REVIEW OF NATURAL GAS DISCOVERY AND PRODUCTION FROM CONVENTIONAL RESOURCES IN TURKEY

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Approval of the Graduate School of Natural and Applied Sciences

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ABSTRACT

REVIEW OF NATURAL GAS DISCOVERY AND PRODUCTION FROM CONVENTIONAL RESOURCES IN TURKEY

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Oil and natural gas are the most strategic raw materials to meet the expanding energy requirement in today's world. They have great impact on issues such as economy, national security, development, competition, and political consistency.

Being a developing country, Turkey's natural gas requirement is increasing rapidly. However, the production is far from covering the demand. Recent assumptions point out that natural gas demand of Turkey will reach 44 billion cubic meters in 2010 with a financial burden of 10 billion $ to the national economy.

Therefore Turkey requires meeting natural gas demand by using its own conventional natural gas resources. The geological researches and global data encourage Turkey to drill more exploration wells in offshore side of Western Black Sea .In early 2007, the production will be started in Western Black Sea Region with 1.42 million cubic meter gas per day.

Moreover, further exploration and production activities in the region are still continuing in order to increase the production.

In this thesis, issues such as importance of the natural gas for Turkey and the world, Turkey's present energy situation and natural gas supply and demand scenarios for Turkey have been investigated. The possible impact of natural gas exploration and production in Black Sea region on Turkey's economy in near future has been emphasized. An extensive literature survey using related printed and unprinted media has been performed in order to collect the necessary data and information.

Keywords: Natural gas, Natural gas production of Turkey, Supply and Demand Scenarios, Black Sea, Economic effects

ÖZ

TÜRKİYE'DE KONVENSİYONEL KAYNAKLARDAN GERÇEKLEŞTİRİLEN DOĞAL GAZ KEŞİFLERİNİN VE ÜRETİMİNİN İNCELENMESİ

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Günümüz dünyasında, petrol ve doğal gaz, artan enerji ihtiyacını karşılayabilecek en stratejik enerji ham maddeleridir. Bu enerji kaynakları ülkelerin ekonomisi, ulusal güvenliği, gelişimi, rekabet gücü ve politik tutarlılıkları konularında önemli rol oynarlar.

Gelişmekte olan bir ülke olarak Türkiye'nin doğal gaz ihtiyacı hızla artmaktadır. Ancak, üretim talebi karşılamaktan çok uzaktır. Son tahminler, 2010 yılında, Türkiye'nin doğal gaz ihtiyacının en az 44 milyar metreküp olacağını ve ithal edilen bu gazın Türkiye bütçesine en az 10 milyar dolarlık bir yük getireceğini göstermektedir.

Sonuç olarak, Türkiye, doğal gaz talebini, kendi rezervlerden karşılamalıdır. Jeolojik araştırmalar ve global veriler, Türkiye'yi Batı Karadeniz bölgesinde daha fazla deniz sondajı yapmak için cesaretlendirmektedir. 2007 yılı başında, Batı Karadeniz'de günde 1,42 milyon metreküp gaz üretimine başlanacaktır. Ayrıca, doğal gaz üretimini arttırmak için, Batı Karadeniz bölgesindeki keşif ve üretim çalışmaları devam etmektedir

Bu tezde, doğal gazın Türkiye ve dünya için önemi, Türkiye'nin mevcut enerji durumu, Türkiye'deki doğal gaz gereksinimi ve temini ile ilgili senaryolar vb. konular araştırılmıştır. Karadeniz bölgesindeki doğal gaz keşiflerinin ve üretiminin, yakın gelecekteki Türkiye ekonomisine olası etkileri vurgulanmıştır. Gerekli veri ve bilgilere ulaşmak için, basılı ve basılı olmayan yayınlardan geniş bir kaynak araştırması yapılmıştır.

Anahtar Kelimeler: Doğal Gaz, Türkiye'nin Doğal Gaz Üretimi, Arz – Talep Senaryoları, Karadeniz, Ekonomik Etkiler

To My Wife

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I would also like to dedicate my study to my wife for her great trust, patience and support throughout my life.

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CHAPTER 1

INTRODUCTION

Fossil Fuels are the most important raw materials to supply the energy demand of the world. Although, natural gas has not got an older history like oil, it has gained importance in the last 30 years and its share in the pie is increasing. In near future, natural gas will be the second energy source after oil.

According to World Energy Outlook 2004 **[1]**, world primary energy, energy exist in a naturally occurring form such as coal, oil or natural gas before converting into an end-use form, demand will expand by almost 60% between 2002 and 2030, reaching 16.5 billion tonnes of oil equivalent. Two-thirds of the increase will come from developing countries. Fossil fuels will continue to dominate global energy use. They will account for around 85% of the increase in world primary demand. Their share in total demand will increase slightly, from 80% in 2002 to 82% in 2030.

Turkey started to use natural gas in 1987. Until 1992, it has mainly been used to produce electricity. After 1992, industrial usage started to become popular. On the other, natural gas was also promoted as a clean and effective energy source for residential usage. By the delivery lines, gas has been delivered to big cities and after 1995, residential usage increased significantly. Now, electricity production is still having the biggest share. However, residential usage has already passed the industrial usage and with the new projects, it will continue to increase.

According to GDPA Reports **[2]**, the supply for 2004 was app 21.66 billion m^3, while the consumption was approximately 21.47 billion sm^3. Only 3.3 % of the supply was Turkey's production and the rest should be supplied by imports. According to BOTAS Reports **[3]**, the demand will be around 43.92 billion sm^3 in 2020 and with the existing take-or-pay contracts, total import will be around 40.79 billion sm^3. If Turkey cannot explore new wells, the production share will be 1.9 %. Explorations in Black Sea might be the solution for Turkey.

CHAPTER 2

GENERAL INFORMATION

2.1. Importance of Crude Oil and Natural Gas In Energy Sector

Primary energy consumption increased by 4.3% in 2004, compared to 2003 consumption. The strongest rise was in Asia Pacific, up by 8.9%, while North America recorded the weakest growth at 1.6%. Coal remained the fastest growing fuel, rising 6.3% globally. Oil consumption grew by 3.4%, the most rapid rate since 1986. Natural gas use rose by 3.3%. Hydroelectric and nuclear generation also experienced strong growth, rising 5% and 4.4%, respectively. **[4]**

2004 was a year of rising energy prices and growing concern in many parts of the world about the security of future supplies. At $38 per barrel (Brent), the average oil price for the year was almost $10 above the 2003 level. The increase was driven mainly by demand growth, particularly in Asia, where Chinese consumption rose by 900,000 barrels per day (b/d) –almost all of which was accounted for by imports. Globally, with economic growth at a 15-year high, demand for oil grew by 2.5 million b/d. **[4]**

The surge in demand reduced the level of spare capacity from around 3 million b/d in 2003 to as little as 1 million b/d by mid-2004. That tightness, combined with concerns over the continued conflict in the Middle East and instability in a number of other producing countries, led to the increase in prices that continued beyond the end of the year. **[4]**

Oil demand growth also stretched the international refining system, resulting in large discounts for heavy, sour crude and the highest refining margins in at least 15 years. High oil prices stimulated substitution, and consumption of natural gas and coal rose by 3.3% and 6.3%, respectively. **[4]**

Despite this, however, the market operated very effectively. There was no physical supply shortage. New supplies continued to come on stream in Russia, West Africa and in parts of OPEC, largely in response to the increase in investment in exploration, development and infrastructure that has occurred over the last five years. More new supplies are due on stream this year. Working in co-operation, the industry – public and private – has once again demonstrated its ability to provide for the world's growing energy needs. **[4]**

With oil prices at their current level, concern about what is going to happen in the energy market is inevitable. Energy is essential to the functioning of complex modern societies. **[4].**

2.2. World Natural Gas Demand and Supply

World natural gas consumption grew by 3.3% in 2004, compared with a 10-year average of 2.3%. Consumption in the USA, the world's largest market, stagnated in the face of high prices and industrial restructuring. Outside the USA, gas consumption rose by 4%, with the largest gains in Russia, China and the Middle East. **[4]**

Gas production rose in every region except North America, where US output continued to decline. In Europe, growth in the Netherlands, Russia and Norway more than offset the ongoing decline of UK output. **[4]**

International trade in natural gas increased by 9% in 2004. Pipeline shipments rose by more than 10%. Russia accounted for the largest increment, but growth was widely distributed across the world. Shipments of liquefied natural gas (LNG) rose by 5.4% last year below the 2003 growth rate. Algerian exports fell by 8% because of an accident at the Skikda liquefaction plant. US LNG imports continued to rise rapidly, up 29%, while Japanese imports declined by 3.5% as nuclear plants returned to operation following shutdowns in 2003. **[4]. (Tables 2.1, 2.2 & 2.3)(Figures 2.1,2.2,2.3,2.4,2.5,2.6 & 2.7)**

Table 2.1: World Natural Gas Proved Reserves **[4]**

Natural Gas: Proved reserves	**at end 1984** Trillion cubic metres	**at end 1994** Trillion cubic metres	**at end 2003** Trillion Cubic Metres	Trillion Cubic feet	**at end 2004** Trillion cubic metres	Share of total	R/P ratio
USA	5,53	4,59	5,29	**186,9**	**5,29**	2,9%	9,8
Canada	2,81	1,90	1,60	**56,6**	**1,60**	0,9%	8,8
Mexico	2,17	1,94	0,42	**14,9**	**0,42**	0,2%	11,3
Total North America	**10,51**	**8,42**	**7,32**	**258,3**	**7,32**	**4,1%**	**9,6**
Argentina	0,67	0,54	0,61	**21,4**	**0,61**	0,3%	13,5
Bolivia	0,13	0,11	0,78	**31,4**	**0,89**	0,5%	*
Brazil	0,08	0,15	0,25	**11,5**	**0,33**	0,2%	29,5
Colombia	0,11	0,21	0,11	**3,9**	**0,11**	0,1%	17,3
Peru	+	0,34	0,25	**8,7**	**0,25**	0,1%	*
Trinidad & Tobago	0,31	0,29	0,59	**18,8**	**0,53**	0,3%	19,2
Venezuela	1,67	3,97	4,22	**148,9**	**4,22**	2,4%	*
Other S. & Cent. America	0,24	0,23	0,17	**6,0**	**0,17**	0,1%	*
Total S. & Cent. America	**3,23**	**5,83**	**6,98**	**250,6**	**7,10**	**4,0%**	**55,0**
Azerbaijan	n/a	n/a	1,37	**48,4**	**1,37**	0,8%	*
Denmark	0,10	0,12	0,09	**3,1**	**0,09**	◆	9,3
Germany	0,31	0,22	0,21	**7,0**	**0,20**	0,1%	12,1
Italy	0,25	0,30	0,19	**5,9**	**0,17**	0,1%	12,8
Kazakhstan	n/a	n/a	3,00	**105,9**	**3,00**	1,7%	*
Netherlands	1,90	1,85	1,49	**52,7**	**1,49**	0,8%	21,7
Norway	0,56	1,73	2,46	**84,2**	**2,39**	1,3%	30,4
Poland	0,09	0,16	0,12	**4,1**	**0,12**	0,1%	26,4
Romania	0,21	0,43	0,31	**10,4**	**0,30**	0,2%	22,3
Russian Federation	n/a	n/a	48,00	**1694,4**	**48,00**	26,7%	81,5
Turkmenistan	n/a	n/a	2,90	**102,4**	**2,90**	1,6%	53,1
Ukraine	n/a	n/a	1,11	**39,2**	**1,11**	0,6%	60,6
United Kingdom	0,73	0,66	0,59	**20,8**	**0,59**	0,3%	6,1
Uzbekistan	n/a	n/a	1,86	**65,7**	**1,86**	1,0%	33,3
Other Europe & Eurasia	37,87	58,41	0,45	**15,7**	**0,45**	0,2%	40,9
Total Europe & Eurasia	**42,02**	**63,87**	**64,14**	**2259,7**	**64,02**	**35,7%**	**60,9**

Table 2.1 (Continued)

Bahrain	0,21	0,15	0,09	**3,2**	**0,09**	0,1%	9,2
Iran	14,02	20,76	27,57	**970,8**	**27,50**	15,3%	*
Iraq	0,82	3,12	3,17	**111,9**	**3,17**	1,8%	*
Kuwait	1,04	1,50	1,57	**55,5**	**1,57**	0,9%	*
Oman	0,22	0,26	0,99	**35,1**	**1,00**	0,6%	56,5
Qatar	4,28	7,07	25,78	**910,1**	**25,78**	14,4%	*
Saudi Arabia	3,61	5,26	6,75	**238,4**	**6,75**	3,8%	*
Syria	0,10	0,24	0,25	**13,1**	**0,37**	0,2%	72,0
United Arab Emirates	3,11	6,78	6,06	**213,9**	**6,06**	3,4%	*
Yemen	-	0,43	0,48	**16,9**	**0,48**	0,3%	*
Other Middle East	+	+	0,05	**1,9**	**0,05**	◆	31,7
Total Middle East	**27,40**	**45,56**	**72,77**	**2570,8**	**72,83**	**40,6%**	*****
Algeria	3,44	2,96	4,55	**160,4**	**4,55**	2,5%	55,4
Egypt	0,24	0,63	1,72	**65,5**	**1,85**	1,0%	69,1
Libya	0,63	1,31	1,49	**52,6**	**1,49**	0,8%	*
Nigeria	1,36	3,45	5,00	**176,4**	**5,00**	2,8%	*
Other Africa	0,56	0,78	1,18	**41,5**	**1,18**	0,7%	*
Total Africa	**6,22**	**9,13**	**13,94**	**496,4**	**14,06**	**7,8%**	**96,9**
Australia	0,75	1,30	2,46	**86,9**	**2,46**	1,4%	69,9
Bangladesh	0,35	0,30	0,44	**15,4**	**0,44**	0,2%	33,0
Brunei	0,24	0,40	0,35	**12,1**	**0,34**	0,2%	28,3
China	0,89	1,67	2,23	**78,7**	**2,23**	1,2%	54,7
India	0,48	0,70	0,85	**32,6**	**0,92**	0,5%	31,3
Indonesia	1,70	1,82	2,56	**90,3**	**2,56**	1,4%	34,9
Malaysia	1,39	1,93	2,46	**87,0**	**2,46**	1,4%	45,7
Myanmar	0,26	0,27	0,45	**18,5**	**0,53**	0,3%	71,0
Pakistan	0,52	0,59	0,79	**28,2**	**0,80**	0,4%	34,4
Papua New Guinea	-	0,43	0,43	**15,1**	**0,43**	0,2%	*
Thailand	0,21	0,18	0,43	**15,1**	**0,43**	0,2%	21,1
Vietnam	-	0,13	0,24	**8,3**	**0,24**	0,1%	56,5
Other Asia Pacific	0,23	0,35	0,38	**13,4**	**0,38**	0,2%	38,4
Total Asia Pacific	7,02	10,07	14,06	**501,5**	**14,21**	7,9%	43,9
TOTAL WORLD	**96,39**	**142,89**	**179,21**	**6337,4**	**179,53**	**100,0%**	**66,7**
Of which: European Union 25	3,62	3,44	2,80	**97,1**	**2,75**	1,5%	12,8
OECD	15,62	15,00	15,14	**530,3**	**15,02**	8,4%	13,7
Former Soviet Union	37,50	58,15	58,50	**2065,2**	**58,51**	32,6%	78,9

* Over 100 years

\+ Less than 0.05

◆ Less than 0.05%

n/a not available

Notes: Proved reserves of natural gas - Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions

Reserves/Production (R/P) ratio - If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that level.

Source of data: The estimates in this table have been compiled using a combination of primary official sources and third party data from Cedigaz, and the OPEC Secretariat. The reserves figures shown do not necessarily meet the definitions, guidelines and practices used for determining proved reserves at the company level, for instance those published by the United States Securities and Exchange Commission or recommended for the purposes of UK GAAP, nor do they necessarily represent BP's view of proved reserves by country

Table 2.2: World Natural Gas Production **[4]**

Natural Gas: Production *

Billion cubic metres	1997	1998	1999	2000	2001	2002	2003	**2004**	Change 2004 over 2003	2004 share of total
USA	543,1	549,2	541,6	550,6	565,8	544,3	549,6	**542,9**	-1,2%	20,2%
Canada	165,8	171,3	177,4	183,2	186,8	187,8	182,7	**182,8**	◆	6,8%
Mexico	31,7	34,3	37,2	35,8	35,3	35,3	36,4	**37,1**	2,0%	1,4%
Total North America	**740,6**	**754,8**	**756,2**	**769,6**	**787,9**	**767,4**	**768,7**	**762,8**	**-0,8%**	**28,3%**
Argentina	27,4	29,6	34,6	37,4	37,1	36,1	41,0	**44,9**	9,4%	1,7%
Bolivia	2,7	2,8	2,3	3,2	4,7	4,9	5,7	**8,5**	49,6%	0,3%
Brazil	6,0	6,3	6,7	7,2	7,6	9,2	10,1	**11,1**	9,6%	0,4%
Colombia	5,9	6,3	5,2	5,9	6,1	6,2	6,1	**6,4**	4,6%	0,2%
Trinidad & Tobago	7,4	8,6	11,7	14,1	15,2	17,3	24,7	**27,7**	12,0%	1,0%
Venezuela	30,8	32,3	27,4	27,9	29,6	28,4	25,2	**28,1**	11,5%	1,0%
Other S. & Cent. America	2,4	2,5	2,1	2,2	2,3	2,3	2,2	**2,5**	15,3%	0,1%
Total S. & Cent. America	**82,5**	**88,5**	**90,0**	**97,9**	**102,6**	**104,4**	**115,0**	**129,1**	**12,2%**	**4,8%**
Azerbaijan	5,6	5,2	5,6	5,3	5,2	4,8	4,8	**4,6**	-3,5%	0,2%
Denmark	7,9	7,6	7,8	8,1	8,4	8,4	8,0	**9,4**	18,4%	0,4%
Germany	17,1	16,7	17,8	16,9	17,0	17,0	17,7	**16,4**	-7,5%	0,6%
Italy	19,3	19,0	17,5	16,2	15,2	14,6	13,7	**13,0**	-5,5%	0,5%
Kazakhstan	7,6	7,4	9,3	10,8	10,8	10,6	12,9	**18,5**	42,9%	0,7%
Netherlands	67,1	63,6	59,3	57,3	61,9	59,9	58,4	**68,8**	17,9%	2,6%
Norway	43,0	44,2	48,5	49,7	53,9	65,5	73,1	**78,5**	7,3%	2,9%
Poland	3,6	3,6	3,4	3,7	3,9	4,0	4,0	**4,4**	8,7%	0,2%
Romania	15,0	14,0	14,0	13,8	13,6	13,2	13,0	**13,2**	1,6%	0,5%
Russian Federation	532,6	551,3	551,0	545,0	542,4	555,4	578,6	**589,1**	1,8%	21,9%
Turkmenistan	16,1	12,4	21,3	43,8	47,9	49,9	55,1	**54,6**	-0,9%	2,0%
Ukraine	17,4	16,8	16,9	16,7	17,1	17,4	17,7	**18,3**	3,4%	0,7%
United Kingdom	85,9	90,2	99,1	108,4	105,8	103,6	102,9	**95,9**	-6,7%	3,6%
Uzbekistan	47,8	51,1	51,9	52,6	53,5	53,8	53,6	**55,8**	4,1%	2,1%
Other Europe & Eurasia	13,4	12,4	11,5	11,2	11,0	11,3	10,7	**10,9**	2,0%	0,4%
Total Europe & Eurasia	**899,1**	**915,5**	**934,9**	**959,5**	**967,7**	**989,4**	**1024,3**	**1051,5**	**2,7%**	**39,1%**
Bahrain	8,0	8,4	8,7	8,8	9,1	9,5	9,6	**9,8**	1,4%	0,4%
Iran	47,0	50,0	56,4	60,2	66,0	75,0	81,5	**85,5**	4,9%	3,2%
Kuwait	9,3	9,5	8,6	9,6	8,5	8,0	9,1	**9,7**	6,6%	0,4%
Oman	5,0	5,2	5,5	8,7	14,0	15,0	16,5	**17,6**	6,7%	0,7%
Qatar	17,4	19,6	22,1	23,7	27,0	29,5	31,4	**39,2**	24,8%	1,5%
Saudi Arabia	45,3	46,8	46,2	49,8	53,7	56,7	60,1	**64,0**	6,6%	2,4%
Syria	3,8	4,3	4,5	4,2	4,1	5,0	5,2	**5,2**	-	0,2%
United Arab Emirates	36,3	37,1	38,5	38,4	39,4	43,4	44,8	**45,8**	2,2%	1,7%
Other Middle East	3,3	3,2	3,4	3,4	3,0	2,6	1,8	**3,2**	80,2%	0,1%
Total Middle East	**175,4**	**184,0**	**193,8**	**206,8**	**224,8**	**244,7**	**259,9**	**279,9**	**7,7%**	**10,4%**
Algeria	71,8	76,6	86,0	84,4	78,2	80,4	82,8	**82,0**	-1,0%	3,0%
Egypt	11,6	12,2	14,7	18,3	21,5	22,7	25,0	**26,8**	7,5%	1,0%
Libya	6,0	5,8	4,7	5,4	5,6	5,7	6,4	**7,0**	9,3%	0,3%
Nigeria	5,1	5,1	6,0	12,5	14,9	14,2	19,2	**20,6**	7,3%	0,8%
Other Africa	4,9	5,0	5,4	5,9	6,6	8,0	8,1	**8,7**	7,1%	0,3%
Total Africa	**99,4**	**104,8**	**116,9**	**126,6**	**126,8**	**130,9**	**141,5**	**145,1**	**2,6%**	**5,4%**
Australia	29,8	30,4	30,8	31,2	32,5	32,6	33,2	**35,2**	6,2%	1,3%
Bangladesh	7,6	7,8	8,3	10,0	10,7	11,4	12,3	**13,2**	7,0%	0,5%
Brunei	11,7	10,8	11,2	11,3	11,4	11,5	12,4	**12,1**	-2,0%	0,4%
China	22,2	22,3	24,3	27,2	30,3	31,9	34,4	**40,8**	18,5%	1,5%
India	23,0	24,7	25,9	26,9	27,2	28,7	29,9	**29,4**	-1,7%	1,1%
Indonesia	67,2	64,3	71,0	68,5	66,3	70,4	72,8	**73,3**	0,7%	2,7%

Table 2.2 (Continued)

Malaysia	38,6	38,5	40,8	45,3	46,9	48,3	51,8	**53,9**	4,0%	2,0%
Myanmar	1,8	1,8	2,6	4,4	6,2	6,5	6,9	**7,4**	6,6%	0,3%
New Zealand	5,1	4,5	5,2	5,5	5,8	5,5	4,1	**3,6**	-13,8%	0,1%
Pakistan	15,6	16,0	17,3	18,9	19,9	20,6	21,1	**23,2**	10,0%	0,9%
Thailand	15,2	16,3	17,7	18,6	18,0	18,9	19,6	**20,3**	3,4%	0,8%
Vietnam	0,5	0,9	1,3	1,6	2,0	2,4	2,4	**4,2**	75,3%	0,2%
Other Asia Pacific	3,5	3,6	3,6	3,7	3,9	5,5	6,7	**6,6**	-1,2%	0,2%
Total Asia Pacific	**241,8**	**241,6**	**260,0**	**272,9**	**281,1**	**294,2**	**307,7**	**323,2**	**5,0%**	**12,0%**
TOTAL WORLD	**2238,9**	**2289,0**	**2351,7**	**2433,2**	**2490,9**	**2531,1**	**2617,1**	**2691,6**	**2,8%**	**100,0 %**
Of which European Union 25	211,1	209,8	213,1	218,4	220,1	215,4	211,9	**215,2**	1,6%	8,0%
OECD	1032,1	1046,4	1056,7	1077,5	1103,0	1089,3	1094,4	**1098,6**	0,4%	40,8%
Former Soviet Union	627,4	644,6	656,3	674,5	677,3	692,2	723,1	**741,3**	2,5%	27,5%
Other EMEs	579,5	598,0	638,7	681,2	710,6	749,5	799,5	**851,7**	6,5%	31,6%

* Excluding gas flared or recycled

^ Less than 0.05

◆ Less than 0.05%

Notes: As far as possible, the data above represent standard cubic metres (measured at 15oC and 1013 mbar); as they are derived directly from tonnes of oil equivalent using an average conversion factor, they do not necessarily equate with gas volumes expressed in specific national terms.

Because of rounding some totals may not agree exactly with the sum of their component parts.

