KADİR HAS ÜNİVERSİTESİ
SCHOOL OF GRADUATE STUDIES IN
ENERGY AND SUSTAINABLE DEVELOPMENT PROGRAM

RENEWABLE ENERGY IN TURKEY: A CLEANER, SELF-SUFFICIENT ALTERNATIVE TO COAL

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MASTER'S THESIS

İSTANBUL, JULY, 2019

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Submitted to the Institute for Graduate Studies of Kadir Has University in partial fulfillment of the requirements for the degree of Master's in the Program of Energy and Sustainable Development.

İSTANBUL, JULY, 2019

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This work entitled **RENEWABLE ENERGY IN TURKEY: A CLEANER, SELF-SUFFICIENT ALTERNATIVE TO COAL** prepared by GÖZDE NUR KARAGÖZ has been judged to be successful at the defense exam held on 19/07/2019 and accepted by our jury as MASTER'S THESIS.

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RENEWABLE ENERGY IN TURKEY: A CLEANER, SELF-SUFFICIENT ALTERNATIVE TO COAL

ABSTRACT

The world is in the midst of a transformative energy transition, moving to renewable energy sources from fossil fuels. The biggest reasons for this transition are global climate change and resource scarcity, both of which are caused by the use of fossil fuels. Among fossil fuels, coal has the highest emissions and causes more significant damage to people and the environment. Despite its negative effects, coal has a large share of the world's energy mix. However, many countries are moving away from coal and switch to renewable energy sources. Turkey is not one of those countries, as the energy system is still heavily dependent on fossil fuels and coal specifically. Turkey is planning on new coal-fired power plants in addition to existing ones and is generally supporting the coal industry. In addition to the environmental harm to Turkey – and the world – of its coal usage, most of the coal that Turkey burns is imported, thus contributing to the country's trade deficit. In order to limit the negative effects of coal use, Turkey needs to utilize its high renewable energy potential. This study reviews the current situation of coal and renewable energy sources in Turkey. It aims to look at current coal and renewable energy policies and compare them. According to this analysis, it will then offer suggestions for how Turkey can phase out coal and switch to renewable energies.

Keywords: Renewable Energy, Energy Policies, Coal, Energy Transition

TÜRKİYE’DE YENİLENEBİLİR ENERJİ: KÖMÜRE DAHA TEMİZ BİR ALTERNATİF

ÖZET

Dünya, bir enerji dönüşümü sürecinde ve fosil yakıtlardan yenilenebilir enerji kaynaklarına geçmekte. Bu geçişin en büyük nedenleri, fosil yakıtların kullanımından kaynaklanan küresel iklim değişikliği ve kaynak kıtlığıdır. Fosil yakıtlar arasında kömür en yüksek emisyonlara sahiptir ve insanlara ve çevreye daha fazla zarar vermektedir. Olumsuz etkilerine rağmen, kömür dünyanın enerji tüketiminde büyük bir paya sahiptir. Ancak, birçok ülke kömürden uzaklaşmakta ve yenilenebilir enerji kaynaklarına geçiş yapmaktadır. Türkiye, bu ülkelerden biri olmaya çalışmakta fakat henüz bu ülkelerden biri değildir çünkü var olanlara ek olarak yeni kömür yakıtlı enerji santralleri planlıyor ve genellikle kömür endüstrisini desteklemeye yönelik politikalar izlemekte. Kömür kullanımının Türkiye'ye ve dünyaya sağladığı çevresel zararlara ek olarak, Türkiye'nin yaktığı kömürün çoğu ithal edilmekte ve bu da ülkenin ticari açığını arttırmaktadır. Kömür kullanımının olumsuz etkilerini azaltmak için, Türkiye'nin yüksek yenilenebilir enerji potansiyelini kullanması gerekir. Bu çalışma, Türkiye'deki kömür ve yenilenebilir enerji kaynaklarının mevcut durumunu gözden geçirmektedir. Mevcut kömür ve yenilenebilir enerji politikalarına bakmayı ve bunları karşılaştırmayı amaçlamaktadır. Çalışma bu analize göre, daha sonra Türkiye'nin kömürü nasıl aşabileceği ve yenilenebilir enerjilere nasıl geçebileceği konusunda öneriler sunacaktır.

Anahtar Sözcükler: Enerji, Kömür, Yenilenebilir Enerji, Enerji Dönüşümü

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LIST OF ABBREVIATIONS

ADHD: Attention Deficit and Hyperactivity Disorder

BP: British Petroleum

CO2: Carbon dioxide

CSP: Concentrated Solar Power

EGC: Electricity Generation Company

EIA: Environmental Impact Assessments

EMRA: Energy Market Regulatory

ETKB: Ministry of Energy and Natural Resources

ETUC: The European Trade Union Confederation

EU: European Union

EÜAŞ: Electricity Production Incorporated Company

GHG: Green Gas Emissions

GW: Gigawatt

GWEC: Global Wind Energy Council

HEAL: Health and Environment Alliance

IEA: International Energy Agency

IPCC: Intergovernmental Panel on Climate Change

IRENA: International Renewable Energy Agency

LCOE: Levelized Cost of Energy

MTA: General Directorate of Mineral Research and Exploration

MTAE: General Directorate of Mineral Research and Exploration Institute

Mtoe: Million Tons of oil equalivent

MW: Megawatt

MWt: Thermal megawatt

OECD: Organisation for Economic Co-operation and Development

PM: Particulate Matter

PV: Photovoltaics

R/P: Resource to Production

RERA: Renewable Energy Resource Areas

RES: Renewable Energy Sources

TEİAŞ: Turkey Elcetiricity Generation Distribution Incorporated Company

TEMA: The Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats

TKİ: Turkey Coal Enterprises

TMMOB: The Union of Chambers of Turkish Engineers and Architects

Toe: Tons of oil equalivent

TPAO: Turkish Petroleum Corporative

Tpes: Total primary energy supply

TTK: Turkey Hard Coal Enterprises

TÜREB: Turkey Wind Energy Union

TURKIS: Mine and Coal Enterprises

TWh: Terawatt Hour

UNFCCC: United Nations Framework Convention on Climate Change

US: United States

VAT: Value Added Tax

WBA: World Bioenergy Association

YEGM: General Directorate of Renewable Energy

YEKA: Renewable Energy Resource Areas

YEKDEM: Renewable Energy Support Mechanism

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INTRODUCTION

Energy has always played an essential role in human life and has served as a critical input for the economies. Prior to the advent of coal, people could only use wood, wind, fire and water streams in their daily lives as energy sources. Thereafter, coal enabled the Industrial Revolution and became the main energy source, followed by oil and natural gas in the twentieth century. Coal, oil and natural gas – fossil fuels – have become the most important sources for meeting the rising energy demand of a majority of countries.

At present, countries are adapting new strategies to move away from fossil fuels, and the share of renewable energy sources (RES) in the world energy mix is increasing. There are two important reasons for this: global climate change and resource scarcity. The biggest contributor to global climate change is fossil fuels, which emit carbon dioxide (CO_2) and other greenhouse gases (GHG) when they are combusted. The increasing amount of GHG in the atmosphere causes temperatures to rise and accordingly serious results of climate change. Today, the world's average temperature is almost 1.5 °C higher than pre-industrial levels and is set to continue to rise (IPCC, 2018). This rise in temperature is changing the planet's ecosystem, including hydrological, meteorological and climatological parameters (van Vliet et al., 2012). The most dramatic and direct impacts of climate change are extreme storms, droughts and floods, but further effects are seen in reduced crop productivity and forced migration (UNFCCC, 2018).

Resource scarcity is another important reason for the energy transition. Fossil fuels are finite resources, meaning they will run out eventually. According to BP (2018a), global proven reserves of oil and natural gas are only sufficient enough to meet 50.2 years and 52.6 years, respectively. The reserves-to-production (R/P) ratio of 134 years for coal, however, is almost three times higher than the other fossils fuels (BP, 2019a). Hence, an energy system based on fossil fuels is not a sustainable option for the world (BP, 2018a). Also, fossil fuels are unevenly distributed, which creates a problem of energy security for countries that are poor in them. In the age of fossil fuels, energy security has been a major concern of states. Dependence on fossil fuels remains so today, as 69% of countries face energy-import dependency (TheGlobalEconomy, 2015).

Among fossil fuels, coal is the most harmful. Because of its higher carbon and sulphur content, coal causes higher GHG emissions and more pollution than oil or gas. Nevertheless, coal still retains a significant share in the total global primary energy consumption (27.1%) and in electricity generation (38.1%). Moreover, many new coal power plants are expected to be built in the future, and coal is forecast to have a 20% share in the world energy supply until 2040 (BP, 2018a; ExxonMobil, 2017).

However, due to coal's negative impacts, countries are adopting new policies to move away from it and switch to RES, which provide electricity generation with no GHG emissions and, by nature of being renewable, are also inexhaustible. In addition, RES are present in many regions across the world and are thus available for local use. Hence, energy import-dependent countries could switch to RES to become more self-sufficient.

The transition to RES is happening quickly. In 2018, the world added an estimated 178 gigawatts (GW) of renewable energy to its energy mix (REN21, 2018). The electricity generated from RES has more than doubled in the last decade (BP, 2018a). This increase is expected to continue. Until 2040, the largest installed capacity is expected to come from solar PV and other renewables. To accelerate the pace of this transition, countries are crafting new strategies and on both the national and international levels (REN21, 2018).

Turkey is struggling with this transition. It remains highly dependent on imports for supplying energy. According to data from the Energy Ministry of Turkey, the country imported 75% of its total primary energy demand in 2017. Import dependency of hydrocarbon sources reached 93.9% in oil and 99.3% in natural gas. On the other hand, import dependency is the lowest in coal, consisting of 61.9% of consumption. This external dependence has led to a steady increase in the country's current account deficit (Kok and Benli, 2017). Energy import-dependence is a major issue for the Turkish economy; energy imports cost $43 billion and account for 20% of total imports (Türkiye Cumhuriyeti Ticaret Bakanlığı, 2019). This overall situation not only threatens Turkey's energy security but also harms the economy and environment.

Turkey's CO_2 emissions are also rapidly increasing. In the last decade, Turkey's CO_2 emissions rose by 50.51%. At present, Turkey's annual growth of CO_2 emissions is, 12.7%, which is the second largest growth rate in the world after Estonia (BP, 2018a). The biggest contribution to its CO_2 emissions is from the power sector, in which coal-powered plants accounted for 37.2% of Turkey's electricity at the end of 2018 (TEİAŞ, 2018). The country currently has 71 coal power plants; there are also four plants under construction, 29 that are pre-permitted, and 12 that are permitted (EndCoal, 2019). Imported coal accounted for 20.66% of Turkey's electricity generation in 2018 (TEİAŞ, 2018). The amount paid for coal imports was $749 million in 2002; this increased to $4.6 billion in 2018 (TTK, 2018). In order to offset this economic burden, one of the main objectives of the Turkish government is to reduce coal imports and promote domestic coal by providing incentives to domestic coal production; however, coal imports keep increasing. In addition to the economic and environmental impacts, coal mining in Turkey presents many social issues. Since 2009 coal mining-related deaths totaled 403, which is the highest among European countries (TMMOB Makina Mühendisleri Odası, 2018; Wikiwand, 2019). There are also many health costs of using coal for electricity generation: at least 2,876 premature deaths per year, around 3,823 new cases of chronic bronchitis in adults, 4,311 hospital admissions and 637,643 lost working days (Gümüşel and Stauffer, 2015). The economic cost of the effects of coal on health is estimated to be between €2.9 and €3.6 billion annually (Gümüşel and Stauffer, 2015).

Despite these facts, coal is still forecast to have a significant share in Turkey's power generation in the coming decades. Existing policies aim to supply the increasing energy demand with coal-powered generation facilities. Among the most prominent objectives of the Ministry of Energy and Natural Resources' 2015-2019 Strategy Plan is the use of domestic coal resources. Goals 2, 4, and 10 of the Plan included targets and strategies to use domestic energy resources, including coal. In the plan, the most efficient use of domestic coal resources was identified as one of the main objectives, and electricity generation from domestic coal is targeted to reach 60 billion kWh/year in 2019. On the other hand, in the Electricity Market and Security of Supply Strategy Paper prepared by the Ministry, the government targeted to use more lignite for electricity generation by 2023. The emphasis on imported coal is also given in these texts.

In order to reduce the harmful effects of burning coal, Turkey could switch to renewable energy resources, as it has high renewable energy potential. So far, its utilization of these resources has been well below its potential. Renewable energy resources, including hydro and geothermal, accounted for 32% of electricity generation in 2018; if these were removed, and only wind and solar were measured, the figure would drop to 9% of total generation. As is the case around the world, Turkey's share of RES in its energy mix is increasing. Turkey added 3,995 megawatts (MW) of installed capacity in 2018; RES accounted for 48% of this total installed capacity, including total hydro and geothermal power (TEİAŞ and TÜBİTAK, 2019). In the last decade, installed capacity of renewables grew by 185%, from just 13,586.55 MW in 2007 to 38,751.10 MW in 2017 (TEİAŞ, 2018).

These increases, however, are not enough. In order to achieve energy security and become more self-sufficient, Turkey is aiming to further increase its share of RES. The renewable energy targets are included in the strategic plans of the Energy Ministry. However, there are many barriers to the dissemination of renewable energy installments. Although a rapid increase in RES is expected, coal will continue to contribute a higher level of electricity generation than renewables.

The main purpose of this study is to examine the situation of coal and RES practices and policies in Turkey and make a comparison between these two sources. In order to compare them, this study will focus on the incentives and external costs of coal use, namely health and environmental indices. In this regard, to be able to understand the effects of followed policies and given incentives, the external cost of coal use will be shown with numeric data, which will be used to compare with cost analyses of wind and solar power.

This work is presented in five chapters. The first chapter is the "Coal Developments in the World". The second chapter provides a brief overview of energy in the Turkey with a focus on coal. It provides a brief background on coal in Turkey: its current reserves, consumption and trade. The third chapter gives the external costs of burning coal mainly in combustion and in mining. The fourth chapter introduces the current situation of renewable energy source in Turkey; the potential and its consumption. Chapter 5 reviews the recent policies that have been directed towards coal and the dissemination of RES. The fifth chapter makes a comparison between coal and renewable energy policies. Finally, conclusion section gives recommendations to Turkey on its coal and RES policies so that it might make a more successful switch to RES based on other successful examples in the world.

CHAPTER 1

COAL DEVELOPMENTS IN WORLD

1.1. ENERGY MIX AND TRANSITION

The world is dependent on fossil fuels for its energy. Today, fossil fuels account for 83.9% of the total primary energy consumption in the world (Figure 1.1) (BP, 2018a). This share has been high since the nineteenth century, and the consumption of fossil fuels is constantly rising in gross terms, even if in relative terms it has gradually declined. For instance, the share of fossil fuels in primary energy consumption was 94.1% in 1960, but has decreased by 16% to 79.6% in 2015.[1]

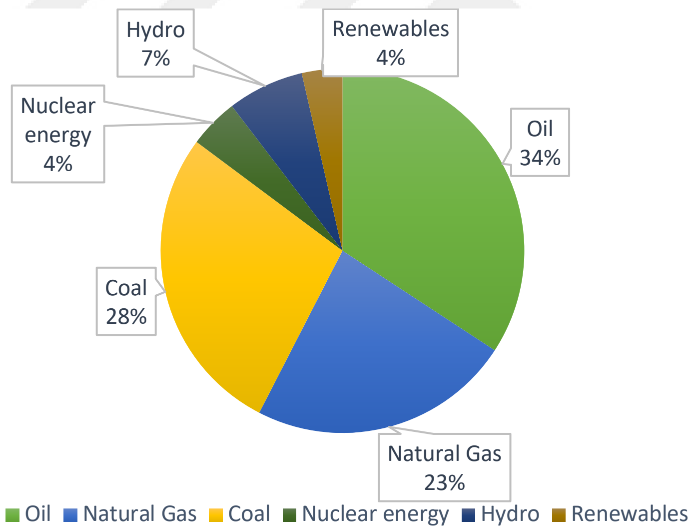


Figure 1.1 World energy mix 2017

Source: BP 2018a

However, the world is in the midst of an energy transition to RES from fossil fuels. There are two main reasons behind this transition: global climate change and resource scarcity. Fossil fuels are having significant negative impacts on human life and the environment. Burning them creates huge amounts of CO_2 and GHG emissions. Air pollution caused by

[1] World Bank, N.D. (https://data.worldbank.org/indicator/eg.use.comm.fo.zs)

fossil fuels creates undesirable living conditions for people and other health issues, premature deaths, environmental and air pollution, and many other deleterious effects. Today, the earth's temperature is 1.5°C higher than during pre-industrial times (IPCC, 2018). This will have major impacts on the world like changing climate patterns, floods, droughts and many others.

