

# Present Status and Future Projections of Electrical Energy in Turkey

Mehmet BİLGİLİ<sup>1</sup>\*

<sup>1</sup> *Cukurova University, Adana Vocational School of Higher Education, 01160, Adana, Turkey*

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## ABSTRACT

In Turkey, electricity is generated from thermal, hydro, wind and geothermal power plants. There is no commercial nuclear power plant yet. Turkey's energy demand has grown rapidly almost every year and, it is expected to continue growing. According to the high scenario, the total installed capacity and gross electricity generation of Turkey will reach to 91,827 MW and 450,152 GWh by the year 2017, respectively. On the other hand, net electricity consumption of the country will increase to 355,600 GWh. For meeting this rising energy demand, Turkey gives a great importance to the private sector investments. In this paper, present situation of Turkey's electrical energy and future projections are investigated in order to give some help to energy planners in the country.

**Key Words:** *Electricity consumption, electricity generation, future projections, installed capacity, Turkey.*

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## 1. INTRODUCTION

Turkey is located in the Northern Hemisphere at the junction Europe and Asia, and it has a land surface area of 774,815 km<sup>2</sup> officially. It is situated in Anatolia and southeastern Europe, and it borders eight countries: Bulgaria to the northwest; Greece to the west, Georgia to the northeast; Armenia, Azerbaijan (the exclave of Nakhichevan), and Iran to the east; and Iraq and Syria to the southeast. The Mediterranean Sea and Cyprus are to the south; the Aegean Sea and Archipelago are to the west; and the Black Sea is to the north. Due to its geographical position, it has increasingly important role to play as an "energy corridor" between the major oil and natural gas producing countries in the Middle East, Caspian Sea and the Western energy markets [1,2,3]. The economy and population of Turkey grow rapidly.

According to the Turkish Statistics Institute (TUIK), Turkey's population as of December 31, 2007 is 70,586,256. It grew by 4.1 percent since 2000 [4].

Turkey, with its young population, growing urbanization, social and economic developments, has been one of the fast growing energy markets of the world for the last two decades [5]. It is expected that the demand for electric energy in Turkey will be 307 billion kWh by the year 2015 and 435 billion kWh by the year 2020 [6]. Turkey is presently an energy-importing country. This situation has been causing financial problems. More than about 74% of energy consumption in the country is met by imported energy sources, and the share of imports grows each year continuously [7]. The imported energy sources consist of oil, natural gas and hard coal. For the year 2003, the amount of the

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\*Corresponding author, e-mail: mbilgili@cu.edu.tr

imported oil is 50% (4.7 billion dollars) in the total of imported energy sources, and it is followed by natural gas with a percentage of 40% (3.8 billion dollars) and hard coal with a percentage of 10% (0.8 billion dollars) [8]. For the year 2007, the total cost of imported energy sources such as oil, natural gas and hard coal is 33.8 billion dollars.

Energy is one of the most significant components in the economic development of countries. It is also certain that energy is the most important necessity of human life and hence there is an increasing relation between the level of development and amount of energy consumption. It is inevitably essential for the economic and social growths and an improved quality of life in Turkey and other countries. This situation makes energy resources significantly important for the whole world

## 2. INSTALLED CAPACITY

In Turkey, electricity is generated from thermal, hydro, wind and geothermal power plants. But, there is no nuclear power used for electricity generation yet. The development of Turkey's installed capacity in electricity generation between 1975 and 2008 is illustrated in Figure 1 [7,12]. It can be seen here that thermal and hydro powers became the fastest growing installed capacities in the country. On the other hand,

[9,10]. Out of various energy sources, an electric power is considered to be a kind of energy source which can be used in variety industry. In general, electricity is generated from the hydropower, thermal and nuclear power plants. Other types of energy production sources are wind, wave, sun and biomass [11].

In this paper, present situation of Turkey's electrical energy and future projections are investigated. Firstly, the growth of installed capacity, electricity generation and electricity consumption between the years 1975 and 2008 is reviewed. Then, energy resources used in electricity generation are identified. In addition, the Turkish electricity generation capacity projection for the period of 2008-2017 is researched in order to analyze energy use and make future projections.

geothermal and wind powers became relatively small installed capacities. As reported by the Turkish Electricity Transmission Company (Turkiye Elektrik İletim A.S., TEİAŞ), while the installed capacity of Turkey's electric power plants was 4,187 MW in 1975, it increased to 41,813 MW in 2008. In this installed capacity, the share of thermal power plants was 66.00% (27,595 MW) in 2008. Hydro accounted for 33.06% (13,825 MW), and geothermal + wind for 0.94% (394 MW).

