Makale Gönderim Tarihi: 01.09.2020
Yayına Kabul Tarihi: 03.11.2020

Importance of Domestic Coal (Lignite) Reserves on Turkey's Energy Independency

Serkan Inal*, Ozum Yasar, Kerim Aydiner
Department of Mining Engineering, Karadeniz Technical University, Trabzon, Turkey
**** Corresponding Author:** Tel: +90 462 3773643 Fax: +90 462 3257405*
***E-mail:** serkan.inal@ktu.edu.tr*

Abstract
This article surveys a policy of Turkey's energy planning over coal. Energy supply pattern of Turkey is highly dependent on the foreign resources. Electric production of the country relies largely on hydropower, natural gas and coal. Though the country has considerable lignite reserves suitable for energy production in thermal power plants, many of the plants constructed in the last two decades utilize imported coal. Future energy plans of the country consider resource diversification, decreasing foreign dependence and diversification of the dependent countries. However, current energy perspective of the country shows significant deviations of the strategies developed. Domestic lignite reserves of the country offer satisfying alternatives over the foreign coal. Additional efforts to enhance the effective utilization of domestic lignite reserves are required. This paper presents a detailed assessment of the future energy perspective of Turkey. For this purpose, the development plans, the past trends and the future projections of country about the coal and global energy supply-demand pattern were evaluated.
Keywords: Coal, Lignite, Energy, Energy planning, Turkey

Özet
Bu çalışma Türkiye'nin enerji planlama politikasını kömür üzerinden incelemektedir. Türkiye'nin enerji tedarik modeli yüksek oranda dış kaynaklara bağımlı durumdadır. Ülkenin elektrik üretimi büyük oranda hidroelektrik, doğal gaz ve kömüre dayanmaktadır. Türkiye önemli miktarda termik santrallerde değerlendirilmeye uygun linyit rezervlerine sahip olmasına rağmen son 20 yılda kurulan santrallerin birçoğu ithal kömüre dayalıdır. Ülkenin gelecek enerji planları; enerji kaynaklarının çeşitlendirilmesi, dışa bağımlığın azaltılması ve bağımlı olunan ülkelerinde çeşitlendirilmesi yönündedir. Bununla birlikte mevcut enerji perspektifi bu geliştirilen stratejiden ciddi sapmalara sahiptir. Ülkenin yerli linyit rezervleri ithal kömüre karşı önemli bir alternatif seçeneği sunmakta olup, yerli linyit rezervlerinin etkili bir şekilde kullanımının arttırılması için ilave çabalar gerekmektedir. Bu derleme Türkiye'nin enerjide gelecek perspektifini detaylı olarak değerlendirmektedir. Bu amaç ile ülkenin, enerjide geçmiş yönelimleri ve gelecek projeksiyonu ile geliştirilen planlamalar kömür ve küresel enerji arz talep modeli açısından değerlendirilmiştir.
***Anahtar Kelimeler:** Kömür, Linyit, Enerji, Enerji Planlama, Türkiye*

1.Introduction

Energy is an important necessity of modern life and one of the development indicator in terms of energy usage per capita and as a remarkable part of energy usage access to electricity is considering as a basic human right in several platforms and debates are continuing with an increase incrementally [1], [2]. Growing of energy demand in the world due to increasing of population is also well known. However, in decision of energy sources selection considering different point of views such as economic, social and environmental is needed. Therefore, these considerations must be individual for each country in terms of their statue. Especially in developing countries, energy requirements increase faster which is highly related to industrial and economical improvements. Turkey can be given as a very good example for this as one of the fastest growing power markets in the world in last two decades [3]. At this point the main question is how to decide an energy sources with a good balance of the considering environmental effects, life standards of citizens and economic progress of country.

Turkey has promised at Doha Climate Change Conference to decrease CO_2 emission but the energy demand of country is growing with an increase of population and environmental effects increase in parallel [4]. On the other hand with planning economical improvements alternatives of Turkey are also very limited for energy planning based on energy resources. Turkey has lack of primary fossil energy resources and therefore import-dependent country with 93% for oil and 99% for natural gas and total external dependence of Turkey is around 66% in energy production and it's still increasing [5], [6]. Additionally, nuclear energy resources of Turkey are also limited [7]. Therefore, under construction of two nuclear power plants will not help to reduce of external dependency of the country. Nonetheless, Turkey has sufficient coal reserves especially lignite and high potential on renewable energy possibilities. Also, energy program of Turkey involve using indigenous coal reserves especially lignite and continue to investments on renewable energy [8]. In this paper, energy sources were compared economic, social, and environmental point of view, using of coal in energy sector in the world and Turkey analyzed and the significance of Turkey's coal resources to become more independent in energy production elucidated.

2. The Significance of Coal in Turkey and The World

The strategic concerns are the most fundamental reasons making the coal is important. Countries need policies to meet their energy needs to overcome the possible negative political situations. These policies focus basically on reducing external dependency and diversifying energy sources. Coal gives possibility to make this approach possible with reserves that spread more homogenously all over the world than the other energy sources (see Fig. 1). It is very important for countries to reduce the risk of accidents and interruptions in energy supply arising from accidents, political interventions, terrorism or industrial disputes. With the effect of these concerns, many countries, such as China, India, Indonesia, Australia and South Africa, rely mainly on local coal resources for their energy needs. As a proof of this evaluation, it can be shown that 83% of the hard coal produced are used within the producer countries. Lignite is also a resource with a low potential for international trade. 90% of the lignite produced is used for

power generation in power plants located near the production area [10].
Turkey's coal reserves do not exhibit a balanced picture contrary to world when the coal types are considered. Turkey has a very low potential for anthracite and bituminous coals. On the other hand, Turkey has considerable amount of reserves of low quality coals. Therefore, Turkey has the potential to switch to the energy policies based on to use national resources which have been adopted by many other countries in the world. Turkey has a total of 17.5 billion tons of lignite (94%) and 1.13 billion tons of hard coal (6%) reserves, which have been identified as of November 2017 [11], [12]. Lignite reserves in Turkey are demonstrated in Fig.2 on the basis of regions.