Today, there are many treaties and conventions to limit global climate change and its consequences. Under the Paris agreement, countries made policy commitments to reduce demand for fossil fuels, but these have yet to put emissions on a course consistent with climate change targets. Policies for to slow extraction of fossil fuels gained attention lately (Day and Day, 2017). Supply-side policies can be categorized as government provision of fossil fuels or funds, whereby the government acquires production rights or compensates resource owners to leave reserves undeveloped (Harstad, 2012).

The fossil fuels are also scarce, meaning that they will be depleted in the future. The global reserves-to-production (R/P) ratio, which measures the average life of a specific resource's reserves, is 50.2 years for oil, 52.6 years for natural gas, and 134 years for coal (BP, 2018a). Thus, an energy system based on resources that will eventually deplete is not sustainable. This is an important factor propelling the energy transition.

In addition, the reserves of these sources are not unevenly distributed around the world, which creates problems for importing countries to access energy. The legacy of the 1973-4 oil crisis was to conceptualize energy sources as a form of power. The experience of the use an oil embargo to coerce Western states to act in a particular way contributed to analysts conceptualizing energy mainly in terms of its use as a possible weapon (Balmaceda, 2018). This led countries to seek to meet their energy demand by using domestic sources.

1.2 RENEWABLE ENERGY SOURCES

RES are driving the energy transformation that we see today. Because of the severe effects of fossil fuels, the world is now transitioning to RES. There are many reasons why RES is preferred over fossil fuels. First of all, RES provide a cleaner type of energy generation. The sources are not exhaustible as opposed to fossil fuels and are well distributed throughout the world. Thus, many import-dependent countries could use them to become self-sufficient in energy. Thus, RES consumption has been growing rapidly in the last decade. Since 2008, the global installed capacity of RES more than doubled (Figure 1.2) (IRENA, 2018a). It increased from 1,057,962 MW in 2008 to 2,179,099 MW in 2017. Excluding hydro power, the share of RES in global electricity generation was 8.4% (BP, 2018a).

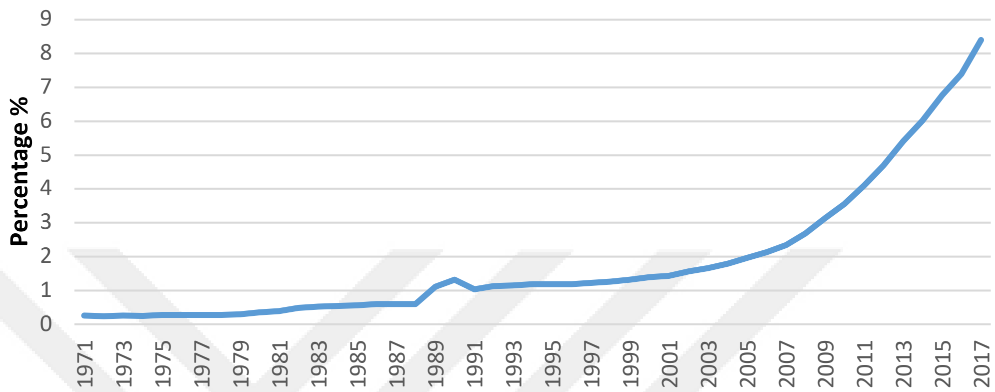


Figure 1.2 Share of RES in total electricity generation

Source: BP 2018a

In 2017, excluding hydropower, RES consumption grew by 17% (REN21, 2018). Looking at each individual RES, there has been significant change. Solar power installments were 98 GW, accounting for 37% of the total installed capacity in 2017, which is the highest share among all resources. Total solar PV installed capacity grew by 1642% in the last decade (BP, 2018a). Wind installations also grew by astronomical numbers. In the last decade, wind installations grew by 341.8%. There have been records in wind installations in Europe and India, and in offshore wind installations in 2017; overall global wind installations grew by 11% in 2017 compared to 2016 (GWEC, 2017). Biomass and geothermal grew at a much slower rate than solar and wind. Biomass applications grew by 23.1% from 2005 to 2016 (WBA, 2018). Geothermal occurrence depends on the geographical location and geology of a country; thus geothermal is not as abundant as solar and wind, and it only grew by 34.1% over the last decade (WBA, 2018). With growing concern about the environment and importing energy, some countries are adopting new policies to increase their use of RES. These policies are generally in the form of subsidies or tax cuts; governments offer different types of incentives to increase the share of RES in their energy mix. As of 2017, RES policies were established in 121 countries (IRENA et al., 2018). These policies will have a significant effect in increasing RES installed capacity. Forecasts show that the share of RES will increase rapidly in the upcoming decades. In 2023, it is expected that RES, excluding hydro, will cover 13% of the total power generation in the world (OECD/IEA, 2018). With many energy efficiency improvements, the increase of electrification, and the adaptation of home appliances to energy transition, the share of RES is expected to reach nearly 18% by 2040, up from only 3.6% today (BP, 2018a; OECD/IEA, 2018). When the projections of IEA examined, the new policies scenario, which includes current policy frameworks and ambitions and evolution of known technologies together, between 2018-2040 global primary energy demand shows an increase over a quarter. According to this scenario highest increase is expected on renewables. Even though there is no decrease demand for coal expected increase is a small number as 2% (Table 1.1) (OECD/IEA, 2018).

Table 1.1 World primary energy demand projection

Source: OECD/EIA, 2018

	Current		**New Policies Scenario**		**Increase (%)**
	2000	**2017**	**2025**	**2040**	**2017 to 2040**
Coal	2308	3750	3768	3809	2%
Oil	3665	4435	4754	4894	10%
Gas	2071	3107	3539	4436	43%
Nuclear	675	688	805	971	41%
Renewables*	662	1334	1855	3014	126%
Hydro	225	353	415	531	50%
Modern bioenergy	377	727	924	1260	73%
Other	60	254	516	1223	381%
Solid biomass	646	658	666	591	-10%
Total	10027	13972	15388	17715	27%
Fossil fuel share	80%	81%	78,50%	74%	
CO_2 Emissions (Gt)	23,10	32,6	33,9	35,9	10%
Notes: Mtoe = million tonnes of oil equivalent; Gt = gigatonnes. Solid biomass includes its traditional use in three-stone fires and in improved cookstoves.					

1.3 COAL OUTLOOK IN THE WORLD

Coal has a significant place in today's energy world as it has been for many centuries. Coal consumption dates back thousands of years ago to China around 4000BC, although it has been for different purposes than people do today (Ritchie and Roser, 2019). Coal has been known and used for centuries as an energy source, but was not a major component of global energy consumption until the Industrial Revolution. After this, however, coal began to be used extensively. Coal led to many foundational technological developments, such as the steam engine, the railroad, and the steamship, which fundamentally shaped society. Coal consumption has grown ever since, and has retained its position as a major energy source to today (Figure 1.3).

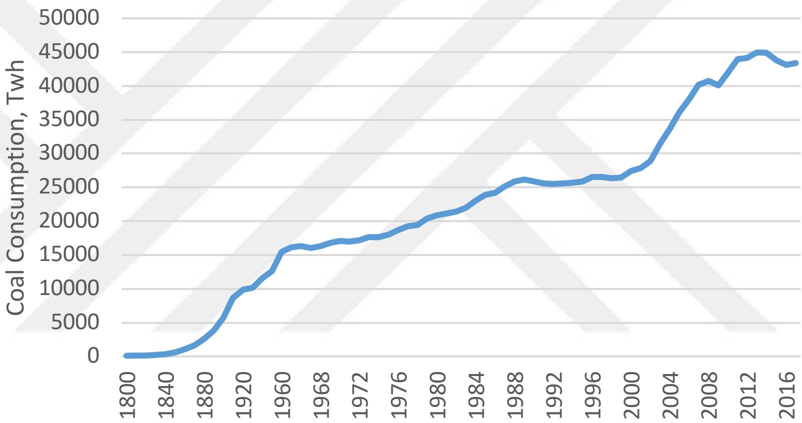


Figure 1.3 World total coal consumption

Source: Ritchie and Roser, 2019

When it first started being used, coal dominated the world and for over a century, coal was the world's dominant energy source (Cleveland, 2009). With the introduction of other resources such as oil and natural gas, the share of coal naturally fell (Figure 1.4). However, it still has a significant share (27.6%) in the total primary energy consumption (BP, 2018a).

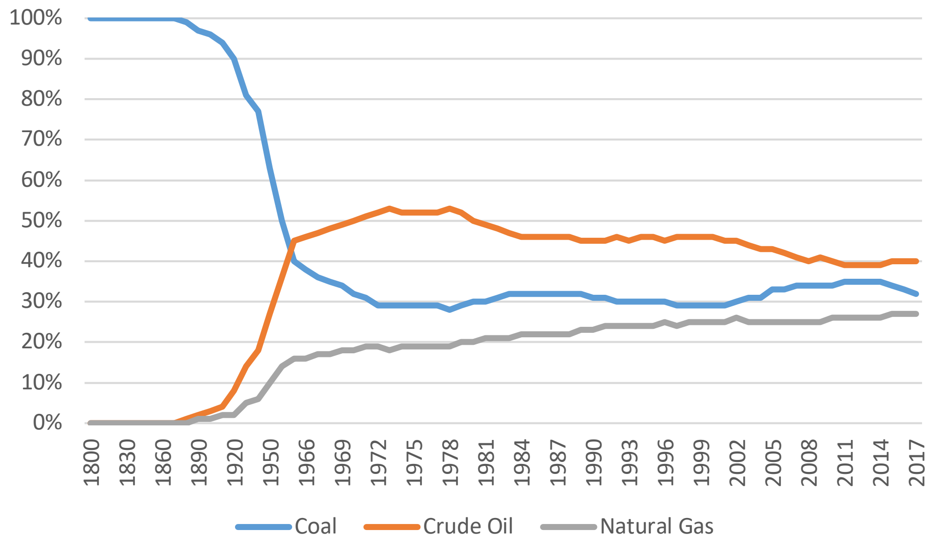


Figure 1.4 Share of each fossil fuel in total fossil fuel consumption in the world

Source: Ritchie and Roser, 2019

Despite efforts to curtail the use of fossil fuels, coal production has steadily increased. In 2017, coal production rose by 3.2%, which corresponds to 105 million tons of oil equivalent (Mtoe), the highest increase since 2011. This growth came mostly from Asia, namely from China and India, where production rose 3.6% and 6.9%, respectively. Consumption has also increased in many others regions. India had the highest consumption growth rate in 2017 of 18 Mtoe. While many countries have dramatically increased their use of coal, others have reduced theirs (BP, 2019b).

At the same time, people are growing more aware of the negative effects of coal consumption and more concerned about the environment, prompting more countries to move away from coal. According to the International Energy Agency (IEA), the world had the largest decline of coal production, 418 metric tons (mt), in 2016. This decline, which doubled the one in 2015, can be mainly attributed to the setting of quotas for mine operating days in China. Looking at different regions, overall consumption of coal increased only in Europe and in Asia in 2017 (Enerdata, 2018). India and China were the main drivers of Asia's consumption growth. Although there has been a decline in two consecutive years in 2015 and 2016, overall consumption of coal has risen over the past four decades. Moreover, after the decline in 2015 and 2016, coal demand rose again in 2017 (IEA, 2018a).

Coal consumption has significant negative impacts on the environment. Energy-related CO_2 emissions are the highest in the world compared to any other sector. Moreover, global energy-related CO_2 emissions reached an historic high of 33.1 Gt CO_2 in 2018 (IEA, 2019). The growth in CO_2 emissions in 2018 was 1.7%, which was 70% higher than the average increase since 2010. This increase in global CO_2 levels was mainly caused by the combustion of fossil fuels (Figure 1.5). The biggest contributor to this increase came from coal-fired power plants.

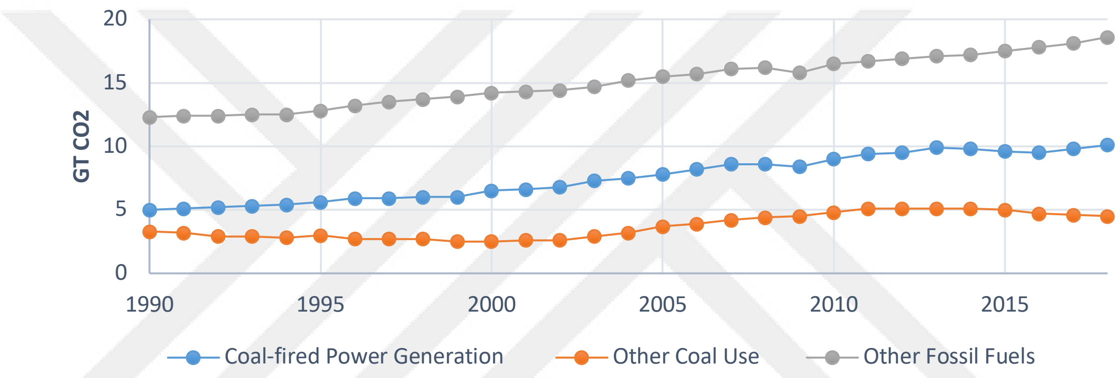


Figure 1.5 Global energy-related CO2 emissions by source

Source: IEA, 2019

Current CO_2 levels are three times higher than preindustrial levels. The consequences of this rise are already apparent. Global temperatures are 1°C higher than preindustrial levels, and the forecasts show that these levels might reach up to 1.5°C depending on different scenarios (IPCC, 2018). Coal alone is responsible for 0.3°C of the 1°C increase of global temperatures (IEA, 2019).

It is estimated that the share of coal consumption in the world's total energy mix will fall slightly. However, coal consumption will still have a significant share in the global energy mix. The projections show that coal's share in the energy mix will fall to 25% from 27% (IEA, 2018b). This decrease will come from the policies hindering the growth of coal specifically in Europe and the United States, while those supporting coal in India and China will offset this decline.

Despite its effects, coal will retain a significant share because it is the largest and most readily available energy source (Cleveland, 2009). Among fossil fuels, coal has the largest share of R/P. The average R/P ratio is 134 for coal in the world as mentioned before (BP, 2018a). The largest coal reserves in the world are in the United States, followed by China, Russia and Australia.

The coal trade constitutes a massive portion of global energy trade. Many countries import coal for their energy security. In 2017, exports of all types of coal increased by 3.3% (IEA, 2018b). Since 2000, total exports of coal grew by 119.5%. Interestingly enough, the trade of coal is growing faster than coal consumption itself. In 2017, the biggest exporters of coal were Indonesia with 28.5% and Australia with 27.6% of the total global coal exports. On the other hand, total coal imports grew by 5.2% in 2017 compared to the previous year. The biggest contribution to this increase came from China, where total coal imports have risen by 6.1%. The three biggest coal importers are China, India and Japan.

With coal being the most readily available energy source, countries around the world are still using it. To overcome the environmental and health costs associated with coal use, new technologies are being developed to decrease the amount of emissions and particles caused by coal combustion. One of the latest technologies is the “clean coal technology”. “Clean coal technologies (CCTs) are technologies that facilitate the use of coal in an environmentally satisfactory and economically viable way” (Chang et al., 2016). With the improvements of this technology, clean coal power plants are now more efficient in electricity generation and have lesser GHG emissions (Melikoglu, 2018). However, the cost of this technology is still too high. This technology is now becoming more widespread in the world specially in the US, China and the European Union.

CHAPTER 2

ENERGY SITUATION IN TURKEY WITH A SPECIAL EMPHASIS ON COAL

2.1. TURKEY'S ENERGY OUTLOOK

Turkey is one of the world's major developing countries. It has a growing economy and population. In line with this growth, Turkey's energy demand is growing rapidly. Turkey has a total primary energy supply (tpes) 157.7 Mtoe (BP, 2018a). The country's tpes had an average growth rate of 4.4% in the last decade and grew by 9.5% from 2016 to 2017. This growth is the third highest in the world after Estonia and Latvia. This fact puts energy security on top of items of Turkish policy agenda.

Turkey's installed capacity for generating electricity was 88,497 MW as of January 2019 (Figure 2.1). Hydropower has the largest share with 31.9%, natural gas 29%, and total coal 22%. However, Turkey required 300,716 GW of electricity generation at the end of 2018 (Figure 2.2). Natural gas has the biggest share of production with 30%, followed by imported coal with a share of 20.66%, or 62,149 GW of total production. The share of total coal is 37% of Turkey's total electricity generation.

