

# Overview Of Renewable Energy Sources In Turkey

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**Abstract**—This Living things need energy to sustain their daily lives. The most advanced living species human initially used his own body energy, but has benefited from the animals he has domesticated over time. From the middle of the nineteenth century, it is certain that human has contributed to the changes related to natural factors. Human beings have benefited from fossil sources since the 19th century and nuclear sources since the 20th century. Nuclear energy requires high technology for the production and use and is extremely dangerous for living life and, therefore it is both costly and suitable for malicious use. Therefore, the use of nuclear energy leads to various strains between countries.

Approximately 80% of the world's generated energy is derived from fossil fuels. According to the third assessment report of The United Nations Climate Change Intergovernmental Panel on Climate Change (IPCC) stated that published in 2001, the global average surface temperature will rise between 0.4 and 0.8 ° C in the 20th century and will rise to 1.4-5.8 ° C in the 1990-2100 periods by emphasizing the danger of global warming.

While fossil energy sources pollute the atmosphere, they are rapidly consuming. In addition, countries that do not have enough fossil energy resources are obliged to pay foreign exchange in large quantities as they become dependent on countries with energy resources.

For this reason, mankind has been searching for alternative energy sources. He has accelerated his work on renewable energy sources such as solar, wind, tide, biomass, geothermal, which are both

Everlasting and harmless to the environment and all living creatures. The expression "the consumption share of renewable energy sources should be at least 25% of all energy resources". Stated in the final declaration of the United Nations Climate Change Conference held in 2014.

Turkey's renewable energy resources are discussed in this study. For this purpose, both worlds and Turkey's energy potential and use have been investigated and compared.

**Keywords**—Renewable Energy; Turkey's; Renewable Energy; Productivity.

## I. INTRODUCTION

There is a linear relationship between societal development levels and energy consumption. It can be said that societies consuming more energy are developed societies and societies consuming less energy are less developed in general. [1],[2] Worldwide average energy consumption values per capita are given in Table I [5]

TABLE I. WORLDWIDE ANNUAL ENERGY CONSUMPTION PER PERSON

Countries	Annual Energy Consumption Per Person (kWh)
World Average	2.500
Advanced Countries Average	8.900
USA	12.322
Turkey	2.791

According to this data, developed countries consume energy more than three times of the world average, while the US consumes nearly five times as much energy, and Turkey has a very close rate to the world average. When the average of the world is thought to have been raised by the USA and developed countries, it can be said that there are societies that haven't met energy sources yet. According to International Energy Agency data, there are 1.3 billion people in the world who do not have access to energy [3] [4] [6].

While developed countries are trying to preserve and maintain their current position, underdeveloped countries are striving to catch up with them.

## II. ENERGY OVERVIEW IN THE WORLD

The need for energy is rapidly increasing due to the rapid increase in the world population as well as the developing technology. Some of the countries that consume the most primary energy in the world in 2013, 2014 and 2015 are given in Table II. [7].

TABLE II. ENERGY CONSUMPTION BY YEARS FOR THE MOST ENERGY CONSUMING COUNTRIES IN THE WORLD (MTOE).

Country	2013	2014	2015	Share in World (%)
China	2.903,9	2.970,3	3.014,0	22,9
USA	2.271,7	2.300,5	2.280,6	17,3
India	626,0	666,2	700,5	5,3
Russia	688,0	689,8	666,8	5,1
Germany	325,8	311,9	320,6	2,4
Saudi Arabia	237,4	252,4	264,0	2,0
Turkey	120,3	123,9	126,9	1,0
South Africa	124,6	128,0	124,2	0,9
Ukraine	114,7	101,0	85,1	0,6

Globally, 22.9% of the world's energy is consumed by China, the fastest developing and most populous country in the world, and 17.3% by the United States, the most developed country in the world (Table 2.1). With a population of approximately 80 million Turkey has a share of 1% in world's energy consumption.

According to the year 2015 data, about 85% of the energy consumed worldwide is obtained from fossil sources and about 10% is derived from renewable sources including hydraulic energy. (Table III). [8] [16].

TABLE III. SOURCE-BASED WORLD PRIMARY ENERGY CONSUMPTION DISTRIBUTION (MTOE)

	2015	%	2035	%
Oil	4257	32	4892	29
Gas	3135	24	4319	25
Coal	3840	29	4032	24
Nüklear	583	4	927	5
Hydro	893	7	1272	7
Renewables	439	3	1715	10
TOTAL	13147	100	17157	100

\*Renewables includes wind, solar, geothermal, biomass and biofuels.

It is estimated that the world population's need for primary energy resources will grow by 30% between 2015 - 2035. According to this assumption, it can be said that in 2035, 17.16 billion tons of oil equivalent energy will be needed to meet the world's energy needs [9].

