

ENERGY VULNERABILITY AND INTERNATIONAL TRADE
ASSESSING TURKEY'S ENERGY VULNERABILITY
WITH A COMPARATIVE OUTLOOK OF THE EU

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Thesis Abstract

M. Şükrü Nenem, “Energy Vulnerability and International Trade

Assessing Turkey’s Energy Vulnerability with a Comparative Outlook of the EU”

Energy trade has always been one of the major aspects of international trade for many countries. In order to ensure the continuity of their services, energy dependent countries are obliged to source their energy demand through imports. However, factors like increasing energy consumption, higher degrees of dependence to certain type of fuels, concentrated nature of the energy suppliers, excess reliance on expensive means of power generation, fluctuating energy prices, import bill and the carbon content of the primary energy supply designate the degree of a country’s vulnerability to energy as well as its preparedness to adverse energy related events.

After offering a general outlook to global energy market, this study defines the indicators that contribute to energy vulnerability of a country and computes Turkey’s performance on each parameter. The comparison of Turkey’s standings with the performance of the EU indicates that Turkey performs relatively worse than the EU deeming the country more vulnerable to an energy crisis.

However, the study suggests that Turkey has plentiful opportunities to reduce its energy vulnerability in case its energy politics are governed properly. In addition to its comparative advantage in renewable energy, in case correct and accurate energy investment decisions are made, Turkey’s energy vulnerability is ready to decline. The study comes with policy recommendations to shift energy vulnerability downward both at the governmental level and at the micro level.

Tez Özeti

M. Şükrü Nenem, “Enerji Hassasiyeti ve Uluslararası Ticaret

Türkiye’nin Enerji Hassasiyetinin Ölçümü ve AB Verileri ile Karşılaştırılması”

Enerji ithalat ve ihracatı, birçok ülkenin uluslararası ticaret yapısını şekillendiren önemli bir unsur olmuştur. Enerjiye bağımlı olan ülkeler, ulusal ölçekte hizmetlerin kesintisiz olarak devam etmesi için, enerjiye olan ihtiyaçlarını ithalat ile karşılamak durumunda kalmaktadır. Ancak, artan enerji talebi, belirli enerji kaynaklarına yüksek oranda bağımlılık, ithalatta belirli ülkelere karşı olan bağımlılık, üretimde pahalı enerji hammadelerinin kullanımı, dalgalanan enerji fiyatları ve yüksek ithalat faturası ile enerji tüketiminden kaynaklanan karbon salınımı gibi faktörler, devletlerin kümüle enerji sistemlerine olan dayanıklılığını belirleyen parametreleri oluşturmaktadır.

Bu çalışma, enerji piyasalarına genel bir bakış sunduktan sonra, Türkiye’nin enerji sistemlerinin dayanıklılığının performansı tanımlanan parametreler bazında değerlendirilmektedir. Türkiye’nin özellikle nicel parametrelerdeki durumu, Avrupa Birliği’ne üye devletlerin ortalama verileri ile karşılaştırıldığında, Türkiye’nin enerji sistemlerinin hassasiyet seviyesinin daha yüksek olduğu gözlemlenecektir.

Ancak bu çalışma, enerji politikalarının uygun şekilde yönlendirildiği takdirde, Türkiye’nin enerji’ye olan dayanıklılığını arttırabileceğini ortaya koymaktadır. Yenilenebilir enerjideki rekabetçi avantajına ek olarak, Türkiye, doğru ve tutarlı enerji yatırımlarını hayata geçirmesi ile birlikte enerji sistemlerini güçlendirebileceği ve öngörülemeyen gelişmelere karşın daha sağlıklı bir duruş sergileyebileceği ortaya konulmaktadır. Çalışma sözkonusu amaca ilişkin devlet politikası bağlamında yönetsel tavsiyeler sunmakla birlikte, birey bazında alınabilecek aksiyonları öne çıkarmaktadır.

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To the people I am happy with and to the people I will be happy with ...

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CHAPTER I

INTRODUCTION

The use of energy has been a motor of development for the human society. According to Chontanawat, Hunt and Pierse (2006), energy is a product that maximizes consumer's utility. Through energy consumption, human kind can produce goods and services and thus control and adapt to environment. Within industrialized nations, consumption of energy resources is crucial to fulfill basic services including agriculture, transportation, waste collection, information technology and communications. As an outcome of industrialization process and enhancing technology, a big portion of manpower has gradually shifted to machinery which requires energy to operate and this process deemed energy as a consequential input for production. In order to keep efficiency and to boost economy, nation states should go on with their production facilities and thus should stipulate energy continuously.

Throughout the history, energy related motivations had been highly influential for the implementation of major political decisions and acts. Soon after industrial revolution, access to energy resources has constructed the basic motivation for powerful states' government policies. As a concrete example, the origins of the European Union traces back to energy related collaboration called European Coal and Steel Cooperation which had the modest purpose of centralizing control of the national coal and steel industries of the six member countries. As was the case in history, energy related issues compose an integral phase of countries' foreign politics today either. For instance, energy flow is used as an aversive measure by certain nation states for the goal of exerting sanctions over other states. Moreover, the global growth in demand for goods and services is forecasted to keep the volume of demanded energy to increase further.

As per Kirby's article (2008), International Energy Agency (IEA) announced that the world will need almost 60% more energy in 2030 than it consumed in 2002. As per the estimation, fossil fuels will continue to meet most of the demand by 2030. Considering that energy resources are limited and many nations are dependent on external resources, it is foreseen that energy topic will continue to become prioritized in government's agenda.

Today, only a limited number of countries are able to meet their energy demand through its own domestic resources where most of them are obliged to import through external resources. As of 2007 data, the share of oil in primary energy consumption is 40% in OECD countries. OECD countries can only supply 39% of their total oil demand. On the other hand, natural gas whose dependency rate was 25% formed 24% of the primary energy spending within OECD in 2007 (BP, 2008). These facts illustrate that industrialized countries portray a necessity to import energy in order to keep the continuity of its services and operations.

In addition to the scarcity of domestic energy resources, the concentrated nature of energy reserves in certain geographical regions deems particular countries energy rich while the remaining others are nominated as dependents. This polarization leads enormous degrees of energy trade to occur on a global basis. Since the number of energy exporter countries is quite limited, individual exporter countries and the associations they form can easily alter the structure of global energy market not only in terms of setting the prices but also within the framework of energy trade terms and conditions. In other words, little number of countries has control over the flow of excessive volumes of money within the context of energy trade. On the other hand, energy prices are highly sensitive to speculation, developments in global political and financial environment as well as the domestic issues and interests of the energy exporter

countries. In the summer of 2008, crude oil prices have exceeded 150 dollars per barrel but a few months later the prices have shifted below 50 dollars. These facts illustrate the instable nature of a sector whose trade scheme's scope is massive. The cost of energy imports to Turkey was 48.2 billion USD in 2008. Considering that its export bill was 7.5 billion USD and the total trade deficit was 69.9 billion USD in the mentioned year, energy trade led to a major aspect of Turkey's trade deficit.

Since the interruption of energy does not only avert the continuity of basic services and infrastructures, but may also halt the domestic economic activities of a country, governments have no option other than guaranteeing the continuity of energy supply. Any breaks in the flow of energy would lead to serious costs on national economies (Chen, 1996). From this perspective, measures regarding energy production and consumption side gains additional vitality. On the consumption side, issues regarding the quantity of energy spending are the major focus of concern. Factors like gross energy demand, the fuel type of the consumption mix and energy efficiency are some key areas of interests in the consumption side. On the other hand, from the perspective of production, energy investments and existence of alternative energy resources that could soar total national energy production is the point of focus. Since the gap between the production and consumption is fulfilled through imports, the scope and politics regarding energy imports has a direct impact on macroeconomic balances. For this reason, any threats for the supply of energy either on production or import side have a negative effect on a nation's economy. The unfavorable outcomes of unappreciated energy policies do not only negatively affect economic indicators but also assists in developing concerns relating to national sovereignty. Dependence on external resources for ensuring energy inflow is a point of self sufficiency issue whereas the dependence on particular energy exporter countries is foreign politics concern to be considered. On the other hand, patterns in energy consumption have an influence over

the environment. Excess reliance on carbon rich fuels contaminates the environment and leads pollution.

Such negative upshots that might result from a potential discontinuity of energy supply, inefficient and environmentally unfriendly consumption patterns designates a certain level of economic, politic, social and ecological threats for nation states. For this reason, energy topic, undoubtedly, is a critical topic that straightly relates with countries' future prosperity and political interests. In this context, higher degrees of energy insecurity and vulnerability both in demand and supply side are a focus of concern for governments.

This study will emphasize the strength and importance of energy topic for Turkey by initially focusing on its role within its foreign trade. A general outlook to global energy consumption and production structure will be investigated in the third chapter which would provide a benchmark to compare Turkey's standing. Fourth chapter offers an outlook regarding the energy security and vulnerability in the literature and defines the criteria that deem the vulnerability level of a country towards energy where fifth chapter assess Turkey's performance on those indicators and contrasts its status with the EU. Sixth chapter will implement Grey Analysis Model to evaluate the attractiveness of each type of power plants which is aimed to develop an insight regarding the most efficient investments to reduce energy vulnerability. The last chapter will present the conclusion and policy recommendations that are based on objective calculations in energy vulnerability parameters and their ranking within the European Union.

This study has contribution to the literature in the sense that it is one of the earliest studies that defines solid energy vulnerability criteria for Turkey after scanning the existing vulnerability parameters in the literature and computes Turkey's

performance on those defined indicators. As a consequence of the harmonization process and the commitments for the Kyoto protocol that is freshly agreed by Turkey, its standing in key performance parameters is contrasted with that of the EU in order to develop a comparative insight. Moreover, offering a roadmap with a methodological approach in terms of detecting what type of plant investments would work best for Turkey's energy vulnerability using a decision analysis algorithm is another contribution of this work. The decision tool employed called "Grey Relational Analysis" have been firstly implemented to Turkey's energy industry with this paper.

CHAPTER II

ROLE OF ENERGY TRADE IN TURKEY'S MACROECONOMIC BALANCES

Energy trade has always been one of the major aspects of international trade for many countries. Energy exporters enjoy massive returns they obtain through energy trade since dependent countries are obliged to source their energy needs through external resources. The mismatch in the distribution of energy reserves leads energy trade to occur on a global scale. Countries that lacks primary energy resources and consume significant volumes of energy has no option other than importing it unless their domestic production is large enough to cover total demand. For Oğulata (2002), being an energy dependent country, energy trade has been a major area of concern for ensuring the continuity of economic activities within Turkey. Since the country is not blessed with adequate levels of energy resources and the increasing trend for energy consumption is an undeniable fact, energy trade has been forming potential threats for Turkey's macroeconomic indicators.

For the analysis, data obtained from Turkish Undersecretariat of the Prime Ministry for Foreign Trade (TMFT) will be employed throughout the chapter. Energy trade related data are cross checked and verified with the information of Turkish Statistics Institute and Ministry of Energy.

In 2008, in monetary terms, Turkey's energy imports have boasted and became tenfold of the 1990 value.

Table 1. Turkey's Energy Imports, Energy Exports and Energy Trade Deficit (TMFT, 2009)

Year	in 1000 USD		
	Energy Imports	Energy Exports	Energy Trade Deficit
1989	3,247,338	258,614	-2,988,724
1990	4,622,407	296,347	-4,326,060
1991	3,756,887	290,358	-3,466,529
1992	3,760,095	233,127	-3,526,969
1993	3,964,662	176,507	-3,788,155
1994	3,817,632	243,850	-3,573,783
1995	4,620,801	289,611	-4,331,189
1996	5,777,946	118,467	-5,659,479
1997	5,881,302	72,494	-5,808,808
1998	4,325,202	158,584	-4,166,618
1999	5,004,619	206,250	-4,798,369
2000	9,221,241	292,666	-8,928,575
2001	8,014,661	337,019	-7,677,642
2002	9,126,585	641,436	-8,485,149
2003	11,392,962	765,621	-10,627,342
2004	14,299,533	1,129,399	-13,170,133
2005	21,030,745	2,176,123	-18,854,623
2006	28,610,414	3,358,470	-25,251,944
2007	33,791,135	4,500,741	-29,290,394
2008	48,281,193	7,531,460	-40,749,733

As the Table 1 shows, Turkey's energy imports have increased from 1989 to 2008, except 1994 and 2001 where financial and economic crises have led to reduction in total energy demand and thus shrank imports. On the other hand, the reduction in the energy import bill in 1998 is a direct outcome of the decline in energy prices which is reflected to the value of imports directly.

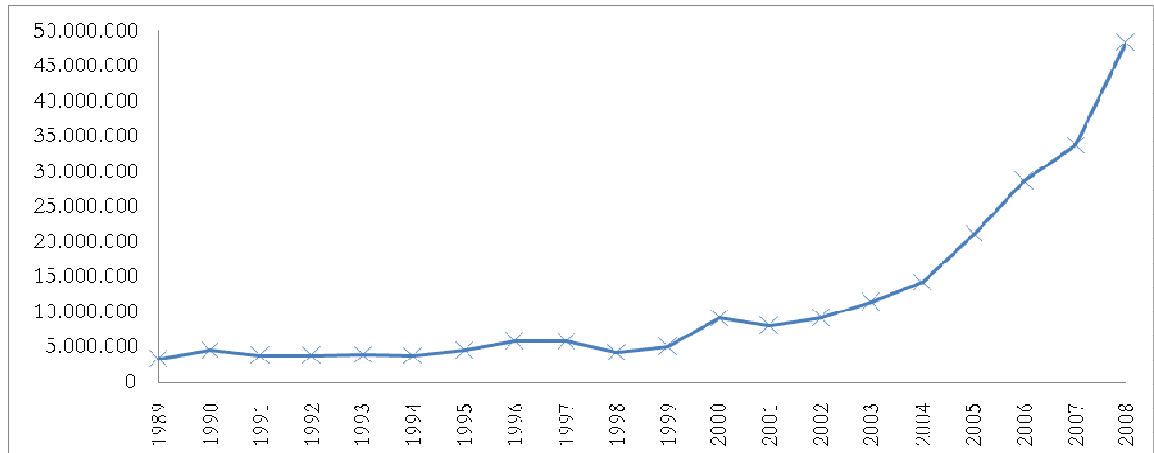


Figure 1. Turkey's total energy imports value in 1000 x USD (TMFT, 2009)

Although the pace of increase in energy imports was low during the 90s, a sharp upward trend process has begun after 2001. As Hamilton's studies in 1996 and 2003 puts forward, oil prices correlates directly and positively with energy bill. The findings of Lee dated 1995 and 2002 confirm the above statements. As of 2008, Turkey's energy bill has reached to the peak value which is an outcome of record high energy prices

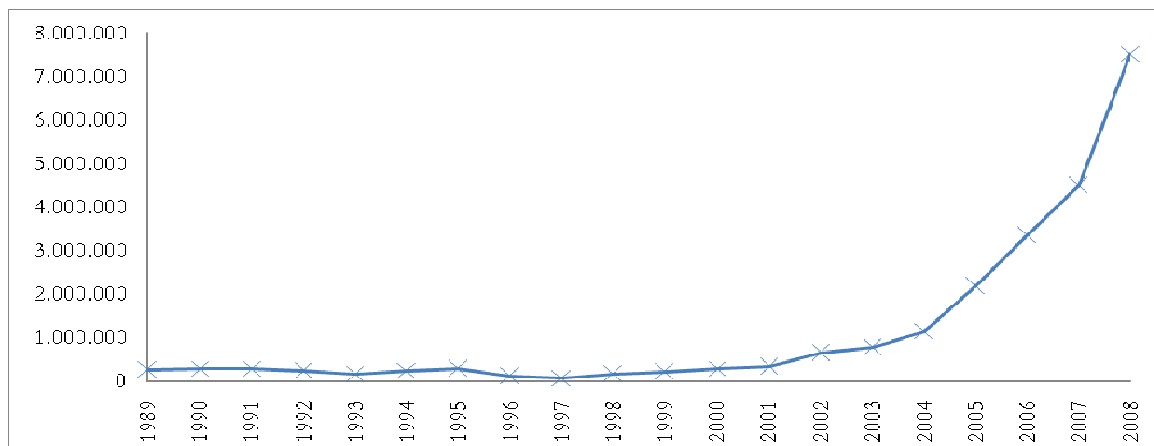


Figure 2. Turkey's total energy exports value in 1000 x USD (TMFT, 2009)

In line with Turkey's increase in energy imports, the value of exports have surged after 2000 too. It should be clarified that exports in USD have fluctuated from 1989 to 1999 due to the variations in energy prices and changes in local demand which forwarded energy either to domestic consumption or exports. However, after 2000, Turkish energy exports have accelerated continuously and reached to its peak value in

2008. Although boom in exports is advantageous to ensure the sustainability of the economy, it should be noted that since a large portion of Turkey's exported energy commodities' raw materials are imported from external resources, it is inferable that energy exports are somewhat dependent on the energy imports (Bruno, 2008). In other words, there exists a tight link between the realizations of energy exports with the continuity of imports.

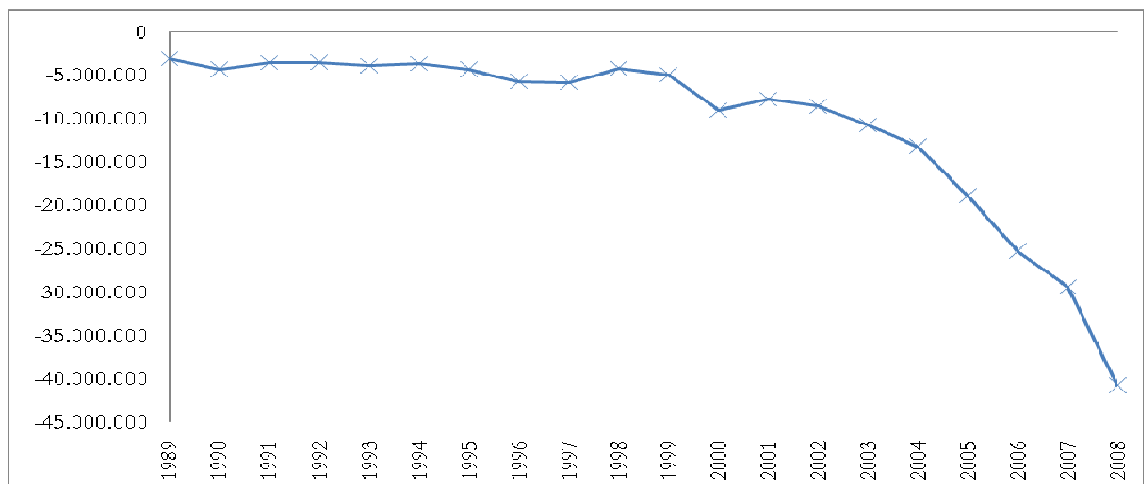


Figure 3. Turkey's energy trade balance in 1000 x USD (TMFT, 2009)

Although the exports have actualized its peak in 2007, since the increase in imports have thrived either, the soaring in exports was not influential enough to avert energy deficit gap to widen and to become the peak low of past two decades. From 1989 to 2008, the energy trade deficit has boomed by 1,263% as depicted in Figure 3.

Even though both energy imports and exports have demonstrated an upward trend in the period of analysis, their pace of increase has not been similar to each other. When compared to the standing of 2000 to 2007, since energy prices have not considerably varied in the 90s, the change in energy trade structure within previous decade was not more striking than that of the current. Since the growth in energy exports was not able to compensate the enormous rise in imports, Turkey's energy trade deficit has continued to deepen and reached to almost 40.1 billion USD in 2008.

Given such huge deficit scheme that is sourced by excessive energy imports, needless to say, energy trade embodies an integral aspect of Turkey's international trade. Although energy export's share has not been far above 4% of the overall exports from 1989 to 2008. The share of energy imports among Turkey's total imports has historically been from 10% to 25%. On average Turkey's energy imports have formed roughly 20% of the total national imports (İzmen, 2009).

Table 2. Turkey's Total Imports, Total Exports, Trade Deficit and Energy's Percentage Share (TMFT, 2009)

Year	1000 x USD			Energy's share in		
	Total Imports	Total Exports	Trade Deficit	Total Imports	Total Exports	Trade Deficit
1989	15,792,143	11,624,692	-4,167,451	20.6%	2.2%	71.7%
1990	22,302,126	12,959,288	-9,342,838	20.7%	2.3%	46.3%
1991	21,047,014	13,593,462	-7,453,552	17.8%	2.1%	46.5%
1992	22,871,055	14,714,629	-8,156,426	16.4%	1.6%	43.2%
1993	29,428,370	15,345,067	-14,083,303	13.5%	1.2%	26.9%
1994	23,270,019	18,105,872	-5,164,147	16.4%	1.3%	69.2%
1995	35,709,011	21,637,041	-14,071,970	12.9%	1.3%	30.8%
1996	43,626,642	23,224,465	-20,402,178	13.2%	0.5%	27.7%
1997	48,558,721	26,261,072	-22,297,649	12.1%	0.3%	26.1%
1998	45,921,392	26,973,952	-18,947,440	9.4%	0.6%	22.0%
1999	40,671,272	26,587,225	-14,084,047	12.3%	0.8%	34.1%
2000	54,502,821	27,774,906	-26,727,914	16.9%	1.1%	33.4%
2001	41,399,083	31,334,216	-10,064,867	19.4%	1.1%	76.3%
2002	51,553,797	36,059,089	-15,494,708	17.7%	1.8%	54.8%
2003	69,339,692	47,252,836	-22,086,856	16.4%	1.6%	48.1%
2004	97,539,766	63,167,153	-34,372,613	14.7%	1.8%	38.3%
2005	116,774,151	73,476,408	-43,297,743	18.0%	3.0%	43.5%
2006	139,576,174	85,534,676	-54,041,498	20.5%	3.9%	46.7%
2007	170,062,715	107,271,750	-62,790,965	19.9%	4.2%	46.6%
2008	201,960,779	132,001,810	-69,958,969	23.9%	5.7%	58.2%

As Table 2 shows and Aysan and Hacıhasanoğlu (2007) points, Turkey's exports have accelerated since 2001 by an annual range of 21.5% while the rate of increase for imports has been 19.5%. This outperformance of growth in Turkish exports was not

adequate enough to reduce the size of national trade deficit. From this perspective, energy trade composes an important portion of Turkey's overall trade deficit whose contribution rarely fell below 30% of the entire trade deficit since 1989. Indeed energy trade's participation to overall trade deficit was 58.2% in 2008. From 1996 to 1998, due to the decrease in energy prices, energy deficits' participation to trade deficit was minimal. However, after the new millennium, combined with the influence of increasing energy prices and national demand, energy imports have formed almost half of Turkey's overall trade deficit. In 1994 and 2001, when Turkey had faced with financial and economic crisis, energy imports' participation to total trade deficit was approximately 70%. Although the imports were reduced during the crisis years and the energy consumption has slightly declined, the fall in demand was not adequate enough to contract energy deficit. Since a certain part of public services is obliged to be provided even during the phase of a crisis, the energy demand could not be radically shifted downward in these years.

In addition to its significant effect on international trade, energy trade is a vital participant of Turkey's current account deficit.

Table 3. Turkey's Energy Trade Deficit And Current Account Deficit (IMFT, 2009)

Year	1.000.000 USD	
	Energy Trade Deficit	Current Account Deficit
1996	-5,659	-2,437
1997	-5,809	-2,638
1998	-4,167	1,985
1999	-4,798	-1,341
2000	-8,929	-9,822
2001	-7,678	3,392
2002	-8,485	-1,524
2003	-10,627	-8,036
2004	-13,170	-15,604
2005	-18,855	-23,155
2006	-25,252	-31,316
2007	-29,290	-37,996
2008	-40,750	-41,416

As depicted in Table 3 above, excluding 2000, from 1996 to 2002, the deficit of energy trade was more than Turkey's current account deficit. Although the process has reversed after 2004, energy trade has continued to be a tremendous actor of Turkey's current account deficit whose contribution has varied from 77 to 80% since 2004. As per 2008 data, energy trade deficit was very close to the country's overall current account deficit.

All these mentioned macroeconomic indicators state that energy trade is an integral aspect of Turkey's international trade. While the share of energy exports within Turkey's overall export pattern is almost negligible, energy imports embody a major share of the country's total imports. This great volume of mismatch in energy imports and exports thus heavily participates in Turkey's foreign trade deficit and current account deficit. In that respect, energy trade is a very vital topic for Turkey's macroeconomic balances. The following chapter will investigate the trends in terms of

reserves, production, consumption of energy in the globe which will develop an insight to comprehend the trends leading energy trades to accelerate.

CHAPTER III

GENERAL ENERGY OUTLOOK

This chapter provides an insight regarding global developments in energy industry from the 80s to 2007 and demonstrates how global developments in the energy industry impacted Turkish energy market. The goal of the chapter is to comprehend the trends in the energy sector on a global scale and then to link them to the Turkish energy market. The first section of the chapter investigates global energy sector where the second section analyzes Turkish energy market within the framework of primary and non – primary energy resources. Major areas of focus are structured on energy reserves, production and consumption with an outlook to energy prices. Within the context of fossil resources, oil and derivatives, natural gas and mineral coal are referred. Thus primary energy resources cover fossil fuels and renewable energy while non – primary energy resources majorly include nuclear energy and electricity power.

Global Energy Outlook

Factors like increasing world population, rapid industrialization of emerging economies, climate change and environmental developments affect global macro balances of the energy sector. Production and consumption of energy is shaped by parameters such as the overall demand, energy prices, depletion level of energy resources and etc. This section will present a global outlook on a regional scale which is divided as the Middle East covering Iran and the entire Arabian Peninsula in addition to its geographical mainland, Europe and Eurasia that involves geographical Europe and ex - Soviet Union countries, Central – South and North America, Africa and Asia Pacific that involves far eastern countries as well as Australia. The section will start by

mentioning total primary energy consumption and will progress with its breakdowns at the fuel type level.

The data of this section is obtained from British Petroleum's Statistical Review of World Energy which is published in June 2008. The accuracy and the validity of the information that are presented in the report have been cross checked with the data of the some official departments including US Department of Energy and Eurostat.

Global Primary Energy Review

Forming a major portion of global energy resources, the consumption of primary energy has accelerated rapidly in the past few decades. The world has consumed 11,099.3 million tons oil equivalent (mtoe) of primary energy in 2007 while total consumption used to be 7,599.1 m toe in 1987 implying that 46% rise in primary energy demand is achieved in the past twenty years. The average annual growth rate has been 2.5% in the last five years where the energy demand grew by 2.2% in the last decade where the figure was 1.9% from 1987 to 2007. Hence it is deduced that the increase in primary energy consumption got accelerated in every year.

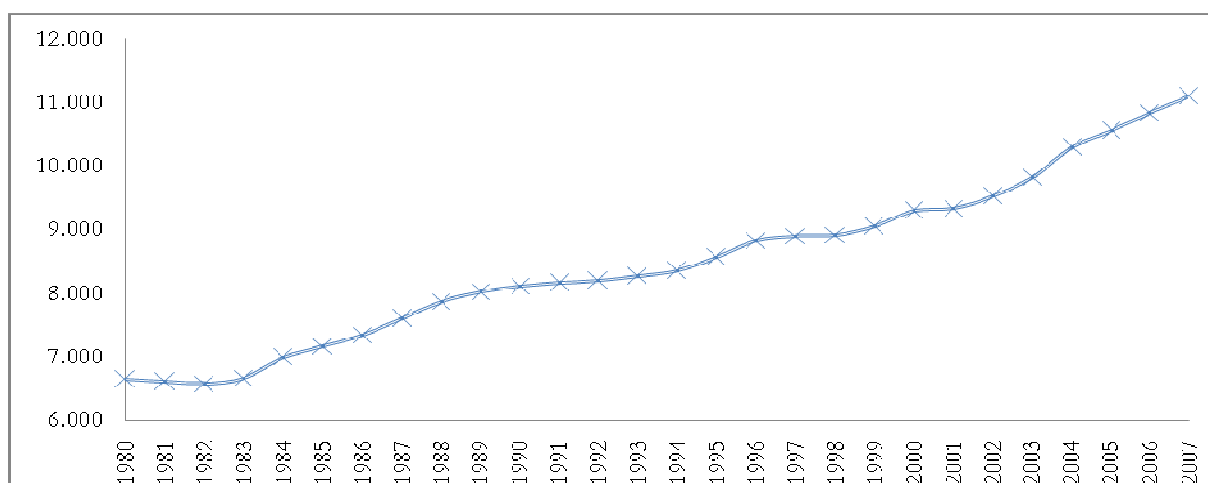


Figure 4. World's primary energy consumption in mtoe as of 2007 (BP, 2008)

According to 2007 data, countries in Asia Pacific consumed the majority of the primary energy. A total of 3,801.9 mtoe of energy is consumed in the region that contributed to 34.3% of the world's energy consumption. China has been the major consumer in Asia Pacific region. It spent 16.8% of the world's total energy in 2007. Japan, India and South Korea followed China in the region with their respective consumption shares of 4.7%, 3.6% and 2.1%.

Table 4. Primary Energy Consumption per Region and Their Shares as of 2007 (BP, 2008)

Regions	Consumption (mtoe)	Consumption Share (%)
Middle East	574.1	5.2%
Europe and Eurasia	2,987.5	26.9%
Africa	344.4	3.1%
South and Central America	552.9	5.0%
North America	2,828.6	25.5%
Asia Pacific	3,801.8	34.3%
TOTAL WORLD	11,089.3	100.0%
European Union	1,744.5	15.7%
OECD	5,566.4	50.2%

Countries in Europe and Eurasia followed Asia Pacific with a total consumption level of 2,987.5 mtoe that formed 26.9% of the globe's overall energy consumption. In the region, Russian Federation has been the leading energy consumer with 692 mtoe embodying 6.2% shares of the global primary energy consumption. European Union member countries consumed 1,744.5 mtoe of primary energy in 2007 and thus contributed to overall consumption by 15.7%. Northern America materialized an almost similar consumption rate to Europe and Eurasia with a total of 2,838.6 mtoe of primary energy of which 2,361.4 of it belongs to United States. United States exhausted 21.3% of the world's energy in 2007. It is the major energy spending country of the world. South and Central America and the Middle East spends both around 5% of the total energy whereas the Africa's share is only 3.1%.

Table 5. Leading Primary Energy Consumers and Shares as of 2007 (BP, 2008)

Consumer Country	Consumption (mtoe)	Percentage Share
United States	2,361.4	21.3%
China	1,863.4	16.8%
Russian Federation	692.0	6.2%
Japan	517.5	4.7%
India	404.4	3.6%
Canada	321.7	2.9%
Germany	311.0	2.8%
France	255.1	2.3%
South Korea	234.0	2.1%
Brazil	216.8	2.0%
United Kingdom	215.9	1.9%
Iran	182.9	1.6%
Turkey	107.6	1.0%
Others	2,954.3	26.6%

The scope of regional distribution of primary energy consumption reveals that industrialized countries spend the majority of energy. Two enormous emerging economies China and Russian Federation follows United States in the consumption of primary energy. These three countries together form almost half of total global energy consumption which is a clear depiction of unequal nature of energy consumption split. The following sections will analyse oil's, natural gas', coal's and renewable energy's historical reserve, production, consumption and price values developments since 1980.

Global Oil Outlook

Oil is a major resource of energy and power and thus it is frequently demanded by nation states to meet their energy needs. Oil is still being extensively used and is deemed as a vital energy resource. Since oil designates a major aspect of energy trade to many nation states, developments concerning its demand, production and price trends have direct consequences on global financial markets. World's total proven oil reserves were adding up to 667.2 million barrels as of 1980. However, with the discovery of new reserves, this number rose substantially until 1990 but the growth has slowed down later. In 2006, 1,239.5 million barrels of oil were calculated to be founded in the world. From

2006 to 2007, the figure has declined by 0.1% in 2007 and became 1,237.9 million barrels.

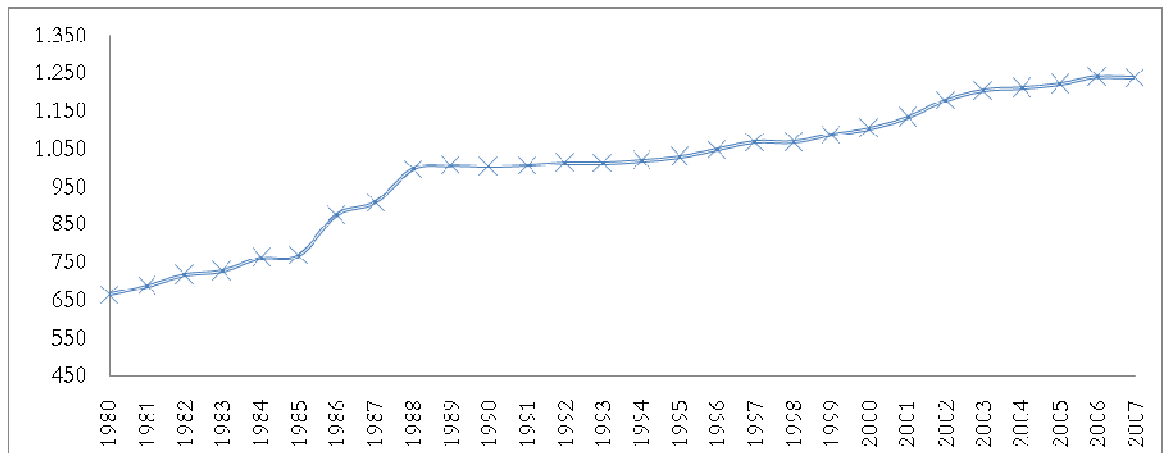


Figure 5. Proven oil reserves of the world in thousand million barrels (BP, 2008)

At the end of 2007, 61% of world's proved oil reserves were founded in the Middle East where Saudi Arabia and Iran compose 21.3% and 11.2% of the entire reserves respectively. Kuwait with 8.2% and United Arab Emirates with 7.9% of the shares are other important reserve-holders in the region. The figure is followed by European and Eurasia region with 11.6% of the whole oil reserves. Russia's share composes more than half of the region's reserves by 6.4% that is followed by Kazakhstan with 3.2%. Southern and Central America on the other hand owns 9% of world's proven oil resources. Venezuela in this geographical region accommodates the majority of oil reserves with its 7% share of world's total oil supplies. In African continent with its 9.5% share in proven oil reserves, Libya and Nigeria are apparent with their corresponding share of 3.3% and 2.9% respectively. Northern America, with US' 2.4%, Canada's 2.2% and Mexico's 1% contributes by 5.6% to world's oil reserves by 5.6%. Finally Asia Pacific lodges only 3.3% percent of oil reserves with China the greatest reserve holder in the region owning 1.3% of world's whole reserves.

Table 6 presents reserves and productions of region's oil resources as well as their estimated remaining lifespan denoted by R/P. For the illustration of remaining

lifetime, in case it is higher than 100 years, it is displayed as “>100”.

Table 6. Regions’ Oil Reserves, Production in Thousand Barrels and R/P as of 2007 (BP, 2008)

Regions	Thousand Barrels		Percentage Share		Years
	Reserves	Production	Reserves	Production	R/P
Middle East	755,320	25,176	61.0%	30.9%	82.2
Europe and Eurasia	143,710	17,835	11.6%	21.9%	22.1
Africa	117,480	10,318	9.5%	12.7%	31.2
S. and Cent. America	111,210	6,633	9.0%	8.1%	45.9
North America	69,290	13,665	5.6%	16.8%	13.9
Asia Pacific	40,840	7,907	3.3%	9.7%	14.2
TOTAL WORLD	1,237,850	81,534	100.0%	100.0%	41.6

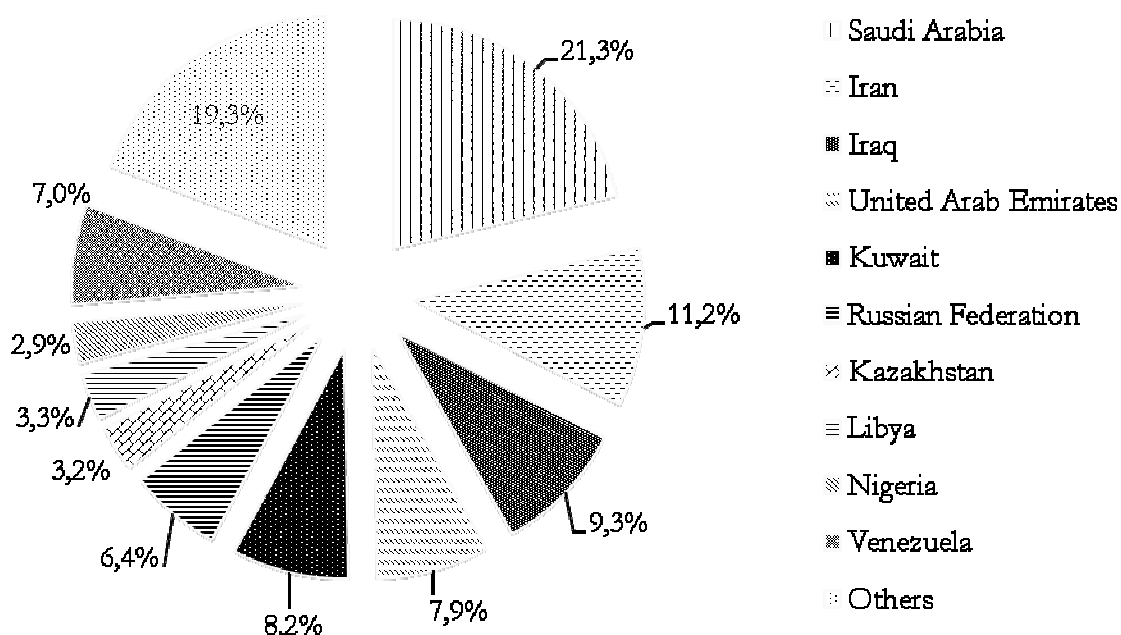


Figure 6 : Oil reserve shares of the leading oil – rich countries as of 2007 (BP, 2008)

EU's share in proven oil reserves is only 0.5% where OECD member countries' oil owning rate is 7.1%. Furthermore, the share of former Soviet Union countries is recorded as 10.4%. Thus a significant disparity in oil resources is inspected where industrialized countries' owning rate is deliberately low.

From the supply side, contrary to the reduction in oil production from 62.9 million barrels in 1980 to 56.6 million barrels in 1983, due to the boom in overall demand, oil production has increased continuously until 2007 excluding 1999.