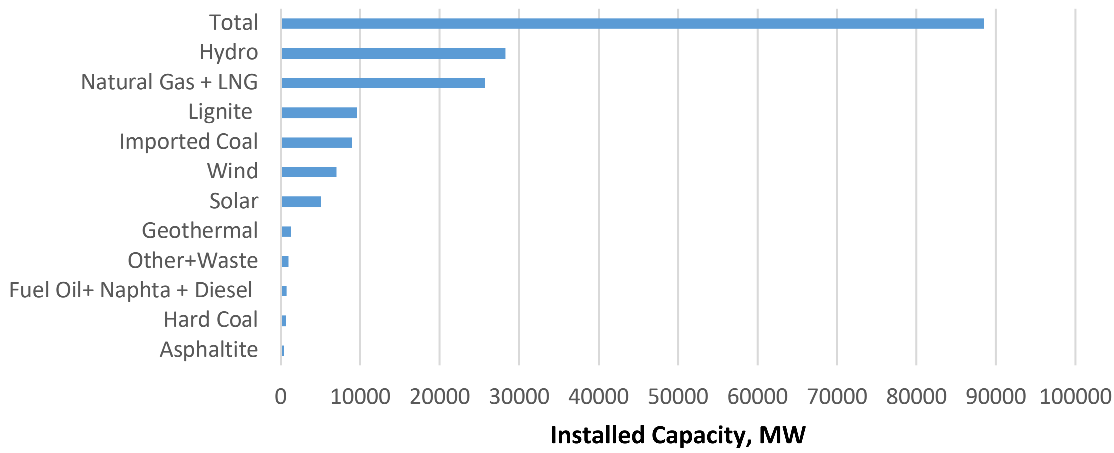


Figure 2.1 Turkey electricity ınstalled capacity, 2019

Source: TEİAŞ and TÜBİTAK, 2019

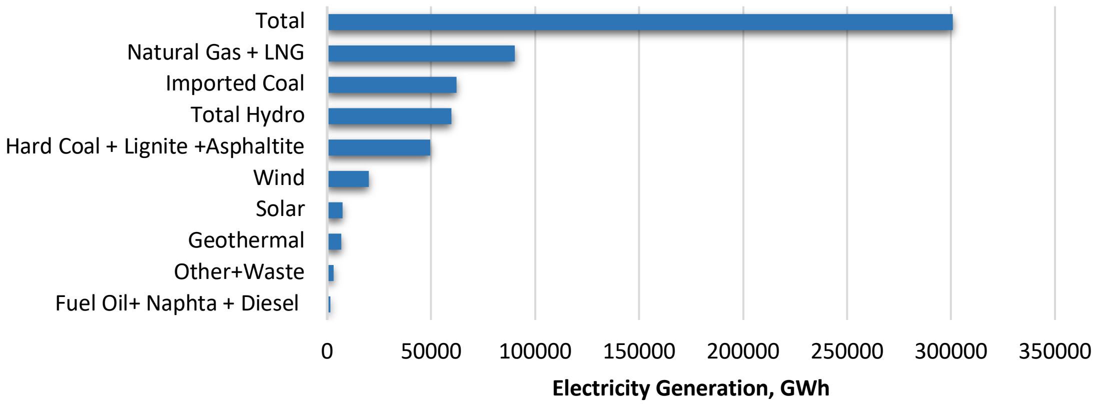


Figure 2.2 Turkey electricity generation by source, 2018

Source: TEİAŞ, 2018

The energy and electricity composition has a big disadvantage. Turkey is an energy-dependent country because there are not enough fossil fuels to produce its own energy to meet domestic energy demand. Turkey thus relies on imports for 75% of its energy consumption. This dependency causes a huge burden on the economy. For the year 2018, the total amount paid for energy imports was $43 billion, which equals to almost 20% of total imports. This amount was 15.6% higher than the year before (Türkiye Cumhuriyeti Ticaret Bakanlığı, 2019).

Turkey import almost all of its oil and natual gas consumption. Fossil fuels account for In 2017 Turkey's natural gas production was equal to less than 1% of its natural gas demand (EPDK, 2018). To cover its energy demand, Turkey imported 99.3% of its natural gas consumption, and Russia had the most significant share of these traded volumes (Figure 2.3.) (EİGM, 2018). During the same year, Turkey produced approximately 6% of its oil demand and imported 93.9% of it, primarily from Iran, Russia and Iraq. 27% of oil imports came from Iran, 19% from Russia and 17% from Iraq in 2017 (Figure 2.4.) (TPAO, 2018). Compared to gas and oil, Turkey has more coal reserves than other fossil fuels, and its import dependency is lower at 61.9% (TPAO, 2018).

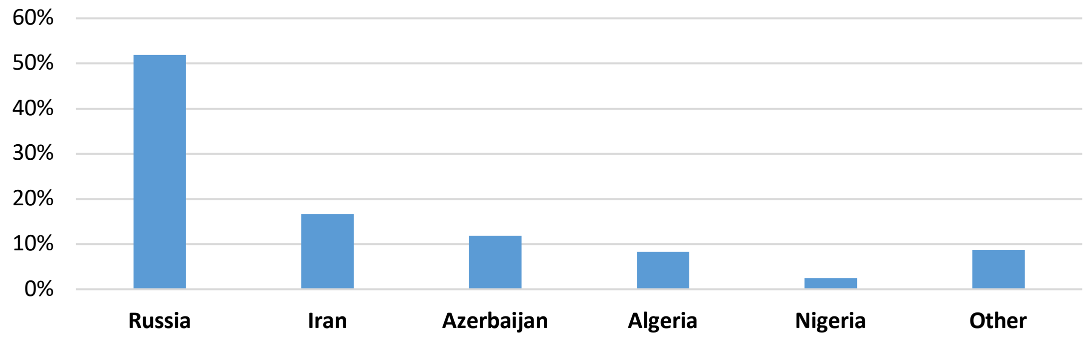


Figure 2.3. Natural gas trade volumes of Turkey by country (million sm^3)

Source: EPDK, 2018

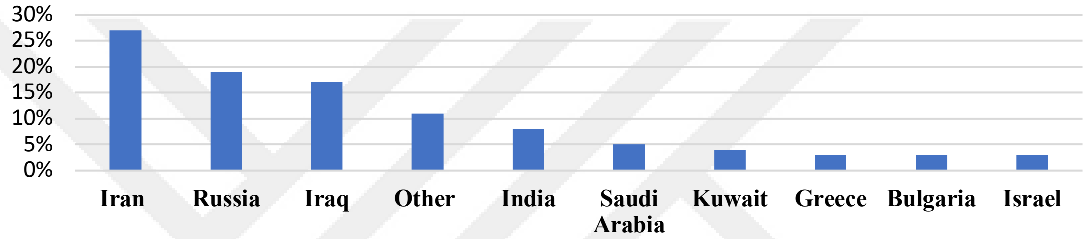


Figure 2.4 Turkey's Oil Imports as percentage by country 2017

Source: TPAO, 2018a

2.2. COAL OUTLOOK

However, Turkish coal production remained insufficient to meet the energy needs of Turkey, including during the Ottoman period. Nevertheless, at the beginning of the twentieth century, coal was the most important produced source for the Empire in terms of quantity and value (Eldem, 1994). Lignite also existed in the pre-Republic period; lignite deposits in Anatolia began to be explored in the 1860s and, whether lignite or hard coal, coal has been the most important source of energy in Turkey for a long time (Yorulmaz, 1998).

There are different statistics for Turkey's coal reserves from international and national sources. For example, according to the data from the *BP Statistical Review of World Energy*, Turkey has 11,353 million tons of proved coal reserves, with 10,975 million tons of sub-bituminous and lignite and 378 million tons of anthracite and bituminous coal. This equals 1.1% of all proved reserves of coal in the world (BP, 2018b). On the other hand, according to Republic of Turkey Ministry of Energy and Natural Resources, Turkey's total coal reserves are about 3.2% of the world's total lignite/sub-bituminous coal reserves, and Turkey has 17.3 billion tons of lignite reserves (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2018). Of its 17.3 billion tons of lignite reserves, 46% are located in the Afşin-Elbistan basin (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2018). Turkey's lignite reserves by basin can be seen in Table 2.1.

Table 2.1 Total lignite reserves by basin
Source: MTA, 2017

Basin	Total Reserve (Ton)	Basin	Total Reserve (Ton)
Afsin- Elbistan	4.642.340.000	**Tekirdag — Saray**	141.175.000
Konya-Karapinar	1.832.000.000	**Cankiri-Orta**	123.165.000
Eskisehir (Alpu)	1.453.000.000	**Bolu (Salip.-Merkez)**	98.000.000
Afyon-Dinar-Dombayova	941.000.000	**Canakkale — Can**	92.483.000
Manisa-Soma	861.450.000	**Edirne**	90.000.000
Mugla — Milas	750.214.000	**Bingol — Karliova**	88.884.000
Tekirdag-Malkara	618.000.000	**Bursa (Keles—Orhaneli)**	85.000.000
Tekirdag-Cerkezkoy	573.600.000	**Eskisehir(Koyunagili)**	57.430.000
Afsin — Elbistan (MTA)	515.000.000	**Adiyaman-Golbasi**	57.142.000
Ankara-Beypazari	498.000.000	**Ankara (Golbasi)**	48.000.000
Adana-Tufanbeyli	429.549.000	**Bolu — Goynuk**	43.454.000
Konya(Beysehir-Seydisehir)	348.000.000	**Corum-Dodurga**	38.500.000
Kutahya-Tuncbilek	317.732.000	**Balikesir**	34.000.000
Sivas — Kangal	202.607.000	**Kutahya-Gediz**	23.945.000
Kutahya-Seyitomer	198.666.000	**Amasya-Yeniceltek**	19.791.000
Istanbul (Silivri)	180.000.000	**Yozgat — Sorgun**	13.206.000
Bolu — Mengen	142.757.000	**Others**	1.928.810.000

As much as considered as a small amount, according to the Turkey Hard Coal Institute, Turkey had a total of 1,520,095,725 tons of hard coal reserves as of 2017 (Table 2.2) (Türkiye Taş Kömürü Kurumu, 2018). The most critical hard coal reserves in Turkey are in Zonguldak and its vicinity, where reserves are estimated at 1.3 billion tons, and the proved reserves are roughly 506 million tons (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2018).

Table 2.2 Turkey hard coal reserves (Tons)

Source: TTK, 2018

Reserve Types	Zonguldak				Amasra		Total
	Armutçuk	**Kozlu**	**Üzülmez**	**Karadon**	**A**	**B**	
Ready	1.909.048	3.320.811	382.384	1.848.519	440	-	**7.900.762**
Visible	6.174.821	63.052.937	133.756.420	130.855.192	4.159.659	395.954.757	**733.953.786**
Possible	15.859.636	40.539.000	94.342.000	159.162.000	3.693.649	151.161.950	**464.758.235**
Probable	7.883.164	47.975.000	74.020.000	117.034.000	7.758.000	58.812.778	**313.482.942**
Total	**31.826.669**	**154.887.74 8**	**302.500.80 4**	**408.899.711**	**16.051.308**	**605.929.485**	**1.520.095.725**

On the other hand, most of Turkey's coal reserves are lignite coal with low thermal value. Although thermal values of lignite are between 1,000 kcal/kg and 4,200 kcal/kg, approximately 90% of Turkey's lignite's value is below 3,000 kcal/kg (Türkiye Kömür işletmeleri Kurumu, 2016).

2.3. COAL CONSUMPTION AND IMPORT OF TURKEY

Turkey uses all of its lignite production and does not import any lignite. Until the 1980s, almost all of Turkey's hard coal needs were met by domestic production, especially for consumption in the iron and steel sector. However, in the following years, domestic production could not keep pace with the increase in demand (Figure 2.5). While 80% percent of total coal consumption was covered by domestic sources at the beginning of the 1980s, this number declined to 45% by the end of that decade. As of 2017, total hard coal consumption was 37,475,000 tons, only 3.29% of which could be covered with domestic sources (Türkiye Taş Kömürü Kurumu, 2018).

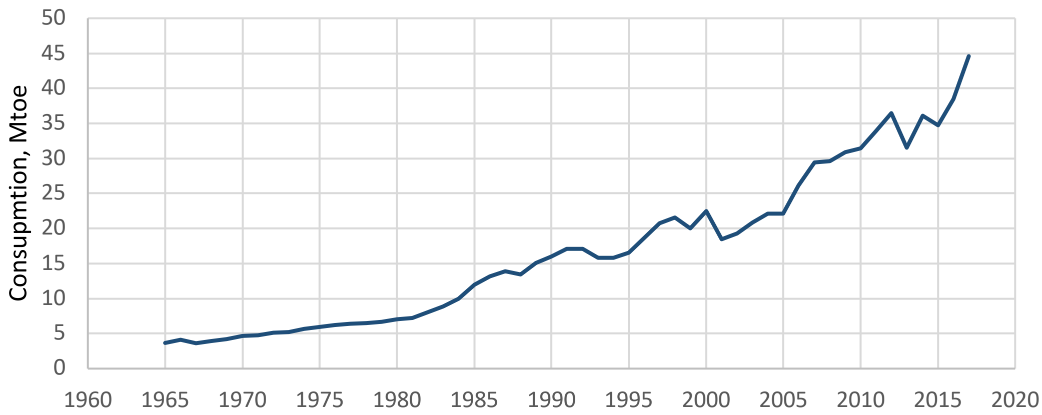


Figure 2.5 Coal consumption of Turkey

Source: (BP, 2018b)

Starting with a symbolic amount of 16,000 tons in 1973, hard coal imports exceeded 1.5 million tons/year in only a 10-year period. In 2009, imports reached 20.3 million tons. In 2017 coal consumption in Turkey was 37.4 million tons and only 3.29% of which could be provided with domestic hard coal (Figure 2.6.).

Turkey paid $749 million for coal imports in 2002 and $986 million in 2003. In 2007, this amount increased to $2,049 million. In 2016, the amount of foreign exchange outlaid for coal imports rose to $5,300 million. In the first three months of 2017, $5,379,000 of precious foreign currency was paid for hard coal imports (Türkiye Taş Kömürü Kurumu, 2018).

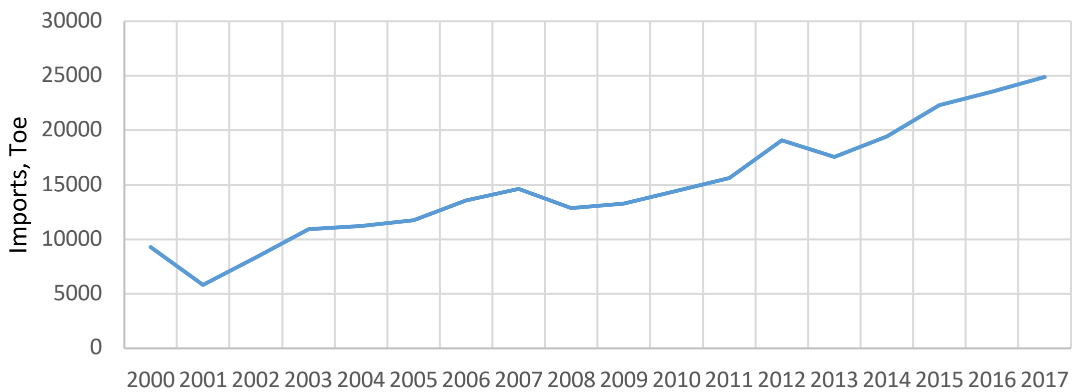


Figure 2.6 Total import of hard coal and coke

Source: (ETKB, 2018).

In order to meet Turkey's rising energy demand since 2005, domestic resources have been given importance in the country's policies. This included detailed lignite exploration activities in the Afşin-Elbistan lignite basin from 2005-2008 financed by EÜAŞ and implemented by the MTA. Support from the Turkey Coal Enterprises in various basins has also provided significant increases in exploration work, which was carried out by MTA lignite reserves, so that lignite reserves could be discovered in more than forty cities (Ediger, 2014). As a result of ongoing coal-exploration activities, which were intensified since 2005 by the MTA in line with the policy of the use of domestic resources in energy, 13 new coalfields were discovered, four of which had vast reserves (Karapınar-Ayrancı, Eskişehir-Alpu, Afyon-Dinar, Tekirdağ-Malkara). Also, the amount of reserves was increased in three existing fields (MTA, 2017). As a result of this policy, lignite reserves, which were 8.3 billion tons in 2005, reached 17.3 billion tons in 2018, with an increase of over 9 billion tons (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2018). This increase meant an almost doubling of the total amount over the last ten years.

Yet hard coal production remained insignificant and heavily subsidized (EUROCOAL, 2018). In 2016, hard coal production was 1.3 mt (EURACOAL, 2017). By the end of 2016, the share of coal in total primary energy consumption in Turkey was 28% (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2018). However, hard coal production dropped by 7.7% to 1.2 mt in 2017. Despite the decrease in production, hard coal deliveries to power plants increased by 11.2% to 18.8 mt from 16.9 mt in 2016. This increase was procured with increasing coal imports in 2017. Coal imports were 36.6 mt in 2017, which is 4.9% higher compared to imports in 2016 (EURACOAL, 2017). In the first half of 2018, a total of 53.9 TWh of electricity were generated from coal-based power plants, and the share in total electricity generation was 33.0% (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2018). As of the first half of 2018, coal-fired power plant installed capacity is 18.666 MW, or 21.4% of the total installed capacity. The installed capacity based on domestic coal is 10,570 MW (12.1%), and the installed capacity based on imported coal is 8,794 MW (10.1%) (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2018).

