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Energy diversity and nuclear energy for sustainable development in Turkey

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ABSTRACT

This study aims to investigate the effects of using nuclear and renewable energy on the economic growth of Turkey. In the last fourteen years, average growth of Turkish economy is up about 4.85%, annually. In relation to this, Turkish electricity demand has increased annually about 6%–8% during this period. This demonstrates the need for a sustainable energy policy to meet energy demand. Electricity sources of Turkey are mainly thermal and renewable. Natural gas and coal dominates to the other thermal sources. Turkey imports substantial amount of natural gas and coal mainly from Russia, Iran etc. This external dependence on energy resources has led to a continual increase in the current account deficit of Turkey. Therefore, Turkey needs to reduce its external dependency and find some new sustainable energy sources. Nuclear power generation in Turkey will reduce the dependency on energy generation in a significant way. In this study; Turkey's established power capacity and electricity generation have been investigated. The current state of the renewable energy resources of the country and the potential resources available and the nuclear energy in Turkey have been examined in detail.

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1. Introduction

Energy is one of Turkey's most important developmental priorities. The level of development of an individual country is directly related to the economic and social level. Energy is one of the most important factors that play an active role in achieving this level of development. Energy, which is the condition of sustainable development, can only make great contributions to industrialization and the overall development of communities, given the reliable economic conditions and environmental considerations. In parallel with population growth, industrialization, urbanization and technological developments in the world, energy demand is rapidly increasing. The amount of energy use is one of the important indicators of economic magnitude, quality of life and social development in developing countries. Rapid population growth and economic development in the country caused an increase in energy demand [1]. Turkey is largely dependent on fossil fuels such as petroleum, natural gas and coal, which make up a significant part of energy consumption. The share of these resources in energy consumption is about 57% [2]. Turkey's energy resources, especially oil and natural gas, are very limited and dependency on imports is very high. At the beginning of the 21st century, Turkey was unable to meet its energy needs due to the growing population and industrialization, thus the gap between energy production and energy consumption was opened. Under these circumstances, effective use of their resources has become increasingly important. Turkey still supplies about 60% of its main energy consumption from imported energy sources. This percentage is 56% for electricity production. Turkey spent about $ 60 billion to meet energy demand in 2015 and this energy cost is constantly increasing. This payment is expected to reach about 70 billion USA dollars in 2017 if oil prices does not over $ 50–60 per barrel and gas prices does not rise $500 per m^3. Currently, Turkey has significant quantities and a diverse range of renewable energy sources. Taking this into consideration, renewable energy sources can be considered as one of the most effective solutions for clean and sustainable energy in Turkey.

In this study, the latest developments in Turkey's energy policy are examined and the energy use of the sector is analyzed. It has been investigated whether existing policies provide a sustainable vision with expensive imported natural gas. This study also deals with energy politics in the context of Turkey's new energy geopolitics. In addition, Turkey's nuclear energy policies have been extensively addressed in the cause and effect relationship. In this context, the impacts of nuclear power plants on the living

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ecosystem and the environment have been discussed and the potential risks posed by these power plants have been addressed.

2. Turkey's energy sources and Russian relations

The economic and social development observed in Turkey in recent years has accompanied an increase in energy and especially electricity demand. Turkey has a wide range of energy sources such as coal, lignite, asphalt, oil, natural gas, hydro, geothermal, wood, animal and plant wastes, sun and wind. It is clear that the oil, natural gas and coal used in electricity generation in the country cannot meet the increasing energy demands [3]. Turkey is not currently equipped with a nuclear power plant. But very interestingly, public opinion has been witnessing heated discussions on nuclear energy since the 1970s. Transition to electricity generation using nuclear power plants is one of the vital factors to reduce the dependency of the country on natural gas to Russia and Iran. There have been many attempts to establish and use nuclear power plants in Turkey. But all of these attempts have been failed because of the pressure of environmentalists, high investment and operating costs. In May 2004, technical reviews resumed under the supervision of the Ministry of Energy and Natural Resources. The "Nuclear Energy Act", which aims to establish three nuclear power plants of 5 thousand megawatts between 2010 and 2020, was enacted on January 17, 2007 [4]. In summary, the current government appears to be committed to building three nuclear power plants. It is planned to build two power plants in the short term. In this regard, an important public opinion was formed throughout the country. One is on the north coast of Turkey near a city named Sinop. The other one is decided to be located in the south coast of Turkey near a southern city of Akkuyu. Sinop nuclear project will have a capacity of 4800 MWe, ATMEA1 reactor type with a 60-year lifetime and is expected to have an overall cost about $22–25 billion. Total investment cost of the Akkuyu nuclear project is expected to be $20 billion. Akkuyu plant will have 4800MWe, VVER-1200 (AES-2006) units with a 60-year lifetime. Third unit will be considered after progress has been made on the first two. A Russian consortium for Akkuyu was chosen to build the first four reactors on a build-own-operate (BOO) model and a Mitsubishi-Areva consortium is in discussions for the next four reactors.