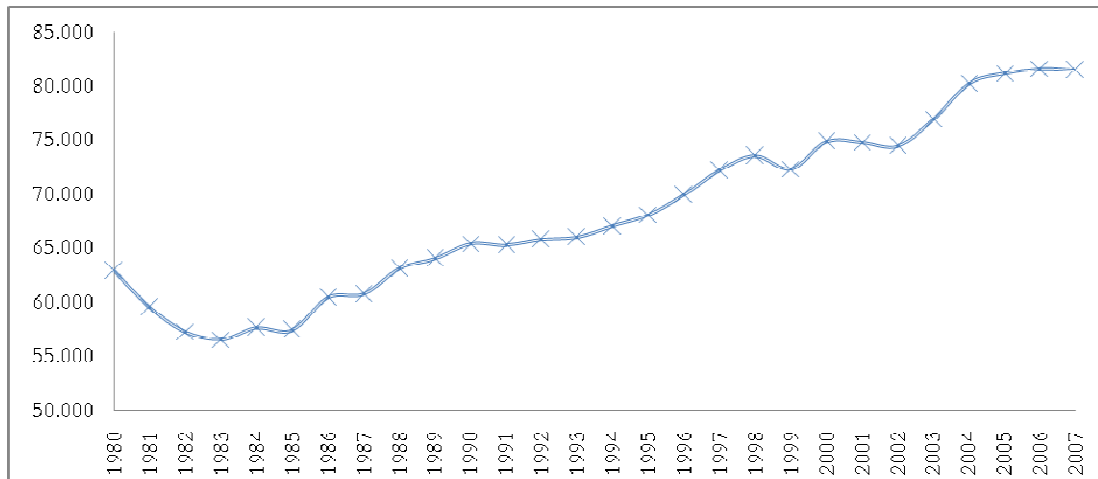


Figure 7. World's total oil production per thousand barrel

Oil production schemes do not comply completely parallel to reserve holdings of regions and individual oil resource owner countries. Although Middle Eastern countries host 61% of world's entire oil reserves, they contributed to 30.8% of world's oil production in 2007. Countries in Eurasia and Europe participated to overall production by 22% where North America's and Africa's shares are calculated to be 16.5% and 12.5% respectively. Asia Pacific region having only 3.3% of the world's oil resources extracted 9.7% of 2007's total supplied oil. European Union participates to oil production by 2.9% whereas the figure is 43% for OPEC countries and 23% for OECD states. These figures imply the disparity between the volume of oil reserves holding and productions.

In this context, the discrepancy between the rise in global oil demand and oil-rich country's change in oil production designates the degree of oil supply and demand mismatch. Although, OPEC countries own around 75% of the total oil reserves, they have been contributing to production by around 43% to 45% since long. Iraq produces less than 3% of the world's oil resources, even though it owns roughly 10% of the proven oil reserves where Saudi Arabia's reserve holding and production rate is 23.1% and 16.1% respectively. Contrary to lesser degree of participation of oil rich countries to whole global oil supply, countries with fewer volumes of reserves spend their oil

resources more generously. For instance, since 2002, Russia has been participating to production from 10% to 12% where it only hosts 6.3% of proven reserves. China on the other hand contributes to overall oil production by 4%, a rate which is quite more than the percentage of its reserves.

Table 7: Production and Percentage Barrel and Share as of 2007

Producer Country	Production (Barrel)	Percentage Share
Saudi Arabia	10,413	12.6%
Russian Federation	9,978	12.6%
United States	6,879	8.0%
Iran	4,401	5.4%
China	3,743	4.8%
Mexico	3,477	4.4%
Canada	3,309	4.1%
United Arab Emirates	2,915	3.5%
Kuwait	2,626	3.3%
Venezuela	2,613	3.4%
Norway	2,556	3.0%
Nigeria	2,356	2.9%
Brazil	1,833	2.9%
United Kingdom	1,636	2.0%
Others	22,798	27.1%

It could be inferred that, although some oil rich countries perception to oil production issue is a matter of trade and they take oil extraction decisions in line with their financial return expectations, some other less rich oil reserve owning countries bounteously spend their resources. United States for instance produces much more than some oil rich countries in order to meet its domestic demand, although its reserves are quite limited. Russian Federation on the other hand is an aggressive oil producer both in order to meet its soaring demand and to become more competitive and dominant in the energy market. Indeed, Russia has overtaken Saudi Arabia as the world's largest oil producer in some particular periods. (Noe, 2006)

In this context, R/P ratio that stands for Reserve to Production ratio gains additional importance. This index calculates the length of time that remaining reserves would last if production would continue with a given year's production rate. Given the data of 2007, in total, the world is able to supply oil only for another 41.6 years.

Northern America from this perspective is recorded to be the most generous region of the world with expected 13.9 more years for complete depletion, followed by Asia Pacific and Europe – Eurasia region with 14.2 and 22.1 years respectively. Middle East's R/P ratio is 82.2 years followed by Central and Southern America with 45.9 years. Africa on the other hand exhibited an R/P ratio of 31.2 years. On a general outlook, OECD countries have 72.7 years of lifespan left where this figure is 7.8 for the EU countries. On average, world's total oil R/P ratio is calculated to be 41.6 years.

In terms of oil spending, complying with rising demand for energy, global oil consumption displayed an upward trend in the past few decades too.

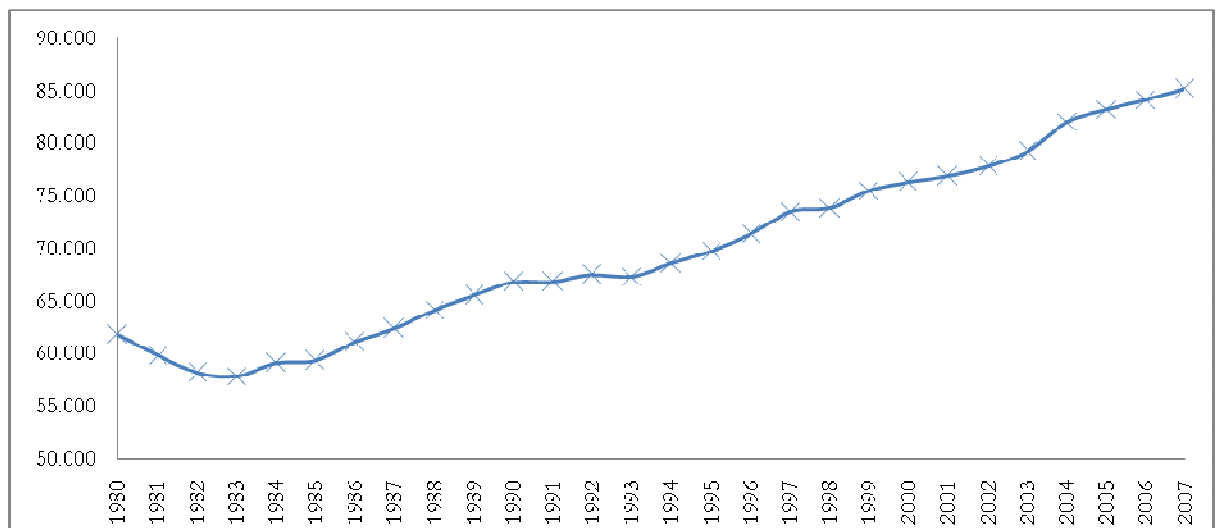


Figure 8: World's total oil consumption in thousand barrels (BP, 2008)

In 1985, 59,391 thousand barrels of oil per day was consumed where this figure is actualized as 66,855 in 1990, 69,841 in 1995, 76,340 in 2000 and finally 85,220 in 2007.

Table 8: World's Leading Oil Consumers and Their Shares as of 2007

Consuming Country	Consumption (Thousand Barrels)	Consumption Share
United States	20,698	23.9%
China	7,855	9.1%
Japan	5,051	5.8%
India	2,748	3.3%
Russian Federation	2,699	3.2%
Germany	2,393	2.8%
South Korea	2,371	2.7%
Canada	2,303	2.6%
Brazil	2,192	2.4%
Saudia Arabia	2,154	2.5%
Mexico	2,024	2.3%
France	1,919	2.3%
Italy	1,745	2.1%
United Kingdom	1,696	2.0%
Iran	1,621	1.9%
Netherlands	1,044	1.2%
Turkey	666	0.8%
Others	24,040	29.1%

Northern America, particularly the United States is the largest oil consumer, as per 2007 data, it formed 23.9% of the entire oil consumption. Since its consumptions are exceeding its productions, United States is regarded a net oil importer. Furthermore, being a major economy of the globe, Japan made up 5.8% of entire oil consumption. On the other hand emerging economies' oil consumption patterns grabs attention too. As of 2007 data, China with Hong Kong spent 8,373 thousand barrels of oil and performed 9.7% of world's entire oil consumption. India formed 3.3%, Russia 3.2% and Brazil 2.4% of the whole consumption. All these mentioned countries except Russian Federation are dependent on oil imports from exporter countries.

Table 9. Oil Production and Consumption in Regions and Their Self Sufficiency as of 2007 (BP, 2008)

Regions	Thousand Barrels		Percentage Share		Ratio
	Production	Consumption	Production	Consumption	Prod. / Cons.
Middle East	25,176	6,203	30.9%	7.3%	Self sufficient
Europe and Eurasia	17,835	20,100	21.9%	23.6%	88.7%
Africa	10,318	2,955	12.7%	3.5%	Self sufficient
South and Central America	6,633	5,493	8.1%	6.4%	Self sufficient
North America	13,665	25,024	16.8%	29.4%	54.6%
Asia Pacific	7,907	25,444	9.7%	29.9%	31.1%
TOTAL WORLD	81,534	85,219	100.0%	100.0%	
European Union	2,394	14,861	2.9%	18.2%	16.1%
OECD	19,170	48,934	23.5%	60.0%	39.2%

Geographically, Asia Pacific is the major oil consumer region making up 30% of the overall consumption, followed by Northern America by 28.7% and Europe by 24%. EU's share in world oil consumption is 17.8 %. Although, the EU has participated to oil production by 2.9%, it consumed 17.8 % of the world's overall oil consumption in 2007 deeming the block as an oil importer actor. Moreover, OECD member countries are net oil importers too as they make up 56.9% of the world's whole oil spending against their production ratio of 23%.

From the perspective of prices, undoubtedly oil prices are highly volatile and exhibits a very fluctuating nature. In 1970, per barrel price was recorded as 9.65 USD where it became 93.8 USD in 1980, a decade after. Although, the price was 16.69 USD in 1998 again ten years later, in early 2008, the price has exceeded 100 USD and approached to 147 USD in July 2008 which fell back to around 50 USD in 2009.

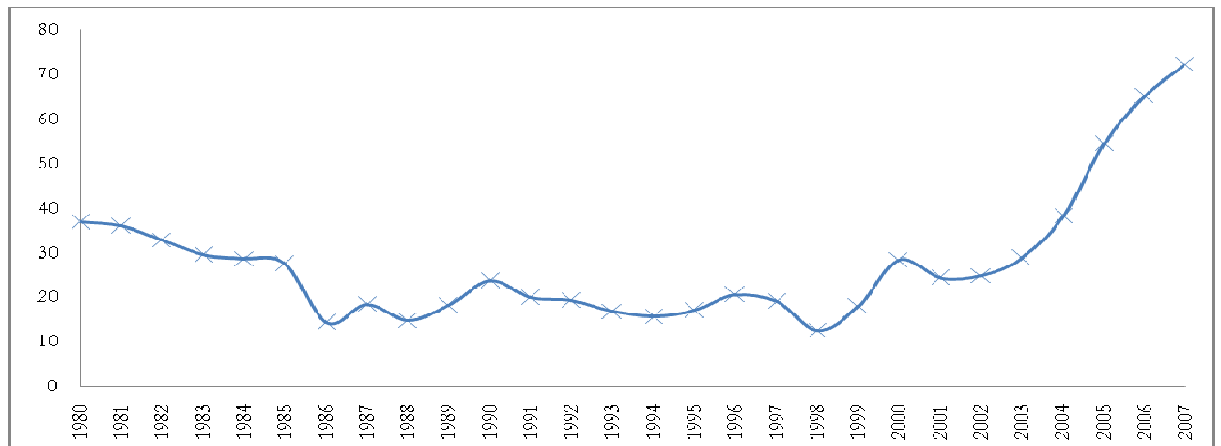


Figure 9. Crude oil prices in USD from 1980 to 2007 (WEC, 2007)

To sum up, oil is an important primary energy resource that is extensively consumed in the world. Oil resources in the world are quite limited and they are concentrated in a few regions. Oil resources is estimated deplete in 41.6 years. From this perspective, oil reserves and production are not proportional for oil rich countries who base their production decision on commercial circumstances. As part of their widespread energy needs, industrialized countries consume a big majority of oil and derivatives. Moreover, the political aspect of the oil production decision is undeniable. For these reasons, oil prices have varied significantly throughout the history.

Global Natural Gas Outlook

Being the cleanest form of fossil energy resources, natural gas' share within primary energy consumption grew rapidly in the past few decades. The scope of natural gas consumption extended to serve as an attractive alternative to oil. This section evaluates the trends in natural gas reserves, production, consumption and prices.

As of 2007, world's proven gas reserves were 177.36 trillion cubic meters (tcm). In the last twenty years, proven gas reserves have surged substantially. At the end of 1987, total reserves were found to be 106.8 tcm and 146.4 tcm in 1997. With the discovery of new reserves, natural gas resources have demonstrated an upward trend.

However, the growth of reserves has slowed markedly after 2001. In the last two decades, the growth in reserves was averaged 3.2% per year; however this figure has declined to 0.9% per year after 2001.

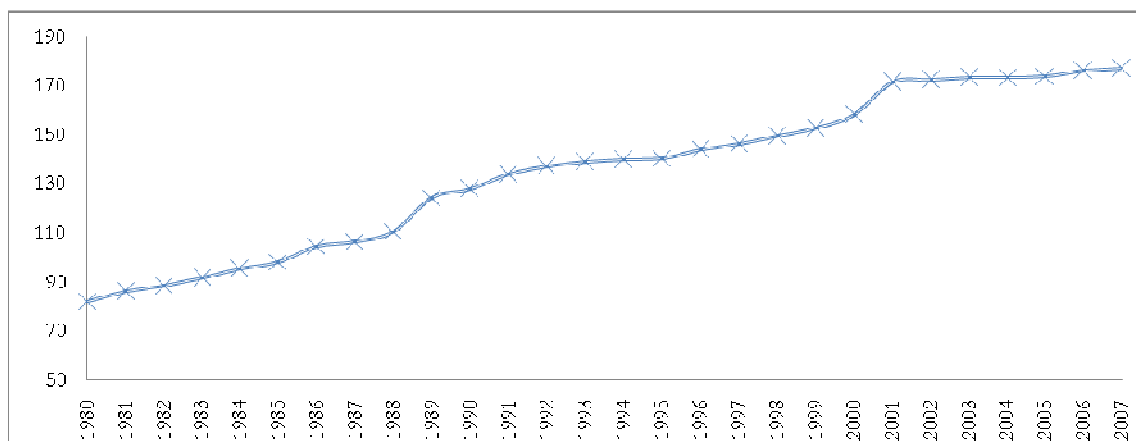


Figure 10. World's proven natural gas reserves in trillion cubic meters as of 2007 (BP, 2008)

As per 2007 data, as was the case in oil reserves, Middle East is again the leading natural gas holder with its share of 41.3%. It is followed by Europe and Eurasian countries with 33.5%. Africa and Asia Pacific compiles an equal share of 8.2% of world's gas reserves. Northern and South America together hosts 9% of gas reserves where the resources are almost equally split between the North and South.

Table 10. Regions' Natural Gas Reserves, Production in bcm and R/P Ratios (BP, 2008)

Regions	Billion cubic metres		Percentage Share		Years
	Reserves	Production	Reserve	Production	R/P
Middle East	73,210	355,80	41.3%	12.1%	>100
Europe and Eurasia	59,410	1,075.70	33.5%	36.6%	55.2
Africa	14,580	190.40	8.2%	6.5%	76.6
S. and C. America	7,730	150.80	4.4%	5.1%	51.2
North America	7,980	775.80	4.5%	26.4%	10.3
Asia Pacific	14,460	391.50	8.2%	13.3%	36.9
TOTAL WORLD	177,370	2,940.00	100.0%	100.0%	60.3

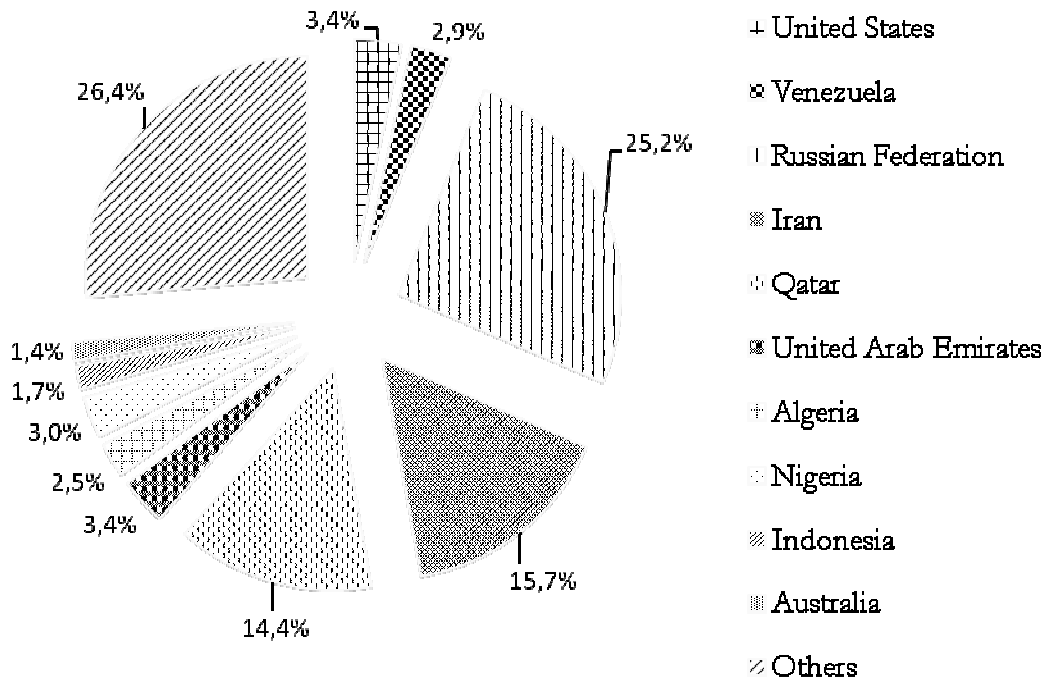


Figure 11. Leading natural gas reserve owners and their share in total proven reserves (BP, 2008)

Russia's share in gas reserves is tremendous. With 44.65 trillion cubic meters, Russia owns more than a quarter of world's proven gas reserves. Iran's and Qatar's acquisition rate is 15.7% and 14.4% respectively. United States, Venezuela, United Arab Emirates, Nigeria and Algeria are some other gas reserve holders. They all lodge from 5 to 6 trillion cubic meters of gas, contributing to roughly 3% of entire reserves. European Union is quite poor in gas reserves with 2.84 trillion cubes adding up to only 1.6% of the whole proven resources. On the other hand, OECD countries' split in total gas reserves is only 8.9% deeming that most industrialized countries lack natural gas reserves.

In 2007, 2,940 bcm of gas is generated where the figure was 1,801.1 bcm in 1987 marking a 63.2% rise in gas production in two decades. Annual average growth in gas production was 2.36% in the last twenty years.

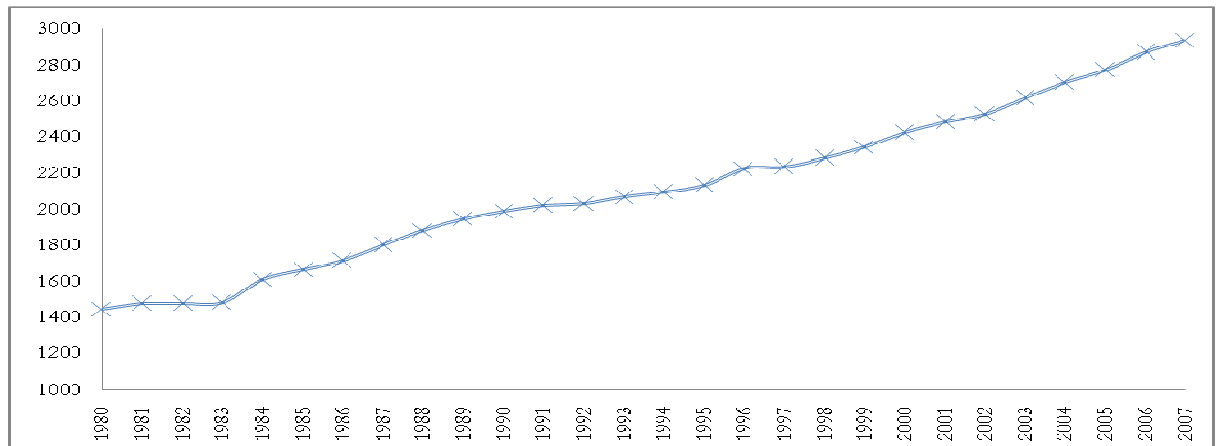


Figure 12. World's natural gas production in billion cubic meters (BP, 2008)

Although countries in the Middle East host the biggest share of gas resources, they do not produce the majority of the supplied gas. As of 2007 data, despite the region's owning rate of 41.3%, its production contribution to global supply was actualized by only 12.1%. Although Iran and Qatar accommodates from 14% to 15% of the proven reserves, their participation to production was only 3.8% and 2% respectively. Europe and Eurasia region on the other hand supplied almost more than a third of the gas. The region's contribution to production was 36.5% in 2007. Russia in this context is the greatest gas supplier with 20.6%. Norway, United Kingdom, Netherlands and Uzbekistan are other important actors of the region with their participations from 2.5% to 3%. North America is another major gas supplier region with 775.8 bcm adding up to 26.6% of the entire production. United States in this region is the biggest supplier with an involvement rate of 18.8%. Canada with 183.7 billion cubic meters of gas production in 2007 scored 6.2% of the world's overall gas supply although it owns only 0.9% of the proven gas reserves. On the other hand, the production share of Mexico happened as 1.6%. Within Asia Pacific which offered 13.3% of the total produced gas, China, Indonesia and Malaysia had each from 2% to 2.5% contribution. Africa's participation in gas production is 6.5% with Algeria, the main producer of the region by 2.6%. The shares of Egypt and Nigeria were 1.6% and 1.2% respectively. Finally, around 5% of the supplied gases were originated from

Southern and Central America. Argentina, Trinidad & Tobago and Venezuela sourced 1.5%, 1.3% and 1% of the offered gases respectively in 2007.

Table 11. World's Leading Natural Gas Producers as of 2007 (BP, 2008)

Country	Production (billion cubic feet per day)	Percentage Share
Russian Federation	58.8	20.7%
United States	52.8	18.6%
Canada	17.8	6.3%
Iran	10.8	3.8%
Netherlands	8.7	3.1%
Norway	8.7	3.1%
Algeria	8.0	2.8%
Saudi Arabia	7.3	2.6%
China	6.7	2.4%
Turkmenistan	6.5	2.3%
Indonesia	6.5	2.3%
Malaysia	5.9	2.1%
Qatar	5.8	2.0%
United Kingdom	5.7	2.0%
Others	74.5	26.2%

European Union was able to generate 6.5% of the whole gas production whilst the OECD member countries' share was 37.2%. Contrary to their limited reserve ratios of 8.9%, OECD countries supplied more than a third of the entire natural gas. When their reserve and production ratios are analyzed, it is deduced that United States and Canada are very generous countries in natural gas supply.

From the perspective of R/P ratio, the remaining lifetime of global natural gas reserves is calculated to be 60.3 years. Northern America is again the most openhanded region with almost a decade of remaining gas resources left. United States' gas is about to deplete in 10.9 years. Conversely, Middle East is estimated to have more than a century left for the depletion of their gas resources. While Africa can supply gas for another 76.6 years, the figure is 55.2 for Europe and Eurasia region. Russian Federation, the leading gas supplier of the globe, is expected to supply gas for another 73.5 years. On the other hand, the remaining lifespan of Asia Pacific's and Southern – Central America's gas is forecasted to be 36.9 and 51.2 years respectively. (BP, 2008)

In 2007, the world has consumed 2,921.9 bcm of gas, where the consumption was 1,766.8 bcm in 1987, managing a 65.3% raise in gas consumption. Average annual growth in gas consumption rate is calculated to be 2.42% since 1987, a figure which is slightly higher than the growth in production which was 2.36% in the same period.

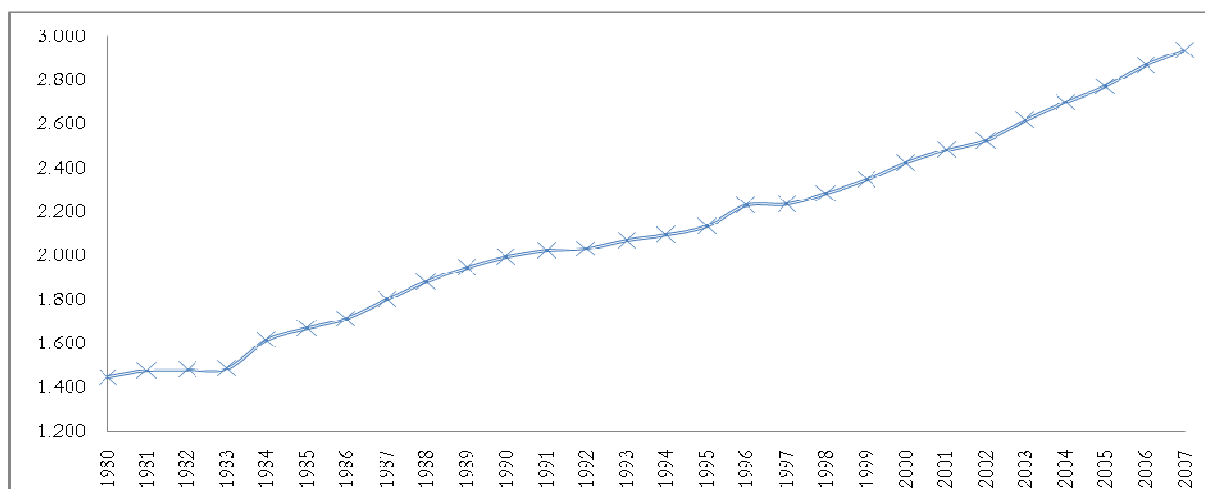


Figure 13. Global natural gas consumption in bcm from 1980 to 2007 (BP, 2008)

As of 2007 data, European and Eurasian region was the leading gas consumer with 39.4% of entire consumption. In the region, Russian Federation's share embodies 15% of the world's total gas spending.

Table 12. Global Natural Gas Production, Consumption, Percent Shares and Production to Consumption Ratio as of 2007 (BP, 2008)

Regions	Billion cubic metres		Percentage Share		Ratio
	Production	Consumption	Production	Consumption	Prod. / Cons.
Middle East	355.8	299.4	12.1%	10.2%	Self sufficient
Europe and Eurasia	1075.7	1155.7	36.6%	39.6%	93.1%
Africa	190.4	83.5	6.5%	2.9%	Self sufficient
South and Central America	150.8	134.5	5.1%	4.6%	Self sufficient
North America	775.8	801.0	26.4%	27.4%	96.9%
Asia Pacific	391.5	447.8	13.3%	15.3%	87.4%
TOTAL WORLD	2940.0	2921.9	100.0%	100.0%	
European Union	191.9	481.9	6.5%	16.5%	39.8%
OECD	1093.3	1454.3	37.2%	49.8%	75.2%

Northern America is the second biggest consumer region with 27.6%. United States, the leading gas consumer of the world, spent 652.9 bcm of natural gas which in other words adds up to 22.6% of the whole consumption. Asia Pacific region's share is 15.3% with Japan and China consuming the most gases of the region by 3.1% and 2.3% respectively. Middle Eastern countries contribute to gas consumption by 10.2%. Southern and Central America as well as the African continent spends quite lower degrees of gas. Their respective shares are 4.6% and 2.8 %.

Table 13. Leading Natural Gas Consumers and Their Consumption and Percent Shares as of 2007 (BP, 2008)

Consumer Country	Consumption (billion cubic feet per day)	Percentage Share
United States	63.2	22.6%
Russian Federation	42.5	15.0%
Iran	10.8	3.8 %
Canada	9.1	3.2%
United Kingdom	8.8	3.1%
Japan	8.7	3.1%
Germany	8.0	2.8%
Italy	7.5	2.7%
Saudi Arabia	7.3	2.6%
China	6.5	2.3%
Ukraine	6.3	2.2%
India	3.9	1.4%
South Korea	3.6	1.3%
Turkey	3.4	1.2%
Others	93.1	32.7%

In 2007, European Union's share in overall gas consumption was 16.5% by 46.6 billion cubic feet per day. This figure deems the block as a net gas importer. On the other hand, OECD countries made up 49.9% of the entire natural gas consumption. Comparing this standing with their split in gas production which was 37.4%, industrialized countries are concluded to be net gas importers too. Although United States is a vital gas producer with 545.9 bcm, it is still not completely self sufficient to meet their consumption of 652.9 bcm. In this arithmetic, since major industrialized economies are obliged to import gas, market price of natural gas gains additional

importance. For this reason, evaluation of historical natural gas prices would be insightful.

There are various data from extensive region's resources to assess the trends in gas prices. Below are the data sets from European Union, Japan, United Kingdom and United States Market.

Table 14. Natural Gas Prices in USD Since 1984 (BP, 2008)

US dollars per million Btu	LNG	Natural Gas			
	Japan Cif	European Union cif	UK NBP Index	US Henry Hub	Canada (Alberta)
1984	-	3.76	-	-	-
1985	5.23	3.83	-	-	-
1986	4.10	3.65	-	-	-
1987	3.35	2.59	-	-	-
1988	3.34	2.36	-	-	-
1989	3.28	2.09	-	1.70	-
1990	3.64	2.82	-	1.64	1.05
1991	3.99	3.18	-	1.49	0.89
1992	3.62	2.76	-	1.77	0.98
1993	3.52	2.53	-	2.12	1.69
1994	3.18	2.24	-	1.92	1.45
1995	3.46	2.37	-	1.69	0.89
1996	3.66	2.43	1.87	2.76	1.12
1997	3.91	2.65	1.96	2.53	1.36
1998	3.05	2.26	1.86	2.08	1.42
1999	3.14	1.80	1.58	2.27	2.00
2000	4.72	3.25	2.71	4.23	3.75
2001	4.64	4.15	3.17	4.07	3.61
2002	4.27	3.46	2.37	3.33	2.57
2003	4.77	4.40	3.33	5.63	4.83
2004	5.18	4.56	4.46	5.85	5.03
2005	6.05	5.95	7.38	8.79	7.25
2006	7.14	8.69	7.87	6.76	5.83
2007	7.73	8.93	6.01	6.95	6.17

From 1997 to 2007, the price of natural gas climbed by 236.8 % in EU CIF market, by 207.1% in UK – Heren NBP Index, by 175.2% in US Henry Hub Market and by 354% in Canada Market. Within the same period, the surge in crude oil prices in OECD countries' CIF market was marked as 262.8 %. As Table 14 shows, it is very evident that natural gas prices have showed a quite significant upward demand especially after 2000. The trend in gas prices is very similar to the trend in oil prices lead us to

infer that, since natural gas serves as a clear substitute of oil, natural gas prices have affected from the parameters that influences oil prices either.

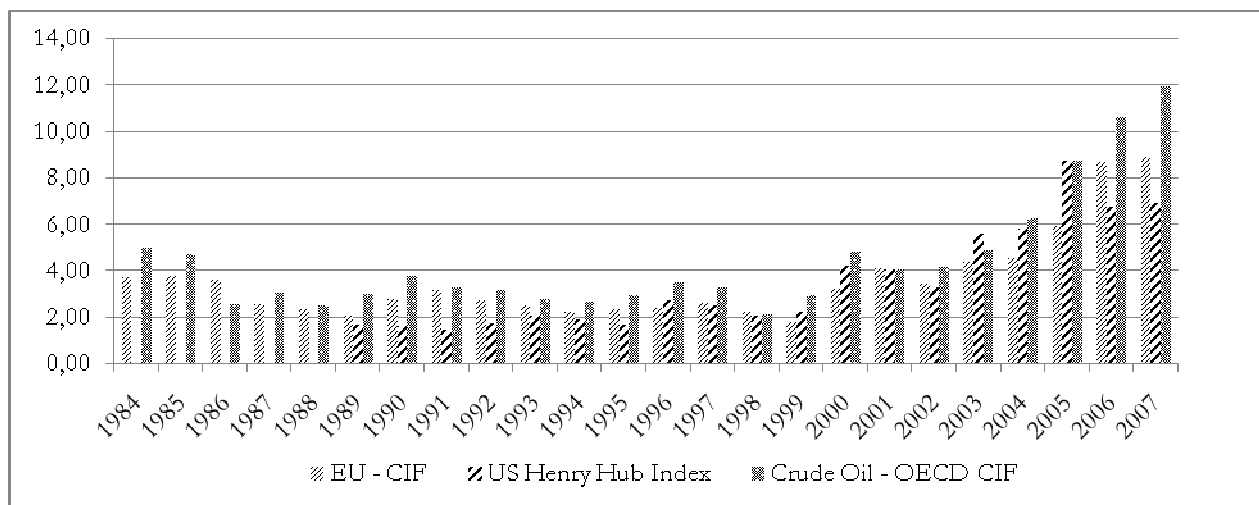


Figure 14. Natural gas prices in several markets

To sum up, natural gas reserves are moderately limited and are located in a concentrated geography similar to oil reserves. On the other hand, there exists a mismatch between natural gas reserves and production. The gas richer countries are reluctant to generate more volumes of gas and leads to a process that pulls the market price of the gas up notably.

Global Coal Outlook

Coal has always been a traditional way of generating energy. Although it is not the environmentally friendliest way of obtaining energy, it is still extensively employed and deserves a deeper outlook as performed in previous sections for oil and natural gas. Thus, this section assesses the global developments in coal reserves, production, consumption and prices.

As of 2007 data, the proven reserves of anthracite and bituminous coal were 430,896 million tons where the reserves for sub-bituminous coal and lignite were 416,592 million tons, adding up to a total 847,488 tons of coal. 32.1% of the coal reserves are located in Europe and Eurasia. In this region, Russian Federation holds

157,010 million tons of reserves that form 18.5% of world's total. Ukraine and Kazakhstan are other important coal owners with their respective share of 4% and 3.7%. Asia Pacific is the second largest reserve owning region that compiles 30.4% of the total coal assets. China in this region is the major actor with 114,500 million tons of coal resources that contributes to 13.5% of the total reserves. The corresponding percentages of Australia and India are 9.0% and 6.7%. Northern America, the third coal rich region, has 29.6% of the total coal reserves. United States with 242.721 million tons of reserves that forms the world's 28.6% of coal resources is the leading coal resources owner country of the globe. Contrary to its enormous levels of blessings in oil and natural gas reserves, the Middle East is quite poor in coal which owns only 0.2% of the total coal reserves. In Africa, South Africa with 48.000 million tons of coal reserves makes up 5.7% of the entire coal reserves. Other countries in Africa host only 1.605 million tons coal reserves which barely adds up to 0.2% of the full coal resources. Central and Southern America with 16.276 million tons of reserves contributes to world's coal sources by 1.9%.

Table 15. Total Coal Reserves of the Regions and Their Shares as of 2007 (BP, 2008)

Region	Million Tones			Percent
	Anthracite and Bituminous	Sub-bituminous and Lignite	Total	Share
North America	116,592	133,918	250,510	29.6%
S. and C. America	7,229	9,047	16,276	1.9%
Europe and Eurasia	102,042	170,204	272,246	32.1%
Middle East and Africa	50,817	174	50,991	6.0%
Asia Pacific	154,216	103,249	257,465	30.4%
WORLD TOTAL	430,896	416,592	847,488	100.0%

European Union member states' coal reserves adds up to 3.5% of the world's proven coal resources whereas the figure is 42.1% for OECD countries.

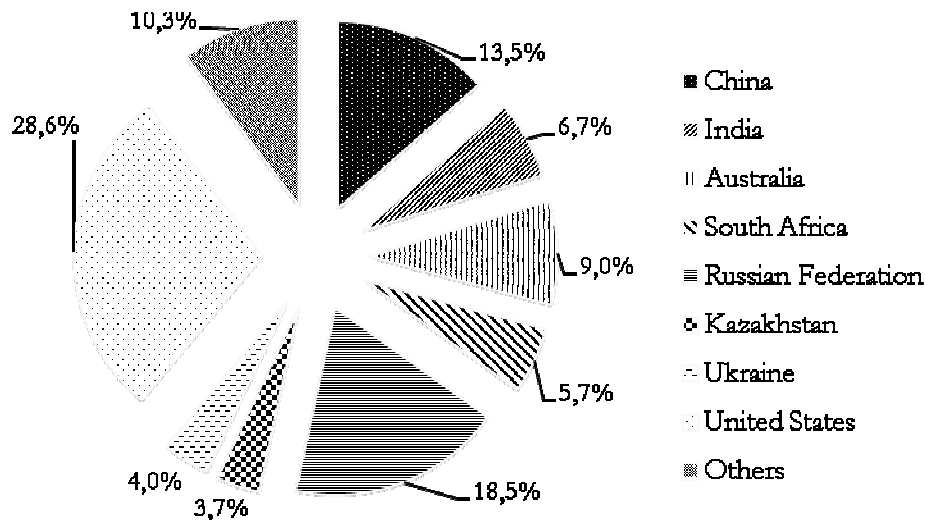


Figure 15. Leading coal reserve holder countries and their shares as of 2007 (BP, 2008)

As of 2007, world's total coal production was 6,395.6 million tons. The production has risen gradually from 4,628.9 million tons in 1987 by 38.1% in two decades. Due to decline in oil prices from 1990 to 1993 and from 1998 to 1999, coal production has declined in those years as the demand has shifted to alternative fossil energy resources. Contrary to this standing, the boom in oil and natural gas prices after 2000 has increased coal production by 5.7 % on average in the last 5 years.