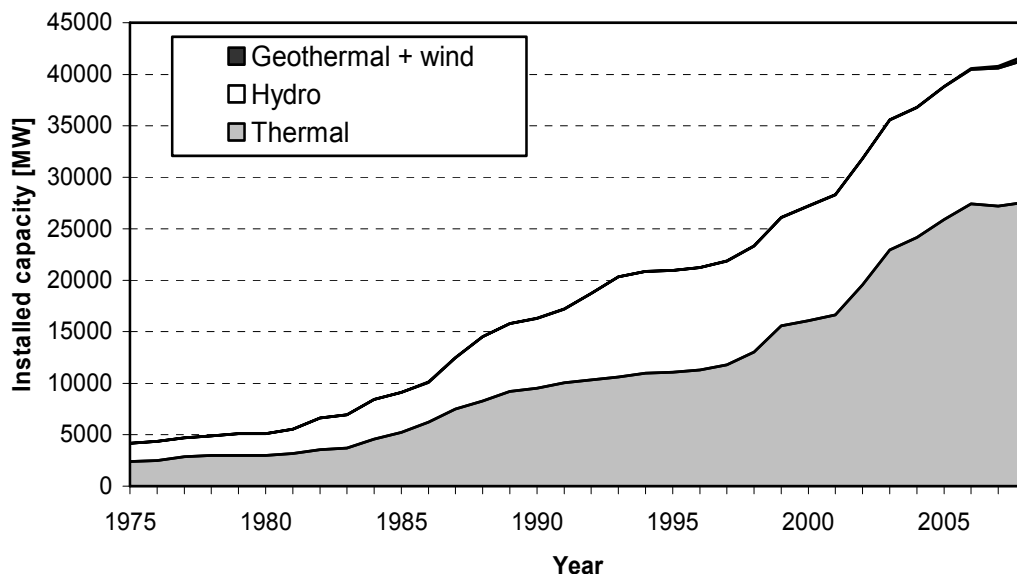


Figure 1. Development of Turkey's installed capacity between 1975 and 2008.

## 3. ELECTRICITY GENERATION

As seen from Figure 2, electricity generation in Turkey increased rapidly due to the rate of population growth, the high rate of industrialization, social and economical development. While the total electricity generation of Turkey was 15,623 GWh in 1975, it increased to 198,418 GWh in 2008. The thermal power became the fastest growing energy generation in the country. It increased from 9,719 GWh in 1975 to 164,139 GWh in

2008. In addition, electricity generation produced by the hydro power increased from 5,904 GWh in 1975 to 33,270 GWh in 2008. However, electricity generation produced by the geothermal and wind power is relatively small. It increased from 22.1 GWh in 1984 to 1009 GWh in 2008. Of the total electricity generation in 2008, 82.72% came from thermal power plants, while 16.77% came from hydro power plants. In addition, geothermal + wind power plants met 0.51% of Turkey's electric power generation.

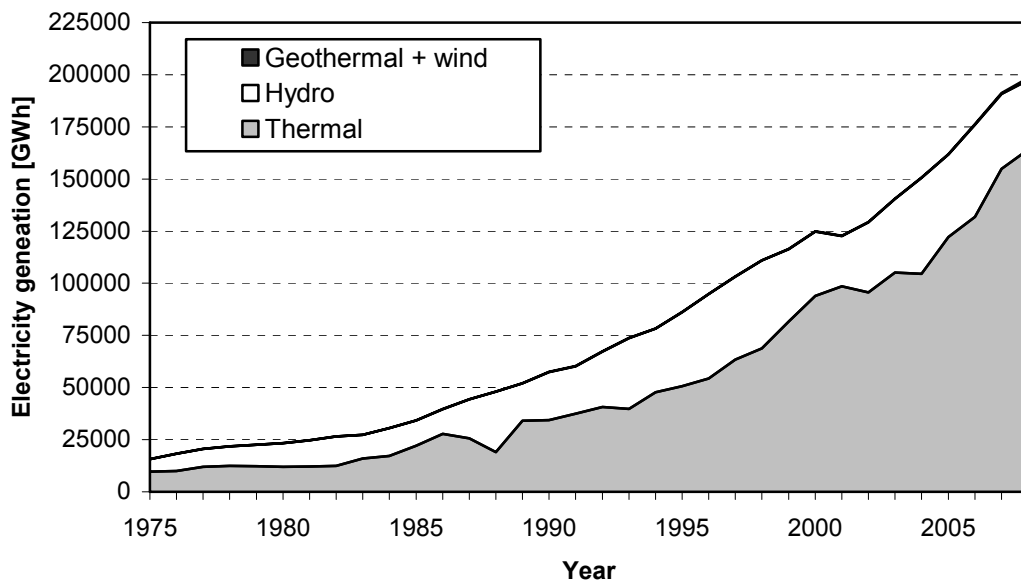


Figure 2. Development of Turkey's electricity generation between 1975 and 2008.

