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Renewable Energy and Coal Use in Turkey

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1. Introduction

The development level of a country is directly related to its economical and social level. One of the most important factors that takes an active role in achieving such development level is energy. Energy, which is the requirement of sustainable development, can only be an impulsive force in industrialization and overall development of societies if it is supplied on time, with sufficient quantity and under reliable economical conditions and considering the environmental impacts. The demand for energy increases rapidly in parallel with the population increase, industrialization and technological developments in Turkey and the other developing countries in the world.

Turkey has been developing since the foundation of the Republic of Turkey in 1923. Turkish Government played a leading role in energy production and in energy use, as well as in other fields, and implemented several policies to increase electricity production. By 1950s, thermal power plants were used commonly in electricity production. In the following years, hydroelectric power plants were put into operation in order to use the considerable amount of water resources of the country. Coal-fired power plants using national resources accounted for 70–80% of the thermal electricity production. After 1960s, oil, an imported resource, was replaced with national resources due to two petroleum crises. Therefore, the proportion of use of lignite in the energy field increased. By 1980s, energy production lead by the government went on. Afterwards, applications of liberal economy policies resulted in implementation of different energy production methods, and the country had a increasing tendency to meet energy demand by imports as a result of improvement in international economic relations. Natural gas became prevalent in the country as well as all over the world and accounted for 50% of the electricity production in 2009 (Fig 1, Table 1).

On the eve of 21st century, Turkey was unable to meet its energy requirement with its limited sources as a result of the increasing population and industrialization and thus the deficit between the energy production and energy consumption increased rapidly. Under such conditions, utilizing own resources more effectively had become more important increasingly day by day. Turkey became more dependent on imports year to year. It still supplies about 71% of its primary energy consumption from imported energy sources. This percentage is 59% for electricity production. It is now vital for Turkey to attach importance to coal and renewable energy sources, which are the largest domestic energy sources of Turkey, in order to meet this increasing energy deficit. Especially, it is possible to produce electricity using the said domestic sources.

• Population	73.722.988 (2010)
• Gross national product (GNP)	615 billion \$
• GNP per capita	8.215 \$/person
• Primary energy production	30.328 ktoe (thousand tons of oil equivalent)
• Distribution of primary energy production	Lignite 52%, wood 12%, hydraulic 10%, Petroleum 8%, hard coal 4%, other 14 %
• Primary energy consumption	104.117 Ktoe
• Distribution of primary energy consumption	Petroleum 29 %, natural gas 31 %, lignite 15 %, hard coal 14 %, hydraulic 3 %, other 8 %.
• Distribution of primary energy consumption by sectors	Industry 23 %, residential 27 %, transportation 15%, energy 25%, other 10%
• Rate of primary energy [production/consumption]	29 %
• Primary energy consumption per capita	1435 Koe (Kilogram oil equivalent)
• World primary energy consumption per capita	1710 Koe
• Installed capacity	44.761 MW
• Distribution of installed capacity by primary energy sources	Renewable 35 %, natural gas 26 %, lignite 18 %, petroleum 4 %, imported coal 5 %, hard coal 1%, other 11 %
• Electricity generation	194.813 GWh
• Distribution of electricity generation by primary energy sources	Natural gas 49 %, renewable 19%, lignite 20 %, petroleum 3%, imported coal 6 %, hard coal 2 %, other 1 %.
• Electricity gross consumption	194.079 GWh
• Electricity gross generation per capita	2.685 kWh/person
• Electricity net consumption per capita	2.162 kWh/person
• World electricity generation	20.202 billion kWh (2008)
• World electricity consumption	16.880 billion kWh (2008)
• World electricity generation by primary energy sources	Coal 42%, natural gas 21%, nuclear 14 %, hydraulic 16%, petroleum 6%, biomass 3%, other 4 %. (2007)
• World electricity production per capita	3012 kWh/person (2008)
• World electricity consumption per capita	2516 kWh/person (2008)

Table 1. Energy Profile of Turkey (2009)

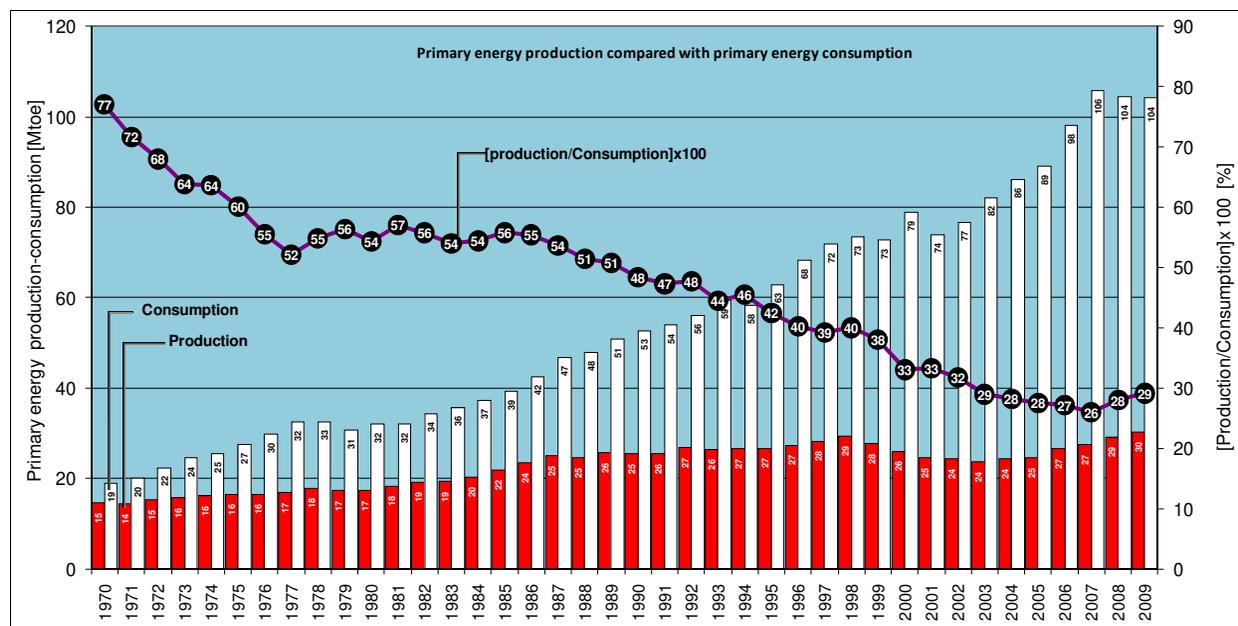


Fig. 1. During period of 1970-2009, primary energy production-consumption and rates of production and consumption (data from MENR,1970-2009)

In this chapter, the primary energy production- consumption of renewable energy sources of Turkey and coal as well as the development of their use rates in electricity production are discussed for a definite time period. In addition, some information is given about the projected use rates of such energy sources in energy production and projected consumption in Turkey for the years 2015 and 2020.

2. Energy outlook of Turkey

When the Republic of Turkey was founded in 1923, Turkey's population was 12 million. Installed capacity of electricity production, total electricity production, per capita electricity production and per capita electricity consumption were 33MW, 45 GWh, 3.6kWh and 3.3 kWh, respectively. Initially, almost all electricity demand was met by thermal power plants. The foundation of the Turkish Republic became the start of the development of the country. In 2009 year, the population has reached 73,7 million increasing about by six fold. In 2009 year, installed capacity reached 44.761MW increasing about by 1356-fold, electric production reached to 194.813 GWh increasing by 4329-fold. Per capita electricity production and electricity consumption reached 2685 and 2162 kWh increasing by 745-fold and by 655-fold, respectively. In 2009 year, primary energy production and consumption were 30.328 Ktoe and 104.117 Ktoe respectively. Also, distributions of primary energy production were lignite 52%, wood 12%, hydraulic 10%, hard coal 4%, and petroleum 8%. Distribution of primary energy consumptions were petroleum, natural gas, lignite, hard coal, hydraulic and other 29%, 32 %, 15%, 14 %, 3 % and 8%, respectively (Table 1). The net effect of all these factors is that Turkey's energy demand has grown rapidly almost every year and is expected to continue growing (Arioğlu and Yılmaz, 1997a; SIS, 2003,2004; Yılmaz, 2003, 2004,2011; TEIAS, 2004, 2009; Yılmaz and Uslu 2007; BP, 2009).

Energy has been the most important investment sector over the world. Turkey's energy needs are increasing quickly. Primary energy production-consumption and rates of production and

consumption are illustrated in Fig.1. Since Turkey is an energy importing country more than about 70% of the country's energy consumption is met by imports, and the share of imports is growing in the following years. While the primary energy consumption in 1970 was 18.84 mtoe, it reached 104 mtoe (million ton oil equivalent) with an increase rate of 552% in 2009. Primary energy production and consumption rates realized 1.39% and 4.29% per year, respectively. In other words, increase in consumption is three times bigger than the increase in production. While the ratio that production meets consumption was 77 % in 1970, this ratio reduced and reacted to 29 % in 2009. In other words, Turkey has been a country that depends on other countries in energy fields, especially in terms of oil and natural gas. (Fig. 1). (Yılmaz, et al, 2005; Yılmaz, 2003; Yılmaz and Arioğlu 2003; Yılmaz and Uslu, 2007; Yılmaz 2006; Yılmaz 2009; Yılmaz 2011; Arioğlu 1994; Arioğlu 1996).

Distribution of total electricity generation by energy resources during the period 1940-2009 is shown in Fig 2. As seen in the figure, renewable, oil-natural gas and coal accounted for 8%, 6%, 86 of electricity production in 1940. The share of the coal reduced continuously in the following years and reached as 55% in 1960, 25% in 1980 and again increased to 29%(imported coal included) in 2009. The increase rate of use of renewable energy sources was accelerated especially from 1960s, as seen in the electricity production capacity, and use rate of renewable energy sources was recorded as 8 % in 1940, 37% in 1960, 52% in 1980 and decreased to 19% in 2009. Because, after the year 2000, a sharply increase in share of imported natural gas in electricity production, lowered the use of domestic lignite and hard coal. Turkey is dependent on foreign countries especially in terms of oil and natural gas. In 1960, imported oil made up 8% of electricity production and this rate abruptly increased in the after years and it's had been reached 30% in 1970. During period 2000s years, imported of the natural gas sharply increased and reacted to 50% in 2009. Natural gas has been fast-growing fuel of energy market in Turkey. The tremendous growth and increased trend in gas demand during the period 1990-2009 showed that Turkey will need much more gas in the following years. Especially the share of the natural gas consumed in electricity generation has sharply increased and is considered to increase also in the future (Yılmaz 2008; Yılmaz 2011).

Turkey became more dependent on imports year to year. It still supplies about 71% of its primary energy consumption from imported energy sources. This percentage is 59% for electricity production. These rates are exactly seen in Fig 3. and Fig. 4 during of the period 1970-2009. In Fig 3 show that Turkey's primary energy consumption was 77% share of the domestic energy sources in 1970. While 54% of the consumed energy in 1980 was by the domestic energy sources, this percentage decreased to 33% and 29% in 2000 and 2009 respectively. On the other hand, share of the imported energy sources was increased from 23% in 1970 to 71% in 2009. In Figure 4 distribution of electricity production by domestic and imported energy sources are given in historical order. As seen in Figure, while domestic energy sources had a share of 68% in electricity production in 1970, imported energy sources had a share of 42% in electricity generation. After the 1970s years, oil crisis started. Turkey gave importance on lignite, coal and own renewable energy potential sources. So the rate of electricity production using Turkey's domestic sources was increased. But in 1990s use of imported natural gas in electricity production has sharply increased to 45% and 59% in 2000 and 2009 respectively. It is now vital for Turkey to attach importance to coal and renewable energy sources, which are the largest domestic energy sources of Turkey, in order to meet this increasing energy deficit. Especially, it is possible to produce electricity using the said domestic sources (Yılmaz 2006; Yılmaz 2011, Yılmaz and Arioğlu 1997b).