As can be seen, the installed power from domestic coal-fired power and imported coal-fired power are quite close to each other. In the following chapter, Turkey's coal-fired power plants will be examined more deeply.

2.3.1. Coal-Fired Power Plants in Turkey

As announced by the Turkish Ministry of Energy and Natural Resources, the number of electricity power generation plants in the country, including unlicensed plants, is 6.886 in the first half of 2018. Of these existing plants, 636 are hydroelectric, 63 coal, 232 wind, 40 geothermal, 303 natural gas, 5,422 solar, and 190 "other" power plants. As mentioned in the previous chapter, domestic coal sources used to generate electricity in Turkey consist mainly of low-quality lignite coal, as Turkey has a limited amount of hard coal resources. According to data from the Energy Market Regulatory Agency (EMRA), there are 34 domestic coal-fired power plants in operation with production licenses; one of them is asphaltite, another is hard coal, and the rest are lignite-fired. There are also six power plants in the construction stage. Data from TEİAŞ indicates that the installed capacity of domestic lignite and asphaltite-fired thermal power plants is 9,911.60 MW, with 40,694.4 GWh of electricity produced, as of the end of 2017. In addition, there are 10 imported coal-fired power plants in operation with production license and seven more are in under construction, according to EMRA. According to TEİAŞ, the installed capacity of imported coal-fired thermal power plants is 8,793.9 MW, with 51,118.1 GWh of electricity produced in lignite-fired thermal plants as of the end of 2017.
The number of coal-fired power plant units in Turkey can be classified in the following way: six announced, 29 pre-permitted, 12 permitted, four under construction, and 71 in operation, making a total of 122 as of January 2019. The 71 units in operation have a total installed capacity of 18,826 MW (Table 2.3.) (End Coal, 2018). These thermic power plants are generally located in the Aegean and the Central Anatolian part of the country; closer to the high electricity demand centers (Figure 2.7.). Until 2013, the state operated the large-scale coal-fired power plants that used domestic coal. However, with the privatizations since 2013, the operating rights of these coal fields were transferred to private companies (TMMOB, 2017).

Table 2.3 Turkey's coal-fired power plants*

Source: End Coal, 2018

Turkey	Announced	Pre-permit	Permitted	Under Construction	Shelved	Operating	Cancelled 2010-2018
Units	6	29	12	4	31	71	62
MW	12,800	17,311	6,555	800	24,554	18,826	41,031

** Includes units 30 MW and larger*

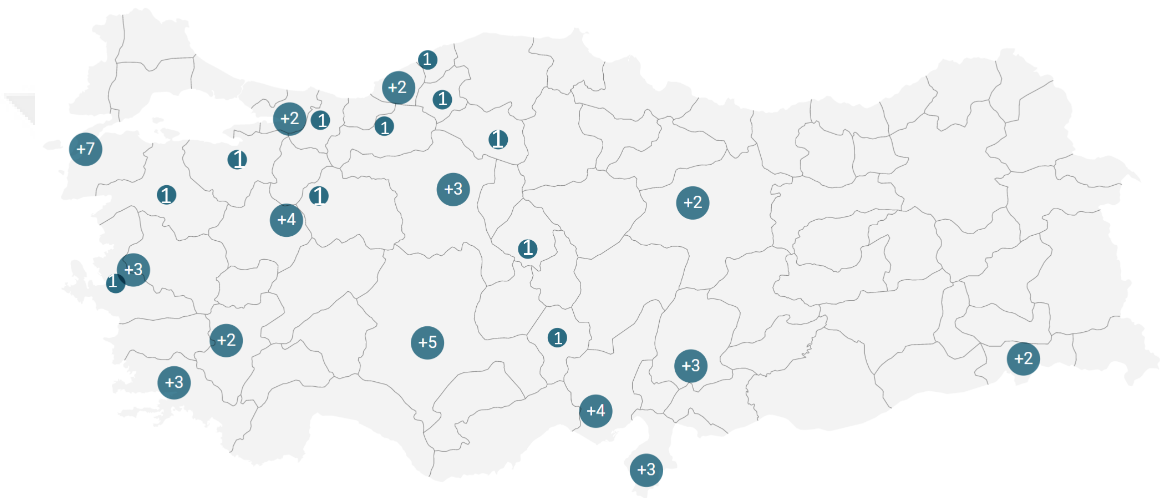


Figure 2.7 Number of existing and under construction coal power plants in Turkey

Source: TMMOB, 2017

The total capacity of the announced, pre-permitted and permitted will be 36,666 MW (End Coal, 2018). These thermic power plants are also located in similar locations. These projects also include the expansion of the existing power plants.

As mentioned in the previous section, new coal reserves obtained through exploration accelerated after 2005. These reserves provided the impetus for building power plants. The majority of the resources mentioned are licensed to public institutions. The total installed power potential of these resources is uncertain but believed to be around 20,000 MW. Although an additional 20,000 MW in capacity is a difficult target to achieve, once economic, technical, financial or environmental obstacles are reached, Turkey's coal production will increase fourfold, and consumption will increase threefold. This production situation is equal to 180 times the production of the whole Zonguldak basin and approximately 20 times that of the Soma basin. This increase will lead at least 150 million mt of additional CO_2 emissions, which is nearly equal to Turkey's current carbon dioxide emissions caused by electricity production (TMMOB, 2017).

CHAPTER 3

EXTERNAL EFFECTS OF COAL

The cost of electricity generation can be calculated as the total of project development costs, technology costs, engineering works, utility systems costs, operating costs, and purchase of fuel and other inputs (Acar et al., 2015). In the context of the cost-benefit calculations used in EIAs, the cost of coal used as a fuel in thermal power plants is calculated based on the market price of coal. Although this method is widely accepted, the market price does not take into account the economic costs of the negative effects of coal during the mining, transport and combustion phases. Therefore, the price of coal does not include all the costs it creates; in other words, a shareholder who wants to generate energy by buying coal does not pay all the costs of the coal that he uses. These unpaid costs are charged to various segments of society: the negative health effects of coal mining to miners, the negative health effects caused by coal-fired power plants to people living in their vicinity, and the damage to agricultural production suffered by farmers (Akbulut, 2017). Hence, the market value of coal is cheaper than it should actually be, as all the effects of coal in the production, transportation and consumption stages carry additional economic costs (Akbulut, 2017).

As it has been said in previous chapters, coal-fired electric power plants have an important place in Turkey's energy policies and are a cheap source of energy. However, a large-scale coal-fired power plant works for approximately 40 years and will have many impacts throughout its lifecycle. Moreover, the new coal-fired power plants will cause a significant increase in carbon emissions and thus contribute to global climate change. Thus, the current policies of Turkey portend that Turkey’s climate commitment are consistent with a warming of over 4°C (EUROCOAL, 2018).

During the lifecycle of a coal power plant, thousands of tons of harmful pollutants are released into the atmosphere every year. Pollutants are released from the chimneys of coal-fired thermal power plants, and these wastes pollute water and soil and therefore pose a great threat to public health (Figure 3.1). Building new coal-fired power plants means that harmful substances remain in the atmosphere for years, and future generations will live with their negative health effects (Gümüşel and Stauffer, 2015).

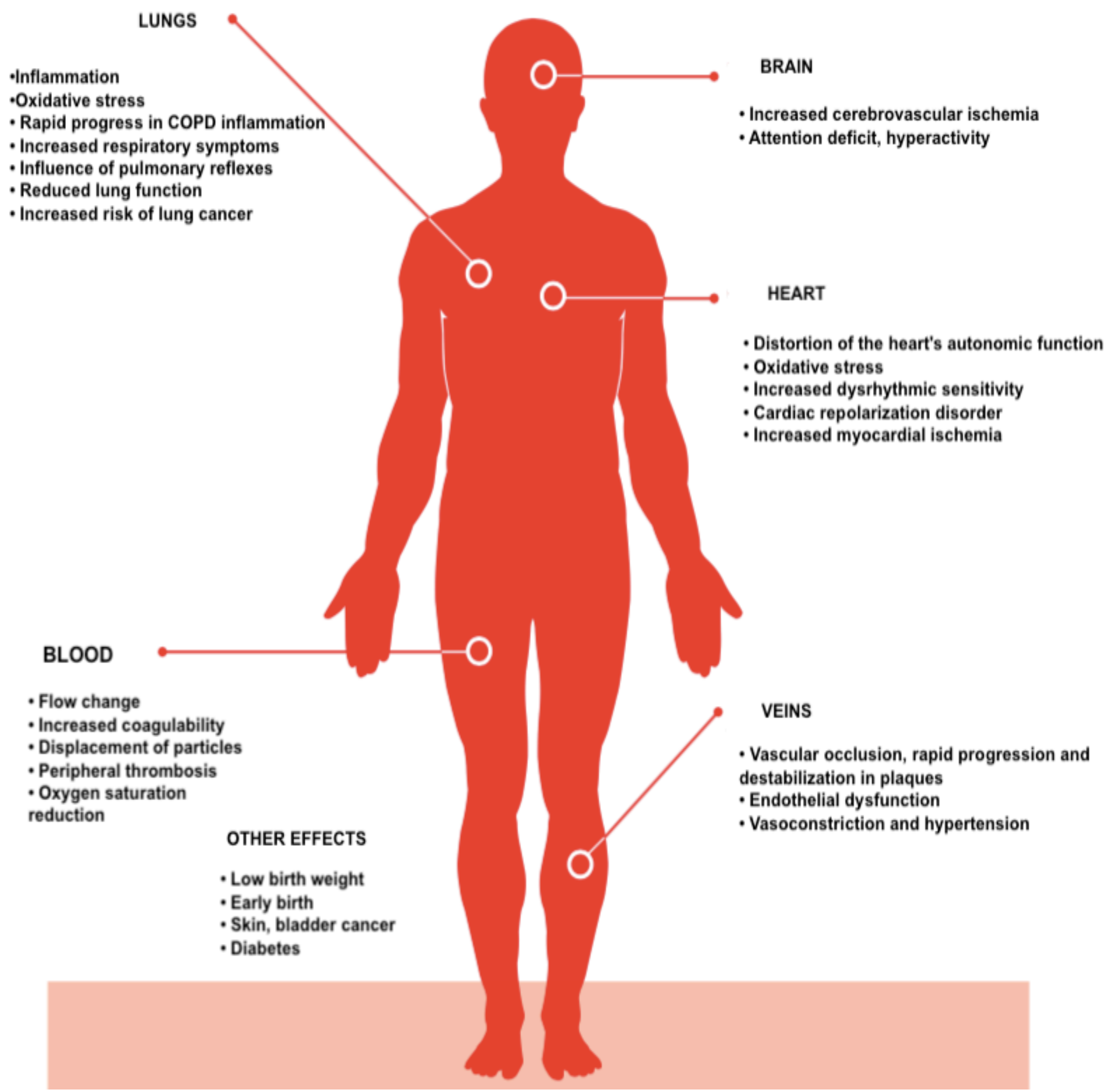


Figure 3.1 Health Effects of Coal-fired Power Plants

Source: Gümüşel and Stauffer, 2015

A report published by the Health and Environment Alliance (HEAL) in 2015 showed that the health costs of coal use for electricity generation in Turkey cause at least 2,876 premature deaths per year, 3,823 new cases of chronic bronchitis in adults, 4,311 hospital admissions, and 637,643 lost working days (Gümüşel and Stauffer, 2015). The economic cost of coal on health is estimated to be between 2.9 and 3.6 billion euros annually. These figures issue reflect the cost of exposure in Turkey to particulate matter (PM) impacts associated with the two major groups of chronic diseases – respiratory and heart disease. Another is the release of mercury and lead into the air during the operation of a coal-powered thermic plant. In addition, other metals and semi-metals are emitted from coal-fired thermal power plants that are frequently covered by the term heavy metals in the medical context. These include arsenic, beryllium and chromium, which are known to cause cancer (Gümüşel and Stauffer, 2015).

A material flow analysis for Turkey estimated that coal-fired power plants produce 10,551 kg of mercury into the atmosphere and that 88% of this amount is released into the air annually (Civancik-Uslu and Yetis, 2015). Cognitive development may be adversely affected by intensive exposure to mercury, and irreversible damage to vital organs of a fetus may occur. Therefore, large amounts of mercury emissions from thermal power plants are serious concerns for human health (Gümüşel and Stauffer, 2015). The mercury released into the air enters the water cycle through rainfall and accumulates as it rises in the food chain. It is stored in large quantities especially in some species of fish. People can also be exposed to mercury through consuming fish contaminated with mercury (Sackett et al., 2010). Nutrient ingestion of organic mercury causes toxic effects and congenital disorders. It significantly affects children's brain development. This damage is neurologically irreversible and is usually due to exposure to mercury in the early-fetal period. Nowadays, brain damage occurs by exposure to lower doses than in the past (Grandjean et al., 1997).

Lead is also released from some coal-fired power plants. Like mercury, lead damages children's developing nervous systems. In adults, it can degrade the functions of the cardiovascular system, which can lead to death and cause high blood pressure or anemia (World Health Organization, 2010, 2001). It affects almost every system in the body and is directly toxic in high doses (Gümüşel and Stauffer, 2015). Current research shows that children who are exposed to mercury or lead are three to five times more likely to have problems related to attention deficit and hyperactivity disorder (ADHD), and this exposure usually occurs before birth (Olivier et al., 2012).

Pollutants released into the air from the chimneys of coal-fired thermal power plants pose an even greater threat to public health compared to the wastes that enter the water and soil. Coal thermal power plants are found to emit a large amount of particulate matter (PM), sulfur dioxide, and indirectly they release nitrogen oxides, which causes ozone formation (Myllyvirta, 2014). The health-related concerns of these pollutants are about particulate matter (PM 2.5) and ozone gas, which have a diameter of less than 2.5 microns (Gümüşel and Stauffer, 2015). Particulate matter in the air affects people more than other pollutants. The main components of PM are sulphate, nitrates, ammonia, sodium chloride, carbon, mineral powder and water. PM 2.5 is more dangerous because it can even interfere with the gas exchange in the lungs by reaching the peripheral areas of the bronchi (Myllyvirta, 2014). According to HEAL, 20% of health problems attributable to PM exposure in Turkey stems from coal burned in power plants. Also, the cloud of exhaust gas from the chimneys can be transported across borders by traversing hundreds of kilometers; pollutants can accumulate in ecosystems and in the lungs of people. For this reason, the health damage caused by the use of coal is not limited to areas in the vicinity of the plants themselves. The height of the chimneys and wind conditions determine where the pollution is carried (Gümüşel and Stauffer, 2015).

In addition to all these deleterious effects, two more terms are important: "loss life year" and "lost working day". A report from Stuttgart University converted the number of deaths attributed to air pollution to the number of years lost due to premature deaths. Accordingly, in the case of life loss caused by particulate pollution, the life span of the individual is reduced by approximately 11 years, while life loss due to exposure to ozone gas is shortened by nine months. The study revealed that pollution from coal-fired power plants caused approximately 7,900 deaths in 2010 (Myllyvirta, 2013). Researchers estimated that the lives of these people have decreased by 86,000 years in total. An investigation of over 500,000 adults from fifty U.S. states with different levels of air pollution between 1982 and 1999 revealed that air pollution increased the risk of death (Myllyvirta, 2013). Moreover, air pollution, as well as increasing the risk of developing a variety of diseases, including employees whose health problems cause additional sick leave. This refers to term "lost working day." These permits are spread over a wide range, ranging from small-scale respiratory tract infections and cough disorders to convalescence after a heart attack (Myllyvirta, 2013).

A further key issue is that emissions from coal-fired power plants cause acid rainfall and heavy metal-containing fly ash accumulation. These emissions damage plants, agricultural areas, ecosystems, and properties (TEMA, 2017). In 2015, HEAL made an assessment of the health impacts and costs of thermal power plants based on updated emissions data on health effects and costs of thermal power plants and new scientific evidence on the health effects of air pollution in Turkey. According to this assessment, the primary health effects resulting from coal-fired power plants are the following (Gümüşel and Stauffer, 2015). Cost calculations for this data are given in euro in the Table 3.1 below.