Table 2.3: World Natural Gas Consumption **[4]**

Natural Gas: Consumption Billion cubic metres	1997	1998	1999	2000	2001	2002	2003	**2004**	Change 2004 over 2003	2004 share of total
USA	653,2	642,2	644,3	669,7	641,4	661,6	645,3	**646,7**	0,2%	24,0%
Canada	83,8	85,0	83,1	83,0	82,8	85,6	92,2	**89,5**	-2,9%	3,3%
Mexico	32,3	35,4	37,4	38,5	39,0	42,7	45,8	**48,2**	5,1%	1,8%
Total North America	**769,3**	**762,6**	**764,8**	**791,2**	**763,2**	**789,9**	**783,3**	**784,3**	**0,1%**	**29,2%**
Argentina	28,5	30,5	32,4	33,2	31,2	30,3	34,6	**37,9**	9,5%	1,4%
Brazil	6,0	6,3	7,1	9,3	11,7	14,4	15,9	**18,9**	19,1%	0,7%
Chile	2,8	3,3	4,6	5,2	6,3	6,5	7,1	**8,2**	16,1%	0,3%
Colombia	5,9	6,2	5,2	5,9	6,1	6,1	6,0	**6,3**	4,6%	0,2%
Ecuador	0,1	0,1	0,1	0,1	0,2	0,1	0,1	**0,1**	-	~
Peru	0,2	0,4	0,4	0,3	0,4	0,4	0,5	**0,9**	64,3%	~
Venezuela	30,8	32,3	27,4	27,9	29,6	28,4	25,2	**28,1**	11,5%	1,0%
Other S. & Cent. America	8,5	10,0	11,3	11,9	13,6	14,4	16,5	**17,6**	7,0%	0,7%
Total S. & Cent. America	**82,9**	**89,1**	**88,5**	**94,0**	**99,1**	**100,7**	**105,8**	**117,9**	**11,4%**	**4,4%**
Austria	8,1	8,3	8,5	8,1	8,6	8,5	9,4	**9,5**	0,9%	0,4%
Azerbaijan	5,6	5,2	5,6	5,4	7,8	7,8	8,0	**8,5**	6,9%	0,3%
Belarus	14,8	15,0	15,3	16,2	16,1	16,6	17,2	**18,5**	7,6%	0,7%
Belgium & Luxembourg	12,5	13,8	14,7	14,9	14,6	14,8	16,0	**16,3**	1,7%	0,6%
Bulgaria	4,1	3,5	3,0	3,3	3,0	2,7	2,6	**3,1**	21,3%	0,1%
Czech Republic	8,5	8,5	8,6	8,3	8,9	8,7	8,7	**8,8**	1,5%	0,3%
Denmark	4,4	4,8	5,0	4,9	5,1	5,1	5,4	**5,4**	~	0,2%
Finland	3,2	3,7	3,7	3,7	4,1	4,0	4,5	**4,4**	-3,0%	0,2%
France	34,6	37,0	37,7	39,7	41,7	41,7	43,3	**44,7**	3,1%	1,7%
Germany	79,2	79,7	80,2	79,5	82,9	82,6	85,5	**85,9**	0,4%	3,2%
Greece	0,2	0,8	1,4	1,9	1,9	2,0	2,3	**2,4**	7,5%	0,1%
Hungary	10,8	10,9	11,0	10,7	11,9	12,0	13,1	**13,0**	-0,8%	0,5%
Iceland	-	-	-	-	-	-	-	**-**	-	-
Republic of Ireland	3,1	3,1	3,3	3,8	4,0	4,1	4,1	**4,1**	-0,8%	0,2%
Italy	53,2	57,2	62,2	64,9	65,0	64,6	70,7	**73,3**	3,8%	2,7%
Kazakhstan	7,1	7,3	7,9	9,7	10,1	11,1	13,0	**15,2**	17,3%	0,6%
Lithuania	2,6	2,3	2,4	2,7	2,8	2,9	3,1	**3,1**	-0,3%	0,1%
Netherlands	39,1	38,7	37,9	39,2	39,1	39,3	40,3	**43,5**	8,0%	1,6%
Norway	3,7	3,8	3,6	4,0	3,8	4,0	4,3	**4,6**	5,6%	0,2%
Poland	10,5	10,6	10,3	11,1	11,5	11,2	11,2	**13,2**	17,7%	0,5%
Portugal	0,1	0,8	2,3	2,4	2,6	2,8	3,0	**3,1**	1,6%	0,1%
Romania	20,0	18,7	17,2	17,1	16,6	17,2	18,3	**18,8**	2,6%	0,7%
Russian Federation	350,4	364,7	363,6	377,2	372,7	388,9	392,9	**402,1**	2,3%	15,0%
Slovakia	6,3	6,4	6,4	6,5	6,9	7,2	7,0	**6,8**	-3,1%	0,3%
Spain	12,3	13,1	15,0	16,9	18,2	20,8	23,6	**27,3**	15,5%	1,0%
Sweden	0,8	0,9	0,8	0,7	0,7	0,8	0,8	**0,8**	-0,3%	~
Switzerland	2,5	2,6	2,7	2,7	2,8	2,8	2,9	**3,0**	2,3%	0,1%
Turkey	9,4	9,9	12,0	14,1	16,0	17,4	20,9	**22,1**	5,7%	0,8%
Turkmenistan	10,1	10,3	11,3	12,6	12,9	13,2	14,6	**15,5**	5,7%	0,6%
Ukraine	74,3	68,8	73,0	73,1	70,9	65,0	71,2	**70,7**	-0,7%	2,6%
United Kingdom	84,5	87,9	92,5	96,8	96,3	95,1	95,4	**98,0**	2,7%	3,6%
Uzbekistan	45,4	47,0	49,3	47,1	51,1	52,4	47,2	**49,3**	4,5%	1,8%
Other Europe & Eurasia	14,7	14,6	12,9	13,4	15,1	14,2	14,3	**13,7**	-4,6%	0,5%
Total Europe & Eurasia	**936,1**	**959,9**	**981,3**	**1012,9**	**1025,7**	**1041,5**	**1074,9**	**1108,5**	**3,1%**	**41,2%**
Iran	47,1	51,8	58,4	62,9	70,2	79,2	82,9	**87,1**	5,1%	3,2%
Kuwait	9,3	9,5	8,6	9,6	9,5	8,0	9,1	**9,7**	6,6%	0,4%
Qatar	14,5	14,8	14,0	9,7	11,0	11,1	12,2	**15,1**	24,0%	0,6%
Saudi Arabia	45,3	46,8	46,2	49,8	53,7	56,7	60,1	**64,0**	6,6%	2,4%
United Arab Emirates	29,0	30,4	31,4	31,4	32,3	36,4	37,9	**39,6**	4,6%	1,5%
Other Middle East	19,6	20,5	21,5	22,1	22,8	23,6	23,9	**26,6**	11,4%	1,0%
Total Middle East	**164,9**	**173,7**	**180,1**	**185,4**	**199,4**	**215,1**	**226,1**	**242,2**	**7,2%**	**9,0%**
Algeria	20,2	20,9	21,3	19,8	20,5	20,2	21,4	**21,2**	-0,9%	0,8%
Egypt	11,6	12,0	14,3	18,3	21,5	22,7	24,6	**25,7**	4,5%	1,0%
South Africa	-	-	-	-	-	-	-	**-**	-	-
Other Africa	14,4	14,9	15,2	17,0	17,1	18,8	20,7	**21,7**	4,9%	0,8%

Table 2.3 (Continued)

Total Africa	**46,1**	**47,7**	**50,9**	**55,2**	**59,1**	**61,7**	**66,7**	**68,6**	**2,9%**	**2,6%**
Australia	21,4	22,4	23,2	23,6	24,0	25,2	24,3	**24,5**	1,1%	0,9%
Bangladesh	7,6	7,8	8,3	10,0	10,7	11,4	12,3	**13,2**	7,0%	0,5%
China	19,3	19,3	21,4	24,5	27,8	29,6	32,8	**39,0**	19,0%	1,5%
China Hong Kong SAR	2,6	2,5	2,7	2,5	2,5	2,4	1,5	**2,2**	44,5%	0,1%
India	23,0	24,7	25,9	26,9	27,2	28,7	29,9	**32,1**	7,1%	1,2%
Indonesia	31,9	27,8	31,8	32,3	33,5	34,5	33,4	**33,7**	0,8%	1,3%
Japan	65,1	69,5	74,6	76,2	79,0	71,9	76,5	**72,2**	-5,7%	2,7%
Malaysia	16,7	17,4	16,1	24,3	25,8	26,8	31,8	**33,2**	4,4%	1,2%
New Zealand	5,1	4,5	5,2	5,5	5,7	5,5	4,1	**3,6**	-13,8%	0,1%
Pakistan	15,6	16,0	17,3	18,9	19,9	20,6	23,4	**25,7**	9,8%	1,0%
Philippines	^	^	^	^	0,1	1,8	2,7	**2,5**	-7,7%	0,1%
Singapore	1,5	1,5	1,5	1,7	4,5	4,9	5,3	**7,8**	45,7%	0,3%
South Korea	16,4	15,4	18,7	21,0	23,1	25,7	26,9	**31,6**	17,4%	1,2%
Taiwan	5,1	6,4	6,2	6,7	7,4	8,5	8,7	**10,1**	16,4%	0,4%
Thailand	14,6	15,9	17,4	20,5	22,5	24,4	27,5	**28,7**	4,7%	1,1%
Other Asia Pacific	4,3	4,7	5,0	5,1	5,2	5,3	5,7	**7,8**	38,1%	0,3%
Total Asia Pacific	**250,2**	**255,6**	**275,3**	**299,7**	**319,0**	**327,1**	**346,8**	**367,7**	**6,0%**	**13,7%**
TOTAL WORLD	**2249,5**	**2288,6**	**2340,8**	**2438,3**	**2465,5**	**2536,0**	**2603,5**	**2689,3**	**3,3%**	**100,0%**
Of which European Union 25#	376,6	391,4	406,6	419,9	430,2	431,6	450,9	**466,9**	3,5%	17,4%
OECD	1264,3	1276,8	1306,2	1352,5	1341,7	1367,6	1387,6	**1406,1**	1,3%	52,3%
Former Soviet Union	519,1	529,4	536,2	551,9	553,1	565,5	574,9	**590,0**	2,6%	21,9%
Other EMEs	466,1	482,3	498,4	534,0	570,8	602,8	641,0	**693,1**	8,1%	25,8%

^ Less than 0.05

◆ Less than 0.05%

Excludes Estonia, Latvia and Lithuania prior to 1985 and Slovenia prior to 1991

Notes: The difference between these world consumption figures and the world production statistics is due to variations in stocks at storage facilities and liquefaction plants, together with unavoidable disparities in the definition, measurement or conversion of gas
supply and demand data

As far as possible, the data above represent standard cubic metres (measured at 15 degrees C and 1013 mbar); as they are derived directly from tonnes of oil equivalent using an average conversion factor, they do not necessarily equate with gas volumes
expressed in specific national terms

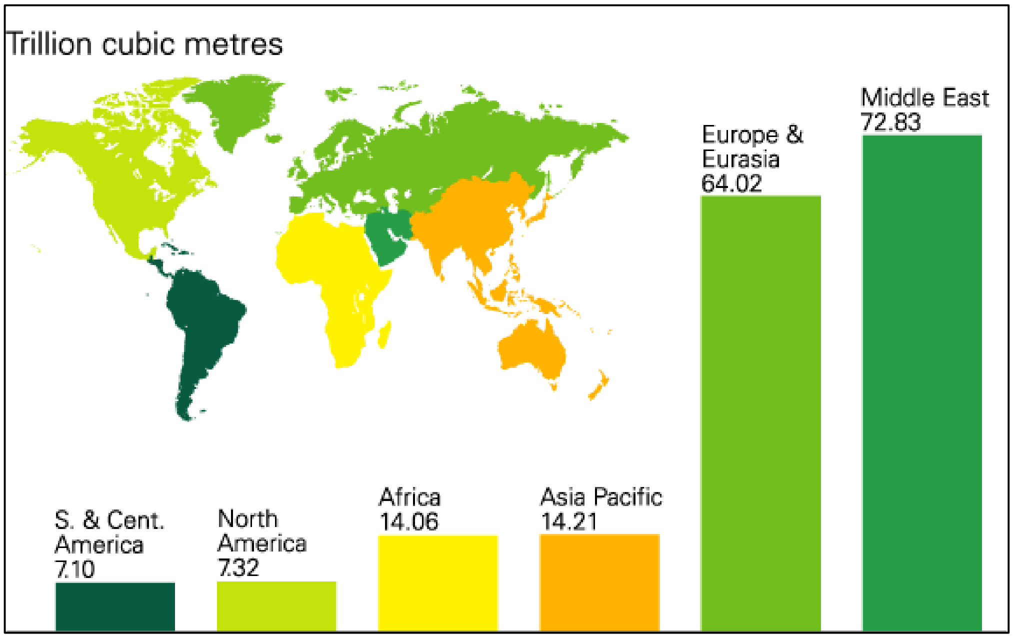

Figure 2.1: Proved Natural Gas Reserves at End 2004 **[4]**

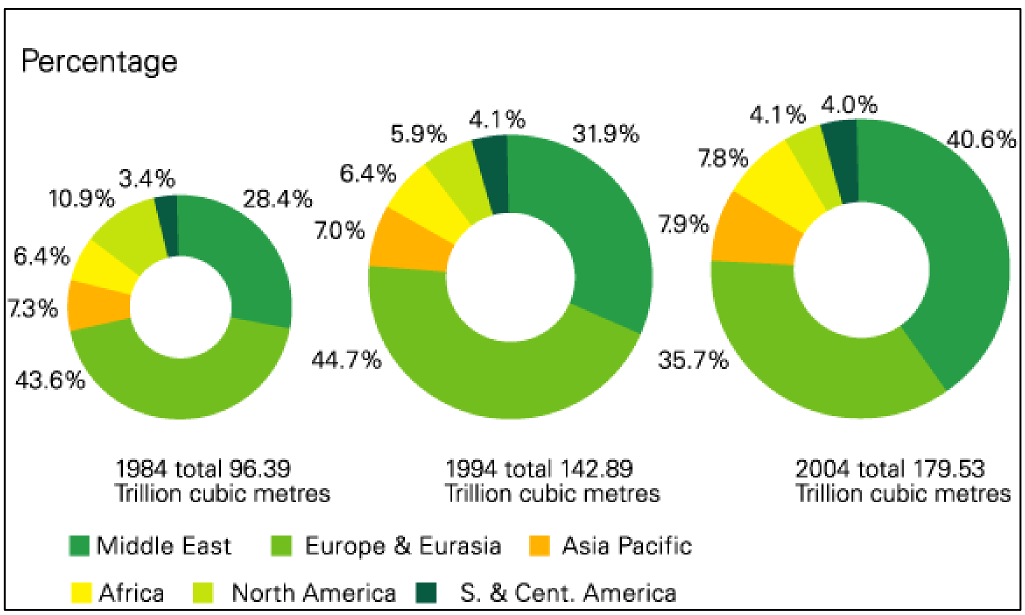

Figure 2.2: Distribution of Proved Natural Gas Reserves in 1984, 1994 and 2004 **[4]**

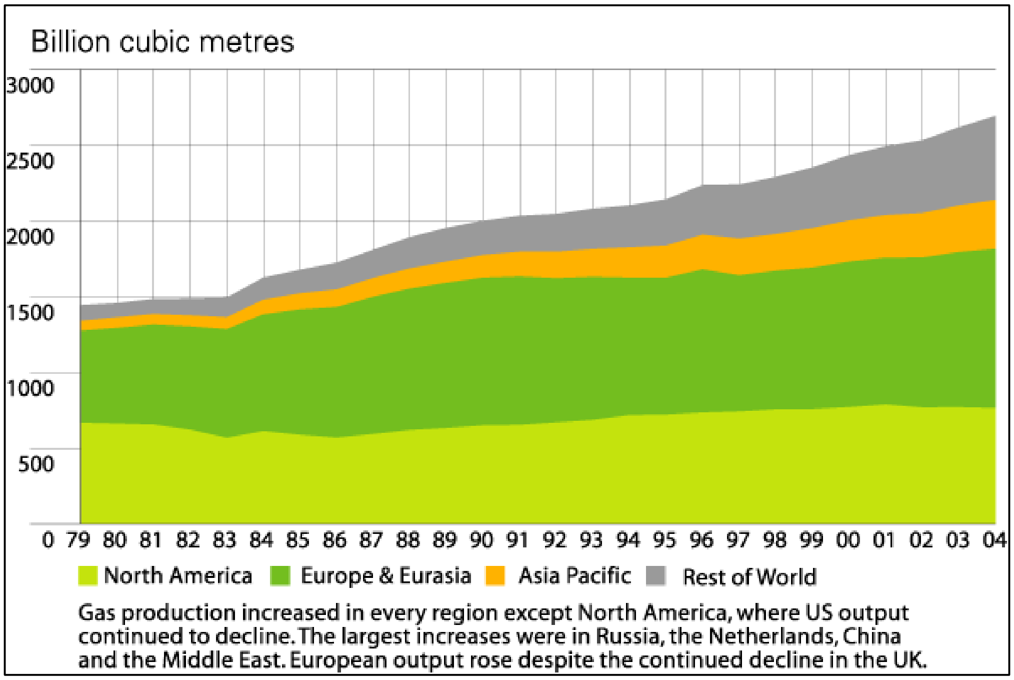

Figure 2.3: Natural Gas Production by Area **[4]**

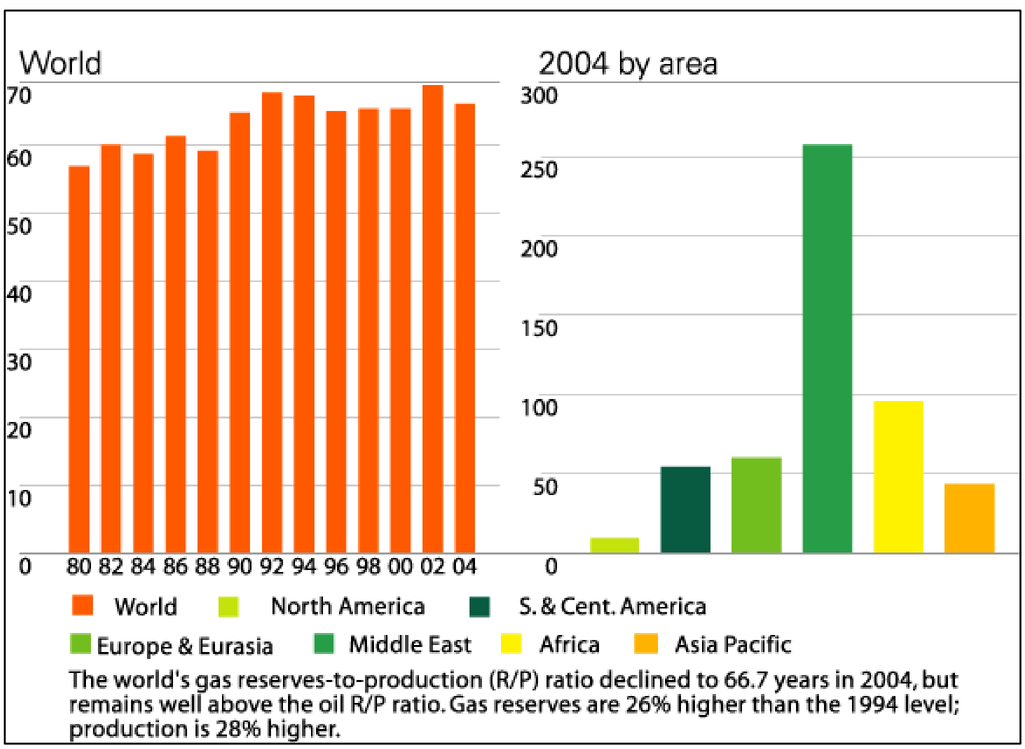

Figure 2.4: Natural Gas Reserves-to-production (R/P) Ratios **[4]**

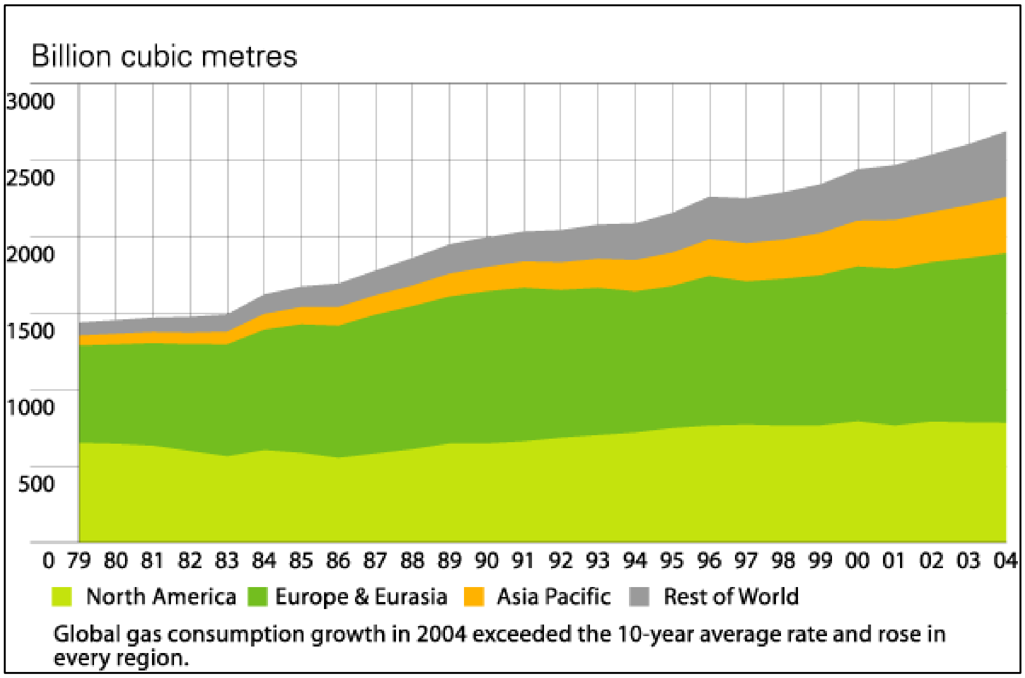

Figure 2.5: Natural Gas Consumption by Area **[4]**

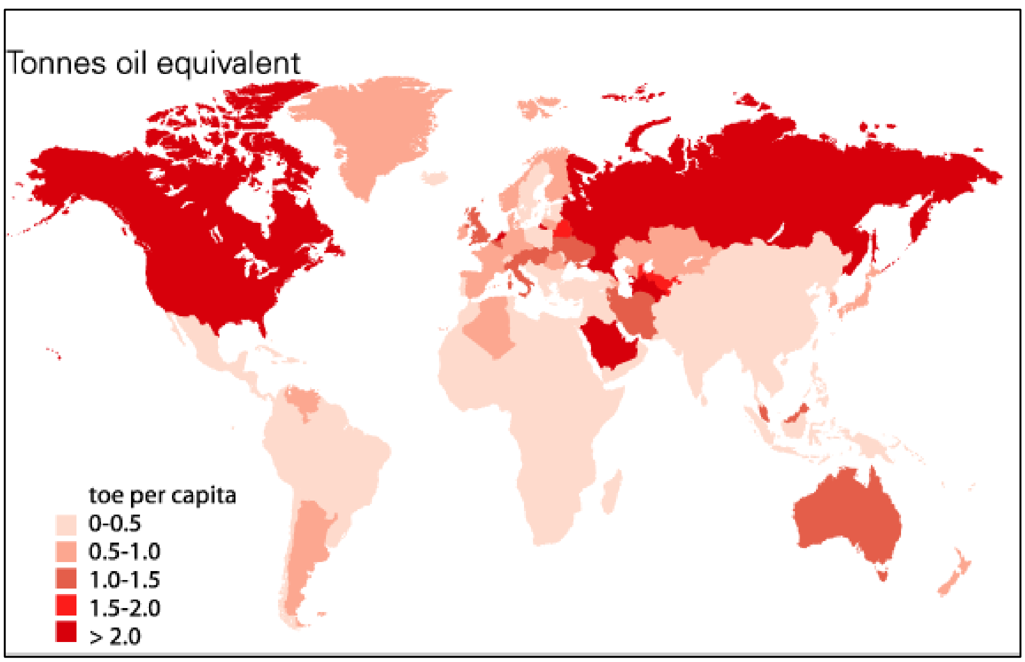

Figure 2.6: Natural Gas Consumption per Capita **[4]**

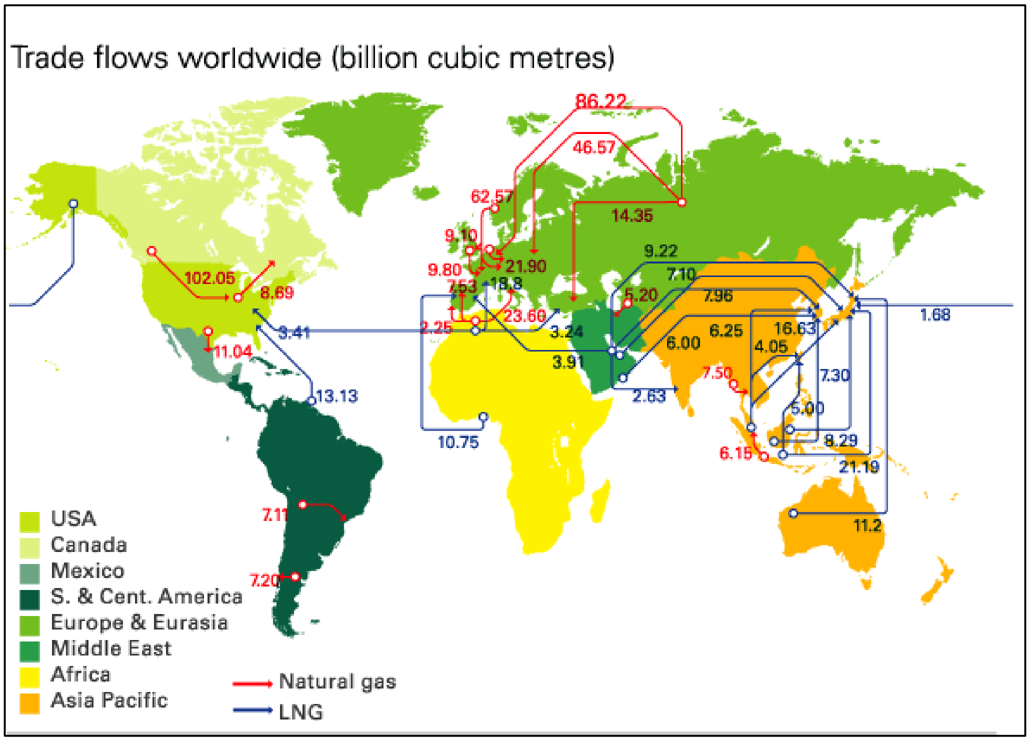

Figure 2.7: Major Trade Movements of Natural Gas **[4]**

According to World Energy Outlook projection, Primary demand for natural gas will grow at a steady rate of 2.3% per year over the projection period. By 2030, gas consumption will be about 90% higher than now, and gas will have overtaken coal as the world's second-largest energy source **(Figure 2.8 & 2.9)**. The share of gas in total primary energy use will increase from 21% in 2002 to 25% in 2030. The power sector will account for 60% of the increase in gas demand, with its share of the world gas market rising from 36% in 2002 to 47% in 2030. The power sector will be the main driver of demand in all regions. This trend will be particularly marked in developing countries, where electricity demand is expected to rise most rapidly. A small but growing share of natural gas demand will come from gas-to-liquids plants and from the production of hydrogen for fuel cells. **[1]**