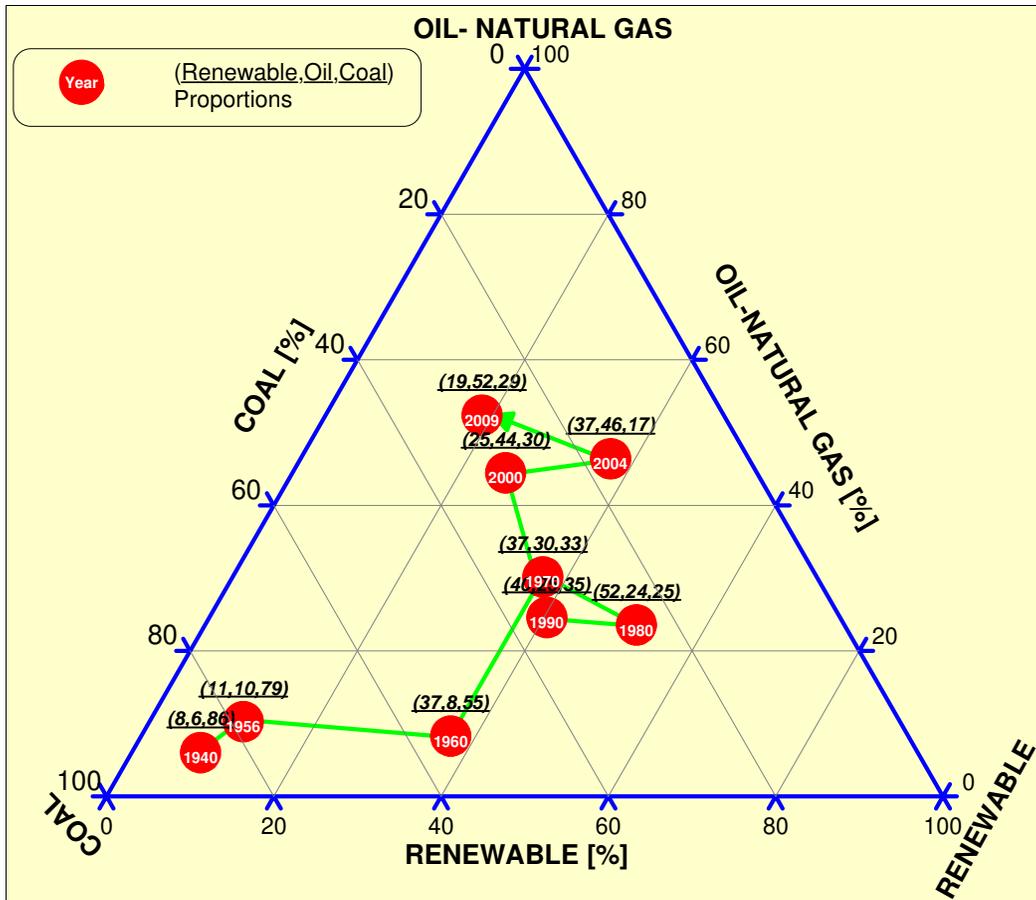


Fig. 2. Distribution of primary energy sources in electricity production by years (data from TEIAS, 2009)

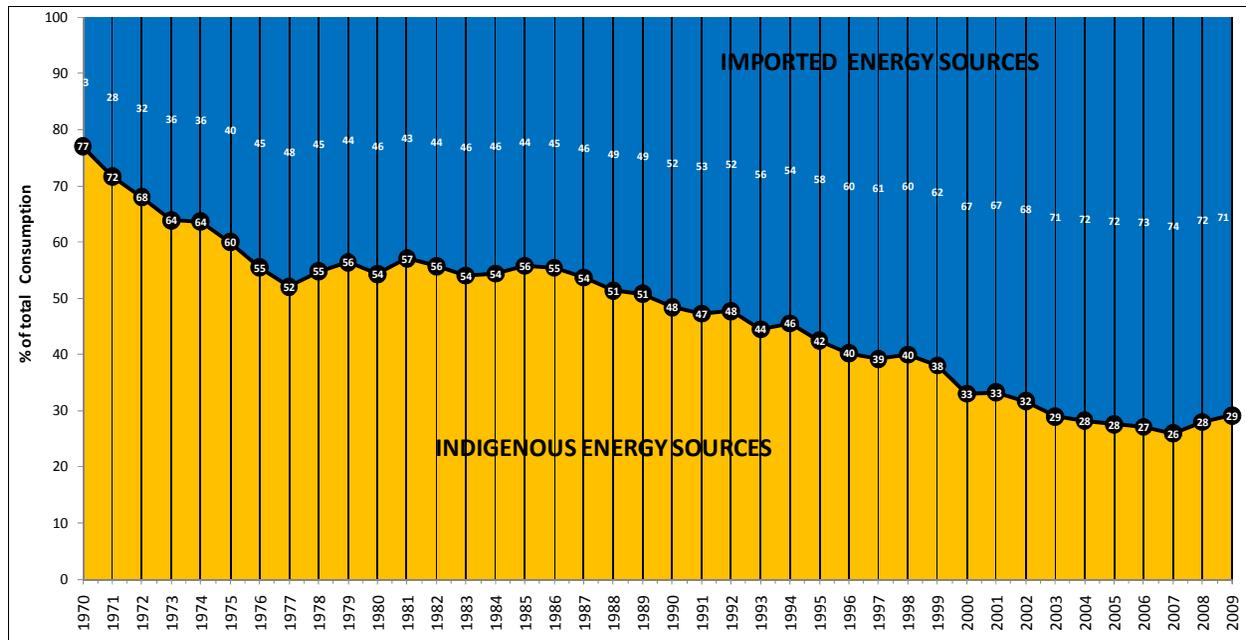


Fig. 3. During the period 1970 and 2009, primary energy consumption with domestic and imported energy sources (data from MENR, 1970-2009)

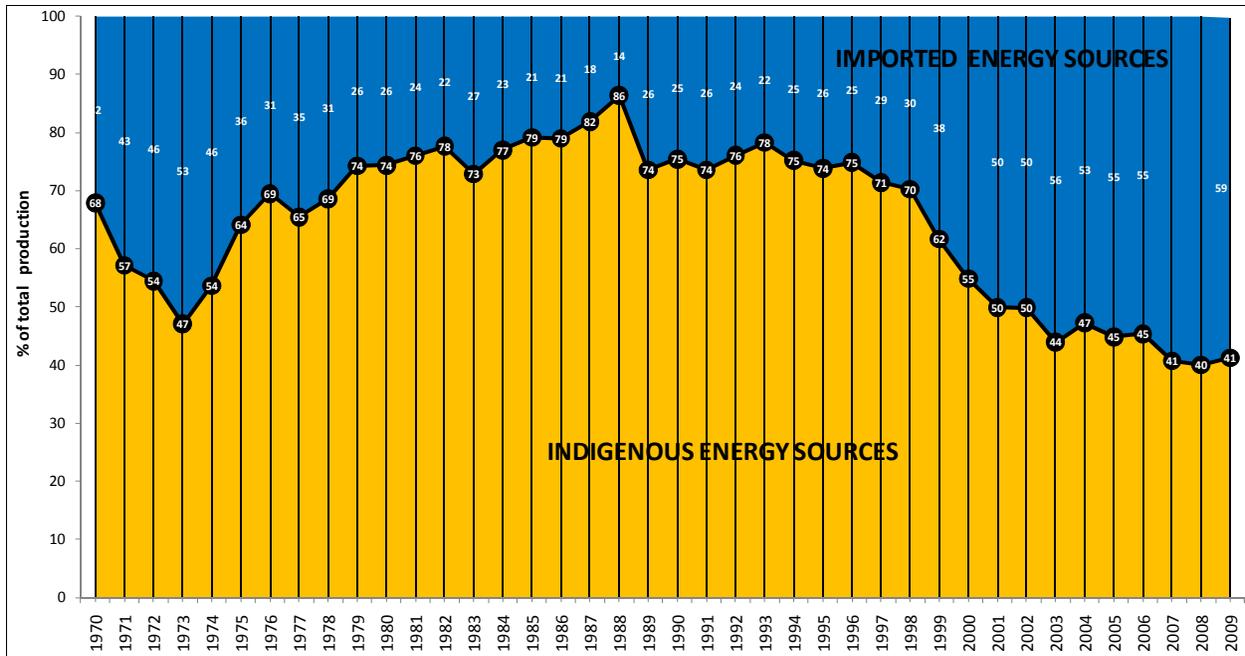


Fig. 4. During the period 1970 and 2009, in electricity generation imported and indigenous energy sources (data from TEIAS, 1970-2009)

3. Renewable energy use in Turkey

Totally energy demand of Turkey was making up about 29% of domestic resources and about 71% import resources. Turkey's primary energy production is 30.3 Mtoe (Table 1, Fig 1.). Turkey got a great share coal which is consisted of 57%. The primary energy that follows the coal and their shares are as follows; oil 8%, natural gas 2% and renewable energy 33%. Distribution of the share on the renewable energy are hydraulic, geothermal, wood, animal and vegetable waste and other 10%, 6%, 12%, 1% and 1%, respectively in primary energy production (Fig 5.). On the other hand, primary energy consumption of Turkey is 104.1 Mtoe in 2009. The biggest energy consumption resource is natural gas with 32% and followed of this gas; oil 29%, coal 30%, and renewable energy 9% in consumption (Fig5). Distribution of the share on the renewable energy are hydraulic, geothermal, wood, animal and vegetable waste and other 3%, 1%, 3%, 1% and 1%, respectively in primary energy consumption (MENR, 2010; TKI, 2004,2009). Turkey is dependent on the import of foreign primary energy sources especially; oil, natural gas and hard coal. Recently, according to research estimates, this trend is likely to continue in the near future.

Turkey has two main energy resources with large capacities. These are coal and renewable energy resources. Both energy resources constitute 90% of the primary energy production. The total primary energy production was 31% in 1970 and increased to 50% and 57% in 1989 and in 2009 respectively and this rate was met by coal. The share of the renewable energy resources was 43% in 1970 and decreased to 33% in 2009 (Fig. 6) (Yılmaz 2006; Yılmaz 2011).

