20-20-20 OBJECTIVE OF THE EU AND SITUATION OF TURKEY

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ABSTRACT

20-20-20 OBJECTIVE OF THE EU AND SITUATION OF TURKEY

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European Union climate and energy package, known as “20-20-20 objective”, is a highly ambitious agreement among the member countries of the European Union that mainly focuses on greenhouse gas emission, renewable energy and energy efficiency. After tough negotiations between members, the agreement was adopted at the European Council and voted and accepted by the European Parliament on December 2008.

According to the agreement, first target is at least 20% reduction in greenhouse gas emission of the European Union until 2020 according to 1990 level. Second one is increasing the share of renewable sources among all energy sources up to 20%. Third one is that 20% increase in energy efficiency is aimed so that around 20% saving of energy consumption with the same economic and industrial pace of activity is achieved by 2020. These targets are specified in order to make the European Union a leader in the fight against global warming and to be an example for the rest of the world.

2020 targets of the EU are not directly binding for Turkey as it is not a full member country yet. On the other hand, Turkey specified its own energy targets for 2023 in line with the EU acquis.

In this thesis; 20-20-20 objective of the European Union, reasons behind the agreement, achievements performed so far and feasibility of the targets are going to be analyzed. Moreover, circumstances in Turkey in terms of its 2023 energy targets are going to be investigated in details. In addition, situation of Turkey is going to be compared with the European Union and with the projections of the next five years; some suggestions are going to be offered.

Keywords: 20-20-20 objective, global warming, energy efficiency, renewable energy, carbon emission

ÖZ

AB'NİN 20-20-20 HEDEFİ VE TÜRKİYE'NİN DURUMU

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Avrupa Birliği'nin "20-20-20 Hedefi" olarak da bilinen iklim ve enerji paketi, Avrupa Birliği üye devletleri arasında, temelde sera gazı salınımı, yenilenebilir enerji ve enerji verimliliği üzerine odaklanan, büyük hedefleri olan bir anlaşmadır. Üyeler arasındaki zorlu müzakerelerin ardından, Avrupa Konseyi'nde kabul edilmiş, Aralık 2008'deyse Avrupa Parlamentosu tarafından da oylanmış ve yürürlüğe girmesine karar verilmiştir.

Anlaşmaya göre, ilk hedef sera gazı salınımının 2020 yılına kadar 1990 yılı seviyesinin %20'sine düşürülmesidir. İkinci hedef ise yenilenebilir enerji kaynaklarının tüm enerji kaynakları arasındaki payının %20'ye çıkarılmasıdır. Üçüncü olarak, enerji verimliliğinde %20 artış amaçlanmaktadır. Bu sayede, 2020 itibariyle, aynı iktisadi ve endüstriyel ilerleme seviyesinde, enerji tüketiminde yaklaşık %20 tasarruf sağlanabilecektir. Bu hedefler Avrupa Birliği'ni küresel ısınmada lider yapmak ve dünyadaki diğer ülkelere örnek olmak amacıyla ortaya konmuştur.

Türkiye Avrupa Birliği'ne üye olmadığından 2020 hedefleri Türkiye'yi doğrudan bağlamamaktadır. Öte yandan Türkiye AB müktesebatına uyum sağlamak için kendi 2023 enerji hedeflerini belirlemiştir.

Bu tezde, Avrupa Birliği'nin 20-20-20 hedefi, anlaşmanın ardında yatan sebepler, şu ana kadar kaydedilen başarılar ve hedeflerin uygulanabilirliği incelenecektir. Ayrıca, Türkiye'nin 2023 hedefleri açısından durumu ayrıntılı bir şekilde araştırılacaktır. Buna ek olarak, Türkiye'nin durumuyla Avrupa Birliği'ninki karşılaştırılacak ve önümüzdeki 5 yıllık tahminler ışığında bazı önerilerde bulunulacaktır.

Anahtar Kelimeler: 20-20-20 hedefi, küresel ısınma, enerji verimliliği, yenilenebilir enerji, karbon emisyonu

To Pınar…

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TABLE OF CONTENTS

LIST OF FIGURES

FIGURES

LIST OF TABLES

TABLES

LIST OF ABBREVIATIONS

CPV	: Concentrated Photovoltaics
CSP	: Concentrated Solar Power
EMRA	: Energy Market Regulatory Authority
EPA	: Environmental Protection Agency
ETS	: Emission Trading System
EU	: European Union
GDP	: Gross Domestic Product
IEA	: International Energy Agency
IGCC	: Integrated Gasification Combined Cycle
INDC	: Intended Nationally Determined Contribution
LULCC	: Land Use and Land Cover Change
LULUCF	: Land Use, Land Use Change and Forestry
NASA	: The National Aeronautics and Space Administration
OECD	: The Organization for Economic Co-operation and Development
OTC	: Over the Counter
PV	: Photovoltaics
RES	: Renewable Energy Sources
TOE	: Ton of Oil Equivalent
UNFCCC	: United Nations Framework Convention on Climate Change

CHAPTER 1

INTRODUCTION

1.1 Global Warming

Global warming is defined as average temperature increase of earth's surface, atmosphere and oceans that has occurred gradually over the past two centuries. Average temperature of Earth has risen by 0.8 °C from the beginning of 20th century and by the end of 21st century, another 0.3 to 4.7 °C increase is estimated by Environmental Protection Agency (EPA) [1].

In Figure 1, temperature anomaly data of NASA from the year 1880 can be seen.

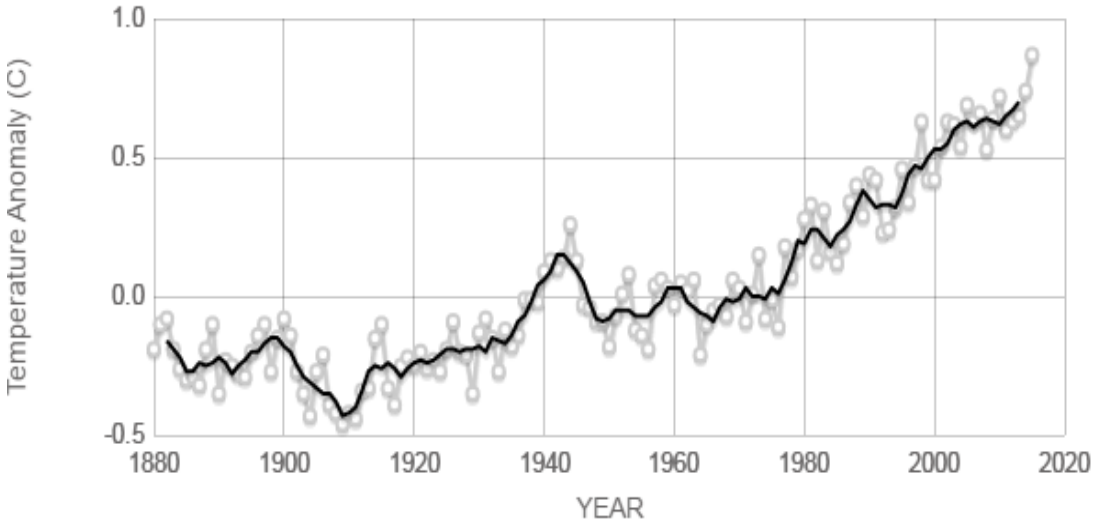

Figure 1 Global Temperature Anomaly [2]

Human activities since the Industrial Revolution are considered as primary reasons of global warming. Burning fossil fuels for heating and electricity generation, deforestation and industrial processes releases greenhouse gases to the atmosphere. Actually, greenhouse gasses are necessary to keep the temperature of Earth at a habitable level since they absorb sunlight that is reflected from Earth's surface and oceans. However, presence of enormous amount of greenhouse gasses in the atmosphere causes a dangerous warming of the globe that is called the Greenhouse Effect.

The most prevalent greenhouse gasses are Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O) and Fluorinated gasses.Carbon dioxide, which is released to the atmosphere mostly by human activities, is the main source of global warming. Main contributor of carbon dioxide emission is combustion of fossil fuels such as coal, oil and natural gas. Second large contributor is deforestation. When the trees are cut, they release carbon that they stored by photosynthesis. Moreover, since they are the main factor of carbon absorption from the atmosphere, deforestation also contributes to global warming by absorbing less carbon dioxide. Industrial processes are other contributors to carbon dioxide emission. In Figure 2 from NASA, it can be seen that Carbon dioxide level in the atmosphere is at the highest level in history [3].

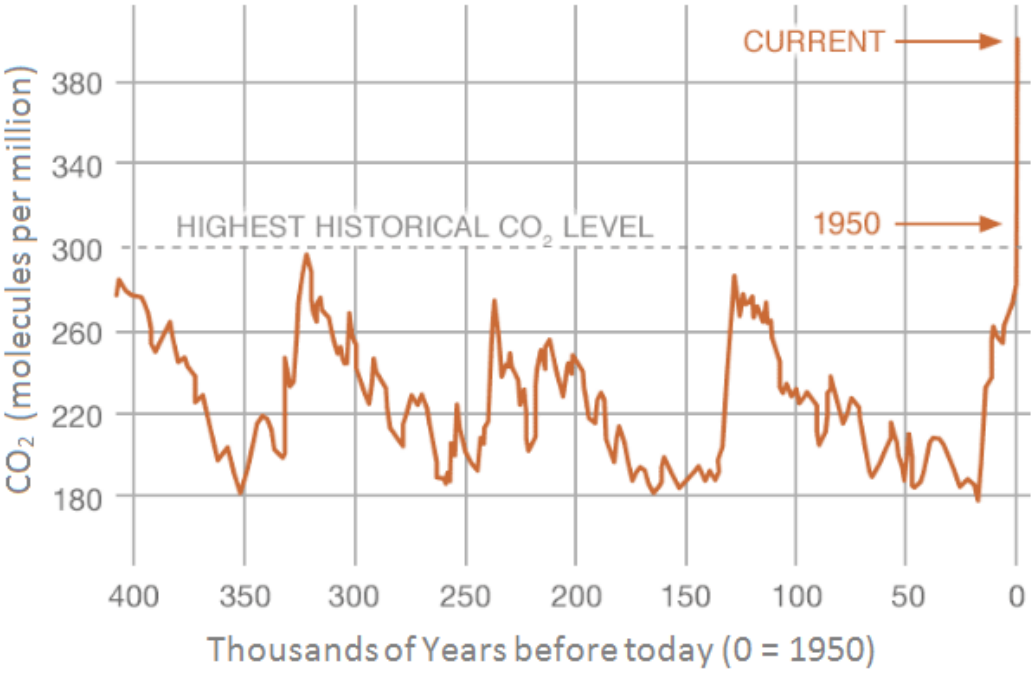

Figure 2 Carbon Dioxide Level in the Atmosphere [3]

Methane is produced from various natural sources. However, by using natural gas, mining, some agricultural practices, with solid wastes and landfills mostly humans are liable for releasing this greenhouse gas. Its concentration in the atmosphere is a lot lower than that of Carbon dioxide but it is 20 times more destructive than it.

Nitrous oxide and Fluorinated gases like Hydrofluorocarbons, perfluorocarbons and Sulfur hexafluoride are emitted to the atmosphere by some agricultural and industrial activities. They are emitted in smaller quantities than Carbon dioxide and Methane [4].

If global warming cannot be controlled, elevation of sea level is expected because of melting of the polar ice caps which is already on progress. This is going to cause the lower surfaces of the Earth to submerge. Moreover, acidity of the oceans is going to increase. Therefore, ecosystem characteristics are going to change and many species

are going to be endangered. Also there is going to be threats to human health, especially those of children and elders. Intensity, period and incidence of extreme weather events such as floods, storms, drought, high and low temperature records are going to increase. These changes are going to jeopardize our food supplies and water resources; damage our infrastructure and ecosystems and our health.

Greenhouse gases can stay in the atmosphere for long period of times. Therefore, even if greenhouse gas emission is stopped completely at the moment, the Earth is going to continue to get warmer until greenhouse gas concentrations in the atmosphere decreases to a regular level. Because of that some serious precautions must be taken all over the world.

1.2 Purpose and Motivation of the Thesis

In this thesis, the studies carried out until now and the progress made in order to control global warming, which is the biggest threat for our future, has been examined. The European Union is trying to be a leader in battle to control global warming. For this purpose, "2020 Climate and Energy Package" has entered into force and ambitious targets called 20-20-20 Objectives have been determined by the European Union. In the study, it is aimed to examine feasibility and sufficiency of these targets, efforts in order to reach these targets and possible level that can be reached. Moreover, Turkey is a country facing the negative impacts of global warming. It is estimated that such impacts will get worse eventually and affect more areas from agriculture to energy sector. Therefore, Turkey needs to adapt measures to overcome or at least alleviate the impacts of global warming. The thesis is prepared as an attempt to answer the question of whether 20-20-20 objectives of the EU provide a useful and feasible framework for Turkey to deal with global warming and challenges that come with it or should Turkey adapt different objectives in line with the needs and necessities of the country.

1.3 Scope of the Study

This study consists of eight chapters. In Chapter 1, brief information about global warming and its effects to humans and the environment is given. In addition, purpose and motivation, and scope of this thesis are given. In Chapter 2, studies done for fighting against climate change globally are mentioned and objectives and energy perspectives of the EU and Turkey are identified. In Chapter 3, energy efficiency concept, its importance and benefits are explained. The EU's targets on energy efficiency and Turkey's current situation and its targets in order to comply with the acquis of the EU are examined. Targets are evaluated in terms of their feasibility and sufficiency. Moreover, projections of the EU and Turkey are investigated for 2020 and 2023. In Chapter 4, the same approach as Chapter 3 was applied to carbon emission. In Chapter 5, renewable energy sources and their global potentials are mentioned. In addition, progress of Europe and Turkey on increasing share of renewable sources on primary and final energy consumptions are analyzed. Moreover, renewable energy potential of Turkey is investigated. In addition, targets are evaluated in terms of their feasibility and sufficiency. Moreover, projections of the EU and Turkey are investigated for 2020 and 2023 as it is done for energy efficiency and carbon emission targets. In Chapter 6, coal energy and its situation in Turkey and Europe is identified. In addition, advantages and disadvantages of coal, developments done on clean coal technologies and incentives on coal that are given by Turkey's government are mentioned. Moreover, comparison of generating electricity using renewable sources and coal is done. In Chapter 7, situation of Turkey in progress reports of the EU is summarized. Finally, in Chapter 8, a brief conclusion of the study is given. Moreover, recommendations for achieving energy targets of both the EU and Turkey are provided.

CHAPTER 2

HISTORICAL BACKGROUND

In this chapter, the actions taken by humankind to prevent harmful effects of global warming and to limit global temperature increase at a habitable level is identified. In the next section, general information about Kyoto Protocol is given and the progress made after Kyoto Protocol is analysed. In the second section, the Paris Agreement which is the continuation of Kyoto Protocol is focused and current situation is defined. In the third section, efforts of the European Union after the Kyoto Protocol and 2020 objectives are mentioned. In the last section, as a candidate country for joining the European Union, energy perspectives of Turkey and its 2023 targets are defined.

2.1 Kyoto Protocol

Kyoto Protocol to the United Nations Framework Convention on Climate Change, shortly known as Kyoto Protocol named for Japanese city Kyoto was an agreement, which was negotiated in December 1997 and entered in force on February 16th, 2005 after the ratification of Russia. This delay was due to the terms of the agreement that are at least 55 parties are required to ratify the protocol and their total greenhouse gas emission must be at least 55% of total greenhouse gas emission of the entire world. Signing this agreement did not bring any legal obligations; it was only an indication of support. However, after ratification it was going to become a contractual agreement. Only two of the signatories rejected to ratify the agreement,

which are the USA and Australia. Actually, Australia was going to be allowed an increase in greenhouse gas emission up to 8%. However, the Australian Government rejected because of the fact that it was going to be bad for their economy until 2008. The USA rejected to ratify the Kyoto Protocol because of the same reason although the USA is the largest economy and leading carbon emitting country [5].

According to the agreement, developed countries were subjected to heavier burden since the main reason of global warming was their 150 years of industrial activities from the Industrial Revolution. The objective of the protocol was to reduce greenhouse gas emission; which are defined as Carbon dioxide (C02), Methane (CH4), Nitrous oxide (N20), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF6); by 5.2% below of 1990 level until 2012. However, this 5.2% reduction did not mean that all countries were supposed to decrease their greenhouse gas emissions by the same percentage. On the contrary, some countries, especially developing ones, were allowed to increase their greenhouse gas emissions [6].

At the first commitment period of the Kyoto Protocol (2008-2012), 38 industrialized countries that are given in Appendix-A, which are Annex I countries in the Kyoto Protocol, were committed to comply with the targets for greenhouse gas emissions [7].

From Annex I countries, Canada withdrew from the Kyoto Protocol in 2012. The USA on the other hand, was the only country that rejected to ratify the agreement although around 35% greenhouse gas emission of the world belongs to it.

The Kyoto Protocol allowed some flexibility mechanisms for the countries to meet their targets. These flexibility mechanisms were Emission Trading, Joint Implementation and Clean Development Mechanisms. The Emission Trading Mechanism was allowing countries, mostly industrialized ones, to buy greenhouse gas emission permits from other countries so as to attain their emission reduction

targets. By Joint Implementation, any Annex I country was able to support emission reduction projects that other Annex I countries of economic transition have instead of reducing their own emission. Clean Development Mechanism was allowing Annex I countries to buy greenhouse gas emission reduction units from non-Annex I countries. These countries are mostly developing ones and they do not have any legal obligations for greenhouse gas emission. However, there are financial incentives for these countries so that they become willing to decrease their greenhouse gas emissions.

At the end of the first commitment period of the Kyoto Protocol, 12.5% emission reduction was achieved as it can be seen in Figure 3 [8]. However, since Canada withdrew, it is not included in this statistic. Moreover, as it can be seen in Figure 3, there is an excessive amount of decrease in carbon emission after 1990 which is the year that the Soviet Union (USSR) collapsed. After the collapse of the Soviet Union, an abrupt decrease in manufacturing industries occurred in new countries especially in Russia and Ukraine. This was the key reason for this 12.5% decrease in emission. Without Russia and Ukraine (also Canada because of the withdrawal), other parties that ratified the Kyoto Protocol reduced their emission by only 2.7%. Moreover, considering largest carbon emitters the USA and China did not ratify the agreement, it is not easy to say that Kyoto Protocol was a success.

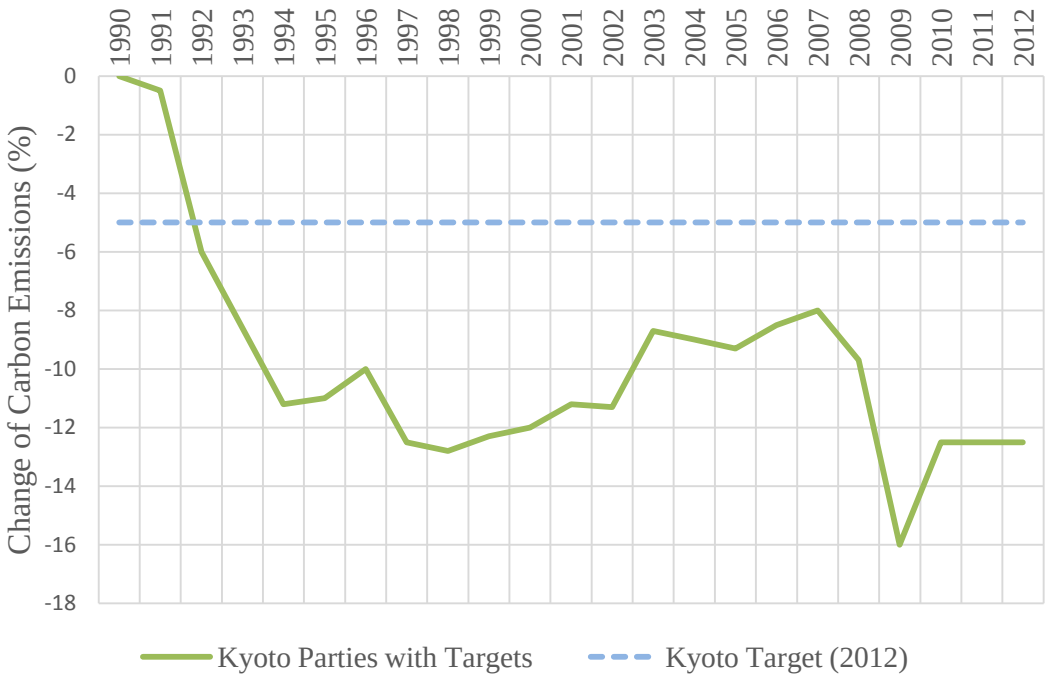

Figure 3 Kyoto Protocol Carbon Emissions [8]

2.2 Paris Agreement

21st conference of the parties of the United Nations Framework Convention on Climate Change was held in Paris from 30 November to 12 December 2015. It is the first time in history that all nations came together for a common cause in order to fight against global climate change. Before Paris Agreement, it was already accepted by most of the countries that global temperature rise must be limited by 2 degrees Celsius above pre-industrial level. However, in the Paris agreement, the importance of pursuing temperature rise in 1.5 degrees Celsius takes place. In addition, the agreement states that all parties must reach their peak levels in greenhouse gas emissions emphasizing the fact that this could take longer for developing countries. Moreover, at the second half of this century, it is aimed to be reached a balance between anthropogenic emissions and carbon sink by forests, oceans and soil.

The Paris Agreement states that each country should prepare, communicate and follow their Nationally Determined Contributions (NDCs) for years ahead. NDCs are going to be submitted every five years to the UNFCCC secretariat starting from 2020. This is one of the main achievements of the agreement since tracking long term goals of the Paris Agreement would be easier and all parties would take responsibilities.

The Paris Agreement came into force on 4 November 2016, 30 days after when 55 Parties that are responsible for at least 55% of greenhouse gas emission of the world. Today, 170 Parties have ratified the agreement among 197 Parties to the Convention.

2.3 2020 Objectives of the EU on Energy

In the first period of the Kyoto Protocol, the EU and its 15 member countries committed to decrease their greenhouse gas emissions by 8% which is more than 5% emission reduction accepted by the Kyoto Protocol. The EU distributed this emission reduction commitment into legally binding national targets to its members according to their economic growth. European Council Decision 2002/358 /EC express this under "Burden Sharing Agreement" between 15 member states and emission reduction targets are distributed in tones of CO_2 as in Table 1 [9]. The countries that joined to the EU after that decision were subjected to similar targets except for Cyprus and Malta.

Table 1 Emission Level Allocated to the EU and the Members in Kyoto Protocol First Commitment Period [9]

Party	**Allocated Emission Level (Megatons of CO_2 Equivalent)**
European Union	19621.3
Belgium	673.9
Denmark	273.9
Germany	4868.0
Ireland	314.1
Greece	668.6
Spain	1666.1
France	2819.6
Italy	2416.2
Luxembourg	47.4
Netherlands	1001.2
Austria	343.8
Portugal	381.9
Finland	355.0
Sweden	375.1
United Kingdom	3396.4

The first period of the Kyoto Protocol was a success for the EU since between 2008 and 2012; total emission of the EU was 23.5 Gigatons of CO_2 equivalent, which corresponds to a decrease of 19% [10].

At the second commitment period of the Kyoto Protocol (2013-2020), the EU countries and Iceland complied with a 20% emission reduction together. To play a leading role in the world, the European Union decided to implement its own precautions to fight against global warming. Therefore, more impassioned environmental targets than the Kyoto Protocol were accepted which is named “the 2020 Climate and Energy Package”. The European Council employed these new environmental targets after meeting on 8 and 9 March 2007. After tough negotiations by member countries of the EU, the plan was accepted on December

2008 at the European Council and a weak later it was voted by the European Parliament [11].

The 2020 Climate and Energy Package, known as “20-20-20 Targets” includes three main objectives for the EU until 2020. These objectives are:

- 20% decrease in greenhouse gas emissions of 1990 levels
- 20% increase in energy efficiency
- Increasing renewable sources in energy consumption to higher than 20% level

Moreover, a 10% biofuel use in transportation sector was targeted until 2020. Also the EU promised to raise its decrease in greenhouse gas emission up to 30% if the countries that emit most of the greenhouse gases to the atmosphere commit to decrease their emissions by global agreements [12].

2.4 Energy Perspectives of Turkey

Ministry for EU Affairs of Republic of Turkey defines the basic target of Turkey’s energy policy to provide adequate and reliable energy with competitive prices and considering environmental effects in order to ensure economic growth and social development. Moreover, the Ministry defines priorities of Turkey’s energy policy as

- Providing accessible energy to customers considering cost, time and quantity
- Ensuring free market applications for public and private sectors
- Reducing dependency on energy
- Increasing power of Turkey in regionally and globally
- Increasing variety of sources and technologies
- Utilizing maximum amount of renewable sources

- Increasing energy efficiency
- Reducing environmental impacts of energy use to a minimum amount

Although 2020 targets of the EU is not directly binding for Turkey, Chapter 15 that is opened during membership negotiations of Turkey focuses on domestic energy market, energy efficiency, renewable energy sources, nuclear safety and radiation protection and security of supply.

Today, the most important energy source of Turkey and the European Union is petroleum and natural gas. Reaching to these sources that are concentrated on some specific areas of the world in a secure way is therefore crucial for both of them. In this context, Turkey plays an important role on realizing the Southern Gas Corridor that is one of top priorities of the EU. Completion of similar gas transmission projects is going to integrate Turkey to the European Energy Market and contribute to security and diversity of supplies of the EU.

In order to comply with electricity and natural gas directives that are the most important regulations of energy acquis, Turkey made important progress on liberalization of electricity and natural gas sectors. Within this scope, Electricity Market Law No.4628 and Natural Gas Market Law No.4646 entered into force in 2001 that are prepared in parallel with electricity and natural gas directives of the EU. Electricity Market Law is updated according to current conditions on 30 March 2013. According to Electricity Market Law No.4628, Energy Market Regulatory Authority (EMRA) is constituted in 2001 in order to regulate and supervise realization of market activities in a free and competitive manner. In parallel to the applications in the EU, limit of eligible customer in electricity market is specified by EMRA. Moreover, remarkable development is made in privatization of generation and distribution assets.

The European Union gives precedence to renewable energy for both ensuring security of supply and fighting against climate change. Turkey is also a rich country of renewable energy sources and promotes use of these sources in the context of harmonization with the EU. On the purpose of supporting and increasing the usage of renewable sources, Law No. 5346 on Utilization of Renewable Energy Resources for the Purpose of Generating Electricity entered into force in 2005. In 2011, some changes were made in Law No.5346 with Law No.6094 and incentives on electricity generation with renewable energy sources were defined. With Energy Efficiency Law No.5627, base price on electricity generated by renewable sources is specified. Moreover, small facilities became free of licenses to generate electricity.

2023 targets of Turkey on renewable energy is defined as following in Electricity Market and Security of Supply Strategy Paper that was published on 18 May 2009.

- At least 30% share of renewable energy sources on electricity generation
- Utilizing all of hydro power potential of Turkey
- At least 20000 MW of wind power Installed capacity
- Utilizing 600 MW of geothermal potential
- Establishing regulations for utilizing solar energy and other renewable sources
- Decreasing share of natural gas on generating electricity to 30%

When 2023 targets are defined, renewable energy share of Turkey in electricity generation was around 20%. Hydraulic installed capacity of Turkey was 15000 MW. This means, more than half of hydro potential of Turkey had not been used. In addition, geothermal and wind capacities were negligible compared to 2023 targets. Moreover, share of natural gas in electricity generation was around 45%. Considering the situation in 2009, 2023 energy targets of Turkey seems quite demanding.