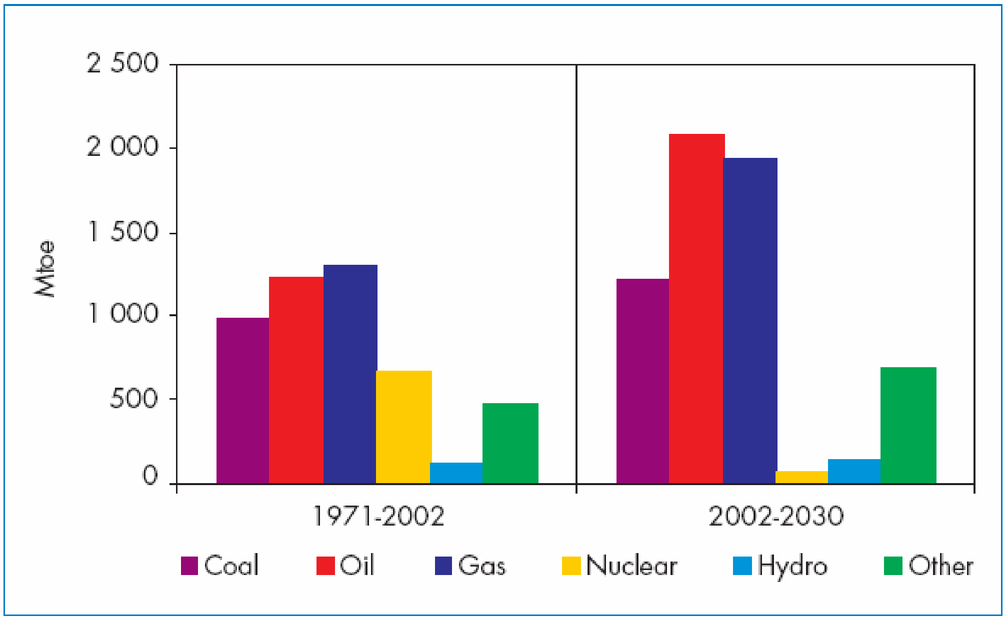

Figure 2.8: Increase in World Primary Energy Demand by Fuel **[1]**

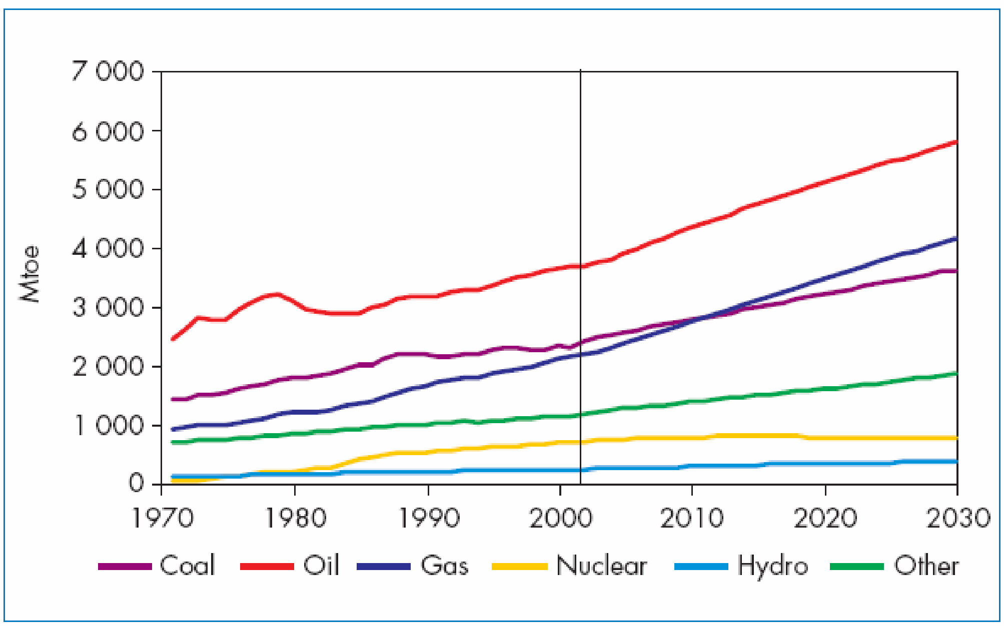

Figure 2.9: World Primary Energy Demand by Fuel **[1]**

Global consumption of natural gas is expected to increase more in absolute terms than that of any other primary energy source, almost doubling to 4900 bcm (4130 Mtoe) in 2030 **(Table 2.4)**. Demand will grow at an average annual rate of 2.3%. Most of the increase will come from the power-generation sector. The share of gas in total world primary energy demand will increase from 21% in 2002 to 25% in 2030. **[1]**

Table 2.4: World Natural Gas Primary Demand (bcm) **[1]**

	2002	2010	2020	2030	2002-2030*
OECD North America	759	866	1 002	1 100	1.3%
OECD Europe	491	585	705	807	1.8%
OECD Pacific	130	173	216	246	2.3%
OECD	**1 380**	**1 624**	**1 924**	**2 154**	**1.6%**
Russia	415	473	552	624	1.5%
Other transition economies	220	254	311	360	1.8%
Transition economies	**635**	**728**	**863**	**984**	**1.6%**
China	36	59	107	157	5.4%
Indonesia	36	53	75	93	3.5%
India	28	45	78	110	5.0%
Other Asia	109	166	242	313	3.8%
Brazil	13	20	38	64	5.8%
Other Latin America	89	130	191	272	4.1%
Africa	69	102	171	276	5.1%
Middle East	219	290	405	470	2.8%
Developing countries	**597**	**864**	**1 307**	**1 753**	**3.9%**
World**	**2 622**	**3 225**	**4 104**	**4 900**	**2.3%**
European Union	*471*	*567*	*684*	*786*	*1.8%*

* Average annual growth rate.
** World totals include stock changes and statistical differences.

The projected growth in gas demand is in line with historical trends. Global consumption rose by 2.5% per year from 1990 to 2002. Demand has faltered since the start of the current decade, increasing by only 1% in 2001 and, according to preliminary data, by 2.4% in 2003. The economic downturn and warmer winter weather across the northern hemisphere contributed to slower growth in 2001. A slump in gas use in the United States – the result of stagnating production and soaring prices – also played a role in 2001 and 2003. Since 2000, demand has grown most strongly in Latin America. As in the previous estimations, gas demand will grow most rapidly in Africa, Latin America and developing Asia. The use of gas will grow by more than 5% a year in China and India, where gas will win market share from coal in the power sector and in industry. **(Figure 2.10).[1]**

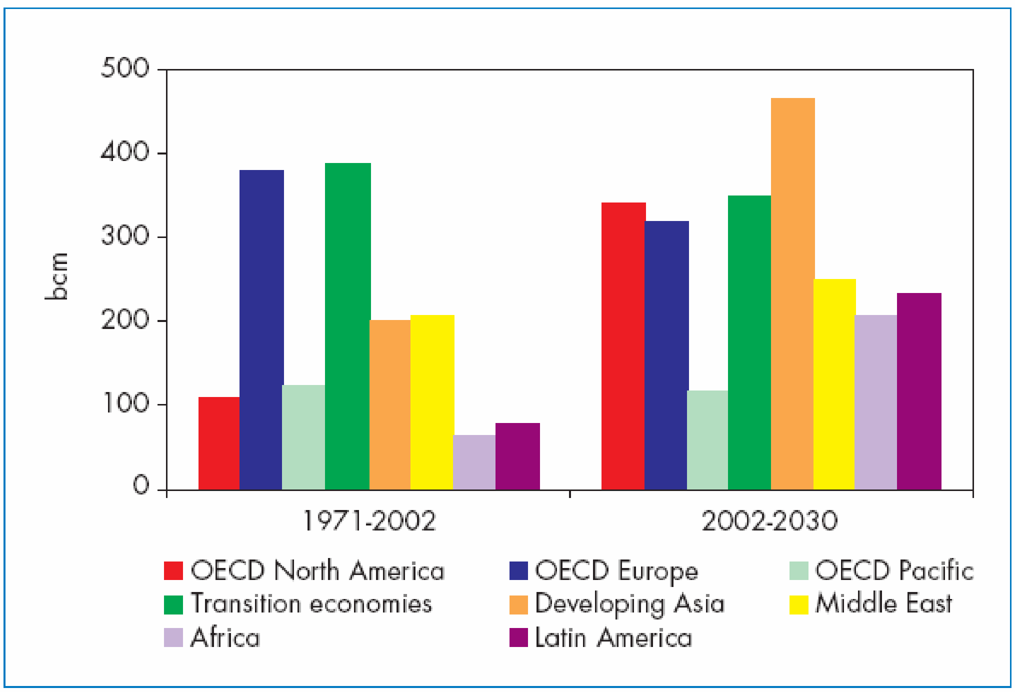

Figure 2.10: Incremental Demand for Natural Gas by Region **[1]**

Demand will increase most in volume terms in developing Asia as a whole. The region's share of world demand will jump from 8% in 2002 to 14% in 2030. Per capita gas consumption will, nonetheless, remain highest in the mature markets of OECD North America and the transition economies. By 2030, OECD North America alone will still account for 23% of world gas consumption, OECD Europe for 16% and Russia for 12%. **[1]**

At 1.5% per annum, final gas consumption will grow much more slowly than will primary use over the projection period. Industrial demand will grow faster than that of any other sector, and industry will remain the largest end-consumer of gas. Industrial demand is expected to increase most rapidly in developing countries, by 2.9% annually. But this will happen only if the needed gas-supply infrastructure is built. In the transition economies, expected improvements in energy efficiency will hold the growth in gas demand down to less than 2% per annum. There is tremendous scope for efficiency gains in Russian manufacturing industry – especially in chemicals and in iron and steel, which use large amounts of gas. Industrial gas demand in OECD countries will grow by less than 1% per year, roughly the same rate as over the past three decades. Gas demand in other final sectors – mainly residential and services – will grow by 1.4% per year. Growth in the use of gas for space and water heating will be limited by saturation effects in many OECD countries. There is little scope for establishing and extending local distribution networks in many parts of the developing world, because heating needs are small or because incomes are too low. The share of gas in overall final energy, available to the user following the conversion from primary energy carriers, use in these sectors will nonetheless remain broadly constant at about one-fifth. **[1] (Figure 2.11 & 2.12)**

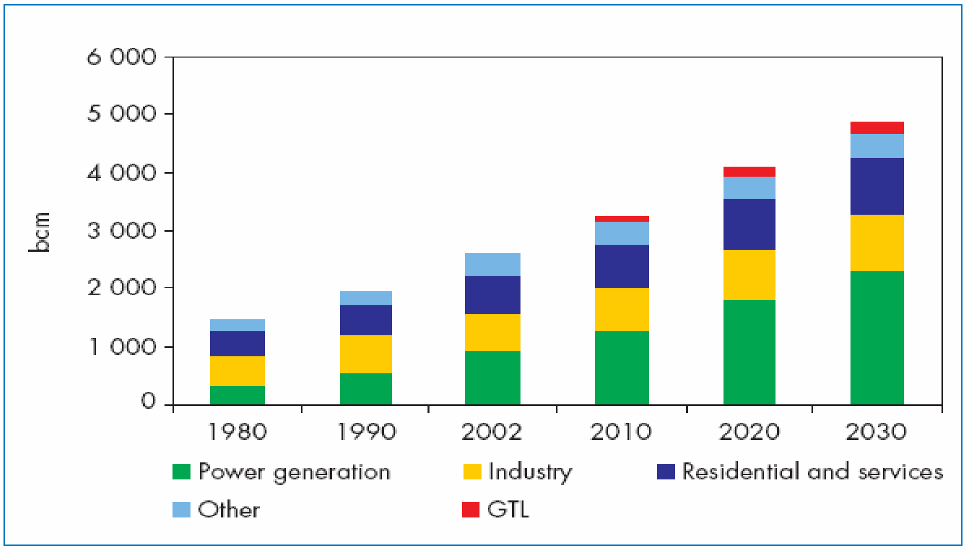

Figure 2.11: World Natural Gas Demand by Sector **[1]**

The average gas import price in Europe is assumed to peak in 2005 in lagged response to high oil prices in 2004. Prices are assumed to fall back to around $3.30/MBtu (in year-2000 dollars) towards the end of the current decade and then rise gradually to $4.30 by 2030. Gas-to-gas competition is expected to exert some downward pressure on gas prices at borders as spot trade develops. But the cost of bringing new gas supplies to Europe is expected to rise as the distances over which the gas has to be transported lengthen and import costs increase. This is assumed to offset the impact of falling unit supply costs and of growing competition. On balance, gas prices are expected to rise slowly in relation to oil prices from 2008 on. **[1].**

CHAPTER 3

PRESENT SITUATION OF TURKEY

3.1. Energy History of Turkey

Turkey is relatively well endowed with energy and mineral resources. The extensive mountainous terrain provides numerous hydroelectric sites, although most are far from the main population and consumption centers. Turkey also has substantial exploitable lignite resources and small reserves of hard coal, petroleum, and natural gas. Commercially exploitable deposits of many minerals have been located, but the territory has been surveyed only partially. Exploitation of these natural resources has occurred relatively slowly. **[5]**

The combined demands of industrialization and urbanization nearly tripled energy consumption in the 1960s and 1970s. An inappropriate pricing policy, especially the subsidy of petroleum that led to unduly cheap products, was one cause of shifts in the sources of energy that exacerbated shortages. In 1960 more than half of the primary energy consumed came from noncommercial sources, mainly firewood but also manure and other agricultural wastes. These noncommercial sources, plus domestic coal and lignite, accounted for more than 80 percent of all primary energy consumed; oil supplied only 18 percent. By 1980, in contrast, oil supplied about 47 percent of the primary energy consumed, coal and lignite about 21 percent, hydroelectric power 8 percent, and noncommercial sources such as firewood and animal wastes only 23 percent. By 1992, 43.5 percent of final energy came from petroleum, 31.1

percent from lignite and hard coal, 4.1 percent from hydroelectric power, 6.9 percent from natural gas, and 14.4 percent from other energy sources, including solid fuels, geothermal, solar power, and wind power. **[5]**

Imports of petroleum averaged more than 15 million tons per year in the early 1980s and increased to about 23 million tons in the early 1990s. Because of Turkey's fractured substrata, deposits are often contained in small pockets, which make exploration and extraction difficult. For example, a study in 1985 claims that Turkey has oil deposits at very deep levels, but it was not known how large the deposits might be. Shell Oil determined that oil at Paleozoic levels would be recoverable, and other investigations proved significant deposits in central Anatolia under the salt flats in the plain north of Konya. In 1991 British Petroleum began exploring for oil in offshore areas of the Black Sea. It is also suspected that the Aegean shelf contains considerable petroleum deposits, but as long as relations with Greece remain strained, conflicting claims to the Aegean seabed limit prospects for exploration. To speed up the exploration process, the government in 1983 eased regulations on such activities by foreign oil companies, allowing them to export 35 percent of production from fields they discovered in onshore and 45 percent from offshore fields. Although several foreign concerns started exploration after the liberalization package went into effect, up to the mid-1990s no major finds had been reported. **[5]**

The state-owned oil company, Turkish Petroleum Corporation (TPAO), Shell Oil, and Mobil control most petroleum output, which had climbed gradually to a peak of 3.6 million tons in 1969 but declined to about 2.1 million tons in 1985 as deposits were depleted. By the early 1990s, output had increased once again to nearly 4.4 million tons. The main petroleum project during the 1980s was an attempt at secondary recovery at the Bati Raman fields in southeastern Anatolia, which were expected to produce roughly 1.5 million tons a year over a twenty-year period. **[5].** In 1986, CO_2 Injection Project has been started and upto now 7,1 billion m^3 CO_2 has been injected to the reservoir. To be able to increase the efficiency of CO_2 Injection Project, Polymer/Gel has been pumped in to 3 wells in July 2002 and in to 4 wells in June 2004. The results were pretty satisfied. By July 2005, 90.000 – 100.000 bbls additional oil has been produced. To be able to develop the field and gather more data from the reservoir, 3 new wells (2 horizontal, 1 multi lateral) have been spotted in the late 2004 and completed in February, 2005. These wells are producing with the predicted rates from March 2005. Moreover, similar secondary recovery projects have been developed for Raman Field (Work Over Operations), Garzan Field (Water Injection Operations) and Batı Kozluca Field (WAG-Water Alternating Gas Operations). **[6].**

TPAO stepped up oil exploration efforts at home and abroad in the hope of raising output. But prospects for new domestic finds were endangered by the escalating conflict with Kurdish rebels in southeastern Turkey. Western operators in the area were nervous after a sharp increase in the number of attacks on oil installations. Mobil suspended operations at its 3,200-bpd Selmo field and other small sites after Kurdish attacks on its staff. In the early 1990s, talks were underway on a possible transfer of the Selmo operation to TPAO. Shell Oil's rig near the 25,000-bpd Batman refinery was also hit, although operations there continued. TPAO reported no attacks. Total Turkey production in 1993 of about 78,600 bpd--down from about 84,500 bpd in 1991--met 17 percent of its 458,000-bpd needs. In 1993, TPAO pumped about 60,550 bpd, Shell Oil about 14,500 bpd, Mobil about 3,230 bpd, and Aladdin Middle East about 330 bpd. On several aging fields, rising water content has halved productivity. TPAO drilled sixty exploration wells in 1993, only one of which hit oil. In 1994 it planned to drill eighty-one, stepping up work outside the affected southeast. Meanwhile, Mobil was doing seismic work in central and southern Turkey, and Shell Oil and United States Arco were both exploring in the southeast. **[5].**

In 2003, TPAO produced 11,1 million barrels of crude oil from its fields, which constituted % 68 of the total crude oil production of Turkey. Oil production from Batman, Adıyaman and Thrace Regions was 57%, 42% and 1%, respectively. **[7].**

Five refineries with a total capacity of about 713,000 bpd meet most of Turkey's need for petroleum products. Until early 1995, about 85 percent of refinery capacity was in public hands in four refineries located at Aliaga near Izmir, Kocaeli, Kirikkale, and Batman. A fifth refinery, jointly owned by Mobil, Shell Oil, British Petroleum, and a Turkish company, is located at Mersin. **[5]**

Natural gas became important in the 1980s. Gas tapped in Thrace (Trakya, European Turkey) was piped to the Istanbul region and used to produce electricity, thereby reducing the need for energy imports from Bulgaria. In 1986 Turkey began construction of a pipeline to carry Soviet natural gas from the Bulgarian border to Ankara; the line was completed in the late 1980s. In 1990 government officials announced that they also desired to purchase natural gas from Algeria, a move that would help balance Turkey's large purchases from the Soviet Union. **[5]**

Demand for electricity has increased rapidly, in large part because of the growth of industry, which consumed more than 56 percent of electricity in 1992. By 1985 thermal plants produced 53 percent of total installed capacity; hydroelectric plants produced the remainder. During the early 1980s, shortages of electricity had to be covered with imports from Bulgaria and the Soviet Union. In 1984 Turkey and the Soviet Union agreed to build a second transmission line that would allow future increases in Soviet electricity deliveries. Although in the 1990s electricity imports meet less than 1 percent of Turkey's needs, Turkey wants to be independent of supplies from unreliable neighbors. **[5]**

Sources for generating such electricity varied. By 1992 electricity generated by coal accounted for 36 percent of total installed capacity, with hydroelectric plants accounting for 40 percent. The rest was generated using petroleum products. **[5]**

Nuclear power stated as an option to solve Turkey's energy problems. Officials had long discussed on the possible scenarios. During the 1980s, the military government drew up a nuclear energy program and established the Nuclear Power Plants Division of the Turkish Electricity Authority to make feasibility studies and to build nuclear plants. Given Turkey's desire to diversify its energy sources, nuclear power was expected to remain on the agenda. **[5]**

By late 2005, however, no electricity had been generated from nuclear power. **[5]. (Table 3.1 & 3.2).**

Table 3.1: Turkey Primary Energy Sources Consumption **[8]**

TURKEY PRIMARY ENERGY SOURCES CONSUMPTION															
							GEOTHERMAL								
YEARS	PITCOAL (10^3 Tones)	LIGNITE (10^3 Tones)	ASPHALT (10^3 Tones)	OIL (10^3 Tones)	N. GAS (10^6 m3)	HYDRAULIC (GWh)	ELECTRIC (GWh)	HEAT (10^3 Tep)	WIND (GWh)	SUN (10^3 Tep)	WOOD (10^3 Tones)	ANIMAL AND PLANT REM. (10^3 Tones)	ELECTRIC IMPORT (GWh)	ELECTRIC EXPORT (GWh)	TOTAL (10^3 Tep)
1981	4522	16179	560	15090	16	12616		60			16023	12689	1616		32049
1982	5044	17716	861	16127	45	14167		82			16760	12607	1773		34388
1983	5336	20663	750	16705	8	11343		100			17086	12748	2221		35697
1984	5678	25632	225	16990	40	13426	22	178			17256	11978	2653		37425
1985	6189	34767	523	17270	68	12045	6	232			17368	11039	2142		39399
1986	6545	42354	607	18688	457	11873	44	304		5	17570	11343	777		42472
1987	7220	40653	631	21239	735	18618	58	324		10	17693	11059	572		46883
1988	7525	33080	624	21302	1225	28950	68	340		13	17711	10987	381		47910
1989	6825	47557	409	21732	3162	17940	63	342		19	17815	10885	559		50705
1990	8191	45891	287	22700	3418	23148	80	364		28	17870	8030	176	-907	52987
1991	8824	48851	139	22113	4205	22683	81	365		41	17970	7918	759	-506	54278
1992	8841	50659	197	23660	4612	26568	70	388		60	18070	7772	189	-314	56684
1993	8544	46086	102	27037	5088	33951	78	400		88	18171	7377	213	-589	60265
1994	8192	51178	0	25859	5408	30586	79	415		129	18272	7074	31	-570	59127
1995	8548	52405	66	27918	6937	35541	86	437		143	18374	6765	0	-696	63679
1996	10892	54961	34	29604	8114	40475	84	471		159	18374	6666	270	-343	69862
1997	12537	59474	29	29176	10072	39816	83	531		179	18374	6575	2492	-271	73779
1998	13146	64504	23	29022	10648	42229	85	582	6	210	18374	6396	3299	-298	74709
1999	11362	64049	29	28862	12902	34678	81	618	21	236	17642	6184	2330	-285	74275
2000	15525	64384	22	31072	15086	30879	76	648	33	262	16938	5981	3791	-437	80500
2001	11176	61010	31	29661	16339	24010	90	687	62	287	16263	5790	4579	-433	75402
2002	18830	52039	5	29776	17694	33684	105	730	48	318	15614	5609	3588	-435	78331
2003	17535	46051	336	30669	21374	35330	89	784	61	350	14991	5439	1158	-588	83826
2004	18904	44823	722	31729	22446	46084	93	811	58	375	14393	5278	464	-1144	87818
2005*	19421	56577	738	30016	27314	39561	94	926	59	385	13819	5127	636	-1798	91576

*Temporary

Table 3.2: Turkey Primary Energy Sources Production **[9]**

TURKEY PRIMARY ENERGY SOURCES PRODUCTION

YEARS	PITCOAL (10^3 Tones)	LIGNITE (10^3 Tones)	ASPHALT (10^3 Tones)	OIL (10^3 Tones)	N. GAS (10^6 m3)	HYDRAULIC (GWh)	GEOTHERMAL		WIND (GWh)	SUN (10^3 Tep)	WOOD (10^3 Tones)	ANIMAL AND PLANT REM. (10^3 Tones)	TOTAL (10^3 Tep)
							ELECTRIC (GWh)	HEAT (10^3 Tep)					
1981	3970	16476	560	2363	16	12616		60			16023	12689	18299
1982	4008	17804	860	2333	45	14167		82			16760	12607	19186
1983	3539	20956	750	2203	8	11343		100			17086	12748	19313
1984	3632	26115	225	2087	40	13426	22	178			17256	11978	20322
1985	3605	35869	523	2110	68	12045	6	232			17368	11039	21935
1986	3526	42284	607	2394	457	11873	44	304		5	17570	11343	23538
1987	3461	42896	631	2630	297	18618	58	324		10	17693	11059	25077
1988	3256	35338	624	2564	99	28950	68	340		13	17711	10987	24607
1989	3038	48762	416	2876	174	17940	63	342		19	17815	10885	25754
1990	2745	44407	276	3717	212	23148	80	364		28	17870	8030	25478
1991	2762	43207	139	4451	203	22683	81	365		41	17970	7918	25501
1992	2830	48388	213	4281	198	26568	70	388		60	18070	7772	26794
1993	2789	45685	86	3892	200	33951	78	400		88	18171	7377	26441
1994	2839	51533		3687	200	30586	79	415		129	18272	7074	26511
1995	2248	52758	67	3516	182	35541	86	437		143	18374	6765	26719
1996	2441	53888	34	3500	206	40475	84	471		159	18374	6666	27386
1997	2513	57387	29	3457	253	39816	83	531		179	18374	6575	28209
1998	2156	65204	23	3224	565	42229	85	582	6	210	18374	6396	29324
1999	1990	65019	29	2940	731	34678	81	618	21	236	17642	6184	27659
2000	2392	60854	22	2749	639	30879	76	648	33	262	16938	5981	26047
2001	2494	59572	31	2551	312	24010	90	687	62	287	16263	5790	24576
2002	2319	51660	5	2420	378	33684	105	730	48	318	15614	5609	24259
2003	2059	46168	336	2375	561	35330	89	784	61	350	14991	5439	23783
2004	1946	43709	722	2276	708	46084	93	811	58	375	14393	5278	24332
2005*	2170	55282	888	2281	980	39561	94	926	59	385	13819	5127	25185

*Temporary

3.2. Historical Natural Gas Production In Turkey

Totally 32 gas fields including 4 CO_2 fields were discovered in Turkey till the end of 2004. **(Table 3.3).** By the end of 2004, recoverable natural gas reserve of Turkey is 7.403.688.526 sm^3. **[2] (Table 3.4)(Figure 3.1 & 3.2)**

Table 3.3: Turkey Discovered Natural Gas Fields **[2]**

FIELD	DISCOVERY DATE	DISTRICT	CASE NO.	PRODUCING FORMATION	AVERAGE DEPHT (M.)	SPECIFIC GRAVITY
TÜRKİYE PETROLLERİ A.O.						
Hamitabat	1970	I	ARİ/TPO/1946	Hamitabat	3,000	0.590
Kumrular	1970	I	ARİ/TPO/1946	Soğucak	3,150	0.601
Çamurlu	1975	X	ARİ/TPO/2436	Sinan	1,450	0.646
G.Dinçer (3)	1982	X	ARİ/TPO/2691	Çamurlu	2,530	0.859
Umurca	1984	I	ARİ/TPO/2690	Osmancık	1,900	0.625
G.Hazro (3)	1986	X	ARİ/TPO/2893	Hazro	3,780	
K.Marmara	1988	I	ARİ/TPO/3096	Soğucak	1,200	0.603
Karacaoğlan (3)	1989	I	ARİ/TPO/3381	Ceylan	3,383	0.615
Değirmenköy (S)	1994	I	ARİ/TPO/3411	Soğucak	1,200	0.630
Karaçalı (O)	1995	I	ARİ/TPO/3302	Osmancık	2,200	0.628
Değirmenköy (D & O)	1996	I	ARİ/TPO/3411	Danişmen & Osmancık	1,023	0.591
Silivri	1996	I	ARİ/TPO/3406	Danişmen &Osmancık	1,225	0.566
Karaçalı (D)	1997	I	AR/TPO/3160-3338	Danişmen	1,190	0.600
Yulaflı	1999	I	ARİ/TPO/3751	Danişmen & Osmancık	1,972	0.644
Sevindik	2000	I	ARİ/TPO/3842	Danişmen	2,400	0.654
G.Karaçalı	2001	I	AR/TPO/3791	Osmancık	1,840	0.845
Vakıflar	2001	I	AR/TPO/3791	Osmancık	1,076	0.795
Çayırdere(8)	2003	I	AR/TPO/3792	Osmancık	710	0.557
N.V.TURKSE SHELL						
Katin (3) (4)	1972	X	ARİ/NTP/1852	Katin kumtaşı	3,150	0.740
Derin Barbeş (4)	1984	X	ARİ/NTP/1852	Katin kumtaşı	3,300	0.750
DEMIRSU ASS. TURKEY INTERNATIONAL INC. *						
Kandamış (1)(5)(7)	1985	I	İR/WIL/2694	Osmancık	1,000	0.573
THRACE BASIN NATURAL GAS CORP. TURKEY						
Bayramşah (1) (5) (7)	1987	I	İR/WIL/2694	Osmancık	1,100	0.809
Hayrabolu (2)	1990	I	İR/TGT-PIN/2926	Osmancık	1,200	
Tekirdağ Sığ (6)	1999	I	ARİ/TGT-ETE/3860	Osmancık	225	0.570
AMITY OIL INTERNATIONAL PTY. LTD.						
Göçerler (9)	2000	I	AR/AOI/3589	Osmancık	1,298	0.610
Adatepe (9)	2003	I	AR/AOI/3648	Osmancık	1,298	0.610
THRACE BASIN NATURAL GAS CORP. TURKEY & ENRON THRACE EXP. AND PRO.BV.						
Gazioğlu (6)	2002	I	ARİ/TGT-ETE/3861	Osmancık	920	
Mavi Marmara (6)	2003	I	ARİ/TGT-ETE/3861	Osmancık	500	
TÜRKİYE PETROLLERİ A.O.						
Dodan (CO2)	1965	X	ARİ/TPO/822	Ü.Sinan	1,190	1.360
Dodan (CO2)	1969	X	ARİ/TPO/822	Garzan	1,792	1.270
Dodan (CO2)	1969	X	ARİ/TPO/822	Mardin	2,035	1.406
Çamurlu (CO2)	1977	X	ARİ/TPO/2436	Çamurlu	3,200	0.646

(*) Company name changed as Thrace Basin Natural Gas Corp.Turkey,on June 26,1986.
(1) Transferred to Polmak Sondaj San A.S. in 1989.
(2) Huffco Turkey Inc. became a share holder in the lease area in 1990. Company name of Huffco Turkey Inc. changed as Pinnacle Turkey Inc. on June 15.20
(3) Depleted or closed to production.
(4) Transferred to N.V.Turkse Perenco in 1997
(5) Transferred to Wilco Turkey Ltd. in 1999
(6) Enron Thrace Exp.and Pro.B.V. became a shareholder in the area in 2001.
(7) Due to P.L. 68/2 lease relinquished.
(8) Has a joint venture agreement with Amity Oil Int.Pty.Ltd.
(9) Has a joint venture agreement with TPAO.

