<u>İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY</u>

ENERGY OF TURKEY IN 2023

M.Sc. Thesis by

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FOREWORD

Energy consumption is increasing all around the world with population. The national studies show that it will continue to increase. To supply energy demand every country is seeking clean and economical ways to be powerful. Economic stability of the countries is linear with its energy production.

The present thesis was prepared to see the vision of Turkey for 2023. Both energy in the world and Turkey were studied to make a comparison. By this method, positive and poor sides of Turkey tried to be realized with respect to other countries. Technological activity areas were analyzed.

I want to thank my supervisor Prof.Dr.Hasancan OKUTAN for his great support, kindness and understanding me in this very hard period. He always tries to answer my questions, and solve my problems in a positive manner.

I want to thank especially to my family for their support and understanding me. They are besides me as always to do.

I want to also thank my engage Gürcan KAÇAK for his supports, sympathy and understanding in my very hard period to end this thesis.

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ABBREVIATIONS AND ACRONYMS

BAU : Business as usual

Bbl/d : barrels per day

Bbl : barrel

Bcm : billion cubic meters

BO : Built Operate

BOT : Built Operate Own

CFC : chlorofluorocarbons

DIE : Turkish State Statistics Institute

DOE : The U.S. Department of Energy's Office of Fossil Energy

DSI : State Hydraulic Works

ECBCS : Energy Conservation in Buildings and Community Systems

EE : Eastern Europe

EEIG : European Economic Interest Grouping

EIA : Energy Information Administration

EJ : exajoule

ECCJ : Energy Conservation Center of Japan

EECC : Energy Efficiency Coordination Committee

EIE : General Directorate of Electrical Power Resources Survey Administration

EU : The European Union, whose members are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

FSU : Former Soviet Union

GDP : Gross Domestic Product

GEF : Global Environmental Facility

GHGs : Greenhouse gases

GPS : Positioning Systems

IEA : International Energy Agency

IEAE : International Atomic Energy Agency

IGDAS : Istanbul Gas Distribution Inc.

IGU : International Gas Union

INPRO : Innovative Nuclear Reactors and Fuel Cycles

JI : Joint Implementation

kpe : kilogram petroleum equivalent

LNG : liquefied natural gas

MAM : Marmara Research Center

MIT : Ministry of International Trade and Industry of Japan

MENR : Ministry of the Energy and Natural Resources

MGK : Turkey's National Security Council

Mmst : million short tons

MTEP : million ton equivalent petroleum

Mtoe : million ton oil equivalent

n/a : not applicable

NCCG : National Climate Coordination Group

NEA : Nuclear Energy Agency

NPP : Nuclear Power Plants

OECD : Organization for Economic Co-operation and Development

PV : Photovoltaic Cell

R&D : Research and Development

SPO : State Planning Organization

TAEK : Turkish Atomic Energy Authority

Tcm : trillion cubic meter

TEAS : Turkish Electricity Generation and Transmission Company

TEDAS : The Turkish Electricity Distribution Company

TEM : Trans-European Motorway

TFC : Total Final Consumption of Energy

TKI : Turkish Lignite Enterprise

TOOR : Transfer Operating

TPAO : Turkish State Petroleum Company

TPES : Total Primary Energy Supply

TSP : Total Suspended Particles

TTK : Turkish Hard Coal Enterprise

UNFCCC : United Nations Framework Convention on Climate Change

USITA : The United States International Trade Administration

WEC : World Energy Council

WTO : World Trade Organization

ENERGY OF TURKEY IN 2023

SUMMARY

Energy is one of the most important concepts for all countries in the world to be powerful both economically and technologically. Importance on energy topic shows an increase by population growth. If we could not add new energy sources besides known sources in a near future these sources could not meet the demand of the human being.

The present thesis was prepared to see the vision of Turkey for 2023. Both energy in the world and Turkey were studied to make a comparison. It is quite certain that globalisation is just one of the results of the information revolution that we are all witnessing in the world. As the world is becoming a global marketplace, economic factories coupled with historical, cultural and political assets shape a country's role for the next millennium. The central stage of the next millennium, many observers agree, will be Eurasia. Given the trends in production, communication and information technologies, Europe and Asia will form an integrated whole, interlinked and interdependent. As you all know, Turkey is at the center of Eurasia.

For the next millennium Turkey has many positive sides. Its culture, geography, young nation and young labor force are some of them. New oil and gas pipelines are under construction. Besides, Turkey has reserves of mostly talked energy sources uranium and thorium.

Privatization models of Built Operate Own (BOO), Built Operate Transfer (BOT) and Transfer of Operating Rights (TOOR) play an important role in the energy revolution period of Turkey.

The Turkish energy policy is mainly concentrated on assurance of energy supply, reliably, sufficiently, in time, in economic and clean terms and in a way to support and orientate the target growth and social developments. In the frame of these subjects, energy planning studies of the country, taking into account of short, medium and long term policies. The government focused its efforts on improvement of domestic production by utilizing public, private and foreign sources and increasing efficiency by rehabilitation and acceleration of existing construction programs to initiate new investments on reasonable accounts.

2023 YILINDA TÜRKİYE'DE ENERJİ

ÖZET

Tüm dünya ülkelerinin ekonomik ve teknolojik olarak güçlü olmalarında enerji en temel unsurlardan biridir. Artan nüfus yoğunluğu ile beraber enerji konusuna olan ilgi de bir o kadar artmaktadır. Şu anda sahip olduğumuz enerji kaynaklarına yenilerini ekleyemezsek, sahip olduğumuz bu kaynaklar yakın gelecekte enerji ihtiyacımıza cevap veremeyecekler.

Bu çalışma 2023 yılında Türkiye'nin enerji konusundaki vizyonuna yön çizebilmek için hazırlanmıştır. Kıyaslama yapabilmek için hem dünya ülkeleri hem de Türkiye'nin şu andaki durumu karşılaştırılmıştır. Tüm dünyanın şahit olduğu gibi globalleşme bilgi devriminin bir sonucudur. Dünya global bir market pazarı haline geldikçe ekonomik etkenler tarihsel, kültürel ve politik değerlerle birleşip ülkelerin gelecek yüzyıldaki rolünü belirlemektedir. Gelecek yüzyılın ana merkezi bir çok kişinin katıldığı üzere Avrasya'dır. Üretim, komünikasyon ve bilgi teknolojileri alanlarındaki trendlerle beraber Avrupa ve Asya bütünleşip kenetleneceklerdir. Bilindiği gibi Türkiye Avrasya'nın tam merkezinde bulunmaktadır.

Gelecek yüzyıl için Türkiye'nin pek çok pozitif tarafları vardır. Kültürel ve coğrafi yapısı, genç nüfusu ve işgücü bu pozitif yanlardan bazılarıdır. Yeni petrol ve gas boru hatları yapım aşamasındadır. Bununla beraber dünyada önem kazanan en önemli iki kaynak olan uranyum ve toryum Türkiye'de bulunmaktadır.

Yap-İşlet-Devret ve Yap-İşlet özelleştirme modelleri Türkiye'nin enerji devrimi döneminde çok önemli rol oynamaktadır.

Türkiye'nin enerji poliçesi, enerjinin temiz, güvenilir ve ekonomik olarak temini yolundadır. Enerji poliçesi kısa, orta vade ve uzun dönem enerji senaryolarını hesaba

katmaktadır. Tüm çabalar kamusal, özel ve yabancı kaynakların yerli enerji üretimine katılımının sağlanması ve yeni yatırımların yapılması yolundadır.

1. INTRODUCTION

Energy has an attractive role in the economical development of the countries. In the globalisation period of the world, every country is seeking to supply new sources of energy to be powerful.

Population is a key factor. Since energy demand is increasing by population. We live in a world where the population is growing, where many of those in developing countries still do not have access to modern energy services, and where the impacts of pollution and greenhouse gas emissions are of rising concern. The need to ensure that progress in advanced fossil fuel technologies, in non-fossil fuel technologies, and in energy efficiency technologies is maintained and accelerated is widely accepted in the energy sector as one of the key responses to these challenges.

Rapidly expanding energy production and consumption produce a wide range of environmental impacts at the local, regional and global levels. With respect to global environmental issues, while Turkey's CO2 emissions are still the lowest among other OECD countries in terms of per capita emissions, they too have been growing rapidly. CO2 emissions have been increasing an average annual rate of 4.3 % since 1990. The Turkish government must continue to harmonizing standards and regulations for environmental quality with those of EU and other international bodies.

It is quite certain that globalisation is just one of the results of the information revolution that we are all witnessing in the world. As the world is becoming a global marketplace, economic factories coupled with historical, cultural and political assets shape a country's role for the next millennium. The central stage of the next millennium, many observers agree, will be Eurasia. Given the trends in production, communication and information technologies, Europe and Asia will form an integrated whole, interlinked and interdependent. As you all know, Turkey is at the center of Eurasia.

Energy is one of Turkey's most important development priorities. Rapid increases in domestic energy demand have forced Turkey to increase its dependence on foreign energy supplies and to face the prospect of a severe energy shortage in the 21st Century. Energy is essential to economic and social development and improved quality of life in Turkey as in other countries. Energy is considered a prime agent in the generation of wealth and also a significant factor in economic development.

Turkey has a several pipeline projects under way. They could have a positive effect on the diversity and security of supply in many consuming countries. They could also help avoid further environmental strain on the maritime routes through Bosporus.

Spending on research, development and demonstration has long been positively associated with the pace and quality of technological innovation in many sectors of human endeavor. In the field of energy, it is a widely held view that spending on research and development is an important precursor to the technological advances required to secure sufficient, safe and environmentally acceptable energy supplies, and to use them more efficiently.

Technological advances will be of critical importance in improving living conditions. Advances, which improve the production and transportation of energy, and the efficiency of its use, may be expected to produce major public benefits, which warrant governmental support, including funding and other incentives for private sector efforts.

According to long-term investment plans, energy consumption will nearly quadruple by 2020. Lignite and hydropower will see the largest growth in production. Gross electricity demand is projected to increase by slightly over 7 % annually within the same period. In order to meet the projected demand in electricity, Turkish authorities anticipate that 43,000 MW of capacity will be needed by 2010.

The vision of Turkey for 2023 is to meet energy demand using domestic energy resources as the highest priority. In the next 20 year this will occur by mixing of public, private and foreign capital. New and renewable energy sources must be improved. Future energy facilities would have no environmental impact. Conventional pollutants would be captured and either disposed have or converted to marketable co-products. There would be no solid or liquid discharges. Emissions of carbon dioxide and other greenhouse gases must be reduced by new technologies. The captured carbon would be recycled into useful products

Turkey has many positive effects for the 2023 with respect to other countries. Some of them are: geographical situation, its close culture to Europe and Asia, young labor force, green land area, and renewable energy potential and rich mines.

To supply the growing energy demand the government should continue the process of liberalization, restructuring and privatization in the energy sector. Turkey has made early and extensive use of financing models such as build-own-operate (BOO) and built-own-transfer (BOT).

2. ENERGY IN THE WORLD

2.1. INTRODUCTION

Energy in the world is important for us to realize the Turkey's position at the moment and for the future expectations. In the globalization period of the world, energy is the most important topic for all countries. [1] Energy demand and consumption is increasing every day in all around the world as seen from Figure 2-1. Every country is seeking new sources of energy to be powerful.

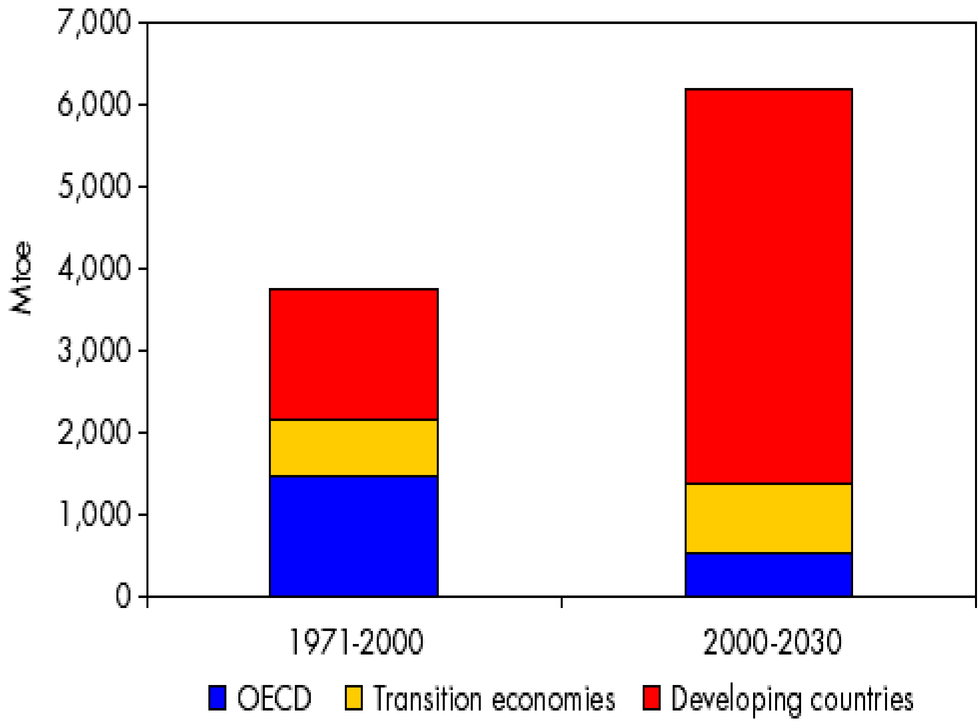

Figure 2-1: Increase in World Primary Energy Production [2]

Following figures show the actual and estimated world population, energy and electricity demands (a Millions of barrels per day of oil equivalent). As seen energy demand and electricity consumption is showing increasing trend with world population.

According to the World Bank and OECD data’s, it is expected that the world economy will increase nearly 3, 1% annually until 2020. In OECD Europe and OECD North America this value will be 2.1% and 1.7% in Pacific. It is also expected that the East Asia economy will increase nearly 4.2% in a year. China 5.2 %, India is 5%. [1]

The population of the world is also important since it specifies the energy demand. According to IEA World Energy Outlook 2000, the world population reaches to the 7.4 million People. [1] World production increased from 372060 quadrillion J in 1992 to 427180 quadrillion J in 2001. [3]

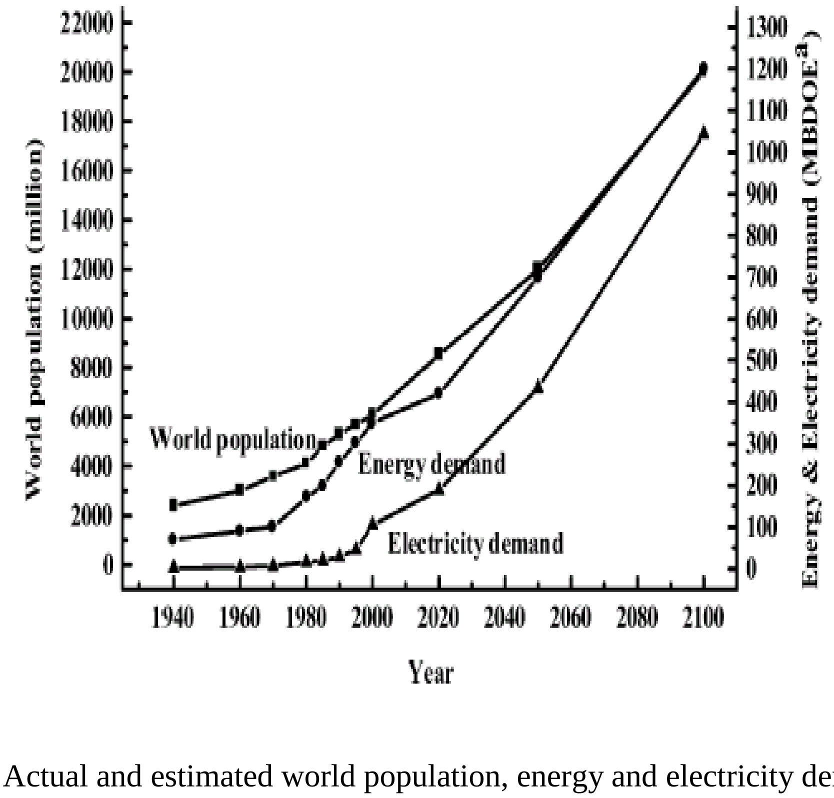

Figure 2-2: Actual and estimated world population, energy and electricity demands (a Millions of barrels per day of oil equivalent). [4]

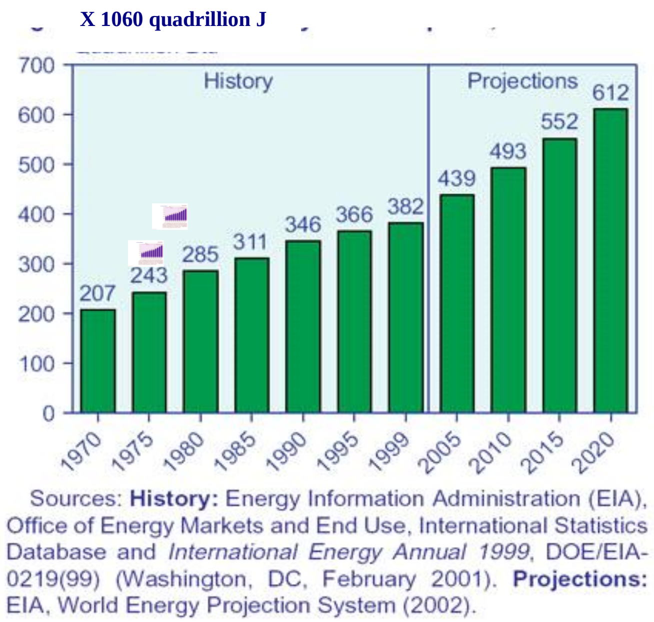

Figure 2-3: World Energy Consumption, 1970-2020 [3]

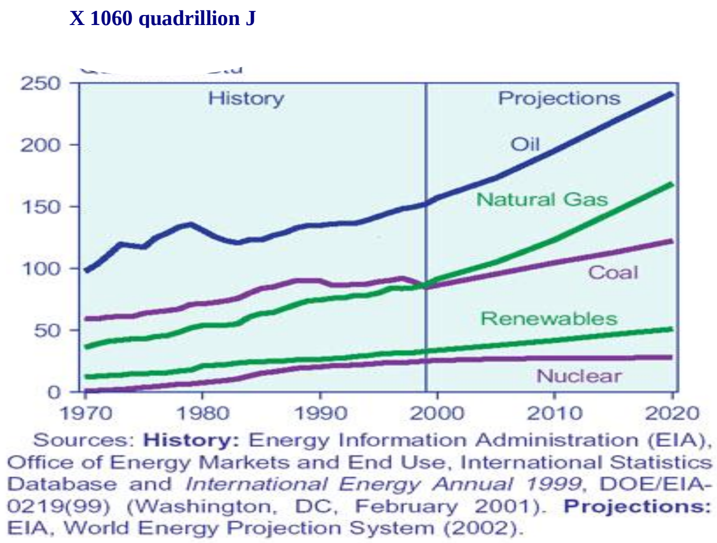

Figure 2-4: World Energy Consumption by Fuel Type, 1970-2020 [3]

It can be seen from Figure 2-3 that world energy consumption is continuing to increase. Especially after 2000 year this consumption shows rapid increase. From Figure 2-4 we can also analyze that oil; natural gas and coal consumption will be higher than nuclear energy and renewable energy consumption. This will help us to choose our energy strategies for the next millennium.

Until 2020 the world energy demand will increase 2% annually. It is expected that energy source of 8610 MTEP in 1997 will reach to the 13529 MTEP in 2020 by 68% difference. [1]

Between 1992 and 2001, the world's total output of primary energy -- petroleum, natural gas, coal, and electric power (hydro, nuclear, geothermal, solar, wind, and wood and waste)--increased at an average annual rate of 1.6 percent. [3]

In 2001, three countries--the United States, Russia, and China--were the leading producers and consumers of world. These three countries produced 38 percent and consumed 41 percent of the world's total energy. [3]

According to World Energy Outlook 2002, energy use continues to grow inexorably; fossil fuels continue to dominate the energy mix and developing countries fast approach OECD countries as the largest consumers of commercial energy. The Earth’s energy resources are undoubtedly adequate to meet rising demand for at least the next three decades. But the projections raise serious concerns about the security of energy supplies, investment in energy infrastructure, the threat of environmental damage caused by energy production and use and the unequal access of the world’s population to modern energy. Governments will have to take strenuous action in many areas of energy use and supply if these concerns are to be met. A key result of the Outlook is that energy trade will expand rapidly. [2]

From the following figure we can also see the world power generation capacity additions. As seen capacity additions in gas is much more with respect to other energy types. Secondly, coal is following the gas. And the third one is the hydropower. Gas capacity additions are important since gas is assumed to be taking the place of coal and oil by its additional properties.

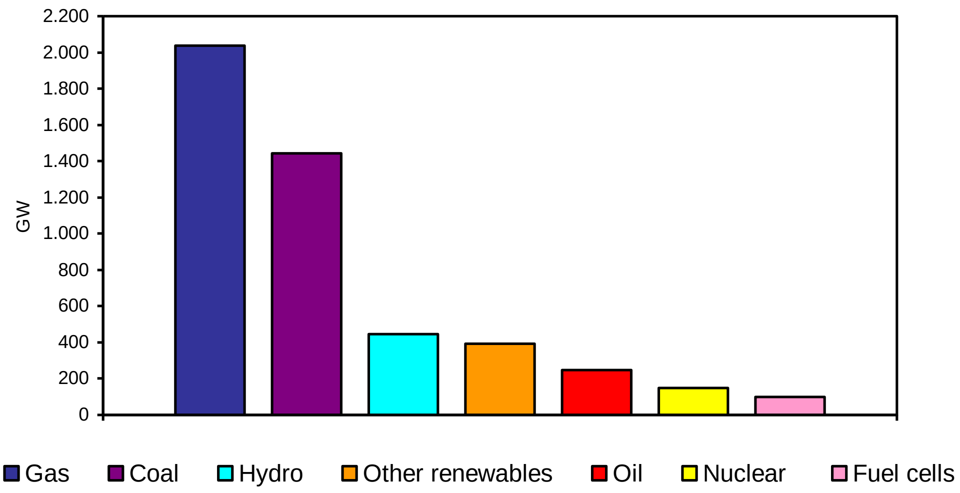

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Figure 2-5: World Power Generation Capacity Additions, 2000-2030 [5]

In particular, the major oil- and gas-consuming regions will see their imports grow substantially. This trade will increase mutual dependence among nations. But it will also intensify concerns about the world's vulnerability to energy supply disruptions, as production is increasingly concentrated in a small number of producing countries. [2]

2.2. ENERGY SOURCES

2.2.1. Crude Oil and Natural Gas Liquids

The period 1996-1999 was marked by large variations in the price of crude oil. The price per barrel started to slide in late 1997 and finally bottomed out at $10/bbl at the end of 1998. Two factors can be held responsible for this decline: a slowdown in the growth of oil demand and a supply surplus. In 1997, the economic crisis in Asia sharply reduced oil demand growth even as the non-observance of production quotas by OPEC countries led to excess supply. (See Figure 2-6) To help counteract this price collapse, OPEC decided to cut production by 1.5 million b/d in March 1999. This drop in production, combined with the recovery of oil demand growth and a tight situation on the reformulated gasoline market in the United States, caused prices to rebound to over $35/bbl (in July 2000). [6]

Confronting this price escalation, OPEC boosted production four more times during 2000 for a total increase of 3.7 million b/d, enabling the price to stabilize in the vicinity of $25/bbl. [6]

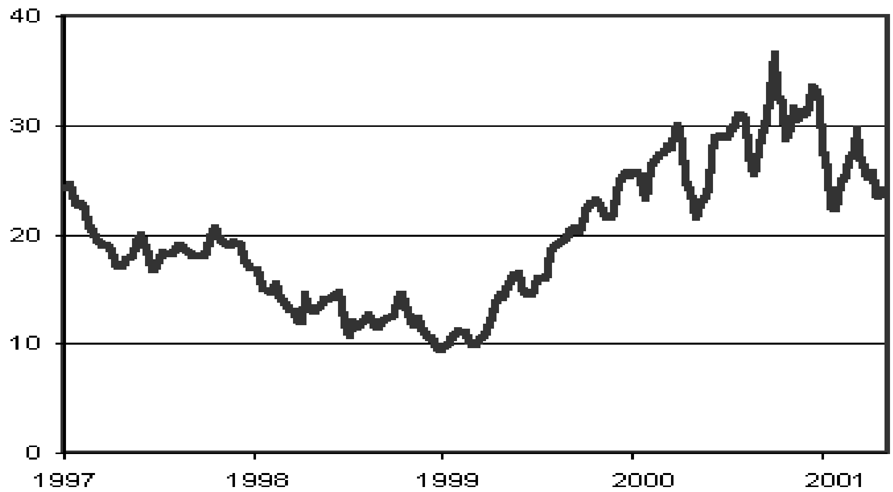


Figure 2-6: Evolution of Oil Price ($/bbl) (Dated Brent) 1997/2001 [7]

Between the 1998 WEC Survey of Energy Resources and the present Survey, proved recoverable reserves of hydrocarbons (as reported by WEC Member Committees and other sources) remained fairly stable overall: oil reserves fell by 2.7% while gas reserves went up by 2.8%. [8]

In the case of oil, Africa and South America were the major regions to experience growth (of around 4% in each case) whereas Africa (+13%) and Oceania (+11%) witnessed the largest percentage additions to gas reserves. At the current rate of production, the industry could continue to produce oil for 40 more years, gas for over 55 years. The geographic breakdown of hydrocarbon resources remains basically unchanged, with a high concentration in the Middle East (65%) and in the OPEC countries for oil, and a more equitable distribution between the FSU (37%) and the Middle East (35%) for gas. (See Figure 2-9) [8] Following figures shows the oil reserves at the end of 2001 in the world and distribution of them:

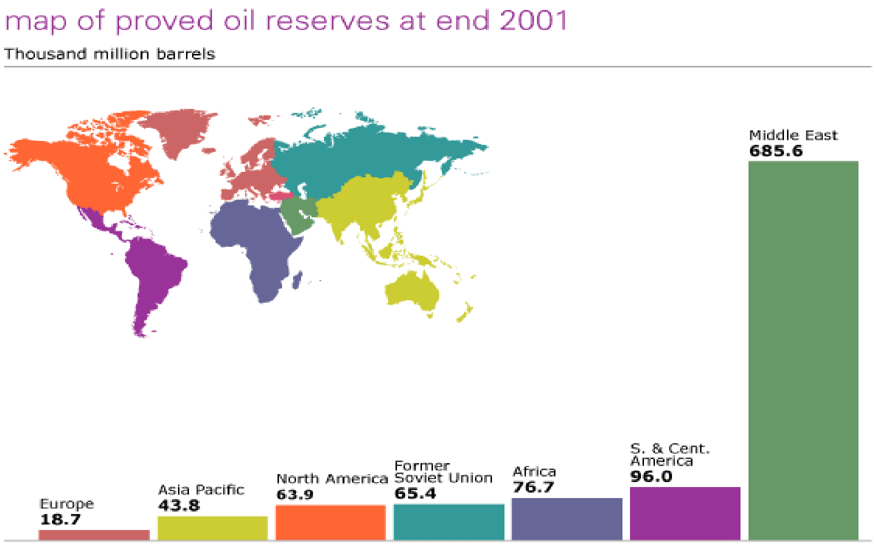


Figure 2-7: Proved oil reserves at end 2001 [9]

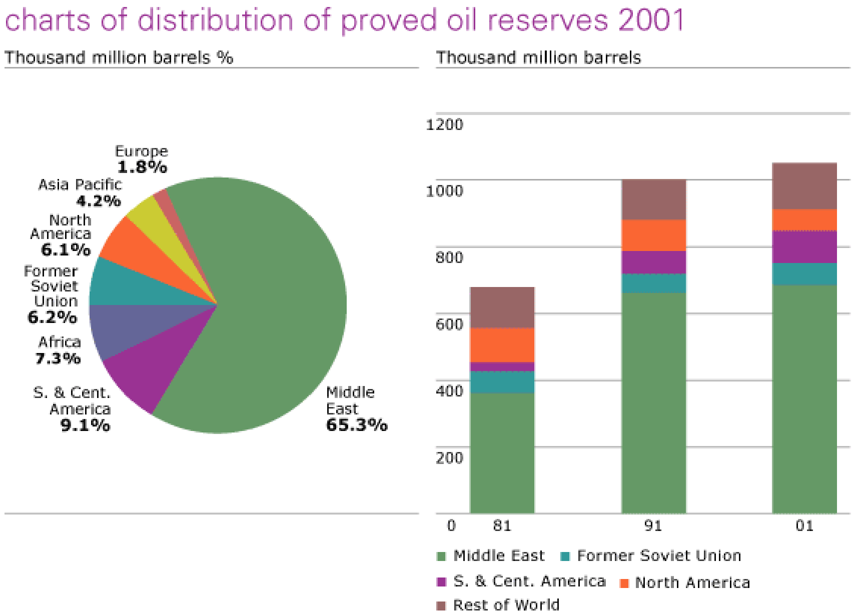


Figure 2-8: Distribution of proved oil reserves [9]

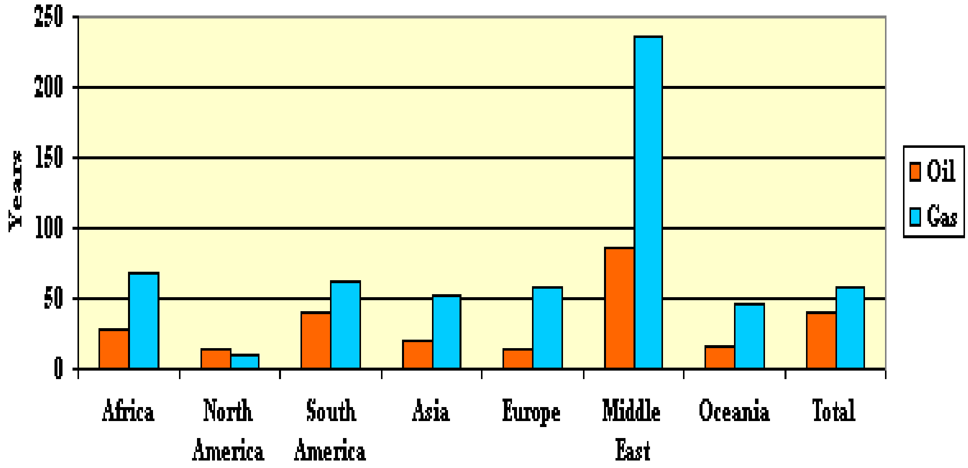


Figure 2-9: Hydrocarbon reserves / production ratios [8]

During the 1990's, even more than in the 1980's, the discoveries of new oil fields were concentrated in a small number of countries. In point of fact, during the period 1990-1999, 50% of new fields were concentrated in 10 of the 95 countries where discoveries were made. These new fields were primarily located in regions long known or recently found to be oil-rich: Iran and Saudi Arabia, on the one hand, and Brazil and Angola (deep offshore) on the other. Brazil and Angola reported a high reserve renewal rate. [8]

Today, the potential represented by deep offshore resources has not yet been clearly determined. Sedimentary areas lying in over 200 m of water represent nearly 55 million km^2 of sedimentary basins, or four times the conventional offshore surface area. The permits that have already been delivered only cover 5% of this area. [8]

Deep-offshore conditions present certain characteristics (high pressures, low temperatures, large water-depth range, the constant presence of ocean currents, etc.) that are radically different from those typifying conventional offshore operations. [8]

For oil companies, the next target depth is 3000 m. (See Figure 2-10) Meeting this objective constitutes a major industry challenge for the next 5 to 10 years.