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency includes eco-design requirements, cogeneration, energy performance of buildings, summer time application and energy label issues. For its 2023 energy efficiency target, the EU gives priority to combined heat and power generation, promoting energy efficiency strategies, usage of energy sources in a harmless way to the environment, enhancing energy performance of buildings and improving energy efficiency in Industry.

In extent of harmonization with EU legislation, Energy Efficiency Law No.5627 entered into force in Turkey in 2007. With this law, some precautions were taken for preventing waste of energy, burden of energy costs on economy and protecting the environment. Moreover, some regulations were made for labeling electrical home appliances.

Regulations on buildings for energy efficiency became more of an issue since more than 40% of total energy consumption is done in buildings. Because of this, the EU specifies special regulations in order to increase energy performance. Energy performance of a building is calculated considering assumed energy consumption of heating, cooling, air conditioning and lighting systems. In order to classify the buildings according to their energy usage and ensure more efficient energy usage, Ministry of Environment and Urbanization released a regulation on energy performance of buildings on 15 December 2008.

In energy chapter (Chapter 15), nuclear energy also takes place. Nuclear safety on all phases of nuclear energy generation, managing radioactive wastes, deactivating nuclear power plants and increasing public awareness are the most important sections of this chapter. Turkey's desire of building a nuclear power plant revealed the need of making new regulations. The European Union gives priority on nuclear safety and on 25 June 2009, Council Directive 2009/71/Euratom published on establishing a Community Framework for the nuclear safety of nuclear installations.

Turkey started working in parallel with this directive. In this extent, transforming Turkish Atomic Energy Authority to an independent regulatory authority is being considered. Furthermore, various regulations were published about nuclear safety and together with the EU, a project is going to be performed to construct regulatory authority for nuclear safety.

CHAPTER 3

ENERGY EFFICIENCY TARGET OF THE EU AND TURKEY

Energy efficiency is one of three main categories of 2020 Climate and Energy Package of the European Union. In this chapter, targets, achievements and failures of both the European Union and Turkey is investigated in terms of energy efficiency. In the first section, general information on energy efficiency and situation of the world are given. In the second section, energy efficiency target of the European Union is defined. In addition, precautions taken by the Union to satisfy its targets and its improvements on energy efficiency are identified. Moreover, current situation and projections are analysed. In the last section, same approach in the second section is followed for Turkey.

3.1 Energy Efficiency

Energy efficiency is defined as using less energy to provide the same service or using the same energy to provide more service. Generally it is achieved by applying more efficient technology or production processes. However, reducing energy use by behavior changes of people is also an effective way of increasing energy efficiency. With increasing energy prices, nowadays energy efficiency has become a part of daily life of people. For instance, insulating our residences to reduce fuel costs in winter, replacing incandescent light bulbs with fluorescent or led lights, choosing electronic devices that consume less power are some simple methods of applying energy efficiency in daily lives.

Energy efficiency is becoming the center of energy policies all around the world since it is closely related to reducing air pollution, decreasing carbon footprint, decreasing energy bills and ensuring security of supply. However, according to International Energy Agency (IEA), only one-third of the economic potential of energy efficiency has been used and 70% of energy use of the world occurs without considering any sort of efficient energy use. Moreover, IEA suggests that improvements of energy efficiency on buildings, industrial processes and transport may lead to a 30% cut of world's energy consumption by 2050. Since global warming is highly related to energy use, with other measures taken for reducing carbon emissions to the atmosphere, efficient energy use is also a major contributor for the fight against global warming. According to the Vienna Climate Change Talks 2007 Report under support of the United Nations Framework Convention on Climate Change (UNFCCC), it is stated that energy efficiency is a low cost way of reducing carbon emission [19].

With technological developments in last 15 years, appliances that are used in houses such as ovens, refrigerators, dishwashers, clothes washers and dryers have become a lot more efficient. For instance, refrigerators consume 40% less electricity today than it was 15 years ago. Therefore, changing old appliances with newer ones is a good way to improve energy efficiency. If all appliances older than 10 years are changed all over Europe, it is calculated that there will be annual 20 billion kWh of electricity saving and it corresponds to 18 billion kilograms of Carbon Dioxide emission reduction. Moreover, using free air to dry clothes instead of a clothes dryer unless it is not compulsory is also a good option for reducing energy use [20].

Buildings are another major energy consumers and increasing energy efficiency of the buildings is therefore very effective for overall improvement of energy efficiency. Decreasing energy use of a building is not enough itself for increasing energy efficiency because it depends on various factors. Building materials keeps some of the heat that is produced to warm the building in them, which is called

embodied energy. Moreover, overall energy efficiency of a building is affected by the percentage of the building that is used. If a building is largely empty, heat loss increases. Also energy recovered by recycling the building materials is taken into account [21].

In order to reduce energy consumption, there are several methods to implement in building designs. For example, in passive solar building design, without using electrical and mechanical devices, buildings are designed in such a way that it collects solar energy in winter and reflects in summer. Windows, walls and floors are oriented for letting maximum amount of sunlight inside the building. This does not only decrease amount of energy to heat the building, but also decrease the electrical energy that is used for lighting. An example of a building designed considering passive solar energy can be seen in Figure 4 [22].

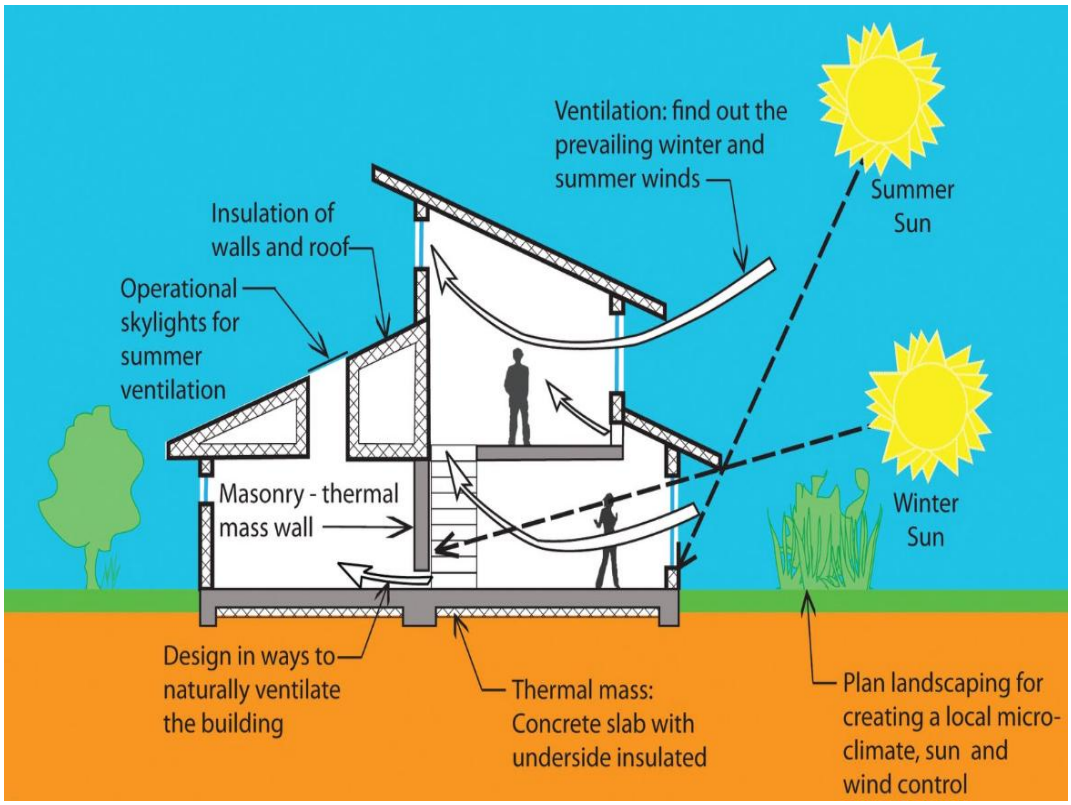

Figure 4 Passive Solar Energy Building Design [22]

Moreover, building's location, surroundings, material that used for the design of the roof, basement slab are other factors that affect energy efficiency. Dark colored roofs for places in cooler climates may be a good choice since it can reach up to 39°C higher than light colored roofs and some of that heat is transmitted inside the building according to the material used.

In transportation sector, there are various ways to improve energy efficiency. Because of low efficiency of internal combustion engines, replacing the cars using that type of engines with electric cars is by far the best way to improve energy efficiency in transportation. However, there are some other ways to improve fuel efficiency such as using aerodynamics to decrease drag force, using right air pressure for tires and using turbochargers. Moreover, using energy efficient tyres and applying eco-driving programmes can increase fuel efficiency considerably. According to the International Energy Agency (IEA), using energy efficient tyres can decrease fuel consumption by 5% and rising awareness of the society to apply eco-driving tips can result in 15-20% decrease in fuel consumption and CO_2 emission [61].

In recent years, governments have started to understand the importance of energy efficiency. In most of the developed countries, energy intensity, which is the amount of energy used to produce a unit of output, has peaked between 2005 and 2010. In Figure 5, global annual change of energy intensity from 1981 to 2016 can be seen. Accordingly, in the last 6 years, energy intensity has decreased drastically compared to previous 20 years. With the expected technological developments and increasing public awareness, decrease in energy intensity in future is going to be higher than today.

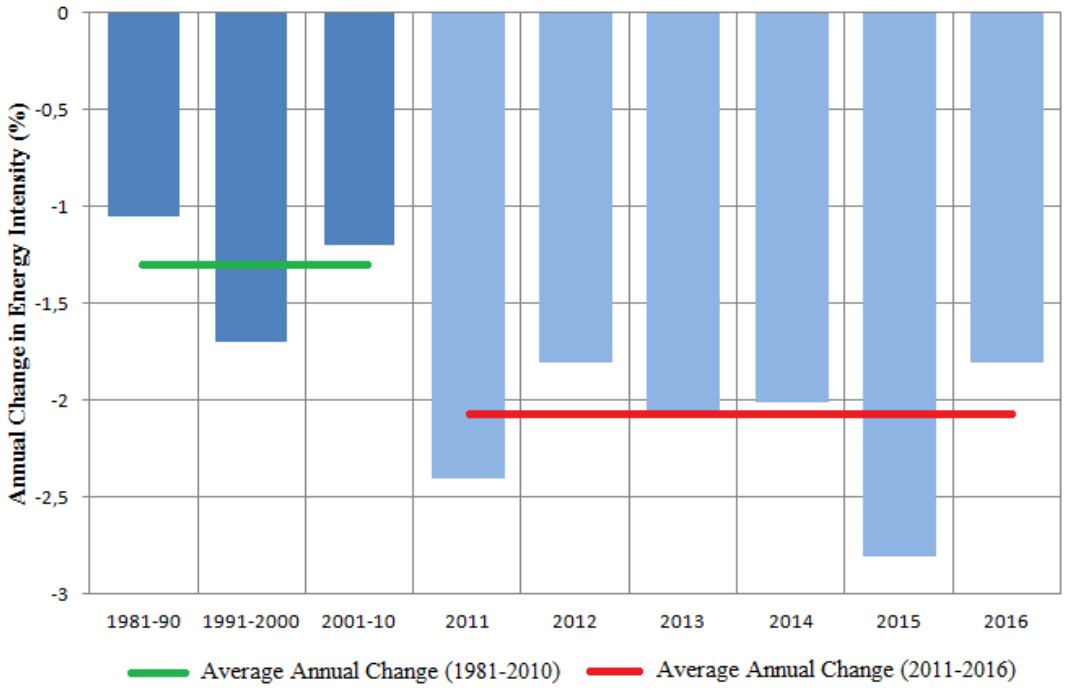

Figure 5 Global Annual Change in Energy Intensity [61]

For decades, energy related global greenhouse gas emissions increased continuously. However, as it can be seen in Figure 6, after 2014, it became steady despite GDP increase. Figure 7 depicts the factors affects the amount of energy related greenhouse gas emissions between 2014 and 2016. Accordingly, decrease of energy intensity and increasing fuel mix compensated the effect of GDP increase to greenhouse gas emissions.

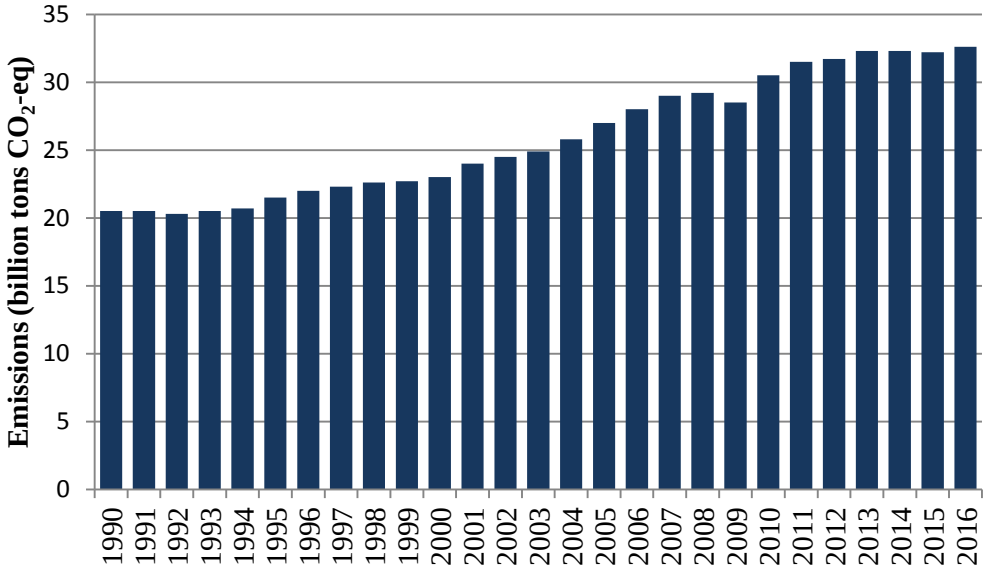

Figure 6 Global GHG Emissions [61]

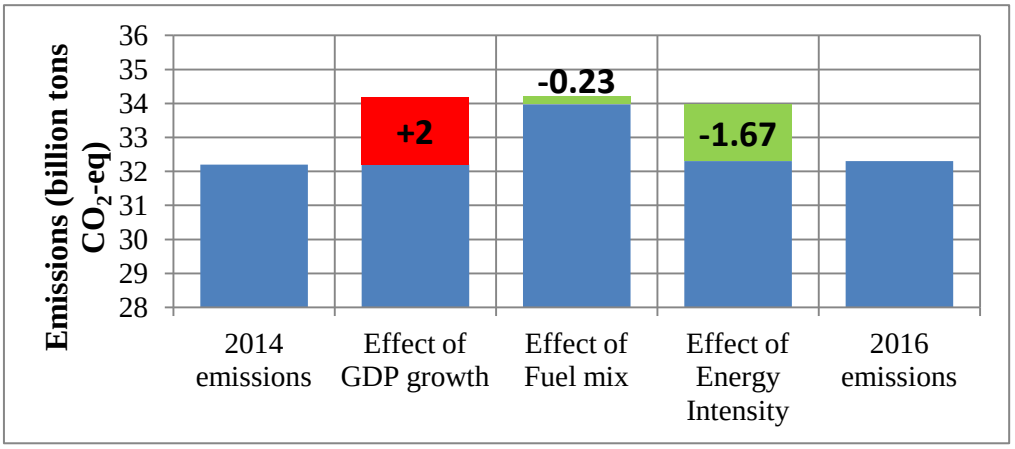

Figure 7 Factors Affecting GHG Emissions (2014-2016) [61]

Between 2000 and 2016, global energy efficiency enhanced 13% which is equal to annual energy need of the European Union. As it can be seen in Figure 8, mostly developed countries are responsible for the increase of energy efficiency and most of the countries that increased it are European. Energy efficiency is one of the

strategical priorities of the European Union and in the next section, the targets and the achievements of the Union on energy efficiency will be analysed.

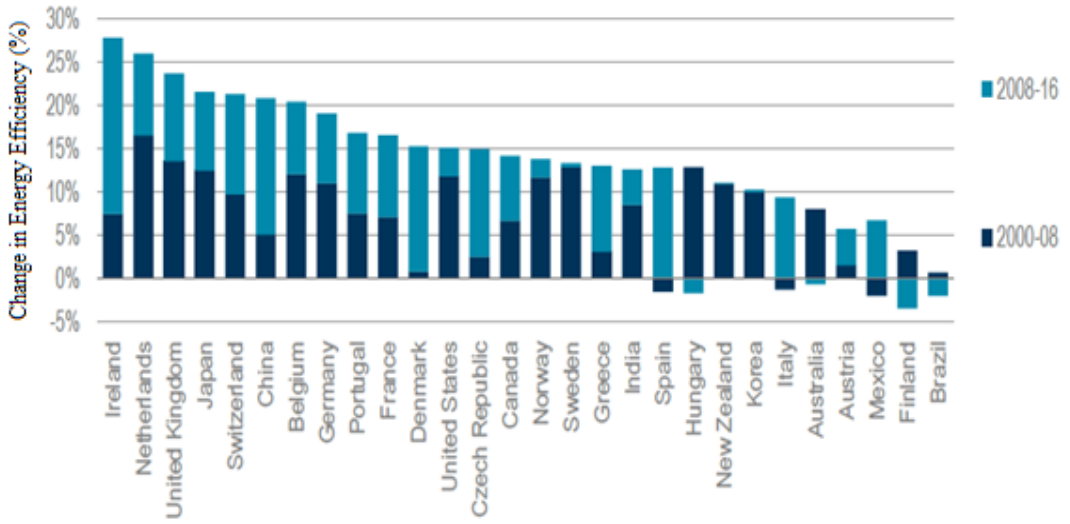

Figure 8 Change of Energy Efficiency in Some Countries (2000-2008 and 2008-2016) [69]

3.2 The Energy Efficiency Target of Europe

Energy efficiency target of the European Union is at the center of the Climate and Energy Package since it affects other targets directly as well. Between 2009 and 2011, improvements in energy efficiency was very limited and projections revealed that only half of the target could be achieved until 2020. Therefore, in 8 March 2011, the European commission published Energy Efficiency Plan in order to take necessary precautions and determine the roadmap to reduce the gap between projections and 2020 targets on energy efficiency.

According to the plan, buildings have the largest energy efficiency potential in the European Union since 40% of final energy consumption is done in public and private buildings. Renovation of the public and private buildings to decrease energy losses and changing home appliances with more efficient ones are expressed as basic precautions that can be taken in the buildings since Space heating, lighting and electrical appliances constitute 82% of energy use in buildings.

Transport and industry sectors follow buildings by their energy efficiency potential. 20% of Europe's primary energy is consumed in industry. Although it is the sector that increased energy efficiency most until 2011, according to the Energy Efficiency Plan there is still remaining potential. The European Commission plans to encourage small and medium sized enterprises to invest in and implement eco-design technologies. For large companies, the Commission plans to implement regulations so that their improvements in energy efficiency can be tracked annually [62].

Transport sector accounts for 32% of final energy consumption of the European Union and 96% of the fuel used in this sector consists of fossil fuels. Therefore, one of the main reasons of the Union's energy dependency is the imported fuels for transport. In order to fight against this situation, the European Commission released the White Paper, which is a roadmap to a single European transport area. According to the White Paper, by 2050, 60% decrease in the emissions from transport sector is targeted. Moreover, there is going to be no fossil-fueled vehicles in the cities of the Union. In addition, 40% use of low carbon fuels in aviation and 40% decrease in shipping emission are other targets that are described in the White Paper [63].

In order to satisfy 20% energy efficiency improvement target of the European Union, the European Parliament and the European Council published directive 2012/27/EU on energy efficiency on 25 October 2012. The directive set some legislation to help the EU states to meet the EU's target on energy efficiency.

In the directive, it is stated that increasing energy efficiency is one of the least expensive ways to reduce energy dependency of the union. Moreover, it is mentioned that trying to achieve energy efficiency target could create various job opportunities with development of technology on energy area. In addition, all member states are asked to set an indicative national energy efficiency target taking into account the measures described in the directive and overall targets of the union on primary energy consumption.

The directive emphasizes that both public and private buildings must be renovated with a long-term strategy. In addition, each year, 3% of total floor areas of government owned buildings have to be renovated according to the directive. Moreover, purchasing buildings or any products for public use is limited only with those that have higher energy efficiency.

All member states are supposed to prepare an energy efficiency obligation scheme to ensure at least 1.5% end-user energy saving each year starting form 1 January 2014 until 31 December 2020. Details of the energy efficiency obligation scheme are described in the energy efficiency directive 2012/27/EU. Moreover, each member states are supposed to provide high quality metering and detailed bills to inform end-users and so as to achieve public awareness on energy efficiency.

Energy efficiency directive 2012/27/EU indicated that all member states must set up individual targets for energy efficiency so that the European Union reaches 20% energy efficiency target in 2020. However, only some of the member states set up ambitious targets on energy efficiency and according to the targets, only 17.6% of improvement in primary energy consumption is projected by 2020 that is lower than the target. In Appendix-B, individual 2020 targets of member states on primary and final energy consumptions and target of the European Union can be seen [23].

In 23 November 2017, the European Commission published a progress report on energy efficiency in order to evaluate the progress made by member states according to Article 24 of the Energy Efficiency Directive 2012/27/EU. Accordingly, final energy consumption of the European Union decreased in recent years despite GDP increase as it can be seen in Figure 9. In 2015, there has been a slight increase due to weather conditions and lower fuel prices. The union is on track to achieve its 20% energy efficiency target if the trend of final energy consumption from 2005 is sustained.

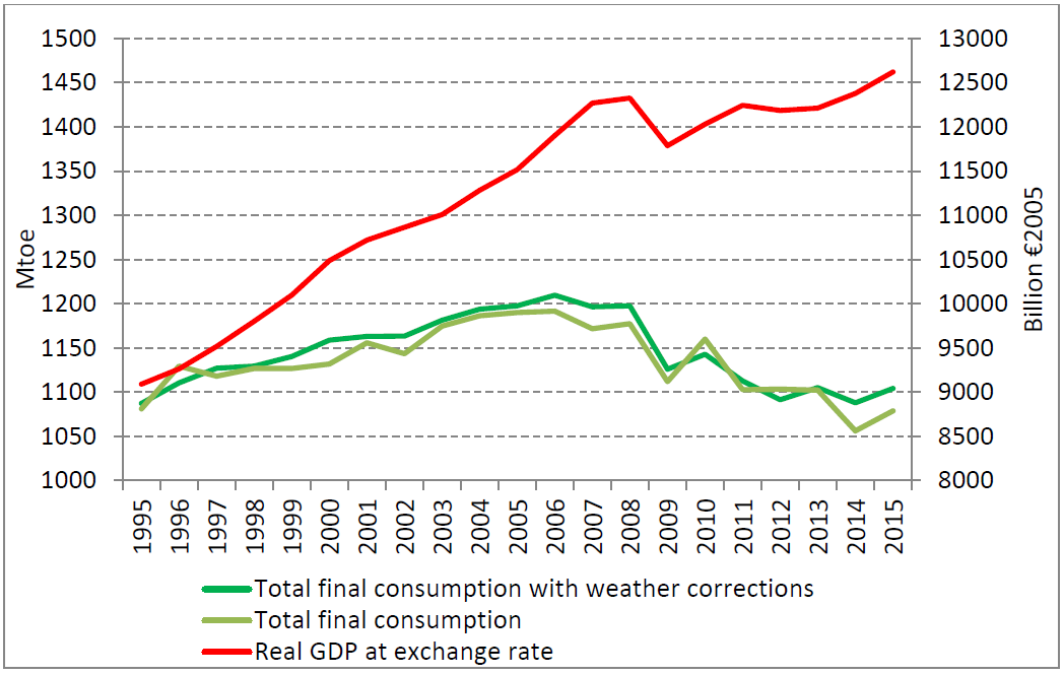

Figure 9 Final Energy Consumption of the EU (1995-2015) [23]

Since 2005, final energy consumption of the EU decreased from 1192 Mtoe to 1084 Mtoe which is already lower than 2020 target of 1086 Mtoe. However, primary energy consumption decreased from 1713 Mtoe to 1531 Mtoe, which is 3.2% above the 2020 target. Progress report also indicates that 18 member states made good progress to achieve their 2020 final energy consumption target. In addition, the report indicated that final energy consumption decreased in all member states except Lithuania, Malta and Poland and primary energy consumption decreased in all member states except in Estonia and Poland from 2005 to 2015.

As a result, 2020 energy efficiency target of the European Union is a feasible and adequate target for fighting against global warming and climate change. This target is also closely related with carbon emission reduction target and going to help to achieve 20% carbon emission reduction of the European Union.

3.3 The Situation of Turkey

Energy efficiency is a concept that intercepts with providing security of supply, sustaining low energy costs, struggling with climate change and preserving the environment.

National Energy Efficiency Action Plan of Republic of Turkey that was published on May 2016 defines 2023 energy efficiency targets of Turkey, emphasizes the works that already have been done and determines the roadmap until 2023. Moreover, the action plan is prepared in order to coincide with the targets that the European Union identified to reduce its primary energy use.

According to the data provided in the action plan, between 2002 and 2007, Gross Domestic Product (GDP) of Turkey increased by 7% annual average. With the global financial crises that started at the end of 2008, Turkey's economy downsized by 4.8% in 2009. However, after 2009 Turkey compensated this crisis and in Figure 10, increase in GDP of Turkey and some European Countries in recent years can be seen [24].

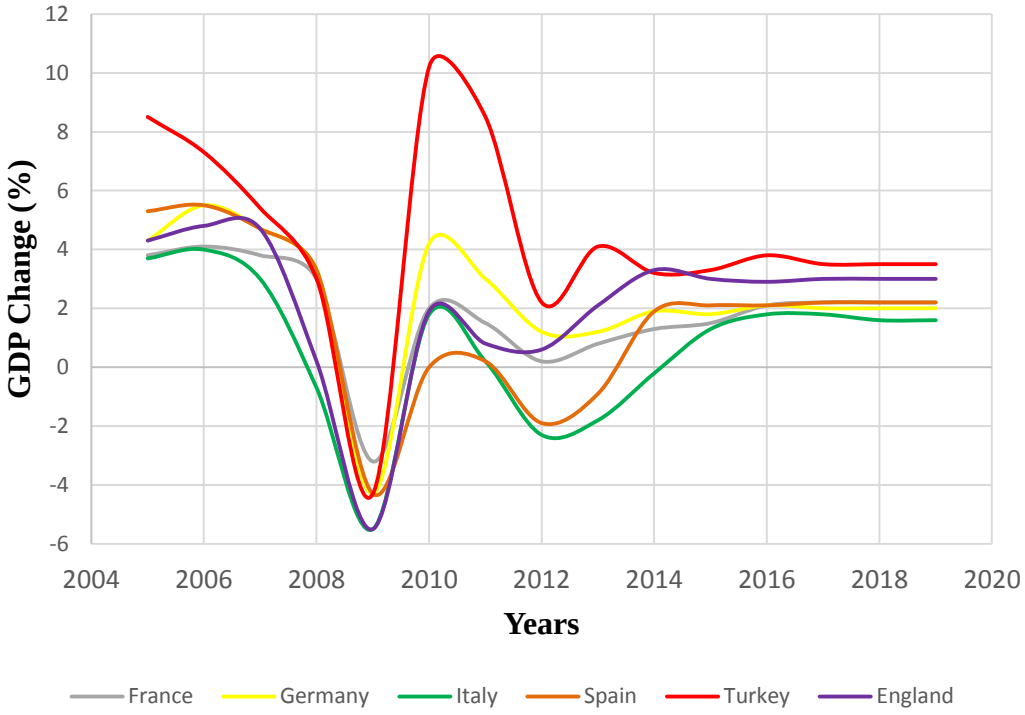

Figure 10 GDP Increase of Turkey and Some European Countries in Recent Years [24]

Growing of the economy of Turkey has also increased its energy consumption. In Figure 11, Turkey's change of GDP and primary energy use can be seen. It can easily be observed that primary energy use is proportional to GDP [25].

