DETERMINANTS OF ELECTRICITY CONSUMPTION IN TURKEY

(M. A. Thesis)

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DETERMINANTS OF ELECTRICITY CONSUMPTION IN TURKEY

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FINAL APPROVAL FOR THESIS

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ÖZET

TÜRKİYE’DE ELEKTRİK TÜKETİMİNİN BELİRLEYİCİLERİ

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Danışman: Doç. Dr. Selim YILDIRIM

Bu çalışmanın temel amacı, Türkiye'de elektrik tüketiminin belirleyicilerinin neler olduğunu ortaya koymaktır. Elektrik tüketimi seviyesinin belirleyicileri olarak, kişi başına gelir, sanayileşme düzeyi, finansal gelişme, eğitim düzeyi, karbon emisyonu, fiyat, kentleşme, ticaretin açıklığı verileri 1960-2016 yılları arasında kullanıldı. Ekonometrik tahminler Phillips ve Hansen'ın (1990) Fully Modified OLS (FMOLS) ve Park'ın (1992) Canonical Eş Bütünleşme Regresyon (CCR) modelleri kullanarak yapılmıştır. Yapılan ekonometrik analizlerden elde edilen sonuçlar Türkiye'de elektrik tüketimi üzerinde, gelir ve karbon emisyonlarının pozitif bir etkiye sahip olduğunu, kentleşme ve fiyatın ise elektrik tüketimi üzerinde ters yönlü negatif etkiye sahip olduğunu göstermiştir. Diğer değişkenler istatistiksel olarak anlamlı bir sonuç vermemiştir.

ABSTRACT

DETERMINANTS OF ELECTRICITY CONSUMPTION IN TURKEY

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Anadolu University, Graduate School of Social Sciences, March 2018

Supervisor: Assoc. Prof. Selim YILDIRIM

The main aim of this study is to determine electricity consumption in Turkey. We used annual data from 1960 to 2016 for electricity consumption level, per capita income, industrialization level, financial development, education level, carbon emission, price, urbanization, trade openness. The estimation is done by using the Phillips and Hansen's (1990) Fully Modified OLS (FMOLS) and Park's (1992) Canonical Cointegrating Regression (CCR) models. The estimations attained the results of income and carbon emission having a positive effect while urbanization and price employed a negative effect on the consumption of electricity in Turkey. The other variable showed no statistically significant results.

STATEMENT OF COMPLIANCE WITH ETHICAL PRINCIPLES AND RULES

I hereby truthfully declare that this thesis is an original work prepared by me; that I have behaved in accordance with the scientific ethical principles and rules throughout the stages of preparation, data collection, analysis and presentation of my work; that I have cited the sources of all the data and information that could be obtained within the scope of this study, and included these sources in the references section; and that this study has been scanned for plagiarism with "scientific plagiarism detection program" used by Anadolu University, and that "it does not have any plagiarism" whatsoever. I also declare that, if a case contrary to my declaration is detected in my work at any time, I hereby express my consent to all the ethical and legal consequences that are involved.

(Signature)

Başak SEZGİN

TABLE OF CONTENTS

Page

Page

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

α :	Alfa
β :	Beta
γ :	Gamma
δ :	Delta
λ :	Lambda
ε :	Epsilon
η :	Eta
ϕ :	Phi
Σ :	Sigma
AC	Alternating Current
ADF:	The Augmented Dickey-Fuller tests
CCR:	Canonical Cointegrating Regression
DSİ	The General Directorate of State Hydraulic Works
EAV	Extra Hihg Voltage
EÜAŞ:	Electricity Generation Corporation Inc
FMOLS:	Fully Modified Ordinary Least Squares
GDP:	Gross Domestic Product
GWh:	Gigawatt Hour
HEPP	Hydroelectric Power Plant
LPG:	Liquefied Petroleum Gas
MW:	Megawatt
PP:	Phillips-Perron tests
TEAŞ:	State Electricity Generation and Transmission Corporation
TEİAŞ:	Turkish Electricity Transmission Co. Inc.
TEK:	Turkish Electricity Authority
TEDAŞ	Turkish Electricity Distribution Co.
TETAŞ:	Turkish Electricity Contracting and Trading Co. Inc.
TURKSTAT:	Turkish Statistical Institute

CHAPTER 1

1. INTRODUCTION

Electricity has been in our life for almost more than a century. One of the most long going topic of the recent years is the level of electricity consumption and how to supply it. Countries are bound to electricity whether it is to elevate the quality of life or for development of industry or lightening and transportation. What makes electricity unique to other commodities is, it has to be consumed when it is produced due to the fact electricity cannot be stored. Therefore, calculating the production of electricity should be done rigorously which show the importance of modelling electricity consumption and the determinants of electricity consumption.

This study is primarily focused on determinants of electricity consumption for Turkey between the years 1960 and 2016. The objective for the study was to suggest the right model for the electricity consumption and find out the relationship between income, industrialisation, financial development, education levels, carbon emission, price of electricity, urbanisation, and trade openness.

The thesis is organised as follows: Chapter 2 give a general description of energy, its sources, and electricity as well as the historical progress of energy and electricity.

Chapter 3 assesses the existing literature on electricity consumption. This chapter starts by reviewing electricity consumption studies around the world then studies that examined Turkey.

Chapter 4 provides empirical time series evidence for Turkey. Chapter 4 is also applying the models to test electricity consumption determinant for Turkey. We have used the Phillips and Hansen's (1990) Fully Modified OLS (FMOLS) and Park's (1992) Canonical Cointegrating Regression (CCR) models for our estimations. Data sources are also assessed in this chapter.

Finally, Chapter 5 presents some concluding remarks and proposals for further research.

This thesis makes a contribution to electricity demand literature, it should also be interest of public sector economist and practitioners of electricity producers, consumer as well as development economists.

CHAPTER 2

2. ENERGY

2.1. Definition of Energy

The general accepted definition of energy is that it is the ability to do work. Energy is mostly a theoretical concept and it helps to explain most natural events. According to classical mechanics the definition of energy is the capability to do work. Work in this concept meaning the force upon a particle which is able to make a displacement on it. In quantum mechanics energy is defined as quantified or packages of energy waves proportional to the frequency. When an electron changes what is called energy level in an atom, it gives off quantified energy by emitting light which is called a photon. Photon is a discrete bundle or quantum of electromagnetic energy. According to special relativity, the Newtonian mechanics does not apply when a particle comes near to the speed of light therefore energy can be defined as the speed of light's square times the particle's mass. Since the speed of light is constant the energy can be equivalent to the particle's mass. (Yörükoğulları, 2015, p.4) The amount of energy in the universe does not change but energy can change form. It is stated as the law of conservation of energy that energy cannot be created from nothing or be destroyed, it can only be transformed (Aubrecht, 1989, p. 41). Although there are many sorts of energy forms: Heat (thermal), Light (radiant), Motion (kinetic), Electrical, Chemical, Nuclear energy, Gravitational, all of it can be categorized under two main categories: Kinetic energy and potential energy.[1]

2.2. Energy Sources

Energy sources can be considered to be primary and secondary energy sources depending on whether it is converted or directly used. The primary energy sources are directly obtained from nature while secondary energy sources are converted from primary energy sources. Primary energy sources can be grouped as non-renewable energy, renewable energy and waste. Secondary energy sources come in the form of

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[1] https://www.eia.gov/energyexplained/index.cfm?page=about_forms_of_energy (Date Of Access: 09.10.2017)

either electrical energy or fuel which are transformed from the primary energy sources. The Figure 2.1. shows the primary energy sources conversion to secondary energy sources which is then converse to electricity and heat that is consumed. (Demirel, 2016, p. 28)

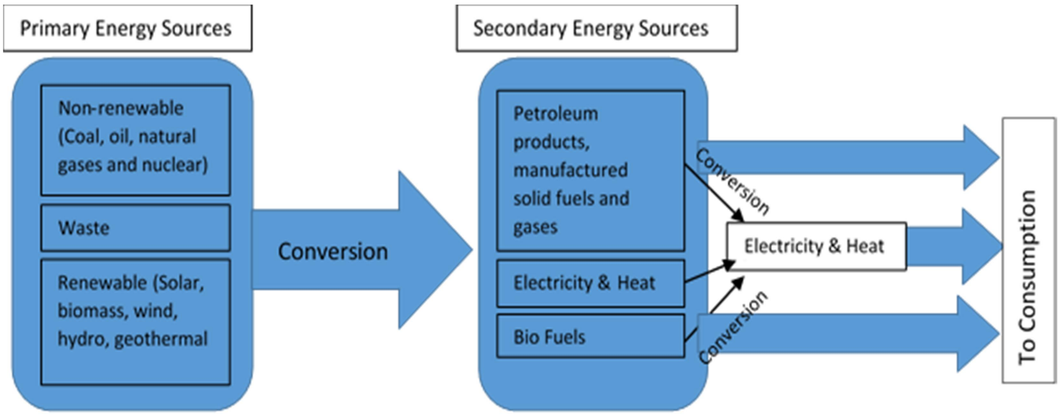

Figure 2.1. *Primary and Secondary Energy Sources (Demirel, 2016, p. 28)*

The pie chart for energy sources according to the amount is consumed is shown in Figure 2.2. It can be seen that oil has the largest share with 33%, the second largest being coal with 28% and the smallest share is renewable energy sources with 3%. It can be gathered that renewable energy sources including hydroelectricity has a share of 10% in the world while non-renewable energy sources have 90% share.

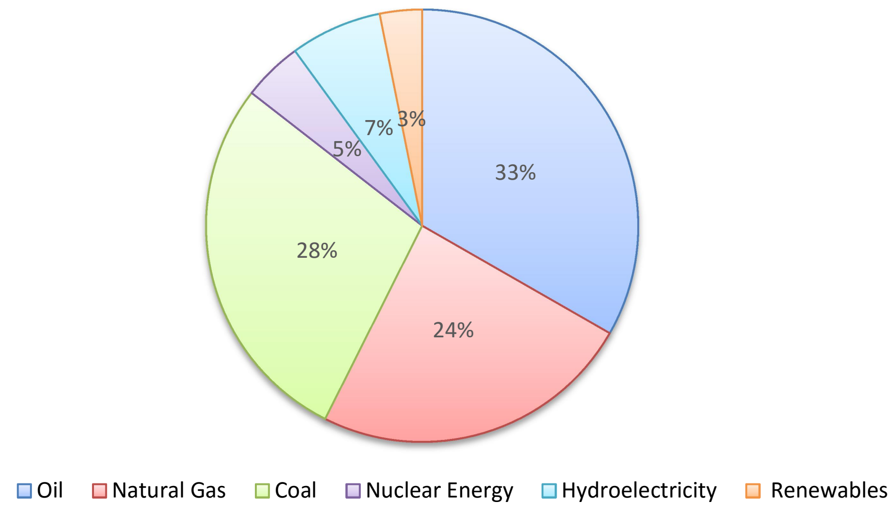

Figure 2.2. *Energy Consumption By Energy Source (2016)*

2.2.1. Primary energy sources

Primary energy sources are directly obtained from nature and they can be grouped as non-renewable energy sources, renewable energy sources and waste.

2.2.1.1. Non–renewable energy sources

Non-renewable energy sources are formed from the exposure of dead animals and plants to heat and pressure in the course of millions of years. As a result, these sources are mainly made up of carbon.

2.2.1.1.1. Coal

The plants that covered the earth nearly 360 million years ago were buried under silt and sediments and were subjected to high temperatures and pressure resulting in physical and chemical changes in the buried plants which is how peat is formed. After several million years of heat and temperature effects the peat is transformed into coal.[2] Coal is a sedimentary rock which contains several different elements such as hydrogen, sulphur, oxygen and nitrogen. Coal had a significant role in the industrial revolution as it was the main energy source. The first usage of coal was recorded in the 1880s where it was used for generating electricity to factories and homes. (Demirel, 2016, p. 31) The energy released from coal is the stored energy in the decayed plants that was harnessed from the sun through photosynthesis. Coal is mainly used in generating electricity as well as transportation fuel and other energy supplies.[3] Similar to most fossil fuels, coal is used by burning it in a boiler which is used to heat water to obtain steam. The steam is piped to a turbine in order to spin the blades of the turbine much like a propeller. The turbine's blades rotate turning the shaft that is connected to the centre. The shaft can be combined to a coil and the rotation of the coil creates a magnetic field producing alternating current (AC). The alternating current is what we used to generate electricity. The steam is then cooled with cooling water that is obtain from lakes, rivers or cooling towers. The cooled water is reused to make steam. In order to increase the efficiency recent developments are working on mixing water with ammonia to lower the boiling point and releasing more steam when boiled (Aubrecht, 1989, p. 190). Coal is a cheaper option for countries that use oil as their energy source. But coal can be harmful to the

[2] https://www.worldcoal.org/coal/what-coal (Date Of Access: 16.10.2017)

[3] https://www.worldcoal.org/coal/what-coal (Date Of Access: 16.10.2017)

environment as it releases its impurities like sulphur and nitrogen when it burns, and it can cause acid rains. Burning coal also releases a great amount of carbon dioxide which can trap the earth's heat causing, what most scientist believe, and earth's climate change. The amount of carbon dioxide released from coal for every released energy is the highest than any other fossil fuel. Although coal has impurities such as the contain of sulphur, advancing technology is continuing to develop methods of processing tiny particles and desulfurization units that are required to be installed in new plants. (Demirel, 2016, p. 31)

2.2.1.1.2. Oil and petroleum

Oil or petroleum was formed by sediments covering dead plants and marine organisms, like algae, at the bottom of oceans, swaps and lakes. Heat and pressure that was subjected to nearly millions of years transformed these dead plants and organisms to fossil fuel. Petroleum can be found where ancient seas used to be located as well as ocean floors. The crude oil that is used for energy sources is extracted from these petroleum reservoirs by drilling machines.[4] Crude oil is a thick black liquid which consists mostly of hydrogen and carbon atoms. The physical and chemical properties of oil, such as density, heating value, viscosity, depends on the combustions of its hydrocarbons molecules which can vary in molecular weight. Oil is mainly used as transportation fuel for cars, planes etc…Oil is used for producing commodities addition to be used for fuel. The first processes of refining crude oil produce fuels that are rich of energy. The remaining's of the oil from these processes is then used for pharmaceuticals, solvents, fertilizers, pesticides, and plastics. The main fuels that are produced from oil are: Liquefied Petroleum Gas (LPG), Gasoline, Petroleum Diesel, Kerosene, Jet Fuel, and Fuel Oil. Liquefied petroleum gas, a flammable gas that is made up of a mixture of butane and propane, is used in heating and fuel for vehicles. Gasoline is a product of crude oil that is mostly formed of aliphatic hydrocarbons and it is used to fuel internal combustion engines (Demirel, 2016, p. 33). Petroleum diesel is a high-density fuel which is used in mostly public transportation vehicles but also diesel engine trucks, trains, and boats. It is a less flammable fuel and compared to gasoline it is less likely to stall which is the reason why it is used in farm and construction equipment as well as tanks and trucks. Diesel engines can also be used to generate energy and is used

[4] https://www.nationalgeographic.org/encyclopedia/petroleum/ (Date Of Access: 16.10.2017)

in backup generators in many industrial facilities, large buildings, institutional facilities, hospitals.[5] Kerosene and jet fuel are generally used in powering aircraft engines. Jet fuel is usually preferred due to its performance under cold-weather. Like other carbon fuels oil contains impurities and sulphur that contributes to the air pollution and acid rains. It also releases harmful gases such as nitrogen oxides, carbon monoxide, sulphur dioxide, and ozone. The wide and crucial use of oil makes it a vital energy source for today's economy (Demirel, 2016, p. 34, 35).

2.2.1.1.3. Natural gas

The formation of natural gas is similar to petroleum, the dead organisms are cover with sand and silt over the course of millions of years. The buried mixture of dead organisms, earth, and sometimes water is exposed to pressure and heat which changes the organic mixture into coal, oil and natural gas. Because it is buried under the ground drilling is the method used to obtain it. Sometimes natural gas can be found alongside with oil in oil reservoirs. Natural gases are mostly composite of methane gas with far less percentage of various other gases. If a natural gas is formed of mostly methane, it can be considered as dry natural gas whereas wet natural gas commonly has liquid hydrocarbons and nonhydrocarbon gases which include ethane, butane, propane, and pentane.[6] The small percentage of carbon dioxide is why natural gas is a cleaner source of energy. Natural gases are an important source for electricity production as well as a good alternative for transportation fuels. Its growing need is shown with The International Energy Agency expecting the demand of natural gases increasing twice its current consumed percentage. Natural gases are used to produce electricity which provided from the usage of steam and gas turbines as well as transportation fuel, industrial heating and residential heating. (Demirel, 2016, p. 35) Natural gases are transported through a pipeline network. At the first step, it is drilled and gathered it is then transported in to plant where contaminants such as hydrocarbon gas liquids, nonhydrocarbon gases, and water are removed in order to transport safely through the high-pressured, long-distance pipelines. These long-distance pipelines convey the natural gas to storage tanks and facilities. [7]

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[5] https://www.eia.gov/energyexplained/index.cfm?page=diesel_use (Date Of Access: 18.10.2017)
[6] https://www.eia.gov/energyexplained/index.cfm?page=natural_gas_home (Date Of Access: 18.10.2017)
[7] https://www.eia.gov/energyexplained/index.cfm?page=natural_gas_delivery (Date Of Access: 18.11.2017)

2.2.1.1.4. Nuclear

An atomic bond is the strong attraction between subatomic particles which formed the atoms and molecules. These bonds release a massive energy that can be used to produce electricity once they are broken which is achieved by nuclear fission or nuclear fusion.[8] Nuclear plants operate through energy being emerge from fission reactions of uranium or other nuclear fuels thus no harmful gases appear in nature. Nuclear plants choose uranium atom to use in nuclear fission. The type of uranium that is commonly used in nuclear plants is called Uranium-235, which is an isotope of uranium. The fission reaction is a process accomplish by freeing atom's neutrons and photons into forms of gamma rays and resulting in extremely high release of energy and heat which is the main source that is used to produce electricity. The steam that comes from the heated water turns the large turbines that generates electricity. This is a similar process to power plants with coal, oil, or other gas-fired turbines. The amount of energy obtained from nuclear fission is exceedingly high compared to fossil fuelled power plants but at the same time it is more expensive compared to other power plants to build and the disposal of the waste from the nuclear plants are the biggest trials that are being faced. (Demirel, 2016, p. 36) A nuclear power plant does not produce waste that cause air pollution or releases carbon dioxide like fossil fuelled power plants. It produces radioactive waste that can threaten the health and lives of humans or any other living creatures for thousands of years. The uranium mill tailings, used reactor fuel, and other radioactive wastes a nuclear power plant produces should be disposed or handled with special regulations and precautions. Radioactive waste decay half of its level in a time specific to each material. This time it takes to decrease half of its level is called radioactive half-life and the decaying of the radioactive material is called radioactive decay. Radioactive waste that are called low-level radioactive waste have a short radioactive half-life and can be covered with material that seals the radioactivity which prevents it from harming the environment. The high-level radioactive waste which are the used reactor fuels that can no longer be used for producing energy, have a long half-life and decay in a long period of time. [9] The expansion towards nuclear power plants started with the oil crisis in early 1970s. Countries that are poor in oil and other

[8] https://www.eia.gov/energyexplained/index.cfm?page=nuclear_home (Date Of Access: 18.11.2017)
[9] https://www.eia.gov/energyexplained/index.cfm?page=nuclear_environment (Date Of Access: 20.11.2017)

hydrocarbon resources endorsed in nuclear power stations to reduce their dependence on these resources and ensure energy supply security.[10]

2.2.1.2. Renewable energy sources

Renewable energy resources are resources that are derive from nature and can be restocked form nature. The main renewable energy sources may be listed as: hydroelectric, solar energy, biomass, wind, geothermal heat, and ocean. The increasing concern surrounding climate change and global warming also the rising price of oil has the governments turning attention renewable energy sources being used. The advantages of renewable energy are that it is cheap in the long run while fossil fuel prices tend to increase causing it to be more expensive than renewable energy sources. Although new technology for renewable energy sources are still processing and have not completed developing, they are improving to decrease the cost and waste at the same time being more efficient compared to fossil fuel sources. As of 2016 the total amount of renewable energy usage for generating electricity in the world is up to 18% and wind power alone has the majority for some areas. In most countries, household's hot water is provided by solar hot water panels and it is also noted that oil fuels consumption has decreased due to renewable biofuels taking its place in several countries. (Demirel, 2016, p. 42)

2.2.1.2.1. Hydro energy

Hydro energy is created by the force of flowing water. A hydroelectric power plant generates electrical energy from transforming a dammed water's potential energy to kinetic energy by using the water turbines and generators. The potential energy of the water is proportional to the height between the water source and the water's outflow which is named the head and it is one of the factor affecting the produced energy. The other factor being the volume of the water. A large pipe, which is called a penstock, is used to maintain the pressure that rises from the head at the same time delivers water to the turbines (Hinrichs and Kleinbach, 2006). Some hydroelectric systems use the kinetic energy of river and oceans to produce energy instead of dams. Using hydroelectric power can be beneficial in many ways such as the pollution it creates are lower than

[10] http://www.enerji.gov.tr/tr-TR/Sayfalar/Nukleer-Enerji (Date Of Access: 15.12.2017)

fossil fuel and nuclear plants due to the fact it generates electric without the combustion of fuels resulting in less waste. From an economic stand point hydroelectric plants have a longer life span (plants that were built nearly 50 or 100 years ago can still be in service), the cost of labour to operate a plant is lower compared to other power plants such as nuclear power plant, and the construction cost is paid off in electricity sales after the 5 to 8 years of full operating. (Demirel, 2016, p. 43)