According to another scenario, growth statistics and energy consumption of world countries are shown in Fig 2 [10].

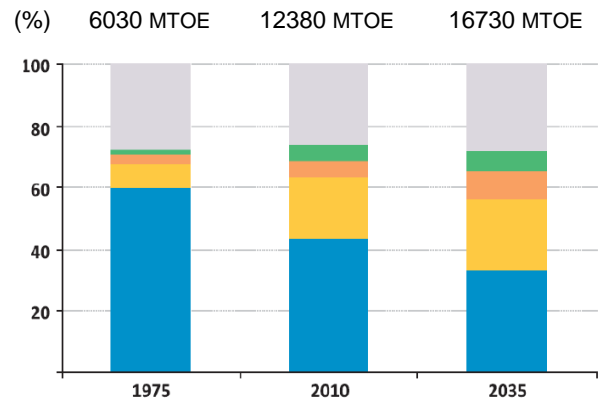


Fig. 1. Global Energy Demand

As seen in Figure 2.1, it is estimated that in 2035 the primary energy need will be 16.73 billion TPE. While the total energy demand of the OECD countries decreases, China, India and the Middle East countries will increase, and in remaining countries there will be no change in energy demand. It can be said that the negativity of population growth in OECD countries and day by day increasing energy efficiency reduce the energy demand while the increasing population growth and annual growth rates in China, India and Middle East countries have increased the energy demand.

As is known, fossil fuel reserves are rapidly declining; especially oil and natural gas reserves are approaching critical levels. The total oil reserves in the world are around 1.7 trillion barrels and it is estimated that this amount can cover 51 years of consumption. Natural gas reserves are 187 trillion square meters at the end of 2015 and it can cover 53 years consumption while coal reserves can cover 114 years consumption [11]. In the next 20 years, it can be said that the energy demand cannot be met and there will be crises on energy resources on a global scale. Therefore, mankind will need alternative energy sources Renewable energy sources, such as the solar, modern biomass and wind energy, meet only the 3% of energy demand today. (Fig. 2.) [16]. According to the report published by Eurelectric, in the EU in 2015, 29% of electricity is produced from renewable energy sources and 56% from low carbon sources. [12]

Electricity is the commonly used type of energy. The share of renewable resources in electricity generation is increasing day by day. According to the year 2015 data, electricity consumption in world primary energy consumption on sectoral basis has a share of 42% (Table 4). According to the predictions of 2035, this ratio is expected to increase to 47% (Table IV).

TABLE IV. WORLD PRIMARY ENERGY CONSUMPTION SHARES ON SECTORAL BASIS [8]

Sector	Energy Consumptions (MTOE) and Rate (%)			
	2015	%	2035	%
Transport	2471	19	3027	18
Industry	3117	24	3610	21
Non-combusted	817	6	1227	7
Buildings	1222	9	1296	8
Power	5519	42	7997	47

### III. OVERVIEW OF TURKEY'S ENERGY RESOURCES

It is envisaged that the existing installed power exceeding 70 000 MW will be increased to 120.000 MW, the installed wind energy capacity will be increased to 20.000 MW, 600 MW geothermal power and 3,000 MW solar energy power plants will be established for the year 2023, the 100th anniversary of the foundation of our Republic[6].

Turkey is one of the countries which have a huge demand for energy sources. As a matter of fact, consumption of primary energy resources, which was 78.8 MTPE in 2000, reached 114.5 MTPE in 2011 [17]. In the same period, primary energy resources production was 32,2 MTPE (Table V) [9].

TABLE V. PRODUCTION AND CONSUMPTION OF PRIMARY ENERGY SOURCES IN TURKEY BY YEARS (1990-2011)

	1990	1995	2000	2005	2010	2011
Production (MTOE)	25478	26719	27621	26285	32493	32229
Consumption (MTOE)	52648	62893	78865	89099	109226	114480

The production of primary energy resources in Turkey between 1990 (25.48 GTOE) and 2011 (32.2 GTOE), in the last 21 years, has increased at the rate of 26.5%. In the same period, consumption of primary energy sources increased by 117.4% (Table VI). The domestic resource utilization rate of total energy consumption decreased from 77% (1970) to 28.1% (2011) due to the rapid increase in energy demand.

Turkey's dependence on foreign energy sources is increasing year by year due to the fact that consumption of primary energy sources is more than the local production. Approximately 72% of the energy consumed in Turkey is provided by external purchase (Table VI). It is a country scarce in energy resources. The difference between production and consumption is imported from foreign countries. Turkey a net importer of fossil energy sources, meets 92% of the need in 2014, (99% natural gas and 94% coal, a total of 74.9%) with importation [8].

