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The increase of exploitability of renewable energy sources in Turkey

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Abstract
Turkey is rapidly growing in terms of both its economy and its population. In parallel, its demand for energy is increasing fast. Energy is one of Turkey's most important development priorities. Today, Turkey's economy is mainly dependent on oil, gas, coal, and electricity. Turkey's energy production meets only a part of its total energy consumption and thereby is an energy-importing country. On the other hand, Turkey has a large potential for renewable energies. The most important renewable sources are wind, biomass, hydro, solar and geothermal. Turkey would have to commit to the development and implementation of renewable energy technologies and energy conservation. The implementation of renewable energy technologies would reduce the current national and global environmental problems as well as national energy insecurity associated with the production and use of fossil energies. The article stresses the significance of the use of renewable energy sources (RES) regarding the fact that the climate changes are a real problem and RES are a real solution. The article also shows the potential of biomass, solar energy, hydro energy, wind energy, and geothermal energy, as well as the actual state of exploitability of these RES in Turkey. There are identified barriers to RES implementation and proposed measures to overcome them. There are present strategies for improvement and an increase of exploitability of RES potential in compliance with the world policy in this regard. The aim of this article is to point out the necessity of creating an enabling environment for promoting RES and the gradual removal of barriers to stronger penetration in the energy market.

Keywords: Sustainable energy; exploitability; renewable energy; climate change; Turkey

1. Introduction

Protection of global climate, valuable sources saving and feasible development in the whole world are important challenges which must be overcome in this century [1-3]. The main requirement for achievement of the said objectives is the change of awareness of energy as a source [4-6]. Fossil fuel reserves are limited. Statistical reserves of oil are calculated to be sufficient for some 30 years more, gas reserves for about 60 years and coal reserves for about 200 years more. The increase in the price of fossil fuels, emissions of carbon dioxide and other gases that cause the greenhouse effect and impacts climate changes will make people reduce the energy consumption [7-9]. These climate changes themselves will significantly determine energy policy in the world in the course of the 21st century [10-14].

Energy security may be defined as resilience to disruptions in energy supply. In Turkey, supply security discussions focus mostly on the availability of energy resources. Turkey's import dependency in primary energy stands at 75%. In Turkey, 98.6% of natural gas, 93% of oil and 92% of hard coal consumption is derived from imports [10]. This puts Turkey in a vulnerable position in the face of price fluctuations and probable supply disruptions in the import of fossil fuels due to political, logistical or other reasons [16-18].

For Turkey, achieving the twin goals of satisfying increasing power demand and reducing fuel import dependency is crucial to sustaining economic growth without increasing dependence on natural gas imports [18]. Energy imports is the item that has the most negative impact on the current account deficit of Turkey, and the share of the power sector in

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energy imports is around 40% [15]. According to the Ministry of Energy Natural Resources (MENR), Turkey's installed capacity potential for hydropower, wind and geothermal are 36 GW, 48 GW and 2 GW, respectively. The country's solar energy potential is calculated as 380 billion kWh of electricity per annum, while its biomass potential is 1.3 billion kWh of electricity per annum [15-18].

2. Renewable energy policy targets

All EU member states have recognized the importance of the integration of the RES in the energy sector for reasons related to environmental protection, security, diversification of energy supply, and to social development [5]. As indicated in Table 1 from about 118 million tons of oil equivalent (Mtoe) at present, the EU will see a rise to roughly 1,000 Mtoe of renewable energy by 2050, an increase of more than 88% of current renewable energy deployment within 40 years [3-5]. On the other hand, all member countries of the EU have the obligation to increase the share of renewable energy sources in their electricity production and to set their objectives such as how many renewable energy sources in relation to the total consumption they want to develop in the following period [4].

Table 1.Contribution renewable energy consumption in EU region (Mtoe)

Renewable Energy Sources (RES)	2014	2020	2030
Wind	16.2	72	133.5
Hydro	50.4	34.2	38.5
Photovoltaic	1.2	48	116
Bioenergy	130.6	226	359.1
Geothermal	3.2	35.5	188
Solar Thermal	2.1	70	122
Concentrated solar power (CSP)	0.6	12.1	33.1
Ocean	0.1	1.5	14
TOTAL RES (Mtoe)	204.4	499.3	1,0004.2

The goal of the Turkish Energy Sector Development Strategy is to build a sustainable energy system with a balanced development of relations between environmental protection, competitiveness, and security of energy supply [10]. It will enable energy supply to Turkish citizens and the economy, under the conditions of an uncertain situation in the global energy market and with scarce local energy resources. One of the specific tasks of the strategy is to set targets for RES in accordance with the EU approach and targets as outlined in the EU energy and climate change policy package. Basic objectives of the program in the RES field are: more efficient use of domestic potentials in energy production, reduction of greenhouse gas emissions, the reduction of fossil fuels imports, local industry development, and new jobs creation [10, 13, 15, 18].