2.2.1.2.2. Solar energy

The sun is the source of life on earth and it also contains powerful sums of energy which could meet the need of energy globally. The nuclear reactions of the hydrogen nuclei fusion to the helium nuclei in the sun release enormous amounts of energy. The solar radiation that reaches the top atmosphere of the earth is almost in half decreased as the oxygen nitrogen and ozone surrounding the upper atmosphere absorbs the ultraviolet radiation. The water vapour and the carbon dioxide in the lower atmosphere absorbs the longer wavelength radiation. The amount of solar radiation that reaches the earth over time is close to constant (Hinrichs and Kleinbach, 2006, pp. 163-165). The solar radiation that the sun emits is used in order to generate energy, in forms of heat and electricity. Solar systems are categorized as either active or passive depending on the way they collect and convert solar radiations. Active solar energy systems use solar thermal collectors to convert the sun's radiation to electrical energy while passive solar energy systems rely on the heat of the sun (Demirel, 2016, p. 44). Photovoltaic cells (PV cells) are the most common used solar cells. The sunlight is made of photons, and when it falls on a PV cell it can either be reflected, pass through it or be absorbed by it. The absorbed photons are collected by semiconductor materials such as silicon which the PV cells are made up of. In the PV cells the electrons are freed and are drift to the surface of the cell. This results in the cell having a positive and negative charge creating a voltage potential similar to a battery's negative and positive terminals. The cells are connected to a circuit with conductors that the electrons are able to freely flow and an external load. Since the maximum sunlight is absorbed when the sun is directly facing the cells tracking systems are being developed for more efficient PV cells. PV cell systems provide direct current meaning it can supply electricity for the location it is built. It is environmentally friendly and can be convenient as it is easy to install and can be any size. [11]

2.2.1.2.3. Biomass

The energy stored in plants and algae that came from the sun can be used as a source of energy as well as the carbon which is in the structure of all living organisms. The carbon cycle illustrates the circulation of carbon in nature. Carbon is found in the atmosphere as carbon dioxide molecules. Autotrophs like algae and plants can produce organic compound using carbon dioxide that is found in the air and minerals from the ground or water by photosynthesis. The organic compound produced is then consumed by heterotrophs which are organisms that obtains its food from other organisms. The consumed organisms that contains carbon atoms pass through the food chain and eventually are decomposed by soil bacterium, fungus, or invertebrate which releases the carbon in forms of organic compound and carbon dioxide back into nature. This is called the food chain which is an important part of the biological carbon cycle. The geological carbon cycle goes on in the course of millions of years. Carbon can react with calcium ions in forming shells of marine organisms in which by the death of these organisms becomes part of ocean sediment, soil, rocks, and fossil fuels' formation. The fossil fuels that are formed in the Earth's crust releases the carbons that they contain to the atmosphere in the form of carbon dioxide when they are burned to generate energy. Erupted volcanoes also allow carbon to enter the atmosphere. Up until the industrial revolution the carbon cycle kept at an equilibrium with the carbon used for organic compound and the carbon released being fairly equal to each other. After the industrial revolution with the use of fossil fuels like coal, humans began releasing extensive amounts of carbon to the atmosphere and in addition decreasing the number of forests by chopping trees. The combination of these two leads to carbon dioxide levels being the highest ever recorded.[12] The turn to biomass energy source has come up due to the need of replacing conventional fuels with alternatives in order to meet the need of the energy demand and to decrease the negative impact on nature. Biomass energy is the term used for the energy derived from biological organisms such as crops, trees and

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[11] https://www.eia.gov/energyexplained/index.cfm?page=solar_photovoltaics (Date Of Access: 20.11.2017)

[12] https://www.khanacademy.org/science/biology/ecology/biogeochemical-cycles/a/the-carbon-cycle (Date of Access: 20.10.2017)

other plants, waste like manure. Wood, crop and waste can be converted to ethanol or other gases that is used for transport fuel to heating fuel while microalgae and oilseeds are converted into liquid diesel made from plant oil that is used as fuel for transports (Hinrichs and Kleinbach, 2006, pp. 545, -547).

2.2.1.2.4. Wind

Wind is the flowing air caused by atmospheric pressure changes. It is known to be used by humans from early in history in the form of sail attached to the boat or windmills that were used to produce food by grinding wheat and corn. In the 19th century while windmills were used for pumping water they were also being started to be used for generating electricity. The oil crisis leads to considering alternating energy sources which wind power was one of them.[13] Wind energy is one of the fastest growing energy forms in the present time which can be the result of not only the powerful energy wind turbines provides but also the near to zero impact it has the environment. The location of the turbines is important because the constant wind is what wind energy depends on. High altitudes preferred since the wind speed is not only continuous, but it can reach speeds that are over 160 km/h. The drawbacks to wind power is its unpredictability although it has near to zero impact on nature (Demirel, 2016, p. 54). The visual pollution of the large wind turbines and concerns about inferences in communication as well as the noises it makes are also minor drawbacks of wind energy (Hinrichs and Kleinbach, 2006, p. 401). The wind turbines used today are giant. The wind blowing the blade itself does not speed it enough to create electricity, it has a low rpm (revolutions per minute). A shaft that is attached to the blades the wind spins is also attached to a planetary gear set that resembles a propeller, to increase the speed. The speed ratio is nearly 1 to 90 meaning it increases the rpm so that it can produce electricity. The electricity generated in the top of the turbine is sent to a transformer using cables to be produced and transmit electricity.[14]

2.2.1.2.5. Geothermal heat

The earth's internal heat caused from the decay of the radioactive minerals it contains, volcanic activities and absorbed solar energy, is originated from the formation

[13] http://windenergyfoundation.org/about-wind-energy/history/ (Date of Access: 08.11.2017)
[14] https://energy.gov/eere/wind/how-do-wind-turbines-work (Date of Access: 08.11.2017)

of the planet. The temperature difference of the earth's surface and core conducts a continuous heat between them and this is the sources of geothermal heat. Geothermal heat is extracted through drilling into the earth's crust to hot water or steam reservoirs. The hot water or steam can either be used to generate electricity by rotating turbines, if it has a lower temperature it can also be used directly for heating houses and other buildings. Geothermal energy is used not only for producing electricity through steam and water but also can be used for heating in homes and industrial plants. The continuous conduction of heat from the energy source makes it a strong competitor against coal plants. Geothermal energy is not only sustainable, but it is also harmless to the environment, reliable and affordable (Demirel, 2016, pp. 54, 55).

2.2.1.2.6. Ocean (marine) energy

The oceans which cover more of the earth than land can be a powerful alternative energy source. The gravitational pull of the moon creates strong tides and winds creates waves in the ocean. The basics of using tides and waves is to use dams that force tides to turn turbines which creates mechanical energy and generates electricity. The mechanical energy of the ocean depends on the movement of the waves and tides which does not have a constant movement unlike the thermal energy which depends on the sun. The sun's heat warms the surface of the ocean while the depths of the ocean remains colder. This temperature difference creates the thermal energy that is provided from the ocean.[15] The thermal energy of the ocean can be used as the temperature difference between shallow and deep waters are enough that a heat engine can be operated. The generator sourced by the ocean's current has near to no impact on the environment and it does not risk wildlife while being powerful enough to generate thousands of houses (Demirel, 2016, p. 56).

2.2.2. Secondary energy sources

Secondary energy sources are transformed from primary energy sources in order to store, move, and deliver energy easier. Secondary energy sources such as electricity and hydrogen are energy carriers and are used to transform primary energy source to an easily usable form. Electricity is the common used secondary energy source.[16]

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[15] http://www.renewableenergyworld.com/ocean-energy/tech.html (Date of Access: 11.11.2017)
[16] https://www.eia.gov/energyexplained/index.cfm?page=secondary_home (Date of Access: 10.10.2017)

2.2.2.1. Electricity

Electric charges are separated in to two: Positive charge and negative charge. Two of the same charge repel each other and the opposite charge (negative to positive or positive to negative) attract each other. Electrical charge is measured in Coulomb in SI units. The electrical work can be defined as the movement of the electrons caused by the electrical force. The amount of this electrical work can be measured as the electrical potential of a charge. The electrical potential energy, or the potential as it is commonly known, is the voltage that causes the charges to flow which generates the current. The current can also be defined as flow of charges in a period of time. One Coulomb of charge per second is the measure of the current's unit Ampere. The electrical power from these sources is the potential it has times the current it delivers (Aubrecht, 1989, p. 60). The charges tend to flow from high voltage to low voltage similar to water flowing from higher altitudes to a lower one. Electricity flow is calculated based on the Ohm's law which can be expressed as I=V/R where I is current in Ampere, V is potential in Volts and R is resistance in Ohm. Resistance is the property of a material that shows how much it resists current. It acts as a friction the electrical current is controlled with. If a material's resistance is high less current will pass through it and if the resistance is low too much current may pass. Copper wires are commonly used due to the fact that not only does it have a low resistivity that allows current to flow without excessive amounts of losses, it is also affordable compared to gold or platinum which have lower resistivity than copper. (EJ Moyer, 2010, p. 7) The higher efficiency compared to other energies is the reason electricity is preferred as well as it is easy to control and transport also electricity can be considered a cleaner energy source than other energy sources. These reasons combined results in almost all devices used today to be run by electricity. Electricity can be generated with conventional sources such as hydropower or thermal and non-conventional sources such as wind power, fuel cells, and photovoltaic cells. (Theraja and Theraja, 2005, pp. 855-864)

2.2.2.1.1. Electricity Generation

The basic idea of generating electrical power in any power plant is the transformation of kinetic energy to the electrical energy with the flow of electrons. This is achieved by using a turning coil or loop in a fixed magnetic field. The magnetic field will allow current to flow across the coil. Brushes or slip rings that are made from conducting material allow the current to be transform to the connected wires. The loop rotates at 360 degrees thus the magnetic flux changes signs meaning the current around the loop changes direction resulting in an output that is back and forth flowing sine wave. The current changes over time according to $I(t) = I_{max} * \sin \omega t$, where ω is the angular frequency a value that is equal to $\omega = 2\pi f$. The 'f' is frequency of the electric current, it is 50Hz for Turkey while in America it is 60Hz. This would mean the direction switches every 1/50th of a second for Turkey. In industrial power plants the generators run on similar basis: The rotor which is the rotating magnet that turns in a set of coils and the stator which is the fixed ring that carries the current. The one difference would be in the industrial generator the magnetic field of the rotor is made by the rotor being an electromagnet by the small current flowing through the winding which are separately located on the rotor itself. This method is used due to the large scale of the industrial generator. (EJ Moyer, 2010, pp. 10-15) The main components for an industrial generator is the engine, alternator, fuel system, voltage regulator, cooling systems, lubrication system, battery charger, control panel, and the main assembly. (Wolfgang, 2014, pp. 4-12) The generated electric power of a power plant can be measured in kW (1000 watts); the amount of energy it generates in an hour is measured by kWh (kilowatt hours). (Demirel, 2016, p. 57)

2.2.2.1.2. Electricity transmission and distribution

Electric transmission systems are the connection between the power plants that generate electricity and the load which is where the electricity is consumed. The components of electricity transmission and distribution system are power plants, high-voltage transmission lines, substations, distribution lines, transformers, service lines. The generated energy is normally around 15kV to 25kV which is considered low voltage for long distance transmission. Transformers are used to increase the voltage to up to 500 kV which is called extra high voltage (EHV), while reducing the current. The transformers which are connected to the power plants are connected to transmission lines. Transmission lines generally have an AC three-phase system. The increased voltage allows the electricity to be transmitted to far distances due to the fact high-voltage lines losses are smaller compared to low-voltage lines losses. Substations that are located just outside the cities, reduces the extra high voltage to high voltage of

220kV and transmitters to high voltage lines that are located within the cities. This high voltage is then reduced again in another substation to about 69kV where it is connected to the electric distribution system. The sub-transmission line that are mostly located within major streets inside the city carry the electricity to distribution substation where the voltage is lowered to 12kV. The distribution lines that are connected to the distribution substation transmitter electricity by overhead or underground lines. For houses and other local loads, the voltage is reduced to 230/115 V by step-down transformers, on the other hand large industrial plants and factories use voltage either directly from a sub transmission line or from a separate distribution line. The underground lines are costly but have a lesser effect on human health and the environment than over ground lines which are generally used in open areas. (Karady, 2001) The electrical grid also referred to as the power distribution grid, is the system of interconnection of the transmission system, it started with utilities connecting their transmission systems which allowed the benefit of lower cost electric generation service and power disturbances have less effect. [17]

2.2.2.2. Hydrogen

Hydrogen is the first element on the periodic table since it contains only one proton for each atom. The universe has an abundance of hydrogen atoms. The sun is made up of hydrogen and helium atoms which are constantly forming with radioactive reactions called fusion. This results in radiant energy appearing which is vital for life on earth due to the fact it is used in photosynthesis. While on earth hydrogen can be found as compounds such as methane (CH_4) and water (H_2O), it does not exist in gas form. The pure form of hydrogen is produced by steam reforming which is cheaper, and electrolysis which is costlier. Similar to electricity, hydrogen is an energy carrier. Hydrogen is a clean energy source due to the fact it extracts water when burned in an engine or fuel cell. Hydrogen is used to produce ammonia (NH_3) which is used as a fertilizer and as fuel cells to produce electricity. Hydrogen fuel cells are efficient but also building it is expensive (Demirel, 2016, pp. 56, 57). Hydrogen fuel cells combine hydrogen atoms to oxygen atoms resulting in electric current and also water molecules. Compared to internal combustion engines fuel cells are more efficient. Hydrogen fuel

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[17] https://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery (Date Of Access: 17.11.2017)

cells are used to produce electricity where transmission lines do not exist, and small fuel cells are used in electrical devices like laptops and also cars. The hydrogen fuel cell cars are less preferred because of the refuelling stations limited number. Liquid hydrogen has also been used as rocket fuel since the 1950s.[18]

2.3. Historical Progress of Energy

Nearly 500 000 years ago humans started using wood to make fires to provide heat, food, and light. Using fire for heating and food was the first step for humans to manipulate nature in order to use energy. The introduction of agriculture and farming led humans to settle in permanent residences instead of the nomadic lifestyle they have lived, as well as discovering the benefits of water and wind power. Windmills and watermills were built for the first time and they were used to meet the needs of food supplies, shelter and clothing. These improvements increase the amount of food available and resulted in the increase of the population and also the need of land. (Bithas and Kalimeris, 2015, p. 6) During the time of the Renaissance coal was started to be used as well as windmills and wood (Aubrecht, 1989, p. 38).

In the 18th century an English inventor named James Watt invented a machine that run on steam power and his invention lead to the industrial revolution which change the world. The industrial revolution which started in England between the years 1750 and 1830, made it possible to produce in large quantities with less effort which resulted in more people getting more goods and services as well as various industries developing. The steam machines were used in transportation such as boats and trains and this enabled the raw materials that were located far away from factories to be used in production. At the end of the 18th century gas took the place of coal as the main energy source and oil was also used for oil lamps. The invention of the light bulb led to the replacement of the oil lamps in households and the light bulbs were also used in transportation, industry and lighting. Farming was no longer the primary economic activity and more people started leaving villages and country sides to live in larger cities to work in industry and service sectors. This resulted in new social and professional classes. The revolution that started in England speared across Europe by the 19th century and at the time of the First World War, Germany had the most powerful

[18] https://www.eia.gov/energyexplained/index.cfm?page=hydrogen_use (Date Of Access: 17.11.2017)

industry with its developments in iron, steel, electricity, and machinery and chemistry sectors. The 19th century was not only the pioneer of electrical and chemical industries but also it was the pioneer of energy production. Coal gas was first discovered in 1812 and was widely used in heating and lighting houses and streets throughout the 19th century. (Özdemir, 2012, pp. 24-26)

2.3.1. Historical progress of electricity

The knowledge of electricity and electrical energy has existed even among the prehistoric humans who used lighting to kindle wood (Aubrecht, 1989, p. 45). Although electricity is a relatively new energy source and started to be used practical very recently the nature of electricity was known ever since the Ancient Greeks. People from Ancient Greek have known the concept of static electric when they notice that when a piece of amber was rubbed to a piece of cotton fabric it could pull small feather and straw pieces, it could sometimes even create small sparks when brought close to a person. In the time of the Renaissance scientist of the time was investigating the connection between static electricity and magnetism, the most noted work being a British scientist William Gilbert's works. But the significance of electricity and was mostly discovered after the industrial revolution and in the 19th century where the properties of electricity was discovered. Stephan Gray was the first to classify metals as conductive and non-metals as insulators. In 1752, Benjamin Franklin conducted his famous kite experiment where he found that lightning has electrical properties and he also discovered that electric loads have plus and minus ends. Coulomb calculated the electrostatic force of electrical charges which is proportional to the magnitude of the charges and inversely proportional to the square of the distance between the two charges. An Italian scientist, Alessandro Volta invented the electric battery by transforming chemical energy into electrical energy and obtaining a constant flow. Michael Faraday was the scientist who made it possible to use electricity as we use it today. In 1831 he discovered electromagnetic induction which lead him to hypothesize that to induce a current in a nearby circuit it would be paramount to change magnetic field. He conducted the first generator by placing a moving conductor into a magnetic field and obtaining electromotive force. This lead to the advancement of the dynamo, electric motor and transformer. While Faraday discovered the principles of electromagnetic induction, Maxwell discovered the equations to describe the electromagnetic field. This lead to Maxwell's equations being considered by many scientists the most important scientific success of the 19th century. Maxwell formed the fountain for classical electromagnetism, quantum field theory, classical optics, and electric circuits. (Özdemir, 2012, p. 31) French physicist named Andrea Marie Ampere is the first person to put forth the relation between electric and magnetic leading to him finding the science of electrodynamics which he named. Ampere is also the unit used to measure electric current.[19] Georg Simon Ohm was the person who stated that the electricity acted similarly to water flowing through a pipe and this lead to discovering the current in a circuit is directly proportional to the electric pressure and inversely to the resistance of the conductors which is now called the Ohm's law. Ohm is also the unit used to measure electrical resistance.[20]

The invention of the electric battery by Alessandro Volta and Hans Christian Oersted's experiment evidencing the connection between magnetism and electricity lead scientist to begin experimenting on using these principles in communication. An American inventor named Samuel Morse, utilized electromagnetic discoveries, especially the electromagnetic relay from Joseph Henry and in collaboration with Gale and Vail, constructed a single-circuit telegraph. The telegraph worked as the key pushed down completing the circuit which sent an electric signal through the wire and it was received at the other end by the receiver. The system was formed of a key, a battery, wire and for the wire a line of poles between stations and a receiver. A code in which letters and numbers were assigned to dots was created to transmit messages, this code was later known as the Morse code. Another American invertor named Thomas Alva Edison developed a Quadruplex system for the telegraph which made it possible for four messages to be transmitted at the same time using the same wire.[21] While Edison was trying to develop Alexander Graham Bell's invention, the telephone, by using a transmitter with compressed carbon that would vibrate as sound was made into it, he thought of a method to record sound which would lead to the invention of the phonograph. The phonograph was a device with cylinder coated with tinfoil, a diaphragm and a needle that could records and playback sound. The device amazed both Edison and was marketed by The Edison Speaking Phonograph Company which was

[19] https://www.britannica.com/biography/Andre-Marie-Ampere (Date Of Access: 23.11.2017)
[20] http://www.code-electrical.com/ohmslaw.html (Date Of Access: 23.11.2017)
[21] http://www.history.com/topics/inventions/telegraph (Date Of Access: 23.11.2017)

established in 1878. This invention made Edison a well-known and recognized inventor. Edison then decided to turn his attention to electrical lighting and with financiers backing his ideas The Edison Electric Light Co. was established. This company wanted to devise an electrical lighting system that could power a whole city. Once a long-lasting incandescent light bulb was successfully assembled these light-bulbs were aligned in the Menlo Park laboratory to give a spectacle on New Year's Eve for large crowds.[22] The first light bulb that Edison and his staff made was regulator-controlled vacuum bulb with a platinum filament which would have been impractical due to the high cost of platinum. After testing various other materials Edison by using the works of a physicist named Joseph Wilson Swan found out a filament made from carbonized thread could provide good enough light as_well as having a high resistance unlike a low resistance platinum filament._[23]

In the year 1884, a Serbian engineer, Nikola Tesla who had just graduated and had sailed to America with only four cents in his pocket. He found employment alongside Thomas Edison. At the time the direct current system Edison built for incandescent light bulbs were being used. The DC system had a low voltage, it was safe but could only generate electricity in a short distance. Tesla proposed using alternating current that was a periodically direction changing energy flow that could travel greater distance and transmitted greater quantities of energy. Edison thought the idea was impractical and insisted his DC system was superior. At the end Tesla wore down Edison and claimed he could built system that would run on alternating current and would be more efficiency than Edison's dynamos. Edison challenge Tesla for fifty thousand dollars to make his system safer and more efficient which Tesla did by constructing a fully functioning induction motor that ran on alternating current. Tesla never got the money Edison promised, so he quit and picked up odd jobs like digging ditches in New York. After saving enough money, he opened his own company named Tesla Electric Light Company, where he would have developed AC generators, wires, transformers, lights, and a 100 horsepower AC motor. Eventually, Tesla's system of alternating-current dynamos, transformers, and motors' patents were bought by an American entrepreneur and engineer George Westinghouse who was the head of Westinghouse Electric

[22] https://www.loc.gov/collections/edison-company-motion-pictures-and-sound-recordings/articles-and-essays/biography/life-of-thomas-alva-edison/ (Date Of Access: 02.12.2017)
[23] https://www.britannica.com/biography/Thomas-Edison (Date Of Access: 02.12.2017)

Company in the May of 1888. This lead to the power battle that would later be known as the “War of Currents” between Edison’s direct-current systems and the Tesla-Westinghouse’s alternating-current approach. At the World’s Columbian Exposition held in Chicago, 1893, the alternating current generator was used for the first time to light the exposition. This success lead Tesla and Westinghouse to build the first hydro-electric power plant at Niagara Falls in 1895 which carried power to Buffalo a year later. Tesla is noted for many other inventions such as the Tesla coil which is used in radio, televisions and other electronic equipment even today. In 1900, Tesla return to New York and started working on an idea that could wireless communication. In order to achieve this, he found a financier, J. Pierpont Morgan to construction a wireless world broadcasting tower in Long Island that would provide the world with wireless communication that could be used to send messages, pictures, weather forecasts, stock reports… But the project was abandoned due to the insufficient funding and the eventual withdraw of Morgan’s support. [24]

2.3.2. Energy in the present world

The energy sources used are generally producing large amounts of carbon waste which has a negative effect on the environment. It has been a long-standing challenge to reduce the carbon waste released to the environment and to transition to renewable energy instead of carbon producing non-renewable energy. In 2016 although the energy efficiency has increased, the growing world population and economies has offset it and the decreased energy intensity. Also, the oil and gas producers worldwide have, reduced cost and have restructured and refinanced whenever possible while some have bankrupted in 2016 (World Energy Council, pp. 8-10). Figure 2.3. shows the energy consumption of the world from 2006 to 2016. As it can be seen there is a steady increase in energy consumption, except for the crisis year 2008.