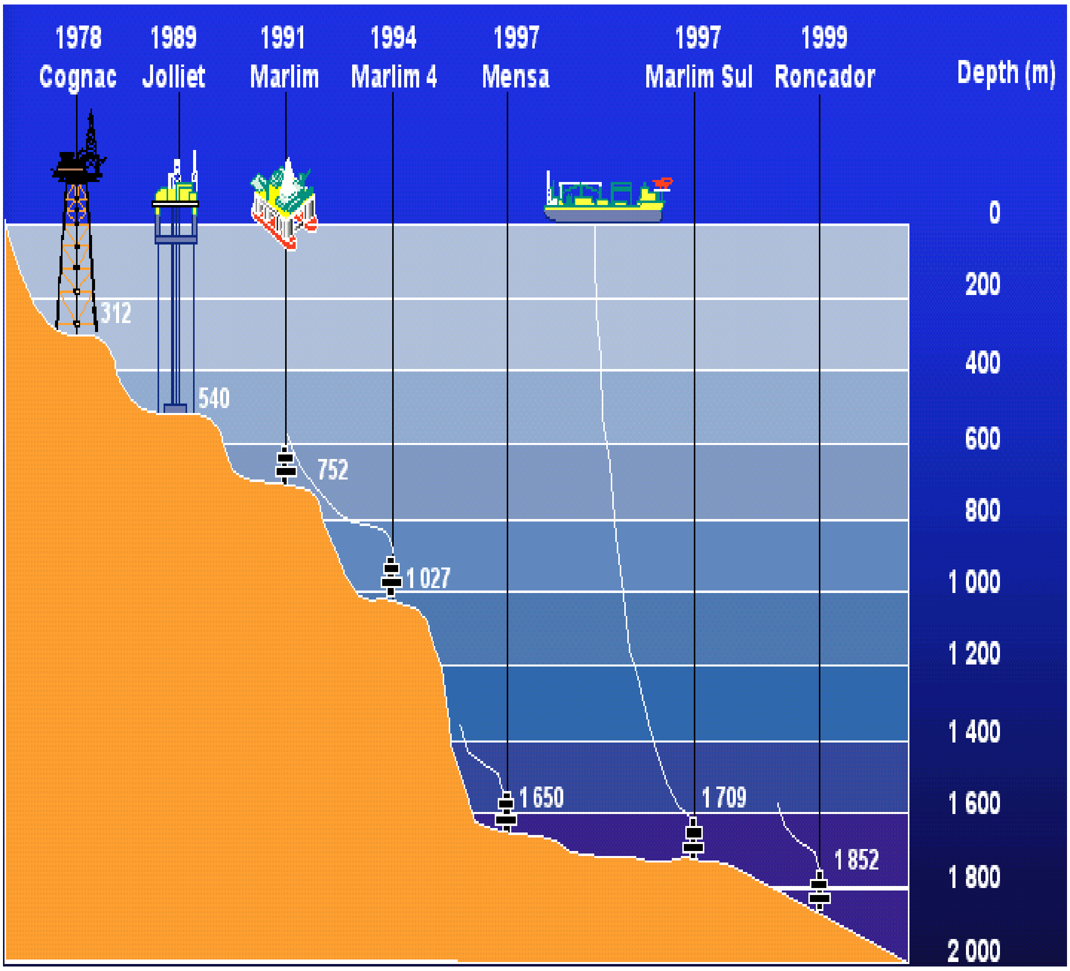


Figure 2-10: Deep Offshore Production Records, [8]

BAU projections for oil production profiles for the world, OPEC Middle East and all other areas are shown in Figure 2-11, assuming ultimate recoverable reserves of conventional oil of 2.3 trillion barrels. In this figure, world demand for liquid fuels has been extended to 2030 at the average growth rate of 1995-2020 in order to illuminate the longer-term oil supply picture. The transition from conventional to non-conventional oil as the marginal supply in 2015 is assumed to raise the oil price from $17-25 (1990 money values) over the period 2010 to 2015. The use of non-conventional oil expands rapidly after 2015 as it meets the increase in demand for liquid fuels and compensates for the decline in conventional oil production. [10]

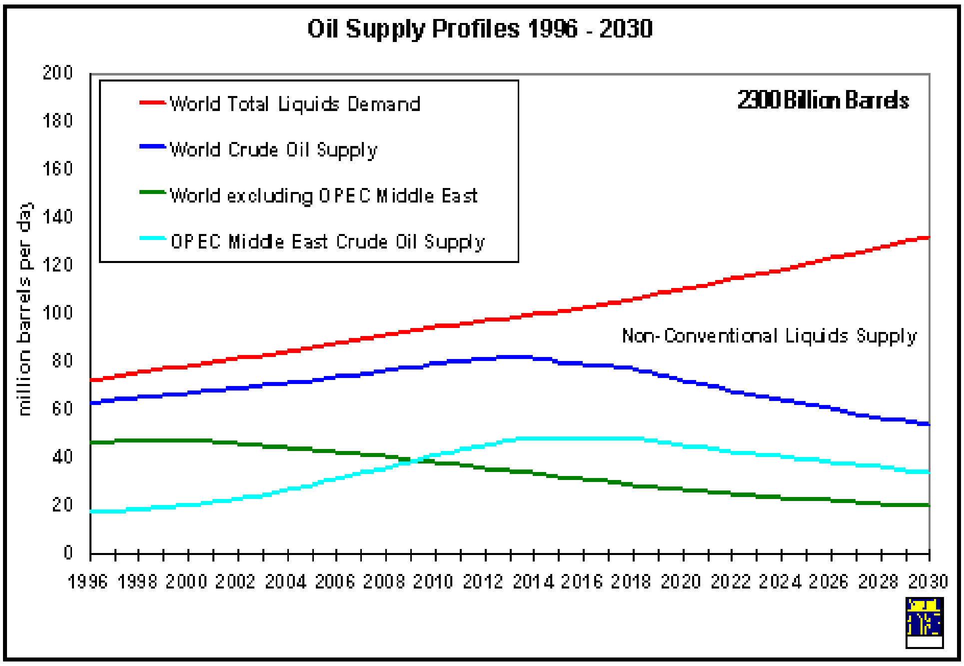


Figure 2-11: Oil Supply Profiles 1996-2030 [11]

2.2.2. Natural Gas

Natural gas, as a cleaner burning source of fossil fuel than oil or coal, is now commonly believed to offer part of the solution to climate change and problems associated with poor air quality. Once considered largely a waste product of oil production, natural gas is currently experiencing a huge increase in demand around the world. As a plentiful, economically viable, and less polluting fuel, natural gas makes sense for developing economies looking for new sources of power. Technology transfer from developed countries will be required to meet this need. [8]

The environmental benefits provided by natural gas and advances in technology are ensuring its role as the preferred fuel. There has been a steady increase in natural gas production over the past ten years. Data reported by WEC Member Committees for the present Survey, supplemented by information derived from other sources (including Cédigaz), indicate that world production of dry marketable natural gas was some 2.4 trillion cubic meters (85 trillion cubic feet) in 1999, an increase of 4.1% over the comparable 1996 total published in the 1998 Survey. Trends indicate that this steady increase will continue in the coming years as the world moves towards less carbon-intensive energy strategies. Early indications point to accelerated growth during 2000, reflecting the implementation of new and expanded LNG export schemes in Nigeria, Oman, Qatar and Trinidad. [8]

The world natural gas demand will increase nearly 2.7% annually. Demand for natural gas today is 22% assumed to be increased 26% in 2020. [3]

China's consumption of coal in 1999 decreased; at the same time it increased its natural gas consumption by 10.9% over 1998. In the Asia Pacific region, consumption of natural gas increased by 6.5%. With nearly 50% of the world's population and growing economies that demand energy, this region has the potential to significantly impact the future demand curve for all energy sources. It is anticipated that a fairly significant portion of the demand will be met by natural gas. [8]

Viewed regionally, the African continent had the fastest rate of growth in consumption, with an increase of 9.1% in 1999. Africa has a growing potential not only as a market for natural gas, but also as a producer. The transfer of technology from industrialized nations to developing countries will play an important role in balancing increasing consumption with the need for reducing emissions from fossil fuels. As a relatively abundant, economically feasible and cleaner fossil fuel, natural gas has many benefits for developing countries, especially as population migration from rural areas to urban centers puts increasing loads on urban air sheds. Foreign capital investment will be essential for developing the appropriate infrastructure, where required, and expanding existing infrastructures. [8]

The International Gas Union (IGU), which represents both developing and industrialized countries, provides an ideal venue to foster the co-operative spirit required to take advantage of these development opportunities. Market instruments, such as the Clean Development Mechanism proposed by the Kyoto Protocol, would deliver the incentive for industry to act on the opportunities. [8]

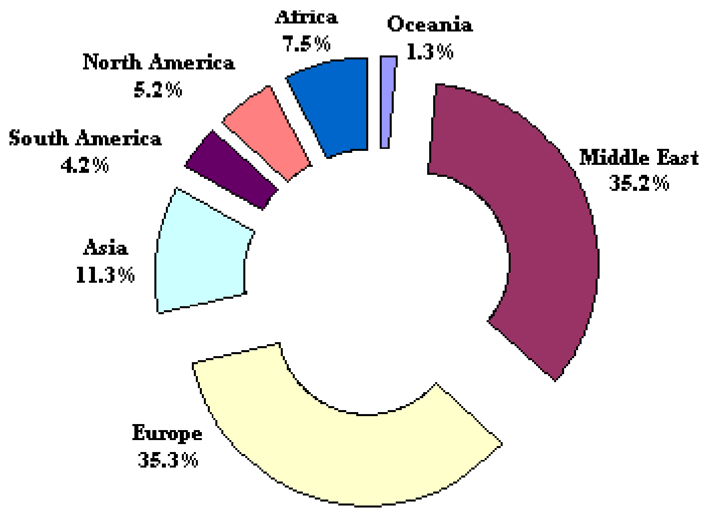


Figure 2-12: Proved gas reserves at end-1999-regional distribution [8]

As seen from Figure 2-12, Europe and Middle East have nearly same amounts of gas reserves. Then, Asia and Africa content follows.

In short, the current increase in demand for natural gas is not a short-term scenario. Rather, the gas industry is experiencing steady growth on a worldwide basis, which is likely to continue for many years to come. The challenge is to ensure that the focus is not just on meeting the demands of an expanding market, but on reducing harmful emissions and achieving greater efficiencies in the production and consumption of natural gas. [8]

The IGU is focused on advancing this awareness and promoting the important role of natural gas as a partial solution to climate change and in improving air quality. In combination with energy conservation, natural gas will help to bridge our current energy needs with the non-carbon emitting and renewable energy sources that will become viable in the future. [6]

As demand for energy grows, increased effort should be focused on the transfer of technology from developed countries to developing countries. The IGU, with members from both categories, will take the opportunity during the next few years to explore opportunities for joint projects that involve technology transfer. [6]

For regions other than OECD Europe and OECD North America plus Mexico, gas production assumed to be determined by domestic demand until cumulative production reaches 60% of ultimate gas reserves in those regions. This assumption allows for a possible increase in gas reserves in those regions, as a result of new discoveries and of new technologies that allow known reserves now considered to be uneconomic to be brought into production. Beyond that point, gas production is assumed to decline at 5% p.a. [10]

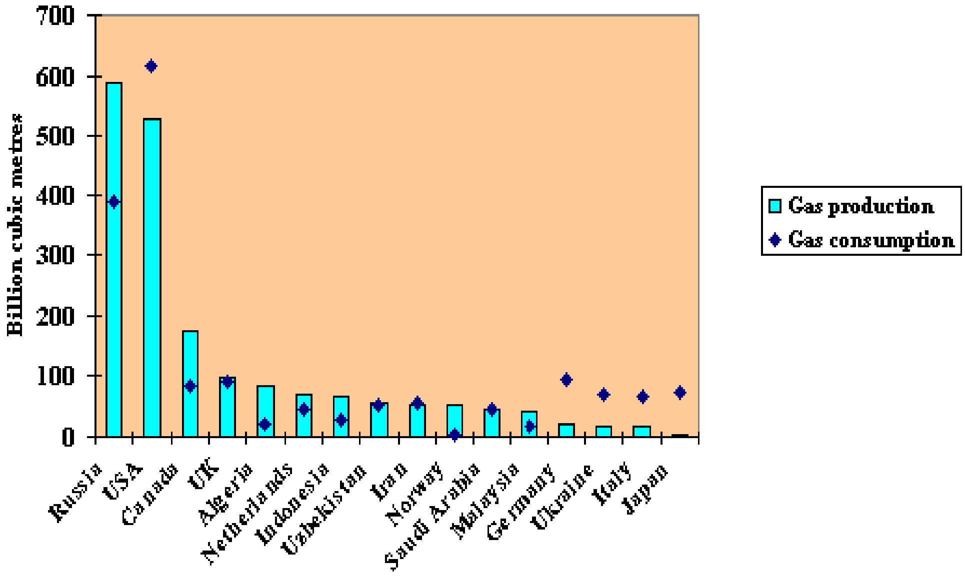


Figure 2-13: Gas production and consumption, 1999-leading countries [8]

As seen from Figure 2-13 gas production is highest in Russia followed by USA. However, USA's consumption of gas is greater than its production.

Table 2-1 shows BAU projections of indigenous gas production and net imports by region:

Table 2-1: Natural Gas Production and Net Imports [10]

Indigenous Production (Mtoe)	1995	2000	2010	2020
OECD North America (including Mexico)	592	674	799	478
OECD Europe	199	222	276	238
OECD Pacific	31	54	87	68
Transition Economies	585	631	882	1316
China	17	30	57	78
Rest of World (excluding Mexico)	396	486	795	1630
World Total	1819	2098	2895	3807
Net Imports (Mtoe)				
OECD North America (including Mexico)	-2	-2	61	526
OECD Europe	104	153	232	386
OECD Pacific	42	42	42	74
Transition Economies	-74	-108	-173	-363
China	0	0	0	0
Rest of World (excluding Mexico)	-76	-91	-168	-629
World Total	-6	-6	-6	-6

2.2.3. Coal

Within the total world reserves, there was a slight adjustment between the three primary categories with the bituminous increasing by 2%, while sub-bituminous declined by 1% and lignite reserves by around 3% below the previous recorded levels. [8]

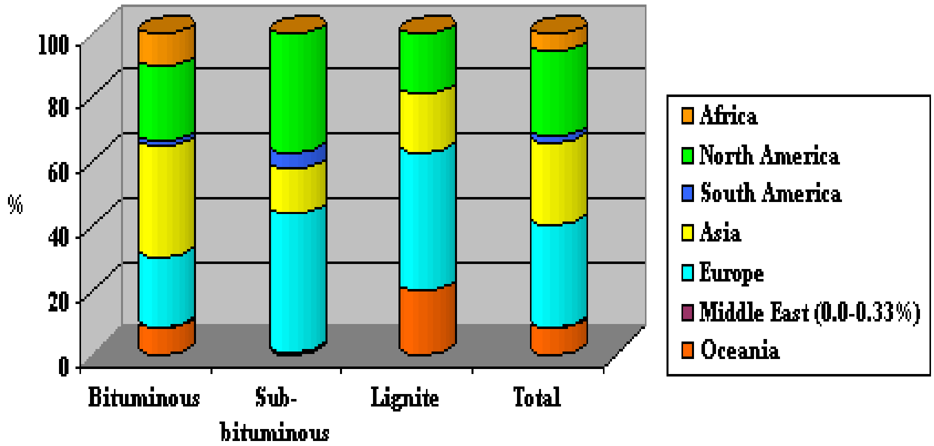


Figure 2-14: Proved coal reserves at end-1999-regional distribution [8]

On a geographic basis, South America is the one continent with little in the way of coal reserves – only 2.2% of total reserves and only 1.5% of the bituminous reserves. Africa has less than 6% of total reserves with these reserves concentrated in the bituminous category and dominated by South Africa with about 90% of the total. Botswana and Zimbabwe have the only significant reserves outside South Africa. Both North America and Asia have over 25% each of total reserves. While the reserves in North America are almost equally split between bituminous coal and sub-bituminous/lignite, Asia has a significantly higher proportion of reserves in the bituminous classification, accounting for around 35% of total bituminous reserves worldwide.

Total coal reserves held by Europe were slightly over 30% of the world total, while the individual categories show a higher share of world sub-bituminous and lignite reserves and a lower proportion of bituminous (22%). (See Figure 2-14) Two countries dominate European reserves: Germany (21%) and the Russian Federation (50%). In respect of bituminous reserves, Germany, Poland, Russian Federation and the Ukraine account for over 95% of the European total. [8]

The two major uses for coal – steel production and electricity generation – continue to be at the heart of development for most countries seeking economic growth. Coal supplies around 23% of the total global primary energy demand, around 38% of total world electricity production and is an essential input for steel production via the BOF process, which accounts for almost 70% of total world steel production. [10]

The coal industry – production and consumption – will change because of the emerging political circumstances and new market conditions. Coal will need to reduce its environmental footprint. [10]

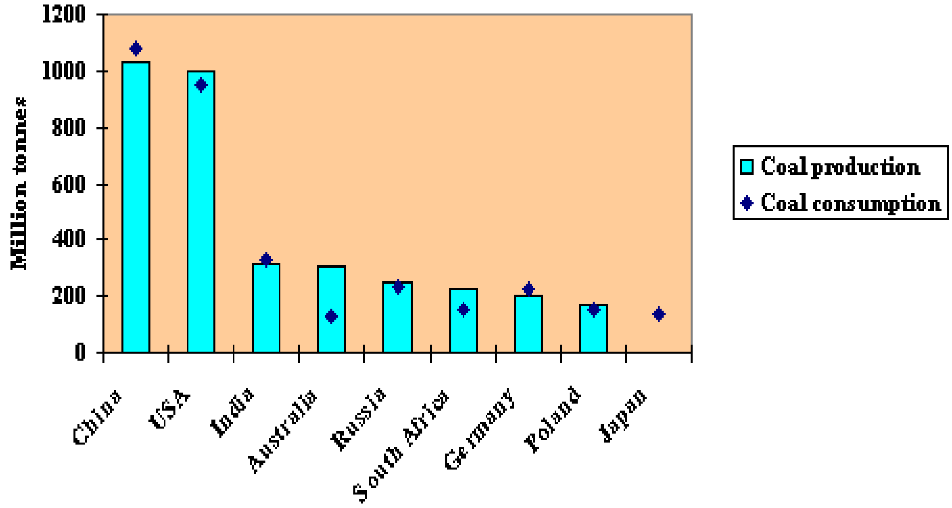


Figure 2-15: Coal production and consumption, 1999- leading countries

Coal use is expected to decline in Western Europe, Eastern Europe, and the former Soviet Union (FSU). Increases are expected in the United States, Japan, and developing Asia as seen from Figure 2-15 in the upper page. In Western Europe, coal consumption declined by 35 percent between 1985 and 1999 displaced in large part by the growing use of natural gas and, in France, nuclear power. Even sharper declines occurred in the countries of Eastern Europe and the former Soviet Union (EE/FSU), where coal use fell by 48 percent between 1985 and 1999 as a result of the economic collapse that followed the breakup of the Soviet Union, as well as some fuel switching. The projected slow growth in world coal use suggests that coal will account for a shrinking share of global primary energy consumption. In 1999, coal provided 22 percent of world primary energy consumption, down from 27 percent in 1985. In the IEO2002 reference case, the coal share of total energy consumption is projected to fall to 20 percent by 2020. [3]

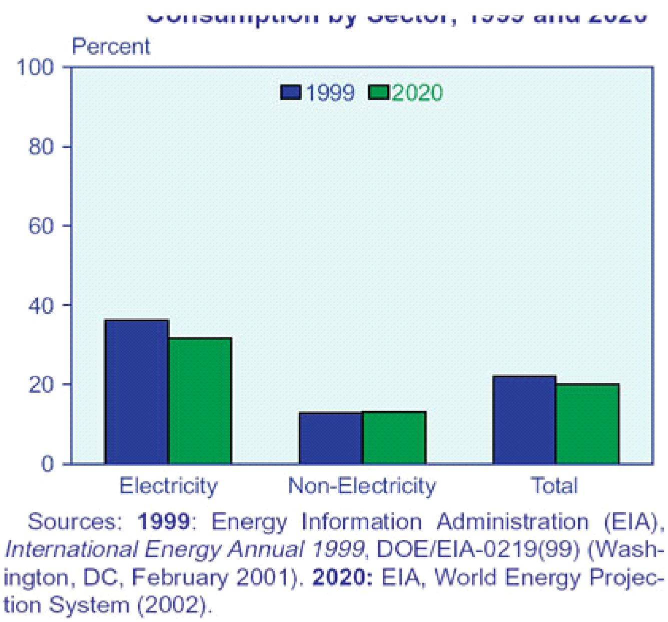


Figure 2-16: Coal Share of World Energy Consumption by sector, 1999 and 2020

As seen from Figure 2-16 coal consumption is mainly in the electricity generation. And it assumed to be decreased by new technologies and modernization studies.

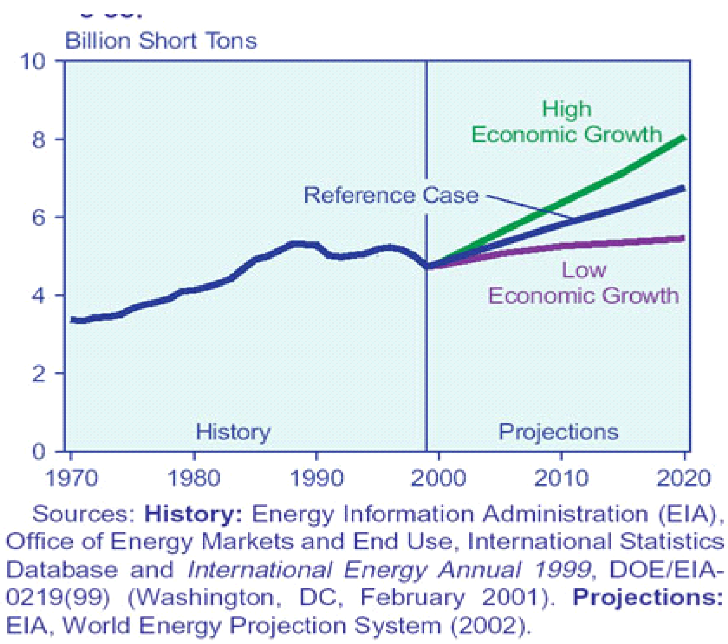


Figure 2-17: World Coal Consumption, 1970 – 2020

In Figure 2-17 world coal consumption in three cases can be analyzed. As seen after 2000 year with respect to all three-category high economic scenario, low economic scenario and reference point coal consumption will show an increase up to 2020.

Highlights of the IEO2002 projections for coal are as follows: [3]

1) World coal consumption is projected to increase by 2.0 billion tons, from 4.7 billion tons in 1999 to 6.8 billion tons in 2020. Alternative assumptions about economic growth rates lead to forecasts of world coal consumption in 2020 ranging from 5.5 to 8.1 billion tons.

2) Coal use in developing Asia alone is projected to increase by 1.8 billion tons.

China and India together are projected to account for 29 percent of the total increase in energy consumption worldwide between 1999 and 2020 and 83 percent of the world's total projected increase in coal use.

China is projected to add an estimated 100 GW of new coal-fired generating capacity (333 plants of 300 megawatts each) by 2020 and India approximately 65 GW (217 plants of 300 MW each).

The share of coal in world total primary energy consumption is expected to decline from 22 percent in 1999 to 20 percent in 2020. The coal share of energy consumed worldwide for electricity generation is also projected to decline, from 36 percent in 1999 to 32 percent in 2020.

World coal trade is projected to increase from 604 million tons in 1999 to 776 million tons in 2020, accounting for between 11 and 12 percent of total world coal consumption over the period. Steam coal (including coal for pulverized coal injection at blast furnaces) accounts for most of the projected increase in world trade.

Traded coal on a global level continues to expand. While the long-term importers remain in the trade – and continue to increase demand – other countries have emerged as significant markets as their domestic coal industry is further exposed to a competitive coal market. Germany and the UK are notable in this group, along with Spain. The second half of the 1990's has seen the consolidation of China and Indonesia as two of the top five exporters, with around 10% of the global export market each. [8]

2.2.4. Uranium

Canada produces the largest share of uranium from mines (35% of world supply), followed by Australia (22%). Canada is the world's largest producer of uranium. In 2002 production at 13,689 tones of uranium oxide concentrate (11,607 tones U) was about a third of total world production. Its value was about C$ 600 million. [40]

Nearly 50% of the production in 1997 was from open-pit mining, versus 32% from underground. About 13% was produced using ISL technology. The balance was produced by other methods.

The distribution by mine-type remained about the same in 1998. The increasing importance of open-pit mining as compared with 1996 was caused by closure of underground mines and increased output from existing large open-pit mines. [8]

From Figure 2-18 we can see that cumulative production of uranium is highest in North America, Asia has the major proved reserves.

