal power plants, so the energy production will increase and contribute to the developing economy of Turkey.

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. In other words, consuming natural gas is a disadvantage for Turkey in terms of development. In Turkey, energy production from renewables should be improved to reduce the dependency and environmental pollution and increase the development level of the country by increasing the economic level of the country. The authors believe that Turkey does not use its renewable energy sources efficiently and should promote new technologies and use all its renewable energy potential.

The phenomenon of global climate change is a very serious economic, social and environmental problem. In order to diminish of this problem, the governments should be supported to utilizing renewables most effectively. Turkey is rich in bioenergy and has adequate facilities and environmental conditions in terms of the development of this resource. In order to reduce the dependence of Turkey on foreign energy, transition to energy forestry and energy agriculture, development of obtaining biofuel from them and wastes, and biogas obtained from fertilizers, waste and garbage are required to be given importance.

Acknowledgments

I gratefully acknowledge Prof. Dr. K. Kaygusuz for critical reading of the manuscript.

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