In 2013, renewables accounted for 29% of Turkey's power generation [10]. The target for 2030 is to increase the share of renewables in power generation to 35%. Toward this end, Turkey intends to utilize all technically and economically feasible hydropower capacity (around 40 GW) and reach 20 GW wind, 3 GW solar and 600 MW geothermal installed capacity. The MENR analysis indicates that by 2030, Turkey could generate 50% of its power from renewables. For achieving this target, installed capacity of wind and solar power should be substantially increased. The MENR envisages that by 2030, installed capacity of solar power and wind power could reach 24 GW and 27 GW, respectively [10, 13, 15]. Table 2 shows Turkey's energy production and consumption in 2013 [10].

Energy policies in Turkey should focus on the enhancement of renewables and 50% renewables in power generation by 2030 should be the new minimum target (see Table 3). This shall serve as a powerful message to investors, encouraging them to allocate required funds for investments in renewable energy technologies, particularly wind and solar. On the other hand, the strategy of energy development until 2030 in Turkey predicts that the share of new RES without large hydro power stations, in total primary energy consumption, should rise from 2.4 to 12.6% in 2030 while the share in total final energy consumption should rise to 2.5–5.4% in the period 2014–2030. Proposed measures which would be taken to increase the utilization of renewable energy resources in Turkey are [10, 13, 15]:

- Financial measures: Aimed to promote the

implementation of sustainable renewable energy through the establishment of appropriate financial instruments.
- Legal measures: Aimed to develop, implement, maintain and continuously improve an effective legislative system to promote the implementation of renewable energy.
- Technology development: Aimed to promote, enhance and develop technologies for the implementation of sustainable renewable energy.
- Capacity building and education: Aimed to develop mechanisms to raise public awareness of the benefits and opportunities of renewable energy.

Table 2.Turkey's energy production and consumption 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

Table 3.Installed electricity generation capacity in Turkey (MW)

Energy sources	2014	2018	2023	2030
Hard coal	5 005	6 672	8 755	12 257
Lignite	9 288	12 380	16 245	22 743
Oil	737	854	1 000	1 000
Natural gas	24 672	24 818	25 000	25 000
Nuclear	0.0	0.0	9 600	12 000
Hydropower	23 660	29 146	36 000	36 000
Geothermal	340	456	600	1 000
Wind	4 485	11 400	20 000	38 000
Solar	320	1 514	3 000	16 000
Biomass	156	540	1 000	1 000
Total	68 658	87 743	121 200	165 000

3. Renewable energy potential and utilization in Turkey

Projections are important tools for long-term planning and sustainable energy policy settings [2]. Renewable energy sources (RES) are the chief support of energy independence of Turkey in the future [8]. Technically usable energy potential of the said RES in Turkey is very important and has been estimated to over 40.3 Mtoe per year, which makes about 30% of the total primary energy consumption. At the moment, the share of energy from RES in Turkey is about 36% (including large hydro). Beside hydro energy and a limited quantity of geothermal energy and biomass, other renewable energy sources are not used. Turkey is considered to have the potential to produce 42.3 Mtoe from renewable energy sources. Having in mind that the domestic energy production in 2014 was 13.9 Mtoe, it can be concluded that Turkey could produce a half of its primary energy from RES. Table 4 shows Turkey's renewable energy potential in 2014 [10].

3.1. Biomass

Energy need has been increasing day by day with population increase and developing technologies. This situation leads the need for finding new energy sources. For the last decades, biomass energy has been considered as an alternative to available energy sources. Biomass energy has found great opportunities for being environmentally friendly sustainable energy source, providing safe environmental management and targeting development throughout the world. For this reason, utilization of biomass energy has gained importance as an energy source in Turkey.