#### 4. ENERGY RESOURCES

Although Turkey has a wide range of energy resources, they are limited. Turkey does not possess huge fossil fuel reserves. Almost all types of oil and natural gas are imported from neighboring countries. Excluding lignite; coal, oil and natural gas reserves capacities in Turkey are low and can not meet projected domestic demand. Coal is a major fuel source for Turkey. Domestically produced coal accounted for about 24% of the country's total energy consumption, used primarily for power generation, steel manufacturing and cement production. Turkey is a large producer of lignite. Turkey has substantial reserves of renewable energy resources. Main renewable energy resources are; hydro, biomass, wind, biogas, geothermal, and solar in Turkey [13].

Turkey's electricity generation is based on the solid-fired resources (hard coal, lignite and imported coal), the liquid-fired resources (fuel-oil, diesel oil, LPG, Naphtha), natural gas, hydro, and others such as renewable energy and wastes sources. The solid-fired and hydraulic resources being the basic; oil and natural gas resources are main primary energy resources of Turkey in electricity generation. Figure 3 shows the development of Turkey's electricity generation by the primary energy resources between 1975 and 2008 [12]. As seen from the figure that the natural gas consumption became the fastest growing primary energy source in the country. In electricity generation, the share of the natural gas was 49.74% (98,685 GWh) in 2008. The solid-fired resources accounted for 29.09% (57,716 GWh), hydro for 16.77% (33,270 GWh), liquid for 3.79% (7,519 GWh), and others such as renewable energy and wastes sources for 0.62% (1,229 GWh).

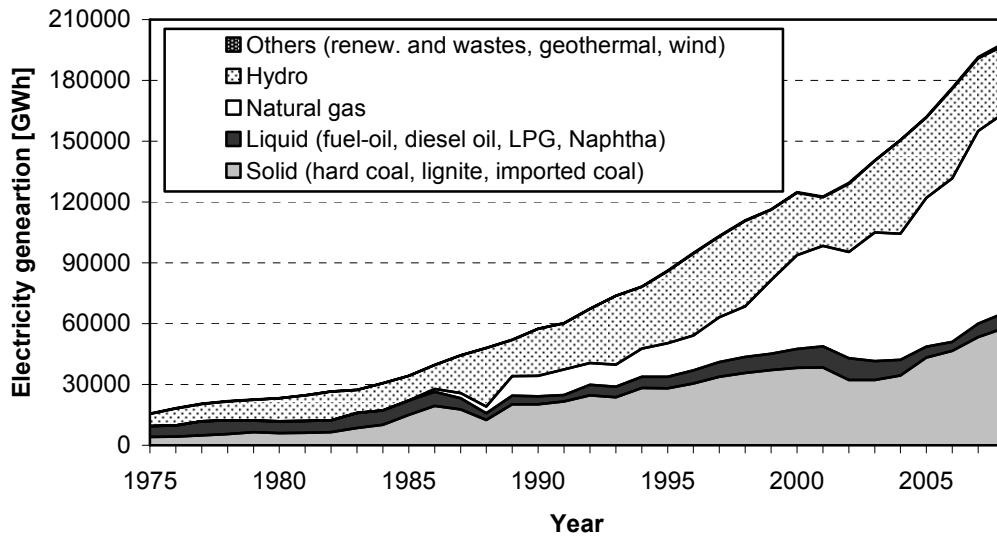


Figure 3. Development of Turkey’s electricity generation by the primary energy resources between 1975 and 2008.

**5. ELECTRICITY CONSUMPTION**

Like other developing countries, Turkey also faces an ever increasing electricity demand. Electricity consumption constitutes a small fraction of the total energy consumption in Turkey, although its share increases year by year [14]. Electricity energy is used in nearly all kinds of human activity, such as industrial production, residential, agriculture, transportation, lighting and heating. Much of the growth in electricity

consumption of Turkey since 1970 has taken place in the residential sector. Although the amount of electricity consumed by the industrial sector has increase, its share in total electricity consumption has fallen down between the year 1970 and 2004. Presently, residential sector is the biggest consumer of the electricity energy in Turkey. Industrial sector is the second biggest consumer of the electricity energy. The transportation and agriculture sectors are relatively small consumers of electricity energy [15,16].

