COAL REPORT

TURKEY'S COAL POLICIES RELATED TO CLIMATE CHANGE, ECONOMY AND HEALTH

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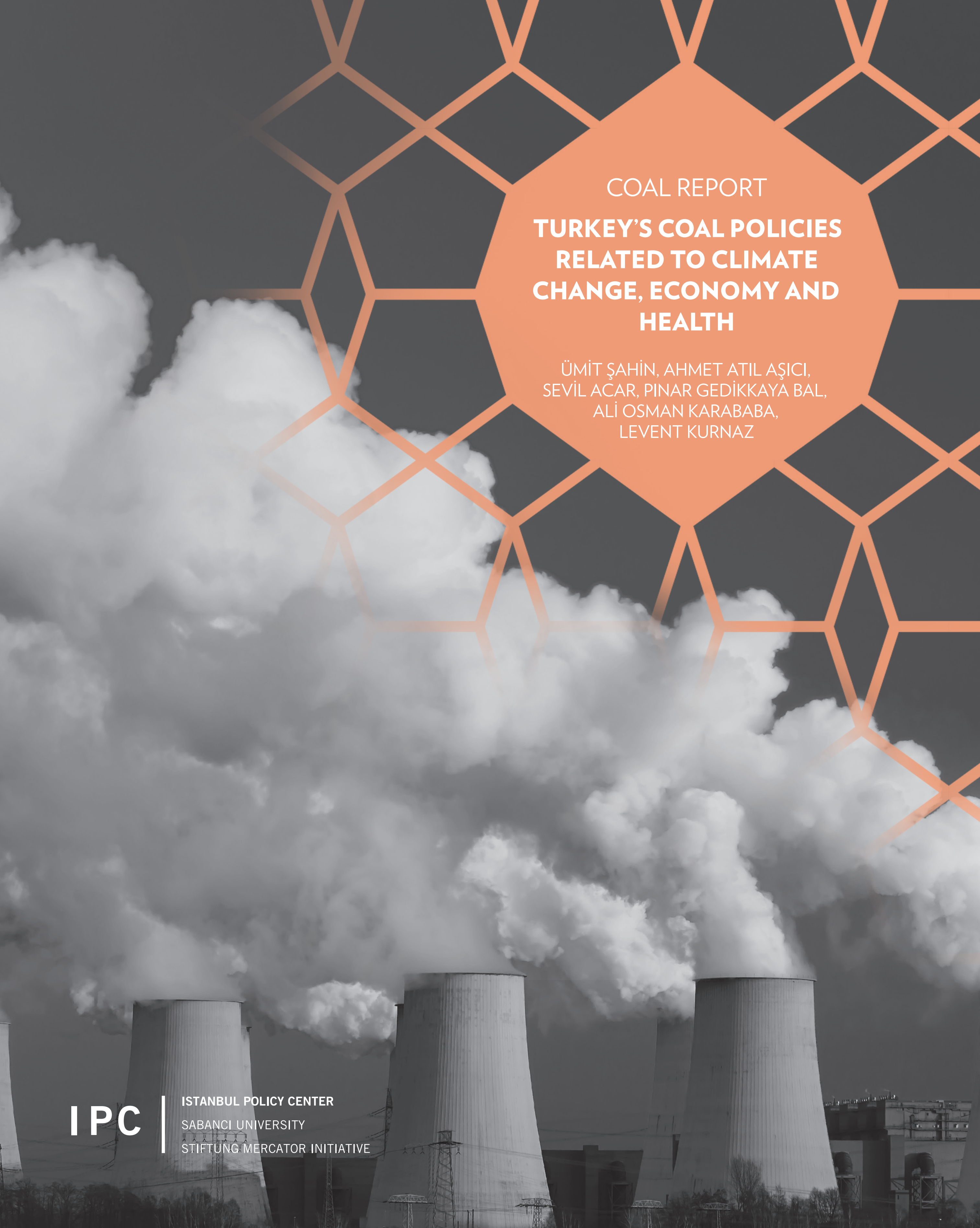

IPC
ISTANBUL POLICY CENTER
SABANCI UNIVERSITY
STIFTUNG MERCATOR INITIATIVE

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CONTENTS

EXECUTIVE SUMMARY

This report addresses the current status of coal in Turkey as an energy and greenhouse gas source, its impacts on health, the association between increasing the share of coal in electricity generation and climate and economic policies, and the discussions on "clean coal."

Coal in Turkey's Energy and Climate Policies

Coal, which has a 29% share in the world's primary energy supply, accounts for 40% of global electricity generation. Coal comprises 44% of global CO_2 emissions resulting from fossil fuels and 72% of CO_2 emissions resulting from electricity and heat generation. As the energy source that has caused the most greenhouse gas emissions, coal is the primary cause of climate change.

We have already emitted two-thirds (1,900 out of 2,900 $GtCO_2$) of the greenhouse gases that can be released into the atmosphere before the global temperature increases by 2°C. The potential emissions of current fossil fuel reserves are four times higher than the remaining global budget. Therefore, to keep climate change below 2°C warming, three-fourths of fossil fuels and a larger portion of coal reserves should remain underground.

The share of coal, oil, and gas in Turkey's primary energy supply was 88% in 2013. Almost more than 70% of electricity is produced from fossil fuels. Total installed capacity is 71 GW, 20.5% of this coming from coal-fired power plants. The installed capacity of coal-fired power plants has increased by 77% when compared to 2004.

Turkey, in which greenhouse gas emissions increased 110% in 2013 when compared to 1990, is among the top 20 emitters in the world. The share of coal in its total emissions is approximately 33%, and coal emissions have increased by 130% during this time period. The government, which foresees that Turkey's energy demand will double by 2023, aims to meet most of its increased need by building new coal-fired power plants. Turkey is ranked fourth in the world in regard to constructing new coal-fired power plants after China, India, and Russia. In addition to the 25 coal-fired power plants in use and three new ones under construction, more than 70 new coal-fired power plants with a total installed capacity of 66.5 GWs are currently in the pipeline. It can be estimated that these planned coal-fired power plants would emit nearly 400 million tons of greenhouse gases annually. Therefore, if these plans are realized, the emissions of these new plants will be almost be as high as Turkey's current total annual emissions, which measured 459 million tons in 2013.

Turkey's energy strategy aims to "use all existing domestic lignite and hard coal potential for energy generation purposes" and "to utilize thermal power plants based on imported coal, which has high calorie value, to ensure supply security." This approach ignores the contribution that Turkey should make towards combating global climate change and precludes a meaningful mitigation policy.

Coal Mining in the Turkish Economy

The share of coal mining in the total production of the Turkish economy is below 1%, and its contribution to growth rates is very low. The employment rate in the sector is also low, and its share in total employment decreased from 1.3% in 1998 to 0.7% in 2013. Therefore, the reason for the recent increase in incentives provided to the coal sector is the carbon-intensive economic growth pathway of the Turkish economy, which stimulates the economy via carbon-intensive energy generation rather than increasing economic growth rates or creating jobs directly in coal mining.

The sectors that contributed the most to the annual growth rate in Turkey from 2002-2009 are real estate services, domestic transportation, machinery and equipment rental, textile, retail trade, wholesale trade, and construction. It should be noted that most of these sectors are related to construction. This, in turn, led to an increase in energy imports by creating demand for energy intensive sectors such as iron/steel and cement. The share of energy imports in the foreign trade deficit has increased from 40.3% to 63.7% since 2004.

Public support and incentive programs increased low-tech, energy intensive, polluting, and low value-added production after the 2008 crisis. One can also include in these social costs the increase in the number of occupational accidents that have taken place as a result of the pressure to rapidly expand the economy. Further, the severity of environmental regulations has gradually weakened, and Turkey's position in the international rankings for strictness and the enforcement of regulations receded to 85th and 79th, respectively, among 140 countries in 2012.

Coal Investments and Current Incentives in Turkey

According to the official projections, coal-fired power production will reach 200 TWh with a threefold increase by 2030. When its limited reserves are taken into account, it is obvious that Turkey would continue to be dependent upon imported hard coal, and therefore, it would not be possible to eliminate its dependence on imported energy sources.

The most significant support provided to coal in Turkey is incentives for hard coal imports through direct payments from the treasury. Coal investments are also encouraged within the framework of the New Investment Incentive System that entered into force in 2012. There are also incentives provided to the fossil fuel sector such as support for R&D costs, finances allocated to new coal-fired power plants, investment guarantees, and price and purchase guarantees.

Coal is also supported by excluding such investments from environmental legislation. The deficiencies and exemptions in the implementation of Environmental Impact Assessments (EIA) can be qualified as incentives. When all measurable coal incentives in Turkey are taken into account, the amount of incentive per kWh is calculated as approximately 0.01 USD (0.02 USD, if coal support to poor families is included). A total of 730 million USD worth of incentives was provided to the coal sector in 2013.

G20 leaders who convened in 2009 had promised to end all ineffective fossil fuel incentives gradually in the middle term. According to some projections, if only the incentives provided to coal are removed, an emissions reduction of 5.4% would be achieved when compared to the baseline path in Turkey by 2030.

International Barriers against the Use of Coal

The European Union (EU) has claimed a leading role in the transformation to a low carbon economy. As part of its energy targets for 2030, the EU has agreed to increase the share of renewable energy in total energy consumption to 27% and to decrease greenhouse gas emissions by at least 40% when compared to 1990 levels. The EU has announced that it would reduce its emissions by more than 80% when compared to 1990 levels by 2050.

The EU aims to eliminate CO_2 emissions from energy production by 2050. The energy provided from coal is expected to decline from 16% to 8% by 2050. Since burning coal does not comply with future low carbon targets and the existing environmental directives have already put negative pressure on the coal sector, some of the coal mines and coal-fired power plants are being closed.

OECD General Secretary Angel Gurria has also called upon the governments of the world to review plans for new coal-fired power plants by stating that such plants are currently the most important threat to the future of the earth. Due to its record high air pollution and new climate objectives, even China, which is the biggest coal consumer in the world, has consumed less coal in 2015 and used more renewable resources and new technologies.

Eventually, Turkey may face increased costs and commercial restrictions if it does not make the required policy changes.

Health Impacts of Coal-Fired Power Plants

Coal-fired power plants are among the most polluting industries for the air and the environment in general. The hazardous waste discharged into the environment from coal-fired power plants is comprised of suspended particles, sulphur dioxide, nitrogen oxides, carbon dioxide, carbon monoxide, volatile organic compounds (VOC), dioxins, hydrochloric acid, ash, radioactive materials, and heavy metals.

Air pollution has a number of adverse effects on human health: vulnerability towards respiratory tract infections, aggravation in allergic respiratory system diseases and Chronic Obstructive Lung Disease, irritation of the eyes, respiratory system cancers, increases in the prevalence of respiratory and circulatory system diseases and mortality rates. The International Agency for Research on Cancer (IARC) has included outdoor air pollution as one of the leading causes of cancer in humans (Group 1).

Scientific studies have proved that in the most polluted periods there is a correlation between deaths and hospital admissions and the concentration of air pollutants. Further studies have shown that decreases in the respiratory functions of people living near the vicinity of coal-fired power plants have been linked to coal-related outdoor air pollution.

Globally, 3.7 million fatalities were reportedly linked to outdoor air pollution in 2012. Ischemic heart diseases and stroke ranked among the top causes of death, each accounting for about 40% in total. In Europe the number of working days lost due to air pollution was calculated as 4,100,000, and the cost of health impacts was calculated as 42.8 billion USD. It was estimated that the coal-fired power plants currently in operation in Turkey account for at least 2,876 premature deaths, 637,643 working days lost, and 3.6 billion euros in additional costs.

Is "Clean Coal" Possible? – Carbon Capture and Storage (CCS) Technologies

The technology for capturing and storing CO_2 generated by coal-fired power plants and other facilities before exiting the funnel is called Carbon Capture and Storage (CCS). Obtained CO_2 can be placed in geological structures, oceans, and mineral carbonates after being compressed, or it can be transported for use in industrial operations later.

Capturing and storing carbon instead of releasing it into the atmosphere requires energy. Furthermore, carbon capture is a more expensive technology than releasing carbon freely into the atmosphere since either such capture systems should be added to the old power plants or new power plants should be built with these technologies. The transportation of captured carbon to the storage location is done via pipelines or land-sea transportation. Since the carbon dioxide obtained by carbon capture is corrosive due to its water vapor content, infrastructure costs will increase substantially. Further, transportation methods via land or sea have not been tested on an industrial scale.

Moreover, we have little technical knowledge and experience regarding storage. So far, only 5 million tons out of 50 billion tons of annual global greenhouse gas emissions (1/10,000) could be stored in the carbon capture and storage projects in operation. The cost of implementing this approach, for instance, in one unit inside the Afşin-Elbistan coal-fired power plant in Turkey, is approximately 80 USD per ton. Even though some countries have presented CCS as the solution of the future, they have not elaborated and developed policies on what their legal responsibilities and related costs would be. This incomplete policy may turn into a weakness of the free market and lead to the use of possibly hazardous methods in the long-term.

Conclusion

The economic life of a newly built coal-fired power plant is approximately 40-50 years. If Turkey keeps coal at the heart of its energy policies, if it continues its public support and incentives for coal, and if the new coal-fired power plants in the pipeline are constructed, Turkey's energy policies will lock-in its commitment to coal, and Turkey will inevitably become more dependent on fossil fuels. This may lead to higher emissions until and after 2050. This could also hinder the competitiveness of renewable energy technologies and jeopardize renewable energy investments.

Therefore, in order to combat climate change, to build a sustainable energy policy, and to reduce health and other social costs, incentives for coal should be removed, and policies that increase the share of coal in electricity generation in Turkey should be abandoned. Turkey's climate and energy policies should be reconstructed on the basis of the future low carbon economy, renewable energy, and energy efficiency.

INTRODUCTION

Turkey, which is one of the top twenty countries in terms of population and economy, is at a crossroads around which the tension between climate and energy policy is ever increasing. As the term chairman of the G20 Leaders' Summit that was held in Antalya on November 15-16, 2015, Turkey also assumed within this framework the responsibility to pave the way for positive steps towards climate policies and fossil fuel subsidies.

Prior to the 21st United Nations Climate Change Conference of Parties (COP 21) that was held in Paris in December last year, countries submitted their greenhouse gas mitigation targets to the Secretariat. Turkey, which had submitted its Intended Nationally Determined Contributions (INDC) to combating against climate change on September 30, 2015, was one of the countries to determine an emissions mitigation target and sign the Paris Agreement. However, Turkey submitted a rather inadequate and controversial mitigation target. The reasons for this inadequacy have to do with Turkey's current understanding of economic growth and development, high energy demand increase projections, and more importantly, the weight of fossil fuels, especially coal, in its energy policies. Coal-based fast energy generation scenarios inhibit Turkey from moving towards greenhouse gas mitigation targets.

In its national energy strategies and action plans, Turkey, which derives 88% of its total energy generation and nearly 70% of its electricity generation from fossil fuels, aims to increase the usage of coal, primarily domestic coal, and its share in energy generation. Although it is the most polluting energy source in terms of both carbon dioxide, which causes climate change, and gas and particulate matter emissions, which affect the environment and human health negatively, coal is at the heart of Turkey's official energy policies due to its perceived low costs and compatibility with Turkey's fast-paced economic development targets. Considering the share of its domestic coal sources, Turkey has marked coal as its most important fossil fuel, thus, encouraging its utilization. In other words, Turkey, which is foreign dependent in terms of energy sources, aims to reduce this foreign dependency by using its domestic coal potential to the end.

However, a coal-based energy policy entails increasing the usage target and share of not only domestic but also imported coal. The building of many coal-fired power plants based on domestic and/or imported coal has been planned, and the construction of some has begun. This, in turn, weakens the idea that "more coal usage reduces foreign energy dependency." Additionally the target for utilization of all domestic coal also creates serious problems in terms of climate change, environmental and human health, as well as work safety and sustainable energy policy.

Due to its high carbon dioxide emissions, using more coal leads to a rapid increase in greenhouse gas emissions in Turkey and makes combating climate change impossible. The social cost of coal is also high due to its negative effects on the environment and human health, and considering coal as a cheap resource is the result of a one-dimensional and short-sighted approach. Rapid exploitation of coal reserves also leads to serious problems regarding work safety and disasters such as the Soma mine accident in 2014 in which 301 people were killed.

Turkey's consideration of more coal as a compulsory element for increasing employment and economic growth appears as a scientifically controversial and predominantly political decision. Turkey's incentives for coal usage and the support it gives to coal mining will determine the future of Turkey's energy sources as not only its domestic but also its imported coal supplies ensure a fossil fuel dependent path for the Turkish economy and energy infrastructure for the next 50 years.

All these discussions should be made scientifically and in light of global developments. Criticizing climate and energy policies, which have been shaped through political preferences, using up-to-date data and contemporary approaches is a must for the establishment of healthier and more sustainable policies.

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The current status of coal as an energy and greenhouse gas source in Turkey as well as the association between the trend of increasing the share of coal in future electricity generation and economy policies are addressed in this report.

The first part of the report indicates that coal is primarily responsible for the release of greenhouse gases that cause climate change and addresses the current status of energy infrastructure, share of coal, and plans towards increasing the share of coal in the future in Turkey.

The second part discusses the involvement and weight of coal in the Turkish economy and the structural transformation and current tendencies of an economy fixated on coal in its energy policies.

The third part of the report addresses coal investments and government support and incentives provided to coal in Turkey and reveals the problems resulting from such situations in terms of Turkey's climate policies.

In part four, Turkish policies regarding increasing the share of coal are assessed in light of international developments. Future obstacles resulting from the transition of the European Union to a low carbon economic model and the decarbonization trends in other countries are among the main topics discussed in this section.

Part five discusses the environment and the health impacts of coal, as well as the public health problems arising from coal-fired power plants.

The sixth and final part of the report examines whether the "clean coal" argument suggested frequently in the field of climate policy is technically possible or not. The technical, economic, and legal challenges with regard to the application of carbon capture and the storage technologies stipulated to mitigate emissions from coal are addressed here.

PART 1

COAL'S INVOLVEMENT IN TURKEY'S ENERGY AND CLIMATE POLICIES

Ümit Şahin

1.1. Climate Change, Carbon Budget and Coal

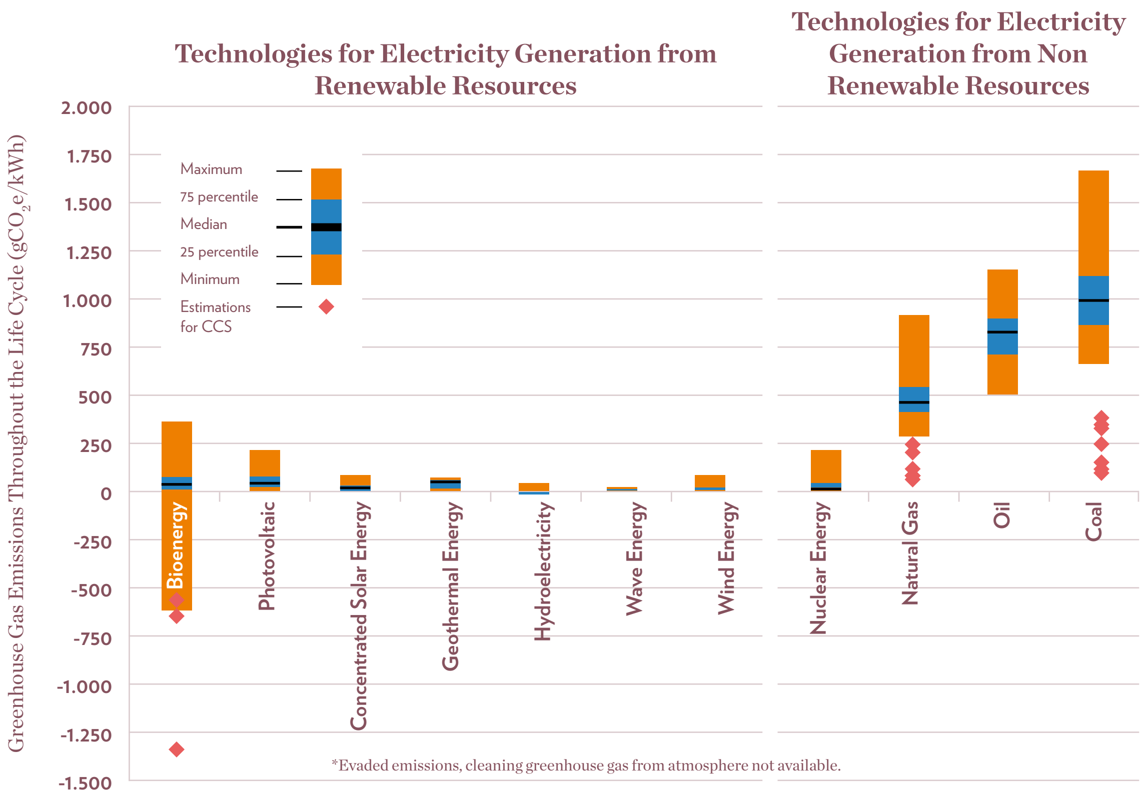
The average temperature of the earth has increased by 0.85°C in the last century due to climate change (IPCC, 2013). This increase has gradually accelerated over the last 40 years. 2015 was measured as the hottest year since 1880, when instrumental temperature measurement were first recorded; and 14 out of the hottest 15 years have been in the twenty-first century (NOAA, 2015). This significant rise leads to an increase in the frequency and severity of extreme weather and climate events such as precipitation changes, ice melting, sea level rise, floods, tornadoes, droughts, and heat waves. Such negative events result in water and food crises, climate-related migrations, decline in biodiversity, and other ecological-social problems. Located in the Mediterranean basin, which is one of the most climate change sensitive regions, Turkey is also considered to be one of the countries most negatively affected by climate change due to water shortage, drought, decrease in agricultural production, sea level rise, and heat waves (Şen, 2013).

Anthropogenic climate change emerged after the Industrial Revolution and is associated with human activities. Such human activities are predominantly due to changes in consumption, such as the burning of fossil fuels, i.e. coal, oil, and gas, for energy generation and industrial processes, and land use changes such as deforestation and opening of new agricultural areas, which are directly related to the economic system and social life. Human activities lead to an increase in the atmospheric greenhouse gas concentrations, and this increase, in turn, warms the earth with a speed and scale never seen before throughout human history. Atmospheric concentrations of the main greenhouse gases, namely carbon dioxide, methane, and nitrous oxide, have reached their highest level in the last 800 thousand years. The fact that atmospheric carbon dioxide concentration, which remained around 280 ppm during the pre-industrial period (before 1750), exceeded 400 ppm in 2014 and has increased annually by approximately 2-2.5 ppm (Scripps, 2015) shows that the maximum acceptable emissions level of 450 ppm—required for limiting global warming to 2°C at most in order to prevent climate change from reaching its most dangerous point—can be exceeded very quickly if current emissions continue.

According to the Intergovernmental Panel on Climate Change (IPCC), the releasing of carbon dioxide into the atmosphere as a result of burning fossil fuels and industrial processes is responsible for 78% of the increase in emissions between 1970 and 2010. Among fossil fuels, coal releases the most carbon dioxide emissions. As of 2012, with its 29% share in the world primary energy supply, coal provided 40% of global electricity generation with 9,168 TWh. Coal accounts for 44% of global CO_2 emissions resulting from fossil fuels and 72% of CO_2 emissions resulting from electricity and heat generation (IEA, 2014a; IEA, 2014b).

Generating electricity from coal causes much higher greenhouse gas emissions when compared to renewable energy sources and other fossil fuels. As a result of burning coal in an average thermal

Figure 1.1 – Greenhouse gas emissions throughout the life cycle of 1 kWh of electricity produced from each one of the energy sources (Source: IPCC, 2012)

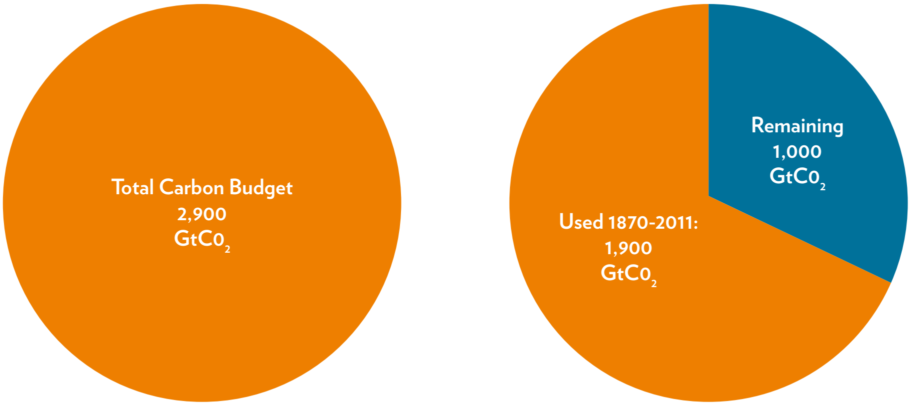


power plant, approximately 1,000 grams of CO_2e greenhouse gas per each kWh of electricity generated throughout its life cycle is released into the atmosphere. This amount exceeds 1,500 grams in high emission systems and recedes only to 750 grams in the most efficient thermal power plants. This amount on average is nearly 500 grams for natural gas, and in the most efficient gas plants it is 350 grams. However, in renewable energy power plants, greenhouse gas emission levels throughout their life cycle vary between 5 to 50 grams per each kWh of electricity (10-20 grams for wind and 35-50 grams for photovoltaic solar panels) (IPCC, 2012).

This means that the greenhouse gas emissions from the most efficient coal power plant in its entire life cycle is nearly two times that of a natural gas power plant and approximately 75 times a wind power plant. Emissions of renewable and fossil fuel electricity generation are compared in Figure 1.1, which is taken from the IPCC 2011 Special Report on Renewable Energy Sources and Climate Change Mitigation.