Table 4.Turkey's renewable energy source potential in 2014

	Hydropower	Wind energy	Solar energy	Biomass	Geothermal
Installed power (MW)	23 641	3 630	40.2	288.2	405.1
Electricity generation (GWh)	40 396	8 385	-	1 172	2 250
Heat (Mtoe)	-	-	0.796	n.a	0.05
Target in 2023 (MW)	36 000	20 000	5 000	1 000	1 000
Potential	160 TWh/y	48 000 MW	1500 kWh/m^2-y	20 Mtoe	2 000 MW

Mtoe: Million tons of oil equivalent

In the area of biomass combustion for combined production of heat and electricity, Turkey has significant possibilities comprising the use of briquettes and pellets. The potential of biomass in Turkey of 36.4 Mtoe is comprised of agricultural production (about 60%) and forest biomass (about 40%). Turkey, and especially its northern region has a relatively big potential of biomass which is produced as a surplus in primary agricultural production. The total biomass production from annual crops in Turkey rises to over 12.5 million tons per year [2, 10, 17].

3.2. Hydropower

The most important RES of Turkey is hydroelectric power potential (about 160 TWh/yr) with about 40,000 GWh exploited so far, so the rest of the hydroelectric power potential which is technically usable in Turkey is about 67,000 GWh placed in about 1270 locations [10]. This potential is mostly in the South-Eastern Anatolian (GAP) region (22,300 GWh), the Çoruh river basin (14,900 GWh), and the Seyhan and Ceyhan rivers (11,000 GWh) for building individual power stations with a capacity bigger than 10 MW and an annual production of about 8,200 GWh. In about 900 potential locations on the rivers in Turkey, including small rivers, the building of small hydroelectric power plants (up to 10 MW), has been established with possible production of about 12,800 GWh per year. When establishing possibilities for exploitation of the biggest part of the rest of the hydroelectric power potential, one should consider a crucial impact of non-energetic criteria related to multipurpose exploitation of waters and political agreements on sharing hydroelectric power potential with neighboring countries [10, 13, 15, 17].

3.3. Solar energy

Serbia has a very favorable natural potential of about 1.3 Mtoe per year and a special convenience which is characterized by seasonal complementarity of solar and wind energy potentials. The average intensity of the solar radiation in the territory of the Republic of Turkey ranges from 1.4 kWh/m2 per day in the north to 1.9 kWh/m2 per day in the south during January, and from 6.4 to 8.6 kWh/m2 per day during July. Yearly average value of global radiation energy for the territory of the Republic of Turkey is 1,500 kWh/m2 in northwest Turkey and 1,850 kWh/m2 in southeast Turkey, while in its central part it is about 1,600 kWh/m2 per year. The lowest values in Turkey match the highest values in Germany which is far ahead of the others in solar energy exploitation [10, 15, 17].

According to the 2013 census there are about 8.5 million households in the Republic of Turkey. If on average every fifth household installed a 4-6 m2 surface solar collector, about 4,150 GWh of thermal energy per year would be produced which could mainly replace electricity consumption and partly replace fossil fuels used for sanitary water heating, which would insure a reduction in carbon dioxide emission by 6.3 million tons per year [17].

3.4. Wind energy

Wind energy is the most economical RES used at the present. Actually, expenses for wind energy exploitation have been reduced so much that they rival many traditional technologies for energy production. Wind strength in the windiest area of Turkey is comparable to the wind strength in windiest areas of Europe. Technologically justified potential is about 17 Mtoe. Turkey has made a respectable amount of investment on wind energy sector during the last two decades. As of 2013, the installed capacity of the country has reached to 2,760 MW and it is scheduled to reach 20,000 MW by the end of 2023, which will be centenary of the Republic of Turkey. The most attractive sites are the Marmara Sea region, Mediterranean Coast, Agean Sea Coast, and the Anatolia inland [10, 15]. The highest wind speed values given in the literature are 5.1–5.2 m/s in Bandırma, 6.3– 7 m/s in Bozcaada, 6.4 m/s in Karaburun and Karabiga 7.1 m/s in Nurdagı, 7 m/s in Senköy. While the average density of wind power is below the 40 W/m2 in 89.3% of Turkey's total domain, it is over 40 W/m2 in 10.7% and it exceeds 100 W/m2 in 0.8%. There are also some regions of Turkey where average density of wind power reaches 294.1 W/m2 level [13, 15]. The most important factor which should be considered

when building wind energy plants is the speed of the wind in the particular location. In order to consider a location, the lowest yearly speed of the wind should range from 4.9 to 5.8 m/s [10, 13, 15, 17].