Coal has a number of advantages over oil and natural gas, such as lower prices per unit energy, higher production rates and spread of coal resources across a wide area which makes coal geopolitically advantageous [13]. When considering the reserves and the production rates in 2016, coal can be regarded as a source having the longest life among the other fossil energy sources in the world as well as in Turkey. It is estimated that the world oil and natural gas reserves have a life span of approximately 50 years, whereas it is 150 years for coal reserves. The estimated life of oil and natural gas reserves of Turkey are 19 and 14 years, respectively. On the other hand, life of coal in Turkey is estimated to be more than enough 163 years considering the 2016 production amounts (see Table 1). However, the predicted lifetimes of the resources may increase depending on the results of the exploration work carried out or may decrease by the increase in the energy requirement.

Table 1. Lives of world fossil energy resources on regions based on [14], [15].

Region / Country	Oil ** (years)	Natural Gas ** (years)	Coal ** (years)
North America	32.3	11.7	356
South and Central America	119.9	42.9	138
Europe and Eurasia Region	24.9	56.3	284
Middle East	69.9	124.5	*
Africa	44.3	68.4	54
Asia Pacific Region	16.5	30.2	102
World Total	50.6	52.5	153
Turkey	19.2	13.5	163
* Extremely low production rates are discarded ** The lives of the resources are calculated according to the reserves and the production volumes at 2016.			

Coal mining and usage also have socioeconomic advantages. Coal mining provides serious employment in the region where it is made. It also increases the regional mobility and trade volume in different business areas. It also contributes to the development of the infrastructure of the region and to the investment in many aspects depending on the production and transportation requirements. A few examples from an economic point of view, can be given as follows; Germany has invested 2.6 billions euros in the lignite-operated thermal power plant of Neurath Unit F and G [16] and China has a tax income of 65 million $ just from a thermal power plant [10].

Moreover, a few developed countries such as Germany, England and Japan have a highly developed mining equipment and machinery industry and also coal mines in these countries are still running, even if these are not profitable, due to being an indirect driving force for machinery and equipment industries. In the majority of the underdeveloped or developing countries, such as Colombia, South Africa and Indonesia, coal mining provides direct or indirect employment opportunities [17].

Another socioeconomic significance of coal mining is the employment. For example; in Turkey approximately 18,500 people are employed in the hard coal sector and 37,500 people in the lignite sector according to the 2013 data. On the other hand, 300 to 450 million dollars' worth of coal was distributed to poor families, annually between 2009 and 2013. In 2015, the total number of families supported by coal amounted to 2 million. This case is also an important to better understand the place of the coal in the understanding of social state [18], [19].

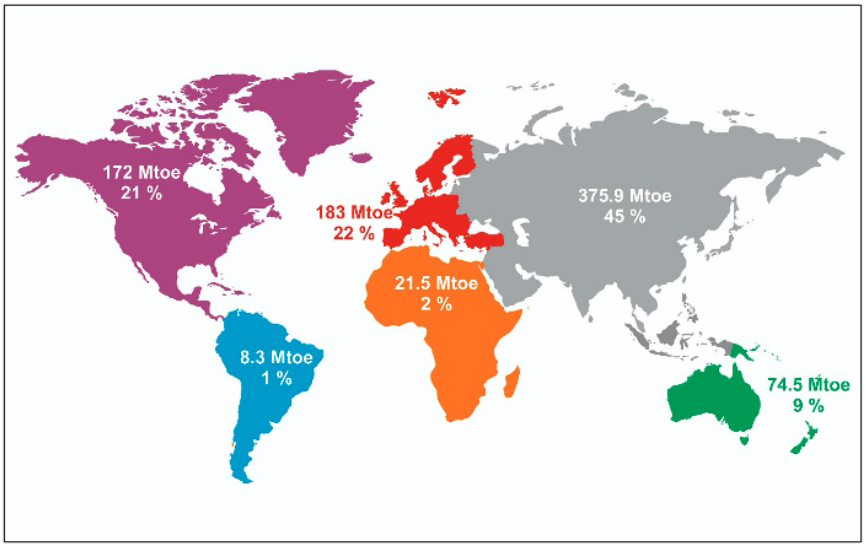

Fig. 1. Distribution of coal reserves worldwide [9].

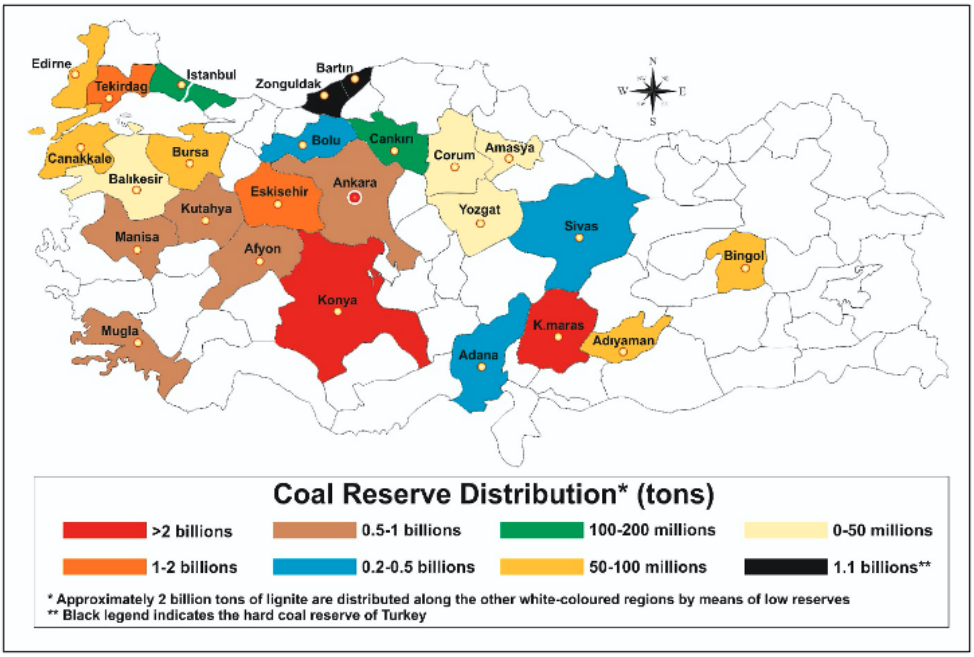

Fig. 2. Lignite and hard coal reserves of Turkey on the basis of regions [11].