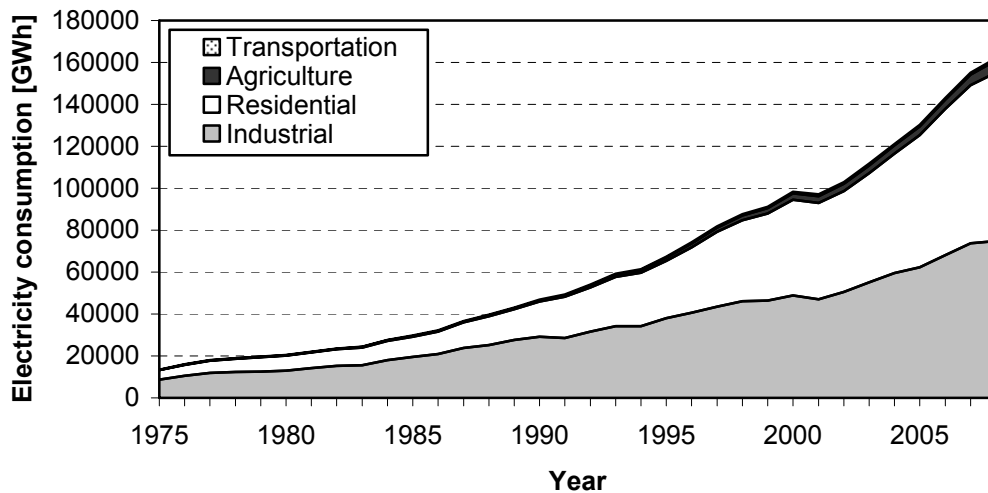


Figure 4. Development of sectoral electricity energy consumption in Turkey between 1975 and 2008.

The development of sectoral electricity energy consumption in Turkey between 1975 and 2008 is shown in Figure 4 [17]. Turkey’s net electricity consumption has been increasing at an average rate of

7.88% per year since 1975. While net electricity consumption was 13,492 GWh in 1975, it increased to 161,948 GWh in 2008. For the total consumed electricity of 161,948 GWh, 80,332 GWh was used by

residential sector, 74,851 GWh by industrial sector, 5,807 GWh by agriculture sector, and 959 GWh by transportation. The Turkish government is planning for an 8% growth rate annually for the next 15 years. By the year 2020, the net electricity consumption will have reached to 434,565 GWh [6,18].

**6. FUTURE PROJECTION**

The estimation of electricity consumption is of great importance for the future electricity policies, such as conservation programmes, the planning of capacity expansion and the construction of nationwide interconnection of power network [19]. Moreover, accurate forecasts of electricity energy demand are important for effective implementation and decision on capital-intensive investments. Turkey’s energy forecasting studies have been officially carried out by the Turkish Ministry of Energy and Natural Resources (MENR) by using Model for Analysis of Energy Demand (MAED) simulation technique. MAED (Model for Analysis of Energy Demand) is used to forecast the medium and long term energy demand, considering the relationships between several factors that affect the social, economical and technological system of the country [20].

TEIAS (Turkish Electricity Transmission Company) [21] has planned two scenarios both for demand and resource projections, called the Turkish Electricity Generation Capacity Projection. In this capacity projection study, Turkey’s future installed capacity and gross electricity generation values are calculated by considering the existing power plants, other projects which are currently under construction and new projects granted by licence by the end of January 2008. Related data to the average and firm values for the next 10 years are obtained from the Electricity Generation Corporation (EÜAŞ), Turkish Electricity Trade and Contracting Corporation (TEDAS) and General Directorate of State Hydraulic Works (DSİ) for the existing and under construction thermal power plants, and also hydro power plants. Data for new projects granted by license by the end of December 2007 were taken from the Energy Market Regulatory Authority (EPDK) and these data were updated according to “Progress Report of January 2008” published by the EPDK (Energy Market Regulatory Authority). While calculating generation capacities, the average generating values of hydro power plants under normal hydrologic conditions and firm generating values of hydro power plants under dry hydro conditions are considered separately.