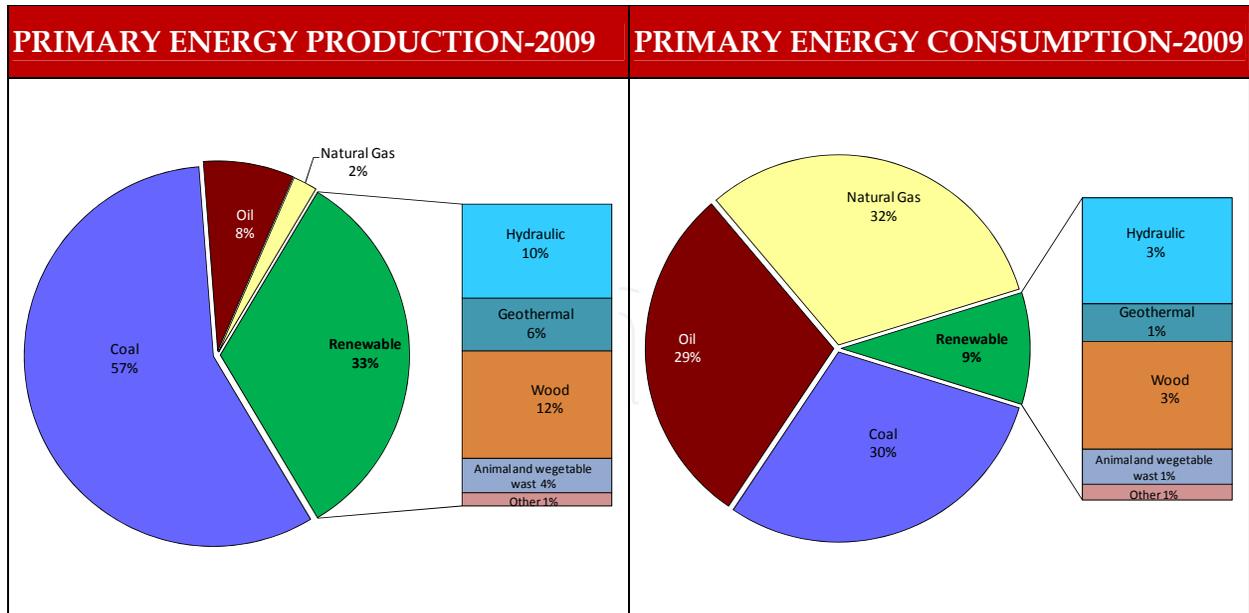


Fig. 5. Total primary energy production and consumption by energy sources in 2009 (data from MENR, 2009)

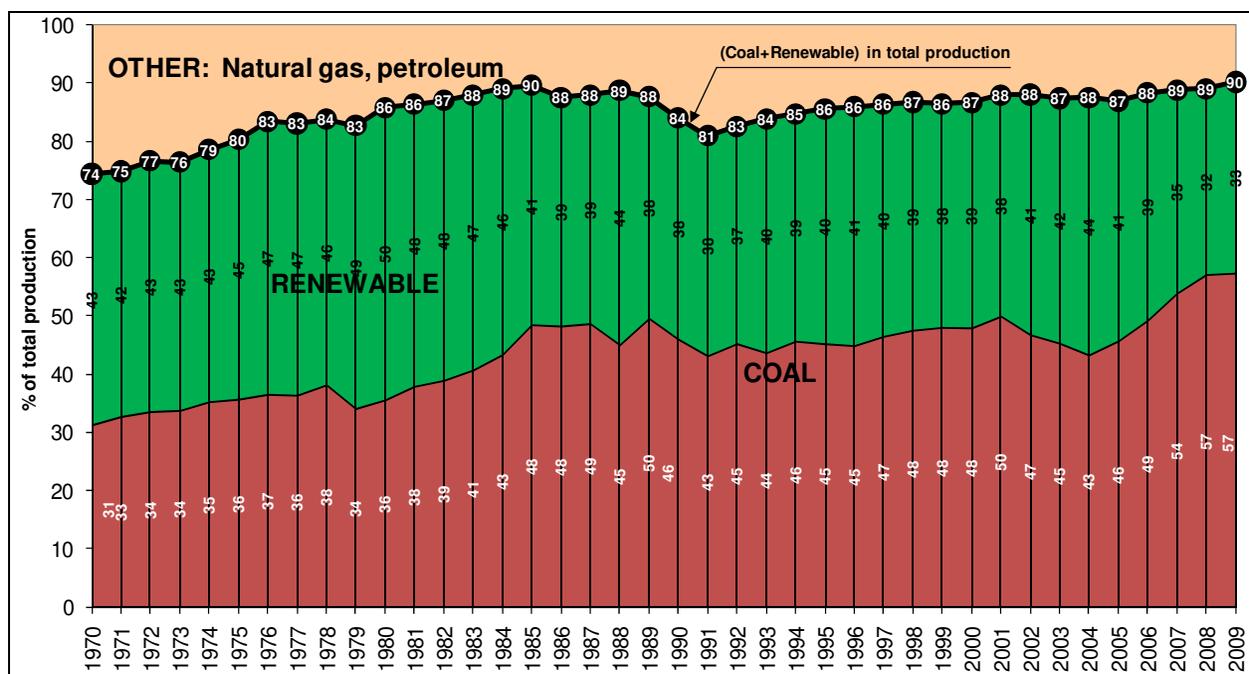


Fig. 6. During of the period 1970-2009, total primary energy production with rates of renewable energy and coal (data from MENR 1970-2009)

The distribution of renewable energy sources in primary energy production in Turkey is illustrated in Fig. 7 for the term 1970 and 2009. The energy sources used for the primary energy production are hydraulic energy, geothermal energy, wood, animal and vegetable waste. On average 43% of the primary energy production was met by the renewable energy in 1970. This percentage increased to 50% in 1980 and due to the imported natural gas, this rate was decreased to 33% in 2009. The shares of the energy sources in this production rate

were as follows: 10% hydraulic, 6% geothermal, 12% wood and 4% animal and vegetable waste in 2009. According to this data, the largest energy source used in primary energy production was wood and hydraulic. While the share of the wood and waste and drug has decreased, the share of the hydraulic, geothermal has increased (Yılmaz 2008; MENR,1970-2009; SIS, 2003–2004; TEIAS, 2004,2009).

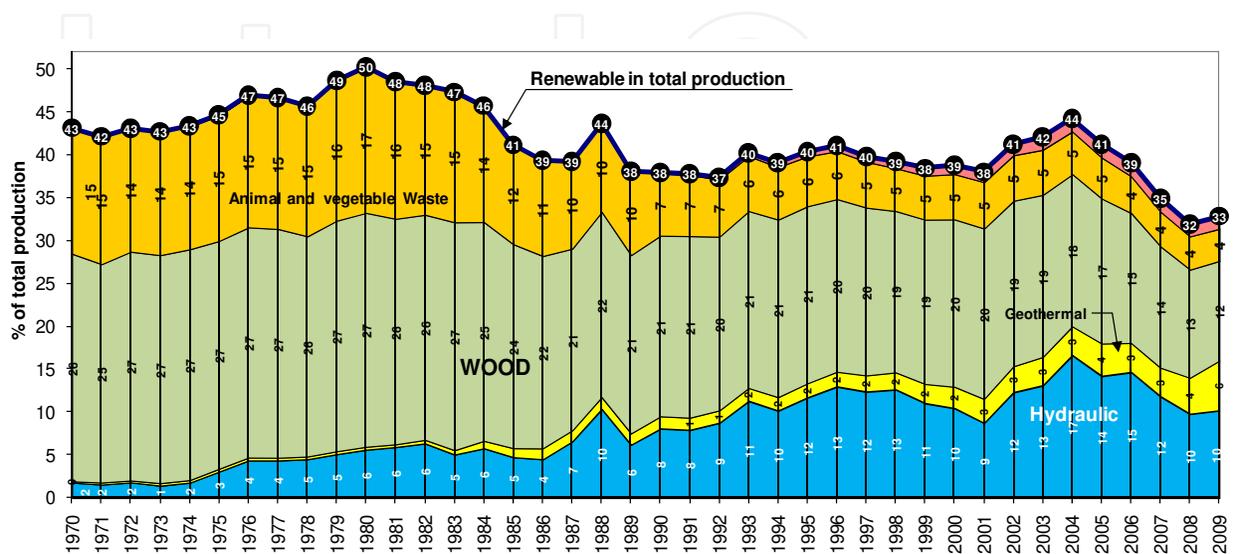


Fig. 7. During of the period 1970-2009, renewable energy sources and rates used in primary energy production (data from MENR 1970-2009)

The development of the total share of renewable energy sources in primary energy consumption in Turkey is illustrated in Fig. 8 for the term 1970 and 2009. Turkey's main energy production resources are hard coal, lignite and renewable energy. The total domestic energy production was 77% (hard coal 15%, lignite 8%, renewable 33% and other oil-gas 21%) in 1970. The share of total domestic energy sources in overall primary energy production was 48% (hard coal 4%, lignite 18%, renewable 18 and other 8%) in 1990, and it decreased to 29% (hard coal 1%, lignite 15%, renewable 10% and other 4%) in 2009. In other words, the share of the renewable energy resources was 33% in 1970 and decreased to 10% in 2009. As seen in Figure 8, Turkey's total domestic energy sources in overall production has decreased from 1970 and 2009 term. When use of renewable domestic energy sources is considered in terms of primary energy production, it decreased to 10% levels in the recent years.

The primary energy consumption of Turkey has increased day by day and it will follow in the future. The development of the total share of renewable energy sources in primary energy consumption in Turkey is illustrated in Fig. 9 for the term 1970 and 2009. The energy sources used for the primary energy production are hydraulic energy, geothermal energy, wood, animal and vegetable waste. The share of total renewable energy sources in overall consumption was 33% in 1970 (hydraulic 1% wood 20%, waste and drug 11%) and it decreased to 23% (hydraulic 4% wood 11%, waste and drug 5%) in 1990. In 2009, the share of renewable energy sources in total primary energy consumption decreased and reached to 9% (Yılmaz 2008; MENR, 2006-2009; SIS, 2003–2004; TEIAS, 2004-2009).

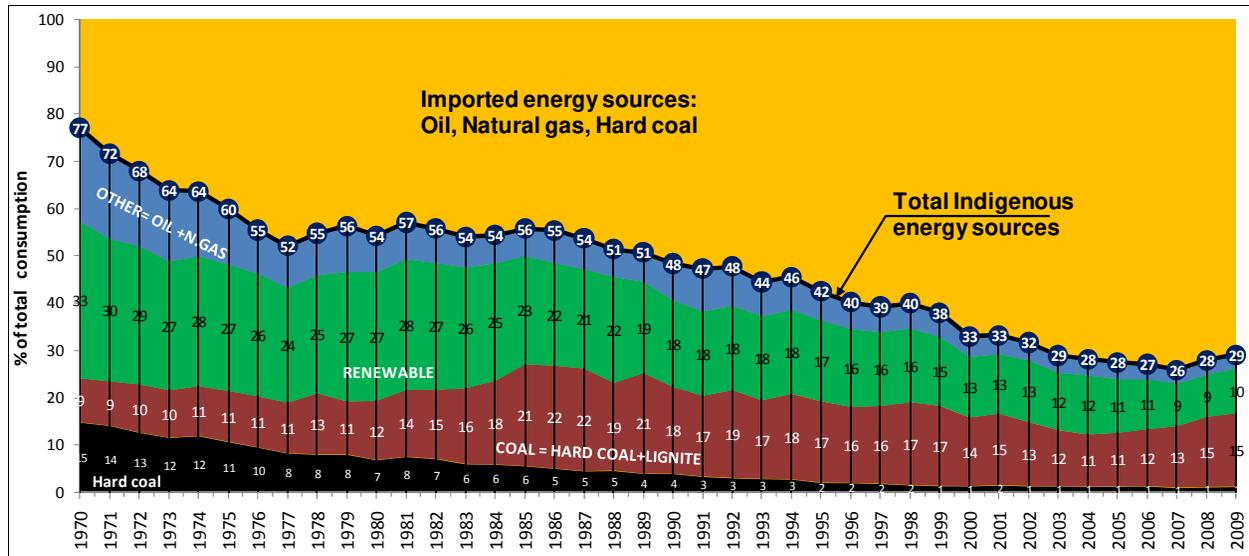


Fig. 8. During of the period 1970 and 2009 development of the total share of renewable energy sources in primary energy production (data from MENR 1970-2009)