2.1. A Brief Overview on Global Coal Utilization

85% of the world's energy demand is met by fossil fuels (coal, oil and natural gas). The share of the coal in the world electricity production is 42%. Half of the electricity production in the US and about 70% in China are provided by coal-fired power plants [20]. This rate is about 33% as of the early 2018 in Turkey. 15.57% of the coal used in electricity generation in 2017 comes from the domestic hard coal and lignite, and 17.61% is imported coal [21].

Coal was used as the main energy source all over the world in the 1960s. Over the following years, it has begun to lose its market due to progress in the production, conversion and utilization technologies of petroleum. World energy production according to the resources, the shares for the year 2015 are 31.7% petroleum, 28.10% coal (coal-peat and shale oil), 21.20% natural gas,

4.9% nuclear, 9.70% % of biofuels and wastes, 2.5% of hydro and 1.5% of other alternatives are renewable energy with 13,7%. (see Fig. 3). Today, renewable energy presents a significant development trend. Therefore, there is an estimate that renewable energy will make a significant leap as a result of technological developments. Nevertheless, coal is nowadays still an important source of energy because of various concerns and reasons. It is anticipated that it will maintain this significance in the near future. Coal is currently used in thermal power plants for the purpose of generating electricity, in industrial buildings (especially steel and cement industries) and as fuel for buildings. The share of coal usage has been decreased when compared to the past usage and the future predictions expect even more decreases due to environmental concerns. Factors controlling this decline can be defined as coal and electricity production costs, political conditions, socioeconomic justifications and technological developments.

Coal is used in different purposes which can be seen in Fig. 4. Globally, in 2015, the use of coal is 65.5% for heating and electricity production, while it is 82.7% in OECD countries.

The use of hard coal in this area led by China, which has significantly increased its production in the last 40 years, is seen. When the share of the coal in global electricity generation is considered, different regional trends can be recognized. Even within OECD countries, there are differences. In the OECD member European countries, the rate of 49.1% in 1971 decreased to 22.2% in 2016. In OECD member countries, the coal utilization rate decreased from 41.01% in 1971 to 27.1% in 2016. When the Asian-Oceania is considered in OECD countries, the share of electricity production from coal is increased from 18.0% in 1971 to 39.4% in 2016. When looked at the non-OECD countries, China can be considered as a locomotive country in many aspects. The share of China in world coal use was around 12-13% in 1971, while in 2015 it reached 40%, catching OECD countries. Today, this ratio is between 51 and 52%. The greatest share of the steep increase in the use of coal in the iron and steel industry over the last 40 years belongs to China. The share of non-OECD countries in total coal consumption is now around 1 Gt and which is 82.8% of total world consumption [24] and 76% of total coal production are achieved by non-OECD (with China) countries (see Fig. 5). Additionally, sum of the world coal export and import reached 1,213 Mt in 2016.

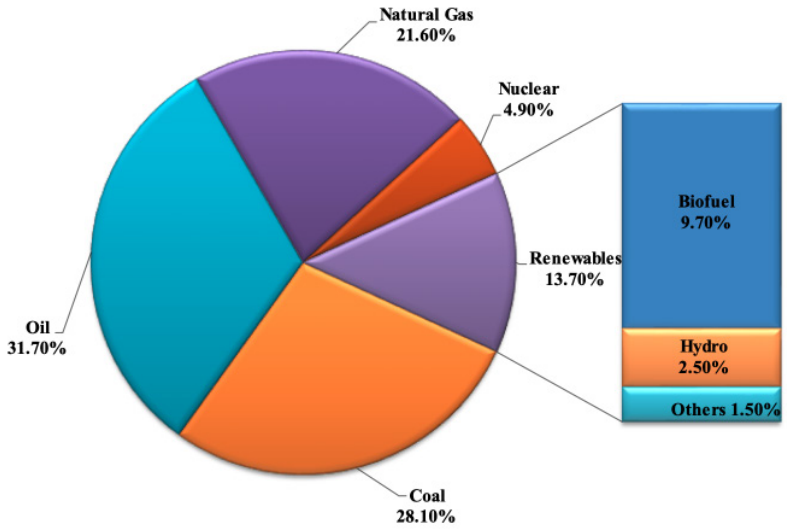

Fig. 3. Shares of total primary energy resources usage of world in 2015 [22].

*Values also include air and marine fuel deposits. In this graph, peat is given in bituminous schist. Other renewable sources include geothermal, solar, wind, current / wave / ocean, heat, etc.

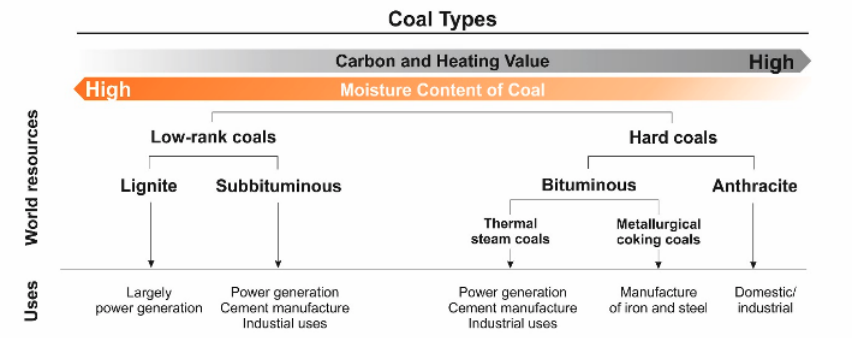

Fig. 4. Coal types and usages [23].