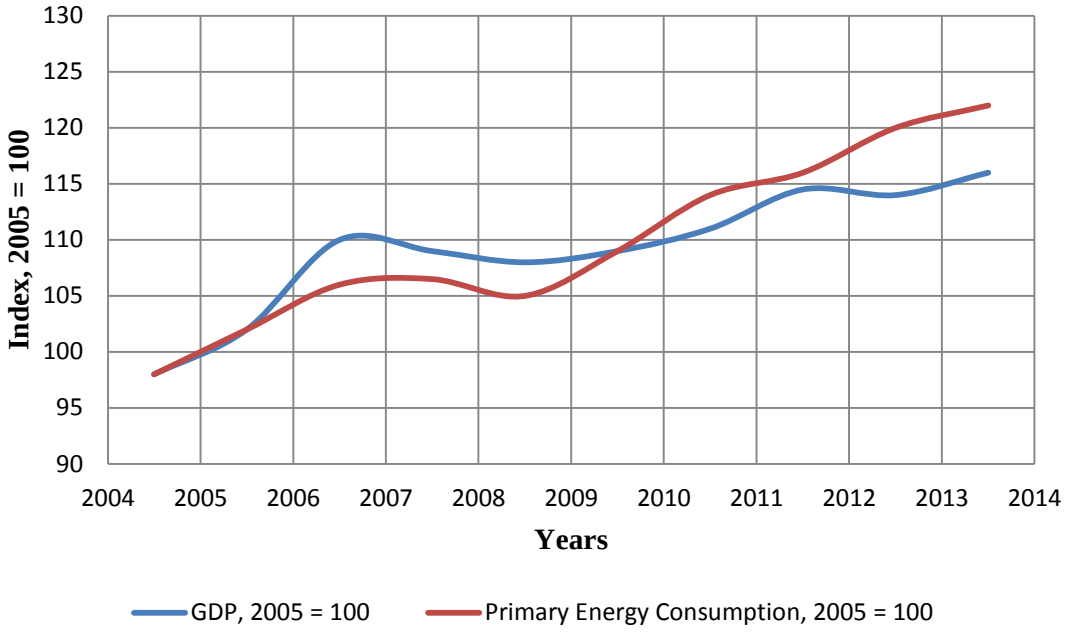

Figure 11 Change of GDP and Primary Energy Usage of Turkey [25]

Majority of primary energy necessity of Turkey is met using fossil fuels. However, Turkey is not a rich country of fossil fuel resources. Therefore, most of these fuels are imported and this situation causes high amount of current account deficit. In Figure 12, share of energy in current account deficit of Turkey can be seen [24].

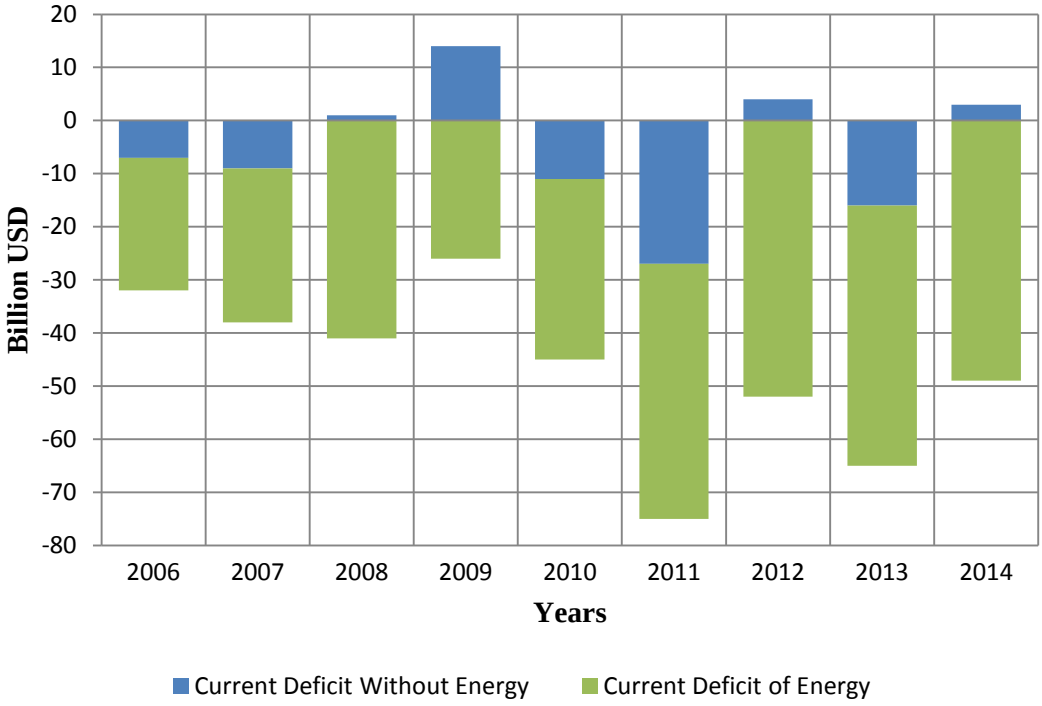

Figure 12 Share of Energy in Current Account Deficit of Turkey [24]

In 2013, Turkey imported 75,5% of primary energy sources. Petrol and natural gas is first and second biggest imported sources respectively and their total share in all imported sources reaches up to 98%. Since Turkey is such a dependent country on fossil fuels and energy, applying energy efficiency measures is important.

In recent years, there have been some developments on energy efficiency after Energy Efficiency Law with Law number 5627 is issued. Moreover, Energy Efficiency Strategy Document that was published in 25 February 2012 specifies applications that must be performed between 2012 and 2023 and defines the responsible people and institutions for these applications. In Energy Efficiency Strategy Document, energy use per GDP of Turkey is targeted to be reduced 20% until 2023. With recent studies, energy density of Turkey is decreased in recent years and this change can be seen in Figure 13 [24]. According to these data,

between 2009 and 2016, energy density of Turkey decreased by 5.9%. In coming years, with expected growth rate, Turkey must give energy efficiency a high priority in order not to encounter any problems in energy supplies.

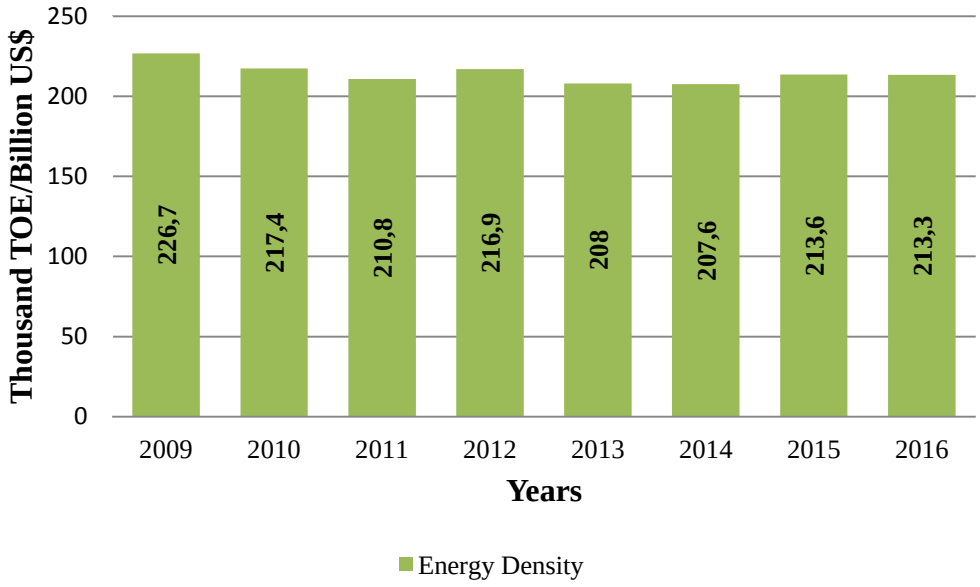

Figure 13 Energy Density of Turkey in Recent Years [24]

In Energy Efficiency Strategy Document, strategical objectives, targets and actions are specified. Many strategical objectives such as decreasing energy density and energy loss in industry and services sectors, increasing high energy efficiency and environment friendly buildings, decreasing losses on generation, transmission and distribution of electricity, decreasing fossil fuel use in transport sector and encouraging people to use public transport are determined. Moreover, responsible institutions and institutions that are going to co-operate and timetable of these objectives are stated in the document.

According to data given in National Energy Efficiency Action Plan, until 2023, decrease in energy density per GDP in value of year 2005's American Dollar is targeted to be 42.2 Thousand TOE/Billon $2005 as it can be seen in Figure 14.

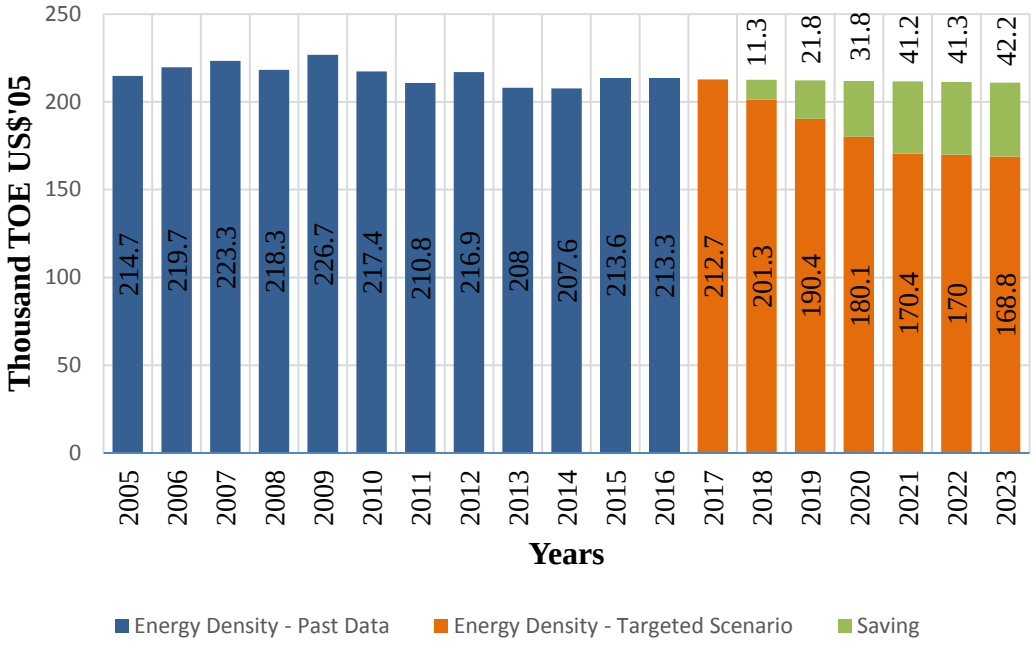

Figure 14 Energy Density Projection of Turkey [24]

In National Energy Efficiency Action Plan, support mechanisms by the government on energy efficiency projects of energy users under the name of "Supporting Energy Efficiency Projects" are defined. Accordingly, energy users on industry, services and transportation sectors are going to make use of these support mechanisms. Projects are going to be evaluated according to their savings rate, feasibility and time of compensating the expenses and 20% of investment costs suitable projects are going to be granted. With this method, 2834 thousand TOE energy savings are predicted until 2023. Furthermore, voluntary energy efficiency agreements based on economic incentives are being practiced. According to these agreements, 20% of energy costs of industrial facilities that consumes more than 1000 TOE energy per year are given by the Ministry of Energy and Natural Resources as long as 10% energy density reduction is committed.

Some of policy measures step forward in National Energy Efficiency Action Plan are incentives given for buildings. Accordingly "Energy Performance Certificate"

application that was published on 5 December 2008 and updated on 1 April 2010 is aimed to developed further. With this application, new buildings are classified according to their annual energy consumptions and CO_2 emissions and the ones below class C is not permitted to be used. A class C building consumes 200 kWh/year per meter square but class B and A buildings consume 160 and 128 kWh/year per meter square respectively. Moreover, additional incentives are planning to be given to the buildings that are built within urban transformation. According to the application that is planned to become valid in 2018, 2% and 4% discount in interest is considered for class B and class A buildings that are built within urban transformation. Moreover, in order to have resemblance to one of the targets in Energy Efficiency Directive of the European Union that is 3% of public buildings must be renewed to improve energy efficiency, energy consumption of public buildings is aimed to be decreased by 20% until 2023.

Furthermore, constituting 27% of GDP of Turkey, energy efficiency potential of industry sector is extremely high. With the precautions taken in energy efficiency, in spite of the growth in industry, energy consumption between 2010 and 2014 remained steady and even decreased after 2014.

However, 20% increase in energy efficiency is very challenging for Turkey considering it is a developing country with increasing energy need every year and it is obvious that this target cannot be achieved until 2023 without making extreme economic sacrifices. Therefore, energy efficiency target of Turkey should be revised in compatible with its sustainable development. Instead of trying to comply with the EU acquis directly, a more reasonable target around 10% increase in energy efficiency may be adapted providing that more demanding targets are going to be set after 2023.

CHAPTER 4

CARBON EMISSION TARGET OF THE EU AND TURKEY

Carbon emission is another category of 2020 Climate and Energy Package of the European Union and it is also the main reason of global warming. In this chapter, targets and progress of both the European Union and Turkey is investigated in terms of carbon emission reduction. In the first section, general information is given about carbon footprint. In the second section, carbon emission reduction target of the European Union is defined. In addition, precautions taken by the Union to satisfy its targets and its improvements on decreasing carbon emission are identified. Moreover, current situation and projections are analysed. In the last section, same approach in the second section is followed for Turkey.

4.1 Carbon Footprint

Carbon footprint is a term that is used to describe total greenhouse gas emissions of an organization in carbon dioxide equivalent. Carbon dioxide equivalency of a gas is proportional to its mass and global warming potential. According to Global Footprint Network, carbon footprint constitutes 60% of human's total Ecological Footprint that is a measure of human impact on Earth's ecosystem [25].

Greenhouse gases can be emitted with various kinds of sources such as transport, burning fuels, land clearance and industrial processes. These sources are generally categorized into two as indirect sources and direct sources. Indirect greenhouse gas emission sources are the sources that do not cause emission from final energy

consumption. Burning fossil fuels to generate electricity can be considered as an indirect source of greenhouse gas emission. Burning fossil fuels for transportation is on the other hand is a direct source.

Nowadays, calculation of carbon footprint of an individual or organization is easier with free online carbon footprint calculators. After some detailed questions, these tools calculate carbon footprint and provide solutions to reduce it. Software of University of California, Berkeley's CoolClimate Network is one of the most popular of these tools all around the world.

Reducing carbon footprint is extremely important for the future of life on earth. There are various ways to reduce it such as replacing fossil fuel power plants with the ones that use renewable energy, reforestation, investing on new technologies for developing more energy efficient products and designing more energy efficient buildings to reduce fossil fuels burnt for heating.

After Kyoto Protocol, in order to reduce carbon emission, flexibility mechanisms such as Clean Development Mechanism, Joint Implementation and Emission Trading are introduced for the countries that ratified the protocol. Clean Development Mechanism provides emission reduction projects and the quantity of emission reduction can be used in Emission Trading. Joint implementation is another flexibility mechanism. With this mechanism, Annex I countries of Kyoto Protocol can invest an emission reduction project in any other Annex I countries and it is counted as they reduced the emission domestically. Emission Trading provides economic incentives usually for industrial facilities. This mechanism is generally government controlled and governments allocates limited amount of carbon emission permits. Therefore, if a factory wants to exceed its allowed emission, it has to buy emission allowance from a factory that emits less carbon than allowed. By emission trading system, renewable sources to generate electricity become more competitive than fossil fuels due to lower carbon emissions.

4.2 The Carbon Emission Reduction Target of Europe

After Kyoto Protocol, in order to limit global temperature rise at $2^{o}C$ above pre-industrial level, the European Commission made recommendations for EU climate policies on the report named "Winning the Battle Against Global Climate Change" on 9 February 2005. These recommendations included applying agreed projects immediately and effectively, increasing public awareness, focusing on more research, making strong co-operation with third countries [26].

In Annex I of the report, the effects of continuing climate change were given. Accordingly, sea levels are expected to rise between 0.09 and 0.88 meters with a central value of 0.48 meters until the year 2100 and this is going to have serious outcomes such as flooding, coastal erosion and the loss of coastal regions. Moreover, in Southern Europe, agricultural activities are expected to be affected in a bad way. Also energy use is expected to change. In winters, due to warmer climate, usage of energy for heating is likely to decrease. However, with hotter summers, energy use for cooling is expected to increase. With thermal stress and infections, health of citizens is going to be affected in a bad way either. Furthermore, significant impacts on ecosystems and water resources are expected and more than 2.4 billion people are going to suffer from water deficiency on a global scale.

Therefore, the European Union decided to take more action on preventing global climate change and to become pioneer on a global scale. Moreover, in order to satisfy 8% decrease in carbon emission compared to 1990 level as agreed on Kyoto Protocol, current projections were not enough. Because of this, on 10 January 2007, Commission of the European Communities (the European Council, the European Parliament, the European Economic and Social Committee, and Comity of the Regions) published a communication called "Limiting Global Climate Change to 2 degrees Celsius The way ahead for 2020 and beyond" and this action plan was pioneer to Europe's 2020 targets for energy and climate change. In the communication, it is mentioned that until 2020, developed countries must decrease

their carbon emission by 30% compared to 1990 levels in order to stay within 2^{o}C limit. Moreover, by 2050, carbon emission must decrease by 50% globally compared to 1990 levels. This means that developed countries must decrease their emissions by 60-80%. Because of these situations, before any international agreements take place, the EU decided to decrease their emissions by 20% until 2020 compared to 1990 level by EU Emission Trading Scheme, or Emission Trading System, (ETS) and other projects.

Emission Trading System is the foundation of the EU's battle against climate change. It is a cap and trade system, i.e. the cap is total allowed greenhouse gas emission in the system and greenhouse gas emission allowances can be traded between participants in the system. All companies are given emission allowances according to their sector and other properties. When a company exceeds its emission allowance, it has to buy allowance from another company. Oppositely, if a company stays below the allowed emission, it can sell the remaining emission allowance to another company or save it for removing from its future emissions. Moreover, it is possible to buy international credits from emission reduction projects in third countries in a limited amount. Emission Trading System is effectively used in 31 European countries including Norway, Iceland and Liechtenstein and constitutes around 45% of greenhouse gas emission of the EU.

The first phase of the ETS (2005-2007) was like a trial phase. It was mostly a preparation for the second phase in order to satisfy the targets of Kyoto Protocol. In the first phase, CO_2 emissions from power plants and industries with high energy intensity were included in ETS. Carbon emission allowances were given to companies and a penalty for exceeding the allowed carbon emission is determined as 40 Euro per ton. Since allowances were given based on estimates in the first phase, before starting to second phase allowances that can be transferred were accepted as zero [27].

In the second phase (2007-2012), cap of the allowances were lowered by 6.5% compared to 2005 levels. Iceland, Norway and Liechtenstein were joined to ETS in addition to 28 European Union member states. Moreover, penalty for exceeding allowed carbon emission were increased to 100 Euro. Furthermore, aviation sector was included to ETS. Because of the economic crisis in 2008, carbon emissions became less than expected and a large amount of allowances were transferred to succeeding years. In Figure 15, increase of the volume of the carbon trade can be seen. Here, amount of traded allowances are shown in million tones [27].

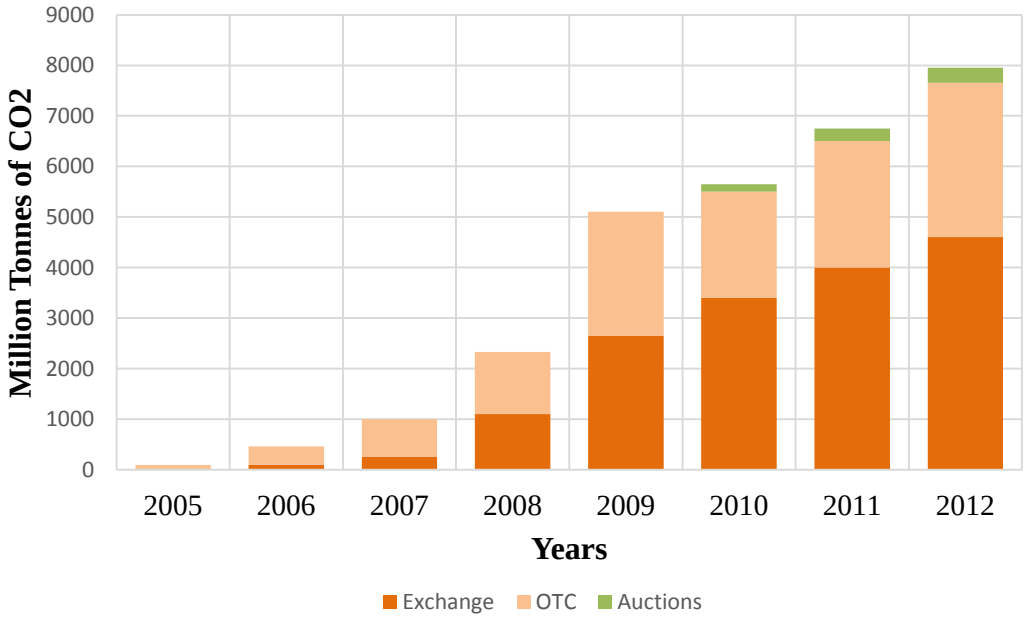

Figure 15 Increase of Carbon Trade of the EU [27]

In 2013, phase 3 of ETS started and it is going to end in 2020. In phase 3, national caps were transformed into EU-wide caps. Free allocation of allowances was replaced by auctioning. Therefore, auctioning became the main way of allocation of allowances. Sectors and greenhouse gases included in ETS were increased. Being the first and largest emission trading system all over the world, with these

improvements, the EU's Emission Trading System constitutes more than 75% of carbon trade all over the world.

The European Union is on track to satisfy its 2020 carbon emission reduction target as it can be seen in Figure 16. Accordingly, in 2005, more than 20% reduction is already achieved as compared to 1990 level.

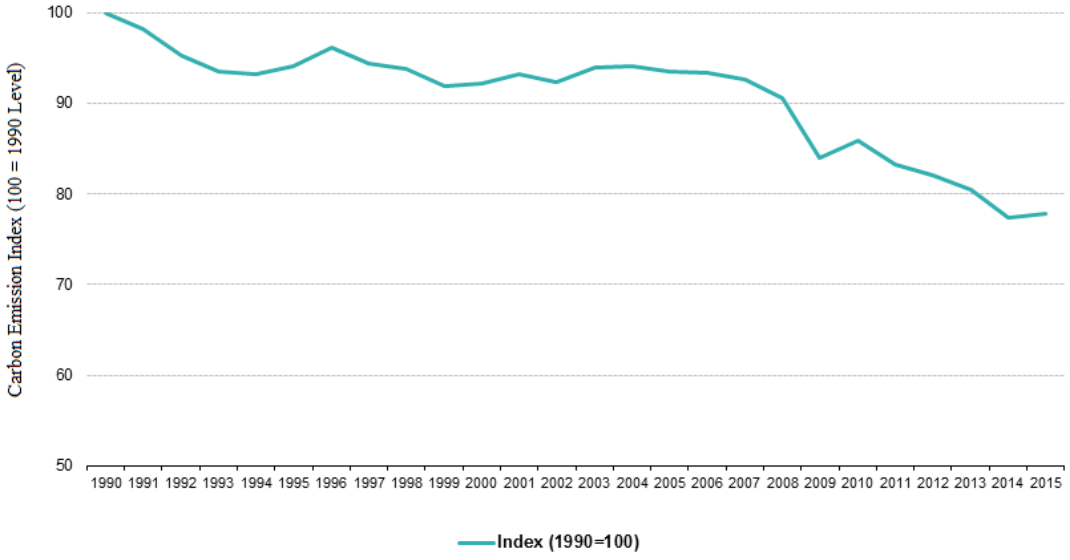

Figure 16 Change of Carbon Emission of the EU from 1990 Level

4.3 The Situation of Turkey

United Nations Framework Convention on Climate Change that is the foundation of the battle against climate change was accepted in 1992 and came into force in 1994. The ultimate purpose of the agreement was to reduce greenhouse gases in the atmosphere to a level that does not cause dangerous effects on climate system. Basic principles of the agreement can be summarized as equality principle, same but differentiated responsibilities principle, prudence principle, supporting sustainable development right and responsibility.

According to the agreement, all countries are obliged to collect greenhouse gas emission data and share their national policies. In the agreement, in addition to the responsibilities for any countries, there are different responsibilities for developed countries that are placed as Annex-I and Annex-II lists. For Annex-I countries, there were an obligation to reduce their greenhouse gas emissions to 1990 levels until 2000 and Annex-II countries were assigned to help developing countries to fulfill their responsibilities and transfer technology. At the beginning, Turkey was both in Annex-I and Annex-II lists as an OECD member. In 2001, Turkey was removed from Annex-I and preserved in Annex-I with its different situation. Then, Turkey joined in the United Nations Framework Convention on Climate Change.

With Kyoto Protocol, some binding carbon emission limitations were applied for developed countries. With the law numbered 5386 that was accepted in Turkish Grand National Assembly on 5 February 2009 and 2009/14979 numbered Council of Ministers Decision Turkey joined in Kyoto Protocol on 26 August 2009. However, Turkey does not have any quantified carbon emission target or any obligations.

Considering socio-economic indicators, greenhouse gas emission profile, historical responsibility, carbon emission, GPD and energy consumption per capita and its position in Human Development Index, Turkey is a middle-income developing country. In Figure 17, carbon emission per capita of Turkey and in Figure 18, comparison of it with some other countries can be seen [28]. Considering this situation of Turkey, it is impossible that Turkey commit a reduction in carbon emission referencing a year in the past. However, Turkey plans to limit its carbon emission with the precautions in order not to affect its sustainable development and fight against poverty. Moreover, Turkey declares that carbon emission activities are going to be made suitable with its national programs and strategies, quantifiable, reportable and verifiable.