Since 2000, very strong trade, tourism and economic relations have been established between Turkey and Russia in the diplomatic sense. Unfortunately, on November 24, 2015, the Turkish war jet had dropped the Russian SU-24 jet on the Syrian border. This situation caused a great diplomatic crisis between countries. This crisis led to the formation of major breaks between the two countries in every sense. However, despite all these negativities, Russia did not reduce natural gas flow and used it as a threat against Turkey. Such a crisis could bring very serious problems in the country when it was thought that 55% of Turkey's natural gas consumption was supplied from Russia. This incident showed that how fragile and sensitive balances in Turkey is in terms of energy. As a result, the president of Turkey made a visit to Russia on August 9, 2016. This visit started a new era between the two countries. After this visit, relations quickly returned to normal. Moreover, on 10 October 2016 the agreements were signed between the two countries regarding the realization of the "Turkish Stream Project".

Turkey has rich renewable energy sources thanks to its geographical location [5]. Installed capacity in Turkey by sources also can be seen in Fig. 1. Turkey is located in a humid and warm climate zone, which includes most of East-West Asia and Europe. Turkey's national energy production is currently unable to meet the supply of energy and the gap between supply and demand is increasing. This situation encourages the government to be aggressive in using energy resources. However, the negative impacts on the environment and ecology of the new facilities, which are taken into operation, bring new debates. The negative effects of fossil fuel consumption on environment and ecology are also a separate problem. In this sense, air pollution is an important environmental problem as shown by the academic studies in this subject. It is envisaged that carbon emissions will increase significantly if existing policies continue [6]. At present, the most important domestic fossil energy source in Turkey is coal for many years. Turkey is the world's largest producer of lignite coal after China. Turkey accounts for about 24% of its energy needs from this source. Coal is generally used in electricity generation, cement and iron and steel industry. This source comes mainly from Southwest and Southeast Afsin-Elbistan basins where 7339 million tons are economically available. The government plans to increase the coal supply from 20.1 Mtoe in 1999 to 118.4 Mtoe in 2020 [7]. Mentioned before, Turkey has a large amount of renewable energy reserves. Domestic and renewable energy sources are the key to sustainable energy not only for Turkey but also for the entire world. Therefore, Turkey should develop medium and long-term new energy strategies to reduce the share of fossil fuels in energy consumption [8]. Turkey is some country rich in renewable energy resources. The energy production made with these sources constitutes about 14.4% of the total energy used [7].

Hydroelectric energy is Turkey's main renewable energy source. 591 hydroelectric power plants are in operation and their total installed capacity is about 26,503 MW. The rate of this power to established power is about 34%. Electricity generation from these plants is approximately 70 GWh [9]. In addition, geothermal energy beneath the surface of the western Anatolia; wind and solar energy available at western, eastern, and middle Anatolia and nuclear energy by abundant thorium and uranium ores lying throughout Anatolia and hydrogen potential accumulated at the submarine of Black Sea are the other potential renewable energy sources in Turkey. In this regard, the major areas of renewable energy research in Turkey are hydropower, solar thermal, wind, geothermal, photovoltaic energy, and new programs such as hydrogen energy, fuel cells, etc. [10].

3. Electricity generation characteristics and supply projections

Turkey is one of the important energy consumers of the world with its developing economy. Turkey's Total Primary Energy Supply (TPES) was 129.7 million tonnes of oil-equivalent (Mtoe) in 2015, representing an increase of 54% from 84.2 Mtoe in 2005 (Fig. 2). Likewise, the share of the coal is reported to be approximately 29%, by 2015, the share of hydro and renewable energy resources in total resources is about 10% [11].

Given the situation in the energy sources of electricity, the dominance of fossil fuels here is clearly visible. The electricity demand of Turkey has increased significantly in the last 15 years, as shown in Fig. 3. This demand has reached about 264 TWh in 2015, which is expected to reach 416 TWh in 2023, according to estimates of the Ministry of Energy and Natural Resources. Electricity from renewable sources amounted to 83.8 TW-hours (TWh) in 2015, or 32.3% of total generation. Renewables in electricity generation include hydropower (66.9 TWh or 25.8% of total electricity generation), wind power (11.6 TWh or 4.4%), geothermal energy (3.4 TWh or 1.3%), biofuels and waste (1.5 TWh or 0.6%) and solar power (0.4 TWh or 0.2%).

In addition, Turkey's share of renewable energy sources in electricity generation over the years is given in Table 1.

As seen here, the usage rate of renewable energy sources has increased by about 400% in the last 25 years. Among the IEA member countries, Turkey has the thirteenth highest share of