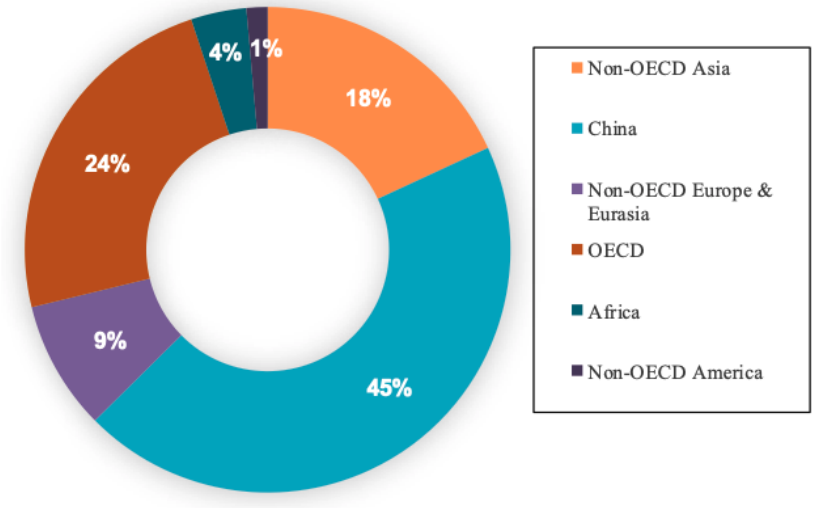

Fig. 5. Regional coal production of world in 2016 [22].

* Include Steam coal, coke coal, lignite and recovered coal

2.2. Coal Utilization in Turkey

Primary energy supply in Turkey in 2016 was realized as 136.2 million TOE. In primary energy demand the shares of sources are as natural gas 28%, coal 28%, petroleum 31% hydraulic energy 5 % and non-hydropower renewable energy sources 8%. When the variation of primary energy supply on sectors basis is examined, it is seen that the produced energy is used by industry (25%), housing and services (24%), transportation (20%), energy conversion plants (23%), non-energy use (5%) and agriculture and livestock sector (3%) (see Fig. 6).

In contrast to the world, lignite is a considerably dominant source in energy production of Turkey. 66% of hard coal produced is used in electricity production, 15% of which is used in coke furnace. 16% of hard coal is used in industry led by cement (63%), iron and steel industry (20%) and 18% is used in housing (22%) and trade and services sectors (72%). The amount of lignite used in energy production is 89%, forming the bigger portion of the production. Within this proportion 6% is used in industry, which are food (22%), textiles (38%), cement (15%) and ceramics (3%) as major sectors. Finally, 6% of total lignite consumption in Turkey stated in the class of other sectors which are (76%) housing and (24%) trade & services (see Fig. 7).

In comparison with the past energy policies and installed power plants, it can be seen that Turkey's energy production is dependent largely on the foreign investment. Not only in terms of coal usage, but also that the installed power plants and the vast majority of electric production are realized from natural gas imported in high percentages. The same is true for coal-fired power plants. While about 37.5% of the electricity produced is from natural gas-powered power plants, more than half (53.2%) of the coal-fired power plants that share about 33% of the total electricity generation use imported coal (see Table 2).

Table 2. Variation of electric production sources of Turkey [21].

Source	Production (MWh)	Ratio (%)
Natural Gas	117 760 512	37.53
Hydropower	62 196 866	19.82
Imported Coal	55 485 713	17.68
Hardcoal and Lignite	48 832 294	15.56
Wind Power	19 461 947	6.20
Geothermal	5 827 309	1.86
Biogas	2 403 559	0.77
Other	1 631 075	0.52
Import-Export Difference	-649 725	-0.21
Solar Power	885 000	0.27
Total	313 834 550	100

The vast majority of Turkey's coal consumption is the imported coal. In the early 1980s, while approximately 80% of the country's coal consumption was supplied from domestic sources, the ratio decreased down to 45% at the end of 1980 [17]. Since 2001, the imports have accounted from 8 million tons (76%) to 36 million tons (94%) of the demand for hard coal (see Fig. 8), although varied for various reasons as economic crises, efforts to returning to domestic sources and the changes in energy demand. The vast majority of these imports are from Russia, Colombia, USA, South Africa, Australia and Georgia [29]. In 2016, amount of the coal imported was reached to 36 million tons having a share of 94% in energy sources imported. The cost of this amount to Turkey was $ 5.3 billion. The size of the coal imports of Turkey may be seen more clearly, when considering the fact that Turkey's exports of mining products in 2016 was at $ 4.5 billion [17].

It can be said that lignite production has followed an increasing trend since 1988, even though it has occasionally dropped (see Fig. 9). In addition to the general foreign dependence in the energy sector, Turkey may be considered as an important lignite producer in the world. However, it is very difficult to say that the coal production is sufficient, especially lignite, nor that the power plants operating with domestic coal are at a level that will reduce the external dependency.

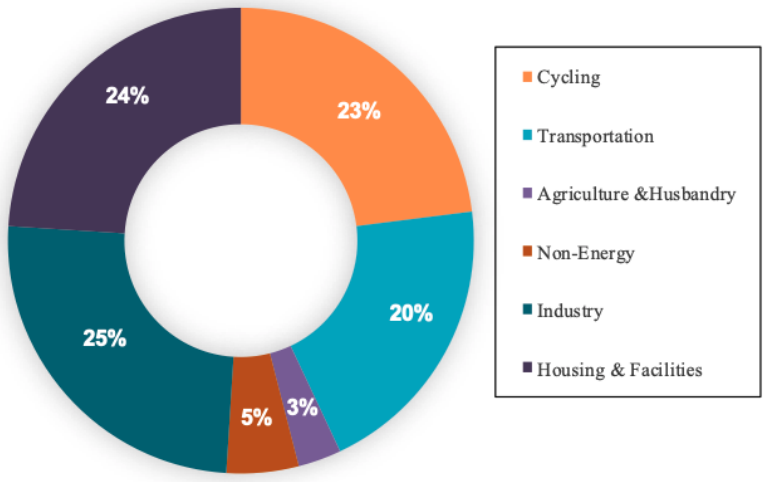

Fig. 6. Primary energy demands of Turkey in 2016 by sectors [25].