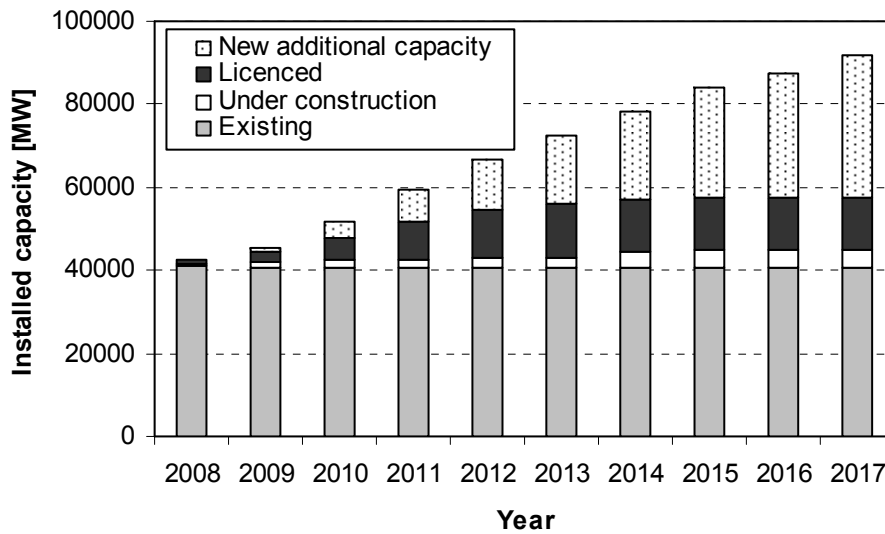


Figure 5. Turkey’s installed capacity for the period of 2008-2017 according to the high scenario.

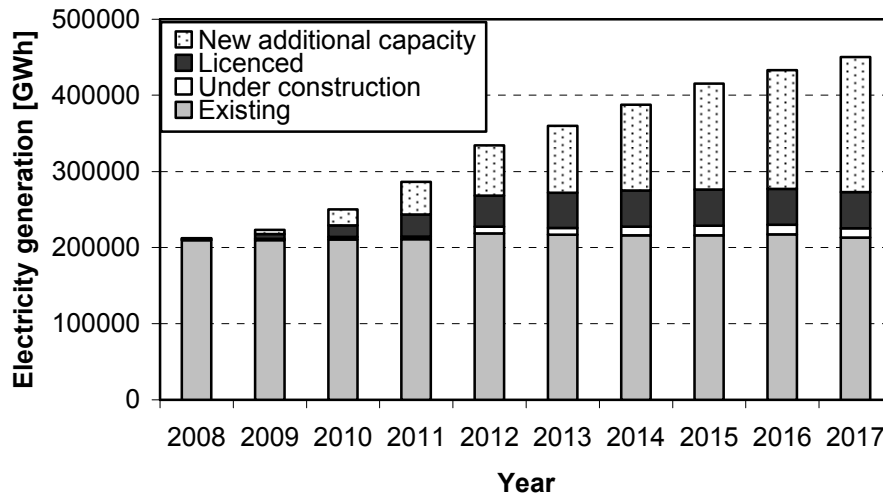


Figure 6. Turkey's gross electricity generation for the period of 2008-2017 according to the high scenario.

According to the high scenario, in order to cover the energy demand, with the addition of 4,319 MW capacity under construction, 12,818 MW capacity granted by licence and expected to be in service on proposed date and also 34,155 MW capacity calculated by the long term generation expansion planning study adding to the existing system, hence, the total installed capacity and gross electricity generation will reach to 91,827 MW and 450,152 GWh by the year 2017,

respectively. Turkey's future installed capacity and gross electricity generation for the period of 2008-2017 are presented in Figures 5 and 6, respectively. The breakdowns of this total installed capacity and electricity generation by thermal, hydro, and wind and renewable resources are shown in Tables 1 and 2, respectively.

Table 1. The breakdown of total installed capacity of Turkey according to the high scenario.

Year	Thermal		Hydro		Wind + other renewable		Total MW
	MW	%	MW	%	MW	%	
2008	27,539	64.91	14,043	33.10	845	1.99	42,427
2009	28,345	62.41	15,727	34.63	1,347	2.97	45,420
2010	31,327	60.74	18,760	36.38	1,487	2.88	51,573
2011	35,679	60.04	22,124	37.23	1,621	2.73	59,424
2012	39,984	59.96	24,955	37.42	1,746	2.62	66,685
2013	42,699	59.09	27,687	38.32	1,871	2.59	72,257
2014	45,779	58.53	30,445	38.92	1,996	2.55	78,220
2015	49,294	58.79	32,430	38.68	2,121	2.53	83,845
2016	51,309	58.66	33,913	38.77	2,246	2.57	87,468
2017	53,984	58.79	35,472	38.63	2,371	2.58	91,827

Table 2. The breakdown of electricity generation of Turkey according to the high scenario.