TABLE VI. PRODUCTION AND CONSUMPTION OF TURKEY'S PRIMARY ENERGY RESOURCES ON THE BASIS OF RESOURCE [9]

Source Type	Production of primary energy resources		Consumption of primary energy resources	
	KTOE	%	KTOE	%
Coal	17870	55,5	35841	31,3
Natural Gas	652	2,0	36909	32,2
Oil	2555	7,9	30499	26,6
Hydraulic	4501	14,0	4501	3,9
Biomass	3555	11,0	3573	3,1
Geothermal energy	1463	4,5	1463	1,3
Other renewable sources	1633	5,1	1712	1,5
TOTAL	32229	100	114480	100

By the end of 2016, Electricity production in Turkey was 273.4 GWh, while consumption was 278.3 GWh [11]. 184,889 GWh of our electricity production was supplied from thermal power plants, 67,268 GWh from hydroelectric power plants and 21,230 GWh from other renewable energy sources (Table 3.3) [10].

#### A. The Fossil Energy Resources Potential of Turkey

Current fossil energy sources in Turkey are given in Table 3.4. Turkey is not a rich country in terms of these types of resources except lignite. With 15.2 billion tonnes of reserves, Turkey has about 1.7% of the coal in the worldhis reserve contains 13.9 billion tonnes of lignite and 1.3 billion tonnes of coal. It is estimated that there is a coal reserve which can be used for 167 years according to current production conditions (Table VII).

TABLE VII. TURKEY'S RESERVES OF FOSSIL ENERGY SOURCES [11].

Source	Apparent	Possible	Probable	Total
Coal (Million tonne)	525	424	368	1319
Lignite (Million tonne)	13.442	450	7	13.900
Oil (Million tonne)	42	-	-	42
Asphaltite (Million tonne)	45	29	8	82
Bitumens (Million tonne)	555	1086	269	1641
Natural gas (Billion m <sup>3</sup> )	7	-	-	7

Oil, which ranks first in world primary energy consumption, has 42 million tonnes reserves in Turkey (Table 3.4). The consumption of oil in 2012 is about 29 million tons. 7.9% of this consumption is domestic production and the rest is met through importation. The imports are mainly obtained from countries like Iran (51%), Iraq (17%), Russia (12%), Saudi Arabia (11%) and Kazakhstan (7%) [12].

### B. Turkey's Renewable Energy Potential

It is aimed to increase the share of renewable resources in total installed power by at least 30% by 2023 [6] [9]. Considering fossil resources, Turkey is more advantageous in terms of potential renewable energy sources. Especially, hydraulic, wind, solar, biomass and geothermal energy potential are high in Turkey. (Table VIII).

TABLE VIII. TURKEY'S RENEWABLE ENERGY POTENTIAL AND USAGE [13].

Renewable Energy Source	Gross Potential (GWh/year)	Used Potential (GWh/year)	Usage Rate %
Hydraulic	430-450	35.33	8
Wind	400	61	15
Solar	365	4.07	1.0
Geothermal	16	0.89	5.6
Biomass	1.58	0.067	4.2

As can be seen from Table 3.5, the most significant potentials in renewable energy sources in Turkey are hydraulic, wind and solar energy. Among these resources, the biggest usage rate is wind energy with 15%, followed by hydraulic (8%) and geothermal (5.6%) energy. In general, it can be said that the potential of renewable energy sources cannot be utilized adequately in Turkey, especially hydraulic and solar energy. Although solar is rich in terms of radiation, this potential is underutilized.

Turkey has a significant biomass potential thanks to the vegetation and temperate climate. However, this potential cannot be used productively because the society is not as conscious of energy efficiently. A large part of the biomass energy potential is used as heat energy in non-commercial enterprises, especially with conventional methods.

### IV. CONCLUSION AND DISCUSSION

Due to its security and benefits to the environment and economy, energy is used abundantly and widely in the world. The use of renewable energy sources is increasing in many countries of the world due to competition between other production technologies, rapid improvements, developing technologies and correspondingly lower costs.

It is obvious that cheap, quality and reliable energy should be supplied for a sustainable growth and development in Turkey. In the meeting of energy demand, high dependency on fossil energy sources reveals the necessity of evaluation of domestic and renewable energy resources and diversification of resources. Turkey's per capita electricity consumption is about one-third of the average of developed countries. However, the fact that the installed capacity value in the last 25 years has increased by four times is the biggest parameter that shows the rate of increase of electricity consumption per capita in the

future. Reducing the negative difference between Turkey's energy supply and demand, closing the current account deficit in external payments and putting the renewable energy resources into operation have a great importance in being a free, independent and strong country for Turkey.

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