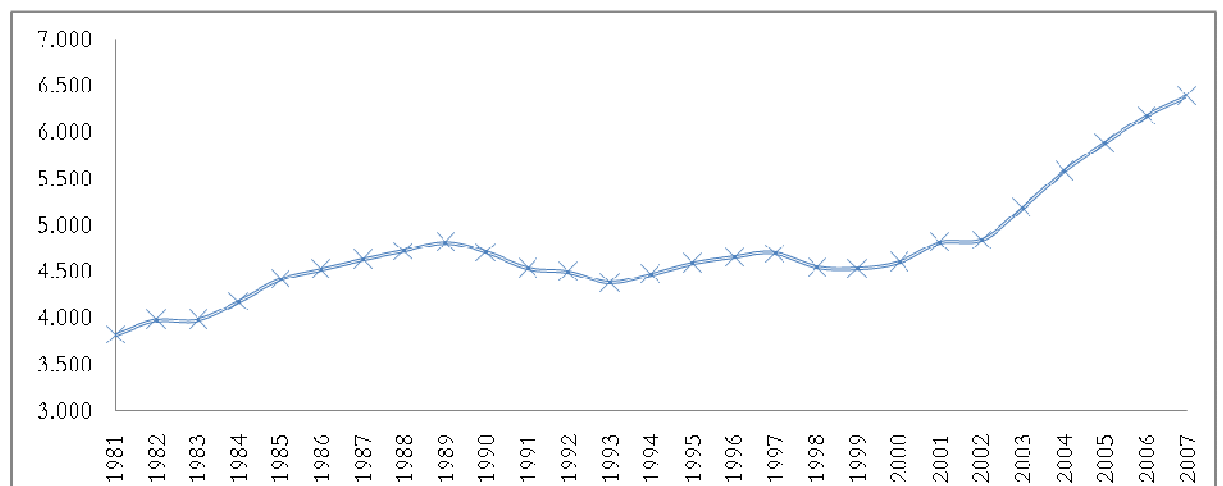


Figure 16. Total global coal production in million tons since 1981 (IEA, 2005)

Although, Europe and Eurasian region host the majority of the coal reserves, the region is not the leader in coal production. This is similar to the case in oil and

natural gas where the leading reserve holder region does not produce the majority of the energy. As of 2007, countries in Europe and Eurasia region contributed to production by 14.2% with 1,214.2 million tons in 2007. Russia extracted 4.7% of the world's total supplied coals where Poland, Kazakhstan, Ukraine and Germany scored from 1.5% to 2%. Asia Pacific is the leader coal producer region with 3,699.9 million tons making up 59% of the overall coal supply. China is the world's leading coal producer with 1,289.6 million tons of oil equivalent (mtoe) or 2,536.7 million tons forming 41.1% of the world's whole coal production which is much higher than its reserve ratio of 13.5%. Australia and India follows China in Asia Pacific region by 6.9% and 5.8 % respectively. North America supplied 1,120.8 million tons of coal in 2007 and made up 20.1% of the world's production. United States in this region extracted a great share of the coal with 1,039,2 million tons (587.2 mtoe) and shaped 18.7% of the global supply. In African continent, South Africa participated to world's coal production by 4.9% with 269.4 million tons of coal where Africa's overall production scored 151.2 mtoe. South and Central America's participation to coal production was actualized as 86.6 million tones shaping only 1.8% of the world's total coal production. Finally, although the share of Middle East in oil and gas production was abundant, the region's contribution to coal production is almost zero. European Union supplied 5.7% of the globe's total extracted coal in 2007 whereas OECD countries offered approximately a third of the entire production.

Table 16. World's Leading Coal Producer Countries' Production in mtoe and Their Shares as of 2007 (BP, 2008)

Producer Country	Production (mtoe)	Percentage Share
China	1,289.6	41.1%
United States	587.2	18.7%
Australia	215.4	6.9%
India	181.0	5.8%
South Africa	151.8	4.8%
Russian Federation	148.2	4.7%
Poland	62.3	2.0%
Germany	51.5	1.6%
Ukraine	39.6	1.3%
Turkey	15.8	0.5%
Others	393.2	12.6%

Table 16 shows that, China is spending its coal resources in a much faster manner than its reserves whereas the figure is exactly the opposite in two other major coal reserve holders that are United States and Russian Federation.

Table 17. Regions' Coal Reserves, Production in mtoe and R/P Ratios as of 2007 (BP, 2008)

Regions	m TOE		Percentage Share		Ratio	
	Production	Consumption	Production	Consumption	Prod. / Cons.	R/P (Years)
Middle East	0.5	6.1	0.0%	0.2%	8.2%	N/A
Europe and Eurasia	445.4	533.7	14.2%	16.8%	83.5%	224
Africa	154.2	105.9	4.9%	3.3%	Self sufficient	186
South and Central America	55.3	22.4	1.8%	0.7%	Self sufficient	188
North America	629.9	613.3	20.1%	19.3%	Self sufficient	224
Asia Pacific	1,850.2	1,896.2	59.0%	59.7%	97.6%	70
TOTAL WORLD	3,135.5	3,177.6	100.0%	100.0%		133
European Union	178.3	317.9	5.7%	10.0%	56.1%	50
OECD	1,033.4	1,184.3	33.0%	37.3%	33.0%	168

Taking 2007's production values as a reference, the R/P values show that the world is able to supply coal for another 133 years. From the perspective of coal, Asia Pacific region is the most generous region whose remaining lifespan is 70 years where China, the major reason of the region's generosity, can supply coal for only another 45 years. Countries in Europe and Eurasia can supply coal for 224 more years where the

figure is very promising with 500 years for Russian Federation. North American continent is calculated to supply coal for 224 additional years where United States' lifespan is estimated to be 234 years. Africa's coal reserves are expected to survive by another 186 years where South Africa can supply coal for 178 years. Central and Southern America region can offer coal for 188 more years. Hence, coal is expected to supply energy for a longer duration when compared to the R/P of oil and natural gas.

In 2007, the world has consumed 3,177.6 mtoe of coal. The figure was 2,194.1 mtoe in 1987, 2,268.4 mtoe in 1995, 2340.4 mtoe in 2000 and 2892.4 mtoe in 2005 illustrating that the coal consumption have risen continuously and it achieved a 44.7% growth in the past two decades. However, it should be noted that, China's consumption was recorded as 466.8 mtoe in 1987 and became 1,311.4 mtoe in 2007. Of the 983.4 mtoe increase in global coal consumption in the last twenty years, 844.6 mtoe was sourced directly from China.

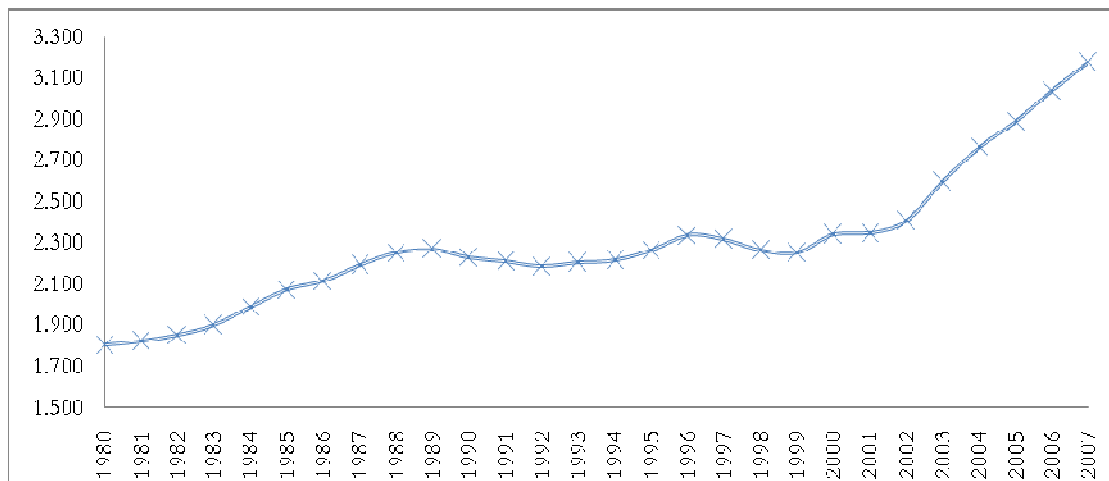


Figure 17. Total global coal consumption since 1980 in mtoe (BP, 2008)

As of 2007 data, 59.7% of the globe's entire coal consumption was taking place in Asia Pacific region with 1,896.2 mtoe. China and Hon Kong with 1318.8 mtoe forms 41.5% of world's overall coal consumption followed by India 6.5% and Japan 3.9%. Northern America with 613.3 mtoe composed 19.3% of the consumption where United States' contribution to overall coal spending was 18.1%. Europe and Eurasia added up

to overall coal spending by 16.8% where Russia's and Germany's share is calculated as 3% and 2.7% respectively. Coal spending is not intensive in African continent with 105.9 mtoe adding up only to 3.3% of the global coal spending. South Africa in the region is the only major coal consumer with 97.7 mtoe. Middle East on the other hand almost lacks coal spending whose total consumption was only 6.1 mtoe in 2007, contributing around 0.2% of the entire consumption. Like the Middle East, South and Central America, with 22.4 total mtoe coal consumption participates to coal spending by 0.7%.

Table 18. Leading Coal Consumers, Their Consumption and Percent Shares as of 2007 (BP, 2008)

Consumer Country	Consumption (mtoe)	Percentage Share
China	1,311.4	41.3%
United States	573.4	18.1%
India	208.0	6.5%
Japan	125.3	3.9%
South Africa	97.7	3.1%
Russian Federation	94.5	3.0%
Germany	86.0	2.7%
Poland	57.1	1.8%
Ukraine	39.3	1.2%
Turkey	31.0	1.0%
Others	553.8	17.4%

European Union in 2007 formed 10% of the overall coal spending. Compared to its 3.5% participation to production, it is inferred that European Union is a net coal – importer. OECD member's participation to coal consumption is 37.3% in 2007. Unlike the figure in natural gas, OECD countries produce more coal than they consume, deeming them coal exporters.

From the perspective of prices, there exist various sets of data that could give an essence regarding the historical developments in coal prices. Below are the USD prices of coal from Northwest Europe market, US Central Appalachian coal spot price index and Japanese steam coal market.

Table 19. Coal's Historical Price Development Since 1987 in USD per Tonne (BP, 2008)

US dollars per tonne	Northwest Europe	US Central	Japan CIF	Japan steam coal import cif price
1987	31.30	-	53.44	41.28
1988	39.94	-	55.06	42.47
1989	42.08	-	58.68	48.86
1990	43.48	31.59	60.54	50.81
1991	42.80	29.01	60.45	50.30
1992	38.53	28.53	57.82	48.45
1993	33.68	29.85	55.26	45.71
1994	37.18	31.72	51.77	43.66
1995	44.50	27.01	54.47	47.58
1996	41.25	29.86	56.68	49.54
1997	38.92	29.76	55.51	45.53
1998	32.00	31.00	50.76	40.51
1999	28.79	31.29	42.83	35.74
2000	35.99	29.90	39.69	34.58
2001	39.29	49.74	41.33	37.96
2002	31.65	32.95	42.01	36.90
2003	42.52	38.48	41.57	34.74
2004	71.90	64.33	60.96	51.34
2005	61.07	70.14	89.33	62.91
2006	63.67	62.98	93.46	63.04
2007	86.60	51.12	88.24	69.86

From the table above, it is deduced that, coal prices depict a fluctuating nature. According to Northwest Europe market price, per ton USD price of coal in 2002 was almost equal to 1987 price. In Japanese market, from 1999 to 2003, the price was even lower than that of 1987 price. However, a few years later, the prices began to ascend and achieved its peak in 2007.

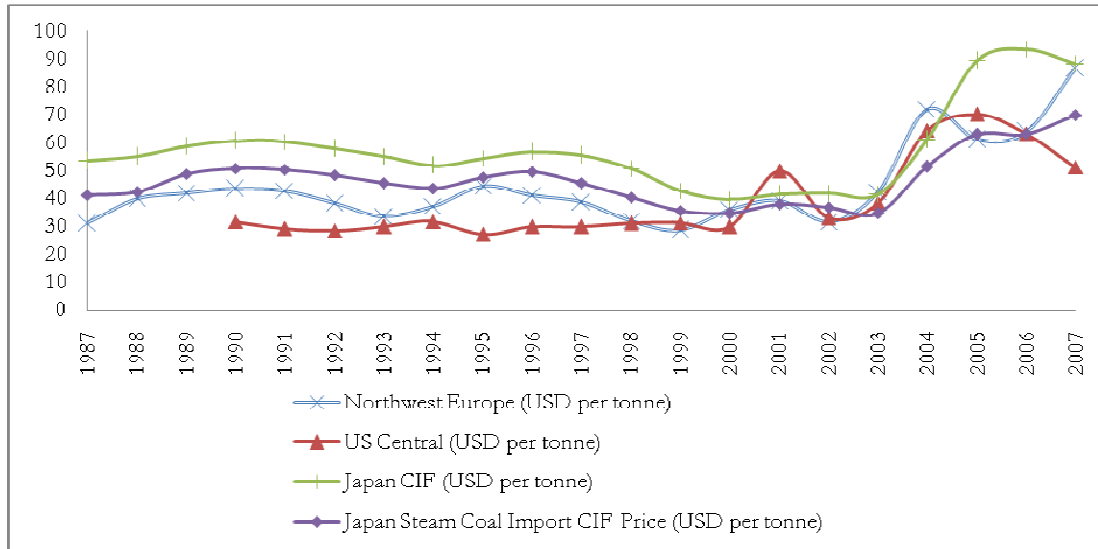


Figure 18: Coal price's for various markets

In the previous 5 years, the surge in coal prices 173% for European market and 110% for Japan coking coal market. Regional divergences in coal prices are inspected too. In 2000, although European prices have surged, in the United States market and Japan steam coal market, the prices had fallen. Moreover, In 2007, unlike the figure in European and Japanese market, US Appalachian coal prices fell by 18.8 compared to 2006 data.

It should be noted that, since coal is an appreciated substitute of primary energy resources, trends in natural gas and oil in terms of production and consumption patterns as well as price highly affect the market conditions concerning coal too. As a remark, although coal is not the cleanest form of primary energy, it is still majorly demanded and employed and it could be inferred that due to its respectively higher degree of R/P ratio, it will continue to be consumed frequently in the future too.

Global Hydro Review

While the previous sections were focusing on global trends in fossil energy resources, this section reviews one of the most extensively employed means of renewable energy within the framework of primary energy resources. Hydroelectricity,

one of the most popular forms of renewable energy, is the process of generating electricity by hydropower which is attained by the use of the gravitational force of flowing or falling water. Once a hydroelectric facility is built, the production process does not generate direct waste, and has a considerably lower output level of the greenhouse gas carbon dioxide than fossil fuel powered energy plants. Since countries consume what they produce within the context of renewable energy and their prices are minimally subject to the effect of global political and financial turmoil, the sole emphasis is placed in their production - consumption patterns. Throughout this section, the notions of production and consumptions is used interchangeably.

As of 2007 data, total consumption of hydroelectricity was 3134.3 Terawatt-hours which added up to 709.2 mtoe. In 1987, total consumed hydroelectricity was 2,063.3 TWh which was 2,520 TWh in 1995, 2,697.5 TWh in 2000 and 2,962.7 in 2005. The growth in hydropower consumption was 51.9% in the last two decades, 20.5% in the previous ten years and 16.6% in the last half decade. This situation and Figure 19 below indicates that although the growth in hydro consumption has slowed in late 1990s, the consumption has re-accelerated after 2003 when the prices of fossil resources have significantly climbed up.

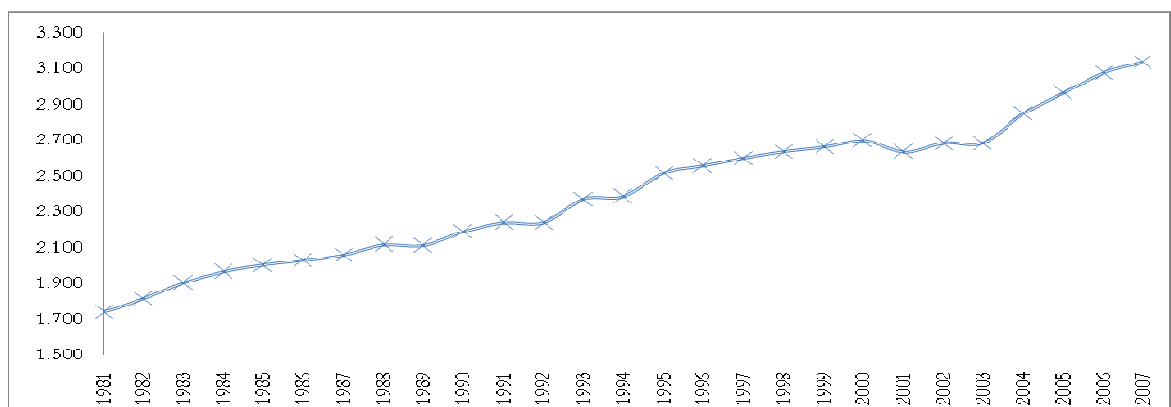


Figure 19. Total global hydroelectricity production in TWh (BP, 2008)

As per 2007 data, countries in Asia Pacific region compile 27.3% of the overall hydroelectricity consumption. China is the leading hydroelectricity consumer with 482.9

TWh making 15.4% of the world's overall hydro consumption. In 1987, China's consumption was rated 100 TWh which rose by 382.9% in two decades. From this perspective, 35.8 % of the growth in hydroelectric consumption since 1987 sourced from China. India and Japan in Asia Pacific follows China with their corresponding percentage of 3.9% and 2.7%. Europe on the other hand has 26.6% of the overall hydroelectricity consumption where Russia and Norway compiles a significant part of this share with their respective shares of 5.7% and 4.3% of the world's overall hydroelectricity spending.

Table 20: World's Hydroelectricity Consumption per Region as of 2007 (BP, 2008)

Regions	Consumption (TWh)	Consumption (%)
Middle East	22.7	0.7%
Europe and Eurasia	833.7	26.6%
Africa	98.2	3.1%
South and Central America	676.5	21.6%
North America	646.1	20.6%
Asia Pacific	857.1	27.3%
TOTAL WORLD	3,134.3	100.0%
European Union	341.6	10.9%
OECD	1,306.2	41.7%

Central and South America is the third most hydroelectricity consuming region with 676.5 TWh, adding up to 21.6% of the total consumed hydro power. Brazil in the region is the major hydroelectricity consumer with 371.5 TWh contributing to 11.9% of the entire consumption. Northern America with 646.1 TWh of total consumption entails 20.6% of the hydroelectricity consumption where Canada holds 11.7% of the total hydro production and the United States' share is 8 %. Within Africa, total hydroelectric consumption is recorded as 98.2 TWh where 79.6 TWh of it is spent by South Africa and contributed to world's consumption by 2.5%. Middle East's participation to hydroelectricity consumption is 0.7% where only Iran's share is significant in the region by its contribution of 0.6%.

Table 21. Leading Hydroelectricity Producing Countries and Their Shares as of 2007 (BP, 2008)

Consumer Country	Production (TWh)	Percentage Share
China	482.9	15.4%
Brazil	371.5	11.9%
Canada	368.2	11.7%
United States	250.8	8.0%
Russian Federation	179.0	5.7%
Norway	135.3	4.3%
Venezuela	83.9	2.7%
Japan	83.6	2.7%
Sweden	66.2	2.1%
France	63.6	2.0%
Turkey	35.6	1.1%
Others	978.1	32.4%

In 2007, with overall spending of 341.6 TWh, the EU has formed 10.9% of the world's total hydroelectricity consumption. OECD countries on the other hand, with 1,306.2 TWh made up 41.7% of the total hydro consumption.

Hydroelectricity power that is highly appreciated due to its clean and less costly nature of energy generation is widely used by two major emerging economies, China and Brazil, too. In addition to geographical constraints in terms of raining patterns and feasibility to construct hydro plants, industrialization levels of nation states could be regarded as another determinant illustrating their commitment to invest in renewable energy.

To sum up section 3.1.1., fossil energy reserves are quite limited and they are concentrated in several regions of the globe while the production of this energy is perceived as a political and economic decision resulting in an unbalanced pattern of production whilst more reserve holding countries offer less volumes of energy compared to the ones that owns relatively smaller share of the reserves. The production of renewable energy, on the other hand, is both a matter of geographical convenience and administrative commitment to invest in renewable energy. Decreasing lifespan and lessening degrees of reserve discoveries for fossil energy resources combined with the

rising demand for energy is another fact that makes the world more vulnerable to future energy supply. These trends indeed has surged the prices of energy tremendously especially in the recent years. Ups in the cost of energy production have led hydro production to grow rapidly excluding Middle East and Africa.

Global Review of Nuclear Energy and Electricity

Motivations like the limitations in their reserves, unpredictable nature of their prices and environmental hazards puts the consumption of primary energy into a riskier and unappreciated status. For this reason, the importance of alternative energy resources involving nuclear energy comes into the priority list in the agenda of many nation states.

Since the shortage of primary energy resources leads nation states to import energy from external resources and this process poses economic and politic problems regarding energy security, the importance of non – primary energy resources have soared ultimately. The following sections analyzes global patterns in electricity and nuclear production.

Global Nuclear Energy Consumption

Nuclear energy is a controversial mean of power generation due to the concerns on production safety. In 26 April 1986, a reactor accident has happened in Chernobyl Nuclear Power Plant in Ukraine. The accident was considered to be the worst plant disaster in history that resulted to many catastrophic events (Worley, 2008). In response to its threats on safety, nuclear energy offers the option to generate a clean form of energy to nation states independently (Vattenfall, 2009). For this reason, although there exists a debate about the employment of nuclear energy in many countries including Turkey, several nation states excessively exercise it within its power production portfolio.

As of 2007 data, total nuclear consumption was 2,748.9 TWh which is equivalent to 622 mtoe. The growth in nuclear energy has thrived in the 80s. In 1980, total volume of nuclear consumption was 711.4 TWh which increased by 181.5% and became 2,002.8 TWh by 1990. The figure was 2,582.9 TWh as of 2000. Since then, the growth in nuclear employment has slowed down. Indeed from 2005 to 2007 nuclear consumption has slightly declined.

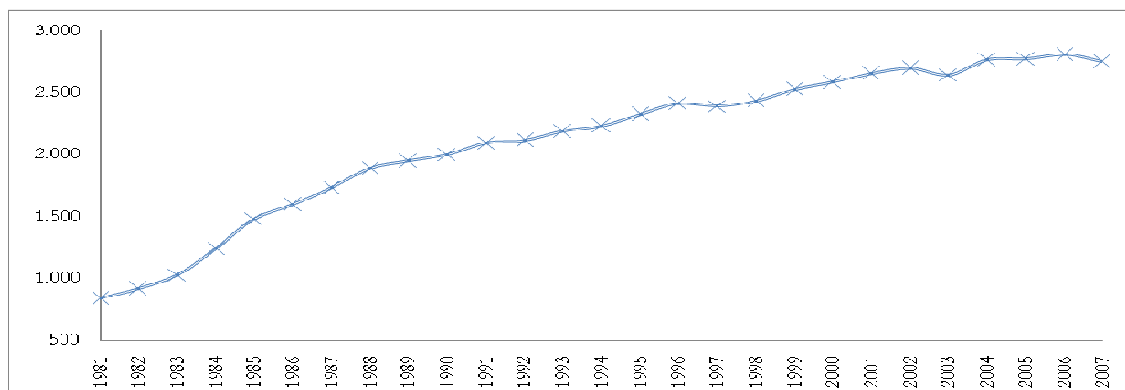


Figure 20. Total global nuclear consumption in TWh (BP, 2008)

According to 2007 data, 44.3% of the nuclear consumption took place in Europe and Eurasia region. 16% of the world's nuclear spending happened in France. Russia and Germany on the other hand with 159.8 TWh and 140.5 TWh formed 5.8 % and 5.1% of the overall nuclear consumption respectively. The participation of Spain, Sweden, United Kingdom and Ukraine in the region has contributed to nuclear consumption ranged from 2 to 3.5%. Northern America was the second largest nuclear energy consumer region with 952.7 TWh composing 34.7% of the overall consumption. United States has been the leading nuclear consumer country of the world which formed 30.9% of the entire spending with 849.9 TWh.

Table 22. Nuclear Consumption of Regions and Their Shares as of 2007 (BP, 2008)

Regions	Consumption (TWh)	Consumption (%)
Middle East	0.0	0.0%
Europe and Eurasia	1,218.1	44.3%
Africa	13.2	0.5%
South and Central America	19.4	0.7%
North America	952.7	34.7%
Asia Pacific	545.6	19.8%
TOTAL WORLD	2,749.0	100.0%
European Union	935.4	34.0%
OECD	2,300.7	83.7%

Asia Pacific consumed 545.6 TWh of nuclear energy in 2007 which is mainly shared by Japan with 279 TWh and by South Korea with 40.6 TWh. As of 2007 data, Japan embodied 10.1% of the entire nuclear consumption whereas the share of South Korea was actualized as 5.2%. China with 62.9 TWh of nuclear energy has also been an important actor as it contributed to nuclear consumption by almost 2.3%. South and Central America with Argentina's and Brazil's total contribution of 19.4 TWh compose 0.7% of nuclear consumption similar to the case of Africa in which South Africa was the sole nuclear consumer with 13.2 TWh forming 0.5%. The Middle East on the other hand completely lacks nuclear consumption.

Table 23: Major Nuclear Energy Consuming Countries and Their Shares as of 2007 (BP, 2008)

Consumer Country	Production (TWh)	Percentage Share
United States	848.9	30.9%
France	440.4	16.0%
Japan	279.0	10.1%
Russian Federation	159.8	5.8%
South Korea	142.9	5.2%
Germany	14.5	5.1%
Canada	93.3	3.4%
Ukraine	92.5	3.4%
Sweden	67.4	2.5%
United Kingdom	62.4	2.3%
Spain	55.0	2.0%
Others	366.8	13.3%

European Union's total nuclear spending was 935.4 TWh in 2007 and made up 34% of the overall nuclear consumption. The share of OECD countries' nuclear spending was 2300.7 TWh which is equal to 83.7% of world's total. As a result, nuclear energy is mainly employed by industrialized countries where the share of developing countries is relatively lower.

Global Electricity Consumption

Electricity is a secondary form of energy that is manufactured through fossil, nuclear or renewable resources. Electricity demand is shaped by parameters like population, industrialization and technology. In 2007, world's total electricity generation was 19,894 TWh which used to be 11,854 TWh in 1990 meaning that the production has boomed by 67.8 % in seventeen years. From 1997 to 2007, electricity production has soared by 30%.

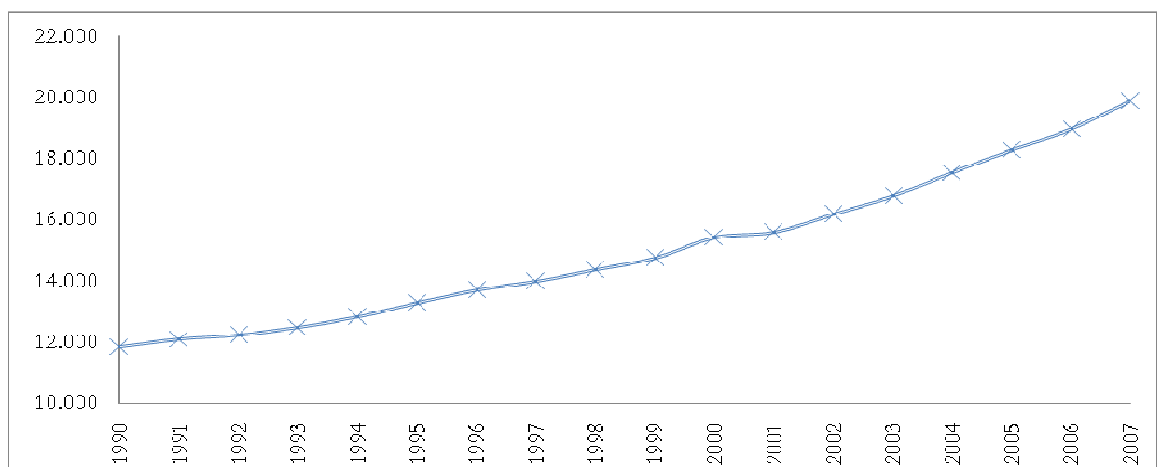


Figure 21: World's total electricity production since 1990 (BP, 2008)

Table 24 indicates that, 35.2% of the total electricity generation occurred in Asia Pacific region where China owned 16.5% shares of the globe's entire electricity generation. Japan and India followed it with their corresponding participations of 5.8 % and 3.9%.

Table 24: Distribution of Total Electricity Production per Region as of 2007 (BP, 2008)

Regions	Production (TWh)	Production (%)
Middle East	692.1	3.5%
Europe and Eurasia	5,326.8	26.8%
Africa	612.6	3.1%
S. and C. America	1,033.5	5.2%
North America	5,224.0	26.3%
Asia Pacific	7,005.7	35.2%
TOTAL WORLD	19,894.7	100.0%
European Union	3,387.6	17.0%
OECD	10,766.5	54.1%

As per 2007 data, Europe and Eurasia with European Union's 17% contribution to electricity generation follows Asia Pacific by 26.8 %. Russian Federation with 1,104.9 TWh of electricity generation shaped 5.1% of the total electricity production in 2007 followed by Germany and France by 3.2% and 2.8 % respectively. North America with 5,224 TWh of production formed 26.3% of the entire electricity generation where 4,368 TWh of this rate was supplied by United States. Middle East's and Africa's total participation to electricity production is very limited with 3.5% and 3.1% respectively.

Table 25: Leading Electricity Producers and Their Respective Shares as of 2007 (BP, 2008)

Producer Country	Production (TWh)	Percentage Share
United States	4,367.9	22.0%
China	3,277.7	16.5%
Japan	1,160.0	5.8%
Russian Federation	1,014.9	5.1%
India	774.7	3.9%
Germany	636.5	3.2%
Canada	602.4	3.0%
France	566.5	2.8%
South Korea	440.0	2.2%
United Kingdom	297.5	2.0%
South Africa	261.5	1.3%
Iran	193.3	1.0%
Turkey	191.0	1.0%
Others	6,110.1	30.2%

Turkey's Energy Outlook

Turkey is a growing emerging economy. According to the ranking of International Monetary Fund (2008), Turkey is the seventeenth largest economy of the world. As a consequence of the rapid industrialization and growth in economy, Turkey's demand for energy has boomed significantly. Thus Turkey's energy consumption has increased continuously over the past years. Although its scope is not sufficient to fully meet the local energy demand, Turkey produces a limited amount of fossil and renewable energy resources. This section analyzes Turkey's energy production and consumption patterns in order to comprehend its status within the global energy market. In the first part of the section, Turkey's Primary Energy will be reviewed whereas the second part focuses on its electricity market. The data of this section is obtained from Turkish Statistics Institute (TSI) and it has been cross checked and verified with the data of the Turkish Energy Ministry (TEM).

Turkey's Primary Energy Review

Turkey produces a variety of fossil and renewable energy resources within its primary production mix. Lignite is the major fossil fuel asset for Turkey. Although some oil, natural gas and mineral coal production exist, their scope is far from being sufficient to meet domestic demand.

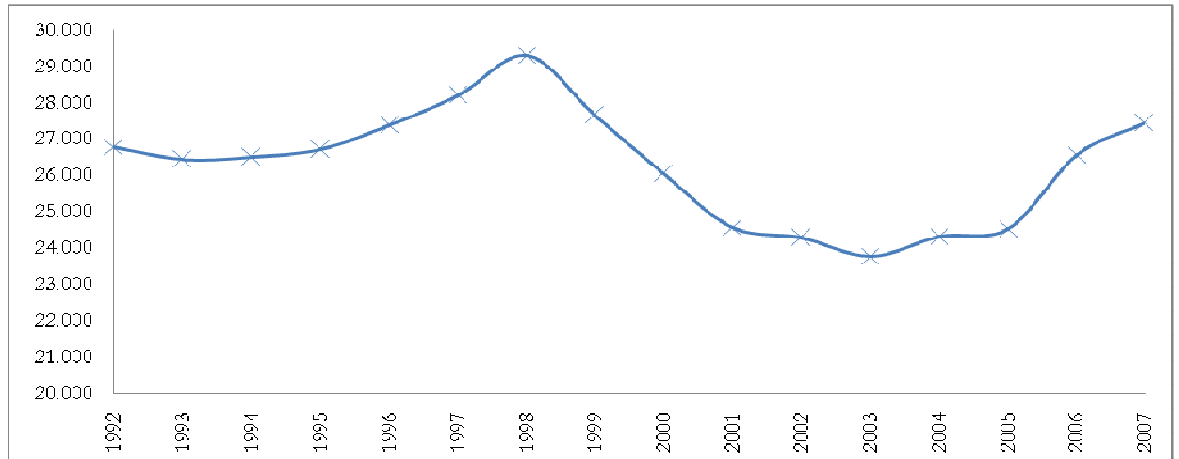


Figure 22. Turkey's total primary energy production since 1992 in oil equivalent

It is inferred from the table that Turkey's primary energy production did not significantly increase in the last fifteen years. The production showed a stable trend from 1992 to 1998 but later declined until 2003. From 1998 to 2003, the shrinking in overall primary energy production was 14%. By 2004, energy production have recovered and exceeded 27,000 toe in 2007.

Table 26. Turkey's Primary Energy Production (TSI, 2008)

Energy Production (toe)	Oil	Natural Gas	Mineral Coal	Lignite	Biomass	Hydro	Solar	Geothermal Heat	Others	Total
1992	4,495	180	1,727	10,299	7,209	2,345	60	388	91	26,794
1993	4,087	182	1,722	9,790	7,148	2,988	88	400	36	26,441
1994	3,871	182	1,636	10,471	7,109	2,698	129	415	0	26,511
1995	3,692	166	1,319	10,735	7,068	3,131	143	437	28	26,719
1996	3,675	187	1,382	10,899	7,045	3,553	159	471	15	27,386
1997	3,630	230	1,347	11,759	7,024	3,431	179	531	78	28,209
1998	3,385	514	1,143	12,792	6,983	3,639	210	582	76	29,324
1999	3,063	644	1,023	12,221	6,883	2,971	236	618	0	27,659
2000	2,887	582	1,060	11,418	6,457	2,662	262	648	71	26,047
2001	2,679	284	1,145	11,124	6,211	2,073	287	687	86	24,576
2002	2,564	344	1,047	10,311	5,974	2,906	318	730	88	24,282
2003	2,494	510	1,132	9,501	5,748	3,046	350	784	218	23,783
2004	2,389	644	1,081	9,141	5,532	3,971	375	811	388	24,332
2005	2,395	816	1,184	9,648	5,325	3,410	385	926	460	24,549
2006	2,284	839	1,348	11,545	5,159	3,813	403	898	291	26,580
2007	2,223	819	1,588	12,742	5,027	3,097	420	914	623	27,453

In Table 26, a detailed breakdown of primary energy resources is presented. In major terms, lignite and renewable energy is the major asset of Turkey's primary energy production.

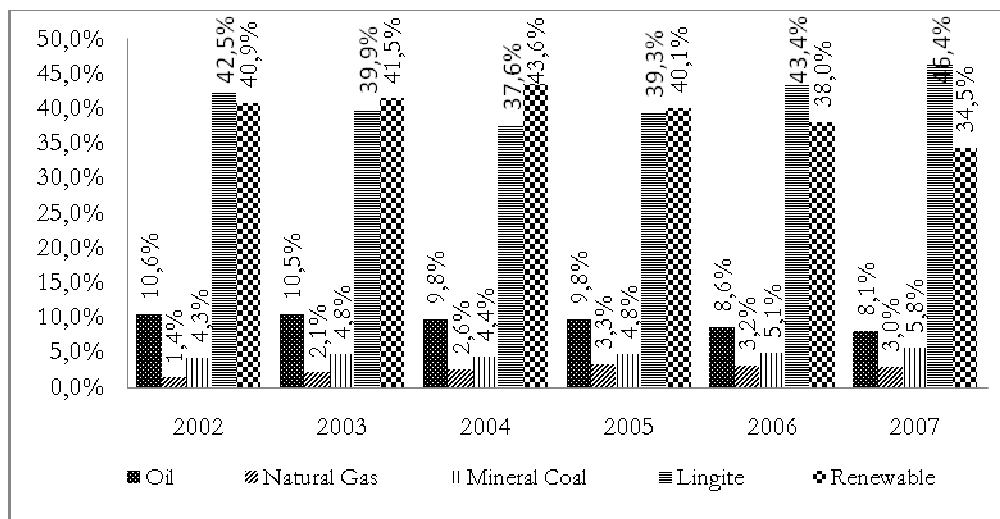


Figure 23. Percentage share of major primary energy production in Turkey

As Figure 23 depicts, Coal (mineral and lignite) together with renewable energies involving hydro, biomass, geothermal and solar designate an integral portion of Turkey's overall energy production. The share of coal production within Turkey's overall energy production mix was 52.2% in 2007 where the share of renewable was 34.5%. Excluding 2003 and 2004, the share of lignite and coal together did not fall below 40% since 1992 and the average share of coal in Turkish energy production structure had been 44.9% since 1992. On the other hand, although the contribution of oil has decreased from 4,495 toe to 2,223 toe in the last fifteen years, natural gas production has boomed both in absolute terms and in percentage terms. From the perspective of renewable energy, although the share of biomass has fallen, hydro and solar productions have surged. Neglecting the contribution of wind power which was only 30 toe in 2007, total renewable energy production has stayed rather stable from 1992 to 2007.

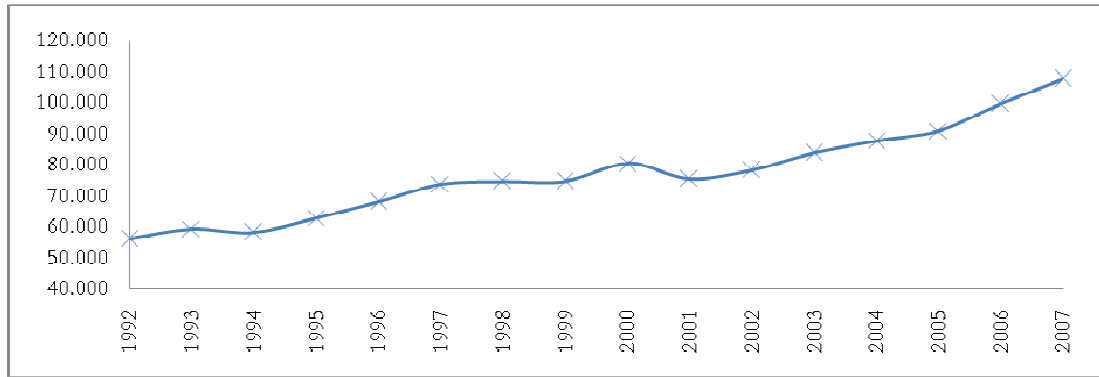


Figure 24: Turkey's primary energy consumption curve in toe

Despite Turkey's stable primary energy production pattern, its consumption has risen from 56.135 toe in 1992 by 91.7% until 2007 and became 107.625 toe. Excluding 1994 and 2001 when Turkey was faced with financial crisis, the energy consumption has increased continuously.