Year	Thermal		Hydro		Wind + other renewable		Total GWh
	GWh	%	GWh	%	GWh	%	
2008	173,461	81.75	36,923	17.40	1,792	0.84	212,176
2009	180,295	80.80	39,344	17.63	3,489	1.56	223,128
2010	200,625	80.13	45,410	18.14	4,330	1.73	250,365
2011	230,060	80.29	51,897	18.11	4,578	1.60	286,535
2012	270,024	80.88	59,069	17.69	4,781	1.43	333,874
2013	289,613	80.46	65,367	18.16	4,956	1.38	359,936
2014	310,561	80.12	71,920	18.55	5,131	1.32	387,611
2015	334,967	80.64	75,096	18.08	5,306	1.28	415,369
2016	350,591	80.93	77,139	17.81	5,481	1.27	433,211
2017	365,349	81.16	79,147	17.58	5,656	1.26	450,152

According to the low scenario, the total installed capacity and gross electricity generation are expected to be 75,481 MW and 376,440 GWh by the year 2017, respectively. Of the total installed capacity, 40,536 MW belongs to the existing power system, followed by the power plants under construction with 4,319 MW capacity, other power plants granted by licence and expected to be in service on proposed date with 8,599

MW capacity, and expected new power plants calculated by the long term generation expansion planning study with 22,028 MW capacity. Turkey's future installed capacity and gross electricity generation for the period of 2008-2017 are shown in Figures 7 and 8, respectively. The breakdowns of this total installed capacity and electricity generation by thermal, hydro, and wind and renewable resources are shown in Tables 3 and 4, respectively.

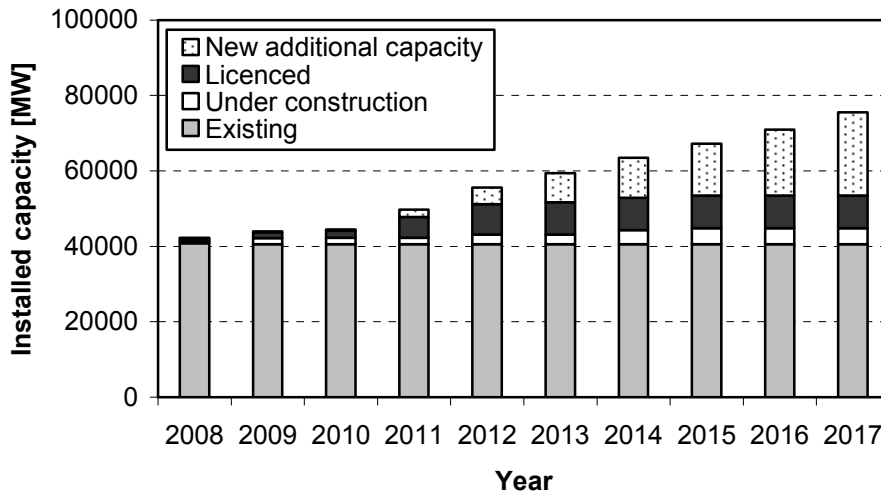


Figure 7. Turkey's installed capacity for the period of 2008-2017 according to the low scenario.

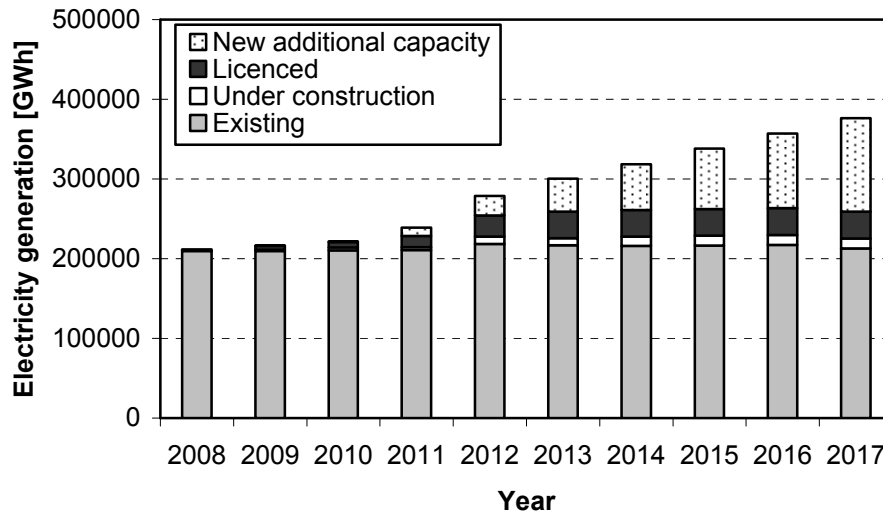


Figure 8. Turkey's gross electricity generation for the period of 2008-2017 according to the low scenario.