Table 3.1 Health effects and economic costs of coal-fired power plants
Source: Gümüşel and Stauffer, 2015

Health Effect	Level of Effect (Number of Case or Day)	Economic Cost (€)
Death (Adults)	2876	3110
Life year loss (Adults)	86393	2428
Premature deaths	13	22
Chronic bronchitis (adults)	3823	100
Bronchitis (Children)	25576	8
Hospital admissions due to respiratory disorders (All age groups)	2864	3
Hospital admissions due to cardiovascular disorders (All age groups)	1447	2
Activity Loss (All age groups)	7976070	357
Asthma Symptoms (Children)	225384	5
Lost work day	637643	40
Total Value (lower limit)	-	2964
Total Value (upper limit)	-	3646

3.1. HARMFUL EFFECTS OF LIGNITE

As a result of burning one ton of lignite, less air pollution generally occurs compared to burning the same amount of hard coal. However, since lignite has a lower energy content than hard coal, about three times more lignite coal will have to be burned to produce the same amount of electricity. Therefore, a lignite power plant will generate a higher amount of harmful pollutant emissions than a hard coal-fired thermal power plant with the same electrical power output. Turkey's indigenous lignite has low calorific value and relatively high amounts of ash, moisture, and sulfur content. Therefore, the air pollution arising from the burning of this lignite is also high (Say, 2006).

Coal-fired thermal plants as a whole are the source of three times more than the World Health Organization's satisfactory level of particulate matter (PM), sulfur dioxide (SO2), mercury, arsenic, and cadmium in the air of Turkey's cities (Cagla Uyanusta Kucuk and Ilgaz, 2015). The coal plants causing the most harmful effects on health in Turkey are the state-owned Electricity Generation Company's (EGC) Afşin-Elbistan, Soma, and Tunçbilek plants. Afşin-Elbistan and Soma also have the highest possible pollution-related mortality rate in Europe (Myllyvirta, 2013). If the expansion project of the Afşin-Elbistan power plant is realized, it is estimated that this plant will cause "loss life years" of 8,000 each year. In Europe, it is accepted that the most negative impacts on human health will be caused by this project (Myllyvirta, 2014).

Another issue with thermal power plants is that they need large amounts of water for processing and cooling. A large amount of water is drawn, used and consumed from the source to convert the heat into mechanical energy and then to electrical energy (Gündoğan et al., 2018). Therefore, thermal power plants are generally installed on the shores of water. If thermal power plants do not return water to their source, this is called water use. The amount of water consumption varies according to the systems used. The majority (90%) of systems used in Turkish thermal power plants have lower system costs because they consume more water. In this case, coal-fired power plants make a major contribution to climate change while increasing the stress on water resources (El-Khozondar and Koksal, 2017). Thus, they are continually harming their assets in a vicious cycle by causing water scarcity (IEA, 2016; van Vliet et al., 2012).

In addition, thermal power plants pose a threat in the form of wastewater, including slag troughs, washing and cleaning water, oily water, coal-stock area drainage, etc., which poses various environmental and social risks (Gündoğan et al., 2018). According to TÜİK data, in 2016 a total of 8.5 billion m^3 of wastewater was discharged by all kind of thermal power plants in Turkey. There is no classification by type of the plants. When the cooling water was removed from this amount, only 10.5% of the remaining part was treated (TÜİK, 2016). In terms of solid wastes, a total of 19.5 million tons of waste, including 12 thousand tons of "dangerous" waste was reported in the year 2016 (Gündoğan et al., 2018).

3.2. ACCIDENTS IN COAL MINING SECTOR IN TURKEY

The mining sector is rife with occupational accidents and diseases. This is especially true in Turkey, where complex geological structures in the coal regions make it even more difficult to manufacture with fully mechanized systems; hence coal production is mainly carried out using labor-intensive manpower (TTK, 2018). The shortcomings in the legal regulations, implementation, and lack of effective supervision over occupational safety result in serious injuries, disabilities, and death rates from mining-related occupational accidents (Acar et al., 2015). Due to the often-repeated fatal mining accidents in recent years, questions have been raised relating to the structure of the mines, as well as about the health and safety of workers. In the coal sector alone, a total of 649 people lost their lives due to occupational accidents and occupational diseases in the period from 2007-2016, while the number of those who became permanently incapable of working reached 83,427 (Table 3.2). Among the causes of the explosions and fires in the mines in Turkey, not exactly fulfilling the requirements of the production process, deficiencies and defects in production plans and projects, and lack of air conditioning are among the primary culprits (Güyagüler, 2002). From this point of view, it can be said that employment in the coal sector is not attractive. Poor and dangerous working conditions, low wages, lack of unionization, and security risks increase the social costs of coal mining for the public (Acar et al., 2015).

Table 3.2. Occupational injuries and deaths related to coal mines in turkey
Source: Acar et al., 2015; TMMOB Makina Mühendisleri Odası, 2018

Year	Occupational Injuries	Occupational Deaths
2007	6293	38
2008	5728	30
2009	8193	3
2010	8150	92
2011	9217	58
2012	8828	20
2013	11289	36
2014	10026	335
2015	7429	26
2016	8274	11
Total	83427	649

At the same time, mining activities and electricity production affect the availability and quality of water resources, and lead to the pollution of the land and loss of biodiversity.

CHAPTER 4

RENEWABLE ENERGY SOURCES IN TURKEY

Turkey has significant potential for renewable energy sources (RES) (Ediger and Kentel, 1999). Geological structure of the country, various geographical formations as well as the climatic belt that Turkey located are factors that supports this potential (Arslan, 2017). Turkey tries to follow up the recent global developments; therefore, its renewable energy installed capacity and energy generation from renewable sources keeps increasing (Figure 4.1).

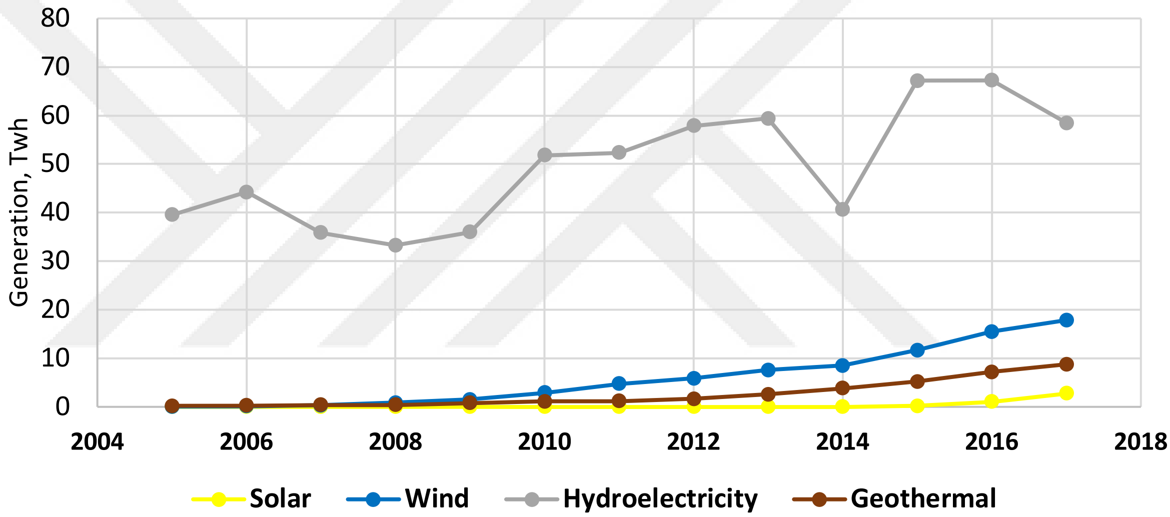


Figure 4.1 Renewable energy generation by source in Turkey

Source: TEİAŞ

4.1. HYDROPOWER

Although hydropower is described as renewable, there are many questions about its sustainability. Hydropower dams are built on vast lands, and main concern is that dams can harm local ecosystems (Matejicek, 2017). In order to clear the areas where hydropower plants will be built, hundreds if not thousands of trees need to be cut down, which invariably changes the climate of the area and the variety of animals decreases. As animals living nearby try to adapt to their new environmental conditions, many do not survive. In addition, dams cause the temperature of the river water to change, which disrupt its habitat. Dams also reduce the amount of water that travels downstream, so the lower parts of the river and its soil structures, vegetation, animal life, and bacteria systems are all disrupted. In addition, the deltas melt into the area where the river reaches the sea, the soils are salinized, and the chemical features of all the mixing waters are adversely affected (Atak and Öztok, 2013).

However, it is certainly possible to make hydropower dams more environmentally friendly. Building a hydropower plant in Turkey requires an Environmental Impact Assessment (EIA), since this requirement entered the law with Article 10 of the Environmental Law No. 2872 in 1983. However, new EIA regulations have been put into force, published in the Official Gazette dated 25 November 2014, with some amendments. These new regulations have clear weaknesses. For instance, most of the decisions reached are characterized as "no need for EIA" and do not provide a detailed examination (Yaman and Haşıl, 2018). Meanwhile, existing hydroelectric plans and practices in Turkey remain a threat to its rivers. To ensure sustainable hydropower production in Turkey, hydropower regulations should be restructured within the framework of international standards, such as those of the EU (Atak and Öztok, 2013). Furthermore, to increase hydroelectric potential in a sustainable way, small hydro plants that are connected to grid can be used to generate electricity. Small hydro projects have 1-20 MW of generating capacity, so they require less construction work and cause fewer negative environmental effects (Matejicek, 2017).

The theoretical potential of hydropower in Turkey is listed at 433 billion kWh/year, whereas technical potential is 216 billion kWh/year and economic potential is 140 billion kWh/year(ETKB, 2019a). In 2017, hydropower produced 58.2 billion kWh (ETKB, 2019a). As of January 2019, there were 538 river hydro power plants with 7,755 MW of installed capacity and 120 dam hydro power plants with 28,291 MW of installed capacity (TEİAŞ and TÜBİTAK, 2019). Total electricity generation from hydropower was 59,754 GW at the end of the 2018 as seen in Figure 4.2.

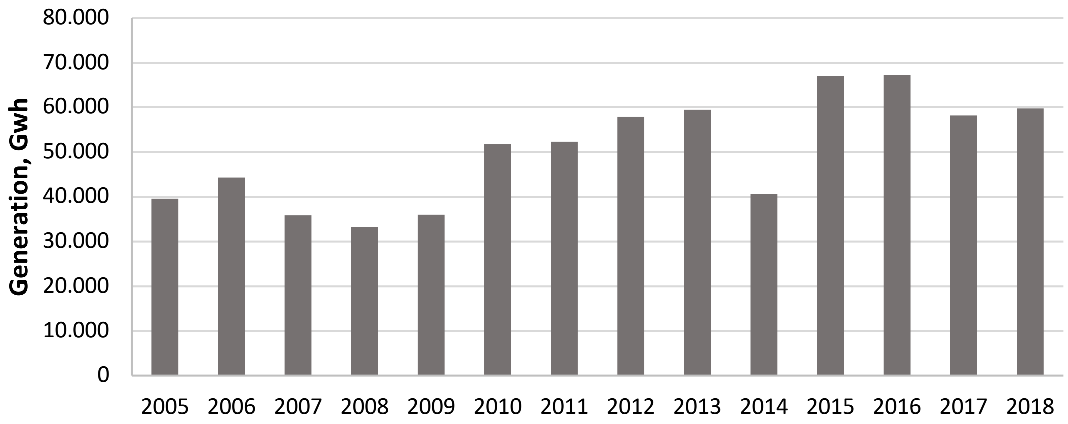


Figure 4.2 Electricity Generation from Hydropower in Turkey

Source:TEİAŞ

4.2. WIND ENERGY

Wind energy use is rapidly increasing today throughout the world and is one of most commonly used alternative energy sources (Arslan, 2017). The nearly fivefold increase in global wind energy capacity since 2008 can be seen in the Table 4.1 (IRENA, 2018a). With proper planning of placement, wind turbines are the best option, all things considered, for minimizing the impact on the environment (EWEA, 2012). wind energy has the lowest levelized cost of energy, ranging between $30-$60. However, the cost of offshore wind turbines is much higher at $113 (Lazard, 2017). In addition, wind energy created 1,148 jobs worldwide in 2017 (IRENA, 2018b). Denmark is an excellent example of how efficient wind energy can be (State of Green, 2017). In 2017, 43.6% of Denmark's electricity came from wind turbines (Climate Action, 2018).

Table 4.1 World wind energy installed capacity

Source: IRENA, 2018a

Years	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
World Installed Capacity of Wind (MW)	114,799	150,101	180,719	220,013	269,642	301,551	349,188	416,798	467,227	513,939

The shorelines and mountain valley structures put Turkey in a very advantageous position in wind energy potential. As can be seen on the map in Figure 4.3, the Aegean, Marmara, Mediterranean, Black Sea coastline, and Southeast Anatolia regions have high wind potential, with an average speed of 4.5–10 m/s. According to the General Directorate of Renewable Energy, Turkey's wind energy capacity is 48,000 MW from only 1.3% of its total land (ETKB, 2019b). Given such promising conditions, Turkey is giving real importance to improving its installed wind capacity. In 2007, installed capacity of wind was 0.36% of total installed capacity, but this reached 6.6% in 2018 (TEİAŞ, 2018). The yearly installation of wind turbines peaked in 2016 with 1,387.75 MW, according to the TÜREB statistic report, 2019 (Figure 4.4.). Only 497.25 MW of installed capacity of wind turbines added in Turkey in 2018 (TÜREB, 2019).

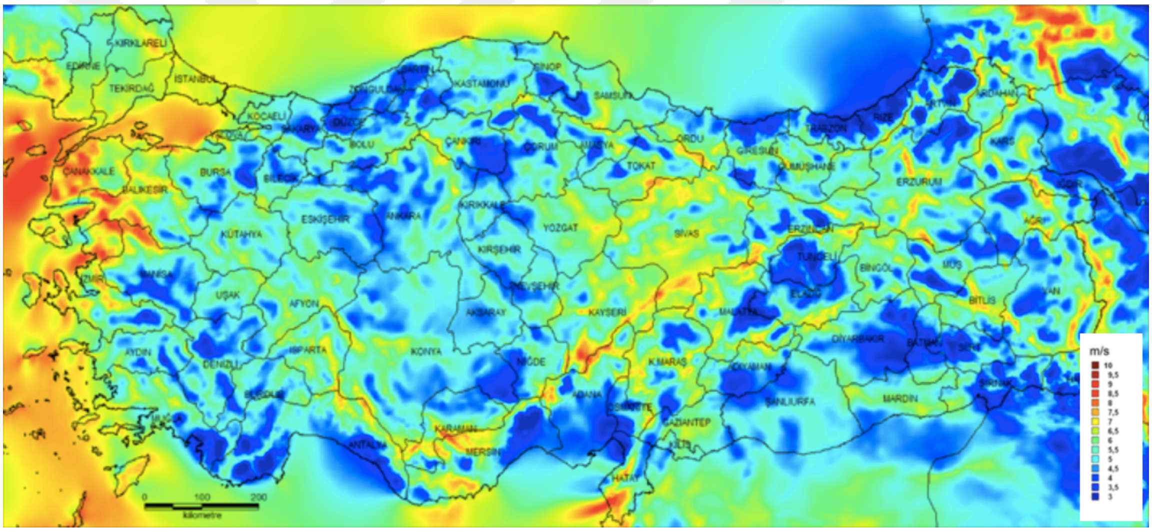


Figure 4.3 Turkey wind energy potential atlas, wind speed

Source: YEGM

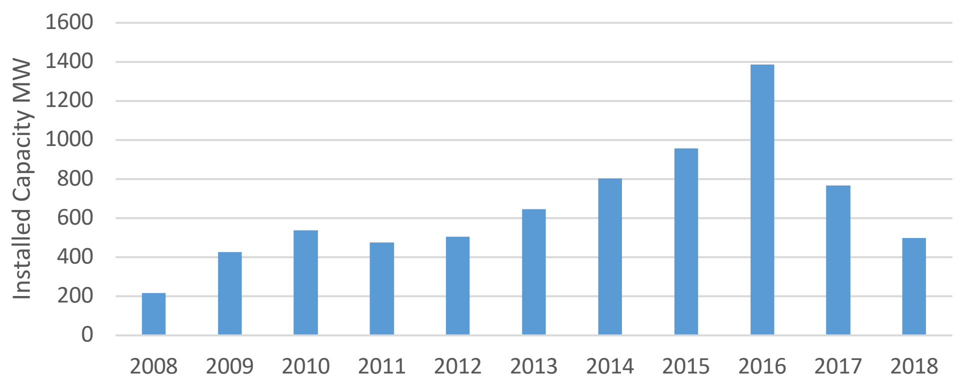


Figure 4.4 Turkey wind energy installations

Source: TUREB, 2019

As of January 31, 2019, there were 250 wind power plants with the 7,006 MW of installed capacity in Turkey, and 74 of them were unlicensed. Also, electricity production from these plants was 19,982.2 MW in 2018 (TEİAŞ and TÜBİTAK, 2019).