Table 27. Turkey's Primary Energy Consumption since 1992 (TSI, 2008)

Consumption (toe)	Oil	Natural Gas	Mineral Coal	Lignite	Biomass	Hydraulic	Solar	Geothermal Heat	Others	Total
1992	24,865	4,197	6,105	10,423	7,209	2,345	60	388	543	56.135
1993	28,114	4,532	5,712	9,918	7,148	2,988	88	400	562	59.462
1994	27,142	4,921	5,124	10,331	7,109	2,698	129	415	388	58.257
1995	29,324	6,313	5,905	10,605	7,068	3,131	143	437	28	62.954
1996	30,712	7,213	7,401	11,187	7,045	3,553	159	471	413	68.154
1997	30,615	9,265	8,291	12,423	7,024	3,431	179	531	2,020	73.779
1998	30,449	9,690	8,592	12,631	6,983	3,639	210	582	1,933	74.709
1999	30,239	11,741	7,426	12,314	6,883	2,971	236	618	2,297	74.725
2000	32,297	13,728	10,147	12,519	6,457	2,662	262	648	1,780	80.500
2001	30,936	14,868	7,305	11,429	6,211	2,073	287	687	1,607	75.402
2002	30,932	16,102	9,039	10,435	5,974	2,906	318	730	1,895	78.331
2003	31,806	19,450	11,461	9,471	5,748	3,046	350	784	1,710	83.826
2004	32,922	20,426	12,356	9,450	5,532	3,971	375	811	1,975	87.818
2005	32,192	24,726	12,693	9,326	5,325	3,410	385	926	2,090	91.074
2006	32,551	28,867	14,901	11,188	5,159	3,813	403	898	1,862	99.642
2007	33,482	32,683	16,593	14,015	5,027	3,097	420	914	1,394	107.625

In 1992, Turkish oil consumption was 24.865 toe contributing to 44.3% of the overall local energy consumption. The share was 47.8 % in 1993, which is the peak in the duration of analysis. However, the share of oil within Turkey's overall consumption mix began to fall in mid 1990s and became 31.1% in 2007. However, this fall in oil

consumption is compensated by the rise of natural gas consumption which was contributing to 7.5% of the entire consumption in 1992 and 31.3% in 2007. Coal consumption has risen significantly by 80.1% from 1992 to 2007. However, this increase did not significantly alter lignite and mineral coal's share in Turkey's energy consumption mix which fluctuates between 25 – 30% bandwidth, as coal consumption surged in quite parallel to overall energy demand increase. Since the absolute production of renewable energy did not increase in the period of analysis but the energy demand has increased, the share of renewable energy in Turkish consumption have declined.

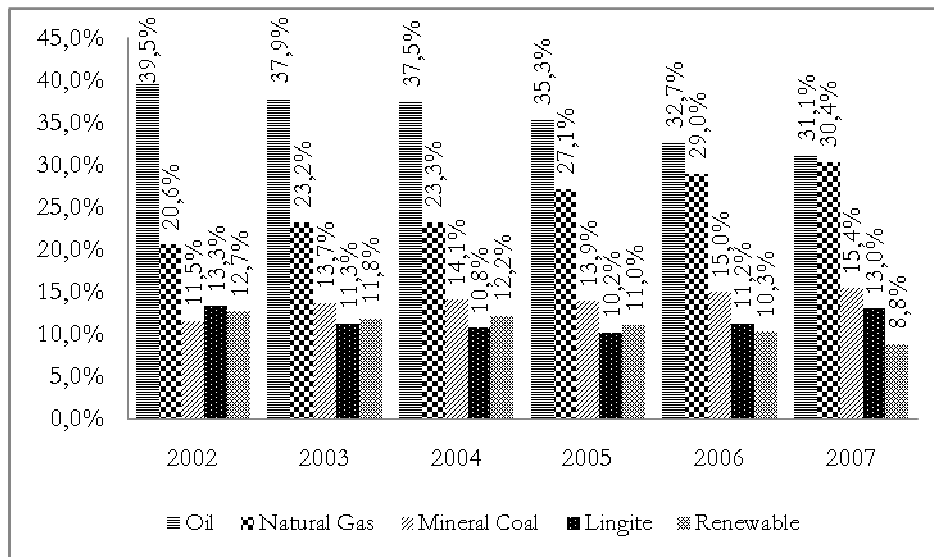


Figure 25. Percentage share of major primary energy consumption in Turkey

When Turkey's energy production and consumption patterns are evaluated, it would be inspected that although primary energy production has fluctuated, total energy consumption has continuously increased. Analyzing the production and consumption values, it is noticed that Turkey is quite dependent on imports from external supplier countries. For this reason, Turkey keeps importing oil, natural gas and coal. As the next section will focus, electricity imports do not form a vital part of Turkey's overall energy import structure and from 2004 to 2007, Turkey was a net electricity importer. In the table below, Turkey's import table from 1997 to 2007 is given.

Table 28. Turkey's Total Primary Energy Imports (TEM, 2008)

Energy Imports (toe)	Oil	Natural Gas	Mineral Coal	Lignite	Others	Total
1997	28.264	9.069	6.370	22	3.496	47.221
1998	29.099	9.388	6.685	4	2.344	47.520
1999	29.019	11.338	5.719	2	2.855	48.932
2000	30.917	13.597	8.381	2	4.155	57.052
2001	29.518	15.017	5.179	2	3.511	53.227
2002	31.684	15.895	7.544		1.391	56.514
2003	32.798	19.104	10.430		973	63.304
2004	34.143	19.997	10.598		2.452	67.190
2005	34.350	24.304	11.200		356	70.210
2006	36.166	27.727	13.088	5	528	77.513
2007	36.984	31.888	14.767			83.639

It is inferred from the table that, as Turkey's increase in energy demand is met by importing more. The imports have risen by 78.1% in the previous decade. Among the energy commodities, natural gas' import grew by 262.5% , 132.4% for mineral coal and 28.5% for oil.

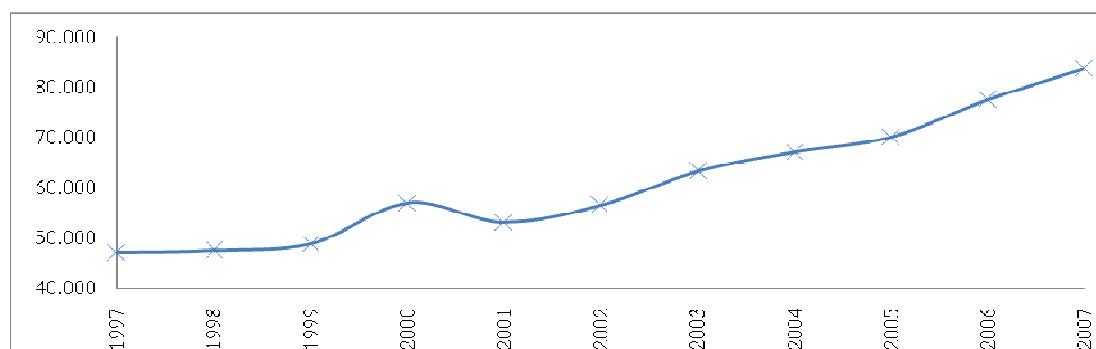


Figure 26. Turkey's energy imports since 1997 in toe

Despite the huge surge in natural gas imports, oil has been the most imported energy commodity for Turkey. As per 2007 data, 45.8 % of Turkey's energy imports are met by oil and its derivatives, 36.6% by natural gas, 16.5% by mineral coal and almost 1% via electricity.

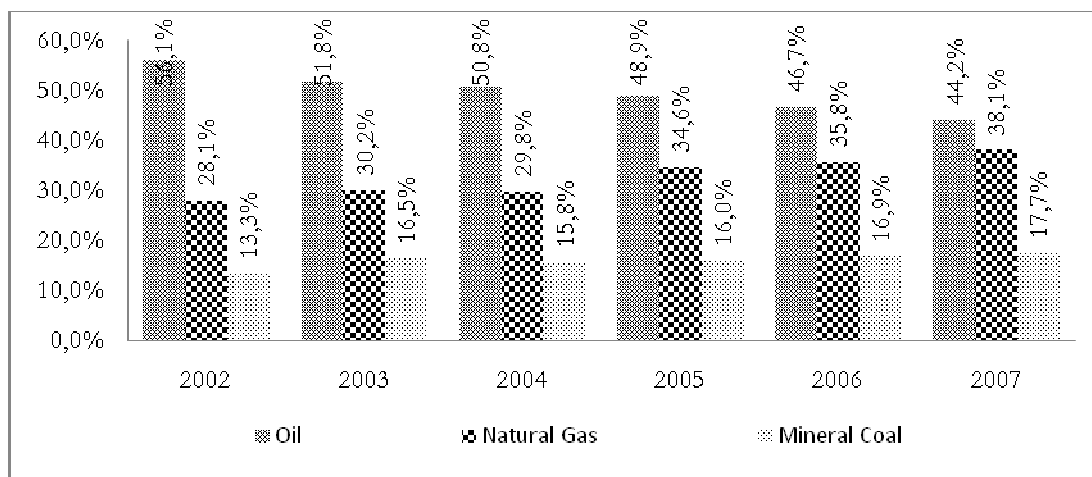


Figure 27. Percentage share of Turkish major primary energy imports

Turkey's Oil Outlook

Turkey has very limited oil reserves. In 1992, Turkey was able to produce 4.495 toe of oil which gradually fell year by year and became 2.223 toe in 2007. Thus, the shrinking in oil production was 50.5% in the last fifteen years. Turkey with its own oil resources was able to meet 2.1% of its overall energy demand in 2007.

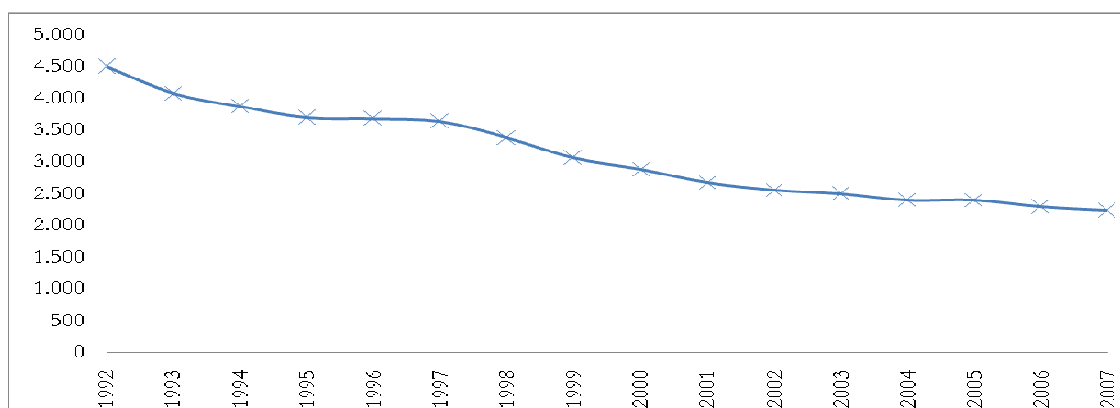


Figure 28. Turkey's oil production since 1992 in toe (TEM, 2008)

Turkey, consumed an average of 666 thousand barrels of oil in 2007. Tons equivalent of this figure is 33.482 making up 0.8 % of world's entire oil consumption. Since 1990, Turkey illustrated a rising oil consumption trend with marked interruptions in 1994 and in 2001, the years when the country experienced financial and economic crisis. However, in total, the boom in oil consumption is calculated as 35.3% in Turkey, since 1992.

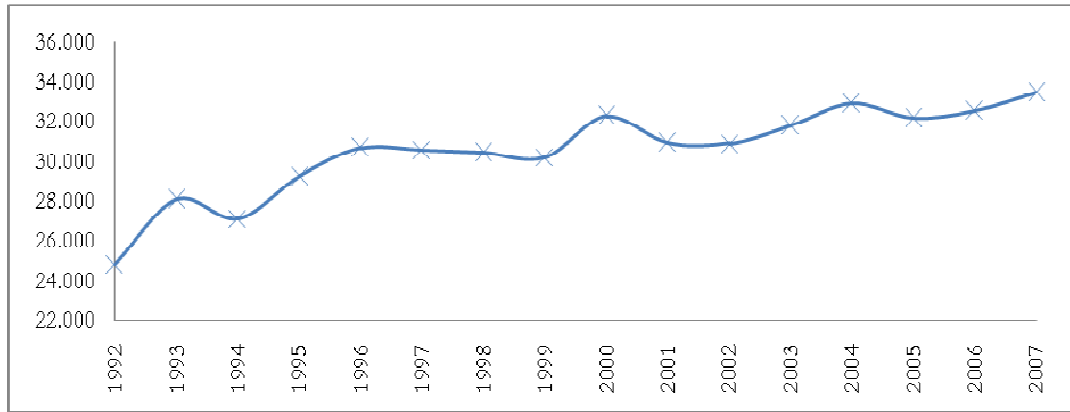


Figure 29. Turkey's oil consumption since 1992 in toe (TSI, 2008)

It is noticed that Turkey's oil consumption did not surge in great volumes after 2000 compared to the values mid 1990s. In 1997, Turkey spent approximately 30,615 toe of oil which only ascended by 9.3% in a decade and became 33,482 toe. Hence, the growth radically decelerated in the previous 15 years. In 1992, oil was composing 44.3% of the overall energy consumption where the figure became 40.1% in 2000 and 31.1% in 2007.

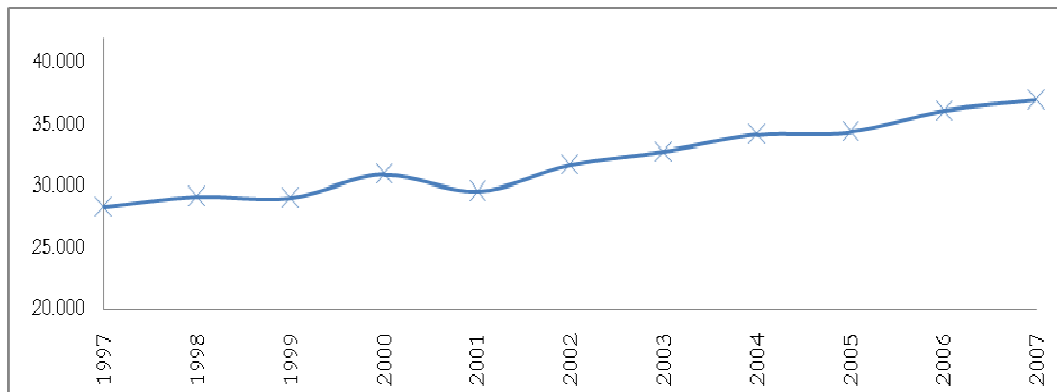


Figure 30. Turkey's oil imports since 1997 in toe (TEM, 2008)

The mismatch between the supply and demand deems Turkey as a net oil importer. Oil imports have risen from 28.264 toe in 1997 to 36.984 toe in 2007. It is inferred from the table that, oil imports have decreased by 4.5% in 2001, as an outcome of the financial crisis.

Turkey's Natural Gas Outlook

Similar to the case in oil, Turkey almost lacks gas reserves and it is far from being self sufficient. As per 2007 data, Turkey, with its own natural gas resources was able to meet only 0.17% of its overall energy consumption. It should be noted that, since 1997, although they are not quite large and promising reserves, new natural gas resources are being discovered. There was an increase from 232 toe in 1997 to 819 toe of natural gas production in 2007, signaling a 253% growth. Turkey began consuming gas after 1985. When the country had consumed 0.4 million tons of oil equivalent of gas in 1986, total consumption in the world was recorded 1.518,8. However, the consumption began to thrive dramatically after mid 1990s and reached to 6,313 toe in 1995, 13,728 toe in 2000, 24,726 toe in 2005 and 32.683 toe in 2007. From this perspective, Increase in Turkey's gas consumption is calculated as 252.7% in the last decade. In 1992, natural gas was composing 7.5% of the total energy spending where the figure became 17.1% in 2000 and 30.3% in 2007.

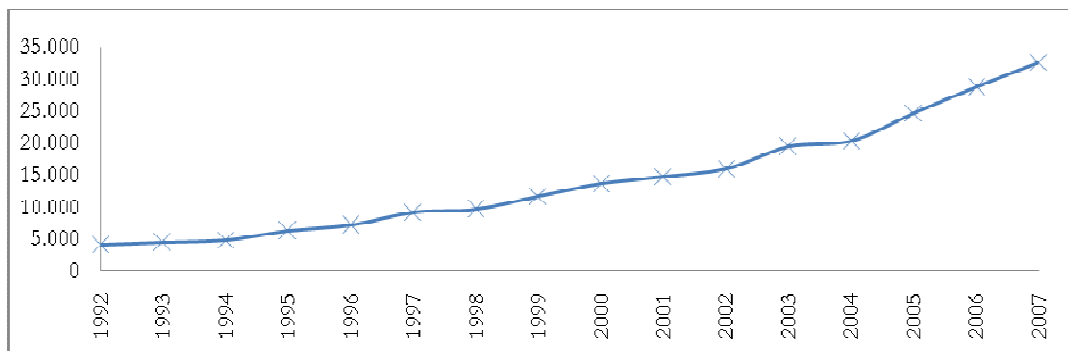


Figure 31: Turkey's natural gas consumption since 1992 in toe (ISI, 2008)

In line with Turkey's rising demand for natural gas, its imports have ascended tremendously too. As Table 28 shows, gas imports have risen from 9,069 toe in 1997 to 31,888 toe in 2007.

Turkey's Coal Outlook

Unlike the desperate view in oil and natural gas, Turkey owns a degree of coal reserves. As per 2007 data, Turkey holds 1.814 million tons of sub-bituminous and lignite coal reserves. This amount forms 0.2% of the world's proven coal reserves. On the production side, Turkey generated 14.331 toe of mineral coal and lignite and contributed to world's coal production by 0.5%. With this production rate, Turkey's R/P ratio for coal is calculated to be 24 years which is far below the world's average coal lifespan of 133 years.

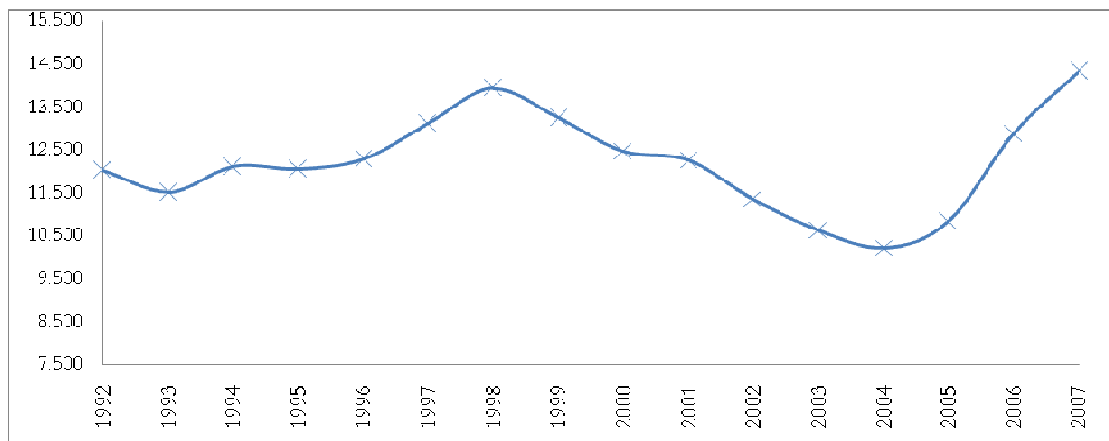


Figure 32. Turkey's total coal production since 1992 in toe (TEM, 2008)

In 1980s, Turkey's overall coal production varied from 6,000 to 12,000 toe whereas the figure was 12,054 toe in 1995, 12,478 toe in 2000 and finally 14,331 toe in 2007. The increase in coal production in the last fifteen years is calculated to be 19.2%. However, the majority of this growth is actualized in 2007 due to the increase in lignite production from 61,484 tons to 72,121 in a year from 2006 to 2007. From 1998 until 2004, a declining trend in coal production is observed. A great portion of Turkey's coal production is supplied via lignite. In 2007, 88.9% of the entire coal production was handled from lignite. Despite 23.7% increase in lignite's production from 1992 to 2007, mineral coal's production decreased 1,727 toe to 1,588 in the same years depicting a reduction by 8 %.

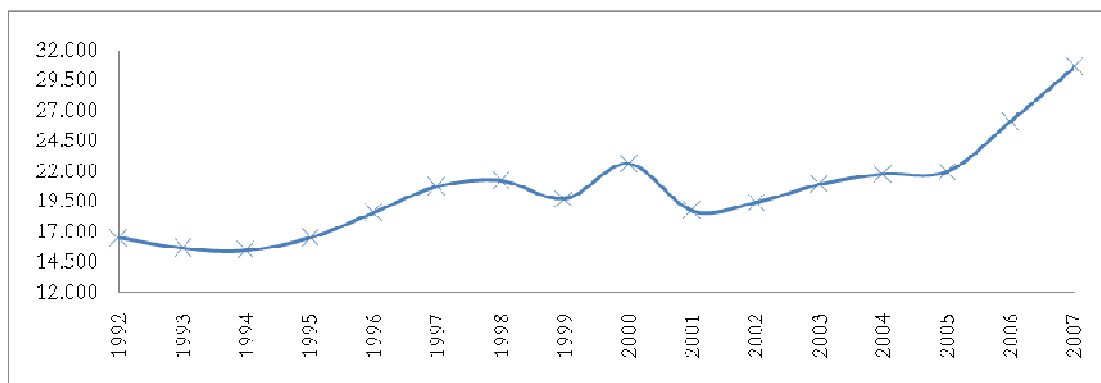


Figure 33 : Turkey's total coal consumption since 1992 in toe (TEM, 2008)

From the perspective of consumption, in the 80s, Turkey's coal consumption varied from 7,000 toe to 18,000 toe, where the figure was 16,510 toe in 1995, 22,666 toe in 2000 and 30,608 toe in 2007. The improvement in coal consumption was 81.1% in the last fifteen years. Among coal consumption, mineral coal is slightly more consumed than lignite. In 2007, 54% of the coal consumption was met by mineral coal whereas the figure was 46% for lignite. From 1992 to 2007, the augmentation in mineral coal consumption was 165.8 % whereas the growth was 30.5% for lignite.

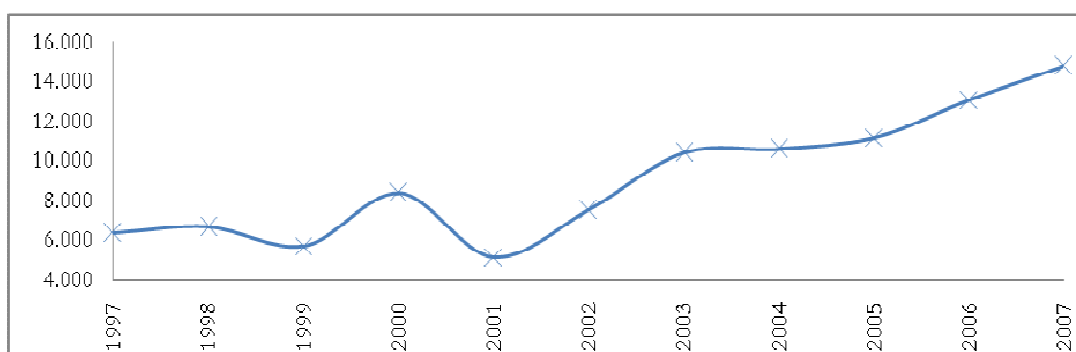


Figure 34. Turkey's total coal imports since 1997 in toe (TEM, 2008)

Although Turkey hosts a modest amount of coal reserves, its demand still exceeded the supply and turned the country to a net coal exporter as was the case in oil and natural gas. As Table 28 shows, Turkey imports coal in the form of mineral coal. Due to self sufficiency, lignite is not generally imported. In the last decade, Turkey's net coal imports rose by 131.6% toe.

This arithmetic indicates that, although Turkey owns some coal reserves and meet a portion of its demand through its natural resources, it is not completely self sufficient and the remaining lifespan of the coal reserves is quite limited. On the other hand, although coal consumption is increasing rapidly, its production does not grow in the same manner, indeed the production fell by 26.6% from 1998 to 2004.

Turkey's Renewable Energy Outlook

While Turkey has limited fossil energy resources and its energy demand is increasing, the importance of renewable energy is becoming more apparent. Since Turkey does not employ nuclear energy, the trends and developments in renewable energy production has gains additional importance.

Turkey's renewable energy production displayed a varying nature. From 1992 to 1998, the trend used to be upward, however after 1998, the production has declined. Downward trend has continued until 2004 and the process has reverted since then.

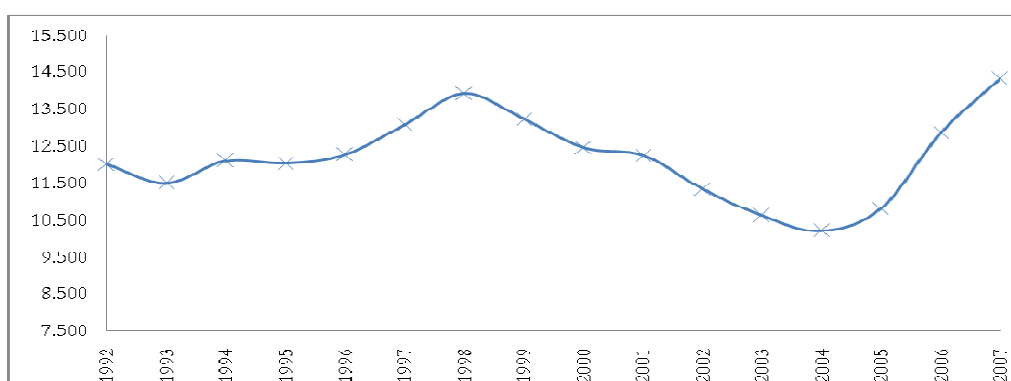


Figure 35. Turkey's renewable energy production since 1992 in toe (TEM, 2008)

Turkey's Hydroelectricity Outlook

Composing a central part of renewable energy, hydroelectricity consumption has fluctuated significantly in Turkey. As per 2007 data, Turkey consumed and produced 35.6 TWh of hydroelectricity. In 1987, Turkey had consumed 18.6 TWh of hydro energy, while the consumption was 35.6 TWh in 1995, the same standing achieved in 2007. The production was 42.2 TWh in 1998 and 24 TWh in 2001. It is noteworthy to

mention that Turkey's hydroelectricity consumption has been forming from 1% to 1.5% of world's overall hydro consumption since 1990.

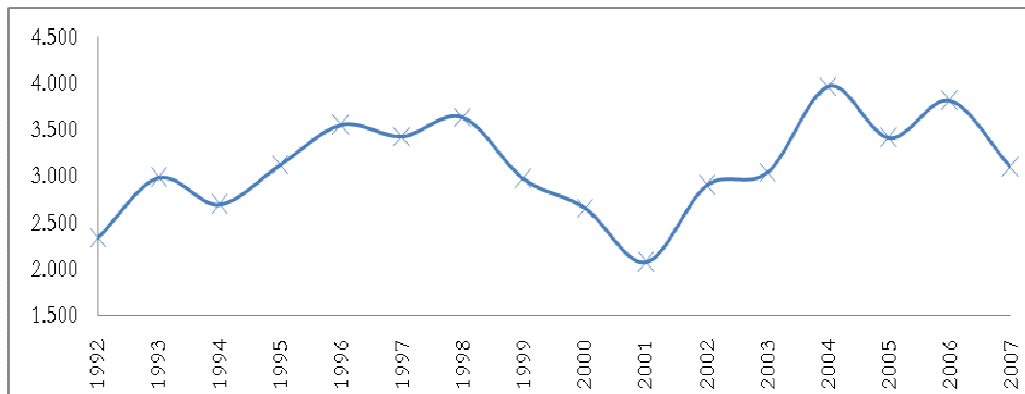


Figure 36. Turkey's hydro electricity production since 1992 in toe (TEM, 2008)

Turkey's Biomass Outlook

Turkey's energy generation through biomass, the organic materials from animals and plants including wood, crops and alcohol fuels have declined by 30% in the past fifteen years.

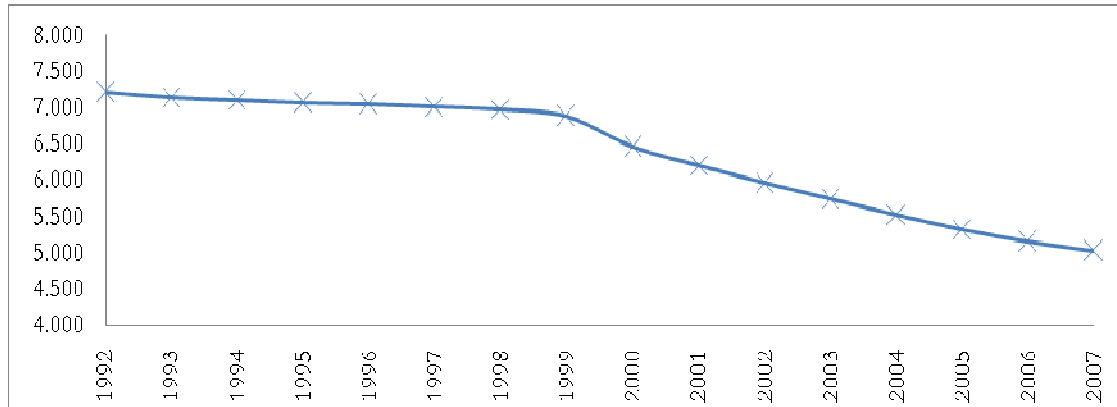


Figure 37: Turkey's biomass production since 1992 in toe (TEM, 2008)

A General Look to Turkey's Other Renewable Resources

Solar and geothermal heat's contribution within Turkish renewable energy consumption mix is increasing rapidly. In 1992, only 40 toe of solar energy was generated where it became 410 toe in 2007. From the perspective of geothermal heat, it increased from 388 toe to 914 from 1992 to 2007. Moreover, since 2000, Turkey is making use of wind power although its participation to energy production is very small.

As of 2007, 30 toe of energy is generated from wind power.

Turkish Electricity Market Review

As Turkey grew, its demand for electricity surged simultaneously. Excluding 2001, when September 11 events happened that led immediate rise of energy prices combined with Turkey's domestic banking system and exchange rate turmoil that affected total production in the country, consistent rates of increase in demand and production is observed. The growth since 1992 has been 183.8 %.

Electricity is one of the least traded forms of energy for Turkey since it is produced through a mixture of both local and foreign raw materials in domestic power plants. As mentioned previously, electricity trade shape almost 1% of total energy imports. Rather than importing electricity directly, Turkey imports the raw materials to produce electricity.

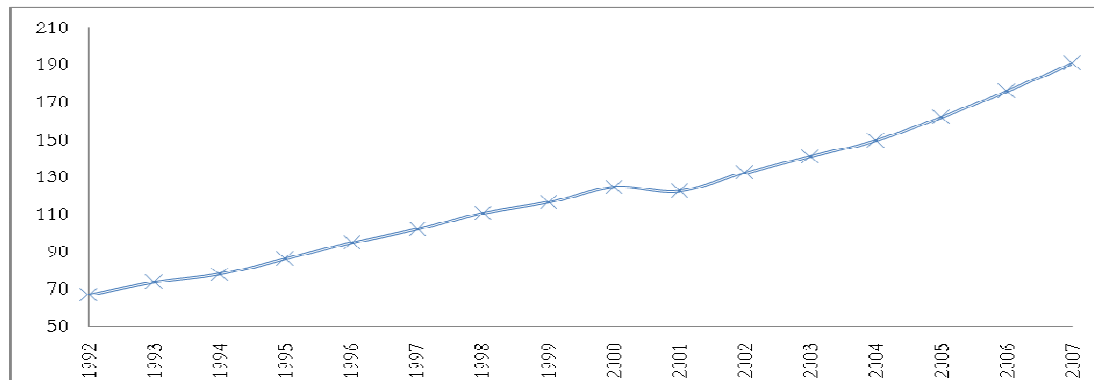


Figure 38. Turkey's electricity production since 1992 in TWh. (TSI, 2008)

As seen in Table 29, Turkey became a net electricity exporter since 2004. The ratio of electricity imports among the total consumed electricity do not exceed 3% implying that Turkey is self sufficient in terms of supplying its own electricity.

Table 29. Turkey's Electricity Trade – Imports and Exports in TWh since 1997 (TSI, 2008)

Electricity Trade (TWh)	Imports	Exports
1997	2,5	0,3
1998	3,3	0,3
1999	2,3	0,3
2000	3,8	0,4
2001	4,6	0,4
2002	3,6	0,4
2003	1,2	0,6
2004	0,5	1,1
2005	0,6	1,8
2006	0,6	2,2
2007	0,9	2,6

As of 2007, about half of the electricity supply was produced by the state authorities. 48.3% of the electricity is generated through the state company called Energy Production Inc. (EÜAŞ) and its subsidiaries. 23.6% of the output was from power stations that are operating under build-operate terms, 7.5% was from build-operate-concede terms, 9.6% was from licensed private sector and 8.4% was from auto-producer groups, leaving the rest to mobile stations.

In 2007, 80.9% of the production was supplied through thermal power plants, where the figure was 18.7% for hydroelectric plants, leaving only 0.4% to wind and other renewable energy resources. As of 2007, natural gas is used to generate 45.2% of Turkey's overall electricity where hydraulic plants served to produce 26.1%. The share of national coal for generating electricity was 19.9% where the share of imported coal was 5.8 %. Liquid fuel was the raw material for 2.7% of the total supplied electricity where the other forms have participated to production by % 0.3.

To sum up, Turkey highly relies on thermal resources to generate its electricity. Despite the increasing electricity demand, Turkish renewable energy production did not show a consistent pattern. For this reason, Turkey's import for oil, gas and mineral coal has increased over the past years.

CHAPTER IV

LITERATURE REVIEW

In this chapter, academic and application based studies regarding energy security, energy vulnerability and Turkey's energy insecurity is presented. Most of the study that is presented here is from academic papers, government resources and independent studies of the private initiatives. In this chapter, the literature is reviewed under three headings where the first part focuses on energy security, the second section investigates energy vulnerability and the last section focuses on Turkey's energy security and vulnerability.

Literature Review on Energy Security

According to Cambridge Energy Research Associates (2006), the concept "energy security" is about providing the energy supply that is able to meet the demand at a price level that does not destruct the overall balances of the economy in an environmental sustainable manner. Engaging a time and space dimension, the concept is precisely defined as (1) reliable supply of energy with plentiful primary energy sources and geographical suppliers; (2) reliable transportation of energy supply; (3) reliable distribution networks and delivery facilities of supply to final consumers; (4) maintaining reasonable energy prices over a continuous period. According to the institute, time dimension of the security of the energy supply is vital and involves technology, politics, economics, investments planning and weather conditions. The space dimension on the other hand indicates that disruption in energy supply may have local, national but also international causes and implications.

According to Jean-Marie Chevalier (2005), what is new about security of energy supply since 2000 is the exacerbation of uncertainties that are surrounding the world energy scene. For her, the uncertainties are structured around (1) climate change and environmental policies uncertainties which drastically increase market risks in terms of price and volume; (2) geopolitical uncertainties; due to the unstable or potentially unstable nature of energy exporter and transit countries especially after September 11; (3) regulatory uncertainties in the course of market liberalization were expected to enhance energy security, however these processes are complex and energy investors needs to take risk of regulatory changes into account; (4) the unexpected, covering highly unpredictable events like terrorist attacks, hurricanes, wars, heat waves, civil unrest, earthquakes, and SARS since the energy facilities are not designed and built to resist the unexpected when it happens.

In the EU report of “Towards a European Strategy on Energy Supply Security” (2001), the energy security issue had initially arisen from concerns about the physical energy supply security. However, recent concerns have been focused on the economic conditions affecting those supplies. Physical risk will remain as long as energy supply has to rely on transportation and related infrastructure. Diversification of energy resource suppliers reduces the chance of serious disruption to access to energy. There are several risks that could endanger the security of energy supply, such as exporting countries’ decision to use energy flow as a mean of political pressure tool. The option of a potential energy price shock is another risk, followed by continuing higher prices and its negative impact on the economy. This situation could create a long-term supply/demand imbalance, with the probability of serious tensions in national and international markets. In addition, these threats can have environmental implications at local, regional and international levels. Europe’s strong dependence on energy imports

was stressed in 2000. The report has foreseen a raise in dependency from 50 percent in 2000 to 70 percent in 2020 – 2030.

According to Egnard Gnansounou (2006), long term energy security is a globally prioritized topic on energy policy agenda due to the significance of issue within macroeconomic and military perspective. Among the reasons of concerns relating to rising energy insecurity, he points to rapid economic growth of in emerging countries such as China and India. Gnansounou mentions about two paradigms regarding the ensuring the security of energy supply. On one end is the trust towards market oriented instruments for optimizing the energy supply mixes where in the other more government intervention is argued. It is mentioned that the energy policy in the industrialized countries is presently navigating between these two paradigms with an uncertain cursor position.

Literature Review on Energy Vulnerability

Energy vulnerability is a highly differentiated concept which highly deviates from energy dependency and energy security. World Energy Council report (2007) focuses on the divergence between energy dependency and energy vulnerability. According to Jacques Percebois (2007), one can be dependent without being vulnerable and be vulnerable without being dependent. The vulnerability is rather a qualitative concept that helps to assess the scope of energy security where energy dependency is a quantitative one. For him, the independency rate measures the part of national energy consumption which is produced domestically whereas vulnerability expresses the unbearable dimension of an energy supply.