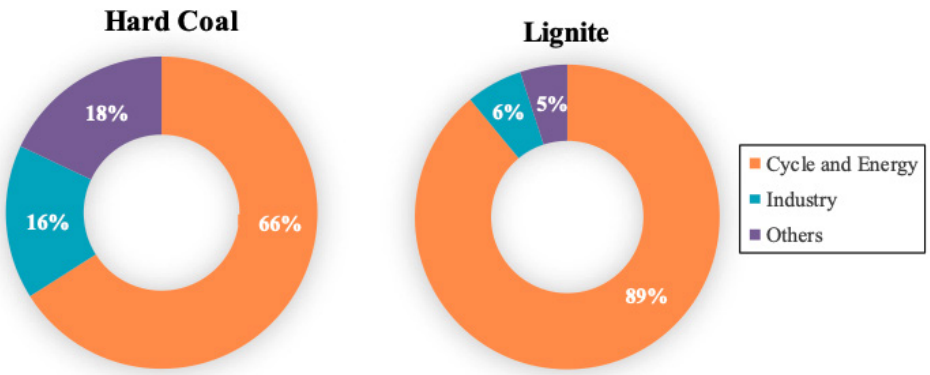

Fig. 7. Shares of sectors in terms of hard coal and lignite utilization Hardocal (left) and Lignite (right) use sectors [26].

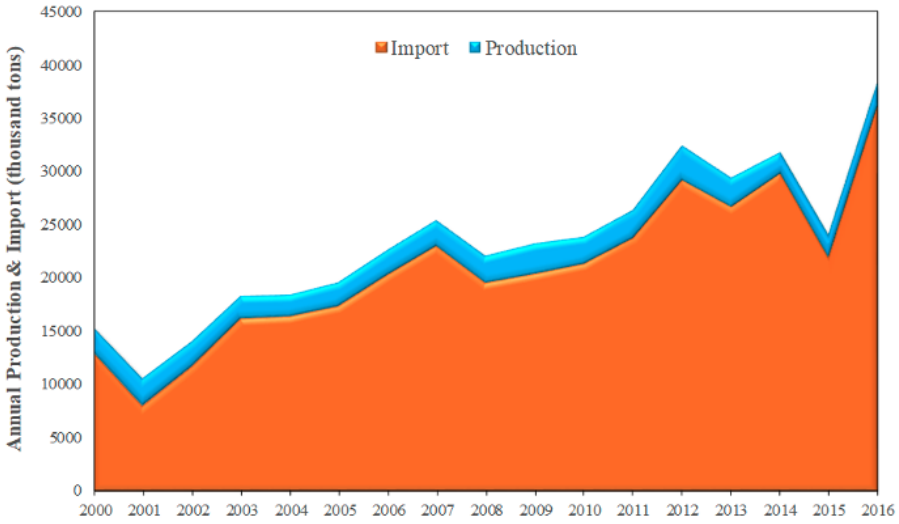

Fig. 8. Yearly hard coal production and export of Turkey [17, 26, 27, 28].

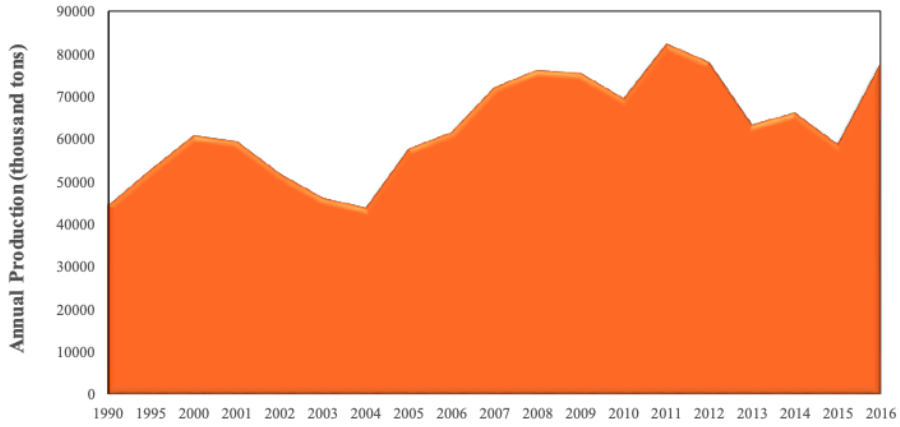

Fig. 9. Yearly lignite production of Turkey [27, 28].

3. Energy Sources of Turkey : Existence State and Historical Development

Falling into the category of developing countries, the energy demand of Turkey has been increasing every day. The energy independency strategy which is the most important requirement for being a developed country in the future is of vital importance. But given the current trends about the energy, Turkey is not likely to be a country using its own resources for the energy demand in the near future. During 1970-1986 period Turkey produced its electric mainly from liquid fuels and hydroelectric power plants. After 1986, natural gas took part as an alternative source among the energy production sources and natural gas power plants have increasingly been used in electric production [30]. As of 2015, total natural gas consumption in Turkey is 48.8 billion m^3. It produced only 0.8% (399 million m^3) of this amount while using 50% of this amount for electricity generation [31]. On the other hand, Turkey depends largely on the imported coal, while not giving special importance to its existing domestic energy sources such as lignite, new generation renewables and hydropower. When looking at the past from the present, it can be seen that Turkey has implemented a strategy of domestic resources, mainly as a result of the

oil crisis of 70s [32]. Due to the Cyprus embargo (at mid-70s), it has experienced problems in reaching adequate technologies and has not achieved the desired success in this policy [33]. Nevertheless, the country, which maintained its domestic resources strategy, relatively in the 80s and 90s, has been increasingly dependent on the imported coal in 2000s [32]. During 2000-2005 period Turkey has not constructed domestic coal fired power plants but the natural gas conversion power plants using imported natural gas were preferred instead of the domestic coal-fired power plants [6], [34].

3.1. Fossil Fuel Energy Sources

Though power plants using domestic coal are started to be constructed after 2005 as of the end of 2016 Turkey has 10 imported coal plants having total capacity of 9,437 MW (12,1%) and 51 domestic coal power plants with 7,879 MW capacity (10%). In 2017, approximately 53% of the electric is produced from imported coal power plants [6], [21], [27]. The main reason for the current situation is the lack of capital. Similarly, there is a $ 30-35 billion total investment requirement for the use of domestic coal potential, ranging from 3 to 3.5 $ billion per year over a 10-year period.