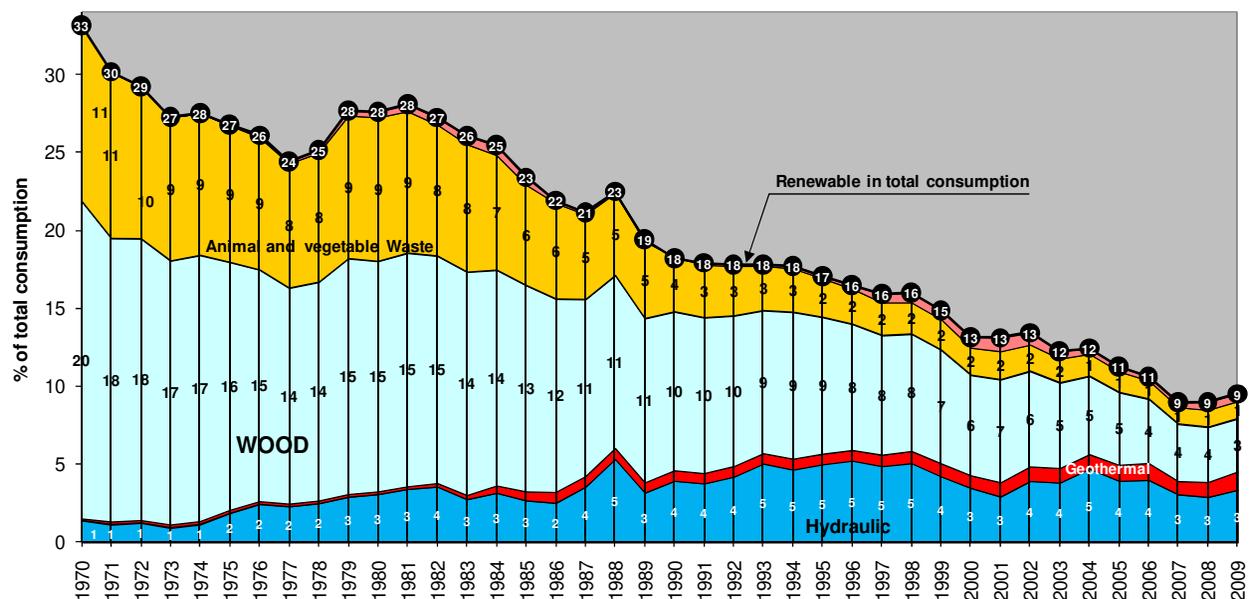


Fig. 9. During of the period 1970 and 2009 development of the total share of renewable energy sources in primary energy consumption (data from MENR 1970-2009)

3.1 Energy production using renewable energy sources

Distribution of installed capacity of Turkey by energy sources during the period 1940 and 2009 is illustrated in Fig. 10. The overall installed capacity was 217 MW in 1940 and the rate of renewable energy source was 3%. The overall installed capacity increased 164 times in 2003 and reached 35587 MW. The renewable source, which was 7.8 MW at the beginning of the term, increased 1614 times and reached 12594 MW (35%). The increase rate of use of renewable energy sources was accelerated especially in the middle of 1950s. This rate increased to 33%, 38%, and 35% in 1973, 1986 and in 2009 respectively. Especially, the electricity production using natural gas caused that this rate decreased. While hard coal

accounted for 50% of total installed capacity and 80% of electricity production in 1950, its share reduced continuously in the following years and realized 1.1% in installed capacity and 1.9% in electricity production. Lignite proved its importance during the petroleum crisis in 1973–1979. After 1973, its importance increased. The share of lignite in electricity production increased to 45% from 20% and its share in installed capacity reached 35% in the 1980s. After the year 2000, an increase in share of natural gas, both installed capacity and in electricity production, lowered the use of lignite. In 2009, the share of installed capacity by resources was 1%, 19%, 35%, 4%, 26% and 11% for hard coal, lignite, renewable, crude oil, natural gas and other, respectively (Yılmaz et al., 2005; Yılmaz, 2004,2011; Yılmaz 2008; Yılmaz and Aydiner, 2009; Yılmaz and Uslu, 2006).

The most important and the largest energy capacities of Turkey's are coal and renewable energy resources. Both energy resources constitute 61% (hard coal 16%, lignite 13% and renewable 32%) of the total installed capacity in 1970. The total installed capacity increased and reached to 78% (hard coal 2%, lignite 29% and renewable 47%) until 1995. In this rate just only hard coal percentage decreased, lignite and renewable increased as domestic energy sources. But, after this time the total installed capacity decreased and reached to 54% (hard coal 1%, lignite 18% and renewable 34%) in 2009 as illustrated in Fig 11.

In Figure 12, distribution of electricity production of Turkey by energy resources is given in a long historical order for 1940 and 2009 term. As seen in the Figure, coal (especially hard coal) had a share of 80% in electricity production in 1940. In the same year, the share of electricity production by resources was 6%, 3%, 6%, 5%, for lignite, renewable, crude oil and other, respectively. The rate of electricity production using renewable energy resources and lignite had begun increasing in time reached to 21% and 14% respectively in 1973. The share of hard coal sharply decreased and reached to 12% in 1973. By the middle of 1960s, use of oil

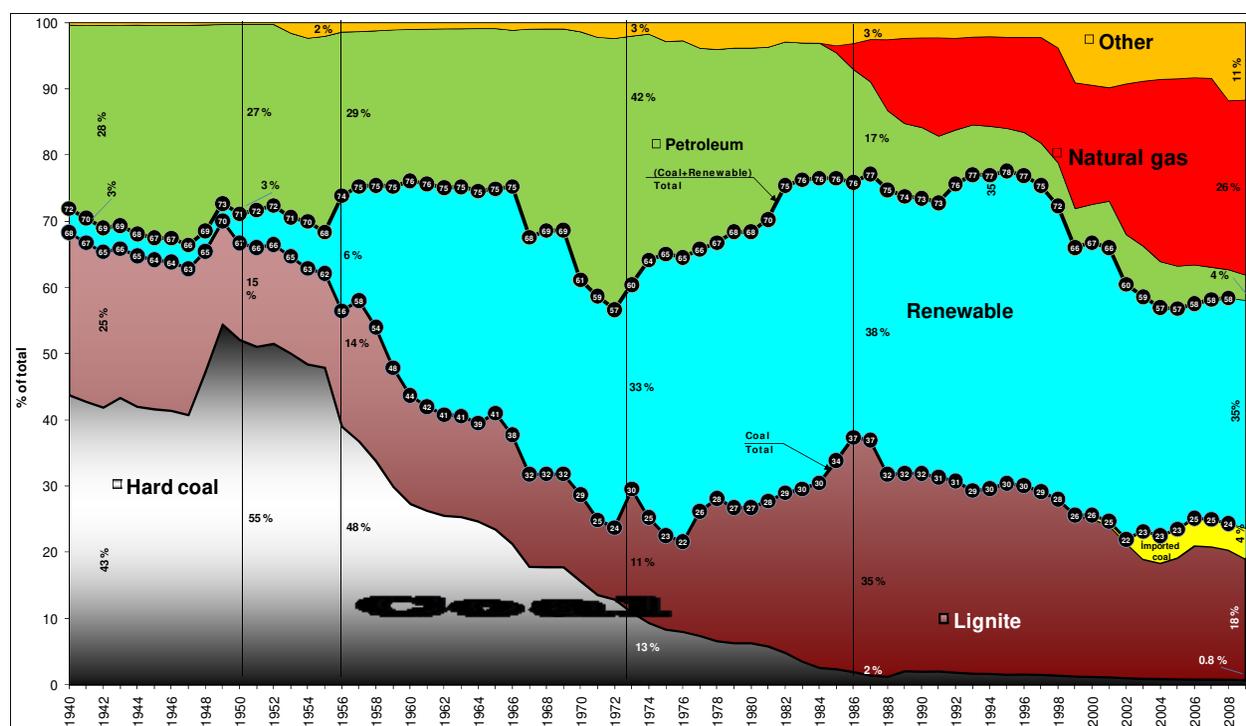


Fig. 10. During period of the 1940- 2009 distribution of installed capacity by energy sources (data from TEIAS 2009)

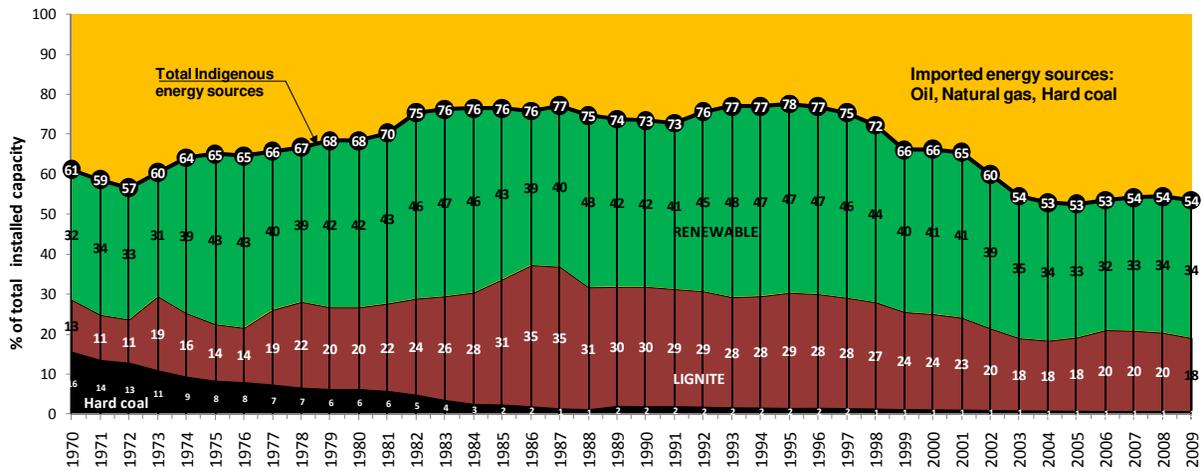


Fig. 11. During of the period 1970 and 2009 development of the share of renewable energy and coal by the total installed capacity (data from TEIAS, 2009)

in electricity production increased, since it is a cheaper than other resources, and this was quickly renounced after the oil crisis in 1973. After the crisis, Turkey gave importance on lignite, one of its own energy resources, and the share of coal in electricity production began increasing and reached 50%. After 2000s, use of natural gas began using in electricity production as in all other areas and its share in electricity production reached 45% in a very short time until 2003. Also imported hard coal began to use in electricity production with 6% in 2003. The share of natural gas has increased and reached to 49% in electricity generation in 2009. At the same year, distribution by resources was as follows natural gas: coal (hard coal %2 + lignite %20) renewable %19, oil %3, and imported hard coal 7% (Yılmaz 2008; Yılmaz, and Aydinler, 2009).