There are many parameters that compose the energy vulnerability index and the term can be apprehended at the level of a geographical region, nation state, energy firm

or a group of customers. Since vulnerability is multiform, various indicators to assess the vulnerability levels are introduced. (Babusiax, 2006) In broad terms, Babusiax analyses energy vulnerability at three phases and level. (1) Macroeconomic level - including parameters like import concentration, energy bill, energy intensity, energy dependency and diversification of the energy mix; (2) Microeconomic level - the standpoint of the consumers that is characterized by the risk of supply disruption and by the attendant increases of the price which is measured by stock levels, energy interruption levels; (3) Electricity balances that depends on “margin of capacity surplus”, “net import rate” and “interconnection rate”. Awerburch relate energy vulnerability with a country’s overall macroeconomic balances. Since fluctuations in energy prices alter energy bill, energy intensity and dependency leading to alterations in the balance sheet of a country. It is crystal clear that high prices had a strong negative impact on economic growth and oil demand. However the question of how energy prices variations impact economic growth is a difficult question.

Slav Slavov and Jean Eudes Moncomble on behalf of World Energy Council identify energy vulnerability as a multi-dimensional quantity and introduce a variety of factors. These parameters are energy dependency rate, cost of energy imports, price volatility, exchange rates, technology, energy transport facilities and etc. Taking all these factors into consideration, they argue that definition of vulnerability indicators is possible for different sectors, for different energies, for market dynamics on the supply and demand side and for macroeconomic costs and prices. To assess imports concentration, they use Hirschmann-Herfindahl index or Shannon-Wiener index alternatively in the report of Dutch Energy Research Centre – ECN (Jansen et al., 2004; Schaeppers et al. 2007). In the report, some additional dimensions like diversification of energy sources, long term political stability and depletion of resources in regions of

origin is addressed. To assess energy bill, Slavov et al. advise factoring dependency rate with energy intensity and average energy cost. In their study, they also talk about Europe's shift from extensive use of solid fuels in 1960s to natural gas, nuclear and renewable energy in 2005 and argue that rising energy mix within the EU-15 has broadened and led to reduced risks of energy supply but some of the new energy resources show high price volatility like natural gas or production volatility like the renewable energies.

Gupta (2008) applied component analysis method and used the eigenvalues to determine the importance of principle vulnerability indicators. According to this approach, the weight of a principal component is as high as its contribution to the total variability of observations. Hence, it might be questionable if the weights should be derived from subjective approaches relating to their contributions to the overall concept of energy vulnerability or from objective means on the observation's variance.

In his paper Gnansounou (2006) has merged all indicators of energy vulnerability on five distinct dimensions. These are (1) Energy intensity of the Gross Domestic Product, (2) Energy import dependency, (3) Energy related carbon dioxide emissions as against the TPES, (4) Electricity supply vulnerability and (5) Non diversity in transport fuels. Gnansounou normalized various indicators to values between zero and one with a formula and then ranked 37 industrialized countries in accordance to their performance. According to his ranking, Canada is found to be best performing country in energy vulnerability whereas southern Cyprus performed the worst. Turkey is listed as the 28th country among 37 signaling that higher levels of energy vulnerability exist within the country.

Walter Carlsnes (1988) links energy vulnerability issue with national security. Moving from the proposition that being vulnerable to foreign threats would seem to be

particularly risky for a country whose foreign policy is neutral; Carlsnes argues that given the logic of Sweden's neutrality, vulnerability to energy that characterize the country's beholdenness to the international environment remains a fundamental national security problem. In this context, energy policy and foreign policy of even neutral states are associated. Carlsnes relates Swedish foreign policy neutrality to the notions of vulnerability and credibility in Sweden's relationship with the superpowers. He points that the autonomy on which Swedish foreign policy is based is undermined by energy policies which are not a credible basis for neutrality. To cope with energy vulnerability, on top of diversifying its energy suppliers, Swedish government prepared a referendum for the establishment of nuclear plants and the citizens voted for this precaution.

According to Yergin (2006), the objective of energy security is to assure adequate, reliable supplies of energy at reasonable prices and in ways that do not jeopardize major national values and objectives. Moving from this assumption, energy vulnerability is about energy security caused due to the lack of sufficient domestic supplies. According to Andrews (2005), energy policy is debated because "there are high stakes and sharp ideological differences". In order to reduce energy vulnerability, supply and demand side policies are proposed. In the supply side policy, commercial energy's conversion, extraction, transmission, distribution and exploration is focused whereas on the demand side measures relating to effective energy consumption, load shifting and re allocation of demand to off-peak periods.

In the energy white paper of the UK government with the report *Our energy future – Towards a low carbon economy*, it is stated that United Kingdom consumes more energy than it actually needs. It is emphasized that the cheapest, cleanest and safest way of shaping the energy policy is to use less energy by consuming energy efficiently. To be

able to manage this objective, measures to reduce emissions are introduced. On the other hand, the importance of delivering the savings through a mixture of policy tools such as emissions trading, energy efficiency commitment, tax incentives and product regulations are proposed. The reports indicates that, although the United Kingdom has been a net energy exporter, the forecasts say that the country will be dependent on energy imports and thus will be more vulnerable energy related issues shortly. The strategy of UK government within this perspective is to closely following up market related dynamics, diversifying resources, working with private sector and producer nations to promote the conditions needed for investment in energy infrastructure, designing effective policy and regulatory framework.

In DOE report of the United States (2008), it is mentioned that global energy demand is estimated to surge by over 34 %. The American economy's reliance on fossil energy is expected to rise too leading to greater energy security and vulnerability concerns. In this context, United States government's administrators needs to work hard in order to diversify its energy supply by promoting alternative and renewable sources of energy, to encourage the expansion of nuclear energy in a safe and secure manner, to increase domestic production of conventional fuels and investing in science and technology. On the other hand, US government develops policies to increase energy efficiency and conservation, modernize electric power infrastructure and expand the strategic petroleum reserve. Patrick Clawson and Simon Henderson (2005) in their article Reducing Vulnerability to Middle East Energy Shocks argue that high oil prices, Gulf region's instability and the tensions in the Middle East adds up to energy vulnerability of the United States. This volatile region may lead to disruption in the inflow of energy to the country. As part of a broad national strategy to reduce vulnerability and the dependence on foreign energy supplies, the United States needs to

invest in ways to make energy markets less vulnerable to sudden changes especially that might occur in the Middle East. In this context, several foreign policies related measures are suggested to protect the global energy infrastructure by encouraging political reform as part of the fight against violent extremism and by promoting antiterrorism “best practices” abroad. Williams and Alhajji (2003) in their paper “*The Coming Energy Crisis?*” United States is as vulnerable and in most cases more so, than at the time of 1973 Embargo.

In his paper *Coping with Energy Insecurity: China’s Response in Global Perspective*, Kent Calder (2006) stresses to China’s substantial and rising energy imports and surging overall energy demand. The IEA expects that China’s primary energy demand will rise at 2.7 percent annually in the period 2000 – 2030 while the global energy demand is likely to grow by 1.7 percent. Calder indicates that China’s energy policies within the context of vulnerability will attract more attention ever for the future periods of time as approximately 70 % of China’s primary energy consumption is provided via coal which China is highly self sufficient with nearly 13 % of world’s proven reserves. However, with rising energy demand, need for new forms of energies like oil and natural gas are estimated to rise too. According to International Energy Agency, oil dependency of China is expected to rise from 30 percent in 2000 to 55 percent in 2010, 68 percent in 2020 and around 74 percent of total demand by 2030. Deepened import dependence will bring a set of energy vulnerabilities for China. According to author, Chinese analysts perceive United States as a potential threat to Chinese energy security. Considering the fact that economic sanctions are vital tools used by United States especially after the Cold War, 7,000-mile sea-lane domination from Shanghai to the Straits of Hormuz through which half of China’s oil supplies must pass by American Navy is a potential threat in this context. Thus, China works hard to

reduce its energy vulnerability. To be able to reach this objective, the country should (1) geographically diversify its energy supplies, (2) increase its energy efficiency, (3) shifting a portion of oil reliance towards nuclear power, natural gas and hydroelectric power, the supply of which is less susceptible to sea – lane interdiction, (4) Reducing reliance on international majors, while conversely increasing the share of energy imports flowing through Chinese owned or controlled intermediaries; and (5) strengthening the military infrastructure and ability to independently protect Chinese energy supplies.

Toichi (2006) focuses on Japan's excess reliance on natural gas and oil imports and stresses that such situation posed serious threats for Japanese energy supply in the recent years. In his paper Japan's Energy Strategy, Yasou Tanabe (2005) identifies four key strategies of Japan's energy policy. (1) Establishment of an International Energy Strategy focusing on Asian Regional Cooperation. For Tanebe, from the phase of supply to consumption, formation of the market system requires the constant government engagement since the market function is affected by geopolitical elements. In this context, he identifies the "to do" list on the supply side as developing the condition that makes supply capability built out of resource potentials, strengthening relations with energy exporting countries, diversifying supply resources whereas on the demand side, introducing and strengthening the emergency response, strengthening the function of energy markets in Asia – Pacific region and encouraging energy efficiency. (2) Encouraging energy saving and environmental protection efforts by enhancing public awareness. (3) Diversification of Energy Supply and (4) Robust and flexible energy supply system by promoting the utilization and liberalization of distributed energy resources and by optimizing energy supply systems.

Ken Koyama (2008) points that, rising energy prices, rapidly growing energy demand, and excessive competition for access to energy resources, growing geopolitical

risks, emerging resource nationalism, linkage between energy market and financial market and environmental challenges for sustainability are some vital factors of growing import dependency which is perceived as vulnerability. Koyama stresses to the importance of environmental problems as an emerging challenge. In this context, global warming, local environment problems should be addressed globally and in a long term perspective. According to him, Kyoto target is short-term up to 2012 with limited impact on capping global GHG emission. In this context, there are options and measures taken in Post Kyoto framework. In this context, he proposes (1) Fair burden sharing based on globally shared long term vision and scientific and objective data; (2) best utilization of effective policy options to combat global warming as an externality; (3) importance of technology and adaptation while effect of global warming is expected to rise. Furthermore, Koyama talks about some challenges for energy conservation, renewable energy and nuclear power. Within the perspective of renewable and energy conservation, he focuses on importance of further research and development, technology transfer and environmental protection while safety issues, public acceptance, emerging terrorist tendencies and rising international attentions and discussion on non – proliferation issue and control on nuclear fuel cycle are the challenges within the context of nuclear power.

Clark Wilson and Jake Page (1981) in his book *Energy, Vulnerability, and War: alternatives for America*, proposes that the extreme centralization of US' central energy systems and rising dependence on unstable energy import suppliers could lead to dangerous events involving a potential enemy attack to American energy infrastructure. For him, the "United States has reached a precarious state of national vulnerability," not only because of dependence on imports but also because of the "less obvious danger of the centralized nature of our high-energy, technological society." He warns that the

more United States centralize its energy systems, the more it stick out to its adversaries a reachable chin, in the form of a small array of big and important targets. Thus the enemy might believe that quite simply and at little cost, they could cripple the country. He mentions that “it would take a minimal attack by an adversary, or only a relatively unsophisticated strategy on the part of a band of terrorists, to bring to its knees the energy system of the United States". As the precaution of such negative outcomes, he suggests alternative decentralized of energy resources and the internalization of the energy supply through conservation and intensive usage of solar energy. This book is interesting in the sense that, given that it was written in 1981, it accurately foreseen the energy related challenges that United States may face with in the future.

According to Colin Kearton and Brian Martin (1989), technology composes and integral aspect of certain vulnerabilities including energy what they call as “technological vulnerability”. For them many technological systems are vulnerable to threats including sabotage, attack, sudden macro-economic alterations or social estrangement. They argue that technological vulnerability has been sparse, unsystematic and driven by events. The area of greatest interest has been energy, triggered by the threats to exports of Middle East oil from 1973 onwards. This has led to examination in oil-importing countries of a variety of strategies, including stockpiling, rationing, indigenous oil production, alternative sources of imports, energy efficiency, and developing non-petroleum energy sources including coal, nuclear and solar power. In order to reduce such vulnerabilities, the authors propose the followings. (1) Direct planning (2) Decentralization of large energy systems to smaller – Japanese electricity supply system during 2nd World War was based on smaller scales of hydro plants and therefore was virtually impossible to destroy by bombing, (3) Diversification of energy resources to increase resilience, (4) Self reliance – different from self sufficiency, self-reliance covers being able to get by with

one's own resources. Its implication includes using imports, outside experts and assistance to some degree, but not becoming completely dependent on them. (5) Simpler cost – effective systems, (6) Public participation in planning and instituting programs of civil defence considering the serious possibility of nuclear attacks.

Literature Review on Turkey's Energy Security

The majority of energy vulnerability related studies focuses on energy security. In his paper Hakan Soyhan (2008) while focusing energy's strategic importance for developing economies, he proposes that Turkey has important comparative advantages in case its energy politics is governed properly. He argues that, Turkey is advantageous with all energy resources existing in the country however the resources other than lignite and hydropower are not still used efficiently to meet internal energy need. Renewable energies opportunities mainly in the form of geothermal, biomass, solar energy, wind and hydropower exists for the future that might contribute for reducing energy vulnerability. However, transition to such renewable energy systems requires further investments and political framework. In this context, he mentions the necessity of establishing nuclear energy. Çiçek et al (2007), indicate that the reasons of the failure of many renewable energy projects are related to the management of such projects. On the other hand these projects are expensive and mainly used premature under-research technologies. They argue that, once the renewable energy facilities are established, they add up to energy security of the country. However it is argued that the present market conditions for investing in renewable energy is not good since the wholesale price of electricity is high, since a majority of the production is provided through oil and gas.

Although the importance of renewable energy is stressed within the context of energy security and vulnerability, Turkish Energy Ministry's report regarding future

consumption estimates worth grabbing the attention. While in mid 2000s, the contribution of fossil energy resources within the consumption mix is around 80 %, this share is expected to rise by 2 % in 2030. According to the report, the demand for natural gas is expected to surge the most. In order to reduce vulnerability, to cope with price volatility and limitations towards carbon dioxide emissions forwarded the attentions for nuclear energy. By 2020, nuclear energy's share is estimated to be 4 %, where hydraulic and other renewable types of energy is expected to be 5 and 4 percent respectively. The government has targeted to hold energy dependency by 70 % in 2020. According to projection coal demand will rise to 36 % in 2020 whereas the oil's share will drop to 28 %. In order to actualize the full potential of lignite and hydraulic energy, the report talks about scarce financial resources for investment which is aimed to resolve by attracting domestic and foreign private initiative?

In his paper "Some thoughts on the Turkish electricity distribution industry", Erkan Erdoğan (2008) focus on the necessity to conclude Turkish electricity reform. Being an important parameter of energy vulnerability, for the author electricity market requires extra attention. The main reform should involve transferring the responsibility of operations and investment to private sector. Since the government does not have capacity to invest and ensure the supply of electricity, electricity market should be liberalized more than ever. In this context, the importance of privatization is stressed.

To sum up, although in the literature the number of studies regarding energy security is plenty, it is usually associated with foreign policies and is discussed as a part of government policy. Thus the studies regarding Turkey's energy politics are in abundance. However, the works related to energy vulnerability is quite limited. The works that defines the energy vulnerability criteria for Turkey and makes calculations

over those defined parameters and compares the results with the countries that could be set as a basis for comparison are not too much. The study of Gnansounou in his paper “Assessing the Energy Vulnerability : Case of Industrialized Countries” (2008) ranks Turkey as the 28th most energy vulnerable country among 37 industrialized countries. In his study, the energy vulnerability is assessed under five distinct indicators.

The following chapter defines energy vulnerability and its indicators and computes Turkey’s standing on these indicators which later compares its performance with the EU.

CHAPTER V

ENERGY VULNERABILITY INDICATORS AND THEIR ASSESSMENT FOR TURKEY

Energy vulnerability refers to a qualitative concept that measures the sustainability and continuity of a system's macro balances in case of adverse energy related events. It represents the unbearability level of energy supply in face of damaging and critical situations. For a nation state, ability to cope with such unfavorable incidents designates the degree to which said country is vulnerable to an energy crisis. It is noteworthy to mention that, such adverse events should have a reasonable likelihood to occur whose probability could statistically be expressed or could be regarded plausible to happen.

Distinguishing between energy dependency and energy vulnerability is vital in the sense that energy dependency is rather a quantitative concept that measures national energy consumption that is obtained through non – national resources. Higher domestic production rates indicate higher energy independence of a nation state. According to Europe's Vulnerability to Energy Crisis Report by World Energy Council (2008), energy vulnerability is a broader term that covers the context, content and circumstances of energy consumption and production motives. An energy independent country might be vulnerable whereas an energy dependent country might have less degrees of vulnerability. For instance, a self energy generating country could be vulnerable if it exercises obsolete, expensive and unsustainable production facilities while a country which imports energy through a diversified supplier portfolio at sustainable costs deem to be less vulnerable. A net energy exporting country's vulnerability is likely to rise in

case of a fall in energy prices whereas an importer country's vulnerability declines under such conditions.

Market oriented developments, macro economic conditions, political developments and natural disasters might compose a portion of incidents shaping energy vulnerability. Volatility of energy prices, changes in energy demand, depleting energy resources, political instabilities in energy exporting countries, unrenowable nature of energy produced, climate change and etc are some of the parameters ascending energy vulnerability levels. Following section will discuss the parameters and indicators of energy vulnerability.

Energy Vulnerability Indicators

Since energy vulnerability stands for a qualitative concept, there clearly is no single quantifying method that objectively and factually measures it. Being a multi dimensional term, we need indicators to fully comprehend it.

- Import Dependency

Energy dependency composes an integral aspect of the overall energy vulnerability of a state. The more a country's energy supply is dependent on external resources, the more vulnerable its energy systems are. Energy dependency is assessed by calculating the ratio of imports among overall energy consumption.

- Import Concentration

Vulnerability is highly linked with excess energy import dependency. Using external energy resources through a limited amount of suppliers is a factor leading to greater energy vulnerability. In the literature, Hirschmann – Herfindahl index (HHI) is used as a technique to assess supplier concentrations of the relevant country.

$$HHI = \sum_{i=0}^n s_i^2$$

where n is the total number of countries that energy resources are imported from and s_i represents the market share in the energy supply of the supplier country. The cumulative HHI value of a country's energy mix is calculated by deriving each of energy type's HHI value and weighting them with their contributing consumption shares.

- Energy Intensity

Energy Intensity represents energy consumption as a proportion of a country's GDP. As the proportion of energy related consumption as a percentage of GDP increases, vulnerability of relevant country tend to rise (Suehiro, 2007). The more a nation is willing to use energy effectively, to use modern and advanced production facilities and to conserve energy, the more energy intensity is ready to fall and thus to reduce vulnerability level.

$$EI = \frac{\text{Total Energy Consumption in tonnes of oil equivalent}}{\text{Gross Domestic Product}}$$

- National Energy Bill

There is a direct link between the cost of energy and vulnerability. Although there are various elements included in energy bill calculation, according to Europe's Vulnerability to Energy Report (2008), it can be expressed as follows:

$$EB = ED \times EI \times AC \times ER$$

where alternatively, EB stands for the total cost of net energy imports expressed in USD (EIB) in relation to Gross Domestic Product.

$$EB = \text{EIB} / \text{GDP}$$

ED stands for the energy dependency rate representing the percentage of energy imported among total primary energy consumption in toe.

$$ED = \frac{\text{Net Energy Imports}}{\text{Total Energy Consumption}}$$

AC stands for the average supply cost of the energy portfolio imported which is calculated by dividing net energy imports bill expressed in USD by net energy imports expressed by toe.

$$AC = \frac{\text{Net energy imports bill}}{\text{Net energy imports}}$$

ER is the average dollar to TRY exchange rate. Since exchange rates compose an integral aspect of energy vulnerability, it will separately be reviewed as an indicator.

Higher average per unit energy costs, unfavorable exchange rate of local currency, higher energy dependency and high levels of energy intensity adds up to total cost of the imported energy in relation to GDP.

- Carbon Content of Primary Energy Supply

Due to global climate change, greenhouse gases, CO₂ emissions in particular, became more costly than ever. The carbon dioxide content of total primary energy supply (TPES) depends primarily on the reliance of the supply on fossil energy sources. The more the percentage of CO₂ emissions in TPES, the more the country is vulnerable to an energy crisis. Under the commitment of Kyoto protocol, nation states are obliged to keep their carbon emission below a certain limit. As per Kyoto, industrialized countries need to reduce their emission that was actualized in 1990 by 5.2% (UN, 1997)

Countries having a significant market share of coal and oil in Total Primary Energy Supply (TPES) have a high rate of carbon content whereas states making use of natural gas and nuclear tend to score better in this indicator.

- Price Volatility

There exists a correlation between energy vulnerability and volatility of energy prices. Since the energy sector is highly capital intensive some investments are profitable only in the long run. Due to astronomic levels of the sunk costs, investors will opt for investment choices with a short payback period and low risk. Hence, a mechanism to balance and to stabilize the prices energy supply portfolio should be constructed. Since oil and natural gas prices are connected to each other, encouraging consumers to use natural gas when the price of hydrocarbons should be questioned. Stability mechanisms will help to lower energy vulnerability to preserve some segment of the industrial sector from excessive energy prices fluctuation.

Fluctuations in the prices alter the vulnerability levels of the countries in either way depending on their national energy supply. Price volatility has different impacts on net energy exporting countries as it has a direct effect on the amount of revenue generated.

According to Cobb (2006), there are various different methods of assessing volatility which, if not carefully distinguished and understood, can lead to great confusion. According to him, the formulation of the volatility analysis changes depending on the underlying number of observations.

Letting X_t denoting the price of a fuel at time t , δX_t refer to the change in price X_t over a very small but finite interval δt . When started with a large number of daily observations in a series with time measured in years; assuming 252 trading days per year,

δt becomes 1/252. To help with the notation, let $D(x)$ stand for the standard deviation of a random variable x , is

$$D(x) = \sqrt{\text{Var}(x)}$$

Applying a change of variable formula, a transformation of $Y_t = \ln X_t$. Then the daily volatility is expressed as

$$D(\delta Y_t) = \sigma \sqrt{(\delta t)} = \sigma * \sqrt{252}$$

For Cobb, the relationship suggests that the volatility σ as the standard deviation of a series of daily observations can be forecasted

$$\delta Y_t = \ln(X_{t+\delta t}/X_t) \text{ for } t = 0, \delta t, 2\delta t, \dots, \text{ using the relationship}$$

$$\sigma = D(\delta Y_t) * \sqrt{252}$$

If data are available only once per month, 12 times per year, then the standard deviation of the monthly observations will be $\sigma \frac{1}{\sqrt{12}}$. Similarly, if the data are only annual, then the standard deviation of the annual observations will be simply σ .

- Electricity Market

The risk of blackout in the electricity sector is another parameter shaping energy vulnerability. Unlike oil and natural gas, since electricity is a non – storable commodity, electric supply either in the form of production or import needs to contend with an unexpected spike in demand. Below are the vulnerability criteria within electricity market.

Supply – Demand Mismatch: How comfortable is the electricity system of a country in the peak demand period to prevent an energy failure is a vital prerequisite for decreasing the degree of energy vulnerability. An interruption in the electricity for end users causes a cost and thus adds up to vulnerability. The cost is shaped by the structure of the electricity market, the behavior of electric supplying companies, correct demand estimation, quality and scope of production and distribution facilities. Achieving the optimum does not require reaching to zero percent failure but rather to be in the position of supplying electricity to the correct customers. In this context, energy vulnerability of countries is directly related with how far they are pinned in the optimal probability of failure spectrum. In order to assess the vulnerability under this heading, energy imports as a percentage of total consumption could offer a metric to comprehend the scope of mismatch between instantaneous energy demand and supply. Since electricity cannot be stored, reliance on foreign countries for electricity supply implies a very high risk. Countries will be reluctant to be dependent on such a strategic good. On the other hand, imported electricity is costlier than the locally produced one. Importing electricity could be a rational solution in case local production is not sufficient to meet some region's unexpected peak demands.

Resources used for power production: The means of producing electricity designates the degree of a country's energy vulnerability. If a nation state is relying on costly and vulnerable means of electricity production facilities then its electricity market is more sensible to adverse energy related changes.

Interconnection rate with neighbors: Connection with neighboring countries increases the opportunity to enhance mutual assistance and limits the risk of failure. European Union recommends an interconnection rate of 10%. In this context, geographical location of a country has an indirect effect on shaping the vulnerability

levels in terms of the number of bordering countries, island / mainland divide, resource facilities of the neighboring countries and etc.

- Exchange Rate

Variations in currency exchange rates are linked with energy vulnerability. An increase in the exchange rate can make energy imports more expensive for energy importing countries. Even if the price of the energy commodities stays intact, stronger foreign currency can make oil imports more costly leading the country's vulnerability levels to rise.

- Present Energy Import Contracts

Bilateral agreements between the energy exporting and importing countries regarding their terms of cooperation designate a parameter of those countries' energy vulnerability levels. For a net energy exporter state, contracts limit the uncertainty regarding the volumes of energy to be sold and revenue to be generated. For an importer state on the other hand, contracts ensure the continuity of energy supply and approximate price to be paid. Although energy related contracts may stand as a hedging mechanism towards price volatility, it might add up to the vulnerability level of a country in case the signatories involve in a long lasting binding terms as the energy market performs higher degrees of fluctuation and variation.

- Geographical Indicators

Geographical location of a country is linked with its energy vulnerability. Representing a constant indicator, geography of a state to a certain extent dictates its playground. Parameters of energy vulnerability under this indicator could be summarized as follows:

Regional proximity to energy exporting countries: Although the distance from energy exporting countries compose a vital portion of the cost of energy imported, being geographically close to areas have a positive effect on decreasing energy vulnerability as regional proximity increases the probability to ensure the continuity of energy supply in response to adverse events. Accommodating and being close to energy transfer lines (i.e. pipelines) is of the advantage for energy importing countries.

Opportunities for alternative and renewable energy resources: On top of the fact that the existence of traditional fossil and renewable energy resources is a key parameter in shaping the degree of energy vulnerability, variables like duration of daylight, wind blow rates, raining patterns, existence of geothermal resources and etc are at critical importance as they make up renewable energy opportunities in a country enabling it to shift to a cheaper, cleaner and more sustainable energy production structure.

- Investments

Technical advancement levels of energy production and extraction units determine the efficiency levels. Modern plants with newer technologies tend to be more efficient. On the other hand, research and development studies that are being undertaken in the country are vital factors that may help to reduce energy vulnerability. In this context, budget allocation for R&D studies, on-going projects, institutional investments on energy related projects are some of the criteria that may enable a country to develop alternative energy resources or to come up with techniques that uses less energy to generate the same volume of power.

- Political Factors

Political factors cover both inter-governmental and domestic politics dimension of energy vulnerability. Any issue that is present at the governmental politic level is an

area of concern under this indicator of energy vulnerability. Political instabilities in energy exporting countries and pipeline hosting countries, reciprocal relations between the exporter and importer states as well as the capability to secure the internal flow of energy have all an impact on energy vulnerability.

Calculation of Indicators for Turkey

In order to comprehend the levels of Turkey's energy vulnerability, each of the above indicators are calculated in the following sections. For the calculation of quantifiable parameters, the data is obtained from Turkish Statistics Institute and Turkish Energy Ministry.

Import Dependency

Import dependency measures the extent to which a nation state is dependent on foreign countries to sustain its energy supply. In broad terms, it is sourced due to the mismatch between domestic energy production and consumption. Turkey's import dependency is calculated using the data from Energy Ministry. In order to assess Turkey's standing in this indicator, energy production and consumption tables are obtained in the units of thousands of toe. Evaluation under this single unit of measurement offers us the opportunity to comprehend the picture better as the original units of each energy item vary.

It should be stated that, energy consumption is not simply equal to the sum of overall imports and production since all energy products are not produced or imported for domestic spending only. Moreover energy commodities might be stored for later consumption or be exported to other countries. For this reason, while calculating energy dependency, the ratio of imports to consumption should be taken reference rather than calculating energy independency by dividing total production to total consumption and then deriving dependency. In the table below Turkey's energy consumption and import data is presented from 1992 to 2007 and the corresponding dependency of the year is calculated simply by diving imports to consumption.

Table 30. Turkey's Energy Imports, Consumption and Energy Dependency Rate

Year	Imports (toe)	Consumption (toe)	Dependency
1992	31,864	56,135	56.76%
1993	35,861	59,462	60.31%
1994	34,476	58,257	59.18%
1995	39,351	62,954	62.51%
1996	44,274	68,154	64.96%
1997	47,221	71,691	65.87%
1998	47,520	73,082	65.02%
1999	48,932	72,716	67.29%
2000	57,052	78,584	72.60%
2001	53,227	73,589	72.33%
2002	56,514	76,320	74.05%
2003	63,304	82,074	77.13%
2004	67,190	86,200	77.95%
2005	70,210	89,199	78.71%
2006	77,513	98,138	78.98%
2007	82,985	107,625	77.11%

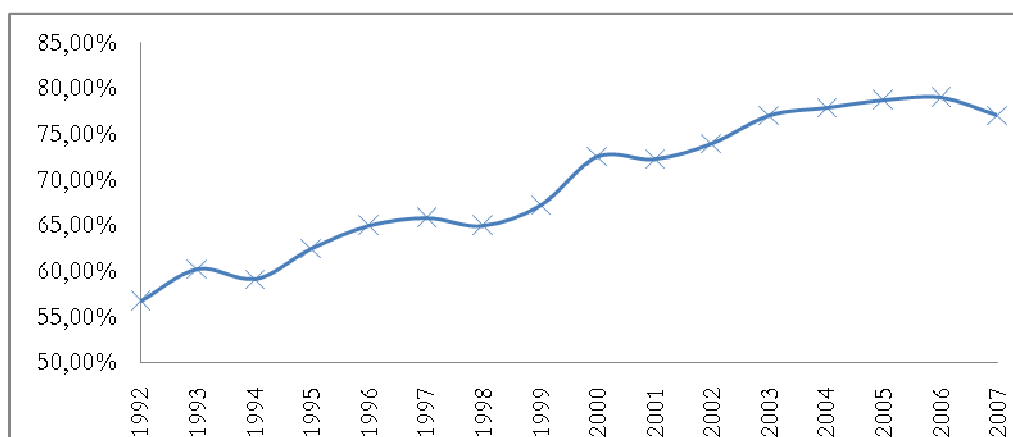


Figure 39. Turkey's import dependency since 1992

Turkey's energy dependency has increased gradually from 56.76% in 1992 to 77.11% in 2007. The dependency made its peak high in 2006 with 78.98%. Following sections evaluate individual energy type's dependency of Turkey. The calculations in below sections employ the import and consumption data presented in Chapter 3.2.

Oil Dependency

Since Turkey lacks its own oil reserves, it is highly dependent on supply from external resources. In 1997, oil dependence ratio was 93% but this figure has later climbed over 100% in 2000 and this trend continued until 2007. In the table below, Turkey's dependence to oil in the last decade is depicted. For the years that the imports have exceeded consumption, dependency is simply taken as 100%.

Table 31: Turkey's Oil Dependency From 1997 to 2007

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Dependency	93.00%	96.30%	96.50%	95.50%	95.50%	100%	100%	100%	100%	100%	100%

Composing 31.1% of the overall Turkish energy consumption according to 2007 data, oil imports embodies an important aspect of energy insecurity and vulnerability of Turkey.

Natural Gas Dependency

Very similar to the pattern of oil, natural gas inflow to the country relies greatly on the continuity of imports from energy exporter countries. Unavailability of domestic natural gas resources led Turkey to score dependency rates from 96% to 100% in the previous ten years. Considering that natural gas' share has reached to 31.2% within Turkish energy consumption mix in 2007, the figure is quite challenging for Turkey as almost all of its natural gas resources are obtained from other countries.

Table 32: Turkey's Natural Gas Dependency from 1997 to 2007

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Dependency	98.1%	96.0%	95.7%	98.2%	100%	97.9%	97.4%	97.1%	97.5%	96.9%	97.7%

Mineral Coal Dependency

Although dependence to external countries for mineral coal is extremely high, it is slightly lower than that of oil and natural gas. Mineral coal dependency has increased by over 10% in a decade from 1997 to 2007. In 2007, the share of mineral coal consumption within Turkey's energy consumption mix was 15.4%.

Table 33. Turkey's Mineral Coal Dependency from 1997 to 2007

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Dependency	77.7%	77.8%	77.0%	82.6%	70.8%	83.4%	91.0%	85.7%	88.2%	87.8%	89.2%

As illustrated in Chapter 3, Turkey is not dependent on imports for lignite whose share was 13% in the country's overall energy spending in 2007. When lignite's consumption and production is aggregated to mineral coal, Turkey's dependency for coal would be calculated as:

Table 34. Turkey's Coal Dependency From 1997 to 2007

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Dependency	32.4%	31.7%	28.8%	37.1%	27.1%	39.4%	51.20%	50.4%	47.3%	49.3%	48.4%

Turkey's modest lignite reserves keep Turkey's coal dependency lower compared to other primary energy resources types.

Import Concentration

Import concentration measures the portfolio diversity of energy suppliers. Rather than focusing on monetary aspect of the imports, the attention is tilted towards how Turkey is dependent to a certain country for a particular energy commodity. To attain this objective and to assign numeric value to assess the concentration, Hirschmann – Herfindahl index is employed. In HHI calculation, the percentage of

each supplier country contributing to imports is used. The statistical data from Turkish Statistics Institute will be used for computing Turkey's import concentration.

Turkish Statistics Institute classifies energy related products into categories depending on their technical characteristics and the institute references its computations over these groups. Base classification of the organization is presented as follows.

Group 1 : Mineral fuels – gases and candles

Group 2 : Mineral coal; solid fuels like briquette and dollop

Group 3 : Lignite (excluding black amber)

Group 4 : Low emulsion coal – Turb

Group 5 : Hard coal and retort coal obtained from lignite and mineral coal

Group 6 : Coal gas, vapor (water gas), poor gases and other gases

Group 7 : Black pitch from distilled from mineral and retort coal

Group 8 : Common black pitch from distilled black coal in high temperature

Group 9 : Black pitch and stump obtained from mineral coal's bitumen

Group 10 : Crude oil (mineral oil and the oil of bituminous minerals)

Group 11 : Oil driven fuels like gasoline, diesel, kerosene

Group 12 : Oil gases and other hydrocarbons

Group 13 : Vaseline, Paraffin, oiled candles, lignite candle and etc

Group 14 : Relics of oils obtained from bituminous minerals and mineral oil

Group 15 : Qum with bituminous and asphalt tar, asphaltit and asphaltite rocks

Group 16 : Bitumen mixture

Group 17 : Electricity energy

Depending on the generalization level of each group, sub groups owning their distinct commodities exist. However, further divisions and categorizations are avoided for the sake of clarity, concrete distinction of groups and to avoid unnecessary product detailing.

Indeed, among above seventeen groups, clustering minor groups into an 'others' group in accordance to their weight in Turkey's overall energy trade structure will help to get a better essence of the big picture. In this context, deciding on which groups to nominate as 'others' is a matter of their relevant percentage within entire energy imports. Crude oil (Group 10), Mineral coal (Group 2), Mineral fuels – gases and candles (Group 1), oil gases and other hydrocarbons (Group 12) as well as Oil driven fuels like gasoline, diesel, kerosene (Group 11) compose a big majority of Turkey's energy trade. From 1989 to 2008, these groups represented 98.35% of the whole energy inflows to the country. Thus, groups other than 1, 2, 10, 11 and 12 will be referred as 'others'. On the other hand, since they are derivative products, Group 1, 11 and 12 will be aggregated under “Oil” heading.

The table below depicts the percentages of energy commodity groups in reference to applicable year's total energy imports where the medium of comparison is their corresponding quantity in toe.

Table 35. The Distribution of Turkish Energy Imports by Fuel Types (TSI, 2008)

Years	Oil and Derivatives	Natural Gas	Mineral coal	Others
1992	72.03%	13.32%	14.42%	0.23%
1993	71.94%	13.76%	12.66%	1.64%
1994	72.16%	14.92%	12.33%	0.59%
1995	69.92%	16.83%	13.11%	0.14%
1996	66.88%	17.71%	14.02%	1.39%
1997	59.85%	19.21%	13.49%	7.45%
1998	61.24%	19.76%	14.07%	4.94%
1999	59.30%	23.17%	11.69%	5.84%
2000	54.19%	23.83%	14.69%	7.29%
2001	55.46%	28.21%	9.73%	6.60%
2002	56.06%	28.13%	13.35%	2.46%
2003	51.81%	30.18%	16.48%	1.54%
2004	50.82%	29.76%	15.77%	3.65%
2005	48.92%	34.62%	15.95%	0.51%
2006	46.66%	35.77%	16.88%	0.69%
2007	43.94%	38.11%	17.70%	0.26%

Table 35 illustrates that, commodity groups that are nominated as 'others' do not mostly shape more than 3% of Turkey's whole energy import portfolio. Oil and its derivatives has been the most imported energy commodity group from 1992 to 2007. In late 80s and early 90s, oil imports was forming from two third to 75% of whole energy trade. However, this trend has reversed in the last decade and it is inspected that these percentages are almost halved. Since natural gas that serves as a substitute of crude oil has penetrated to the Turkish market extensively, it dropped the crude oil's share on Turkey's import structure. Especially, towards mid to late 90s, Turkey began to expand the consumption area of natural gas and boasted its gas imports rapidly.

Mineral coal on the other hand showed almost a stable trend from 10% to 18% of the overall energy imports since 1992. Although, coal is not a very efficient and clean way of power generation, Turkey still imports a considerable amount of these resources

as coal driven plants are employed within the country. Thus, such fixed installed capacity brings along rather coal imports in percentage numbers.

Since Turkey categorizes energy commodities under fuel type group headings, rather than looking at cumulative values of all energy commodity categories in a yearly row and calculate the year's HHI value accordingly, it is a wiser approach to initially calculate each category's HHI values separately and then to compute the year's final HHI index value by weighting each category's percentage in the overall import structure pattern. In case the calculation is performed cumulatively without evaluating each category's HHI distinctly, since the supplier countries for each product category group does not necessarily needs to be the same or similar, HHI sensitivity would be underestimated. The table below depicts the commodity groups and their percentage in the relevant year's overall energy imports.