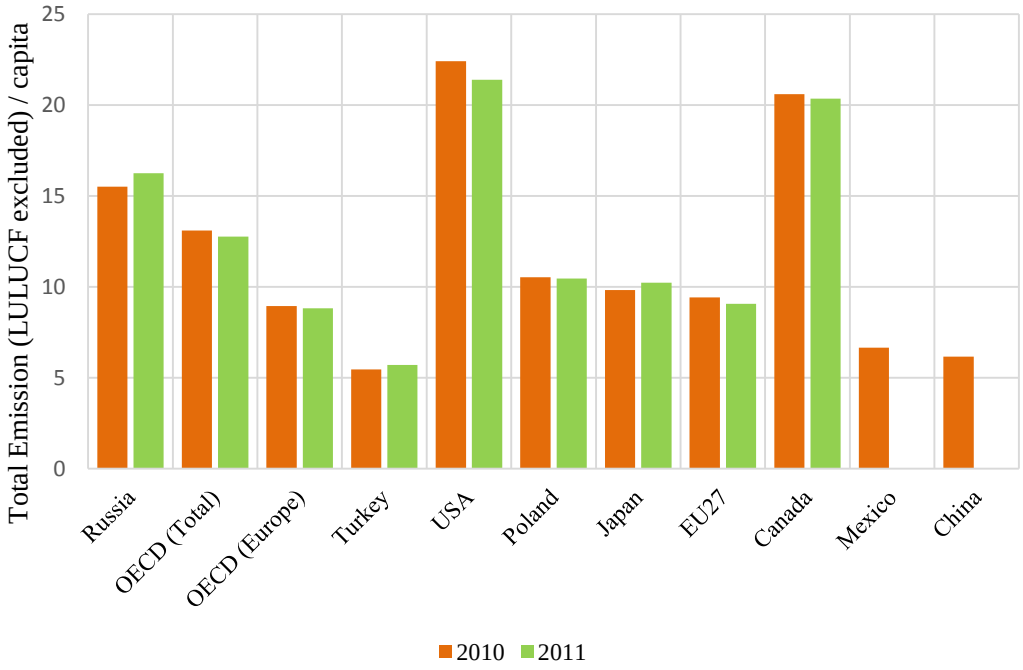

Figure 17 Carbon Emission of Turkey per Capita [28]

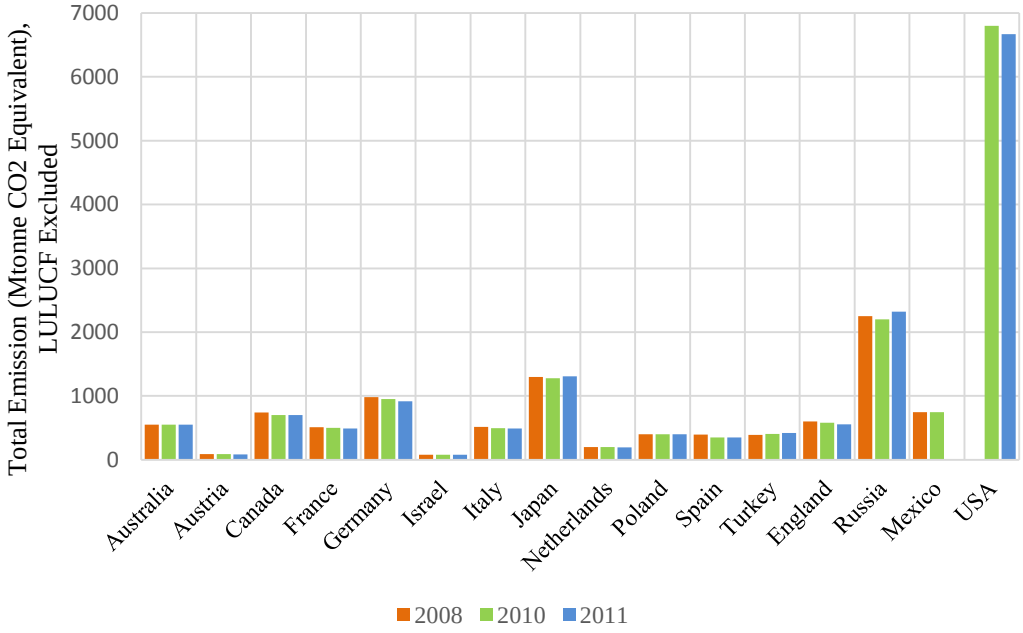

Figure 18 Comparison of Carbon Emission of Turkey with Some Other Countries [28]

One of Turkey's strategic targets is to integrate its fight against climate change and adaptation works to national development plans compatible to "common but differentiated responsibilities" under United Nations Framework Convention on Climate Changes and under special circumstances. Moreover, Turkey plans to make an effort to decrease greenhouse gas emission, decrease the negative impacts of the global warming and adapt to these negative impacts without affecting its sustainable development. Furthermore, increasing financial resources for reduction and adaptation activities, raising the awareness of the public by integrating public and private sectors, universities and non-governmental organizations are other plans of the government of Turkey.

Since energy sector is the primary cause of greenhouse gas emission as it can be seen in Figure 19 and Figure 20, Some of Turkey's targets on energy sector are in line with carbon emission reduction targets [29]. Turkey plans to use its energy potential, particularly hydro and wind power possibly the most efficient way considering security of supply. Moreover, with clean coal technologies and nuclear energy, encouraging the usage of low emission technologies and supporting Research and Development studies are other main plans of Turkey. Furthermore, with increasing share of renewable energy in electricity generation to 30% until 2023 target, rate of increase of carbon emission is expected to slow down. Also with energy performance certificate application for new buildings, encouraging energy efficient buildings will also help to reduce carbon emission. For adaptation of climate change, the studies that are described in Strategy and Action Plan to Combat with Agricultural Drought are targeted to be done as soon as possible. The subjects that are given primacy on being protected against negative effects of climate change are working on enhancing water quality, fighting against animal diseases and plant mites, tackling with forest fires that might increase with increasing temperature and battle against desertification and erosion.

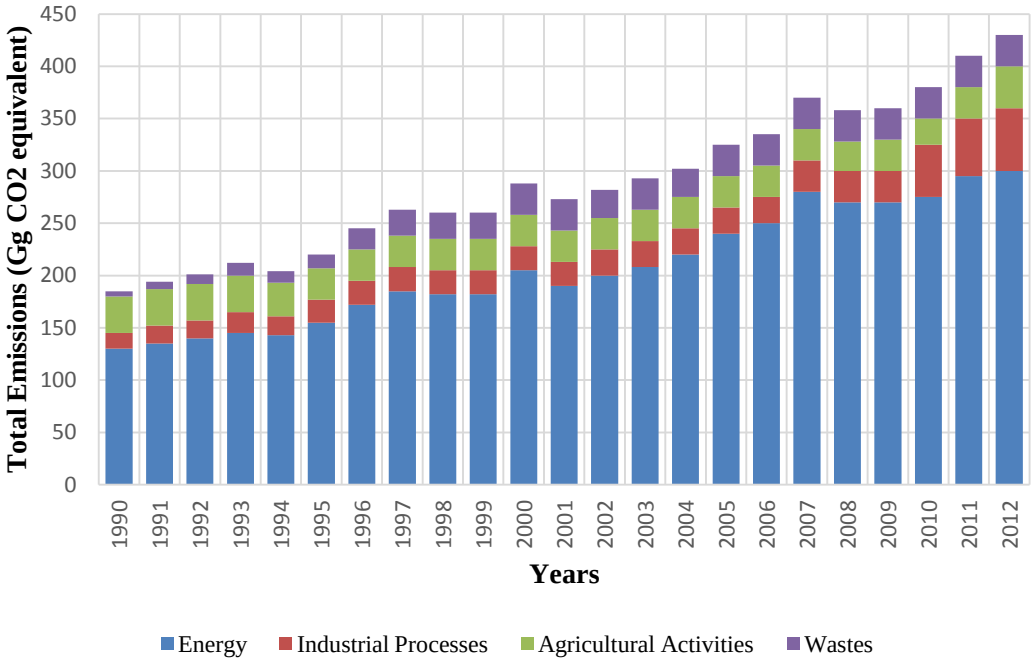

Figure 19 Greenhouse Gas Emission of Different Sectors (LULCC excluded) [29]

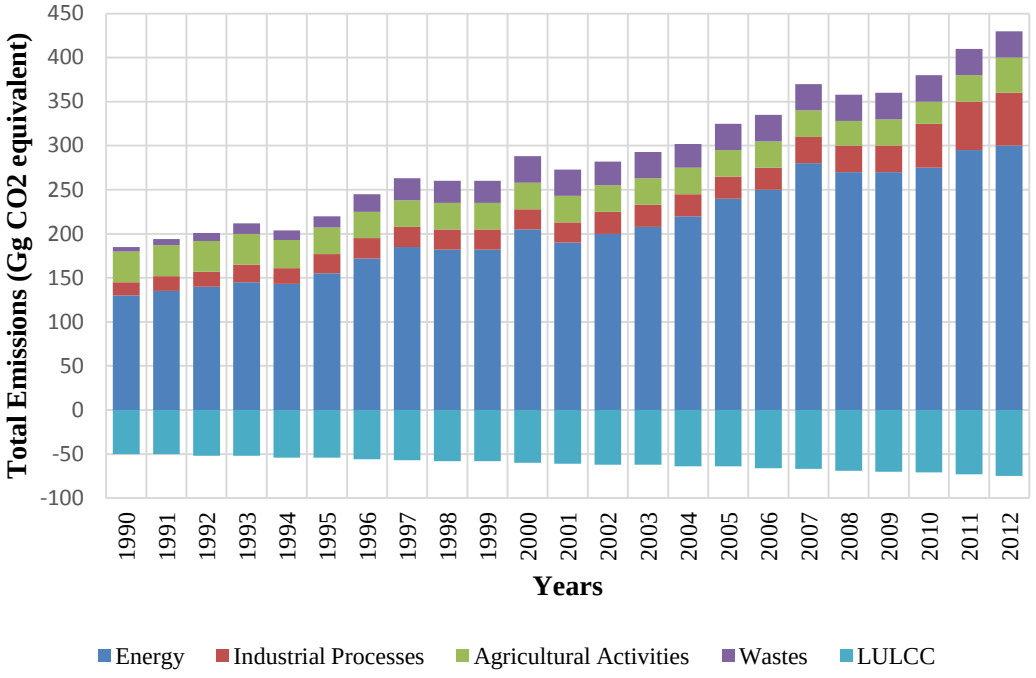

Figure 20 Greenhouse Gas Emission of Different Sectors (LULCC included) [29]

Even if Turkey does not benefit from carbon emission flexibility mechanisms that are defined under Kyoto Protocol, It develops and applies projects on Voluntary Carbon Market that operates independently from these mechanisms and is founded in environmental and social responsibility principles. Although Voluntary Carbon Market represents a small percentage on carbon markets in the world, using this market effectively provides Turkey to join carbon markets in future in an easy way.

In Turkey, 308 projects are traded in Voluntary Carbon Market and more than 20 Million tCO_2 decrease per year in greenhouse gas emission is expected. In Table 2, distribution of these projects according to different sectors can be seen [30].

Table 2 Voluntary Carbon Market Projects in Different Sectors in Turkey [30]

Project Type	**Number**	**Annual Emission Decrease (tCO2 / year)**
Hydro	159	8747634
Wind	106	7951391
Biomass / Biogas	27	3069273
Energy Efficiency	10	432081
Geothermal	6	405309
TOTAL	308	20605688

Before signing the Paris Agreement, Turkey submitted its Intended Nationally Determined Contribution (INDC) to UNFCCC on 20 September 2015. In the INDC, It is emphasized that Turkey is a developing country that achieved 230 percent increase in GDP between 1990 and 2012 with 30% increase in population. In addition, It is also stated that energy need of Turkey increased by 6-7 percent as average in this period. Also, maximum share of current account deficit of Turkey is

energy sector and Turkey has to use its limited energy sources like coal. Moreover, Turkey is only responsible for 0.7 percent of global greenhouse gas emissions from the Industrial Revolution. Considering this situation, it is claimed that Turkey needs to specify a carbon emission reduction target in order not to jeopardize its sustainable development. As a result, Turkey specified its 2030 carbon emission target as keeping it 21% lower than business-as-usual scenario and it can be seen in Figure 21. In 2015, total greenhouse gas emission of Turkey is calculated as 475.1 million tons. This value is almost equal to the business as usual scenario value that was calculated in 2012 for the year 2015 [65].

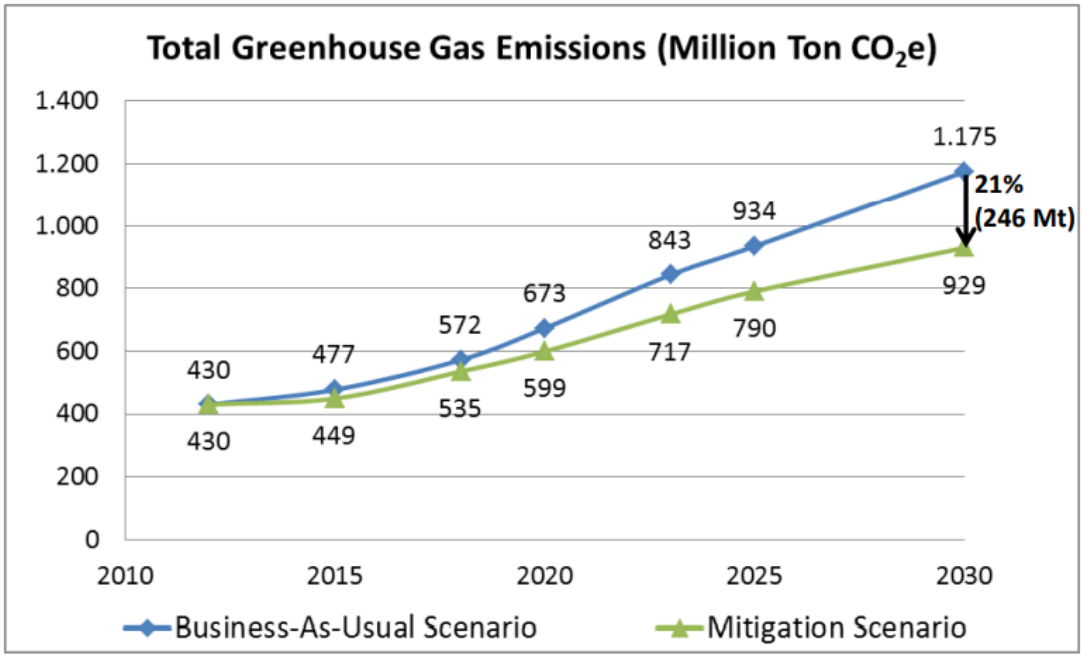

Figure 21 Greenhouse Gas Emission Scenarios of Turkey [65]

According to INDC, carbon emission of Turkey was 440 million tons of CO_2 equivalent in 2012 and energy sector has the largest share of it with 70.2 percent. Industrial processes, wastes and agriculture followed energy sector by 14.3, 8.2 and

7.3 respectively. Share of these sectors in carbon emission of Turkey can be seen in Figure 22 clearly [65].

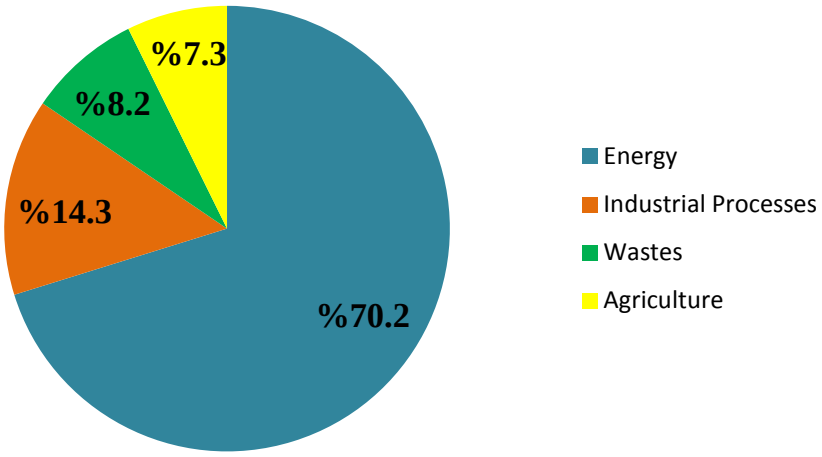

Figure 22 Carbon Emission Share of Sectors in Turkey [65]

Turkey plans to increase solar power capacity to 10 GW, wind power capacity to 16GW and use its all hydroelectric potential until 2030. In addition, a nuclear power plant is going to become operational. Reducing electricity transmission and distribution losses and renewing old state owned power plants are other energy related plans of Turkey in INDC.

In Renewable Energy Action Plan, Turkey targeted to increase its wind power potential to 20GW until 2023. Moreover, reducing electricity transmission and distribution losses to 5 percent was another demanding target of Turkey. Therefore, there is a contradiction between 2023 targets and INDC for Paris Agreement. This is one of the main reasons of Turkey is being accused of determining unsatisfying emission reduction targets for the Paris Agreement [66].

Turkey needs to take some precautions about its carbon emission increase, as it is a candidate for joining the European Union. In addition, Paris Agreement brings responsibilities for not only developed countries but also developing countries. Moreover, with its growing economy, share of Turkey in global carbon emissions is increasing every year. In future, there may be pretty much pressure on Turkey by UN to lower its carbon emissions.

Energy sector is responsible for more than 70% carbon emission of Turkey. Between energy sources, emission per unit energy of coal energy is the maximum. In Turkey, almost 90% of coal energy is used at thermal power plants. As a result, economical burden of a scenario in which Turkey shuts down all its coal power plants and instead builds wind, solar and geothermal power plants is going to be analyzed. This analysis is performed by taking the current installed capacity and electricity generation of Turkey, initial, fix and variable costs of power plants and energy prices into account.

Installed capacity of coal power plants of Turkey was 18000 MW at the end of 2017. 9870 MW of this capacity belong to domestic coal power plants and imported coal power plants have 8130 MW capacity. Average capacity factor of coal power plants can be accepted as 0.6. Installed capacity of Turkey in wind, solar and geothermal power plants are around 6000 MW, 1000 MW and 1000 MW respectively. If this proportion is preserved, assuming that capacity factor of a wind power plant as 0.35, solar power plant as 0.2 and geothermal power plant as 0.85, the resulting capacities for wind, solar and geothermal power plants in order to replace coal power plants can be calculated as:

$$(18000 * 0.6)\ MW = (6 * 0.35 * P) + (1 * 0.2 * P) + (1 * 0.85 * P) \quad (4.1)$$

$$\gg P \cong 3430\ MW \quad (4.2)$$

$$P_{wind} = 6 * 3430 \cong 20580\ MW \quad (4.3)$$

$$P_{solar} = 3430\ MW \quad (4.4)$$

$$P_{geothermal} = 3430\ MW \quad (4.5)$$

where P is the unit installed capacity.

Therefore, instead of 18000 MW of coal power plants, 20580 MW of wind, 3430 MW solar and 3430 MW of geothermal power plant must be constructed and their total capacity is 27440 MW. Initial investment cost and fixed and variable costs of these power plants are as in Table 3.

Table 3 Costs of Some Power Plant Types

Plant Type	**Initial Investment Cost ($/kW)**	**Fixed Operational Costs ($/kW-year)**	**Variable Operational Costs ($/MWh)**
Geothermal	4362	100	-
Photovoltaic	3873	24.69	-
Coal	3246	37.8	4.47
Wind	2213	39.55	-

Initial investment cost of new power plants can be calculated as:

$$Initial\ Cost = (2213 * 20580 * 1000) + (3873 * 3430 * 1000) + (4362 * 3430 * 1000) \quad (4.6)$$

$$\gg Initial\ Cost = \$73.8\ Billion \quad (4.7)$$

Operational cost of 18000 MW of coal power plants is:

$$Fixed\ Operational\ Cost = 37.8 \frac{\$}{kW*year} * 18000\ MW * \frac{1000*kW}{1*MW}$$

$$= \$680.4\ Million/year \quad (4.8)$$

$$Variable\ Operational\ Cost = 4.47\ \frac{\$}{MW*h} * 18000\ MW * \frac{365*24*h}{1*year} * 0.6$$

$$= \$422.9\ Million/year \quad (4.9)$$

$$Operational\ Cost = Fixed\ Operational\ Cost + Variable\ Operational\ Cost$$

$$= \$1.103\ Billion/year \quad (4.10)$$

where,

fixed operational cost: The annual cost of a plant that does not vary in terms of output power such as taxes, maintenance and managerial costs,

variable operational cost: The annual cost of a plant that varies in terms of output power such as fuel cost.

There is only fixed operational cost of wind, solar and geothermal power plants. Their total operational cost is:

$$Operational\ Cost = [(39.55 * 20580) + (24.69 * 3430)$$

$$+(100 * 3430)] * 1000 = \$1.241\ Billion/year \quad (4.11)$$

Their difference is:

$$Additional\ Cost = 1.241 - 1.103$$

$$= 0.138\ Billion/year\ =\ \$138\ Million \quad (4.12)$$

Therefore, in addition to $73.8 Billion initial investment cost, each year there is additional $138 Million for their operation.

Moreover, replacing coal power plants with renewable sources affects employment rate. Ministry of Labour and Social Security reports that 190946 people are working in mining and stone quarries. More than 50000 of these workers are coal miners that work under the ground. Considering the workers on processing and transporting coal and the ones that work at coal power plants, this number reaches up to 100000. Replacing renewable sources cannot provide the same amount of job opportunities. In long term, with investments done on developing renewable energy technology, various job opportunities can be created. However, these additional jobs are not for the workers in coal mines. They are still going to be unemployed and since they are concentrated on specific areas like Zonguldak and Soma, employment rates of these areas are going to drop drastically [68].

Carbon emission of different type power plants can be seen in Table 4. Accordingly, decrease of carbon emission by shutting down all coal fired power plants of Turkey can be found as:

$$\begin{aligned} Emission &= \left(9870\ MW * 1054 * \frac{Ton*CO_2}{GW*h} * \frac{1*GW}{1000*MW} * 0.6 * \frac{365*24*h}{1*year}\right) \\ &+ \left(8130\ MW * 888 * \frac{Ton*CO_2}{GW*h} * \frac{1*GW}{1000*MW} * 0.6 * \frac{365*24*h}{1*year}\right) \\ &= 92.6\ Million\ Ton\ CO_2/year \end{aligned} \quad (4.13)$$

This amount accounts for 16,2% of total emission of Turkey [67].

Table 4 Greenhouse Gas Emissions of Different Type of Power Plants

Source	**GHG Emission (Ton-CO2/GWh)**
Natural Gas	499
Lignite	1054
Imported Coal	888
Nuclear	66
Hydro	26
Wind	10
Geothermal	38
Biomass	26
Photovoltaic	23

Although shutting down coal fired power plants causes 16.2% decrease of Turkey's greenhouse gas emissions, Turkey cannot afford $73.8 Billion for replacing coal power plants with renewables. In addition, it is obvious that there are going to be social problems about unemployment of workers in coal mines. The best option may be keeping capacity of coal power plants steady and giving more incentives for new renewable energy investments.

As a result, Turkey cannot set a carbon emission reduction target as ambitious as the European Union considering its sustainable development. Using its domestic coal sources as well as increasing capacity of renewable energy sources in electricity generation and decreasing share of natural gas is the best option for Turkey to decrease its carbon emission with a reasonable percentage.

CHAPTER 5

RENEWABLE ENERGY TARGET OF THE EU AND TURKEY

Renewable energy is the last category of 2020 Climate and Energy Package of the European Union and it has the highest potential in fighting against climate change. In this chapter, targets and progress of both the European Union and Turkey is investigated in terms of renewable energy. In the first section, general information is given about renewable energy and renewable energy sources. In the second section, current situation and the renewable energy target of the European Union is defined. In addition, precautions taken by the Union to satisfy its targets and its improvements on increasing the share of renewable energy between all other energy sources are identified. Moreover, current situation and projections are analysed. In the third section, renewable energy potential of Turkey is investigated. Then, in the last section, same approach in the second section is followed for Turkey.

5.1 Renewable Energy

Renewable energy is the energy that is gathered from non-depletable sources as sunlight, wind, water flow and geothermal heat. They are renewed on a human timescale and do not emit greenhouse gases or produce any other gases or wastes that are harmful to the environment. Renewable energy is not only used for electricity generation, but also is used for heating and transportation.

Renewable sources have a tremendous amount of potential against finite sources like coal, uranium and petroleum. As it can be seen in Figure 23, potential of solar or

wind energy is higher than total energy consumption of the world [13]. Moreover, in Figure 23, given potentials are annual values for renewable sources but total values for finite sources.

According to REN21's Renewable Global Status Report 2016, 19.2% of global energy consumption and 23.7% of global electricity generation in 2015 were met by renewable sources. In 2015, more than $286 billion was invested in renewable technologies and 7.7 million jobs are associated renewable energy industries.

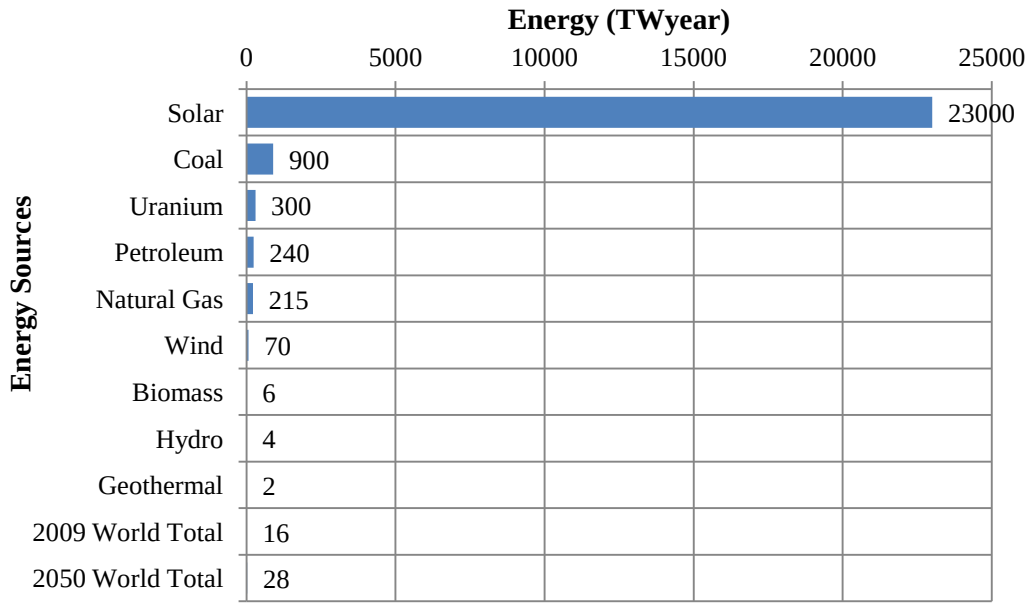

Figure 23 Potentials of Energy Sources [13]

5.1.1 Renewable Energy Sources

Renewable energy sources can be classified as Solar energy, wind power, hydro power, geothermal energy and bioenergy.

5.1.1.1 Solar Energy

Solar Energy is defined as radiant energy emitted by the sun and solar power is the power obtained by using the energy of the light of sun. Solar energy is the energy source that has by far the most potential among other renewable or finite energy sources. There are many developing technologies using solar energy such as solar thermal collector, photovoltaics (PV), concentrated solar power (CSP) and concentrated photovoltaics (CPV) which are main active solar technologies. Moreover, there are also passive solar technologies like orienting a building according to the sun, thermal mass technologies that allow a building store the heat from the sun and create inertia for temperature fluctuations.

Solar power is getting cheaper and more competitive every year. Figure 24 gives installed costs of solar power using photovoltaics in the last 5 years for residential, non-residential and utility-scale generation [14]. The installed cost is any cost that is needed to install and operate a power system; that are solar panels, power electronics, mounting hardware and the installation in this case.