Table 3. The breakdown of total installed capacity of Turkey according to the low scenario.

Year	Thermal		Hydro		Wind + other renewable		Total MW
	MW	%	MW	%	MW	%	
2008	27,412	64.91	14,053	33.28	766	1.81	42,230
2009	27,582	62.74	15,450	35.15	928	2.11	43,960
2010	27,582	62.02	15,834	35.61	1,055	2.37	44,471
2011	30,039	60.44	18,475	37.17	1,189	2.39	49,704
2012	33,977	61.13	20,294	36.51	1,314	2.36	55,585
2013	36,097	60.69	21,942	36.89	1,439	2.42	59,478
2014	38,312	60.33	23,630	37.21	1,564	2.46	63,506
2015	40,672	60.58	24,774	36.90	1,689	2.52	67,135
2016	42,712	60.24	26,372	37.20	1,814	2.56	70,898
2017	45,612	60.43	27,930	37.00	1,939	2.57	75,481



Table 4. The breakdown of electricity generation of Turkey according to the low scenario.

Year	Thermal		Hydro		Wind + other renewable		Total GWh
	GWh	%	GWh	%	GWh	%	
2008	173,051	81.76	36,995	17.48	1,599	0.76	211,645
2009	174,755	80.73	39,144	18.08	2,560	1.18	216,458
2010	177,194	80.00	41,475	18.73	2,818	1.27	221,487
2011	191,683	80.25	44,149	18.48	3,027	1.27	238,859
2012	226,483	81.25	49,028	17.59	3,230	1.16	278,740
2013	243,787	81.12	53,340	17.75	3,405	1.13	300,531
2014	258,537	81.16	56,442	17.72	3,580	1.12	318,558
2015	275,215	81.40	59,128	17.49	3,755	1.11	338,098
2016	291,187	81.54	62,011	17.36	3,930	1.10	357,128
2017	308,230	81.88	64,106	17.03	4,105	1.09	376,440

Turkey’s sectoral electricity consumption for the period of 2008-2017 is presented in Figure 9. It can be seen here that while the net electricity consumption is 161,948 GWh in 2008, it will increase to 355,600 GWh

by the year 2017. For the total consumed electricity of 355,600 GWh, 163,800 GWh will be used by residential sector, 182,087 GWh by industrial sector, 6,613 GWh by agriculture sector and 3,100 GWh by transportation.

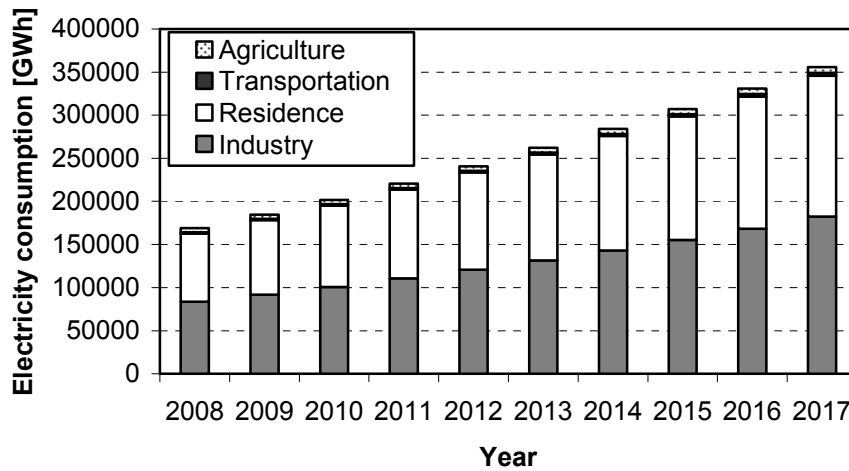


Figure 9. Turkey’s sectoral electricity consumption for the period of 2008-2017.

**7. RESULTS AND DISCUSSION**

In this study, firstly, the growth of installed capacity, electricity generation and electricity consumption in Turkey is reviewed, and then, the Turkish electricity generation capacity projection for the period of 2008-2017 is investigated.

Electricity demand of Turkey grows rapidly as a result of the rate of population growth, a rapid industrialization and economic development. According to the high scenario, the total installed capacity and gross electricity generation of Turkey will reach to 91,827 MW and 450,152 GWh by the year 2017, respectively. In addition, net electricity consumption of the country will increase to 355,600 GWh. However,

Turkey is not a rich country. Because of the fact that Turkey does not have large fossil fuel reserves, it is presently an energy-importing country. Excluding lignite; hard coal, oil and natural gas reserves in country are limited, and they are imported. Therefore, in order to avoid foreign dependency both in sources and funds, Turkey must discover new and renewable energy resources.