Table 36. HHI values of Each Fuel Types

Years	Oil and Derivatives	Natural Gas	Mineral coal	Others	Total
1992	3,365	10,000	2,130	1,874	4,067
1993	3,002	10,000	2,635	1,414	3,892
1994	2,734	8,489	2,663	1,287	3,575
1995	2,100	6,722	2,187	1,863	2,889
1996	2,430	5,154	2,325	1,142	2,880
1997	1,608	5,184	2,125	2,048	2,397
1998	1,536	4,693	2,549	2,493	2,350
1999	1,599	5,340	3,219	2,535	2,710
2000	1,892	5,083	2,474	2,996	2,818
2001	1,987	5,032	3,490	3,840	3,115
2002	1,912	4,737	1,957	3,544	2,753
2003	1,901	4,137	2,483	2,048	2,674
2004	2,305	4,602	2,602	2,358	3,037
2005	2,602	4,704	2,166	2,211	3,258
2006	2,716	4,680	2,191	1,834	3,324
2007	3,235	4,763	2,483	2,061	3,681

Although determining the critical HHI threshold value is controversial, according to Jacques Percebois (2007) on the international journal or Energy Sector Management, a value equal or above 2,500 could be regarded as critical. Under such circumstances, above table depicts that Turkish import concentration exceeds the critical borderline making the country more vulnerable.

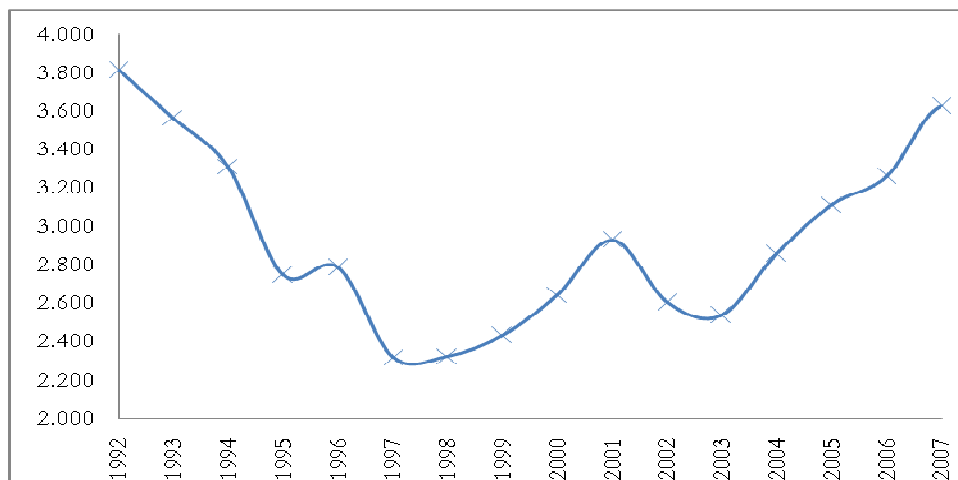


Figure 40. Turkey's cumulative HHI values since 1992

Figure 40 offers a cumulative outlook to country's overall import concentration. The analysis starts with a high HHI value that was experienced in 1992, right after the 1st Gulf War, when Turkey has shifted its oil imports from Iraq to Saudi Arabia immediately which boomed the dependency to Saudi Arabia. In 1997 and 1998, Turkey imported 10.2% and 14.4% of its crude oil from Egypt respectively whose share used to vary from 1% to 6% until 1996 and dropped under one percent after 1999. For this reason, the HHI value in 1997 and 1998 has decreased apparently where it began to rise after 1999 due to gradual increase of highly concentrated natural gas imports within Turkish energy trade mix. Russian Federation's rising dominance in Turkey's energy imports is another vital reason for the surge in HHI with the new millennium. From this perspective, individual concentration indexes of the energy commodities worth deeper analysis as the demand for certain energy groups designate the degree of a country's overall energy vulnerability level due to the inability to substitute between energy resources in short to medium run.

Crude Oil Suppliers

Since the early years of the republic, Middle Eastern countries have been apparent in Turkey's crude oil imports. Iraq was one of the major crude oil suppliers for Turkey until 1st Gulf War. In late 80's, more than 60% of crude oil inflowing to country was arriving from Iraq and the remaining shares were imported from Iran, Libya, USSR, Algeria and Saudi Arabia. However, the 1st Gulf war has shifted Turkish import pattern and Iraqi oil was replaced with Saudi oil which then almost formed half of oil imports in early 90s. Iran's share has dramatically increased in 1992 and the figure exceeded one third of the entire oil inflows in 2006. In 2001, Russian Federation's share in oil imports exceeded 20% and reached to 41.5% in 2007. Table 37 illustrates exporter country's percentage shares of crude oil sales to Turkey.

Table 37. Crude Oil Supplier's of Turkey and Their Share within Oil Imports (TSI, 2008)

Years	Iraq	Algeria	Libya	USSR / Russia	Saudi Arabia	Iran	Syria	Others
1989	62.50%	6.10%	10.70%	4.30%	5.60%	9.40%		1.40%
1990	27.10%	7.00%	13.70%	10.40%	16.90%	13.90%	1.60%	9.40%
1991		0.60%	10.50%	1.10%	64.40%	2.50%	1.60%	19.30%
1992		0.2%	13.50%	2.30%	50.10%	10.50%	0.6%	22.80%
1993			4.40%	5.90%	50.50%	23.60%	1.10%	15.40%
1994		0.30%	11.90%	1.10%	43.70%	26.70%	10.30%	6.00%
1995		7.50%	12.00%	6.30%	39.20%	22.10%	7.10%	5.80%
1996	0.90%	8.10%	12.70%	2.80%	41.10%	20.70%	8.10%	5.60%
1997		5.50%	15.60%	2.30%	23.00%	16.90%	10.80%	25.90%
1998		5.50%	15.30%	2.90%	21.50%	16.10%	9.10%	29.60%
1999		3.20%	17.30%	9.30%	15.80%	20.50%	9.30%	24.60%
2000			17.80%	7.80%	18.00%	16.70%	10.70%	29.00%
2001		0.40%	21.00%	20.00%	15.60%	19.80%	10.70%	12.50%
2002		1.40%	17.40%	16.40%	16.50%	18.40%	10.50%	19.40%
2003	1.50%	1.20%	21.00%	18.90%	15.90%	26.80%	6.10%	8.60%
2004	5.30%	2.10%	23.50%	26.50%	14.40%	22.10%	4.40%	1.70%
2005	4.50%		20.70%	29.70%	15.00%	27.60%	1.50%	1.00%
2006	2.40%		19.20%	28.50%	15.20%	34.10%		0,6%
2007	4.50%		1.20%	41.50%	14.50%	35.60%	1,0%	1,7%

Although oil and its derivatives' HHI values have been above criticalness level until 1996, the half replacement in Saudi shares have led to diversification of crude oil imports and thus reduced the HHI levels, Russia's coming to stage have pulled up the energy concentration since early 2000s.

Natural Gas Suppliers

Turkey's natural HHI values are far above the criticalness borderline. Since the beginning of natural gas consumption, Turkey's HHI values have never fell below 4,000 implying excess dependence to certain countries in the trade of natural gas. Russia has always been the major natural gas exporter to Turkey. In the initial years of gas imports that started in 1987, Russia supplied the entire gas inflow. Towards mid 1990s, although

Russian Federation was still the major gas exporter for Turkey, Algeria became to be an alternative gas supplier for Turkey. In early 2000s, Algeria's share in gas imports have dropped but this decline was substituted by Iran. A little portion of the imported gas arrives from Nigeria. However, these diversifications in the suppliers were not adequate enough to descent Russia's share in natural gas imports below 60%. Table 38 outlines gas suppliers for Turkey since 1989.

Table 38. Natural Suppliers of Turkey and Their Share within Whole Gas Imports (TSI, 2008)

Years	Azerbaijan	Algeria	Iran	Nigeria	USSR / Russia	Australia	Others
1989					100%		
1990					100%		
1991					100%		
1992					100%		
1993					100%		
1994		8.20%			91.80%		
1995		15.70%			80.40%	4%	
1996		35.60%			62.30%	2.10%	
1997		40.40%			59.60%		
1998		36.90%			57.40%		5.70%
1999		34.80%		0.90%	64.20%		
2000		28.80%		6.30%	64.90%		
2001		23.80%		10.20%	66.10%		
2002		24.20%	3.60%	8.40%	63.80%		
2003		17.60%	16.30%	6.80%	59.30%		
2004		15.60%	15.50%	4.90%	64%		
2005		15.20%	16.40%	3.70%	64.70%		
2006		13.50%	18.80%	3.40%	64.30%		
2007	1.40%	11.60%	17.60%	3.50%	65.60%		0.3%

Due to high reliance on Russia, import concentration levels are alerting for Turkey in the sense that its last three years the average value of HHI has scored 4.871, while the average was 4.784 in the previous five years where it was 4.825 and 5.793 in the last ten and fifteen years respectively. These numbers are far above the criticalness

level of 2.500 indicating that Turkish natural gas imports plays a crucial role in designating energy vulnerability.

Mineral Coal Suppliers

Mineral coal imports demonstrate a more diversified supplier assortment compared to oil and natural gas imports. Before the new millennium, United States, Australia and South Africa republic were dominant in Turkish mineral coal trade. However after 2000s, these three countries' shares have dropped while Russia's split has surged tremendously. In the recent half decade, Russia's share exceeded 40%. On the other hand, new states are introduced to Turkish mineral coal supplier portfolio involving China and Colombia.

Table 39. Mineral Coal Suppliers of Turkey and Their Share within Whole Mineral Coal Imports (TSI, 2008)

Years	United States	Australia	South Africa	Canada	USSR / Russia	China	Colombia	Others
1989	48.10%	22.20%	25.50%	1.20%	2.90%			0.10%
1990	36.80%	14.70%	22.90%	1.30%	11.00%			13.30%
1991	34.30%	15.90%	20.20%	1.10%	14.30%			14.20%
1992	32.20%	16.40%	22.70%	4.50%	16.60%			7.60%
1993	20.00%	39.70%	20.10%		15.80%			4.40%
1994	26.50%	39.30%	17.80%	1.50%	9.00%			5.90%
1995	21.60%	30.80%	16.00%	2.00%	22.30%			7.30%
1996	25.00%	12.30%	24.40%	2.90%	30.70%			4.70%
1997	20.50%	22.80%	20.80%	4.50%	27.00%			4.40%
1998	19.10%	15.70%	18.80%	2.80%	39.60%			4.00%
1999	5.70%	14.60%	15.00%	4.30%	52.10%			8.30%
2000	18.70%	20.30%	12.00%	5.80%	39.10%			4.10%
2001	9.20%	11.20%	17.10%	1.50%	54.40%	0.50%		6.10%
2002	8.20%	14.60%	8.80%	19.20%	39.60%	1.80%		7.80%
2003	8.30%	7.80%	13.70%	5.00%	45.30%	7.10%	7.30%	5.50%
2004	8.50%	3.30%	10.30%	5.70%	46.50%	11.80%	7.30%	6.60%
2005	14.90%	6.10%	7.30%	5.70%	40.20%	9.00%	9.90%	6.90%
2006	9.50%	8.40%	9.30%	8.30%	41.30%	9.10%	8.60%	5.50%
2007	8.60%	8.80%	9.60%	7.20%	45.30%	8.70%	6.80%	5.00%

Turkish mineral coal trade depicts a borderline HHI standing which is more acceptable than that of natural gas, scoring 2.360 in the last three years and 2.369, 2.547 and 2.476 in the last five, ten and fifteen years of the analysis respectively encouraging to infer that the concentration has dropped a little below Percebois border of 2.500 recently.

Looking at the big picture, it is quite reasonable to argue that Turkey became to be highly dependent on Russia with the boom in natural gas consumption whose imports are primarily supplied through that country in addition to the thriving percentage increase in oil and mineral coal imports. In 2007, dependence to Russia in crude oil supply was 41.5%, 65.6% for natural gas imports and 45.3% for mineral coal. This standing signals that Turkey became very dependent on Russia for supplying its energy. Hence, high HHI values and excess reliance on certain countries for sustaining energy supply adds up to Turkey's energy vulnerability drastically.

Energy Intensity

Energy intensity is used as an index to measure energy efficiency. It is assessed as units of energy consumed per unit of gross domestic product. This index in a sense measures the energy to be spent to generate per dollar of GDP. The less a country consumes per GDP, the more that country is efficient in energy consumption. Efficiency can be achieved by means of conservation, saving, investing in technologies that help to consume less energy and etc. Although, energy intensity without other vulnerability indicators is not sufficient enough to comment on energy efficiency, reasons like climate conditions and higher standards of living may require a nation state to spend more energy. Turkey's Energy intensity (EI) is calculated in Table 40.

Table 40. Turkey's Energy Consumption, GDP and Energy Intensity

Year	Energy Consumption (toe)	GDP (Million USD)	Energy Intensity (toe / m USD)
1992	56,135	164,171	0.342
1993	59,462	188,029	0.316
1994	58,257	135,543	0.43
1995	62,954	173,195	0.363
1996	68,154	176,571	0.386
1997	71,691	189,416	0.378
1998	73,082	205,539	0.356
1999	72,716	199,154	0.365
2000	78,584	204,888	0.384
2001	73,589	153,523	0.479
2002	76,320	184,829	0.413
2003	82,074	239,822	0.342
2004	86,200	300,087	0.287
2005	89,199	340,263	0.262
2006	98,138	367,330	0.267
2007	107,625	413,246	0.260

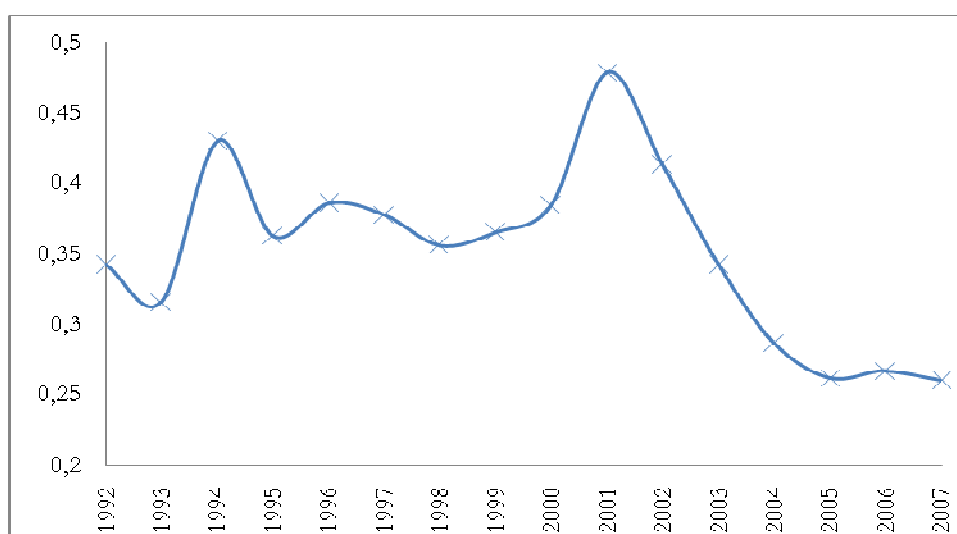


Figure 41. Turkey's energy intensity since 1992 (toe / million USD)

Although interrupted in some years, energy intensity ratio demonstrates a downward trend in Turkey. In the years when financial crisis were prevailing Turkish economy, energy intensity have increased radically. Crisis in 1994 and 2001 had a negative impact on energy intensity. Although both the GDP and energy consumption in these years have dropped, as the percentage decline of Turkish Gross Domestic

Product was higher than energy consumption, EI level have risen. Since, in order to ensure the continuity of basic services, nation states needs to consume above a threshold value of energy, energy demand is less responsive to macroeconomic fluctuations in the short run.

Being a measure of energy efficiency, although interrupted in 1994 and 2001, Turkey's energy intensity ratio have demonstrated a lowering trend implying that per one dollar of GDP, less energy is being consumed. Employing more efficient means of energy consumption, renewing power plants, distribution networks and increasing share of renewable energy within Turkey's consumption mix could be some explanations for this progress within the context of energy vulnerability.

National Energy Bill

This indicator assesses the overall cost of energy consumption over the nation's economy. In section 5.1., alternative formulas to calculate the energy bill were given and both of these calculations will be performed to understand the total national energy bill. In the first method, energy bill is calculated as the product of energy dependency, energy intensity, average energy cost and the exchange rate. However, since National Statistics Institute can offer energy import values in US dollars; the exchange rate factor in the formula could be omitted.

$$EB = ED \times EI \times AC$$

Energy dependency, abbreviated as ED was calculated in 5.2.1 whereas Energy Intensity (EI) was given in the previous section. Turkish Statistics Institute reports the value of total energy imports in USD and the Ministry of Energy reports total energy imports in thousand toe as follows. A simple division of these values would give us average cost of energy per thousand toe.

Table 41. Average Cost of Imported Energy Calculation in USD

Year	Energy Import Bill (USD)	Net Energy Imports (toe)	Average Cost per toe (USD)
1992	3,760,095	31,864	118.0
1993	3,964,662	35,861	110.6
1994	3,817,632	34,476	110.7
1995	4,620,801	39,531	116.9
1996	5,777,946	44,274	130.5
1997	5,881,302	47,271	124.4
1998	4,325,202	48,071	90.0
1999	5,004,619	49,115	101.9
2000	9,221,241	56,326	163.7
2001	8,014,661	52,713	152.0
2002	9,126,585	58,766	155.3
2003	11,392,962	65,582	173.7
2004	14,299,533	68,173	209.8
2005	21,030,745	73,521	286.1
2006	28,610,414	76,975	371.7
2007	33,791,135	82,985	407.2

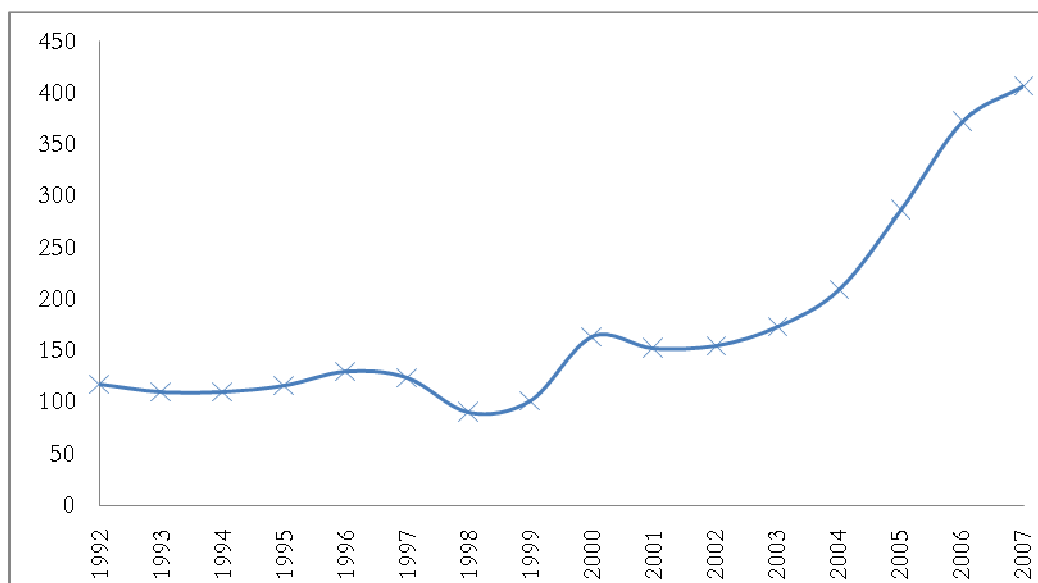


Figure 42. Average cost of the imported energy per toe in USD

Although interrupted in the late 90's heavily, average cost of energy per toe demonstrated an upward trend especially after the new millennium. The effect of energy prices on average cost is very significant. Especially the rise in average energy prices after 2003 attracts attention. Having all factors of the formula ready, Energy Bill can be calculated as follows.

Table 42. Total Energy Bill Calculation of Turkey Using Energy Intensity and Average Cost

Year	Energy Dependency	EI (toe / Billion USD)	AC (USD / toe)	Total Energy Bill (Billion USD)
1992	56.76%	0.342	118.0	22.9
1993	60.31%	0.316	110.6	21.1
1994	59.18%	0.43	110.7	28.2
1995	62.51%	0.363	116.9	26.5
1996	64.96%	0.386	130.5	32.7
1997	65.87%	0.378	124.4	31.0
1998	65.02%	0.356	90.0	20.8
1999	67.29%	0.365	101.9	25.0
2000	72.60%	0.384	163.7	45.6
2001	72.33%	0.479	152.0	52.7
2002	74.05%	0.413	155.3	47.5
2003	77.13%	0.342	173.7	45.8
2004	77.95%	0.287	209.8	46.9
2005	78.71%	0.262	286.1	59.0
2006	78.98%	0.267	371.7	78.4
2007	77.11%	0.26	407.2	81.6

Table 42 indicates that, Turkey's energy bill have varied depending on the alterations in parameters like average energy costs, macroeconomic financial conditions and etc. The energy bill demonstrated record percentage increases when Turkey faced with economic crisis in 1994 and 2001. Parallel to decline in average energy prices from 1997 to 1998, total energy bill have decreased noticeably too. However, the picture has reversed in the following years and the energy bill has demonstrated record high percentage ups. By 2002, average cost of the energy per toe has boasted continuously until the recent downturn in energy prices towards mid 2008.

An alternative way of calculating Total Energy Bill can be obtained by diving net energy imports value to Gross Domestic Product. The computation is performed as follows:

Table 43. Total Energy Bill Calculation of Turkey Using Net Energy Imports and GDP

Year	Net Energy Imports (USD)	GDP (Billion USD)	Total Energy Bill
			(Billion USD)
1992	3,760,095	164,171	22.9
1993	3,964,662	188,029	21.1
1994	3,817,632	135,543	28.2
1995	4,620,801	173,195	26.7
1996	5,777,946	176,571	32.7
1997	5,881,302	189,416	31.0
1998	4,325,202	205,539	21.0
1999	5,004,619	199,154	25.1
2000	9,221,241	204,888	45.0
2001	8,014,661	153,523	52.2
2002	9,126,585	184,829	49.4
2003	11,392,962	239,822	47.5
2004	14,299,533	300,087	47.7
2005	21,030,745	340,263	61.8
2006	28,610,414	367,330	77.9
2007	33,791,135	413,246	81.8

When the results of both calculations are contrasted, the similarity and convergence of the energy bill per toe is noticed easily. The results imply that Turkey is spending more for energy and the increase in the bill is shaped apparently by the fluctuations in global energy prices. When considered in bundle with the influence of energy bill on national macroeconomic instabilities, financial and political fluctuations and disturbances both in local and global scope negatively affect not only the bill paid for energy but also to the country's energy vulnerability.

Carbon Content of Primary Energy Supply

Energy ministry's carbon emission statistics depicts Turkey's performance on carbon emissions including the emission caused by LULUCF (Land Use – Land Use Change and Forestry). Table 44 clearly shows the sharp increase in Turkey's total carbon emissions from 1990 to 2006. The emissions have almost doubled from 1990 to 2006. Although Turkey's carbon emissions has thrived as seen above, evaluating the rise in carbon emission per total energy consumed in toe will give information regarding how clean energy types are employed within Turkish energy consumption structure. Carbon emissions per consumed energy would give an insight regarding the cleanness of energy commodities within the energy mix.

Table 44. Turkey's Total Carbon Emissions and Carbon Intensity Calculation (TSI, 2008)

Year	Total Carbon Emissions	Energy Consumption (toe)	Emissions per toe (Carbon Intensity)
1992	152,932	56,135	2.72
1993	160,908	59,462	2.71
1994	159,104	58,257	2.73
1995	171,854	62,954	2.73
1996	190,668	68,154	2.8
1997	203,723	71,691	2.84
1998	202,713	73,082	2.77
1999	201,712	72,716	2.77
2000	223,806	78,584	2.85
2001	207,379	73,589	2.82
2002	216,433	76,320	2.84
2003	230,987	82,074	2.81
2004	241,884	86,200	2.81
2005	256,434	89,199	2.87
2006	273,705	98,138	2.79

Above table indicates that Turkey was not able to reduce the carbon content of its consumed energy from 1992 to 2006 meaning that the share of cleaner energy did

not increase. Although, Turkey transitioned to consume natural gas, the cleanest form of fossil fuels, the boom in energy demand raised the consumption of solid fuels in absolute terms and thus increased carbon emissions. Taking almost doubling levels of carbon emissions and the lack of inadequate trend for renewing and cleaning the consumed energy, Turkey is environmentally getting more vulnerable to energy too.

From the perspective of Kyoto, although Turkey has fully signed the protocol in early 2009, as of 2006 data, its carbon intensity is higher than the general objective of 5.2% less of the 90s value which would contribute to 2.50 bandwidth.

Price Volatility

Reliance on energy types that exhibit higher degrees of price volatility adds up to overall energy vulnerability of a country. This is the motivation behind the calculation of a price volatility index for each energy groups, using their historical price statistics. Rather than evaluating the import price of the energy products, in order to assess the country's entire energy portfolio's price volatility including domestic resources and foreign supply, wholesale and production price index values will be used to calculate volatility. Using the Institute's average yearly energy prices that is available in local currency as well as the average exchange rate information, prices of certain energy commodities are computed in Table 45. The data of the fields marked with “N/A” is either missing or their disclosure is prohibited by law 5429.

Table 45. Average Yearly Prices of Major Primary and Secondary Energy Resources (TSI, 2008)

Average Yearly Prices (USD)	Per Tonne						M ³	KWh
	LPG	Fuel (Normal)	Fuel Oil	Crude Oil	Mineral Coal	Lignite	Natural Gas	Electricity
1982	357	683	247	177	58	31	N/A	0.056
1983	235	534	163	190	45	24	N/A	0.042
1984	231	461	156	182	41	21	N/A	0.048
1985	261	513	176	215	44	27	N/A	0.074
1986	244	475	165	114	36	25	N/A	0.07
1987	157	403	101	128	36	23	N/A	0.063
1988	127	436	76	94	35	22	N/A	0.052
1989	172	593	104	138	55	31	N/A	0.065
1990	244	840	147	176	64	32	N/A	0.092
1991	203	638	135	136	62	40	N/A	0.076
1992	191	621	116	135	49	41	N/A	0.085
1993	163	519	103	110	56	36	N/A	0.084
1994	118	464	85	109	56	28	N/A	0.066
1995	189	543	120	122	55	29	N/A	0.064
1996	200	571	124	107	50	25	0.096	0.069
1997	202	616	117	94	50	23	0.104	0.061
1998	190	670	102	68	48	23	0.117	0.067
1999	232	772	118	89	34	21	0.107	0.066
2000	280	1008	169	189	46	24	0.155	0.08
2001	437	786	149	141	35	19	0.156	0.072
2002	572	1053	213	161	45	28	0.169	0.093
2003	928	1515	296	226	56	41	0.233	0.111
2004	1000	1726	329	266	67	47	0.209	0.118
2005	N/A	N/A	240	299	108	66	0.251	N/A
2006	N/A	N/A	304	378	121	69	0.318	N/A
2007	N/A	N/A	321	385	129	79	0.307	N/A

It should be noted that for the years that the prices are not disclosed due to law which marked with N/A, the volatility calculations are performed for the existing data only. Applying volatility formulation given in section 5.1.6 in monthly basis, we get the following volatility factors.

Table 46. Price Volatility of Major Primary and Secondary Energy Resources

	Crude Oil	Natural Gas	Mineral Coal	Lignite	Electricity	LPG	N. Fuel	Fuel Oil
Volatility	96.6%	52.7%	71.2%	66.5%	64.7%	92.9%	68.4%	85.5%

Looking Table 46, it is deduced that crude oil has been the most volatile energy commodity in terms of its per ton price. Since crude oil has been making up the greatest portion of Turkey's energy import from external suppliers, it pulls the country's overall energy vulnerability upward. The section below investigates the prices of major energy commodity groups:

Crude Oil Volatility

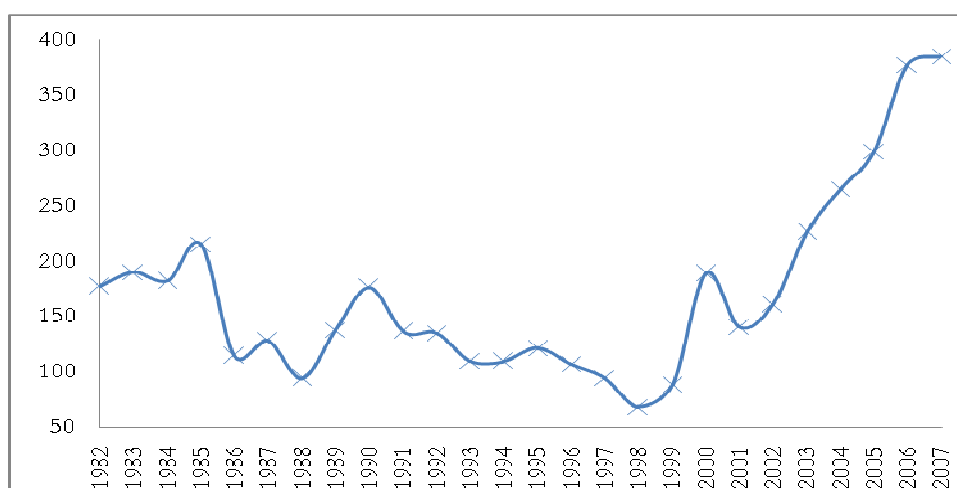


Figure 43. Per tonne wholesale - production oil prices since 1982 in USD (TSI, 2008)

As seen in the chart of per ton USD price of oil for Turkey, in 1988, the price of the crude oil demonstrated a record low price of 94 USD from 215 USD in 1985. Since the end of 1st Gulf War, the declining trend took off and it continued until 1998 which brought the price to 68 USD for Turkey. From 1998 to 2007, excluding 2001 where the oil prices dropped in global market, crude oil prices have thrived tremendously by 466% and reached to 385 USD.

Natural Gas Volatility

Due to the law 5429, natural gas prices after 2004 are not disclosed to public by Energy Ministry and Turkish Statistics Institute. The only data we only have covers the period from 1996 to 2004. The data of 2005, 2006 and 2007 is calculated with the data of Turkish Petroleum and Pipeline Corporation (BOTAS). From 1996 to 2007, the price of natural gas has boomed from 0,096 USD per m³ by 219.8% to 0,096 USD per m³.

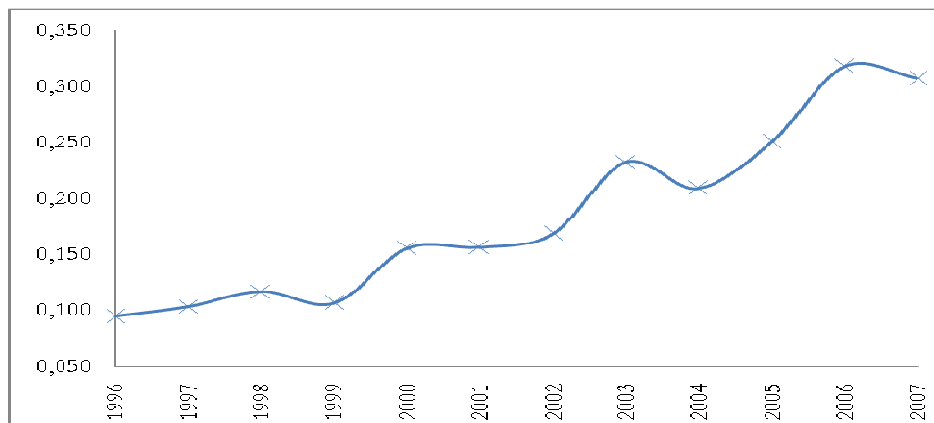


Figure 44. Per meter cube wholesale natural gas prices since 1996 in USD (TSI, 2008)

The high level of fluctuations in the energy prices of the commodities that Turkey extensively consumes makes the country more vulnerable to energy as the import prices fluctuates and the increase in future prices of them are harder to forecast.

Mineral Coal Volatility

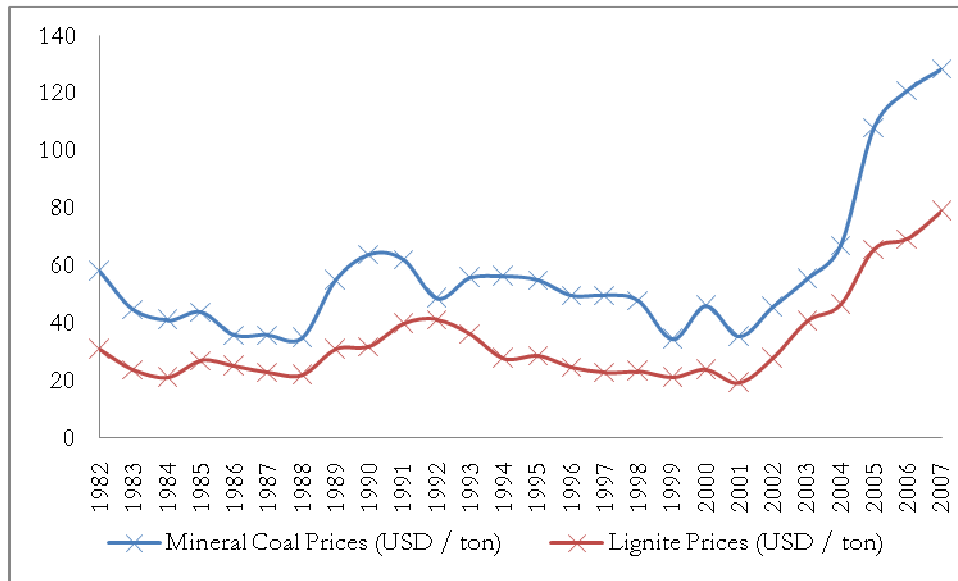


Figure 45. Per tonne mineral coal and lignite prices since 1996 in USD (TSI, 2008)

Mineral coal price's bandwidth is narrower when compared to than that of crude oil. From 1980s to 2005, the price has changed from the floor value of around 35 USD per ton to ceiling value of 65 USD. However, mineral coal prices increased over 100 USD since the demand for this commodity ascended due to sharp increases with the oil and natural gas prices after 2005. Due to Turkey's modest degree of resources and comparably limited variations in the prices in the global market, lignite's price were less volatile when compared with the trend of oil, natural gas and mineral coal. From the 90s to 2005, the prices were around 25 USD to 40 USD per ton. However, with heavily increasing oil and natural gas prices after 2005, as was the case with mineral coal, the price of lignite went up towards 70 USD per ton too.

Electricity Market

Energy vulnerability within electricity market is evaluated by analyzing the accuracy of demand forecasts, types of power production facilities in terms of the fuel type of the input employed and the interconnection with the neighboring countries.

Although excess electricity imports signal enhancing degrees of energy vulnerability, the availability of technical infrastructures for importing electricity in case a need emerges contributes to reduction of vulnerability.

Supply – Demand Mismatch

Meeting the electricity demand through external resources adds up to the vulnerability index of a country. For analysis, Turkey’s total electricity consumption and import values from 1993 to 2007 are given in the table below.

Table 47. Turkey’s Electricity Imports and its Share among Entire Electricity Consumption

Years	Million KWh (GWh)		Share
	Imports	Consumption	
1993	213	73,432	0.29%
1994	31	77,783	0.04%
1995	0	85,552	0.00%
1996	270	94,789	0.28%
1997	2,492	105,517	2.36%
1998	3,299	114,023	2.89%
1999	2,330	118,485	1.97%
2000	3,791	128,276	2.96%
2001	4,579	123,028	3.72%
2002	3,588	129,400	2.77%
2003	1,158	140,581	0.82%
2004	464	150,698	0.31%
2005	636	161,956	0.39%
2006	573	176,300	0.33%
2007	865	191,109	0.45%

Table 47 states that Turkey’s reliance on imported electricity have been below 1% since 2003, although from 1997 to 2002, Turkey’s need for foreign electricity contributed over 2% among overall electricity consumption. Obviously, relying less for imported electricity since 2003 reduces Turkey’s vulnerability in electricity market.

Resources used for Electricity Production

Reliance on cleaner, cheaper and sustainable raw materials for generating thermal electricity is a vital determinant of energy vulnerability from the perspective of electricity market.

Table 48. Contribution of Primary Energy Resources to Total Electricity Production (TEM, 2008)

Years	GWh							Total
	Mineral Coal	Lignite	Fuel Oil	Motor Oil	Natural Gas	Hydraulic	Others	
1997	3,448	30,489	6,997	527	21,886	39,753	2,418	105,517
1998	3,343	32,698	7,128	307	24,441	42,226	3,882	114,023
1999	3,161	33,870	6,883	745	36,301	34,718	2,806	118,485
2000	3,707	34,556	7,813	978	46,004	30,917	4,302	128,276
2001	4,115	34,524	9,219	940	49,228	24,006	995	123,028
2002	4,104	28,118	9,623	270	52,320	33,682	1,285	129,401
2003	8,524	23,590	8,161	5	63,536	35,330	1,435	140,580
2004	11,992	22,502	6,863	7	61,830	46,068	1,370	150,631
2005	13,127	30,001	5,503	2	72,278	39,666	1,448	162,024
2006	13,693	32,341	5,368	17	77,428	44,146	2,674	175,667
2007	15,154	34,782	5,467	16	85,426	48,924	1,340	191,109

The tremendous surge in natural gas operated plants and the modest increase in hydraulic plants is observed in Table 48 whose percentage distribution follows:

Table 49. Percentage Contribution of Primary Energies to Electricity Production

Years	Mineral Coal	Lignite	Fuel Oil	Natural Gas	Hydraulic	Others	Total
1997	3.30%	28.90%	6.60%	20.70%	37.70%	2.80%	100.00%
1998	2.90%	28.70%	6.30%	21.40%	37.00%	3.70%	100.00%
1999	2.70%	28.60%	5.80%	30.60%	29.30%	3.00%	100.00%
2000	2.90%	26.90%	6.10%	35.90%	24.10%	4.10%	100.00%
2001	3.30%	28.10%	7.50%	40.00%	19.50%	1.60%	100.00%
2002	3.20%	21.70%	7.40%	40.40%	26.00%	1.20%	100.00%
2003	6.10%	16.80%	5.80%	45.20%	25.10%	1.00%	100.00%
2004	8.00%	14.90%	4.60%	41.00%	30.60%	0.90%	100.00%
2005	8.10%	18.50%	3.40%	44.60%	24.50%	0.90%	100.00%
2006	7.80%	18.40%	3.10%	44.10%	25.10%	1.50%	100.00%
2007	7.90%	18.20%	2.90%	44.70%	25.60%	0.70%	100.00%

Since 1997, the share of natural gas in thermal electricity generation has thrived significantly. In 2007, natural gas resourced has formed 44.7% of the raw materials used for producing electricity where the figure was 20.7% in 1997. On the other hand, although the total GWh of electricity that the hydraulic plants have produced has increased in the previous ten years, since the increase lagged behind the acceleration of the boom in electricity production, its percentage share has dropped from 37.7% to 25.6%. Although lignite's usage in electricity production remained almost stable, mineral coal's participation have boomed from 3.3% to 7.9% in the last decade. In the past twenty years, the country has achieved significant progress in switching from power generation by coal-fired plants to that using natural gas. Table 50 states that the share of renewable resources is highly limited within Turkey's electricity production portfolio.