[24] https://www.britannica.com/biography/Nikola-Tesla (Date Of Access: 02.12.2017)

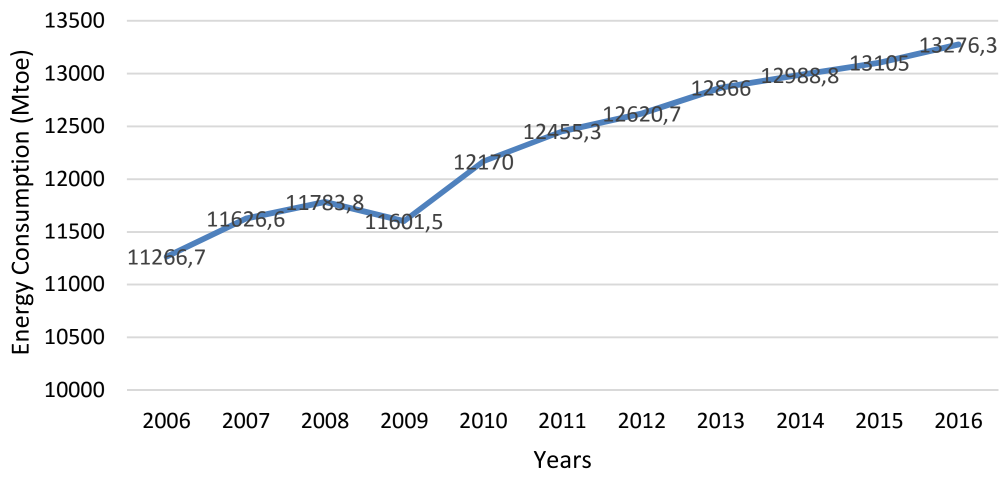


Figure 2.3. *World's Energy Consumption (2006 - 2016)*

2.4. Energy Sector in Turkey

2.4.1. Historical progress of the energy sector in Turkey

2.4.1.1. During the Ottoman Empire

Until the end of the 16th century the Ottoman Empire's technological level was same as the European countries. Although, at the time of the industrial revolution the Ottoman Empire could not keep up with the advancing technology. The capital city of the Ottoman Empire did not have any sort of lighting and the first time the streets were lighted was after the Rescript of Gülhane in 1839 when the people were asked to put oil lamps in front of their houses and shops. While poorer families used oil based products, only the wealthier families used wax in their houses and by the year 1860 wealthier families started using petroleum for lighting. In the year 1846 it was written in a government notice that it was necessary for the public good and that it was the command of the sultan to light up the streets. It was made mandatory to put oil lamps in front of people's houses and shop owner's shops. The efficiency of the coal gas compared to other sources, coal gas facilities widespread in the 19th century and almost all lighting in houses and street were sourced by coal gas at that time. In 1855, Sultan Abdulmecit wanted the newly built Dolmabahçe Palace to be lit like European palaces so in order to achieve that the first gas station built in Istanbul, the Dolmabahçe Gas Station was built. The second gas station to be built was the Kuzguncuk Gas Station and it was built to light the Beylerbeyi Palace. The excess gas was used for the lighting of the streets of Üskudar. The gas station made for social purposes in Istanbul was at 1880, the Yedikule Gas station. These stations lit the street lamps of Istanbul with coal gas light until 1940. (Özdemir, 2012, p. 31) The industrialization initiatives of the Ottoman Empire were mainly based on improving the military or government. In the years 1830 to 1840 the machines that were deported from Europe were to meet the demand of the navy and the palace. While foreigners and non-Muslims in the empire were pioneers of banking and transporting, the Turkish people were mostly farmers, civil servants, soldiers and tradesmen. By the year 1876, the Ottoman Empire was in debt to many European countries who formed an administration to collect their debt named "Duyun-u Umumiye Administration". This administration shifted the major government income source to pay the owned debt. In the beginning of the 20th century, the Ottoman Empire's continued wars had a negative impact on the country's budget. In the first years of the wars, basic needs like bread, wheat, salt, sugar, and gas oil were scarce, although at the time in the Empire the main economic activity was farming, and the industry was not yet developed. Industrialization gained importance only after 1908, after when the second constitutional monarchy was declared. Investments for industrialization were based on national capital but foreign capital dominated the industry and because trading was handled by Greek, Jewish, Levantine, and Armenian living in the Empire instead of the Turks it was a challenge to transition to national capital dominance. Before electricity the Ottoman Empire based its energy solely on physical human strength, the main economic activity was mostly agriculture, farming. Industrialization was an economic area that was intended to improve in a national way, but the wars prevented it. National industry and national trade was especially necessary after the minority groups who were dealing with industry and trading separated from the Ottoman Empire between the years 1917 - 1924. Following the year 1915 and the First World War, any kind of case of foreign trade did not exist and in the year 1922 the Ottoman Empire collapsed. The Ottoman Empire was an open market so transportation, banking, trade dealing was profitable however operating an industry in the Ottoman lands was costly because of the lack of infrastructure, energy, and qualified labour forces. The energy used in the limited amount of industries that were built were mostly based on manpower, stream power and internal-combustion engine which used oil. Electric motors were only used in factories that were in Istanbul. The first application of electricity can be considered the use of telegraph in 1855. The line was drawn between

Istanbul and Edirne and it connected to the Austrian network via Rousseau. In a very short time after also connecting with Europe, telegraph lines were drawn all over the country. When the first telegraph line was drawn in the Ottoman it had only been 18 years since the telegraph lines were drawn in England. In a very short time the Ottoman Empire accepted the telegraph, this was because it required a low cost and the benefit that it brought weighted its cost. The widespread of the telegraph increase communication and therefore diplomacy in the land. Although the telegraph had a widespread acceptance in the empire; the telephone which was spreading in Europe in from 1877, was establish after the constitutional monarchy was declared. (Özdemir, 2012, pp. 37-41)

2.4.1.2. Electricity in the Ottoman Empire

While electricity was popularizing in America, the Ottoman Empire first met electricity in the beginning of the 20th century. The first production of electric was in the 1902 in the town of Tarsus. A water mill located upon the river of Berdan near Tarsus was transformed in to a power plant using a driving belt strapped to the shaft of the mill turning a dynamo that produced 2kW of electricity. This small power plant was later turn to a hydroelectric plant and produced 60kW electricity that supplied the town with electricity.

The capital Istanbul's lighting demand could not be met with gas lighting alone, so The Dolmabahçe Gasworks was closed in order to replace gas lighting with electricity to light the city. After the law regulating concession that were granted to foreign companies was issued in 1910, the government prepared a specification to supply electricity to Istanbul and opened an international tender in accordance with this specification. The Austrian-Hungarian company Ganz which was known for electric tram manufacturer, was permitted with the concession to supply electricity to Istanbul under the new regulation law. The Ganz company combined their power with a couple of other companies established "The Ottoman Electricity Incorporation". This incorporation later built a coal-fired thermal power plant in Silahtarağa that would be the electric power plant in the Ottoman Empire to supply a city. The Silahtarağa Electric Power Plant was the first ever power plant to apply the build-operate-transfer model.

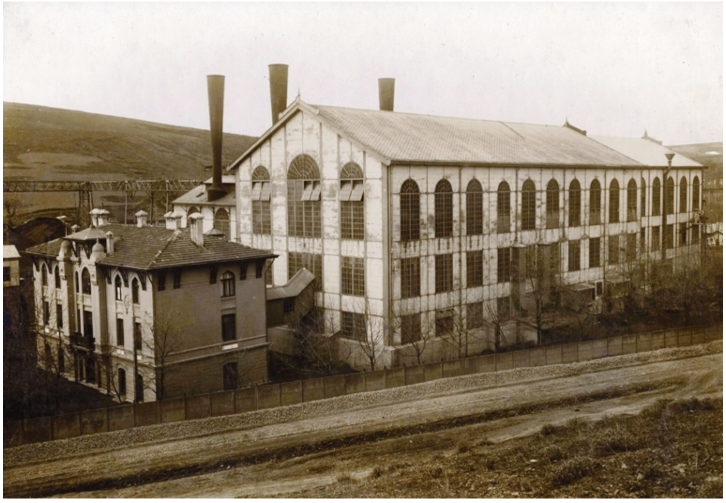


Figure 2.4. *The Silahtarağa Electric Power Plant*
Source: *http://www.santralistanbul.org/pages/index/powerplant/en/*

The electricity produced in Silahtarağa was firstly commercial purpose and was used to run trams in İstanbul. It started the trend for concession companies which was later used for tram operations in İzmir and the general electrification of Istanbul in 1914. During the constitutional monarchy only, Istanbul was provided with electricity. The main source of energy for The Silahtarağa Electric Power Plant was provided from coal which was mostly obtained from Zonguldak. The many of the ships that carried coal from Zonguldak to Istanbul were sank during the first world war, leaving the capital Istanbul and the navy in need of coal supply. With an ongoing war the supply of coal could not be met by importing it from sea and rail roads. This lead to a scarcity in coal and steam coal, and for the production to drastically fall. The “Istanbul Electric Company” which opened in 1914 could not provide electricity to the capital during the First World War due to the scarcity of coal. In the June of 1923, the company’s name was changed to the "Turkish Incorporated Electricity Company". (Özdemir, 2012, pp. 55-58)

2.4.1.3. During the Republic of Turkey

The electricity sector in Turkey was held by foreign companies of Germany, Belgium, Italy and Hungary at the time of 1914. The relationship between European countries had worsen after the First World War which lead countries that depend on European countries to decrease their foreign market which also resulted in their domestic industries to develop. The Turkish Grand National Assembly accepted a law in 1921 that encouraged industrialization and private capitals in sectors that lead to revitalizing some industries. The law permitted taxes and fees including giving free land to business owners for construction. The permission given for importing raw material and machinery without paying customs did not result favourably. The ongoing wars of the Independent War left Turkey with a collapsed economy. Industries and production had stopped, agriculture was lagging new technologies as well as the number of working men had decreased, foreign debts and unemployment had increased, and transportation could not be provided. At the time of the end of the war, most businesses were run by foreign businesses which lead to them abandoning the country pushing the Turkish people to enter a self-sufficiency process. The 1921 Constitution had adopted a principle of national will that provides legitimacy to the War of Independence. After the halt caused by the independence war, electricity extended quickly to the whole country. In 1923 Adapazarı; In 1925, İzmir, Adana, İnebolu, Artvin, Trabzon, Akşehir, Mersin; 1926 in Sivas, Aksaray, Konya, Ayvalık, Bursa, Malatya, Izmir, Kütahya; In 1928, Nazilli, Kırkağaç, Antalya, Afyon, Akşehir, Kırklareli, Samsun, Çorlu, Giresun, Eskişehir, Yozgat; 1929 in Bandirma, Biga, Milas, Ordu, Bafra; In 1930 Balıkesir, Kastamonu, Tekirdağ, Urfa was electrified. At the time of the 10th year of the republic, the number of provinces and districts that had electricity was 105. In July 23th, 1923 with the war of Independence ending, and after the foundation of the Turkish Republic, the Government of the Republic of Turkey issued a law establishing the legal status of the foreign companies in the Turkey. The contracts with the person or companies that received the electricity concession continued the existing contracts and the applications continued as they were. The law stated that any joint-stock company that was establish before March 16th, 1923 were to foresee that in order to ensure their compliance with the present Constitution, the Trade Vicant shall make the necessary arrangements, since almost all of the joint stock companies had laws according to the laws of the former Ottoman Government that are contrary to the Constitutional Law. The "İzmir Economics Congress" which was held between February 17 and March 4, 1923, was attended by the National Trade Union of Turkey and the subject matter was progress to be made in the fields of agriculture, industry, banking and transportation. The decisions taken from the İzmir Economics Congress was in the lines of adopting liberalism although it had been approved that the state should support the private enterprise and invest in the private sector in cases it was not sufficient or profitable. Mustafa Kemal

Pasha even stated in the congress that foreign capital could be an option as long as they are not in conflict with the interests of the state. Straight after the congress the Agricultural Bank of the Republic of Turkey (Ziraat Bank) was reorganized, and in 1927, the “Industrial Promotion Law” was issued with the aim of promoting and protecting industrial establishments. With this law, state subsidies such as cheap government subsidies, various tax exemptions, transportation and transportation incentives and capital incentives were given to the domestic industry sector. When the republic was form in 1923 the installed power capacity was 32.8 MW and only Istanbul, Adapazari and Tarsus, in today's borders of the Republic, were electrified cities. Only 94% of the population had access to electricity therefore the electricity consumption per person per year is about 3 kWh. The works on electrification were accelerated to provide electricity to all of the cities and new industrial facility that were to be established.

The larger cities were planned on lighted with electricity while smaller cities were to be lighted with gas at the beginning. The usage of electricity manufacturing processes started for the factories and cement factories, bakeries, weaving factories, ice making plants, fish processing factories, cigarette factories and small workshops, woollen fabric factories and in the following years, automotive sector factories started using electricity in their manufacturing process. In addition, Osram, Philips, Luma, Astra, Tungsram Kripton brands have begun producing electric wires and light bulbs to trade. Also, auxiliary jobs such as electric repair, electrical material merchandising, etc., which can cope with electrical problems, emerged. The electricity generation and distribution of the Anatolian side of Istanbul which would be around Kadiköy and Üsküdar, was given to Kadıköy Gas Company by the government in 1924. In 1926 the company bought Istanbul Gas Company and formed the company named abbreviated as ‘SATGAZEL’ (Istanbul Gas and Electricity and Enterprises). The importance of gas decreased as the prevalence of electricity increased so the company intended to enlarge the area of which it provided electricity to. In the 1930s it continued the network expansion by installing underwater cables from Kartal to Büyükada and started supplying electricity to the Prince Islands. In 1932, the network was extended to Heybeliada. The first power plant to be establish in Ankara was a direct current dynamo with a power of 35 kWh which was rotated by locomotive at 50 horsepower in Bendderesi, in 1925. The second power plant which was a diesel generator that provided Ankara with electricity, was established in accordance to the policy of privileged partnership in electricity, by the German MAN and AEG companies in 1925. During the time of the Ottoman Empire the concession would be given to the most suitable bidder was selected from among the persons or companies this biding system was turned into auction by underbidding and sealed bid method during the period of the Turkish Republic. The Great Depression of 1929, affected Turkey in the depreciation of the Turkish Lira, increase in imports and decrease in exports, the start of indigenous property incentive initiatives, and deficit in foreign trade. The inflationary environment, excessively raised the electricity prices and the increase in electricity production did not reduce the electricity prices. After the 1929 economic depression and from 1930 onwards in Turkey as well as in the world statist policy had gained importance. Since the effects of the 1929 crisis were not possible to stabilize for the private enterprise in liberal means, state intervention had become more effective in underdeveloped countries like Turkey, where the private enterprise was not strong.

By 1930, the installed power reached 78 MW, and the gross electricity generation was 106.3 GWh while the net consumption reached 96.7 GWh. The population in 1923 was 12.360.000 when we look at 1930 it increased to 14.448.000. The gross production per capita had increased from 3.6 kWh to 7.4 kWh, while consumption per capita had increased from 3.3 kWh to 6.7 kWh. Also, thermal and hydroelectric power was given attention to and in 1930 thermal power capacity increased to 104.4 GWh while hydroelectric capacity increased to 1.9 GWh. The electricity produced in Turkey was produced 94% by foreign companies, 4% by municipalities and 2% by people. Electricity production in Turkey had been in the hands of foreign companies operated by small local power plants and their separate local distribution networks. The electricity which was initially only used for lighting was used in the industry after 1930. Between the years 1930-1939, statist and protectionist politics lead to the import substitute industrialization model for basic consumption and intermediate goods production. The great depression lead to Turkey implementing a closed economy and a state-organized national industrialization. Between the years 1938 and 1944, the electricity generating companies with foreign capital privileged partnerships in the cities of Istanbul, Ankara, Adana, Bursa, Mersin, Balikesir, Gaziantep, Tekirdag, Edirne, İzmir, Antalya, Trabzon and Malatya were bought by the government with the enacted laws in order to nationalize the electricity sector. Only Kayseri and Civari Electricity

Trading Co. was not nationalized (Demirel, 2016, pp. 67, 100). Also in 1930 it was permitted to the municipalities by the law on municipalities, to produce electricity and with the "First Industrial Plan" in 1933, the government was decided to be responsible of generating electricity. Around the year 1935, the Etibank which was establish with the aim to finance mines and raw material used by the industry and power plants operated by the government, the Mineral Research and Exploration which was founded to systematically search and operate the mines with the necessary geology and mining methods, Electrical Works Research Administration which was establish to study the hydropower potential of the country and to prepare an electrification plan for the country by identifying the most suitable underground and water resources, became active. The year 1948 marks an important milestone; the Çatalağzı Thermal Power Plant belonging to Etibank, which was started in 1941 was finished and for the first time a regional power plant had been commissioned. The Çatalağzı Thermal Power Plant was built in the town of Çatalağzı in Zonguldak, a city known for mining coal. In 1952, a transmission line of 154kV was connected to the thermal power plant to supplement the electricity transmitted to İstanbul. From 1914 until 1952 Silahtarağa Power Plant was the only power plant that met the electricity need of İstanbul, with the connection of Çatalağzı the city of İstanbul was supplied by two power plants. In the 1950's a mixed economic policy was followed leading to electricity being produced by not only government enterprises but by private enterprises with build-operate models as well. The 1950's was also the years where Turkey had transited to an interconnected system in electricity transmission, meaning every single power plant large scale or small scale would be connected so a power cut would have a minimum effect. Turkey's electricity capacity had reached 789.5 million kWh and electricity production per person per year had reached 33 kW in these years.

In the years 1952 and 1956, four private companies with domestic capital were allowed to be established, these were Çukurova Electric Co. which would operate in Adana and İçel regions, Kepez Electric Co. which would operate in Antalya region, Northwest Anatolia Electrification Co., which would operate in the Northwest Anatolia Region, Turkish Aegean Electric Corporation which would operate in the Aegean region. Unfortunately, these joint stock companies were not successful therefore they were liquidated. Hydroelectric power plants were decided to be built, in 1953 an establishment called State Hydraulic Works (DSİ) was found which aimed to build hydroelectric power plants. In 1956, the Sarıyar Dam HEPP (Hydroelectric Power Plant) was in service with power of 160 MW, and in 1959, Hirfanlı Dam HEPP in service with power of 128 MW. The private and public sector's investments totalled at 1272.4 MW, electricity production amounted 2815.1 million kWh and annual electricity production amounted to 87kW per capita around the 1960's. In addition, the 5-year development plans have been introduced to ensure the integrity of the units and administration in the other ministries in the energy sector. The Energy and Natural Resources Ministry was found in 1963 to evaluate energy resources and natural resources of the country. The increase amount of production, transmission and distribution of electricity, TEK (Turkish Electricity Authority) was established with the law no. 1312 in 1970. This law also transferred Etibank, DSİ, Iller Bank and municipal power plants to TEK meaning the electricity generation was transferred to TEK while the transmission and distribution lines that belonged to the municipalities where left. In the 1970s, Turkey's installed power was 8623 million kWh with an electricity potential of 2234.9 MW and the electric production per capita per year reached 207 kW. The 1970's world energy crisis lead the construction of the hydroelectric plants to gain importance and the construction of them gaining speed due to the fact thermal power plants energy sources were imported to Turkey. The Gökçekaya Dam HEPP with 278 MW power was built in 1972 and the Keban Dam HEPP with 1330 MW power in 1975. The 1970's saw electricity interruptions and electrical raw material troubles while investments in hydroelectric power plants increased. In the 1980's Turkey had an electric potential of 5118.7 MW and installed power of 23275.4 million kWh as well as the electricity generation per person per year reaching 459 KW. Turkey's economic liberalization policies which started in the 1980s, made changes in the electricity sector. In 1982 problems between the transmission and distribution lines occurred due to municipalities and TEK disagreeing. This resulted in all the electricity facilities being transferred to TEK in order to provide unity. Then the electricity production and selling the produced electricity to TEK was given to private sector without any time constrains. In the year 1984 the principle of TEK being the only electricity producer was abandoned and a law that allow the generation, transmission and distribution of electricity by institutions outside the Turkish Electricity Authority (TEK) was invoked. With the same law build-operate-transfer and the transfer of operating rights were regulated which pave the way for private sector companies to participate in electricity production, transmission and distribution. But the first major project was held in 1996 due to the fact that there was lack of regulation on many subjects. At the beginning of the 1990s, Turkey produced 57543 million kWh of electric power and had an installed capacity of 16315.1 MW while electricity per person per year reached 855 kW. The 1990s were primarily concerned with privatization and the preparation of legal infrastructure for investments in private sector to participate in the energy sector. In the year 1993, TEK was reconstructed as a government-owned corporation and was divided as Turkey Electricity Generation and Transmission Company and Turkish Electricity Distribution Company with the decision of the Council of Ministers. In 1994, the Law on Privatization of TEK had entered into force, but the law was abolished by the Constitutional Court. Also, the same year, private and foreign capital companies were allowed to take part in the production, transmission and distribution of electricity subjected to the provisions of the private law and in the framework of the Build-Operate-Transfer model. At the beginning of the 2000's, Turkey's electricity production had increased to 124921.6 million kWh, and the installed capacity was 27264.1 MW while the electricity generation per capita had reached 1457 kW. While both the 1990's and 2000's continued developments in the electricity sector, in the 2000's the restructuring and the renewal of the legislation of the process of the electricity sector that came from the past was focused on. In the year 2001, the one of the most important advancement in electricity sector was the establishment of the Electricity Market Regulatory Authority which name was later change to the Energy Market Regulatory Authority. The Electricity Market Regulatory Authority was established with the aim to provide consumers with sufficient, high quality, continuous, low cost and environmentally friendly electricity; establish a financially strong, stable and transparent electricity energy market that can operate according to the provisions of private law in a competitive environment; and provide independent regulation and supervision in the market. Also in 2001, TEAŞ (State Electricity Generation and Transmission Corporation) had been divided into three legal entities for each activity. These government-owned corporation were Electricity Generation Inc. (EÜAŞ), Turkish Electricity Transmission Co. Inc. (TEİAŞ), and Turkish Electricity Contracting and Trading Co. Inc. (TETAŞ). In the year 2004, by the decision of the Higher Planning Council, the electricity distribution network within Turkish Electricity Distribution Co (TEDAŞ) had been allocated into twenty-one regions and it has been decided that the areas besides the Kayseri region should be included in the facilities that are to be privatized. In the 2010 the numbers for Turkey's electricity production have been revealed by TEİAŞ as 209 billion 389.5 million kWh in electricity consumption, 181.6 GWh in total electricity generation, a total of 882.5 GWh of electricity purchased from countries like Iran, Georgia and Azerbaijan within the framework of various agreements. Also, production of electricity by the Electricity Generation Corporation (EÜAŞ) thermal power plants decreased by 10.7 percent to 37 thousand 901.5 Gigawatts (GWh) compared to the previous year, while the production in hydraulic power plants increased by 45.4 percent to 41 thousand 210.4 GWh. The production of electricity for the partnerships with EÜAŞ decreased by 12.9 percent (16 thousand 254.7 GWh), for the power plants with transfer of operational rights it decreased by 1.1 percent (4 thousand 323.6 GWh), for the auto producers it decreased by 12.5 percent (11 thousand 807.8 GWh) for build-operate-transfer it decreased 2.2 percent. (13,555.8 GWh) compared to the previous year. Thus, after several years, the share of natural gas in production decreased, while the share of hydropower increased considerably. (Yavuz, Gürkan, & Şimşek, pp. 2-6)