Table 3.4: Turkey Natural Gas Reserves, sm^3 **[2]**

COMPANIES	ORIGINAL GAS IN PLACE(*	RECOVERABLE GAS	CUMULATIVE PRODUCTION	REMAINING RECOVERABLE GAS
T.P.A.O.	13,275,978,723	9,497,178,723	5,986,954,378	3,510,224,345
N.V.Turkse Perenco	4,657,976,055	3,261,672,349	109,033,522	3,152,638,827
Amity Oil İnt.& T.P.A.O	783,000,000	638,800,000	377,781,067	261,018,933
Thrace Basin Nat.Gas Corp	76,342	76,342	76,342	
Thrace Basin.& Pinnacle Turkey	142,000,000	85,300,000	13,607,375	71,692,625
Thrace Bas Nat.Gas Corp.& Enro	1,207,000,000	784,550,000	376,436,204	408,113,796
Total	**20,066,031,120**	**14,267,577,414**	**6,863,888,888**	**7,403,688,526**

* Total of proven and probable & possible reserves.

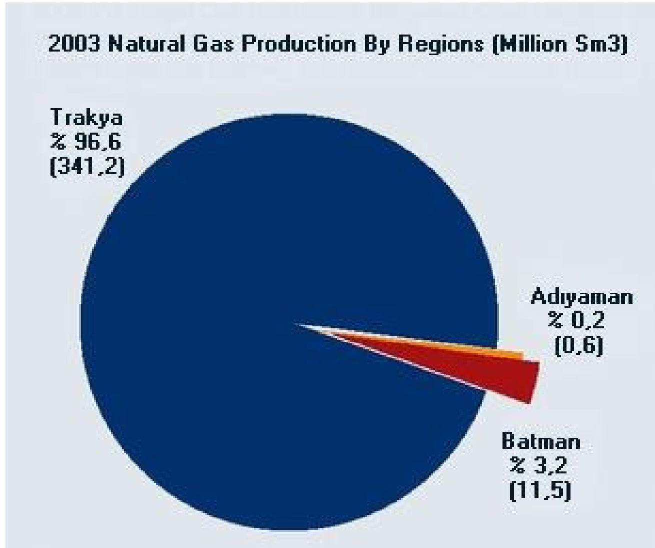

Figure 3.1: 2003 Natural Gas Production by Regions. **[7]**

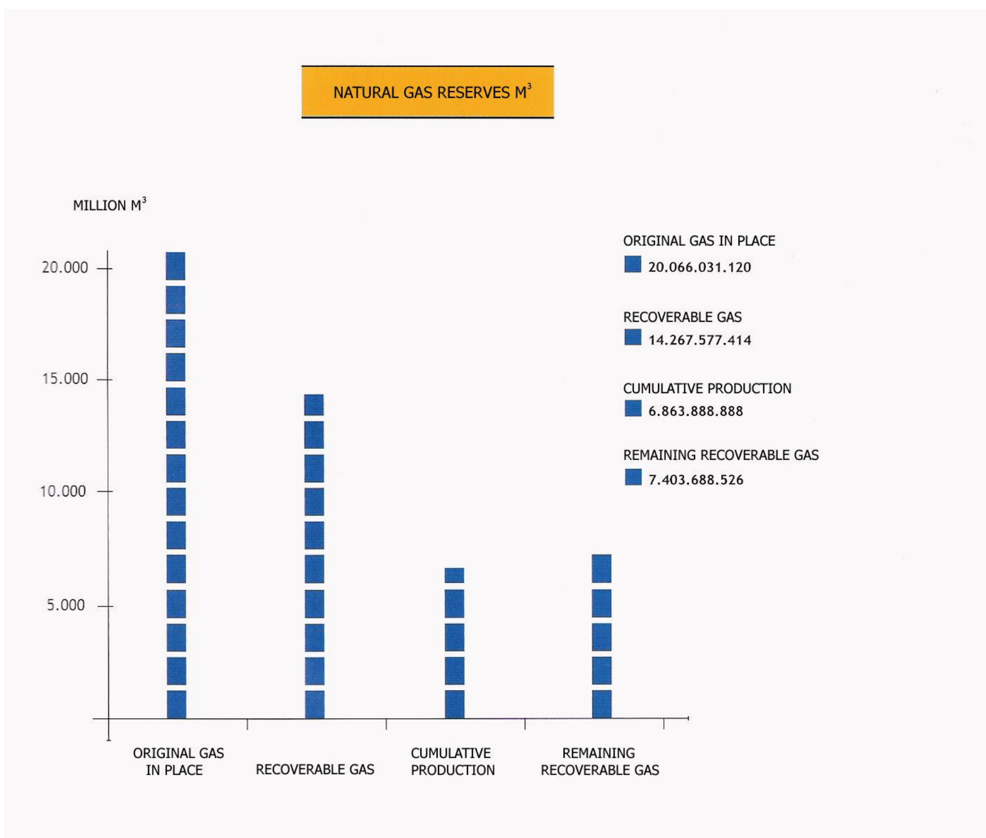

Figure 3.2: Turkey Natural Gas Reserves, sm^3 **[2]**

Natural gas production is realized from Hamitabat, Umurca, Değirmenköy, Karaçalı, Silivri, Yulaflı, Sevindik, Güney Karaçalı, Seymen, Vakıflar, Kavakdere, Turgutbey, Kumrular and Kuzey Marmara fields in the petroleum district I Marmara and Çamurlu field in the petroleum district X Siirt, by Türkiye Petrolleri A.O. and Hayrabolu and Gelindere fields in petroleum district I Marmara by joint venture of Thrace Basin Nat. Gas Corp. + Pinnacle Turkey Inc. Gazioğlu and Tekirdağ Sığ fields by Thrace Basin Nat. Gas Corp. + Enron Thrace Exploration and Production B.V. and Tatarlı field by Thrace Basin Nat. Gas Corp. and Göçerler, Adatepe, D. Adatepe and Çayırdere fields by Amity Oil Int. + TPAO and Derin Barbes field by N.V. Turkse Perenco in the district XI. Total natural gas production from these fields is 707.008.763 sm^3 with an increase of 26 % compared to 2003 production. Cumulative natural gas production of Turkey by the end of 2004 is 6.863.888.888 sm^3. **[2] (Table 3.5)(Figures 3.3 & 3.4)**

Table 3.5: Turkey Natural Gas Production, sm^3 **[2]**

YEARS	GÖCERLER (AOI &TPAO)	ADATEPE (AOI &TPAO)	D.ADATEPE (AOI &TPAO)	CAYIRDERE (AOI &TPAO)	TOTAL (AOI &TPAO)	HAYRABOLU (TGT&PIN)	GELİNDERE (TGT&PIN)	TOTAL (TGT&PIN)	TEKİRDAĞ-SIĞ (TGT& ETE)	GAZİOĞLU (TGT& ETE)	M.MARMARA (TGT& ETE)	TOTAL (TGT& ETE)	TATARLI (TGT)	D.BARBES (NTP)	KATİN (NTP)	TOTAL NTP	TOTAL TPAO	TOTAL
1976																	15,374,200	15,374,200
1977																	18,206,627	18,206,627
1978																	22,494,789	22,494,789
1979																	34,082,243	34,082,243
1980																	23,667,204	23,667,204
1981																	16,265,336	16,265,336
1982																	45,130,615	45,130,615
1983																	7,532,370	7,532,370
1984																	39,636,987	39,636,987
1985																	67,736,139	67,736,139
1986																	456,714,991	456,714,991
1987																	297,124,811	297,124,811
1988																	99,167,018	99,167,018
1989																	173,821,838	173,821,838
1990																	212,488,086	212,488,086
1991																	202,713,307	202,713,307
1992																	197,796,154	197,796,154
1993						1,121,245		1,121,245									199,739,333	200,860,578
1994						904,415		904,415									198,630,497	199,534,912
1995						747,334		747,334									181,514,867	182,262,201
1996						1,624,965		1,624,965									203,967,093	205,592,058
1997						2,411,488		2,411,488									250,804,344	253,215,832
1998						1,632,284	20,457	1,652,741	132,278			132,278		761,755		761,755	561,994,565	564,541,339
1999						819,177		819,177	2,686,376			2,686,376		9,322,960		9,322,960	718,270,214	731,098,727
2000						891,883		891,883	8,353,819			8,353,819		15,373,504	2,781,350	18,154,854	611,822,413	639,222,969
2001						811,755		811,755	26,364,819			26,364,819		17,913,500	698,809	18,612,309	265,773,662	311,562,545
2002	45,415,435				45,415,435	810,478	10,748	821,226	65,249,843	1,229,798		66,479,641		20,205,397	169,089	20,374,486	245,311,950	378,402,738
2003	152,287,135			1,076,760	153,363,895	487,307	173,586	660,893	105,626,934	4,264,926	358,690	110,250,550		20,364,443		20,364,443	275,993,730	560,633,511
2004	100,357,087	43,554,220	17,995,444	17,094,986	179,001,737	934,908	205,345	1,140,253	160,909,084	875,087	384,550	162,168,721	76,342	21,442,715		21,442,715	343,178,995	707,008,763
TOTA	298,059,657	43,554,220	17,995,444	18,171,746	377,781,067	13,197,239	410,136	13,607,375	369,323,153	6,369,811	743,240	376,436,204	76,342	105,384,274	3,649,248	109,033,522	5,986,954,378	6,863,888,888

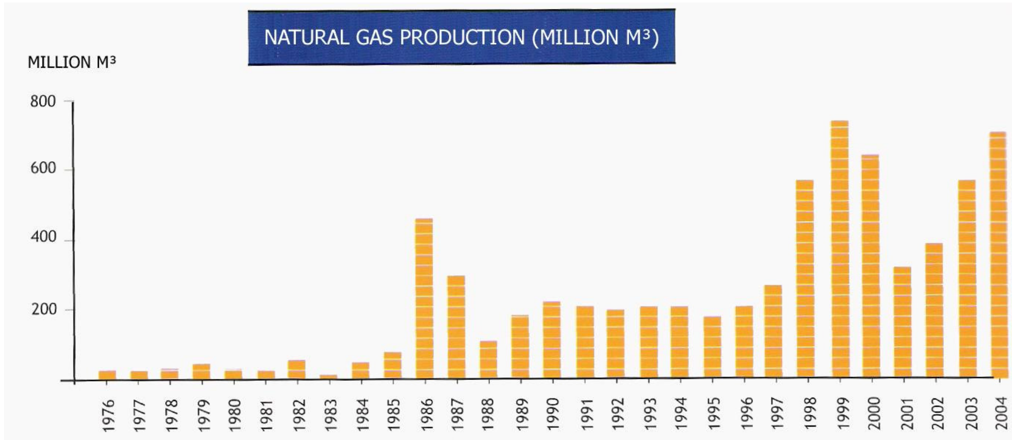

Figure 3.3: Turkey Natural Gas Production, million sm^3 **[2]**

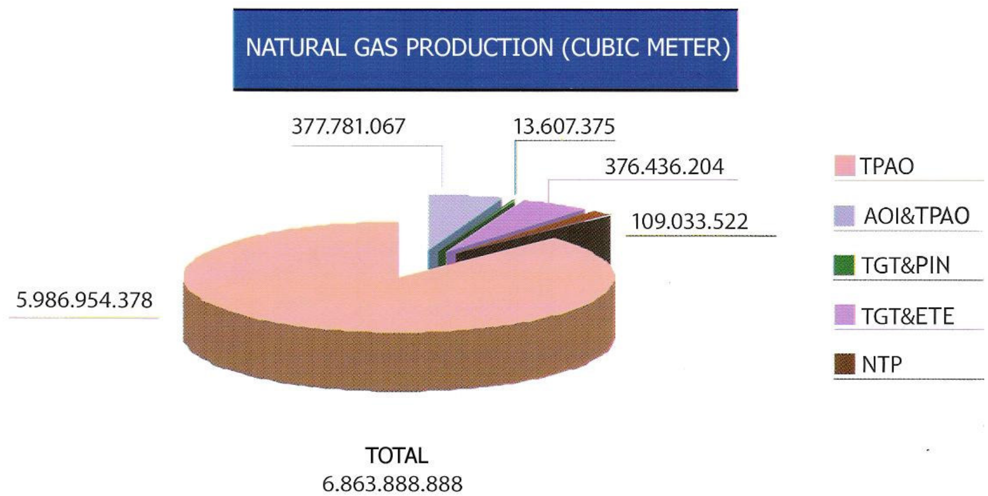

Figure 3.4: Turkey Natural Gas Production, sm^3 **[2]**

In total natural gas production realized in 2004, the share of TPAO is 48,54% (49,23% in 2003), the share of the joint venture of Amity Oil Inc. and TPAO is 25,32% (27,36% in 2003), the share of the joint venture of Thrace Basin Nat. Gas Corp. and Pinnacle Turkey Inc. is 0,16% (0,12% in 2003), the share of the joint venture of Thrace Basin Nat. Gas Corp. and Enron Thrace Exploration & Production B.V. is 22,94% (19,66% in 2003), and finally the share of N.V. Turkse Perenco is 3,03% (3,63% in 2003). **[2]**

In cumulative natural gas production realized from 1976 to the end of 2004, the share of TPAO is 87,22%, the share of the joint venture of Amity Oil Inc. and TPAO is 5,5%, the share of the joint venture of Trace Basin Nat. Gas Corp. and Pinnacle Turkey Inc. is 0,2%, the share of the joint venture of Trace Basin Nat. Gas Corp. and Enron Thrace Exploration & Production B.V. is 5,48% and finally the share of N.V. Turkse Perenco is 1,59%. **[2].**

3.3. Historical Natural Gas Imports of Turkey

In 14 February 1986, Natural Gas Buying Agreement has been signed with Soviet Union (west) to provide public various energy sources. According to this agreement, Turkey would buy 6 billion sm^3 natural gas per year for 25 years. This agreement is still valid. In 1987, Turkey started to use natural gas as an alternative energy source. The growing economy forced the governments to find more and cheap gas. To be able to feed this hungry sector, Turkey has signed new buy-or-pay contracts with Algeria (LNG), Nigeria (LNG), Iran, Turkmenistan, Azerbaijan and Soviet Union (Black Sea). Most of these agreements are still valid. **(Table. 3.6).**

Table 3.6: Turkey Natural Gas Sale and Purchase Agreements **[10]**

AGREEMENTS	VOLUME BCMA (DURING THE PLATEAU PERIOD)	DATE OF SIGNATURE	DURATION (YEARS)	STATUS
Russian Fed. (Westward)	6	14 February1986	25	In operation
Algeria (LNG)	4	14 April 1988	20	In operation
Nigeria (LNG)	1.2	9 November1995	22	In operation
Iran	10	8 August 1996	25	In operation
Russian Fed. (Black Sea)	16	15 December 1997	25	In operation
Russian Fed. (Westward)	8	18 February 1998	23	In operation
Turkmenistan	16	21 May 1999	30	2005
Azerbaijan	6.6	12 March 2001	15	2005

In 2005; 12.301 Million sm³ of natural gas was imported from the Russian Federation, and also 555 Million sm³ of Russian gas was imported through TURUSGAZ and 4.969 Million sm³ of natural gas from the Black Sea, 3.851 Million sm³ and 1.030 Million sm³ of natural gas equivalent of LNG was imported from Algeria and Nigeria, respectively. Also 4.322 Million sm³ gas was imported from Iran. The total import volume reached 27.167 Million sm³. **[11] (Table. 3.7, 3.8)(Figure 3.5)**

Table 3.7: Turkey Natural Gas Movements (1000 sm^3) **[2]**

YEARS	PRODUCTION	IMPORT		TOTAL	CONSUMPTION
		NATURAL GAS	LNG		
1984	39,637			39,637	39,637
1985	67,736			67,736	67,736
1986	456,715			456,715	456,715
1987	297,125	432,736		729,861	729,551
1988	99,167	1,132,053		1,231,220	1,222,238
1989	173,822	3,040,467		3,214,289	3,163,464
1990	212,488	3,256,534		3,469,022	3,418,547
1991	202,713	4,037,148		4,239,861	4,232,246
1992	197,796	4,436,804		4,634,600	4,614,553
1993	200,861	4,954,262		5,155,123	5,121,990
1994	199,535	4,871,225	377,029	5,447,789	5,423,725
1995	182,262	5,526,516	1,192,484	6,901,262	6,833,674
1996	205,592	5,451,673	2,307,299	7,964,564	7,898,598
1997	253,216	6,585,859	2,998,424	9,837,499	9,668,743
1998	564,541	6,547,000	3,347,000	10,458,541	9,927,000
1999	731,099	8,697,517	3,334,280	12,762,896	12,467,036
2000	639,223	10,082,426	4,298,419	15,020,068	14,636,051
2001	311,563	10,388,377	4,823,648	15,523,588	15,836,814
2002	378,402	12,233,064	4,878,426	17,489,892	17,233,643
2003	560,634	16,090,953	4,560,397	21,211,984	20,914,083
2004	707,008	16,818,058	4,135,716	21,660,782	21,467,332

Table 3.8: Turkey NG and LNG Transportation in 2006 (Million Contract Sm^3) **[12]**

	RUSSSIAN FED. (GAZEXPORT)	RUSSIAN FED. (TURUSGAZ)	IRAN	BLUE STREAM	ALGERIA	NIGERIA	TPAO	TOTAL
JANUARY	1.037	64	356	776	489	91	36	2.850
FEBRUARY	1.077	58	490	779	433	86	17	2.940
MARCH	1.127	45	624	551	419	73	5	2.843
APRIL	749	39	611	401	407	176		2.382
MAY	670	42	451	470	325	77		2.035
JUNE	906	45	526	494	172	-	-	2.143
JULY	914	49	588	480	238	-	4	2.269
AUGUST	981	45	548	458	80	156	-	2.268
SEPTEMBER	980	36	300	585	414	-	-	2.315
OCTOBER	766	31	438	592	336	220	-	2.383
NOVEMBER	1158	58	519	802	408	165	6	3.116

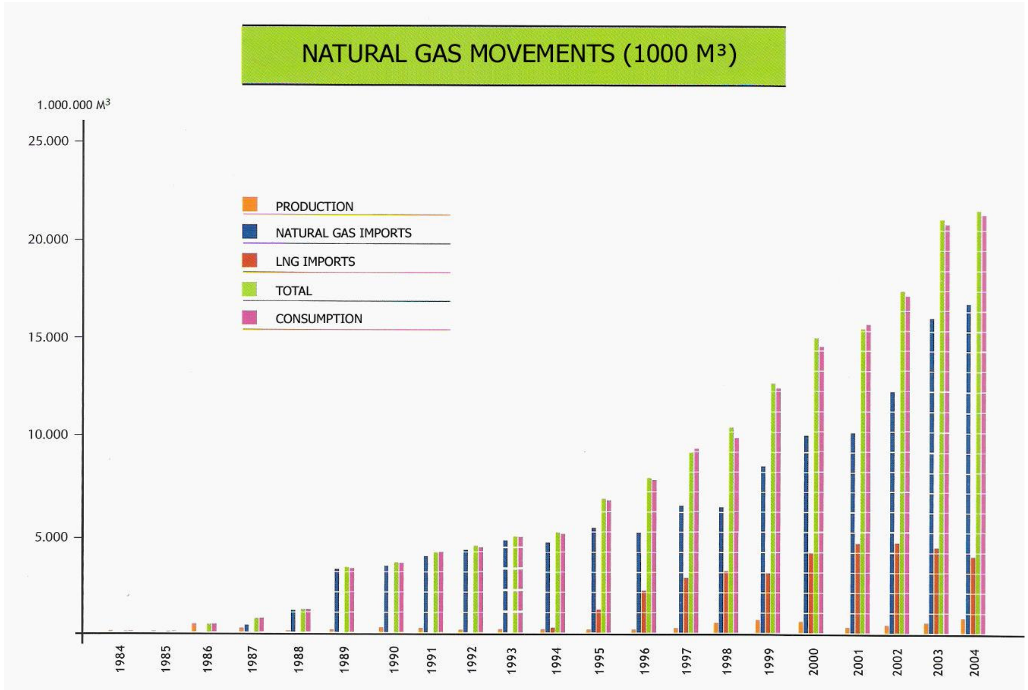

Figure 3.5: Turkey Natural Gas Movements, 1000 sm^3 **[2]**

In Turkey Gas History, BOTAS, established as a partnership of TPAO to deliver Iraq oil to Ceyhan in 15 August 1974, has played very important role. In 1995, BOTAS has been separated from TPAO and become an independent company. Natural gas delivery has begun in 1987. In 2 May 2001, by the new Natural Gas Market law (Law#4646), the monopoly of BOTAS has been broken and new competitors tried to be courage to take the responsibility of long term contracts **[13].** The first tender for contract transfer was held in November 2005 **[14].** Remember that, the take-or-pay contracts are very hard to handle by private companies. However, it is very important to break Botas monopoly to be able to get cheaper and multi-supplier gas to supply Turkey's growing demand.

3.4. Historical Natural Gas Pricing in Turkey

As Turkey's natural gas supply depends on take-or-pay import contracts, the end-user prices are very sensitive. To prevent these uncertainty, government is trying to make long term contracts and store excess gas in natural storage reservoirs. The price was 214.83 US$/1000 sm^3 in 2004 for industrial end-user and 242.77 US$/1000 sm^3 in 2004 for residential end-user. The prices in 2005 are 283.49 and 337.01 US$/1000 sm^3 for industrial and residential, respectively. **(Table 3.9).** The increase in prices for 1 year is 31,9 % and 38.8 % in industrial and residential, respectively.

Table 3.9: Turkey Historical Natural Gas Prices **[15]**

	Natural Gas (Industry) $ / 1000 sm^3	Natural Gas (Residence) $ / 1000 sm^3
1993	141,11	240,72
1994	129,29	190,86
1995	143,54	191,38
1996	171,47	190,53
1997	181,15	217,14
1998	157,99	199,87
1999	148,36	206,40
2000	161,77	239,69
2001	183,58	222,13
2002	199,66	236,00
2003	213,87	247,94
2004	214,83	242,77
2005	283,49	337,01

Most of the natural gas is used to produce electricity. In 1987 the share of power in total demand was 100 %. In 1995, commercial and industrial usage started to increase their shares in total. In 2000, the share of power was 67 %, while residence and industry were 19 % and 13 %

respectively. **(Figure 3.6).** In 2005, although the share of power decreased to 57 %, it is still leader of consumption. The residential and industrial consumption followed power with 21.8 % and 18.6 % respectively. **(Table 3.10).** The residential consumption is high in winter periods as the natural gas is used for heating. **(Table 3.11).** Indeed, the importance of gas storage is showing itself to be able to balance consumption fluctuation between winter and summer periods. Storing excess gas in Summer and using it in Winter period may keep the prices in reasonable interval. According to BOTAS reports, in January 2005, the price was 0.214923 $\$/Sm^3$ and became 0.224052 $\$/Sm^3$ in March 2005 with 4.2 % increase. After that the prices stated stable until June 2005 and became 0.237598 $\$/Sm^3$ in August 2005 with 6 % increase. The biggest increase happened with the beginning of winter and closed the year as 0.265995 $\$/Sm^3$ with 12 % increase (in year 2005 dollars).