3.5. Geothermal energy

Turkey has drilled around 1200 geothermal wells for geothermal electricity production and direct use applications in these geothermal sites since 1960. About one-third of these well-bores have been drilled since 2009 [14]. As of 2013, 60 new geothermal projects have been completed or they are currently under construction in Turkey [15]. The western part of Turkey is an area of plentiful geothermal activity that undergoing significant exploration and exploitation, but with relatively little volcanism. With the new additions, there are more than 290 geothermal sites discovered in Turkey and about 95% of them are low-to-medium enthalpy sites mostly proper for direct use applications [14]. Even though geothermal energy potential of Turkey was theoretically estimated as 31,500 MWt and recently increased to 60,000 MWt, the proved potential by drilling activities (4209 MWt) and natural discharges (600 MWt) is only 4809 MWt. In 2014, 58% of the proved capacity (2705 MWt) is used for geothermal heating, consisting of residence heating (805 MWt), greenhouse heating (612 MWt), thermal facilities heating (380 MWt), balneological use (870 MWt) and heat pump implementations (38 MWt). The most significant change in the activities took place in the exploration of geothermal resources for electricity production. Present installed capacity is 162.2 MWe and it is expected to become above 397 MWe by the end of 2015. The available potential of existing geothermal sources could be used for thermal energy production in various activities: in spas for therapy purposes in swimming pools, for sanitary water heating or room heating, in farms for room heating, in agriculture for greenhouse heating, fish farms [10, 13, 15, 17].

4. Barriers to RES implementation

Renewable energy sources offer a unique opportunity to achieve the transformation needed to ensure energy supply security and effective climate change mitigation [4]. However, like all energy projects, renewable energy projects also have some negative environmental impacts. Environmental and social risks arising from the implementation of renewable energy projects, especially hydroelectric power plants, are well known by most stakeholders. In order to eliminate the risks, these projects should follow strict environmental criteria from the planning stage to the operation stage and be subject to strategic environmental impact assessment processes. Necessary measures to avoid, mitigate and compensate negative environmental and social impacts of renewable energy projects should be taken. In this respect, social and environmental impact assessment processes should be implemented diligently. There are significant barriers to the further implementation of renewable energy that need to be addressed. The key issues include [1-5]:

- Many renewable energy technologies remain expensive, due to higher capital costs, compared to conventional energy supplies for bulk energy supply to urban areas or major industries.
- Implementation of renewable energy technologies needs significant initial investment and may need support for relatively long periods before reaching profitability.
- There is a lack of consumer awareness of the benefits and opportunities of renewable energy.
- The economic and social system of energy services is based on centralized development around conventional sources of energy, specifically electricity generation, gas supplies and, to some extent, liquid fuel provision.
- Financial, legal, regulatory and organizational barriers need to be overcome in order to implement renewable energy technologies and develop markets.
- There is a lack of non-discriminatory open access to key energy infrastructure such as the national electricity grid, certain liquid fuels, and gas infrastructure.

5. Conclusions

By 2050 renewable electricity will provide 100% of the world´s power demand and certainly top it in the “aggressive efficiency” scenario. Considering the detailed analysis of potentials and objective restrictions in using RES in Turkey, it can be concluded that there are enough potentials available to abandon using fossil and nuclear reserves as energy sources. Turkey’s energy market is going

through a rapid change. Over the last decade, power demand has grown by 70%; this is a trend that is expected to continue. Turkish government is compelled to make critical decisions: on the one hand it has to meet the power demand, on the other it has to minimize dependency on energy imports. Turkey's current energy strategy and policies aim to utilize primarily coal, secondarily nuclear and fi nally renewable energy sources.

By 2030, Turkey can meet almost 50% of its power demand from renewable energy resources; mainly solar, wind and hydropower. A renewables-based energy strategy could be cost-comparable to a coal-based strategy. Moreover, a renewables-based strategy could allow Turkey to anchor its GHG emissions from power generation slightly above current levels and limit the pressure on its foreign trade balance.

Strategies and tactics needed to begin with RES exploitation should be considered, because only RES can guarantee long-term feasible development and survival of life on the Earth and can provide energy independence. In conclusion, to facilitate faster development of RES, the necessary measures to encourage renewable energy in Turkey are:

- Adopting international standards and methodology for determining the potential of renewable energy.
- Development of adequate information and statistics system for RES.
- Joint activities of various state institutions in the energy sector, agriculture, construction, education, science.
- Promotion of results of using renewable energy at regional and local levels.

Further technological development and market introduction of renewable energies is the challenge of the future. International cooperation is important to make such a policy successful for the benefit of mankind. Exceptionally rigorous government measures, involving strong financial incentives and/or regulations, would be needed to effect a rapid expansion of renewables-based generation.

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