On a general outlook, Turkey extensively uses fossil fuels for producing electricity which is both expensive compared to its alternatives and environmentally less friendly. Chapter 6 is dedicated to analyze what type of power plants would be pragmatic to invest for reducing energy vulnerability of Turkey.

Interconnection rate with foreign countries

The interconnection opportunities with neighboring countries is an advantage in reducing energy vulnerability for the purpose of ensuring the continuity of electricity supply via imports in case of instantaneous electricity shortages. Looking at Turkey's electricity trade, it is inferable that the country is comfortable in terms establishing connection with neighboring countries as it is able to import and export electricity to Greece, Bulgaria, Georgia, Iran, Azerbaijan, Iran, Iraq and Turkmenistan. Turkey neighboring to eight different countries is technically in a position to supply urgent electricity demand from foreign countries and it is integrating its energy infrastructures

with its neighbors. In 2006, the country took major measures to synchronize its electricity grid with the European grid.

Exchange rate

Since electricity is imported in foreign currency, the changes in exchange rates make up a portion of energy vulnerability. High variations in the exchange rates make a country more sensitive to energy as the energy bill compose a vital aspect of macroeconomic balances. Below are the averaged USD values in exchange for Turkish Lira since 1991. It is observed in the Table 50, Turkish Lira has devaluated in 1994 and 2001. As also seen in Chapter 2 and section 5.2.4., Turkey's energy consumption has reduced but the energy bill has soared in these years.

Table 50. Exchange Rate between US Dollars and Turkish Lira Since 1991 (TSI, 2008)

Years	USD / TL
1992	6,873
1993	10,978
1994	29,962
1995	45,797
1996	81,754
1997	152,423
1998	261,586
1999	420,223
2000	627,080
2001	1,243,374
2002	1,509,645
2003	1,495,948
2004	1,425,940
2005	1,349
2006	1,441
2007	1,306

Present Energy Import Contracts

Energy import contract's effect on energy vulnerability could be two sided. It could reduce uncertainty regarding the price and ensure the continuity of supply from energy exporting countries. However, these contracts could enhance the vulnerability of energy importing country depending on the content of its clauses. The contracts may bind the importer country in terms of price, duration and volume of imports.

For instance, *Blue Stream* covers a major trans-Black Sea gas pipeline that would carry natural gas from Russia into Turkey. The project's cost was 3.3 billion USD for Turkey. The contract binds Turkey to import a total of 16 billion meters cube of natural gas for 25 years. The treaty was signed in 1997. One of the biggest towards the contract was focused on the fact that Turkey's energy was getting more dependent on Russia. On the other hand, the treaty is also criticized because of the probability that Turkey would be paying more for Russian gas while Azerbaijan and Turkmenistan would quote cheaper prices for their gas.

The *Baku – Tbilisi - Ceyhan pipeline* is a successful project for Turkey, Azerbaijan and Georgia. From the perspective of Turkey, the strength of the project is sourced both from enabling the country to further diversify its import channels and to make Turkey into an energy hub and corridor that delivers energy from Asia to Europe. With the project *Azerbaijan, Turkey and Greece Shah Sea Line* transfer Azeri gas to Greece while allowing Turkey to sell the gas that is being transferred. This project was supported by Europe and United States while Russia wanted to block it and tries to lower the attractiveness of the project by offering gas to Greece with very low competitive prices.

However, Turkey had signed many binding energy contracts in the previous decade especially concerning natural gas. Below is a list of a few big ones:

Table 51. Turkey's Major Energy Import Contracts

Signed With	Content	Date	Imports (bcm / year)	Cost of Imports (mil. dollars)	Duration (years)	Started In
Algeria	LNG	14.11.1988	4	636	20	1994
Iran	Natural gas pipeline	08.08.1996	10	1,340	25	2001
Nigeria	LNG	09.11.1995	1.2	192	22	1999
Russia	Blue Stream	15.12.1997	16	1,936	23	2001
Russia	West line capacity expansion	10.12.1996	8	1,072	23	1998
Russia	Natural gas pipeline west route	18.09.1984	6	804	25	1987
Turkmenistan	European natural gas pipeline	21.05.1999	16	2,144	30	2002

Although these agreements help Turkey to attract more natural gas both for its own consumption and transportation to Europe, they are highly binding in terms of length of the contract which is valid for 20 to 30 years, the price and the volume of imports. From this perspective, although these agreements help Turkey to serve as a significant transit state, it could be considered that such scopes of these contracts add up to the vulnerability of Turkey.

The project *Blue Stream* is the most expensive line that Turkey acquires its gas from. The most negative aspect of the cooperation is, Turkey does not have the privilege to sell the gas that arrives the country through the Blue Stream. On the other hand, the dispute regarding Iran – Turkey line has went to arbitration due to inefficient and problematic operation of the project. Despite its projection above 10 billion meter cubes per year, around 4 of it is actualized. Moreover, Kirkuk – Yumurtalık pipeline does not operate with full efficiency as the security of the project is not fully maintained due to the potential terrorist attack threats.

Geographical Indicators

Geographical indicator represents the constant variable which certainly has an effect on nation states' energy vulnerability. In this section, the term "geography" refers both physical location of the country and its characteristic opportunities to generate renewable energy. The analysis of these parameters follows:

Regional Proximity to Energy Exporting Countries

Geographically, Turkey is close to energy exporting countries. Major energy exporting countries in the region like Iran, Russia and Azerbaijan are Turkey's political neighbors. Iraq, an important petroleum reserve holder country borders with Turkey too. Having access to Mediterranean, to Black Sea and to Aegean offers Turkey the possibility to transport Turkmen and Azerbaijani energy resources to the rest of world. With the Baku – Tbilisi – Ceyhan and Baku – Tbilisi – Erzurum pipeline projects, Turkey is competing to become an important transit node of the region. Moreover it is seeking further opportunities to invest in initiatives especially in Syria, Iraq and Turkmenistan that would strengthen the country's position as an energy corridor. With this unique geographical blessing, with correct governmental actions, Turkey could minimize its energy vulnerability.

Opportunities for Alternative and Renewable Energy Resources

Turkey's geographic position offers a variety of renewable energy opportunities. Information regarding these promising assets follows:

Wind: Turkey has a total of 88.000 MW of wind energy potential (Mondaw, 2008). The capacity that is authorized by Turkish Electricity Transmission Inc. (TEIAS) for wind plants is 20.000 MW where the current installed capacity does not exceed 500 MW as of 2008. (Radikal, 2008) During the course of 2008, 40 new wind projects totaling to 4.800

MW are approved. Marmara, Aegean and Mediterranean coastal sites are the most attractive regions wind power in Turkey.

Geothermal: Turkey hosts around one eighth of the world's geothermal potential and is ranked first in Europe and seventh in the world (Serpen, 2005). Despite the potential of 3.500 MW, current installed capacity is not more than 100 MW as of 2008.

Hydropower: Although the potential of hydro electric potential is estimated to be 46.000 MW per year, approximately only one third of this potential is operational. According to Orhon (2001), Turkey owns 16% of the Europe's entire economically feasible hydroelectric potential.

Solar: Turkey has a high potential for solar energy with yearly average solar radiation is 3.6 kWh/m² per day and the total yearly radiation period is approximately 2640 hours. In case correct investments are performed, Turkey could generate 1.100 kWh of energy per meter square (Gönüllü et al, 2006). Turkey has produced a total of 420 toe of energy from solar systems in 2007 which is far below than its potential.

Investments

As per the ministry's data, energy investments averaged 22 billion TRY in 2000 and 2001 where the figure has declined from 2002 to 2004 but later recovered in 2005 and raised back to 21 billion TRY. However, the investments fell back to 12 billion TRY in 2006. From 2000 to 2007, energy sector attracted almost 35% of the entire investments in Turkey. According to the energy ministry's projection each year from 2.000 to 2.500 MW of further investment is needed to meet the rising energy demand. Contrary to the picture mentioned in 5.2.7 where it was founded that Turkey relies less on imported electricity, as per TEIAS's high demand increase projection dated July 2007, electricity supply will not be able to meet the demand after 2009 whereas for the

conservative projection case; the deficit will begin by 2011. This arithmetic indeed boasts Turkey's energy vulnerability significantly. Taking the probability of unexpected events like being not able to complete the planned investments, interruption of natural gas supply, reduction in auto-producers' production forces Turkey to establish facilities from 13.807 MW to 26.298 MW of new production facilities per year. Otherwise, interruptions in energy supply might come into stage in the near future (ITU, 2007). For this reason, private initiatives investments to energy gains huge importance. As of 2007, EÜAŞ and its subsidiaries' share which is owned by the state in total power generation scored 48.2% whereas the private initiatives' and autoproducer's participation was 33.5% and 18.3% respectively. Turkey has achieved an important progress in the privatization of electricity market when compared to the standing of the previous decade where the state plants were forming 88.1% of the total production. With the liberalization of electricity market especially after 2001, the contributions of private initiatives have surged significantly. However, in order to reduce energy vulnerability of Turkey, further investments need to be undertaken.

Political Factors

Political factors shape up the immeasurable extent of energy vulnerability. From the perspective of a net energy importer country, political stability of the country that the energy is purchased from, bilateral relations and interests designate the scope of the politic aspect of the energy vulnerability. On the other hand, on-going global political circumstances, economic developments and common actions of energy exporter countries are other vital determinants to be evaluated under this category. In addition to external factors of political aspect of energy vulnerability, domestic political environment of a country is influential in shaping energy vulnerability too.

As an example of global political events on energy, oil prices could give a meaningful insight. In the last half century, developments in the world especially the ones happening in energy exporting countries have affected the oil prices as depicted in the graph below.

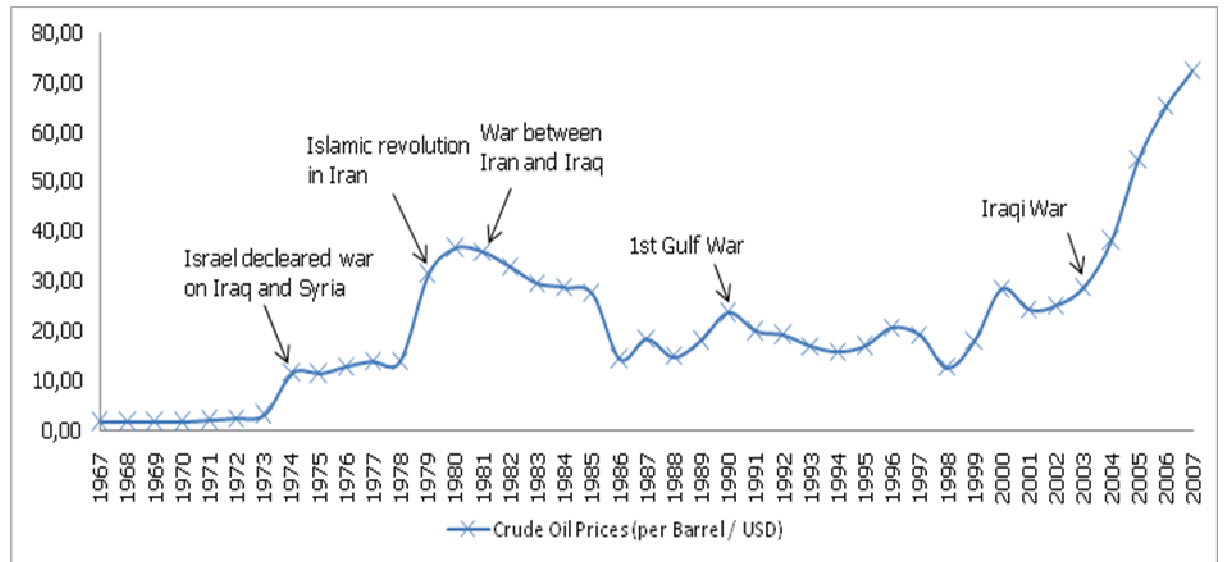


Figure 46. Oil prices in USD and major political events in the early history

Extensive imports of Turkey from politically more unstable countries add up to energy insecurity. For instance, due to unstable political standing especially in Northern Iraq, energy flow is faced with potential dangers. Kirkuk – Yumurtalık pipeline is faced with many sabotage attempts in the near history. In the summer of 2008, although terrorist intervention on the event is not exactly known, Baku – Tbilisi - Ceyhan pipeline’s Refahiye section has exploded which raised concerns regarding sabotage attacks. On the other hand political instability in Georgia is a potential threat for the BTC pipeline too. These realities not only lead to the interruption of energy supply to the country but also negatively affect Turkey’s role as a reliable energy transfer node in the region.

Relations between the energy importer and exporter countries are another parameter to be evaluated within the context of energy vulnerability. In early 2006,

Russia has completely halted the flow of gas to Ukraine which somewhat turned out to be a crisis leading to energy shortages not only in Ukraine but also in Europe. As another example, Iran's president has requested energy embargo to the countries that support Israel within the framework of Gaza conflict started in 2009. For this reason it has attempted to organize Arabic energy exporting countries. The circumstances of the energy exporter country can be influential in enhancing energy vulnerability of the importer country. For instance in early 2009, Iran has stopped supplying gas to Turkey in order to meet its domestic need which boasted for hard climatic conditions.

On - going political conflicts instabilities both in the globe and in the region, energy exporter country's relational power in terms of controlling the flow of energy designates the degree of energy importer countries' energy vulnerability and insecurity as in the case of Turkey.

EU's Energy Vulnerability

Energy vulnerability is a highly prioritized topic for the EU. As per EC 2001a, the roadmap strategy for the security of energy supply is given. For the objective of comparing Turkey's energy vulnerability, European Union is taken as a benchmark. Thus, some of European Union's energy vulnerability indicators are computed and assessed in the following sections. The data are primarily obtained from Eurostat and European Energy Commission (EEC).

Import Dependency

Turkey with dependency ratio above 75% since 2003 relies heavily on the imports to sustain its energy supply. Such huge dependency rates thrives Turkey's energy vulnerability towards criticalness borderline. The dependency has increased continuously from 1992 to 2007 with minor interruptions in 1994 and 2001, the times

when Turkey faced with financial crisis and had to consume less energy and thus increase the share of local energy within energy consumption mix.

Table 52. EU Member States' Net Energy Dependency Calculation as of 2006 (EEC, 2007)

Country	1000 x toe		%
	Consumption	Net Imports	Dependency
S. Cyprus	2.6	3	100.0%
Malta	0.9	0.9	100.0%
Luxembourg	4.7	4.7	98.9%
Ireland	15.5	14.2	90.9%
Italy	186.1	164.6	86.8%
Portugal	25.3	21.6	83.1%
Spain	143.9	123.8	81.4%
Belgium	60.4	53.5	77.9%
Austria	34.1	24.9	72.9%
Greece	31.5	24.9	71.9%
Latvia	4.6	3.2	65.7%
Lithuania	8.4	5.5	64.0%
Slovakia	18.8	12	64.0%
Hungary	27.8	17.3	62.5%
Germany	349	215.5	61.3%
Finland	37.8	20.9	54.6%
EU27	<i>1,825.2</i>	<i>1,010.1</i>	<i>53.8%</i>
Slovenia	7.3	3.8	52.1%
France	273.1	141.7	51.4%
Bulgaria	20.5	9.5	46.2%
Netherlands	80.5	37.2	38.0%
Sweden	50.8	19.8	37.4%
Estonia	5.4	1.9	33.5%
Romania	40.9	11.9	29.1%
Czech R.	46.2	12.9	28.0%
UK	229.5	49.3	21.3%
Poland	98.3	19.6	19.9%
Denmark	20.9	-8.1	-36.8%

Within Europe Union, it is only Denmark which is a net energy exporter country. On average, more than half of the union's shares are dependent on external

supply where the self sufficiency of United States is over 70% deeming the country around 30% dependent on energy imports. Comparing the dependencies of EU member countries with Turkey's dependency rate of 78,9 % in 2006, it is inspected that Turkey's reliance on imports for energy is quite higher than the EU average of 53.8%.

Within European Union, it is only Denmark that is a net exporter of oils. Italy and Romania produces oil to a certain extent however between 100 toe to 120 barrels per day, their production is not enough to sustain self sufficiency. Norway, not being an EU member country, produces 2.556 barrels of oil per day and supplies 16% of the union's crude oil. EU's crude oil production meets around 15% of the unions demand.

From the perspective of natural gas, Denmark, Germany, Italy, Netherlands, Poland and Romania are the reserve holders in the EU. However their production has met around 39 % of the European Union's natural gas demand as of 2007, deeming the union approximately 60% dependent on natural gas imports. In the consumption of coal, within 317.9 m toe of total coal spent in the European Union, 178.3 m toe was produced by the union member countries.

Considering that Turkey is almost completely dependent on external resources for meeting its oil and natural gas demand and has become almost half dependent on coal since 2003 when oil and natural gas prices have boomed significantly and coal served as a cheaper substitute, Turkey's reliance on imports for sustaining its energy supply is higher than the EU average.

Primary Energy Consumption

From 1992 to 2006, EU's average primary energy consumption has increased by 7.97% where Turkey's boom in primary energy demand was 91.8%. Turkey with its rapid industrialization performed a faster demand increase in primary energy compared to EU average.

Table 53. EU's and Turkey's Primary Energy Consumption (Eurostat, 2008)

Years	Primary Energy Consumption (toe)	
	EU	Turkey
1992	1,615.70	56.1
1993	1,607.40	59.5
1994	1,601.10	58.3
1995	1,636.70	63
1996	1,690.90	68.2
1997	1,677.90	73.7
1998	1,694.40	74.7
1999	1,691.00	74.7
2000	1,710.40	80.5
2001	1,737.50	75.4
2002	1,724.00	78.3
2003	1,756.20	83.8
2004	1,778.10	87.8
2005	1,780.00	91.0
2006	1,783.40	99.6
2007	1,744.50	107.6

On a general outlook, EU's primary energy consumption is composed of solid fuels, oil, natural gas, renewable energy means and nuclear energy which is absent in Turkish energy production mix.

Table 54. Primary Energy Consumption Shares of the EU and Turkey

Region	Toe (As Of 2006)						
	All fuels	Solid fuels	Oil	Natural gas	Nuclear	Renewable	Other
Turkey	99.6	28	32.7	28.6	0	10.1	0.2
%	100%	28.1%	32.8%	28.7%	0.0%	10.1%	0.2%
EU27	1825.2	325.2	673.0	437.9	255.3	129.7	4.0
%	100%	17.8%	36.9%	24.0%	14.0%	7.1%	0.2%

The consumption of oil in Turkey is lower than the consumption in European Union in percentage terms. However, Turkey uses natural gas more extensively than the EU average. On the other hand, while Turkey relies heavily on solid fuels by around 28%, the figure is almost 10% lower in EU. Moreover, Turkey's share of renewable energy in the consumption mix is higher compared to the EU. While nuclear energy is not consumed in Turkey, European Union generates a significant portion of its energy through nuclear plants.

Import Concentration

In 2007, EU27 has met 33% and 16% of its oil demand from Russian Federation and Norway respectively. Kazakhstan has provided around 5% of EU's oil demand. In Africa, Libya scored 8% of the supply where Algeria and Nigeria have both contributed to supply around 3%. Saudi Arabia has made up 11% of the oil imports where the figure was roughly 7%. The remaining 14% is supplied through other countries.

The below figure implies that, although the European Union has somewhat dependent on two countries, Russia and Norway, for supplying half of its oil imports, the other half is diversified successfully to an extent to significantly reduce HHI values. Table 55 displays oil suppliers for the EU from 2000 to 2006.

Table 55. Crude Oil Suppliers to EU and Their Sales in Million Tones (EEC, 2008)

Origin	2000	2001	2002	2003	2004	2005	2006	Share 2006(%)
Russia	112.4	136.8	154.7	170.8	188.9	188	189	33.5
Norway	115.9	108.1	103.1	106.4	108.6	97.5	89.1	15.8
Libya	45.5	43.8	39.2	45.9	50	50.6	53.2	9.4
Saudi Arabia	65.1	57.5	53.1	61.5	64.5	60.7	50.9	9
Iran	35.5	31.4	25.9	34.7	35.9	35.4	36.4	6.4
Other, Middle East	54.7	48.3	43.2	27.8	28.5	30	32.1	5.7
Kazakhstan	9.9	9.1	13.4	15.9	22.2	26.4	26.8	4.8
Nigeria	22.4	25.7	18.4	23.2	14.9	18.6	20.2	3.6
Other Origin	54.3	54.3	64.2	56.5	56.1	66.1	66.9	11.8
Total Imports	515.8	514.9	515.3	542.9	569.5	573.3	564.6	100

With this diversification of oil imports European Union has maintained an HHI level of 1.789 in 2006. Comparing this value with Turkey's HHI performance of 2.716 in 2006, we can conclude that Turkey's import pattern is less diversified than EU average deeming Turkey's energy vulnerability to be more than European countries'.

Approximately 40% of the natural gas is supplied through Russian Federation and 23% from Norway. The table below shows the non EU member natural gas suppliers for the union.

Table 56. Natural Gas Suppliers to EU and Their Sales in 1000 Terra Joules (EEC, 2008)

Origin	in 1000 x Terra Joules							Share 2006(%)
	2000	2001	2002	2003	2004	2005	2006	
Russia	4,540	4,422	4,555	4,895	4,951	4,953	4,928	41.0%
Norway	1,985	2,136	2,602	2,699	2,802	2,672	2,844	24.2%
Algeria	2,203	1,957	2,132	2,159	2,042	2,257	2,135	18.2%
Nigeria	172	216	218	336	410	436	561	4.8%
Libya	33	33	26	30	48	209	322	2.7%
Egypt	0	0	0	0	0	202	317	2.7%
Qatar	12	27	88	80	160	196	245	2.1%
T. and Tobago	36	24	19	1	0	30	154	1.3%
Other Origin	113	199	125	100	313	409	223	1.9%
Total Imports	9,095	9,016	9,765	10,302	10,726	11,364	11,729	100%

The table above shows that most of the European countries' dependency for natural gas is only slightly higher than the criticalness borderline. The HHI value for the above table is 2.645 for 2006. Turkey with an HHI of 4.680 as per 2007 data outperformed the energy vulnerability of European Union. Although, the dominance of Russian Federation in European natural gas import mix is quite apparent, the union has managed to well diversify the remaining 60% successfully. In Turkey, almost two third of the natural gas is supplied through Russian Federation.

From the perspective of coal, EU member countries have a well diversified supplier portfolio too. The union imports from Australia, United States, Russia, Indonesia and etc. Table 56 shows the crude oil suppliers for the union.

Table 56. Coal Suppliers to EU and Their Sales in Kilo Tones since 1990 (Eurostat, 2008)

Year	Russia	South Africa	Australia	Colombia	Indonesia	US	Other	Total EU-27
1990	3,945	24,538	17,778	9,065	239	47,013	8,233	110,811
1991	4,057	25,862	20,743	11,642	672	53,855	9,628	126,459
1992	11,122	28,256	22,201	12,087	2,349	49,262	10,764	136,041
1993	9,476	26,711	19,949	11,717	1,911	34,567	7,863	112,194
1994	9,257	27,796	21,427	11,437	3,496	29,936	9,888	113,237
1995	8,906	29,093	19,544	11,478	3,359	41,487	10,562	124,429
1996	6,928	32,716	16,440	18,271	3,822	35,881	9,247	123,305
1997	7,738	34,038	19,355	19,870	5,427	36,115	11,885	134,428
1998	7,768	35,359	22,256	18,952	7,129	29,503	11,847	132,814
1999	10,252	35,264	25,459	19,079	7,710	20,689	12,885	131,338
2000	14,976	40,177	28,600	23,132	8,770	20,447	15,113	151,215
2001	20,875	49,273	29,450	22,633	9,826	20,119	20,437	172,613
2002	23,033	53,961	29,337	21,398	11,074	14,082	18,278	171,163
2003	26,545	56,932	31,004	22,908	13,004	12,619	17,348	180,360
2004	40,382	54,190	30,838	24,224	13,980	15,416	17,032	196,062
2005	48,304	51,698	27,013	24,147	14,102	15,673	15,504	196,441
2006	54,890	53,172	27,258	26,052	20,313	17,265	13,444	212,394

The table indicates that the HHI value for coal imports in 2006 is calculated as 1.807 in 2006 where the figure was 2.191 for Turkey. Although both the HHI value of

Turkey and the European Union is below criticalness borderline, EU has rather a more diversified coal supplier mix.

Considering that the share of oil in EU's primary energy imports are 58.5%, 27.6% for natural gas and 13.9 % for solid fuels where coal contributes to the majority among solid fuel imports, the cumulative HHI value for the EU would be calculated as 2.145 in 2006. Turkey's HHI in 2006 was 3.324 declaring Turkey more vulnerable to energy compared to the European Union.

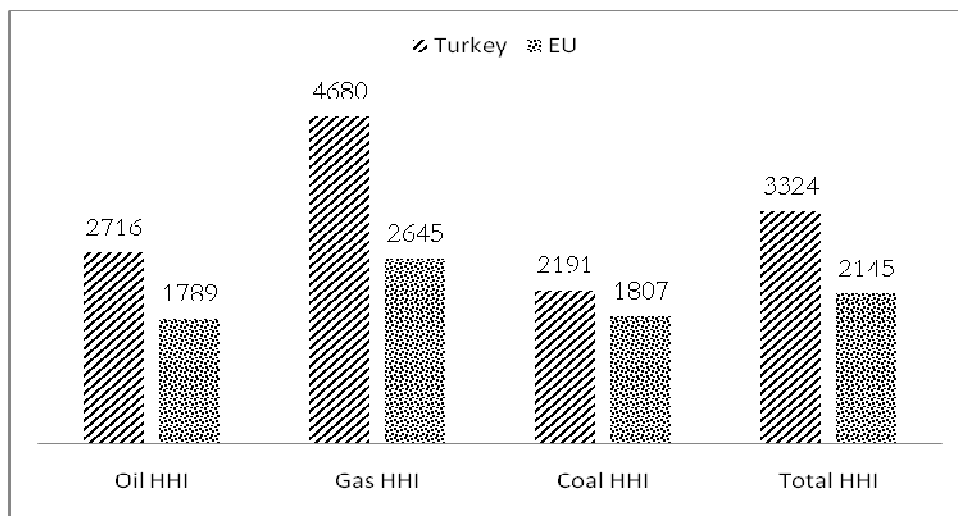


Figure 47. EU's and Turkey's cumulative HHI scores as of 2006

Energy Intensity

European Union's energy consumption per Euro GDP has declined between 1992 and 2006. The increase in the efficiency has been 14% in the period of analysis. When Energy Intensity of the EU is compared with Turkey by converting it to USD using the average currencies, it is inspected that European Union countries spend less quantities of energy per GDP, implying EU's superiority on energy efficiency over Turkey. However, it should be noted that Turkey's increase in Energy Intensity is 24%, 10 points more than the EU average from 1992 to 2006 which signals that Turkey is getting efficient in a faster manner than EU.

Table 58. EU's Energy Intensity and its Comparison With That of Turkey (Eurostat, 2008)

Year	EU - Energy Intensity (toe/Meuro)	Currency (EUR/USD)	EU - Energy Intensity (toe/million USD)	Turkey's Energy Intensity (toe / million USD)
1992	0.205	1,249	0.256	0.342
1993	0.216	1,233	0.267	0.316
1994	0.209	1,119	0.234	0.430
1995	0.209	1,307	0.273	0.363
1996	0.212	1,256	0.266	0.386
1997	0.205	1,13	0.231	0.378
1998	0.201	1,098	0.220	0.356
1999	0.194	1,037	0.201	0.365
2000	0.188	0,938	0.176	0.384
2001	0.189	0,875	0.165	0.479
2002	0.186	0,993	0.184	0.413
2003	0.188	1,115	0.210	0.342
2004	0.185	1,226	0.227	0.287
2005	0.182	1,211	0.221	0.262
2006	0.177	1,268	0.224	0.260

Table 50 implies that EU has progressed in efficient energy consumption since 1992 which also was the case for Turkey. The efficiency growth in Turkey was indeed faster than the EU average which is a good signal from the perspective of energy vulnerability. As Figure 48 shows, although Turkey's EI value is still higher, it is converging to the performance of the European Union faster especially after 2001.

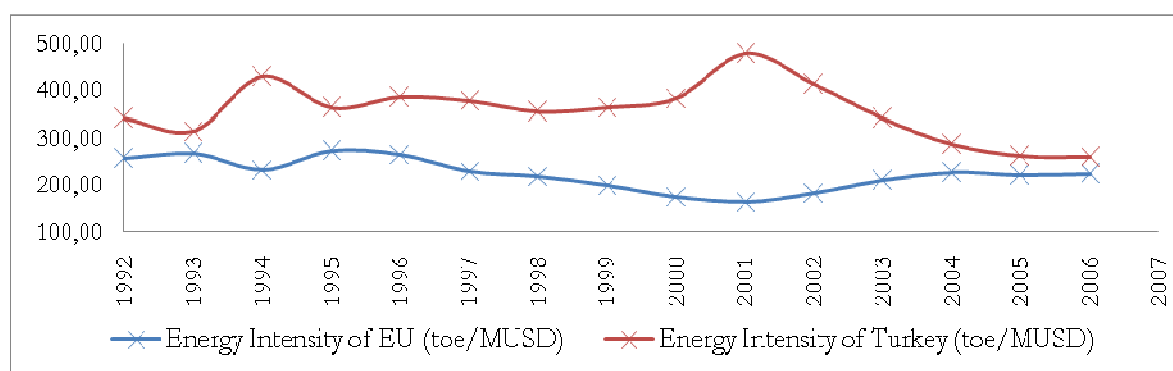


Figure 48. Turkey's and EU's energy intensity since 1992 (x 1000)

Carbon Content

When the carbon intensities of EU countries and Turkey are compared, it is inspected that Turkey's release more carbon dioxide per toe of energy since 1992. Since Turkey relies on solid fuels intensively where the nuclear energy has a place in the consumption mix of the EU, Turkey's carbon intensity is higher.

Table 59. European Union's and Turkey's Carbon Intensity Since 1992 (EEC, 2008)

Years	(tonne CO ₂ / toe)	
	EU - Carbon Intensity	Turkey's Carbon Intensity
1992	2.68	2.72
1993	2.64	2.71
1994	2.64	2.73
1995	2.61	2.73
1996	2.58	2.8
1997	2.56	2.84
1998	2.54	2.77
1999	2.52	2.77
2000	2.52	2.85
2001	2.51	2.82
2002	2.5	2.84
2003	2.5	2.81
2004	2.5	2.81
2005	2.49	2.87
2006	2.5	2.79

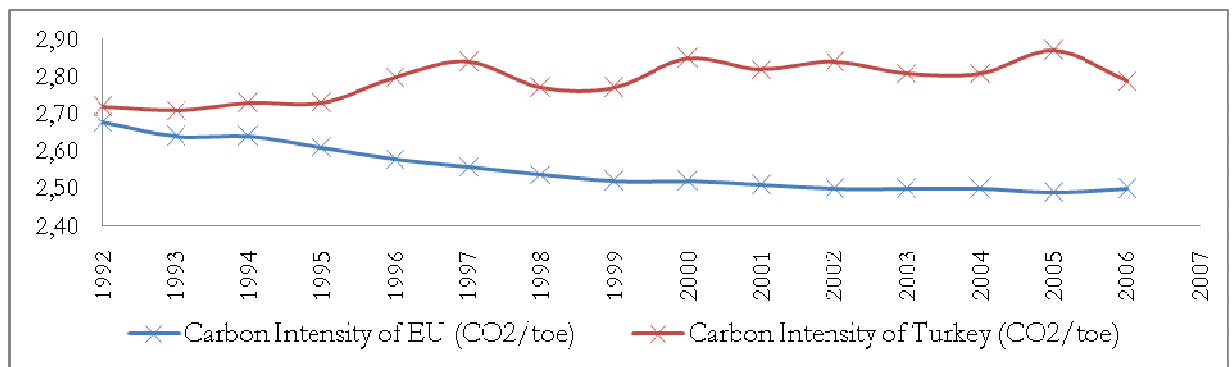


Figure 49. Carbon intensity of the EU and Turkey

Another point to note is that from 1992 to 2006, the EU has decreased its carbon emissions per toe of consumed energy from 2,68 to 2,50 while Turkey did not progress in carbon intensity reduction in the same period of analysis.

Electricity Market

The table below shows the electricity consumption and their means of production for the countries in Europe. The states are shown with their two lettered code.

Table 60. Raw Materials Used For Electricity Generation in European Countries as of 2006 (EEC, 2008)

Gross Electricity Generation 2006 in TWh	Total	Conventional Thermal	Coal	Oil	Gas	Other Power Stations	Nuclear	Pumped Storage	Renewables*
EU27	3,354.00	1,839.3	960.45	131.85	707.25	39.77	989.88	35.62	489.21
Share	100.00%	53.6%	28.60%	3.90%	21.10%	1.20%	29.50%	1.10%	14.60%
AT	63.5	20.92	6.98	1.64	12.03	0.26		2.79	39.8
BE	85.54	33.9	6.85	1.38	25.39	0.28	46.65	1.27	3.73
BG	45.84	21.75	19.08	0.38	2.28	0.01	19.49	0.34	4.26
CH	64.04	1.25		0.18	0.79	0.28	27.82	1.92	33.04
CY	4.65	4.65		4.65					0
CZ	84.36	54.08	49.65	0.26	4.17	0	26.05	0.71	3.53
DE	636.6	387.83	266.97	9.55	77.55	33.77	167.27	7.37	74.13
DK	45.72	35.66	24.63	1.61	9.42				10.06
EE	9.73	9.6	8.79	0.03	0.78				0.13
EL	60.79	52.5	32.26	9.6	10.61	0.03		0.43	7.86
ES	299.46	183.03	66.74	23.83	91.81	0.65	60.13	3.94	52.36
FI	82.3	36.89	22.96	0.48	12.96	0.48	22.91		22.51
FR	574.56	55.3	22.89	7.13	25.28		450.19	5.28	63.79
HR	12.43	6.28	2.26	1.96	2.06			0.12	6.03
HU	35.86	20.81	7	0.52	13.25	0.04	13.46		1.59
IE	27.48	24.64	8.02	2.71	13.91	0		0.36	2.47
IS	9.93	0		0					9.93
IT	314.12	255.6	44.21	45.88	164.31	1.21		6.43	52.09
LT	12.48	2.99	0	0.33	2.46	0.2	8.65	0.41	0.44
LU	4.33	3.25			3.25			0.81	0.27
LV	4.89	2.11		0.01	2.1				2.79
MK		0							
MT	2.3	2.3		2.3					
NL	98.39	85.41	23.74	2.1	59.43	0.15	3.47		9.51
NO	121.71	0.79	0.04	0.02	0.54	0.18		0.39	120.52
PL	161.74	156.46	148.61	2.44	5.02	0.38		0.98	4.31
PT	49.04	32.56	14.96	5.25	12.34	0.01		0.47	16.02
RO	62.7	38.71	25.15	1.61	11.95		5.63		18.36
SE	143.3	4.39	0.88	1.67	1.24	0.6	66.98	0.02	71.92
SI	15.12	5.87	5.44	0.05	0.37	0.01	5.55		3.7
SK	31.37	8.36	5.31	0.72	2.33	0	18.01	0.17	4.83
<u>TR</u>	<u>176</u>	<u>131.78</u>	<u>45.61</u>	<u>4.24</u>	<u>81.63</u>	<u>0.1</u>	-	-	<u>44.43</u>
UK	397.85	299.78	149.35	5.73	142.99	1.71	75.45	3.85	18.77

The table shows that, the number of European countries that employs nuclear energy in electricity generation is in abundance. On average, nuclear energy is used by 29.5% in 2006, whereas the thermal resources are used by 53.6%. The share of renewable energy in Europe's electricity generation mix is 14.6%.

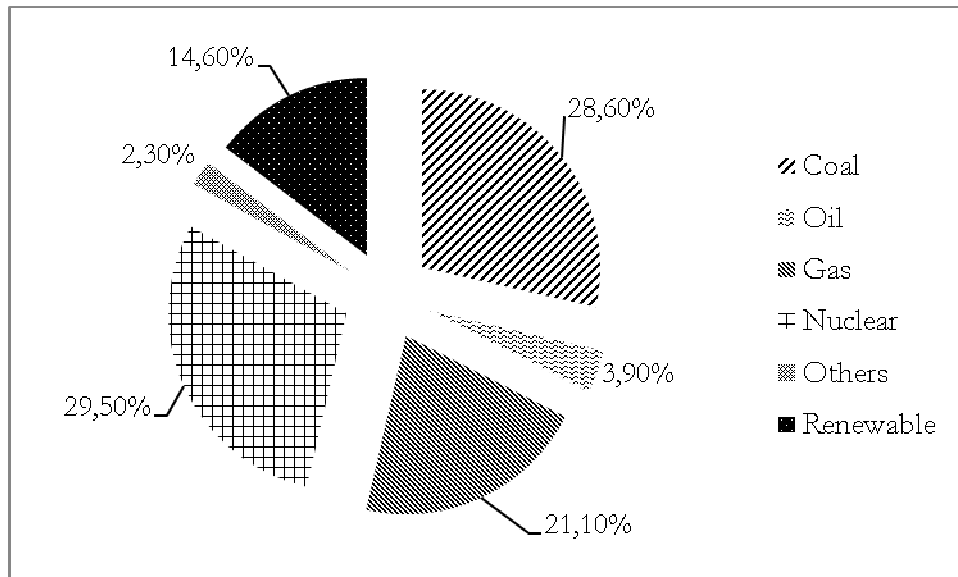


Figure 50. EU's electricity production raw material percentage share as of 2006

Turkey, on the other hand, employs thermal means of electricity production by 74.9 % and renewable means by 25.1%. Thus, although Turkey performs better than the EU in using renewable energies to produce electricity, its excess reliance on costly and comparably more carbon intensive conventional thermal energy increases Turkey's energy vulnerability significantly. Few countries in Europe do not make use of nuclear energy within their electricity generation mix.