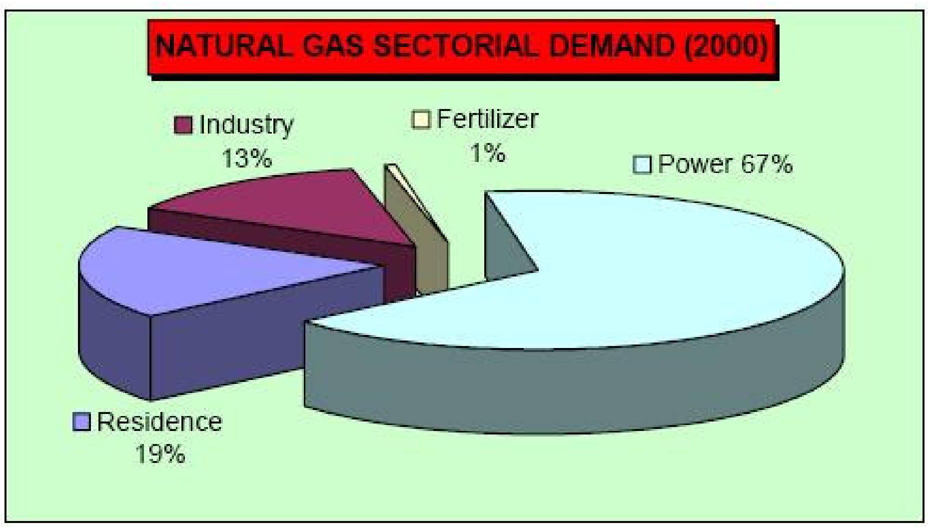

Figure 3.6: Turkey NG Sectorial Demand **[16]**

Table 3.10: Turkey NG Sale (Million Contract Sm³) **[12]**

	POWER	FERTILIZER	RESIDENTIAL	INDUSTRY	TOTAL
1988	1.034	152	0.05	-	1.186
1989	2.759	382	7	5	3.153
1990	2.599	501	50	222	3.373
1991	2.908	485	190	547	4.132
1992	2.633	652	375	861	4.521
1993	2.595	797	549	1.011	4.952
1994	3.037	612	647	955	5.251
1995	3.857	732	1.014	1.190	6.793
1996	4.174	830	1.526	1.376	7.906
1997	5.019	761	2.041	1.899	9.721
1998	5.491	493	2.247	2.041	10.271
1999	7.950	144	2.429	1.858	12.382
2000	9.733	113	2.806	1.914	14.566
2001	10.994	121	2.849	2.063	16.027
2002	11.631	496	2.973	2.277	17.378
2003	13.513	469	3.944	3.012	20.938
2004	13.226	528	4.463	3.892	22.108
2005	15.435	594	5.845	4.993	26.865
2006	15.173	156	6.057	5.800	27.187

Table 3.11: Turkey NG Sales in 2006 (Million Contract Sm³) **[12]**

	POWER	FERTILIZER	RESIDENTIAL	INDUSTRY	TOTAL
JANUARY	1.097	1	1.294	488	2.880
FEBRUARY	1.241	2	1.119	504	2.866
MARCH	1.382	27	879	546	2.834
APRIL	1.283	46	450	511	2.290
MAY	1.232	47	309	524	2.112
JUNE	1.434	28	183	493	2.138
JULY	1.510	0,5	208	437	2.155
AUGUST	1.594	1	163	529	2.287
SEPTEMBER	1.547	1	182	583	2.313
OCTOBER	1.363	1	354	555	2.273
NOVEMBER	1.492	1	919	628	3.040
DECEMBER					

3.5. Historical Cost of Natural Gas Imports to Turkey

Turkey has take-or-pay contracts with several countries. The agreements and the prices are, of course, changing from deal to deal. On the other hand, the contracts are highly confidential due to political and economic reasons. Governments are not intending to share these data with the public. Because of that we have just limited information on this subject.

According to a presentation in Ataum Conference **[17]**, the average price of imported natural gas in 2003 was 133 $/1000 sm^3. That means, Turkey paid app 2.8 billion $ for 21.2 billion sm^3 natural gas in 2003. Again from the same presentation, the average price of 2005 was 197 $/1000 sm^3. The increase is app 48 %. In 2005, the quantity of imported natural gas was 27.2 billion sm^3. So, Turkey paid another 5.4 billion $ to supply its natural gas demand.

CHAPTER 4

PROJECTIONS FOR TURKEY

4.1. Projections of Natural Gas Consumption and Prices in Turkey

As mentioned in the previous sections, Turkey is using most of its imported natural gas for producing electricity by turbines. According to natural gas sectorial demand forecasts, in 2020, power will still have the biggest share with 58.3 %. In 2020 forecasts, industry will be consuming 25.5 % of natural gas, while residential usage will be consuming 15.8 %. **(Figure 4.1).**

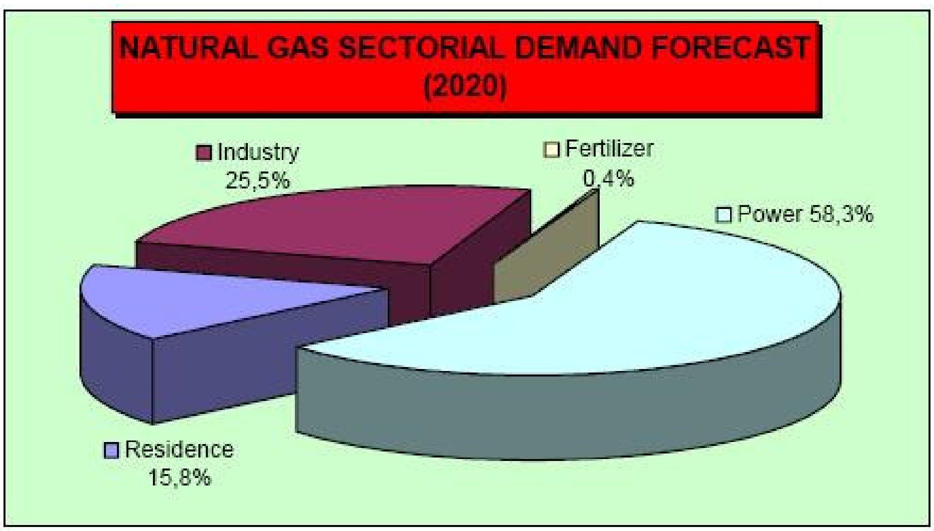

Figure 4.1: Turkey NG Sectorial Demand Forecast **[16]**

As power consuming most of the share, it is obvious that, the power requirement will be the strongest parameter to define future demand. In BOTAS forecasts, we can see this affect very obviously. According to BOTAS 2005 forecast, the total demand would be 39.3, 41.8 and 43.9 billion sm^3 for 2010, 2015 and 2020, respectively. **(Table 4.1).** However, after Turkey Electric Production Company's additional natural gas demand, the forecast has been modified. According to new forecast, the demand values are 44.0, 54.4 and 63.2 billion sm^3 for 2010, 2015 and 2020, respectively. **(Table 4.2).** As Turkey's power production depend on natural gas, the natural gas demand scenarios will alter every year.

Table 4.1: NG Supply and Demand Scenarios 2005 (Million sm^3) **[3]**

DEMAND	YEARS							
	2005	2006	2007	2008	2009	2010	2015	2020
Natural Gas Demand	24,980	32,342	34,876	36,354	37,543	38,531	41,062	43,185
Export to Greece	0	246	492	737	737	737	737	737
Total Demand	**24,980**	**32,588**	**35,368**	**37,091**	**38,280**	**39,268**	**41,799**	**43,922**
CONTRACTED SUPPLIES	**YEARS**							
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2015**	**2020**
Russion Federation	5,000	6,000	6,000	6,000	6,000	6,000	0	0
Algeria (LNG)	4,444	4,444	4,444	4,444	4,444	4,444	0	0
Nigeria (LNG)	1,338	1,338	1,338	1,338	1,338	1,338	1,338	1,338
Iran	6,689	8,600	9,556	9,556	9,556	9,556	9,556	9,556
Russion Fed. (Addition)(West)	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
Russion Fed. (Black Sea)	6,000	8,000	10,000	12,000	14,000	16,000	16,000	16,000
Turkmenistan (*)	0	0	0	0	0	0	0	0
Azerbaijan (**)	0	0	2,000	3,000	5,000	6,600	6,600	6,600
Total Supplies	**30,938**	**35,766**	**40,638**	**43,587**	**47,519**	**51,058**	**40,791**	**40,791**

(*) : There is an uncertainty of purchasing natural gas.
(**) : Annual contracted amounts may change upon changes in the initial date for gas deliveries.

Table 4.2: NG Supply and Demand Scenarios 2006 (Mil. sm^3) **[18]**

DEMAND	YEARS						
	2006	2007	2008	2009	2010	2015	2020
Natural Gas Demand	29,505	32,288	34,430	38,300	43,297	53,616	62,468
Export to Greece	21	492	737	737	737	737	737
Total Demand	**29,526**	**32,780**	**35,167**	**39,037**	**44,034**	**54,353**	**63,205**

CONTRACTED SUPPLIES	YEARS						
	2006	2007	2008	2009	2010	2015	2020
Russion Federation	6,000	6,000	6,000	6,000	6,000	0	0
Algeria (LNG)	4,444	4,444	4,444	4,444	4,444	0	0
Nigeria (LNG)	1,338	1,338	1,338	1,338	1,338	1,338	1,338
Iran	8,600	9,556	9,556	9,556	9,556	9,556	9,556
Russion Fed. (Addition)(West)	8,000	8,000	8,000	8,000	8,000	8,000	8,000
Russion Fed. (Black Sea)	8,000	10,000	12,000	14,000	16,000	16,000	16,000
Turkmenistan (*)	0	0	0	0	0	0	0
Azerbaijan (**)	0	2,000	3,000	5,000	6,600	6,600	6,600
Total Supplies	**35,766**	**40,638**	**43,587**	**47,519**	**51,058**	**40,791**	**40,791**

(*) : There is an uncertainty of purchasing natural gas.
(**) : Annual contracted amounts may change upon changes in the initial date for gas deliveries.

On the other hand, the prices are sensitive, too. Because, as Turkey depended on imported gas, the domestic prices will be affected from contracts prices. **(Figure 4.2).** As Turkey's gas prices are following the same path with world trends and the main natural gas suppliers are almost same for all countries, to estimate future domestic prices, US domestic price forecast data has been used. According to Annual Energy Outlook 2007, the prices will increase with 2.5 % from 2005 to 2010 and increase with 9.7 from 2005 to 2020 for residential prices. On the other hand, the prices will increase with 2.2 % from 2005 to 2010 and decrease with 0.6 % from 2005 to 2020 for industrial prices. [19]

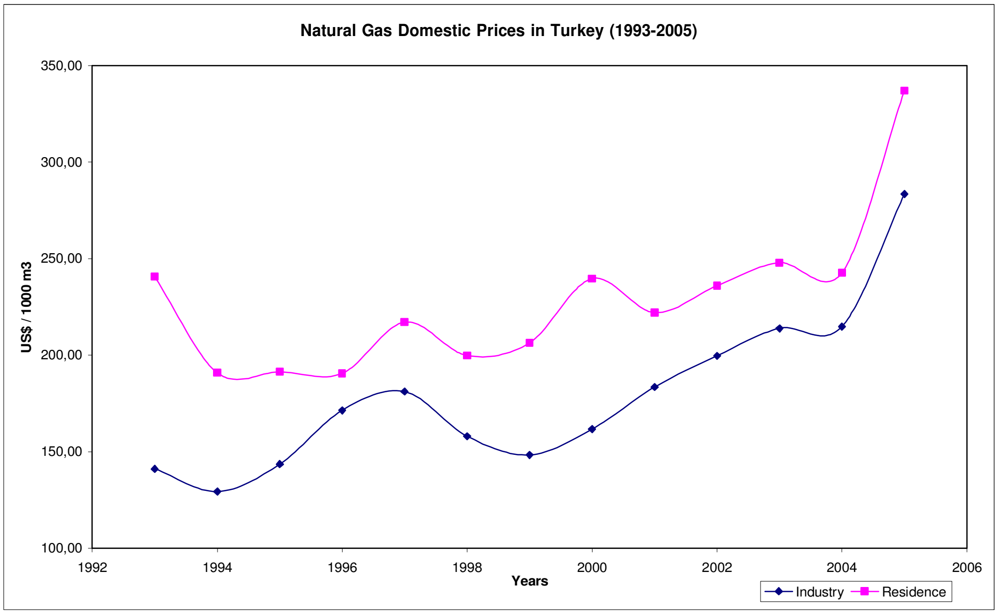

Figure 4.2: Natural Gas Prices 1993-2005 (US$ / 1000 sm^3) **[15]**

By using these ratios, the prices can be forecasted as 345.44 and 369.70 US$/1000 sm^3 for residential in 2010 and 2020, respectively. On the other hand, for industrial, the prices are 289.73 and 281.79 US$/1000 sm^3 in 2010 and 2020, respectively. **(Table 4.3).**

Table 4.3: Turkey Natural Gas Prices Forecast (US$ / 1000 sm^3)

	2010	**2020**
Residential	345.44	369.70
Industrial	289.73	281.79

4.2. Estimated Future Demand and Cost of Gas Imports to Turkey

In 2005 estimates, there was huge supply excess in 2010, and little supply lacks in 2015 and 2020. **(Table 4.1).** However, these scenarios has changed in 2006 forecast. The excess gas, even if Turkey stored it, will not cover the opening between supply and demand in 2015 and 2020. **(Table 4.2).** This opening will be covered by somehow. The possible solutions will not be considered in this section. However, these differences between supply and demand will bring extra loads over Treasury and BOTAS. This amount is expected app 14 billion $ in 12 years. **[17].**

The average import prices were 133 $/1000 sm^3 for 2003 and 197 $/1000 sm^3 for 2005. **[17].** Natural gas prices are expected to follow oil prices in the next decades with the same ratio. **[1].** For the reference scenario the price will be almost same, for the lowest demand scenario the price will drop app 40 % until 2020 and for the highest demand scenario the price will raise app 45 % until 2020. When these ratios applied to Turkey's 2005 average import price should range between 120 US$/1000 sm^3 and 300 US$/1000 sm^3. When the historical and present situations have been taken under consideration, it could be more accurate to range the prices from 180 to 400 US$ / 1000 sm^3 **(Table 4.4 & 4.5)**

Table 4.4: Turkey Natural Gas Import Bills Forecast Acc. to Supply Numbers (Billion $)

							Billion US$
Years	**Supply billion sm3**	**$180,00**	**$197,00**	**$220,00**	**$260,00**	**$300,00**	**$400,00**
2005	30,9		$6,1				
2010	51,1	$9,2	$10,1	$11,2	$13,3	$15,3	$20,4
2015	40,8	$7,3	$8,0	$9,0	$10,6	$12,2	$16,3
2020	40,8	$7,3	$8,0	$9,0	$10,6	$12,2	$16,3
* Prices are for 1000 scum of gas							

Table 4.5: Turkey Natural Gas Import Bills Forecast Acc. to Demand Numbers (Billion $)

							Billion US$
Years	**Demand billion sm3**	**$180,00**	**$197,00**	**$220,00**	**$260,00**	**$300,00**	**$400,00**
2005	25,0		$4,9				
2010	44,0	$7,9	$8,7	$9,7	$11,4	$13,2	$17,6
2015	54,4	$9,8	$10,7	$12,0	$14,1	$16,3	$21,8
2020	63,2	$11,4	$12,5	$13,9	$16,4	$19,0	$25,3

* Prices are for 1000 scum of gas

If Turkey cannot produce any additional natural gas, it is obvious that, all demand should be supplied by import. So, the numbers in table 4.5 should be taken under consideration. Even if the prices stated stable, Turkey will pay 8.7 billion US$ in 2010. When the price difference between 2003 and 2005 are considered, the prices will not be same. Therefore, Turkey should be ready to pay at least 10 billion US$ just to supply its basic natural gas demand in 2010.

CHAPTER 5

BLACK SEA

The Black Sea is located at the north of Turkey and south of Ukraine and Russia, bordered to the west by Romania and Bulgaria and to the southeast by Georgia. There are 3 dominating oil producers in the region: Romania, Ukraine and Turkey, and two dominating gas producers: Ukraine and Romania. Some giant oil and gas fields were discovered in the region, located in Romania, Ukraine and Russia.

Some offshore oil and gas fields were discovered during the last years in Romanian, Ukrainian, Bulgarian, Russian and Turkish sectors of the Black Sea.

Offshore area has not been searched for hydrocarbon presence sufficiently. The geological researches and global data encourage Turkey to drill more exploration wells in offshore side. Especially, Western Black Sea part of Turkey shows gas presence possibility.

Black Sea region is suitable for Turkey to discover sufficient gas reserves to decrease its natural gas import. Turkey is aware that decreasing natural gas import bills may provide great gains on its economy. Because of that, Turkey is focusing on this area with its latest technologies.

5.1. Geology of Black Sea

The general geological setting of the basin has been known for many years. Lying toward the northern margin of the group of orogenic belts related to the closure of the Tethys Ocean, the Black Sea is generally considered to be a result of back-arc extension associated with northward subduction of the Tethyan plate. Although this basin is primarily of extensional origin, most of the Black Sea margins are characterized by (and have been modified by) compressive deformation: the Pontides in northern Turkey and the Greater Caucasus and Gorni-Crimea mountain belts in Russia and Ukraine. Much of the present basin floor is a flat abyssal plain lying at a depth of 2200 m and appears to reflect the presence of a single basin. However, deep-reflection seismic studies have shown that there are two extensional basins in the Black Sea which have coalesced in their postrift phases **(Figures 5.1 & 5.2).[20]**

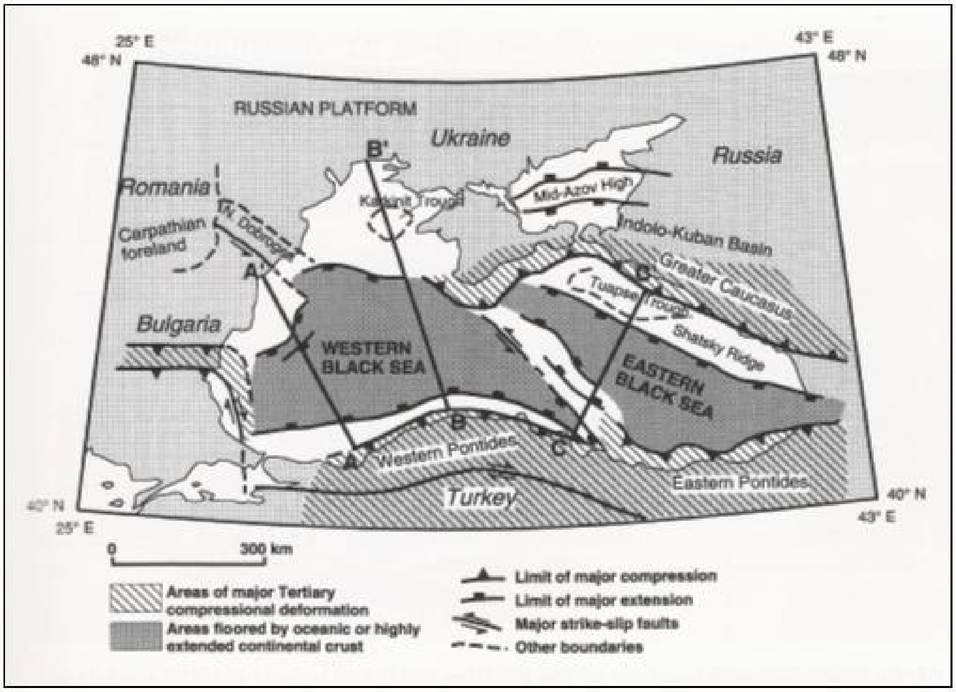

Figure 5.1: Location Map Showing major Tectonic Elements of the Black Sea area **[20]**

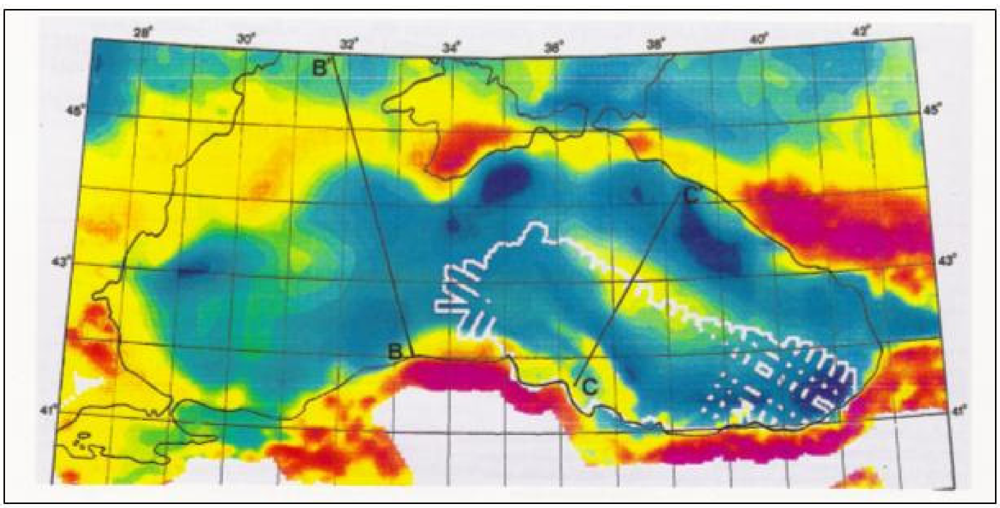

Figure 5.2: Free-air Gravity Map of the Black Sea and location of the profiles analyzed by gravity modeling procedure. (Colors indicate values from 230 mGal (bright pink) to 100 mGal (dark blue)) **[20]**

The Black Sea Basin is a small ocean located behind the Pontide magmatic arc that resulted from the consumption of the Neotethys Ocean to the south. This back-arc basin consists of two oceanic depressions: the Western (middle Barremian) and the Eastern (middle Paleocene) Black Sea basins **(Figure 5.3)**. These basins are separated by a thinned continental ridge (the Mid-Black Sea High) and have different structural and stratigraphic features.**[21]** The Western Black Sea opened with the separation of a fragment including the Western and Central Pontides (north Turkey) from the Moesian Platform (Romania and Bulgaria). Rifting began in the Middle Barremian, with major postrift subsidence and probable oceanic crust emplacement in the Cenomanian. The postrift consists of ≤13 km of flat-lying Upper Cretaceous to Recent volcanics and sediments. Rifting in the Eastern Black Sea probably began in the late Paleocene with rotation of the Mid-Black Sea High away from the Shatsky Ridge-Caucasus (Russia). Extension and probable oceanic crust emplacement were complete by the middle Eocene, and the upper Paleocene to Recent postrift sequence is ~11 km thick. **[20]**

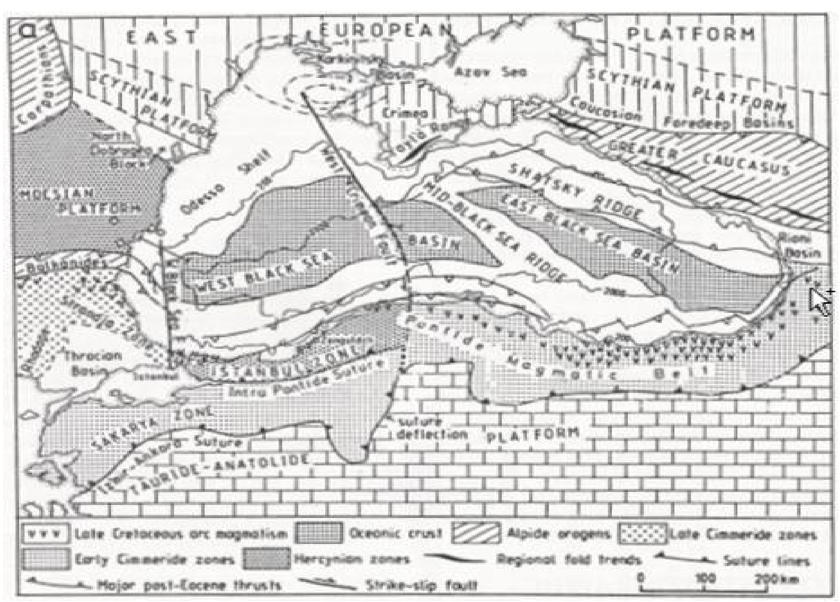

Figure 5.3: Tectonic Setting of the Black Sea Basin **[21]**

The analysis of the sign of the isostatic residual anomaly **(Figures 5.4 & 5.5)** reveals an interesting and pronounced difference between the Eastern and the Western Black Sea basins. The Western Black Sea appears to be in an overall upward state of flexure (under compensated basin center and overcompensated basin flanks), and the Eastern Black Sea is in a downward state of flexure (overcompensated basin center and under compensated basin flanks). This suggests that the level of necking involved in the deformation is deep in the west but shallow in the east.**[20]**

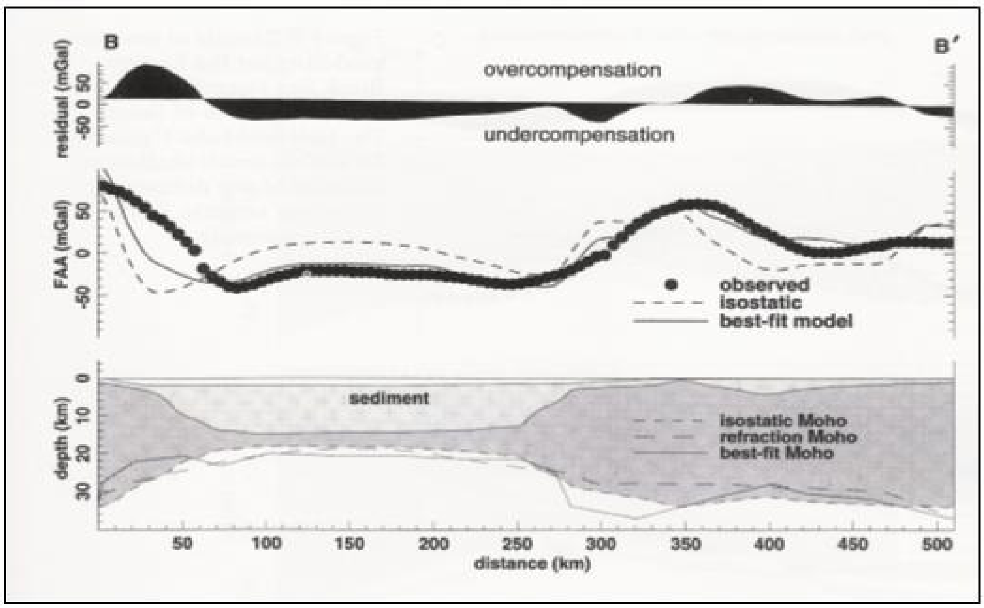

Figure 5.4: Gravity and state of flexure in the Western Black Sea (Detail of BB' Section in **Figures 5.1 & 5.2**) **[20]**

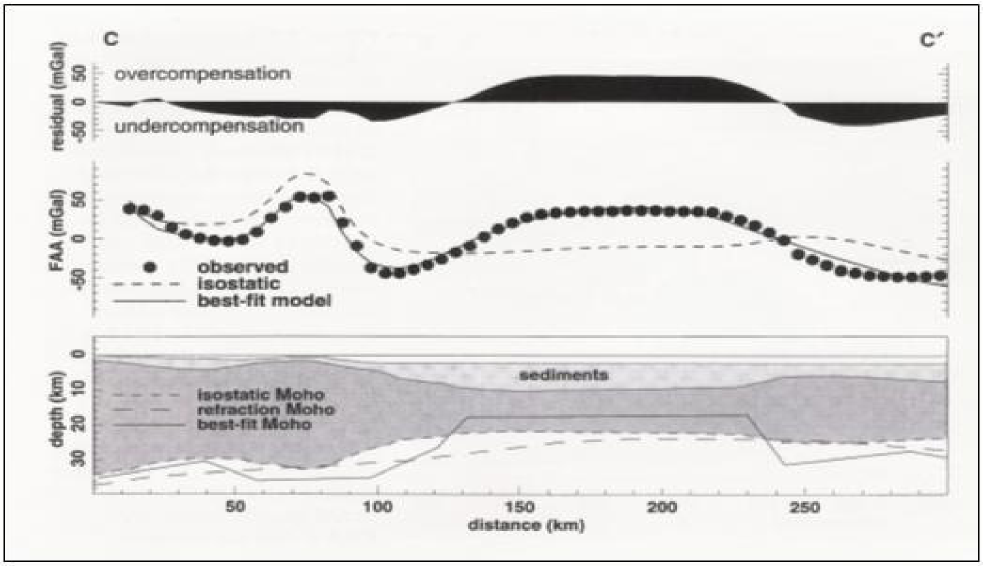

Figure 5.5: Gravity and state of flexure in the Eastern Black Sea (Detail of CC' Section in **Figures 5.1 & 5.2**) **[20]**

Large-scale modeling of lithospheric and crustal thinning of the Black Sea area has shown that the opening the Black Sea basins and the crustal thinning of the area can be simulated by pure-shear deformation, taking into account a finite duration of rifting and nonzero lithospheric strength during the rifting and postrift periods. The main results of the modeling are that the Western and Eastern Black Sea were initiated on lithosphere with very different thicknesses, geothermal gradients, and associated mechanical properties. The Western Black Sea formed by rifting of thick (~200 km) and therefore cold lithosphere with high mechanical strength and an associated deep depth of necking (~25 km). In contrast, the Eastern Black Sea developed by rifting of thin (~80 km) and therefore hot and weak lithosphere, with a shallower depth of necking (~15 km). The differences in initial lithospheric conditions between east and west explain differences in total subsidence and the absence of rift flank uplift in the east. **[20]**

The existence of two very different types of lithosphere in the Black Sea region prior to rifting is supported by paleogeographic reconstructions.