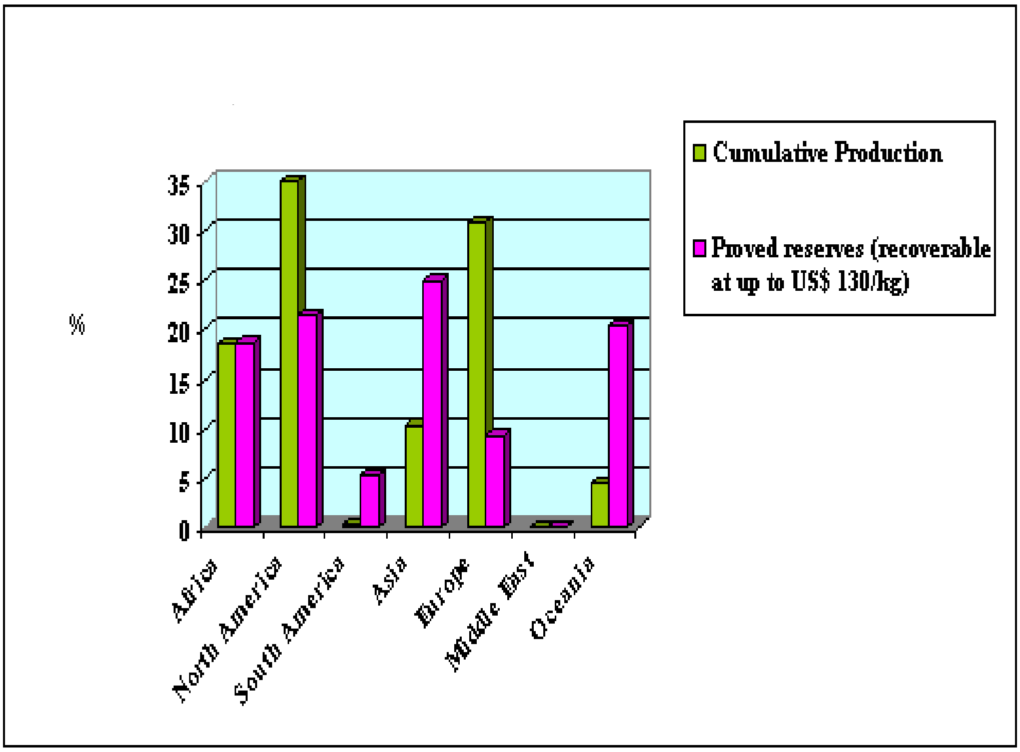


Figure 2-18: Cumulative production and proved reserves of uranium at end -1999- regional distribution [8]

Table 2-2: Production from mines 2001&2000 [12] (Production from mines tones U)

Country	2001	2000
Canada	12520	10682
Australia	7720	7578
Niger	3096	2895
Namibia	2239	2714
Uzbekistan	2400	2350
Russia (est.)	2000	2000
Kazakhstan	2018	1752
USA	1000	1456
South Africa	898	878
China (est.)	500	500
Ukraine (est.)	500	500
Czech Republic	330	500
India (est.)	200	200
France	124	319
Romania	115	50
Spain	30	251
Others	77	121
Total world	35 767	34 746
	(42 180 t U_3O_8)	(40 976 t U_3O_8)

2.3. RENEWABLE ENERGY

2.3.1. Geothermal Energy

Geothermal energy is the natural heat of the earth. Enormous amounts of thermal energy are continuously generated by the decay of radioactive isotopes of underground rocks and stored in our globe's interior. This heat is as inexhaustible and renewable as solar energy. Presently geothermal energy is exploited by producing the underground water stored in permeable rocks from which it has absorbed available heat (hydro-thermal systems) or, in certain types of geothermal heat pumps, extracting heat directly from the ground. Up to 100^{o}C underground water can provide at present, energy for many applications, ranging from district heating to individual residential heating, to agricultural and spa uses and for selected industries. Geothermal fluids between 100^{o} and 150^{o}C can (besides direct heat uses) generate electricity with special (binary) power plants. Above 150^{o}C, the optimal use of the resource is for electricity production. [8]

Worldwide, those hot areas with fluids above 200^{o}C at economic depths for electricity production are concentrated in the young regional belts. They are the seats of strong tectonic activity, separating the large crusted blocks in which the earth is geologically divided (See Figure 2-19). The movement of these blocks is the cause of mountain building and trench formation. The main geothermal areas of this type are located in New Zealand, Japan, Indonesia, Philippines, and the western coastal Americas, the central and eastern parts of the Mediterranean, Iceland, the Azores and eastern Africa. [8]

Elsewhere in the world, underground temperatures are lower but geothermal resources, generally suitable for direct-use applications, are more widespread. Exploitable heat occurs in a variety of geological situations. It is practically always available in the very shallow underground where GHPs can be installed. The risk for a prospector (of not locating hot water in the quantity and with the quality required) is limited in shallow depth targets where prior knowledge gained from earlier surveys is available. There are greater uncertainties on deeper resources where insufficient survey work has been conducted. [8]

Comparing statistical data for end-1996 and the present Survey, it can be seen that there has been an increase in world geothermal power plant capacity (+9%) and utilization (+23%) while direct heat systems show a 56% additional capacity, coupled with a somewhat lower rate of increase in their use (+32%). [8]

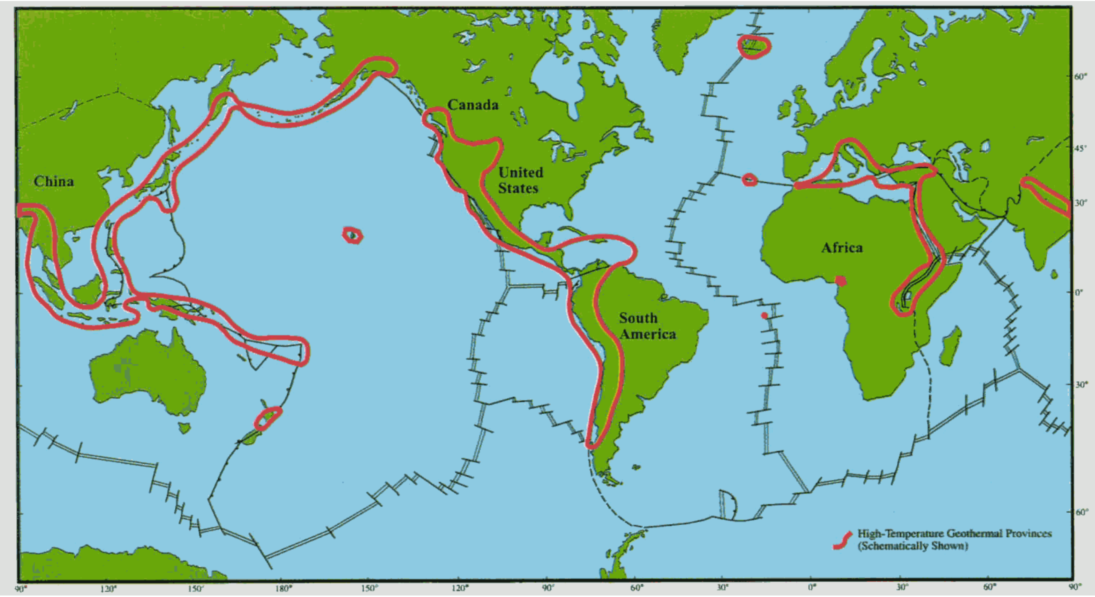


Figure 2-19: The main geothermal areas in the world [8]

Going into some detail, the six countries with the largest electric power capacity are: USA with 2 228 MW is first, followed by Philippines (1 863 MW); four countries (Mexico, Italy, Indonesia, and Japan) had capacity (at end-1999) in the range of 550-750 MW each. These six countries represent 86% of the world capacity and about the same percentage of the world output, amounting to around 45 000 GWh. The strong decline in the USA in recent years, due to overexploitation of the giant Geysers steam field, has been partly compensated by important additions to capacity in several countries: Indonesia, Philippines, Italy, New Zealand, Iceland, Mexico, Costa Rica, El Salvador. Newcomers in the electric power sector are Ethiopia (1998), Guatemala (1998) and Austria (2001). [8]

In total, 22 nations are generating geothermal electricity, in amounts sufficient to supply 15 million houses. The total world use of geothermal power is giving a contribution both to energy saving (around 26 million tons of oil per year) and to CO_2 emission reduction (80 million tons/year if compared with equivalent oil-fuelled production). The long-range future of geothermal energy depends on HDR systems becoming a technological and economic reality. It has been estimated that the heat resources located at economically accessible depths could support, in North America and Europe, an amount of power generation capacity by HDR systems of the same order or greater than present nuclear capacity. Early in 2001 the European Economic Interest Grouping (EEIG) formed by the oil major Shell, the Italian geothermal power producer ERGA and three French and German utilities began a five-year program to drill additional wells and build a power plant in Soultz-sous-Forets. [8]

2.3.2. Biomass

'Biomass other than wood' definition means that agricultural and wood/forestry residues and herbaceous crops grown specifically for energy but excludes forest plantations grown specifically for energy. Currently there are a number of dedicated energy plantations, e.g. Brazil, where there are about 3 million ha of eucalyptus plantations used for charcoal making; China, which has a plantation program for 13.5 million ha of fuel wood by 2010; Sweden, where there are about 16 000 ha of willow plantations used for the generation of heat and power; and the USA, where some 50 000 ha of agricultural land has been converted to woody plantations, possibly rising to as much as 4 million ha (10 million acres) by 2020. But all current plantations have tended to follow traditional agricultural and forestry practices. [8]

Biomass consumption in rural areas of developing countries (including all types of biomass and end-uses) was about 1 tone (15% moisture, 15GW/t) per person/year and about 0.5 tones in semi-urban and urban areas. This assumption is still generally valid today. It seems that while in relative terms traditional biomass energy consumption may be declining in some parts of the world, in absolute terms the total amount of biomass energy is increasing.

There are many variations due to the large numbers of factors involved, such as availability of supply, climatic differences, population growth, socio-economic development, and cultural factors. [8]

The growing interest in biomass energy in the late 1990's is the result of a combination of underlying factors, including: [8]

- Rapid changes in the energy market worldwide, driven by privatization, deregulation and decentralization;
- Greater recognition of the current role and future potential contribution of biomass as a modern energy carrier, combined with a general interest in other renewable (RE);
- Its availability, versatility and sustainability;
- Better understanding of its global and local environmental benefits and perceived potential role in climate stabilization;
- Existing and potential development and entrepreneurial opportunities;

Technological advances and knowledge, which have recently evolved on many aspects of biomass energy and other RE. In addition, there are other more specific factors that are favoring the development of biomass energy: [8]

Growing concern with global climate change that may eventually drive a global policy on pollution abatement. For example, The Hague meeting (COP6), despite its failure, firmly established support for RE which could provide the basis for a global market. Growing recognition among established conventional institutions of the importance of biomass energy, e.g. a World Bank 1996 report concluded that "energy policies will need to be as concerned about the supply and use of biofuels as they are about modern fuel and they must support ways to use biofuels more efficiently and sustainable;

- Expected increases in energy demand, combined with current rapid growth of RE. The Global Environmental Facility (GEF) predicts that developing countries alone will need as much as five million MW of new electrical generation capacity in the next 40 years, most of which could be supplied by RE. For the two billion people who lack reliable energy, most of them in remote areas with little prospect of connecting to an electrical grid, RE remains one of the best options (GEF, 2001);

- A growing number of countries are introducing specific policies in support of RE, with biomass energy playing a central role;
- Environmental pressures will increase the price of fossil fuels as the cheaper sources are depleted. Also, as the external costs are progressively incorporated into the final costs of energy, RE will be put onto a more equal footing with fossil fuels;
- Despite the fact that some technologies have failed to live up to commercial expectations, technology is evolving rapidly and the time-span is being reduced. Significant advances have been made in gasification, co-firing, biogas production, etc. This is reflected in the growing number of modern applications, e.g. electricity generation, ethanol fuels blended with gasoline, biodiesel, etc.

Biomass resources are potentially the world's largest and most sustainable energy source a renewable resource comprising 220 billion oven-dry tones (about 4 500 EJ) of annual primary production. The annual bio-energy potential is about 2900 EJ, though only 270 EJ could be considered available on a sustainable basis and at competitive prices. The problem is not availability but the sustainable management and delivery of energy to those who need it. [8]

Residues are currently the main sources of bio-energy and this will continue to be the case in the short to medium term, with dedicated energy forestry/crops playing an increasing role in the longer term. The expected increase of biomass energy, particularly in its modern forms, could have a significant impact not only in the energy sector, but also in the drive to modernize agriculture, and on rural development. [8]

2.3.3. Solar Energy

With the exception of nuclear, geothermal and tidal energy, all forms of energy used on earth originate from the sun’s energy. Some are renewable some are not. Renewable is the term used for forms of energy that can be regenerated, or renewed, in a relatively short amount of time. The regeneration process may be continuous and immediate, as in the case of direct solar radiation, or it may take some hours, months or years. This is the case of wind energy (generated by the uneven heating of air masses), hydro energy (related to the sun-powered cycle of water evaporation and rain), biomass energy (stored in plants through photosynthesis), and the energy contained in marine currents. The flow of renewable solar energies on earth is essentially equal to the flow of energy due to solar radiation. Every year, the sun irradiates the earth's land masses with the equivalent of 19 trillion toes. A fraction of this energy could satisfy the world's energy requirements, around 9 billion toe per year. [8]

For thousands of years, the sun's renewable energy was humanity's sole source of energy. Its role started to decrease only a few centuries ago, with the progress of industrialization, the diffusion of new technologies, and the discovery of new fossil fuels and eventually nuclear power. Today solar sources provide around 10% of the energy used worldwide, but in the developing countries their share is still of the order of 40%. This contribution could start growing again, thanks to progress in solar technology and the pressure of recurrent energy and environmental crises related to fossil fuels and nuclear power.

To raise the contribution to 50% of world energy use by 2050, as suggested in the Shell Renewable report, would require sweeping changes in our energy infrastructure. These changes can be achieved only through the parallel development of a new, more sophisticated way of thinking about our environment and how we generate and use energy: a new culture that should pervade every part of society and shape the responsibilities of each. [8]

A solar technology that has already had a great impact on our lives is photovoltaic. Not in terms of the amount of electricity it produces (in 1999 only 200 MW were installed), but because of the fact that photovoltaic cells – working silently, not polluting – can generate electricity wherever the sun shines, even in places where no other form of electricity can be obtained. [8]

Today, low-temperature ($<100^{o}$C) thermal solar technologies are reliable and mature for the market. Worldwide, they help to meet heating needs with the installation of several million square meters of solar collectors per year. [13]

As seen from the table, the promotion of renewable energy has been an integral part of Japanese energy policy, and a variety of policies employed to increase capacity, reduce costs and promote a vibrant export business. At the end of 2000, Japan had 314MWp solar power in installed capacity. Expansion has been stimulated by the 70,000 roofs program, under which there was a 50% subsidy for grid connected residential systems of 3-4kW, falling to 35% in 2000. The program received substantial government funding. In 2001 government provided $198m to residential solar generating systems. There also is a 67% capital subsidy for PV installations on commercial buildings. Extra funding has been directed at R&D, helping to set up PV business and supporting NGOs and municipalities. As a result of R&D support, in the last five years, cost of PV units in Japan dropped by 75%. [14]

The star of the European solar market is Germany, a pioneer in rooftop installation of PV systems, starting in '90 with its 1,000 Rooftop Program. In '99 a new five-year program was launched to promote the installation on 100,000 roofs. Capital loans are guaranteed a 10-year interest rate of 1.9%. [14]

Even more important in the development of the German PV industry has been the introduction of the Renewable Energy Law, under which anyone who installs a solar generation system receives 0.5 for energy sold to the grid throughout the lifetime of the system. This is being reduced by 5% a year to reflect the anticipated reduction in the price of PV. [14]

2.3.4. Wind Energy

World wind energy capacity has been doubling every three years during the last decade and growth rates in the last two years have been even faster, as shown in Figure 2-20. Total world wind capacity at the end of 2000 was around 17 500 MW and generation from wind now approximately equates to annual consumption of electricity in Chile or Singapore. Germany, with over 6 000 MW, has the highest capacity but Denmark, with over 2 000 MW, has the highest level per capita and the production accounts for about 12% of Danish electricity. [8]

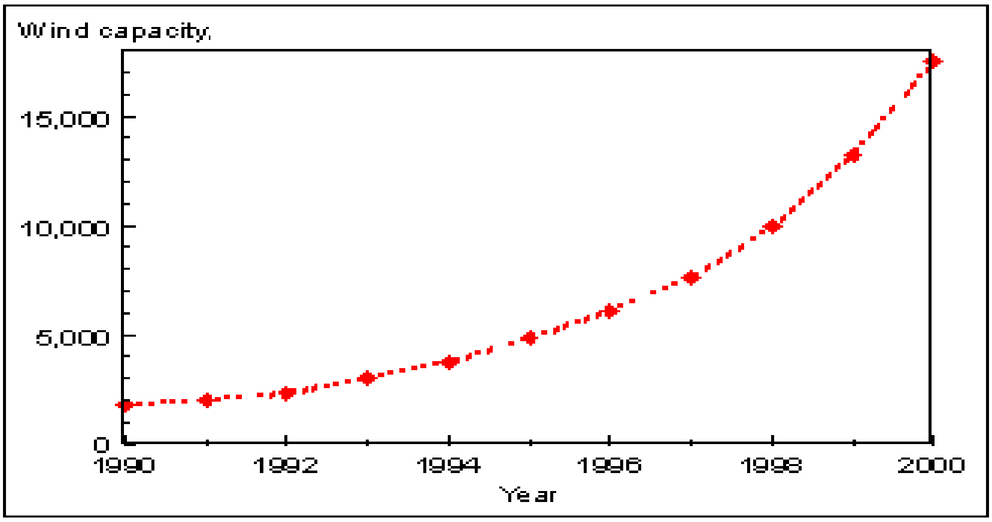


Figure 2-20: Growth of world wind capacity (MW) [8]

The attractions of wind as a source of electricity which produces minimal quantities of greenhouse gases has led to ambitious targets for wind energy in many parts of the world.

More recently, there have been several developments of offshore wind installations and many more are planned. Although offshore wind-generated electricity is generally more expensive than onshore, the resource is very large and there are few environmental impacts. Whilst wind energy is generally developed in the industrialized world for environmental reasons, it has attractions in the developing world as it can be installed quickly in areas where electricity is urgently needed. In many instances it may be a cost-effective solution if fossil fuel sources are not readily available. [8]

Recent rapid growth in Denmark, Spain and Germany shows no sign of slowing and there are plans for further capacity in the United States, Canada, the Middle East, the Far East and South America. If the current growth rate continues, there may be about 150 GW by 2010. The rate of development will depend on the level of political support from the national governments and international community. This, in turn, depends on the level of commitment to achieving the carbon dioxide reduction targets now internationally agreed. Although the technology has developed rapidly during the past ten years, further improvements can be expected both in performance and cost. [8] One can see the installed generating capacity and annual electricity output at end 1999 in the Appendix A.

2.3.5. Hydropower

Technically feasible hydropower potential estimated at nearly 15 000 TWh/yr still exists in the world today, mostly in countries where increased power supplies from clean and renewable sources are most urgently needed to progress social and economic development. While it is not realistic to assume that all of this potential will be developed in the short or even medium term, it is clear that hydro has a substantial role to play in world energy supply. It can also offer a number of environmental and technical advantages, in terms of avoided generation based on fossil fuels [17]. While development of the entire world's remaining hydroelectric potential could not hope to meet future world demand for electricity, it is clear that it is the resource with the greatest capability to provide clean renewable energy to the parts of the world which at present have the greatest need. And when implemented as part of a multipurpose water resources development scheme, a hydro station can offer a number of side benefits, which no other source of energy can compete with [15].

Hydroelectricity, at present the most important of the clean, economically feasible, renewable energy options, can be a major benefit of a water resources development project; however, it is seldom the only benefit. Hydropower stations integrated within multipurpose schemes generally subsidies other vital functions of a project, such as irrigation, water supply, improved navigation, flood mitigation, recreational facilities, and so on. [8]

Today, hydropower provides about 19% (2 650 TWh/yr) of the world's electricity supply, development of the world's remaining technical potential could, by no means, cover the growth in future demand. However, carefully planned hydropower development can, and does, make a great contribution to improving electrical system reliability and stability throughout the world. Also, future development will play an important role in the improvement of living standards in the developing world, where the greatest hydropower potential still exists. [8]

This development, together with the existing installed hydropower capacity (some 700 GW), will make a substantial contribution to the avoidance of greenhouse gas emissions and the related climate change issues. [8]

Information received from WEC Member Committees, supplemented by data published by The International Journal on Hydropower & Dams, indicates that the world's total technically feasible hydro potential is about 14 400 TWh/yr, of which just over 8 000 TWh/yr is currently considered to be economically feasible for development. Installed hydroelectric generating capacity is some 692 GW, with a further 110 GW under construction. [2]

The greatest amount of current development is in Asia (84 400MW), followed by South America (14 800MW), Africa (2403MW), Europe (2211MW) and North and Central America (1236MW) [15].

From the following Figure we can see the installed hydropower capacity at the end of 1999 by regional distribution. By 31% Europe has the main capacity; Asia follows this by 25.1%.

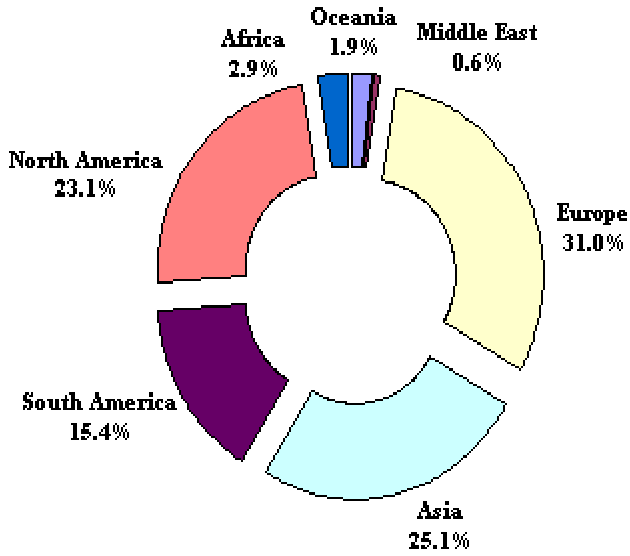


Figure 2-21: Installed Hydropower Capacity at end 1999-Regional Distribution [8]

2.4. ELECTRICAL ENERGY IN THE WORLD COUNTRIES

Worldwide electricity consumption is projected to increase at an average annual rate of 2.7 percent from 1999 to 2020. The most rapid growth in electricity use is projected for the developing world, particularly developing Asia, where electricity consumption is expected to increase by 4.5 percent per year over the forecast horizon. [3]

Robust economic growth in developing Asia is expected to lead to increased demand for electricity to run newly purchased home appliances, such as air conditioners, refrigerators, stoves, space heaters, and water heaters. By 2020, developing Asia is expected to consume more than twice as much electricity as it did in 1999. China's electricity consumption alone is projected to triple, growing by an average of 5.5 percent per year over the forecast period. [3]

Electricity consumption in the industrialized world is expected to grow at a more modest pace than in the developing world, at 1.9 percent per year—a considerably lower rate than has been seen in the past. In addition to expected slower growth in population and economic activity in the industrialized nations, market saturation and efficiency gains for some electronic appliances are expected to slow the growth with of electricity consumption. [3]

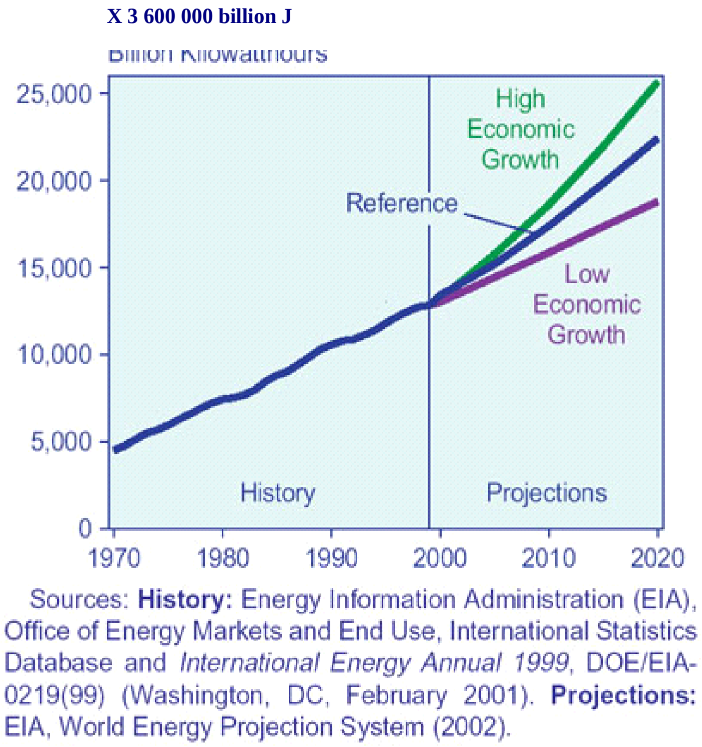


Figure 2-22: World Net Electricity Consumption in three cases [3]

There have been two important developments in the electricity sector in recent years that may affect the way the industry works in the future. The first is the increasing role of foreign direct investment in the developing regions of the world. Greater access to foreign investment in the electricity sector has allowed developing nations to construct the infrastructure needed for substantial increases in access to electricity, a particular problem for many developing nations. [3]

A second important component of the electric industry's evolution over the past several years is electricity reform. Many developing countries have implemented reforms to the rules governing electricity generation and distribution in an effort to secure the foreign direct investment they need to modernize and improve the electricity infrastructure. In industrialized countries, many nations have undertaken electricity reforms to introduce greater competition in domestic markets in an effort to reduce the costs of electricity to consumers. These two factors are driving changes within the electricity sector and are expected to have a profound role on the development of the industry over the next two decades. [3]

The electricity reform includes the followings: [3]

- Unbundling of electricity assets through divestiture, or a vertical separation of ownership, and/or control, of certain electricity assets in order to promote competition, particularly in generation
- Creation of electricity trading arrangements (pools)
- Creation of independent system operators (ISOs) and, in the United States, regional trading organizations (RTOs)
- Privatization of electricity assets through sale or public auction, or the corporatization of the governance of the assets
- Deregulation of electricity prices and the implementation of a more restrained (light-handed) form of regulation where regulation was retained
- Open access to the grid
- Opening up of domestic electricity assets to foreign investment
- Retail competition.

2.5. NUCLEAR ENERGY IN THE WORLD

In the last three decades, nuclear power has played a significant role in electricity generation. Currently nuclear power supplies more than 16% of the world's total electricity. It produces little pollution and virtually no greenhouse gases. [8]

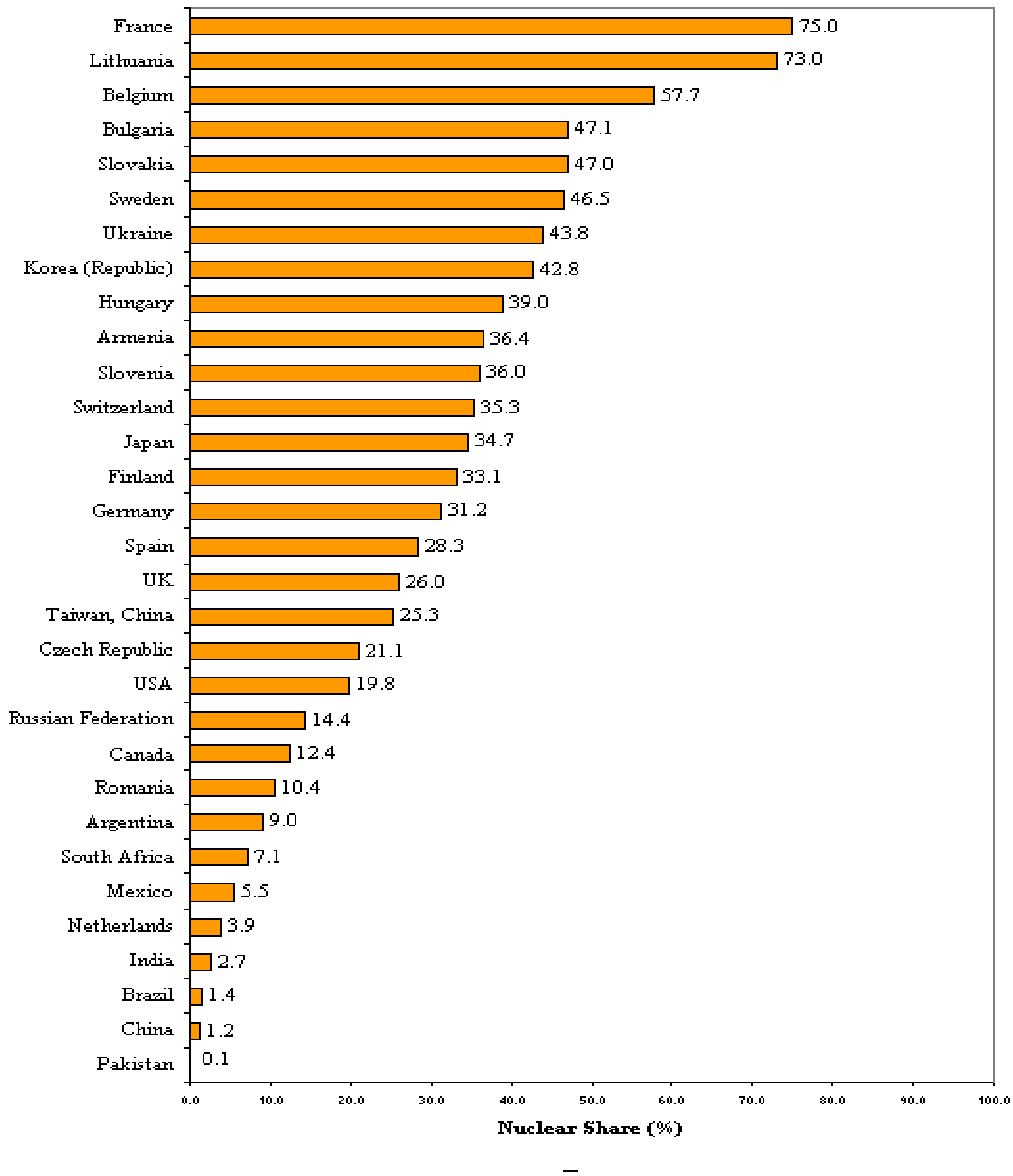


Figure 2-23: Nuclear Share of Electricity during 1999

There are currently 438 nuclear power plants in operation around the world, producing 16% of the world's electricity—the largest share provided by any non greenhouse-gas-emitting source. This yields a significant reduction in the environmental impact of today's electric generation. [16]

According to information provided by WEC Member Committees for the present Survey, supplemented by data published by the IAEA, there were 438 NPPs in operation at the end of 1999, with an aggregate net generating capacity of 349 GW. There were reported to be 41 reactor units under construction, with a total capacity of just over 33 GW. These figures are generally in line with those contained in the IAEA's Power Reactor Information System (PRIS), which shows 433 NPPs (totalling 349 GW) in operation at end-1999, and 37 units (31 GW) under construction. The country that produces the largest percentage of its electricity by nuclear power is France where, 75% of electricity was produced by nuclear. It is followed by Lithuania with 73%, Belgium with 58%, Bulgaria, Slovakia and Sweden with 47%, Ukraine with 44% and Republic of Korea with 43%. In ten other countries, more than 25% of the electricity was produced by nuclear power (see Figure 6.2). The largest contributor to the world's installed nuclear capacity was the USA with 28% of total capacity, followed by France with 18% and Japan with 12%. [8]

In 2000, six new NPPs with a total capacity of 3 056 MW, went critical or were connected to the grid: three NPPs were added in India and one each in Pakistan, Brazil and the Czech Republic. [16]

One NPP was retired – the Chernobyl NPP unit 3 in Ukraine. During the last decade, the number of NPPs almost stagnated in North America and Western Europe, experienced a low growth in Eastern Europe and expanded only in East Asia, principally in China, the Republic of Korea and Japan. If this trend continues, nuclear power's share of world electricity supply will decline, according to the International Energy Agency's (IEA) World Energy Outlook 2000, from the current 16.3% to about 9% by 2020, even though the total number of NPPs world-wide will be slightly increased or maintained almost at the same level. (See Figure 2-23)

The IAEA's projections also show similar results. Current and new additions in Asia and in countries with economies in transition roughly balance the NPPs being retired. [8]

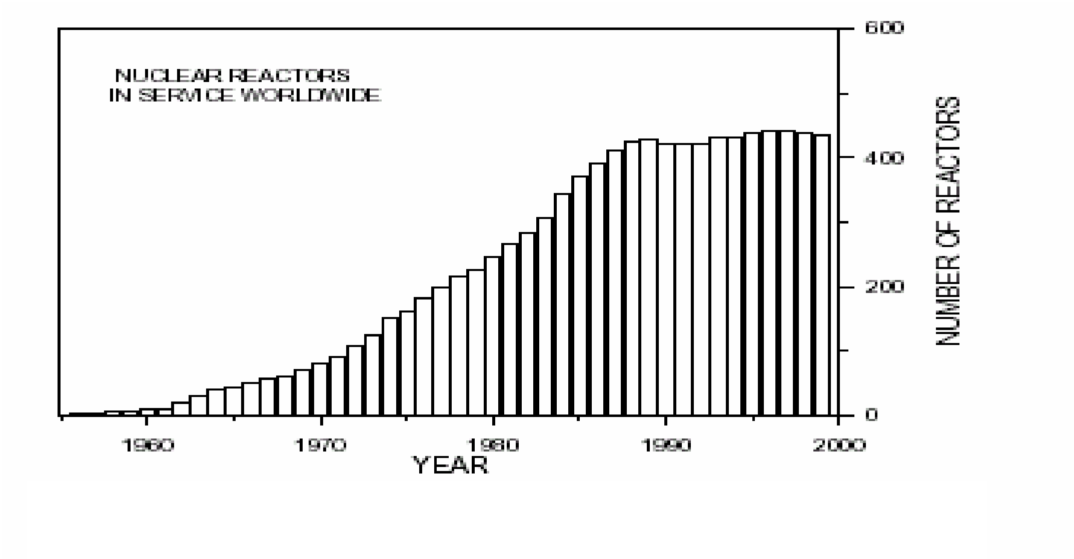


Figure 2-24: Number of Nuclear Power Reactors in service worldwide [17]