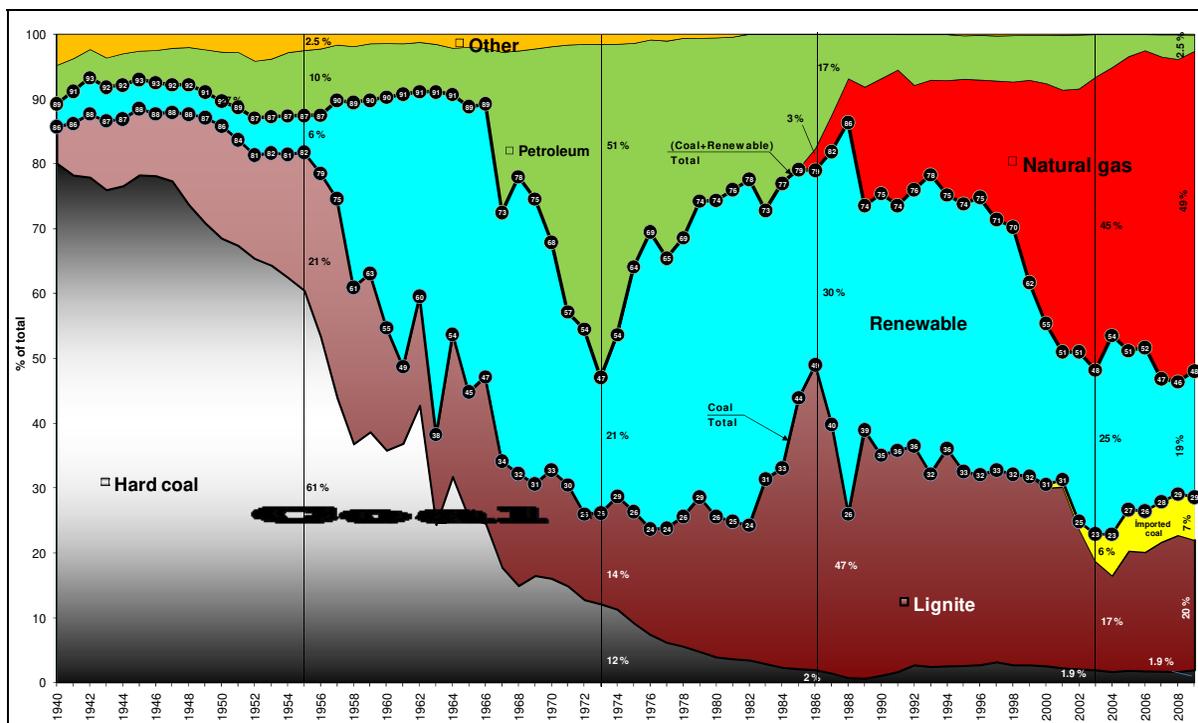


Fig. 12. During period of the 1940- 2009 electricity production by energy sources (data from TEIAS 2009)

The first of the areas where coal and renewable energy can be used most intensively is electricity production. In Figure 13, distribution of the total electricity production by renewable energy and coal sources are given in a historical order. As seen in the Figure, coal (especially hard coal) and renewable energy had a share of 68% (hard coal 16%, lignite 17% and renewable 18%) in electricity production in 1970. The rate of electricity production using renewable energy resources and lignite had begun increasing in time and the share of the hard coal decreased to 1% until beginning of 1988 and the share of renewable energy resources and lignite increased to 42% and 38% respectively. But, after that time the total electricity generation by renewable energy and coal resources decreased and reached to 41% (hard coal 2%, lignite 20% and renewable 19%) in 2009. Turkey has become a country, which imports 70% of its energy resources, during this term. Because after the crisis in 1973, Turkey gave importance on lignite, one of its own energy resources, and the share of coal in electricity production began increasing. However, after 2000s, use of natural gas began prevailing in electricity production as in all other areas and its share in electricity production reached 45% in a very short time.

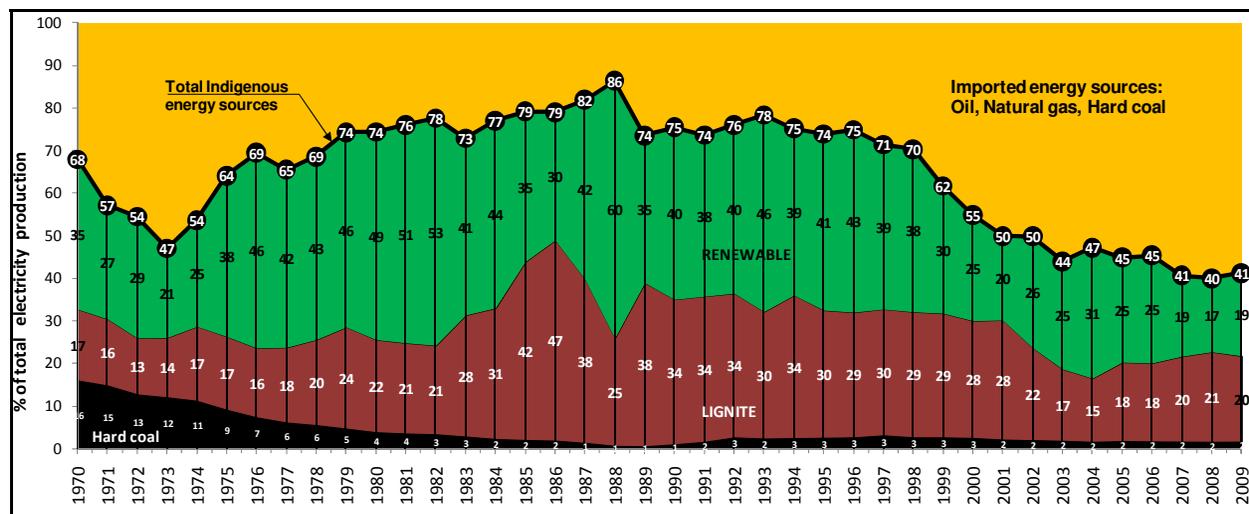


Fig. 13. During of the period 1970 and 2009 development of the share of renewable energy and coal in the total electricity production (data from TEIAS 2009)

3.2 Renewable energy potential of Turkey

The potentials of the main renewable energy sources of Turkey are collectively given in Table 2. The economical potential given in the Table equals the usable potential. The mostly used renewable energy sources in Turkey are biomass energy and hydraulic energy. While geothermal is the third source in the listing, its use is very limited. Use of solar energy is at an emblematic level and use of wind energy is being commenced recently. The overall economical and/or usable potential of the listed renewable energy sources is at a level of 68 Mtoe/year (TUSIAD,1998).

The overall annual electricity production potential of renewable energy sources is 486.3 billion kWh economically. Solar energy, geothermal energy and wind energy potentials are not used or used scarcely. The most used renewable energy source in Turkey is hydraulic energy. Today, the economical hydroelectric potential of Turkey is 129.9 billion kWh and 35% (45.930 GWh) of it is operative, 8% (10.518 GWh) of it is under construction and 57% (73.459 GWh) of it is at project level Table 2.

Renewable Energy Source	Gross	Technical	Economic available
Hydropower (MW) (billion kWh/year)	107 500 430	53 730 215	36652 129.9
Geothermal Heat (MW) (Mtoe/year) Electricity (MW) (billion kWh/year)	31 500 - 4 500 -	7 500 5.4 500 -	2 843 1.8 350 1.4
Solar Heat + electricity (MW) (billion kWh/year) (Mtoe/year)	111 500 × 10 ³ 977 000 80 000	1 400 000 6 105 500	116 000 305 25
Wind Electricity (MW) (billion kWh/year)	220 000 400	115 000 290	20 000 50
Classic Biomass Fuel (Mtoe/year)	30	10	7
Modern Biomass Fuel (Mtoe/year)	90	40	25

Table 2. Potential of Renewable Energy Sources (MENR,2009)

4. Coal and energy

4.1 Energy production based on coal

The coal production culture in Turkey was introduced with the exploration of hard coal by Uzun Mehmet in Köseagzı quarter of Kestaneci village in Zonguldak province on 8th November 1829. Up to date, hard coal has been produced in Turkey. There is no definite information about the first use of lignite. It is known that lignite was being produced in many locations in Turkey, especially in Soma -Kütahya (Yılmaz, 2008).

Hard coal is used intensively in industry and heating and especially in electricity production. Lignite coals are used mostly for electricity production since its calorific value is low. The share of coal in overall primary energy production was 31% (lignite 12%, hard coal 19%) in 1970, and it increased to 46% (lignite 38%, hard coal 8%) in 1990 with an increase rate of 48%. In 2009, the share of coal in total primary energy sources has increased and reached to 57% (lignite 53%, hard coal 4%) as shown in Fig 14. The primary energy production of Turkey has been limited and the largest share in this increase belonged to lignite. It is hope that this rate of percentage increase will continue in the following years. On the other hand, the share of coal in overall consumption was 24% (lignite 9%, hard coal 15%) in 1970, and it increased to 31%

(lignite 19%, hard coal 12%) in 1990 with an increase rate of 16%. In 2009, the share of coal in total primary energy sources decreased and reached to 29% (lignite 15%, hard coal 14%) (Fig. 15). Turkey's primary energy consumption is higher than energy production. In other words, the increase rate of primary energy consumption is about 6 times of that of the production. And Turkey consumes 6 times of its production. If this rate increased in the following years, Turkey would become an import dependent country in terms of energy in the following years (Arioğlu, Yılmaz, 2002a, 2002b, 2002c; MENR, 2009; Yılmaz 2008).

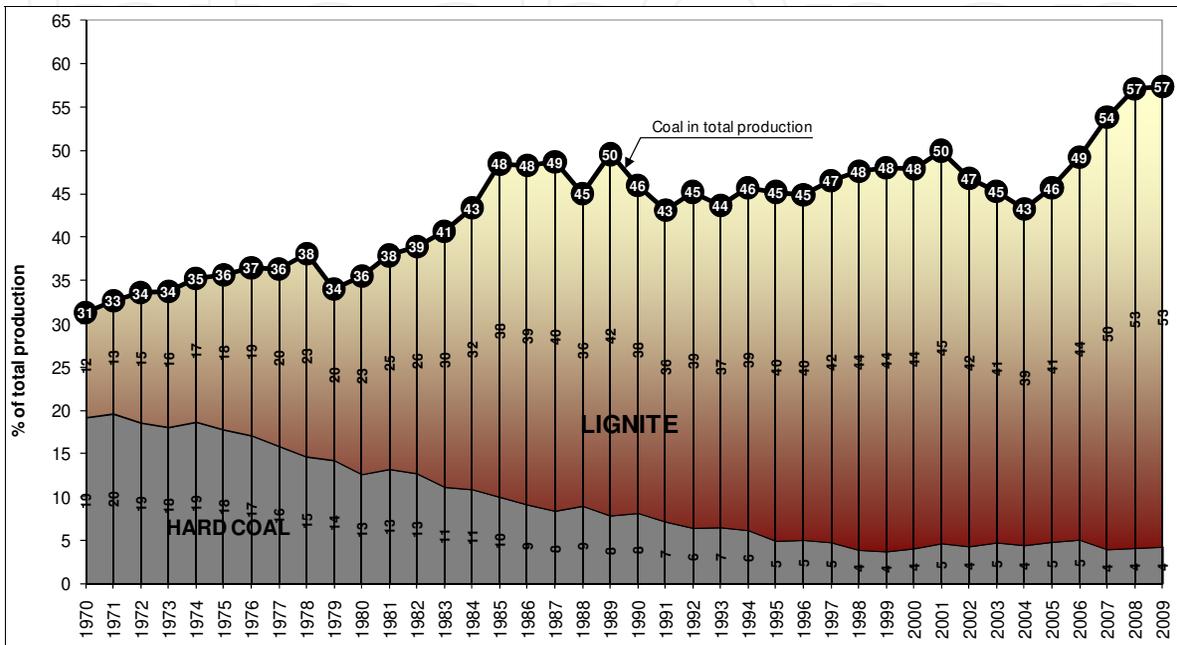


Fig. 14. During of the period 1970 and 2009, development of the share of coal energy sources in primary energy production (data from MENR, 1970-2009)