In the Cancun Climate Conference (COP 16) held in 2010, the countries agreed that dangerous global warming levels should not be exceeded, and

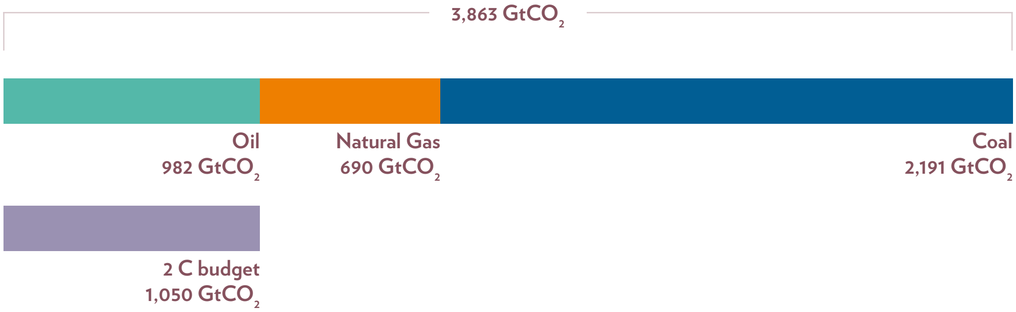
Figure 1.2 – Carbon Budget (Source IPCC, 2014)
65% of our carbon budget coherent with the two-degree target has already been used.



determined that the point of no return is 2°C, with 1.5°C warming considered by many scientists as the safe limit. IPCC also calculated the carbon budget required to keep global warming at 2°C. The carbon budget indicates the amount of carbon dioxide that can be released into the atmosphere by humans while keeping the increase in average temperature below 2°C— in other words the maximum total (historically cumulative) global greenhouse gas emissions. IPCC reported that to keep global warming below 2°C, starting from figures at the beginning of the Industrial Revolution (1750), this level has to fall below 2,900 $GtCO_2$. As shown in Figure 1.2, 1,900 $GtCO_2$ of this budget, i.e. 65 percent thereof, had already been consumed by 2011 (IPCC, 2014).

In 2012, the annual global emission level was 54 $GtCO_2e$ (UNEP, 2014); therefore, if carbon emissions resume at their current level, it can be calculated that the remaining 1,000 $GtCO_2e$, approximately, would be released by 2030.

Figure 1.3 – Comparison of CO_2 content of existing fossil fuel reserves and the remaining carbon budget for two-degree target (Source: Davidson et al., 2013)



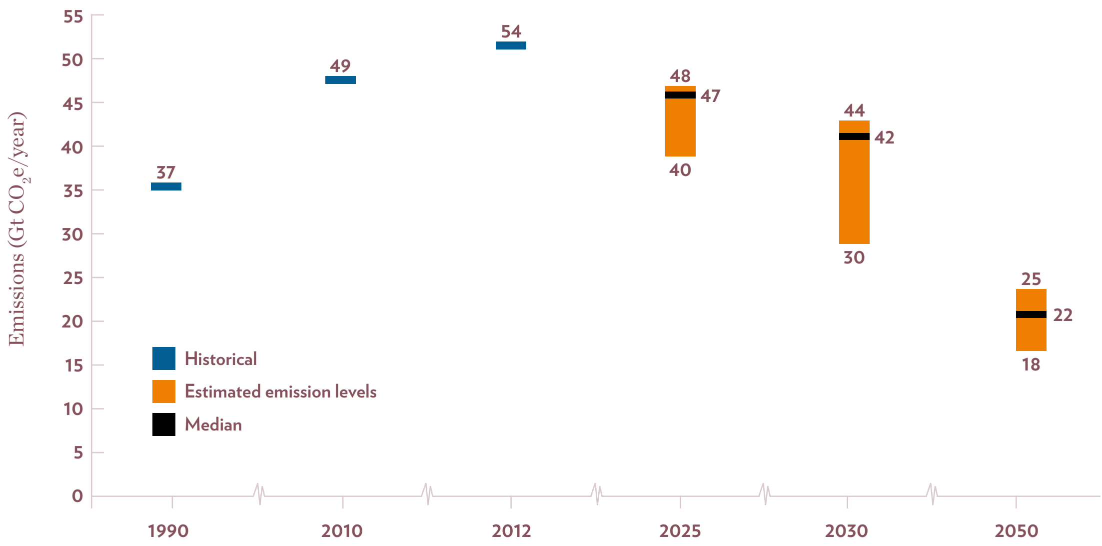
The emissions from the fossil fuel reserves existing in the world amount to nearly 4,000 $GtCO_2e$. Therefore, at least three-fourths of existing reserves must remain underground. Coal comprises the biggest portion of CO_2 content in existing reserves. Existing coal reserves account for more than half (more than 2,000 $GtCO_2e$) of such total (Davidson et al., 2013). Accordingly, an even bigger portion of coal, when compared to other fossil fuels, should be left underground. This suggests that for the decarbonization of the world economy, first and foremost, using coal for electricity generation should be abandoned (Figure 1.3).

According to the United Nations Environment Program's (UNEP) Emissions Gap Report (2014), to achieve the two-degree target starting from the same carbon budget calculation, global emissions should be neutralized between 2055 and 2070. In other words, all of the carbon dioxide released in the atmosphere should be reduced to a level in which it can be captured by the sinks, and it should be reduced to zero between 2080 and 2100. This means that the annual global total greenhouse gas emissions, which were 54 $GtCO_2e$ in 2012, should be reduced to 22 $GtCO_2e$ in 2050, and this decrease should resume quickly (Figure 1.4).

With 459 $MtCO_2e$ in 2013, Turkey produced 0.94% of global greenhouse gas emissions (WRI, 2015). Emissions per capita were 6.04 tons (TURKSTAT, 2015) in Turkey, which accounts for 0.4% of historically accumulated global emission (WRI, 2005). Between 1990 and 2013, the total annual emissions and emission per capita of Turkey had increased by 110.4% and 53%, respectively.

According to the official Intended Nationally Determined Contribution (INDC) of Turkey issued on September 30, 2015, with the current policies total emissions will rise to 1,175 $MtCO_2e$ by 2030. In other words, Turkey will see over a 155% increase when compared to 2013 values (UNFCCC, 2015). According to the reference scenario laid out in INDC, even if the 21% mitigation target according

Figure 1.4 – The level to which greenhouse gas emissions should be decreased by 2050 for achieving the two-degree target (Source: UNEP, 2014)



to BAU (keeping emissions at 929 $MtCO_2e$ in 2030) is achieved, the increase is still more than double the starting value.

Turkey's strategy to focus on coal for energy generation can be identified as the main reason for both its low and inadequate mitigation target and its apathetic sense of responsibility towards falling below the two-degree target.

1.2. Energy Policies and Coal in Turkey

Similar to the rest of the world, the majority of total greenhouse gas emissions in Turkey (70% in 2012) result from the energy sector. Turkey, which is very dependent on fossil fuels in energy generation, is facing a fork in the road. It will either be stuck in its high carbon energy infrastructure by increasing its dependency on fossil fuels or change its policies and choose a sustainable energy path based on renewable sources.

Energy generation in Turkey is dependent on fossil fuels and imported resources. The share of coal, oil, and gas in primary energy was 88% in 2013. As its imported resources share in primary energy supply is 80%, this share increased to 93% for oil and 99% for gas. 58% of its total coal supply is imported. All imported coal is hard coal, whereas only 6% of the coal produced in Turkey is hard coal. While 90% of domestic coal is lignite, a low quality coal, the rest is asphaltite, which is an even lower quality coal than lignite. While 51% of the coal used in Turkey is imported coal, the share of domestic lignite is 38%.

The share of fossil fuels in electricity generation in Turkey is also large. In 2014 Turkey's total electricity energy generation was 250.4 TWh. Electricity generation increased at a rate of 70% between 2004 and 2013 and 315% between 1990 and 2013. Looking at the June 2015 figures, nearly more than 70% of electricity energy is generated from fossil fuels (36% from gas, 27.5% from coal and

Figure 1.5 – Electricity generation by resources by the end of June 2015 in Turkey (Source: MENR, 2015)

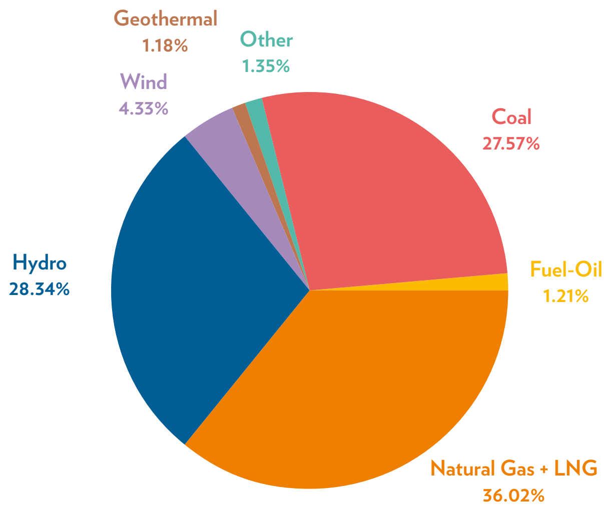
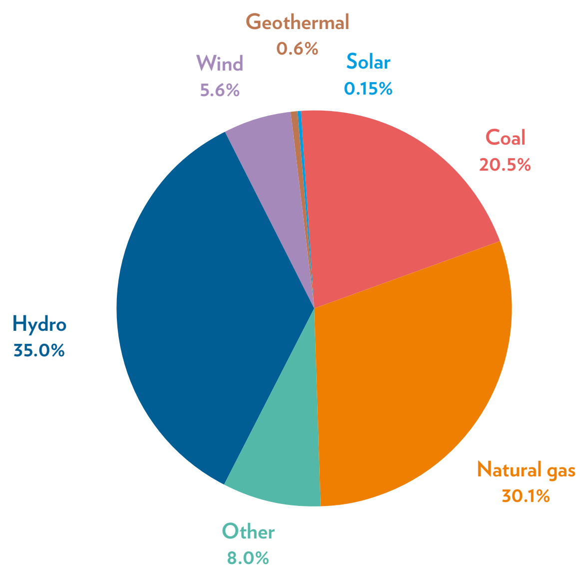


Figure 1.6 –Installed capacity for electricity generation by resources by the end of June 2015 in Turkey (Source: MENR, 2015)



lignite), and 24% is generated using hydropower (MENR, 2015).

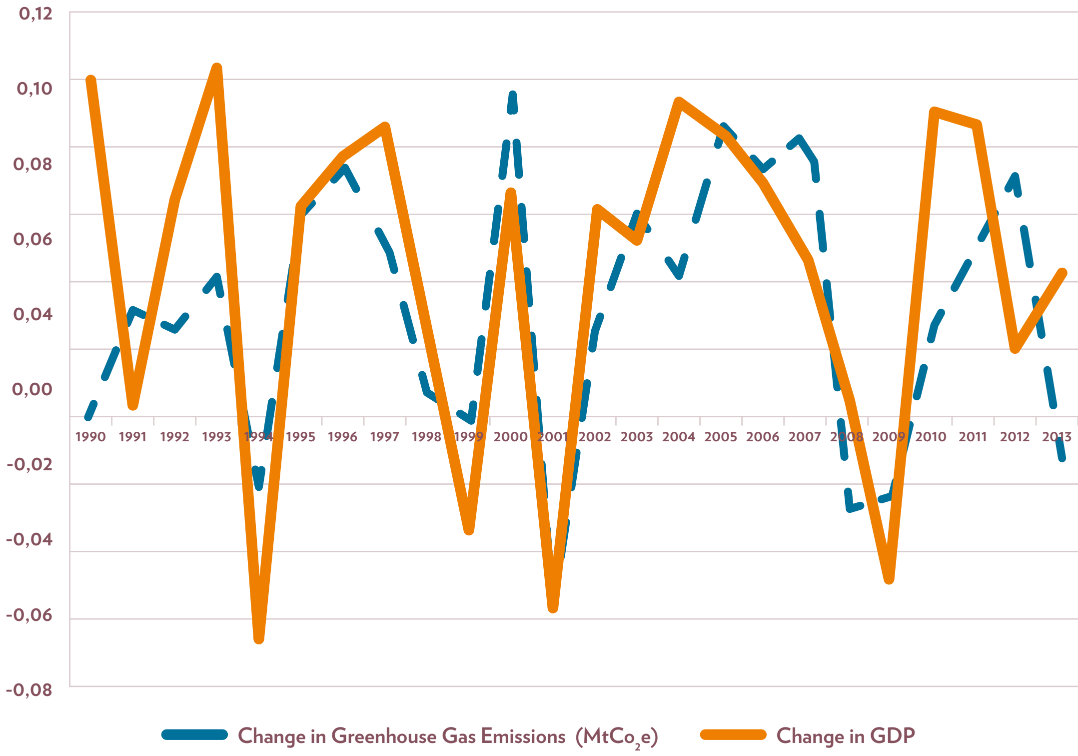
However, since the amount of energy produced by hydroelectric power plants decreased due to the drought experienced in 2013-2014, the share of fossil fuels in energy generation has increased to nearly 80% (Figure 1.5).

Electricity generation installed capacity exceeded 71 GW as of the end of June 2015 (MENR, 2015). More than 50% of this capacity, 20.5% thereof being coal, is composed of fossil fuel power plants (Figure 1.6).

The installed capacity of coal-fired power plants has increased by 77% to 14,659 MW when compared to 2004. 8,244 MW and 6,334 MW are generated in these coal-fired power plants by burning lignite and imported coal or asphaltite, respectively (MENR, 2015).

Energy and the carbon intensity of the Turkish economy are quite high when compared to European countries, showing there is a correlation between economic growth and carbon emissions (Figure 1.7).

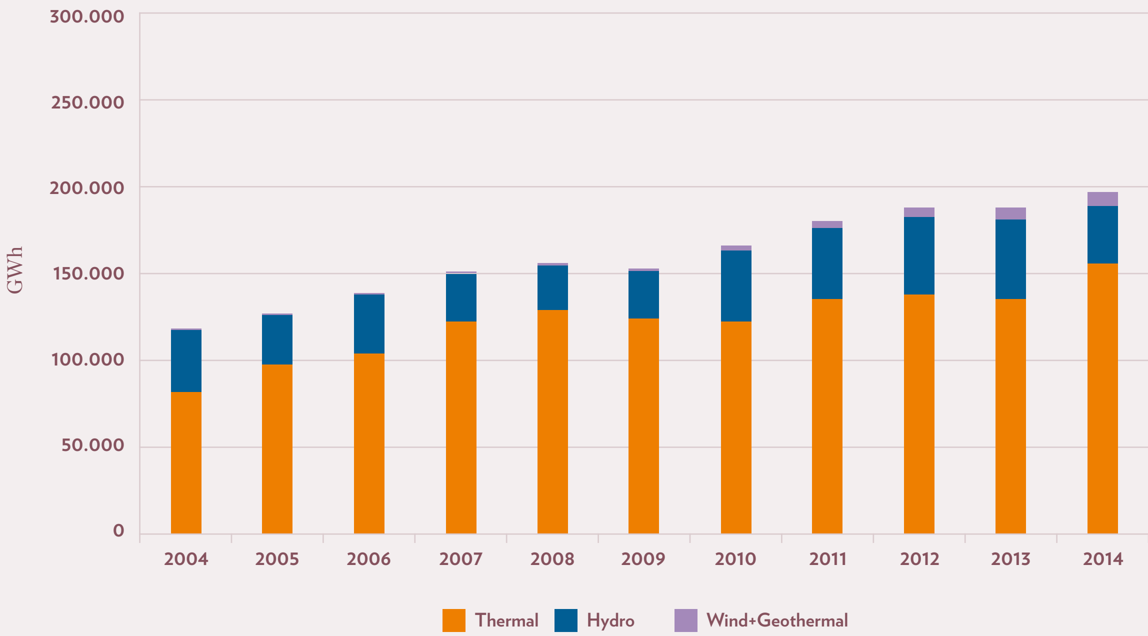
Figure 1.7 – Correlation between the change in greenhouse gas emissions and economic growth (GDP increase rate) (Source: TURKSTAT data)



Energy and Coal Outlook of Turkey*

- The primary energy consumption of Turkey was 125.3 million TOE in 2014, ranked 19th in the world with a share of 1%. (China was ranked 1st with a share of 23%, the United States was ranked 2nd with a share of 17.8%, and Russia was ranked 3rd with a share of 5.3%.) Turkey's electricity generation corresponded to 1.1% of the world's total generation with 250.5 TWh in 2014, and it was again ranked 19th. (China was ranked 1st with a share of 24%, the United States was ranked 2nd with a share of 18.3%, India was ranked 3rd with a share of 5.1%.)
- In 2014, Turkey's electricity generation was 250.4 TWh, and its electricity consumption was 255.5 TWh. An increase of 4.3% in generation and 3.7% in consumption had occurred when compared to the previous year.
- The share of thermal (fossil fuels, particularly gas, lignite, and coal) resources in electricity generation increased to 79.6% in 2014. The share of coal in Turkey in the electricity generation by primary energy resources, increased to 29.56% in 2014 (Figure 1.8 and Table 1.1).

Figure 1.8 – Resource distribution of electric energy generation by years in Turkey (Source: MENR, 2015)



* Citations and diagrams are taken from the most recent "Report on Outlook of Energy and Natural Resources in the World and in Our Country" of MENR (as of July 1, 2015).

Table 1.1 – Electricity generation by primary energy resources in Turkey (GWh) (Source: MENR, 2015)

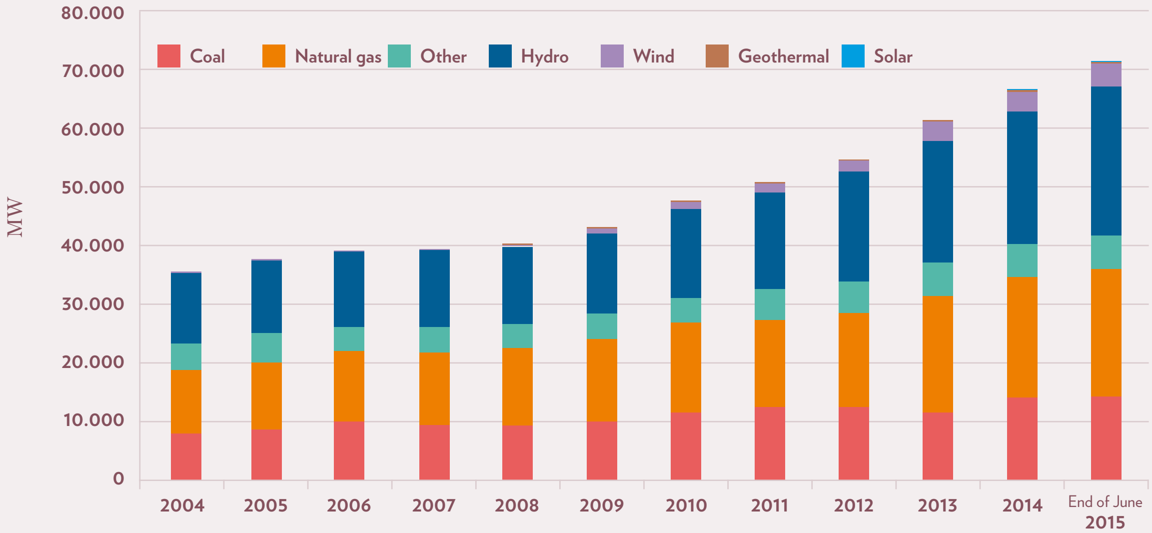
Primary Energy Source		2012		2014		End of June 2015	
		Electricity generation (Gwh)	Installed capacity for electricity production	Electricity generation (Gwh)	Installed capacity for electricity production	Electricity generation (Gwh)	Installed capacity for electricity production
COAL	Hard Coal + Imported Coal + Asphaltite	33,324	13.90%	37,601	15.01%	19,812	15.86%
	Lignite	34,689	14.50%	36,409	14.55%	14,626	11.71%
	TOTAL	68,013	28.40%	74,040	29.56%	34,437	27.57%
LIQUID FUELS	FUEL-OIL	981	0.40%	3,062	1.22%	1,518	1.21%
	DIESEL OIL	657	0.30%	360	0.14%	880	0.70%
	LPG			89	0.04%	48	0.04%
	Naphta			72	0.03%	37	0.03%
	TOTAL	1,639	0.70%	3,583	1.43%	2,483	1.99%
Natural Gas + LNG		104,499	43.60%	120,437	48.09%	45,005	36.02%
RENEWABLE + WASTE		721	0.30%	1,343	0.54%	710	0.57%
THERMAL TOTAL		174,872	73.00%	199,404	79.62%	82,635	66.15%
HYDRO TOTAL		57,865	24.20%	40,396	16.13%	35,410	28.34%
WIND TOTAL		5,861	2.40%	8,385	3.35%	5,407	4.33%
GEOTHERMAL TOTAL		899	0.40%	2,250	0.90%	1,477	1.18%
OVERALL TOTAL		239,497	100%	250,435	100%	124,929	100%

- While the share of private sector electricity generation was 58.4% in 2004, this increased to approximately 79% as of the end of June 2015.
- Installed capacity for electricity production, which was 36,824 MW in 2004, increased to 69,520 MW in 2014, and it increased to 71,604 MW by the end of June 2015, nearly a two-fold increase (Table 1.2 and Figure 1.9). 35% of current installed capacity comes from hydropower, 30.1% from gas, 20.5% from coal, 5.6% from wind, and 8% from other resources. There was an average annual capacity increase of 6.3% per year in the 11-year period between 2004 and 2014.

Table 1.2 – Development of installed capacity for electricity generation in Turkey (Source: MENR, 2015)

Year	Thermal			Hydro	Wind	Geothermal	Solar	Total	Increase (%)
	Coal	Natural Gas	Other						
2004	8,296	11,349	4,500	12,645	18.9	15		36,824	3.5
2005	9,117	12,275	4,487	12,906	20.1	15		38,820	5.4
2006	10,197	12,641	4,520	13,063	59	23		40,502	4.3
2007	10,097	12,853	4,322	13,395	146.3	23		40,836	0.8
2008	10,095	13,428	4,072	13,829	363.65	29.8		41,817	2.4
2009	10,501	14,555	4,284	14,553	791.6	77.2		44,761	7.0
2010	11,891	16,112	4,276	15,831	1,320	94.2		49,524	10.6
2011	12,491	16,003	5,438	17,137	1,729	114.2		52,911	6.8
2012	12,530	17,162	5,337	19,620	2,261	162.2		57,072	7.9
2013	12,428	20,253	5,967	22,289	2,760	310.8		64,007	12.2
2014	14,636	21,474	5,692	23,643	3,630	404.9	40.2	69,520	8.6
END OF JUNE 2015	14,659	21,569	5,756	25,057	4,024	431.2	107.6	71,604	3.0
RATE	20.5%	30.1%	8.0%	35.0%	5.6%	0.6%	0.15%	100%	-

Figure 1.9 – Changes in installed capacity for electricity generation in Turkey (Source: MENR, 2015)



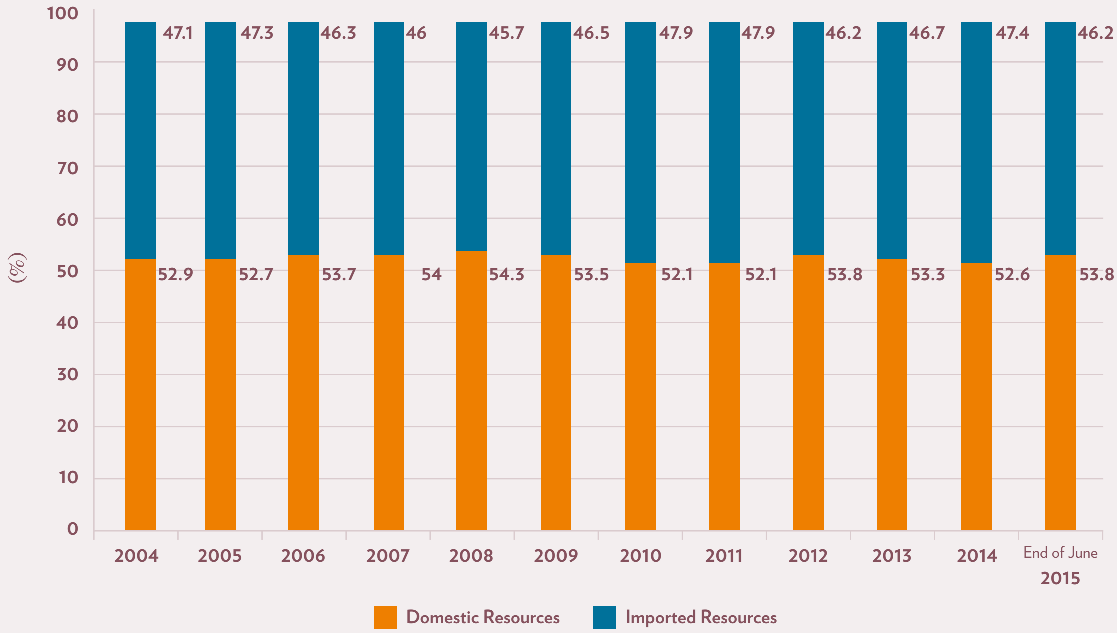
• Installed capacity of thermal power plants was 24,145 MW in 2004, and it had increased to 41,984 MW by the end of June 2015 (Table 1.3).

Table 1.3 – Distribution of the installed capacity of thermal power plants in Turkey (Source: MENR, 2015)

		2004	2009	2012	2014	End of June 2015
SINGLE FUELLED	Lignite	6,451	8,110	8,148	8,238	8,244
	Hard Coal	335	335	335	335	350
	Imported Coal + Asphaltite	1,510	2,056	4,048	6,198	490
	Fuel-Oil	2,308	1,541	1,196	509	1,2
	Diesel Oil	214	27	27	11	1,2
	LPG	10	0	0	0	0
	Naphta	37	21	5	5	5
	Natural gas	11,349	14,555	17,162	21,474	21,569
	LNG			2	2	2
	Renewable + Waste + Waste Heat + Pyrolytic Oil	28	82	159	288	315
	TOTAL	22,241	26,726	31,080	37,060	37,311
MULTI FUELLED	Solid + Liquid	454	552	676	668	658
	Liquid + N. Gas	1,450	2,062	3,273	4,074	4,015
	Total	1,903	2,614	3,949	4,742	4,673
THERMAL TOTAL		24,145	29,339	35,029	41,802	41,984

• Domestic resource-based installed capacity was 19,493 MW (52.9%) and installed capacity of imported resource-based power plants was 17,331 MW (47.1%) in 2004. While domestic resource-based installed capacity had been 38,529 MW (53.8%), installed capacity of power plants fuelled with imported resources was 33,075 MW (46.2%) by the end of June 2015. In the period between 2004 and the end of June 2015, even though the installed capacity from both domestic and foreign resources had increased, no significant change occurred in the rate of such capacity amounts to the total installed capacity (Figure 1.9).

