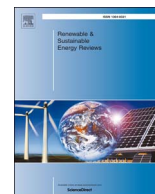




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The role of renewables in increasing Turkey's self-sufficiency in electrical energy

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ABSTRACT

Imported fossil fuels dominate Turkey's total primary energy supply and this situation poses a significant barrier to the country's self-sufficiency. However, Turkey can increase its self-sufficiency by tapping into its rich but under-utilized potential of renewable energy sources (RES). Looking into the data from the period between 1980 and 2014, this study scrutinizes Turkey's self-sufficiency in total primary energy generation and electricity generation and changes that could occur depending on energy policy goals. Also, this study discusses the implications of the increasing utilization of coal reserves in relation to the escalating concerns about climate change. Given the important role of RES in ensuring self-sufficiency, Turkey's rate of utilization of its RES and the possibility of its realizing the Vision 2023 energy targets have been evaluated. The utilization and attainment rates based on the country's 2023 energy targets for all RES reveal that Turkey is far behind the intended progress rate regarding the utilization of RES, except for hydro and geothermal. Our analysis shows that Turkey's self-sufficiency in total primary energy generation and in electricity generation has been deteriorating in the last decades. The rate of self-sufficiency was %54.42 in 1980. However, by 2014 this rate had gone down to %25.05. Turkey's self-sufficiency rate in electricity generation dropped from 77% in 1980 to 37% in 2014. The main reasons for this change are the high energy demand, increasing reliance on imported natural gas and hard coal, and low utilization of RES. Therefore, in order to achieve Vision 2023 RES targets and ensure self-sufficiency in the long run, we suggest the introduction of new energy policy instruments for RES.

1. Introduction

Turkey has experienced a considerable surge in energy demand in recent years, which has had a major impact on its energy supply [1]. As a consequence, the country has become increasingly dependent on energy imports, to the extent that currently about 75% of the total primary energy supply (TPES) is being met by energy imported from other countries [1], natural gas and oil having the highest share in energy imports. In 2014, it had to import nearly 92% of its oil and 99% of its natural gas. Turkey's hard coal import volume has also grown in recent years. The country imported nearly 95% of the hard coal it used in 2014 [1]. As a result, energy security has been a key priority of Turkey's energy policy.

Turkey's total electricity demand has been increasing rapidly. The country's total net electricity generation significantly increased from 23.275 TWh in 1980–250.436 TWh in 2014 [2,3], while the Gross Domestic Product (GDP) increased from 67.46 billions of dollars to 800.11 billions of dollars within the same time period [4]. When the figures concerning Turkey's total net electricity consumption between

1980 and 2014 are analysed, it can be seen that there has been a steady increase in consumption, except for some short periods of decrease in the aftermath of economic crises [3,5,6]. The total net electricity consumption was 554 kwh per capita in 1980, which increased to 3288 kWh per capita in 2014 [3,6–8].

Electricity from hydroelectric power plants (HPPs) accounts for a significant share of Turkey's total energy generation from renewable energy sources (RES). However, at present, most of Turkey's electricity generation comes from fossil fuel power plants (FFPPs). The share of electricity generation from FFPP has increased from 51% in 1980 to 79% in 2014 [2,3]. Although Turkey does not currently generate any electricity from nuclear power plants (NPPs), the government has been advocating the construction of NPP to diversify Turkey's electricity supply portfolio. In May 2010, an intergovernmental agreement was signed between the Russian Federation and the Republic of Turkey, and the construction process of the first NPP of Turkey commenced in the Akkuyu district of Mersin province. The construction of the marine hydro-technic structure of the plant started in 2015. However, it should be noted that the Akkuyu NPP, consisting of four power units with a

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total capacity of 4800 MW, has not yet been granted a production license.

Turkey has a large potential for RES [9–14]. The country's realizable renewable energy potential is equal to 13% of EU-27's total potential, and in this respect Turkey ranks fifth after Germany, France, Spain and the UK. In numbers, Turkey's total electricity generation potential from RES is 240,165 GWh/yr for 138,000 MW economic potential. It has several different types of RES: 144,000 GWh/yr hydro (for 36,000 MW), 14,665 GWh/yr geothermal (for 2000 MW), 60,000 GWh/yr wind (for 48,000 MW), 14,000 GWh/yr biomass (for 2000 MW), and 7500 GWh/yr solar (for 50,000 MW) renewable energy potential [15,16]. Studies on Turkey's RES document the level of RES potential for various RES types and emphasize their important role in finding a solution to the current economic, environmental and energy problems of Turkey [10,13,14,17–22].

There is a global trend of using more RES. Globally, increasing greenhouse gas emissions, the instability of fossil fuels prices, and rising concerns over energy security encouraged many countries to increase their investment in RES [21]. Maturity in developments of renewable energy technologies and decrease in the costs of RES make these sources more acceptable worldwide. Large initial investments of some RES had an adverse effect on market entry. However, in recent years, the costs of renewable technologies have been following a downward trend. There is a recent cost reduction trend for RES technologies in the world, and it is anticipated that solar and wind power technologies will see further decline by 2025 [23]. When the external cost of electricity generation is included while calculating electricity generation costs, electricity generation from wind and solar power is found to be cheaper than generation from coal in Turkey and the costs of RES continue to fall [24].