Even though nuclear power is generally consistent with sustainable development goals, further expansion of nuclear power faces public concern on nuclear waste management and political issues on the potential proliferation of nuclear weapons. Another challenge is to further strengthen the high level of nuclear safety, while improving the economic competitiveness of nuclear power, in particular, to assure profitability in open and deregulated electricity markets. A number of NPPs in many countries have already made a successful transition from a monopoly, cost-plus environment to a competitive market. This has been achieved through an integrated approach to meeting interdependent safety and economic goals. The experience to date shows that safety, operational and economic performance has improved in both privatized NPPs (e.g. UK) and those where electricity markets are being opened to greater competition (e.g. USA). NPP unit capability factor in the world has improved during the last decade by about 7%, which is equivalent to the building of 28 GW of new NPPs. For the USA, the increase is more than 15% - from an average value of below 70% at the end of 1980's to 86% in 1999 and it is estimated to have been around 88% in 2000. Analysis also shows that the NPPs with the best safety records had the highest availability and the lowest operating costs (which have fallen by as much as 40%). [8]

The long-term outlook for nuclear energy needs to be considered in the broader perspective of future energy needs and environmental impact. In order for nuclear energy to play a meaningful and significant role in the global and long-term energy supply of the 21st century, innovative approaches are required to address concerns about economic competitiveness, safety, waste management and potential proliferation risks. In recent years, there have been a growing number of international, as well as national, initiatives and efforts to examine those issues. [8]

At the national level, development of evolutionary and innovative approaches to advanced nuclear reactor design and fuel-cycle concepts is proceeding, mainly in advanced nuclear countries such as the USA, the Russian Federation, Japan, the Republic of Korea, Canada and France. Worldwide annual expenditures for this effort are currently estimated to exceed more than US$ 2 billion. [8]

At the international level, the IEA, the OECD/Nuclear Energy Agency (NEA) and the IAEA have, since early 1999, jointly reviewed worldwide ongoing R&D efforts on innovative reactor designs and have identified options for collaboration. The US DOE inaugurated in January 2000 a new R&D program, the so called "Generation IV" program and formulated the "Generation IV International Forum" (GIF), in which around 10 countries are invited to participate as members with two international organizations (IAEA and OECD/NEA) as observers. In September 2000 at the UN Millennium Summit, the President of the Russian Federation called for interested countries to pool their efforts and join in an international project, to be led by the IAEA, for developing innovative nuclear power technology to further reduce nuclear proliferation risks. Against this background and taking account of its unique and global mandate in dealing with nuclear technology, safety and safeguards matters together, the IAEA established the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) to be implemented initially for two years from early 2001, mainly to focus on the identification of selection criteria and the development of methodologies and guidelines for comparing different innovative concepts and approaches, and to determine user requirements. All interested Member States are invited to participate in INPRO, which is designed to complement other initiatives such as the US GIF. [3]

In conclusion, nuclear power alone may not ensure secure and sustainable electricity supply world-wide, nor may it be the only means to meet the Kyoto Protocol regarding global reduction of greenhouse gas emissions, but it should have an important role in both aspects through technology advancement and innovations. The challenge for reviving the nuclear power option in the 21st century is to address public and political concerns on economic competitiveness, nuclear safety, nuclear waste management and non-proliferation. [8]

2.6. ENERGY AND ENVIRONMENT IN THE WORLD

Recently, environmental problems resulting from energy production, conversion and utilization have caused increased public awareness in all sectors of the public, industry and government in both developed and developing countries. It is predicted that fossil fuels will be the primary source of energy for the next several decades. Growing evidence of environmental problems is due to a combination of several factors, since the environmental impact of human activities has grown dramatically because of the sheer increase of world population, consumption, industrial activity etc. Achieving solutions to the environmental problems that we face today requires long-term potential actions for sustainable development. In this regard, renewable energy resources appear to be one of the most efficient and effective solutions. That is why there is an intimate connection between renewable energy and sustainable development. The risk of climate change due to emissions of carbon dioxide from fossil fuels is considered to be the main environmental threat from the existing energy system. Other environmental problems are acidification and dispersion of metals originating from fossil fuels. Fossil fuels supply a large part of the total primary energy use in the world, about 75%. Shreshtha and Timilsina have studied CO2, SO2 and NOx emissions in the power sectors for selected Asian economies. As the coal quality deteriorates, the greenhouse emission index increases. Supplies of such energy resources as fossil fuels (coal, oil, natural gas) and nuclear fuels (uranium and thorium) are generally acknowledged to be finite, but other energy sources such as solar, hydropower, biomass and wind are generally considered renewable and, therefore, sustainable over the relatively long term. [18]

The United States International Trade Administration (USITA) estimates that four sub sectors of the pollution control equipment market will grow most rapidly in coming years: (1) municipal water treatment and waste water, (2) non-marine related hazardous wastes, (3) non-industrial air pollution and (4) solid waste disposal. In addition, the USITA projects rapid growth in recycling and waste-to-energy markets. [18]

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), agreed to in December 1997, marks an important turning point in efforts to promote the use of renewable energy worldwide. Since the original Framework Convention was signed at the Earth Summit in Rio de Janeiro in 1992, climate change has spurred many countries to increase their support of renewable energy. Even more ambitious efforts to promote renewable energies can be expected as a result of the Kyoto pact, which includes legally binding emissions limits for industrial countries, and for the first time, specially identifies promotion of renewable energy as a key strategy for reducing greenhouse gas emissions. [18]

The Regulation on Environmental Impact Assessment (EIA) was issued in 1993 and prescribes administrative and technical principles. Under the Regulation on Hazardous Waste Control (1995) ash and slag from coal-.red power stations and gypsum from FGD plants are solid wastes, and the Ministry of Environment defines the rules. The Regulation on Noise Control was brought into force in 1986. The Regulation and Control of Harmful Chemical Substances and Products were issued in 1993 to implement programs, policies and principles of legal, technical and administrative control of dangerous chemicals. The General Public Health Law has applied since 1930. Large combustion systems, such as thermal power stations, are in the first rank of no hygienic workplaces under the regulation. [18]

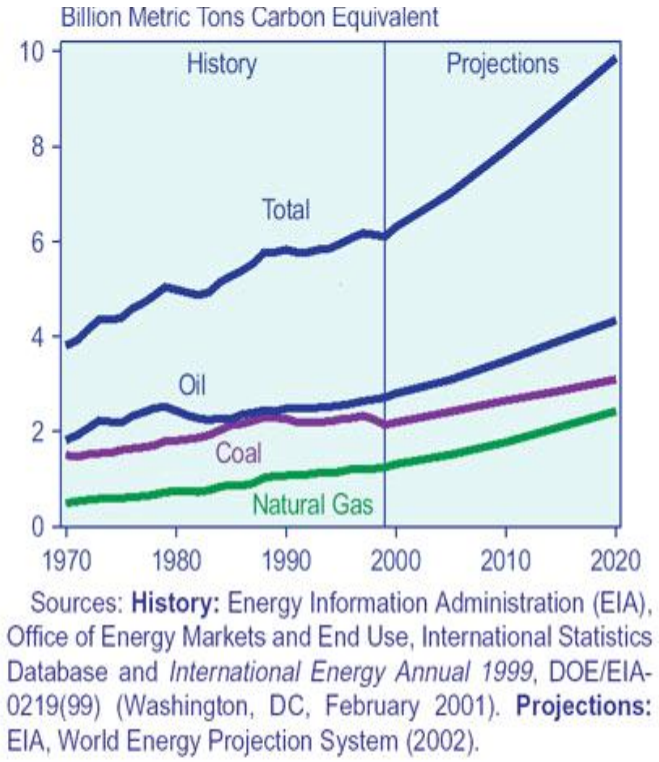


Figure 2-25: World Energy Related Carbon Dioxide Emissions by Fuel Type, 1970-2020 [3]

From Figure 2-24 one can see estimation of CO2 emissions for the near future up to 2020. Although it has been known for more than a century, the possibility of climate warming associated with the combustion of fossil energies has only focused attention in the last ten years, since scientists demonstrated the first tangible effect of this warming and alerted public opinion and the governments about the risks of a climatic upheaval. [17]

The issue of global warming is becoming a major and unavoidable element of world energy policy. Today, about 29 billion tones of CO2 are released into the air annually by human activities, including 23 billion from fossil fuel burning and industry, causing a rapid and disturbing increase in its atmospheric concentration [17]

The increased use of natural gas offers reduced emissions and significant environmental benefits now – locally, regionally and globally – and fulfills an important energy transition role as we look towards the future.

As the global community moves towards a less carbon-intensive energy future, it is important to recognize that natural gas occupies a unique and strategic position in the hierarchy of energy resource options.

Unlike coal and oil, natural gas has a higher hydrogen/carbon ratio and emits less carbon dioxide for a given quantity of energy consumed. However, to fully understand the greenhouse gas profile of any fuel source, it is important to look at its total lifecycle: all of the emissions associated with the fuel, including emissions from initial extraction, processing and delivery as well as those from its final combustion.

Table 2-3: Comparison of Air Pollution from the Combustion of Fossil Fuels (kilograms of emission per TW of energy consumed) [3]

	Natural Gas	Oil	Coal
Nitrogen Oxides	< 43	< 142	< 359
Sulfur Dioxide	< 0.3	< 430	< 731
Particulates	< 2	< 36	< 1333

In the natural gas industry, greenhouse gases are emitted as a result of:

- Processing and compression of the gas;
- Fugitive emissions (unintended losses of gas during transmission and distribution);
- Blow downs (the deliberate release of gas during maintenance operations);

- The combustion of natural gas during day-to-day operations (i.e. for vehicle use, heating).

The World Energy Outlook 2002, which sets out the International Energy Agency's latest energy projections to 2030, depicts a future in which energy use and CO2 emissions continue to grow. These projections based on current policies show fossil fuels continuing to dominate the energy mix, with global energy-related CO2 emissions in 2030 reaching 38 billion tones. [2]

The geographic location of new emissions will shift dramatically, from the industrialized countries to the developing world as seen from Figure 2-26. The developing countries' share of global emissions will jump from 34% now to 47% in 2030, while the OECD's share will drop from 55% to 43%. China alone will contribute a quarter of the increase in CO2 emissions, or 3.6 billion tones, bringing its total emissions to 6.7 billion tones per year in 2030. Even then, however, Chinese emissions remain well below those of the United States. [19]

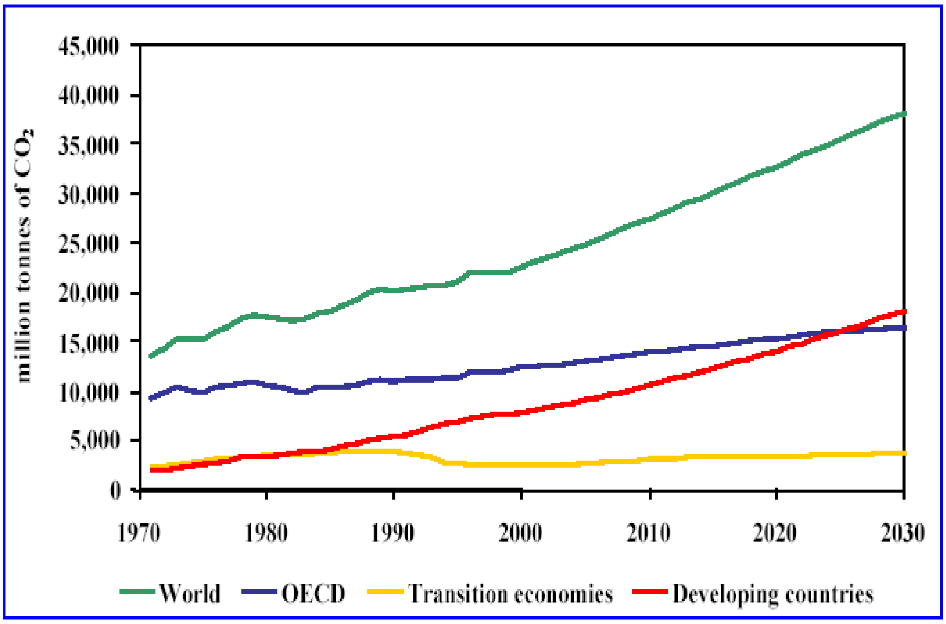


Figure 2-26: Energy-Related CO2 Emissions by Region [19]

In an Alternative Policy Scenario, implementation of policies that are under consideration in OECD countries (the European Directive on renewable, for example) would reduce CO2 emissions by some 2,150 million tones in 2030, or 16% below the Reference Scenario projections described above. This is roughly equal to the combined emissions of Germany, the United Kingdom, France and Italy today. Energy savings achieved by the new policies and measures and by faster deployment of more efficient technologies would be 9% of projected demand in the Reference Scenario in 2030. CO2 savings would be even bigger, because of the additional impact of fuel switching to less carbon-intensive fuels. [19]

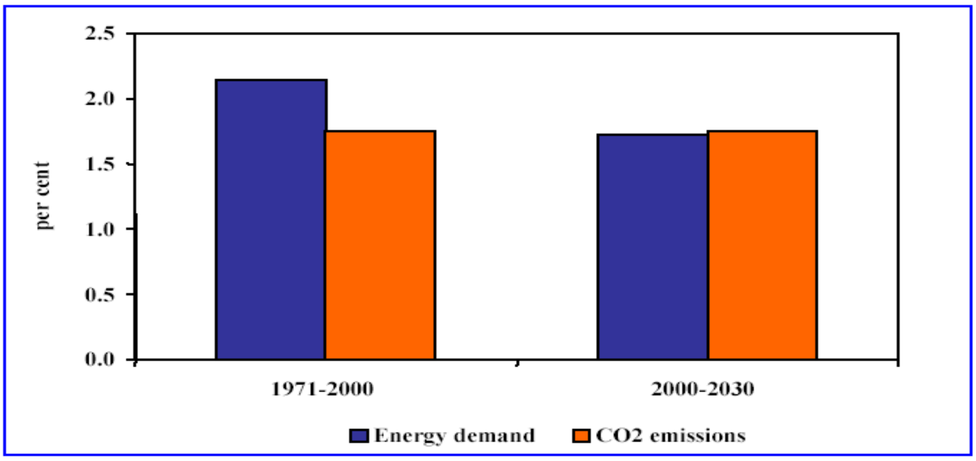


Figure 2-27: Average Annual Growth Rate in World Energy Demand and CO2 Emissions [19]

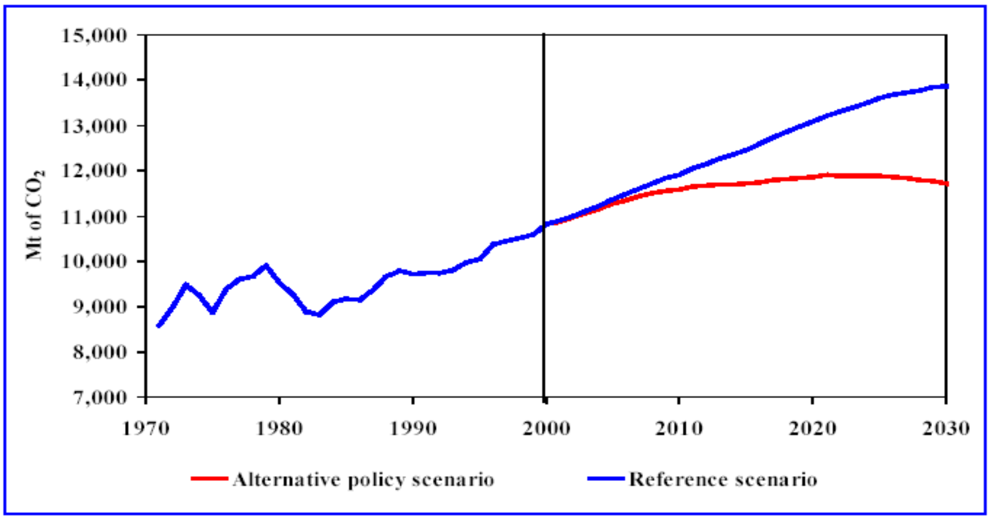


Figure 2-28: Total OECD CO2 Emissions in the Reference and Alternative Policy Scenarios [19]

The biggest reduction in CO_2 emissions in the Alternative Policy Scenario would come from power generation, because of the rapid growth of renewable and the savings in electricity demand. Even under the Alternative Policy Scenario, the three OECD regions would still not individually reach their targets under the Kyoto Protocol. Because of the slow pace at which energy capital stock is replaced, CO_2 savings in the early years would be relatively small, only 3% by 2010. However, “emissions credits” could allow the target to be met in aggregate. The Alternative Policy Scenario projections show a marked reduction in import dependence in the major energy-importing regions. In 2030, OECD gas demand would be 260 billion cubic meters, or 13%, below the Reference Scenario. The percentage fall in imports would be even greater. The reduction in EU gas imports by 2030 would be equivalent to current imports from Russia and Norway. The savings in OECD oil demand would reach 10%, or 0.73 million cubic meters per day. [19]

3. ENERGY IN TURKEY

3.1. INTRODUCTION

Energy is essential to economic and social development and improved quality of life in Turkey as in other countries. Energy is considered a prime agent in the generation of wealth and also a significant factor in economic development. Energy is one of Turkey's most important development priorities. Rapid increases in domestic energy demand have forced Turkey to increase its dependence on foreign energy supplies and to face the prospect of a severe energy shortage in the 21st Century.

Turkey maintains strong economical and political ties to the West, including membership in the Organization for Economic Cooperation and Development (OECD), a Customs Union with Europe and NATO, while simultaneously occupying a position as a leading Muslim nation. In addition, Turkey has strong historical, ethnic and linguistic ties to Central Asia's Turkish peoples. [18]

It is quite certain that globalization is just one of the results of the information revolution that we are all witnessing in the world. As the world is becoming a global marketplace, economic factories coupled with historical, cultural and political assets shape a country's role for the next millennium. The central stage of the next millennium, many observers agree, will be Eurasia. Given the trends in production, communication and information technologies, Europe and Asia will form an integrated whole, interlinked and interdependent. As you all know, Turkey is at the center of Eurasia. Turkey's geographical location makes it a natural bridge between the energy rich Middle East and Central Asian regions. [6]

Turkey is in the process of industrialization and development. The main element and objective of its national energy policy is to supply high quality, reliable and inexpensive forms of energy to the consumers in a timely manner.

Turkey will play an important role for the next millennium because of the following reasons:

A pivotal country: Turkey is going to be a pivotal country in Eurasia. The importance of diversifying the outlets of energy resources is increasingly being understood. Because Turkey provides one of the most suitable and cost effective outlets for Caspian oil and gas, Turkey will also provide stability in the great energy game. Turkey will also constitute a multimodal transportation backbone for three major continents, reminiscent of the legendary Silk Road.

A terminal rather than a bridge: Turkey will become a terminal rather than merely a bridge. It will be a locus of integration, production-consumption and distribution for the political, economic and cultural flows between the West and the regions to its North, East and South. Goods and ideas will be transformed and consumed in Turkey, as well as distributed and diffused to the rest of the world.

Turkey has dynamic economic development and rapid population growth. It also has macro-economic and especially monetary, instability. The net effect of these factors is that Turkey's energy demand has grown rapidly almost every year and is expected to continue growing, but the investment necessary to cover the growing demand has not been forthcoming at the desired pace.

Table 3-1: 1998-1999 Growth Rates of Turkey [20]

	1999	2000	2005	2010	2020
GROWTH RATE %	-6.4	4.6	6.7	7.7	7.8

In 1999, Gross Domestic Product (GDP) was realized as 196 Billion $, as of 1990 prices. The estimation of the GDP growth rates, which was anticipated by the State

Planning Organization (SPO), is given in Table 3-1. These growth rates which are being used in MAED Model (Model for Analysis of Energy Demand), has been executed for projections of general energy and electricity demand of the country by the Ministry of the Energy and Natural Resources (MENR).

On the verge of a new age, the Information Age, the companies and countries are getting closer to each other more than ever due to the process that we shortly call globalization. The driving force behind globalization has been the reduction of national and regional barriers to trade and foreign direct investment, the liberalization of domestic and international financial markets, major improvement in transport, production and communication technologies, as well as closer links between OECD and non-OECD economies. There is no doubt that the interrelated factors of deeper integration among the world's economies provide potential for steadily increasing economic prosperity. [7]

The region, broadly defined to include Central Asia, the Caucasus and the Black Sea countries, attracts increasing attention not only because it constitutes one of the world's most potentially important energy-producing regions, but because it is also a crucial trade and transport corridor linking East and West. Turkey has borders with Greece, Bulgaria, Romania, Georgia, Armenia, Azerbaijan, Iran, Iraq and Syria. Its total area is about 779 452 km^2, about 97 % of which is situated in Asia and 3 % in Europe. Four seas, the Marmara, the Aegean, the Mediterranean and the Black Sea surround Turkey. Total coastlines amount to about 8 333 km. [3]

The prospective weight of the East is expected to increase in the global political, economic and environmental scene and the performance of the western economies may increasingly depend on the policies and performances of the new actors.

Turkey's high rate of economic growth experienced during much of the 1990s, besides resulting in booming industrial production, also led to higher levels of energy consumption, imports, air and water pollution, and greater risks to the country's environment. In addition, increased oil exports from the Caspian Sea region to Russian and Georgian ports and across the Black Sea has led to increased oil tanker traffic (and risks of an accident) through the narrow, winding Turkish Straits (including the Dardanelles, Marmara Sea, and Bosporus Straits). [20]

The Turkish economy has been growing very fast, especially after the 1980's. Despite limitations in domestic resource availabilities, primary and secondary energy demand in Turkey is growing very rapidly, parallel with her industrialization efforts. The annual rate of increase is around 8-10 percent. Today the world has changed dramatically and so have the policies and priorities of Turkey. The global situation now calls for less government intervention and ownership in some sectors, which have been mainly dominated by the state. In Turkey, energy and natural resources like oil and coal are among these sectors where the State is increasingly becoming reluctant to get involved in the operation and maintenance of these installations. In other words, the State is trying to withdraw itself from these sectors, as it should.

The Turkish energy policy is mainly concentrated on assurance of energy supply, reliably, sufficiently, timely, in economic and clean terms and in a way to support and help to realize the economic and social development targets. Diversification of sources and products to maintain energy security has gained more importance. And lastly liberalization of the energy sector and privatization activities of increased efficiency and to lower cost, and also to attract private capital to energy sector is another principle of our policy. Turkey aims to increase the efficiency of its existing power stations and distribution systems and she needs additional capacity. In order to achieve these targets, more private capital participation is expected.

The key elements of Turkish energy policy may be summarized as follows: [20]

- Meeting the medium and long term energy demand through public, private and foreign capital;
- Developing existing local resources;
- Fuel and source diversification and avoiding dependencies on any single fuel or country;

- Securing finance for energy projects by implementing the BOT, BO and Transfer of Operating Right (TOOR) models;
- Accelerating privatization activities in the energy sector;
- Increasing the efficiency, quality and volume of local resources for energy production;
- Implementing energy saving practices;
- Adding new renewable sources as soon as possible to the energy supply cycle;
- Protecting the environment and the public health in the production of energy;
- Planning and realizing energy production, transmission and distribution activities more efficiently.

3.2. ENERGY PRODUCTION AND CONSUMPTION IN TURKEY

3.2.1. Energy Production

Turkey has limited reserves of oil and natural gas, but proven reserves of lignite in the order of 8.4 billion tones. Combustible renewable, especially wood, and the country's water sources, especially the Euphrates and Tigris rivers, are other important indigenous energy resource. [7]

Combustible renewable supplied 9.7%, and hydro 4.2%. Overall, the share of Turkey's energy production in TPES was 35%, down from 64% in 1973 and 49% in 1990. This decrease is due mainly to the increase in oil imports to almost 3.5-fold their 1973 value and 40% of TPES in 1999. Slightly less than half of oil TFC occurs in transport; there is still sizeable oil use in industry, households and power generation. [7]

Table 3-2 shows the primary energy production in Turkey.

Table 3-2: Primary Energy Production in Turkey (Thousand tones oil equivalent) [7]

YEARS	OIL	NATURAL GAS	LIGNITE	HARD COAL	OTHERS	TOTAL
1982	2,450	41	4,652	2,445	9,516	19,104
1983	2,313	7	5,378	2,159	9,356	19,213
1984	2,191	36	6,498	2,216	9,203	20,144
1985	2,216	62	8,212	2,199	9,014	21,703
1986	2,514	416	8,949	2,151	9,204	23,234
1987	2,762	270	9,827	2,111	9,783	24,753
1988	2,692	90	8,603	2,212	10,670	24,267
1989	3,020	158	10,564	2,027	9,645	25,414
1990	3,903	193	9,524	2,080	9,423	25,123
1991	4,674	185	9,117	1,827	9,335	25,138
1992	4,495	180	10,299	1,727	9,707	26,408
1993	4,087	182	9,790	1,722	10,240	26,021
1994	3,871	182	10,471	1,636	9,899	26,059
1995	3,692	166	10,735	1,319	10,343	26,255
1996	3,675	187	10,876	1,382	10,767	26,887
1997	3,630	230	11,759	1,347	10,721	27,687
1998	3,385	514	12,792	1,143	11,030	28,864
1999	3,087	665	12,242	1,030	10,035	27,059
2000	2,925	631	12,830	1,769	9,438	27,593
2001	2,679	284	12,772	1,255	10,417	27,407

Natural gas imports have also grown significantly in the last half-decade, up to 15% of TPES in 1999. In line with the forecasts of strong energy demand growth, TPES is expected to increase to 298.45 Mtoe in 2020, 4.2 times its 1999 value of 70.33 Mtoe. [7]

Following Figure shows the total energy supply of Turkey between of 1973 to 2020. Coal (lignite) meets the main energy demand of Turkey. Then gas and oil follows the coal.

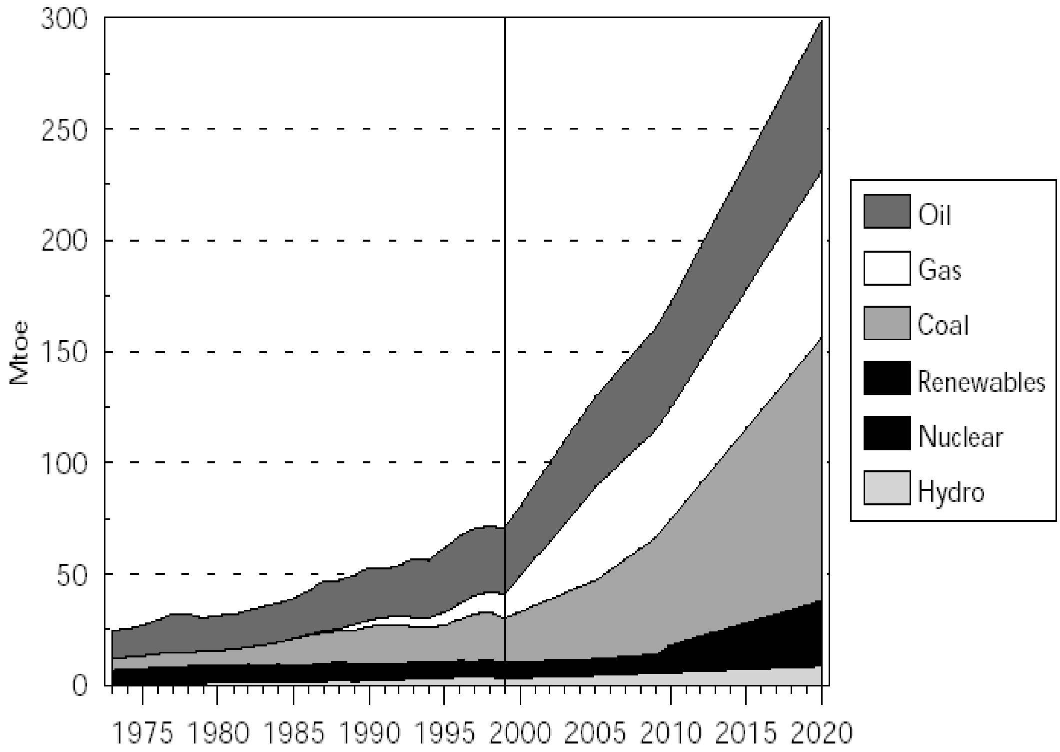


Figure 3-1: Primary Energy Supply, 1973 to 2020 [7]

Following figure shows the energy production by source up to 2020. As seen main energy production of Turkey supplied from coal.

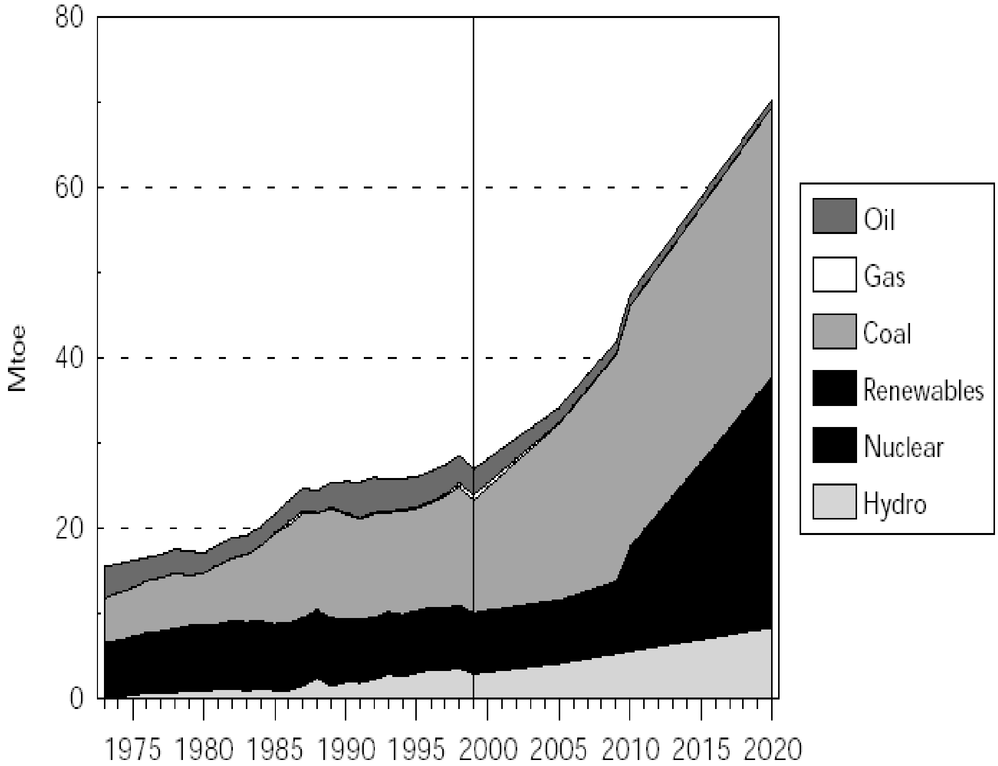


Figure 3-2: Energy Production by Source [7]

3.2.2. Energy Consumption

The level of Turkey's energy consumption is still low relative to similar sized countries, such as France and Germany, with gross inland consumptions of 235 and 339 Mtoe in 1995 and with estimated values of 290 and 350 Mtoe in 2020, respectively. However, Turkey's upward trend may mean it will surpass these countries in the future. Energy use per capita of 1213 kpe (kilogram petroleum equivalent) in 1999 will continue to increase and is estimated to reach 3649 kpe by 2020. In 1998, 38% of Turkey's final energy consumption was used by the industrial sector, 34% by the residential sector, 19% by transportation, 5% by the agricultural sector, and 3% by other sources. The share of the industrial sector in this consumption is expected to continue to grow approximately 9% per year and to reach 49% and 59% in 2010 and 2020, respectively. As Turkey's economy has expanded in recent years, the consumption of oil has increased. This growth in consumption is expected to continue at a rate of about 4.5% per year up to the year 2020. However, the proportion of oil consumption is expected to decrease as compared to natural gas consumption. To illustrate, in 1998, the overall energy consumption was divided into 46% oil, 20% coal and 8% natural gas. These figures are projected to be 29% for oil, 35% for coal and 11% for natural gas by 2020 [21].