Figure 1.10 – Domestic and imported resources of installed capacity for electricity production in Turkey (Source MENR, 2015)



1.3. Turkey's Greenhouse Gas Emissions

Turkey is among the top 20 greenhouse gas emitting countries. Turkey, which accounts for 1.05% of the world population (77.7 million), is the 18th most crowded country, and it was the 18th biggest economy of the world in 2013 (GNP: 821 billion USD). Turkey generates nearly 1% of total global greenhouse gas emissions, and it is ranked 19th among top emitters (WRI, 2015). Therefore, its share in global warming is proportional to the population and the economic size of the country.

In 2004, Turkey became a party to the United National Framework Convention on Climate Change (UNFCCC), which was opened for signature in 1992 and entered into force in 1994. It started issuing its annual greenhouse gas inventories, which are required under the Convention, by 2006. The most recent one was the 1990-2013 inventory issued in May 2015. According to the inventories, Turkey's emissions have been increasing regularly every year. However, there had been changes in all the figures in the last report pertaining to each year following 1990 due to a modification made in the methodology. Since the final version of the report and the reasons for the modifications have yet to be clarified, the figures in this section are based on the 1990-2012 greenhouse gas inventory published in 2014.

Turkey's emissions in 1990 were 188.4 million tons (without emissions from land use) and 439.9 million tons in 2012 (TURKSTAT, 2014). The

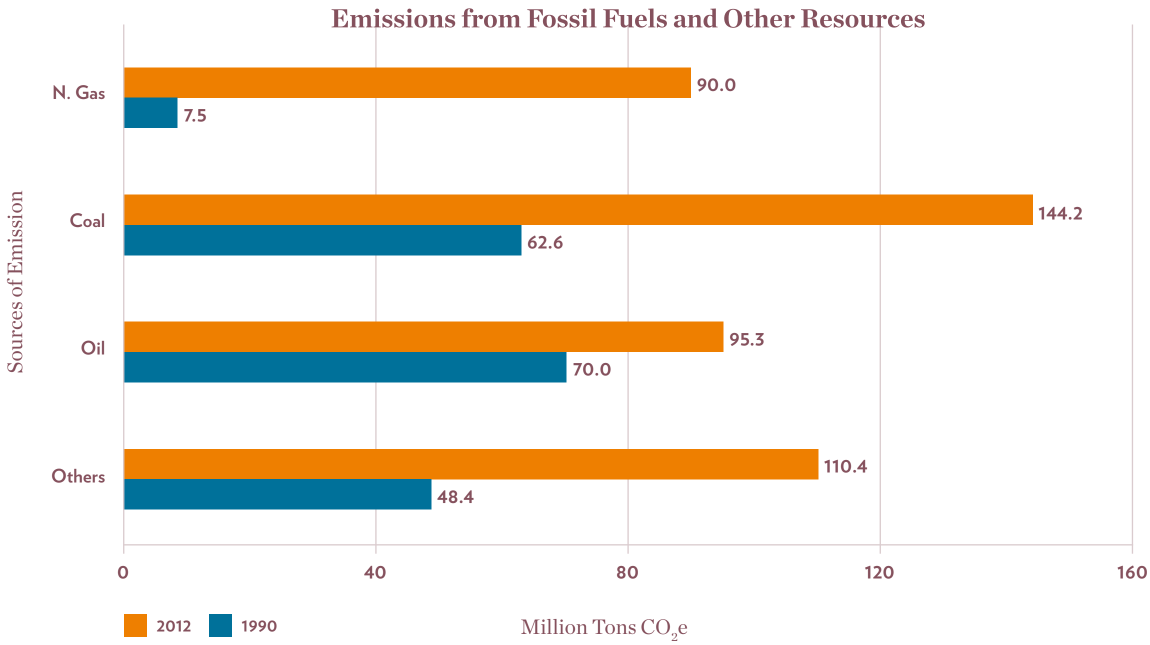
133.4% increase seen in Turkey's emissions from 1990 to 2012 is the highest among Annex-1/OECD countries. This increase rate was 74.4% according to the 2004 figures in the first inventory. Turkey has characteristically had the highest increase rate among Annex-1/OECD countries since that time. The increase rate from 1990 to 2013 decreased to 110.4% in the last inventory issued in 2015 due to the methodological changes (TURKSTAT, 2015).

Like most other countries, energy generation is the primary source of Turkey's emissions. Total emissions from energy have increased from 132.9 million tons in 1990 to 308.6 million tons in 2012. The increased rate of emissions from energy, 132.2%, is just about the same as the increase in the rate of total emissions. The share of energy in total emissions was 70.2% in 2012. Industrial processes, waste, and agricultural activities follow energy with 14.4%, 8.2%, 7.3%, respectively.

According to the Convention emissions of six greenhouse gases are included in emission inventories: Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The level of CO_2, which is the most important greenhouse gas, has increased from 141.6 million tons in 1990 to 357.5 million tons in 2012. The level of methane has increased from 34.1 million tons in 1990 to 61.6 million tons in 2012, and the level of nitrous oxide has increased from 12.2 million tons in 1990 to 14.8 million tons in 2012. Emissions of the other three greenhouse gases are very low.

CO_2 emissions have increased by 152.5% from 1990 to 2012. The increase in methane was 81% and in nitrous oxide 21%. This shows that the increase in total greenhouse gas is mainly the result of CO_2.

Figure 1.11 – Changes in the share of fossil fuels in greenhouse gas emissions in 1990 and 2012 in Turkey (Source: Algedik, 2015)



1.4. Increasing Tendency towards Coal in Turkey

The increase in energy related emissions in Turkey is mainly related to the increase in the use of coal. Until 2001, there has not been an increase in coal consumption parallel to the increase in carbon dioxide emissions. In 1990, the share of coal in carbon dioxide emissions was 44%, and by 2001 it had decreased to the lowest level of 33.7%. An increase started following this date, and in 2009 the share of coal in emissions increased to 43.2%. Emissions from coal, which amounted to 62.6 million tons in 1990, increased to 70.5 million tons in 2001 and to 144.2 million tons in 2012, an increase of 130%. The share of coal in total emissions in 2012 was approximately 33% (Figure 1.11). Between 1990 and 2012, the emissions from coal burned in thermal power plants had increased by 219%, whereas the increase in total emissions for the same period was 133.4% (Algedik, 2015).

In strategic plans, it is foreseen that Turkey's energy needs would increase twofold by 2023. The latest estimations foresee that until 2030 Turkey's energy needs will increase by 5.25% annually. Thus, total energy generation should be increased from 213 TWh in 2013 to 440 TWh in 2023 and to 619 TWh in 2030 (WWF, 2014). Turkey aims to meet this increased demand by constructing many new coal, hydroelectric, and wind power plants. With this policy, it is intended to increase the share of both domestic and imported coal in energy generation for the purpose of decreasing the current deficit by reducing dependency on natural gas imports. Additionally, there are plans for the commissioning of two or maybe three nuclear power plants between 2020 and 2022. An increase in energy generation from renewable resources, i.e. mainly wind is also intended.

However, as Turkey's energy demand estimations are usually higher than the actual values, these high estimations are used as justification for planning the construction of many power plants. Estimations that are also reflected in the Development Plans can be given as examples. The Tenth Development Plan (2013) foresees that electric energy demand would increase to 341,000 GWh in 2018, i.e. increase by 41% when compared to 2012; thus, installed capacity of electricity should increase by 36.7%. In fact, although the electricity demand foreseen for 2013 in the Ninth Development Plan (2006) was 295,500 GWh, in 2013 this value was 245,000 GWh; in other words, it remained 17% below the estimate. Also, as per data from TEİAŞ (Turkish Electricity Transmission Corporation), Turkey's existing power plants in 2014 had the capacity to meet an energy demand of 320,000 GWh. It can be seen that this figure is very close to the energy demand estimation foreseen for 2018 in the Tenth Development Plan. Therefore, it is hard to say that new coal power plant decisions are made based only on prospective energy demand estimations.

Coal has an important place among Turkey's development plan priorities. It is indicated in the Tenth Development Plan that domestic coal sites were opened to the private sector for electricity generation to provide "energy supply security," and an agreement was made with the United Arab Emirates for increasing the electricity generation in Afşin-Elbistan lignite fields. The use of domestic resources through the private sector for electric energy generation should be utilized as much as possible, and coal fields with small reserves would be open for utilization in regional power plants (Ministry of Development, 2013).

According to the Domestic Resource Based Energy Generation Program Action Plan (2014-2018) issued during the preparatory period of the Tenth Development Plan, there will be an increase in electricity generation from coal from 43 TWh in 2013 to 57 TWh in 2018. According to the 2013 Energy Balance Statistics of the Ministry of Energy

Tenth Development Plan (2014-2018)
Coal in Domestic Resource-Based Energy Generation Program Action Plan

- The Tenth Development Plan is intended to increase the share of domestic resources in primary energy generation, which was 27 percent at the end of 2012, to 35 percent at the end of 2018 and to increase the domestic coal-based electricity generation, which was 32 billion kWh in 2013 to 57 billion kWh in 2018.
- Large lignite mines such as Afşin Elbistan, Konya Karapınar, and Trakya Ergene will be opened for tender for the construction of a coal-fired power plant by EÜAŞ (Electricity Generation Corporation) using demand guarantee-revenue sharing models, or Build-Operate or Build-Operate-Transfer models, in which purchase guarantee is provided for a certain time.
- The model of transferring lower capacity lignite basins to Organized Industrial Zones to generate the electricity they need without asking for a royalty fee will be studied.
- A coordination unit that accelerates the investment process of all other electricity generation plants including lignite sites to be opened to private sector and sites to be newly contracted through royalty procedures will be formed.
- For long-term supply security, Turkey needs imported hard coal as well as domestic coal. In order to organize activities such as obtaining foreign coal licenses in suitable countries, prospecting, exploration, production, and import of other minerals to be used as energy resources, a company will be formed to deal with issues such as price advantages and continuity.
- R&D efforts that would enhance the quality and efficiency of coal at all levels will be carried out, pilot plants will be installed, and final implementation will be performed by TÜBİTAK (Scientific and Technological Research Council of Turkey) MAM Energy Institute, universities, and techno parks.
- It will be ensured that the incentive system is updated annually and its effectiveness is increased by monitoring developments so that domestic coal and thermal energy investments can proceed rapidly.

Source: Ministry of Development, Domestic Resource Based Energy Generation Program Action Plan (2014-2018), November 2014

and Natural Resources (MENR), dependency on imports for energy generation from coal is 58%, and most of the generation from domestic resources is based on lignite. When the low calorie value of Turkey's lignite reserves are taken into account, a 33% increase of domestic resources stated in the Five Year Plan will lead to an increase in the use of lignite, and this, in turn, will cause higher greenhouse gas emissions.

Turkey is ranked fourth in the world with regard to countries that increased their coal investments—immediately after China, India, and Russia (Yang and Cui, 2012).

Currently, 25 coal-fired power plants are used in electricity generation in Turkey (excluding auto producers and smaller ones below 50 MW). The construction of three new coal-fired power plants is ongoing.

The coal-fired power plants that are in operation are located in Çanakkale (Çan, Karabiga), Bursa (Orhaneli), Kocaeli (Gebze), Manisa (Soma), İzmir (Aliağa), Kütahya (Tunçbilek, Seyitömer), Zonguldak (Çatalağzı), Ankara (Nallıhan), Eskişehir (Mihalıççık), Muğla (Yatağan, Yeniköy, Gökova), Yalova (Taşköprü), Bolu (Göynük), Sivas (Kangal), Adana (Yumurtalık-Sugözü), Kahramanmaraş (Afşin-Elbistan), Hatay (İskenderun), and Şırnak (Silopi) provinces. Coal-fired power plants under construction are in Adana (Tufanbeyli), Çanakkale (Karabiga), and Kütahya (Tunçbilek) provinces.

Construction of more than 70 new coal-fired power plants has been planned—some are licensed, some are at the license/pre-license or EIA stage, and some are officially announced but not documented—in Kırklareli (Demirköy), Tekirdağ (Marmara Ereğlisi), Çanakkale (Çan, Biga, Lapseki, Gelibolu, E,zine), Balıkesir (Bandırma), Manisa (Soma), İzmir (Aliağa, Kınık), Muğla (Milas), Bursa (Keles, Demirtaş OIZ), Eskişehir (Alpu), Kütahya (Tunçbilek, Domaniç), Afyon (Dinar), Konya (Karapınar, Ilgın), Düzce (Akçakoca), Bartın (Amasra, Mugada), Zonguldak (Çatalağzı, Ereğli, Karabük), Amasya (Merzifon), Çankırı (Orta), Sivas (Kangal), Kahramanmaraş (Afşin-Elbistan), Mersin (Silifke), Adana (Ceyhan, Yumurtalık), Hatay (Erzin, İskenderun), Adıyaman (Gölbaşı), Elazığ (Kovancılar), Bingöl (Kiğı-Adaklı), and Şırnak (Silopi). There are related environmental conflicts and protests organized by local people and environmental movements in many of these locations, as well as ongoing lawsuits for cancellation of EIA procedures. One of these protests was particularly successful as the construction of a large coal-fired power plant project in the Gerze district of Sinop had been prevented by the local movement.

Additionally, the construction of large power plants with high installed capacity, the likes of which do not currently exist in Turkey, have been in the pipeline. Examples are Afşin-Elbistan C-D-E units, which will have a total installed capacity of 6,500 MW; Konya-Karapınar coal-fired power plant, which will have an installed capacity of 5,250 MW; and Afyon-Dinar coal-fired power plant, which will have an installed capacity of 3,500 MW. The largest existing coal-fired power plants (such as Afşin-Elbistan A and B, Sugözü, Çatalağzı, Karabiga) have an installed capacity between 1,000 and 1,500 MW, and the average size of others is around 400-600 MW.

The total installed capacity of the coal-fired power plants in the pipeline corresponds to nearly 66.5 GW. Since there are coal-fired plants with an installed capacity of less than one-fourth (nearly 15 GW) of such amount, and the current total installed capacity of Turkey from all resources is 71.6 GW, construction of new coal investments nearly equal to the current capacity can be seen as an important problem in terms of both environmental and public health, as well as economic considerations. The possible annual greenhouse gas emissions of such new coal-fired power plants will also be very high.

According to the IPCC (2012), production of 1 kWh of electricity from coal produces 1,000 grams of carbon dioxide emission on average. In the case of the construction of all new power plants in the pipeline (66.5 GW), and according to the 70% capacity factor, approximately 400 million tons of greenhouse gas emissions (i.e. close to Turkey's total emissions in 2013) will be added every year. Even if we assume that all of the power plants in the pipeline cannot be constructed, if one-third of the electricity generation, which is estimated to increase to approximately 600 Twh in 2030, comes from coal as in the strategic plans, then half of such amount would still be emitted due to burning only coal at the current levels. If domestic lignite, the calorific value of which is low, would be used in some of the power plants to be constructed, then since their emissions would be higher, this estimate could be quite conservative.

Coal in Turkey's Strategic Energy Plans

- The amount of electricity generated from domestic coal will be increased to 60 billion kWh per year at the end of the period.
- Conversion of existing domestic coal resources to electricity generation investments and exploration of new resources will be ensured.
- An increase in the production of domestic coal will be provided. It will be ensured that all coal sites, the license of which is held by the State, are made available for investments using appropriate models (transnational agreement/public private partnership of lignite sites with large reserves, etc.).
- The number of technical staff of relevant units of MTE will be increased, and current infrastructure conditions will be improved for exploration of new coal sites and making existing sites available for investment.
- It will be ensured that efforts required for a Hard Coal Exploration Project for domestic hard coal similar to the Lignite Exploration Project are carried out and exploration activities are launched.

Source: Ministry of Energy and Natural Resources 2015-2019 Strategic Plan

Using another calculation method, if the MENR electricity generation target of 60 billion kWh from domestic coal-fired power plants is realized until the end of the period foreseen in the 2015-2019 Strategic Plan, it can be projected that the emissions caused only from these power plants would be 60-90 million tons in 2018. It is clear that if all these plans are realized, the existing total greenhouse gas emissions in Turkey would skyrocket.

The energy strategy of Turkey aims to "use all existing domestic lignite and hard coal potential for energy generation purposes" and "to utilise thermal power plants dependent on imported coal, which has high calorie value, to ensure supply security." This approach ignores the possible contribution of Turkey to the global combat of climate change and precludes a climate policy that involves greenhouse gas reduction.

Since the Ministry of Energy and Natural Resources announced that 2012 was "the year of coal," it has been expected that coal would be the fastest growing sector in the Turkish energy market in the following years. Currently, domestic coal and lignite projects are argued to be the cheapest investments. The most important financial support given to the coal sector from the government is coal incentives. According to the calculations of the International Institute of Sustainable Development (IISD), the subsidies provided by Turkey to the coal sector in 2013 were approximately 730 million USD. In other words, the support provided for each 1 kWh of electricity generated is 0.01 USD, and when the coal aids made to households are taken into account, such amount rises to 0.02 USD (see Part 3 in this report). Such supports have also paved the way for imported coal. Thus, total installed capacity of imported coal-fired power plants have increased from 3.9 GW in 2012 to 6.1 GW in 2014 and have drawn near to domestic coal-fired power plants, the total installed capacity of which is 8.1 GW (Algedik, 2015).

1.5. Conclusion

The main discussion about coal in the G20 summit in Antalya was supposed to involve the implementation of the commitment made in 2009 to gradually end all fossil fuel incentives that cannot be effective in the middle term (See Part 3). As the G20 term chairman, Turkey ensured that the topic of climate finance was included in the meeting agenda and was expected to take the lead in putting the topic of fossil fuel incentives into the implementation decision. However, instead increases in such incentives were included in Turkey's development targets.

When considering the 40-50 year economic life of a newly built coal-fired power plant, plans to create new coal mines and construct new domestic and imported coal-fired power plants, and the magnitude of the investments in the pipeline, it seems that Turkey's energy infrastructure will be dependent on fossil fuels, especially coal, until 2050 and beyond. The target of limiting global warming to 2°C requires reducing global emissions to 42 billion tons in 2030 and to 22 billion tons in 2050 (See Figure 1.4; UNEP, 2014). The emissions mitigation target (929 million tons) set by Turkey in its INDC report means that Turkey is aiming to emit more than 2% of the maximum global emissions (required for the two-degree target) in 2030 and 4% in 2050. (This share is currently 1%.) Moreover, if the new coal investments are realized, it could be expected that such amount would be exceeded even after 2050 because of a highly coal dependent energy system. Therefore, Turkey's future coal plans can prevent Turkey from meeting the two-degree target. Furthermore, Turkey's per capita emissions can exceed 10 tons by 2013, making it one of the top greenhouse gases emitters worldwide.

Turkey, which has not set any mitigation target in international climate negotiations, claiming for many years to be an Annex 1 country that has "special circumstances," plans to be a party to the new climate regime after COP 21 in Paris by undertaking greenhouse gas emission mitigation. However, fossil fuels, especially coal, in its current energy strategy have made Turkey's position in the negotiations quite contentious. A coal-based energy policy makes it impossible to combat climate change. It also complicates Turkey's desire to have a constructive position in international negotiations. In the midst of a world economy that aims at decarbonization, it would be wiser for Turkey to reduce the carbon intensity of its economy and to choose a sustainable energy future based on renewable energy and energy efficiency.

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PART 2

THE ECONOMICS OF COAL MINING IN TURKEY

Ahmet Atıl Aşıcı

2.1. Coal Mining in Turkey

Coal mining is assessed within the Mining and Quarrying (MAQ) class according to the sectoral divisions defined by the Turkish Statistical Institute (TURKSTAT). As per accounts specific to lignite and anthracite, the share of mining in the total production of the Turkish economy is below 1%, and this rate is decreasing. Additionally, the contribution made by the Mining and Quarrying sector to employment rates is rather low. As shown in Figure 2.1, while the Turkish economy grew by an annual average of 3.9% between 1998-2013 (yellow line), the MAQ sector achieved a growth rate over the general average only between 2004-2008. Yet since its share in total production is low, it is hard to say that it has made a significant contribution to growth rates.

Figure 2.1- Share of mining and quarrying sector in the growth of the Turkish economy between 1998 and 2013 (Source: TURKSTAT)

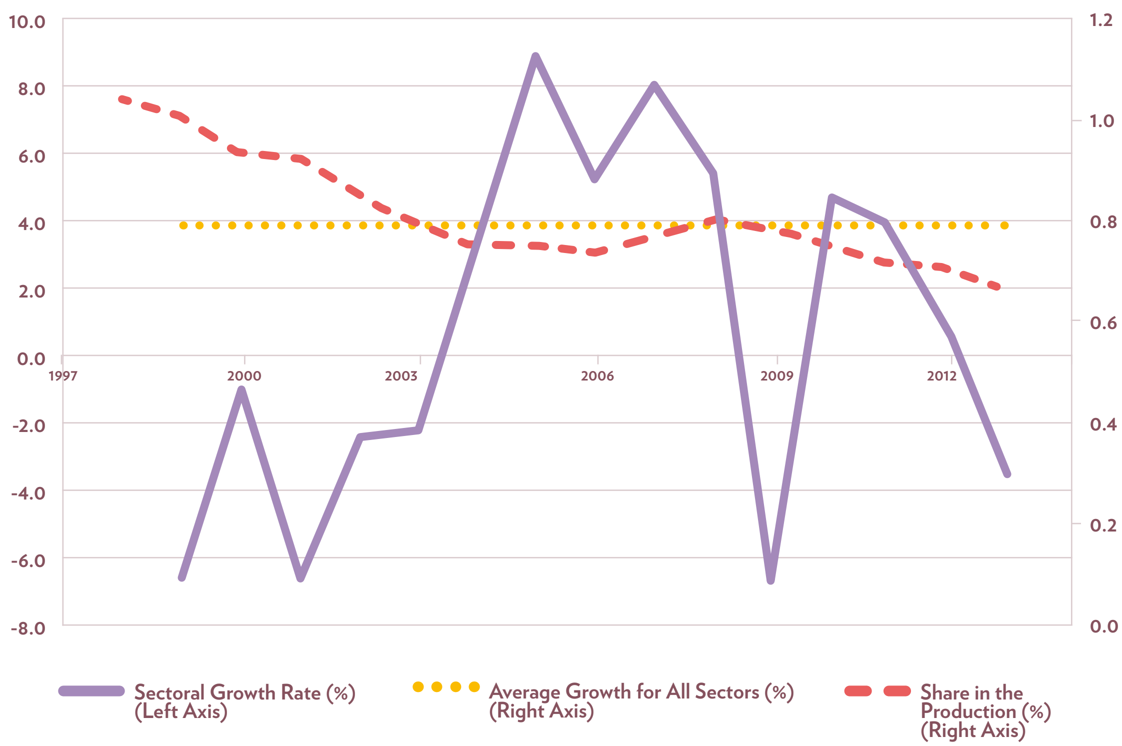
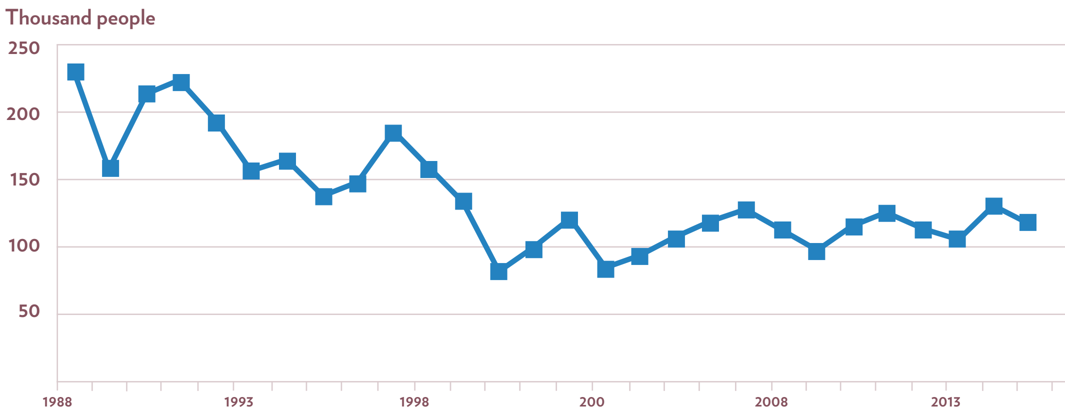


Figure 2.2- Change in the employment figures of the mining and quarrying sector between 1998 and 2013 (Source: TURKSTAT)



As seen in Figure 2.2, the number of people employed by the Mining and Quarrying sector is again fairly low. It is seen that the employment in the MAQ sector declined from 229,000 people in 1998 to 117,000 people in February 2015. The share of the sector in total employment decreased from 1.3% to 0.7% in the same period.

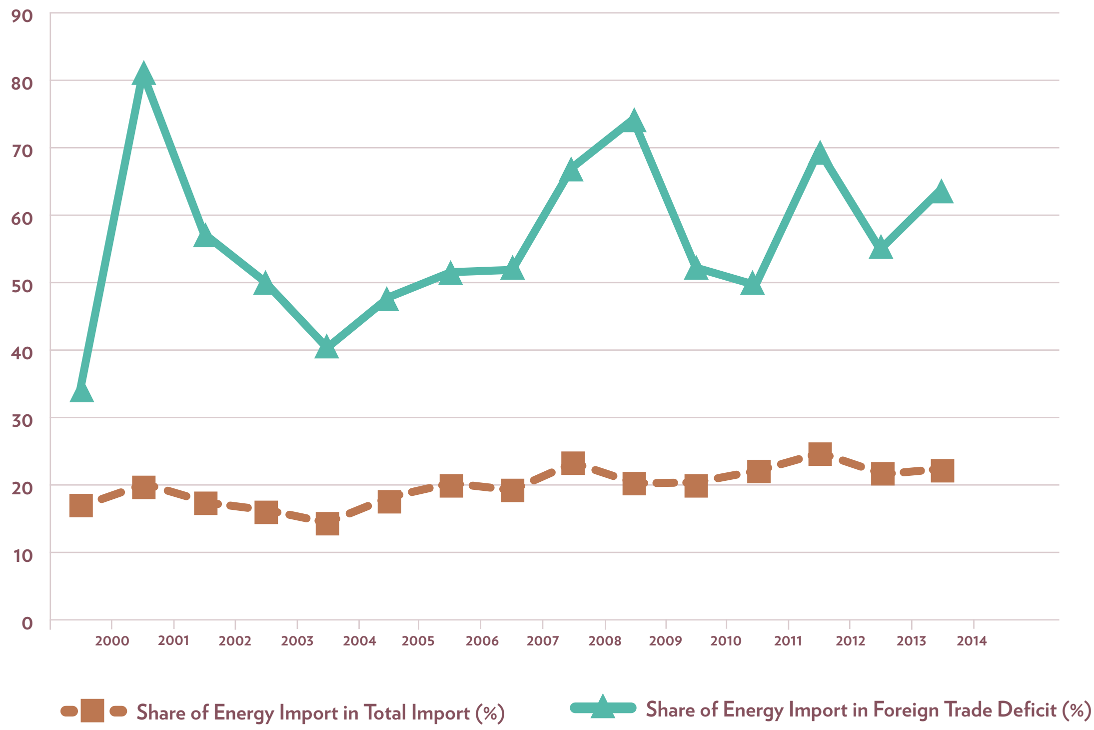
According to the data, the increasing (direct and indirect) incentives given to the sector is not to increase economic growth rates or reduce unemployment, given the low shares in total production and employment, but can be argued to be required by the characteristics of the economic growth path taken in the 2000s. Energy consumption in Turkey—which chose a growth path through energy intensive sectors and, accordingly, increased imports of energy resources—thus increased the current account deficit that adversely affects the sustainability of economic development. In response, policy makers decided to use domestic energy resources more. Incentives provided to domestic lignite mining and coal-fired power plants in which domestic lignite is to be used are discussed in part three of the report.