4.3 GEOTHERMAL ENERGY

Due to intense tectonic movements taking place in the country, geothermal energy potential in Turkey is high (Figure 4.5**)** (Aksoy, 2014)**.** 95% of geothermal resources are low, and medium temperature, which are suitable for direct use, ie, residential heating, greenhouse and spa tourism and the 6% is suitable for power generation (ETKB, 2019c)**.** The first studies to determine this geothermal energy potential were initiated by MTA in 1962. The first electricity production in geothermal energy was started in 1975 by the General Directorate of MTA at Kızıldere Power Plant with a power of 0.5 Mwe (ETKB, 2019c).

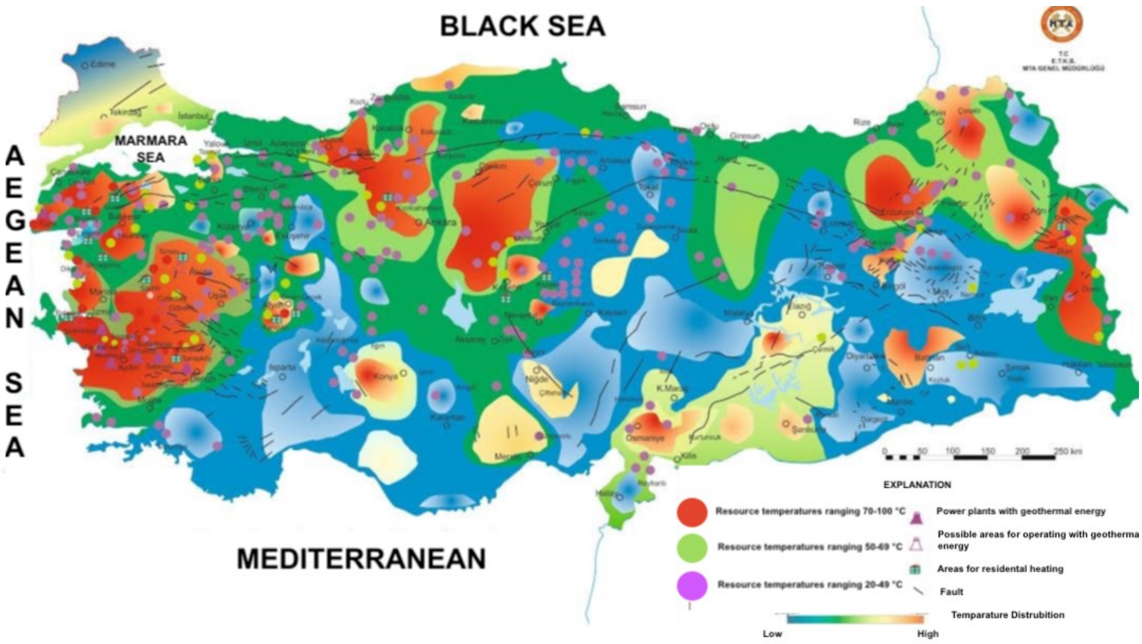


Figure 4.5 Geothermal potential of Turkey

Source: ETKB, 2019

Geothermal possible theoretical heat potential of Turkey is 60 thousand MWt and technical electrical potential is 4600 MWe (Türkiye Jeotermal Derneği, n.d.). Today, with the increasing support of the Ministry of Energy, especially with the introduction of the Law on Geothermal Resources and Natural Mineral Waters in 2008, private sector's geothermal exploration, development and investment activities have increased (ETKB, 2019c).**.** As of the end of December 2018, available heat capacity reached to 5,000 MWt. By the at the end of 2018, Turkey's installed capacity reached 1260 MW (Figure 4.6) and the total electricity generation realized as 6.905,6 Gwh (TEİAŞ and TÜBİTAK, 2019).

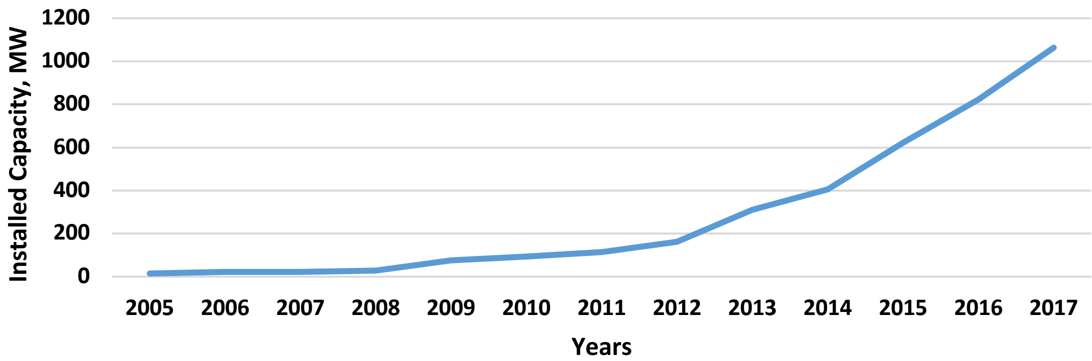


Figure 4.6 Geothermal installed capacity of Turkey

Source: TEİAŞ, 2018

On the other hand, like hydro energy, geothermal is not a sustainable source. It may be considered as alternative energy. It is still not clear effects of geothermal use on climate change (Ruzzenenti et al., 2014). Over use of a geothermal energy source my temporarily deplete the source. This brings concerns about sustainability of geothermal energy (Cook et al., 2015). A major concern about the geothermal energy is related to the reinjection of chemicals to the underground. Geothermal fluids are known to have physicochemical properties that are incompatible with terrestrial ecosystems. Geothermal fluids should be processed and re-injected into geothermal reservoirs after being used for energy production (Alimonti and Soldo, 2016). In addition, disposal of geothermal brines and precipitation of salts and silicas causes serious environmental problems (Ruzzenenti et al., 2014). Unfortunately, these processes have high economic costs because drilling and maintenance of additional wells, as well as processing and pumping of geothermal fluids are required (Alimonti and Soldo, 2016).

If re-injection is performed correctly and the geothermal fields are used with caution, geothermal energy can be used continuously for a longer time. Thus, reinjection improves the sustainability of geothermal sources (Rivera Diaz et al., 2016).

For the reason, in the facilities in our country, hence the reinjection process is costly, it is carried out a few hundred meters deep underground instead of the point taken. In these regions, especially the rich underground and surface water sources are also seriously exposed to poisonings such as heavy metals and boron. It causes irreversible pollution and inefficiency in our soils and waters. Gases such as sulfur released from the chimneys of the plants cause severe air pollution (Melikoglu, 2017).

4.4. SOLAR ENERGY

Solar energy is one of the most prominent RES. It has a relatively easy installation process and is easy to use. The advantage of generating electricity from solar power is that it provides generation without CO_2 or other CO_2 emissions. There is only a minute, insignificant amount of emissions during the production phase of solar cells. This creates an important advantage over fossil fuels since the world is struggling with global climate change, which is caused by burning fossil fuels (Energy for humanity, 2015). With the issue of global climate change becoming more serious, the attractiveness of solar is increasing. This is mostly because of the increased efficiency of solar cells rather than just increasing overall solar power capacity and a rapid fall of costs. Then electricity generation from solar first began, the efficiency of the solar cells was just 11%. However, the most recent studies show that the energy efficiency of new produced solar cells are 20%, an increase of 82.8% in the last 60 years (Aggarwal, 2019; Kalogirou, 2009).

Solar energy production is increasing rapidly around the world. In 2017, a total of 99.1 GW of grid-connected solar was installed, an almost 30% increase from 2016. As a result, world solar capacity reached beyond 400 GW (Figure 4.7.). China and the United States are the top two countries for solar energy production. Installed capacity of solar energy is 131 GW in China, which accounts for one-third of global capacity, and 51.5 GW in the United States (OECD/IEA, 2018; REN21, 2018). Japan and Germany follow them with total capacity of 49.3 GW and 42 GW, respectively (OECD/IEA, 2018; REN21, 2018).

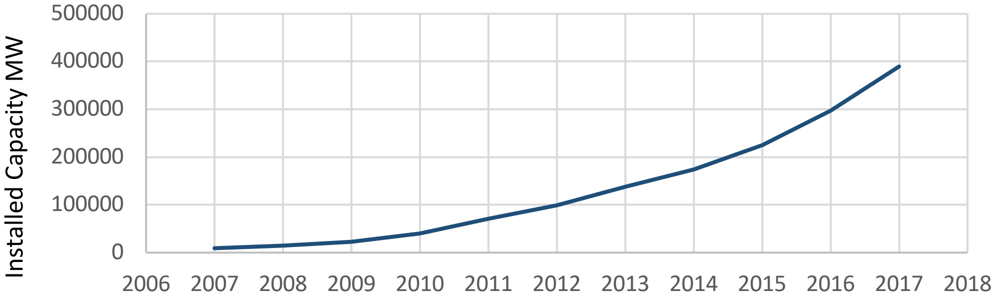


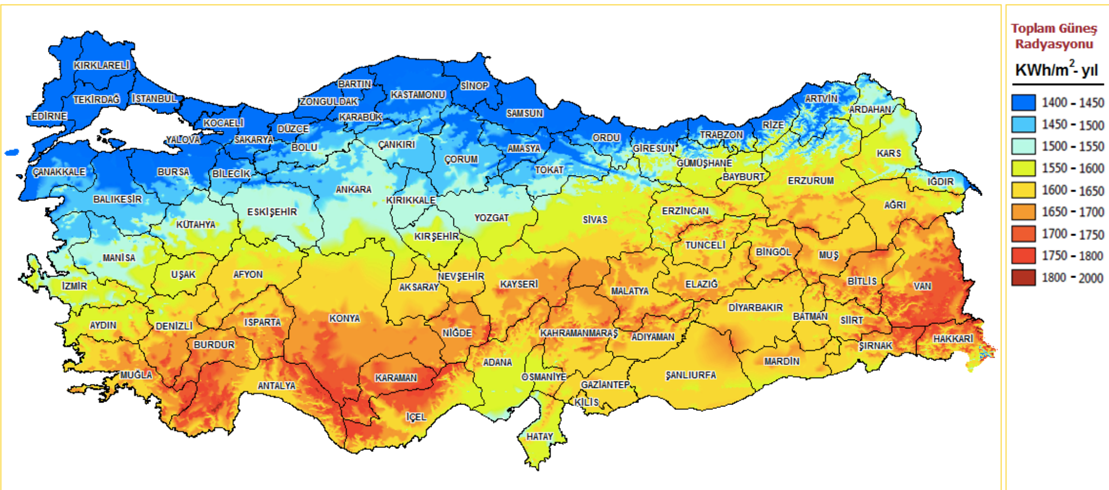
Figure 4.7 World solar installed capacity

Source: BP, 2018b

Turkey's geographic location gives it good potential for solar energy. According to the Turkey Solar Energy Potential Map (Table 4.2.), the total annual sunshine duration is 2,741 hours (7.5 hours daily), and total annual solar energy is calculated at 1,527 kWh/m² (4.2 kWh/m² daily) of Turkey (ETKB, 2019d). Solar energy potential is calculated as 380 billion kWh/year. The map in the Table 4.2 shows Turkey Solar Energy Potential Map (YEGM, 2019).

Table 4.2 Turkey solar potential map

Source: YEGM, 2019a



The first recorded use of solar energy in Turkey was in 1986, which was only 5,000 toe (Figure 4.8.) (ETKB, 2019d). As of 2018, 876,720 toe of heat energy was produced using solar collectors. Turkey's total established solar collector area, as of 2018, was 20,200,000 m^2 (ETKB, 2019d). Thermal solar is the most common and is used for producing hot water in the south and west of Turkey (Ediger and Kentel, 1999).

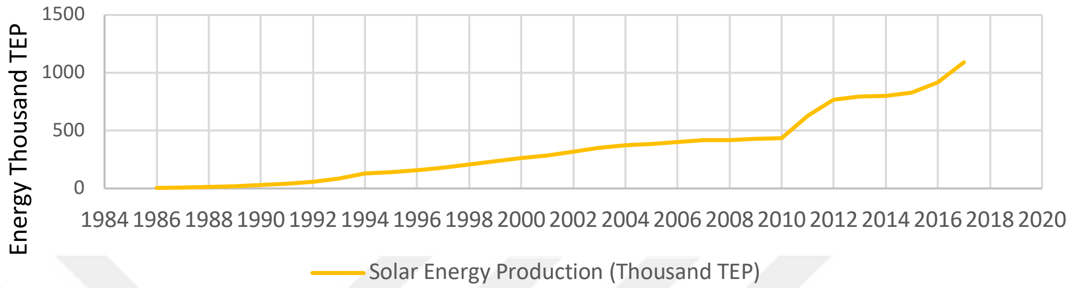


Figure 4.8 Solar energy production in Turkey

Source: EİGM

Electricity production from solar energy began in 2014 in Turkey (TEİAŞ, 2018). As of 31 January 2019, the total number of solar power plants reached 6,009 with total installed capacity of 5,068 MW (Figure 4.9.). Of these, 5,009 MW comes from unlicensed plants and the rest from licensed (TEİAŞ and TÜBİTAK, 2019). As of 2018, the share of solar energy in Turkey's total electricity production increased to 2.5%, with a total amount generated of 7,477.3 GWh (ETKB, 2019d).

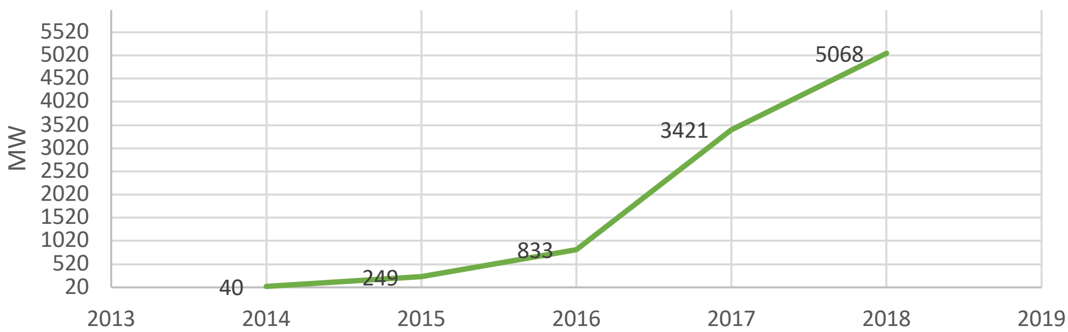


Figure 4.9 Solar energy for electricity production installed capacity in Turkey

Source: TEİAŞ, 2018

CHAPTER 5

NATIONAL AND DOMESTIC ENERGY POLICIES AND A COMPARISON BETWEEN RENEWABLES AND COAL

The Turkish government emphasized the importance of energy security within the framework of its strategy for the energy sector. In order to reduce foreign dependency on natural gas and oil, it identified coal, renewable energy and nuclear energy as priority areas. Coal, as the only fossil source Turkey has in significant quantity, has gained great importance in this context. Government support for the coal industry aims to continue to develop domestic reserves and support economic growth by meeting the increasing domestic and industrial demand. To encourage investors, Turkey has announced numerous incentive mechanisms both for exploration of new coal sites and harnessing coal for electricity generation. However, in addition to the priority given to coal, renewable energy remained in the background. While the energy strategy focused strongly on the use of domestic coal resources, renewable energy targets have always been limited (Table 5.1) (Acar et al., 2015).

Table 5.1 Renewable energy targets of Turkey[2]

Energy Sources (MW)	2017	2019	2023
Hydro	27.700	32.000	34.000
Wind	9.500	10.000	20.000
Solar	1.800	3.000	5.000
Geothermal	420	700	1.000
Biomass	540	700	1.000

The Renewable Energy Law dated 2005 (law no. 5346) provides a renewable energy support mechanism that covers different incentives and benefits for renewable energy

[2] Source: ETKB, N.D.

projects. The Renewable Energy Law provides different feed-in tariffs (fixed minimum electricity sale prices) depending on the type of renewable energy projects.

On the other hand, The General Directorate of Mineral Research and Exploration (MTA) speeded up its coal exploration activities in Turkey with discovery of 13 new lignite deposits (MTA, 2017). In Article 407 of the Ninth Development Plan, 2007-2013, it was aimed to maximize the share of domestic and renewable energy resources in production. The most significant targets for domestic energy use are first stated in "Electricity Energy Market and Supply Security Strategy Document", which was put into force by the High Planning Council in 2009. It targeted to utilize the current proven lignite reserves for electricity generation and increase electricity generation from renewable sources to 30% by 2023 (MENR, 2014).

Finally, in the Ministry of Energy and Natural Resources 2015-2019 Strategy Plan, the use of domestic coal resources had a prominent place. In the goals 2, 4 and 10 of the plan, the most efficient use of domestic coal resources has been identified as one of the main objectives and electricity generation from domestic coal is targeted to reach 60 billion kWh/year by 2019. With this plan, it is expected that the installed licensed solar capacity will increase to 3,000 by 2019 (MENR, 2014).