The Western Black Sea developed on the stable continental Moesian Platform in a setting generally considered to be "back-arc" but without any contemporaneous volcanics. The lithosphere in this case would be expected to be both thick and cold. In contrast, the Eastern Black Sea developed on a preexisting back-arc basin, north of an Upper Cretaceous (and a later, Eocene) volcanic arc. The lithosphere in this case would be expected to be both thin and warm. **[20]**

One of the features predicted for a rift initiated on thick, cold, and therefore strong lithosphere (such as the Western Black Sea) is a substantial associated flank uplift, a result primarily of the high flexural rigidity of the plate **(Figure 5.6)**. This tends to produce major rift flank erosion. Such erosion is in fact observed in the Western Pontides where the latest prerift strata - Upper Jurassic-Neocomian limestones - were eroded, karstified, and in places completely removed prior to the Aptian. In contrast, the flanks of rifts initiated on hot, warm, and therefore weak crust (such as the Eastern Black Sea) tend to subside. Seismic lines across the Shatsky Ridge - the northern rift flank of the Eastern Black Sea - show no evidence for synrift erosion. **[20]**

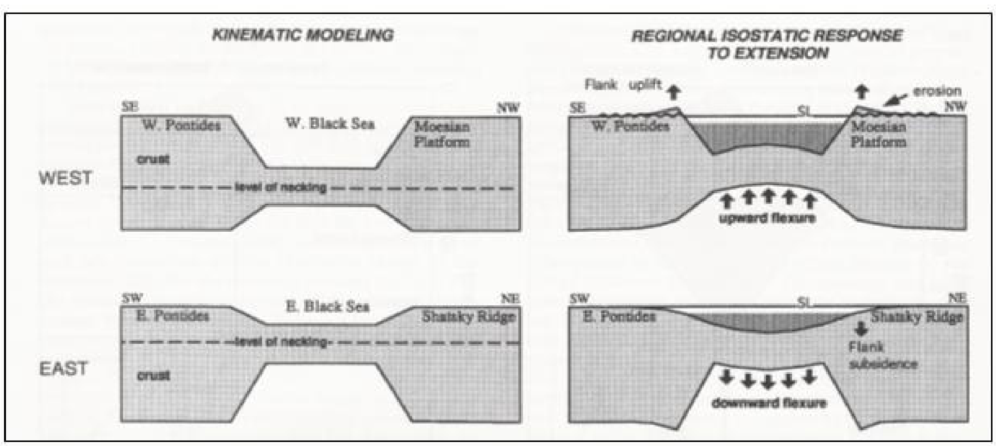

Figure 5.6: Diagram illustrating a scenario for the large-scale deformation of the Black Sea Basin and the surrounding regions **[20]**

Basins developed on thick lithosphere involving a larger depth of necking tend to undergo more total subsidence. This provides an explanation for why the Western Black Sea has a thicker sedimentary fill than the Eastern Black Sea. Marginal rift basins developed on a thick lithosphere appear also to generally rift over longer periods than basins developed on thin lithosphere. Ultimately, the integrated strength of the lithosphere seems to have an important role in controlling the duration of rifting. The strong Western Black Sea lithosphere **(Figure 5.7)** apparently rifted for about 30 m.y., while rifting and spreading in the Eastern Black Sea, characterized by a much weaker lithosphere **(Figure 5.7)**, were completed within 8 m.y. **[20]**

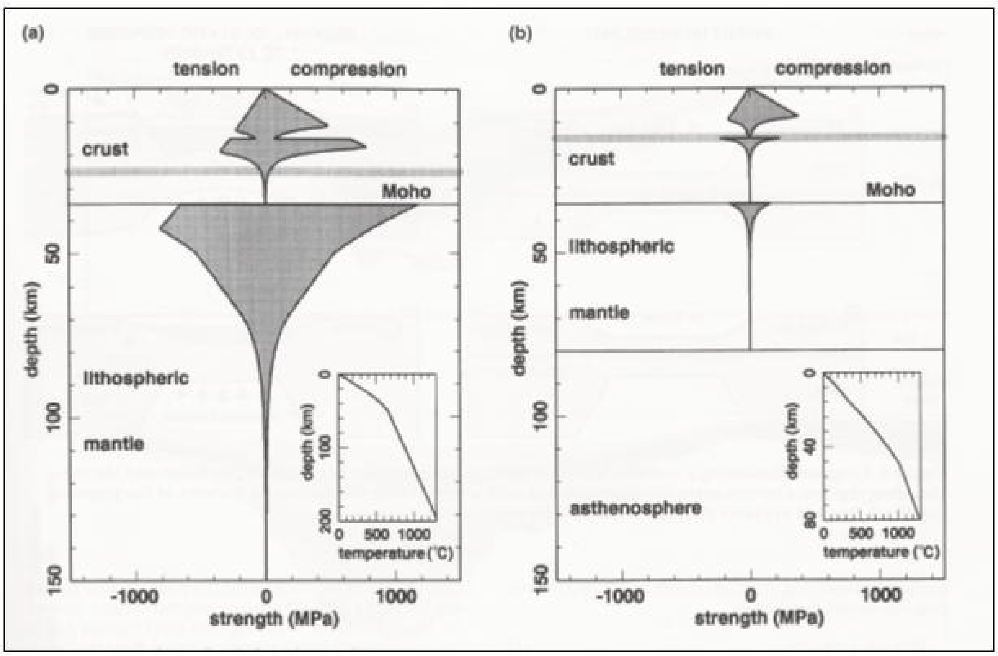

Figure 5.7: Strength vs. depth for a layered rheology calculated for a) Western Black Sea and b) Eastern Black Sea **[20]**

Figures 5.8 & 5.9 summarize the development of the Western and Eastern Black Sea, predicted by the stratigraphic modeling, from the end of rifting to the present day. The Western Black Sea began rifting in the Late Barremian, and by the Cenomanian was a deep (~5000 m) marine basin with oceanic crust and limited synrift sediments toward the basin center. Although water depth decreased somewhat through the Late Cretaceous, Paleocene, and early Neogene, the deep basin persisted until the Sarmatian sea level fall, which reduced the basin to a relatively small lake ~800 m deep in the center. The Eastern Black Sea began rifting in the late Paleocene and subsided rapidly with little rift flank uplift or erosion to form a deep (~4000 m) marine basin. A draping horizon is visible on seismic over parts of the rift margins and may be interpreted as pelagic. During the late Eocene, an increase in sediment supply from compressional belts to the Pontides or possibly the Greater Caucasus led to the deposition of a thick upper Eocene sequence (including oil-prone source rocks) and a consequent decrease in water depth from 3600 to 2800 m. Like its western counterpart, the Eastern Black Sea remained a deep basin until the Sarmatian so that all upper Eocene to middle Miocene sediments will be of deep-water origin. The Eastern Black Sea was also converted into a lake during the Sarmatian ≤400 m deep on the Badut profile. As sea level returned to normal in the late Miocene, water depth increased dramatically to 2800 m in both eastern and western basins due to the loading effect of the water. During the Quaternary, increased sediment supply led to significant subsidence and sediment accumulation, but the water depth decreased only slightly to the present-day value of 2200 m. **[20]**

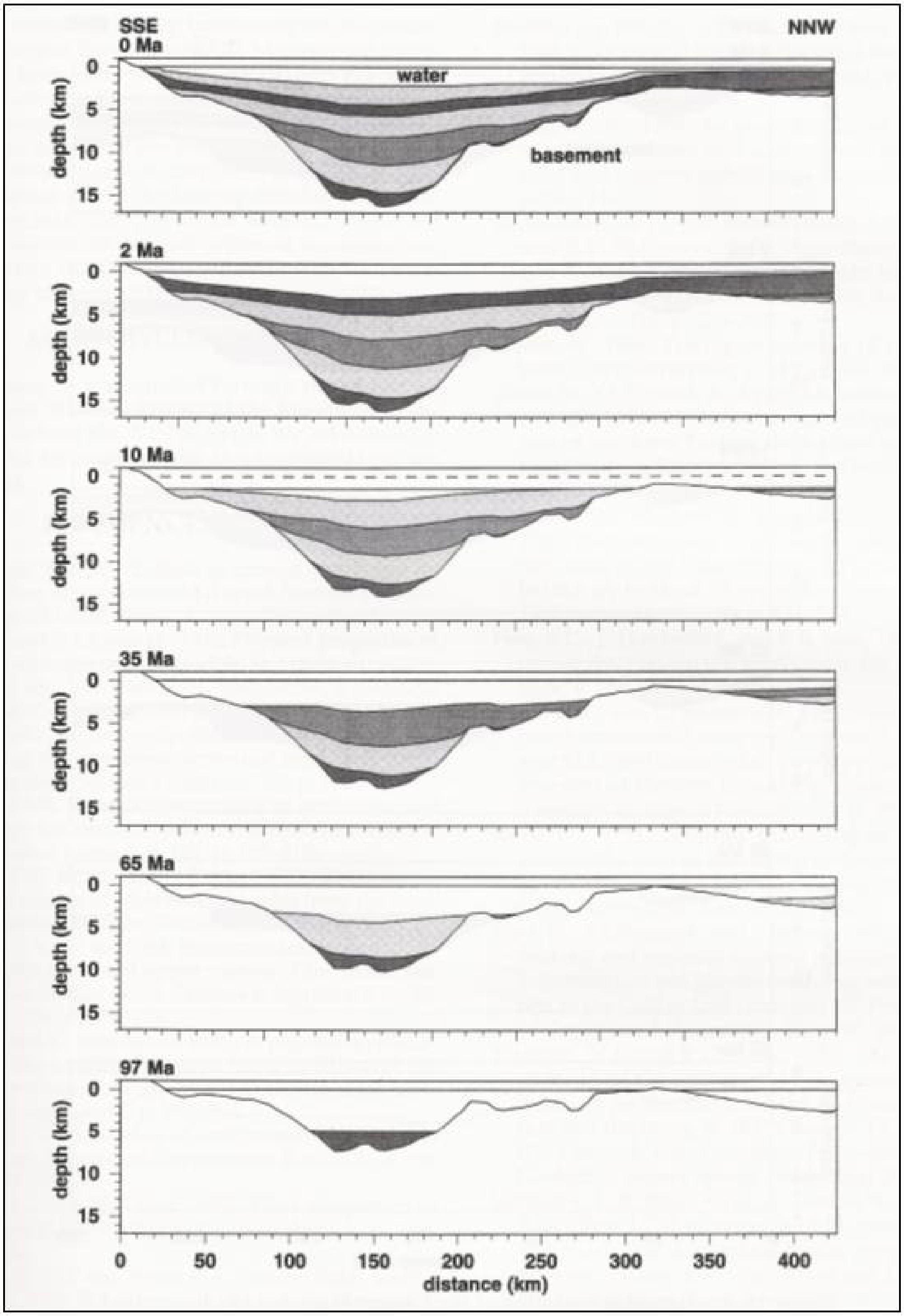

Figure 5.8: Stratigraphic Evolution of the Western Black Sea (Akcakoca Profile) (AA' in **Figure 5.1) [20]**

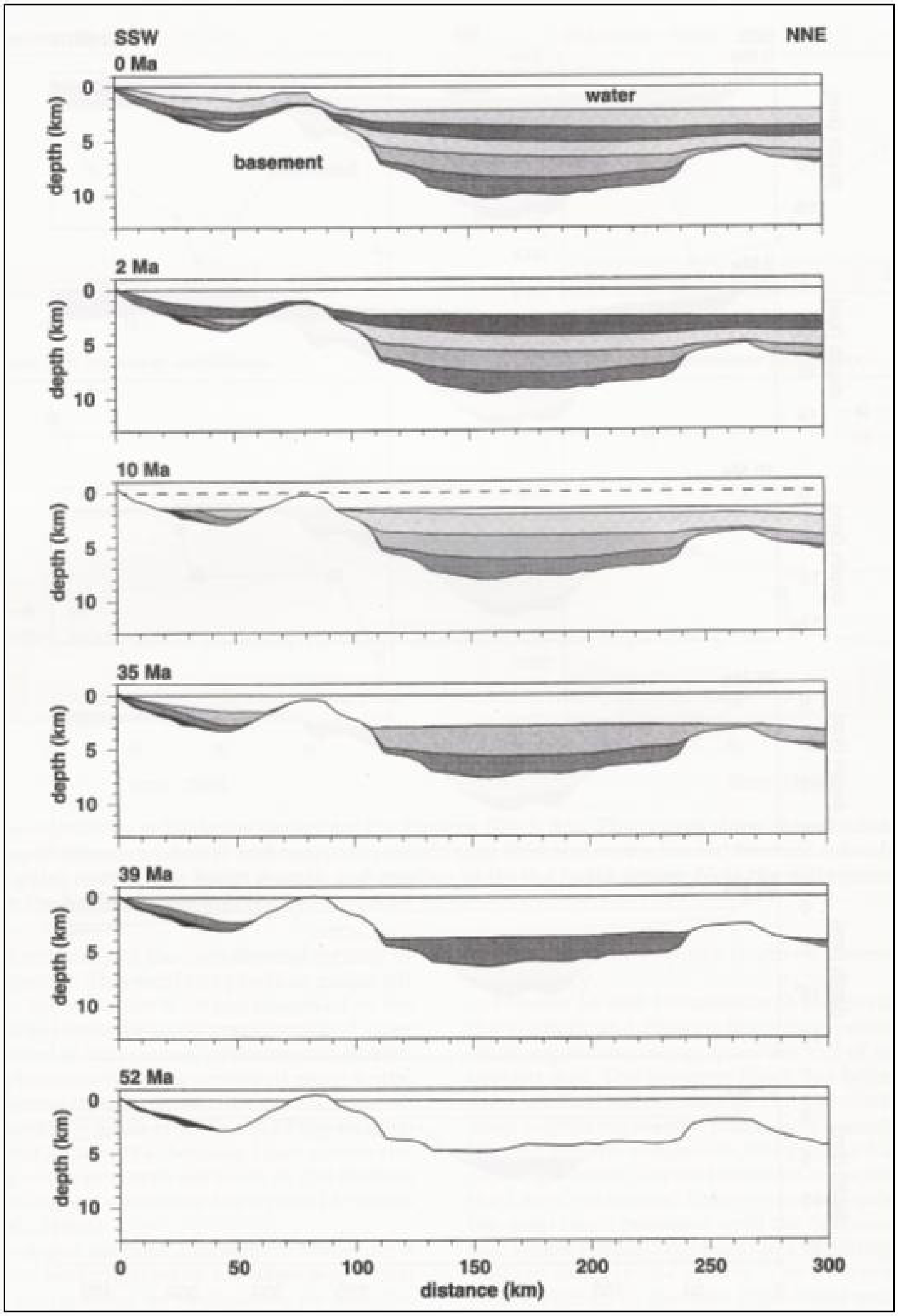

Figure 5.9: Stratigraphic Evolution of the Eastern Black Sea (Badut Profile) (CC' in **Figure 5.1) [20]**

The critical problem in the exploration potential of the Southern Black Sea margin is the timing of the hydrocarbon generation, because most of the prospective traps formed concurrently with the deformation of this margin during the early Eocene compression. If large quantities of hydrocarbon had been generated and expelled before this period, they would mostly be lost to the surface during the Eocene thrusting. On the contrary, if the hydrocarbon generation took place during or after this tectonic event, their entrapment would be possible. Vitrinite reflectance analysis of many Cretaceous surface samples shows that these source rocks are early-mature to mature, indicating that potential for hydrocarbon generation during or after the early Eocene existed in the subsurface. **[21]**

On the basis of both the kerogen type and the nature of the hydrocarbon shows, it may be concluded that the Eocene is promising in terms of gas, whereas the older sediments should be tested for oil. Maturation analyses indicate that main hydrocarbon generation postdated the formation of the structural traps and, therefore, no oil was lost to the surface during the early Eocene deformation. **[21]**

5.1.1. Potential Source Rocks

Rock-Eval pyrolysis and total organic carbon (TOC) analyses indicate that the southern continental margin sequence of the Black Sea Basin contains fair to good potential source rocks in various stratigraphic levels. In the synrift part of the sequence, these rocks constitute the Kilimli, Sapça, and Tasmaca formations, whereas in the postrift part, they occur mostly in the Kusuri Formation of the Eocene.**[21]**

The Kilimli Formation of Aptian age crops out discontinuously in the Western Pontides between Zonguldak and İnebolu. It consists mainly of ≤200 m-thick dark gray to black lagoonal shales, rich in organic matter and glauconite. These locally well-bioturbated shales contain common gastropods, brachiopods, and some nannofossils. Similar organic-rich shales are found in the Albian Sapça Formation **(Figure 5.10)**. Within this formation, they alternate with turbiditic sandstones, marls, and sandy limestones. Geochemical analyses of a number of surface and core samples of these shales from the area between Zonguldak and Sinop show that they can have enough organic matter to be considered a potential source rock for petroleum. The organic matter is mainly of algal origin (Type I and II kerogen) and the TOC content ranges mostly from 0.5 to 1.5 wt%. Vitrinite reflectance (R_o) values are generally >0.6, indicating that these organic-rich shales have reached the oil window **(Figure 5.10)**. The synrift sequence is terminated with the Cenomanian Tasmaca Formation, comprising a 100 m to 400 m-thick uniform sequence of blue to black, relatively deeper marine shales and clayey limestones, in part with abundant slumps and exotic blocks of various sizes **(Figure 5.10)**. The shales are also organic rich with Type II kerogen and have TOC values similar to those of the shales of the Kilimli and the Sapça formations below, although the R_o values are generally 0.5 to 0.6, implying that they are immature **(Figure 5.10)**. **[21]**

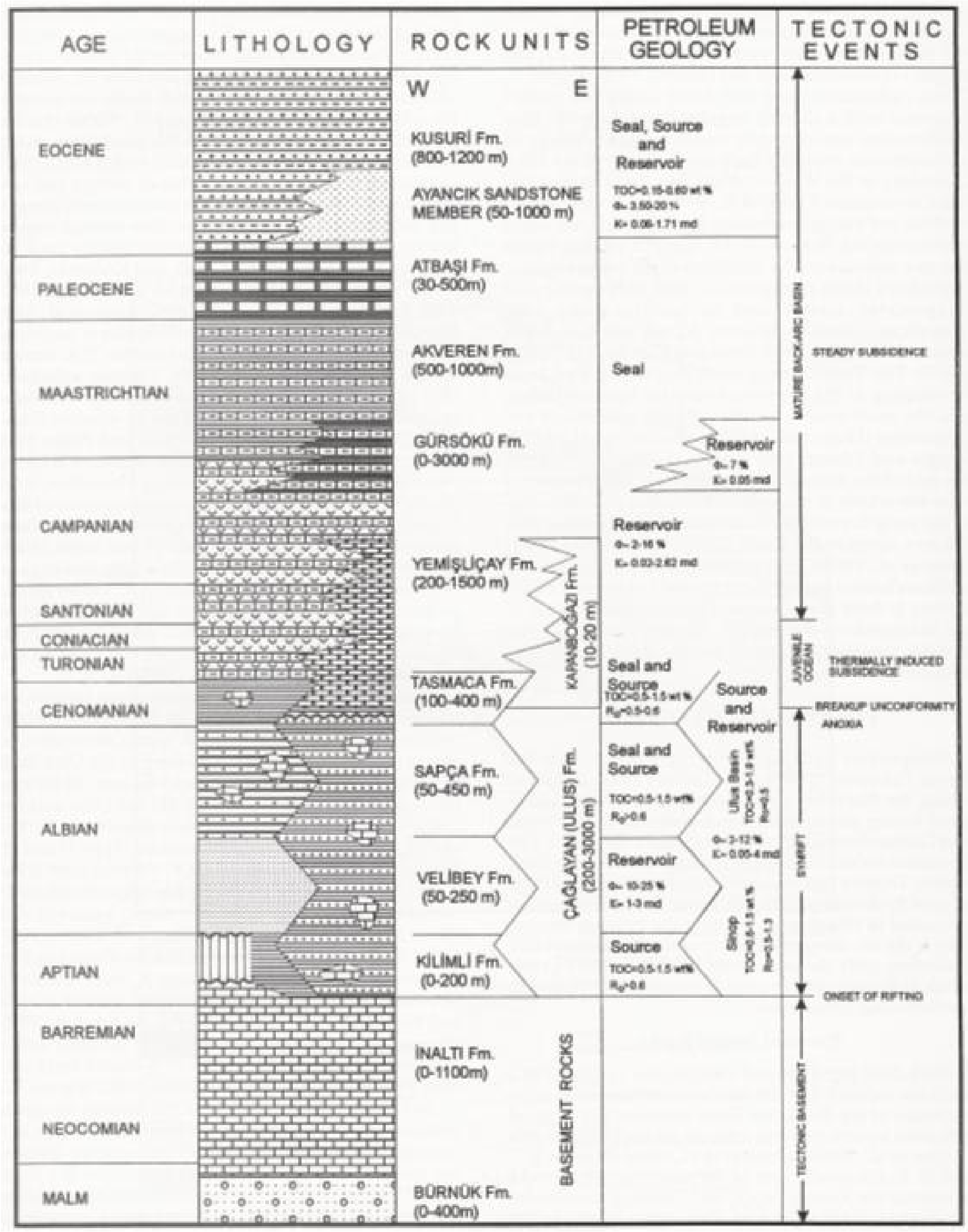

Figure 5.10: Stratigraphy and Petroleum Geology of the Zonguldak-Sinop Region with Major Cretaceous Tectonic Events **[21]**

The division of the synrift sequence into various formations was established only in the Zonguldak-Inebolu region **(Figure 5.11)**; such division seems difficult elsewhere. Therefore, in the Ulüs Basin to the south and the Sinop region to the east, all the synrift sediments are collected under the Ulüs and the Çağlayan formations, respectively **(Figures 5.11 & 5.10)**. The shales in the Ulüs Formation contain Type II and III kerogen and generally have a TOC varying from 0.3 to 1.9 wt %. Maturation level of these organic-rich sediments seems low as indicated by the R_o values of ~0.5. On the contrary, the shales of the Çağlayan Formation of the Sinop region show R_o values mostly between 0.5 and 1.3 and are, therefore, mature **(Figure 5.12a)**. They have Type II and III kerogen with TOC content between 0.6 and 1.5 wt % **(Figure 5.12b)**. **[21]**