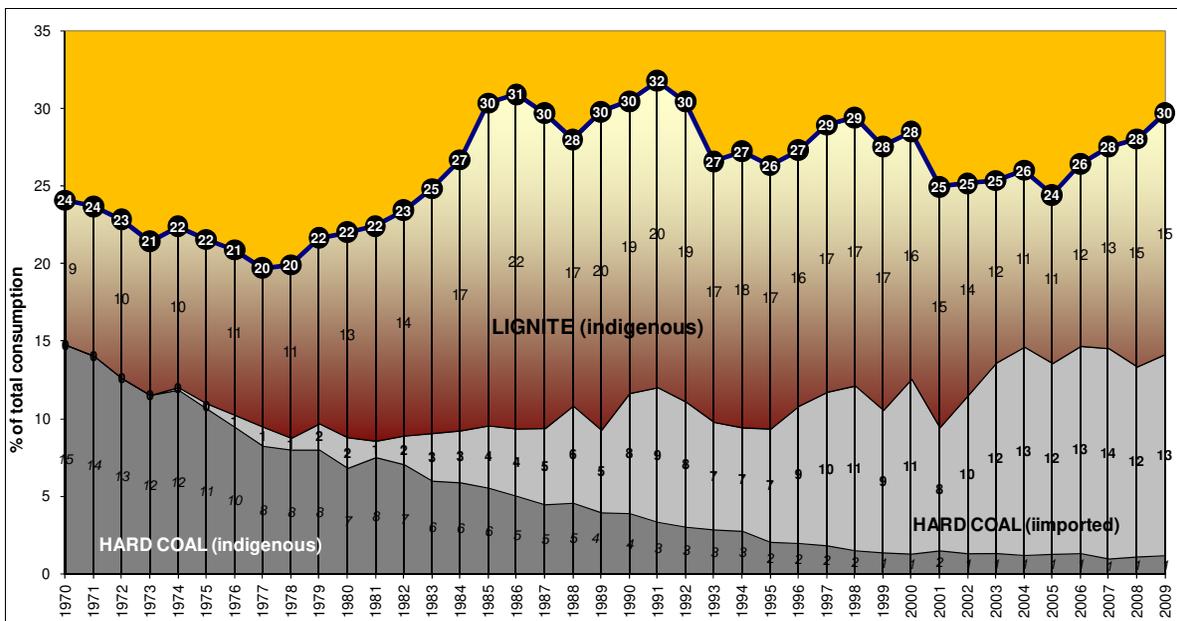


Fig. 15. During the period of 1970 -2009 development of share of coal in primary energy consumption (data from MENR, 1970-2009)

4.2 Coal potential, production and consumption

Turkey has an important potential from the point of view of coal reserves (Fig. 16). Apart from the hard coal and lignite reserves, asphaltite, bituminous shale and peat reserves are also present in the country. Turkey's significant hard coal basin exists in Zonguldak province which is on the Western Black Sea Region. The total reserve (ready + proven + probable + possible) is about 1.3 billion ton (Table 3). Hard coal reserves are distributed into five districts. Distributions of total reserves among these five districts are: Ereğli 34 million tons; Zonguldak 884 million tons; Amasra 408 million tons; Kurucaşile 1 million tons; Azdavay 5 million tons. The calorific value of the hard coal differs from 6.500 to 6.650 kcal/kg (Table 3) (TTK, 2004,2009; TKI, 2004,2009).

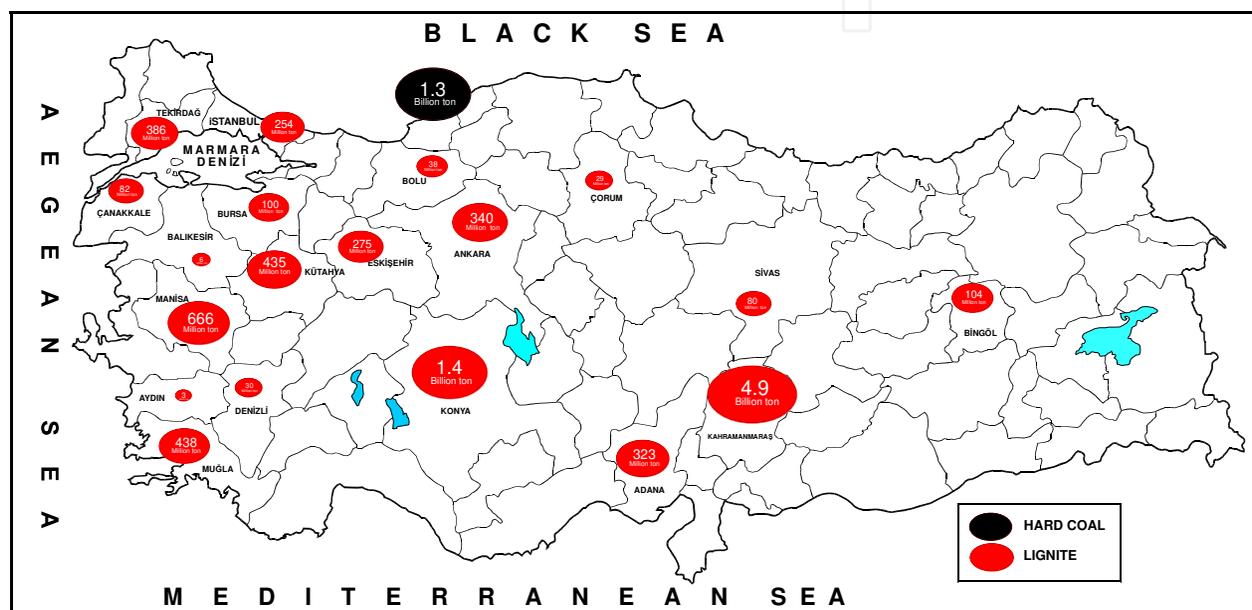


Fig. 16. Distribution of hard coal and lignite reserves of Turkey

Location		RESERVES (1000 TON)				Calorific value, kCal/kg
Province	District	Proven	Probable	Possible	Total	
Zonguldak	Ereğli	11.241	15.86	7.883	34.984	6650
Zonguldak	Center	351.272	294.043	239.029	884.345	6650
Bartın	Amasra	172.107	115.052	121.535	408.694	6000
Bartın	Kurucaşile		1		1	6500
Kastamonu	Azdavay		5.593		5.593	6500
TOPLAM		534.62	431.548	368.447	1.334.615	-

Table 3. Distribution of hard coal reserves of Turkey (MENR 2010)

Hard coal Production is maintained under very difficult geological conditions. The production depth reached 600-1000 m in some regions. Such difficult working conditions caused that the unit costs increased and this affected the competitive power of the country in world's markets. In addition, the expected increase in production could not be achieved and contrary to expectations the production was decreased to 3 million tons from 9 million tons (Table 4). This

production level can meet only 10%-12% of the overall consumption of Turkey, which are 22-23 million tons. While, especially in the recent years, a significant part of the produced hard coal is used for electricity production, the remaining coal is consumed for other purposes, such as iron and steel industry, household fuel etc as illustrated in Fig.17 and Table 4. In 2009, the share of hard coal consumption by sectoral were 70%, 27% and 4% for industry, power station and house hold, respectively (Yılmaz 2011; TTK 2009; MENR 2010).

Years	Hard coal production/consumption (x1000 ton/year)		[production /consumption] x100], %	Consumption [x1000 ton/year]			Distribution of total consumption, %		
	Production	Consumption		Industry	Power station	House hold	Industry	Power station	House hold
2000	2,392	15,525	15.41	12,777	2,034	714	82.3	13.1	4.6
2001	2,494	11,176	22.32	8,106	2,274	796	72.5	20.3	7.1
2002	2,319	13,830	16.77	10,920	2,051	859	79.0	14.8	6.2
2003	2,059	17,535	11.74	12,845	3,706	984	73.3	21.1	5.6
2004	1,946	18,904	10.29	13,435	4,565	904	71.1	24.1	4.8
2005	2,170	19,421	11.17	13,227	5,259	935	68.1	27.1	4.8
2006	2,319	22,798	10.17	16,315	5,618	865	71.6	24.6	3.8
2007	2,462	25,388	9.70	18,611	5,912	865	73.3	23.3	3.4
2008	2,601	22,720	11.45	15,658	6,197	865	68.9	27.3	3.8
2009	2,863	23,698	12.08	16,472	6,361	865	69.5	26.8	3.7

Table 4. Hardcoal production, consumption and using areas

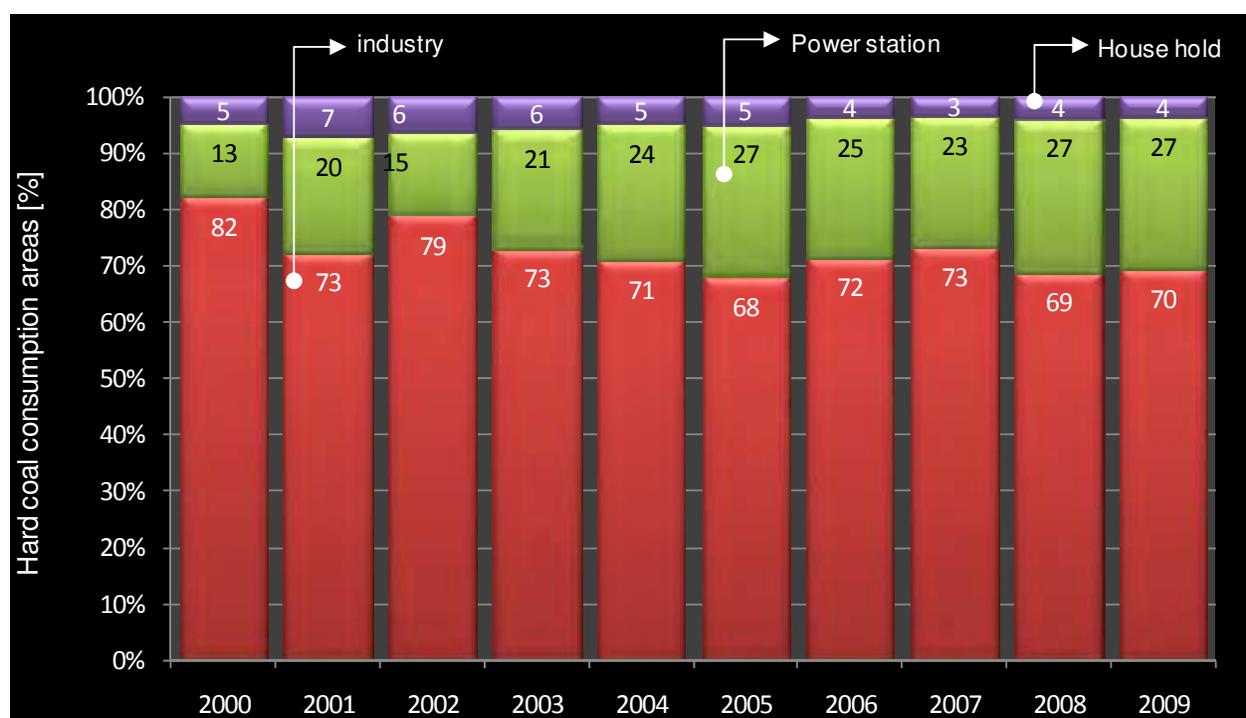


Fig. 17. Distribution of hard coal consumptions by sectoral (data from MENR 2000-2010)

Lignite reserves constitute the large portion of total coal reserves. Lignite deposits dispersed all over the country (Yılmaz, 2006). The most important known lignite deposits reserves are located in Afşin Elbistan, Muğla Soma, Tunçbilek, Seyitömer, Beypazarı and Sivas regions (Fig. 16). About 40% (4.9 billion tons) lignite reserve is located around Afsin-Elbistan which is in the southeast of the Turkey (Yılmaz and Uslu 2007). Although total lignite reserves were about 8.07 billion tons (TKI 2009; TKI, 2010), Turkey's new total lignite reserves including proven, probable and possible reserves have reached about 11.4 billion tons after recent exploration activities. Turkey has a share of 2.5% in the world reserves and 8.2% in the world production (Yılmaz , 2011). Distribution of the lignite reserves in the Turkey is shown in Table 5 (TKI, 2004; 2010). Turkey's coal deposits are operated by companies which are Turkish Hard Coal Enterprise (TTK), Turkish Coal Enterprises (TKI) and the Electricity Generation Company (EUAS) and Private sectors. TTK is authorized for hard coal production, processing and distribution. More than half of lignite reserves are produced by TKI. Production of remains are belongs to private companies and EUAS for we in power plants. The distribution of reserves is as follows: TKI 21.5 %, EUAS 42 %, MTA 23% and Private sector 13.5% (Table 5.) (Yılmaz 2008, EUAS 2004,2009; Anaç 2003).

