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Energy policies for sustainable energy future in Turkey

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Abstract
As a developing country, Turkey's prosperity and welfare depends heavily on having access to reliable and secure supplies of energy. As a result, the country's future energy requirements have become a policy priority in recent years. Fossil fuels such as coal, oil, and natural gas are currently the world's primary energy sources. These energy sources have depleted in reserves in recent years and they can also cause irreparably damage to the environment such as global warming and climate change. These environmental concerns can be addressed, to some extent, through more sustainable solutions such as the use of renewable energy resources. In Turkey, the economic and environmental impacts of fossil fuels use have become hard to ignore. In recent years, Turkey has been catching up with global call to shift to renewable energy use and is now putting a focus on renewable energy in its future energy mix. The paper discusses challenges and concerns over the sustainable energy of the country.

Keywords: Renewables; sustainable energy; energy policy; bioenergy; energy governance

1. Introduction

Population and economic growth have over the years increased the demand for energy consumption and consequently put pressure on scarce natural resources such as fossil fuel sources. Estimates from the International Energy Agency (IEA), a 56 % increase in global energy consumption is foreseen by 2040 [1]. Figure 1 shows that most of the projected growth in energy consumption comes from Non-OECD developing countries [2].

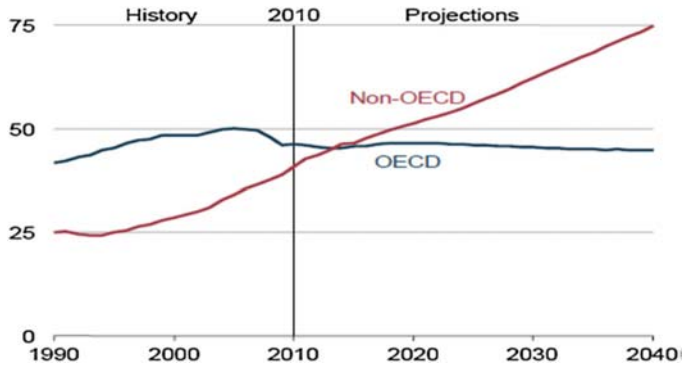

Figure 1. OECD and Non-OECD petroleum and other liquid fuels consumption. Source: Ref. [2].

Fast-paced economic growth among developing nations drives the increase in demand for fossil fuels as strong growth in income per capita raises demand for personal transportation and freight transport as well as demand for energy in the commercial and industrial sectors. Figure 2 indicates projected shares of the fuels consumption of Non-OECD countries are expected to grow substantially with Non-OECD Asian nations led by China shows the largest growth in liquid fuels consumption. The increase in demand for energy not only puts pressure on the finite natural resources but may also result in geopolitical conflicts when nations lay territorial claims in order to secure access to these resources [1-5].

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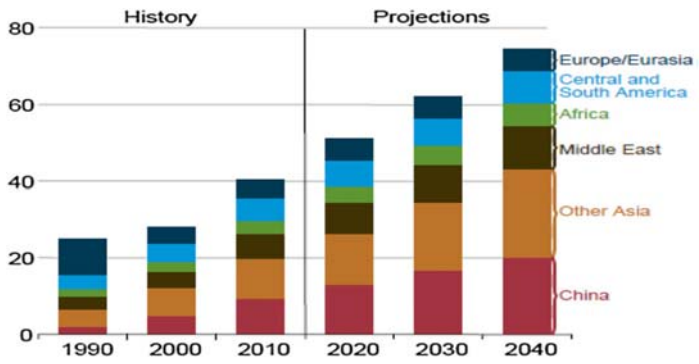

Figure 2. Non-OECD petroleum and other liquid fuels consumption by region. Source: Ref. [2].

Energy consumption followed the same structural patterns and evolution. As a result, in 2012, industry and residential sectors accounted for the lion share of total final energy consumption with about 30% each, followed closely by the transport sector (20%), the Turkish economy transformed from one focused mainly on agriculture into one oriented towards the industry and tertiary sectors [6]. In 1923, when the Republic of Turkey was established, the economic structure was completely based on agricultural production and the changes in GDP were dependent on the harvests. This structure changed in time in favor of the industry sector and the share of agriculture in GDP fell to 8% in 2012 compared to over 30% in the 1960s. Nevertheless, agriculture will continue to remain one of the important components of the Turkish economy in the future. Currently, the industry, agriculture and tertiary sectors dominate the economy, and by 2030 this structure will persist [7-9].

Turkey's energy industry is a critical sector of growth for the entire economy, contributing to one-fifth of the national growth domestic product (GDP) over the past decade and it is one of the twelve critical sectors for growth in the Economic Transformation Program [9]. As Turkey aims to become a developed nation by 2023, the country has increased its focus on securing energy through cost-effective means and diversifying its fuel supply portfolio. Total installed generation capacity at the end of 2014 was 29.1 GW. With projected GDP to grow at 5.5–6.0 % in 2023 [9], the government anticipates an additional 6 GW of new electricity generation will come online between 2015 and 2020 in order to meet the country's electricity demand [6]. Petroleum and other liquids and natural gas continue to be the primary sources of energy, contributing 40 and 36 % respectively towards the total energy consumption in 2014. About 27 % of the country's energy consumption is met by coal. Biomass and waste contribute 8 % while hydropower makes up 12 % to total consumption.