RES incentive mechanisms are incorporated into markets to compensate for cost-related barriers and to increase RES deployment rate. Financial incentives are important policy instruments to encourage RES investors. By deploying these incentive mechanisms, governments indirectly aim to decrease CO₂ emissions and improve energy supply security [25]. In Turkey, the level of financial incentives and appropriate credit opportunities for domestic entrepreneurs is lower than some European countries [13].

Coal is still a widely used energy source worldwide [26], and it is the main domestic fossil energy source of Turkey. A large majority of Turkey's coal reserves consist of lignite. However, the lignite found in the country has low calorific value and high amount of humidity, sulphur and ash. Turkey has 1.5% of the world's coal reserves, while its lignite reserves represent 6% of the global lignite deposits [27]. As the major domestic energy source of Turkey, lignite constituted about 12% of the TPES in 1980 and in 2014 [1]. The second most important coal type is hard coal, which is followed by other types of coal found in Turkey's much smaller reserves [27]. Energy sector's high share in GHG emissions, which have been steadily increasing, is an alarming global environmental issue and therefore requires that Turkey's coal reserves be handled in the most efficient and environmentally friendly way possible. Because of its physical and chemical properties, lignite needs special attention to ensure its utilization in an efficient and environmentally friendly manner [21,22,28].

Governments support coal industry by providing subsidies to coal. Global fossil fuel subsidies amounted to US\$ 548 billion in 2013. The amount of fossil fuel subsidies were over four-times the value of RES subsidies in the same year. Turkey's coal subsidies amounted up to around US\$ 300 million in 2013. Through a simple elimination of the coal subsidization scheme, Turkey can reduce its aggregate GHG emissions by as much as 5% without a significant loss in its GDP. Coal subsidy phase-out would decrease CO₂ emissions and fiscal burden, and it offers prospects for generating green jobs and green energy [26]. It should also be pointed out that a considerable body of literature emphasizes the harmful environmental impact of coal utilization and re-

commends that coal be replaced by RES as a more efficient and effective solution to reduce the GHG emissions of Turkey [17–19,27].

Turkey does not have enough indigenous natural gas and oil reserves to supply its increasing fossil fuel demand. Turkey's dependence on energy imports places a big burden on its foreign trade deficit. This dependency, on oil and gas in particular, forms the backdrop for policy concerns related to energy supply security. Energy supply security is defined as “the uninterrupted availability of energy sources at an affordable price” [29]. To ensure energy supply security, the gap between demand and supply should be reduced; energy efficiency indicators should be improved; the optimal energy mix should be achieved; and vulnerability to energy price fluctuations should be reduced [9]. Energy diversification can be achieved through the utilization of both RES and non-RES as well as multiple carriers. RES are an important focus in energy diversification due to the scarcity associated with non-RES besides other problems associated with non-renewable energy sources mentioned above.

Reaching energy self-sufficiency and sustainability is one of the most important policy instruments to ensure energy supply security [30,31]. In view of environmental and economic impacts of coal utilization, RES appears to be one of the most efficient and effective solutions for becoming more energy self-sufficient than ever before.

Energy self-sufficiency rate is defined as the ratio between domestic production and TPES in a given year. In 2014, the level of self-sufficiency in OECD countries was estimated as 78%, and for the EU countries it was 47% on average [32,33]. Better utilization of RES and domestic sources could ensure self-sufficiency in the energy sector. Fossil fuels are finite sources and can irreparably harm the environment. For these reasons, the utilization of RES in the energy sector is one of the best methods to increase energy self-sufficiency rates and to achieve the rapid emission reductions that need to be set as a priority goal. Deployment of RES reduces GHG emissions, increases energy self-sufficiency, and consequently increases energy supply security [17,18,30]. Achieving energy self-sufficiency based on renewables would also enable significant reductions in environmental pollution [17,34–36]. As a result of the developments in the use of RES in meeting the rising worldwide energy demand, many successful projects have been carried out in order to achieve energy self-sufficiency through RES [37,38].

In this study, Turkey's self-sufficiency in TPES and in electricity generation has been analysed for the period between 1980 and 2014. The increasing utilization of coal, which is the main indigenous fossil fuel of Turkey, has been discussed against the backdrop of rising concerns about climate change. Considering the negative environmental effects of coal and important role of RES in ensuring self-sufficiency in energy, more attention has been paid to RES as Turkey is a rich country in terms of the variety and potential of RES.

Utilization and attainment rates of RES in Turkey with respect to achieving self-sufficiency in electrical energy generation have been determined. Having more information on the actual and potential shares of RES in TPES and electricity generation will help Turkey set more appropriate energy policies.

The structure of this article is as follows: Section 2 analyzes TPES by source types over the period of 1980–2014. Also, future TPES scenarios with respect to Turkey's 2023 energy vision are given in this section. In Section 3, utilization rates of primary energy sources for electricity generation are defined. In Section 4, changes in GHG emissions and the role of coal in increasing GHG emissions are discussed. In Section 5, the utilization rates of RES in Turkey and attainments regarding the 2023 energy policy targets are analysed. In Section 6, Turkey's energy self-sufficiency and self-sufficiency in electricity generation rates between 1980 and 2014 are calculated, and this is followed by an analysis of the economic implications of importing energy. Finally, in Section 7, some general conclusions are drawn and several recommendations are made.

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