Existing energy policies became ineffective due to the following facts.

i) after 70s, the energy sector was left to private investors as a result of the policy change from state and/or mixed investments economic policy to liberal market policy,

ii) The domestic investors did not make new investments due to large-scale risks,

iii) the foreign capital was not attracted to the energy field, causing the current policy to become ineffective with the current policy [6].

The quality of existing lignite reserves is generally low, making the option of generating energy with domestic coal less attractive. However, almost all of Turkish lignite reserves are suitable for firing thermal power plants [27], [32]. Thus, in addition to the incentives made in this regard, it is an inevitable to develop investment alternatives in which the public sector takes more place.

3.2. Renewable Energy Sources

Turkey has a potential in other energy resources. Hydroelectric history of Turkey dates quite back. Wind energy potential evaluation initiatives and the establishment of new facilities have been carried out since 1986 [35]. Turkey has made big way in renewable energy, especially after 2009 and has provided significant increases in installed capacity based on renewable energy. Numerically a significant increase has been realized in low-capacity hydro power stations established in small rivers since 2007 [18], [36]. However, these projects have two problems. The first one: the plants that are installed without the detailed assessments and thus cannot obtain efficiency. Although Turkey has a hydroelectric potential of 45 GW, it is among the countries that

may face to a water shortage problem. Therefore, it should not be forgotten that hydropower production can be affected in the negative direction [37]. The second problem is the likelihood that the regional employment in such sectors as regional agriculture and animal husbandry, will be affected. It is necessary to make integrated plans not only on energy basis in order not to disturb the natural balance and not to worsen the socio-economic conditions of the region in where a power plant is established.

Turkey added at Tenth Development Plan, the objective of enhancing seriously the capacity of renewable energy sources, especially solar and wind [38]. As of 2016, Turkey's installed renewable energy capacity reached to 34.2 GW from 15.5 GW of 2009. At the end of 2017, shares in the renewable energy sources in produced electricity is as follows; hydraulic (19.82 %), wind (6.2%), geothermal (1.86%), biogas (0.77%) and, sun (0.27%) (see Table 2). In 2015, Turkey raised the renewable energy capacity to $ 1.9 billion by 46% of increase when compared to the previous year. With this figure, it becomes one of the four European countries exceeding the $ 1 billion limit, together with Britain, France and the Netherlands [39]. These developments and investments are important, as promising as they are, at the same time. Turkey has better conditions than many European countries in terms of renewable energy potential. Turkey's East and South East have suitable conditions for hydroelectric, while Aegean region has potential for wind and geothermal energy and solar energy capacity in each region is quite high. It is estimated that 43.2% of the total demand can be fulfilled by solar energy and that the wind energy can supply 10.3% of total demand [37]. Another point that needs to be mentioned here is that technological investments are crucial in the use of natural resources and in the assessment of available energy resources [40]. If Turkey fails to improve the technology of renewable energy sources, after 15-20 years it may be forced to pay the costs as it did for oil and natural gas [33]. Therefore it is important for Turkey to prepare development plans to make investments in technology both to use domestic resources and to utilize renewable energy efficiently.

3.3. Nuclear Energy Sources

Since 2010, Turkey took significant steps for the aim of the using nuclear energy, in addition to existing energy sources, which has so far been in its agenda. Agreements have been signed for two nuclear power plants to be established by Russia and Japan, in Mersin and Sinop provinces, respectively [41], [42]. Nuclear energy is considered as an effective method to reduce external dependence and increase energy diversity and minimize environmental impacts [43]. It is therefore preferred by Turkey. However, there is a need for evaluation taking into consideration the current situation in Turkey. Turkey is quite a poor country in nuclear power plant fuel. Near twelve thousand tons reserve of the country corresponds to a very small portion of the world reserves. Existing uranium reserve has had an economic valuation opportunity in the past but these reserves are no longer in economic condition as a result of the high grade and low production cost resources in Canada and Australia, additionally due to the developments in nuclear energy technology. In terms of thorium reserves, Turkey has 374 000 tons of thorium reserve, corres-

ponding to 6% of world reserves. The country can be regarded as having rich resources, with this amount. However, no thorium processing plant exists in the country. Although the nuclear energy production studies targeting on using thorium and uranium together continue, there is no nuclear power plant using only thorium [7]. Therefore, Turkey has not any possibility both to use reserves of uranium in nuclear power plants and to build plants using thorium reserves. Neither it does not seem likely in the near future. While it is true that an energy diversity will be provided with the nuclear power plants to be built, it is a fact that these power plants will not reduce external dependency. It is also difficult to say that it will provide a diversity in terms of the dependent countries. For instance, Akkuyu (Mersin) nuclear power plant construction is to be carried out with Russia, the procurement of resources will also take place in the same country. Turkey already imports 53% of natural gas demand from Russia. For this reason, Akkuyu nuclear power plant project, which is constructed together with the same country, is far from diversifying the countries being dependent on foreign energy. At the second plant to be built in Sinop, enriched uranium purchased from different countries will be used. In this case, there is no possibility of reducing the dependency on foreign countries even if it is possible to create the diversity of the country where imports are made. For the remote future, investments in enrichment facilities necessary for the utilization of uranium and thorium reserves, and R&D work should not be lagging behind the world. The high cost of these facilities necessitates a very comprehensive nuclear energy plan. It can be said that the only possible benefit of the nuclear power plants in the near future is the decrease in the amount of greenhouse gas emissions. Turkey takes place in the Annex 1 countries defined according to Kyoto Protocol with 110% increase in greenhouse gas emissions from 1990 [44]. Turkey prioritized the economic development while pushing back environmental concerns [45]. Two worries affecting this issue are; i) the likelihood of slowing the capacity increase of environmental policies (direct impact) and ii) the direct negative impact of the cost of environmental policies (indirect impact) on economy. To continue its economic development, Turkey had any commitment to decrease emissions, when signed Kyoto Protocol and Paris Treaty. However, it has announced that it will reduce its greenhouse gas emissions by 21% after 2020 with the "National Contribution" declaration (BAU-Business as Usual), which it presents on combating climate change and covers 2020-2030 [46]. Looking at the average values, the unit electricity generation (GWh) causes about 20% more CO_2 emissions than the use of lignite (1,054 tons) and coal (888 tons). In natural gas (499 tons), this value is still high and is about half of coal. While using renewable energy (45.5 tons for all renewable energy) and nuclear energy (29 tons), greenhouse gas emissions are between 1/30 to 1/50 for coal, respectively [47]. Nuclear power is more advantageous than natural gas and coal-based thermal power plants in terms of greenhouse gas emissions per unit of energy, and it is certain that the nuclear power plants put in the power generation portfolio will benefit from it.