2. Energy production and consumption in Turkey

2.1. General overview

As a developing country, due to its fast growing economy and population Turkey's installed capacity has increased rapidly as shown in Figure 3. Turkey is an energy importing country and dependent on the imported energy sources as given in Table 1 [7]. Furthermore this trend seems to be continuing in the future. Energy sources in Turkey are hard coal, lignite, oil, natural gas, hydropower, geothermal, wood and wastes, solar and wind energy [6-9]. 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 biomass/wastes, solar, coal, natural gas, geothermal electricity and geothermal heat [10-20]. Turkey's various renewable energy sources represent its second largest energy source after coal. 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 2023. The largest regional hydropower project in Turkey is the Southeastern Anatolia Project (GAP). Upon competition, GAP will have an installed capacity of 7476 MW [6-9; 15-18].

Table 1. Turkey's energy situation in 2013 (Mtoe)

Energy source	Production	Consumption
Hard coal	990	17 692
Lignite	13 973	13 182
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

Mtoe: Million tons of oil equivalent
Source: Ref. [7]

Table 2. Turkey's total installed power capacity in 2013

Energy source	Amount (MW)	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

MW: Mega Watt
Source: Ref. [7]

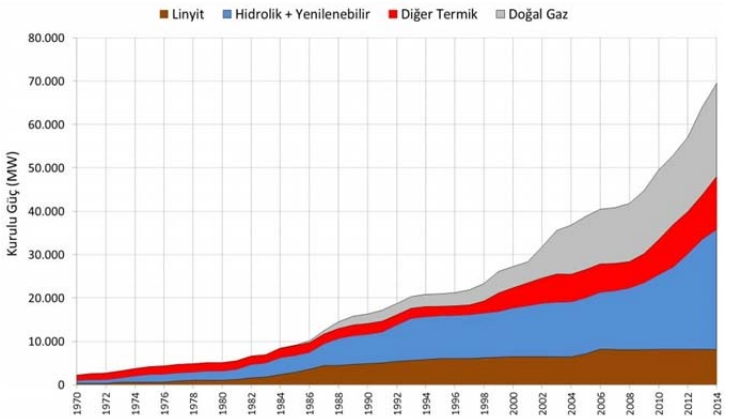

Figure 3. Turkey's installed capacity by energy sources. Source: Ref. [7].

2.2. The role of renewables

Renewable 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. The composition of renewable energy supply has changed and wind power is beginning to claim market share. The share of biomass in the renewable share is expected to decrease with the expansion of other renewable sources as shown in Table 3 and 4. These tables show that there is an important renewable energy potential in Turkey [6-9].

Table 3. Present renewable energy potential in Turkey

Energy source	Potential (MW)	Power plants With license (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. [7]

Table 4**.** Potentials for investment for renewable energies in Turkey

Sectors	Million $	Remarks
Hydroelectric	144	Economical development potential of 28,600 MW, Corresponding 100,000 GWh/a
Wind power	67	Economical development potential of 48,000 MW With wind speed > 7 m/s
Solar thermal	195	Economical development potential of 131,000 GWh/a, Corresponding to approx. 300 million m^2 collector area
Biogas	6	Agricultural residual material and dung, when used for electricity generation, 1,000 MW_e and 7,000 GWh/yr

Source: Ref. [6-9]

Turkey's theoretical hydroelectric potential is 1% of that of the World and 16% of Europe [6-8]. The gross theoretical viable hydroelectric potential in Turkey is 433 billion kWh and the technically viable potential is 216 billion kWh [7]. The economically viable potential, however, is 140 billion kWh. 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 [6]. In 2015, 166 hydropower plants are under construction 8.600 MW of installed capacity to generate average annual 20.000 GWh representing 14% of the economically viable potential [7]. In the future, 1540 more hydropower plants will be constructed in order to make use of additional 26 860 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 [8, 9].

Turkey has a great potential of biomass and bio-energy production [10, 11, 19]. 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 2013 [20]. 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 [17-20].

Among the renewable energy alternatives, geothermal energy in Turkey has become very attractive [7]. 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 [6-9].

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. Except some special applications PV installation is almost none existing in Turkey. However, solar energy is widely used for heating water [15]. 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 [7]. It is expected that there will be three 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 [6-9].

Turkey has a theoretical wind energy potential of nearly 90,000 MW [7]. So far only about 1,000 MW capacity wind farms are in operation in Turkey, generating less than 0.5% of total electricity consumed [6]. 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 [8, 9]. 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 2 968 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 [17-20].

3. Conclusions

Turkey is a developing country and has formulated a number of energy-related policies. In recent years, the country has also committed to reducing climate change and promoting sustainable development. This is evidenced from a wide-range of initiatives and policy implementation from a policy of heavy reliance on fossil fuels to those promoting renewable energy in energy generation mix. Key institutions, policy drivers, and legislative frameworks have also been put in place to facilitate the implementation of these policies. Although these policies and initiatives provide significant motivation and interest for the development and utilization of renewable energy and energy-saving technologies, the policy frameworks and the institutions governing these policies are at best constrained with lack of capabilities and abilities to deliver the intended objectives of these policies and action plans. This is partly due to the lack of coordination and consistency in policy framework and technical as well financial challenges faced by key players in promoting the growth of renewable energy and green technologies in Turkey. The government and its agencies should look across these policies so that they can maximize positive synergies where possible to avoid redundancies and fragmented authoritarianism when they formulate future energy policies.

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