2.4.1.4. Energy today in Turkey

The energy consumption in Turkey according to data from August 2017 is percentage wise 43% natural gas, 30% electricity and 20% motor consumption. The total electricity consumption was 28,105,116 MWh as of August, the production sources for electricity was listed as natural gas with the largest share of 38%, followed by imported coal with 18%, hydroelectric power plant (from dams) with 15%, lignite with 13%, and wind with 8%. (Karakış, 2017). In Turkey, lignite can be evaluated in national reserves and production quantities at medium level and coal at low level according to world standards. Nearly 3.2% of the world total of lignite / sub bituminous coal reserves can be found in Turkey. The most important coal reserves in Turkey are located in and around Zonguldak which has a total coal reserve of 1.30 billion tons, while the apparent reserve is 506 million tons while 46% of Turkey's lignite reserves are located in the Afşin-Elbistan basin. However, since most of the lignite found in Turkey have a low thermal value, its preferred use is in thermal power plants. By 2005, in order to meet the increasing energy demand with the industrialization and population increase and the targets of giving importance to domestic resources in energy production and reducing external dependency; the discovery of new coal fields and the development of known fields have been accelerated.[25] Approximately 72% of the world's oil and natural gas reserves are located vicinity of Turkey which includes energy-rich Caspian, Central Asia, and Middle East countries. The oldest pipeline that is located in Turkey is the Iraq-Turkey Crude Oil Pipeline that transports Kirkuk's oil in northern Iraq to the west. Another pipeline carrying oil is the Baku-Tbilisi-Ceyhan (BTC) Crude Oil Pipeline that was opened in 2006 and had reached the carrying capacity of 1.2 million barrels per day in 2009. An increase in the importance of shale gas lead to the search of shale gas in Turkey which resulted in wells being opened in South-eastern Anatolia and Trakya Regions and studies on reserve determination are being continued.[26] Natural gases are mainly used for heating and as a whole the supply-demand of natural gas annually is balanced however in the winter months when the demand for natural gas increases there can be imbalances in the supply-demand due to maximum level of daily consumption, temperature being below the seasonal norms, and obstacles in the route countries. The supply sources and routes of natural gases are diversified in order to obtain a supply-demand balance.[27] The first nuclear power plant to be open in Turkey will be Akkuyu Nuclear Power Plant which is planned to start operating in 2023. The second nuclear power plant to be establish in Turkey is Sinop Nuclear Power Plant project which conducted as an intergovernmental agreement on nuclear power plant construction and cooperation with Japan. Nuclear power plants are needed in order to meet the increasing electricity demand and to reduce the risks arising from import dependency.[28] The Hydroelectric production of Turkey was measured as 67.3 billion kWh in 2016.[29] Wind power plant establishment terms in Turkey are considered to be areas that are 50 meters above ground level and have a wind speed over 7,5 m/s where 5 MW per square kilometer electricity can be generated. The wind energy potential in Turkey is identified as 48,000 MW as well as the total area corresponding to the potential is 1.30% of Turkey's surface.[30] Turkey has a high solar energy potential because of its geographical position. The Solar Energy Potential Atlas of Turkey (GEPA), identified the annual sunshine time to be 2,737 hours (total daily 7.5

[25] http://www.enerji.gov.tr/tr-TR/Sayfalar/Komur (Date of Access: 15.12.2017)
[26] http://www.enerji.gov.tr/tr-TR/Sayfalar/Petrol (Date of Access: 15.12.2017)
[27] http://www.enerji.gov.tr/tr-TR/Sayfalar/Dogal-Gaz (Date of Access: 15.12.2017)
[28] http://www.enerji.gov.tr/tr-TR/Sayfalar/Nukleer-Enerji (Date of Access: 15.12.2017)
[29] http://www.enerji.gov.tr/tr-TR/Sayfalar/Hidrolik (Date of Access: 15.12.2017)
[30] http://www.enerji.gov.tr/tr-TR/Sayfalar/Ruzgar (Date of Access: 15.12.2017)

hours), and the annual total incoming solar energy as 1,527 kWh / m².yıl (daily total of 4.2 kWh / m²).[31] The geothermal potential of Turkey is theoretically calculated a 31,500 MWt (Megawatts thermal) and 78% of the potential areas are located in Western Anatolia, 9% in Central Anatolia, 7% in Marmara Region, 5% in Eastern Anatolia. The majority of the geothermal resources are in the range of low and medium temperature which is suitable for direct applications (heating, thermal tourism, mineral waters etc.) while about 10% is suited for indirect applications such as electric energy production. The first electricity production in geothermal energy applications in Turkey was started in 1975 named the Kızıldere Power Plant which was built in Sarayköy district of Denizli province with a power of 0.5 MWe (Megawatt electric). Turkey's total geothermal heat capacity which is the amount of visible heat, has reached 15,500 MWt.[32] Turkey's biomass waste potential is about 8.6 TOE (million tons in oil equivalent), the amount of biogas produced can be estimated to be 1.5 to 2 MTEP (million tonnes of equivalent petrol).[33]

2.4.1.5. Electricity today in Turkey

Turkey's main energy source for generating electricity by 2017 can be listed as: 34% from natural gas, 31% from coal, 24% from hydraulic power, 6% from wind, 2% from geothermal energy and 3% from other sources which is shown in the Figure 2.5.. Natural gas with a percentage of 34 is the main energy source in Turkey followed by coal and hydro energy sources.

[31] http://www.enerji.gov.tr/tr-TR/Sayfalar/Gunes (Date of Access: 15.12.2017)
[32] http://www.enerji.gov.tr/tr-TR/Sayfalar/Jeotermal (Date of Access: 15.12.2017)
[33] http://www.enerji.gov.tr/tr-TR/Sayfalar/Biyokutle (Date of Access: 15.12.2017)

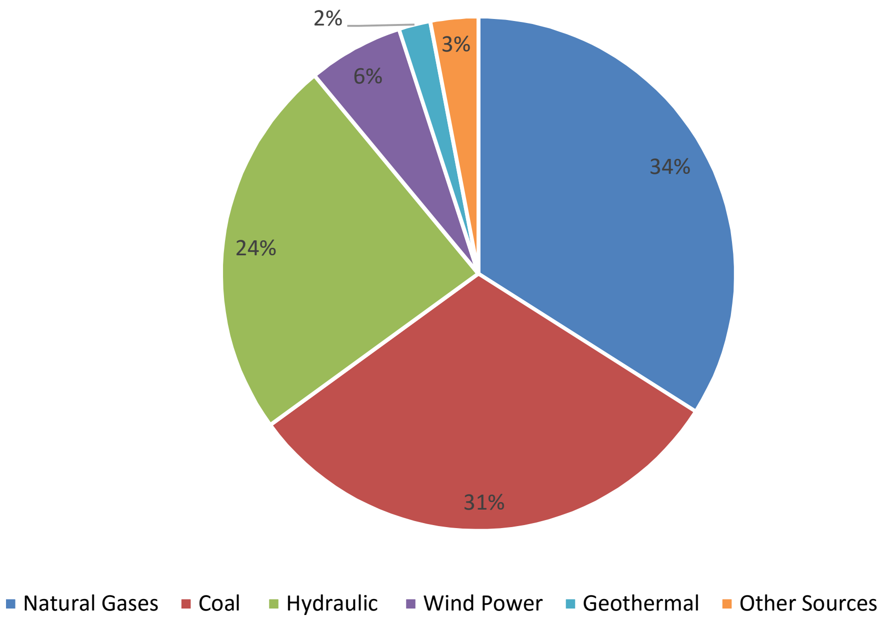
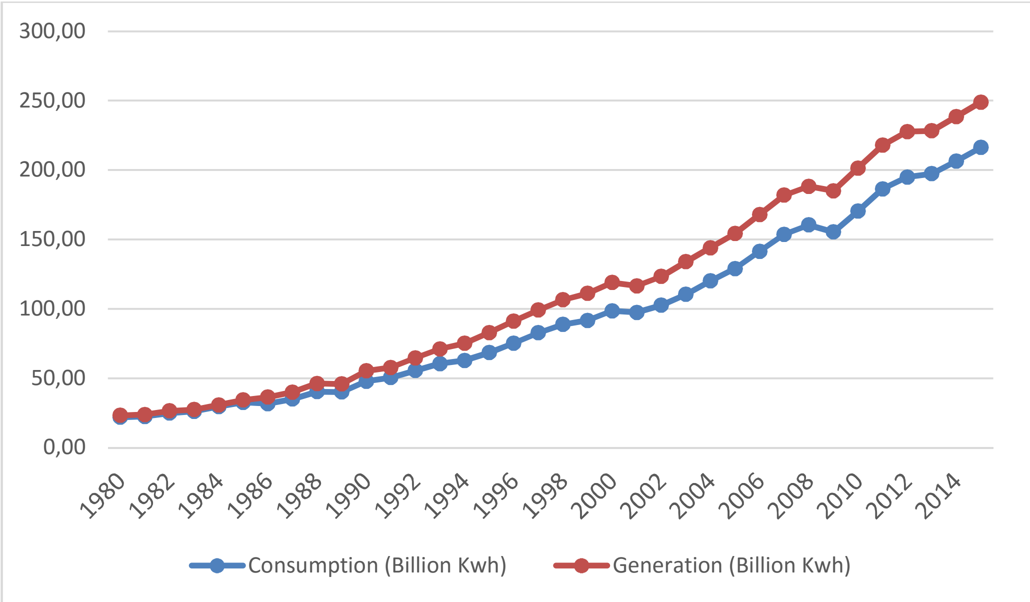


Figure 2.5. *Electricity Generation by Energy Sources in Turkey (2017)*

Source: *http://www.enerji.gov.tr*

Turkey's 278.4 billion kWh electric energy consumption in 2016 increased by 4.7% to 167.1 billion kWh in 2017 and electricity production increased by 6.7% compared to the end of July of 2016, to 167.3 billion kWh by the end of July 2017. As of the end of July 2017, the total installed capacity of electricity has increased by 2,049 MW and the installed power reached 80,546 MW by the end of July 2017. According to the projections, electricity consumption is expected to reach 385 TWh (terawatt hour) in 2023 with an average annual increase of 4.8%. As of the end of July 2017, EÜAŞ has a 25.1% share, free production companies have a 61.5% share, build-operate power plants have a 7.6% share, build-operate-transfer stations have a 1.7% share, power plants with transferred the operating rights have a 2% share and unlicensed plants have a 2% share in the installed power in Turkey. The number of electricity generation power plants in Turkey including unlicensed power plants, have increased to 3.098 and of the existing power plants, 613 are hydroelectric, 40 are coal sourced, 186 are wind powered, 33 are geothermal sourced, 288 are natural gas sourced, 1,773 are solar powered and 165 use other sources. The acceleration in the electricity consumption prompts the works on strengthening the electricity infrastructure to continue uninterruptedly. In addition to the strengthening efforts carried out nationally, a significant ground has been gained to strengthen Turkey’s international electrical connections and increase capacity. In this context, a Long-Term Agreement was signed between TEİAŞ (Turkish Electricity Transmission Corporation) and ENTSO-E (European Network of Transmission System Operators for Electricity) on April 15, 2015 and the Turkey's electricity system was permanently connected to the European electricity system. [34]



Source: *https://www.eia.gov*

Figure 2.6. *Turkey's Electricity Consumption and Generation (1980-2015)*

Figure 2.6. shows the comparison between electricity generated and electricity consumed in Turkey starting from 1980 to 2015. It can be seen that until 1990 a balance is seen. Despite the increase in production after 1990, the gap between production and consumption increased.

[34] http://www.enerji.gov.tr/tr-TR/Sayfalar/Elektrik (Date of Access: 15.12.2017)

CHAPTER 3

3. REVIEW OF THE LITERATURE

3.1. Introduction: Overview

The aim of this Chapter is to review existing studies of the determinants of electricity consumption in the World in general and specifically in Turkey. Empirical studies of the electricity demand have received considerable attention in both developed countries and developing countries. There are several empirical studies that have examined the determinants of the demand for electricity in a number of countries.

3.2. Demand for Electricity

The review of existing literature in the field of economics of the electricity consumption shows that studies in this area mainly focus on either testing whether electricity consumption plays a positive role in stimulating economic growth or determining the electricity consumption. There are many cross-country and single country empirical studies that support the positive association between electricity consumption and economic growth. Taylor (1975) surveyed the demand for electricity. In his work, he critiques economic literature on determinants of electricity. He points out that determinants of electricity consumption are a function of the level of income, the price of the goods and the prices of the other goods.

$$q = f(x, p_1, p_2, \dots p_x) \qquad (3.1)$$

Where q denotes the quantity consumed of electricity, x refers to income and p_1, p_2., …. p_x represent the price of the goods (Taylor, 1975: p.79).

Taylor has also analyses and critiques the short run and long run demand for electricity. In demand analysis, residential consumption, industrial consumption, commercial consumption critically reviewed respectively. (Taylor, 1975: pp.80-90).

Taylor has also provides an evaluation and critique of studies concerning electricity demand. He summarised and described studies as follows: The price elasticity of demand for electricity, for residential, commercial and industrial is much larger in the long run than in the short run. Income elasticity of demand is also having same pattern. In the long run, price elasticity of demand is indicated to be elastic. Income elasticity in the long run showed mixed results. (Taylor 1975; p. 108)

3.3. Previous Empirical Studies

Beenstock, Goldin and Nabot (1999) discussed the demand for electricity in Israel. They used quarterly data for estimating the demand for electricity by households and industrial companies. The research methodology is based on a nested demand

$$H = H(C, P_c; T) + u \qquad (3.2)$$

Where:

H : denotes the consumption of electricity in the household sector,

C : denotes consumer spending,

Pc : denotes the relative price of elasticity,

T : captures meteorological influences on the demand for electricity,

u : denotes a disturbance term.

They found that non-cointegration between electricity consumption and the relative price of electricity. They found seasonal unit roots in electricity consumption. The seasonality in electricity demand is stochastic rather than deterministic.

Tiwari (2000) paper has analysed determinants of residential electricity demand in Bombay. He used 6358 households survey of Bombay Metropolitan Regional Development Authority in the years 1987 and 1988. Used equation to estimate price elasticity is:

$$Ln\, E = a + Ey\, Ln\, Y + Ep\, Ln\, P \qquad (3.3)$$

where,

E : denotes household electricity expenditure,

Y : is income,

P : is price per unit of electricity.

The estimated elasticities for income is positive and 0,34 and elasticities for price -0,70. The main conclusion of this study is that residential electricity consumption is inelastic with respect to both income and price (Tiwari, 2000).

Nasr, Badr and Dibeh (2000) estimated electricity consumption in post war Lebanon for the period of 1993-1997. The model is estimated using ordinary least squares and has the following form:

$$C_t = A_t + B_1 TI + B_2 DD_t + u_t \qquad (3.4)$$

Where:

C_t : electricity consumption;

A : Constant;

B_1, B_2 : response coefficients of consumption to explanatory variables;

TI_t : total imports;

DD_t : degree days and

U_t : residual term.

They found that the impact of the gross domestic product proxied by total imports is a significant determinant of energy consumption, whereas degree days have a negative correlation. (Nasr, Badr and Dibeh, 2000).

Al-Faris, Abdul Razak F. (2002) used cointegration techniques to estimates the effects of economic variables on electricity demand in the Gulf Cooperation Council countries for the time period of 1970-1997.

Their empirical model is shown below

$$\Delta Q_t = \alpha 0 + \alpha 1 \Delta X_t + \alpha 2 \Delta Pe_t + \alpha 3 \Delta Pl_t + \alpha 4 \ell t - 1 \qquad (3.5)$$

Where,

Q : electricity consumption

X : GDP as a measure of real disposable income,

Pe : real price of electricity,

Pl : real price of alternative fuel (LPG), and

$\ell t{-}1$: the estimated residual form, and its coefficient represents the speed of adjustment to equilibrium values.

Their finding showed that elasticities of price and income are notoriously small which may indicate that the majority of people in these countries consider electricity as a necessity. Cross-price effects (of competing fuels) are small which may support the argument that the scope of energy switching, especially in residential sector, is still limited. (Al-Faris, Abdul Razak F. 2002; p. 121)

Mohamed and Bodger (2005), study on forecasting electricity consumption in New Zealand. Their study uses gross domestic product, average price of electricity and population of New Zealand during the period 1965–1999.

The proposed multiple linear regression model is;

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + u \qquad (3.6)$$

Where:

Y : electricity consumption,

X1 : GDP,

X2 : electricity price (cents/kWh),

X3 : population, and

U : the error (disturbance term or white noise).

The finding of this study is that the electricity consumption correlated effectively with all variables. (Mohamed, and Bodger, 2005)

Zachariadis, and Pashourtidou, (2007) paper analyse empirical analysis of electricity consumption in Cyprus. Using annual data from 1960 to 2004, they used cointegration and error-correction techniques for an empirical analysis of electricity use in Cyprus.

Their empirical model used for estimation is:

$$\Delta e_t = \alpha_{01} + \alpha_{11}\Delta e_{t-1} + \alpha_{21}\Delta y_{t-1} + \alpha_{31}\Delta p_{t-1} + \alpha_{41}\Delta tdd_t + u_t \qquad (3.7)$$

where

e : electricity

y : income

p : price

Δtdd : the stationary variable of total degree-days

Residential and commercial electricity use have been examined also the dynamic interaction between electricity use, income, prices and the weather has been analysed. Their findings show that the long-term impact of income and prices on electricity use is significant. Weather fluctuations seem to be the most significant cause of short-term variation in electricity consumption while the effect of income and prices is not significant in the short run. In the causality analysis indicates that electricity prices can be treated as purely exogenous, income and prices clearly Granger-cause electricity use, and there is bidirectional causality between residential electricity consumption and private income (Zachariadis and Pashourtidou, 2007)

Ziramba (2008) has studied on the demand for residential electricity in South Africa with a function of real gross domestic product per capita, and the price of electricity during the period of 1978–2005. Ziramba (2008) empirical model for estimation takes the following form:

$$lnEC_t = \beta_0 + \beta_1 t + \beta_2 ln\ _t + \beta_3 lnP_t + e_t \tag{3.8}$$

where

lnEC : natural log of the per capita residential EC (kWh per capita),

ln Y : natural log of real per capita income,

ln P : natural log of the real residential electricity price

t : time trend

The results of this study show the statistically significance of the income variable as well as the income elasticity of demand, while the price elasticities had negative sign as was expected they concluded to be statistically insignificant. The income elasticity of demand had a positive sign and the long-run elasticity had a value of 0.31 in the ARDL model. These findings were coherent to the studies that were previous made. The positive sign of the elasticity denotes to the residential EC being a normal good that will increase as income increases (Ziramba, 2008).

Louw, et al., (2008) paper has investigated determinants of electricity demand for newly electrified low-income African households. Below general ad-hoc model used for estimation:

$$Wh = f(PElec, PAltFuels, Income, Rooms, HHSize, ApplCost, \quad Time\ Elec, lights, credit) \qquad (3.9)$$

Where:

Wh : average number of watt hours used

PElec : price of electricity paid by the household

PAltFuels : price of alternative fuels

Income : total income earned per month

HHSize : number of persons living in the household

ApplCost : cost of most commonly used appliances

TimeElec : number of years household has been electrified for,

Lights : number of working electric lights a household has

Credit : whether the household has had access to credit in the past

Overall the results of this study showed the income inelasticity of electric demand and that it is especially an important component for low-income households. Electricity has come to be considered a basic necessity for households. The results showed that for low-income households the fuels like electricity and paraffin were used as substitution for each other if the prices increased for one fuel. The study states that this price sensitivity is also a factor in higher income households. The study has also found out, although not fully analysed, the demand of electricity is strongly affected by the cost of appliances. It also suggests cross-subsidisation and access to credit may be solutions to the low electricity consumption although it has a risk of negatively effecting higher income groups. (Louw, et al., 2008).