Thermal power plants are the most important option in electricity generation of Turkey. In thermal power plants, mechanical power is produced by a heat engine, which transforms thermal energy, often from combustion of a fuel, into rotational energy. Most thermal power stations produce steam, and these are

sometimes called steam power stations. In comparison with hydro power, thermal power plants take less time to design, obtain approval, build and recover investment. However, they have higher operating costs, typically shorter operating lives (about 25 years) [22]. Furthermore, thermal power plants increase local pollution through SO<sub>x</sub>, NO<sub>x</sub>, volatile organic compounds, and oils containing primarily particulates and increase global pollution through CO<sub>2</sub>, the greenhouse gas that causes global warming. These strong pollutants have harmful effects on living organisms and the entire ecosystem [23].

Because of the fact that thermal power plants are the most important option using national coal sources in the electricity production in Turkey, a significant amount of pollutants has been produced. However, Turkey has a substantial reserves of renewable energy resources such as hydro, wind and solar. In this regards, renewable energy resources appear to be one of the most efficient and effective solutions for the clean and sustainable energy sources. So, Turkey should use available renewable energy sources as much as possible.

Hydro power plants are the most important option as a renewable, clean and economical energy sources for Turkey [11]. In hydro power plants, hydro-turbines convert water pressure into mechanical shaft power, which can be used to drive an electricity generator, or other machinery. The power available is proportional to the product of pressure head and water discharge. Hydroelectric plants tend to have longer lives than fuel-fired generation. The major advantage of hydroelectricity is elimination of the cost of fuel. Since no fossil fuel is consumed, emission of carbon dioxide from burning such fuels is eliminated. In addition, reservoirs created by hydroelectric schemes provide a lot of facilities such as secure water supply, irrigation for agricultural production and flood control, and societal benefits such as increased recreational opportunities, improved navigation, the development of fisheries, cottage industries, etc [22].

Turkey has significant wind energy potential when compared with other European countries. Turkey has the highest share of technical wind energy potential in Europe. Theoretically, Turkey has 166 TWh a year of wind potential [24,25,26]. It is estimated that Turkey's technical wind energy potential is 83,000 MW, economically potential is approximately 10,000 MW depending on the technical condition [26,27]. There are a number of regions in Turkey with relatively high wind speeds. The most attractive sites are the Marmara Sea region, Mediterranean Coast, Aegean Sea Coast and the Anatolia inland. Especially, the regions of Aegean and Marmara have higher wind energy potential comparing to the other regions [28]

Geothermal energy is one of the most promising alternative energy sources. It is also environmentally advantageous energy source which produces for less air pollution than fossil-fuel sources. It can be utilized in various forms such as electricity generation, direct use, space heating, heat pumps, greenhouse heating, and industrial usage in Turkey [29,30]. Turkey has a

significant potential in geothermal energy. It is the 7th richest country in the world in geothermal potential for its direct use and for electricity generation [28]. Turkey's geothermal energy potential is about 38,000 MW. Of this potential around 88% is appropriate for thermal use (temperature less than 473 K) and the remainder for electricity production (temperature more than 473 K) [31].

## 8. CONCLUSION

As a developing country, Turkey's population is expected to exceed 83 million in 2020. In parallel to this development, Turkey also faces an ever increasing electricity demand. By the year 2020, the net electricity consumption will have reached to 435 TWh. Unfortunately, Turkey is presently an energy-importing country. Excluding lignite; coal, oil and natural gas reserves in country are limited.

Electrical energy is inevitably essential for economic and social growth and improved quality of life in Turkey, as in other countries. This situation makes energy resources extremely important for all countries. In Turkey, there is no nuclear power plant, and electricity is generated from thermal, hydro, wind and geothermal power plants. Because of the fact that thermal power plants are the most important option in electricity generation of Turkey, a significant amount of pollutants has been produced. In addition, for these power plants almost all types of oil and natural gas are imported from neighboring countries. However, Turkey has substantial reserves of renewable energy resources such as hydro, wind and solar. In this regard, renewable energy resources appear to be the one of the most efficient and effective solutions for clean and sustainable energy sources. So, Turkey and its utilities should use their renewable energy sources.

Consequently, it can be concluded that Turkey should try to use renewable energy sources as much as possible. Due to high rate of demand for electricity a wide range of investment are vitally necessary to be made in near future.

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