At first glance, although it seems reasonable to move towards domestic resources as a remedy to the vicious cycle of faster growth-import-current deficit, it can be seen that the chosen path is full of dilemmas when the characteristics of the path the economy has entered are considered.

In Turkey, *real estate services, domestic transportation (highway, pipeline, etc.), machinery and equipment rental, textile and textile products, retail trade, wholesale trade, and construction sectors* shouldered much of the economic growth period (i.e. contributed the most to the annual growth rate) from 2002-2009 (Aşıcı, 2015). When the interdependency of such sectors is examined, it can be seen that most of these sectors are related to construction. For example, while construction activities, which have increased in the last 10 years in Turkey, triggered machinery and equipment rental as well as marketing of residences and offices, this led to an increase in energy imports by creating demand for energy intensive sectors such as iron-steel and cement.

The share of the energy imports in the Turkish current account deficit is shown in Figure 2.3.

Figure 2.3: The share of current deficit in energy import in Turkey (Source: Undersecretariat of Treasury Foreign Commerce Statistics)



From 2004-2014, the share of energy imports in total imports increased from 14.2% to 22.2%; and energy imports' share in the merchandise trade deficit, which is the most important component of the current account deficit, had also increased from 40.3% to 63.7%. In other words, at of the end of 2014, energy imports accounted for the largest item included in the foreign trade deficit, 53.8 billion USD out of a total 84.6 billion USD.

2.2. Transformation of the Economic Structure

A country's economic structure is not static. It is constantly evolving toward the end of a dynamic process depending on many different factors. The regulation power of policy makers in some of such factors is rather limited. Developments in international markets, in which countries export their goods and resources, can be given as an example. The shrinking of the EU market since the 2008 crisis, which used to absorb more than half of Turkey's exports, and the economic expansion experienced worldwide in the early 2000s have affected Turkey's role in the global division of work, its volume of imports and exports, and thus, its economic structure. International agreements, such as the one in which the EU committed to reducing its greenhouse gas emissions by 20% by 2020, are also an important factor in the growth path that the Turkish economy has entered. But yet, economic structure is not entirely dependent on external conditions. Policy makers in the country also have a certain rate of effect. Even though this *policy* *space* is increasingly narrowed down in today's globalizing world by international organizations such as the World Trade Organization-IMF-World Bank, there are countries that manage to pull the economic structure to a more sustainable point through rationalist policies.

There are many various instruments through which policy makers can use to evolve the economic structure in a certain direction such as industry policy, incentives, taxing, regulations, laws, directives, etc.

Therefore, the economic structure in an open economy like Turkey is shaped by both external and internal factors.

2.2.1. Significant Internal and External Developments That Have Shaped the Economic Structure in Turkey

Going back to 1980, one can see the factors that have determined the characteristics of the Turkish economy today. Even though Turkey has experienced important developments since its foundation in 1923 (Boratav, 2010), the main transformation of the Turkish economy occurred in 1980 when the economy opened to global markets (for a detailed assessment see Öniş, 2010). Internal and external factors that determined this transformation are as follows:

- 1980 - Liberalization of foreign trade (Internal Factor)
- 1989 - Liberalization of financial flows (Internal Factor)
- April 1994 - Economic crisis (Internal Factor)
- 1995 - Customs Union with EU (Internal Factor)
- 1997-1998 - Asian Crisis, Russian Crisis (External Factor)
- 1999 - Stand-by agreement with the IMF for economic stability (Internal Factor)
- 1999-2000 - Deregulation of financial markets in the United States (External Factor)
- September 11, 2001 - Al Qaida attacks on the United States (External Factor)
- 2001-2006 - Expansionary money policy of the FED (U.S. Federal Reserve) (External Factor)
- February 19, 2001 - The biggest economic and social crisis in the history of the Republic (Internal Factor)
- 2001 - Transition to the Strong Economy Program introduced by Kemal Derviş (Internal Factor)
- 2002 - Beginning of single party rule by the AKP (Justice and Development Party) (Internal Factor)
- 2005 - Launch of full membership negotiations with EU (Internal and External Factor)
- 2003-2015 - Entry to new markets such as African, Arabian, and Gulf countries (Internal and External Factor)
- 2008 - Global Crisis (External Factor)
- 2008-2009 - Economic recession and crisis in Turkey (Internal Factor)
- 2009-2011 - Economic rescue packages in Turkey (Internal Factor)
- 2012 - Input Supply Strategy (GITES), Vision 2023, and unlimited deregulations (Internal Factor)

The internal and external developments outlined above have determined the transformation of the Turkish economy in the post-1980 period. The Turkish economy began to join global markets in 1980 when foreign trade was liberalized, and the removal of the capital account restrictions in 1989 accelerated this process. As a closed economy prior to 1980, import substitution had been the main motive of industry policy. Under such policy, the priority had been given to the imports of intermediate and investment goods that could substitute for imports of consumption goods since foreign currency revenues from exports were quite limited. With the decision to open to foreign markets in 1980, a period of export-oriented industrialization started. However, the transformation decision was ill-prepared and uninformed. The transformation was nothing more than a compulsory response to the economic crisis, as well as foreign exchange problems, that rendered Turkey unable to import the most basic of resources such as energy, which had gradually increased at the end of the 1970s. The import substitution industry policy implemented up until 1980 had not been able to establish intermediate goods or investment goods sectors that would nourish the exports of the country.

Therefore, the impact of this liberalization decision on Turkey's economic structure was extensive. The industrial structure shaped "to produce all it needs by itself" during the closed economy period began to concentrate on goods that can compete in external markets. Textile, which shouldered economic growth and exports in this period, is an example of such a sector. Industrial exports, which adapted to the new conditions relatively quickly, increased. But because foreign dependency in intermediate goods and investment goods could not be broken, the sustainability debate on economic growth remained alive. The record high current accounts deficit faced at the end of 1993 was the most fundamental factor that pulled the country into the next year's crisis. Instability gradually increased along with growing political tension in the country, and the 1997 Asian and 1998 Russian crises reinforced this instability. Thus, to regain economic stability, the government signed a stand-by agreement with the IMF, but the relative improvement gained could not be maintained as the required reforms were not realized in time. In this period, significant external developments were experienced that affected Turkey as well as other countries.

The U.S. government decided to liberalize financial markets in 1999 and 2000 to recover from its own economic problems. It was after this that the real estate bubble, which would pop in 2008, had begun to inflate. In response to the recession that happened after the 9/11 attacks, the Fed continued its expansionary monetary policy until the 2008 crisis, and as a result an abundance of money was pumped into markets worldwide. It can easily be seen that such abundance caused a significant addition to the amount of money entering into world trade and into countries such as Turkey competing for its share in such trade. Turkey did not make a good start to this period, and in February 2001 it suffered the biggest crisis in the history of the Republic. After this crisis, while the new IMF prescription *Transition to Strong Economy Program* was introduced at the end of 2002, the AKP came to power. The AKP adopted this program, and the transformation of the economic structure accelerated during this period. Rapid reduction of the share of agriculture in production and employment was at the fore of this transformation. While the government was trying to exit conventional export markets, record high foreign direct investment started to flow into Turkey with the help of Arabian and Gulf capital that turned to Turkey after the 9/11 attacks. This period was reinforced by investments coming from the West after the start of full accession negotiations with the EU. Strengthening its relations with Arabian and Gulf countries enabled Turkey to open new export markets; however, due to real estate speculations experienced in such countries, Turkey built up a large share of the iron-steel, cement, and production sectors, i.e. low value-added sectors.

While this trend—in which no intervention was made in order to ensure economic growth—was ongoing, the real estate bubble that started to inflate in the early 2000s in the United States blew up, and Turkey, along with the rest of the world, entered into an economic crisis. As one of the most rapidly declining economies in the world in 2009, Turkey managed to get out of the crisis thanks to the trade connections it developed and its strong public finance structure; however, the social and environmental costs of such recovery were dire.

Transformation of the Economic Structure: Outlook of Soma

The city of Soma, once renowned for the quality tobacco it produced, again came to the fore after the mining accident that resulted in the death of 301 workers on May 13, 2014. Further, the struggle of the villagers against 6,000 olive trees cut for the construction of a thermal power plant in Yırca, located in the same region, also displayed the structural transformation that the Turkish economy has gone through.

As part of the stand-by agreement signed with the IMF to eliminate the financial instability of the late 90s, the government promised a reformation of the agricultural sector. Part of the conditions of the agreement was the privatization of state-owned enterprises (SOEs) such as TEKEL (state monopoly of tobacco and alcohol), as well as a repeal of the support price system in agriculture, which was part of the Transition to Strong Economy Program announced in 2002 under IMF supervision. One of the most important changes brought with law no. 4733 in 2002 was the popularization of contract farming, which left the tobacco farmers to the mercy of the buyer (Karakaş, 2014).

As a result of factors such as the end of support purchases and rapid increases in input costs, the number of tobacco producers in the country decreased from 406,000 in 2002 to 51,000 in 2011, whereas the tobacco production amount declined from 160,000 tons to 45,000 tons over the same period. This rapid decrease in agriculture, especially in tobacco production, pushed farmers to earn their living in other sectors. Most of the miners who lost their lives in Soma were either ex-farmers themselves or children of ex-farmers.

With Keynesian government supported investments and incentive programs, the wheels started to turn again, and low value-added, low technology, energy and pollution intensive production increased even more following the 2008 crisis and has since continued to shoulder economic growth. The energy investments required by such economic structuring have continued to increase during this period. This, in turn, has led to environmental conflicts, especially in the Black Sea Region, on the basis of small scale hydro power plants.

The deaths resulting from work accidents in shipyards before the 2008 crisis can be included among the social costs of such conditions—even though the news of deaths coming from shipyards has now ceased due to the suspension of ship orders and bankruptcy of many shipyards after commerce narrowed because of the global crisis. Yet, fatal work accidents began to increase in the construction and coal mining sectors, which form the basis of the current economic growth model.

Annual fatal workplace accidents on a sectoral basis are given in Figure 2.4. We see that deaths in the construction and mining and quarrying sectors have increased during periods in which the economy is stimulated through the energy-intensive construction sector (2010 and 2011). In 2012 when the economy began to falter, worker deaths decreased accordingly; yet, since official statistics for 2014—when accidents such as Soma and Ermenek occurred—are not issued by the relevant authorities, they could not be provided herein.[1]

As the increasingly foreign dependent economy grew, it boosted the current account deficit to an unsustainable point. This led the government to

1 Until recently, it was possible to access statistics regarding worker deaths compiled by the Social Security Institution from the website of the Ministry of Labor and Social Security. With increasing worker deaths, the ministry restricted access to such data with the statement, “Data not accessible because SSI has stopped sharing data as required by omnibus law.” There cannot be any other action that reflects the perspective of the government on work safety more clearly than the above.

Figure 2.4 – Worker deaths on a sectoral basis (Source: ILO, 2015)

take measures that would reduce import dependency, especially in energy. It is possible to consider the incentives provided to domestic lignite production and domestic lignite-fired power plants in light of such developments. In addition, it should also be noted that the government's neglect of the workplace security measures that need to be taken by employers serves as an implicit incentive provided by government bodies.

2.2.2. Environmental Impacts of the Transformation in Economic Structure

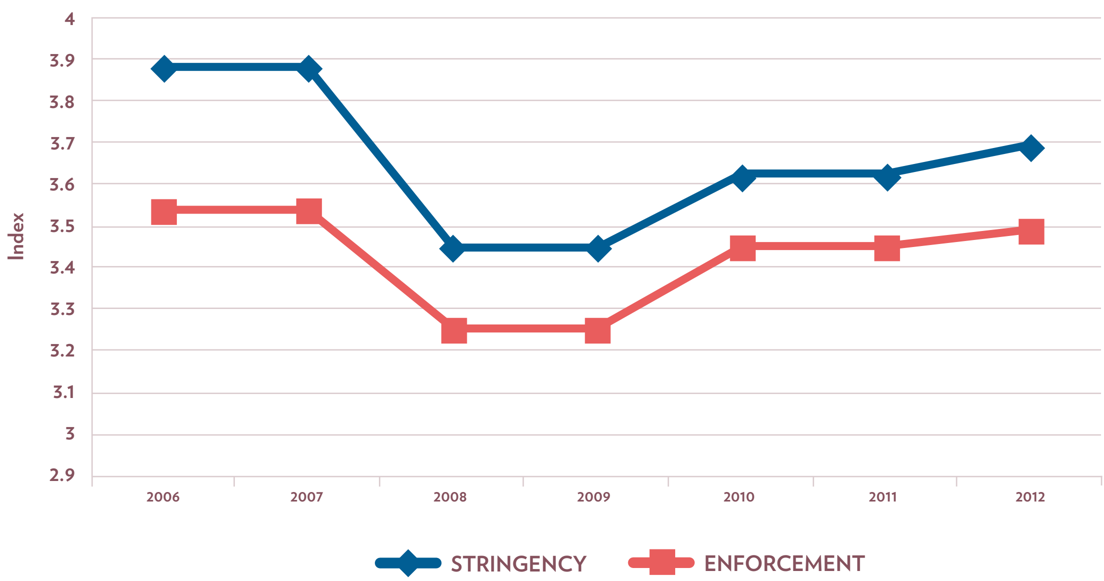
The fact that the government, which desires to reach its targets stipulated in the Vision 2023 document via the shortest possible way, has directed its incentives, industry policy, and regulation instruments toward "economic growth at all costs" can be seen as the primary reason for the mass workplace accidents that occurred in Soma, Ermenek, and Torunlar İnşaat. Due to the effects of increased public awareness after these accidents, the government, which had attempted to ensure economic growth by avoiding workplace safety and environmental standards, signed the ILO contract no. 176, which regulates workplace security conditions in mines. But, due to pressure from the sector, the implementation of this measure was postponed in August 2015 until 2020. This attitude is just one piece of evidence that environmental and labor standards are seen as an obstacle to economic growth.

World Economic Forum-WEF uses two sets of data to regularly measure the direction in which countries' environmental standards evolve. The first set of data shows the stringency of environmental regulations, and the second shows to what extent such regulations are applied, i.e. enforcement level. As seen in Figure 2.5, the stringency of environmental regulations in Turkey had gradually weakened between 2006 and 2012. In 2012 Turkey's position in the international rankings for stringency and enforcement of regulations had receded to 85th and 79th, respectively, out of 140 countries. Regulations that are becoming increasingly flexible are not implemented adequately.

Vision 2023

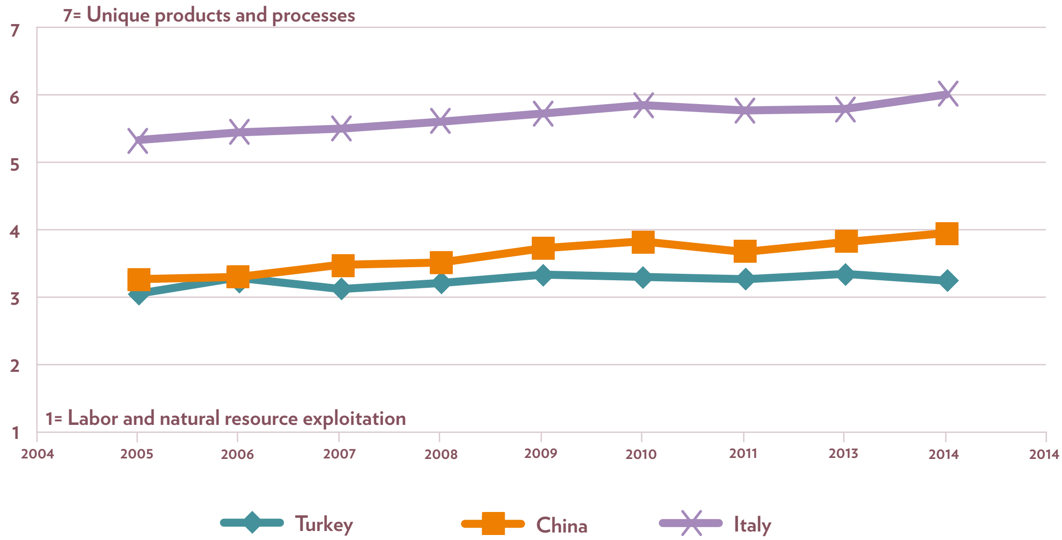
In 2012, the Justice and Development Party (AKP) government announced a long-term development strategy called Vision 2023. The main objective of the strategy was to enlarge the Turkish economy so that it rises from its position as the 17th largest economy in the world in 2012 to be among the top 10 largest economies in 2023. Accordingly, it aimed to increase exports to 500 billion USD and income per capita to 25,000 USD in 2023. As a remedy to the foreign deficit problem, which increased due to economic growth, a series of documents such as Input Supply Strategy (GITES) and New Incentive Law were drawn up and implemented. To mitigate import dependency of economic growth, sectors such as iron-steel and non-iron metals, automotive, machinery, chemical products, textile and leather, and agriculture were selected as key sectors. Under the New Incentive Law, regardless of in which region it would be produced, domestic coal mining and energy generation with domestic coal particularly were considered as strategic investments and were granted the most generous incentives (Acar et al. 2015). However, despite the decrease in economic growth rates that narrowed the current deficit, as of the end of 2014 the rate of the current GDP deficit was standing at 5.7% of GDP, which was below expectations.

Figure 2.5 - Changes of environmental regulations in Turkey between 2006 and 2012 (Source: WEF Executive Opinion Surveys, 2006-2013)



WEF also measured the type of products that countries compete for in world markets. The higher the index value (ranging from 1 to 7), the more the country derives its competitiveness through high value-added products that could not be imitated by other countries (such as tablet computers). If a country is near one point, which is the lowest value, it means that such a country is competing in global markets with labor and natural resource-intensive products (ship breaking, mining, etc.).

Figure 2.6 – Competitiveness structure
(Source: WEF Global Competitiveness Index, 2005-2013)



In Figure 2.6, the competitiveness structure is shown by comparing Turkey with China, which is a rapidly growing developing country, and with Italy, which is a developed country but recently has been in a state of economic crisis. Accordingly, while Turkey was ranked 76th among 120 countries in 2005, its position receded to 95th among 144 countries in 2013. China rose to 45th in 2013.

Using the examples of a country with a rapidly growing economy like China and a developed country like Italy, the figure above displays that renouncing labor and environmental standards and gaining competitiveness through exploitation of nature and labor is not the only way to get out of an economic crisis.

2.3. Conclusion

The unsustainable growth path of the Turkish economy is not accidental: It is the result of the various policies implemented. The fact that the economy is focused on products with low value-added in energy and pollution-intensive sectors is because such products appeal more to the private sector. If subsidies, incentives, and strategic plans were formed in a different way, the economic structure would display a different outlook.

It does not seem possible for a country located in one of the most vulnerable regions to global climate change, and which is considerably foreign-dependent in terms of energy, to achieve the targets stipulated in Vision 2023 while also raising its quality of life. Development plans should be reviewed in accordance with these two important restrictions, and the investment and innovation climate should be improved so as to increase the share of high value-added, low energy and pollution-intensive products in total production.

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PART 3

COAL INVESTMENTS AND CURRENT SUBSIDIES IN TURKEY

Sevil Acar

3.1. Coal Investments and Coal-Fired Power Plants in Turkey

3.1.1. New Investments in Coal Mining

Turkey has been making a special effort to operate in existing coal reserves and to find new reserves for many years now. Recently, the coal reserves of the country have increased by six billion tons (IEA Clean Coal Centre, 2014). The state financed mobilization and exploration of the General Directorate of Mineral Research and Exploration (MTA) and Turkish Coal Enterprises (TKİ) have played the biggest role in this increase. In order to mitigate foreign dependency on energy and due to high imported coal, oil, and natural gas prices, in 2005 the "Development of Our Lignite Reserves and Exploration of Lignite on New Sites" project was launched under the coordination of TKİ. Following this, the state supported coal exploration program revealed 5.8 billion tons of new coal reserves and thus increased coal reserves by more than 50% (OCI, 2014). The new coal reserves are located in the Afşin-Elbistan, Trakya, Manisa-Soma, Konya-Karapınar, Afyon-Dinar, Eskişehir Alpu, and Kırklareli-Vize basins. There are already around 13.9 billion tons of known coal reserves, the majority (13.4 billion tons) of which are composed of low quality lignite. The rest of the known reserves are relatively high quality hard coal reserves found mostly in the Zonguldak basin. Despite this increase in domestic sources, on the other hand, Turkey's coal imports have accelerated since the mid-90s. As stated in the "Electric Energy Market and Supply Security Strategy Paper" published in 2009, the completion of investments with regard to all coal reserves and utilization of all known lignite and hard coal reserves for electricity generation purposes is projected for 2023.

3.1.2. New Investments in Coal-Fired Power Plants

In accordance with TEİAŞ Electricity Generation Statistics, as of 2013, 12.5 GW of Turkey's total electricity generation installed capacity, i.e. 20% thereof, consisted of coal-fired electricity generation; and 64 terawatt-hours (TWh) of total generation, i.e. 27% thereof (14% from hard coal+imported coal+asphaltite and 13% from lignite), consisted of coal. While lignite accounts for two-thirds (8.2 GW) of Turkey's total coal-fired generation capacity, since the calorific value of lignite is lower than hard coal, it provides less than half (30.2 TWh) of the total generation. Most hard coal power plants use imported coal, whereas the fuel needs of lignite power plants are met through domestic resources (Acar, Kitson and Bridle, 2015).

According to official projections, by 2030 total electricity generation is expected to rise from 240 TWh to above 600 TWh. The share of coal in total generation will increase from approximately 27% to around 32%. When the increase in total generation is taken into account, this increased percentage seems limited at first; however, this means that coal-fired generation would increase threefold and reach near levels of 200 TWh. This increase in generation will be met by an increasing installed capacity of lignite and by a threefold increase in coal-fired power plants, reaching approximately 35 GW.

35% of this increase in capacity will be realized in hard coal, and the remaining 65% will be realized in lignite. When limited reserves are taken into account, Turkey will have to continue importing most of its hard coal, and therefore, it would not be possible to eliminate its dependence on imported energy sources. Domestic coal production focused on lignite, as well as having many power plants operating with hard coal, shows that domestic coal production does not comply with Turkey's energy security target. Increased dependency on imported coal will not only increase the current deficit but also bring Turkey's energy security efforts to a stalemate (Acar et al., 2015).

On the other hand, in the joint report of WWF and Bloomberg New Energy Finance (BNEF, 2014), it was revealed that the official electricity demand increase projections calculated by TEİAŞ are not realistic and that the demand would only be 93% more than its current level in 2030. Under these circumstances it was anticipated that an increase in the installed capacity for electricity would be more limited.

3.1.3. Coal Investments in G20 Countries[1]

Among the G20, Turkey is not the only country that prioritizes coal mining and coal-fired power plant investments. The Liberal Party government in Australia, a country rich in coal beds, approved new coal infrastructure investments in the previous period and revealed its intentions to expand coal production even more despite its adverse effects on the environment. In response, some commercial banks started to withdraw the funds they had previously provided for the improvement of coal production due to rising concerns that the Australian government had been neglecting problems related to the environment. In May 2014 Deutsche Bank, followed by HSBC and Royal Bank of Scotland, withdrew the funds they had allocated to coal. Despite this, the government recently had given the green light to begin mining 16 billion USD worth of coal located in the Galilee basin, which, if realized, would be the biggest coal mine in Australia (ODI-OCI, 2014).

Similarly, companies such as Teck Resources, Hillsborough Resources, and HD Mining in Canada are operating within rich coal beds and continue to explore expanding coal basins. As the leading primary energy consumer of the world, China supports large-scale coal projects through the Chinese Development Bank. Even in Germany, which has sound policies for the improvement of renewable energy, coal production and consumption have increased recently with the support of the government. Swedish Vattenfall Energy Company has lignite coal beds in Eastern Germany and makes expansion plans for opening new beds. Similar expansion efforts for coal can also be seen in Indonesia and Japan (ODI-OCI, 2014).

3.2. Coal Subsidies in Turkey[2]

It is generally accepted that fossil fuel subsidies are provided by the government to producers or consumers for the purpose of decreasing the cost of energy from fossil fuels, increasing the price acquired by energy/fossil fuel producers, and decreasing prices faced by energy/fossil fuel consumers. These subsidies can be in the form of direct transfers, cross subsidies, price controls, purchase guarantees, tax exemptions, and similar instruments. To meet increasing energy demand and to ensure energy

1 For more detailed information on this section please see the report titled *The Fossil Fuel Bailout: G20 subsidies for oil, gas and coal exploration* published by Oil Change International (OCI, 2014).

2 The findings of the report titled Coal and Renewable Energy Subsidies in Turkey (Acar, Kitson and Bridle, 2015) published by International Institute for Sustainable Development - Global Subsidies Initiative are summarized in this section. For more detailed information on subsidies, see the aforementioned study.

security, Turkey plans to increase its electricity supply through large-scale investments made in coal-fired electricity generation.