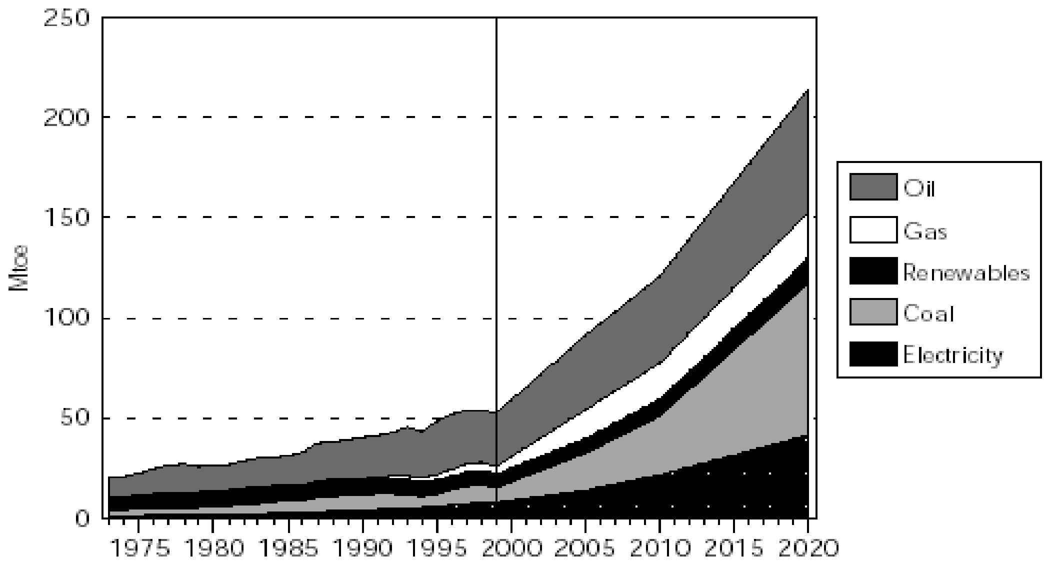


Figure 3-3: Total Final Consumption by Source [7]

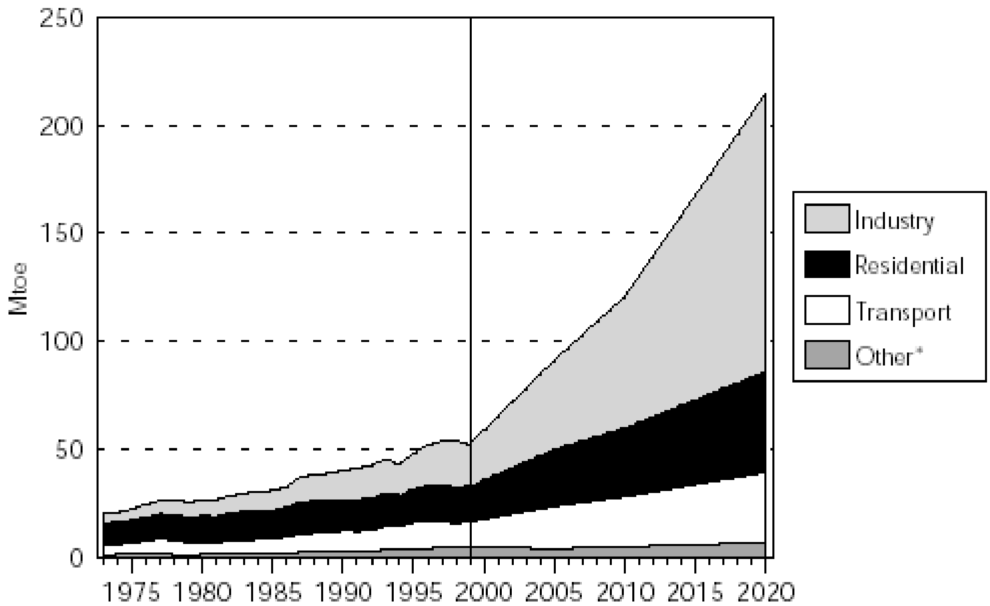


Figure 3-4: Total Final Consumption by Sectors [7]

Table 3-3: Primary Energy Consumption in Turkey (Thousand tones oil equivalent) [7]

YEARS	OIL	NATURAL GAS	LIGNITE	HARD COAL	OTHERS	TOTAL
1982	16,933	41	4,616	3,077	9,639	**34,306**
1983	17,540	7	5,294	3,255	9,501	**35,597**
1984	17,840	36	6,408	3,464	9,499	**37,247**
1985	18,134	62	7,933	3,775	9,263	**39,167**
1986	19,622	416	8,879	3,992	9,259	**42,168**
1987	22,301	669	9,189	4,404	9,996	**46,559**
1988	22,590	1,115	7,932	5,204	10,729	**47,570**
1989	22,865	2,878	10,207	4,722	9,693	**50,365**
1990	23,901	3,110	9,765	6,150	9,706	**52,632**
1991	23,315	3,827	10,572	6,501	9,700	**53,915**
1992	24,865	4,197	10,743	6,243	10,250	**56,298**
1993	28,412	4,630	9,918	5,834	11,051	**59,845**
1994	27,142	4,921	10,331	5,512	10,769	**58,675**
1995	29,324	6,313	10,570	5,905	11,068	**63,180**
1996	30,939	7,186	12,351	5,560	11,999	**68,035**
1997	30,515	9,165	12,280	8,495	10,912	**71,367**
1998	30,349	9,690	12,631	8,921	12,576	**74,167**
1999	33,166	11,740	12,314	7,708	11,775	**76,703**
2000	34,893	14,071	12,830	8,149	9,728	**79,671**
2001	30,721	14,967	13,091	6,972	12,231	**77,982**

3.3. TURKEY ENERGY CONSUME SECTORS

3.3.1. Residential / Commercial

By rapid urbanization and increasing population energy usage will increase in future years. In developing countries, the relatively low consumption of energy is both a cause and an effect of existing development problems. Increased consumption without regulatory controls will only be possible at the high price of a destroyed environment. With respect to 1997 data's 34.5 % of energy is consumed in this area. Besides 30-40 % of electrical energy is used for lightening, and 60-70 % of it is used for machines in our houses. [22] To decrease the energy consumption we must use energy save machines. Isolation is also another factor for houses and for buildings to save energy.

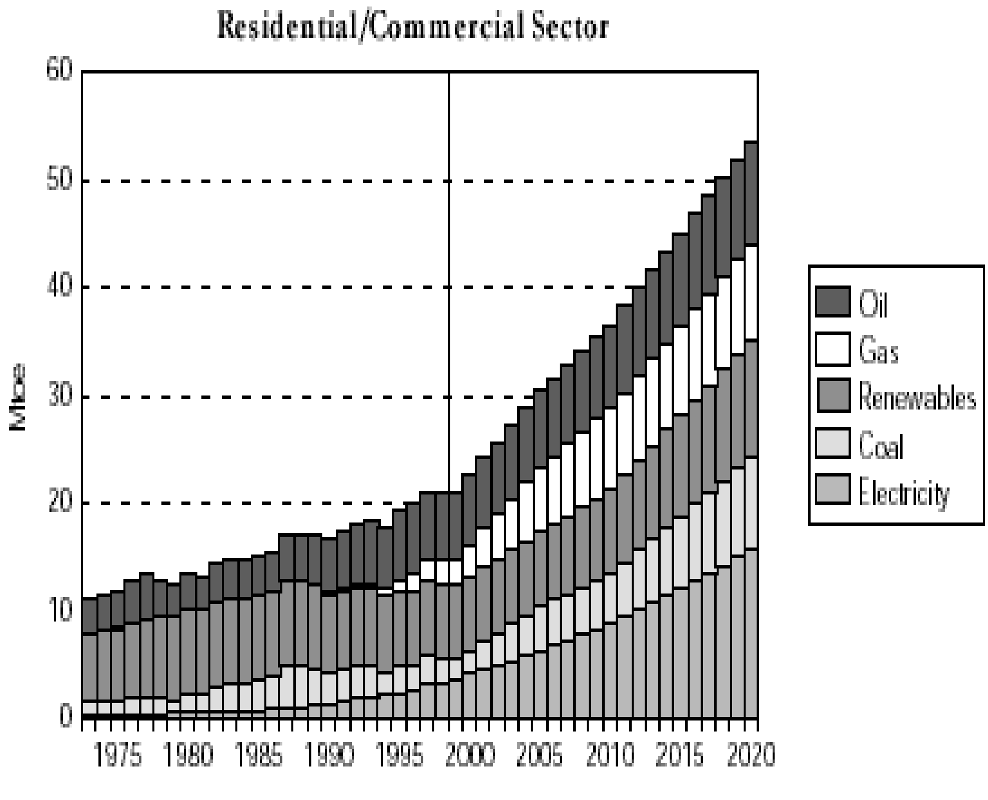


Figure 3-5: Energy Consumption in Residential / Commercial Sector [7]

Electricity, oil and coal are the main energies consumed in residential / commercial sector as seen from Figure 3-5.

3.3.2. Industry

In energy consumption, industry was the first fastest growing sector between 1973 and 1995 with an annual average growth of 6 %. With respect to data in 1997 30.9 % of primary energy is consumed by industry. Electric energy consumption in this sector is 53.2. % [22] To save energy in this area plants must be adapted to new technologies. Over the same period, energy consumption in this sector decreased in Europe. This certainly reflects Turkey's rapid industrialization and her specialization in heavy industries. Final consumption is expected to show acceleration in the future due to the expected rapid increase in these sectors, coupled with the residential / commercial sector. [23] Industry consumed mainly coal and electricity as seen from Figure 3-6.

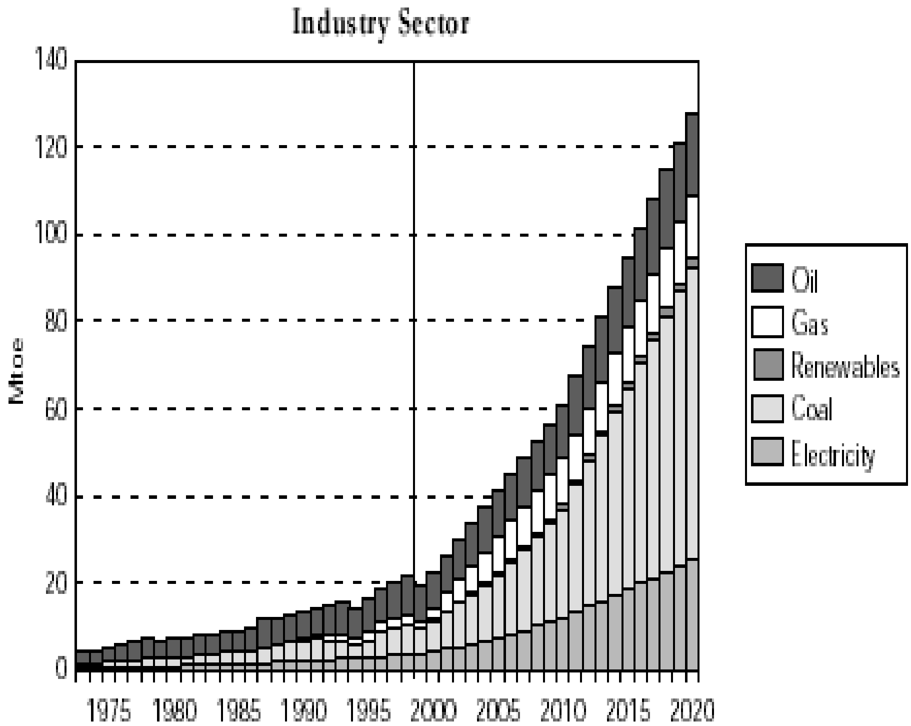


Figure 3-6: Energy Consumption in Industry Sector [7]

3.3.3. Transport

Transport demand has also increased rapidly at an average annual rate of 4.6 % between 1973 and 1995. With respect to 1997 data's 20.6 % of energy is consumed in this area. In Turkey mostly highway is used for transportation of both people and loads. Highways together with 85 % of load transfer do 94 % of passenger transfer. With respect to analysis it was seemed that 22 % of destroyed energy could be saved from highways. To do this firstly traffic problem must be solved in mega cities especially in Istanbul. To use diesel motor vehicles is important for us. Also, we must increase the metro capacity in crowded cities. At the start it can be seemed costly but as time passes it will be comfortable both economically and environmentally. [23]

For instance the number of passenger cars has increased more than tenfold since 1973 and around 85 % of freight transport is made by road. [23]

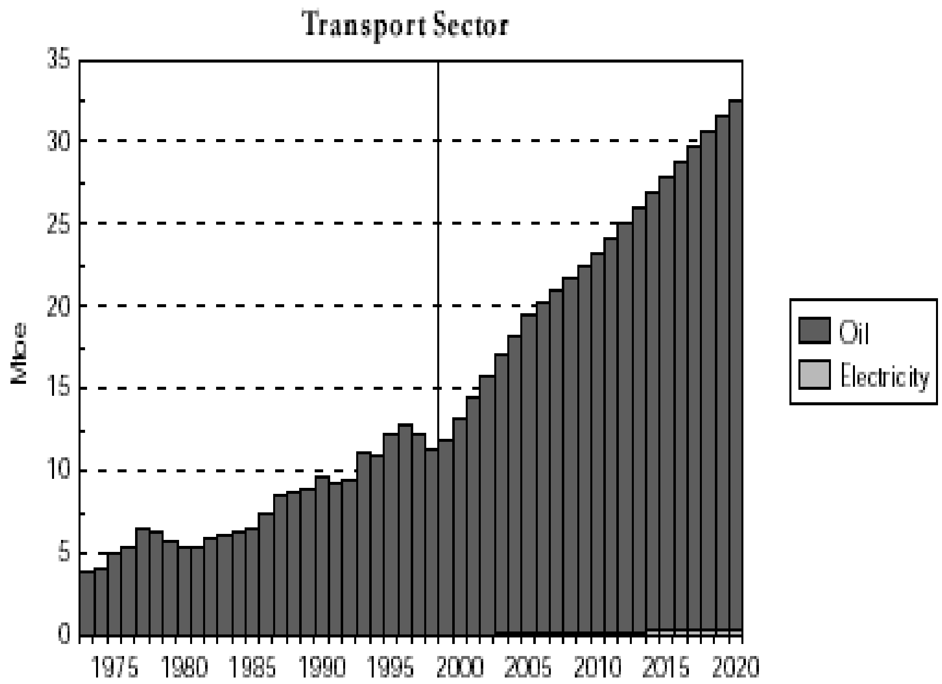


Figure 3-7: Energy Consumption in Transport Sector [7]

With a total of 11.37 Mtoe, transport accounted for 15.7% of TPES and 21.1% of TFC (43% of oil products consumption) in 1998. (See Figure 3-7) Total energy consumption of the transport sector is projected to more than double to 23.26 Mtoe by 2010 and to reach 26.7 Mtoe by 2015. In that year, its share is projected to be about 12% of TPES and 16.5% of TFC. [7]

3.4. ENERGY EXPORT AND IMPORT

Energy is an indispensable factor for the social and economic development of societies. The usage level of electricity is an indication of the economic prosperity of nations. In Turkey, the growing population, industrialization and increasing standard of living has considerably increased the dependence on imported energy. [21]

The rapid growth of demand and the stabilization of energy production have resulted in a quick increase of energy imports in Turkey. Between 1973 and 1995, net energy imports increased nearly 7 % per year. This trend is expected to continue even more quickly in the future. [23]

Table 3-4: Energy Import in Turkey [9]

ENERGY IMPORT (Mtoe)						
	1990	**%**	**2000**	**%**	**2001**	**%**
Oil	23,399	75.6	32,001	56.9	30,678	58.2
Natural Gas	2,964	9.6	13,487	24.0	14,895	28.3
Coal	4,208	13.6	8,744	15.5	5,377	10.2
Coke	0	0.0	506	0.9	366	0.7
Electricity	15	0.0	326	0.6	394	0.7
Total	30,936	100.0	56,280	100.0	52,699	100.0

As seen from the table in 2000, import of oil is 33.22 Mtoe, which is 59.1 % of total energy import; by 13.49 Mtoe natural gas is 24 %. Coal is 16.4 and electricity is 0.6 [24]

According to Ministry of the Energy and Natural Resources future plans energy import between 2000-2025 will be 4,178 Mtoe. [22]

Turkey imports its electricity from Bulgaria, Georgia and Iran as seen from the following table.

Table 3-5: Total Electricity Supply, 1998 [24]

Source	*Generation (GWh)*	*Contribution (%)*
Generator		
TEAS	78,581	70.8
Concessionary Companies	2,299	2.1
Production Companies	2,517	2.3
Autoproducers	10,131	9.3
Affiliated Partnerships	17,494	15.8
Total Generation	111,022	
Imports		
Bulgaria	1,863	
Georgia	459	
Iran	170	
Total Imports	2,492	
Exports		
Azerbaijan	271	
Total Exports	271	
Total Domestic Supply	113,243	

Source: World Energy Council, Turkish National Committee, 1998, TEAS, 1999.

3.5. ENERGY SOURCES OF TURKEY

3.5.1. Hard Coal & Lignite

Turkey has significant coal reserves, especially lignite, but also some hard coal. Turkey has hard coal (anthracite and bituminous) reserves of around 1.1 billion short tons, plus lignite reserves as high as 8 billion short tons. Turkish lignite has low calorific value and high sulfur, dust and ash content. Turkish hard coal is of low grade but of coke able or semi-coke able quality. Lignite is found almost all regions of the country. The most important reserves are in the Afşin-Elbistan, Muğla, Soma, Tunçbilek, Seyitömer, Beypazarı and Sivas regions. Around 40% of Turkey's lignite is located in the Afsin-Elbistan basin of southeastern Anatolia, while hard coal is mined only in one location -- the Zonguldak basin of northwestern Turkey. The fully state-owned Turkish Hard Coal Enterprise (TTK) operates this mine. [22]

Besides Antalya-Kemer and Diyarbakır-Hazro regions have small hard coal sources, which have 20 million reserves. [22]

Table 3-6: Turkey Hard Coal Reserves (Million tons Equivalent) [22]

PLANTS	APPEAR	PROBABLE	POSSIBLE	TOTAL	Water %	Ash %	S %	AID Kj/kg
ZONGULDAK ARMUTÇUK	19165	11509	10185	41309	6	9	0.9	6275
ZONGULDAK KOZLU	63400	55926	47975	167301	5	12	0.8	6740
ZONGULDAK ÜZÜLMEZ	161135	94342	74020	329497	5	12	0.8	6740
ZONGULDAK KARADON	151442	153752	117144	422338	5,5	13	0.8	6710
BARTIN AMASRA	32799	133304	---------	166103	7	14	1,5	5840
TOTAL	428391	448833	249324	1126548				

Turkey produced 74 million short tons (Mmst) of coal (mainly lignite) in 2000, and consumed 91 Mmst. It is used mainly for power generation. [22]

The fully state-owned enterprise Turkish Lignite Enterprise (TKI) was responsible for about 56% of lignite production in 1998. Private companies produce about 10% of the total. The remainder is produced by two opencast lignite mines that are owned by the state-owned electricity company. Between 1990 and 1999, hard coal imports rose by more than 6% per year. Low-sulfur coal is imported for residential use and in order to meet the requirements of the iron and steel industry. Hard coal imports for heating purposes have decreased because of the increasing use of natural gas in the residential sector. Total coal supply in 1999 was 20.1 Mtoe. In 1999, coal supply amounted to 28.5% of TPES and coal consumption to 14.2% of TFC. The power sector accounts for the largest coal demand and consumes mainly lignite. Almost 80% of lignite production is used in power plants. In contrast, less than 9% of hard coal supply is used for power generation. [7]

Industry is the main consumer of coal. And it is expected in future to increase still. To overcome this problem usage of coal in industry must be examined. New technologies must be introduced to save the waste energy. Since, one can see that the most of waste energy is from the industry again. Between 1993 and 1999, TTK underwent an austerity program involving a drastic decrease in the workforce, the postponement of new investments, and the depreciation of most of the capital stock. So, TTK is not a competitive coal producer. The government should carefully revise its expectations of high coal demand growth to make them more realistic. The commendable strategy of reducing subsidies and overstaffing in the coal industry should not be abandoned. Since energy is undergoing reform the strategy must be in a way to yield benefits and enable coal industry to survive. [7]

Turkey hard coal reserves couldn’t meet the needs. It is expected to import 6,6 million tones of hard coal in 2010 and 41,9 million tones in 2020 with respect to the planning of The Ministry of Energy and Natural Resources. To overcome this problem more research must be done to find new coal plants. Because of the economical problems MTA do not make any investment for researches. [7]

It can be best to be done an arrangement with MTA & Government on this topic. Also new coal search technologies must be used to increase the efficiency. [22]

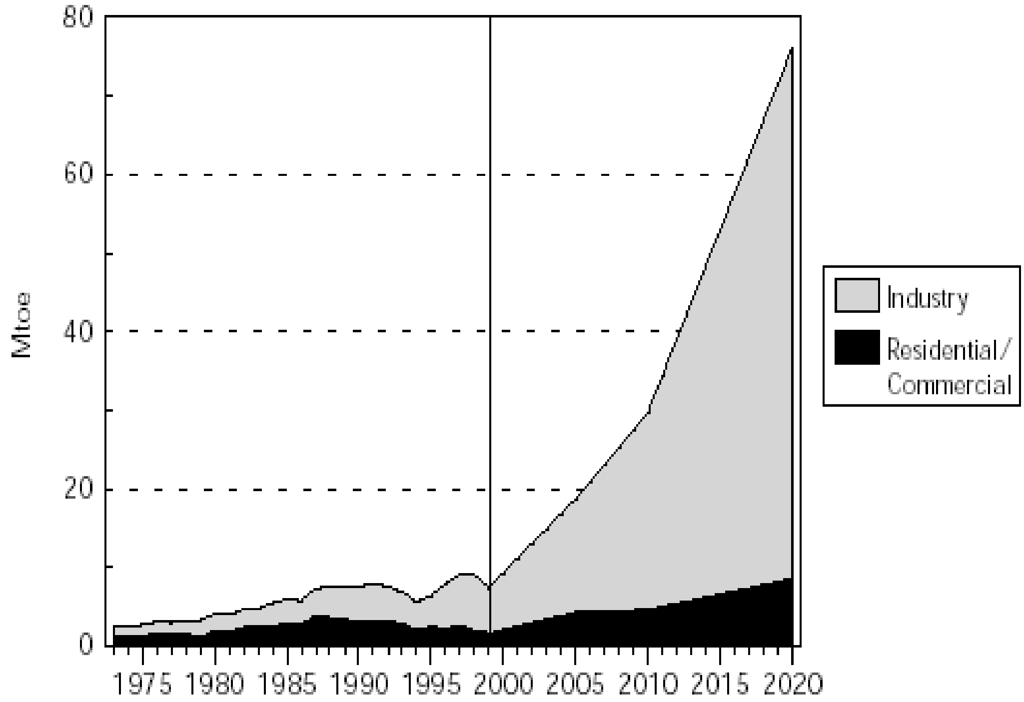
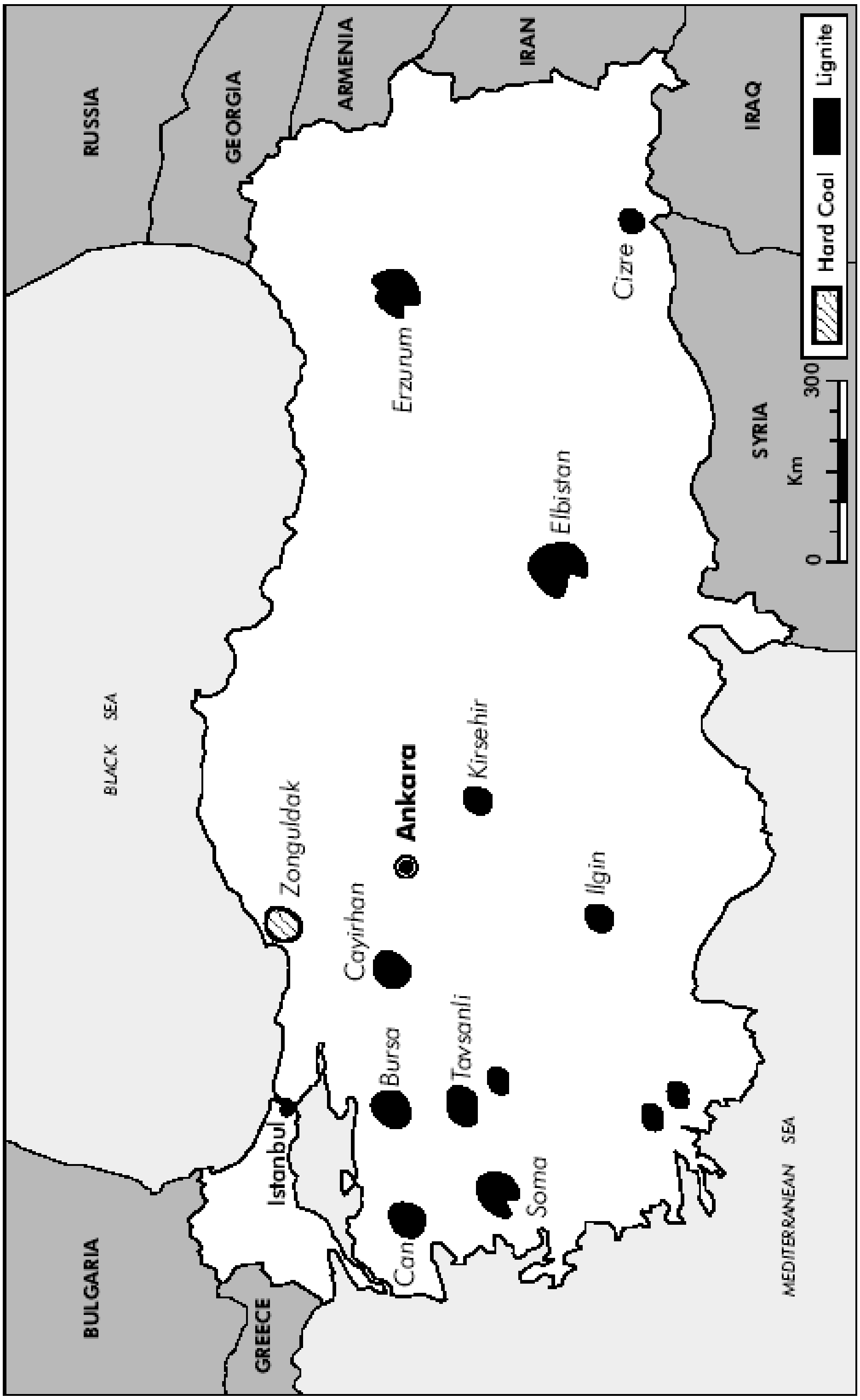


Figure 3-8: Coal Consumption by Sector, 1973 to 2020 [7]

In early 2000, TTK hired 4,012 new workers for underground mining. The stated purpose was refreshment of the workforce especially with respect to skills. Of this number, 3,012 were direct surface workers. The earlier workforce cuts had led to the reduction of coal output to just under 2 million tones in 1999. Since the government plans to expand hard coal production, it considered new hiring and upgrading of skills to be necessary. [7]

The government is considering privatization of TTK and TKI in the medium to long term in the framework of its long-standing privatization program. The government also had plans to transfer the operating rights of the most profitable lignite mines to the private sector, especially those owned by TEAS, which deliver coal to mine mouth power plants. [7]



Sources: TKI and General Directorate of Mineral Research and Exploration of Turkey.