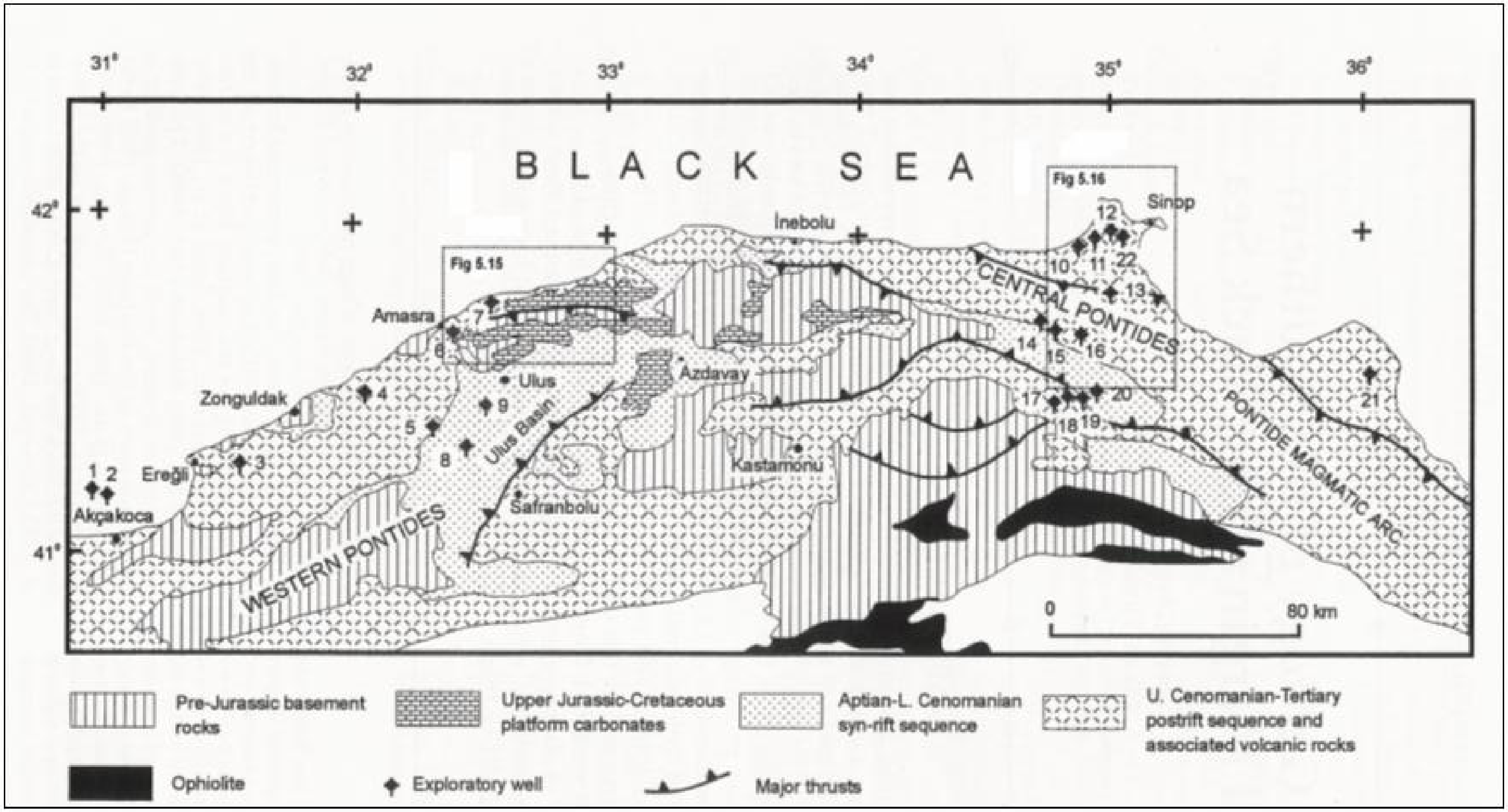

Figure 5.11: Simplified Geological Map of the Zonguldak-Sinop Region. 1-2=Akcakoca-1-2, 3=Eregli-1, 4=Filyos-1, 5=Bartin-1, 6=Amasra-1, 7=Cakraz-1, 8=Gegendere-1, 9=Ulus-1, 10=Sinop-3, 11=Karasu-1, 12=Sinop-1, 13=Erfelek-1, 14=Akveren-1, 15=Fasilli-1, 16=Soguksu-1, 17-18-19-20=Boyabat-1-2-3-4, 21=Badut-1, 22=Sinop-2. **[21]**

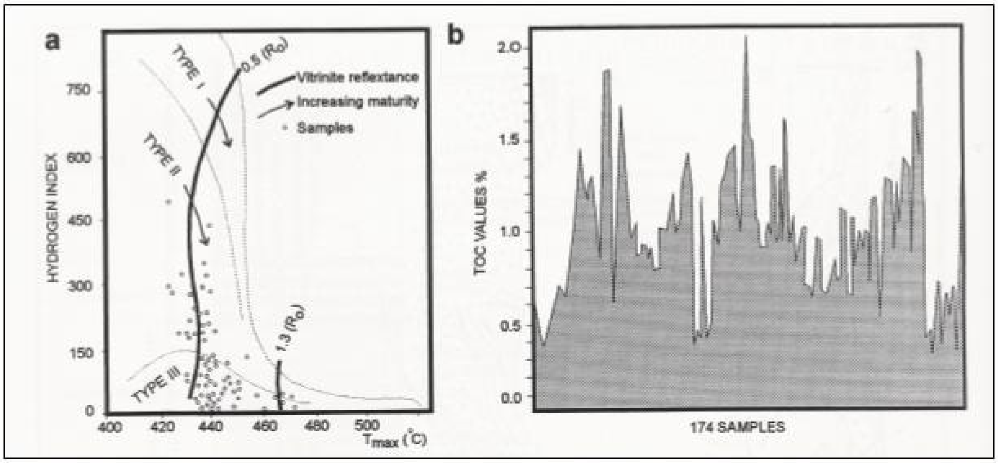

Figure 5.12: a) Rock-Eval Pyrolisis and b) Total Organic Carbon (TOC) Analyses of the Shales of the Çağlayan Formation from the Sinop Region **[21]**

Analytical data derived from the postrift sequence indicate that the Eocene Kusuri Formation is the main unit of this sequence containing potential source rocks. This formation is a thick (800-1200 m) shallowing-upward unit of turbiditic sandstones, shales, marls, and limestones, containing tuffs, agglomerates, and lavas toward the Southern Pontides **(Figure 5.10)**. The shales of this sequence mostly contain Type III kerogen **(Figure 5.13a)** and have a TOC mostly between 0.15 and 0.60 wt % **(Figure 5.13b)**. In the Zonguldak region, these source rocks are not sufficiently buried to have reached the oil window, but in the Sinop region they seem to have been deeply buried enough to have acted as a productive source rock **(Figure 5.13a)**. This is also indicated by the gas shows at the base of this formation in well Boyabat-2. **[21]**

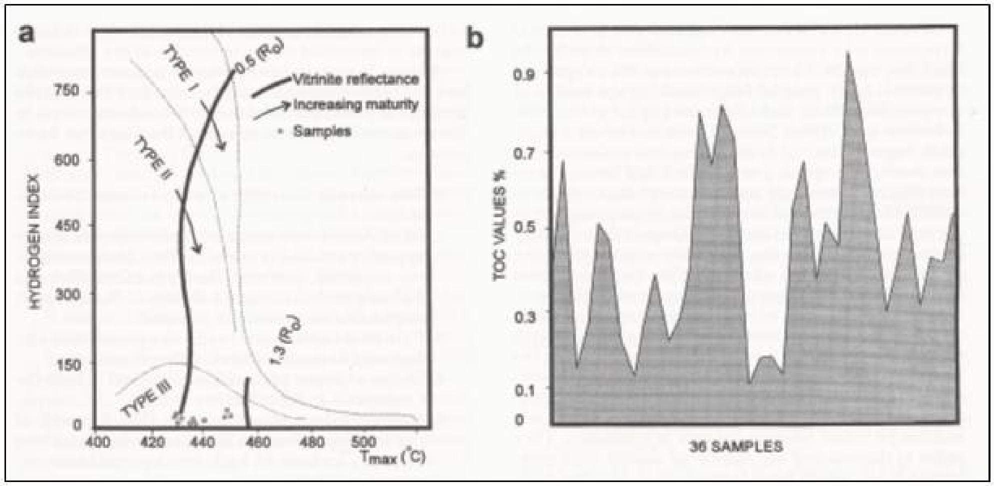

Figure 5.13: a) Rock-Eval Pyrolisis and b) Total Organic Carbon (TOC) Analyses of the Shales of the Kusuri Formation from the Sinop Region **[21]**

5.1.2. Potential Reservoir Rocks

Potential reservoir rocks in the arc margin sequence of the Black Sea Basin are represented mainly by clastic sediments. They exist mostly in the synrift Çağlayan Group and the postrift Yemişliçay, Gürsökü, and Kusuri formations **(Figure 5.10)**.

The best reservoir rocks in the Çağlayan Group are the sandstones of the Albian Velibey Formation. This formation consists mainly of medium to thickly bedded (locally cross-bedded) sandstones, in part with conglomerates and sandy limestones **(Figure 5.10)**. The sandstones are variable, but are generally composed of medium- to coarse-grained, well-sorted, glauconitic quartz arenite to quartzose litharenite. Generally, they are mineralogically and texturally mature. The sand grains include quartz and lithic fragments with minor amounts of feldspars, mica, and glauconites. Lithic fragments are formed from sedimentary, volcanic, and metamorphic rocks derived from the basement rocks. Glauconites, having little or no internal structure, occur in moderate amounts within the sandstone beds in the upper part of the formation. The cement consists of quartz and minor amounts of calcite, siderite, and chlorite. The degree of cementation varies from place to place and apparently controls the amount of the porosity. In the Zonguldak region, the Velibey sandstones may have ≤25% porosity; in the Sinop area, the equivalent sandstones, which form 150 to 200 m-thick turbiditic units, have law porosity values, ranging from 2% to 12%. In the latter area, the permeability of the sandstones is also low varying between 0.05 and 4 md **(Figure 5.10)**. **[21]**

5.1.3. Potential Cap Rocks

Regional and local lithologic seals with respect to the reservoir rocks are furnished by the Sapça Tasmaca, Akveren, and Kusuri formations **(Figure 5.10)**. **[21]**

The reservoir sandstones of the Velibey Formation pass laterally and upward into the thick sequence of shales, marls, and argillaceous sands of the Sapça Formation, and then into the shales and clayey limestones of the Tasmaca Formation. These two formations have a total thickness of 850 m, and therefore should provide a good seal. **[21]**

The Akveren Formation sits on the Yemişliçay Formation in the Zonguldak region and on the Gürsökü Formation in the Sinop region. This 500 to 1000 m-thick sequence of tight calciturbidites with interbedded shales should provide adequate sealing for any reservoir development in both the Yemişliçay and the Gürsökü formations **(Figure 5.10)**. **[21]**

The Eocene reservoirs may be sealed by the thick interturbidite shales, marls, and volcanics within the Kusuri Formation **(Figure 5.10)**. The volcanics may act as an effective seal, particularly when they are weathered and altered to clay minerals. **[21]**

5.1.4. Exploration History

Hydrocarbon shows have been known in northern Turkey for more than 100 years. Some of them have been collected for medical purposes. Six hydrocarbon seeps are known in the Black Sea and adjacent onshore areas **(Figure 5.11)**. Carbonates of the Yılanlı Formation (Middle Devonian-Visean) and sandstones of the Alacaağzı Formation (Namurian) contain two oil seeps in the Zonguldak area. Gas is seeping out ~5 km west of Ülüs from turbidite sediments of Cretaceous age (Aslancı seep). Another oil seep, the Ekinveren seep, is located near Boyabat in the Central Pontides in Cretaceous sandstone, along a fault zone **(Figure 5.11)**. Offshore, there are two seeps: Çayeli (oil) and Inceburun (gas). **[21]**

The first exploratory well (Boyabat-1) was drilled in 1960, targeting the İnaltı Formation of Late Jurassic-Early Cretaceous age **(Figure 5.11).** Six years later, a second well was drilled to test Lower Cretaceous and Tertiary units (Badut-I). Gas shows were encountered in the volcaniclastic Yemişliçay Formation, and the well was abandoned. In 1967 and 1968, Fasıllı-I and Karasu-I wells were drilled and abandoned as dry holes. In 1970 and 1971, two offshore wells were drilled in the western part of the Black Sea (Igneada-I and Karadeniz-I) **(Figure 5.11)**. In spite of minor oil shows, both were abandoned as dry holes. In 1975 and 1976, three wells were drilled in the Central Pontides to test some surface structures and the stratigraphy in the area. In the same year, Akçakoca-I and 2 wells were drilled to test one structure offshore Eregli. In Akçakoca-I, gas shows were encountered in Eocene sands, and 2.5 MMCFGD (million cubic feet of gas per day) was tested. Between 1986 and 1994, 14 more onshore wells were drilled, penetrating different formations ranging in age from Carboniferous to Cretaceous. Of these, six wells (Gegendere-I, Bartin-I, Filyos-I, Soğuksu-I, and Boyabat-3 and 4) have gas shows; the remaining eight wells were abandoned as dry holes. **[21]**

5.2. Geology of Western Black Sea

The older of the two basins, the Western Black Sea, rifted with the dissection of an Upper Jurassic to Lower Cretaceous carbonate platform that had been established on the southern margin (Moesian Platform) of the northern supercontinent, Laurasia. The limestones are as young as Middle Barremian in the Western Pontides (Inalti Formation), where they are unconformably overlain by Aptian-Albian synrift sediments including shallow-water sandstones, submarine slides, and olistostromes and turbidities (Çağlayan and Ulus formations). Unconformably overlying the synrift strata is a unit of pelagic carbonates and distal tuffs of Cenomanian age (Kapanboğazı Formation) that is interpreted to mark the change from rift to drift in the Western Black Sea. Seismic reflection data on the Romanian shelf - the conjugate margin to the Western Pontides - show tilted extensional fault blocks draped by chalks that can be dated as Cenomanian to Maastrichtian. These constraints suggest that rifting took place over a period perhaps as long as 30 m.y., with spreading occupying at most 6-7 m.y. (corresponding to a spreading rate of about 5 cm/yr). **[20]**

Beneath the Western Black Sea, the Moho rises from a depth of 45 km beneath the Pontides mountain belt to ~20 km in the center of the Western Black Sea, falling again to the north to a depth of 40-45 km beneath the Russian Platform. The postrift fill in the Western Black Sea is as deep as 15 km in the basin center, and the crust has a thickness characteristic of oceanic crust. **[20]**

In the Early Cretaceous, the crust beneath the location of the rift that was to become the Western Black Sea was part of the Moesian/European Platform with a characteristic crustal thickness of ~35 km. it is possible that crust along this southern margin of Laurasia had been thickened during the Middle Jurassic Cimmerian orogeny, but the deposition of shelf carbonates during the Late Jurassic and Early

Cretaceous (~35 Ma) suggests stabilization of the region. **[20]**

The Western Black Sea Basin formed by tearing, along the juvenile Pontide magmatic arc, a Hercynian continental sliver, the İstanbul Zone, from the southern margin of Laurasia **(Figure 5.14)**. The Istanbul Zone consists mainly of a sedimentary sequence, ranging in age from Ordovician to Cretaceous; the Ordovician to Carboniferous part corresponds with a typical Atlantic-type continental margin facies. It moved south during the Late Cretaceous to Paleocene along two transform faults, opening in its wake the Western Black Sea Basin **(Figure 5.14)**. The İstanbul Zone collided at the end of the early Eocene with a Cimmeride zone, the Sakarya Zone, obliterating the arm of the Neotethys Ocean in between [the Intra-Pontide Ocean] and ending the extension in the Western Black Sea Basin. The base of the Sakarya Zone of pre-Jurassic metamorphic and accretionary complex rocks is unconformably overlain by Jurassic to Cretaceous sediments.**[21]**

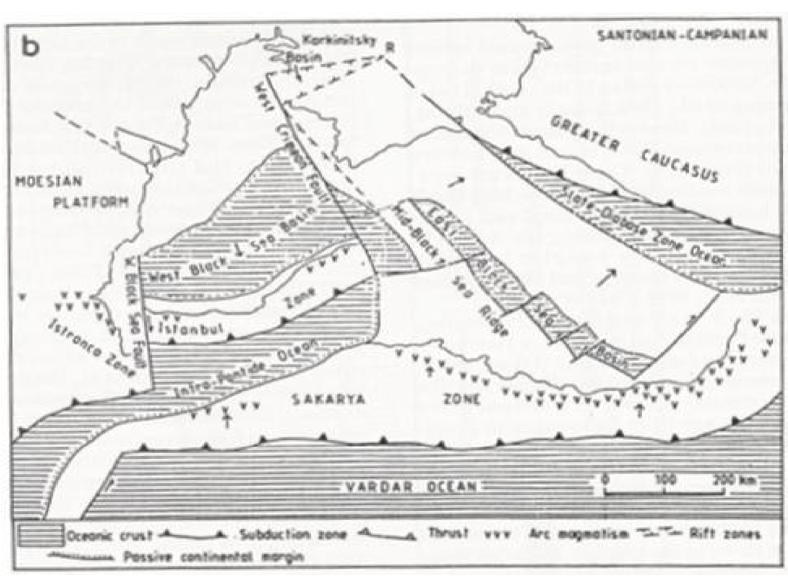

Figure 5.14: Tectonic Evolution of the Western and Eastern Black Sea Basins During the Cretaceous **[21]**

Stratigraphic evolution of the Western Black Sea Basin is dearly demonstrated by the Cretaceous to Lower Tertiary rocks of both the İstanbul and the Sakarya zones exposed between Zonguldak and Sinop **(Figures 5.11, 5.15 & 5.16)**. **[21]**

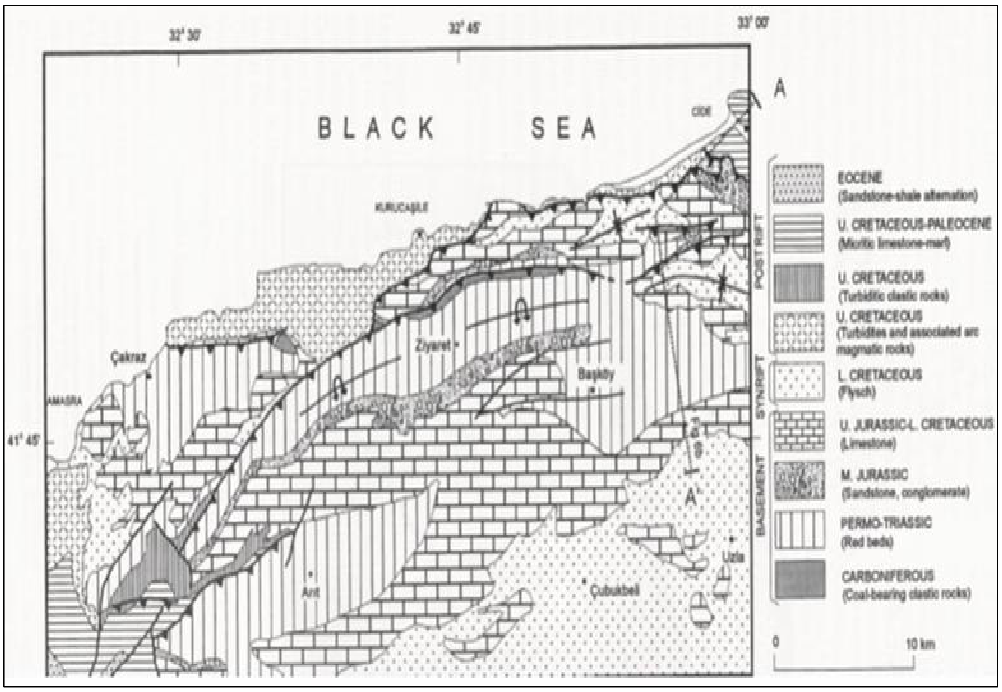

Figure 5.15: Geological Map of the Amasra-Cide Area **[21]**

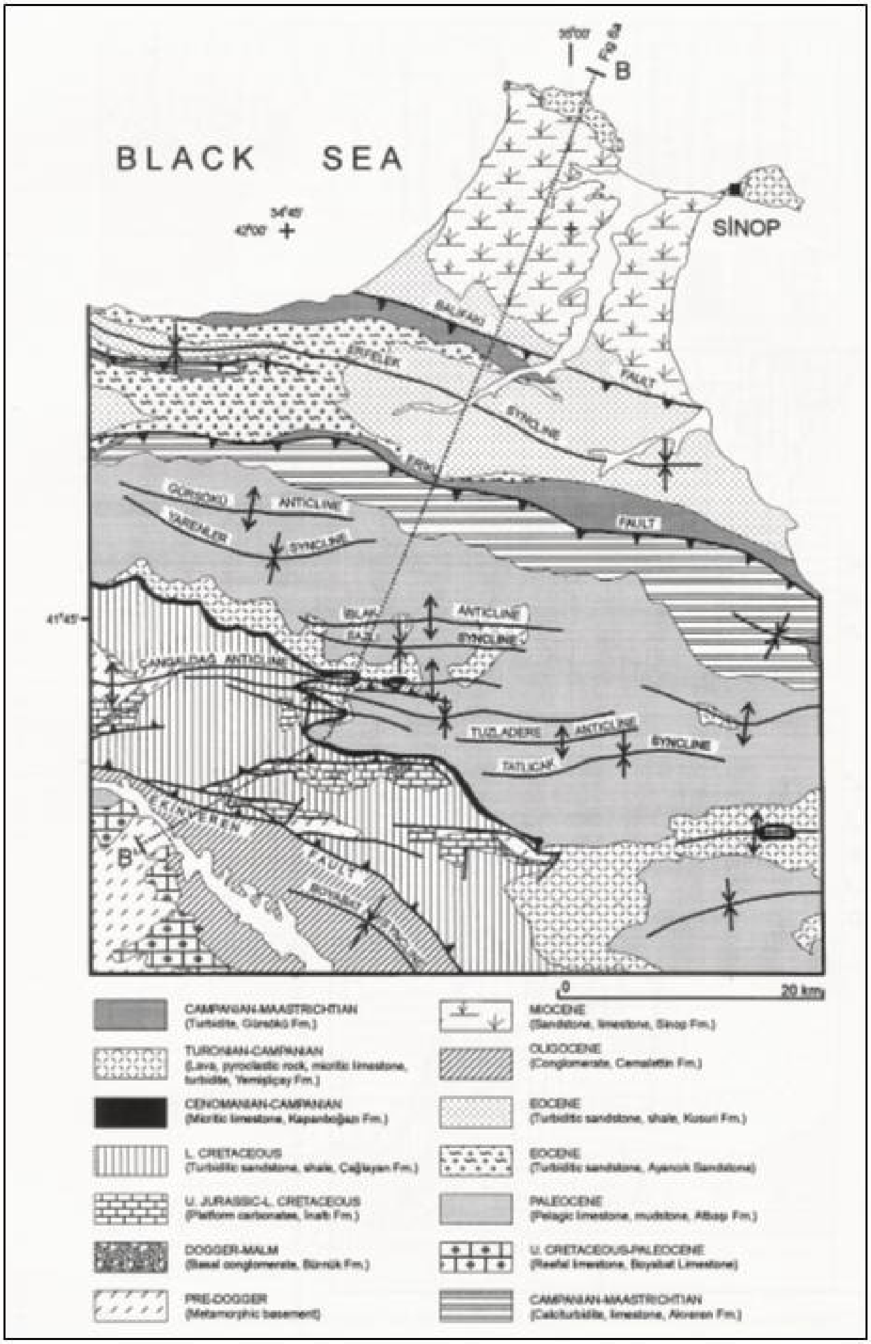

Figure 5.16: Geological Map of the Sinop Area **[21]**

The synrift sediments of the Black Sea Basin (≤1300 m thick) range in age from Aptian to Lower Cenomanian (the Çağlayan Group) **(Figure 5.10)**. In some localities, lagoonal and organic-rich black shales and marls formed much of the early fill on the rift floor (the Kilimli Formation) **(Figure 5.10)**. In the Western Pontides, the rift floor was constituted by the pre-Aptian sequence of the İstanbul Zone; in both the Central and Eastern Pontides, it is represented by the Sakarya Zone. When the block faulting accelerated in the Albian, the rift floor subsided further and deposited marginal marine glauconitic sandstones, passing up to deeper marine blue to black shales, turbiditic sandstones, and sandy limestones, in part with boulder beds, debris flows, and slumps (the Velibey and the Sapça formations) **(Figure 5.10)**. These mass-flow deposits contain huge exotic blocks derived mostly from the rift basement. They were deposited, together with the proximal turbidites, in the areas adjacent to the actively rising fault blocks. As the rift basin was further attenuated and subsided to considerable depths, it accumulated organic-rich black shales and subordinate limestones interrupted sporadically by coarse mass-flow deposits (the Tasmaca Formation) **(Figure 5.10)**. Occurrence of the organic-rich black shales in the synrift sequence records that the waters in the rift were anoxic during this stage of the rifting. The anoxia probably resulted from the restricted water circulation, although high primary organic production may also have played an important role in the accumulation of these sediments. **[21]**

In the Western Black Sea Basin, the rift-drift transition is marked by a drastic change in sedimentation during the late Cenomanian. Deposition of the organic-rich black shales ceased, and accumulation of red pelagic carbonates and marls started (the Kapanbogazı Formation) **(Figure 5.10)**. These carbonates were laid down above the synrift sequence with a slightly angular unconformity. This post breakup unconformity and the drastic change in sedimentation probably indicate the onset of sea-floor spreading in the Western Black Sea Basin during the late Cenomanian. Following the 20 m-thick red pelagic carbonate accumulation, the sedimentation on the southern margin of this basin became dominated by ≤8000 m-thick volcanogenic turbidites (both terrigeneous and carbonate) and deep-water clastic and carbonate rocks (the Yemişliçay, Gürsökü, Akveren, Atbaşı, and Kusuri formations) **(Figure 5.10)**. The Pontide magmatic are, which had been developing in the Pontides since the Aptian-Albian, was the main source for the volcanic material in the turbidites. Toward the end of the Eocene, an overall shallowing occurred over the whole of the southern margin, probably due to the early Eocene collision between the İstanbul and Sakarya zones in the south. This collision and the continuing intracontinental convergence resulted at the end of the Eocene in both deformation and erosion of the sediments on the margin. Because of this tectonic activity, younger sediments are not significantly represented everywhere. **[21]**

As an example of gas seep, the Aslancı gas seep, which is in the Ülüs Basin in the Western Pontides **(Figure 5.17)**, has high amounts of C_{2+} hydrocarbons (13%), which indicate that it is a wet gas. Geochemical analyses **(Table 5.1)** reported that several units (Alacaağzı, Zonguldak, and Ülüs formations and Tertiary rocks) are capable of producing gas. In the basin, >6000 m of sediments are present. Since Cretaceous sediments at the surface are not mature, Cretaceous and pre-Cretaceous units that have been buried deep enough can produce gas. Wet gas shows have also been encountered in Bartin-1 and Filyos-1 wells, which are located to the north and west of the Ülüs gas seep.**[22]**