The report *Coal and Renewable Energy Subsidies in Turkey* (Acar, Kitson and Bridle, 2015) was published by the Global Subsidies Initiative in March and calculates the external costs of coal, including environmental and health-related costs, by analyzing the cost resulting from supporting coal production and investments through subsidies and compares such costs with those of solar energy and wind power. The types and amounts of coal subsidies revealed by the report are summarized below:

- The most important support provided to coal is the financial aid given to the hard coal sector through *transfer payments from the Treasury*. These transfers are mostly used to subsidize hard coal imports, because domestic resources can only meet a small portion of the total demand. Table 1 shows the amount of such transfers from 2009 to 2013. These transfers vary in the range of 260 million USD to 300 million USD per year.

- Coal investments are also subsidized within the framework of the *New Investment Incentives System* that entered into force in 2012. This system consists of four plans: (1) General Investment Subsidy Plan; (2) Regional Investment Subsidy Plan; (3) Large-Scale Investment Subsidy Plan; (4) Strategic Investment Subsidy Plan. Investments to be made in coal exploration, coal production, and coal-fired electricity power plants are subsidized under the Regional Investment Subsidy Plan and are granted high subsidy rates by being defined as "priority investments." This program divides regions and cities in Turkey into categories as per their development level and aims to support related industrial branches according to the potential of the city. In general the program provides subsidies, conditions, and rates of which are specific to the region, such as customs tax exemption, VAT exemption, tax discount, social insurance premium support (employer's share), land assignment, and interest support. Regions are ranked from one to six, with the 6th Region receiving the highest subsidy. Coal investments benefit from 5th Region subsidies (only investments made to the 6th Region benefit from the 6th Region subsidies).[3]

- *Research and Development (R&D) support*: The government supports the fossil fuel sector in terms of R&D costs. Among fossil fuels, coal has the largest share. The International Energy Agency (IEA) reports that in 2009 the government had spent TRY 2.6 million on R&D for coal.

- *State support given for mineral exploration*: The 2010-2014 Strategic Plan of the Ministry of Energy and Natural Resources documents the budget allocated by the Ministry to coal, petrol, and natural gas exploration works between 2010-2014 (MENR, 2010, p. 41). The amounts are given in the table. Such budgets vary between TRY 35 million and TRY 51 million (approximately 23-34 million USD) within the plan period.

- *Rehabilitation support*: As part of the privatization process, the government provides funds for the improvement of hard coal mines and coal power plants.

- *Public expenditure made for coal-fired electric power plants*: The budget allocated for new coal power plants was calculated as TRY 28 million

3 1st Region: Ankara, Antalya, Bursa, Eskişehir, İstanbul, İzmir, Kocaeli, Muğla 2nd Region: Adana, Aydın, Bolu, Çanakkale, Denizli, Edirne, Isparta, Kayseri, Kırklareli, Konya, Sakarya, Tekirdağ, Yalova 3rd Region: Balıkesir, Bilecik, Burdur, Gaziantep, Karabük, Karaman, Manisa, Mersin, Samsun, Trabzon, Uşak, Zonguldak 4th Region: Afyonkarahisar, Amasya, Artvin, Bartın, Çorum, Düzce, Elazığ, Erzincan, Hatay, Kastamonu, Kırıkkale, Kırşehir, Kütahya, Malatya, Nevşehir, Rize, Sivas 5th Region: Adıyaman, Aksaray, Bayburt, Çankırı, Erzurum, Giresun, Gümüşhane, Kahramanmaraş, Kilis, Niğde, Ordu, Osmaniye, Sinop, Tokat, Tunceli, Yozgat 6th Region: Ağrı, Ardahan, Batman, Bingöl, Bitlis, Diyarbakır, Hakkari, Iğdır, Kars, Mardin, Muş, Siirt, Şanlıurfa, Şırnak, Van

(approximately 15 million USD) for 2013 and nearly TRY 31 million (approximately 14 million USD) for 2014.

These figures also include new domestic coal-fired thermal power plants with 3,500 MW capacity to be completed by the end of 2013 (MENR, 2010).

Apart from these, there are also other immeasurable subsidies. Some of those subsidies are listed as follows:

- *Investment guarantees* provided by the Treasury to coal power plants with 15-20 years of operational life left (for example, Çayırhan and İskenderun thermal power plants).
- For certain periods, *price and electricity purchase guarantees* also include lignite-fuelled generation investments: Turkey's long-term electricity purchase agreement framework and tendering system guarantee revenues for new electricity generation investments. Large energy projects are financed through this implementation. A long-term electricity purchase model and tender system is developed to provide privileges for electricity generation projects in long delivery periods such as coal power plants (OCI, 2014). Electric power plants based on Build-Operate-Transfer and Build-Own-Operate models enter into long-term electricity purchase agreements for selling electricity to the public.
- Subsidies are also supported through environmental legislation exemptions that are granted explicitly or actually. Examples of the inadequacy of environmental legislation or non-compliance with existing legislation and standards are also known to exist. Subsidies can be qualified as a significant deficiency in the implementation of the Environmental Impact Assessments (EIA). CEE Bankwatch Network (2013) revealed that the environmental impact assessments of planned coal-fired power plants have not been completed. According to statistics from the Ministry of Environment and Urbanization, EIA reports of more than 40 coal-fired electric power plants and related facilities have been approved, and there have not been any coal projects or EIA reports that have been rejected between 1999 and January 30, 2015. In addition, coal power plants with thermal power less than 300 MWt (thermal megawatt) are exempted from the environmental impact assessment. If the capacity of a power plant that is not subjected to assessment increases to a level at which the power plant would be eligible for assessment through power addition or expansion, that power plan will not be obliged to prepare an EIA report. EIA legislation was changed in November 2014 in order to conform with the European Union (EU). However, such changes turned out to be non-compliant with EU targets. For example, one of the changes stipulates EIA exemption for enterprises at the decommissioning stage after the power plants are closed down.
- *Coal aid to poor families* is the only subsidy provided to consumers. This program, which is executed by the Ministry of Family and Social Policies Directorate General of Social Aids, was implemented in 2003. Since its establishment, more than two million households have benefited from this subsidy. The amount of coal supplied by TKİ and dispatched to poor families is at least 500 kg per household. Transfers made from Turkey Hard Coal Authority (TTK), Turkish Hard Coal Enterprises (TKİ), and Electricity Generation Corporation (EÜAŞ) are reported by the Turkish Court of Accounts.

When all measurable coal subsidies in Turkey are taken into account, based on the data of Acar et al. (2015) for 2013 the amount of subsidy per kilowatt-hour is calculated as approximately 0.01 USD. When the subsidies provided to consumers such as coal aid are included, this amount increases to 0.02 USD per kilowatt-hour. As also seen in

Table 1: Subsidies provided to the coal sector in Turkey

Coal Subsidies		2009	2010	2011	2012	2013	Birim	Source
Support to Producers (Mining & Electricity Generation)	Investment Incentives to Lignite Mining*	1	N.A.	3	9	7	No. of incentive documents	Ministry of Economy
	Investment Incentives to Hard Coal Mining*	N.A.	N.A.	N.A.	1	2	No. of incentive documents	Ministry of Economy
	Government R&D Expenditures on Coal	1.68	N.A.	N.A.	N.A.	N.A.	million USD	IEA
	Exploration Subsidies**	N.A.	23.11	22.89	23.41	24.36	million USD	MENR
	Rehabilitation during privatization-hard coal	23.00	19,00	N.A.	N.A.	N.A.	million USD	OCI
	Aid to the Hard Coal Industry (Direct Transfers from the Treasury)	264.42	302.98	286.68	258.18	298.47	million USD	EA, Under secretariat of the Treasury
	Rehabilitation during privatization - power stations	N.A.	2.00	2.00	2.00	2.00	million USD	Oil Change International
	Expenditures for New Coal Power Plants***	N.A.	13.86	13.73	14.05	14.62	million USD	OCI
	Unquantified Subsidies	1. Investment, Price, and Purchase Guarantees to Coal Power Plants 2. Subsidies provided under the New Investment Incentive Scheme in the form of exemptions from customs charges, VAT, social security, allocation of land and below market interest rates 3. Exemptions from environmental regulation including temporary exemptions for existing coal plants and permissive EIA procedures						MENR
Support to Consumers	Coal Aid to Poor Families	356.4	295.6	390.4	413.2	392.3	million USD	Undersecretariat of the Treasury

Source: Acar, S., Kitson, L. and Bridle, R. (2015). *Coal and Renewable Energy Subsidies in Turkey.* International Institute for Sustainable Development (IISD) - Global Subsidies Initiative (GSI) Report, page 12.

Notes:

* Investments made in coal exploration, coal production, and coal-fired power plants are subsidized under the Regional Investment Subsidy Plan as customs tax exemption, VAT exemption, tax discount, social insurance premium support (employer's share), land assignment, and interest support.

** These figures contain the estimated budget allocated by the Ministry of Energy and Natural Resources (MENR) for coal, petrol, and natural gas exploration works between 2010 and 2014 under the 2010-2014 Strategic Plan of the Ministry.

*** These figures reflect expected budget spending on coal power plants between 2010 and 2014. As stated in Strategic Plan Target 1.2, by the end of 2013 construction of new coal thermal power plants with an installed capacity of 3,500 MW will be completed (MENR, 2010). The subsidy amount in those budgets is unknown.

Table 1, a total of 730 million USD worth of subsidies was provided to the coal sector in 2013. Another note to point out is that these estimations remain below the actual total subsidies realized because investment guarantees, regional investment subsidies, or other immeasurable subsidies are not included in such estimations.

When this subsidy estimation is compared to previous studies, it is higher than the amounts previously found. As a matter of fact, IEA (2009) calculated the subsidies provided to the hard coal sector to be around 398 million USD. The figure presented above is even higher than the OECD's estimation (2013), which reveals many subsidies but reports limited measurable subsidy data. The amount calculated by OCI (2014) for 2013 was 560 million USD. On the other hand, the estimations of the current study cannot be compared to the findings of the IMF, which take exteriorities into account but does not define total subsidy components.

3.3. Fossil Fuel Subsidies in Other G20 Countries

The G20 leaders who convened in 2009 had promised to end all ineffective fossil fuel subsidies (FFS) gradually in the middle term. The European Union had also included the target of ending such subsidies in its strategy for 2020. The topic of fossil fuel subsidies started to come to the fore more so in the Rio+20 Conference, which was convened through the call of the United Nations in 2012, and then was perpetuated in later discussions. In fact, gradually decreasing and completely removing the FFS suggestion was one of the topics that received the most votes within the Rio Dialogues.

On the other hand, according to 2011 data from the International Energy Agency, governments are providing 12 times more subsidies to fossil fuels than they provide to renewable energy. While the energy subsidy policies in G20 countries vary, many countries continue to support coal and energy generation from coal. Governments of G20 countries transfer 88 billion USD worth of resources each year solely to fossil fuel exploration activities (ODI-OCI, 2014). For example, even though Germany aims to increase its share of renewable resources to 40-45% by 2025, it also transferred three billion euros to coal production in 2012 and continues to be the biggest supporter of coal in Europe (G20, 2014).

Similarly, the Australian and Canadian governments have used various subsidy mechanisms to increase fossil fuel exploration operations in addition to direct fossil fuel production supports. In total these subsidies cost around 2.9-3.5 billion USD per year in Australia. The Australian mining sector, which also contains coal companies, receives a two billion USD share from such funding. The federal government of Canada provides a minimum of 928 million USD of subsidies to fossil fuels (ODI-OCI, 2014). Among G20 countries, Canada is included in the countries that provide the largest share of state funding to fossil fuel exploration operations and, through the credit agency Export Development Canada and its shares in entities such as the World Bank and European Bank for Reconstruction and Development, transfers significant amounts of funding to projects overseas (ODI-OCI, 2014).

In India, which has a considerable amount of fossil fuel reserves, the government has spent approximately 70 million USD in coal exploration, mining, and research and development operations in 2013. Coal India Limited, which is 90% publicly owned, plans to invest nearly 9.8 billion USD in coal projects in overseas countries between 2012 and 2017. One and a half billion USD of this amount was set aside to be used in Mozambique between 2013 and 2014 (ODI-OCI, 2014).

Coal mining started to increase rapidly in Indonesia, where petrol production has decreased recently, and net coal export has increased by six fold since 2000 (BP, 2014). The Indonesian government provides tax facilities and exemptions that support exploration works in fossil fuel sectors.

The United Kingdom, United States, Japan, Korea, and South Africa are also among the G20 countries that continue to provide state support to fossil fuel, especially the coal sector. The Japanese government allocates 724 million USD annually to petrol, natural gas, and coal exploration operations overseas. Despite its decreasing domestic coal reserves, Korea continues to fund coal mining, exploration, coal-fired power plant projects, and operations in overseas countries. In the United States, although the coal industry similarly continues to shrink, the four major companies that mine coal were the companies that benefited the most from subsidies (in total 26 million USD) regarding research and development costs in 2013 (ODI-OCI, 2014).

3.4. Economic and Environmental Impacts of Coal Subsidies

Studies that elaborate upon the possible socio-economic and environmental impacts of coal and other fossil fuel subsidies have recently increased. Most of these studies focus on various scenarios to understand the impact of reduction, full elimination, or reformulation of subsidies. In six different studies in which Ellis (2010) reviewed subsidy reduction scenarios, it is found that subsidy reform would lead to a significant amount of increase in income and decrease in CO_2 emissions on a global scale.[4]

As for the national analyses, in a UNDP (2012) study on fossil fuel subsidies in Vietnam, it is shown that elimination of subsidies would increase actual gross domestic product (GDP) by 1% and significantly decrease greenhouse gas emissions.

According to a study that examines the macro-economic and environmental impacts of coal subsidies in Turkey within a general equilibrium model (Acar and Yeldan, 2015), if the production and investment subsidies provided to coal are eliminated by 2030, CO_2 emissions would decrease significantly in regions with both high and low income. As per such scenario, in 2030 an emission decrease of 5.4% nationwide would be realized when compared to the base path. Given the fact that the coal sector comprises only a small portion of the sectoral composition of the country, it is clear that eliminating only the subsidies provided to coal would be significantly beneficial in terms of combating environmental pollution and climate change. Existing coal subsidies make competitiveness of renewable energy technologies more difficult and jeopardize renewable energy investments, as well as make the energy system dependent on fossil fuel-based energy generation (i.e. "lock-in") (Bridle and Kitson, 2014).

Also, a climate policy that aims to achieve the 2°C temperature increase target regarding global warming requires world governments to completely abandon fossil fuels such as coal, petrol, and natural gas. If the subsidies provided to such sectors are eliminated, it is expected that most of the "polluting" projects would be abandoned and investments would shift to other sectors. According to analyses conducted by CTI (2013), such a potential sectoral transformation and renunciation of subsidies would lead to 28 trillion USD of gross loss of earnings for the fossil fuel industry in 2035: Large volumes of fossil fuel would be idle as stranded assets. In other words, even though they have not reached the end of their economic life span, existing coal and other fossil fuels will become idle due to not bringing in any income in a world that has transitioned to a low carbon economy. As per the latest calculations, 80% of coal, petrol, and natural gas reserves of large-scale companies have been marked as "un-burnable carbon" due to the danger of climate change (CTI, 2013).

4 For the findings of the six studies referred to by Ellis (2010) see: https://www.iisd.org/gsi/sites/default/files/effects_ffs.pdf.

3.5. Conclusion

It is known that fossil fuel subsidies usually cause negative economic outcomes. These subsidies are often costly and lead to the allocation of a smaller share from the state budget to other fields, increasing extravagant consumption and market distortions. In spite of such disadvantages, governments use these subsidies to protect vulnerable social groups, increase economic, development, and ensure energy security. However, subsidies cannot attain the desired targets most of the time. Moreover, fossil fuel subsidies are not environmentally sensitive policy instruments; they conflict with sustainable growth/development targets, hinder development of low carbon technologies, combat climate change, and weaken public finance.

The measurable subsidies provided to coal in 2013 comprised nearly 0.1% of Turkey's nominal GDP. Even though this figure seems insignificant, continuation of such subsidies with the addition of new subsidies and guarantees condemns the country to a coal dependent technical, institutional, and legal structure and prevents the development of renewable energy. Therefore, subsidies provided to fossil fuels should be removed. As a G20 member country, Turkey has made a commitment to eliminate fossil fuel subsidies that increase extravagant consumption and are not efficient in the middle term. Since the 10th Leader's Summit of G20 was held in Turkey in 2015, such commitment will especially be important. Turkey's G20 Chairmanship term in 2015 provides an opportunity for underlining such a commitment and taking the steps required for the realization of the commitment.

Elimination of coal subsidies may lead to adverse effects such as a decrease in employment in coal-based sectors; therefore, strategies towards compensation of possible losses of employment and mitigation of adverse effects should be developed. The actual cost of coal, in which the social and environmental impacts of coal are taken into account, should be noted during decision-making processes in the energy sector. Renewable energy has the potential to play a much bigger part in the resource distribution of Turkey's electricity generation in the future. Finally, the assumption that domestic coal production would ensure energy security should be reconsidered (Acar et al., 2015).

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PART 4

INTERNATIONAL AND REGIONAL BARRIERS AGAINST THE USE OF COAL WITH SPECIAL REFERENCE TO TURKEY'S ACCESSION TO THE EUROPEAN UNION

Pınar Gedikkaya Bal

Over the last couple of decades, fossil fuel consumption in the world has accelarated in parallel with increased industrialization and, consequently, has led to serious environmental problems like climate change as well as pollution of air, water, and soil at such levels as to threaten the earth's sustainability in the years to come. What is needed to be done is actually straightforward. The excess emissions of greenhouse gases, mainly carbon dioxide, which results from the burning of fossil fuels, is the major reason for the world's environmental problems. Therefore, the solution to the present environmental problems lies in decarbonizing the world economy. Oil, as a carbon intensive fossil fuel, is getting scarcer and will finally be phased out in the coming years. However, coal, having the highest carbon emissions, will still be available in the future. To ensure a sustainable world, the use of coal should also be phased out, leaving its place to renewable energy sources.

While in some parts of the world many countries are still dependent on coal for energy production, in other parts of the world an energy revolution is already under way with the aim of transforming to a low carbon economy. The European Union (EU) is a pioneer in this issue. Not only in the EU but also in the United States and in some emerging economies, governments are taking the necessary measures to limit the use of coal and decarbonize their economies, though at different speeds. Aside from national efforts, which are most of the time ineffective for a global solution, regional and international initiatives are also evolving.

This chapter highlights the recent developments that are taking place at the global and regional levels related to limiting the use of coal with the aim of decarbonizing. The chapter aims to show that at different levels, national, regional, and international, efforts are under way to limit the use of coal. These efforts might easily become barriers or restrictions for those countries who are free riding in their coal policies. The chapter concludes that those countries who do not take steps to decarbonize their economies might face trade barriers and restrictions in world markets as well as extra costs of production and penalties due to burning coal.

In this respect, in the first part the EU's low carbon goals, policies, and legal structure related to the use of coal will be examined. Then, some examples from the international arena will be given, since covering all international developments would not be possible within the limited number of pages. Lastly, the effects of these developments on Turkey will be evaluated.

4.1. The EU's Plan for a Low Carbon Future

Since its establishment, energy has been a very important issue for the EU. The European Coal and Steel Community (1951) was a landmark achievement in European energy cooperation, showing the importance of coal in those years. Over time, with technological developments new sources of energy like nuclear, natural gas, and renewables have been introduced.

Since the 1960s, the world has been witnessing the environmental outcomes of using energy, especially fossil fuels. The burning of fossil fuels like coal and oil increases the concentration of greenhouse gases in the atmosphere, which has led to climate change. In the European Union this threat was taken seriously, and mitigating climate change, as well as adapting to its impacts, has been prioritized since the 1990s. In addition to climate change, the world has also been aiming to reduce air pollution and waste. In this respect, the EU has issued various regulations and directives to fight climate change and other types of environmental degradation.

This process officially started with the signing of the Kyoto Protocol in 1997. Under the protocol, the EU aimed to reduce its greenhouse gas emissions by 8% below its 1990 levels in the first commitment period between 2008 and 2012. To achieve this target, the EU has developed various regulations and directives that have helped member states reach this target and beyond.

4.1.1. The 2020 Package

The climate and energy package, which had been accepted by all EU member states in 2007 and became binding legislation in 2009, aims to help the EU meet its ambitious climate and energy targets for 2020. These targets known as "20x20x20" targets have set three goals for 2020: a 20% reduction in EU greenhouse gas emissions from 1990 levels, raising the share of the EU energy consumption produced from renewable resources to 20%, and a 20% improvement in the EU's energy efficiency. This package signalled the EU's commitment to becoming a highly energy efficient and low carbon economy in the near future. With these targets, the EU shows its resolve to combat climate change, increase its energy security, and strenghen its competitiveness. By putting emphasis on renewables, the EU also aims to create new jobs to create "green growth". Within this package, a legal framework for the environmentally safe use of carbon capture and storage technologies was also introduced. In 2011, energy efficiency was added as another target through the Energy Efficiency Plan and Energy Efficiency Directive (European Commission, 2015a). The EU has also committed for the second period of the Kyoto Protocol (2013-2020) to decrease its emissions by 20% below base year levels (European Commission, 2015b).

4.1.2. The 2030 Framework

In October 2014, EU member states agreed on new targets for 2030 that included at least 40% reduction in greenhouse gas emissions compared with 1990, an increase in the share of renewable energy within total energy consumption to 27%, and an increase in energy efficiency by at least 27%. With this new framework, the EU has aimed to achieve continued progress towards a low-carbon economy. Within this low-carbon economy, the EU aims to build a competitive and secure energy system with affordable energy for all consumers, increase energy security by decreasing energy imports, and create new opportunities for growth as well as new jobs (European Commission, 2015c).

4.1.3. The 2050 Roadmap

In an effort to show its dedication to a low carbon future, the EU has announced it will cut its emissions to 80% below its 1990 levels by the year 2050. In this roadmap, the EU has planned the way forward for the main sectors responsible for Europe's emissions: power generation, industry, transport, buildings and construction, agriculture. The roadmap describes how these sectors will make the transition to a low carbon future in the most cost-effective way. In a low carbon economy, there will be more need for renewable energy sources, and the use of fossil fuel-based energy like coal and oil should be minimized. New technologies will be necessary in all aspects of life to create this low carbon future (European Commission, 2015d). This will spur innovation, create new jobs, and increase Europe's comparative advantage in world markets once more.

To achieve these targets, the EU has been working on various regulations and directives in an effort to reduce greenhouse gas emissions and combat air pollution and other types of environmental problems like water pollution and waste. In the EU, the emissions, as well as the environmental impact, of every product are being considered carefully.

The greatest potential for cutting emissions is in the power sector. The EU aims to eliminate its carbon dioxide emissions from the power sector almost totally by 2050. According to the roadmap, carbon emissions from the power sector will be reduced by 54-68% by 2030 and 93-99% by 2050. In transport and heating, fossil fuels will be replaced by electricity. In producing electricity, renewable sources like wind, solar, water, and biomass or other sources that are low in carbon emissions like nuclear power plants or fossil fuel power stations equipped with carbon capture and storage technology will be used. Apart from the power sector, energy intensive industries will also contribute by cutting their emissions by more than 80% by 2050. For this to be achieved, the EU is trying to strengthen the emissions cap that is being applied to the power sector within its Emissions Trading Scheme (European Commission, 2015e).

4.2. Barriers against Coal in the EU

The targets the EU has put in place to limit its emissions will require a technological revolution in energy production. In this respect, low-carbon energy technologies have become very important for the EU. The EU wants to be the leader of the low carbon economy and in this way creates a new comparative advantage for itself in the world markets. In accordance with this, the EU wants to have secure, cheap, and sustainable energy. The answer to all these concerns is renewable energy. With renewables, the EU can reduce its emissions and reach its targets, and its energy imports would decrease, making Europe more independent and secure in its energy supply. In this new sector of renewables and low-carbon technologies, the EU can be a leader in world markets, create new jobs and decrease unemployment, and establish a new goal to unite Europeans and enhance European integration. These new technologies may enliven Europe again in the coming years. The cost of renewable energy has already declined in Europe, and the "green" sector has evolved. Low carbon concerns have started to disseminate into other sectors. A low carbon revolution is on its way in Europe. Coupled with the EU's energy efficiency efforts, from construction to automobiles almost all sectors work with the same goals, principles, and restrictions. For example, the EU aims to make all new buildings "zero energy" by the end of this decade. In the automobile sector, hybrid and electric cars are already introduced. Energy labels are being used on products to promote the use of less and less energy. Eco-designs of products have led to the use of less energy. The emissions trading scheme, the carbon market, and the environmental directives all work toward the same end: achieving a low carbon future.

Coal consumption in the world differs from region to region. In some emerging economies like China, India, and South Africa, as well as in some developed countries like Australia, Canada, and the United States, extraction or the use of coal is expected to increase. India is expected to more than double its coal consumption by 2035 (Hope, 2014). But in the EU, the goal of achieving the transition to a low carbon economy requires a decrease in the use of coal.

According to the European Commission, energy produced from coal is expected to decrease by 50% in 2050 from 16 to 8%. In 2010, 24% of the EU's electricity was produced from coal. In 2030, coal will be used to produce only 12% of the EU's electricity and in 2050 this will decrease to 7% (Hope, 2014). Some of the existing environmental directives are already putting negative pressure on the EU's coal sector since burning coal cannot coincide with the goals of a low carbon future. Coal mines and coal-fired power plants are closing. The directives and regulations put into place for environmental concerns have been unfavorable towards coal. What is more is that in the coming years the new legislation being prepared for the low carbon future is expected to force more coal power plants to shut down.

4.2.1. Legal Treatment of Industrial Pollutants in the EU

For the last two decades, the EU has been trying to control its industrial activities with the aim of minimizing polluting emissions in the atmosphere, water, soil, and waste. The grand aim is to achieve a high level of environmental and health protection, achieve targets, and transform the EU into a low carbon economy.

1. Integrated Pollution Prevention and Control (IPPC) Directive

This is one of the earliest directives on pollution control. Over the years, it has been improved. The aim of the IPPC Directive is to prevent and/or reduce pollutants coming from industrial and agricultural installations in sectors like energy, minerals, metals, chemicals, agriculture, and waste management. The directive sets the minimum requirements for getting the "permits" required to operate a business in these sectors (Directive2008/1/EC, January 15, 2008).