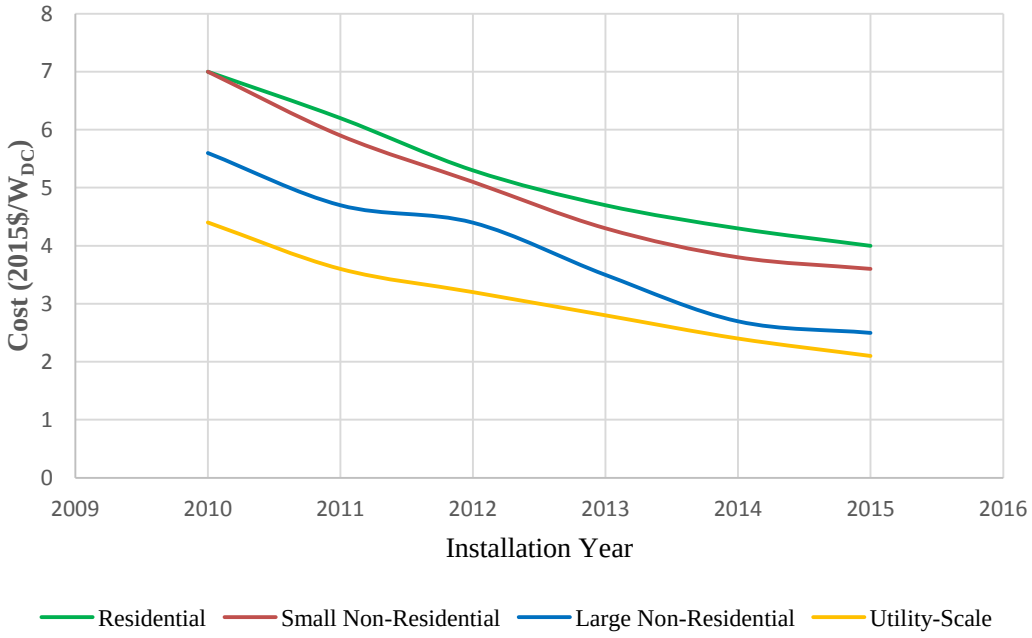

Figure 24 Median Installed Prices of Photovoltaics [14]

Decreasing of installed cost of electricity generation using photovoltaics is mainly caused by decreasing cost of the cost of power electronics, i.e. inverters that converts DC power generated by photovoltaic to AC power suitable for the grid. Figure 25 reveals this fact since module (solar panels) prices are not changing since 2012 [14].

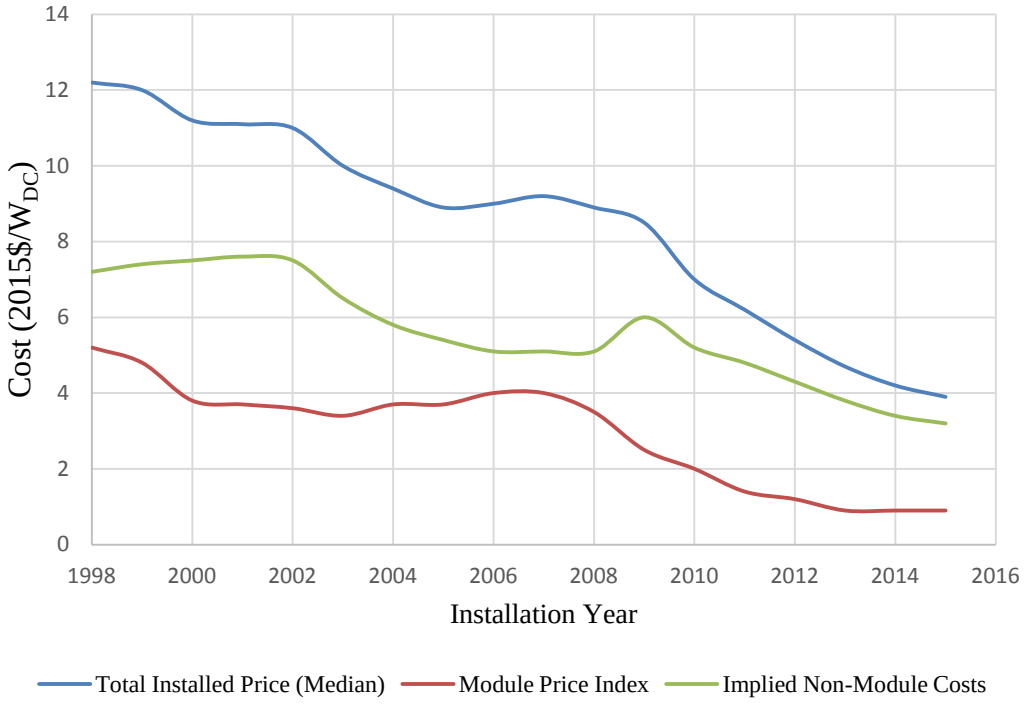

Figure 25 Residential Photovoltaics Installed Prices [14]

There are many numbers of benefits of using solar energy especially in long term such as increasing sustainability, reducing pollution and helping to decrease global warming, keeping fossil prices affordable. Moreover, since there is no raw material, there is no problem as security of supply. Therefore, energy independence can be achieved using solar power. However, main disadvantage of solar power is that after sunset, electricity cannot be generated using solar energy. Therefore, surplus energy produced in daytime must be stored in batteries; which is an expensive solution; or other supplies must be used. Despite of this disadvantage, advantages of solar

energy overrides and according to Renewables 2016 Global Status Report of REN21, 50GW of global capacity of photovoltaics is added in 2015 which can be seen in Figure 26 [15].

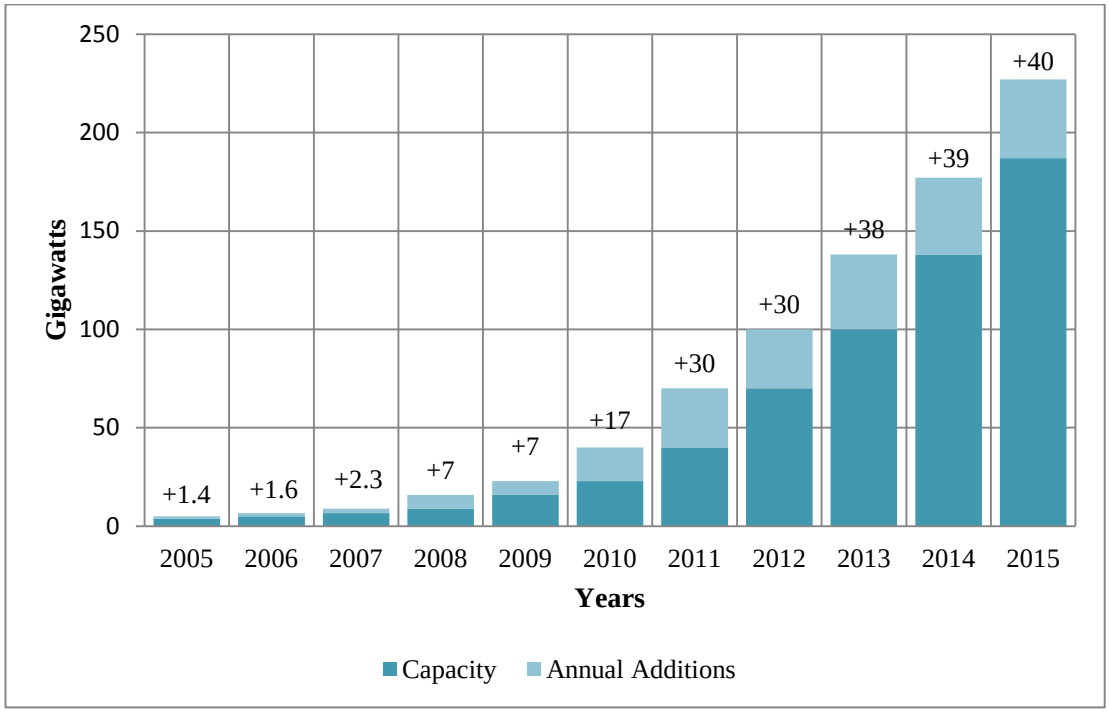

Figure 26 Installed Capacity of Photovoltaics in the World [15]

5.1.1.2 Wind Power

Wind power comes from kinetic energy of the wind that is converted to mechanical power and then to electricity. Wind power is proportional to cube of the speed. Therefore, wind speed is very important for wind turbines in order to acquire maximum efficiency for electricity generation. Therefore, offshore, seaside and high altitude areas have the greatest wind potential [16].

Capacity of modern utility-scale wind turbines are between 600kW and 5MW of rated power. However, commercial wind turbines are mostly between 1.5 and 3 MW of rated power. In 2015, a single wind turbine of 7.5MW capacity was installed. This means that wind turbine technology is still being developed.

2015 was a record for addition of wind power installed capacity in the world. 4% of electricity that is used in the world was generated using wind power. With a 63GW addition; installed capacity of wind power has increased 22%. In Table 5, leading countries of wind power addition in 2015 and top countries by total wind power capacity can be seen [15].

Table 5 Wind Power Top Countries by Addition and Total Capacity [15]

TOP COUNTRIES BY ADDITIONS	**TOTAL END-2014 (GW)**	**ADDED 2015 (GW)**	**TOTAL END-2015 (GW)**
China	114.6	30.8	145.4
United States	65.4	8.6	74
Germany	39.2	6	45
Brazil	6	2.8	8.7
India	22.5	2.6	25.1
Canada	9.7	1.5	11.2
Poland	3.8	1.3	5.1
France	9.3	1.1	10.4
United Kingdom	12.6	1	13.6
Turkey	3.7	1	4.7
TOP COUNTRIES BY TOTAL CAPACITY	**TOTAL END-2014 (GW)**	**ADDED 2015 (GW)**	**TOTAL END-2015 (GW)**
China	114.6	30.8	145.4
United States	65.4	8.6	74
Germany	39.2	6	45
India	22.5	2.6	25.1
Spain	23	0	23
United Kingdom	12.6	1	13.6
Canada	9.7	1.5	11.2
France	9.3	1.1	10.4
Italy	8.7	0.3	9
Brazil	6	2.8	8.7
World Total	**370**	**63**	**433**

5.1.1.3 Hydro Power

Hydro power comes from kinetic energy of falling or fast moving water, which is turned into mechanical and then electrical energy. Hydro power is used in 150 countries in the world and China is the largest electricity producer using hydro power. In 2015, 16.6% of the world's total electricity and 70% of the electricity generated from renewable sources was using hydro power. In Table 6, top countries by addition of hydro power in 2015 and top countries by total capacity of hydro power can be seen [15]. It is estimated that 28GW of new hydro power capacity was added in 2015 and it is the source that has the most installed capacity among all renewable energy sources.

Table 6 Hydro Power Top Countries by Addition and Total Capacity [15]

TOP COUNTRIES BY ADDITIONS	**ADDED 2015 (GW)**	**TOTAL END-2015 (GW)**
China	16.1	296
Brazil	2.5	92
Turkey	2.2	26
India	1.9	47
Vietnam	1	15
Malaysia	0.7	5
TOP COUNTRIES BY TOTAL CAPACITY	**ADDED 2015 (GW)**	**TOTAL END-2015 (GW)**
China	16.1	296
Brazil	2.5	92
United States	0.1	80
Canada	0.7	79
Russian Federation	0.1	48
India	1.9	47
World Total	**63**	**1064**

5.1.1.4 Geothermal Energy

Geothermal energy comes from the heat under the crust of the earth and it has been used since Paleolithic times for bathing and space heating. With technological developments, today it is mostly used to generate electricity but it is also still used for heating buildings. It releases some amount of greenhouse gases to the atmosphere but it cannot be compared to fossil fuels. Therefore, it is a clean and sustainable energy source.

One of the main advantages of geothermal energy is that its power output can be controlled unlike wind and solar power plants. Wind and solar power plants are useless if there is no wind blowing and sun is not shining respectively. Therefore, it can be a complementary source if it is used with solar or wind power plants. Moreover, it can be a base load power plant since a constant amount of power can be delivered using geothermal energy.

In 2015, 315MW of installed capacity using geothermal energy is added in the world and total capacity of geothermal energy is increased to 13.2GW. In Figure 27, total capacity of top 10 countries that use geothermal energy can be seen. With 159MW of addition of geothermal capacity, Turkey was leading country in 2015 and half of the geothermal capacity addition of the world was accomplished. [15].

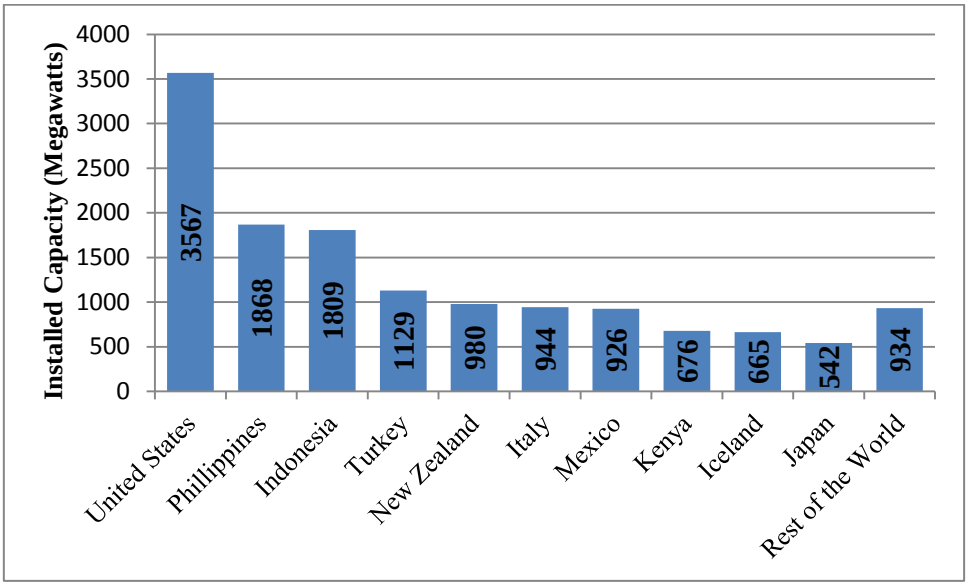

Figure 27 Top 10 Countries by Total Capacity of Geothermal Energy [15]

5.1.1.5 Bioenergy

Biomass is any organic material produced from living organisms. It can directly be used by combustion for heating or generating electricity. Moreover it can be converted to biofuels which are liquid or gaseous fuels that can be used as primary energy sources. Most commonly used biofuels are ethanol and biodiesel that are mostly used in transportation. Wood is accepted to be traditional biomass that cannot be treated as a renewable energy source since it is not sustainable. Actually, combustion of modern biomass produces same amount of greenhouse gases as fossil fuels. However, crop fields or fast growing trees that are planted to be biomass absorbs carbon dioxide in order to store energy with photosynthesis which is the source of bioenergy. If it is used carefully, i.e. not so fast, bioenergy is a sustainable, clean and trusted energy source.

In Figure 28, usage of bioenergy in different sectors can be seen. It contributes to as a primary energy supply more than any renewable energy source [15].

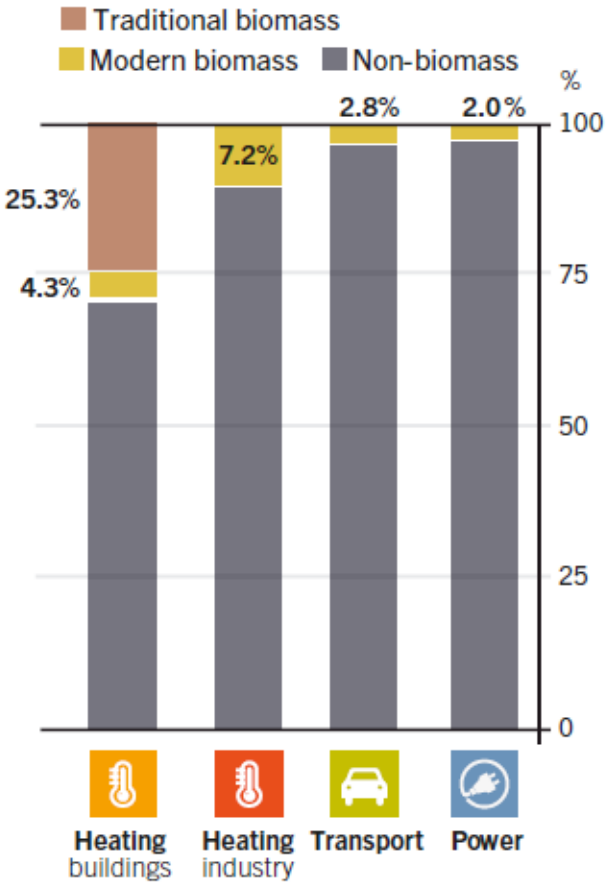

Figure 28 Biomass Usage in Different Sectors [15]

5.2 Current Situation in Europe

In order to achieve 2020 renewable energy target of the EU, that is reaching 20% share of renewables on final energy consumption, the renewable energy directive 2009/28/EC was published by the European Parliament and the Council on 23 April 2009. In addition to 20% target for overall share of renewables on energy consumption, 10% target for renewables on transportation is also covered with this directive. With this directive, 20% target of the EU is translated into individual targets of member countries as it can be seen in Appendix-C [17]. These individual targets are specified by accepting 2005 levels as starting point and considering renewables potential of each country. The lowest target belongs to Malta with 10% share of renewables and the highest one belongs to Sweden with 49%.

With this directive, calculation rules for share of renewable sources among gross final energy consumption were set. Electricity generated by using pumped storage units is excluded from the calculation of renewable energy shares. Moreover, passive energy systems were considered as contributing to energy saving instead of renewable energy use. Therefore it was excluded from the context of this directive. For electricity generation using hydro power and wind power, normalization rules were defined because of their high variations by years.

The directive allows member countries to cooperate with each other or non-member countries. These cooperation mechanisms are defined as;

- Statistical transfers of renewable energy between member states,
- Joint renewable energy projects between member states,
- Joint renewable energy projects between member states and third countries,
- Joint renewable energy support schemes.

Statistical transfer of renewable energy allows member states to transfer a certain amount of energy produced from renewable sources from a member country to another one. On condition that notifying the quantity and the price of the transfer to the Commission no longer than three months after the relevant year, member states count the transferred amount of energy to their national targets.

Two or more member states can participate in joint projects according to the directive. This participation may be between private operators. Moreover, a member state can participate in a joint project with a third country. Details and conditions of these joint projects are specified in the directive [17].

Moreover, a joint support scheme is defined as any mechanism implemented by a group of Member States in order to reduce cost of renewable energy or make renewable competitive in the market.

For 10% target of share of energy from renewable sources in transportation, biofuels have high importance. In order to count biofuels as a renewable energy source, sustainability criteria are defined in Article 17 of the Directive 2009/28/EC and after a year, an official journal on "practical implementation of the EU biofuels and bioliquids sustainability scheme and on counting rules for biofuels" is published. With the Directive, biofuels are counted as renewable energy sources whether the row material is farmed inside or outside of the European Union as long as the sustainability criteria are satisfied.

In order to count biofuels and bioliquids as renewable energy sources, they must contribute to greenhouse gas reduction from the atmosphere. Therefore, greenhouse gas emission savings of biofuels are defined at least 35% until 2017. In 2017, the saving is defined as 50% and after 1 January 2018, it is defined as 60% for biofuels counted as renewable energy sources. Biofuels that are produced from raw materials taken from forests and other wooded lands, areas that are protected by laws for nature protection purposes, natural grasslands that will remain as grassland unless there is no human intervention are defined as they would not be counted as renewable energy sources.

On 15 June 2015, the European Council published Renewable Energy Progress Report. According to the progress report, share of renewable sources in gross final energy consumption of the European Union in 2014 was projected to be 15.3% considering 2013 and earlier years' data and it can be seen that the EU is on track to meet its 2020 targets on renewable energy. Table 7 shows 2014 final energy consumption by sectors and 2020 targets. In heating and cooling sector, 2020 target for share of renewable sources is 21% and with 17% share of renewable sources in 2014, the EU is very close to satisfy its target [18]. However, in transportation sector, it can easily be seen that the EU is progressing slower than other sectors. According to the progress report, the main reason for this slowness is the lack of completing the policy to restrict the risk of indirect land-use change and expansion

of second generation biofuels. In electricity sector, the EU is on track to satisfy the targets specified in National Renewable Energy Action Plans as 26% of electricity generation is done using renewable sources in 2014.

Hydropower is still the largest contributor to renewable electricity generation. However with the development of wind power and photovoltaics, share of hydropower among all renewable energy sources has dropped from 94% to 43% between 1990 and 2013. Wind power and solar photovoltaics are second and third contributor to renewable energy share respectively.

Table 7 2014 Gross Final Energy Consumption by Sectors [18]

Sectors	**2014 Final Energy Consumption (%)**	**2014 RES Share of Sectors (%)**	**2020 RES Share Goals of Sectors (%)**
Heating and Cooling	46	17	21
Transports	30	6	10
Electricity	24	26	34

If national 2020 targets are considered, some member states have already exceeded their 2020 targets and most of them are expected to attain their objectives. However, as it can be seen in Figure 29, some countries must take some serious precautions to fulfill their objectives [18].

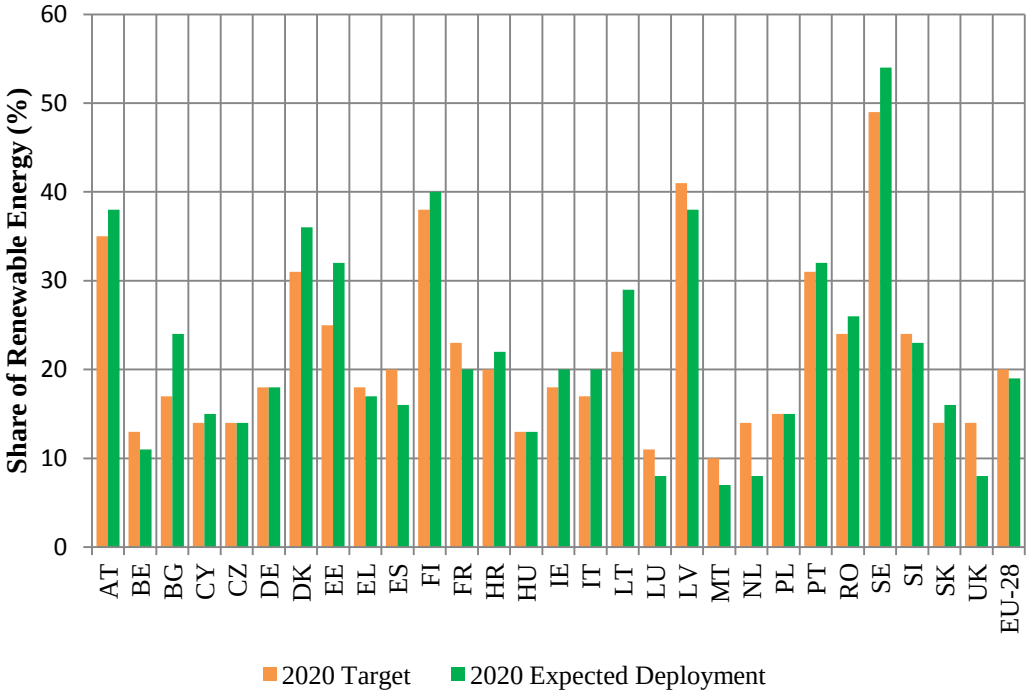

Figure 29 2020 National Targets and Expectations on Renewable Energy Share [18]

In order to make the European Union a leader of renewable energy in the world, the European Commission published a proposal for a revision of the Renewable Energy Directive. In the proposal, share of renewable sources in final energy consumption is targeted to be 27% until 2030. The European Council also agreed the proposal in October 2014. Moreover, the European Parliament invited the Commission to present this proposal and even suggested to increase renewable energy target to 30%. It is expected that the 2030 framework on renewable energy will provide more investment and employment opportunities.

5.3 Renewable Energy Potential of Turkey

With rapidly growing economy, Turkey constitutes a big part of energy market in the world. Although it has a great renewable energy potential, Turkey preferred to use fossil fuels in the past years and became a dependent country on energy. After

5346 numbered “Law Related Usage of Renewable Energy Sources on Electricity Generation” is issued, usage of renewable energy has increased quickly. In 2013, while electricity generation using renewable sources in the world was 22%, in Turkey it became 29% under favor of hydraulic energy sources.

Hydraulic Power is the first of all renewable sources in Turkey and it has a great potential. Turkey has 16% among all hydraulic potential in Europe and after Norway, it is in second place between European countries. In Figure 30, total installed capacity of Turkey and share of hydraulic power in recent years can be seen [31]. Accordingly, at the beginning of 2017, more than 30% of installed capacity was hydraulic power plants with 28000 MW installed capacity.

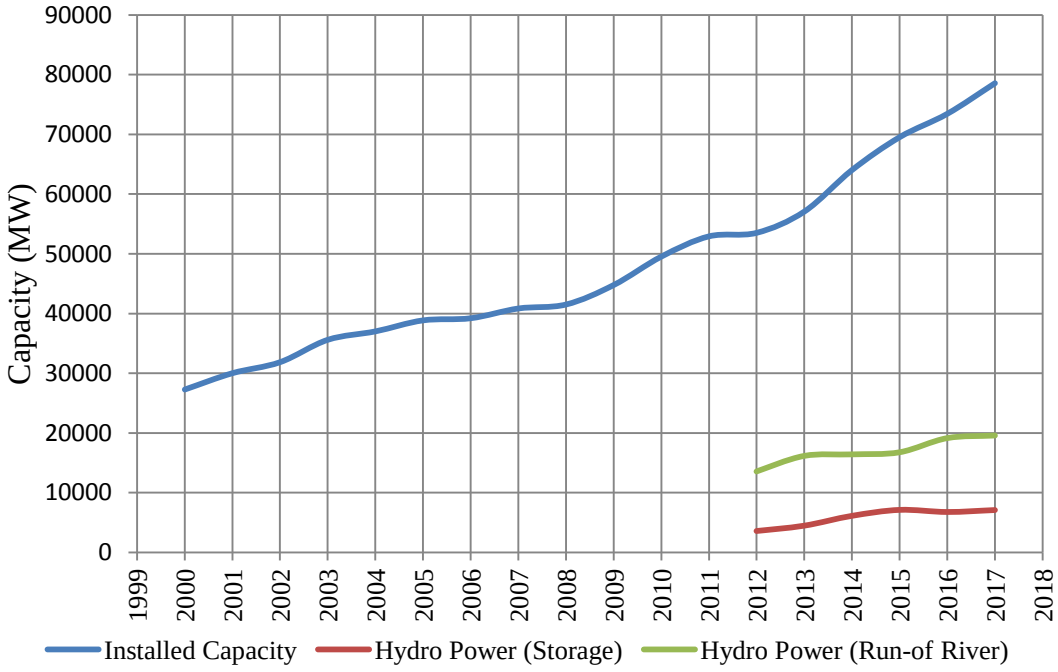

Figure 30 Installed Capacity and Share of Hydraulic Power in Turkey [31]

In recent years, share of wind power in all energy sources increased rapidly. In Table 8, capacity of wind power plants built between 2006 and 2017 and their share

in total electricity generation can be seen [32]. According to Wind Energy Potential Map which is prepared in 2007, total wind energy potential of Turkey is 48000 MW and if all wind energy potential of Turkey is used, power plants are going to cover 1.3% of Turkey's surface. Especially, wind energy potential of Turkey's northwestern towns is quite high and In Figure 31, wind capacity factor map of Turkey can be seen [33].