One of the reasons that coal is privileged is its cost, which is lower than other sources of power generation and is a domestic resource. The cost of coal naturally depends on inputs, including technical costs and the market price. However, in addition to the cost of coal extraction and combustion that are reflected in state-given incentives, there are external economic, social and environmental costs to society. As discussed above, coal has large, meaningful, pernicious external costs, such as polluting the local environment. These costs thereby affect the environment and public health and trigger climate change on a global scale by increasing GHG.

The levelized cost of energy (LCOE) is used to calculate the average cost of an energy project over its lifecycle, including capital, operational, maintenance, fuel, and financing costs (Girouard, 2018). With the development of technology, the LCOE of renewable energies has fallen in recent years. Therefore, the need for incentives will decrease in the near and medium term and will further undermine the commercial logic of using coal. The decrease in coal's LCOE is also falling slightly, as seen in the Figure 5.1. However, it is assumed that in spite of factors such as new coal facilities that are expected to be built in the future, all other costs will remain at the current level, with the increase in costs caused by the extraction of technically more complex coal reserves (Acar et al., 2015). Given this situation, it can be said that wind and solar energy can compete with coal in terms of cost, even without taking into account health and carbon dioxide costs. However, if the incentives and investments in coal-fired energy production continue, the possibility of utilizing these falling costs will be limited. The resources and efforts that can be used for improving RES technologies would be used on coal instead. Then again, coal sources will be depleted, eventually, and all such investments will be wasted to some extent. By pursuing coal over renewables, Turkey will fail to adapt to international trends, which are increasingly focused on the externalities of energy and its costs, as well as the reduction of renewable energy costs.

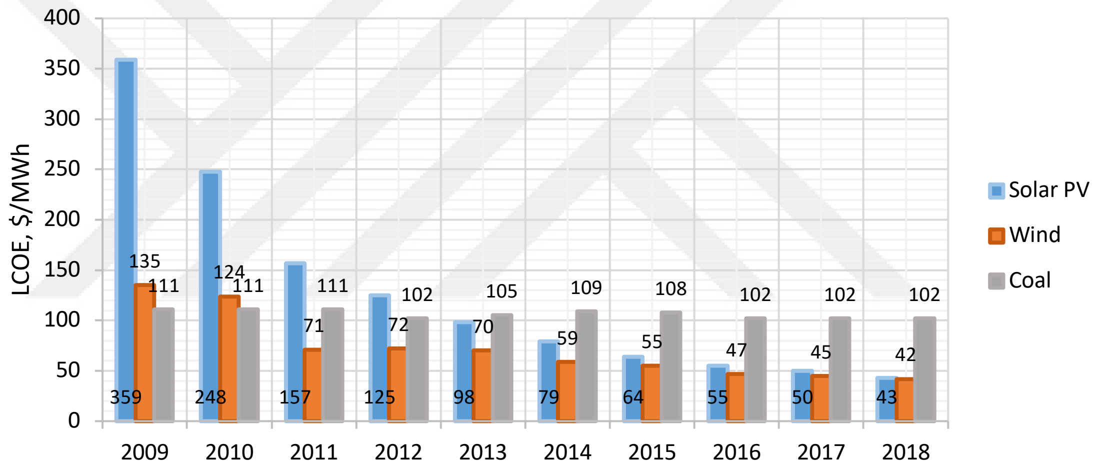


Figure 5.1 Historical levelized cost of energy of utility-scale generation

Source: Lazard, 2018

5.1. RENEWABLE ENERGY INCENTIVES

First legal regulation related to renewable energy sources is "The use of renewable energy sources for electricity production law no. 5346" dated 05.10.2005.[3] With this law, it is aimed "to expand the utilization of renewable energy sources for generating electric energy", "to benefit from these resources in a secure, economic and qualified manner",

[3] Source: Official Gazette : 18.05.2005/25819 Law No.: 5346

“to increase the diversification of energy resources”, “to reduce greenhouse gas emissions”, “to assess waste products”, “to protect the environment” and “to develop the related manufacturing industries for realizing these objectives.” This law also includes incentives for electricity production from renewable energy resources (Table 5.2).

Table 5.2 Renewable energy feed-in-tariffs

Source: Herdem Law, 2015

(Provision of the law dated 29/12/2010 and numbered 609)	
Type of Production Facility Based on Renewable Energy Resources	Feed-in-tariff Prices (US cents/kWh)
Hydroelectric production facility	7.3
Wind power-based production facility	7.3
Geothermal power-based production facility	10.5
Biomass-based production facility (including landfill gas)	13.3
Solar power-based production facility	13.3

This law limits the total licensed installed capacities of solar power up to 600 MW that are commenced until 31 December 2013. The President is authorized by this law to determine the future limits. The pre-license contest for solar generation licenses are now closed until the President sets news limits for the future applications.

Another incentive provided by Law 5346 is local content support for domestically manufactured equipment. In the event that the mechanical and/or electro-mechanical parts used in the licensed renewable energy production facilities are manufactured domestically or for the electrical energy supplied to the transmission or distribution system by producing in these facilities, an extra price is added to feed-in tariffs for a period of five years from the date of the production facility’s establishment. Only licensed renewable energy production facilities can benefit from this incentive, however. Local contributions by type of sources are given in Table 5.3. Additionally, the use of state properties is granted for RES facilities like in national parks, nature parks, natural monuments, nature conservation areas, conservation forests, wildlife development areas, special environmental protection zones, and relevant Ministry of Natural Protected Areas (Herdem Law, 2015).

Table 5.3 Renewable energy local content contributions

Source: Herdem Law, 2015

Type of Facility	Local Production	Local Content Contribution (US cents/kWh)
A-Hydroelectric production	1-Turbine	1.30
	2-Generator and power electronics	1
B-Wind power generation facility	1- Blade	0,8
	2-Generator and power electronics	1
	3-Turbine tower	0.6
	4- All mechanical equipment in rotor and nacelle groups (except payments made for the blade group, generator and power electronics)	1.3
C-PV solar power generation facility	1-PV panel integration and solar structural mechanics production	0.8
	2-PV modules	1.3
	3-Cells forming the PV module	3.5
	4-Invertor	0.6
	5-Material focusing the solar rays onto the PV module	0.5
D-Intensified solar power generation facility	1-Radiation collection tube	2.4
	2-Reflective surface plate	0.6
	3-Sun tracking system	0.6
	4-Mechanical accessories of the heat energy storage system	1.3
	5-Mechanical accessories of steam production system that collects the sun rays on the tower	2.4
	6-Stirling engine	1.3
	7-Panel integration and solar structural mechanics	0.6
E- Biomass power generation facility	1-Fluid bed steam tank	0.8
	2-Liquid or gas fuel steam tank	0.4
	3-Gasification and gas cleaning group	0.6
	4-Steam or gas turbine	2
	5-Internal combustion engine or stirling engine	0.9
	6-Generator and power electronics	0.5
	7-Cogeneration system	0.4

Finally, the facilities that start operating before the end of 2025, the law applies an 85% discount on permits, rent, easement rights and usage permit charges of the power transmission lines for RES production facilities in the first ten years of investment and operation (Erdem and Erdem, 2016).

Also, to promote renewable energy investments in Turkey, the Renewable Energy Resources Support Mechanism (YEKDEM) was established. In this sense, issued under the Law 5346 (also known as YEK Law- 18.05.2005), the Regulation on Certification and Support of Renewable Energy Resources (YEKDEM Regulation) entered in the force on 1 October 2013 (Erdem and Erdem, 2016). Renewable energy sources covered by this law include wind, solar, geothermal, biomass, biomass gas (landfill gas), wave, current and tidal channel or river type or a reservoir area, which has a power generation power of fifteen square kilometers.

YEKDEM arranges the main scale of supports and incentives for renewables, including feed-in tariffs, and handles application for licensing or unlicensed electricity manufacturers (Herdem Law, 2015).

Through the support mechanism, Law 5346 gives 10 years of purchasing guarantees to licensed/unlicensed facilities that generate renewable electricity. The YEKA Strategy seeks to strengthen Turkey's renewable energy industry by requiring the generation of renewable energy technologies domestically and necessitating that they were be proportional in terms of national company ownership and labor force (British Chamber of Commerce in Turkey, 2017). That is to say, developers should involve domestic enterprises, build local factories, create jobs for local workforce, and invest in research and development (O'Brian, 2018). The first two projects described within the framework of this strategy are a 1000-MW wind energy project with a 500-1000 MW solar panel production facility and a production plant for wind turbines that will start operating at the end of 2018. The installed capacity should start producing electricity by the end of 2021 (Daily Sabah, 2017). However, to be able to benefit from this guarantee, applicant facilities must be in operation between 18 May 2005 and 31 December 2020. Feed-in tariff prices, meanwhile, will depend on the production type, as outlined below (Herdem Law, 2015). For the facilities that will apply for commence generation after 31 December 2020, Renewable Energy Law authorizes the President to determine the feed-in tariffs (in terms of tariff amounts, terms and the eligible energy sources) (Boden et al.,2019). Then

Minister of Energy and Mineral Sources, Berat Albayrak, made a statement in 2017, that YEKDEM would discontinue after 2020, arguing that YEKDEM had made a valuable contribution, but had met its deadline. Albayrak also said that YEKA would be the incentive mechanism for a more competitive process that would also support the public finances with support and incentives (Dünya, 2017).

Once the 10-year provision for renewable energy is expired, renewable energy generation facilities will not be able to benefit from the RES Mechanism. They will only be able to sell their electricity to the market or through bilateral agreements.

The attractiveness of YEKA projects comes from different advantages. These advantages are:

- The capacity of 1,000 MW installed power of YEKA only indicates that there may be a fixed demand of about 2.5 years for the production facility.
- Demand for such a high volume of power will result in a reduction in central investment costs from economies of scale.
- The most attractive condition on the power plant side is the acquisition of the right of purchase guarantees over a fixed price in electricity sales for 10 years (Deloitte, 2017).

The Pros and Cons of YEKDEM are like given below (Herdem Law, 2015).

- Encourages people to invest in renewable energy
- Gives guarantees via feed-in tariffs and therefore minimalizes the risk
- Feed-in tariffs determined by foreign currencies may both cause risk or advantage
- Market prices might be higher than the pre-determined tariffs

In addition to the 600MW limit for solar power plants and YEKDEM, there is an alternative method was created. On 9 October 2016, the Regulation on Renewable Energy Resource Areas (RERAs) was published in the Official Gazette.[4] RERA allows the use of chosen state-owned areas to private parties for electricity generation from RES. RERAs are granted through a contest, the procedures of which are regulated in the RERA Regulation.

[4] Source:Official Gazette 9.10.2016/29852

Different from the general licensing procedure, RERA regulation allows very high installed capacities to be allocated to one owner by obtaining the usage rights of the RERA. Like the requirement of YEKDEM, it is required from the applicant to manufacture renewable energy parts in Turkey, whether in the applicants own manufacturing line or by a local third party._If it's specified in RERA, the holder of RERA rights should perform research and development activities in that process.

Also, electricity generated from the facilities in RERA is subject to a purchase guarantee determined in the RERA agreement and purchase period starts from the date of obtaining the RERA Usage right until the end of determined duration._After the expiration, the licensee can sell the generated electricity in the market with the generation license. These facilities will not have an option to opt in or opt out to the RES Mechanism.

Renewable energy generators can benefit from feed-in tariffs without having an energy generation license. People who exceed their own consumption can sell the excess electricity to the grid. There is a purchase guarantee for 10 years for this type of generation. The electricity is bought by the designated distribution companies. However, unlike the licensed generation facilities, after the end of 10-year period, unlicensed facilities cannot sell their electricity.

Thereunder Electricity Market License Regulation (EMLR), electricity generation facilities based on domestic natural resources including RES, only pay 10 per cent of the total pre-licensing and license-obtaining fees in the application process. Following the completion date of the license, the applicants do not pay annual license fees for 8 years. Additionally, domestic natural resources and renewable energy sources are given priority by TEIAS in the connection of the facilities.

RES are also subsidized within the framework of the April 2012 New Investment Incentive System (Council of Ministers Decree No. 2012/3305). This aid provides exemption from VAT and Customs Duties for the machinery and equipment that will be used in power plant. Regardless of the region facilities that covers the capacity and minimum investment amount (which is TRY 1 million in Regions 1 and 2, and TRY 500,000 in Regions 3, 4, 5 and 6) requirements are supported under this framework. Yet, for solar electricity generation facilities can only benefit if they use locally manufactured panels.

5.2. COAL SUBSIDIES

5.2.1. New Investment Incentive System

Same as RES, coal projects are subsidized within the framework of the April 2012 New Investment Incentive System (Council of Ministers Decree No. 2012/3305). Investments in coal exploration and production and coal-fired power plants are subsidized under the Regional Investment Incentive Plan and are classified as priority investments and subjected to high incentive rates. This program categorizes them according to their level of development in the regions and cities of Turkey and aims to support the coal industry in relation to the economic potential and specific needs of the region or city (Acar et al., 2015). The conditions and rates including customs duty exemption, VAT exemption, tax deduction, social insurance premium support (employer's share), land allocation and interest support in the form of incentives vary accordingly (Table 5.4.) (Resmi Gazete, 2012).

Table 5.4 Coal subsidies from 2012 new investment incentive system

Source: Resmi Gazete, 2012

<table>
<tr><th colspan="4">Investment type:</th><th>V. Region</th></tr>
<tr><td colspan="4">VAT exception</td><td>✓</td></tr>
<tr><td colspan="4">Custom Duty Exception</td><td>✓</td></tr>
<tr><td colspan="4">Tax Reduction (%)</td><td>80</td></tr>
<tr><td rowspan="2">Investment Contribution Rate (%)</td><td colspan="3">In OIZ*</td><td>40</td></tr>
<tr><td colspan="3">Out of OIZ</td><td>50</td></tr>
<tr><td rowspan="4">Insurance Premium Employer Share Support</td><td rowspan="4">Support Period</td><td colspan="2">In OIZ</td><td>7 years</td></tr>
<tr><td colspan="2">Out of OIZ</td><td>10 years</td></tr>
<tr><td rowspan="2">Support Upper Limit</td><td>Inside of OIZ</td><td>35%</td></tr>
<tr><td>Outside of OIZ</td><td>No Limit</td></tr>
<tr><td colspan="4">Land Allocation</td><td>✓</td></tr>
<tr><td rowspan="2">Interest support (Points)</td><td colspan="3">TL Indexed Loans</td><td>5 points</td></tr>
<tr><td colspan="3">Foreign Currency Indesed</td><td>2 points</td></tr>
<tr><td colspan="5">* Organized Industrial Zone</td></tr>
</table>

In addition, the advantages provided under the Electricity Market Law and the relevant legislation are[5]:

- In the case of pre-license applications, the minimum capital of the company is 5%, whereas for domestic coal plants it is 1%.
- In the case of license applications, the minimum capital of the company for other plants is 20%, while it is 5% for domestic coal plants.
- In the case of more than one application, domestic coal plants are given priority.
- In the first 10 years of the investment and operation period, the forest permit permissions of the power plant and the related facility are 85% discounted. Forestry Peasants Regeneration Income and Afforestation and Erosion Control Income are not collected for plants in operation until 31 December 2020.

5.2.2. Capacity Market

Regulation on Electricity Market Capacity Mechanism prepared by Energy Market Regulatory Authority (EMRA) entered into force in April 2018. This capacity mechanism operating by Turkey Electricity Transmission Company (TEIAS). TEİAŞ makes capacity payments to the legal entities holding production licenses within the budget determined annually for the establishment and / or preservation of sufficient installed power capacity, including the reserve capacity required for supply security in the electricity market (ICCI, 2019).

Plant operators wishing to benefit from the capacity mechanism have to apply by the 15th day of October of the year before the year they want to take the incentive. TEİAŞ will announce the facilities that will benefit from the capacity mechanism by evaluating the applications.

Power plants with an installed capacity of less than 100 MW will not be able to benefit from the capacity mechanism supports. The installed power limit will be 50 MW for power plants that produce electricity for domestic sources. Within the capacity mechanism, electricity generating plants based on water (hydroelectricity), solar and wind will not be included in this mechanism.

[5] Source: 5.06.2012 -Council of Ministers Decree No. 2012/3305

In the capacity mechanism, the distinction between imported coal and domestic coal has also been clearly made. If imported coal power plants produce electricity from domestic coal during an invoicing period, they will benefit from the capacity payment in proportion to the amount of production made by using domestic coal.

Through the capacity markets, power plants receive an additional payment not only for the amount of electricity that they produce but also for the capacity they provide to the market. In the situation of excess supply, this payment decreases; conversely, it increases when a supply deficit is estimated. This method does not encourage domestic coal plants directly, but provides a stable return to all plants.