2. Industrial Emissions Directive (IED)

The EU Parliament and Council issued a Directive on November 24, 2010 that brings together the IPPC Directive with six others under a single directive on industrial emissions. The Directive covers industrial activities with high pollution potential such as energy industries, production and processing of metals, the mineral industry, chemical industry, and waste management. The Directive contains special provisions for large combustion plants (> 50 MW), waste incineration, installation and activities using organic solvents, and installations producing titanium dioxide. Under this Directive, in order to receive a permit to operate, installations are required to take preventive measures against pollution, should apply the Best Available Techniques (BAT), cause no significant pollution, reduce waste in a manner that creates the least pollution, maximize energy efficiency, prevent accidents, and remediate the sites when the activities come to an end (Industrial Emissions, 2013; Directive 2010/75/EU, 24.11.2010).

Since January 7, 2014, the IED has replaced the IPPC, the Waste Incineration Directive (WID), the Solvent Emissions Directive (SED), and the three directives related to titanium dioxide as a single directive on industrial emissions. In this way, overlaps are cancelled and procedures have been simplified. By January 1, 2016, this Directive is planned to replace the Large Combustion Plants Directive as well. The IPPC has so far covered 50,000 installations, and more will be covered by the IED. With this Directive, the public will have the right to partcipate in the decision-making process. The public will have access to permit applications, will be permitted to voice their own opinions, and will be informed of the results of the monitoring of the releases (Industrial Emissions, 2013; Directive 2010/75/EU, 24.11.2010).

3. The Energy Union

The new European Commission President Jean Claude Juncker has labeled the energy union as one of the central priorities of his mandate. In a speech he had made in the European Parliament (Juncker, 2014: 6), he emphasized the importance of a resilient energy union with a forward-looking climate change policy. In this speech, he had strongly supported renewable energy in Europe:

> "...we need to strengthen the share of renewable energies on our continent. This is not only a matter of a responsible climate change policy. It is, at the same time, an industrial policy imperative if we still want to have affordable energy at our disposal in the medium term. I strongly believe in the potential of green growth. I therefore want Europe's Energy Union to become the world number one in renewable energies." (Juncker, 2014: 6)

What Juncker has said is nothing new in the EU though. Since these goals had been drafted years ago, the enabling factors, policies, and regulations are already present in the EU.

4.3. Possible Barriers against Coal in the International Arena

There are various efforts being put forth at the global level to limit the negative environmental impacts of coal and the use of coal itself.

4.3.1 Efforts under the United Nations (UN)

To avoid dangerous levels of climate change, a paradigm shift to a low carbon and sustainable economy is necessary. This fact is accepted by the UN. In parallel with the post-2015 development agenda as well as with the Rio+20 process, the UN aims to define and support sustainable development goals worldwide. Under the leadership of the UN Framework Convention on Climate Change (UNFCCC), the countries of the world are trying to finalize a global agreement to limit their greenhouse gas emissions with the aim of fighting climate change and making the transition to a low carbon economy.

According to the latest IPCC Synthesis Report[1] published in 2014, carbon emissions will ultimately have to fall to zero. The report has emphasized that carbon emissions mainly from coal, oil, and gas have currently risen instead of fallen. Based on its latest report, the UN Secretary General Ban Ki Moon has made an open call to investors and governors to reduce their investments in coal and the fossil fuel-based economy and move toward renewable energy (Carrington, 2014).

4.3.2.Efforts under the Organization for Economic Cooperation and Development (OECD)

The achievement of a low carbon economy cannot be realized only by establishing goals for the future. The alignment of policy and regulatory frameworks should be achieved today. The new OECD Report (OECD et al., 2015) calls for such an alignment between climate goals and existing policy and regulatory frameworks. As the OECD is perceived to be the club of rich and industrialized countries, this call can be seen as an important step forward towards a low carbon economy.

According to the OECD Report, coal-fired power generation might cause more than 500 billion tons of carbon dioxide to be emitted into the atmosphere until 2050. This amount is almost equal to half of the carbon budget that the world has until 2050 to stay within the limit of the two-degree threshold for dangerous climate change (OECD et al, 2015).

Referring to this report, the OECD Secretary General Angel Gurria has called on governments around the world to rethink their plans for new coal-fired power plants as these plants are presently the most urgent threat to the future of the world. Gurria warned that these coal-fired power plants would continue to emit in the future, consequently, "many could turn into stranded assets, having to be mothballed decades before their economic lifetime had expired" (Harvey, 2015).

1 For the IPCC report, please see: https://www.ipcc.ch/report/ar5/ (accessed on 29.06.2015).

4.3.3. Efforts under the World Trade Organization (WTO)

Although WTO aims to liberalize trade, countries are allowed to restrict trade with the aim of protecting the environment. Presently, the WTO does not have specific rules dealing with trade in energy. However, the Doha Mandate aims to open trade in environmental goods and services. Many of these goods and services have direct relations to clean energy and energy efficiency—like solar panels, solar water heaters, as well as services like environmental consultancy (WTO News, 2015). The Director-General of the WTO, Roberto Azevedo, perceives the liberalization of trade in environmental goods to be a very important turning point:

> "Collective elimination or reduction of trade barriers here would provide WTO members with greater access to a variety of imported goods involving clean energy technologies — and some of the services which support them. This work could also help to stimulate innovation and facilitate the development of clean energy industries — including in countries where they do not yet exist, allowing for new green business opportunities to flourish." (WTO News, 2015)

A group of WTO members have already launched a process to eliminate tariffs on environmental goods and services. These countries account for almost 85% of the global environmental goods trade. This kind of an agreement has the potential to reduce the cost spread between fossil fuel-based energy and renewable energy (Burns, 2009). This process culminated in the Joint Statement of thirteen countries together with the European Union at Davos in January 2014, committing to reducing tariffs on the APEC list[2] of Environmental Goods by the end of 2015 (Joint Statement, 2014). In June 2015, seventeen WTO members, including Turkey, came together again in Geneva to discuss cutting tariffs on a list of over 650 tariff lines and more than 2,000 products (Biores, 2015a). Negotiations were planned to continue until September when the list of products was to be completed and then will (hopefully) be concluded during WTO's ministerial conference in Nairobi in December 2015 (BioRes, 2015b).

The participants of the Environmental Goods Agreement (EGA) also announced that they were planning to prepare a list of 54 tariff lines and products on which tariffs will be reduced below 5% along with the 21-nation Asia-Pacific Economic Cooperation (APEC) list. The EU is considerably the most supportive party for the realization of such a deal to achieve a breakthrough together with the UN Climate negotiations to be concluded at the end of 2015 (Bio Res, 2015a). Along with these developments, a world market and a world trading system in environmental products is evolving. The EGA is seen as a "living agreement" that will continue its evolution in the coming years (European Commission, 2015f).

4.3.4. China's Coal Policy

One of the key factors shaping the global coal market is China's management of its coal power. Other factors that might have an impact on China's coal policies are finalization of a global agreement, the level of technological development on clean energy, the cost effectiveness of new technologies, and the increasing and strengthening of local resistance movements all around the world and in China itself.

Although coal is the cheapest energy source because of its environmental impacts, it is becoming an expensive investment. With "clean coal" technologies, investment and production in the coal sector might continue, but still the cost of these technologies compared with renewable energy sources is expected to be at a disadvantage in the future.

2 In 2012, the 21-nation APEC group committed to lowering applied tariffs to 5% or below on 54 tariff lines by the end of 2015.

Besides, even with clean coal technologies, the environmental impacts of coal cannot be dissolved. The most important barriers to investment in coal-fired power plants and coal mining are the carbon emissions penalties that might be imposed in the future both at the national and international level and uncertainty about future environmental policies (Thurbar, 2014).

China is the world's largest consumer of coal, producing 70-80% of its energy from it and accounting for almost half of the world's coal consumption (48%) (The Center for Media and Democracy, 2015). Since 2007, it has started to import coal, since its own supply is not enough. However, compared to 2011 statistics, China has started to consume less coal in 2015. China has been able to achieve this by using more renewable energies and new technologies (The Center for Media and Democracy, 2015).

China's coal consumption has had vital impacts on human health. Air pollution in some cities has exceeded acceptable levels with record numbers (Greenpeace website). As a result of increasing air and water pollution, in 2011 the government established new regulations for coal and some pollutants, and in 2013 the Chinese government introduced a plan to reduce emissions. In certain pilot cities, carbon markets were established for emissions trading. Further, many buildings in China are now using air purifiers, and health expenses are decreasing day by day. Shortly, with new regulations and policies, as well as seeing a reduction in health defects, the advantage of burning cheap coal in China will fade away. Air and water pollution in China have been the subject of mass protests. The Chinese government is even considering a carbon tax (Center for Media and Democracy, 2015). Recently, China has announced the launch of the world's largest carbon market by 2016 (BioRes, 2014).

The EU's relationship with China concerning low carbon development is also very important for the future of the world coal market. This relationship has the potential of being "the de facto engine of global energy transformation" (Simon, 2015).

4.4. Regional and International Barriers against Coal in Turkey's Transition to a Low Carbon Economy

In the current period of transition to a low carbon economy, extracting and burning coal neither environmentally nor economically coincides with the requirements of the new era. With new policies and regulatory frameworks, it has already become costly to burn coal. The new realities of the world are pushing countries towards renewable energies. For Turkey as an emerging economy, it is very important to follow these changes at the regional and global levels. Turkey should be able to continue its development by aligning its climate and environmental policies and regulations with the EU and the rest of the world. In this respect, Turkey should turn to renewable energy sources rather than conventional fossil fuels. Turkey should be able to invest more in renewable energy sources. In this way, Turkey might decrease its dependency on imported coal as an energy source, secure its investments from extra costs emanating from the requirements of the EU Directives, and, most importantly, change its energy policy in order to be canalized onto a low carbon path. Turkey can manage its emissions easier and hence take a role in the global fight against climate change. This would provide Turkey with prestige in the global arena. Turkey, by going through this change, would become a part of the low carbon economy and could gain comparative advantage vis-a-vis those who had lagged behind. Turkey would be ready for the challenges waiting for the world in the coming decades, and it would have the chance to move forward together with developed countries for a healthier world.

If Turkey does not make the necessary change in its policies, it might face increasing costs to continue with its existing policies. The accession negotiations between Turkey and the EU began in 2005. In 2009 the Environment Chapter was opened. Since then Turkey has harmonized a number of EU Directives into the Turkish legal system. Therefore, in accordance with various environmental EU Directives[3] mentioned above, as well as the EU's bilateral agreements with third parties on clean technologies, Turkey needs to acquire new technologies and capture, store, or reduce sulphur, carbon dioxide, and other pollutants that will otherwise increase costs and decrease Turkey's comparative advantage in both European and world markets. Concerning the old installations, it would be very costly to make the necessary changes to keep up with the requirements of these directives. For the new installations, it would again be very costly to make the initial investment in accordance with these directives.

4.5. Conclusion

The cost of fossil fuel production is expected to rise all over the world in the years to come due to the measures needed to be taken to decrease fossil fuels' environmental impacts, whereas the cost of investment and production of renewable energy is expected to decrease as new technology develops faster. Western Europe is already going through its transition to a low carbon economy: The goals have been set and the necessary policy and regulatory frameworks have been aligned with these goals. In this way, Europe will decrease its environmental impacts on the planet and attain a comparative advantage in world markets due to lower energy costs.

Taking into consideration the possible future barriers and restrictions, as well as the EU accession negotiations, Turkey would benefit from renewable energy investments to a great extent. The cost-competitiveness and evolving policy environment around the world is enhancing the growth of the renewable energy sector. In parallel with these developments, the amount of international climate and clean energy financing is also growing. The energy sector in the coming years has been evolving quickly towards a low carbon model. Those countries who can adapt to this change and take the initiative can seize the opportunity to become leaders in renewable energy production. Thus, they will be ready for the energy challenges of the future. Additionally, they will have the advantage of accessing special funds available in world markets. Turkey should get ready for the possible regional and international barriers in the energy sector. Turkey should create an enabling environment for the transition to a low carbon economy by preparing its domestic market with a supportive environment in terms of construcing a technical, political, financial, legal, and regulatory basis. To make all of these efforts visible and useful, Turkey should become a respectful part of international agreements. Turkey should not be guided by old policies and face additional costs, barriers, and penalties, deprived from a successful future. Instead, Turkey should adapt itself to the new global realities and decarbonize its economy to prepare for future challenges.

3 For an extended analysis on Turkey's compliance with EU legislation, see TEPAV (2015), "Turkey's Compliance with the Industrial Emissions Directive: A Legislation gap Analysis and its Possible Costs on the Turkish Energy Sector." The report can be downloded from http://www.tepav.org.tr/upload/files/haber/1427475571-5.Turkey___s_Compliance_with_the_Industrial_Emissions_Directive.pdf.

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PART 5

COAL-FIRED POWER PLANTS AND THEIR IMPACTS ON HEALTH

Ali Osman Karababa

Turkey's energy generation is based mainly on fossil fuels (coal, oil, gas) and water (hydroelectricity), as well as small amounts of renewables (wind and very little amounts of geothermal and solar power). Nearly one-fifth of existing energy generation in Turkey is provided by coal-fired power plants. In addition to those already existing, construction of approximately 80 new coal-fired power plants has been planned (HEAL, 2015).

No energy generation technology is completely harmless. Wind and solar power, however, are less harmful when compared to the other resources. As seen in Table 1, apart from wind and solar energy, all energy resources have negative effects on the environment and human health at various levels. Coal-fired power plants have the largest environmental impacts, which start before its combustion in power plants. Since coal mines are usually open, they create ecological damage and visual pollution due to the destruction of surrounding green cover. The air and noise pollution, as well as damage to roads and work-related accidents, resulting from large vehicles that are used for mining and transportation of minerals should be noted.

Table 1. Environmental impacts of energy resources during energy generation

Energy source	Air pollution	Water pollution	Soil pollution	Food pollution	Radiation	Acid rain	Visual pollution	Climate change
Coal	X	X	X	X	X	X	X	X
Oil	X	X	X	X	-	X	X	X
Natural gas	X	X	X	X	-	X	X	X
Nuclear	X	X	X	X	X	-	X	-
Hydroelectricity	-	X	X	X	-	-	X	X
Wind	-	-	-	-	-	-	X	-
Solar	-	-	-	-	-	-	X	-
Geothermal	-	X	X	X		-	X	-

5.1. Environmental Impacts of Coal

Coal-fired power plants operate through the transformation of water to vapor via heat energy obtained by burning coal, which is mined from open or closed mines, at different qualities (from lowest quality lignite to highest quality hard coal). At the end of the burning process, apart from the thermal energy we benefit from, ash and funnel gas at different quantities and qualities depending on the type of the coal are also released. Ash is usually mixed with water; the resulting fluid is moved to a storage area (ash dam). A significant portion of the ash exiting the funnel with gaseous waste is captured using usually electrostatic filters installed inside the funnel, and the rest is released into the atmosphere. In some power plants the sulfur in the funnel gas is captured through a desulphurization unit added to the system. Unfortunately, such units are only available in a few power plants in Turkey.

Coal is the most pollutant resource among fossil fuels, and coal-fired power plants are one of the most polluting industries. Domestic lignite of low calorific value is used in some of the coal-fired power plants in Turkey. Thus, it is inevitable that more coal would cause larger amounts of environmental pollution.

Environmental impacts of coal-fired power plants can be assessed as shown in Figure 1. From mining coal in open-cast or closed mines to the transportation of the ore to the power plants and its burning, energy generation from coal is not a clean operation.

As in all open-cast mining operations, the initial process conducted on coal sites is “stripping”, which involves complete destruction of green cover on the soil, scraping of the soil that does not contain ore, and ultimately, extracting the coal (Holmes, 2003). As seen in Figure 2, the magnitude of open-cast coal

Figure 1. Environmental impacts of coal-fired power plants

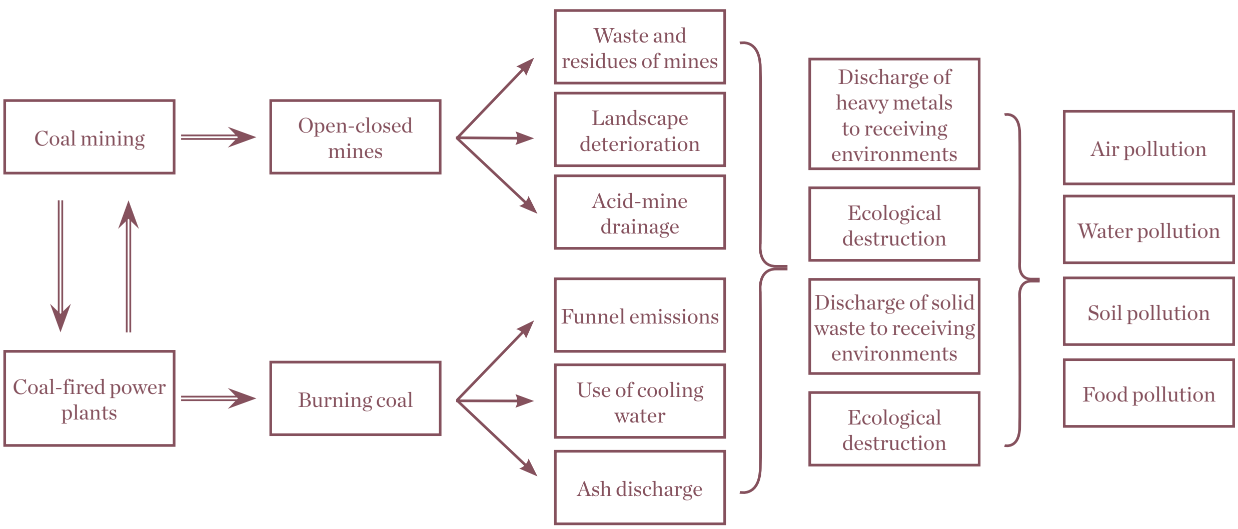
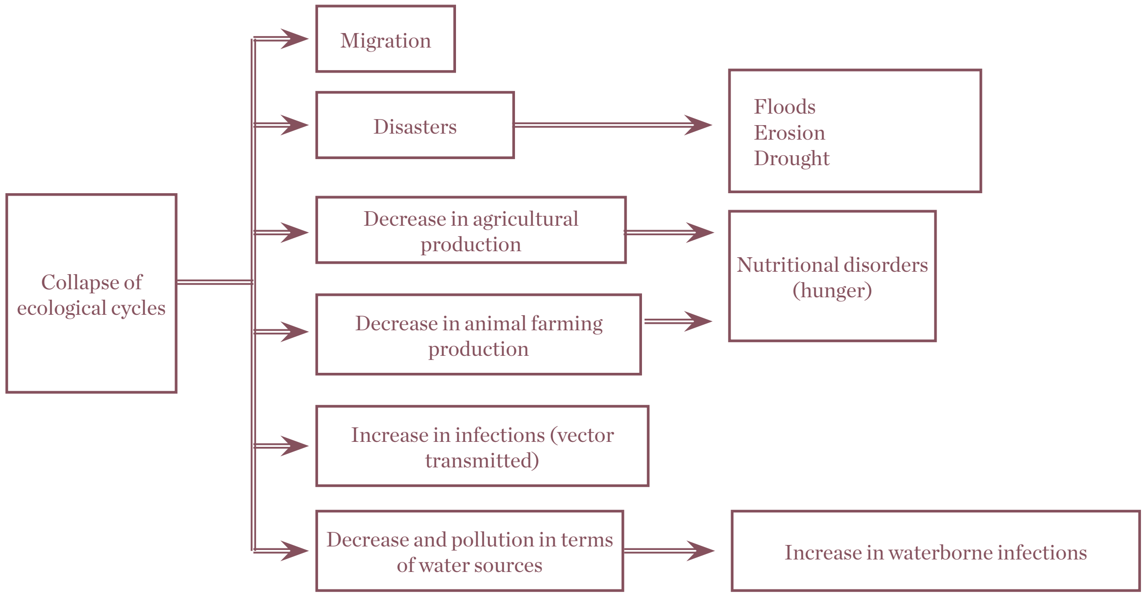


Figure 2. Anticipated impacts of ecological disasters on environment and human health (WHO, 2005)



mines, enormous pits due to working processes, and destruction of the ecosystem may result in disasters such as floods, erosion, drought, and subsequent problems of migration and environmental pollution (especially in water, soil, and thus, food) that might seriously affect human health.

Living and non-living elements in nature cannot remain unaffected. Under these conditions it is not possible for the environment to remain clean enough to support a healthy life.

Lakes where waste is stored, transportation and storage of tailings, acid-rock drainage formation, and dust from waste, as well as lack of rehabilitation, are among the safety risks of mining operations. Major environmental pollutants caused by coal mines are heavy metals, radioactive isotopes, and some chemicals (Table 2).

Figure 3. Environmental pollution impacts of thermal power plants

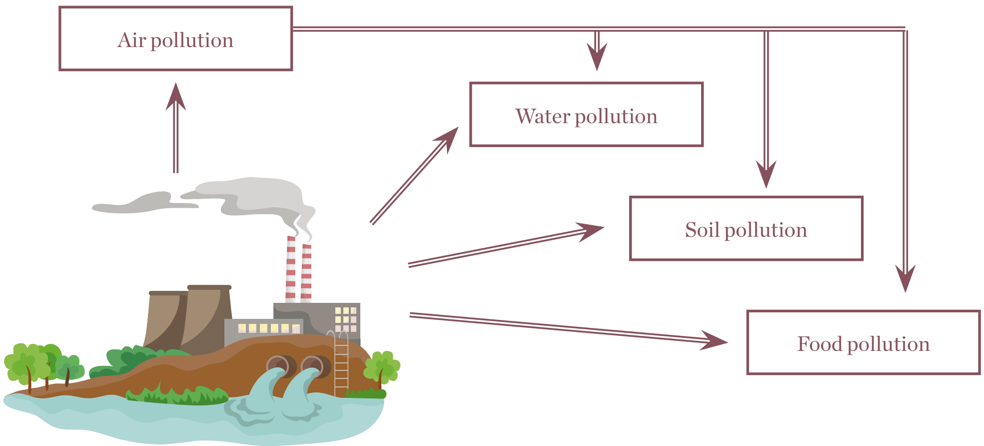


Table 2. Risks, affected areas in mining and mining business and related toxic compounds (MIT, 2013)

<table>
<tr><th>Risk</th><th>Affected area</th><th>Related toxic compounds</th></tr>
<tr><td>Overflowing the waste dam lake</td><td>Underground waters, surface waters, soil</td><td rowspan="10">Water pollutants:
- radionuclides, mostly thorium and uranium, in majority of cases
- heavy metals,
- acids
- fluorides

Air pollutants:
- radionuclides, mostly thorium and uranium, in majority of cases
- heavy metals,
- HF, HCl, SO_2 etc.</td></tr>
<tr><td>Collapse of waste dam lake wall due to poor construction</td><td>Underground waters, surface waters, soil</td></tr>
<tr><td>Collapse of waste dam lake wall due to earthquake</td><td>Underground waters, surface waters, soil</td></tr>
<tr><td>Pipe leakage</td><td>Underground waters, surface waters, soil</td></tr>
<tr><td>Faulty seal of the waste lake bottom</td><td>Underground waters</td></tr>
<tr><td>Waste rock heaps being exposed to rain</td><td>Underground waters, surface waters, soil</td></tr>
<tr><td>Dust output from waste rocks and panel strip</td><td>Air, soil</td></tr>
<tr><td>Rehabilitation failures after mining attempts</td><td>Land use, long-term soil pollution</td></tr>
<tr><td>Funnel gas not being filtered</td><td>Air, soil</td></tr>
<tr><td>No waste water treatment</td><td>Surface waters</td></tr>
</table>

Major pollutants discharged into the receiving environments from coal-fired power plants are listed as follows (MIT, 2013; EPA, 2015; Vardar and Yumurtacı, 2010; Avcı, 2005; Öztürk and Özdoğan, 2004; Curezone, 2015):

- Suspended particles
- Sulphur dioxide
- Nitrogen oxides
- Carbon dioxide
- Carbon monoxide
- Volatile organic compounds (VOC)
- Dioxins
- Hydrochloric acid
- Ash
- Radioactive substances
- Heavy metals (arsenic, chrome, cadmium, lead, mercury, copper, vanadium, nickel, zinc, selenium, antimony)

There are serious problems in choosing the right location for coal-fired power plants. Construction of coal-fired power plants close to the mines, which would decrease transportation costs, may cause serious scientific inaccuracies and social resistance. The most significant examples of such circumstances in Turkey were in Aliağa, Gerze, and Bursa. For example, the environmental impacts of the three coal-fired power plants located in Muğla, an exceptionally attractive touristic site, should be particularly noted. Yatağan, Yeniköy, and Kemerköy are three non-sanitary enterprises (i.e. an enterprise that has serious impacts on human health according to the environmental legislation) that are located very close to each other, as close as 10-40 kilometers. Thus, the effects of these three plants should be assessed together (cumulatively). These three power plants have been constantly at

Table 3. Pollutant effects of Yatağan, Yeniköy and Kemerköy Thermal Power Plants

Pollutant Effect	Yatağan (630 MW)	Yeniköy (420 MW)	Kemerköy (630 MW)	TOTAL
Thermal Effect (Kcal/sec)	2,394,000	1,596,000	2,394,000	6,384,000
Sulfur dioxide (ton/year)	238,500	189,000	283,500	756,000
Nitrogen oxides (ton/year)	163,800	109,200	163,800	436,000
Carbon monoxide (ton/year)	4,725	3,150	4,725	12,600
Solid particles (ton/year)	22,050	14,700	22,050	58,800
Hydrocarbons (ton/year)	1,575	1,050	1,575	4,200
Ash (ton/year)	35,280	23,520	35,280	94,080

the top of the environmental agenda due to their human and environmental health risks. Harmful pollutants released from these three power plants according to their energy generation capacity are calculated using standard data and presented in Table 3.

The magnitude of the data given in the table shows the extent to which the region is under a significant environmental threat. Amounts of radioactivity and heavy metals were not included in the table because there is no standard data on this.