4. Facts and Plans of Turkey's Energy Policy

If the future of the coal and the electricity production of Turkey are considered, one sees two different facts, as targets and realizations. Within Turkey's prospective energy targets and some steps which are in the context of state's planning gives hope to reduce foreign dependency. However, it is not possible to say that external dependency will decrease from a broader perspective. For example, the target to operate a domestic coal-fired power generation plant with a total installed power of 1,013 MW for 2015 realized as 457 MW hours leaving below the targets [18]. Some positive developments that have taken place and are planned in the forthcoming period can be listed as follows [18], [25], [27], [38], [40]:

i. In 2003, the number of drillings for natural gas and oil was 81 and for coal was 12, these numbers was increased to 136 and 238, respectively in 2015,

ii. A total of 7.38 billion tons of new lignite reserves were discovered between 2005 and 2010,

iii. Research and innovation work to identify different utilization methods and increase efficiency of utilization of the domestic resources, especially for coal, have been performed by some public enterprises as Turkish Coal Enterprises (TKİ), Scientific and Technological Research Council of Turkey (TÜBİTAK) and ETI Mining,

iv. Investment in potentially high coal basins, making appropriate investment and financing models for electricity generation separately for each basin,

v. The aim of introducing incentives for power generation facilities based on domestic coal and renewable energy sources, which will run until 2020,

vi. The target to increase domestic coal-produced electricity to 57 billion kWh, which is 32 billion kWh by the end of 2018,

vii. The aim to establish 600 MW geothermal, 3 000 MW solar energy and 20 000 MW wind energy power plants to be fully operational by 2023.

However, it is observed that the actual projects (particularly the ones that are still in the process of installation) do not meet the targets. As can be seen in Fig. 10, 35% of the power plants that are set up in 2017 use imported natural gas and 11% of them use imported coal. Based upon this fact, it can be stated that only 46% of the new plants will be outsourced. On the other hand, 14% of the plants are planned to use coal and origin (domestic or imported) of the coal used in these plants are not provided. Hence, percentage of the total foreign dependency is likely to exceed 50%.

On the other hand, Turkey is largely dependent on foreign sources of natural gas considering the primary energy demand projections. The use of renewable energy sources is expected to increase in the same way as in the recent trend. It is expected that the energy investments for

the coal-fired plants will decrease after 2030's. Lignite-related energy demand is predicted to be in a downward trend (see Fig. 11).

When the quantities of sources in the past, present and possible future energy projections are assessed on concrete facts, it turns out that lignite, which is the only sufficient domestic resource, needs to be seriously evaluated. Therefore, it is necessary to increase the research work carried out to increase the use of domestic coal. When assessed together with all the energy sources together, Turkey appears to be in a position self-sufficient not only in renewable energy capacity and but in the lignite reserves. For this reason, planning of the energy policy of the country will be beneficial by evaluating all the related aspects of energy phenomenon on the long term including environmental, economic, strategic, socio-economic aspects.

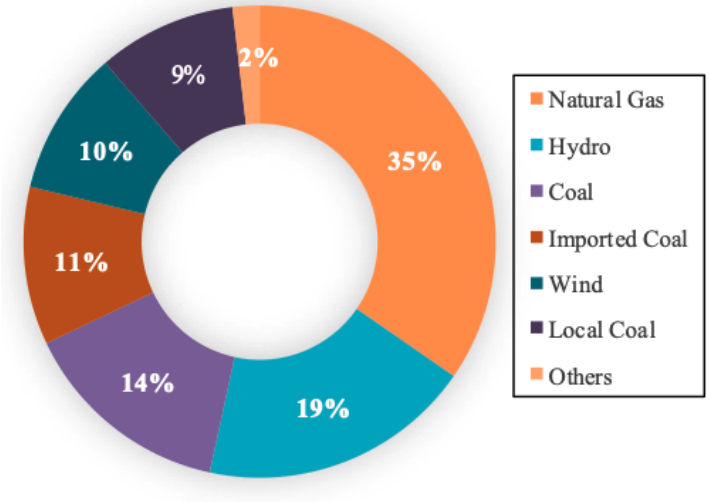

Fig. 10. Power plants under construction as of 7 January 2017 [Source: 36].

* The percentage of project actual achievements (as of the date the data were provided) were listed above 10%.

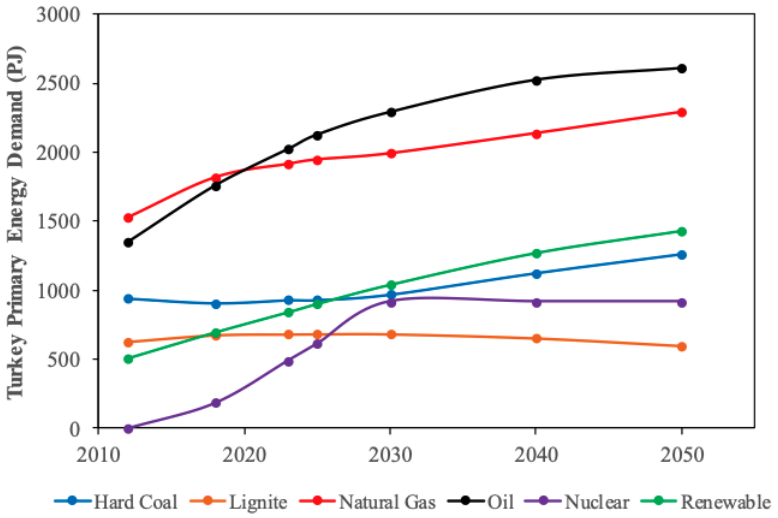

Fig. 11. Primary energy demand forecasting for Turkey [Source: 55].