Ekpo, Chuku, and Effiong (2011) paper titled the dynamics of electricity demand and consumption in Nigeria. Between 1970 and 2008, a boundary testing approach was used in Nigeria to empirically investigate electricity demand and consumption dynamics. It also provides background analysis of electricity demand and consumption trends in Nigeria.

Their empirical model for estimation is:

$$\Delta LEC_{\tau} = C_0 + \beta_1 LEC_{\tau-1} + \beta_2 LEPR_{\tau-1} + \beta_3 LPCI_{\tau-1} + \beta_4 LPOP_{\tau-1} + \beta_5 LINDO_{\tau-1} \quad (3.10)$$

Where:

Δ : the first-difference operator,

βi : long-run multipliers,

C_0 : the intercept (drift).

LEC : electricity consumption (KW)

LEPR : electricity prices

LPCI : real GDP per capita

LPOP : total population

LINDO: industrial output

Findings of the study show that long term electricity consumption is positively affected by the income, population and industrial sector production. It has come to a conclusion that the electricity price is insignificant because it is determined by the government.

The income elasticity indicates that electricity is normal good which increases with income, while magnitude of the population parameter suggest that population drives the consumption of electricity more than other variables in the Nigerian case. (Ekpo, Chuku, and Effiong, 2011).

Syed (2011) paper was comprehensive paper analysing cointegration and vector error correction analysis to determination the long and short run dynamics between electricity demand and its determinants. The time series data study uses for Pakistan from 1970 to 2010. An extensive literature on electricity demand given in this paper.

The used model for empirical analysis of electricity demand in Pakistan is:

$$ELEC = \alpha + \beta_1 RI + \beta_2 EP + \beta_3 CUST + \beta_4 APPL + \varepsilon_i \quad 3.11$$

Where

ELEC	: Electricity consumption
RI	: Real income
EP	: Electricity prices
APPL	: Stock of electric appliances
CUST	: Number of customers
ε_i	: Error term

Results of this study suggest that electricity demand should focus on the effective income and price policies to control increasing demand. In long run, electricity demand is income and price elastic at residential and agriculture sectors thus price decrease is best response in these sectors. (Syed, 2011),

Xia and Hu, (2012) analyses the determinants of the intensity of electricity consumption in China using data from Chinese cities at the provincial level in 2009. Their paper the most elaborate representation of electricity consumption intensity in China. The model used include so many variables as output concentration, decease rate of energy intensity of industry, population concentration, industrial concentration, fiscal concentration, share of industrial employment, share of industrial output, decease rate of electricity consumption intensity, investment concentration, share of industrial electricity consumption, decease rate of energy intensity, urbanization degree of the province, share of non-agricultural population, urbanization degree of the city, average retail price of electricity, annual average temperature and ensured reserves of iron ore.

The results showed that key category factors such as industrial structure, regulatory content, urbanization grade, price, natural condition and resource ability are determinants of electricity intensity in China. The variation of each determinant in the region, comparative weights of all factors and detailed classifications of cities are shown. In order to facilitate understanding of electricity consumption in China, related policies have been dealt with for the electricity administration (Xia and Hu, 2012).

Ubi, Effiom, Okon, and Oduneka (2012) examined the determinants of electricity supply in Nigeria (from 1970 to 2009), using a parametric econometric methodology of ordinary least squares.

The used model for defining determinants of electricity supply in Nigeria is:

$$ES_t = \alpha_0 + \alpha_1 P_t + \alpha_2 lnGF_t + \alpha_3 lnRF_t + \alpha_4 TEC_t + \alpha_5 PW_t + u \qquad (3.12)$$

Where:

ES_t : Electricity supply in Megawatts hours at time t

P_t : Price of electricity per Megawatt at time t

GF_t : Government funding of electricity in Nigeria at time t

RF_t : Quantity of rainfall per year at time t

TEC_t : The state of technology at time t

PW_t : quantity of electricity or power lost per year in Megawatts at time t

u : the error term

$a_0 - a_5$: Parameters to be estimated

The results show that the level of technology, government financing and power loss is statistically significant determinants of Nigerian electricity supply, Because of average of 40% of power is lost in transmission per annum, the government needs to invest more in the electricity sector in order to complete electricity energy projects with the latest technology to increase electricity supply. The key constraint of electricity supply has been defined as industrialization and economic development in Nigeria. Since electricity is under-priced in Nigeria, price is not a significant variable affecting Nigeria's electricity supply. The most reliable determinants of the electricity supply in Nigeria are a strong result of the workforce, power loss, state financing and technology level. (Ubi, Effiom, Okon, and Oduneka, 2012).

Zaman, Khan, Ahmad and Rustam (2012) paper is case study of determinants of electricity consumption function in Pakistan. This study investigates the function of electricity consumption in Pakistan between 1975 and 2010, particularly in economic growth, foreign investment and population growth. The study adopted the boundary test procedure for simultaneous integration. And also, a dynamic short-term causality test is applied to determine the causality between determinants of electricity consumption.

The form of estimated model:

$$\Delta lnEC_t = \beta_0 + \beta_1(lnEC)_{t-1} + \beta_2 \ln(\mathrm{RGDP})_{t-1} + \beta_3 \ln(FDI)_{t-1}$$
$$+\beta_4 \ln(POP)_{t-1} + \sum_{i=1}^{p} \beta_5 \Delta \ln(EC)_{t-i} + \sum_{i=0}^{q} \beta_6 \Delta \ln(RGDP)_{t-i} \quad (3.13)$$
$$+\sum_{i=0}^{r} \beta_7 \Delta \ln(FDI)_{t-i} + \sum_{i=0}^{s} \beta_8 \Delta \ln(POP)_{t-i} + +u_t$$

where

Δ	: the first-difference operator and
u_t	: a white-noise disturbance term
ln(EC)	: the natural log of electricity consumption
ln(RGDP)	: the natural log of real GDP
ln(FDI)	: the natural log of foreign direct investment
ln(POP)	: the natural log of population.

The results show that foreign direct investment, income and population growth are positively related to electricity consumption in Pakistan. However, the intensity of these determinants differs in terms of electricity consumption (Zaman, Khan, Ahmad and Rustam, 2012).

Ubani, (2013) is another paper considering determinants of the dynamics of electricity consumption in Nigeria. The study using an annual time series data covers from 1985 to 2005. The main aim of this work is to empirically determine which factors that affect the electricity consumption rate in Nigeria.

Multiple linear regression was used in this study. The empirical model is:

$$EC = \alpha + \beta_1(Pden) + \beta_2(HHelec) + \beta_3(Area) + \beta_4(Bk) + \beta_5(Urb) + \beta_6(Emp) + \beta_7(Dist) + \beta_8(PCI) + \beta_9(Ind) + \beta_{10}(P) + \beta_{11}(HH) + \beta_{12}(Mk) + e \quad 3.14$$

where:

EC	: electricity consumption rate
α	: the constant of regression equation
B	: $\beta_1 \ldots \beta_{12}$ is the regression coefficient.
PCI	: per capita income,
P	: the price per unit of electricity
Urb	: the degree of urbanisation
Pden	: the population density,
Area	: the land area (density),
HH	: the number of households per capita
Mk	: the number of market/state
Bk	: the number of banks per capita
Ind	: the number of manufacturing industry per capita
HHelec	: the number of households with electricity per capita,
Empl	: the employment rate per capita
Dist	: the distance of each state to power generating station and
e	: the residual error term.

The results of the study showed that electricity consumption was significantly related to degree of urbanisation, population density, number of manufacturing industry, number of households with electricity, employment rate and distance to nearest power generating station.

Unlike previous studies that the study identified new factors, these are the employment rate and the number of households with electricity. They are useful and effective for determining electricity consumption in Nigeria (Ubani 2013).

Kavousian, Rajagopal and Fischer, (2013) work apply a methodology is based on the data set of 1628 households' electricity consumption in the USA. Structural and behavioural determinants of residential electricity consumption, by developing separate models for daily maximum and minimum consumption. This analysis is micro level.

The regression equation of the model:

$$y_j \beta_{0j} + \sum_{i=1}^{M} \beta_{ij} X_{ij} + X_j * \sum_{i=M+1}^{K} \beta_{ij} X_{ij} + \varepsilon_j \qquad (3.15)$$

where

y_j : the electricity consumption (kWh) of household j

X_{ij} : the value of the determinant i for household j

β_{ij} : the regression coefficient for that determinant

M : the number of variables (household features)

K : the total number of variables

ε : the error term.

The main findings of this study show that the most important determinants of residential electricity consumption are weather, location and floor area. Furthermore, number of refrigerators and entertainment devices are important determinants of daily minimum consumption. On the other hand, number of occupants and high-consumption appliances such as electric water heaters are the most significant determinants of daily maximum consumption (Kavousian, Rajagopal and Fischer, 2013).

Bedir, Hasselaar and Itard (2013) study aimed to identify the impact of the use of lighting and other electrical appliances in Dutch houses on electricity consumption and determine what constitutes the determinants. The data were collected by questionnaire in 323 houses in the Netherlands. Estimates were made using three regression models.

This research proved that duration of electrical appliance uses, and household characteristics are important predictors in models of electricity consumption. The results also show that hourly data on presence at home or in rooms do not help to explain electricity consumption with regression analysis. No correlation was found between electricity consumption and mechanical ventilation systems. Household size cause an increase on electricity consumption increases. They found in their first model that total duration of appliance use alone explained 37% of the variance in electricity consumption (Bedir, Hasselaar and Itard, 2013).

Krishnamurthy and Kriström, (2013) study is different from other studies that their objective of study is an estimation of price and income elasticity selected eleven OECD countries. They used survey data, including countries Australia, Canada, Chile, France, Israel, Korea, Japan, the Netherlands, Spain, Sweden and Switzerland.

They find strong price responsiveness, with elasticities for most countries in the sample. They find evidence for non-price related factors to significantly affect energy demand.

Price elasticity are in contrast with many existing studies indicating more policy space for demand reduction than previously thought. All variables, is negatively associated with demand, except for price and home ownership. Age is positively associated and is significant while education and home ownership are insignificant (Krishnamurthy and Kriström, 2013).

Blázquez, Boogen and Filippini (2013) study is important because it analysed the residential electricity demand in Spain using aggregate panel data at the province level for 47 Spanish provinces for the period from 2000 to 2008.

The study analysed the price, income, and weather conditions' impact over the residential electricity demand in Spain in which the impact of the weather variables has been significant to the electricity demand. The short-run and long-run elasticities have been found to be lower than one and negative which is the expected result (Blázquez, Boogen and Filippini, 2013).

Dhungel (2014) develops an econometric model to test for the effect on the relationship between electricity consumption and selected macroeconomic variables in Nepal. This study attempts to investigate electricity consumption as dependent, and foreign aid and GDP as explanatory variables for the period of 1974-2011. The data were collected from the ministry of finance of Nepal, ministry of energy of Nepal, Central bureau of statistics, and Nepal Rastra Bank.

The model used for estimation:

$$EC = b_0 + b_1 FA + b_2 GDP + u \qquad (3.16)$$

where,

EC : Electricity consumption in million KWh,

FA : Foreign aid in million rupees

GDP : Gross domestic product in million rupees

u : Residual-difference between observed and estimated values

The main findings of this study are that a strong relationship exists between electricity consumption, foreign aid and gross domestic product over the period of 1974-2011 (Dhungel, 2014).

Nawaz, Iqbal and Anwar (2014) modelled electricity demand using the Smooth Transition Auto-Regressive model in Pakistan over the period 1971-2012. The study's results indicate that the level of development is the main factor determining electricity consumption while the electricity price change has found to have no impact on consumption. The reason for this is stated as the absence of alternatives to electricity as the closes alternative, oil, would be costlier than the price of electricity. It has found the GDP per capita elasticity of the electrical consumption is greater than one meaning each unit change of the GDP per capita results in electricity consumption changing more than the change in GDP per capita. The study forecasted the electricity demand would excel the growth of the GDP and precautions like finding alternatives to increase the production of electricity would be beneficial (Nawaz, Iqbal and Anwar, 2014).

Huang (2015) develops an empirical model of determinants of household electricity consumption in Taiwan and employs quantile regression. The cross-sectional Family Income and Expenditure Survey conducted once a year by the Taiwan government. In this study the data used during the period of 1981 to 2011. The research examines how the effects of socio-economic and demographic household characteristics on electricity consumption change over time. They employ quantile regressions and claim that if the residual series is non-normal quantile regressions can be more efficient than the OLS method.

The findings of this study indicate that the impacts of electricity consumption on demographic, socioeconomic, and household dwelling characteristics may differ across quantiles and change over time and also household income and household size were significant in all quantiles for each year (Huang, 2015)

Fakih and Marrouch (2015) has investigated the electricity consumption, employment and growth nexus for Lebanon. The method used in the paper is Granger causality. The causal relationship between electricity consumption and growth in Lebanon is examined for the period 1980–2011. The theoretical framework for investigation of the electricity use, employment and national income causal relationships formulates as:

$$lnGDP_t = \beta_0 + \beta_1 lnELC_t + \beta_2 lnEMP_t + \varepsilon_t \quad (3.17)$$

Where;

β_1 and β_2 : the coefficients to be estimated and represent the long-run elasticities of ELC_t and EMP_t respectively

$lnGDP_t$: log of the real GDP

$lnELC_t$: log of the electricity consumption

$lnEMP_t$: log of level of employment

ε_t : the stochastic error term.

The main finding of this study is that economic growth in Lebanon is more responsive to the employment level than to electricity consumption (Fakih and Marrouch, 2015).

Alawin, et al., (2016) paper analysed the energy sector in Jordan for the period 1985-2006. The study used the following model with the ARDL technique:

$$EC_t = \alpha_0 + \alpha_1 RGDP_t + \alpha_2 POP_t + \alpha_3 P_t + \alpha_4 EFF_t + U_t \quad (3.18)$$

Where

ECt : the growth rate of electricity demand

RGDPt : the growth rate of the real GDP

POPt : population growth rates

Pt : energy price growth rate

EFFt : the growth rate of efficiency improvements in the manufacturing sector

Ut : random errors.

The study showed that the growth of the real GDP and population caused higher demand for electricity. On the hand, the energy price index and efficiency improvement in the manufacturing sector were negatively related to the demand. The study used real GDP growth rate, population growth, the domestic energy price index and improvement in production efficiency in the manufacturing sector with an Auto Regressive Distribution Lags (ARDL) model to determine the components of the electricity demand in Jordan. Consistently the results have shown the real GDP and population growth has a positive and significant effect on the growth in electricity also the manufacturing sector performance improvements decrease the electricity demand. The findings also point out an unusual effect of electricity consumption reducing if the level of domestic inflation rises (Alawin, et al., 2016).

Sekantsi, Thamae and Mohatonyane (2016) paper is a comprehensive paper analysing electricity consumption in Lesotho. In this paper the role of financial development, industrialisation and urbanisation on electricity consumption in Lesotho. The study covers between 1973 and 2012.

The empirical model used is:

$$ENC_t = \beta_0 + \beta_1 GDP_t + \beta_2 FD_t + \beta_3 IND_t + \beta_4 URB_t + \beta_5 Z_t + \varepsilon_t \qquad (3.19)$$

Where:

ENC_t : the natural logarithms of electricity consumption

GDP_t : the natural logarithms of economic growth

FD_t : the natural logarithms of financial development

IND_t : the natural logarithms of industrialisation

URB_t : the natural logarithms of urbanisation

Z_t : any exogenous variable affecting the demand for electricity in Lesotho

t : the time period

β's : long-run parameters to be estimated

ε_t : the white noise error term

They assumed all the coefficients of the explanatory variables are expected to be positive.

The results of the study show in the long-run economic growth, financial development and industrialisation have a positive relation with the consumption of electricity. But the results reveal that electricity consumption has no meaningful relation with urbanisation. The electricity demand has increased with the regulation introduced which is pointed out as the reason for the increased level of electrificated household in the study. Similar to the introduction of regularities political instabilities are stated to be factors that affect the energy demand. The reliance on imported electricity is suggested in the study to be reduced with the use of more efficient energy (Sekantsi, Thamae and Mohatonyane, 2016).

Kwakwa, (2017) examined a long-run analysis of determinants of electricity consumption in Egypt. This paper is case study of Egypt and main motivation of our thesis. Sample period of the study is between 1971 and 2012. He claims that determinants of electricity consumption in Egypt are electricity consumption, price, per capita income, urbanisation, financial development, carbon emission, trade and education.

The model demand for electricity consumption as follow:

$$EC_t = \alpha + \beta_1 Y_t + \beta_2 P_t + \beta_3 FIND_t + \beta_4 IND_t + \beta_5 TRADE_t + \beta_6 EDU_t + \beta_7 URB_t + \beta_8 CO_t \quad (3.20)$$

Where:

EC : the level of electricity consumption

Y : income

P : price of electricity

IND : level of industrialisation

FIND : financial development

TRADE : trade openness

URB : urbanisation

CO : carbon emission a measure of environmental degradation

EDU : education

The findings of the paper are that urbanisation, education, financial development, income and trade positively affect electricity consumption. On the other hand, industrialisation had negative effect on electricity consumption. No significant effect on electricity consumption in Egypt were found the variables price and carbon emissions. (Kwakwa, 2017).

3.4. Demand for Electricity: Case Studies for Turkey

Bagdadioglu, Price and Weyman-Jones (1996) paper is the first study on Turkish electricity demand. The paper analysed efficiency and ownership in electricity distribution with a non-parametric model. Bagdadioglu, Price and Weyman-Jones paper concentrates on ownerships and efficiency rather than determinants of electricity consumption. This paper includes in the literature review because the firs study on the issue. Main findings of this study suggest that there was no significant difference of overall technical between distribution organizations. Furthermore, they found no evidence on pure technical efficiency for which the government offered franchises and the rest of the public distribution organizations (Bagdadioglu, Price and Weyman-Jones, 1996).

Akan and Tak, (2003) estimated demand for electricity for Turkey using an econometric model. The study's object is to model the determinants of electricity demand, and to examine the short and long-run demand elasticities.

The model for econometric estimation is:

$$lnEC = \alpha + \beta_1 lnGDP + \beta_1 lnP + Dum + \varepsilon \quad (3.21)$$

Where:

lnEC : per capita electricity consumption (in natural logarithmic form)

lnGDP : per capita GDP (in natural logarithmic form)

lnP : annual average electricity price (in natural logarithmic form)

Dum : Dummy crisis years 1994 and 1999 dummy change

According to the electricity demand model that is established concludes the long-run elasticities of income are greater than the short-run elasticities of income. The price elasticities are found to be low as a result of electricity losses and leakages, the unstable interventions the public authority made on electricity prices, and the saturation of the use of electricity in the country not yet being reached. Finally, a five years projection for electricity consumption was made in the study which showed that electricity demand would increase at high rates (Akan and Tak, 2003).

Altinay and Karagol (2005) investigates the causal relationship between electricity consumption and income. The sample period covers 1950 to 2000 with Turkish data. Their work demonstrates that a strong evidence for unidirectional causality. Electricity consumption Granger cause to the income. The causality running from electricity consumption to the income means electricity consumption forego the economic growth in Turkey. Electricity supply is critically important to meet the growing electricity consumption. They claim that supply of electricity is necessary for sustainable economic growth in Turkey (Altinay and Karagol, 2005).

Nişancı (2005) has investigated the relationship between electricity demand, electricity consumption and economic growth in Turkey. In this study, electricity demand in Turkey has been estimated in different sectors and the causality between electricity consumption and national income has been tested. A one-way causality relation has been found between electricity consumption and national income which would suggest a decrease in electricity consumption will cause a decrease in national income. It has been found in all sectors the income elasticity is smaller than one in the short-run but greater than one in the long-run (Nişancı, 2005).

Akay and Atak, (2007) study aimed to forecast total and industrial electricity for Turkey with the GPRM (Grey prediction with rolling mechanism) method and has found it is a reliable method for electricity projection. It urges future studies to evaluate the GPRM method for forecasting electricity in other sectors such as residential, agriculture and transportation and short-term load. (Akay and Atak, 2007).

Halicioglu (2007) study analyses residential electricity demand dynamics in Turkey. Sample period of the study is between 1968 and 2005. The model he used for estimation is a modified residential electricity demand model in semi-logarithmic form as follows:

$$lnC_t = \alpha_0 + \alpha_1 lnY_t + \alpha_2 lnP_t + \alpha_3 lnU_t + \varepsilon_t \qquad (3.22)$$

where:

lnCt : the natural logarithm of the per capita residential electricity consumption (kWh)

lnYt : the natural logarithm of the real per capita income

lnPt : the natural logarithm of real residential electricity price

lnUt : the natural logarithm of the urbanization rate

The key findings of the study is that short-term elasticities are lower than long-term elasticities. Urbanization change in the housing energy demand equation also seems statistically significant. Direction of causality runs from income, price and urbanization to residential energy demand in the long run (Halicioglu, 2007).

Kınık (2008) has investigated residential electricity demand in Turkey. In this thesis, annual data for 1975-2005 period are used. The study's results state that constraints on electricity consumption has a negative effect on economic growth while the increase in electricity generation has a positive effect on economic growth. This implies that policy makers should consider implementing policies to control electricity generation and supply. It also states the urbanization rate, population, education level, economic growth are factors the residential electricity demand in Turkey depend on directionally (Kınık, 2008).

Karagöl, Erbaykal and Ertuğrul, (2011) examines the relation between electricity consumption on economic growth with a bound test approach. The results state a positive effect of electricity consumption on economic growth in the short-run but when the long-run effects are examined a negative one is seen. It is explained that in the short-run electricity consumption is not only an input for industry development but also an input to improve quality of life which concludes the positive effect on economic growth. In the long-run however is explained as reduced energy cost due to the increase electricity consumption per capita. The result lead to the implication that in order to increase the growth performance at the same time make it sustainable for Turkey, alternative and low-cost electricity generation should be provided (Karagöl, Erbaykal and Ertuğrul, 2011).