Figure 3-9: Coal Deposits in Turkey [7]

3.5.2. Oil

In general, Turkish oil consumption has increased in recent years, although the country's recent economic recession plus price deregulation measures (which have raised the price of many oil products) since June 1999 appear to have interrupted this trend for the time being. During the first four months of 2002, for instance, it appears that Turkish oil consumption and imports were down approximately 60,000 barrels per day (bbl/d) (9538 cubic meter) from the same period in 2000. In the long run, Turkish oil demand and imports are expected to resume steady growth. Oil provides around 42% of Turkey's total energy requirements, but its share is declining (as the share of natural gas rises). Around 90% of Turkey's oil supplies are imported, mainly from the Middle East (Saudi Arabia, Iran, Iraq, and Syria) and Russia. Turkey's port of Ceyhan is a major outlet for Iraqi oil exports, with pipeline capacity from Iraq about 1.2 million bbl/d. [22]

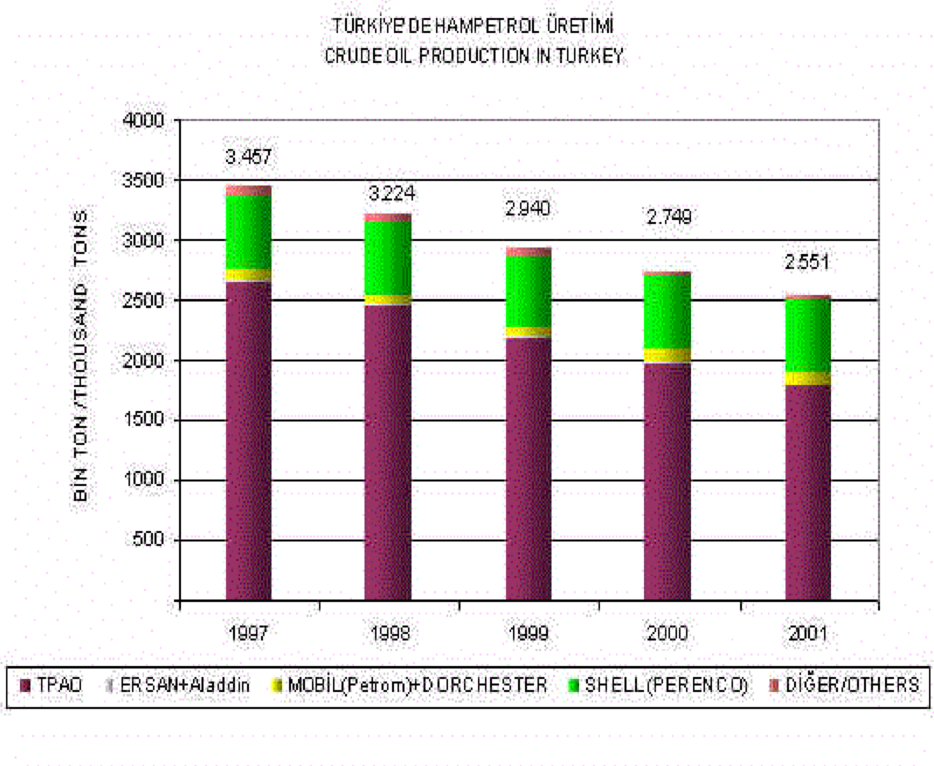


Figure 3-10: Crude Oil Production in Turkey [11]

In 1954, liberalized petroleum legislation opened up oil exploration to private companies both domestic and foreign. These changes in the Government's petroleum policy were embodied in the Petroleum Law numbered 6326, which today governs all oil exploration and exploitation activities. In the same year, Law numbered 6327 established the Turkish Petroleum Corporation (TPAO), a national petroleum company. TPAO took over from MTA the exploration and exploitation of the petroleum resources of the country. [11]

Turkey's oil production is accounted for primarily by three companies -- the Turkish State Petroleum Company (TPAO), and foreign operators Royal Dutch/Shell (Shell) and Exxon Mobil. Smaller companies include Petrol of Romania (produces around 413 cubic meter/day in the Selma block) and Aladdin Middle East (76.3 cubic meter/day in Siirt and Gaziantep). TPAO alone accounts for about 80% of the country's total oil output (currently around 8903 cubic meter/day, down from 14,308 cubic meter/day in 1991). Turkish oil fields are generally small, and scattered around the country. Oil fields in the country's southeast (specifically the Hakkari Basin, Turkey's main oil producing area) are generally old and expensive to exploit. In addition to the Hakkari Basin, Turkey contains oil prospects in its European provinces, in the Black Sea shelf region, and in other oil basins in southern and southeastern Turkey. Potential oil reserves in the Aegean Sea have not been explored due to conflicting Greek claims over the area. [11]

For several years, it has been reported that as much as 15,898 cubic meter/day of oil and oil products were being smuggled into Turkey via tanker truck, mainly from northern Iraq. This "border trade" costs the Turkish treasury millions of dollars in lost tax revenue. In March 2000, Turkey's National Security Council (MGK), concerned at lost tax revenues as well as harm to state companies Petrol Ofisi (Poaş, the country's largest fuel retailer) and Tüpraş (which controls 85% of Turkey's refining capacity), imposed controls on petroleum product smuggling from Kurdish areas of northern Iraq, Iran, Georgia, the Azeri enclave of Nakhchevan, Syria, and Bulgaria. A previous crackdown on smuggling in May 1999 reportedly had little effect. On September 18, 2001, Turkey reportedly stopped the diesel oil trade at the

Habur border gate with Iraq, but allowed it to restart on January 7, 2002. In May 2002, a major petroleum market reform bill was sent to Turkey's parliament. [11]

If enacted, the law will liberalize pricing of oil and oil products as well as integrate pipeline, refining, and distribution functions. Tüpraş and Poaş are to be privatized as well. [3]

The government expects oil consumption to increase fastest in the transport sector, leading to a near tripling of demand by 2020. Industrial demand is also expected to more than double in 2020. Following figure shows the past oil consumption with the future demand.

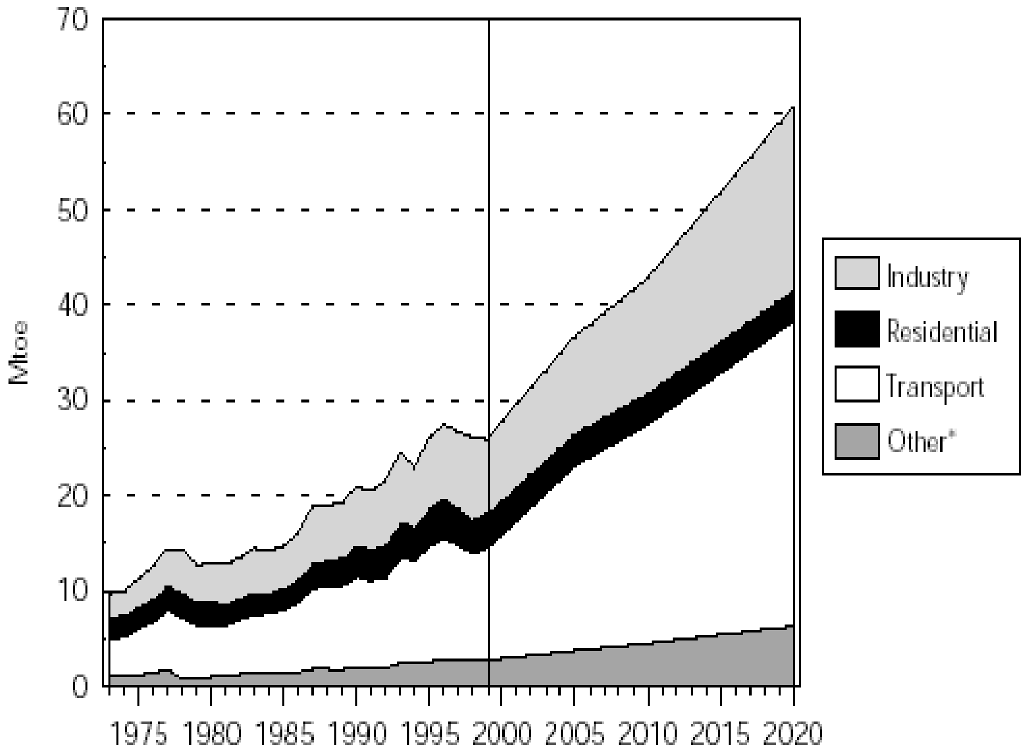


Figure 3-11: Final consumption of Oil by Sector, 1973 to 2020 [7] (* includes commercial, public service and agricultural sectors.)

Turkey’s oil reserves are minor. It covered approximately 10% of its primary oil demand through its own production, remain had to be imported. There are five oil refineries in Turkey with a total capacity of 32 million tones. Four of they are owned by the state owned company Tüpraş: İzmit, İzmir, Kırıkkale and refineries. The refining capacity of Tüpraş is 27.6 million tones per year, or 86 % of Turkey's total refining capacity. [7]

The fifth refinery is owned by the private company ATAŞ and is situated near Mersin on the Mediterranean coast. Ataş is a joint venture of Mobil (51%), Shell (27%), BP Amoco (17%) and the local company Marmara Petroleum (5%). [7]

Table 3.7 explains the oil retailers and their share in the Turkish market.

Before 1990, Iraq was the largest oil supplier. In 1990, after the UN sanctions against Iraq, Turkey increased its crude oil purchases from Saudi Arabia and Iran. Beginning in December 1996, limited oil imports from Iraq were once more allowed, under UN Resolution 986. From that time, Turkish oil imports from Iraq have continued and even grown slightly. Table 3-8 shows Turkish crude oil imports by country of origin.

Table 3-7: Oil Retailers and their share in the Turkish Market, 1999 [7]

Company	*Sales (million tonnes)*	*Market Share (%)*	*Number of Sales Outlets*
Petrol Ofisi (POAS)	7.0	40	5,259
Turcas	1.3	7	769
Shell	1.8	10	572
BPAO	3.1	17	926
Total	0.9	5	339
Selyak	0.5	3	135
Opet	1.4	8	439
Tu-Ta *	0.1	1	166
Petline	0.3	2	179
Turkuaz	0.3	2	186
Bölünmez	0.1	1	58
Aytemiz	0.6	4	112
Delta**	..	..	10
Total	**175.4**	**100**	**9,150**

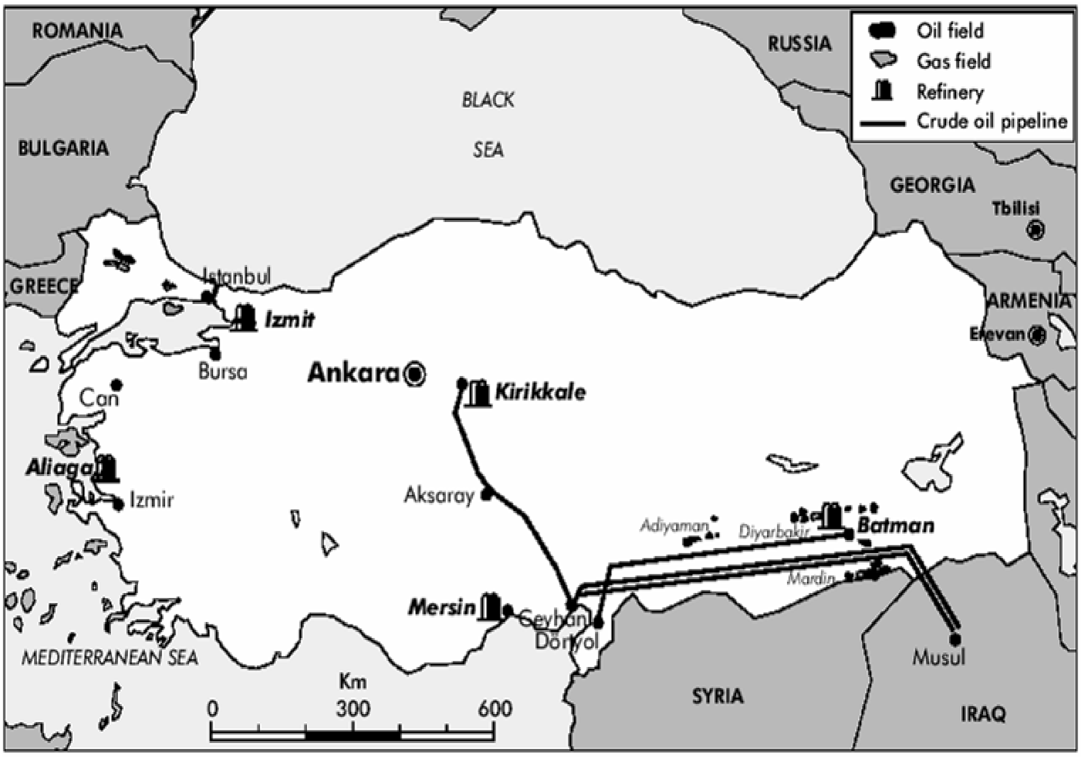
* TABAS and TURCAS merged their downstream activities in 1999.

** Delta was established in 1999.

Table 3-8: Turkish Crude Oil Imports by Country of Origin (Mtoe) [7]

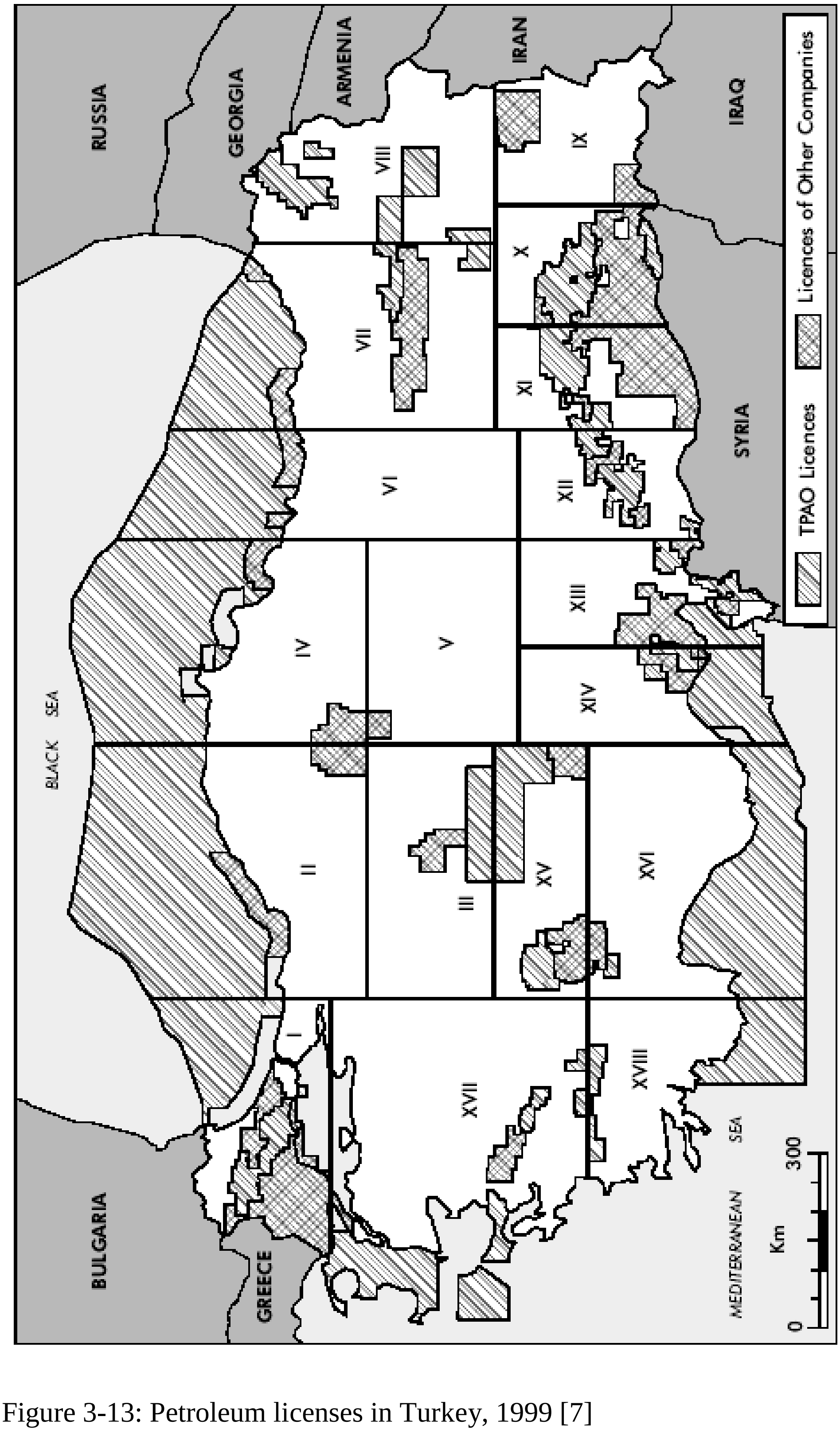
Country of Origin	*1990*	*%*	*1998*	*%*	*1999*	*%*
Saudi Arabia	2.9	14.4	5.4	22.8	3.6	15.7
Iraq	6.8	33.8	3.1	13.1	4.8	20.9
Iran	3.5	17.4	4.5	19.0	4.8	20.9
Libya	2.6	12.9	3.3	13.9	3.6	15.7
Russia	2.0	10.0	0.9	3.8	2.5	10.8
Syria	0.3	1.5	2.2	9.3	2.1	9
Other	2.0	10.0	4.3	18.1	1.6	7.0
Total	**20.1**	**100.0**	**23.7**	**100.0**	**23**	**100.0**

Turkey's three main known petroleum reserves lie near Hamitabat in Thrace in the European part of the country and in the south-eastern Anatolia near Adıyaman and Diyarbakır/Batman as shown in the following figures: [7]



Source: BOTAS.

Figure 3-12: Petroleum Reserves and Infrastructure in Turkey, 1999 [7]



Source: TPAO.

Figure 3-13: Petroleum licenses in Turkey, 1999 [7]

3.5.3. Natural Gas

Turkey has limited gas resources. The country's total natural gas reserves are estimated at 19.2 bcm and recoverable gas at 13.1 bcm. There are 14 gas fields, two of which have been producing since the 1970s. These fields include: Hamitabat, Umurca, Karacaoğlan, Karacali, Değirmenköy, Kuzey Marmara (offshore), Silivri, Çamurlu, Ardıç, Kumrular, Havrabolu-Gelindere, Tekirdağ Sig and Derin-Barbes. The Çamurlu field is in the South-eastern Turkey. All the others are in Thrace. TPAO owns the first ten fields in the above list. [22]

Turkey consumed 14.72 bcm of natural gas (nearly all imported) in 2000, accounting for around 17% of Turkey's total energy consumption (Turkish gas consumption in 2002 is estimated at around 19.82 bcm). Prior to Turkey's recent severe economic problems (plus price deregulation moves), Turkish natural gas demand had been projected to increase extremely rapidly in coming years, with the prime consumers expected to be natural-gas-fired electric power plants and industrial users. Consumption of natural gas is mainly by industry and residential / commercial. (See Figure 3-14)[22]

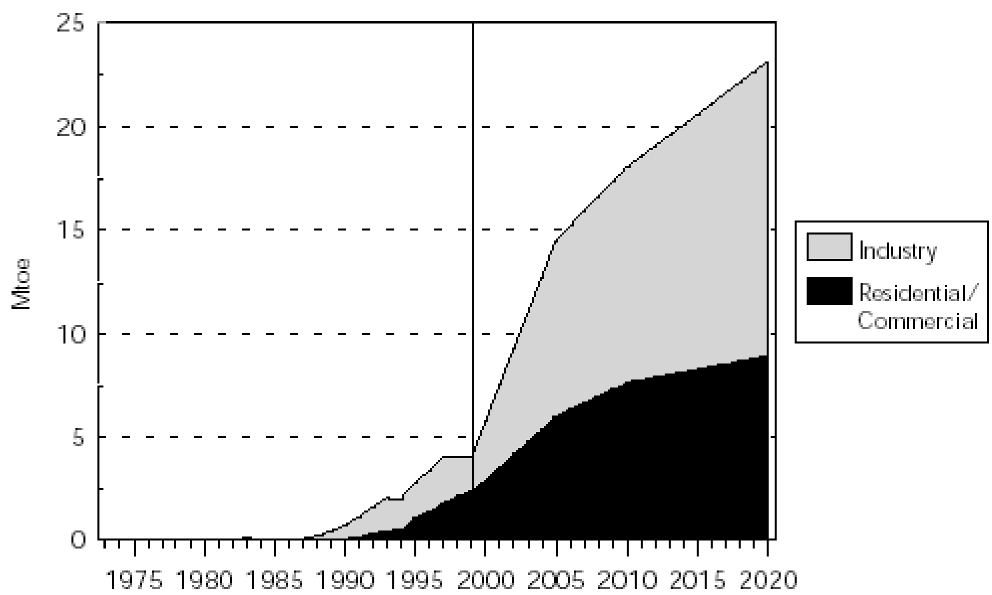


Figure 3-14: Natural Gas Consumption by sectors [7]

The largest gas usage is anticipated in power generation, where gas demand is expected to double between 2001 and 2010. In all consuming sectors gas has replaced oil and coal. The government has encouraged the use of natural gas to replace lignite in the residential sector to reduce urban pollution. [7]

Now, however, state natural gas and pipeline company Botaş has revised its natural gas demand growth projections down sharply based on Turkey's economic problems. For instance, Turkish natural gas demand had been forecast at about 1.6 trillion cubic feet (Tcf) in 2005, but now is expected to reach only 1.1 Tcf in that year, a 37% downward revision. Many analysts now believe that, given lower Turkish natural gas consumption forecasts, only one of the main import options under development (i.e., Blue Stream, Trans-Caspian Pipeline - TCP, Shah Deniz) can be supported for some time. [7]

This sharp downward revision in Turkey's projected natural gas demand could have significant repercussions, since Turkey already has signed contracts for far more natural gas than it is expected to need. To date, Turkey has signed deals for around 2 Tcf per year of natural gas imports beginning in 2005, around three times greater than current Turkish gas consumption. Of this total, over 20% is already coming from Russia via Bulgaria (studies on expanding the Russia-Bulgaria-Turkey "Main Line" are underway), 17% from Iran, and 9% from Algeria and Nigeria combined as liquefied natural gas (LNG). In the future, around one-fourth of Turkey's gas imports are to be supplied from Russia via the Black Sea, another quarter from Turkmenistan (beginning in 2005), and about 10% from Azerbaijan (beginning in 2005). Under the "take-or-pay" provisions of natural gas supply contracts with countries like Iran and Russia, Turkey reportedly could be forced to pay cash penalties of up to $1 billion per year if it fails to purchase contracted gas. Already, the National Iranian Gas Company (NIGC) has stated that, if Turkey fails to take the volume of natural gas agreed to for 2002, NIGC will invoke a penalty clause under "take or pay" provisions. [7]

Natural gas is Turkey's preferred fuel for new power plant capacity for several reasons:

- Environmental (gas is less polluting than coal, lignite, or oil);
- Geographic (Turkey is close to huge amounts of gas in the Middle East and Central Asia);
- Economic (Turkey could offset part of its energy import bill through transit fees it could charge for oil and gas shipments across its territory);
- Political (Turkey is seeking to strengthen relations with Caspian and Central Asian countries, several of which are potentially large gas exporters). The United States, among others, has been encouraging Turkey to utilize its unique geographical position to become a major transit center for natural gas from the Caspian/Central Asia to Europe. At the same time, however, Turkey's reliance on Russia for gas imports could reach 70% or higher, seemingly undercutting Turkey's goal of diversifying its fuel suppliers.

Turkish natural gas production in 2000 (0.65Bcm) met around 4% of domestic natural gas consumption requirements. Major natural gas producers in Turkey include Arco, TPAO and Shell. Marmara Kuzey (North Marmara), which came on-stream in May 1997, is the country's largest non-associated gas field. Marmara Kuzey is located offshore in the Thrace-Gallipoli Basin of the Sea of Marmara. In March 2002, the Göçerler natural gas field was officially opened, 16 months after its discovery in the Thrace basin. Production potential is estimated to be as high as 2.8 Bcm per year. Also, in July 2001, TPAO announced that it had found gas in the Mersin and İskenderun bays in Turkish areas of the Mediterranean. Currently, most Turkish associated gas is re injected into oilfields as part of an Enhanced Oil Recovery (EOR) system. [3]

3.5.4. Uranium

Turkey also have some uranium plants which is grade is lower (% U3O8). In the world, uranium grade percentage is greater than the 1%. Following table shows the uranium reserves of Turkey:

Table 3-9: Uranium Reserves of Turkey [20]

AREA	Grade (U3O8 %)	RESERVE (TON U_3O_8)
SALİHLİ KÖPRÜBAŞI	0,05	2852
EŞME-FAKILLI	0,05	490
SÖKE-KÜÇÜKÇAVDAR	0,04	208
SÖKE-DEMİRTEPE	0,08	1729
YOZGAT-SORGUN	0,1	3850
TOTAL	0,04-0,1	9129

At the moment, with these uranium plants in Turkey there is no technology to produce uranium in an economical way. [22]

3.5.5. Thorium

The only thorium plant is found in Eskişehir-Sivrihisar-Kızılcaören area. This is also one of the most important thorium plants in the world. There are 380 000 tones reserve has a grade of 0, 2 % ThO2. [22]

3.6. ELECTRICAL ENERGY IN TURKEY

3.6.1. Electricity Transmission

The Turkish Electricity Distribution Company (TEDAS) has the responsibility for operation of Turkey's electricity transmission system. Turkey has connected its electricity grid to neighboring countries from which it buys and sells electricity, even though the Turkish system is not set up for synchronous operations with the other countries. The connections are as follows: [23]

Azerbaijan (34.5 kilovolts [kV] and 154 kV); Armenia (220 kV); Bulgaria (400 kV); Georgia (220 kV); Iran (154 kV); Iraq (400 kV); Syria (66 kV)

3.6.2. Installed Capacity

Turkey's rapid growth in electricity demand, which has led to almost doubling of installed generating capacity over the past decade, is expected to continue for the foreseeable future. This could lead to building a total installed generating capacity of as much as 65,000 MW by 2010. MENR believes this would require an investment of $3-5 billion per year. An historical summary of installed electricity generating capacity in Turkey is shown in Table 3-10. [3]

Table 3-10: Installed Electricity Generation Capacity in Turkey, 1990-2000(in thousands of MW) (N/A - not applicable) [11]

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Hydroelectric	7,71	8,38	9,69	9,87	9,86	9,94	10,1	10,34	10,54
Nuclear	n/a	n/a	n/a	n/a	n/a	n/a	n/a	N/a	n/a
Geothermal/Solar/	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Wind/Biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Conventional Thermal	10,08	10,32	10,64	10,98	11,07	11,3	11,77	13,02	15.56
Total Capacity	**17.21**	**18.71**	**20.34**	**20.86**	**20.95**	**21.25**	**21.89**	**23.35**	**26,12**

3.6.3. Generation and Consumption

Turkey's electricity generation is based on hydropower and fossil generation. The share of hydroelectric generation in gross electricity output stood at about 40% throughout the 1990s, but is expected to decline in future, and is subject to fluctuations in proportion to rainfall. Its share in 1999 was 29.8% (124920 TW), down from 38% the preceding year. Coal accounted for 31.8% (133200 TW), oil for 6.9%, and gas for 31.2% (131040 TW). Nearly all coal used in power generation is domestic lignite (29.1% out of 31.8%); imported hard coal accounts for only 2.7%. Renewable have only very minor shares in power generation in Turkey: geothermal accounts for 0.1% or 43200 TW, and combustible renewable for about 0.2% or 86400 TW. Following figure shows the development of electricity generation by fuel between 1973 and 2020. [7]

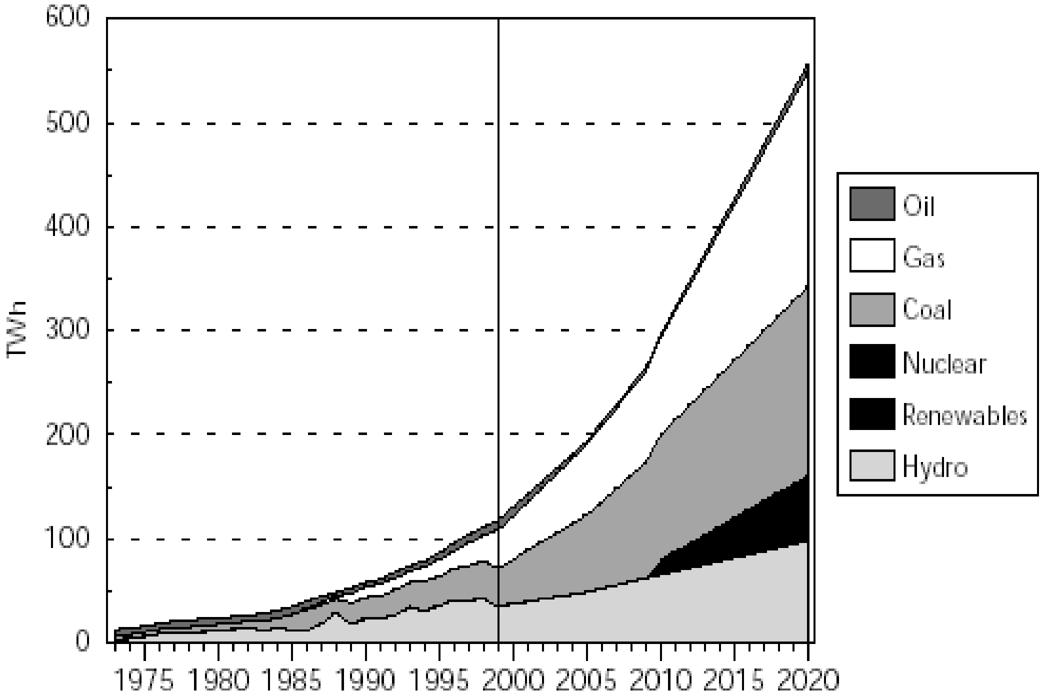


Figure 3-15: Electricity Generation by Source, 1973 to 2020 (TWh) [7]

Net electricity generation in Turkey has more than doubled over the past decade, but is not sufficient to keep up with expected demand. As a result, Turkey is importing electricity, and signed an agreement with its neighbor, Bulgaria, which will allow Turkey to purchase (33.7 billion kWh) 33.7 billion kWh of electricity over the 10-year period from 1999 to 2009. This deal has had implications for future power plant construction planning, because import of electricity from Bulgaria, at 3-3.5 cents per kWh, is actually cheaper than the incremental cost of producing electricity from a new thermal-electric power plant (about 5 cents per kWh). [3]

Electricity consumption in Turkey has been growing very rapidly (an annual increase of 9 % per year). This increase has been largest among all IEA countries. However, growth in energy supply capacity has not been consistent with growth in electricity demand. Accordingly there are some power shortages. Electricity consumption is expected to increase at about the same pace in the future. Most of the increase will be in hydropower, followed by lignite and gas. To provide enough electricity, new capacities will be built. Total expenses in generation capacity up to 2010 are estimated at about 60 billion US dollars including 46 billion for new capacity and 14 billion for maintenance and operation. [3]

Table 3-11: Electricity Generation and Consumption, 1990-2000(in billion kWh) [3]

	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Net Generation	75.2	83.1	91.4	99.4	106.7	111.4	119.2
hydroelectric	*30.3*	*35.2*	*40.1*	*39.4*	*41.8*	*34.3*	*30.6*
nuclear	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
geo/solar/wind/biomass	*0.1*	*0.3*	*0.2*	*0.4*	*0.3*	*0.3*	*0.3*
conventional thermal	*44.8*	*47.6*	*51.0*	*59.6*	*64.6*	*76.8*	*88.3*
Net Consumption	69.4	76.6	84.9	94.6	102.2	105.6	114.2
Imports	0.0	0.0	0.3	2.5	3.3	2.3	3.8
Exports	0.6	0.7	0.4	0.3	0.3	0.3	0.4

MENR has planned for a very large increase in electric generating capacity over the next twenty years. As shown in the Table 3-12, the largest growth is planned for natural gas fired generation.