LIGNITE						
Coal field	Reserves (1000 TON)				Ration in total, %	Calorific value, Kcal/kg
	Proven	Probable	Possible	Total		
EÜAŞ	4.718	104	-	4.822	42.0	1031-4900
TKİ	2.239	218	1	2.458	21.5	
MTA	1.803	685	123	2.611	23.0	
Private sector	1.077	337	138	1.554	13.5	
TOPLAM	9837	1344	262	11.445	100	
ASPHALTITE						
Location		Reserves (1000 TON)				Calorific value, Kcal/kg
Province	District	Proven	Probable	Possible	Total	
Şırnak	Silopi	31.812	16.21	1	49.022	5310
Şırnak	Merkez	7.724	13.26	6.3	27.284	5330
TOPLAM		39.536	29.47	7.3	76.306	-

Table 5. Distribution of Lignite and Asphaltite Reserves of Turkey (Data from, TTK, 2004; TKI, 2010).

The lignite mined from most lignite deposits is low calorific value lignite and the calorific value of 90% of them is between 1000 and 3000 Kcal/kg (Fig.18). In this context, a significant part of the lignite production is used for electricity production (Fig 19.). Lignite production depends on electricity production. Lignite production reached to 76 million ton/year especially in 1970 and 2009 term, when the lignite production is very effective in electricity production. Its production decreased to 45 million ton/year after 2000, since its use in electricity production repressed after 2000. The overall lignite consumption can be met by the domestic production (Fig.19.)

Lignite production depends on electricity production. While 1% of produced lignite in 1970 was used in power stations, 5% was used as house hold and industry. In 2000, the share of lignite consumption by sectoral were 82% and 18% power station and house hold and industry, respectively. In 2009, the share of the power station in lignite consumption increased and reached to 83% (Fig. 19).

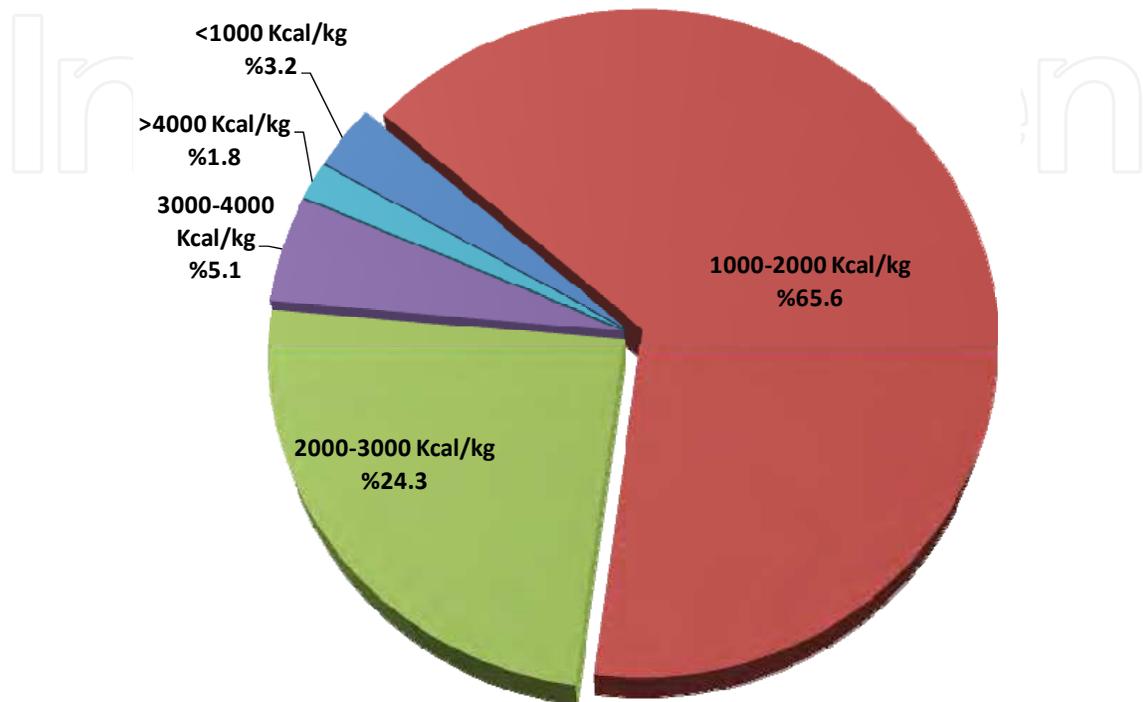


Fig. 18. Lignite by calorific value

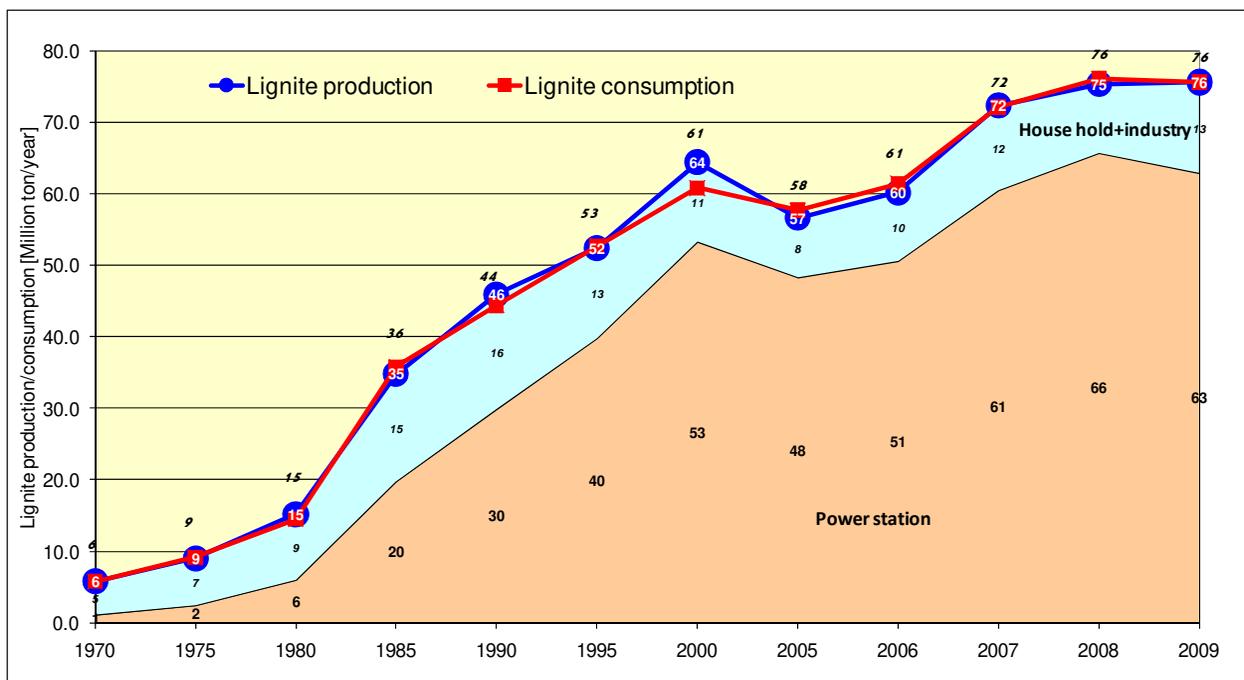


Fig. 19. Lignite production/ consumption and consumption areas (data from TKI, 1970-2009)

5. Future projection

The primary energy production–consumption of Turkey and distribution of electricity production of Turkey by sources projected for the years 2015 and 2020 are given in Figs. 20–21. No major change is seen or foreseen in the development of share of domestic energy sources in primary energy production. It is planned that this rate will be 32% in 2015 and 30% in 2020. In other words, 70% of the primary energy production of Turkey will be dependent on imports. On the other hand, renewable energy sources and hard coal constitute 90% of the primary energy consumption; 5–10 points increase is foreseen in the share of coal in primary energy production 2015 and 2020. It is planned that this share will be 54% and 61%, respectively, for the years. The dependence on imported energy sources for electricity production projected for the years 2015 and 2020 are 47% and 50%, respectively (Fig.22). It is projected that the share of coal in electricity production will increase to 28% in 2020 and no significant change is planned in electricity production using renewable sources and it is projected that this share will decrease to 23% in 2020. In other words, Turkey does not plan to introduce any expansion in energy production until 2020 when compared with today's conditions according to its energy projections (Yılmaz,2008; TPAO 2006).

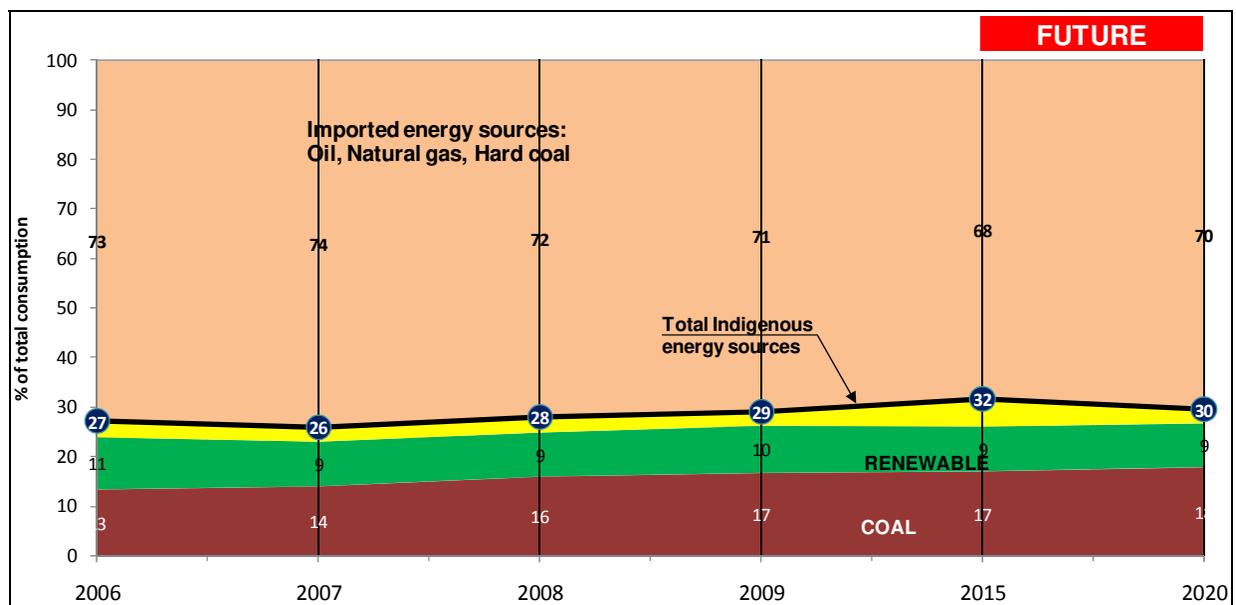


Fig. 20. Projection of development of the share of domestic energy sources in overall primary energy consumption (data from MENR, 2006,2010).

