



Sustainable energy development in Turkey

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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 discusses the sustainable energy development 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. 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. 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. 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. 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 [1-12].

2. Energy situation in Turkey

2.1. General overview

As a developing country, due to its fast growing economy and population Turkey's energy consumption has increased rapidly. For example, while total primary energy consumption in 2000 was 86 Million tons of oil equivalent (Mtoe) in 2014 it raised 120 Mtoe and total energy production in 2000 was 32 and 32 Mtoe in 2014 [13-18].

Turkey is an energy importing country and dependent on the imported energy sources as given in Table 1. 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. 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

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wastes, solar, hard coal, natural gas, geothermal electricity and geothermal heat [13-18].

Table 1. Turkey's energy production and consumption in 2014 (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. [14]

Turkey's various renewable energy sources represent its second largest energy source after coal [16]. Wood and animal waste account 32 %, hydropower 37 %, geothermal 19 % and wind and solar account for 10.6 % each of total renewable energy production. Table 2 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 [18]. 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 [13-18].

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 2.

Table 2. Turkey's total installed power in 2014 (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. [14]

3.2.1. Hydropower

The gross theoretical viable hydroelectric potential in Turkey is 433 billion kWh and the technically viable potential is 216 billion kWh [14]. 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 218 hydroelectric power plants in operation with total installed capacity of 26 160 MW generating an average of 52.000 GWh/year, which is 35% of the economically viable hydro potential [18]. 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 [17]. 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 [10, 14, 15].

3.2.2. Bioenergy

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. 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 2014. 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 [13-18].

3.2.3. Geothermal energy

Among the renewable energy alternatives, geothermal energy in Turkey has become very attractive. It is unfortunate that geothermal energy in direct use can only be utilized locally. But, firing fossil fuels at 1500 °C, and using the generated heat at only 50-60 °C is obviously a thermodynamic waste. Turkey has a significant potential in geothermal energy and there may exist about 2000 MW_e for electrical power generation. Turkey's total geothermal heating capacity is about 31,500 MW_{th}. At present, heating capacity in the country runs at 1220 MW_{th} equivalent to 147,000 households. These numbers can be heightened some sevenfold to 7,080 MW_{th} equal to 760 000 households through a proven and exhaustible potential in 2016. Turkey must target 1.2 million households equivalent 7,900 MW_{th} in 2020 [13-18].

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 [13-18].

Except some special applications PV installation is almost none existing in Turkey. However, solar energy is widely used for heating water [14]. 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 [14]. So far only about 1,000 MW capacity wind farms are in operation in Turkey, generating less than 0.5% of total electricity consumed. 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 [14]. Capacity is likely to grow rapidly, as plans have been submitted for just under a further 600 MW of independent facilities. At start 2015, total installed wind energy capacity of Turkey is only 3 900 MW [14, 15, 18]. 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.

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. On the other hand, 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.

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