The amount and density of the air pollutants released by coal-fired power plants, magnitude of dispersion and the duration of their effects vary depending on the following characteristics (MoE, 2011):

- Height of the funnel releasing pollutants
- Quality and quantity of the fuel
- Topographic structure of the region or the location
- Meteorological conditions (such as speed of wind and precipitation)
- Wrong site selection
- Unfiltered release of combustion products into the atmosphere
- Use of old technology

Problems resulting from the waste discharged from coal-fired power plants into the environment can be listed as follows (Avcı, 2005; Uslu, 1991 a, b):

- Impacts on natural flora and vegetation
- Impacts act on agricultural products
- Impacts on humans
- Impacts on wildlife
- Impacts on soil
- Impacts on surface waters
- Impacts on underground waters
- Impacts on air
- Impacts on settlements and archaeological sites

Airborne pollutants have also indirect impacts such as:

- Pollution of drinking and irrigation water sources
- Damage to vegetation
- Micro-climatic changes (humidity, temperature, and wind changes in the environment)

Sulfur dioxide and nitrogen oxides from coal-fired power plants mix with water in the air and cause acid rain. Acid rain adversely affects plant survival in the short-term by causing foliage to wither and die. Acid rain also changes the pH of the soil to the acidic range and disrupts soil balance, affecting plants in the long-term, ultimately killing them (MoE, 2011; Müezzinoğlu, 2000; Güler, 2012). Furthermore, the soil ecosystem in the region may deteriorate, and wildlife, plants, and human life may be adversely affected in the long-term. Agricultural production in the region decreases and may in some cases cease altogether. Therefore, governments may be obliged to pay compensation to farmers. Due to the green cover loss in these regions, erosion and flooding may increase (MoE, 2011).

Acid rain also adversely affects buildings. The destruction of a building's facade necessitates frequent repairs and, thus, economic losses. It is documented in Turkey that archaeological sites have been adversely affected by acid rain (Müezzinoğlu, 2000).

Waste from coal-fired power plants causes acidification and chemical pollution of underground and surface waters in the region. These effects may be a problem for human health in the long-term, especially as water shortages are expected to gradually increase in Turkey.

5.2. Air Pollution and Health

The health impacts of air pollution have been clearly outlined in the scientific literature since the 1950s, especially following the epidemiological studies that were carried out after the 1980s.

The International Agency for Research on Cancer (IARC), which works under the World Health Organization, identified outdoor air pollution as the Group 1 cause of cancer in humans on September 17, 2013. Based on the evidence in the scientific literature, the IARC announced that outdoor air pollution causes lung cancer and increases the risk of bladder cancer. Suspended particles, one of the most important components of outdoor air pollution, have also been listed among Group 1 carcinogenic factors in humans (IARC, 2014).

The impacts of air pollution are unquestionably a cause of a number of health problems. This associ-

Figure 4. How humans are affected by environmental effects – main factors

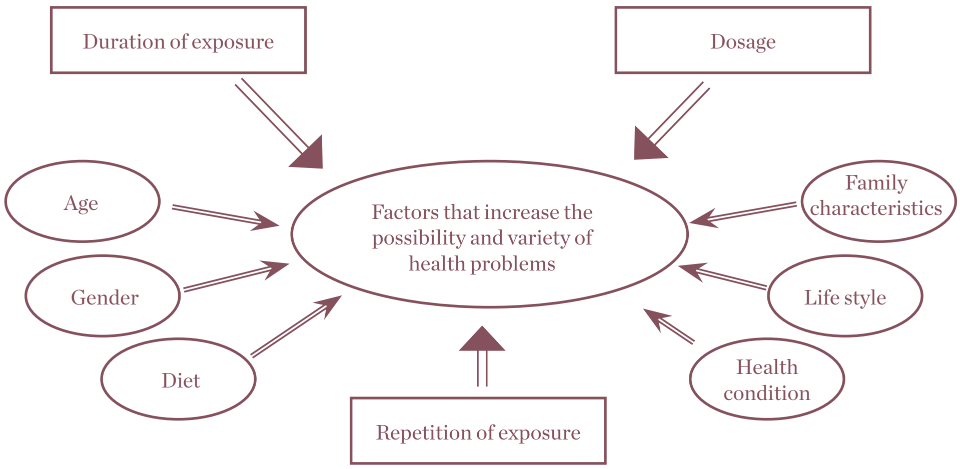
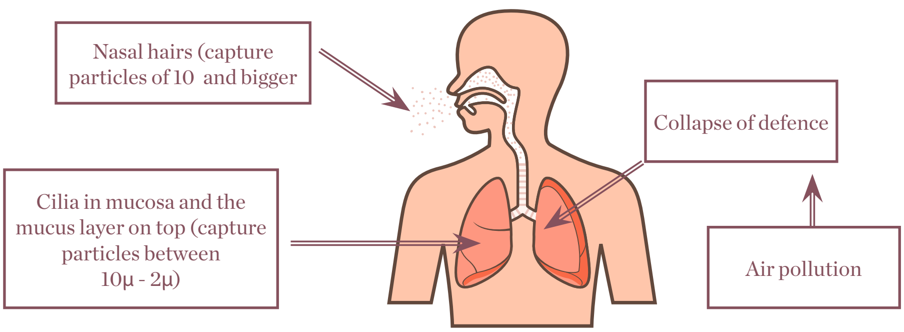


Figure 5. Respiratory system defence mechanism and the impact of air pollution



ation is clearly supported by scientific data. This is the result of a multi-component exposure process as shown in Figure 4. Even though the density of the pollution in the environment and the length of the exposure are the most important factors, health problems have been worsened due to the impact of other factors.

As seen in Figure 5, the human respiratory system has its own defense mechanism against external impacts. The first line of defense is nasal hair. Particles larger than 10 microns in the air are captured at this stage. Then, cilia of the respiration system mucosa and the mucus layer take over. Here, particles with a size of up to two microns are captured and prevented from reaching the alveoli in the lung. However, since cilia may lose their function over time, this line of defense may collapse and the lungs become increasingly susceptible to external hazards. If one lives in a polluted area and/or smokes, the dysfunction of cilia and collapse of the defense system accelerates.

The impacts of air pollution on human health are listed as follows (Moeller, 2005):

- Tendency to contract respiratory infections
- Aggravation of allergic respiratory system diseases
- Aggravation of chronic obstructive lung diseases
- Irritated eyes
- Respiratory system cancers
- Increase in the prevalence of respiratory and circulatory system diseases
- Increase in the fatality of respiratory and circulatory system diseases

It has been proven in studies that there is a direct correlation between deaths and hospital admissions when concentrations of air pollutants increase. In 2000, when air pollution from coal-fired power plants intensified and resulting social reactions increased in Yatağan, a team of specialists assigned by the Turkish Medical Association assessed that the number of in-patient treatments in Yatağan State Hospital due to respiratory diseases was two times more than the number of in-patient respiratory treatments in hospitals in central Muğla. The number of in-patient treatments for diseases such as bronchitis, asthma, and emphysema was three times higher (Uçku et al., 2000).

Studies show that a decrease in the respiratory functions of people living within the vicinity of coal-fired power plants is due to air pollution caused by these power plants (Pala, 2012).

The following are the most affected groups by air pollution (Uçku et al., 2000; Peled, 2011):

- Infants and children
- Pregnant women and nursing mothers
- Elderly
- People with chronic respiratory and circulatory system diseases
- Industrial workers
- Smokers
- Low socio-economic groups

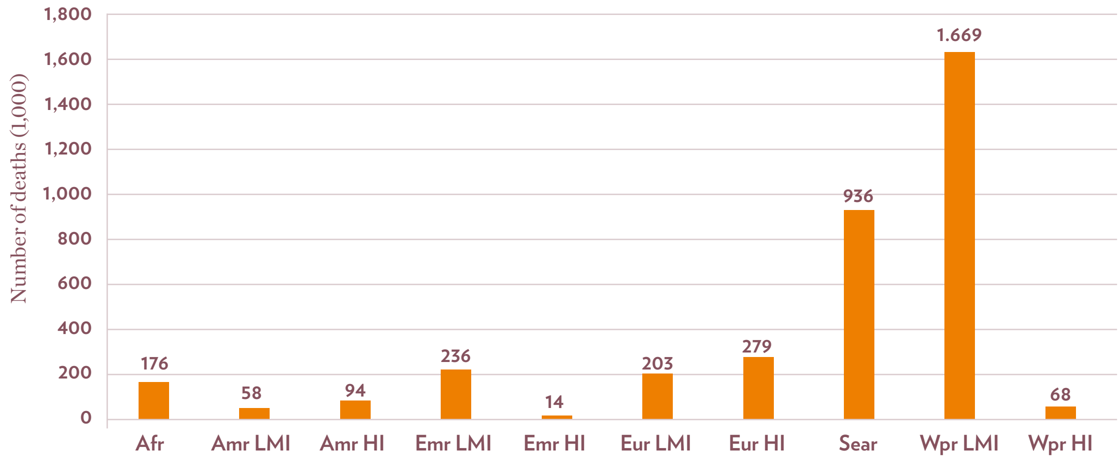
There are some historical examples of fatalities caused by short-term intensive air pollution periods. Some of these examples are (Müezzinoğlu, 2000; Wikipedia, 2015):

- 1930, Belgium, Mesue Valley: 60 deaths
- 1948, Donora, Pennsylvania: 20 deaths, 7,000 patients
- 1952, London: 4,000 deaths (12,000 according to other sources)

- 1948-1962, London: 3,500 deaths
- 1953, 1963 and 1966, New York: 1,000 deaths in total

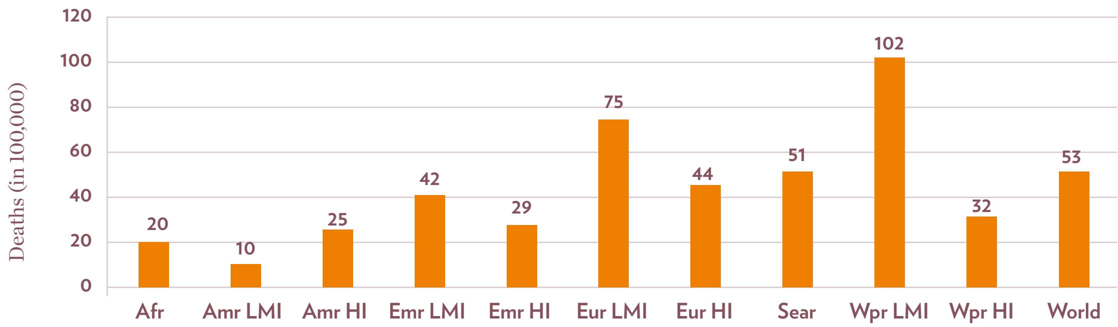
Globally 3.7 million deaths were reported in 2012 due to outdoor air pollution. 88% of such fatalities occurred in countries with low and medium income levels, which comprise 82% of the world's population. 1.67 million people died due to outdoor air pollution in the Western Pacific, 936,000 in Southeast Asia, and 236,000 in the Eastern Mediterranean. An assessment of the age and gender

Figure 6. Number of deaths associated with outdoor air pollution by regions (1,000) (WHO, 2012)



Amr: America; **Afr:** Africa; **Emr:** Eastern Mediterranean; **Eur:** Europe; **Sear:** Southeast Asia, **Wpr:** Western Pacific; **LMI:** Low and medium income; **HI:** High income

Figure 7. Number of deaths associated with outdoor air pollution by regions (100,000) (WHO, 2012)



Amr: America; **Afr:** Africa; **Emr:** Eastern Mediterranean; **Eur:** Europe; **Sear:** Southeast Asia, **Wpr:** Western Pacific; **LMI:** Low and medium income; **HI:** High income, **World:** World distributions of the deceased shows that 53% (1,937,000) were male, 25 years and older; 44% (1,632,000) were female, 25 years and older; and 3% (127,000) were children below 5 years old. Ischemic heart diseases and stroke ranked at the top among the causes of death, each accounting for about 40% of total deaths (Figures 6, 7, 8) (WHO, 2012).

These diseases, including asthma attacks, respiratory system diseases, and ischemic heart diseases, often lead to untimely deaths and present a significant public health problem as they are a direct cause of the air pollution related to coal-fired power plants. The magnitude of such problems according to the data from the Clean Air Task Force is summarized in Table 4 (Schneider, 2004).

Figure 8. Deaths associated with outdoor air pollution by diseases in 2012 (WHO, 2012)

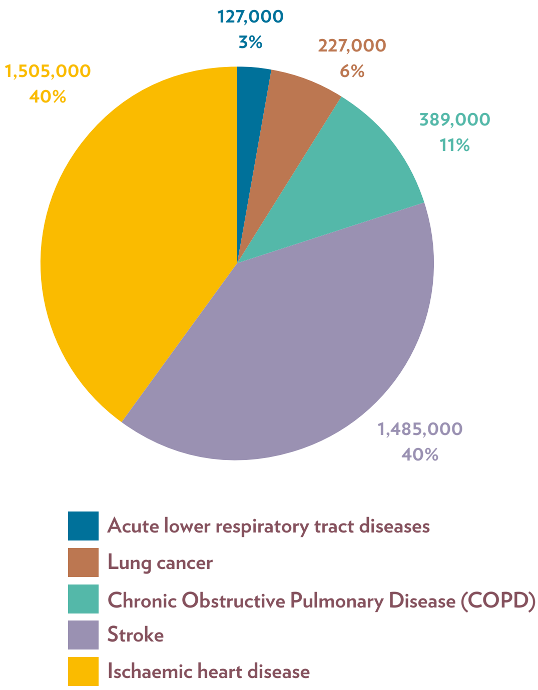


Table 4. Health impacts of thermal power plants in United States of America (annual)

Health impacts	Number of cases
Death	23,600
Hospital admissions	21,850
Emergency service admissions	26,000
Heart attack	38,200
Chronic Bronchitis	16,200
Asthma attack	554,000
Loss of work day	3,186,000

5.3. Health Impacts of Coal-Fired Power Plants

According to a report issued by the Health and Environment Alliance (HEAL), a non-governmental organization in the European Union, the health impacts of coal-fired power plants within the 27 member states are shown in Figure 9. According to the report, 18,200 premature deaths annually have been associated with coal-fired power plants. The number of workdays lost due to health-related reasons was found to be approximately 4,100,000. Although it is not ethical to measure the monetary considerations of health, the values calculated by economists show that the costs of health impacts are significant, around 42.8 billion EUR (Jensen, 2013).

The impacts of coal-fired power plants according to the assessment made for Turkey using the method in the HEAL study were published in the report "Unpaid Health Bill." According to the report, the health costs of coal power plants currently in operation in Turkey accounted for at least 2,876 premature deaths, 637,643 lost working days, and 3.6 billion EUR (Figure 10) (HEAL, 2015).

Figure 9. Health impacts of coal-fired power plants in the European Union (Jensen, 2013)

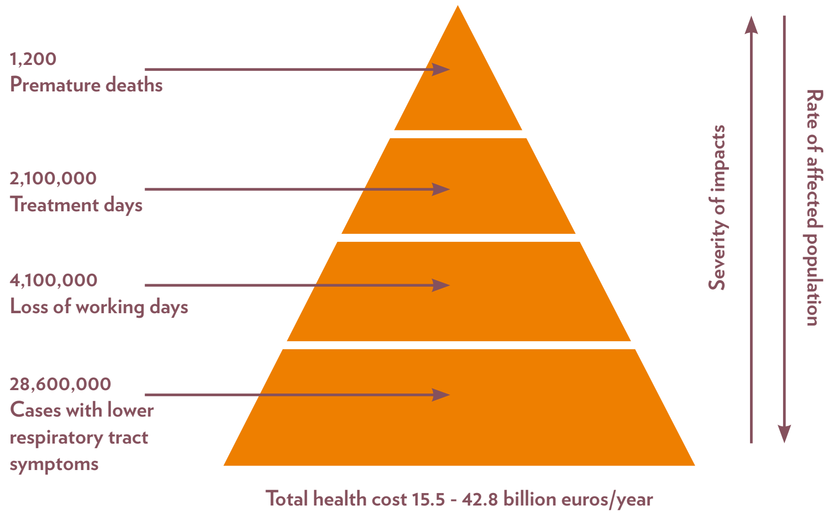
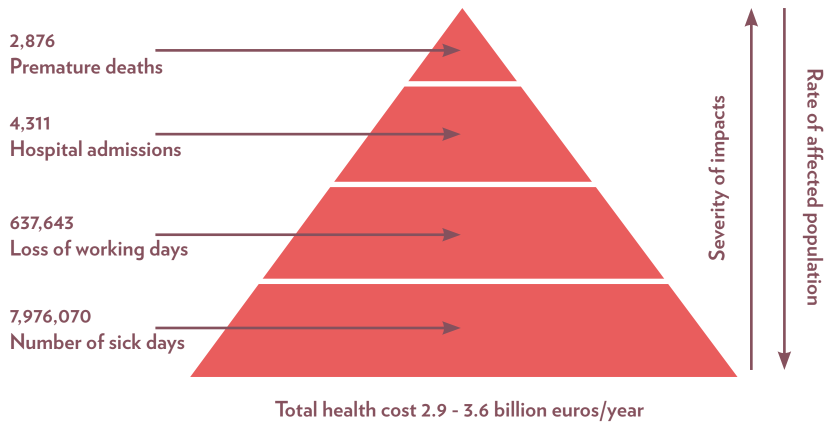


Figure 10. Health impacts associated with pollutant release from hard coal or lignite-fired power plants in Turkey



In the report's assessment on respiratory system diseases in Turkey, there are five million chronic obstructive pulmonary disease (COPD) patients (500,000 diagnosed cases) and two million children with asthma—asthma being prevalent in 5-7% of adults, too. In 2014, 25,658 people died from acute respiratory tract diseases, and 23,642 people died from respiratory cancers (HEAL, 2015).

According to the HEAL report, the health impacts associated with coal-fired power plants are presented below by affected organs and tissues (Jensen, 2013):

Lungs: Inflammation, oxidative stress, rapid progress and aggravation in COPD, increase in symptoms of respiration system diseases, impaired pulmonary reflexes, decrease in lung functions, and increase in lung cancer risk.

Heart: Autonomic dysfunction, oxidative stress, increased dysrhythmic sensitivity, cardiac repolarization disorder, increased myocardial ischemia.

Brain: Increased cerebrovascular ischemia, loss of attention, hyperactivity disorder.

Veins: Vascular occlusion, rapid progress and destabilization in the atherosclerotic plaques, endothelial dysfunction, vasoconstriction, and hypertension.

Blood: Flow changes, increased coagulation, particle displacement, peripheral thrombus, decreased oxygen saturation.

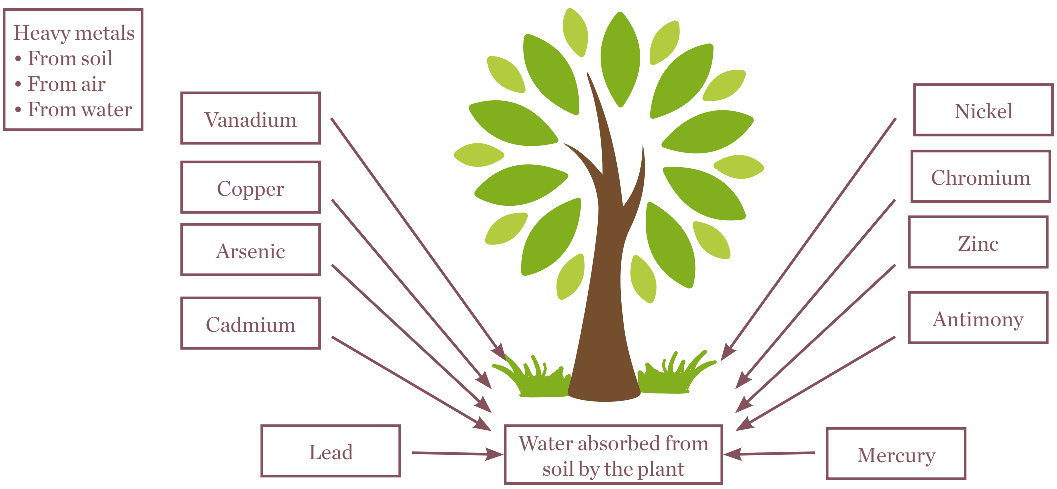
Other impacts: Low birth weight, premature delivery, skin and bladder cancers, diabetes.

5.3.1. Possible Effects of Heavy Metals on Human Health

Coal-fired power plants release different heavy metals to the receiving environments according to the composition of the coal they use (Karaca, 2001; Gür and Yaprak, 2011; Karaca et al., 2009).

As seen in Figure 11, it is understood that heavy metal pollution from coal-fired power plants enters plants and thereby the food chain through the soil, air, and water they absorb; then, the heavy metals are transferred to humans by food and adversely affect human health.

Figure 11. The involvement of heavy metals from thermal power plants in plant life



The health effects of heavy metals increase depending on the duration of exposure, re-exposure, and intensification of the amount of exposed active substances. This is also true of the health effects of heavy metals discharged into the environment from coal-fired power plants. Occurrence time and intensity of symptoms of such effects may vary depending on other variables such as proximity to the power plant, air currents and other meteorological conditions, inherent response of the individual, as well as the exposure criteria mentioned above.

Effects of arsenic on human health (ATSDR, 2007):

1. Skin reactions (Thickening of skin, darkening of skin color)
2. Hair loss
3. Easy breakage of nails
4. Anemia due to affected bone marrow
5. Disturbance of heart rhythm
6. Eye diseases (conjunctiva and cornea)
7. Severe bronchitis
8. Circulatory disorders (darkening in skin color due to affected capillary vessels, gangrene and related skin lesions and loss of limbs)
9. Deterioration of liver functions and associated hepatitis
10. Deterioration of kidney functions
11. Cancer (skin, respiratory tract, lungs, liver, kidney, bladder, prostate)

Effects of cadmium on human health(ATSDR, 2008):

1. Extreme fatigue
2. Breathing difficulties
3. Functional disorders in kidneys, liver, and digestive system
4. Increased fragility of bones
5. Cancers of different systems

Effects of mercury on human health (ATSDR, 1999):

1. Direct effects on the nervous system and accumulation in the brain
   a) Shaking in the head, hands, arms, and legs
   b) Deterioration of memory and loss of sense
   c) Changes in attitude (extreme sensitivity, aggressive behavior, and fear)
   d) Hearing loss
   e) Speech disorders
   f) Vision disorders
   g) Coordination disorders
2. Accumulation in the kidneys
   a) Decrease in filtration of blood
   b) Increased mercury accumulation in the body
   c) Increased mercury sensitivity

Effects of lead on human health (ATSDR, 2007):

1. Nervous system retention
2. Weakness in fingers, wrists, and ankles
3. Anemia due to deterioration of blood making
4. Hypertension
5. Memory loss and concentration problems
6. Brain and kidney damage (high levels of exposure)
7. Burton lines
8. Deterioration of brain development in unborn babies
9. Pale skin and mucosa, fatigue, headache and joint pain, anorexia, gastrointestinal disorders, constipation, anemia

Effects of antimony on human health (ATSDR, 1992):

1. Irritation in eyes, throat, respiratory tract
2. Urination disorders
3. Dysrhythmic heart beats
4. Various skin diseases
5. Lung and bladder cancers
6. Miscarriage in pregnant women
7. Transfer of heavy metals through breast milk, occurrence of similar symptoms in babies

Effects of zinc on human health (ATSDR, 2005):

1. Various skin diseases
2. Breathing difficulties
3. Irritation of respiratory tract and pneumonia
4. Pleurisy, hemoptysis
5. Different system cancers

Effects of chromium on human health (ATSDR, 2006):

1. Dermatitis, skin ulcers
2. Water retention in the respiratory tract, chronic rhinitis, bronchitis, chronic pharyngitis, asthma, lung cancer
3. Kidney failure, kidney function disorders
4. Liver failure and dysfunction
5. Various organ cancers

Effects of nickel on human health (ATSDR, 2005):

1. Allergenic reactions on skin, impacts on respiratory system and asthma

Effects of copper on human health (ATSDR, 2004):

1. Visual impairment and loss of vision, liver failure

Mercury should be particularly taken into consideration when coal-fired power plants and heavy metals are considered. Burning coal is one of the most significant sources of mercury released into the atmosphere from human activities. In this context, coal power plants are the largest source of mercury in Europe, and it is estimated the same goes for Turkey as well. In a material flow analysis conducted for Turkey, it was calculated that coal-fired power plants release 10,551 kg of mercury into the environment annually. Current evidence suggests that infants who have been exposed to mercury or lead either in the womb or after birth are three to five times more likely to have problems related to attention deficit and hyperactivity disorders (ADHD) (HEAL, 2015).

5.3.2 Health Effects of Radioactive Substances

Uranium, thorium, and radium are radioactive substances in the funnel emissions and ashes produced as a result of coal combustion. These substances have harmful effects on human health due to the radiation (alpha, beta, gamma rays) for long periods of time (half-life of radioactivity of radium is 1,600 years) (Nakaoka et al., 1984; Baba, 2002).

The average uranium concentration in coal samples taken from various regions of the world is 1.0±0.5 ppm, and the thorium concentration is 3.3±1.6 ppm. In the technical report published as the result of an analysis of coal and ash samples from Yatağan Coal-fired Power Plant, uranium concentration was measured as 12.8 ppm and thorium concentration as 14.4 ppm. Uranium concentration in ash was measured as 27.0 ppm and thorium concentration in ash as 24.8 ppm (Ankara Nuclear Research and Training Centre, 1993).

Ash from coal-fired power plants may contain high levels of radioactivity. Therefore, there are possible health risks for people working in and living around power plants. The radioactivity levels in volatile ash from coal-fired power plants is higher than ash produced through burning and storing in ash dams (Pandit, 2011).

As the dose, duration, continuity, and repetition of exposure increase, the possibility and variety of health problems that may occur on a societal level also increases.

Health effects likely to occur due to exposure to radiation (Moeller, 2005; Etzel and Balk, 2003):

1. Genetic effects

2. Carcinogenic effects

3. Effects on embryo and fetus

Genetic effects of radiation (MEB, 2011):

> Partial defects, deletion, duplication, displacement, and inversion of the chromosomes and punctual changes in DNA, which determines the genetic structure of humans, may emerge as a result of exposure; there are somatic disorders and increased cancer development.

Carcinogenic effects of radiation (Moeller, 2005; Etzel and Balk, 2003):

> Depending on the dosage and duration of radiation exposure, primary tissues (gonads, thyroids, breasts, etc.) containing rapidly producing cells and then tissues containing matured cells (nerve, bone, etc.) are most likely to be effected. Cancer development is expected, especially within the aforementioned tissues.