Table 3-12: Electric Power Capacity Development in Turkey [11]

Fuel Type	2010		2020	
	Installed (MW)	**Generation** (GW)	**Installed** (MW)	**Generation** (GWh)
Coal	16,106	104,035	26,906	174,235
Natural Gas	18,856	125,548	34,256	225,648
Fuel Oil & Diesel	3,125	17,993	8,025	49,842
Nuclear	2,000	14,000	10,000	70,000
Hydro & Renewable	24,982	85,719	30,031	104,043
Total	**65,069**	**347,294**	**109,218**	**623,768**

Presently there are five fossil-fueled power plants in Turkey with generating capacities greater than 1,000MW. The largest of these is the 1,400MW. Bursa combined cycle power plant, located near the village of Ovaakça in Bursa province. A summary of Turkey's largest thermal-electric power plants is shown in Table 3-13.

Many other thermal-electric power plants are under construction or in the planning stages. Five of these will be greater than 1,000MW capacity. InterGen, with its Turkish partner Enka, is constructing three large gas-fueled combined cycle power plants that were the first to proceed under Turkey's "Build-Own-Operate" (BOO) program. One of the largest coal-fueled power plants under development is a 1,300MWe facility at İskenderun in southern Turkey that is scheduled for completion in 2003, and will burn imported coal; Siemens is the lead developer of the consortium that is constructing and will own the power plant. [11]

Table 3-13: Thermal-Electric Power Plants in Turkey [11]

Generating Facility	Owner	Location	Fuel	Capacity
Conventional Thermal Power Plants				
Afsin-Elbistan A	TEAS	Malatya	Coal	1,36
Soma	TEAS	Manisa	Coal	1,034
Yatagan	TEAS	Muğla	Coal	630
Kemerköy	TEAS	Muğla	Coal	630
Seyitomer	TEAS	Kütahya	Coal	600
Cayirhan	Park Termik	Ankara	Coal	450
Tunçbilek	TEAS	Kütahya	Coal	429
Yeniköy	TEAS	Muğla	Coal	420
Kangal	TEAS	Sivas	Coal	300
Catalagzi	TEAS	Zonguldak	Coal	300
İskenderun Works *	Isdemir	Hatay	Coke	220
Orhaneli	TEAS	Bursa	Coal	210
Aliaga Refinery	Tupras	İzmir	Oil	207
Gas Turbine Combined Cycle				
Bursa	TEAS	Bursa	Natural	1,4
Ambarli	TEAS	İstanbul	Natural	1,349
Hamitabat	TEAS	Tekirdağ	Natural	1,2
Uni-Mar (Marmara Ereglisi)	International (and others)	Tekirdağ	Natural Gas	504
Trakya Elektrik	Enron, (and others)	Tekirdağ	Natural Gas	498
Gebze *	Çolakoglu	Kocaeli	Natural	247
Esenyurt Doga	Edison Mission	İstanbul	Natural	180
Aliağa TEAS	TEAS	İzmir	Oil	180
Bursa *	Bis Enerji	Bursa	Natural	174

Note: "conventional thermal" means boiler + steam turbine
* Auto production (cogeneration) facility

A summary of some of Turkey's planned thermal-electric power plants is shown in Table 3-14.

Table 3-14: Planned Thermal-Electric Power Plants in Turkey [11]

Generating	Owner	Location	Fuel	Capacity	Status
Conventional Thermal Power Plants					
Afsin-Elbistan B	TEAS	Malatya	Coal	1,44	Construction (start-up 2003-5)
Afsin-Elbistan C	TEAS	Malatya	Coal	1,44	Planned
Iskenderun	Siemens (and others)	Hatay	Coal	1,3	Construction (start-up 2004)
Çan	TEAS	Çanakkale	Coal	320	Construction
Orta	TEAS	Çankiri	Coal	125	Planned
Gas Turbine Combined Cycle					
Gebze	InterGen, Enka	Kocaeli	Natural Gas	1,555	Construction (start-up 2002)
Izmir	InterGen, Enka	Izmir	Natural Gas	1,525	Construction (start-up 2004)
Adapazari	InterGen, Enka	Kocaeli	Natural Gas	780	Construction (start-up 2003)
Baymina	Tractebel	Ankara	Natural Gas	770	Construction (start-up 2003)
Igdir	AKFEN-	Igdir	Natural	500	Planned
Alapi	n/a	n/a	Natural Gas	206	Construction (start-up 2002)
Karadeniz	Atam	Zonguldak	Natural	200	Planned
Eskisehir	Esel	Eskisehir	Natural	200	Planned

Note: "conventional thermal" means boiler + steam turbine
n/a - not available or not applicable

Cogeneration of combined heat and power (CHP), or "auto production" as it is known in Turkey, has been advanced by governmental support and the continuing need for additional electricity generation within Turkey.

Following table shows Turkey’s auto production by fuel type:

Table 3-15: Turkey's Auto production by Fuel Type (as of March 2000) [8]

Fuel	**Capacity (MW)**	**Share %**	**1999 (GWh)**	**Share %**
Natural Gas	1,335	64.2	7,264	67.0
Fuel Oil	455	21.9	1,895	17.5
Renewables	93	4.5	838	7.7
Liquified	63	3.0	343	3.2
Naphtha	63	3.0	237	2.2
Hard Coal	35	1.7	182	1.7
Hydroelectric	19	0.9	20	0.2
Diesel Fuel	10	0.5	64	0.6
Lignite	6	0.3	5	0.0
Total	**2,079**	**100.0**	**10,848**	**100.0**

As late as 1994 there were only four cogeneration plants in operation, with a total capacity of only 30MW. Since then, incentives were offered in the form of a 100% tax deduction and duty exemptions for auto production facilities and guaranteed purchasing of any surplus electricity by TEDAŞ. These improved the climate for cogeneration in Turkey so much that by mid 2001, there were 90 operating cogeneration plants (with a total capacity of 2,400MW), 55 cogeneration plants under construction (with an additional capacity 2,060MW), and 153 cogeneration plants (representing another 10,400MW) under evaluation by the Ministry of Energy and Natural Resources (MENR). Many of these are or will be located in so-called "organized industrial zones" or "OSBs". The total installed cogeneration capacity is expected to reach up to 6,000MJ by 2005, which would represent about 20% of Turkey's total installed electricity generating capacity.

Natural gas is the preferred fuel for auto producers, but there have been natural gas shortages in the late 1990s that have forced some of these small cogeneration power plants to turn to alternative fuels -- not a preferred solution, since most alternative fuels are more expensive than natural gas (on a heat content basis, including deliver costs to the plant site) and some alternate fuels (such as heavy oils) have a high sulfur content. The ongoing expansion of Turkey's natural gas transmission system will be beneficial for auto production. [25]

3.7. RENEWABLE ENERGY SOURCES FOR TURKEY

As for renewable energy sources, the production and consumption of energy in Turkey was 11Mtoe in 1998. Renewable energy source production is the second biggest production source after coal production. Two thirds of the need for renewable energy sources is met by biomass, while the remainder is mainly met by hydroelectric energy. For instance, 38% of the total electricity production was provided by hydroelectric energy in 1998 [21].

3.7.1. Hydropower

Turkey's geography -- a rectangular plateau peninsula surrounded on three sides by seas -- is highly conducive to hydroelectric power generation; Turkey has about 1% of the total world hydroelectric potential. There are many rivers in Turkey and four separate watersheds. The Persian Gulf watershed in eastern Turkey includes the Tigris River (known in Turkey as the Dicle River) and the Euphrates River (known in Turkey as the Fırat River), which flow southwest into Iraq and eventually merge and empty into the Bay of Basra at the northern end of the Persian Gulf. The Black Sea watershed covers much of northern Turkey, and includes Turkey's longest river, the Kızılırmak. The Mediterranean watershed covers much of southwestern Turkey, where rivers either flow south to the Mediterranean Sea or west to the Aegean Sea. The fourth watershed covers the region around the Marmara Sea, which includes several smaller rivers. [26]

Devlet Su Isleri (DSI), the General Directorate of State Hydraulic Works, is Turkey's state water agency, and has the responsibility for developing all of water resources in the country. DSI has the mission of planning, designing, constructing, and operating Turkey's dams and hydroelectric power plants, as well as domestic water and irrigation projects. The Turkish government agency responsible for making surveys for identifying the hydroelectric potential of Turkey's water resources is Elektrik Isleri Etut Idaresi (EIE), the Electrical Power Resources Survey and Development Administration. [26]

As of the end of 2001, Turkey had 125 hydroelectric power plants in operation, ranging in size from the 2,400MJ Atatürk Power Plant (presently the 6th largest capacity hydroelectric facility in the world) all the way down to many small facilities of less than 2MW in capacity. Most are owned and operated by DSI; independent companies who own hydroelectric projects in Turkey include

Birecik AS, which owns a 672MW power plant on the Euphrates River, and Cukurova Elektrik AS (CEAS) which presently has more than 1,000MW generating capacity. Hydroelectric power plants in Turkey currently account for about 40% of Turkey's electricity demand. The Turkish government hopes to see hydroelectric capacity expanded to 35,000MW by the year 2010. Ultimately, the construction of more than 300 additional hydroelectric power plants are projected for Turkey to make use of the potential remaining hydroelectric sites; these have a potential of about 69 000 GWh per year. This long term plan would bring about an additional 19,300MJ of hydroelectric capacity online at a cost of more than $30 billion. [26]

GAP is the biggest hydroelectric plant for Southeastern Anatolian Project, by its completion 22 irrigation dams and an additional 19 hydroelectric power plants on the Tigris and Euphrates Rivers and their tributaries has already been started to work. The project also covers, besides agriculture and electric power development, related social and economic sectors including industry, transportation, mining, telecommunications, health, education, and tourism. However, many of these planned dams, such as the 1,200MW Ilisu Dam, are controversial because of the large amount of land that would be flooded and the large number of people that would be displaced. DSI has also planned a cascade of a eleven large hydroelectric dams on the Çoruh River in northeastern Turkey; some of these are already under construction. This is also a somewhat controversial undertaking, as the Çoruh is widely regarded as one of Turkey's most scenic rivers and as one of the top ten-whitewater rafting rivers in the world. In February 1998, the U.S.-Turkey Joint Statement on Hydropower Projects was signed which listed nine hydroelectric projects to be negotiated with consortia headed by American firms. In November 1998, the Ministry of Energy authorized DSI to negotiate the contracts and cooperate with the Turkish Treasury for finalization of loan agreements. Of the nine projects, three -- Hakkari, Alpaslan II, and Konaktepe -- are now under contract. The status of the remaining six is unresolved. [26]

A summary of the major hydroelectric power plants that are planned and under construction is shown in Table 3-16. [27]

Turkey also has rigorous plans for the development of its substantial hydropower potential. Nearly 5000MW of hydro-capacity is under construction, the largest schemes being Deriner in the north of the country (670MW) and Berke in the southeast (510MW). Schemes built on the concept of ‘build-operate-transfer’ (BOT) are being encouraged strongly, and bilateral agreements have been signed with a number of countries to further international cooperation in hydropower development. Of 485 hydro projects, which DSI (State Hydraulic Works) has identified for development in total, 104 are already in operation, 37 are under construction, and 344 (with a capacity of 10 500MW) are planned. [15]

By the year 2010, Turkey is planning to exploit two thirds of its hydro-potential, aiming to increase hydro production to about 80000GWh/yr. By 2020 this will rise to 110000GWh/yr, and by 2023 it could be 120000GWh/yr, in time to celebrate the 100th anniversary of the Turkish Republic [26].

Table 3-16: Hydroelectric Generating Plants in Turkey [26]

Generating	Owner	Location		Capac	Status
Ilisu	DSI	Batman	Tigris	1,2	Planned
Deriner	DSI	Trabzon	Çoruh	670	Construction
Yusufeli	DSI	Artvin	Çoruh	540	Planned
Boyabat	Kepez AS	Sinop	Kizilirmak	510	Construction
Yedigoze	DSI	N/a	Seyhan	300	Planned
Artvin	DSI	Artvin	Çoruh	320	Planned
Borcka	DSI	N/a	Çoruh	300	Planned
Gursogut *	Lemna Int'l (and others)	Eskihesir	Sakarya	242	Planned
Cizre	DSI	Mardin	Tigris	240	Planned
Munzur	n/a	N/a	Munzur	235	Planned
Hakkari *	Raytheon; ABB (and others)	Hakkari	Zap	208	Planned
Alpaslan II *	Earth Tech; Harza; (and others)	Mus	Murat	200	Planned
Karg *	Black & Veatch (and others)	Eskisehir	Sakarya	194	Planned
Pervari *	Parsons; ICF Kaiser (and others)	Siirt	Botan	192	Planned
Kopru	DSI	N/a	Kopru	189	Planned
Camlihemsi	DSI	N/a	n/a	180	Planned
Eric *	Black & Veatch (and others)	Erzincan	Karasu	170	Planned
Silvan	DSI	Diyarbaki	Tigris	150	Planned
Yamula	n/a	Kayseri	Kizilirmak	150	Planned
Konaktepe I & II *	Stone & Webster (and others)	Tunceli	Munzur	138	Construction
Torul	DSI	Gumusha	Harsit	122	Construction
Durak *	Harza; Clark; ABB (and others)	Rize	Durak	120	Planned
Mut *	Morrison Knudsen; (and others)	Icel	Goksu	91	Planned
Aslancik	n/a	Giresun	Harsit	90	Planned
Garzan	DSI	Diyarbaki	Garzan	90	Planned
Kayseri	DSI	Diyarbaki	Tigris	90	Planned

3.7.2. Geothermal Energy

Turkey has significant potential for geothermal power production, possessing one-eighth of the world's total geothermal potential. Much of this potential is of relatively low enthalpy that is not suitable for electricity production but still useful for direct heating applications; at the end of 1999, Turkey's total installed capacity for direct heating was 820thermalMW, of which about 390MW provided heating for 51,600 residences, about 100MW provided heating for about 45 hectares of greenhouses, and about 330MW was used to provide heated water for about 200 spas. By 2010, as many as 500,000 residences could be heated by geothermal power, which would represent the use of about 3,500MW. [3]

Turkey presently has one operating geothermal power plant, a 20MW facility in the Denizli-Kizildere geothermal field in the southwestern Turkey province of Denizli. The facility includes nine production wells, and also has an integrated liquid carbon dioxide (CO_2) and dry ice production factory that can produce a combined total of 40,000 metric tons per year of the two products. Another 20MW power production unit is being planned for this facility. [22]

There are six other geothermal fields that have been identified, all in far southwest Turkey, that may be suitable for geothermal power production: the Germencik-Aydin field in Aydin Province, the Çanakkale-Tuzla field in Çanakkale Province, the Izmir-Sefirihiser field in Izmir Province, the Aydin-Salvatli field in Aydin Province, the Kutahya-Simav field in Kutahya Province, and the Dikili-Bergama field in Izmir Province. The Germencik-Aydin field may be the most promising of these as it has a power potential of at least 100MW; a new 25MW power plant, to be located near the city of Germencik, is in the planning stages. Turkey hopes to generate 500MW from geothermal energy by the year 2010 and 1,000MW by the year 2020. [22]

3.7.3. Solar Energy

Solar energy has interesting potential in Turkey. Turkey is a major producer of flat plate collector systems, producing some 400,000 square meters per year, most of which is used domestically and some exported to the European Union. [22] An estimated 3.5 million m2 of flat plate collectors for solar heating are already installed in Turkey, especially in the southern and western regions and in the residential and commercial sectors. Preliminary studies indicate that the country has an average 2,640 sunshine hours annually, with an average solar intensity of 3.6 kWh/m2 per day, with higher peaks at some locations. A more in-depth evaluation of the solar radiation potential has been initiated in co-operation with the State Meteorological Organization. Solar energy use is expected to increase about sevenfold from its 1999 value of 0.11 Mtoe. [7]

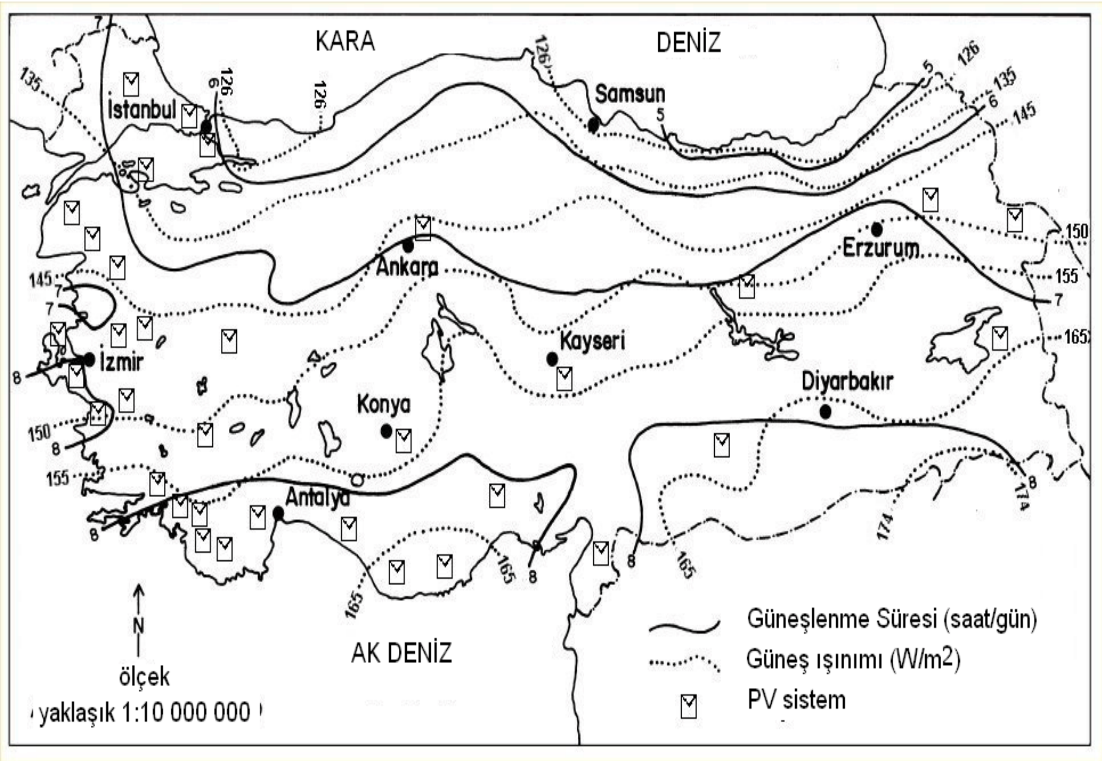


Figure 3-16: Solar Energy Potential of Turkey [28] (güneşlenme süresi : sun shine time ; güneş ışınımı : sun radiation)

3.7.4. Wind Energy

Turkey is encouraging the construction of BOT wind power plants by private power developers. The first wind power facility in Turkey was commissioned in November 1998, and is located near the city of Izmir in western Turkey. The facility has 12 wind turbines for a total capacity of 7.2MW, and is owned by Gucbirligi Holding, Inc. Turkey has a goal of deriving 2% of its electricity from wind power. In 2000, the Government of Turkey had offered a tender for up to 390MW of electricity from wind power. About 25 potential sites for wind power projects had been identified and were undergoing evaluation, but the tender was canceled as part of the IMF-induced economic policy changes. Without the full sovereign guarantees that would in effect result in government subsidies to offset the relatively high expected cost of the power produced, none of 17 wind power projects that had received their BOT approvals have preceded. [27]

3.7.5. Biomass

Bioenergy technologies help protect the environment by making use of renewable plant material such as sawdust, tree trimmings, rice straw, alfalfa and switch grass; poultry litter and other animal wastes; industrial waste; and the paper component of municipal solid waste. [29]

They are used today in a wide variety of processes, including the production of clean transportation fuels, electricity and chemicals. [29]

Biomass is stored solar energy that can be converted to electricity or fuel. Increased use of biomass for energy would lead directly to: reduced greenhouse gas emissions, reduced dependence on foreign oil. [29]

Biomass currently accounts for about 13 percent of Turkey’s total final energy consumption. The importance of biomass in Turkey today is indisputable since the traditional biomass fuel wood, charcoal; crop residues and dung are still primary cooking fuels for some parts of Turkey. [30] The energy forecasts produced by MENR indicate that the total biomass energy used should remain relatively constant at about 7–8 Mtoe. Stabilization of traditional biomass use through the greater penetration of commercial fuels should (1) make an important contribution to mitigating the deforestation problem in Turkey and (2) underpin the importance of forest resources as a carbon sink helping to reduce CO2 emissions from energy generation. Although some scope may exist for developing energy plantations (e.g., for dendro thermal power plants), experience elsewhere indicates that close attention must be paid to issues of sustainability, management, and cost, and the contribution to Turkey's long-term energy requirements would be modest. Nevertheless, taking biomass potential in aggregate, it appears that Turkey could increase its renewable usage significantly—in addition to the current extensive exploitation of hydropower resources using larger hydropower plants. [31]

Energy forestry projects in Turkey need to be emphasized once again as a major output of agro forestry. The growing stock needs to be established as capital from which the yield or interest may be harvested on a sustainable basis. It is estimated that 50% of the felled tree biomass is available for energy purposes. The limiting factors in the utilization of this biomass are collection, sorting and preparation of wastes generated in the different stages of wood processing. [30]

3.8. NUCLEAR ENERGY FOR TURKEY

The Turkish Government has announced plans to build 10 nuclear reactors by 2020. The first reactor is planned to be built at Akkuyu Bay on the southeast Mediterranean coast, and is scheduled to start operation in 2005. The contract for the building of this reactor expected to be awarded in the second half of 1998. [32]

Three international consortia are bidding for the contract. They are led by Atomic Energy of Canada, Limited; Westinghouse of the United States; and Nuclear Power International, a consortium led by Siemens of Germany and Framatome of France. All of the consortia must involve Turkish firms in the bid, and all are required to provide 100% of the financing for the Project. [32]

Turkey's experience with nuclear power dates back to the 1960s – a nuclear research reactor has been operating in Istanbul since 1962 – and successive governments have had plans to introduce commercial nuclear power to the country for three decades or more. By 1972, plans had advanced to the point that site selection studies for a nuclear power plant were carried out. Following these studies, Turkey Electricity Authority was granted a site license by the Turkish Atomic Energy Authority (TAEK) in 1976 for the construction of a nuclear power plant at Akkuyu in southern

Turkey. The Turkish Atomic Energy Authority is in charge of regulation and control of all activities in the nuclear field, including safety inspections and issuance of licenses. It reviews the documents prepared for nuclear capacity tenders and also carries out nuclear R&D. Akkuyu lies near the town of Gülnar on the Mediterranean Sea. The site was selected for several reasons, including the facts that bulky materials can be transported there by sea; that it is located near the major electricity demand centres of Adana, Konya, Antalya and Mersin; and that it is seismically the most stable region in earthquake-prone Turkey. The 1980s saw two unsuccessful attempts to construct a nuclear power plant. An international tendering procedure was launched in the late 1970s and two companies were chosen for construction of the plant and the turbine, and for fuel procurement. However, negotiations with the two enterprises failed in 1980. Two other nuclear power plant projects at Sinop on the Black Sea and at Akkuyu were abandoned in the 1980s, also owing to the impossibility of reaching agreement with the bidders. This was partly because the projects were initially planned as turnkey projects, but were subsequently altered from turnkey to BOT, with the bidders requiring state treasury guarantees for their investment, which the government was not willing to grant. [7]

The Akkuyu nuclear power plant project was inserted once more into the State Investment Program in 1993. Following the release of revised bid specifications, an international tender was opened on 17 December 1996 for a fully credit-financed turnkey plant. The main offer that bidders were expected to submit was for a nuclear plant with a minimum capacity of 800MW and a maximum of 1,400MW+ 5%, in one or two units above or equal to 600MW, to be built at Akkuyu. Bidders were required to fully finance the plant themselves by loans, and to submit corresponding letters of intent from governmental agencies or financial institutions with their bid. A second, optional tender for two or four units of at least 600MW each, totaling at most 2,800MW+ 5%, modeled on the main offer, was also opened. Here, proof of financing was required 18 months after conclusion of the contract. [7]

The start-up date for Turkey's first nuclear power plant was set at 2005/2006. Offers were received from three different consortia on 15 October 1997. The consortia were: [7]

- AECL of Canada, Kuarner John Brown, and Hitachi of Japan, with participation of Güris, Gama and Bayindir of Turkey.

- Westinghouse and Mitsubishi (U.S. and Japan), with participation of Enka and MNG of Turkey.

- Nuclear Power International (NPI), comprising Siemens, Framatome, GEL-A, Campenon Bernard, Hochtief (France and Germany), with participation of Simko, Garanti Koza, STFA and TEKFEN of Turkey.

After reception of the bids, selection of the winning vendors was delayed repeatedly. At the request of TEAS, bidders extended the validity period of their bids several times. As the result of a Cabinet meeting held on 25 July 2000, the Turkish prime minister announced indefinite postponement of the nuclear program, until economic conditions were better. The project had met with resistance on environmental grounds, but industry analysts believe that the main cause of its failure was the Turkish Treasury Department’s refusal to provide a sovereign financial guarantee for the loans being taken by vendor country governments for the nuclear plant – worth between $2.5 billion and $4 billion, depending on the number of reactor blocks. In April 2000, the Treasury had announced its decision, supported by the World Bank, to change the Akkuyu nuclear power plant project from turnkey to BOT and to decline financial guarantees during construction. [7]

In spite of the fact that there is currently no nuclear power project, the Ministry of Energy and Natural Resources expects Turkey’s first nuclear power plant of about 2,000 MW to come on stream by 2015. According to the MENR’s latest forecast, Turkey is to construct 8,000MW of nuclear capacity by 2030. [7]

3.9. PIPELINES

The Geographical position of Turkey makes it very important in the international arena since Turkey is located between the countries possessing rich oil and natural gas resources and the countries that need them. Transportation of these energy resources to the West through Turkey is an appropriate alternative due to economical and technical reasons as well as the political ones. The most important oil and natural gas pipeline projects are the Baku-Ceyhan Oil Pipeline and the Turkmenistan-Turkey-Europe or TCP (Trans-Caspian) Natural Gas Pipeline. Other pipeline projects are Blue Stream from the Russian Federation, gas pipelines from Egypt and from Iran, in addition to the existing Iraq-Turkey oil pipeline. [33]

3.9.1. Gas Pipelines, Terminals, and Storage

There are several existing gas pipelines in Turkey. The Eastern Anatolia Gas Pipeline brings gas into Turkey from Iran and is the main natural gas pipeline in eastern Turkey; the pipeline presently extends as far west as Ankara. The 842-kilometer Russia-Turkey Natural Gas Pipeline runs from Russia through Ukraine, Romania, and Bulgaria into Turkey. An extension of this pipeline brings gas to Ankara and to Hamitabat, where it supplies a combined cycle power plant. In 1996, another 209-kilometer extension of this pipeline to the western Black Sea region called the İzmit-Karadeniz Eresli Natural Gas Transmission Line was finished, and following that, a 208-kilometer extension, the Bursa-Çan Natural Gas Transmission Line, was added to take the pipeline to the city of Çan. In 2000, a 107-kilometer extension to the port city of Çanakkale called the Çan-Çanakkale Natural Gas Pipeline was completed. [33]

The first segment of the $3.3 billion Blue Stream Pipeline, which will transport 16 billion cubic meters per year of natural gas 1,200 kilometers from Russia to Turkey, was completed in March 2002. The pipeline starts at Izobilnoye near Krasnodar in southern Russia and runs overland on the Black Sea coast 370 kilometers to Dzhubga. Construction of the deep-sea portion of the Blue Stream Pipeline began in June 2002. The undersea portion consists of twin pipelines running 375 kilometers under the Black Sea from Dzhubga, Russia, to the Turkish port of Samsun; this undersea portion reaches a depth of 2,150 meters, making it the world's deepest pipeline. From Samsun, the pipeline then runs overland to provide gas to Ankara. The Blue Stream Pipeline was jointly built by Russia's Gazprom and Italy's ENI, with each having a 50% share; the project was undertaken because of Turkey's

1997 agreement with Russia to buy 16bcm per year of natural gas. The schedule for the pipeline calls for 1.99bcm of natural gas deliveries to Turkey in 2002, while from 2003 to 2009, Russia will increase deliveries through the pipeline by 1.99bcm per year until final capacity of 16bcm per year is reached in 2009. [33]

In March 2002, Turkey signed a $300 million deal with Greece to extend an Iranian natural gas pipeline to Greece. The pipeline will go 125 miles inside Turkey and cross the Dardanelles Straits into Greece. This will extend the pipeline from Karacabey in western Turkey to the city of Komotini in northeastern Greece. [33]

The pipeline is expected to carry 0.49 bcm of gas per year, and could be completed by 2005.

Turkey is also planning extensions to the Eastern Anatolia Natural Gas Pipeline within the country. The 565-kilometer Southern Natural Gas Transmission Line Project would extend the Eastern Anatolia Pipeline in three stages: from Sivas to Malatya (168 kilometers), Malatya to Gaziantep (182 kilometers), and Gaziantep to Mersin (215 kilometers). The proposed 618-kilometer Konya-Izmir Natural Gas Transmission Line Project would extend the Eastern Anatolia Gas Main from Konya to Izmir, also supplying the cities of Burdur, Isparta, Denizli, and Nazilli. This project would also consist of three stages: Konya to Isparta (217 kilometers), Isparta to Nazilli (203 kilometers), and Nazilli to Izmir (198 kilometers). BOTAS has planned for completion of both of these projects in 2003. [8]

Georgia, Azerbaijan, Kazakhstan and Turkmenistan have backed a plan to transport natural gas from Turkmenistan and Kazakhstan with a pipeline running under the Caspian Sea to Baku. This proposed $2.7 billion Trans-Caspian Gas Pipeline would be 1,700 kilometers long and carry 16 billion cubic meters of natural gas per year. The projected route of the pipeline is from Turkmenbashy, Turkmenistan, via Baku, Azerbaijan, and Tbilisi, Georgia, to Erzurum in Turkey, where it would link up to the Turkish natural gas pipeline system. There was an intergovernmental declaration in support of the project in November 1999 by Turkey, Turkmenistan, Azerbaijan, and Georgia; the next step would be a definitive agreement by the four governments. Credit Suisse and First Boston have been appointed financial advisors for the project.