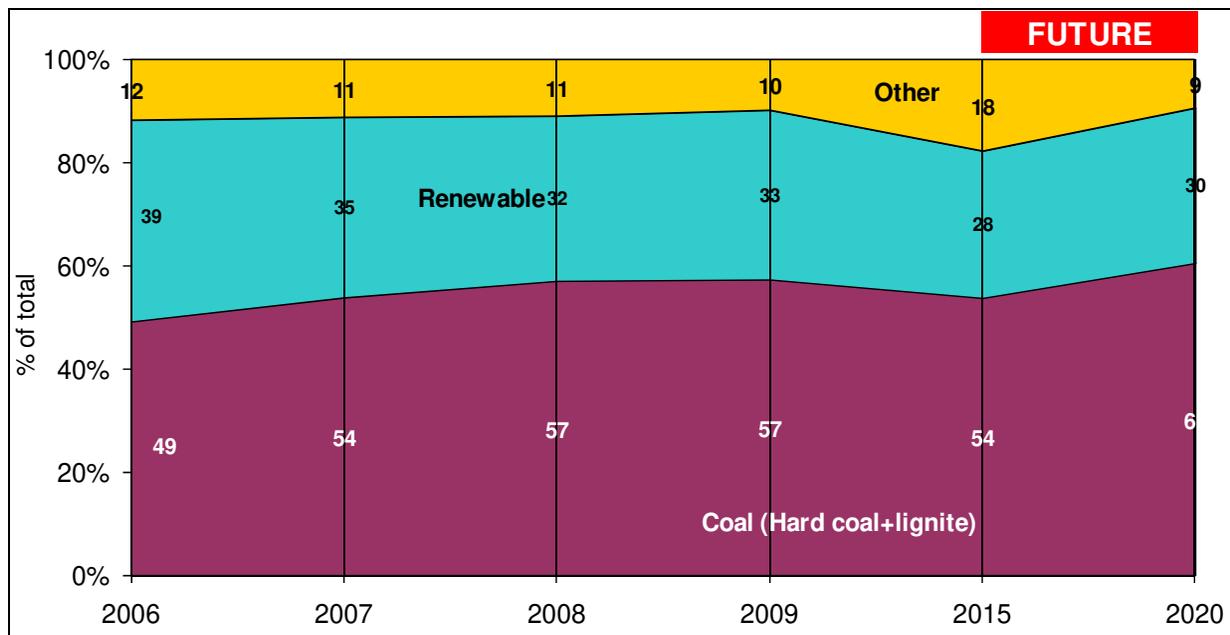


Fig. 21. Projection of distribution of domestic energy sources in overall primary energy production (data from MENR, 2006,2010).

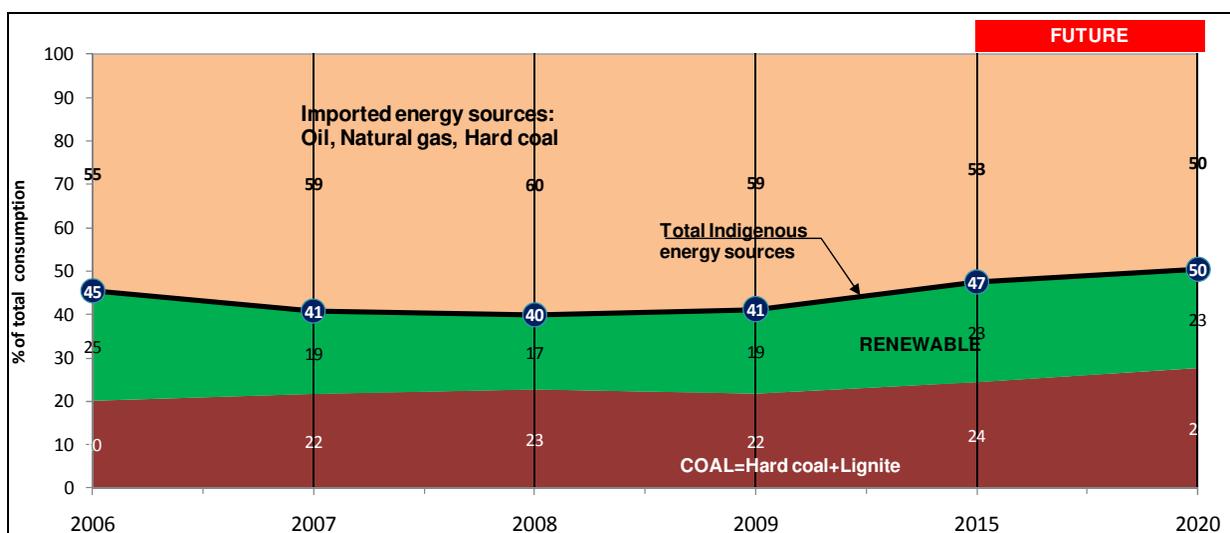


Fig. 22. Projection of development of domestic energy sources in electricity production (data from MENR, 2006,2010).

6. Discussion and conclusion

Turkey imports about 70% of the energy sources it uses in primary energy consumption. This percentage is 59% for electricity production. The imported energy sources are oil, natural gas and hard coal. The load of imports on Turkey’s economy as of 2000-2009 is illustrated in Fig. 23. Turkey spent 29 billion dollars overall for energy imports in 2009. This amount constitutes 29% of the overall exports in 2009 and 21% of the overall imports. In other words, Turkey spends approximately one-third of the income it obtains from overall exports for energy imports. Oil and natural gas are the most imported energy sources with a

percentage of 89% (26 billion dollars) of the overall energy source imports and it is followed by hard coal with a percentage of 11% (3 billion dollars). The incredible increase rate of natural gas consumption in the recent years constitutes an important expense item in the imports items of Turkey. More importantly, use of natural gas in industry and electricity production makes Turkey completely dependent on the foreign countries in terms of energy security. Especially Turkey's supplying over 50% of its electricity production from natural gas causes very severe security problems and Turkey should question this issue very seriously. On the other hand, although Turkey has sufficient hard coal reserves, it increasingly imports hard coal in order to consume it in industry and electricity production due to some reasons such as production difficulties and insufficient investments. Turkey should immediately take action in order to meet such requirements from its own sources. It should not be expected that the domestic production covers the consumption within a very short time, but it should be aimed at meeting or minimizing the deficit between the production and import within a long time. On the other hand, although Turkey has sufficient lignite reserves for electricity production, importing hard coal for this purpose is a completely strategic mistake (Yılmaz,2008).

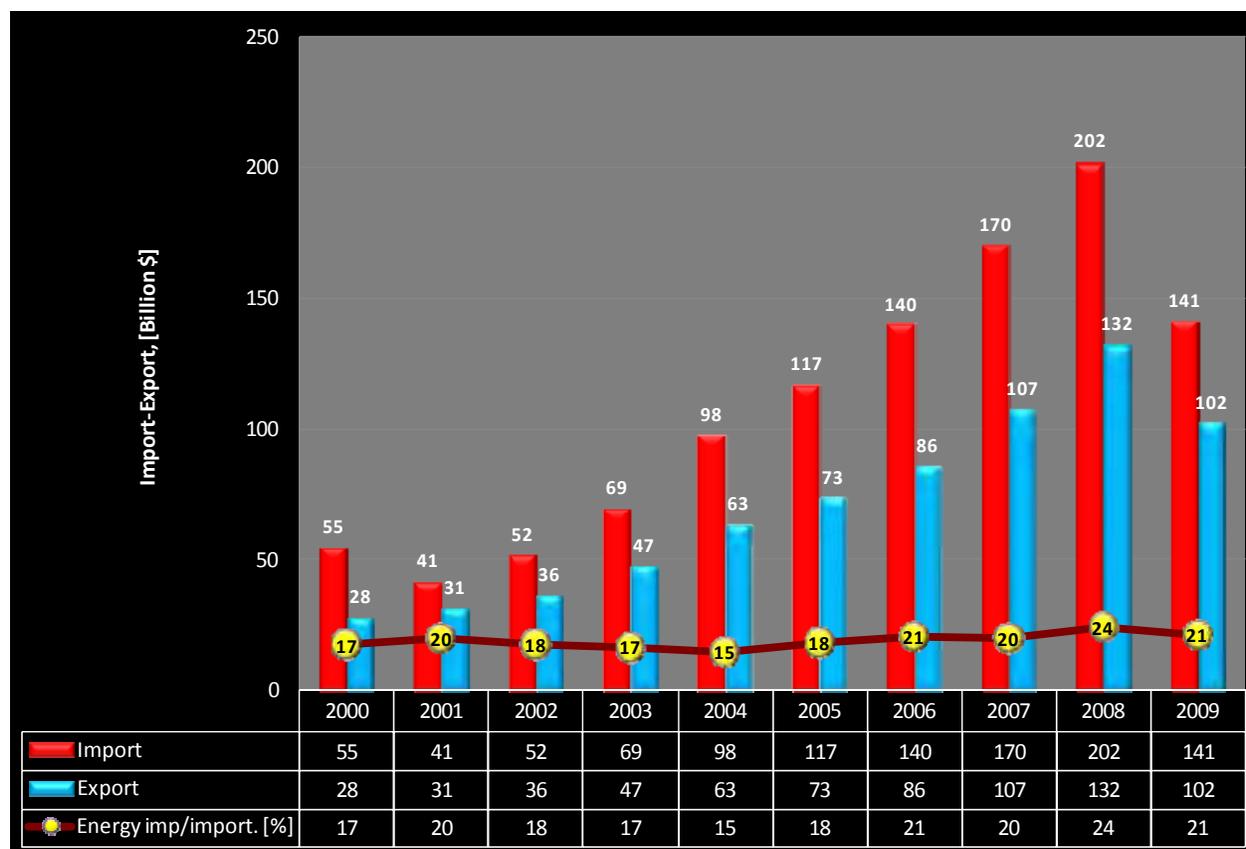


Fig. 23. Load of energy source imports on Turkey's economy

The largest energy sources of Turkey are coal and renewable energy. Turkey should use these energy sources in areas where it can substitute them for oil and natural gas. The first of these areas is electricity production. In projections of Turkey (Fig. 22), it is proposed that 50% of the electricity production will be imported. It is planned that the overall demand for electricity will be 500 billion kWh in 2020. However, there is a potential for producing reliable electricity from renewable energy sources (480 billion kWh) and lignite thermal power plants (100 billion kWh), which are operative and of which the projects are completed, economically (Table 2.). In other words, Turkey has a potential for producing electricity it demands by using only its own sources. It is obligatory to comply with the environmental pollution and emission limits in use and production of coal. The required measures in this regard has been taken in most of the operative power plants and the studies for taking such measures continue rapidly in the other power plants. It is vital for Turkey to take operating the coal reserves by using environment-friendly technologies and utilizing its sources at the highest level among its priorities (Yılmaz, 2008).

7. References

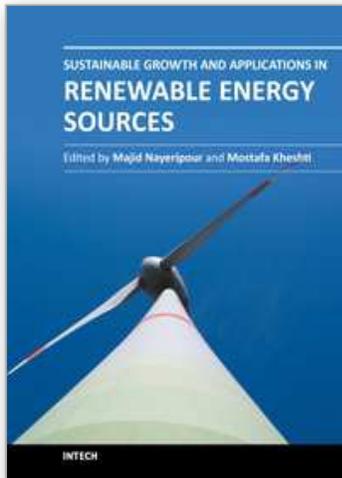
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Worldwide attention to environmental issues combined with the energy crisis force us to reduce greenhouse emissions and increase the usage of renewable energy sources as a solution to providing an efficient environment. This book addresses the current issues of sustainable growth and applications in renewable energy sources. The fifteen chapters of the book have been divided into two sections to organize the information accessible to readers. The book provides a variety of material, for instance on policies aiming at the promotion of sustainable development and implementation aspects of RES.

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