5. An Assessment of Alternative Energy Sources for Future Energy Planning

Fossil fuels are expected to keep its place in the energy supply chain for a considerable period of time. In addition to greenhouse gas emissions, which are considered to be the most important cause of global warming and climate change, the economic and environmental preferences also determine a country's energy sources. The surplus of these decision criteria forces a country to diversify their energy sources. It is possible to say that as a consequence of the concerns and efforts of reducing greenhouse gas emissions from fossil fuels, the trend towards systems such as hydroelectric power plants, wind, solar and biomass energy is increasing.

When looking at the greenhouse gas emissions alone, it seems reasonable to assume that nuclear power plants and renewable energy sources are comparatively low in emissions compared to fossil sources. However, it is useful to consider all possible aspects of energy resources while evaluating them. A large number of factors such as the possible environmental effects in addition to greenhouse gases, loss of lives and property, socio-economic situation, geopolitical position and natural life of the country, the necessity and amount to exported fuel, the cost and the life of the power plant, the technological sufficiency of the country should be considered together.

For example, 85% of electricity obtained from renewable energy, which meets 16.3% of world electricity production, is realized by hydroelectricity. However, in some cases the influence of hydroelectric power plants on the environment is not negligible. These effects are also highly correlated with the welfare of the country, income inequality and external borrowing. In a study evaluating the countries that set up hydroelectric power plants in different time periods between 1980 and 2010, income inequality and external debt increased and per capita income decreased as the number of hydroelectric power plants increased. The main reason for this is the unique characteristics concerning the location of the plant. It is known that, in high mountains and in areas where there is no settlement, power plants are generally not problematic. In some cases, due to environmental impacts of facilities under sea level, there are some consequences such as causing for migration, creating risks to the fisheries sector, causing food safety problems and causing floods [48].

When evaluated the possibility of an accident, it can be said that the hydroelectric power plants and nuclear power plants may have quite destructive consequences in terms of the results of accidents even in the low risk group. New generation renewable power plants should be considered in low risk category both in terms of the accident risks and severity of the consequences of the accidents. On the other hand, some problems may occur in high-capacity large power plants at the stages of energy storage and stabilization of variable production. Energy production from fossil fuels is in the medium risk group in terms of the likelihood of accidents and possible consequences [49]. It is also useful to say that in spite of these widespread evaluations of plants in general, there are unexpected situations. For example, in an interdisciplinary study [50], it is estimated that there will be 1 or 0 nuclear accidents until 2055 with the developing technology, a

nuclear power plant accident (Fukushima) has already occurred. For this reason, one can come up with the more realistic judgments than estimates by expressing the past situation in all power plants with figures. According to the data obtained between 1874 and 2014, in a study assessing accidents in 11 energy systems including biodiesel, biomass, coal, geothermal, hydroelectric, hydrogen, natural gas, nuclear energy, oil, solar energy and wind energy, more than 210 thousands people lost their lives in total 1100 accidents and $ 350 billion in financial losses occurred in these accidents. According to this study, the accidents in hydropower plants constitute 85% of the deaths and the nuclear power plants constitute 70% of the financial losses. When the frequency of accidents per unit energy (TWh) is taken into consideration, the wind energy is dominant. In fact, the accident frequency of wind energy is 4600 times more than coal. Again, when looked at the deaths per unit energy, the wind energy is at the top, with 20 times higher death rates from natural gas and coal. In terms of the material damage, nuclear energy per unit energy is 33 times more expensive than wind energy and 100 times than solar energy [51]. There are also different problems and concerns about the nuclear power plants that some countries do not do new investments while closing their existing power plants. It is known that nuclear energy is responsible for many accidents and for pollution of vast amount of water resources [52], production of high radioactive and harmful waste for human life and nature. In addition, there is only a limited number of uranium enriching countries and this creates external dependency.

Additionally, serious concerns are present about the permanent storage and transport of nuclear waste, it is estimated that 250,000 tons of used nuclear waste are in temporary storage facilities around the world [50]. Although nuclear power plants are important parts of the efforts for keeping global warming below the critical 2°C, issues such as the radioactive wastes need to be stored for up to 1 million years and two major accidents in the last 30 years still present uncertainties [53]. Another problem is the lack of a facility for permanent storage of nuclear wastes [50], [53]. The Onkola project, which is under construction in Finland, is the nearest first to this permanent settlement facility [54]. Thus, given the advantages and controversial nature of nuclear energy, it is difficult to conclude definitively whether nuclear energy can be promoted in all future energy policies [53]. As a result, when a wide range of assessments is made, it can be said that there is not an absolutely harmless and risk-free power generation method, including new generation renewable energy systems. It is certain that the environmental impacts of existing systems and the risks of accidents will vary with developing technology, and it is also useful to determine the energy policies of countries after a multifaceted evaluation, considering the future needs of the region under the circumstances.

6. Conlusions

Turkey is largely dependent on foreign oil and natural gas considering the primary energy demand projections. Though the utilization of renewable energy sources is expected to increase in the same way as in the recent trend, the dependence to fossil fuels will continue for a long time in the foreseeable future. It is estimated that the energy investments for the coal-fired plants will

decrease after 2030's. Lignite-related energy demand is predicted to be in a downward trend following 2030s.

Current energy view of Turkey exhibits two different facts on the basis of targets and realizations. Turkey's energy plans and targets and some actions taken gives hope to reduce foreign dependency. Almost all of Turkish lignite reserves are suitable for firing thermal power. It is inevitable to develop investment alternatives in which the public sector takes more place. When the quantities of sources in the past, present and possible future energy projections are assessed on concrete facts, it turns out that lignite, which is the only sufficient domestic resource, needs to be seriously evaluated. Therefore, it is necessary to increase the research work carried out to increase the utilization of domestic coal. Also, it is necessary to make integrated plans not only on energy basis in order not to disturb the natural balance and not to worsen the socio-economic conditions of the region in which a power plant is established.

Another point to be taken into consideration is that the technological investments are crucial in the use of natural resources and in the assessment of available energy resources. If Turkey fails to improve the technology of renewable energy sources, after 15-20 years it may be forced to pay the costs as it did for oil and natural gas. Therefore, it is important for Turkey to prepare development plans to make investments in technology both to use domestic resources and to utilize renewable energy efficiently.

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