Effects of radiation on embryo and fetus (Bıçakçı, 2009):

> Problems such as the death of the embryo in cases of exposure to radiation happen within the first 10 days of pregnancy; congenital anomalies in cases of exposure to radiation happen within the first six weeks of pregnancy; and growth deficiency and functional disorders in cases of exposure to radiation happen after the sixth week of pregnancy.

5.4. Conclusion

It is clear that coal-fired power plants have serious and irreversible impacts on humans and the environment. Today, when considering the developments in the energy sector and renewable energy potential in Turkey, making investments in coal-fired power plants should be abandoned and a wiser use of limited resources in-hand should be adopted. Accordingly, there must be radical changes in the energy policies of Turkey and several steps should be taken to end the further development of coal-fired power plants:

- leading investments in renewable energy sources,
- preventing foreign dependency on energy,
- promoting energy saving, and
- improving grids.

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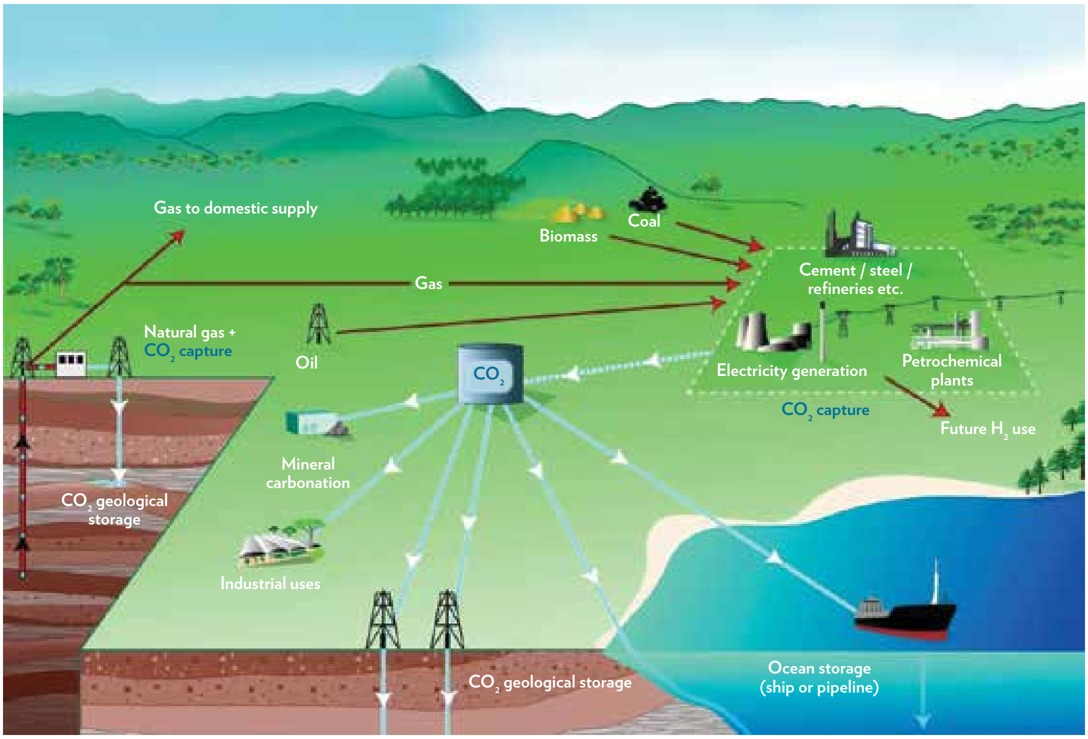
PART 6

IS "CLEAN COAL" POSSIBLE? – CARBON CAPTURE AND STORAGE (CCS) TECHNOLOGIES

Levent Kurnaz

There is no doubt that coal is the dirtiest of all fossil fuels. The CO_2 gas released when coal is burned causes climate change, and the SO_2 gas causes acid rain. Its waste pollutes the surrounding waters, and the majority of underground mercury is released into nature in this way. It would be expected that the share of energy generated from coal would decrease as renewable energy technologies and hydroelectric power improve, as well as nuclear power plants are planned. However, a substantial amount of electric energy in Turkey is generated by coal-fired power plants, and the construction of several new plants is in the pipeline.

Figure 6.1 – Schematic drawing of a possible CCS system (Source: Rubin, 2005)



Thanks to regulations that have been in place since the 70s, burning cleaner coal is accepted as a market standard. As a result, prices of clean coal technologies have dropped and their performance has increased. Technologies with cheaper prices and higher performance have significantly mitigated air pollution in the region by preventing gases such as SO_2 and NOx, as well as dust particles from funnel emissions, from being released into the environment.

Such dust and gas pollutants have mostly local impacts. In other words, it is very unlikely that SO_2 gas emitted from Yatağan coal-fired power plant would reach a tea plant in Rize. Additionally since relative success has been achieved in capturing these gases and dust, and such success has now become an industry standard, today the concept of clean coal is used more in association with the prevention of CO_2 gas, which when released into the atmosphere is the primary cause of climate change as opposed to other pollutants.

The technology for capturing and storing CO_2 gas generated by coal-fired facilities and power plants before it exits the funnel is called Carbon Capture and Storage (CCS) technology (Figure 6.1).

Before concentrating on the capture and storage methods of carbon, the question of how energy is generated in general from fossil fuels and in particular from coal will be addressed.

6.1. Energy and Heat Generation Methods

The oldest of the fossil fuels is coal. Generating mechanical energy by burning coal — in other words the technology for using the heat generated when coal is burnt to turn a piston — has been commonly used throughout the world since the last quarter of the 18th century. Such technology is utilized by heating the water kept in a boiler using the heat generated by burning coal, oil, or natural gas and converting heat into such mechanical energy as a result of the heated water or vapor spinning a fan. The mechanical energy generated can be directly used or transported to remote distances through electricity lines after being easily converted to electric energy. Pursuant to the law of thermodynamics, it is not possible to convert all of the heat generated into mechanical energy. Therefore, when we generate electric energy from fossil fuels in this way, a substantial amount of heat produced is lost. The problem here is related to the laws of nature rather than the lack of skill or ignorance of humanity.

Current technology is able to generate energy from coal through three main processes while striving to maintain the highest level of efficiency:

Combined Cycle Power Plant: In the traditional method, the heat generated from burning coal heats the water, and heated water moves and spins a fan. However, the gas exiting the funnel after the fuel is burnt is in fact hot and can be used to heat the water in another boiler instead of being released into the atmosphere. Naturally the second boiler would not reach a temperature as high as the first one, yet still the generation efficiency in this method is much higher. This method is generally used in natural gas power plants, but there are also examples of using the gas obtained from oil or coal as fuel.

Pulverized Coal Power Plant: When hearing about conversion of heat generated from coal to mechanical energy, one may think of trains or the machinists that feed coal to a boiler in Western movies. However, in industrial applications, feeding coal to the boiler in such a way and burning the coal using the air received from outside leads to the loss of efficiency. Instead, the coal is pulverized into powder and burned using pre-heated air. This method increases efficiency when compared to traditional methods. Nearly half of the electric energy generated in the world is produced through such a method.

Using either of the two methods mentioned above, additional pollutants inside the coal such as sulphur or mercury would be released to the air after burning.

Integrated Gasification Combined Cycle Power Plant converts coal into a mixture of hydrogen and carbon monoxide, and then clears the remaining pollutants. Energy efficiency here is relatively low, and nearly all of the power plant emissions are vapor and carbon dioxide.

Energy is generated in power plants by burning fossil fuels using the various methods listed above. The ratio and pressure of the carbon dioxide resulting from these methods is the most important factor determining which carbon capture method should be used.

6.2. Carbon Capture Methods

Carbon capture can only be applied to large industrial sources. On a large scale, CO_2 sources consist of combustion of fossil fuels or biomasses, industries with high CO_2 emissions, natural gas production, synthetic fuel industries, and fossil fuel-based hydrogen production facilities. Obtained CO_2 can be placed, after being compressed, into geological structures (such as used oil or natural gas wells or deep salt formations), oceans, and mineral carbonates, or it can be transported for use in other industrial operations later.

Carbon capture methods are not coal specific; they can be used for all fuels that release CO_2 into the atmosphere.

The main carbon capture methods are pre-combustion capture, post-combustion capture, and oxyfuel combustion capture. In determining which capture system to use, the most important parameters are CO_2 concentration in gas flow, pressure of gas flow, and the type of fuel.

Post-combustion capture systems separate carbon dioxide from the funnel gas produced after the main fuel burns due to contact with air. Just 3-15% of the funnel gas is CO_2, and the rest is mostly nitrogen. CO_2 is separated from the rest of the air by passing it through a liquid solvent such as monoethanolamine (MEA).

Pre-combustion capture systems produce hydrogen and carbon monoxide by processing the main fuel with vapor and air in a reactor. CO_2 and more hydrogen are acquired through the reaction of obtained carbon monoxide with vapor in a second reactor. The CO_2 and hydrogen mixture can easily be separated into two as CO_2 and hydrogen. The hydrogen obtained here is a decarbonized fuel and can be converted into power or heat by being mixed with oxygen. Even though this process is initially more difficult and expensive than post-combustion systems since the produced CO_2 gas is denser with a much higher pressure, the separation at the end is much easier. It is not possible to install this system into an operating power plant; it can only be used through construction of power plants that operate with this system. On the other hand, when used properly much more efficient combustion and carbon capture can be achieved than with classic systems.

Oxyfuel combustion is designed so that the combustion of the coal takes place in pure oxygen rather than in air. In this case there is no other gas in the funnel gas except vapor and carbon dioxide. Therefore, separation of carbon dioxide is easier. The difficult part is to separate the oxygen from the air. In most models the oxygen is 95-99% pure. Thus, the remaining nitrogen should be separated from the carbon dioxide. Oxyfuel systems are at the testing stage and are used in natural gas-operated power plants rather than coal-fired power plants.

Regardless of which one of the aforementioned methods is used, capturing and storing carbon instead of releasing it freely into the atmosphere requires energy. In addition, since it is necessary that either such capture systems should be added to old power plants or new power plants should be built with these methods, it is a more expensive technology than releasing carbon freely into the atmosphere.

6.3. Transportation Methods of the Captured Carbon

If the factories in which carbon capture takes place are not exactly on the geographical point in which the carbon is stored, the captured carbon needs to be transported to its storage point. Captured carbon can be transported through either of two basic methods: Transportation via pipeline or transportation via land-sea.

Currently, *pipelines* are a matured technology used for transportation of carbon dioxide. The transportation of carbon dioxide through pipelines under high pressure after being compressed has been successfully implemented since the 70s. The purpose of this method is to transport the carbon dioxide to primarily assist in bringing up petrol and natural gas. In this case, it is expected that the carbon dioxide will separate from the nitrogen. Since industry standards are determined by field of use, for pipelines to be used in CCS, especially if the line is passing through communities, attention should be paid to low H_2S density, more careful selection of the path, special protection against high pressure, and prevention of blowouts. In addition, dry carbon dioxide is not corrosive to steel pipelines. Yet, since carbon dioxide, which is obtained at the end of a natural process, also contains vapor, it is highly corrosive. This, in turn, increases infrastructure costs several folds since pipelines should be covered with a special alloy.

Apart from pipelines, *transportation via land and sea* are alternative ways to carry carbon dioxide. In land transportation, railways or tankers can be used; however, when the amount that needs to be transported is considered, instruments provided by land transportation are both limited and expensive. Maritime transportation becomes cheaper especially as the distance increases. The share of carbon dioxide in maritime transportation is not too high, and the reason for this is the low demand. It can be anticipated that the amount transported easily increases with the increase in demand because the characteristics of LPG gas, which is transported via sea, very much resemble those of carbon dioxide. Therefore, systems used for carrying LPG can easily be adapted to the transportation of carbon dioxide. Although accidents may occur in LPG transportation, it is known that this type of transportation is safer than pipelines. In addition since carbon dioxide is less dangerous than LPG, problems regarding safety will be fewer.

In this case there are two important factors affecting the selection of transportation methods: amount and distance. If a small amount of carbon dioxide is carried over a short distance, the most reasonable solution is to transport it via land using tankers. On the contrary, if we are going to carry a big amount of carbon dioxide for a long distance, the best solution should be, if possible, maritime transportation, if not, via pipeline.

It is important to keep in mind that even though such solutions are sure to resolve possible problems, none of these transportation methods have been tested on an industrial scale in terms of being able to carry the required amount.

6.4. Storage Methods of the Captured Carbon

There are three technical problems that are addressed under the carbon capture and storage heading: capture, transportation, and storage of carbon. Among these three headings, the subject for which we have the least technical knowledge and skill is storage. In theory, there are at least three primary methods to store the captured carbon: geological storage, underwater storage, and mineral carbonation. In geological storage the carbon dioxide is stored within rocks underground. In underwater storage the carbon dioxide is carried to the depths of the ocean and released.

Since the water cycle in the oceans is very slow, this released carbon dioxide is expected not to mix with the atmosphere for a long time. In mineral storage, a reaction is created between the carbon dioxide and the minerals in the rocks on the earth to change the structure of the minerals and, thus, nearly infinite storage of carbon dioxide is enabled.

Geological storage means that carbon dioxide is stored in rocks underground. Oil and gas fields, deep salty water structures, and unused coal beds are on top of the list of locations planned to be used for such purpose. The common characteristic of these storage areas is that they are composed of permeable sedimentary rocks. Carbon dioxide under high pressure will be stored by being injected in these rocks. These storage areas might be under land or sea.

The annual greenhouse gas emissions of all countries in the world correspond to approximately 50 billion tons of carbon dioxide, whereas the amount of carbon dioxide per year that can be stored in carbon storage projects that could be operated until now is only around five million tons. In other words, despite the efforts and investments that have been made on this topic for years, only one ten-thousandth of the released carbon dioxide can be stored. This shows that storage efforts are still very primitive when compared to capture and transportation efforts.

Each year approximately 30 million tons of carbon dioxide is injected into oil and natural gas wells to bring up more oil and natural gas. Oil and natural gas exist underground under high pressure. This is the reason why petrol sprays when an oil well is first drilled. But, in time as the oil in the oil field decreases, its pressure also decreases and stops spraying automatically. Thus as a solution, it was decided to inject gas into such wells and enable the petrol to surface. This method is called *Enhanced Oil Recovery – EOR*. The most important gas used in the EOR technique is carbon dioxide. However, before this process is marked as a success for storing more carbon dioxide, it should be known that the purpose of such operation is to bring up petrol, which would emit more carbon dioxide into the atmosphere.

EOR is one of the most important technologies foreseen in the future. However, this simple logic should be kept in mind: When the oil output is burned, the whole of the carbon dioxide that mixes in the atmosphere and is put in the same oil field cannot be captured. Some of it will surely stay in the atmospheric system and cause the world to heat. But then why is the petrol drilled out and then stored underground instead of just leaving it where it belongs?

Carbon dioxide injected in oil or salty water structures deeper than approximately 800 meters is in liquid form. This is due to the pressure and temperature at that depth. Since the density of liquid carbon dioxide is less than the density of water, buoyancy pushes carbon dioxide to the top. Two main mechanisms are used to prevent this from happening. As one could guess, the first is to close the bed with a durable rock, and usually such beds are selected. However, this durable and impermeable rock only prevents the gas from moving upwards. It cannot prevent its lateral movement. Save that lateral infiltration is much slower, this movement is supposed to be prevented by geochemical capture. What is meant by geochemical capture is dissolution of carbon dioxide in water. Over hundreds or thousands of years, water in which the carbon dioxide is dissolving becomes heavier and sinks to the bottom. This water that has sunk reacts with the rocks at the bottom and forms solid carbonate minerals over millions of years. In this way it is anticipated that the carbon dioxide injected into the rocks is removed from the atmosphere not to return for millions of years.

Another method of storing carbon dioxide injected into coal beds that are difficult to drill has been to replace it with the methane in such mines for a long time. This method is called *Enhanced Coal Bed Methane Recovery – ECBM*. Although some carbon dioxide is kept underground, this method was developed for commercial use of methane gas, which is supposed to remain underground.

As a result, there is enough space underground to store all carbon dioxide produced. However, very significant technical and legal steps should be taken for this storage to function. Even when all these steps are taken, there is no guarantee that the carbon dioxide injected underground is not escaping rapidly to mix with the atmosphere again. Still, underground storage is considered as the most suitable method to store carbon dioxide today.

Underwater storage method aims to store carbon dioxide in the depths of the ocean, thus isolating it from the atmosphere for centuries to come. Carbon dioxide is carried to the storage location through pipelines and vessels and is then injected into the depths of the ocean. Despite being theoretically possible, it has not been tested with a functional system.

70% of the world's surface is covered with oceans, and the average depth of the oceans is 3,800 meters. Carbon dioxide in the atmosphere penetrates through the first 100 meters of the depth of the ocean but after is dissolved. Since vertical mixing is very slow in the oceans, it would take thousands of years for the carbon dioxide, which is dissolved in the upper level, to spread towards the bottom. Nearly 40% of the carbon dioxide that has been released since the beginning of the industrial revolution has been absorbed and continues to be absorbed by the oceans. However, independent of the amount released into the atmosphere, oceans can absorb approximately six billion tons of carbon dioxide each year.

Carbon dioxide can be injected into the oceans via two methods: spraying and forming lakes. In the spraying method carbon dioxide is mixed into the water through a pipe that goes to the depths of the ocean. If this operation is carried out at a deep place, the heap formed sinks to the bottom; if it is carried out on the upper levels, it slowly rises to the surface. To form lakes, the pipe is extended over three kilometers into the bottom of the ocean, and carbon dioxide is injected into that spot until it forms a lake on the bottom of the ocean.

In the models, how much of the carbon dioxide would stay in the ocean and not mix into the atmosphere depends on the depth it is injected. As an example, if 800 meters is selected as the injection depth, 22% of the carbon dioxide injected until the end of this century would surface and mix with the atmosphere. If 3,000 meters is selected as the injection depth, after 500 years 71% of the injected carbon dioxide would still remain in the ocean.

The amount of time it takes for the injected gas to rise into the atmosphere again increases as the injection depth of carbon dioxide increases. But, at the same time, injection costs also increase with injection depth and the number of places that can be found at such depth decreases. Since problems associated with injection at insufficient depths would extend over the long-term, the establishment of control and legal mechanisms on this subject is extremely important.

Carbonic acid forms when carbon dioxide dissolves in water and this, in turn, changes the acidity of the oceans. It is known that the pH value of the oceans has decreased by 0.1 since the beginning of the Industrial Revolution. This figure might appear insignificant to most, but for the majority of marine life even the slightest change in the pH value is critical.

Small shellfish living in the upper levels of the sea is nature's primary way of absorbing carbon dioxide from the atmosphere. These creatures use the carbon dioxide they get from the water to build shells for themselves. Then, when they die, they sink to the bottom of the sea and form sedimentary rock. However, being able to build shells deeply depends on the acidity of the water. Since a small increase in the acidity of water makes it harder for them to build shells, it would also hinder one of nature's most important carbon dioxide absorption mechanisms from taking place in the atmosphere. It is anticipated that the change in the pH value of the upper layer of the ocean would increase in the 0.3-0.4 range after carbon dioxide is injected into the depths of the ocean. This is one of the most substantial obstacles in terms of storing carbon dioxide in the oceans.

Mineral carbonation is the soundest method that ensures carbon dioxide is removed from the atmosphere for a long time. In this method alkali and soil alkali metal oxides such as magnesium oxide and calcium oxide react with carbon dioxide to form magnesium carbonate and calcium carbonate. The amount of metal oxides on silica rocks on the world's surface is adequate for storing all of the carbon dioxide that the entire world produces.

Since the product obtained at the end of mineral carbonation is in fact rock, it is not possible for carbon dioxide to be released back into the atmosphere, and this eliminates the obligation to control storage sites for long periods of time. The produced rocks also have a variety of utilization fields such as road construction.

However, the biggest problem with the mineral carbonation is that it is the most expensive method. The main reason for this is due to the requirement to obtain minerals to be used in mineral carbonation by using methods similar to those used for open coal mines. Therefore, the environmental impacts of the mining methods to be used for mineral carbonation should be carefully analyzed.

6.5. Cost of Carbon Capture and Storage

The costs of carbon capture and storage can be broken down into three individual categories: carbon capture, transportation of captured carbon, and storage. For example, Afşin-Elbistan B Coal-fired Power Plant consists of four units, and each unit generates 360 MW of energy.

There are two methods to generate 360 MW of electric energy from coal: pulverized coal power plants (Afşin-Elbistan operates in this method) or integrated gasification combined cycle power plants. The initial set-up cost of pulverized coal power plants is approximately 460 million USD. If this power plant is designed so that it captures carbon, then the cost increases to 750 million USD, i.e. 63%increase. On the contrary, if the same power plant is designed as an integrated gasification combined cycle power plant, initial production costs would be approximately 480 million USD, i.e. only 4% more than the first type. However, if an integrated gasification combined cycle power plant is designed so that it captures carbon; the cost becomes 660 million USD. This is 35% more than the original cost. In other words, if the initial cost structures of all power plants are designed to release the least amount of carbon, it is even possible to be profitable during the construction stage.

Each unit of Afşin-Elbistan B Power Plant releases nearly 280 tons of carbon dioxide per hour. With carbon capture technologies, it is possible to capture nearly 86% of this release. An expenditure of 41 USD per ton is required to achieve such a rate. This means that the price of electricity should be increased by 57%. If this power plant was designed as an integrated gasification combined cycle power plant, carbon capture cost per ton would be 23 USD, and the price of electricity would have increased by 33%. Here, it can be seen how high the price of not paying attention to carbon emissions when the initial investment decision is made would be if it was decided to capture carbon later.

Therefore, when it comes time to decide the fate of coal, systems that can meet future carbon capture requirements should be preferred.

If a pipeline is set up that carries carbon dioxide produced by the Afşin-Elbistan power plant 1,000 km away, the cost of the pipeline would be 8 USD per each ton of carbon dioxide carried in such a way. Maritime transportation, which can be a more suitable solution for some countries in the world, is more expensive than the pipeline if carbon dioxide is to be transported for a distance less than 1,000 km; however, over 1,000 km via maritime transportation becomes cheaper than pipeline transportation. For example, while transporting carbon dioxide via sea for 3,000 km costs 25 USD per ton, the cost of pipeline transport would be 40 USD per ton. Since there are not many natural gas and oil wells in Turkey, this transportation distance may be a lot longer.

The cost of storing carbon dioxide underground varies between 0.5-8 USD per ton. Usually, this cost is dependent on the cost of using depleted oil wells. Since there are not many oil fields in Turkey, it would be accurate to calculate the cost using the upper limit.

Similarly, carrying carbon dioxide via pipeline 500 km from the shore and sending it under the sea requires a cost of 30 USD per ton. Doing the same thing with tankers would cost 15 USD per ton.

Therefore, currently capturing the carbon dioxide produced by Afşin-Elbistan coal-fired power plant, compressing it, carrying it via pipelines to the Black Sea coast, then sending it to the depths of the Black Sea through another pipeline costs approximately 80 USD per ton.

Let us consider the use of a 1 kW electric heater used to heat a house and for an hour. When electric energy generated from coal is used, if we want to capture and store the carbon dioxide, the cost of the energy used would increase by six cents (USD), i.e. approximately 15 kurus (in TRY). This is the lowest cost needed to pay for this on top of the regular electricity bill.

6.6. Legal Dimension of Carbon Capture and Storage

Although carbon capture is a process that should be performed today, it must be ensured that captured carbon will be stored for centuries and does not escape from such storage. The requirement to store this carbon for such a long time entails legal challenges that do not exist in many other fields.

First of all, carbon storage should be constantly controlled in order to ensure that the stored carbon dioxide does not leak. Constant controls would mean a serious economic burden over the long-term. The company or body responsible for storing the carbon dioxide should also undertake the burden of performing such controls. This responsibility means that the company would sign an uncertain commercial agreement. If such company shuts down or goes bankrupt in the future, it should be discussed how the control obligation will be continued. The most natural and correct solution here is to take such responsibility from the companies and assign it to the governments. In order to be able to do this, governments will need to ask for the long-term costs of such controls in cash from the companies that carry out the storage. Even though economically this storage cost is spread over the long-term, these measures would seriously increase the initial storage cost. Therefore, the legal regulations required for a technological model, the trials of which are still ongoing, to operate should also be urgently drafted. When this problem is first experienced, since governments do not have a sense of performing work or having work performed in such a long-term period and the rules and corresponding sanctions are yet to be determined, such a situation carries the potential to cause significant damage within the communities of such governments.

On the other hand, the occurrence of unexpected leakages during transportation and the storage of carbon dioxide can lead to the loss of life and property. Although assigning responsibility for the leakages during transportation is not too hard, for leakages that may occur following a long period of storage, it can be very hard, even impossible, to find a respondent. Since the insurance systems normally used for such circumstances cannot provide coverage for so long, the responsibility again falls to the governments. This shows that the government cannot leave the issue to the determination of the free market and should establish control during either transportation or storage. Even though today countries present carbon capture and storage as the solution of the future, they have not elaborated and developed policies on what their responsibilities in the future will be. Lack of policy in this case could possibly show the weakness of the free market in the short-term as well as harmful effects in the long-term as unregulated use of hazardous methods in the technologies produced would be likely.

6.7. Conclusion

Carbon capture and storage technologies are methods designed to be able to maintain coal-fired industrial systems. The most important factor in order for these methods to function is economic sanctions. So long as these systems consider the carbon dioxide they release into the air as an exteriority, expecting adequate carbon capture and storage cannot be anything more than a dream. If it becomes mandatory for all industrial facilities to pay a fee for the greenhouse gas they release into the atmosphere and as such are forced to convert their exteriority into internality, carbon capture and storage technologies may be utilized. However, determining the cost of carbon capture and storage per ton will certainly lead such facilities to choose whether to accept the penalty or to release the carbon dioxide instead.

The natural first choice in terms of burning coal is to leave the coal underground without burning it. Using the energy it receives from the sun, nature has spent millions of years putting carbon dioxide from the atmosphere underground. By finding such concentrated forms of this energy and burning it, we have spent millions of years of nature's work in the last 250 years. Now what we are trying to do is to store the carbon dioxide underground just like nature has done but in a very imbecilic way. This vanity of humanity, thinking that it can perform such a process better than nature, has led to perhaps the biggest problem in the history of mankind. Even though it may not be the solution to this problem as a whole, carbon capture and storage may be one of the most important methods to prevent the problem from getting worse. In addition to technological developments, urgent work should be done on the legal aspects of this method in order for it to be able to function.

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