A gas show was also encountered in the Akçakoca-1 well **(Figure 5.17)**; 0.07 MMCMPD has been tested. It cannot be determined whether it is biogenic or thermogenic in origin by using its chemical composition (~100% CH_4). Isotopic analysis has not been performed.**[22]**

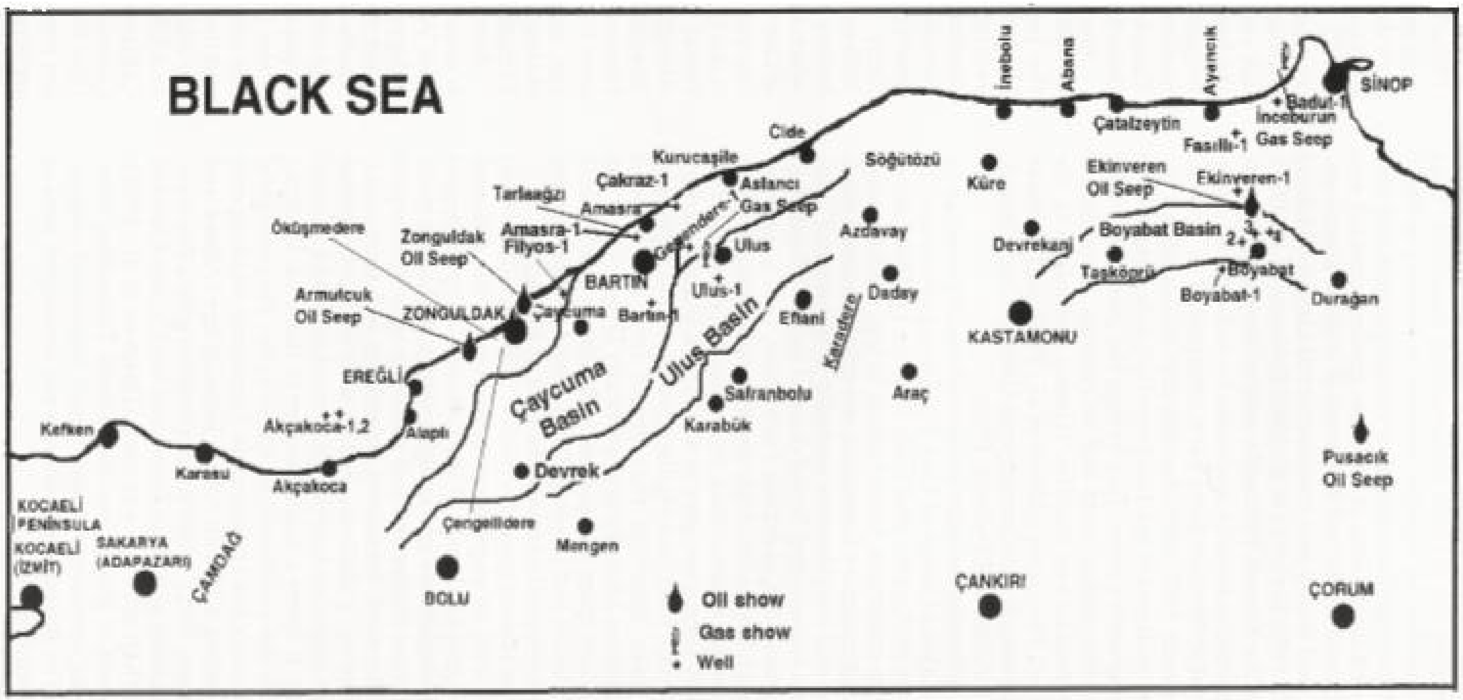

Figure 5.17: Location Map of the Black Sea area **[22]**

Table 5.1: Results of Geochemical Analyses of Samples from the Eastern Pontides **[22]**

Age	TOC (wt %)	P2 (PY) (ppm)	HI	T_{max} (°C)	SCI	R_o (%)	OM Type
Liassic	0.12–1.53	10–3070	3–290	407–498	7.5–9.0	0.82–1.30	III, IV
Cretaceous	0.13–0.79	30–200	7–41	432–485	6.0–8.0	0.88–1.22	III, IV
Eocene	0.47–1.69	140–540	8–80	457–482	6.0–7.0	0.75–0.88	III
Miocene	0.73–1.61	960–8380	55–520	416–437	3.0–3.51	–	II

5.2.1. Geochemical Analysis of Source Rocks of Western Pontides

Organic geochemical studies on subsurface and surface samples indicate that there are several potential hydrocarbon source rock units in the region **(Table 5.2)**. The Kartal Formation (Early Devonian), Yılanlı Formation (Middle Devonian-Early Carboniferous), Alacaağzı and Zonguldak formations (Carboniferous), Himmetpaşa Formation (Middle Jurassic), Çağlayan and Ulüs formations (Cretaceous), Tasmaca Formation (middle Cretaceous), Yemişliçay Formation (Late Cretaceous), and Kusuri Formation (Eocene) are all considered to be potential hydrocarbon source rocks.**[22]**

Table 5.2: Results of Geochemical Analyses of Samples from the Western and Central Pontides **[22]**

Formation	TOC (wt %)	P2 (PY) (ppm) (max)	HI mg HC/g TOC (max)	T_{max} (°C)	SCI	R_o (%)	OM Type
Kartal	0.12–2.35	14–3747	3–196	439(?)	7.5–10	0.65–0.80	IV, III, II
Yılanlı	0.10–7.92	408–13,527	35–305	434–473	6.2–9.0	0.72–2.0	II
Alacaağzı (shale)	0.22–8.03	120–22,492	12–315	412–486	5.0–8.5	0.55–1.33	II, III
Alacaağzı (coal)	30–70	12,600–206,000	22–598	422–447	–	0.75–0.85	II, IV
Zonguldak	0.07–8.03	60–2890	12–51	436–494	5.5–7.5	0.45–1.20	III
Himmetpaşa	0.25–3.92	60–1170	4–68	428–475	6.0–7.5	0.68–0.86	IV, III, II
Çağlayan	0.09–2.14	8–8742	3–417	423–471	3.0–9.0	0.35–1.40	III, II, IV, I
Ulüs	0.25–1.84	10–2494	5–229	427–498	4.0–10.0	0.44–1.70	II, III, IV
Tasmaca	0.35–1.46	1376–4751	110–379	430–443	4.5–6.0	0.45–0.55	II
Yemişliçay	0.29–1.12	–	152–225	443–447	6.5	0.88–0.94	II, III
Kusuri	0.08–0.93	67–661	13–34	432–453	2.5–7.5	0.31–0.33	III

The Kartal Formation is exposed in a few places in the Western Pontides. No well has penetrated this formation in the sub-surface. The unit is composed of predominantly clastics and some carbonates. Total organic carbon (TOC) values range from 0.12 to 2.35 wt %. The organic matter is generally Types III and IV, and in some places Type II. The SCI measurements indicate that the maturity level of the unit changes from middle mature around Bartin and the Çaycuma Basin **(Figure 5.17)** to over mature in areas 25 km to the east of Mengen (SCI = 7.5 and 10, respectively). This means that maturity increases from north to south.**[22]**

The Yılanlı Formation is a carbonate unit with thin beds of black shales that contain up to 7.92 wt % TOC. The kerogen is mostly Type II and the maturity level of the unit changes from middle mature around the Zonguldak and Bartin areas to over mature in other areas, based on the surface samples [R_o = 0.72-2.0%, SCI (spore coloration index) = 6.2-9.0]. This unit is present from İstanbul to the Bartin area; in most areas, it is exposed at the surface. It shows oil potential in a few areas between Bartin and Cide (onshore) where it is covered by younger sediments. The Yılanlı Formation shows a similar maturity trend as the Kartal Formation. **[22]**

The Alacaağzı Formation is prodelta and delta front shale, which contains in its lower part up to 8.03 wt % TOC. It has both Type II and Type III organic matter. The maturity level of the organic matter ranges from middle mature in general to postmature in one locality around Bartin, which may be related to Tertiary volcanics (R_o = 0.55-1.33%; SCI = 5.0-8.5; T_{max} = 412-486°C) **(Table 5.2)**. **[22]**

The Alacaağzı Formation is present between the Zonguldak and Cide areas. It crops out in the Zonguldak area, but it is under cover between Bartin and Cide. Coal samples taken from this formation have also been analyzed. The analytical data **(Table 5.2)** show that samples have high petroleum (oil + gas) source rock potential as indicated by high TOC (30-70 wt %), high HI (222-598 mg HC/ g), high petroleum yield (PY) (12,600-206,000 ppm), R_o (0.75-0.85), and T_{max} (422-447 C) values. **[22]**

The Zonguldak Formation consists of shale, sandstone, and conglomerate of delta plain origin. This formation is present between Zonguldak and Cide. Outcrop samples show up to 5.42 wt % TOC. The kerogen is mostly Type III, which is capable of producing mainly gas, but Type II kerogen is also present. The R_o, SCI, and T_{max} values vary from 0.45-1.2 wt %, 5.5-7.5, and 436-494℃, respectively **(Table 5.2)**, which indicates moderate maturity. Maturity increases from moderately mature in Tarlaağzı to postmature in the Söğütözü area, where the Carboniferous is present as debris flow. In the Amasra-1 well, TOC values of the shaly sections range from 0.07-2.66%. The R_o values, on the surface, range from 0.65-1.2% throughout the unit in the well, which indicates moderate maturity. The Zonguldak Formation is present between Zonguldak and Cide. **[22]**

In the Çakraz-I well, the Alacaağzı and the Zonguldak Formations are mature enough (R_o = 0.62-0.94%; SCI = 5.5-7.5) to generate hydrocarbons, but the kerogen type indicates that organic matter is mostly gas prone (Type III and Type IV). In the Gegendere-1 well, the shales of the Zonguldak and the Alacaağzı formations are rich in organic content (TOC = 1.76-8.03 wt %). Maturity level increases uniformly with depth (R_o values increase from 0.7 to 1.3%), although three reverse faults have been cut. This indicates that maturity level has been reached after faulting. The faulting is probably of post-middle Eocene age. **[22]**

The Himmetpaşa Formation is made up of sandstones at the bottom, dark-gray shales in the middle, and coal and some sandstone at the top. It is not present to the west of Kurucaşile. Organic matter measurements from shaly intervals give high TOC values: ≤3.92 wt %.

Kerogen is predominantly Types III and IV at the bottom and at the top, but Type II has been observed in the middle part of the formation. The unit is early mature to postmature in the south of Cide based on R_o (0.68-0.86%), SCI (6.0-7.5), and T_{max} (428-475°C) values. **[22]**

The Çağlayan Formation is a turbiditic unit made up of shale-sandstone interbedding. It is a very extensive unit in the central and eastern Pontide region. Due to its turbiditic character and variable burial history in different parts of the region, organic geochemical parameters change drastically from one area to another. The TOC values range from 0.09-2.14 wt %, averaging 0.60 wt %. Organic matter varies from Type I to Type IV, but is mainly Types II & III **(Table 5.2)**. Maturity values also show great diversity, which is the result of volcanic and magmatic intrusions during the Late Cretaceous and Eocene, and variable burial history. The R_o, SCI, and T_{max} values vary from 0.35 to 1.40%, 3.0 to 9.0 and 423 to 471°C, respectively, suggesting that the unit is immature between Sinop and Boyabat to overmature in the Inebolu-Abana area. **[22]**

The Ülüs Formation is also a turbiditic unit and is mostly developed in and around the Ülüs basin. The content of organic matter depends on the amount of sand and silt-sized material present. To the west of the Ülüs Basin, inflow of abundant coarse clastics and suspended matter has probably diluted the basinal sediments with respect to organic content. Similar to the Çağlayan Formation, TOC contents, the type of organic matter, and maturity of the unit change frequently in short distances, depending on the turbiditic character of the sediments, magmatic activity, proximity to faults, and burial history, across the basin. The TOC content of the unit varies from 0.25 to 1.84 wt %. The organic matter type changes from Type II to Type IV. R_o, SCI, and T_{max} values are between 0.44 and 1.70%, 4 and 10, and 427 - 498°C, respectively. Maturity increases from west to east and from the margin toward the center of the Ülüs Basin. **[22]**

The Tasmaca Formation consists of bluish-gray colored marl. It has up to 1.46 wt % TOC values, most of which are ~1.0 wt %. The unit has Type II organic matter, which is early mature-marginally mature in surface exposures around Zonguldak. Maturity level increases from south to north, with R_o values changing from 0.45 to 0.55%. Average SCI and T_{max} values are 5.5 and 435℃, respectively. **[22]**

The Yemişliçay Formation has not been considered a potential source rock due to its volcaniclastic nature. In Filyos-1 well, however, it has a 400 m-thick shaly level which has up to 1.12 wt % organic carbon content. The organic matter is Types II, and III, and the kerogen is mature in this interval (R_o = 0.88-0.94 wt %; SCI = 6.5; T_{max} = 443-447℃). Additionally, C_1-C_4 gas reading recorded during drilling in this interval shows that the C_{2+} wet gas ratio is about 80%, which indicates that this zone is in the oil window. Other levels in the Yemişliçay Formation do not have any source rock potential in the well. **[22]**

The Kusuri Formation has TOC values between 0.08 and 0.93 wt %. The organic matter is predominantly Type III, and the maturity level changes from early to middle mature (R_o = 0.31-0.33 wt %; SCI = 2.5-7.5; T_{max} = 432-453℃) **(Table 5.1).** Thus, the unit is considered to be a potential source rock for only gas. **[22]**

5.3. Latest Exploration and Production Activities in Western Black Sea Region

According to Toreador's last test results, Akcakoca 3 has flowed 0.51 MMcmg/d through a 48/64-inch chock from a 10m net pay interval between 1,536m and 1,559m, the deepest of seven potential zones. The company has also successfully tested the uppermost zone in the well flowing around 0.57 MMcmg/d from 25m of perforations between 1,167 and 1,194m through a 48/64-inch choke with a flowing pressure of 1,360 psi. Toreador had previously advised that the well, a sidetrack from the Akcakoca 1 well drilled by TPAO in 1976, kicked off from 250m seeking an Eocene Kusuri Formation objective. It reached a total depth of 2,200m with logs indicating around 80m of net gas pay within a series of at least seven sand prone intervals between 1,696 and 2,130m. Akcakoca 3 was drilled to a bottomhole location approximately 300m south of the Akcakoca 1 location and higher on structure. **[23]**

The Akcakoca-3 is the 10th successful well drilled in the South Akcakoca Sub-Basin natural gas project and the first well drilled by Toreador and its joint venture partners to assess the reserve potential along the Akcakoca trend, in waters too deep for jack-up rig operations. The original well in the area, the Akcakoca-1, drilled in 1973, discovered gas but was subsequently plugged and abandoned. Toreador used the data from the Akcakoca-1 along with seismic data acquired in 2002 and 2005 to drill a series of successful gas discoveries starting with the Ayazli-1 in late 2004 and continuing through early 2006 with the Akkaya, Dogu Ayazli and Bayhanli discoveries and development wells. **[24]**

The new gas discoveries were announced by Toreador and its joint venture partners, TPAO (the Turkish national oil company) and Stratic Energy Corporation, offshore Turkey in the Black Sea. The Guluc-1 well, operated by Toreador in the South Akcakoca Sub-basin (SASB) project area, flowed approximately 0.48 million cubic meter of gas per day through a 48/64-inch choke at a flowing pressure of approximately 1,180 psi. The test came from the commingled flow from approximately 37.5 meters of perforations in six zones between 1,226 and 1,453 meters true vertical depth in the same Eocene-age Kusuri formation as in the other wells in the SASB. The Guluc-1 was drilled in a fault-separated prospect along the same trend as the Akcakoca-3 and -4 wells in the deeper waters of the SASB project area.(ref 3). The second discovery is the Alapli-1 well, operated by TPAO and located to the northeast of the Akkaya Field in an area just outside and adjacent to the SASB project area. The well tested approximately 0.19 million cubic meter of gas per day through a 32/64-inch choke at a flowing pressure of 1,064 psi. Approximately 12 meters of perforations in 2 zones between 1,068 and 1,080 meters true vertical depth in the Kusuri formation contributed to the flow test. Another zone from 1,239 to 1,242 meters true vertical depth is due to be tested. **[25]**

Moreover, according to another announcement from Toreador Resources Corporation (Nasdaq:TRGL) and its partners TPAO (the Turkish national oil company) and Stratic Energy Corporation, the Dogu Ayazli-2 development well confirmed the presence of significant accumulations of natural gas in the Dogu Ayazli structure. Preliminary log analysis indicates natural gas in approximately 106 meters (348 feet) of sands in 10 zones from 727 to 1,173 meters (2,386 to 2,849 feet) true vertical depth in the same Kusuri producing formations as the Dogu Ayazli-1 exploration well. The Dogu Ayazli-2, which was drilled to a bottom hole location approximately 600 meters (1,969 feet) west northwest of the discovery well, will be tested when it is tied back to the Dogu Ayazli production tripod. **[26]**

In 2005, Akkaya-1 delineation well has also successfully tested natural gas. Gas is indicated by logs in zones located between approximately 1136 meters and 853 meters. The first gross interval perforated and tested was between 1135.5 meters and 1050.5 in which an 11 meter section tested at a sustained rate of approximately 0.22 million cubic meter of gas per day on a 36/64 inch choke at a flowing well head pressure of 913 psi. Final shut-in pressure was 1395 psi. **[27]**

The Akkaya-1 well was drilled in the South Akcakoca Sub-Basin project about five miles offshore in the shallow waters of the western Black Sea. The well is productive from the Eocene-age Kusuri formation. The Akkaya well is the first confirmation well drilled after the successful completion of the Toreador's Ayazli-1 well, which is located approximately 7 kilometers to the northwest, that was completed in September 2004. This Tertiary sequence that tested gas in the Ayazli-1 and the Akkaya-1 also tested gas in the nearby Akcakoca-1 well drilled by TPAO in 1976. **[27]**

The Akkaya-1 discovery supports Toreador's previous estimate of potential reserves in the South Akcakoca area of approximately 9.91 billion sm^3 of natural gas based on available information. **[27]**

The first phase of development is underway with first gas production scheduled for delivery in early 2007. Initial production is projected to ramp up to approximately 1.42 million sm^3 of gas per day. **[28]**

Geological analysis and latest test result show that there is a potential in Western Black Sea to produce gas. Because of that, Turkey is focusing on this area with the support of foreign investors.

CHAPTER 6

IMPACT ON TURKISH ECONOMY

6.1. Effects of Exploration and Production of Natural Gas in Western Black Sea on Economy of Turkey

As mentioned in the previous sections, Turkey has dynamic and growing economy. Especially, natural gas requirement is getting bigger and bigger because of developing industry and high electricity requirement. However, the natural gas production is far away from supplying the increasing demand. For this reason, Turkey has to pay billions US$ from its treasury to import sufficient Gas from its neighbors.

Nowadays, Turkey is trying to increase its natural gas production from Western Black Sea to decrease import bills. Toreador and TPAO venture has already discovered some wells enough to produce.

Although the recent production data is not enough to cover whole Turkey's consumption, the percentage of production will increase against the percentage of import.

On the other hand, the geological data and production test results are very encouraged for foreign companies. For example, Toreador has already shared approximately 64 % of its Total 2007 Budget for Turkey Operations. In deed, in 2006, they spent approximately 70 % of their budget in Turkey. **(Table 6.1 – 6.2) [29]**

Table 6.1: Toreador's 2007 Capital Budget **[29]**

	CAPEX ($ millions)	% of Total
Turkey	**$52.5**	**64%**
Romania	14.2	17%
Hungary	9.0	11%
France	5.6	7%
US	0.2	1%
Total	**$81.5**	**100%**

Table 6.2: Toreador's 2006 Capital Expenditures **[29]**

	CAPEX ($ millions)	% of Total
Turkey	**$89.9**	**70%**
France	15.2	12%
Romania	14.2	11%
Hungary	8.3	6%
US	0.9	1%
Total	**$128.5**	**100%**

Even the possibility of natural gas presence in Western Black Sea is providing work force and fresh money entrance for Turkey. On the other hand, foreign companies like Toreador are helping TPAO to investigate Turkey's underground reserves.

It is obvious that, natural gas exploration and production activities in Black Sea region will boost the Turkish Economy.

6.2. Effects of Imaginary Natural Gas Production on Economy of Turkey

As mentioned in the previous sections, Turkey is consuming approximately 57 % of natural gas to produce electricity in 2005. According to forecast scenarios, the share of natural gas in power generation will be approximately 58 %.in 2020. This ratio is not going to change if Turkey does not find any other way to produce electricity, like nuclear energy or hydroelectric power plants.

Natural gas consumption for electricity generation in OECD Europe increases from 14 percent in 2003 to 24 percent in 2015 and 32 percent in 2030. Non-OECD economies, on the whole, relied on natural gas for 24 percent of fuel inputs in 2003 and OECD economies for 15 percent. No change is expected for the non-OECD economies, but in the OECD the natural gas share rises to 20 percent in 2030.In the United States coal-fired steam plants represent 35 percent of the country's installed capacity but 52 percent of its total electricity production. In contrast, natural-gas- and oil-fired units represent 43 percent of U.S. capacity but only 18 percent of electricity production. Natural-gas-fired plants, which provided 15 percent of total U.S. electricity supply in 2003, increase their share to 20 percent of supply in 2015 before dropping back to 15 percent in 2030. At the world level, natural gas consumption increases from 19 percent of total fuel use for electricity generation in 2003 to 22 percent in 2030. **(Table 6.3) (Figure 6.1) [30]**

Table 6.3: Natural Gas Consumption for Power Generation (%) **[30]**

	2003	2015	2030
OECD - Europe	14	24	32
OECD	15	----	20
Non-OECD	24	24	24
US	15	20	15
World	**19**	**----**	**22**

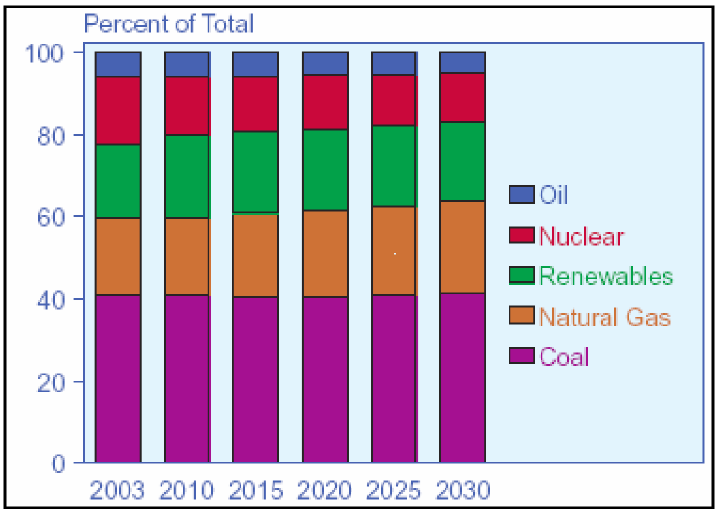

Figure 6.1: Fuel Shares of World Electricity Generation 2003-2030 **[30]**

If Turkey could achieve to decrease its natural consumption in power generation closer to the world's average numbers, it can save significant amount of natural gas. For example, if Turkey decreases the share of natural gas consumption for power generation from 60 % to 30 %, 9.7 billion cubic meter excess gas will be discounted from 2007 demand numbers. This saving can be expressed as extra production.

Also, in near future, Turkey should take gas production from coal mines or depleted oil reservoirs under consideration to overcome high import numbers.

CHAPTER 7

CONCLUSION

Turkey is a developing country and its energy demand is increasing rapidly. Like rest of the world, Turkey is also looking for clean and effective energy source. Natural gas is being used by Turkey for the last 30 years and Turkey's dependence is getting more critical. The power generation of Turkey is highly depended on natural gas and according to projections, power generation will continue to use 58 % of natural gas in 2020.

According to 2004 statistics, Turkey has 7.4 billion sm^3 remaining recoverable gas. Its yearly production is around 707 million sm^3 per year while the consumption is 21.5 billion sm^3 in 2004. The difference is imported from Russian Federation, Algeria, Nigeria, Iran and Azerbaijan.

In 2005, Turkey imported 27.2 billion sm^3 and paid 5.4 billion US$. 2010 demand expectation is approximately 44 billion sm^3 and even if natural gas price is same as 2005, Turkey will pay at least 10 billion US$. On the other hand, due to unbalance between supply and demand, Turkey may loose another 14 billion US$.

The domestic prices are very sensitive and inconsistent as a result of import prices. Turkey's domestic prices can be forecasted as 345.44 US$/1000 sm^3 for residential and 289.73 US$/1000 sm^3 for industrial in 2010. Turkey should increase its natural gas production by discovering more natural gas reserves and modify take-or-pay import contracts to take these prices under control.

According to geological analysis of Black Sea, the hydrocarbon generation has been occurred during or after Eocene compression. That means no oil has been lost to surface. On the other hand, Western Black Sea region has fair to good potential source and reservoir rocks. Because of latest geological researches, test results and global data from other countries surround the Black Sea encourage Turkey to speed up exploration and production activities in offshore side of Western Black Sea Region to discover new gas reserves.

The Western Black Sea, with its possible natural gas reserves, could be the solution to supply Turkey's growing natural gas demand. In deed, in the second quarter of 2007, the production is expected to start with approximately 1.42 million sm^3 of gas per day. There are some other wells in offshore side waiting for completion and the exploration operations are going on.

The expected natural gas production from Western Black Sea is approximately 500 million sm^3 per year. As Botas 2006 natural gas demand and supply senarios, Turkey's 2007 natural gas demand will be 32.8 billion sm^3. That means, in the beginning, only natural gas production from Western Black Sea will supply approximately 1.6 % of total demand. When this number is compared with 2004 production-demand ratio, which was approximately 3.6 %, the importance of Western Black Sea for Turkey can be understood clearly.

Turkey should also decrease the ratio of natural gas consumption in power generation. Consumption of 58 % of natural gas in power generation, together with unfavorable gas import aggreements, cause higher prices in electricity for the end-users. In the world, the share of natural gas in power generation was around 19% in 2003 and expected to become 22 % in 2030. If Turkey can balance its natural gas consumption with world averages, it could save significant amount of natural gas and decrease its gas import bills. For example, by using 2007 demand numbers, if Turkey could decrease natural gas consumption from 60 % to 30 %, it may save approximately 10 billion sm^3 which is equal to estimated potential reserves of South Akcakoca area.

Consequently, using conventional resources efficiently and providing reduction and well distribution of natural gas in sectorial consumption will contribute to Turkey's consistent growing economy.

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