Kavaklioglu, (2011) modelled and calculated of Turkey's electricity consumption. The study used Support Vector Regression (SVR) method to model Turkey's electricity consumption as a function of population, gross national product, imports and exports which are socio-economic indicators for Turkey. It also used the SVR method to forecast future electricity consumption and showed that it will drastically increase in the next twenty years in Turkey therefore the government would benefit in the long-run from planning to expand the capacity for electric power plants (Kavaklioglu, 2011).

Sayın (2013) estimated electricity demand in Turkey for 1998-2011. The study modelled electricity demand for Turkey according to seasonal time series model, with the temperature, gross domestic product and electricity price variables. The results showed that the long-run equilibrium is obtained when the electricity price is chosen as the dependent variable and the gross domestic product is the independent variable, in addition the temperature is an exogenous variable and demand had found not to be statistically significant (Sayın, 2013).

Altıntaş and Koçbulut, (2014) investigated dynamics of electricity consumption and economic growth in Turkey using bounds testing and causality analysis for the period of 1960-2011. Their results suggest that economic growth, exports and investment variables have a positive effect on the long-term electricity consumption in Turkey. According to the short-term Granger causality results of the study, there is a one-way short-term Granger causality relationship between exports electricity consumption, investment and electricity (Altıntaş and Koçbulut, 2014).

Güloğlu and Emre (2014) study aimed to determine the factor of electricity consumption in households and an ordered logit approach has been used. Housing type, the size of household, the structure of the household, real income of the household, the ownership of electrical appliances such as air conditioner, freezer, micro oven, washing machine are found to be the determinants of electricity consumption. The study suggests for Turkey is that the restrictions on the electricity consumption in houses could contribute to decreasing the energy deficit in Turkey since household electricity consumption constitutes the majority of electricity consumption in Turkey (Güloğlu and Emre, 2014).

Karaca and Karacan (2016) estimates demand for electricity consumption with multiple regression method. The main findings of this study are that there is an important relationship between electricity consumption and the gross domestic product, and the change in the gross domestic product is the result of positively influencing electricity consumption (Karaca and Karacan 2016)

Bayramoğlu, Pabuçcu and Boz (2017) used ANFIS model (Adaptive Network-based Fuzzy Inference System) for forecasting primary energy demand for Turkey. In the study, energy consumption for Turkey was estimated using some variables that determine total primary energy consumption. For this purpose, ANFIS model, which is one of the artificial intelligence techniques that produce very successful results for the prediction problems of the future, is used. Determinants of electricity consumption are defined as GDP, population and energy prices. Their findings suggest that no significant increase in Turkey's energy demand is expected based on primary resource in the coming years (Bayramoğlu, Pabuçcu and Boz, 2017).

Overall, it is seen that the studies focus on the relationship between the consumption of electricity and its determinants. There are also studies focus on econometric analysis of the residential electricity demand. However, from the literature, more research needs to be done in this area. This study focuses on determinants of electricity consumption in Turkey.

CHAPTER 4.

4. DETERMINANTS OF ELECTRICITY CONSUMPTION IN TURKEY

4.1. The Model, Data and Methodology

4.1.1. Economic motivations for electricity consumption in Turkey and empirical specifications

Determinants of electricity consumption in Turkey is main motivation of this thesis. In this regard, determinants for electricity consumption can be similar to the traditional theory of determinants which explains determinants for a commodity is determined mainly by price and income expressed mathematically as

$$ELEC_t = \alpha + \beta_i X_t \tag{4.1}$$

- where $ELEC_t$ is the quantity demand for electricity, at time t,
- x is a vector of explanatory variables (price and income) of ELEC and
- β_i represents the coefficient of each explanatory variable i.

Price usually has a negative relationship with energy consumption since a higher price will force consumers to reduce their level of consumption. On the other hand, because of the energy is taken as a normal good income tends to increase its consumption.

The study modelled equation (4.2) for estimation of determinants of electricity consumption in Turkey.

$$ELEC_t = \alpha + \beta_1 YPC_t + \beta_2 IND_t + \beta_3 FIND_t + \beta_4 EDU_t + \beta_5 CE_t + \beta_6 P_t + \beta_7 URB_t + \beta_8 TRAD_t + \varepsilon_t \tag{4.2}$$

Where:

ELEC : the level of electricity consumption

YPC : per capita income

IND : level of industrialisation

FIND : financial development

EDU : level of education

CE : carbon emission

P : price

URB : urbanisation

TRAD : trade openness

YPC, per capita income included in the model because traditional theory of demand which explains demand for a commodity is determined mainly by income. Because of energy is taken as a normal good, income contribute to increase its consumption.

Due to the argument that the industrialization relies on energy production, it is necessary to include industrialisation (IND) to the electricity consumption model in Turkey. If electricity is a variable input for the industry, an economy is expected to cause an increase in electricity consumption in an expansion of the industrial sector. However, when the industrial sector is become more energy efficient, it will cause reduction on electricity consumption. The rapid growth of the Turkish industrial sector has pointed to the importance of the increase in production in the energy sector (Kwakwa, 2017; p. 9).

Financial development (FIND) is another factor affecting energy consumption in the Turkish economy. The effect on energy consumption is twofold. Financial development can cause an increase energy consumption by facilitating trade, economic growth, entrepreneurship and industrialization. At the same time, households and firms offer access to credit to purchase energy-consuming devices for individual use or business investments, thus increasing energy consumption. On the other hand, it suggests that households and firms can access efficient energy equipment when there is good financial development that reduces energy consumption. In addition, the financial development characterized by direct foreign capital inflows leads to the transfer of efficient technology and managerial skills to local firms and thus to a reduction in energy consumption. We have added financial development to the explanatory variables of electricity consumption. (Kwakwa, 2017; p. 11)

It is suggested that the level of education (EDU) reduces energy consumption. Education is considered to play an important role in energy consumption because the higher education level cause low costs of obtaining information on energy related issues. In addition, higher education levels make the individual environmentally friendly. Education can significantly affect the level of electricity consumed in an economy at the national level. For this reason, the level of education variable is added to the electricity consumption function.

Citizens are expected to reduce energy use if they are more concerned about the environment and vice versa. Carbon emissions (CE) have been added to the electricity consumption function because we assume that carbon consumption in Turkey is an effect on electricity consumption.

Price (P) included in the model because traditional theory of demand which explains demand for a commodity is determined mainly by price. Price is expected to have a negative relationship with energy consumption; because a higher price causes a reduction consumers consumption levels

Urbanization was added as an explanatory variable. Because urbanization increases energy demand by changing private consumption patterns. Urbanization provides enrichment and individuals in cities uses more energy-intensive machines.

It was alleged that trade openness (TRAD) had a significant effect on energy consumption. Energy is needed to produce goods for export, and energy is required to transport imported goods to other parts of an economy. This increases an expansion energy consumption in commercial activities. However, when trade has energy-saving equipment that can be used for imports for businesses and household goods, it can reduce energy consumption. In this context, trade is thought to be important determinants of electricity consumption for the Turkish economy. If electricity is thought to be a variable input for the industry, an economy is expected to cause an increase in electricity consumption in an expansion of the industrial sector. (Kwakwa, 2017; p. 9)

Trade includes import and export. Export means more to produce, and the more production has a significant influence on energy consumption and also energy is needed to carry the imported goods to another zone. However, when trade has energy-saving equipment that can be used for imports for businesses and household goods, it can reduce energy consumption. In this context, trade is thought to be important for electricity consumption for the Turkish economy.

4.1.2. Estimation technique

In this study, we follow three-step to find out the determinants of electricity consumption for the Turkish economy as unit root property of the series, cointegration test was applied to understand that whether there is a long-run relationship between variables and estimates of the long-term characteristics of electricity consumption in Turkey, using the Phillips and Hansen's (1990) Fully Modified OLS (FMOLS) and Park's (1992) Canonical Cointegrating Regression (CCR) models. Apart from this, decomposition analysis was conducted to investigate the relative importance of each of the key explanatory variables of electricity consumption in Turkey. In the last equation (4.3), the logarithm of all variables was taken, and the log of the price variable was not taken to measure and interpret the elasticities.

$$\begin{aligned} LELEC_t = \alpha + \beta_1 LYPC_t + \beta_2 LIND_t + \beta_3 LFIND_t + \beta_4 LEDU_t + \beta_5 LCE_t \\ + \beta_6 P_t + \beta_7 LURB_t + \beta_8 LTRAD_t + \beta_9 DUMMY_{1980} + \varepsilon_t \end{aligned} \tag{4.3}$$

Definition of Variables (Equation 4.3)

$LELEC_t$	: natural logarithm of the level of electricity consumption (Electric power consumption, kWh per capita)
$LYPC_t$	: natural logarithm of the per capita income
$LIND_t$	: natural logarithm of the level of industrialisation
$LFIND_t$	: natural logarithm of the financial development (Broad Money: % of GDP)
$LEDU_t$	: natural logarithm of the level of education (School enrolment, tertiary)
LCE_t	: natural logarithm of the level carbon emission (CO2 emissions: metric tons per capita)
P_t	: consumer price index
$LURB_t$	: natural logarithm of the urban population

$LTRAD_t$	: natural logarithm of the total trade as share of GDP
$LIMP_t$	: natural logarithm of the exports of goods and services (% of GDP)
$LEXP_t$	: natural logarithm of the imports of goods and services (% of GDP)

The stationarity of the series is tested using Augmented Dickey-Fuller (ADF) and the Phillips-Perron tests (PP). The use of parametric auto regression in the ADF test handles the serial correlation and heteroskedasticity problems in the residuals which is the reason it is a test widely used, while the Phillips-Perron (PP) test deals better with general forms of heteroskedasticity in the error term. The null hypothesis of the ADF and the PP test for stationarity is declared as the series not being stationary or containing a unit root and alternatively the series is stationary or does not contain unit root.

The relationship between variables in the long-run is tested by examining cointegration among the variables. The cointegration estimation techniques used are the Phillips and Hansen's (1990) Fully Modified OLS (FMOLS) and Park's (1992) Canonical Cointegrating Regression (CCR) models, are used to assess the long-run electricity consumption determinants of Turkey. The estimators are chosen with the robustness of the estimators in face of the serial correlation and endogeneity problem taken in to accounts.

The equation given below displays the Fully Modified OLS estimator,

$$\varphi_{FME} = \left(\sum_{t=1}^{T} Z_t Z_t'\right)^{-1} \left(\sum_{t=1}^{T} Z_t Z y_t^{+} - T\hat{J}^{+}\right)^{-1} \qquad (4.4)$$

For the equation 4.4. the correction term for endogeneity is $y_t^{+} = y_t - \hat{\lambda}_{ox}\hat{\lambda}_{xx}^{-1}\Delta x_t$ where $\hat{\lambda}_{ox}$ and $\hat{\lambda}_{xx}$ are the kernel estimates of the long-run covariances; the correction term for serial correlation is $\hat{J} = \hat{\Delta}_{ox} - \ddot{\lambda}_{ox}\hat{\lambda}^{-1}\ {}_{xx}\hat{\Delta}_{xx}$ where $\hat{\Delta}_{ox}$ and $\hat{\Delta}_{xx}$ are the kernel estimates of the onesided long-run covariances. The approach by Park (1992), that is the canonical cointegration regression, is similar to the FMOLS. The point of the one sided long-run covariances.

The approach by Park (1992), that is the canonical cointegration regression, is similar to the FMOLS. The point of departure, however, is that while the FMOLS uses the transformations of both the data and estimates, the CCR uses only the data transformation and selects a canonical regression among the class of models representing the same cointegrating relationship. The CCR estimator is shown below,

$$\hat{\varphi}_{CCR} = \left(\sum_{t=1}^{T} Z_t^* Z_t^{*1}\right)^{-1} \sum_{t=1}^{T} Z_t^* Z y_t^* \quad (4.5)$$

Where $Y_t^* = (X_t^{*1}, D_t'), X_t^* = X_t - (\hat{\Sigma}^{-1}\hat{\Lambda}_2)\, \hat{V}_t$ and $Y_t^* = Y_t - \hat{\Sigma}^{-1}\, \hat{\Lambda}_2\, \hat{\beta} + [\hat{\eta}_{22^{-1}}\, \hat{\omega}_{21}]\, \hat{V}_t$ denotes the transformed data, $\hat{\beta}$ is an estimate of the cointegrating equation coefficients, $\hat{\Lambda}_2$ is the second column of $\hat{\Lambda}$ and $\hat{\Sigma}$ denotes estimated contemporaneous covariance matrix of the residual (Park, 1992).

4.1.3. Data sources and description

This article uses data to examine the effects of income, industrialization, financial development price, trade openness, carbon emissions and education as determinants of electricity consumption in Turkey between the years 1960 and 2016.

The choice of this period is based on the data availability. Much of the data was taken from the World Development Indicators (2017). Price and education data are taken from TURKSTAT. It is expected that the consumption of electricity energy (kWh per person) and the income will be affected positively. The reason is that the purchase of electricity as a normal commodity, the increase of income will increase the electricity demand. The level of industrialization is measured as the share of industry in GDP. Energy is needed for industrial activity, and the increase in the level of industrialization is expected to increase electricity consumption. However, when industries use energy efficient technology use, this will reduce electricity consumption. It is estimated that measuring the urban population by the number of urban population will increase the electricity consumption positively. The reason for this is that the city centres are characterized by the presence of heavy industries and offices, which are predominantly connected to electricity. The effect of trade openness cannot be determined primarily because trade can increase or decrease electricity consumption. Trade measured by three proxies as export as share of GDP, import as share of GDP, and import and export sum as a share of GDP. Education is measured as the number of tertiary school enrolments, which is expected to reduce the intensity of electricity use. The price is measured as a consumer price index and a negative relationship is expected between electricity consumption and price. Carbon emissions are measured as CO_2 emissions per capita. Financial development with uncertain impact on electricity consumption. Money supply used as proxy for financial development and it was measured money supply as the share of GDP. In Turkey, structural change occurred in 1980. For this reason, step dummy variables were used after 1980.

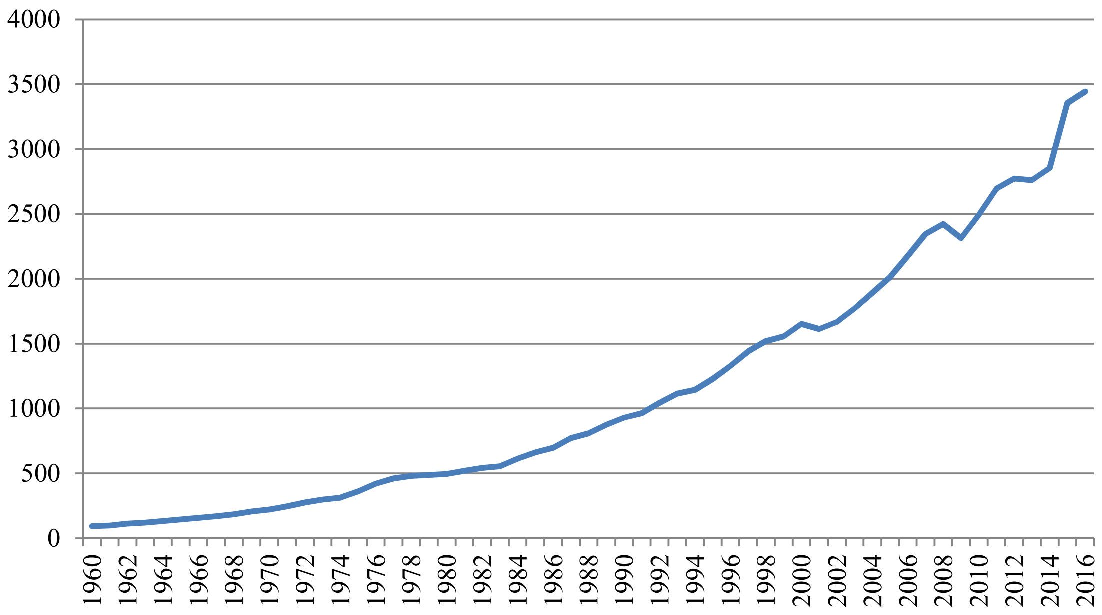


Figure 4.1. *Electric power consumption (kWh per capita)*

In Figure 4.1. the power consumption of electricity is shown in kWh for the years 1960 to 2016. It is seen that the electricity consumption has gradually increased through the years. The lowest point was reached at 92.31kWh in 1960 and the highest point was reached at 3443kWh in 2016.

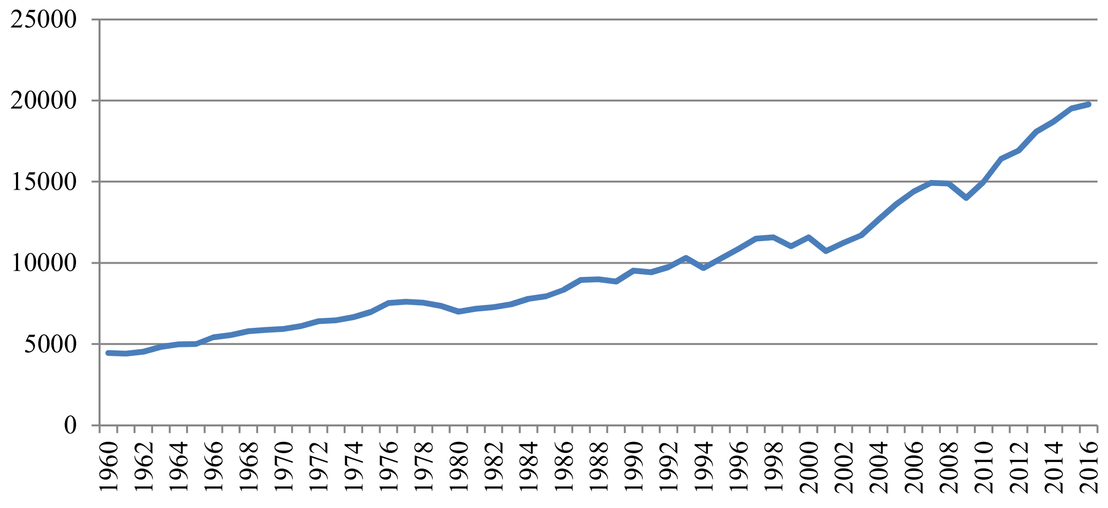


Figure 4.2. *GDP per capita (constant LCU)*

In Figure 4.2. the per capita of GDP is shown for the years 1960 to 2016. The GDP per capita has a steady grow during these years. Between the years 1960 and 1980, Turkey implemented an import substitution policy but after 1980 export oriented industrialisation was chosen instead which ensured a dynamic and fast growth of the economy. Although periodic crisis occurred during the export oriented industrialisation period growth accelerated. Especially the political stability that came after 2002 contributed to the further acceleration of growth.

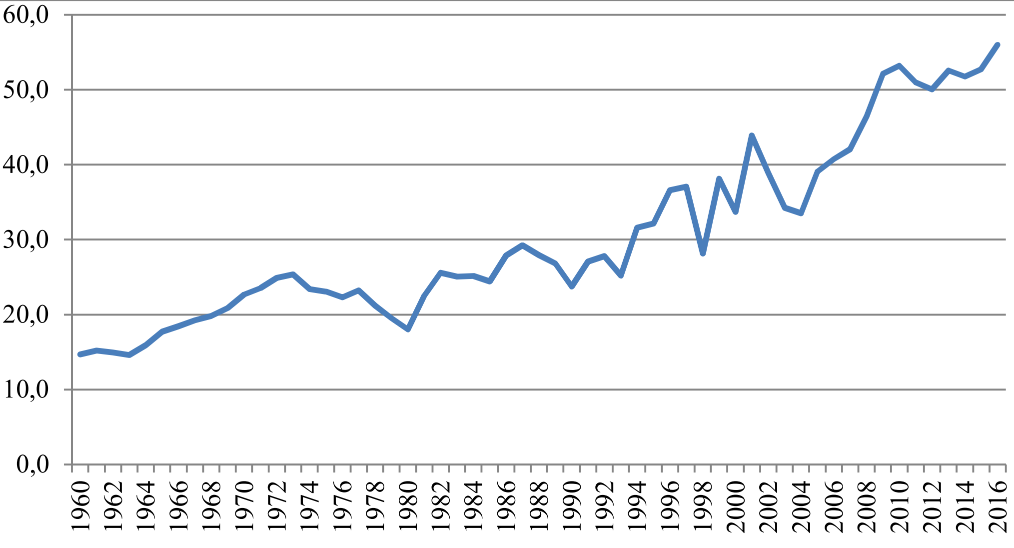


Figure 4.3. *Industry, value added (% of GDP)*

In Figure 4.3. the GDP percentage of industry is shown for the years 1960 to 2016. Industry sector is considered the main determinant of growth. The industry sector in Turkey between the years 1960 and 2016 flowed a fluctuated course. The GDP share of the industry sector increased between the years 1980 to 2000 while after the 2002 it decreased due to developments in the services sector.