Table 8 Installed Capacity and Share of Wind Power in Turkey [32]

Year	Installed Capacity (MW)	Electricity Generation (GWh)	Share in Total Generation (%)
2006	51	127	0.07
2007	146	355	0.19
2008	364	847	0.43
2009	792	1495	0.77
2010	1329	2916	1.39
2011	1806	4724	2.05
2012	2312	5861	2.42
2013	2958	7558	3.07
2014	3762	8367	3.27
2015	4718	11543	4.38
2016	5443	12796	4.81
2017	6516	17909	6.06

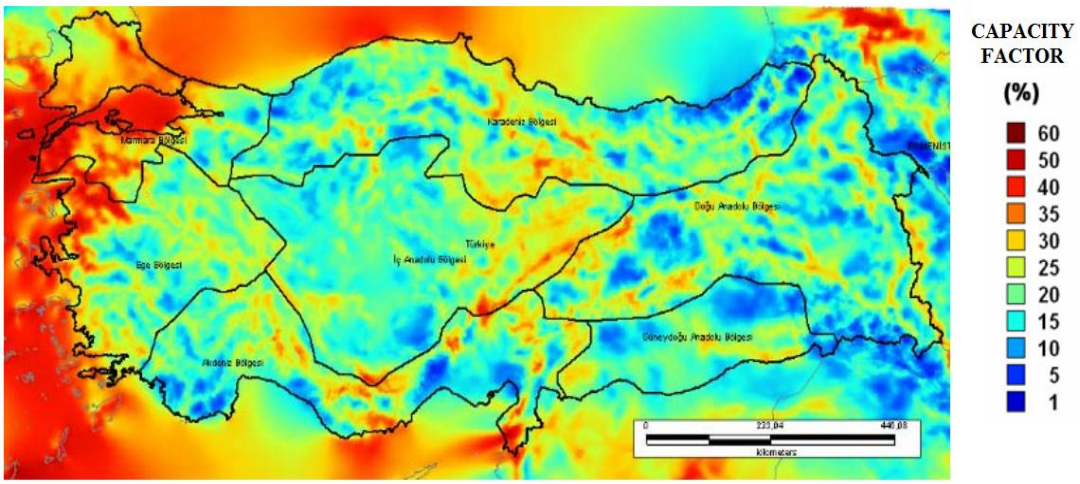

Figure 31 Wind Capacity Factor Map of Turkey [33]

With its location in Mediterranean belt, Turkey is also a lucky country about solar energy. According to Solar Energy Potential Atlas prepared by Ministry of Energy and Natural Resources, average sunshine duration of Turkey is 7.5 hours a day. In Figure 32, Turkey's annual sunshine duration map can be seen [34]. According to the map, especially southern towns of Turkey have a great potential of sun energy.

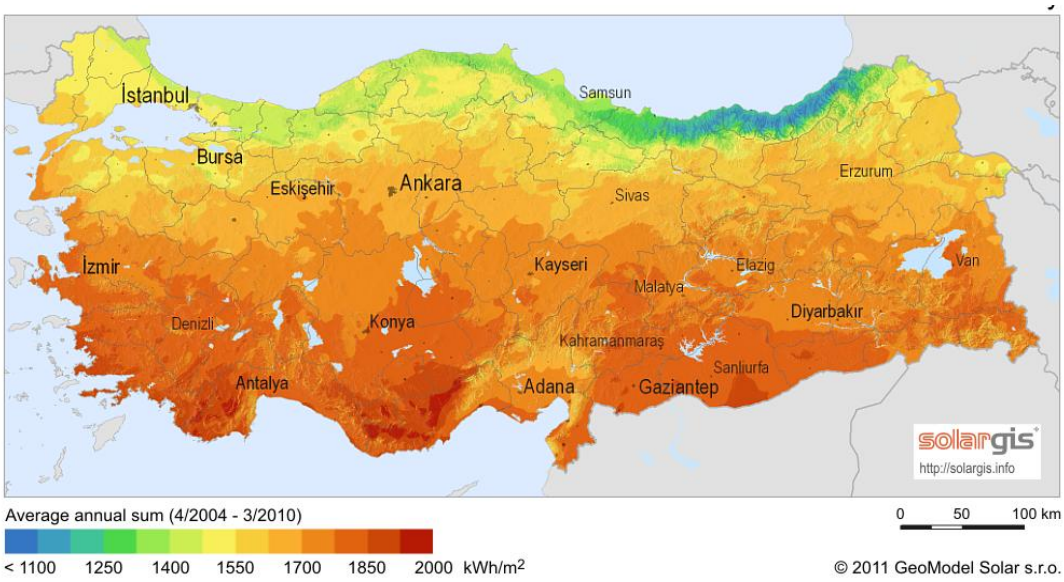

Figure 32 Annual Sunshine Duration of Turkey [34]

In Turkey, solar energy is used more in solar thermal heating than generating electricity. According to the analysis made by Ministry of Energy and Natural Resources, solar thermal water heating setups can be operated in full capacity all year in 17% of Turkey's total area. Moreover, in 94% of total area of Turkey, these setups can operate at minimum 80% capacity in all year. In solar thermal heating usage, Turkey is in fourth position in the world after China, the USA and Germany. In Figure 33, the countries that use solar thermal heating and their shares in global wide can be seen [15].

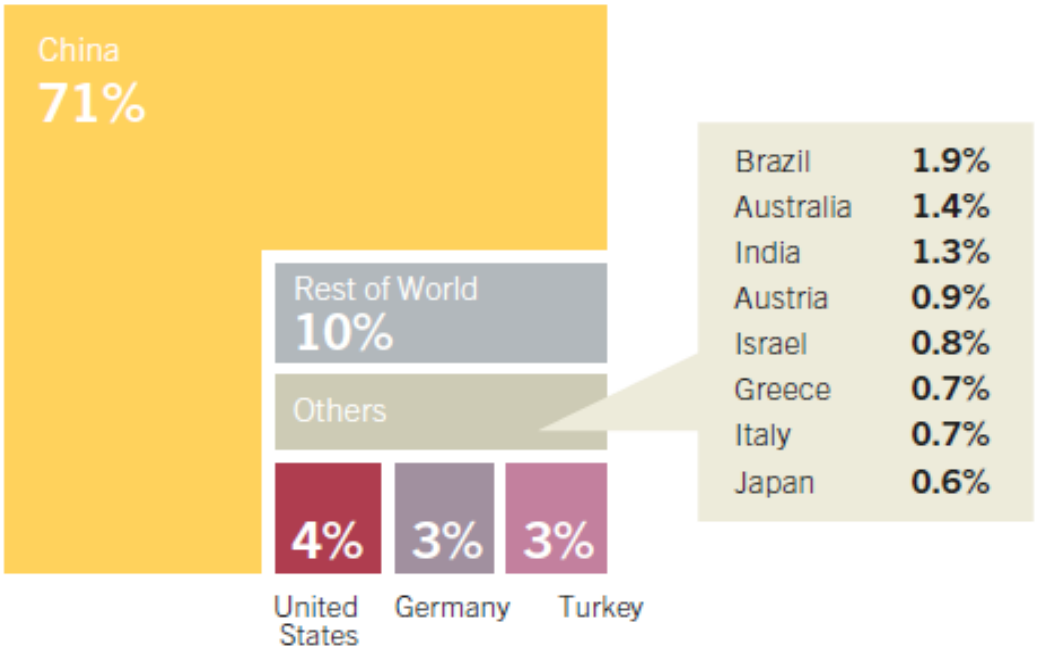

Figure 33 Share of Countries in Solar Thermal Heating [15]

In Turkey, in order to increase the usage of photovoltaic systems, Renewable Energy Sources Law numbered 5346 was revised in 2010 and in 2013 legislation works was completed. With the impact of this, the amount of electricity generated using photovoltaics has increased exponentially in recent years. Total installed capacity of photovoltaic power plants in recent years can be seen in Table 9 [35]. As it can clearly be seen, after 2012, the increase is exponential.

Table 9 Total Installed Capacity of Photovoltaics in Turkey [35]

Year	PV Addition (MW)	Installed Capacity (MW)
2008	0,75	4
2009	1	5
2010	1	6
2011	1	7
2012	5	12
2013	6	18
2014	40	58
2015	141	249
2016	2393	2642
2017	1948	4590

In Turkey, biomass, mostly wood and animal manure had been used as fuel in high amounts. However, with deforestation and regression of livestock, unsustainable biomass use also declined. On the other hand, the use of biomass has increased with the incentive on renewable energy during recent years. According to the Utilization of Renewable Energy Sources Law, biomass means all the solid, liquid and gas fuels that are made of agricultural and forestry products and their side products such as vegetable oil and harvest wastes as well as other organic wastes.

Although biomass usage in generating electricity in Turkey is not widespread, with recent incentives installed capacity of power plants that use biomass increased to 647MW in March 2018. Moreover, there have been incentive in biofuel production in order to achieve 10% renewable energy use in transport sector in 2023 energy targets of Turkey. In 2014, 32240 tons of biodiesel and 68634 tons of bioethanol was produced in Turkey in 2014 [37].

As a rich country of geothermal sources, Turkey is the fourth best country in terms of geothermal power capacity. Geothermal sources are mainly concentrated in western regions of Turkey. In Figure 34, the countries that has largest geothermal power capacity in the world and their total installed capacities can be seen [15].

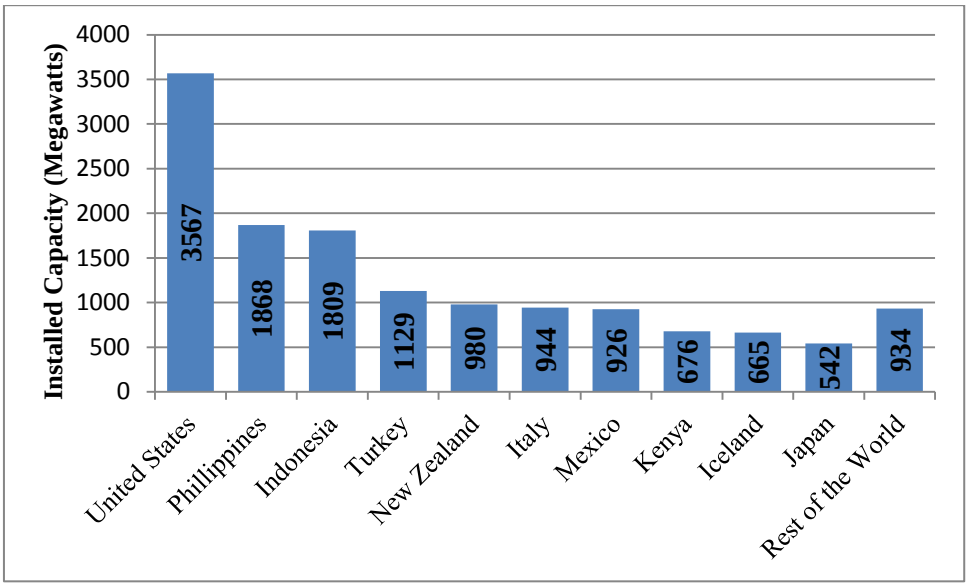

Figure 34 Countries with Highest Geothermal Capacities [15]

In Turkey, Geothermal energy is used in greenhouse heating and residence heating as well as electricity generation. If 2002 and 2016 years are compared, it can be seen that there have been some improvements on geothermal energy. For instance, number of fields suitable for electricity generation has increased from 16 to 25. Area of greenhouses that are heated using geothermal energy has increased 686% and number of residences that are heated using geothermal energy has increased 281%.

5.4 The Renewable Energy Target of Turkey

Directive 2009/28/EC of the European Parliament and the Council for incentive of renewable energy sources that was published on 23 April 2009 specified demanding

targets for all member states of the European Union. Moreover, this directive regulates all member states to prepare national renewable energy action plans covering from 2011 to 2020 until 30 June 2010. As a candidate country for the European Union, Turkey works to be in line with the EU acquis. Therefore, in order to reveal its commitment of joining the European Union, Turkey prepared its national renewable energy action plan from 2013 to 2023.

In 2012, 90% of primary energy consumption of Turkey was consisted of fossil fuels and most of these fossil fuels were imported. In parallel with the growth of Turkey, energy need of Turkey is expected to increase 90% from 2011 to 2023 as it can be seen in Figure 35. In this case, decreasing the dependency on imported fuels and increasing share of domestic and renewable sources in energy consumption becomes extremely important. Turkey is planning to increase the share of renewable sources in generating electricity to 30% until 2023. Moreover, in transport sector, share of renewable sources is wanted to be increased to 10%. Furthermore, energy density is planned to be reduced by 20% according to 2011 data.

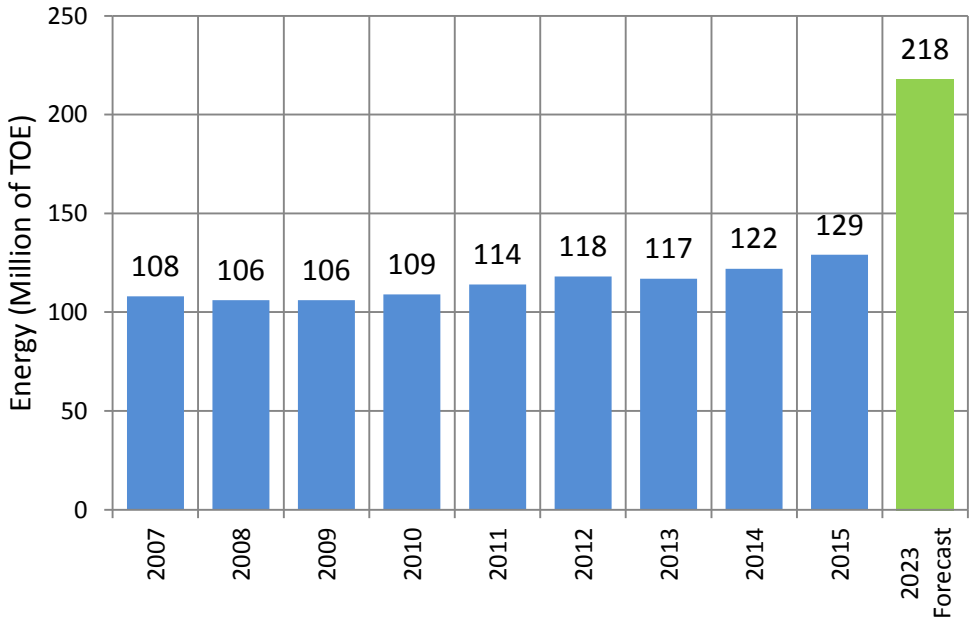

Figure 35 Primary Energy Consumption of Turkey [70]

Turkey's share of sources that are used to generate electricity and their installed capacity in March 2018 can be seen in Table 10. According to this, fossil fuels constitute 53% of installed capacity of Turkey. Although share of renewable sources in generating electricity seem to be close to 2023 target, with the expected increase in electricity need it is important to preserve this percentage. Furthermore, since 70% of renewable sources that are used to generate electricity is hydro power, this ratio can change easily with droughts. Therefore, renewable sources other than hydro power must be concentrated on in order to achieve 2023 targets. In Figure 36, electricity consumption of Turkey in recent years and expected increase until 2023 can be seen.

Table 10 Share of Different Sources on Generating Electricity in Turkey [70]

Sources	**Installed Capacity (MW)**
Natural Gas	27057
Hydro (Storage)	19881
Domestic Lignite	10579
Imported Lignite	8794
Hydro (River)	7582
Wind	6609
Solar	4590
Geothermal	1129
Biomass	647
Total	86868

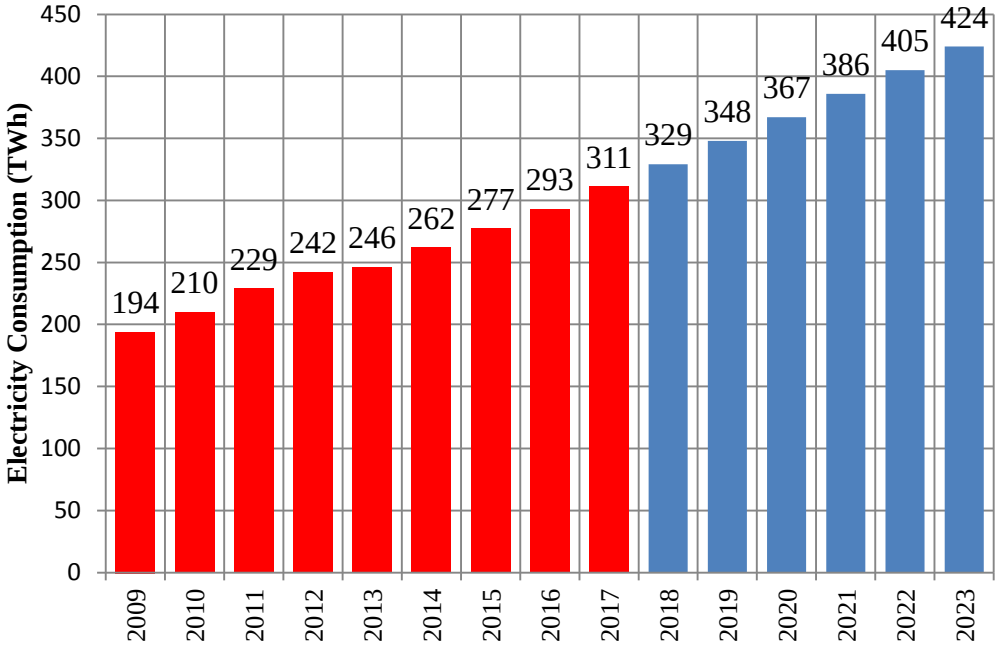

Figure 36 Electricity Consumption of Turkey [70]

In Renewable Energy Action Plan, renewable energy targets of Turkey are defined as the following:

- Reducing the dependency on imported sources due to usage of high amount of fossil fuels
- Increasing the installed capacity up to 125000 MW until 2023
- Increasing the installed capacity of hydro power plants up to 34000 MW by using entire hydro power potential of Turkey
- Reaching the installed capacity of 20000 MW wind power, 1000 MW geothermal and 5000 MW solar energy
- Reducing the losses and leakages down to 5% in electricity transmission and distribution
- Improving bio fuel industry

- Increasing the share of renewable sources to 20% on primary energy consumption and 30% on electricity generation

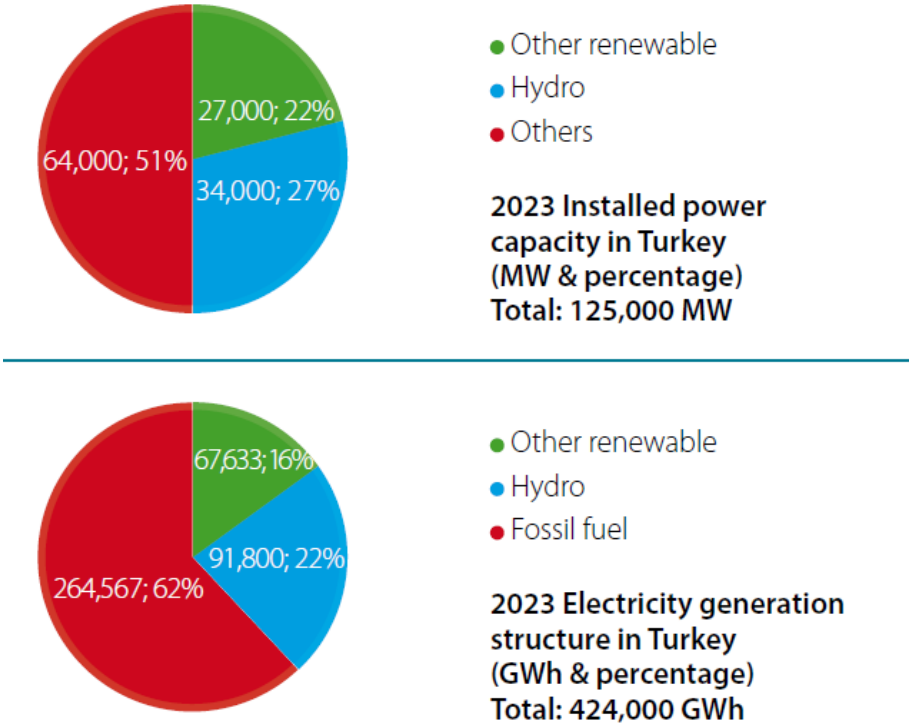

Figure 37 Installed Capacity and Electricity Generation Forecast of Turkey for 2023 [70]

If Turkey achieves these targets, share of sources on electricity generation and 125000 MW of installed capacity is expected to be as in Figure 37 in 2023. Renewable energy targets of Turkey seem to be achievable except the wind power target. Wind power target of Turkey is very challenging and needs to be updated.

CHAPTER 6

COAL ENERGY IN TURKEY

In this chapter, coal energy, which is one of the most controversial and by far the most pollutant energy source, is investigated in terms of different aspects. In the first section, general information of coal energy is given. In the second section, situation of coal in both the European Union and Turkey in recent years and current condition is identified. In the third section, the reason of why investors are reluctant to invest the coal, i.e. the risks of coal are mentioned. In the fourth section, clean coal technologies, which are the technologies to make coal energy less dangerous for the environment, and their benefits are defined. Then, in the fifth section, coal incentives and their reasons in Turkey are described. Finally in the last section, costs of coal energy and other energy sources are compared and comments are made about this comparison.

6.1 Coal Energy

Coal is an organic fossilized matter that is formed in marshes and composed of residues of plants that died millions of years ago. There are different types of coal according to the place, elapsed time and temperature and pressure it is exposed to [39]. Peat is the first step in coal formation. Because of its high water content, heat energy generation using peat is not efficient. With time and increasing heat and pressure, lignite is formed. It is still not efficient enough to generate high amount of heat energy. Therefore, lignite is usually used to generate electricity. With increasing pressure, bituminous and anthracite are formed respectively. As the

pressure increases, more water is removed from coal and percentage of Carbon increases. Therefore, anthracite is the most efficient and qualified coal type [40].

Coal is the most abundant fuel among other fossil fuels and therefore it is the most widely used and the oldest energy source. Until the Industrial Revolution, it was mostly used for heating residences but after that it became the most important fuel for electricity generation and steel and cement sectors and heating systems. Today, share of coal in global electricity generation is around 40%. The main reason of this popularity of coal is of course its lowest price among other fossil fuels. Moreover, the price of coal does not fluctuate like petroleum and natural gas. Despite its relatively higher construction costs, coal power plants are commonly used to supply base load all over the world because of these reasons.

Despite its popularity, coal is one of the most controversial energy sources since it is by far the most pollutant fossil fuel on earth. By burning coal, many greenhouse gases like SO_2, NO_2, CO and CO_2 are released to the atmosphere. After Kyoto Protocol, since most of the countries committed to reduce carbon emission, or at least to increase in a limited amount, they either started to decrease the use of coal or develop cleaner technologies for burning it.

6.2 Situation of Coal in Europe and Turkey

The European Union made lots of effort to decrease the use of fossil fuels and increase the share of renewables as energy sources. In Figure 38, decrease of coal usage of the Union as primary energy source from 1990 can be seen. It is clear that the usage of coal in the EU is halved in the past 25 years. Furthermore, after Paris Agreement, the EU committed to make the most ambitious nationally determined contribution for reducing its domestic greenhouse gas emissions that is a 40%

reduction compared to 1990 levels. Therefore, further decrease in coal consumption throughout the Union is expected in coming years.

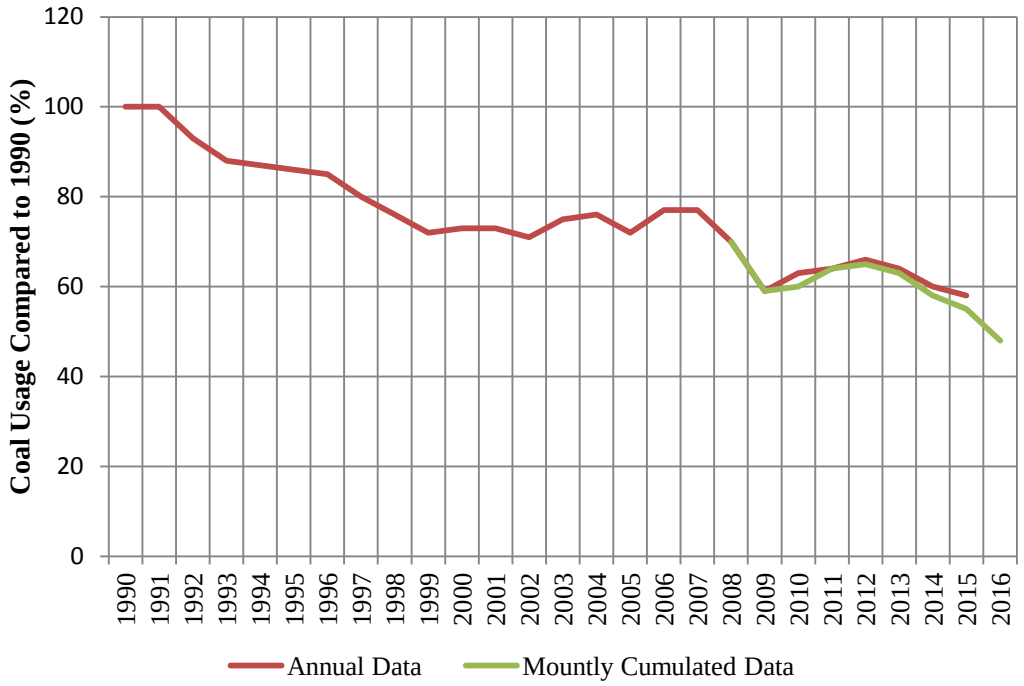

Figure 38 Decrease of Coal Usage in the EU [71]

However, in Turkey, there is a quite opposite situation. As it can be seen in Figure 39, Turkey makes use of coal quite lower than major countries in the world. Moreover, in Turkey percentage of coal among other energy supplies is 27% that is a lot lower than world average of 41%.

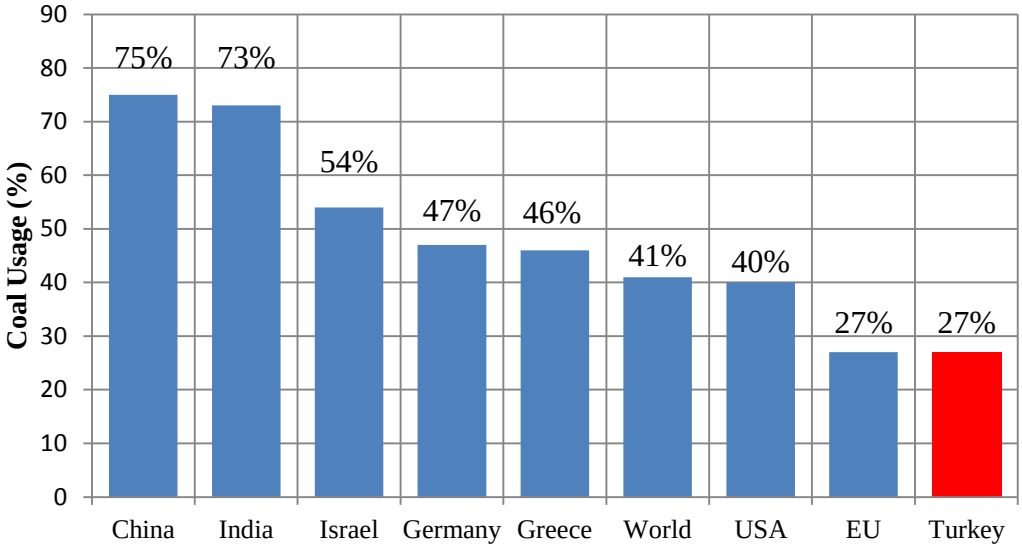

Figure 39 Coal Usage Percentages of Some Countries and Turkey in 2016 [42]

Security of supply may be more crucial for Turkey instead of increasing the usage of its high renewable energy potential. More than 60% of primary energy of Turkey consists of petroleum and natural gas that are almost completely imported. Furthermore, Turkey generated 50% of its electricity using these imported fossil sources in 2016. Being such a dependent country in petroleum and natural gas jeopardize Turkey's security of supply. In recent years, Turkey targets to increase its energy supply diversity and therefore security of supply by concentrating on coal along with nuclear energy. In 2015, primary energy consumption of Turkey is 126.9 billion TOE, 27.3% of which is the share of coal. Moreover, coal based power plant installed capacity of Turkey is 17316 MW that contributes to 22.1% of total installed capacity in 2016. 9437MW of installed capacity, i.e. 12.1% of total installed capacity belongs to domestic lignite sources. In Figure 40, change of Turkey's coal based installed capacity from 2005 to 2015 according to coal types can be seen.