In 2018, within the scope of the Capacity Mechanism, a total of 1.4 billion TL was given to 28 power plants in the form of governmental aid; 733.7 million TL was given to natural gas power plants, 655.4 million TL was given to domestic coal power plants and 18 million TL was given to the imported-domestic coal power plants. With the amendment made in the regulation, the way for the inclusion of hydroelectric power plants in this system was opened for 2019 and 2 billion TL budget was allocated for 43 power plants including 10 hydroelectric, 15 domestic coal, 11 natural gas and 7 imported / domestic coal power plants (TMMOB, 2018).

5.2.3. Purchasing Agreement from TETAŞ

The procedures and principles regarding the supply of electricity from domestic coal were first published in the Official Gazette dated 9 August 2016. The amount of energy to be supplied by the companies for 2016 is determined as six billion kWh and the unit price of electricity to be supplied from the companies for 2016 is 185 TL / MWh. The regulation was amended in 2017 by the council of ministers. With this amendment, the electricity produced by the private companies operating with domestic coal-imported coal mixture or only with domestic coal is purchased by TETAŞ in 2018. The amount and price are determined according to the principles specified for a period of seven years (Council of Ministers Decree No. 2016/9096). The amount of electricity to be obtained from the domestic coal-producing power plants was linked to a formula. Accordingly, if the power plant produces electricity with only domestic coal, the amount of the purchase will be half of the installed capacity of the plant in commercial operation in October of the previous year. If the plant is producing with a mixture of domestic and imported coal, the amount of the purchase will be half of the installed capacity of the power plant that uses the domestic-imported coal mixture, which was in operation in October the year before the purchase. With this method, approximately TL 1 billion additional payment was made to domestic coal fired power plants in 2018 (TMMOB, 2018).

5.2.4. Environmental Legislation

The state also provides exemptions from publicly given or *de facto* environmental legislation. Examples of inadequate environmental legislation or non-compliance with existing legislation and standards are certainly reported, which means that reductions in the application of environmental impact assessments (EIAs) may be considered as incentives. CEE Bankwatch Network (2013) revealed that the EIAs of the planned coal-fired power plants were not completed. According to the statistics of the Ministry of Environment and Urbanization, EIA reports of more than 40 coal-fired power plants and connected facilities were approved between 1999 and 30 January 2015, and no coal project was rejected. In addition, coal power plants below 300 MWt (thermal megawatt) were exempt from an EIA. If the power of a non-evaluated power plant reaches a level that is subject to evaluation by power addition or expansion, it is not mandatory to prepare an EIA (Acar et al., 2015).

Another exemption has also been provided to coal power plants in the privatization process within the framework of Electricity Market Law No. 6446. According to the provisional Article 8 of the Law, a legal respite has been granted to existing coal power plants in the privatization process until the end of 2018, to ensure compliance with the requirements of environmental legislation. This period can be extended to 2021 (EPDK, n.d.).

5.2.5. Outcomes of The Policies

In fact, despite all of Turkey's efforts and incentives, domestic coal's share has not shown a significant increase in the country's electricity generation mix, as seen in Figure 5.2. The share of imported coal, moreover, continues to increase compared to that domestic coal, and imported coal now has a larger share than domestic coal. In 2012, the

Undersecretary of the Ministry of Energy and Natural Resources announced that the year 2012 was the year of coal to reduce dependency on energy imports and increase employment. Its goal was to decrease the share of natural gas in electricity generation and, as it desired the share of natural gas declined to 38% from 43.6% (ETKB, 2019d). However, the share of domestic coal decreased from 20,3% in 2005 to 16,5% in electricity generation while the share of imported coal increased from 6,3% to 20,7% (Figure 5.2).

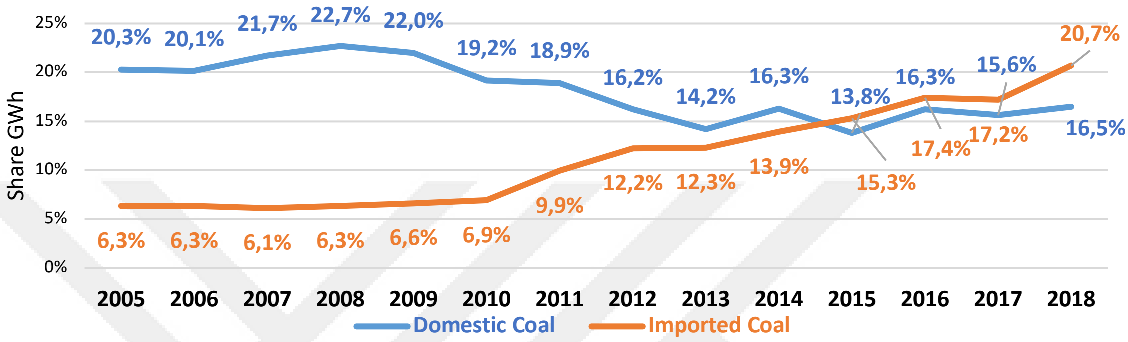


Figure 5.2 Share of coal in electricity generation

Source: TEİAŞ

Electricity generation from domestic coal was targeted to reach 60 billion kWh/year by 2019. However, this ambitious target seems not to be reached since electricity generation from domestic coal has been 49 billion kwh in 2018. On the other hand, electricity generation from imported coal reached 62 billion kwh/year with 55% increase since 2015. According the studies of TMMOB, it is seen that the production and capacity utilization rates of lignite fired power plants have increased in 2018. Technical improvements and productivity increases did not play a role in this increase. The reason for the increase is the purchase guarantee of domestic coal in accordance with the incentive policies implemented in August 2016, and that the electricity generated by domestic coal was purchased by EÜAŞ at a price above the market price.

Although increasing use of domestic coal has been supported in various official documents during the plan period between 2015 and 2019, coal imports increased continuously from 34 million tons in 2015 to 37.4 million tons in 2017. Amount paid for coal imports also increased from $3 billion in 2015 to $4.6 billion in 2018. In addition, when the annual developments of domestic sources examined (Figure 5.3), the insignificant increase of domestic coal power plant's installed capacity proves the unsuccessful energy policies towards domestic sources.

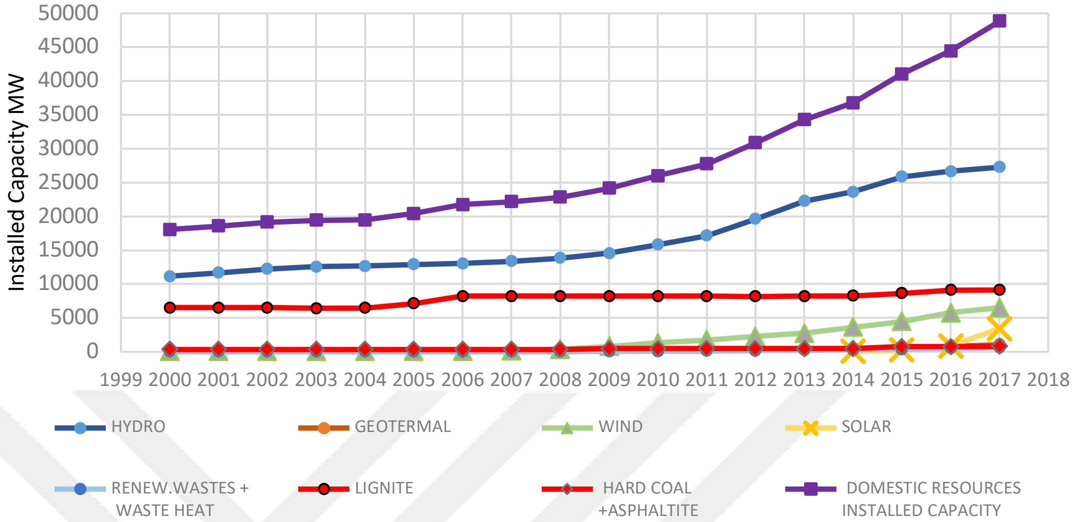


Figure 5.3 Annual developments of domestic resources based installed capacity

Source: TEİAŞ, 2018

The increasing coal imports another fact that shows failure of the targets to increase domestic coal usage. It may improve supply security by diversifying the energy sources but this situation also increases dependency to other countries. Besides, with the increasing coal consumption, CO_2 emissions also keep increasing. Therefore, the best policy to decrease import dependency of Turkey appears to give more importance on renewable energies as an alternative to coals during the present energy transition from fossil fuels to renewables. The existing potential of renewable energy sources of Turkey is sufficient for such a transition in energy system.

From 2011-2017, despite of all the incentives given, the share of domestic coal reached only 15%, while imported coal's share doubled in electricity generation (TEMA, 2018). Needless to say, this situation is aggravating Turkey's current deficit. Payments for coal imports remain inconsistent from year to year. Yet, in 2017, $5,379,000 was paid for hard coal imports (TTK, 2018). It is difficult to draw any other conclusion but that Turkey's efforts to use domestic coal in electricity generation have not helped economy so far.

On the other hand, the support given for increasing coal-fired electricity generation in Turkey only exacerbates the harmful effects to the environment. The continued burning of coal will increase particulate matter, sulfur dioxide, nitrogen oxide, heavy metal and persistent organic pollutant emissions, as well as carbon dioxide emissions. In addition, mining activities and electricity production affect the availability and quality of water resources and lead to pollution and loss of biodiversity.

Despite all these facts, Turkey continues to build new coal-fired power plants. There are currently four plants under construction and six more slated for construction as of 2018. Given the increases in CO_2 emissions that these plants will bring, greater stress will be placed on already vulnerable to water scarcity, and competition for scarce water supplies will intensify. At least 7 GW of proposed coal-fired power plants in Turkey will be built in areas that already face extreme water withdrawal and water stress baseline (Cheng and Lammi, 2013). This particularly pertains to the plans to build a 5,870-MW lignite power plant in Karapınar, Konya. The sinking water level will damage the agriculture in the region and threaten the livelihoods and access to fresh water for 60,000 people (TEMA, 2013). Even the power plants planned in coastal areas will use significant amounts of fresh water to scrub the air pollutants and thus increase the demand for water in the region. In addition, there is always a risk of thermal pollution when using seawater for cooling and no measures have been taken to reduce this (Cheng and Lammi, 2013; EUROCOAL, 2018).

Alternatively, Turkey is already using renewable energies, which offer a cleaner path for decreasing the dependence of foreign energy sources. The continued improvement in renewable energy technology and reduction in storage costs means that reliable power can be achieved at low cost without resorting to coal-fired generation. Along with the great benefits of mitigating air pollution and other harmful environmental and health effects, there are patent economic incentives to switch from fossil fuels and coal in particular to RES. For these reasons, it makes sense for Turkey to focus on developing renewable energy investments as a way to improve its environment, economy, energy security and society (EUROCOAL, 2018).

SUGGESTIONS AND CONCLUSION

The countries of the world are increasingly aware of the actual cost of using coal to generate power and are implementing policies to limit coal production and consumption. Meanwhile, Turkey has an opportunity to create an economic structure based on sustainable principles, and Turkey's energy system can be developed in an environmentally friendly and safe manner. Turkey faces a choice in the distribution of electricity and the production and development policies it will follow. The country currently subsidies fossil fuel production through a mixture of tax cuts and direct spending. These fossil fuel incentives should be removed gradually. Although renewable energy is getting cheaper through incentives and obtaining know-how, it is still struggling to compete with fossil fuels. Fossil fuel incentives, however, disrupt market signals, making renewable energy relatively costlier. This reduces investment motivation for renewable energy and prevents its development.

There are many measures that could be taken to increase the share of RES. First of all, policies should be implemented that phase out coal-fired power plants. Countries are also moving away from coal, and there are several influential examples. One measure that could be taken is a "carbon tax," a fee imposed on those who burn carbon-based fuels (coal, oil and gas) (Carbon Tax Center, 2017). A carbon tax would help significantly in cutting down coal in Turkey and force producers to pay the full cost, including externalities, of producing coal-fired power. However, a carbon tax has not yet been imposed in Turkey; it is only under consideration. In the world, there are currently 57 countries that have implemented or have scheduled implementation of such a carbon tax (The World Bank, 2019). A successful example can be observed in Australia, which set a carbon tax in 2012 and canceled it in 2014 (Geroe, 2019). Within this time period, there was a significant reduction of CO_2 emissions and significant switching from coal to RES. Another successful application was in the United Kingdom. The UK applied a carbon tax in 2013 as a price floor. After the tax was applied, carbon levels started to fall, as did coal consumption by 59% after 2015. The carbon tax scheme is intended to continue until coal is completely phased out. Turkey could choose to follow these examples to phase out coal. Giving Turkey's situation, a carbon tax is not just important for this reason. It would also help reduce Turkey's import payments and reduce its current account deficit. Since

Turkey is heavily dependent on foreign energy both in the power and transportation sectors, a carbon tax could help it reduce its use of oil as well.

There are thousands of people employed in the mining of coal both in Turkey and around the world, which means that, once the coal-fired power plants are decommissioned, there will be thousands of people out of work. In order to prevent this, the government should devise solutions so that the coal workforce does not suffer. The European Trade Union Confederation (ETUC) argues for "greater attention to the adverse consequences of decarbonization and to address them through concrete and effective policies specifically targeting workers from sectors and regions which could be negatively impacted by the transition to a low-carbon economy" (Johnstone and Hielscher, 2017). Subsidies to the people who lose their jobs are one solution. For example, in Alberta, Canada, 45 million Canadian dollars were allocated to coal workers for this purpose (Vriens, 2018). These subsidies could be paid from the revenues of a carbon tax allocation during the phase-out from coal.

The employment dimension of the energy transition must also be considered. Coal mining is currently the only local employment option in certain regions. Therefore, policies that result in a loss of work can be met with resistance. Unfortunately, employment in the coal sector cannot be said to be qualified. Poor working conditions such as precarious work in the mining sector, low wages, lack of unionization and security risks increase the social cost reflected to the public. Also, the recent decline in the unionization rate in the sector prevents workers from struggling to have more humane and democratic conditions (Acar et al., 2015). The possible effects of reform should be evaluated and appropriate compensation mechanisms should be established to minimize the negative impact of this movement. In addition, with the increase of foreign investors in the coal sector, the employment rate of foreign nationals has increased. Recently, the number of Chinese miners employed in the sector, who receive lower wages than the Turkish workers, has been the subject of reports. However, this case has not been discussed widely in Turkey (Acar et al., 2015; Hürriyet, 2012). New job opportunities should be created for these areas as well as educational or retraining opportunities for them to shift to other professions.

Increasing energy efficiency and reducing energy intensity are additional, cardinal steps of today's energy transition from fossil fuels to RES. Today, most of the countries are taking action toward energy intensity as well as Turkey. The recent development programs and strategic plans put too much emphasis on the improvement of energy efficiency and the results have been successful; there have been a 9,1% decrease in the per capita energy consumption from 2000 to 2016 (IEA, 2018c). However, there is still need for an improvement of energy efficiency. For example, Belgium is one of the pioneers of decreasing energy consumption per capita, energy intensity and CO_2 emissions. With vast policies like consumer training, metering of electricity, installment of energy efficient appliances, Belgium was able to cut down per capita energy consumption by 30%(European Commission, 2014; IEA, 2018c). This is one of the reasons why Belgium was able to phase out all of its coal-fired power plants.

Another measure to mitigate coal use is to establish self-sustaining communities, namely microgrids. The decentralization of electricity and its applications are increasing every day. Microgrids are systems in which electricity is consumed where it is produced. These systems are mostly depending on RES for their electricity. Hence, microgrids are important options to increase the use of RES. However, because RES are intermittent, the reliability of these systems is questionable. Many countries today are increasing microgrids and setting out pilot projects to increase their reliability. China is currently establishing many such pilot projects and making tailor-made policies to meet the energy demand of its communities (Wu et al., 2018). These policies have had a significant effect in reducing energy consumption and increasing RES production.

Finally, more resilient and advanced renewable energy policies should be adopted. The increase in electricity demand, when considered alongside the potential of RES, means that Turkey is capable of attracting investments into the renewable energy sector and can reach sector targets. But the lack of technology and investment constrains the construction of new projects. The most important groups in the Turkish business community are continuing to invest in the energy sector and are effective in attracting foreign investors to Turkey. Hence, the RES production is at an initial stage and open to development, which encourages investors (KPMG, 2018). Turkey has great potential for RES and has already reached its 5-GW solar installed capacity goal for 2023.

With the help of new investments, Turkey can play an active role in the energy transition. This potential should be in the form, above all, of substituting RES for coal. Italy is one of the most successful examples in the world in this regard. With structured policies, Italy was able to increase RES while phasing out coal-fired power plants (Littlecott, 2016).

In all respects, when developing solutions for climate change, it is necessary to focus not only on increasing alternative energy sources but also on reducing energy consumption and developing solutions for energy efficiency. Thus, economic growth can be obtained from lower energy inputs. In the time of energy transition, there is much effort needed from each country in the world. Within this scope, Turkey needs to revise its energy policies to increase the share of RES and to cut down coal consumption once and for all.

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