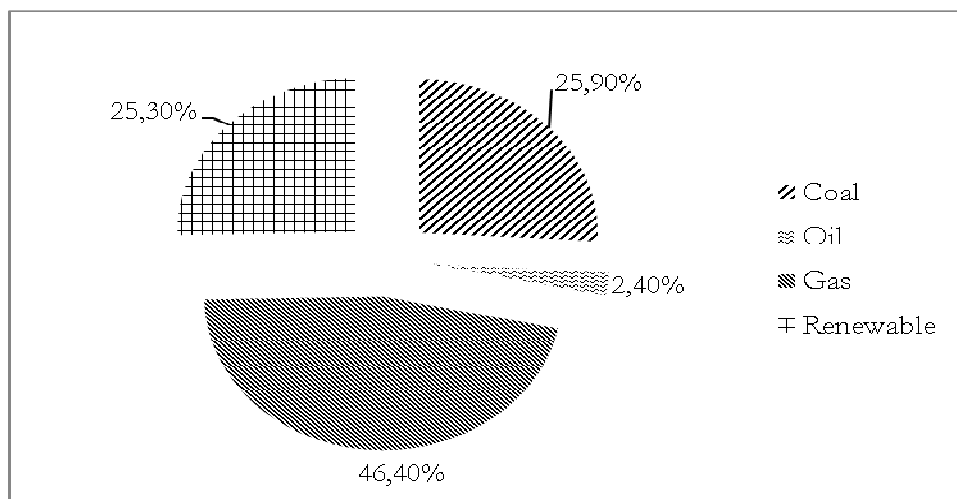


Figure 51. Turkey's electricity production raw material percentage share as of 2006

Table 61 depicts production capacity of EU's and Turkey's plants as of 2006 data. The table shows EU's superiority in wind plants. On the other hand, EU has a considerable volume of nuclear capacity which is almost equal to the difference between Turkey's conventional thermal and hydro plants.

Table 61. Production Capacity of the Power Plants in the EU and Turkey as of 2006 in MW (EEC, 2008)

Region	Total	Production Capacity as of 2006 (MW)				
		Conventional Thermal	Nuclear	Wind	Geothermal	Hydro
EU27	762.164	440,094	133,806	47,685	696	139,883
Share	100,0%	57.7%	17.6%	6.3%	0.1%	18,4%
Turkey	40.565	27.420		59	23	13,063
Share	100,0%	67.6%		0.1%	0.1%	32.2%

Geographical Indicators and Political Factors

European Union imports its energy not only from Russian Federation and Norway, but also from Northern Africa and the Middle East in addition to the overseas market like the United States and Canada especially in coal imports. This picture demonstrates that Europe has diversified its energy supply to hedge the union from any potential interruption threats. On the other hand, Norway, a politically stable and strong country has an important share within Europe's energy trade structure. Turkey does not currently import energy from Norway in significant volumes. Although, Russia is

becoming to be predominant in Europe's energy consumption structure, it should be noted that, 93.5% of the energy consumed within the union is covered by sources other than Russian gas – and natural gas, unlike oil, faces direct competition from other fuels and technologies where Turkey's reliance on Russia for sustaining its energy supply is around 40%.

Geographical proximity to energy exporting countries like the ones in Northern Africa, Nordic region and the Middle East when considered in bundle with the advantages of the easier flow from one country to another as part of the union's advantage reduces EU countries vulnerability to energy.

Renewable Energy

In EC 2001b directive of the European Union, renewable energy is highly encouraged and promoted. Below table shows renewable energy capacity of the European countries and Turkey.

Table 62. Renewable Energy Capacities of the European Countries as of 2006 (EEC, 2008)

Countries	2006 Renewable Capacity in ktoe					
	Total	Biomass	Hydro	Wind	Solar	Geothermal
EU27	129,719	89,512	26,569	7,074	988	5,576
Share	100.0%	69.0%	20.5%	5.5%	0.8%	4.3%
DE	21,113	16,120	1,714	2,641	472	167
FR	18,003	12,784	4,872	188	29	130
SE	14,813	9,415	5,307	85	6	
IT	13,097	4,657	3,181	255	38	4,966
NO	11,635	1,310	10,267	58		
TR	10,538	5,159	3,813	11	402	1,162
ES	9,385	5,064	2,226	2,003	84	8
FI	8,576	7,574	988	13	1	
AT	7,282	4,000	2,999	148	101	35
PL	4,987	4,776	176	22		13
RO	4,781	3,185	1,578	0		18
CH	4,575	1,733	2,662	1	28	151
PT	4,320	3,011	946	252	24	88
UK	4,320	3,523	395	363	37	1
IS	3,259	2	627			2,630
DK	3,257	2,708	2	525	10	12
NL	2,909	2,643	9	235	22	
CZ	1,972	1,746	219	4	3	
EL	1,796	1,010	520	146	109	11
BE	1,767	1,700	31	31	3	2
LV	1,433	1,197	232	4		
HU	1,272	1,164	16	4	2	86
BG	1,140	741	364	2		33
HR	884	366	516	2		
SK	859	474	378	1	0	6
LT	787	750	34	1		2
SI	768	459	309			
EE	531	523	1	7		
IE	420	217	62	139	1	1
LU	79	63	9	5	2	
CY	50	7			43	
MT	0					

As Table 62 shows, Turkey is the sixth mostly renewable energy consuming country in Europe proving that Turkey has comparative advantage in lowering its energy vulnerability when compared with the performance of many European countries. The share of biomass within Turkey's renewable energy consumption is 49 % whereas the share of hydro energy is 36.2% and 11% for geothermal energy. Solar energy's share is barely 3.7 where the share of wind is barely 0.1%. Turkey's share for hydro, geothermal and solar energy is superior to the EU average in percentage terms; wind energy is not yet a promising means of energy generation yet.

Hence, Turkey performs relatively worse than the EU average in energy vulnerability indicators since it is more dependent on imports, has a more concentrated nature of energy suppliers, less efficient in energy consumption, spends more carbon rich fuels and imports from less politically stable countries. On a study conducted by Gnansounou (2008), Turkey is the 28th most vulnerable country among the analyzed 37 industrialized states. Contrary to this negative standing, Turkey has more renewable energy opportunities compared to European Union and thus exhibits a higher potential to reduce its energy vulnerability for the future.

CHAPTER VI

PLANT INVESTMENT DECISION MAKING USING GREY RELATIONAL ANALYSIS

In this chapter, a model study is conducted in order to comprehend which type of plant investment would work best for Turkey. By saying “working best”, several objectives are defined and the model is run over these cases. The decision problem is formulated and evaluated by Grey Relational Analysis method. The first section of this chapter introduces the model, while the next part defines the decision problem and its assumptions. The third section offers the methodology of the model and later parts stress on data assignments and model results.

Grey Relational Analysis

Grey Relational Analysis is a quantitative technique to explore the similarity and dissimilarity among factors while employing specific concept of information and data (Kung, Wen, 2007). In real world challenges, none of the problems are composed of idealized inputs and solutions of white and black, where the presence of perfect information is referred as white or its absence is called black. In fact, cases between these two extremes are nominated as grey or fuzzy. From this perspective, a grey system indicates that a system in which a set of information is known where the rest is unknown. As Chan and Tong puts (2007), the information quantity and quality varies from black through to grey to white. For them since uncertainty always exists, one is always somewhere in the middle, somewhere between the extremes, in the grey area. Grey analysis method with its approach comes to a clear set of statements about the solution of the decision problem. At one extreme, no solution can be defined for a

system with any information. At the other extreme, a system with perfect information has a unique solution. In the middle, grey systems would offer a bunch of available solutions. Grey analysis' objective is not to present the best solution, but to provide techniques for determining a good appropriate solution for real world problems. Thus, the theory of Grey System involves model construction, relational analysis, prediction and decision making of system to be certain about it that is indefinite and incomplete data (Chen et al, 2000). For this reason, rather than relying on highly metric data and tuned data, relative performances of factors designate the superiority of one solution over other. The theory proposes a dependence to measure the correlation degree of factors where similarities lead further correlation. The mathematics model of the Grey Relational Analysis is described in the following section.

Research Design

The goal in this modeling is to develop an insight regarding which type of plants would be a more pragmatic approach for Turkey to invest. Since the inputs used to generate secondary form of energy in the form of electricity is a concern on energy vulnerability, evaluating the alternatives on a contextual basis would unfortunately serve as a roadmap for Turkish energy administration. Types of investments whose strengths and weaknesses deem them in the gray spectrum could be listed as natural gas plants, renewable energy plants (all renewable forms involving hydro, wind, solar, geothermal, biomass, etc.) and nuclear plants. The variables that nominate these alternatives for more or less attractive is listed as follows:

- Plant Construction Cost: The amount of investment required to construct the plant to an extent to make it ready for production.

- Marginal Cost of Production: Cost of generating per unit energy including raw material expenditures, maintenance and waste disposal.
- Dependency to Input: Overall dependence on the raw material used for the operations of the power plant.
- Environment – Friendliness: Includes the cleanness nature of the production facilities from the perspective of carbon emissions.
- Production Certainty: The index assessing how certain the production will go on with the most possible capacity.

Throughout the analysis, public acceptance and safety of each type of power plant is regarded the same. In other words, it is assumed that, the operational safety of each power plant is ensured and public acceptance resulting from security issue is not taken as a parameter for the evaluation of decision. On the other hand, the lifecycles of each type of the plants are taken identical.

Methodology

Combining the works of Wu (2007), Deng (1989), Hsia et al (2004) and Kung et al (2004)'s, the methodology of the Grey Analysis could be formulated as follows:

The original series is represented by

$$x_i = (d_{i1}, d_{i2}, \dots, d_{im})$$

where $i = 1, 2, \dots, k$. k is the number of alternatives subject to decision analysis where each unit under comparison contains m values. In our research, k is three (nuclear, renewable and natural gas) where m is five as we have that much of parameters of consideration.

Prior to calculating the grey relational scale, data pre processing should be done so that the data can be treated with the following two cases and the linearity of normalization to avoid distorting the normalized data.

- i. If the larger value of the parameter is the better;

$$d_i^*(m) = \frac{d_i^{(0)}m - \min d_i^{(0)}m}{\max d_i^{(0)}m - \min d_i^{(0)}m}$$

- ii. If the smaller value of the input is better;

$$d_i^*(m) = \frac{\max d_i^{(0)}m - d_i^{(0)}m}{\max d_i^{(0)}m - \min d_i^{(0)}m}$$

Where

$d_i^*(k)$: The value of grey relation

$\min d_i^{(0)}m$: $x_i^{(0)}$ The minimum value

$\max d_i^{(0)}m$: $x_i^{(0)}$ The maximum value

After this step, Δi of the different data series is computed with below formula:

$$\Delta i = (|d_{01} - d_{i1}|, |d_{02} - d_{i2}|, \dots, |d_{0m} - d_{im}|)$$

Find the global maximum value Δmax and minimum value Δmin in the difference data sets.

$$\Delta \max = \forall_i^{max}(max\Delta_i)$$

$$\Delta \min = \forall_i^{min}(max\Delta_i)$$

Transform each data point in each difference data series to grey relational coefficient. Let $\gamma_i(j)$ represents the grey relational coefficient of the j^{th} data point in the i^{th} data series, then

$$\gamma_i(j) = \frac{\Delta \min + \vartheta \Delta \max}{\Delta_i(j) + \vartheta \Delta \max}$$

Where

$\Delta_i(j)$ is the j^{th} value in Δ_i difference data series ϑ is a value between zero and one. The coefficient ϑ is used to compensate the effect of $\Delta \max$ should $\Delta \max$ be an extreme value in the data series. In general, the value of ϑ can be set to 0.5.

After the calculation of reciprocal coefficients, the next step would be applying the importance weights and obtaining prioritized safety performance score.

$$PSPS_i = \sum_{u=1}^{u=m} \gamma_i(u) * w_u$$

Where w_u refers to the importance weight of the u^{th} parameter. $PSPS_i$ is a value that changes from zero to one where zero illustrates the worst score while one is the best.

Data Assignment

For each of the five parameters those are influential in the process of decision making of the plant investments, both actual data and the indexes that are derived using real data is employed. Since relative performances of the decision alternatives within a specific criteria of concern designates the outperformance of one choice over the other, using indexes serves for the purpose of assigning factual and consistent data for the decision parameters too. Below section delivers information regarding the value assignments for each indicator.

Plant Construction Cost

In International Strategic Research Organization (USAK) Energy Review, a calculation is performed in order to assess the cost of establishing a nuclear and natural gas plant. As per their assumptions, a nuclear power plant is to be constructed whose construction duration will be five years. The plant is estimated to generate electricity after 2013. The comparison is performed among a natural gas and nuclear power plant. Each of them would have 1500 MW of capacity. As a result, the cost of building a 1500 MW nuclear power plant is founded as 4 billion USD where the figure is calculated as 1.2 billion USD for the same capacity for natural gas. (Yılmaz, 2007)

To assign a value for renewable energy plant construction, Turkish Energy Regulation Authority's (EPDK) plant construction units per MW is used. According to the authority, while establishing a natural gas plant costs 1 million USD per MW, it is 2 million for wind, 4.2 million for solar, 1.9 for biogas, 1.7 million for biomass, 2.1 million for geothermal, 1.6 million for hydraulic. Although the average of these values are 2.25 million, since hydroelectric plants are most extensively used within renewable energy and Turkish government has a vision to encourage more hydraulic, geothermal and wind plants, the cost of establishing a renewable plant is taken as 2 million dollar per MW, a value which is closer to hydraulic, wind and geothermal than their complete average. 2 million dollars is the double value of EPDK's natural gas establishment costs.

Hence, to resemble the standing of renewable with that of the nuclear and natural gas, we take the double value of natural gas value of Yılmaz (2007) in USAK energy review and assign the corresponding 2.4 billion establishment cost for renewable power plants. It should be stated that this is the estimated cost of 1,500 MW renewable energy. ITU's study (2007) reports a parallel finding. According to the study group's

researches, cost of establishing a natural gas plant is 795 USD per kW, 1,200 – 1,500 USD for a large hydraulic plant.

Since the relative performances of three plants is important for the operation of the Grey Analysis model, following data could be directly supplied to the model as coefficients.

Table 63. Data Inputs for the Plant Establishment Cost Parameter

	Natural Gas	Renewable	Nuclear
Establishment Cost	1.2	2.4	4

Marginal Cost of Production

According to Nuclear Energy Institute (2008), total Operational Production Costs involving fuel, operation and maintenance costs in cents per kilowatt hours is shown in Table 64 below.

Table 64. Total Operational Productions Costs per KWh for Coal, Gas, Nuclear and Oil Plants

Year	Total Operational Production Costs			
	Coal	Gas	Nuclear	Petroleum
1995	2.57	3.74	2.70	5.85
1996	2.42	4.57	2.53	5.95
1997	2.34	4.64	2.64	5.35
1998	2.29	4.08	2.46	3.76
1999	2.21	4.39	2.22	4.52
2000	2.15	7.28	2.17	6.51
2001	2.21	7.36	2.05	6.02
2002	2.19	4.70	2.03	5.76
2003	2.16	6.42	1.99	6.88
2004	2.24	6.42	1.95	6.54
2005	2.43	8.00	1.87	8.96
2006	2.53	6.95	1.89	10.28
2007	2.57	6.69	1.85	10.83
2008	2.75	8.09	1.87	17.26

Petroleum and Natural gas plants are the most expensive mean of generating electricity. Cost estimations of the institute thus are directly reflected as the inputs to the

model. On the other hand, renewable energy plants perform a relatively better performance compared to gas and nuclear plants as it does not require raw materials to operate. Once established, the cost of producing power through wind, solar and hydro energy is almost zero. Although their contribution to marginal cost of power production is significantly lower, in order to be on the safe side, the costs that could be incurred to per unit could be taken almost half of nuclear plant's value. For this reason, per unit operating cost of an average renewable plant is used as 1.

Table 65. Data Inputs for Marginal Cost Parameter

	Natural Gas	Renewable	Nuclear
Marginal Cost	8.09	1	1.87

Dependency to Input (Raw Material)

As discussed in Chapter 5, Turkey is highly dependent on natural gas imports. The country's reliance on natural gas from external resources is calculated to be above 95 percent. For the sake of simplicity, the input to model for natural gas is given as 95. Although, there exists no dependency for renewable energy to produce electricity, a symbolic rate of 5 is assigned in order to represent reliance on international technical expertise to ensure the service continuity of these plants. From the perspective of nuclear energy, although there is no clear information regarding the scope of uranium reserves, it could be stated that Turkey's uranium reserves were found to be approximately 10,000 tons (Ölmez, 2009). Since these reserves will be sufficient around 30 to 50 years for the operation of nuclear power stations, Turkey will not be dependent on external resources of uranium. However, since the existing reserves have high costs associated with their extraction, the Mineral Research and Exploration Institute (MTA) has initiated to search for new reserves with costs below 80 USD per kilogram. In the latest studies of MTA, new uranium reserves were found in Kırklareli, Balıkesir, Manisa,

Kütahya and Uşak and they state that these reserves might be capable of providing uranium supplies for 100 years after performing detailed studies on them. Under these circumstances a value which is drastically lower than natural gas but slightly higher than renewable's dependency needs to be assigned for nuclear. For this reason, the value of 15 is attached for the dependency of nuclear plants in case Turkey needs to import cheaper uranium or requires considerably higher foreign assistance to ensure the operation of nuclear plants. As a result following data will be used for dependency parameter:

Table 66. Data Inputs for Dependency Parameter

	Natural Gas	Renewable	Nuclear
Dependency	95	5	15

It should be noted that, as previously mentioned, due to the nature of the GRA model, the relative position of each decision alternative are important especially when the data is indefinite and incomplete. Although the gap between the values has a certain degree of influence in determining the superiority levels, its scope is not adequate enough to alter the relative superiority of choices under particular importance weight assignments.

Environment Friendliness

According to Vattenfall as cited in the webpage of school of Physics at the University of Melbourne in Australia (2009), over the entire lifecycle of a nuclear plant including the construction of plant, uranium mining, milling, enrichment, operation, decommission and waste disposal, the total amount CO₂ emitted per produced electricity in kWh is 3.3 grams where CO₂ output from a natural gas plant is founded as 400 grams per kWh. Vattenfall also find that nuclear plants emit slightly less carbon dioxide than renewable energy production facilities including hydro, solar, wind and

biomass although all of these processes emit much less than fossil fuel generation of electricity. Under these circumstances, nuclear will be assigned as the best index which is 1, natural gas plants will get a lower degree which is 0.1 and renewable energy would get 0.9, a score which is closer to the best performance.

Table 67. Data Inputs for Environment Friendliness Parameter

	Natural Gas	Renewable	Nuclear
Environment Friendliness	0.1	0.9	1

Operational Certainty

Since Turkey is expected to be self sufficient in uranium reserves, it will demonstrate a higher level of operation certainty as the country would not be challenged with the disruption of energy imports. This process would deem nuclear plants to be more accurate and consistent in production forecasts. From the perspective of renewable energy, as the estimation of raining, winding patterns are subject to minor alterations; its production certainty would be slightly lower than that of nuclear plant. Finally, since Turkey is highly dependent on natural gas gas prices fluctuate frequently and almost half of gas plant owners are private initiatives who are mostly concerned with profitability, gas plants are nominated as the least certain production mechanisms. From this perspective, following assignments are made for operational certainty.

Table 68. Data Inputs for Operational Certainty Parameter

	Natural Gas	Renewable	Nuclear
Operational Certainty	0.8	0.9	1

When these assignments are aggregated and merged the following table is obtained.

Table 69. Factor Value Assignment Table

Decision Factor	Nature of Assignment	Natural Gas	Renewable	Nuclear
Establishment Cost	The lower, the better	1.2	2.4	4
Marginal Cost	The lower, the better	8.09	1	1.87
Dependency	The lower, the better	95	5	15
Environment Friendliness	The higher, the better	0.1	0.9	1
Operational Certainty	The higher, the better	0.8	0.9	1

Weight Assignment and Model Results

In order to evaluate the decision problem from various perspectives, the model is run for several cases. Each of the case is expected to reflect the standing point of an interest group. The results of the each case follow:

Case 1 - Environmentalist Perspective

In this scenario, more importance is attached to environment related concerns whereas the weights of other factors are taken identical. The distribution of weights is as follows: Establishment cost 15%, Marginal cost 15%, dependency 15%, environment friendliness 40%, operational certainty 15%.

Table 70: Results of the 1st Case

Measurement Attribute	Prioritized Safety Performance Score
Nuclear	0.84
Renewable	0.78
Natural Gas	0.43

The results imply that, although natural gas is the cleanest fossil fuel, it performs significantly worse than nuclear and renewable plants. On a comparative perspective between nuclear and renewable investment, nuclear energy is found to be slightly superior alternative.

Case 2 - Foreign Politics Perspective

In this case, more focus is placed on the concern of energy self sufficiency as a part of foreign politics. The weights of the other factors are taken identical. The distribution of weights is as follows: Establishment cost 15%, marginal cost 15%, dependency 40%, environment friendliness 15%, operational certainty 15%. Table 71 presents the output of the model.

Table 71. The results of the 2nd Case

Measurement Attribute	Prioritized Safety Performance Score
Renewable	0.83
Nuclear	0.80
Natural Gas	0.43

The results show that investing in renewable energy is the best option for this purpose. Nuclear energy's score for the objective of reducing energy dependency is also found to be very promising. Indeed the performance of renewable and nuclear plant's score is very similar to each other. Natural gas plants are again the least attractive alternative to serve for the purpose of energy dependency.

Case 3 – Domestic Perspective, Continuity of Services

Under this scenario, more value is attached for ensuring the power supply continuity where the rest of the parameters have equal weight. Since any interruption leads the services and national production to fall, this case is referred as a domestic interest case. Thus, operational certainty is the highest concern of the decision maker. The distribution of weights is as follows: Establishment cost 15%, marginal cost 15%, dependency 15%, environment friendliness 15%, operational certainty 40%. Table 71 presents the output of the model.

Table 72. The result of the 3rd Case

Measurement Attribute	Prioritized Safety Performance Score
Nuclear	0.84
Renewable	0.70
Natural Gas	0.43

The results show that nuclear energy ensures the continuity of power supply best while renewable energy follows it with a closer Prioritized Safety Performance Score (PSPS) score. As was the result in the two previous cases, natural gas is the least attractive alternative to invest under this objective.

Case 4 - Private initiative perspective

Under this case, an understanding regarding the investment decision of private initiative is developed. More than one scenario is presented under this category.

In the scenario below, investors' major focus of concern is the cost of establishing the power plant. National dependency to natural gas imports is a factor of consideration for an investor since it affects the cost of raw material for power production. On the other hand it is assumed for private investors that, environment concerns and operational certainty have quite lower degrees of importance as these issues are of the prioritized concerns of the national administrations.

Table 73, 74. Weight Contribution for the 4th Case's First Scenario and Output Obtained

Decision Factor	Importance Contribution	Measurement Attribute	Prioritized Safety Performance Score
Establishment Cost	60%	Natural Gas	0.73
Marginal Cost	20%	Renewable	0.71
Dependency	15%	Nuclear	0.53
Environment Friendliness	2.5%		
Operational Certainty	2.5%		

In the second scenario below, the importance of marginal cost and establishment cost is somewhat balanced by setting the following weights:

Table 75, 76. Weight Contribution for the 4th Case's Second Scenario and Output Obtained

Decision Factor	Importance Contribution	Measurement Attribute	Prioritized Safety Performance Score
Establishment Cost	40%	Renewable	0.80
Marginal Cost	40%	Nuclear	0.63
Dependency	15%	Natural Gas	0.60
Environment Friendliness	2.5%		
Operational Certainty	2.5%		

Under this case, private initiative's decision making priorities are simulated and in contrast to previous findings, it is founded that natural gas plants are the best choice for investors who are sensitive to plant establishment costs. Since almost half of Turkey's electricity production is supplied through natural gas facilities, the fourth case proves that natural gas plants are constructed by private initiatives who did not want to make large volumes of initial investments before their plants start producing power. This process signals that their expectations for quicker returns encouraged them to invest in natural gas plants that are the least attractive alternative from the perspective of energy dependency, production continuity and environment. In the second scenario of this case, an investor who places more value to marginal cost of production and who is ready to spend higher volumes of investment for constructing the plant is simulated and

it is founded that, renewable energy plant is nominated as the best choice followed by nuclear energy. Thus it could be inferred that in case investors act in a more patient manner and value marginal cost of power production more rather than focusing on plant's initial construction bill, renewable and nuclear energy would serve better for their purpose.

Case 5 - Equal Importance

In this scenario, the importance of decision factors is taken equal to be 20 %.

The result of the model is given below:

Table 77. Output of the 5th Case

Measurement Attribute	Prioritized Safety Performance Score
Nuclear	0.79
Renewable	0.77
Natural Gas	0.47

In the last case, equal worth is placed for each decision factor and the result has demonstrated that, nuclear and renewable energy are again the best choices where the PSPS score of nuclear energy is slightly better. The performance of the natural gas is quite low which is far behind the performance of nuclear and renewable plants.

It could be said that cases from 1 to 3 serves to decline energy vulnerability of a country since reducing energy dependency, decreasing carbon content of the energy supply, ensuring the continuity of power affect energy vulnerability in a positive way. From this perspective, investing in renewable and nuclear power plants serves significantly positively for reducing energy vulnerability. It is also inspected in the findings of the 4th case that private investor's desire to obtain quicker returns and their

reluctance to spend less for initial plant setup works against energy vulnerability and makes Turkey more sensitive to energy related developments. As it is a fact that the more natural gas plants are established, the state gets more vulnerable to energy, these findings leads to several conclusions and policy recommendations that are discussed in detail in the next chapter.

CHAPTER VII

POLICY RECOMMENDATIONS AND CONCLUSION

The importance of energy for Turkey is eminent. Forming an integral portion of the country's trade and current account deficit, the mismatch between energy imports and exports deem energy topic one of the priority topic of Turkey's agenda. On the other hand, Turkey can clearly be nominated vulnerable to energy when its performance is evaluated in energy indicators such as the dependence on external resources, reliance on certain countries to sustain its energy supply, rising bill for energy, energy efficiency and employing expensive means to generate power.

The assessment of Turkey's performance on energy vulnerability indicators and a solid comparison of these values with the performance of the EU, following policy implications could be drawn for Turkish Energy administration.

- Turkey should diversify its energy suppliers

Turkey displays a concentrated energy import scheme. Excess reliance on Russian imports endangers Turkey's energy sustainability in the long run. Reliance on Russia for natural gas is tremendous by 65.6 % as of 2007 data while Russian crude oil imports formed 41.5 % of the overall imports. Dependency to Russia in coal imports was 45.3 % in the same year. These figures imply that Turkey counts enormously on Russian energy which leads to excess levels of energy vulnerability. Iran on the other hand is another energy exporter country for Turkey where the dependence for oil imports was 35.6 % and 17.6 % for natural gas in 2007. From the perspective of oil trade, 77.1 % of Turkey's oil imports were sourced from Iran and Russia together where

the figure for natural gas trade was 83.2 %. Although coal imports do not signal an alert at the moment, the HHI value is close to the criticalness borderline and relies strongly on Russia.

Considering that Russia has preferred to halt the flow of energy to Ukraine in early 2006 which led to the interruptions of many operations in Europe and Iran has stopped supplying natural gas to Turkey in for a few times in the recent history due to its domestic needs, such acute levels of dependency could be regarded as a potential threat to Turkey's energy circulation. Some countries in European Union has preferred not to import energy from Russia like Spain. On the other hand, EU does not have sympathy towards Iran as their view was clear when Iran intended to supply energy from Nabucco project which was later declined by the union. Thus, diversifying energy suppliers in addition to Russia and Iran will reduce Turkey's vulnerability to energy.

- Turkey Should Invest in Advanced Energy Related Technologies

Employing less energy consuming technologies will contribute to shift total energy spending downward. Using newer and energy friendly home appliances will assist in reducing Turkey's energy demand. From the perspective of power plants, using plants with advanced and sophisticated power generation facilities will lead to less internal consumption and operate more efficiently. The added value of the research and development studies has an indispensable contribution in this context.

- Turkey should focus on energy efficiency

Turkey's energy consumption is increasing very rapidly with a faster manner compared to that of the world's and European Union's. Although the world's primary energy consumption have increased by 24.6 % in a decade from 1997 to 2007, the consumption have boomed by 45.6 % in Turkey where the pattern was only by 3.9 % in the EU average. Although it is natural to expect rises in energy demand in line with country's further industrialization, energy efficiency is not optimally maintained yet. Turkey's energy intensity is still higher than the EU average, although the gap has been radically reduced in the past few years. In that respect, policy makers should develop plans and strategies to increase public awareness that would assist in enhancing energy conservation and efficiency.

- Turkey should invest abroad to be an energy corridor

Making use of its unique location, Turkey should attract projects that would enable the flow of energy over its territories. In this context Turkey should proactively seek and actualize project opportunities. Nabucco project that aims to transfer Caspian energy to Europe over Turkey is expected to be constructed by 2010. This project will help to reduce dependency to Russia for Europe and thus is highly supported. It should be noted that political factors highly influence the destiny of such projects. Although through Nabucco project, Iranian gas could technically be transferred too, Europe did not want to involve energy trade with this country. On the other hand, there are attempts to suspend such pipeline projects in case it conflicts with the interests of another country. Russia for example has proposed alternative projects to Nabucco. Burgas – Alexandroupoli pipeline project is another Russian, Greek and Bulgarian initiative that aims to bypass Turkish Straits and transfer Russian and Caspian oil

through Bulgaria and Greece. In such conflicting arithmetic, Turkey should take correct administrative positions and design attractive political frameworks that magnetize the flow of energy and related investments over its territories.

Turkey's investments in oil production projects abroad are growing rapidly. 89 % of the Turkish Petroleum Corporation's (TPAO) investments were actualized in Azerbaijan, the main venture of the company, in 2007. In 2007, TPAO has invested in 391.1 million dollars for the projects abroad. In addition to Azerbaijan, TPAO is also investing in Libya and Kazakhstan and is in the process of exploring ventures in Turkmenistan, Iraq, and Syria. The Petroleum Corporation should go on with its investments and take more active roles in international energy sector.

- Turkey should use cleaner energy

Turkey's carbon intensity value is above the EU average. Although Turkey has shifted using natural gas in the past decade tremendously, the contribution of oil and coal in Turkey's energy consumption mix is still high with 31.1 % and 28.4 % as of 2007 respectively. Needless to say, employing such carbon rich energy means is not only harmful for the ecosystem and environment but also leads to increase in Turkey's energy vulnerability. Transition to nuclear energy with further replacement of oil and coal with natural gas will decrease carbon emissions.

- Turkey should establish more power plants

As per the electricity supply and demand projection of TEİAŞ (2007), Turkish Electricity Transmission Company, Turkey will face with electricity mismatch in 2009 or 2011, in the better scenario. In case the planned investments are not complete when they are supposed to finish, interruptions in natural gas imports is experienced,

autoproducers' contribution in electricity generation falls, and Turkey's electricity production may not be able to meet consumption in the near future. Other potential reasons like unexpected increase in power demand, decline in water volumes in hydroelectricity plants, long – term malfunctions in power plants may all add up to the mismatch between electricity supply and demand in the medium run. When these probabilities are taken into account, redundant means of electricity production facilities should operate in Turkey. Redundancy will ensure the continuity of electricity supply and hence lessen Turkey's vulnerability to energy.

Autoproducer and private production plants' electricity generation is shaped by their customers demand. When the productions in these facilities are not realized in line with their production projections, total electricity generation in the Turkey might fall too. According to the projection of TEIAS, Turkey needs to make an investment of 3 billion dollars in order to ensure electricity generation. Thus, total production capacity of the power plants needs to be incremented as soon as possible.

- Turkey should invest in Renewable Energy

In an environment where the price of fossil fuels like oil and natural gas is expected to remain high, consuming renewable energy has many advantages for the purpose of reducing Turkey's reliance on external energy supply. Turkey should make use of its geothermal, wind, solar energy more intensively by encouraging investments through attractive incentives. Increase in renewable energy will lead lower degrees of energy imports from energy exporting countries and thus will reduce energy vulnerability. Needless to say, further degrees of renewable energy consumption will help to decrease carbon emission to the atmosphere too.

- Natural gas' Share in Electricity Production Should Get Decreased

Natural gas, being an expensive input of electricity production is extensively used in Turkish electricity production mix. Natural gas is the most expensive way of electricity generation. On the other hand, it is the raw material of electricity that Turkey is the most extensively dependent on. Hence an interruption in natural gas supply clearly has a negative effect on maintaining electricity supply. Although, it is the most costly material, private investors choose to invest in natural gas plants since the return is more immediate compared to any other fossil or renewable power plant. As the 4th case of the 6th chapter clearly shows, investors prefer to invest in natural gas plants due to its lower cost of establishing the production facility. For this reason investors choose to invest in natural gas since they do not want to pay a big volume of money upfront, before their plant gets ready for generating power. This process should be reversed by fostering the encouragement of non natural gas power plants through appropriate policies.

- Electricity market should be efficiently liberalized and the demand for electricity should be accurately forecasted

The electricity sector which had been under the control of the Turkish Electricity Authority (TEK) until 1993 was later divided to TEAS for electricity generation and transmission as well as TEDAS which was responsible for distributing the energy in line with liberalization and privatization targets. In order to comply with the EU directives to establish and operate a liberal electricity market, the companies were then divided into the four separate entities involving EUAŞ for generation, TEIAS for transmission, TETAS for wholesaling and TEDAS for distribution in 2003. For the

purpose of creating a competitive market structure, Electricity Market Balancing and Settlement Regulation began to be implemented in 2006. Within this system, power plant's offer were detrimental in shaping the cost of electricity. Depending on the cumulative nature of offers and instantaneous demands, central authority commands each plant to produce or stop production. In other words, the system covers principles and procedures that relate to balancing the supply and demand on a timely basis and the settlement of debts and receivables to result from the participation of license holding legal entities.

Transmission and distribution activities were operated in a monopolistic manner until 2008 when after the distribution companies within TEDAS started to undertake privatization process. The objectives in these approaches were to establish a competitive market structure for distribution as well as generation and hence enhance the reform process in the electricity sector.

Turkey should facilitate the liberalization of electricity market without making concession from efficiency. The balancing and reconciliation system is criticized for paying too much for private initiatives even when they are not obliged to generate electricity. Under such circumstances, investors choose to invest in natural gas plants which can offer immediate returns. For this reason, the liberalization process in the electricity market should go on with a more efficient manner.

Since energy cannot be stored, its excess production is lost entirely in case it is not exported to other countries. On the other hand, if the projected demand is higher than the supply, electricity is imported if the country is unable provide electricity via domestic means. In other words, the inaccuracy between the energy supply and demand designates the country's reliance on electricity imports. Although Turkey has been a net exporter of electricity since 2004 soon after revolutionary liberalization in the electricity

market, further reduction in electricity imports will enhance Turkey's energy security significantly. As a consequence of the balancing and reconciliation system, instantaneous demands which are to be met by local resources costs more than the market value.

- Nuclear Energy should be considered as an alternative

Turkey's high reliance on external energy thrives country's dependency for energy. Considering that the capacity of the renewable energy is limited which is far from completely meeting Turkey's domestic energy demand, nuclear energy could be considered as an alternative for booming self sufficiency. In 2006, France and Germany were the most nuclear energy spending countries whose contribution to the overall energy spending was 42.4 % and 12.3 % respectively. The dependency in these countries was 51.4 % in France and 61.3 % in Germany. Since France's reliance on nuclear energy is tremendous, the country's dependency is relatively lesser. In case the environmental and operational safeties obligations of the nuclear plants are ensured, nuclear energy could be considered as an alternative to reduce Turkey's energy dependency.

Although Turkey's vulnerability to energy have increased over the past years and it is far below the vulnerability in line with the boom in overall energy demand, Turkey still has comparative advantages in employing renewable energy and to become an energy corridor of the region. In addition to these blessings, in case the appropriate administrative energy policy measures are taken, Turkey can lower its energy vulnerability. Doubtlessly, the reduction in energy vulnerability will have a positive effect on the country's macroeconomic balances. Self sufficiency in energy consumption will have a positive effect on the volume of imports and to downsize the gap in foreign trade and current account deficit.

Thus the fruitful returns of implementing correct and accurate energy policies are abundant. At the macro level, while the correct decisions of the government will help to reduce Turkey's energy dependency, reliance on certain countries for sustaining energy supply and thus extensive scope of energy imports. At the micro level, the individual efforts of the citizens to conserve energy and consume it efficiently will not only reduce energy import bill but also will enhance the domestic prosperity as the spending would shift from energy imports to local projects.

As a consequence, with this study, concrete criteria that compose energy vulnerability are defined and Turkey's performances under these indicators are assessed and compared to that of the European Union. In addition to quantitative and factual parameters, the study came up with qualitative determinants which are insightful enough to realistically comprehend their contribution to energy vulnerability. Although it is found on major parameters that Turkey does not perform better than the EU average, it is a fact that Turkey has many comparative advantages that would enable to reduce its energy vulnerability. As an outcome of Turkey's foreign politics and international commitments, addressing the energy vulnerability issue was an interesting area to investigate since the topic has both political and economical aspect. For this reason the findings to the plant investment decision problem in which the Grey Relational Analysis is employed and the policy recommendations for reducing energy vulnerability forms major contributions of this study. This academic work has been one of the first studies that measured Turkey's vulnerability to energy and contrasted with that of the EU and proposed concrete policy recommendations.

For future studies, each of the energy vulnerability criteria might compose a basis for further researches. On the consumption side studies like demand projections,

energy exporter country optimization, energy efficiency could be studied. On the production side, renewable energy potential, nuclear energy could be investigated in addition to studying the future of fossil resources in Turkey's energy mix. Moreover, this study could be enhanced from the perspective of foreign politics. In addition to focusing on energy's role in the determination of world politics, efforts for deeming Turkey as an energy corridor could be an interesting area of research from a political perspective.

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