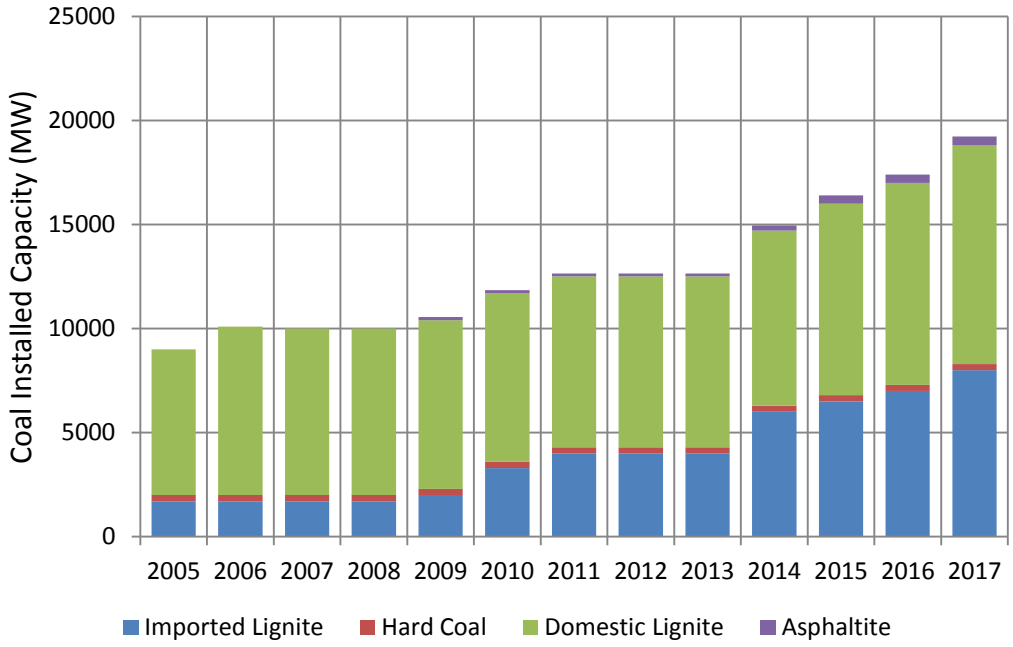

Figure 40 Turkey's Installed Capacity of Coal [42]

According to Electric Energy Market and Security of Supply Strategy Document that was published in 2009, Turkey targeted to reach its maximum potential of its domestic coal sources until 2023. From 2005 until 2015, Turkey's lignite reserve increased from 8.3 billion tones to more than 15 billion tones [41].

Another disadvantage of domestic lignite against imported coal is its low capacity factor. In Figure 41, capacity factors of domestic and imported lignite between 2005 and 2015 can be seen. The main reason of this low capacity factor is that domestic lignite has lower quality. However, other reasons are the fact that their availabilities are low since they are older, firstly government owned and recently privatized but no investment done on increasing their efficiencies. In Table 11 and Table 12, capacities and efficiency of some coal power plants that was built before 2000 and after 2000 can be seen respectively. Accordingly, it can be said that efficiencies of lignite power plants have risen from 33-35% up to more than 40%. As a result, instead of building new power plants, efficiencies of the already built power plants

can be increased with R&D studies. Moreover, interest of investors to domestic lignite sources for new power plants can be enhanced.

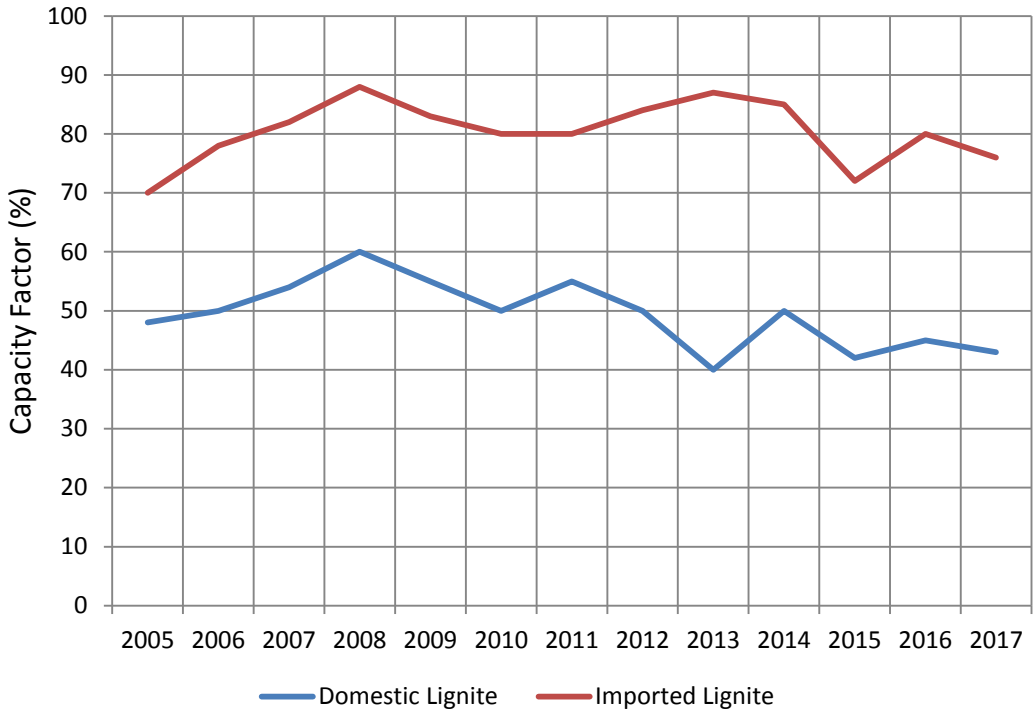

Figure 41 Capacity Factors of Domestic and Imported Lignite [42]

Table 11 Capacities and Efficiencies of Coal Power Plants Built before 2000 [42]

Power Plant	Installed Capacity (MW)	Coal Type	Became Operatioanal In	Technology	Efficiency (%)
Soma A	2 * 22	Lignite	1957, 1958	PC-Subcritical	AR-GE
Seyitömer	4 * 150	Lignite	1973, 1973,	PC-Subcritical	32
Tunçbilek (B 4-5)	2 * 150	Lignite	1977, 1978	PC-Subcritical	33,2
Yatağan	3 * 210	Lignite	1983, 1983,	PC-Subcritical	35,1
Afşin Elbistan-A	3 * 140 + 1 * 135	Lignite	1984, 1985, 1986, 1988	PC-Subcritical	28
Soma B	6 * 165	Lignite	1981, 1982, 1985,	PC-Subcritical	33,1
Yeniköy	2 * 210	Lignite	1986, 1987	PC-Subcritical	34,1
Çayırhan	2*150 + 2 * 160	Lignite	1987, 1987, 1998, 1999	PC-Subcritical	35
Kangal	2 * 150 + 1 * 157	Lignite	1989, 1990, 2000	PC-Subcritical	35,2
Çatalağzı	2 * 150	Hard Coal	1989, 1991	PC-Subcritical	34,4
Orhaneli	1 * 210	Lignite	1992	PC-Subcritical	27
Kemerköy	3 * 210	Lignite	1994, 1994,	PC-Subcritical	34,5

Table 12 Capacities and Efficiencies of Coal Power Plants Built after 2000 [42]

Plant	**Installed Capacity (MW)**	**Coal Type**	**Became Operational In**	**Efficiency (%)**
Sugözü-İskenderun	1320	Imported	2004	39
Afşin Elbistan B	4*360	Lignite	2009	39
Çolakoğlu Metalurji	190	Imported	2012	34
18 Mart-Çan	2*160	Lignite	2003	41
Silopi	1*135	Asphaltite	2009	38
Biga-Değirmencilik	3*135	Imported	2005	37
ZETES-1	160	Imported	2014	36
ZETES-2	2*615	Imported	-	41
Bekirli-Çanakkale	2*600	Imported	2011, 2013	42
Atlas Energy	2*600	Imported	2014	44
İzdemir-Aliağa	350	Imported	2014	44

6.3 Risks of Coal

Turkish Coal Enterprise contracted out 2335 MW coal capacity in Turkey and there are in Environmental Impact Assessment stage. Also, 10.7 Billion tons of domestic coal resources are in project phase. However, a trustworthy study cannot be conducted about how much of these sources are feasible. This is the main reason that investors avoid domestic coal. Due to the fact that no studies are done before the

coal capacity is contracted, in addition to 3-4 years of power plant investment, design and operational works, 3 years of mine analysis and development activity is also performed. Normally these studies are conducted simultaneously and total time until the operation is shortened but because of varying structure of lignite mines in Turkey it cannot be possible. Power plant design is made according to the features of the lignite in the regarding area. Therefore, including pay-back time, almost 15 years of investment is required for a domestic lignite power plant.

Furthermore, there may be unforeseen expanses during mining activities. Moisture and sulfur percentage and amount of calories of the coal, clay in the mine and situation of fault lines may increase the expanses for processing coal. Also since the investment duration is high, possible increases in labor costs and expropriated prices increases the risks of investing domestic lignite. Moreover, since the first electricity generation starts after 7 years of project start, the difficulty of predicting electricity prices in future arises. Changes in costs of renewable energies, future natural gas prices and increments in efficiencies of natural gas power plants complicate predicting the future of coal and prevent investors to invest coal without a guarantee of purchase with a constant price.

Lignite and imported coal power plants are designed to supply base load and their start-stop costs are very high. Starting of a coal power plant takes almost 8 hours and stopping and starting continuously damages the plant. Hence, coal power plants cannot stop their operation when coal prices decreases or at night when electricity prices are very low like natural gas power plants. Therefore, it is sometimes possible to encounter coal power plants operate with a loss.

Since investment costs of coal power plants are very high, financial support from banks are required. Because of long investment durations, possible increases in foreign currency exchange rates strand the investors. Besides these, bureaucratic risks and occupational accident risks detract the investors to invest in coal. As a

result, with regards to expenditures and risks, comparison of other power plants with coal power plants can be seen in Table 13.

Table 13 Comparison of Costs of Coal Power Plants with Other Types of Plants [42]

Type of Power Plant	Duration of Investment	Investment Costs	Variable Operation Costs	Fixed Operational Costs	Fuel Price Risk	Reliability
Domestic Lignite	Long	Medium	Medium	High	Medium	High
Imported Lignite	Medium	Medium	Medium	High	High	High
Natural Gas	Short	Low	High	Low	High	High
Renewable	Short	High	Low	Low	Low	Low
Nuclear	Long	High	Low	Low	Low	High

6.4 Clean Coal Technologies

Coal is the most abundant and available fossil fuel in the world. Also coal has been primary energy source of humans since the Industrial Revolution. Therefore, burning coal for generating electricity has always been one of the most competitive and cheap method. In recent years however, after global warming reached to a critical level, it also became the most controversial energy source among all other sources since it is the most pollutant energy source. However, since it is the most common energy source and hundreds of thousands of people make their livings with it, stopping the use of coal just because of its harmful environmental effects would be a great loss instead of reducing these harmful effects and continue using this reliable energy source.

Clean coal technologies arise in order to provide cleaner methods for using coal as an energy source. These technologies mainly focus on two phenomena. One of them is reducing harmful products that are released by burning coal by capturing them. Second one is increasing the efficiencies of power plants so that they use less coal to

generate the same amount of energy i.e. they release less greenhouse gases and other gases that are harmful to the environment.

Coal preparation plants are the simplest and oldest way to make coal cleaner. In these plants, coal is first crushed into graded sized chunks so that coal and inorganic materials that merged into coal are separated easily. Than the coal is sifted in order to eliminate impurities. After that the coal is washed and dried in order to reduce its increased humidity after washing. In developed countries, coal is usually washed before using it to generate electricity. However, in developing countries, this method is used less because of its cost. In Turkey, bituminous coals are washed but lignite type coals are not washed because of high amount of losses. Advantages of coal preparation plants are lower transportation and storage costs, increasing the efficiency of coal power plants because of purification of coal and reducing the amount of ash that is obtained by burning coal [47].

Carbon capture and storage is a process in which carbon dioxide that emerges by burning fossil fuels is captured and transported to a storage area in order not to pollute the environment. The captured carbon dioxide is usually stored underground geological formations such as oil fields, gas fields and saline formations. When carbon dioxide is stored in oil and gas fields, it also increases the efficiency of oil and gas recovery from these fields. Moreover, there are some applications that carbon dioxide is stored inside the oceans. With this technology, up to 90% of the carbon dioxide that is emitted by burning coal can be captured. However, carbon dioxide is not the only output of burning coal. Therefore, this technology can be supported with other technologies in order to make coal energy cleaner. In Figure 42, an illustration of carbon capture and storage can be seen [48].

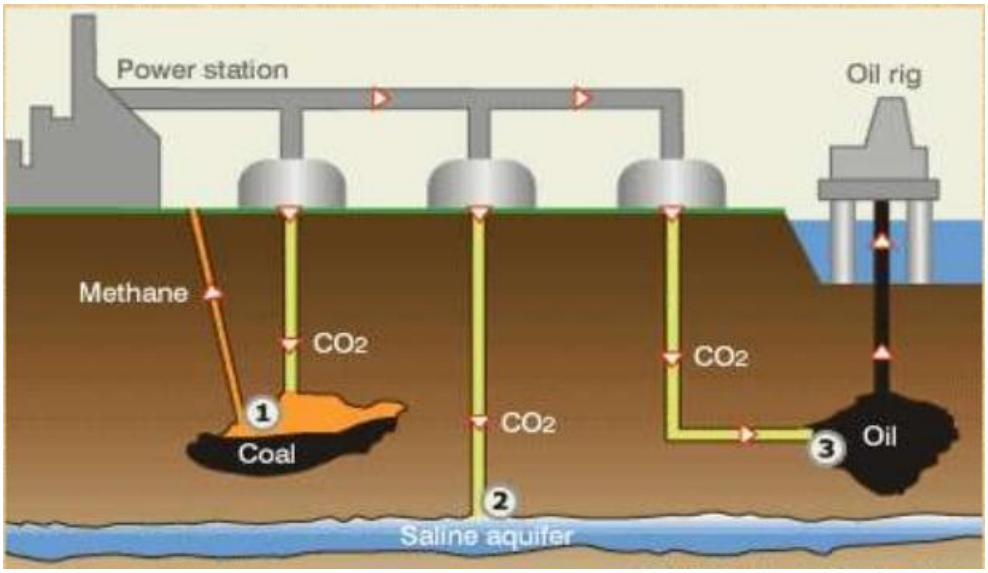

Figure 42 Carbon Capture and Storage [48]

Integrated gasification combined cycle (IGCC) is a newer technology that is used in coal power plants. A typical diagram of IGCC can be seen in Figure 43. With this technology, coal is converted to a gas that is called synthesis gas (syngas) using high pressure gasifier. Then, the syngas is used as fuel in the gas turbine. The steam produced by the syngas coolers is used by the steam turbine in combined cycle. Therefore, efficiencies of IGCC power plants can increase up to 50%. Increasing efficiencies of coal power plants decreases greenhouse gas emissions drastically. Moreover, when the coal is turned into gas form, its impurities can be removed easily and a cleaner fuel is obtained. In Figure 44, comparison of greenhouse gases and other waste materials of a classical pulverized coal power plants and IGCC power plants can be seen.

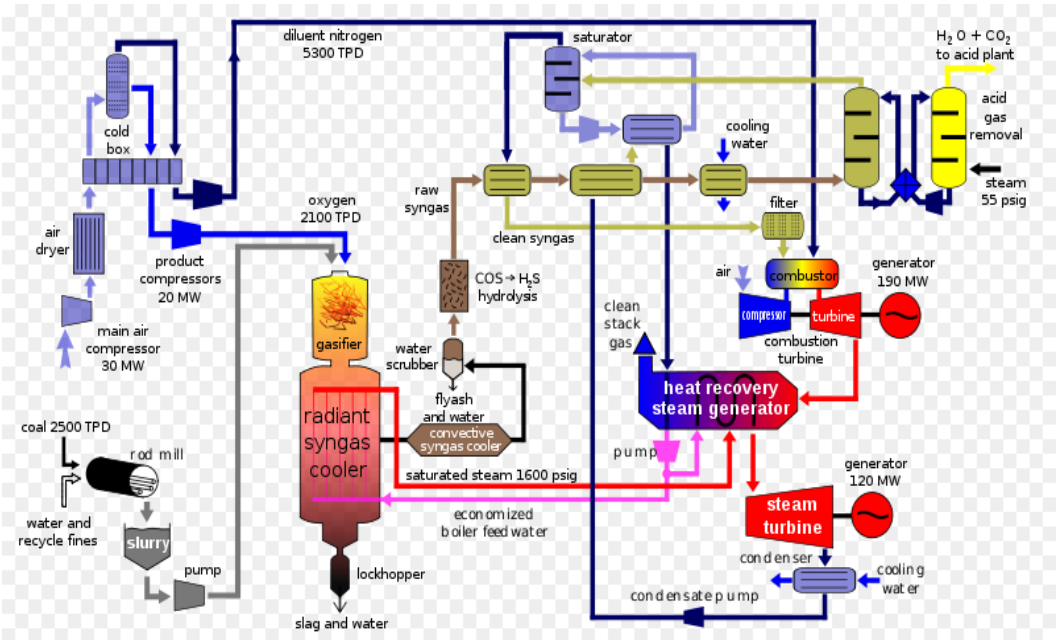

Figure 43 Integrated Gasification Combined Cycle [72]

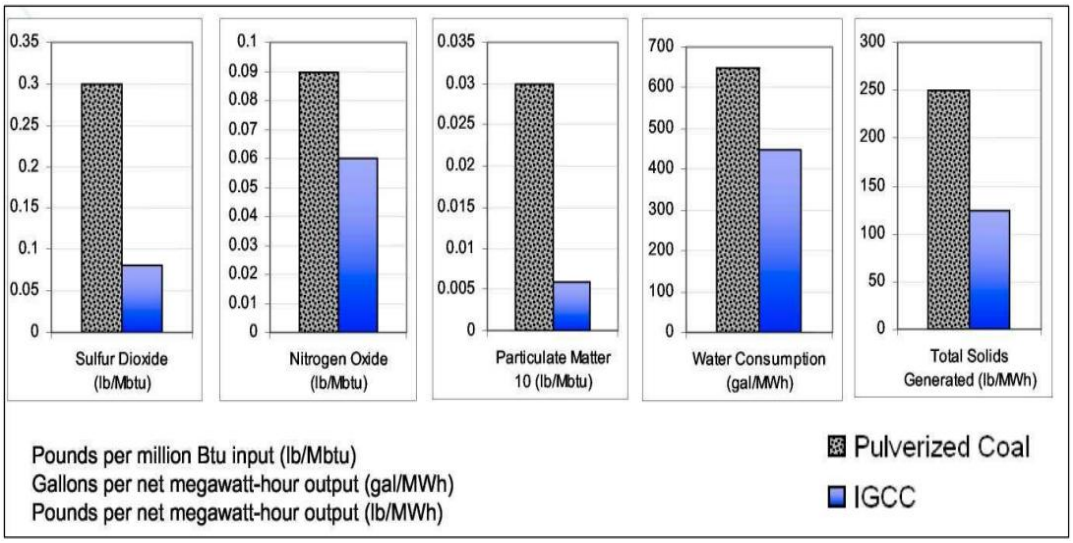

Figure 44 Comparison of Pulverized Coal and IGCC Power Plants [72]

Another clean coal technology is fluidized bed combustion. In this method, limestone and dolomite are added during the combustion process of coal in order to remove sulfur from it. Then, coal is subjected to fluidized bed of ash, sand and

limestone in order to be combusted with the blown air. Within the bed, mixing of gas and solids closely provides fast heat transfer. One of the main advantage of this method is there is no need for preparation of the coal unlike pulverizing type coal power plants. In Figure 45, a typical diagram of a fluidized bed combustion type coal power plant can be seen.

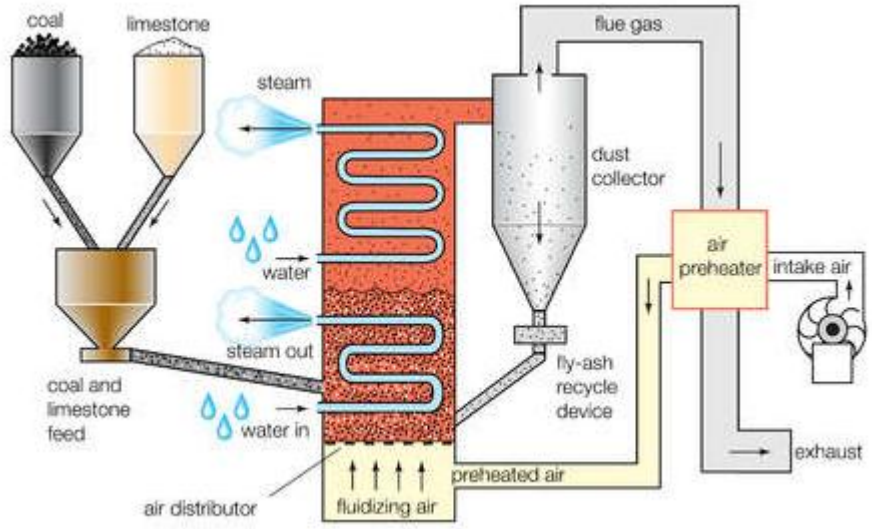

Figure 45 Fluidized Bed Combustion [72]

To sum up, coal is a very important fossil fuel since it is the most abundant one and it is available for more than 70 countries unlike petroleum and natural gas which are owned by a small number of countries. Also there are more than 100 years of adequate coal reserve on earth. However, since it is the most pollutant fuel among all other types of fuels, high amount of investments must be done on clean coal technologies in order not to destroy the environment. With increasing efficiencies of its power plants and decreasing its greenhouse gas emissions, coal remains as one of main energy sources and it seems it is going to continue to be one of them.

6.5 Domestic Coal Incentives and Reasons

Despite the risks of using domestic lignite source mentioned before, the reasons of insisting using it are increasing security of supply, providing employment opportunities more than any other sources, trustworthy electricity generation and decreasing energy import. Comparison of these features with other sources like imported lignite, natural gas and renewable sources can be seen in Table 14.

Table 14 Features of Coal and Other Type of Power Plants [42]

Type of Power Plant	Securing Supply	Creating Employment	Production Reliability	Reducing Importation
Domestic Lignite	High	High	High	High
Imported Lignite	Medium	Medium	High	Medium
Natural Gas	Low	Low	High	Low
Renewable	High	Low	Low	High

Turkey imports all of the natural gas that is supplied by pipelines from three countries, which are Russia, Iran and Azerbaijan, and utilizes 38% of this natural gas in order to generate electricity. For a country, energy deficiency is a lot worse than expensive energy. Therefore, along with renewable sources, domestic lignite sources have importance on security of supply. Imported coal is also not as harmful as natural gas and petroleum on security of supply since it is imported from several countries. However, even if Turkey has good relations with all three countries it imports fossil fuels, pipelines could be insufficient in cold winter days and since priority is given for residential areas for heating purposes, natural gas power plants may have to stop operating. Moreover, these days, electricity consumption becomes maximum, generated electricity may become insufficient and there has to be power cuts for grid to operate safely.

Since mining activities of imported natural gas and coal are not performed by Turkey, mining costs are added to the prices of these sources. This helps other countries to provide employment opportunities. Today, in a 600 MW natural gas power plant, 60 people are employed. However, in an imported coal power plant with the same capacity, this number is 370. Since mining activities of domestic lignite sources are done in Turkey, a 600 MW domestic lignite power plant can employ as much as 1100 people. Therefore, domestic lignite makes a great contribution to economy. However, before extending mining activities, the most important subject to consider is the security of the miners. Activities without taking the necessary precautions for the security of miners cause formidable social problems more than their economical benefits.

One of the main problems of generating electricity from renewable sources is the fluctuations of the generated power. Especially wind energy is variable in hourly basis and it is possible to generate electricity using solar energy only at day time. In order to compensate the fluctuations on generating electricity using wind and solar energy, thermal or impoundment and pumped storage hydro power plants are required. Even if hydro power plants and natural gas power plants are the ones that react quickly, coal power plants can be used for this purpose too. Moreover, coal power plants are the most suitable power plants for supplying base load.

In 2012, at the Council of Ministers, lignite power plants are declared in 5^{th} Region subsidies. These subsidies were immunity of added value task, exemption from customs tax, up to 70% discount in corporate tax, interest support and support for the insurances of the employees. Moreover, although it must be the last support mechanism to think of, one of the first mechanisms that is considered in Turkey is guaranteed purchase in fixed prices. Despite the fact that it is quite beneficial for investors and institutions that provide financial support for the projects, it also damages liberal market mechanisms because this support mechanism reduces the trade volume in free markets.

Another support mechanism that can be applied to domestic lignite power plants is providing additional price. It is not like guaranteed purchases in fixed prices but providing payment in addition to market price as long as the plant is operational. Since the payment increases with the amount of the generated energy, availability of the plants increases. Moreover, this support mechanism harms liberal markets less than providing fixed prices and guaranteed purchases. Furthermore, considering long investment durations of domestic lignite power plants, sometimes it may be better to subsidize old power plants instead of building new ones [42].

6.6 Unit Costs of Renewables and Coal Energy

Energy necessity of the world continuously increases because of technological developments, increase in human population and welfare level. According to International Energy Agency, despite the fact that energy consumption of OECD countries is expected not to change considerably until 2040, 75% increase in energy consumption of other countries is expected between 2005 and 2040. Because of this, more and more power plants are going to be built and reducing their costs are really important.

Before building new ones, initial investment costs and unit energy cost must be taken into account in power plants. Initial investment cost consists of the expenditures for preparing the power plant for energy generation like machinery, equipment, building and terrain. Most of the time, this cost is the maximum cost of a power plant. Unit energy generation cost of a power plant is an economic evaluation criterion combining all of the expenditures in its entire lifetime in order to generate a unit of electricity. Operation and maintenance costs are other main costs of power plants that are needed for the power plant to generate electricity after it is built. Operation costs is divided into two categories as constant operational costs and variable operational costs. Constant operational costs consist of payments and

bonuses of employees, power plant general and executive expenditures and planned maintenance activities. Variable operational costs consists of fuels, water, chemicals, catalysts, gasses and costs of removing wastes. Initial investment costs in terms of $/kW, constant operational costs in terms of $/kW-year and variable operational costs in terms of $/MW-hour of different types of power plants are given in Table 15. According to Table 15; wind, geothermal, solar and hydro power plants does not have any variable operational costs [43].

Table 15 Costs of Different Power Plant Types [43]

Plant Type	Initial Investment Cost ($/kW)	Fixed Operational Costs ($/kW-year)	Variable Operational Costs ($/MWh)
Wind (offshore)	6230	74	-
Nuclear	5530	93.28	2.14
Geothermal	4362	100	-
Biomass	4114	105.63	5.26
Photovoltaic	3873	24.69	-
Lignite	3246	37.8	4.47
Hydro	2936	14.13	-
Wind (onshore)	2213	39.55	-
Natural Gas	917	13.17	3.6

Hydro energy potential of Turkey is calculated as 141 Billion kWh and including run-of-river type power plants, this potential increases up to 180 Billion kWh. However, Turkey utilizes only one third of this potential and each day billions of dollar worth of water is wasted. Turbine prices of hydropower plants vary between 750 and 1250 €/kW that can be accepted as an average of 1000 €/kW. Including mounting costs, project design and other expenses, total initial investment cost increases up to 1250 €/kW. Considering a 1 MW hydropower plant:

$$Initial\ Investment\ Cost = 1250\ \frac{€}{kW} \times 1000\ kW = 1250000\ € \quad (6.1)$$

Capacity factor of this plant should be around 0.8. Therefore, annual energy generation would be:

$$Annual\ Energy\ Generation = 1000\ kW\ \times 365\ \times 24\ h\ \times 0{,}8$$
$$= 7008000\ kWh \quad (6.2)$$

Considering the sale price would be 0.055 €/kWh according to Renewable Energy Law and operating cost of the plant would be 0.01 €/kWh, annual profit and payback period of the plant would be:

$$Annual\ Profit = 7008000\ kWh * (0.055 - 0.01)\frac{€}{kWh} = 315360\ € \quad (6.3)$$

$$Payback\ Period = 1250000\ \div 315360 = 3.96\ years \quad (6.4)$$

However, this calculation is pretty rough. Because, especially in storage type hydropower plants, 10 to 15 years pass between preliminary survey and completion of construction. Even in developed countries, this long time results in high inflation rates. Moreover, as capacity of the power plant increases, lots of unpredicted expanses occurs and because of this, cost predictions of the plant would be erroneous [44].