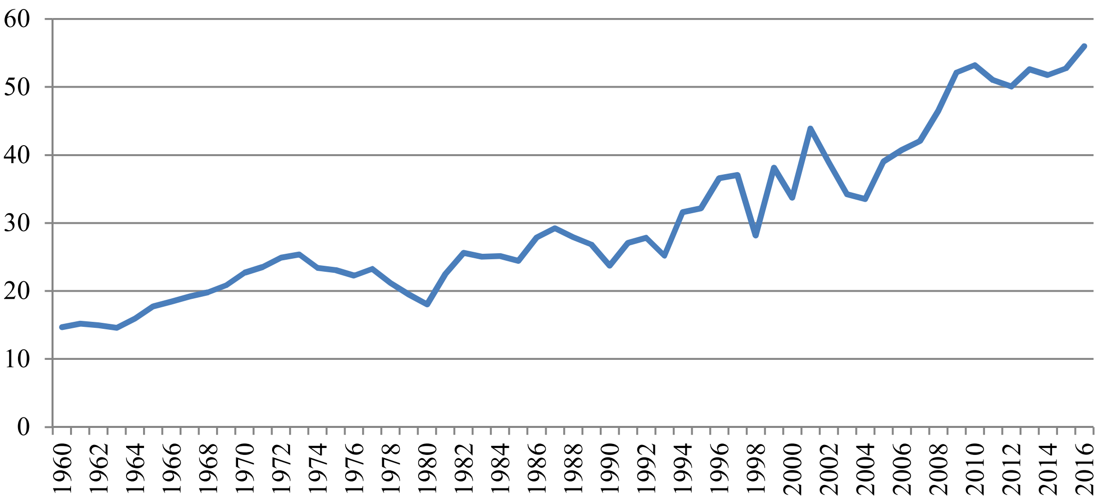


Figure 4.4. *Broad money (% of GDP)*

In Figure 4.4. the broad money percentage of GDP is shown for the years 1960 to 2016. There is seen to be an increasing trend over the years in the percentage of GDP of the broad money. Broad money is used in our study to represent the financial development. The increase in the broad money is an indication of financial development. Financial development and electricity consumption is expected to be positively related.

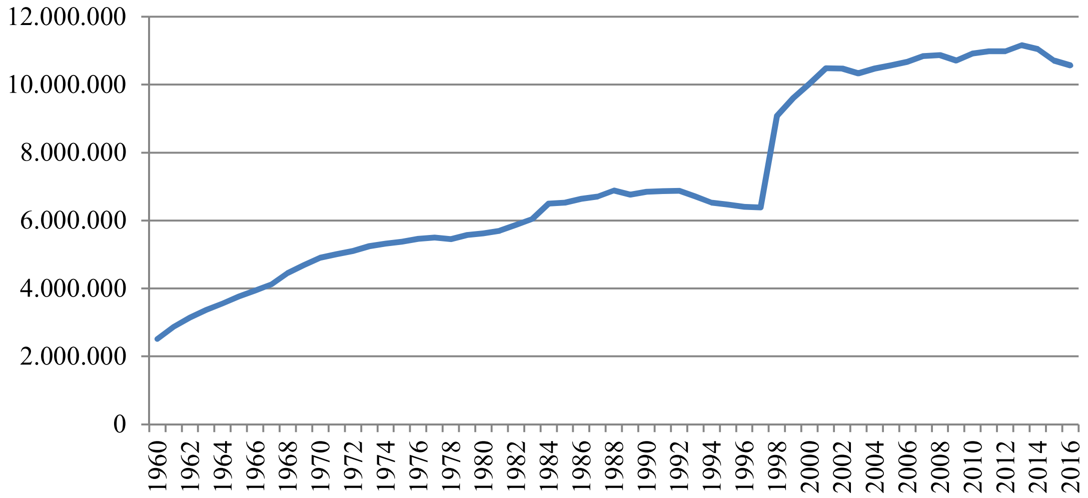


Figure 4.5. *School enrollment, tertiary*

In Figure 4.5. the number of school enrolment is shown for the years 1960 to 2016. The graph shows a gradual increase until around 1997 which there is a sharp climb. After 1999 the graph shows a steady pace.

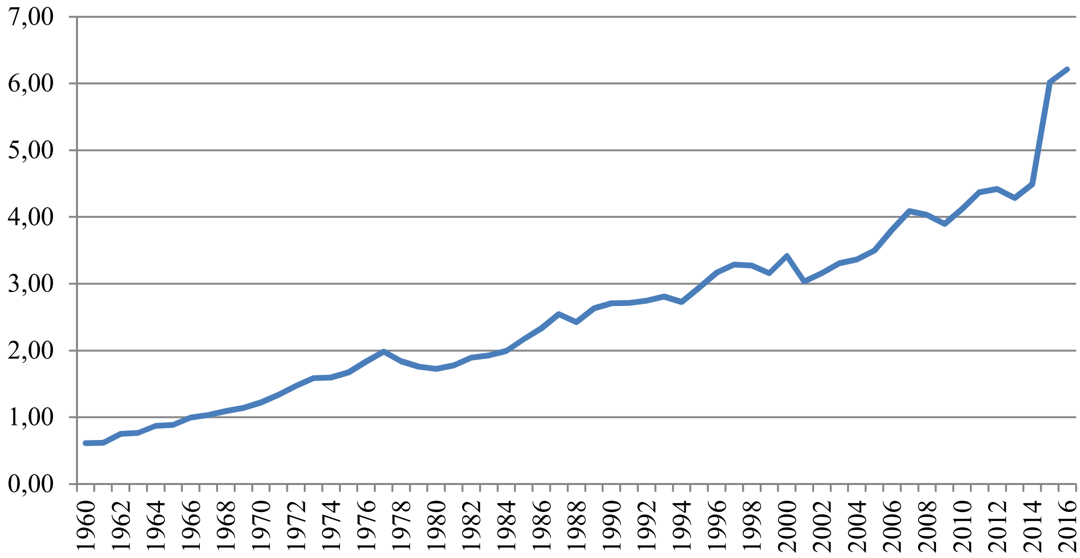


Figure 4.6. *CO2 emissions (metric tons per capita)*

In Figure 4.6. the carbon dioxide emission in metric tons per capita is shown for the years 1960 to 2016. Until 2013 the graph steadily increases, in 2013 there is a sudden increase to 6.00 metric tons from more than 4.00 metric tons.

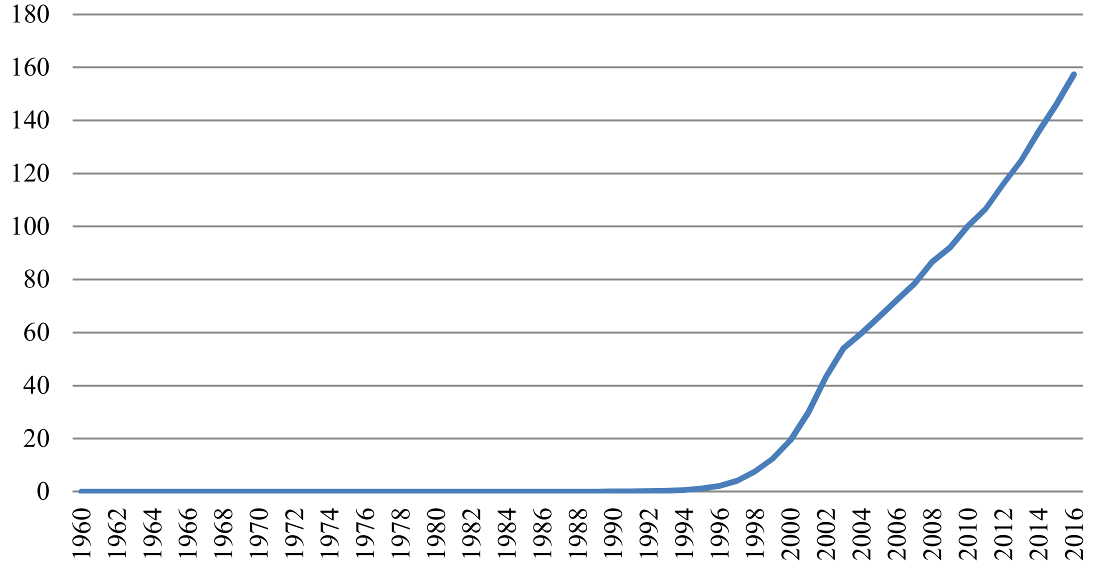


Figure 4.7. *Consumer price index (2010 = 100)*

In Figure 4.7. the consumer price index, taking 2010 as base year is shown for the years 1960 to 2016. The price index has shot up after 2000 and continued to rise sharply. Turkey has experienced high inflation particularly in the 1970's, 1980's and 1990's. Very high inflation rates reduce the ability to represent prices.

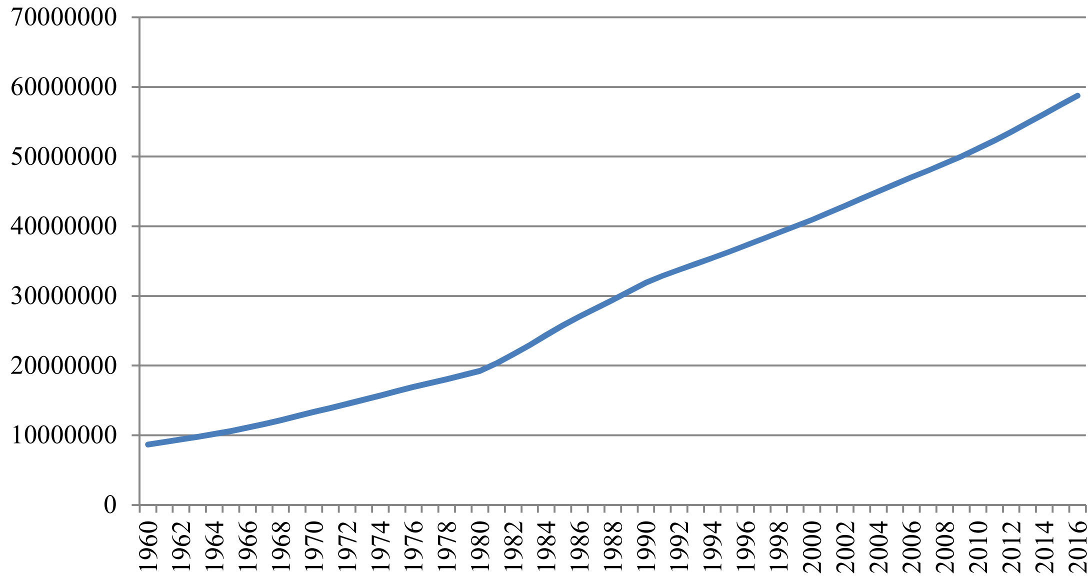


Figure 4.8. *Urban population*

In Figure 4.8. the urban population is shown for the years 1960 to 2016. The urban population has shown a steady increase though the years. Since the 1960's

Turkey's urbanization has rapidly continued. Today, the urban population is about to reach its saturation point.

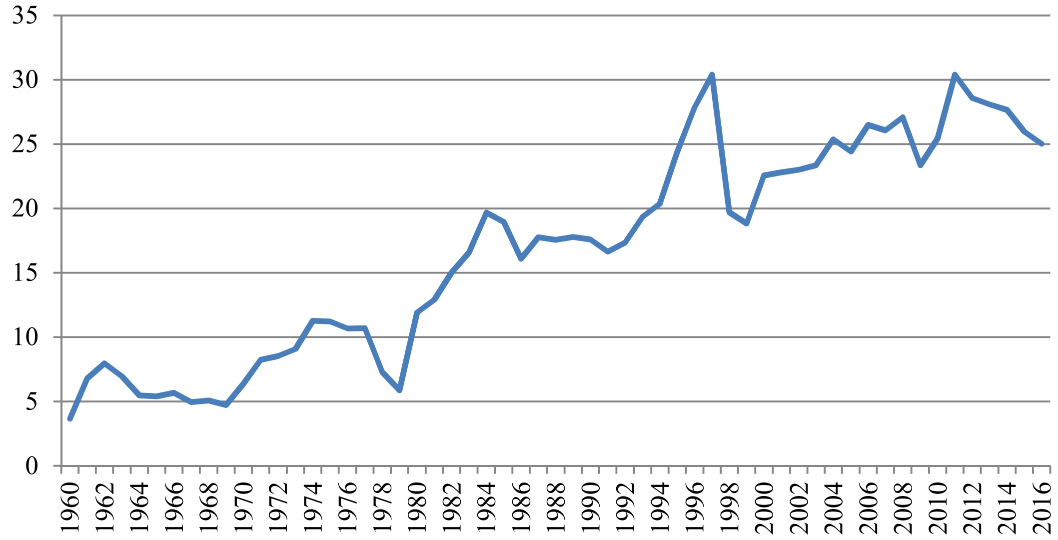


Figure 4.9. *Imports of goods and services (% of GDP)*

In Figure 4.9. the import of goods and services is shown as the percentage of the GDP for the years 1960 to 2016. A fundamental change is seen in the import and export charts after 1980. The policy change in 1980 manifested as a steady increase in the share of imports and exports.

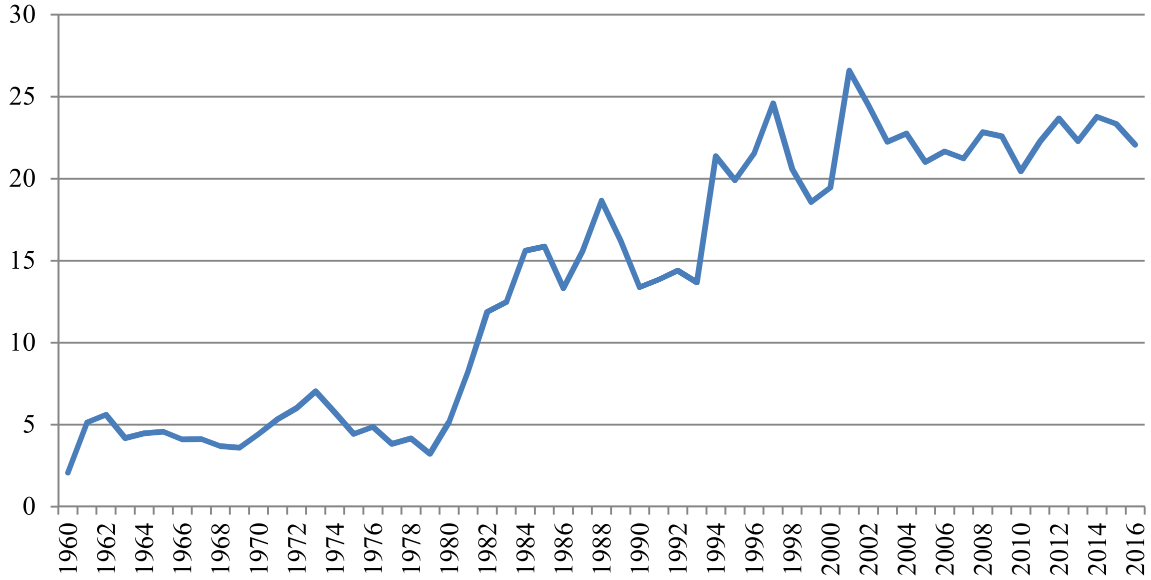


Figure 4.10. *Exports of goods and services (% of GDP)*

In Figure 4.10. the exports of goods and services is shown as the percentage of the GDP for the years 1960 to 2016. There is a sharp increase in the year 1979 due to the fact that in the year 1980 Turkey had adopted an export oriented industrialization.

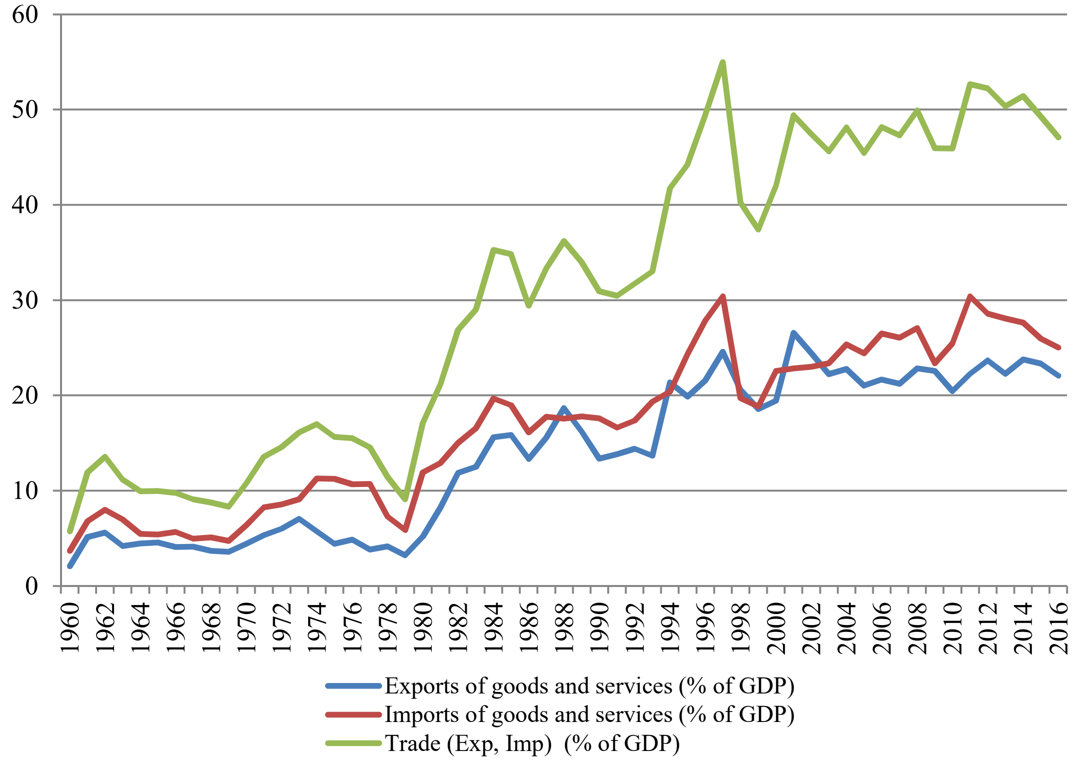


Figure 4.11. *Trade (Exp, Imp) % of GDP*

In Figure 4.11. the import of goods and services is shown as the percentage of the GDP and the exports of goods and services is shown as the percentage of the GDP for the years 1960 to 2016.

4.2. Empirical Results

Findings related to determinants of electricity consumption in Turkey are presented and discussed in this part of the study. First, unit root tests are summarized, followed by cointegration analysis and their results. Using FMOLS and CCR Regressions long-term estimates of electricity consumption in Turkey were studied using three different models.

4.2.1. Unit root tests

The Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests were used to test for unit root, the results of these tests are reported in Table 4.1. and Table 4.2. The results show nearly all variables are non-stationary at level, the variables that are stationary are the level of electric consumption (LELEC) and level of education (LEDU). At first difference all variables except price (P) and urbanisation (URB) become stationary. The results of the test confirm in at least one test that all the variables at level with the exception of stationary variables are non-stationary. On the other hand, at the first difference the variables for income per capita, level of industrialisation, financial development, carbon emission, and trade openness become stationary. The stationarity of the variables will ensure the results of the estimations to not generate any spurious results.

Table 4.1. *Unit root test results with Intercept*

Variable	ADF	PP
At levels		
LELEC	-3.318835**	-4.000894***
LYPC	0.209104	0.217802
LIND	-1.999491	-2.028639
LFIND	-0.973571	-0.537351
LEDU	-2.991593**	-2.695806*
LCE	-1.549879	-1.609269
P	1.213575	5.151415
LURB	-2.374948	-3.622671***
LIMP	-2.164545	-2.166285
LEXP	-2.119848	-2.117794
LTRAD	-2.172836	-2.160333
At first difference		
LELEC	-	-
LYPC	7.351278***	-7.351284***
LIND	-7.874661***	-7.874661***
LFIND	-9.640680***	-13.64520***
LEDU	-	-
LCE	-7.368409***	-7.369646***
P	-0.397223	-0.343807
LURB	-1.766822	-
LIMP	-7.397519***	-7.764544***
LEXP	-8.129061***	-8.112536***
LTRAD	-7.363324***	-7.445702***
At second difference		
P	-7.163303***	-7.174490***
LURB	-4.861007***	-

*, ** and *** denote 1%, 5% and 10% level of significance, respectively.

Table 4.2. *Unit root test results with Trend and Intercept*

Variable	ADF	PP
At levels		
LELEC	-3.318835**	-1.695347
LYPC	-2.219869	-2.425131
LIND	-1.879838	-1.879838
LFIND	-3.669605**	-3.605805**
LEDU	-2.896788	-3.042861
LCE	-3.422205*	-2.808503
P	0.486093	2.077223
LURB	-0.728860	0.000113
LIMP	-3.155728	-3.155728
LEXP	-2.667269	-3.014458
LTRAD	-2.808368	-3.090174
At first difference		
LELEC	-	-6.653926***
LYPC	-7.286215***	-7.286279***
LIND	-8.017305***	-8.126052***
LFIND	-	-
LEDU	-6.175837***	-6.168636***
LCE	-	-7.458747***
P	-2.041722	-2.124596
LURB	-2.909600	-2.350019
LIMP	-7.301739***	-7.639540***
LEXP	-7.985998***	-7.970328***
LTRAD	-7.229044***	-7.299898***
At second difference		
P	-7.229512***	-7.423121***
LURB	-4.821372***	-4.871392***

*, ** and *** denote 1%, 5% and 10% level of significance, respectively.

4.2.2. Cointegration test results

Cointegration tests employed the data. The results for the Engle-Granger and the Phillips-Ouliaris are reported in Table 4.3. and Table 4.4. The alternate trade openness measurements, export, import and sum of export and import, are each tested separately for cointegration tests therefore three separate test results are reported. In at least one test, cointegration is confirmed as well, which would mean that a cointegration exist between electricity consumption, financial development, education, export/import/sum of export and import, urbanisation, industrialisation, income price and carbon emission. Cointegration between variables implies that a long-run relationship exists between electricity consumption and the selected variables in Turkey. For the Turkish economy the long-run electricity consumption determinants can be expressed as the financial development, education, export/import/sum of export and import, urbanisation, industrialisation, income price and carbon emission of Turkey.

Table 4.3. *Engle-Granger Cointegration test results*

Variables	Tau-statistic		z-statistic	
	Value	Probability	Value	Probability
LELEC, LYPC, LIND, LFIND, LEDU, LCE, P, LURB, LIMP,	-5.746587*	0.0747	-42.10785*	0.0606
LELEC, LYPC, LIND, LFIND, LEDU, LCE, P, LURB, LEXP	-5.545844	0.1065	-40.23892*	0.0895
LELEC, LYPC, LIND, LFIND, LEDU, LCE, P, LURB, LTRAD	-5.684107*	0.0836	-41.51673*	0.0688

*, ** and *** denote 1%, 5% and 10% level of significance, respectively.

Table 4.4. *Phillips-Ouliaris Cointegration test results*

Variables	Tau-statistic		z-statistic	
	Value	Probability	Value	Probability
LELEC, LYPC, LIND, LFIND, LEDU, LCE, P, LURB, LIMP,	-5.930529*	0.0529	-46.50571**	0.0214
LELEC, LYPC, LIND, LFIND, LEDU, LCE, P, LURB, LEXP	-5.725681*	0.0776	-44.19995**	0.0378
LELEC, LYPC, LIND, LFIND, LEDU, LCE, P, LURB, LTRAD	-5.870987*	0.0593	-45.90643**	0.0249

*, ** and *** denote 1%, 5% and 10% level of significance, respectively.

4.2.3. Long-run determinants of electricity consumption in Turkey 1962-2016

In Table 4.5. the results of financial development, education, export/import/ sum of export and import, urbanisation, industrialisation, income price and carbon emission on electricity consumption in the long-run are presented. The results for both FMOLS and CCR estimations being similar asserts the robustness of the results. When taken together per capita income (LYPC), carbon emission (LCE), price (P) and urbanisation (LURB) are found to have significant effect on electricity consumption in Turkey. The finding of the study establishes that per capita income and carbon emission have positive impact while price and urbanisation have a negative impact on Turkish electricity consumption. On the other hand, level of industrialisation (LIND), financial development (LFIND), level of education (LEDU), and trade openness (LIMP, LEXP, LTRAD) have seen to have no significant effect on electricity consumption in Turkey. The per capita income, carbon emission, and price coefficients are detected to have a significance level of 10 percent while the urbanisation coefficient has seen to have a level of significance at 1 percent.

4.2.3.1. FMOLS regression results and discussions

Along with the interpretations above, income has been found to be a positive influence on electricity consumption in the Turkish economy. The income having a positive effect on electricity consumption has been confirmed in studies such as Adom and Bekoe (2013), Ekpo et al. (2011), Inglesi (2010), Rafindadi and Ozturk (2016) although the income coefficient was inelastic in their studies. Urbanisation is confirmed to employ a negative effect on the consumption of electricity in Turkey at a significance level of 1 percent.

Table 4.5. *FMOLS Regression results: Dependant Variable LELEC*

Variables	**FMOLS**		**FMOLS**		**FMOLS**	
	Coefficient	Standard errors	Coefficient	Standard errors	Coefficient	Standard errors
LYPC	0.2858***	0.0727	0.2969***	0.0769	0.2835***	0.0730
LIND	0.0103	0.0487	0.0188	0.0472	0.0208	0.0472
LFIND	0.0011	0.0238	-0.0032	0.0251	-0.0004	0.0242
LEDU	0.0367	0.0465	0.0514	0.0467	0.0439	0.0462
LCE	0.3625***	0.0432	0.3617***	0.0446	0.3597***	0.0434
P	-0.0028***	0.0007	-0.0027***	0.0008	-0.0027***	0.0007
LURB	-0.4699*	0.2520	-0.5182**	0.2639	-0.4960**	0.2556
LIMP	-0.0084-	0.0147-	-	-	-	-
LEXP	-	-	0.0116	0.0144	-	-
LTRAD	-	-	-	-	0.0009	0.0161
Constant	0.0765***	0.0104	0.0776***	0.0109	0.0771	0.0105
R-squared	0.748167		0.749708		0.746941	

*, ** and *** denote 1%, 5% and 10% level of significance, respectively

4.2.3.2. Canonical cointegrating regression (CCR) regression results and discussions

The results obtained from the FMOLS Regression and the Canonical Cointegrating Regression (CCR) show similarity to each other. This assures the reliability of the estimations made. In both of the estimations a positive relationship between electricity consumption is found with the variables LYPC and LCE and a negative relationship is found with the variables P and LURB. The LIND, LFIND, LEDU, and Trade (EXP, IMP) variables are found to have no significant effect on electricity consumption in Turkey.

The income per capita (LYPC) finding of a positive relation with electricity consumption is consistent with the literature. The usage of electrical devices is expected to increase as the welfare level elevates with the increase of income.

Carbon emission (LCE) and electricity consumption in Turkey having a positive relationship shows that electricity consumers in Turkey have low sensitivity to the environment. The energy usage is reduced when citizens become more concerned about the environment.

Table 4.6. *Canonical Cointegrating Regression (CCR) Regression results: Dependant Variable LELEC*

Variables	**CCR**		**CCR**		**CCR**	
	Coefficient	Standard errors	Coefficient	Standard errors	Coefficient	Standard errors
LYPC	0.3206***	0.1054	0.3368***	0.1093	0.3213***	0.1009
LIND	-0.0130	0.0773	-0.0070	0.0734	-0.0029	0.0723
LFIND	0.0058	0.0398	0.0009	0.0449	0.0028	0.0413
LEDU	0.0382	0.0575	0.0523	0.0581	0.0446	0.0576
LCE	0.3360***	0.0600	0.3348***	0.0627	0.3327	0.0608
P	-0.0027***	0.0008	-0.0026***	0.0008	-0.003***	0.0008
LURB	-0.4179	0.2580	-0.4755*	0.2731	-0.4470*	0.2644
LIMP	-0.0070	0.0234	-	-	-	-
LEXP	-	-	0.0139	0.0276	-	-
LTRAD	-	-	-	-	0.0028	0.0263
Constant	0.0753***	0.0105	0.0768***	0.0109	0.0761***	0.0106
R-squared	0.742573		0.743841		0.740992	

*, ** and *** denote 1%, 5% and 10% level of significance, respectively

The relationshis between electricity prices and electricity consumption are expected to have a negative due to energy being taken as a normal good. Therefore, consumers will be forced to reduce their level of electricity consumption faced with higher prices.

The negative relation between urbanisation and electricity consumption tells us that electricity consumption in cities decreases as urbanization increases. While the urban population may be consuming more electricity, it is indicated that energy-saving electrical devices may be often used.

Industrialization (LIND) and electricity consumption have been found to have no statistically significant relationship. In the literature however both there are results that found positive relationships as well as those that found negative relationships. Industrialisation has been established to have a negative effect on the total energy consumption according to the study made by Keho (2016). The relationship between industrialization and electricity consumption being insignificant can be considered a sign that the industry in Turkey is connected to other energy sources than electricity.

The financial development variable (LFIND) was measured by the change in the money supply. No significant relationship between financial development and electricity consumption has been found. The literature shows different results, a positive relationship between electricity consumption and financial development is expected. Since financial development affects economic growth the effect of financial development on energy consumption is not direct. Economic growth has a positive effect on electricity consumption. If the economy prioritizes energy savings this effect may not be seen and in Turkey, this effect is not seen between 1960 and 2016.

The level of education (LEDU) seems to have an ineffective impact on electricity consumption in the estimation that was made.

Trade (EXP, IMP) for any of trade openness proxies have concluded to have no significant relationship between electricity consumption in Turkey.

4.2.4. Decomposition analysis

Further, the relative importance of each the significant explanatory variables of electricity consumption in Turkey are explored through a decomposition analysis. The

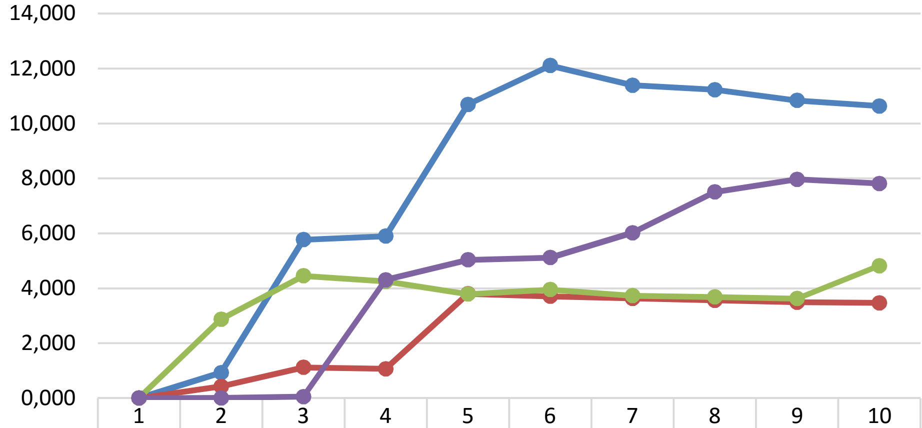
Cholesky decomposition was used in order to assess the percentage of everyone standard deviation shock in electricity consumption ascribed to income, carbon emission price and urbanisation. The results of the Cholesky decomposition was given in Table 4.7. that, for everyone standard deviation shock, the contribution of all factors increases with time.

The contribution of price increases from about 2,87 per cent in the second period to about 4,24 per cent in the fourth period and finally to 4,81 per cent in the tenth period. Income also increases from 5,70 per cent in the third period to 12,10 per cent in the sixth period and 10,63 per cent in the tenth period. Furthermore, carbon emission rises 1,11 per cent in the third period to 3,46. Urbanisation contribute has increased from about 4,30 per cent in the fourth period to about 7,50 per cent in the eight periods and finally to 7,81 per cent in the tenth period. The clear picture of the decomposition analysis can be seen in Figure 4.12.

The implication of this decomposition analysis is the contribution of income to future electricity consumption in Turkey is the greatest followed by urbanisation, while price and carbon emission that have a moderate effect.

Table 4.7. *Cholesky Decomposition Analysis*

Period	SE	LELEC	LYPC	LCE	P	LURB
1	0.040868	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.042983	95.76218	0.929689	0.424593	2.873749	0.009785
3	0.046610	88.59877	5.770364	1.118465	4.455695	0.056703
4	0.047739	84.48335	5.895257	1.068614	4.247694	4.305084
5	0.052231	76.68158	10.69541	3.798578	3.789906	5.034521
6	0.052859	75.11271	12.10708	3.709855	3.952161	5.118194
7	0.054518	75.23251	11.39052	3.628019	3.730942	6.018007
8	0.055392	74.02509	11.22767	3.558986	3.683827	7.504427
9	0.056401	74.08084	10.83856	3.488445	3.625108	7.967052
10	0.056944	73.26668	10.63321	3.466145	4.817220	7.816742



	1	2	3	4	5	6	7	8	9	10
Income	0,000	0,929	5,770	5,895	10,695	12,107	11,390	11,227	10,838	10,633
Carbon Emis.	0,000	0,424	1,118	1,068	3,798	3,709	3,628	3,558	3,488	3,466
Price	0,000	2,873	4,455	4,247	3,789	3,952	3,730	3,683	3,625	4,817
Urban.	0,000	0,009	0,056	4,305	5,034	5,118	6,018	7,504	7,967	7,816

Figure 4.12. *Decomposition Analysis*

CHAPTER 5

5. CONCLUSIONS

Electricity is a form of energy that comes from the existence of charged particles. The flow of these charged particles in a period of time can be defined as electrical current. The electrical power a source generates is measured by the current times the electrical potential which is amount of this electrical work of a particle. Power plants that generates electrical power use various energy sources, the main sources used to produce electricity are fossil fuels, natural gases and hydro energy. Electricity generated from non-renewables sources such as coal or natural gases can be dangerous for the environment while electricity generated from renewable sources such as solar or hydro energy are less harmful to the environment. Electricity has a wide spread usage as it is the dominant energy source for most manufacturing in industries, households' electrical devices, and transport. The fact that electricity is a source that cannot be stored, the generation and transmission of it must be carefully calculated. This is done by the right modelling of electricity consumption.

The first generation of electricity in Turkey was in 1902 by a water mill producing 2kV of energy. The electricity generated in Turkey in 2016 was 167.3 billion kWh which show how much the electric sector has grown. Turkey's energy sources for generating electricity is mainly natural gas, followed by coal, hydraulic power, wind, geothermal energy.

The electricity consumption determinants of Turkey were analysed for the past 50 years (1960 to 2016) to assist the policies of electricity consumption management in Turkey. The results showed income, price, carbon emission and urbanisation had a significant impact on determining the electricity consumption. Fully Modified OLS (FMOLS) and Canonical Cointegrating Regression (CCR) techniques are used to estimate the determinants.

We found that price due to electricity being a normal good has a negative relationship which is an expected result. Another expected result is income having a positive and significant relationship with electricity consumption, again being considered a normal good the increase in income is expected to increase the amount of consumed electricity. In most studies done for both Turkey and for many other countries energy and consequently electricity has been taken as a normal good and has shown results indicating electricity consumption increases from increased wealth and decreases from raising price level.

Urbanisation has a negative relationship which was not an expected result due to the fact most of the reviewed literature showed a positive relationship between electricity consumption and urbanisation. Similarly, carbon emission having a significant impact on electricity is also a finding which is interesting and was not seen in most of the literature done. The negative relationship of urbanization with electricity implies energy saving devices are preferred. Whereas carbon emission is having a positive relationship is concerning due to the increasing electricity consumption's impact on the environment. The positive relationship indicates consumers are less concerned of the environment.

The recommended policies include policy makers to consider electricity pricing and the wealth or the income of the consumers as an important factor on the topic of electricity consumption. Also policies should be encouraging electrical devices and power plants that are environmentally friendly as well as energy efficient to be used in order to provide the increasing carbon emission due to increasing energy consumption.

This thesis is noteworthy because it is a comprehensive analysis of determinants of Turkish electricity consumption. This thesis also uses relatively long and recent data with advances econometric technics.

A suggestion can be made for future work on analysis of determinants of electricity consumption. More single country analysis needs for clear picture of the issue

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Appendix

Appendix 1a. The data used for estimation					
Years	Electric power consumption (kWh per capita)	Broad Money (% of GDP)	School enrolment, tertiary	GDP per capita (constant LCU)	Industry, value added (% of GDP)
1960	92,31	14,70	2.514.592	4.459	17,66
1961	96,92	15,21	2.866.501	4.402	17,61
1962	112,06	14,94	3.147.146	4.537	17,41
1963	120,58	14,59	3.370.679	4.831	17,29
1964	132,06	15,93	3.562.140	4.975	18,29
1965	143,84	17,72	3.769.282	4.995	19,89
1966	156,63	18,44	3.933.251	5.425	20,21
1967	170,27	19,23	4.126.930	5.548	21,07
1968	184,60	19,83	4.450.353	5.786	22,11
1969	205,55	20,86	4.686.572	5.881	22,68
1970	222,39	22,67	4.906.995	5.928	22,54
1971	246,30	23,54	5.013.408	6.110	23,40
1972	276,41	24,89	5.101.196	6.408	24,48
1973	297,34	25,38	5.244.131	6.461	24,45
1974	312,46	23,42	5.324.034	6.663	23,23
1975	358,58	23,06	5.377.708	6.976	23,28
1976	420,58	22,28	5.463.684	7.531	24,70
1977	461,68	23,24	5.499.456	7.613	24,10
1978	479,52	21,18	5.454.566	7.556	23,53
1979	488,53	19,51	5.570.935	7.343	26,26
1980	495,54	18,03	5.618.697	7.003	23,82
1981	519,20	22,49	5.694.860	7.178	27,09
1982	543,35	25,60	5.864.161	7.266	28,19
1983	555,41	25,05	6.042.486	7.457	27,20
1984	613,67	25,13	6.500.539	7.786	26,21
1985	659,75	24,45	6.527.036	7.948	27,13
1986	698,70	27,90	6.635.821	8.336	31,93
1987	771,16	29,24	6.703.895	8.953	32,55
1988	809,18	27,91	6.880.304	8.993	33,94
1989	874,75	26,82	6.766.829	8.860	34,00

Appendix 1b. The data used for estimation					
Years	Electric power consumption (kWh per capita)	Broad money (% of GDP)	School enrolment, tertiary	GDP per capita (constant LCU)	Industry, value added (% of GDP)
1990	929,70	23,74	6.848.083	9.514	32,16
1991	965,31	27,09	6.861.722	9.422	32,69
1992	1.044,36	27,81	6.878.923	9.735	32,38
1993	1.115,20	25,20	6.707.725	10.312	31,10
1994	1.145,50	31,60	6.526.296	9.676	33,25
1995	1.227,33	32,16	6.466.648	10.273	33,24
1996	1.328,35	36,59	6.403.300	10.857	31,60
1997	1.439,98	37,08	6.389.060	11.496	31,85
1998	1.520,10	28,15	9.084.635	11.578	33,80
1999	1.556,34	38,15	9.609.050	11.014	31,15
2000	1.652,75	33,69	10.028.979	11.568	30,05
2001	1.613,02	43,91	10.480.721	10.717	28,70
2002	1.667,42	38,96	10.477.616	11.240	27,88
2003	1.771,92	34,23	10.331.645	11.701	28,34
2004	1.891,93	33,54	10.479.538	12.653	28,76
2005	2.013,89	39,06	10.565.389	13.611	28,97
2006	2.178,86	40,73	10.673.935	14.396	29,85
2007	2.347,12	42,07	10.846.930	14.939	29,85
2008	2.421,98	46,48	10.870.570	14.885	29,47
2009	2.314,11	52,13	10.709.920	14.006	26,97
2010	2.491,63	53,23	10.916.643	14.987	27,98
2011	2.696,31	51,01	10.981.100	16.408	30,62
2012	2.772,06	50,04	10.979.301	16.926	30,34
2013	2.760,65	52,59	11.160.896	18.068	31,62
2014	2.854,57	51,76	11.053.315	18.695	31,88
2015	3.355,00	52,74	10.712.257	19.513	31,67
2016	3.443,00	55,99	10.572.209	19.761	32,36

Appendix 1c. The data used for estimation						
Years	Trade (Exp, Imp) (% of GDP)	Imports of goods and services (% of GDP)	Exports of goods and services (% of GDP)	Consumer price index (2010 = 100)	CO2 emissions (metric tons per capita)	Urban population
1960	5,73	3,67	2,06	0,000071	0,61	8.657.905
1961	11,91	6,79	5,12	0,000071	0,62	9.025.020
1962	13,57	7,97	5,60	0,000073	0,75	9.398.918
1963	11,16	6,97	4,18	0,000076	0,77	9.785.801
1964	9,94	5,47	4,47	0,000077	0,87	10.186.257
1965	9,95	5,40	4,56	0,000081	0,88	10.601.117
1966	9,76	5,66	4,09	0,000085	0,99	11.084.941
1967	9,08	4,96	4,11	0,000091	1,03	11.613.794
1968	8,76	5,08	3,68	0,000091	1,09	12.164.205
1969	8,33	4,74	3,60	0,000098	1,14	12.737.046
1970	10,79	6,36	4,43	0,000105	1,22	13.334.592
1971	13,57	8,25	5,32	0,000122	1,34	13.911.375
1972	14,56	8,54	6,02	0,000136	1,47	14.488.541
1973	16,13	9,09	7,03	0,000157	1,59	15.085.598
1974	17,00	11,27	5,73	0,000181	1,59	15.701.103
1975	15,65	11,23	4,42	0,000216	1,67	16.333.821
1976	15,52	10,67	4,86	0,000254	1,83	16.914.559
1977	14,52	10,71	3,82	0,000323	1,98	17.474.294
1978	11,44	7,29	4,15	0,000469	1,84	18.048.164
1979	9,10	5,88	3,22	0,000744	1,76	18.640.045
1980	17,09	11,93	5,16	0,001564	1,72	19.252.658
1981	21,14	12,90	8,24	0,002135	1,78	20.329.788
1982	26,88	15,02	11,86	0,002794	1,89	21.630.537
1983	29,03	16,56	12,47	0,003671	1,92	22.977.479
1984	35,28	19,67	15,61	0,005448	1,99	24.362.096
1985	34,83	18,97	15,86	0,007897	2,17	25.769.739
1986	29,41	16,10	13,31	0,010631	2,33	27.034.294
1987	33,34	17,76	15,58	0,014760	2,54	28.238.856
1988	36,21	17,55	18,65	0,025633	2,43	29.455.629
1989	33,98	17,78	16,20	0,041852	2,63	30.682.086

Appendix 1d. The data used for estimation						
Years	Trade (Exp, Imp) (% of GDP)	Imports of goods and services (% of GDP)	Exports of goods and services (% of GDP)	Consumer price index (2010 = 100)	CO2 emissions (metric tons per capita)	Urban population
1990	30,94	17,58	13,37	0,067095	2,71	31.923.263
1991	30,48	16,63	13,84	0,111356	2,71	32.891.157
1992	31,74	17,35	14,39	0,189387	2,75	33.738.104
1993	33,02	19,34	13,67	0,314566	2,81	34.589.934
1994	41,75	20,38	21,36	0,648833	2,72	35.453.749
1995	44,24	24,35	19,89	1,220505	2,94	36.333.494
1996	49,37	27,83	21,54	2,201143	3,17	37.230.423
1997	54,97	30,39	24,58	4,088255	3,29	38.142.741
1998	40,27	19,71	20,57	7,548608	3,27	39.068.789
1999	37,40	18,82	18,58	12,445200	3,16	40.002.789
2000	42,00	22,55	19,45	19,279529	3,42	40.942.287
2001	49,40	22,82	26,58	29,767628	3,03	41.937.574
2002	47,46	23,00	24,46	43,152381	3,16	42.963.798
2003	45,60	23,36	22,24	54,068366	3,31	43.992.658
2004	48,12	25,37	22,75	59,791089	3,36	45.015.877
2005	45,44	24,42	21,02	65,852952	3,50	46.026.966
2006	48,15	26,50	21,65	72,173019	3,80	47.021.792
2007	47,29	26,07	21,22	78,492620	4,09	48.004.725
2008	49,91	27,08	22,83	86,690490	4,03	48.999.495
2009	45,93	23,36	22,57	92,109492	3,89	50.038.018
2010	45,90	25,45	20,45	100,000000	4,12	51.145.977
2011	52,66	30,40	22,26	106,471880	4,37	52.327.728
2012	52,25	28,58	23,67	115,938901	4,42	53.566.518
2013	50,35	28,08	22,27	124,626308	4,29	54.847.293
2014	51,41	27,65	23,76	135,661435	4,49	56.148.395
2015	49,29	25,96	23,33	146,067825	6,02	57.448.912
2016	47,08	25,02	22,06	157,424794	6,21	58.749.346