More than 40% of electricity of Turkey in 1998 was being generated using domestic lignite but in recent years, it became only 15%. However, recently electricity generation using domestic lignite sources is supported by the government. Initial

investment costs of domestic coal power plants are between 1250 and 1500 €/kW and an average of 1375 €/kW. Environmental protection costs of lignite (desulphurization, dust collection etc.) are around 0.75 cent/kWh, maintenance and operational costs are around 3 cent/kWh and fuel costs are around 1.8 cent/kWh. Also, capacity factor of a domestic lignite power plant is around 0.5. Considering all these data, payback time of a domestic lignite power plant approaches to 15 years.

Since imported coals have higher calorie densities than domestic coals, they are more profitable. Having higher energy density reduces environment protection costs. Moreover, coal prices are lover for imported coals. Therefore, although initial investment costs are the same, total electricity generation cost of imported coal power plants becomes 4.8 cent/kWh which is lower than domestic coal power plants. If generated electricity is sold with the same price with domestic coal, payback period of an imported coal power plant becomes 11 years.

Being favorite power plants of 1990's, natural gas power plants still have the lowest initial investment costs among other power plant types. However, because of constantly increasing fuel costs increase electricity generation costs and reduce competitiveness of natural gas power plants. Initial investment costs of natural gas power plants vary between 700 and 800 $/kW. Today, electricity generation cost of natural gas power plants is 6.25 cent/kWh 80% of which is fuel costs. Since profit rate of natural gas power plants depends so much on fuel costs, calculation of payback period of a new plant becomes difficult.

Today, 15% of the world's electricity is generated using nuclear energy. Initial investment cost of a 1000 MW nuclear power plant is between 3000 and 3500 $/kWh. Therefore, initial investment cost of nuclear power plants is the highest among other types of power plants. In these circumstances, initial investment cost of Akkuyu nuclear power plant is estimated to be $ 15 Billion. Although it is expected that total variable cost of a power plant that has so much initial investment cost to be low, the situation is quite the opposite. Variable cost of a nuclear power plant is

almost equal to an imported coal power plant. Accordingly, payback period of a nuclear power plant becomes 15 years.

Cost of wind energy, that is the most demanded energy type of today, decreased dramatically in recent years. Turbine prices of 1MW or higher wind power plants are around 1400 $/kW. Also 350 $/kW of mounting and project costs are required for installing a wind power plant. Therefore, initial investment cost of a wind power plant is around 1750 $/kW and for a 1MW power plant:

$$Initial\ Investment\ Cost = 1750\ \frac{\$}{kW} \times 1000\ kW$$
$$= 1750000\ \$ \cong 1350000\ € \quad (6.5)$$

If capacity factor of the area is assumed to be 0.35 and the price of electricity is 0.055 €/kWh, also considering 0.01 €/kWh operating costs annual electricity generation and profit is found as:

$$Annual\ Energy\ Generation = 1000\ kW \times 365 \times 24\ h \times 0.35$$
$$= 3066000\ kWh \quad (6.6)$$

$$Annual\ Profit = 3066000\ kWh * (0.055 - 0.01)\ \frac{€}{kWh} = 137970\ € \quad (6.7)$$

According to this profit, payback period of the plant is therefore:

$$Payback\ Period = 1350000 \div 137970 = 9.78\ years \quad (6.8)$$

Geothermal energy is the interior heat energy of the earth. According to the temperature rates, geothermal energy areas are divided into three as high temperature areas, medium temperature areas and low temperature areas. Medium and high temperature areas are suitable for electricity generation. Initial investment costs of geothermal power plants are around 2500 $/kW, i.e. 1900 €/kW. Capacity factor and operational costs can be accepted as 0.85 and 0.011 €/kWh respectively [45]. If it is sold from 0,055 €/kWh according to Renewable Energy Law, payback time can be calculated as:

$$Annual\ Energy\ Generation = 1000\ kW\ \times 365\ \times 24\ h\ \times 0.85$$
$$= 7446000\ kWh \quad (6.9)$$

$$Annual\ Profit = 7446000\ kWh * (0.055 - 0.01)\frac{€}{kWh} = 335070\ € \quad (6.10)$$

According to this profit, payback period of the plant is therefore:

$$Payback\ Period = 1900000\ \div 335070 = 5.7\ years \quad (6.11)$$

Popularity of solar energy is increasing rapidly because building unlicensed 1MW solar field is relatively easier than other renewable energy sources. According to Law No. 5346 on Utilization of Renewable Energy Resources for the Purpose of Generating Electricity price of electricity generated by solar energy and some incentives can be seen in Table 16.

Table 16 Incentives Given to Solar Energy in Turkey

INCENTIVE	**US Dollar Cent / kWh**
Electricity generated in solar plant	13.3
Construction (domestic)	0.8
PV modules (domestic)	1.3
PV cells (domestic)	3.5
Inverter (domestic)	0.6
Sunlight focusing systems (domestic)	0.5

Accordingly, if construction and photovoltaic modules are provided by domestic sources, guaranteed price for buying electricity is 15,4 cent $/kWh, i.e. 11,4 cent €/kWh. Moreover, costs of building a 1MW solar field can be seen in Table 17. Accordingly, if added value tax is included, a 1MW solar field costs around 1.130.000 € [46].

Table 17 Cost of Building a 1MW Solar Plant in 2016 [46]

Cost Items of the Plant	**Cost (€/W)**	**Cost of 1MW**
Solar panel	0.54-0.64	540000-640000
Inverter	0.20-0.25	200000-250000
Construction	0.07-0.08	70000-80000
Wiring	0.05-0.07	50000-70000
Protection equipment	0.02-0.03	20000-30000
Transformer	0.02-0.03	20000-30000
Other (remote monitoring, meter, transformer cabin, board, wire fence)	0.06-0.07	60000-70000
labour and transport	0.06-0.07	60000-70000
Total (VAT excluded)	1.02-1.04	1020000-1240000

Therefore, if the plant is operated with a capacity factor of 0.2, generated electricity in a year is:

$$Annual\ Energy\ Generation = 1000\ kW\ \times 365\ \times 24\ h\ \times 0.2 = 1752000\ kWh \quad (6.12)$$

If 0.01 €/kWh operation costs is also considered, annual profit would be:

$$Annual\ Profit = 1752000\ kWh * (0.114 - 0.01)\frac{€}{kWh} = 182208\ € \quad (6.13)$$

Payback period is then calculated as:

$$Payback\ Period = 1130000\ \div 182208 = 6.2\ years \quad (6.14)$$

CHAPTER 7

TURKEY IN PROGRESS REPORTS OF THE EU

Turkey is a candidate country for joining the European Union and in order to be accepted as a member, it needs to comply with the acquis of the Union in terms of different aspects. In order to achieve this goal, Turkey is carrying out negotiations with the EU since 2005 and trying to comply with the EU acquis. Each year, performance of Turkey is evaluated by the EU. Therefore, progress reports may be useful to evaluate the progress of Turkey in terms of 20-20-20 objectives from the perspective of the EU.

The Progress Reports are prepared by the European Commission for each one of the candidate countries in order to evaluate the progress of the member states during the accession process to the EU. It initiates a monitoring process for candidate countries in terms of seeing what the expectations of the EU are and how much the candidate states have been able to met those expectations.

The European Commission has published the first Progress Report on Turkey in 1998. The European Commission has continued to publish annual progress reports on Turkey since then. In order to prepare the reports, the European Commission uses various reports, data and information gathered and analyzed by the Commission itself, provided by the government of Turkey, the Member States, various international non-governmental organizations and finally European Parliament reports.

The progress reports include almost all aspects of the Turkish accession process from financial services to agriculture as well as issues relevant to 20-20-20 Objectives. While the renewable energy and energy efficiency are examined under Energy Chapter of the Progress Reports, the issue of greenhouse gas emission is dealt under the Environment Chapter.

In this chapter, the energy and environment chapters of the Progress Reports on Turkey between the year of 1998 and 2016 will be examined with a focus on renewable energy, energy efficiency and greenhouse gas emission as the chapters cover a broader range of issues. The basic rationale behind this is seeing the transformation of Turkey in terms of 20-20-20 objectives from the perspective of the European Commission. In this way, both the demands of the EU from Turkey and what Turkey lacks in terms of the goals set by the EU will be revealed clearly. Methodologically, the energy and environment chapters of the Progress Report on Turkey will be examined separately for each year and then, the problems that have continued during those years and the progress that has been taken will be analyzed.

In the first Progress Report published in 1998, the concepts of renewable energy, energy efficiency and greenhouse gas emission are not mentioned. It was not until 1999 when the second Progress Report was published that the European Commission asked Turkey to improve energy efficiency including losses in power transmission and distribution and to promote the use of renewable energies.

There has been no significant progress in terms of either renewable energy or energy efficiency recorded in the Progress Reports of the years of 2001 and 2002. In 2003, there has been some progress in Turkey in terms of energy efficiency with the adoption of regulations on issues such as energy labeling of home appliances. Some progress also has been made on renewable energy sources with the adoption of the electricity licensing regulation, which requires prioritization of the system connection of renewable energy facilities.

In 2004, a comprehensive energy strategy was adopted by Turkish government while there has been no significant progress in terms of renewable energy sources. On the contrary, some progress has been taken in the field of renewable energy according to the Progress Report published in 2005. Firstly, Turkey has adopted The Law on the Use of Renewable Energy Sources in Electricity Generation, which has contributed to the promotion of renewable energy by providing required legal framework. A number of incentives and competitive price advantages have been introduced by the law, which has been seen as the first step of acquiring the acquis in this field. Turkey was recommended to develop a more comprehensive strategy with more ambitious targets in addition to increasing its administrative capacities such as increasing capacities and collaboration of relevant public institutions. There has been no development in terms of energy efficiency in 2005 [49].

There has been no progress on energy efficiency and limited progress on renewable energy compared to 2005 as there has been still no targets for the increase of renewable energy in Turkey according to the progress report of 2006. On the other hand, Turkey has been recorded as 'partially align' in terms of renewable energy thanks to issuing an implementing regulation on the guarantee of origin in 2006 [50].

In 2007, Turkey adopted a framework law on energy efficiency which also provided some provision on the renewable energy law. The introduction of the law on energy efficiency was recorded as progress both in the areas of energy efficiency and renewable energy. However, the progress report stated that Turkey needs to set targets in both areas as recommended in both 2005 and 2006. The Progress Report of 2007 has been the first report where the progress of Turkey has been evaluated in terms of greenhouse gas emission under Chapter 27- Environment. According to this, Turkey has submitted the Greenhouse Gas Inventory for the years 1990-2004 to the UNFCCC Secretariat while it has not ratified the Kyoto Protocol and is not a party to the Espoo and Aarhus Conventions [51].

In 2008, Turkey has been still not party to abovementioned international agreements and no progress has been made in terms of greenhouse gas emission. Some progress has been reported, on the other hand, in both energy efficiency and renewable energy. An implementing regulation on transportation sector has been published after the adoption of the framework in 2007. In addition, the year of 2008 has been announced as the year of renewable energy which has been followed by incentives to promote renewable energy. Another implementing regulation was issued for the geothermal resources. On the other hand, the targets expected from Turkey to be set have not been available yet and the capacity building for the institutions relevant to the field has been still expected in the report [52].

The report that was published in 2009 was the first in terms of the fact that the progress of Turkey has been reported as 'good' in the Progress report on renewable energy. Introduction of the implementing regulations on geothermal resources and privatization of six geothermal fields for electricity generation has been recorded as positive. According to the report, the 17% of the electricity of Turkey has been produced from renewable energy sources by the end of 2008. The targets demanded in the previous reports has been set in 2009 as producing 25% of the country's electricity from renewable sources by the end of 2020 and installing 20,000 MW of wind power capacity by the same year. As the energy consumption also increases, the target has not been found very ambitious in the report [53].

The limited progress in the energy efficiency thanks to new implementing regulations on energy performance, insulation of buildings, efficient use of energy and energy resources and on the energy efficiency of small and medium-sized enterprises has been followed by no progress in terms of greenhouse emission. The implementing regulations introduced on energy efficiency has not been enough to bring Turkey in line with the EU acquis and further work was required as well as public awareness raising activities on energy efficiency according to the report [53].

In 2010, the growing interest of public sector toward renewable energy has been met with the amendment of electricity licensing regulation to tackle the large number of applications especially for the wind license. In line with this trend, Turkey has also increased rate of electricity produced from renewable energy sources [54]. All in all, these developments have recorded as 'good progress' in the progress report of 2010. The progress regarding energy efficiency has also continued with authorization of private sector to provide energy efficiency services and awareness raising activities.

Turkey was evaluated in terms of its progress regarding climate change for the first time in 2010 under the Environment Chapter. According to this, Turkey has made very limited progress as regards climate change by not aligning itself with relevant international criteria. The target that Turkey set in terms of limiting greenhouse gas emission was also found inadequate. In 2010, Turkey has established a national climate change strategy and relevant institutional changes have been made to coordinate the process better such as the establishment of the climate change department under the Ministry of Environment and Forestry, which constituted the limited progress Turkey has made [54].

The good progress of Turkey has continued in 2011 as stated in the progress report. Turkey has amended its earlier renewable law legislation in a way to include more incentives for both producing renewable energy and producing equipment required in energy production in Turkey. Some progress has also been taken in terms of energy efficiency. Energy efficiency has been promoted both in the buildings and the private sector through regulations, incentives and voluntary agreements. Awareness raising activities have continued in addition to increasing interest of international institutions to support the projects on energy efficiency in Turkey. Despite the abovementioned progress, the report states that Turkey needs further progress to bring its legislation in line with the acquis. There has been a limited progress in terms of climate change especially on awareness raising on the requirement of the EU on climate change. For instance, Turkey has conducted a study for determining a strategy to limit greenhouse gas emission and reset its target

on this subject from 11% to a more realistic target in line with the 2020 projection of greenhouse gas emission, which has been appreciated in the report [55].

In 2012, progress has continued in terms of renewable energy with promotion of the use of renewable energy in various sectors although the incentives for the national production of equipments used at the renewable energy plants was questioned in terms of its compliance with WTO or Customs Union trade rules of the incentive mechanisms. In terms of energy efficiency, the progress was evaluated as good. With the amendment on the implementing regulation on improving the efficiency of energy resource use in 2012, the incentives for the industry have been enhanced. Another implementing regulation on the labeling of energy consumption of the products was introduced in 2012 [56].

Under the climate change, Turkey has made very limited progress as it has not set a target for limiting its greenhouse emission in 2020 although it is among the largest emitters. While Turkey associated itself with some formal EU positions, no progress was made as regards other legislation in the field of climate change.
In the year of 2013, there has been progress in the area of renewable energy thanks to a number of legal changes for increasing use of renewable energy as well as promoting research on renewable energy. There has been no change as regards energy efficiency except increasing the number of authorized consulting companies. Some legal changes and more ambitious targets were still needed. Turkey still could not set a target on reduction of greenhouse emission, which prevents the development of carbon market mechanism in Turkey as well as its alignment with the acquis in this field [57].

The progress on renewable energy has continued in 2014 with the measures taken such as increasing the use of small-scale use of renewable energy. This contributed to the increase in the use of renewable energy compared to 2013. The legislation of Turkey was still not aligned with the EU in term of energy efficiency in 2014 while authorization of consulting companies on energy efficiency has continued. Turkey

still needs a target on its greenhouse gas emissions reductions as country with a high level of emissions. The agreement of Turkey with World Bank within the scope of a support program for the capacity building of Turkey has recorded as a positive development. The program mainly focused on ‘monitoring, reporting and verification in the electricity sector and on technical capacity transfer to Turkey on carbon markets [58].

There has been good progress in renewable energy in the same line with the previous years thanks to its new action plan on national renewable energy plan and implementing regulations in 2015. In line with this, investments from the private sector of the country in renewable energy have continued. The use of renewable energy, on the other hand, has decreased as a result of the draught in country which has a negative impact on hydropower output. The Progress Report of 2015 has continued to emphasize the lack of institutional capacity and legal background for energy efficiency. In the area of carbon emission reduction, Turkey still needs to develop its mechanism for carbon market [59].

Among the areas of renewable energy, energy efficiency and carbon emission, the renewable energy has been the one where has been the most progress when all progress reports are evaluated. In 2016, the success of Turkey in progress on the renewable energy sector lasted as it is stated that Turkey is in line with the acquis to a large extent [60].

There has been little progress in the area of energy efficiency based on progress reports as it is the case in 2016. It is frequently stated in the progress reports that Turkey needs more ambitious targets, stronger institutional capacity and legal background.

The progress of Turkey on the reduction of carbon emission has not been evaluated until 2007 when the progress of Turkey has been evaluated in terms of greenhouse

gas emission. From 2007 to 2016, Turkey could not make a significant progress. It still needs to ratify relevant international agreements, fulfill its obligations under ratified international agreements, improve institutional capacity and know-how of relevant institutions, develop mechanisms for carbon market and set more ambitious targets.

CHAPTER 8

CONCLUSION

Since the Industrial Revolution, because of human activities such as burning fossil fuel, land clearing and increasing industrial activities and energy need because of overpopulation resulted that the amount of greenhouse gases in the atmosphere increased drastically. Increment of the greenhouse gases such as Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O) and Fluorinated gasses caused global temperature to increase almost 1^oC at the past century since these gases can absorb sunlight reflected from earth's surface and oceans. This global temperature rise is called as global warming and its results can be catastrophic for humans, ecosystems and the environment. If global warming cannot be stopped, sea level is expected to elevate and lower surfaces of the earth is expected to submerge. Moreover, ecosystem characteristics are going to change and many species are going to be endangered because of increasing acidity rate of oceans, extreme weather events such as floods, storms, droughts and high and low temperature records. Furthermore, these changes are going to jeopardize our food supplies and water resources. Therefore, more and more people are going to suffer from hunger.

Since humans caused the global warming that threatens our world today, stopping it is also our responsibility and our only choice. In order to fight against climate change, United Nations Framework Convention on Climate Change (UNFCCC) entered into force on 21 March 1994. After that, in order to strengthen the global response to climate change, Kyoto Protocol was negotiated in December 1997 and

entered into force on February 16th, 2005. It was a legally binding agreement for developed countries. Its first commitment period was between 2008 and 2012 and second commitment period started in 2013 and is going to end in 2020. Lastly, Paris agreement was adopted in Paris on 12 December 2015 that was the first time that all countries came together for a common cause.

Being in line with the Kyoto Protocol, the EU determined ambitious targets to fight against global climate change known as the 2020 Climate and Energy Package. Targets of the EU was decreasing greenhouse gas emissions 20% lower than 1990 level, 20% increase in energy efficiency and increasing renewable sources in total energy consumption to 20%. In order to reach these targets, the EU specified national targets according to development and future goals of the member countries and precautions in the Union scale in energy efficiency, renewable energy and carbon emission.

Energy efficiency is defined as using less energy to provide the same service and it is becoming the center of energy policies all over the world. In order to achieve 20% energy efficiency improvement target of the EU, the European Parliament and the European Council published directive 2012/27/EU on energy efficiency on 25 October 2012. In the directive, the precautions that must be taken in the EU and national obligations of the member states take place. As mentioned in Chapter 3, energy efficiency target of the EU is a feasible and adequate target considering 28 member states altogether. Setting a more demanding target would bring heavy burdens to smaller member states. Considering projections, the EU is on track to achieve energy efficiency target.

Decreasing carbon emissions to 20% lower than 1990 level is another 2020 target of the EU. On 9 February 2005, the European Commission made recommendations for EU climate policies on the report named "Winning the Battle against Global Climate Change". In the report, possible effects of global warming to the Union and the importance of fighting against it are described. The foundation of the EU's fight

against carbon emission is the Emission Trading System (ETS). Moreover, increasing renewable energy sources in primary and final energy consumption is another way to decrease carbon emission and fight against global climate change. The EU is also on track to satisfy carbon emission reduction target. Actually, more than 20% emission reduction is already achieved. Therefore, more ambitious emission reduction targets for coming years may be set.

In order to achieve renewable energy target, the European Parliament and the Council published the directive 2009/28/EC on 23 April 2009. With this directive, common set of rules of using renewable energy in the EU is determined. Moreover, binding national targets to achieve 20% share of renewables goal are specified. Although renewable energy target of the EU is reasonable, projections show that the EU is going experience a near miss for achieving it. However, with additional precautions, it is not very difficult to compensate the gap between projections and the target.

2020 targets of the EU are not directly binding for Turkey as it is not a full member country yet. On the other hand, Turkey specified its own energy targets for 2023 in line with the EU acquis. According to these targets, Turkey is planning to reach at least 30% share of renewable energy sources on electricity generation, utilize 20000 MW of wind, 600 MW of geothermal and all possible hydro power potential and decrease the share of natural gas on generating electricity to 30%. Also, 20% increase in energy efficiency until 2023 from 2013 level is another target of Turkey. In order to achieve these targets, Turkey prepared its National Renewable Energy Action Plan from 2013 to 2023. Moreover, in energy efficiency area, National Energy Efficiency Action Plan was published on May 2016. It defines 2023 energy efficiency targets of Turkey, emphasizes the works that already have been done and determines the roadmap until 2023. Since Turkey is a developing country and has no historical responsibility for global climate change, it does not have any specific greenhouse gas emission reduction target. However, Turkey plans to limit its carbon emission without affecting its sustainable development and fight against poverty.

Moreover, Turkey declares that carbon emission activities are going to be made suitable with its national programs and strategies, quantifiable, reportable and verifiable.

According to the projections, Turkey is going to achieve its 2023 renewable energy targets except for 20000 MW wind power installed capacity target. Considering wind power capacity has reached up to only 6500 MW despite significant incentives and deep interest in wind power, it can be said that wind power target is specified higher than possible. In addition, Turkey is also not going to achieve its 20% energy efficiency increase according to projections. As a developing country, achievement of the same energy efficiency increase target as the EU cannot be expected from Turkey. Therefore, this target needs to be updated considering necessities and strength of Turkey.

Main energy problem of Turkey is that the usage of petroleum and natural gas is very high in percentage. Since these sources are mostly imported, this situation causes high current account deficit. Moreover, since these sources belong to some specific countries in the world, there is a serious security of supply problem. Therefore, Turkey needs to consider increasing the use of other domestic sources as well as renewable sources. Other than renewable sources, the most suitable domestic source of Turkey is coal. Despite its damages to the environment, it is very important for Turkey since coal is domestic, cheap and creates the highest number of job opportunities amongst all energy sources and can be mined and processed without the need of advanced technology. As it is necessary to decrease negative impacts of the use of coal in energy sector, clean coal technologies should be imported or developed domestically. Turkey is also starting to use nuclear energy and although it is not a domestic source, it expands the fuel source providers of Turkey and becoming alternative to natural gas.

In conclusion, 20-20-20 objective is a set of ambitious targets for the European Union to be the leader of the combat against global warming and climate change.

The targets are feasible for the Union and good examples for the rest of the world. However, as a middle income developing country, targets of Turkey that are specified to be in line with the EU acquis are not feasible and especially wind power and energy efficiency targets must be revised as suitable with the capability of Turkey. On the other hand, since the global warming is going to affect the Mediterranean belt the worst, Turkey must determine targets that are more ambitious and take serious precautions after 2023 by the help of its rapidly growing economy.

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APPENDIX-A

ANNEX I COUNTRIES EMISSION REDUCTION OR LIMITATION COMMITMENTS

Table A.1 Annex I Countries Emission Reduction or Limitation Commitments [7]

Party	**Emission limitation or reduction commitment (percentage of base year)**
Australia	108
Austria	92
Belgium	92
Bulgaria*	92
Canada	94
Croatia*	95
Czech Republic*	92
Denmark	92
Estonia*	92
European Community	92
Finland	92
France	92
Germany	92
Greece	92
Hungary*	94
Iceland	110
Ireland	92
Italy	92
Japan	94
Latvia*	92
Liechtenstein	92
Lithuania*	92

Table A.1 Continued

Party	**Emission limitation or reduction commitment (percentage of base year)**
Luxembourg	92
Monaco	92
Netherlands	92
New Zealand	100
Norway	101
Poland*	94
Portugal	92
Romania*	92
Russian Federation*	100
Slovakia*	92
Slovenia*	92
Spain	92
Sweden	92
Switzerland	92
Ukraine*	100
United Kingdom of Great Britain and Northern Ireland	92
United States of America	93
* Countries that are undergoing the process of transition to a market economy.	

APPENDIX-B

NATIONAL ENERGY EFFICIENCY 2020 TARGETS

Table B.1 National Energy Efficiency 2020 Targets [23]

Member State	Absolute level of energy consumption in 2020 [Mtoe] as notified by Member States in 2013, in the NEEAP 2014 or in a separate notification to the European Commission in 2015	
	PRIMARY Energy Consumption	**FINAL Energy Consumption**
Austria	31,5	25,1
Belgium	43,7	32,5
Bulgaria	16,9	8,6
Croatia	11,5	7,0
Cyprus	2,2	1,8
Czech Republic	39,6	25,3
Denmark	17,8	14,8
Estonia	6,5	2,8
Finland	35,9	26,7
France	219,9	131,4
Germany	276,6	194,3
Greece	24,7	18,4
Hungary	24,1	14,4
Ireland	13,9	11,7
Italy	158,0	124,0
Latvia	5,4	4,5
Lithuania	6,5	4,3
Luxembourg	4,5	4,2
Malta	0,7	0,5
Netherlands	60,7	52,2
Poland	96,4	71,6
Portugal	22,5	17,4
Romania	43,0	30,3
Slovakia	16,4	9,0
Slovenia	7,3	5,1
Spain	119,8	80,1

Table B.1 Continued

Member State	Absolute level of energy consumption in 2020 [Mtoe] as notified by Member States in 2013, in the NEEAP 2014 or in a separate notification to the European Commission in 2015	
	PRIMARY Energy Consumption	**FINAL Energy Consumption**
Sweden	43,4	30,3
United Kingdom	177,6	129,2
Sum of indicative targets EU-28	1526,9	1077,5
EU-28 target 2020	1483,0	1086,0

APPENDIX-C

NATIONAL RENEWABLE ENERGY SHARE 2020 TARGETS

Table C.1 National Renewable Energy Share 2020 Targets [17]

	Share of energy from renewable sources in gross final consumption of energy, 2005	Target for share of energy from renewable sources in gross final consumption of energy, 2020
Belgium	2,2	13
Bulgaria	9,4	16
Czech Republic	6,1	13
Denmark	17	30
Germany	5,8	18
Estonia	18	25
Ireland	3,1	16
Greece	6,9	18
Spain	8,7	20
France	10,3	23
Italy	5,2	17
Cyprus	2,9	13
Latvia	32,6	40
Lithuania	15,0	23
Luxembourg	0,9	11
Hungary	4,3	13
Malta	0,0	10
Netherlands	2,4	14
Austria	23,3	34
Poland	7,2	15
Portugal	20,5	31
Romania	17,8	24
Slovenia	16,0	25
Slovak Republic	6,7	14
Finland	28,5	38
Sweden	39,8	49
United Kingdom	1,3	15