There are obstacles to overcome before this pipeline can become a reality, however, not the least of which being the economic effects of the new Blue Stream Pipeline from Russia. Turkmenistan and Azerbaijan have also had difficulty reaching agreement on pipeline volumes. It is not yet clear if the Trans-Caspian Pipeline will proceed. [8]

The natural gas transported by this pipeline will meet the supply deficit of Turkey and Europe in the next decades. Azeri and Kazakh gas will also be added to this pipeline.

In the world many countries have a dream that is the revival of the ancient Silk Road, a highway that has an oil pipeline along one side and a natural gas pipeline along the other. The road will be used for general transportation as well as maintenance of the pipelines. The Energy Highway will connect the Caspian and Caucasian Region to Turkey and the rest of the Western World creating an East-West Corridor that will give a breath to Caucasian and Central Asian countries to join the Free World. [3]

Turkey and Iraq have reached a consensus for the construction of a natural gas pipeline from Iraq to the southwestern region of Turkey that would bring a large amount of natural gas to Turkey from gas fields to be developed by Iraq; implementation of this project is dependent on eventual lifting of the United Nations embargo on Iraq. Also, in February 2000, Turkey and Egypt signed a protocol concerning oil and gas issues that among other things declared their intention for constructing a gas pipeline under the Mediterranean Sea that would transport about 140bcf per year of natural gas from Egypt to Turkey. [3]

Besides pipelines, Turkey also receives imported natural gas in the form of LNG. There is a terminal at Marmara Ereğlisi on the Sea of Marmara. This terminal has the capacity to provide 2.97bcm per year of LNG from Algeria. Turkey is also considering LNG imports from Australia, Egypt, Nigeria, Qatar, and Yemen. Also, there are engineering studies underway concerning possible construction of natural gas storage facilities at several sites in Turkey. One of these was for the Northern Marmara and Değirmenkoy gas fields, which could be upgraded for gas storage after their depletion. [3]

3.9.2. Oil Pipelines

Since oil production in Turkey is very limited, approximately 90% of the oil must be imported via tanker or pipeline. At present most of the oil coming from tankers is from Libya or Algeria. Most of the oil arriving by pipeline comes from Russia. Turkey has tried to diversify its oil supply by participating in various pipeline projects, including ones through Iran. Besides pipelines, Caspian Sea oil for Turkey comes via tanker. This requires using the Bosporus, the narrow strait that connects the Black Sea and the Sea of Marmara. At present, 1.4 million b/d of oil goes through the Bosporus.

There are several existing oil pipelines in Turkey. The Ceyhan-Kırıkkale Crude Oil Pipeline is 448 kilometers long, and annually transports about 25 million barrels of oil. BOTAS has been operating this pipeline since 1983. The Batman-Dörtyol Crude Oil Pipeline began operation in 1967, transporting crude from the Batman area to points of use in Dörtyol on the Bay of Iskenderun. This pipeline is 511 kilometers long and can transport about 24 million barrels of oil per year. The Iraq-Turkey Crude Oil Pipeline runs from Kirkuk, Iraq, to the Ceyhan marine terminal in Turkey; it began operation in 1976 and has operated continuously, except for the 1990 to 1996 period when the United Nations embargo on Iraq was in effect. Turkey suspended operation of the pipeline in August 1990, observing the U.N. embargo. In May 1996, the U.N. allowed limited Iraqi oil exports to resume, and oil deliveries to Turkey resumed on December 16, 1996. In 2000, 286 million barrels of oil were transported via the pipeline, which actually consists of two parallel pipelines, the first line 986 kilometers long and the second 890 kilometers. [7]

Much of Turkey's future oil supply is expected to come from countries in central Asia, such as Kazakhstan and Azerbaijan. In 1998, Georgia, Azerbaijan, Kazakhstan and Turkmenistan signed an agreement to build an oil pipeline from the including BP Caspian Sea across Georgia and Turkey to western markets; this pipeline would go from Baku (in Azerbaijan) via Tbilisi (in Georgia) to Ceyhan (in Turkey). This so-called "BTC Pipeline" is estimated to cost about $1.4 billion, with major investors Exploration (38%), SOCAR-Azerbaijan (25%), and six other oil companies, including TPAO. This pipeline would carry 0.15 billion cubic meter of oil per day; the total length will be 1,730 kilometers, of which 1,070 kilometers will be in Turkey. It is expected that 30% of the pipeline cost will be financed by the investors with the remaining 70% will come from the U.S. Exim Bank, Japan's Exim Bank, the International Finance Corporation, and the EBRD. The Host Government Agreements were signed with Azerbaijan, Georgia, and Turkey in October 2000, and since that time, several rounds of increasingly detailed engineering studies have been accomplished. It is currently estimated that the construction of the BTC Pipeline will begin in the first quarter of 2003 and be completed within 32 months. It is expected that BOTAS will be responsible for building the Turkish portion of the pipeline. The Baku-Ceyhan Crude Oil Pipeline Project, which aims at the transportation of the crude oil of Azerbaijan and Kazakhstan to the Western world via marine terminal at Ceyhan on the Mediterranean Sea, has great importance for Turkey and the US. For the Baku-Ceyhan project, the legal groundwork is almost complete with the intergovernmental agreement (IGA) and the host government agreement (HGA). Two new draft agreements for Turkey Agreement (TA) and Government Guarantee Agreement (GGA) are being finalized. [27]

Figure 3-17 shows constructed oil and gas pipelines with new transit routes.

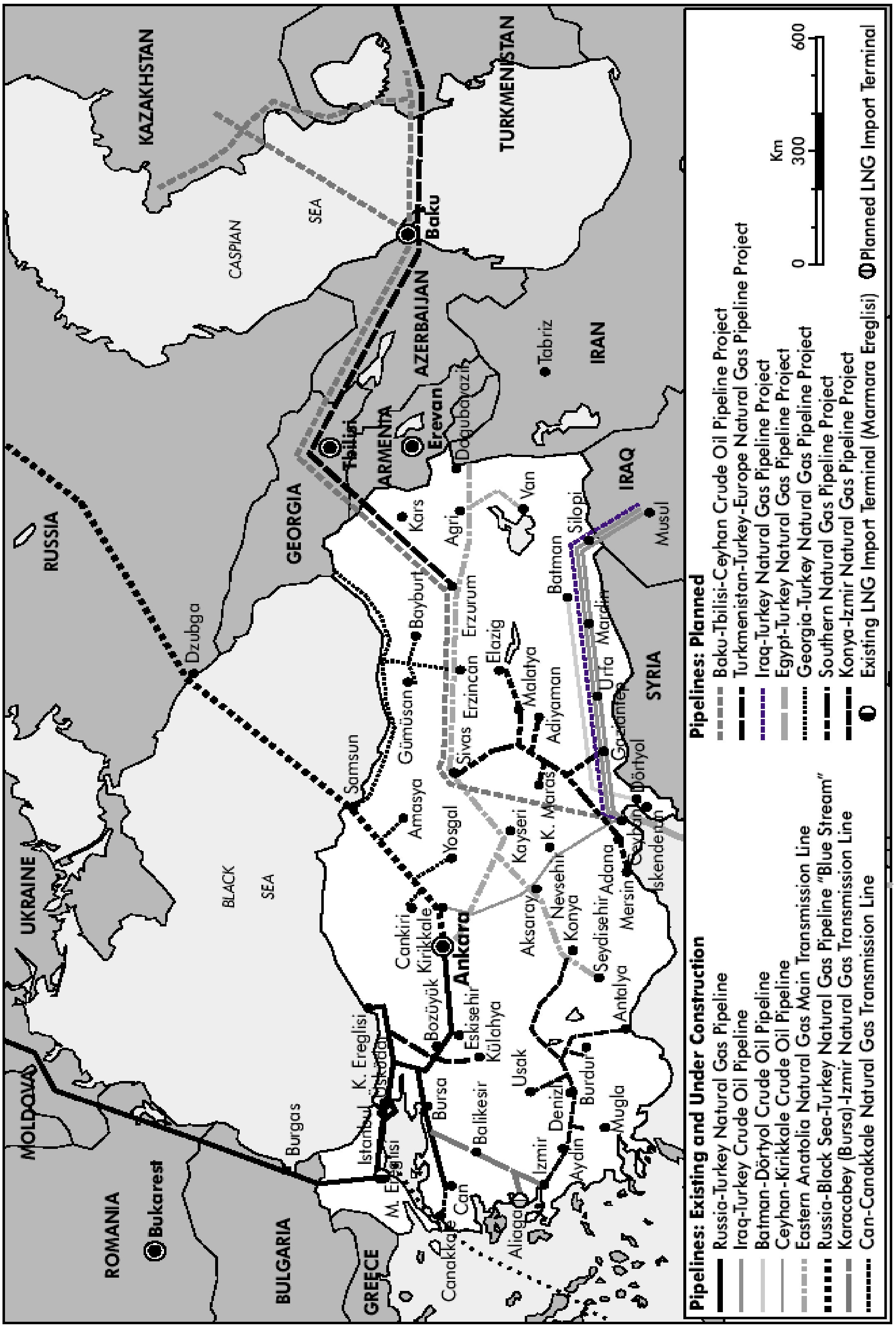


Figure 3-17: Existing oil and gas pipelines and new transit routes

4. ENERGY AND ENVIRONMENT

4.1. General Position of Turkey

Increasing energy demand by population growth has many negative effects in our lives. In all around the world both at the regional and the global levels we have environmental problems because of the rapidly expanding energy production and consumption. Although total suspended particles (TSP) and sulfur dioxide (SO_2) levels have declined in some big cities owing mostly to switching the major heating fuel used from lignite to either imported coal or natural gas, overall emissions have been growing countrywide. [24]

According to a study by TEAS, projected growth in CO_2 emissions (base case) would reach 440 million tones of CO_2 in 2012. This corresponds to an average growth of 6.3% over the period 1999-2012, i.e. more than the historical rate. Such growth would closely track the increase in TPES, projected at 6.2% per year, and would be driven by energy demand in electric power generation and industrial sectors such as iron, steel and cement production. In 2012 coal use would account for about one-half of CO_2 emissions, oil for about one-third, and gas for the remainder.

Although there are growing awareness and several initiatives on environmental policies, global progress has been disappointing. Over the next few decades, environmental problems are expected to intensify at local, national, regional and global levels, due to increasing economic activities and population. Growing consumption of fossil fuels, rising volumes of hazardous and other wastes, the concentration of populations in mega cities, more intensive agriculture, timber and fisheries exploitation will create considerable environmental pressures. For instance, the global issue of greenhouse gas emissions and the associated threat of global warming will certainly constitute a very important challenge. [25]

Given the close links between fossil fuel consumption and carbon dioxide emissions, these emissions are expected to rise by more than 100 per cent during the period to 2020 in a high performance scenario of the world economy. They would grow even faster than the world economic growth, due to the increasing role of coal in the global primary energy. [25]

National Climate Co-ordination Group (NCCG) has been established in Turkey, which conducts national studies in line with those conducted by all countries of the Framework Convention on Climate Change. Those studies are based on the decisions of the government. The State Planning Organization (SPO) is coordinating a project, named ‘‘Turkish National Environmental Strategy and Action Plan’’, which is supported by the World Bank. This project is considered important in starting the activities related to Agenda 21, adopted in the Rio Conference, as soon as possible. The government plans to develop that strategy and an action plan to establish basic environmental standards, to determine an action plan that can be integrated with the overall development program and to identify environmental investment priorities. [25]

According to National Environmental Action Plan, between 1990 and 1996, an estimated 15 million people in Turkish cities were exposed to levels of SO2 and TSP that exceeded World Health Organization standards. [24]

Turkey has made much progress over the last two decades in setting up infrastructure for addressing its environmental problems; an Environment Law was enacted in 1983 and the Ministry of Environment was created in 1991. There are also non-governmental environmental organizations that have emerged. Turkey is a party to many international environmental agreements, including Air Pollution, Antarctic Treaty, Biodiversity, Desertification, Hazardous Wastes, Nuclear Test Ban, Ozone Layer Protection, Wetlands, and Ship Pollution. Turkey has signed but not yet ratified the Arctic-Environmental Protocol and the Environmental Modification treaty. Additionally, Turkey has neither signed nor ratified the United Nations Framework Convention on Climate Change. [24]

4.2. Main Pollutants resulted from Energy Sources

The key pollutants associated with the energy and transport sectors are total suspended particulates (TSP), sulfur dioxide (SO2), nitrogen oxides (NOx) and carbon dioxide (CO2). The burning of Turkey's three principal energy sources emits them: lignite, oil products and fuel wood, which are responsible for most ambient and indoor air pollution. [24]

CO2 and CO are the main GHGs associated with global warming. At the present time, coal is responsible for 30–40% of world CO2 emissions from fossil fuels. SO2 and NOx contribute to acid rain. Essential gaseous pollutants in the atmosphere are: carbon monoxide (CO), carbon dioxide (CO2), methane (CH4), nitric oxide (NO), nitrogen dioxide (NO2), nitrous oxide (N2O), sulfur dioxide (SO2), chlorofluorocarbons (CFCs) and ozone (O3). Global warming has been increasingly associated with the contribution of CO2. Currently, it is estimated that CO2 contributes about 50% to the anthropogenic greenhouse effect. In addition to CO2, several other gases, e.g. CH4, CFCs, halons, N2O, SO2, ozone and peroxyacetylnitrate, produced by industrial and domestic activities, leading to the GHGs, can also contribute to this effect, resulting in a rise in the Earth's temperature. [25]

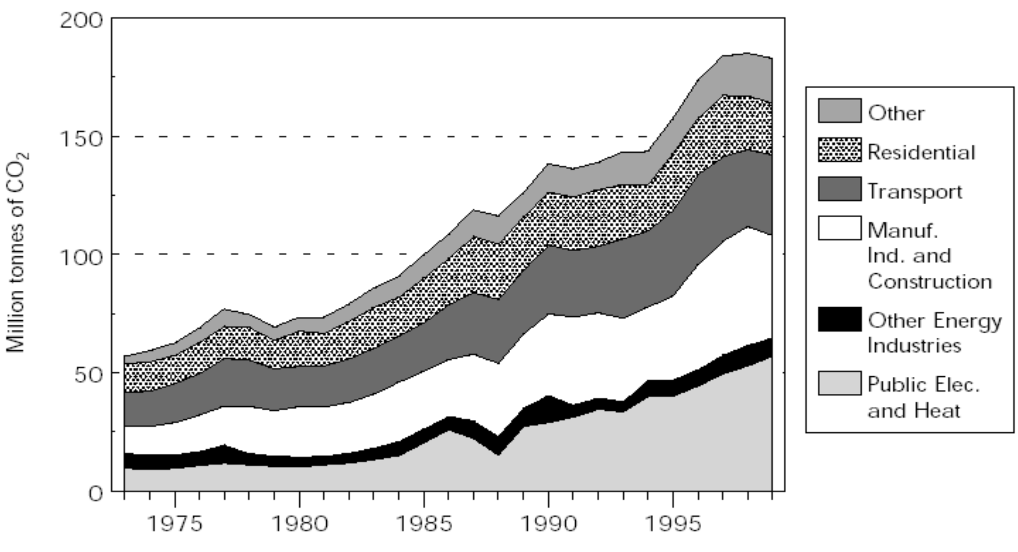


Figure 4-1: CO2 Emissions by Sector, 1973 to 1998 Million tones of CO2 [7]

Figure 4-1 shows CO2 emissions by sector. Public electricity and heat cause major CO2 emissions.

The Turkish Air Quality Control Regulation of 1986 has set ambient air quality standards for four pollutants; these are compared to the WHO standards in the following table 4-1. However, information on air quality in Turkey is limited mainly to regular measurements of SO2 and particulate matter. Pilot studies on measurements of NO2 and O3 have only recently begun in selected cities.

Table 4-1: Turkish and WHO Air Quality Standards (mg/m3) [24]

	Turkish Standards		*WHO Standards*	
Pollutant	*LTS*	*STS* [a]	*LTS*	*STS*
SO_2	150	400	50	125
NO_2	100	300	-	150
PM_{10} (<10μ)	150	300	50	120
O_3 (in ppb)	110	-	100–200	-

μg/m³: micrograms per cubic meter.
LTS: long-term standards (maximum annual average).
STS: short-term standards (maximum daily average).
PM: particulate matter.
ppb: parts per billion.
- not applicable.

[a] Turkey's ambient air quality standard for SO_2 on an hourly basis is 900 μg/m³.

Source: SIS.

Table 4-2: Turkey's CO2 emission/capita compared to other countries (tons) [24]

Table 3
Turkey's CO_2 emission/capita compared to other countries (tons)

	1985	1990	1995	2000
World	4.05	4.08	3.92	3.87
Annex I countries	–	12.02	11.18	10.46
OECD	10.88	11.10	11.08	10.91
Non-OECD Total	2.35	2.42	2.29	2.32
USA	19.43	19.64	19.88	19.95
Russian federation	–	–	10.44	10.46
Republic of Korea	3.86	5.40	7.87	8.64
Mexico	3.59	3.58	3.46	3.38
Turkey	1.97	2.46	2.60	2.71

Source: The International Energy Agency (IEA).

As seen from Table 4-2.Turkey's CO2 emissions are still the lowest among OECD countries but they have been increasing rapidly. [24]

Table 4-3 shows the air pollution trends in some of the big cities of Turkey in winter period. As seen mega cities such as Istanbul, Ankara, Bursa and Diyarbakır have the main TSP and SO2 content.

Table 4-3: Winter Season Air Pollution Trends in Turkish Cities [24]

City	*TSP (average μg/m³)*			*SO_2 (average μg/m³)*		
	1990-91	*1998-99*	*% change*	*1990-91*	*1998-99*	*% change*
Ankara	107	62	−42	218	37	−83
Istanbul	151	68	−55	315	64	−80
Izmir	82	–	–	112	67	−40
Bursa	139	44	−68	329	81	−75
Yozgat	75	35	−53	186	181	−3
Kutaya	111	72	−35	283	277	−2
Erzurum	141	61	−57	262	149	−43
Zonguldak	130	132	+2	89	90	+1
Afyon	111	146	+24	114	149	+23
Diyarbakir	201	112	−44	285	111	−61

Source: State Institute of Statistics and Turkish Ministry of Health. Table reproduced from ESMAP: *Turkey - Energy and Environment Issues and Options Paper*, April 2000.

A significant source of SO2 emissions is the electricity industry. For coal-fired power plants, the SO2 emission standard specified in the Air Quality Control Regulation is 1000 milligrams per cubic meter (mg/Nm3) for plants with a capacity of 300MJ or more.

Historical and projected anthropogenic SO2, NOx, CO, and non-methane volatile organic compounds (NMVOCs) emissions in Turkey are shown in Table 4-4.

Proposed mitigation measures for gas emissions

• Use of low sulfur containing coal.

• NOx controlled by using low NOx burners.

• Smoke emissions will be released from 150 m tall chimneys.

• Electrostatic precipitators are use to collect emissions to atmosphere.

• The quantity of ash particles, SO2 and NOx gases emitted will adhere to international standards [25]

Table 4-4: Anthropogenic Air Emissions in Turkey, 1990-2010 (in thousands of metric tons) [25]

Component	1995	1996	1997	1998	1999	2010
SO2	1,016	1,172	1,234	1,361	1,347	995
NOx	777	847	852	834	911	2,044
CO	3,552	3,684	3,722	3,644	3,607	10,986
NMVOCs	581	613	620	615	613	1,925

4.2.1. Marine Pollution

Marine pollution from oil tanker traffic in the Black Sea and in the Marmara Sea is a serious problem for Turkey. With economic growth and rising energy consumption, Turkey has been forced to import more oil and gas. Increased international demand for Caspian oil and gas has stimulated new pipeline construction, but in the short term has also dramatically increased oil tanker traffic, thus increasing the incidence of oil spills and water contamination, as well as the risk of severe accidents. As a result, the already fragile ecosystems of both the Black Sea and the Marmara Sea are now under serious pressure, and other economic activities such as fishing and tourism are also suffering severe negative impacts. [7]

4.2.2. Greenhouse Effect

Although it has been known for more than a century, the possibility of climate warming associated with the combustion of fossil energies has only focused attention in the last ten years, since scientists demonstrated the first tangible effect of this warming and alerted public opinion and the governments about the risks of a climatic upheaval. [7]

Global warming is another issue where energy questions will be the subject of considerable international political activity. It is an issue that raises key questions about politically sensitive topics, such as national sovereignty and international equity, but the Kyoto conference, attended by 160 countries in December 1997, and world summits, such as the Rio and Montreal meetings, showed that most governments feel the need to address the question. According to the Kyoto protocol, so-called Annex I countries (OECD Members plus economies in transition) must reduce their emissions of six greenhouse gases (GHGs) by at least 5% compared with 1990 levels over 2008–12. [25]

Greenhouse gas emissions are a good example of the progress already achieved. It is calculated that they would be 20 per cent higher in 2010, if Turkey had not started the emission mitigation policies in 1992. Accordingly, Turkey's contribution to global warming remains minimal and far below European levels. [7]

Energy consumption is increased 8 times in 20.century with respect to start. In every type of energy change entropy is increased in the world but usable energy is decreased. As the cause of entropy increase global warm has been occurred. From the earlier times temperature increase is 3 C. Of course CO_2, NO_X emissions and ozone are also play an important role in greenhouse effect of the world. With respect to researches in 2020 CO_2 emissions reach to the level of 9 gigatone carbons. This means that oceans cannot absorb and plants cannot hold this amount. [22]

Although a member of OECD, Turkey is not a party to the United Nations Framework Convention on Climate Change (UNFCCC). This World Bank-funded analysis is designed to assist the Government of Turkey in its interactions with the UNFCCC. [7]

4.2.3. Climate Change

Climate change has become a significant foreign policy issue for Turkey as it continues to press its case for removal from Annexes I and II of the United Nations Framework Convention on Climate Change (UNFCCC). Turkey has not signed the UNFCCC because it is objecting to being included in Annexes I and II of the Convention. Turkey's position is that it is considered a developing country according to criteria used by the United Nations, the World Bank, the Montreal Protocol, UNCTAD, GATT, and the OECD. As such, Turkey has chosen not to become a Party to the Convention because it objects to being on the same list as industrialized countries that have agreed to work toward reducing greenhouse gas (GHG) emissions to 1990 levels. Although Turkey agrees with the UNFCCC's overall objective of stabilizing GHG concentrations in the atmosphere, it defends the principle of "differentiated responsibilities,"arguing that each country should bear the burden of reducing emissions in a way that reflects its own level of development. Turkey maintains that although it is a member of the OECD, its development and emissions patterns correlate more with those of non-Annex I, developing countries. [17]

4.3. Environmental Regulation and Policies in Turkey

In line with growing awareness across the world, Turkey has been devoting due attention to environmental regulation and policy in order to address its own problems on the one hand, and to be an active member of the international community on the other.

Turkey made great progress over the last 15 years in creating mechanisms to address its environmental problems: the 1982 Constitution recognizes the right of citizens to live in a healthy and balanced environment; an Environment Act was passed in 1983; the Ministry of Environment was establish in 1991; public awareness and demand for a clean environment are growing; and active non-governmental environmental organizations are emerging. [25]

At the national level, as a rapidly developing country at the outset of the new millennium, and hence requiring to increasingly consume energy for its economic and social development, Turkey pays serious consideration to the environmental impact of this consumption.

Major potential solutions to environmental problems are [25]:

1. Cleaner technologies,

2. Renewable energy technologies,

3. Efficient energy conversion technologies in which each one has a crucial impact on the environment in terms of the following:

1. Reduction in ambient pollution,

2. Decrease in emissions,

3. Decrease in wastes sent to final disposal,

4. Reduction in energy consumption, and

5. Reduction in the use of raw materials.

The National Environmental Action Plan (NEAP), which has been prepared over a two-year period, responds to the need for a strategy and can supplement the existing development plan with concrete topics in its context. The options related to energy and environmental policies are: [25]

1. Measures to encourage wider use of natural gas.

2. Support the utilization of clean and renewable energy sources as well as passive solar energy applications.

3. Decentralization in energy generation.

4. Optimizing sustainability of energy supply and reducing environmental costs.

5. Setting integrated energy consumption targets for Organized Industrial Zones.

Institutional reforms that have to be done:

1. Establishment of an Energy Observatory.

2. Organization of energy crisis management units at national and regional levels.

Legislative arrangements:

1. Enforcement of regulations and other arrangements to regulate the energy efficiency of domestic appliances.

2. Implementation of heat Insulation Regulation.

Education training is also too important for people to realize the importance of energy supply for the next millennium. The followings must be done in this respect:

1. Organization of energy conservation training at adult education centers.

2. Introducing energy conservation in formal education.

3. Organization of training for households in mass housing and rural areas.

Participation:

1. People’s participation to design and implement energy conservation programs.

2. Formation of energy management units by entrepreneurs in organized industrial firms and small-scale industrial sites.

Economic and financial measures:

1. Introduction of emission taxes in the pricing of fuels.

2. Application of immovable property taxes by considering the limits of energy consumption to be determined with respect to areas.

3. Support for the spread of energy efficient techniques and technologies.

4. Determination of value added tax rates linked to the energy efficiency of vehicles and equipment.

5. Imposing charges on any excess over determined emission standards.

The followings techniques must be put into practice as soon as possible:

1. Encouraging the use of high efficiency-low emission stove and boiler systems.

2. Improvement of power transmission lines.

3. Promoting the diffusion and efficiency of central heating systems.

4. Wider use of process energy (e.g. co-generation).

5. Support for energy efficient technology transfer in industry.

6. Improvement of techniques for energy consumption calculations in buildings.

7. Support the replacement of appliances with low energy efficiency.

8. Establishment of energy management systems in enterprises consuming more than 2000 tons petroleum equivalent energy annually.

9. Use of fluidized bed boiler systems in power plants and industries.

10. Promoting mass transportation.

11. Introducing renewable energy sources for energy supply.

12. Identification and planning of research priorities in energy field.

13. Development of techniques that increase energy efficiency.

14. Inventory of carbon emissions. [25]

In order to limit international emissions of GHGs, the authorities introduced carbon taxes. These carbon taxes vary, however, both across different fuels and across industries. Emissions of all GHGs other than CO2 are exempted from taxation [25].

Broad based carbon/energy taxes are among the most promising and important of the emerging tools for promoting reductions in carbon dioxide emissions. The potential for relocating fuel intensive production in low tax nations is especially troubling because it damages the taxing nations industries without any corresponding benefit to the global environment [25].

The UNFCCC commits the industrialized country Parties (not the developing nations) to take the lead in stabilizing greenhouse gas emissions. The stipulation is incorporated into the Convention because of the right to sustain socio-economic development and the acknowledgment of the specific needs and special circumstances of developed countries. Furthermore, Turkey is acknowledged as a developing country in the Montreal (Ozone) Protocol, relying on the fact that the World Bank, OECD and UNDP have classified Turkey as a developing country. Turkey, albeit a developing country, is placed in Annexes I and II. [7]

Turkey's opposition to its placement in the Annexes is noted in INC/UNFCCC Secretariat document no. A/AC 237/18, Part II, para 35 dated 16 October 1992. Further request for deletion from the Annexes have been included, from then on, in many Secretariat documents. [7]

Turkey has a long-standing demand for deletion of its name from the Annexes to be able to become a party to the UNFCCC. It is not seeking any exemption from the exercise. On the contrary, it is willing to be in the system and is ready to accede to the Convention, following the necessary amendments in the Annexes. Turkey's position vis-a-vis the UNFCCC process is that commitments should be based on equity and fairness by duly taking into account the ‘‘differentiated responsibilities’’ and ‘‘individual circumstances’’ of the Parties concerned. [7]

There are various options under which Turkey could participate in the international legal framework on climate change. Turkey could choose to be a:

(1) Become Party to the UNFCCC as an Annex I country and Party to the Kyoto Protocol:

If Turkey signs and ratifies the UNFCCC as an Annex I and II country, it will come under the following important, but legally non-binding, commitments: [24]

- Adopt national policies and measures to limit its anthropogenic GHG emissions with the objective of returning to 1990 emissions levels;
- Periodically communicate detailed information on these policies and measures, as well as national inventories of GHG emissions, to the UNFCCC Secretariat; and
- Provide financial resources, including technology transfer, to help non-Annex I countries meet the costs of complying with their Convention obligations.

If Turkey becomes a Party to the UNFCCC as an Annex I country and ratifies the Kyoto Protocol as well, it will automatically be included in Annex B of the Protocol and, as such, will have to negotiate a "quantified emission limitation or reduction commitment." As an Annex B Party to the Protocol, it will then come under legally binding obligations to limit or reduce its GHG emissions by the amount it negotiates, with a view to the ultimate goal of reducing overall Annex B emissions by at least 5 percent below 1990 levels in 2008–2012. This could be very difficult for Turkey. [24]

On the other hand, being a Party to the Convention and the Protocol would have significant benefits for Turkey. First, it would finally be able to receive grants and other assistance from the Global Environment Facility (GEF), to which it has contributed funds since 1994. Although Annex I countries are ineligible for grants where the GEF acts as the financial mechanism of the UNFCCC, the GEF can also make grants and other assistance available to those countries that are eligible to borrow from the World Bank by acting outside its role under the UNFCCC. Economies-in-Transition listed in Annex I have received and currently do receive GEF grants under this provision. Using the precedents set by them, Turkey could negotiate directly with the GEF to obtain grants and other assistance in meeting its obligations under the Convention and the Protocol. [24]

Second, as a Party to the Kyoto Protocol, Turkey would be able to participate in the Kyoto Protocol mechanisms (also known as “flexibility mechanisms”) such as Joint Implementation (JI) and emissions trading. JI would allow Turkey to meet part of its commitments by either investing in GHG reduction and sink enhancement (e.g., aforestation and reforestation) projects in other Annex I countries where the marginal cost of abatement is lower than in Turkey, or by hosting such projects implemented by another Annex I Party. Whether it is an investor or a host for JI projects, Turkey would receive credits against its commitments under the Protocol. In addition to JI, Turkey would also be able to participate in the potential carbon markets as an Annex B country eligible for emissions trading under the Protocol. Although the modalities of this mechanism have not yet been deliberated, in its basic form, it would allow Turkey to buy or sell emissions allowances on the open market. [24]

(2) Become Party to the UNFCCC as an Annex I country but not Party to the Kyoto Protocol:

Although being an Annex I Party automatically makes Turkey an Annex B country with a limitation/reduction commitment under the Kyoto Protocol, Turkey would still have the choice of whether or not to ratify the Protocol. Even after the Protocol enters into force, the commitments specified in it would not be legally binding for Turkey until it ratifies the Protocol.

In the meantime, Turkey could still benefit from the opportunities arising from being a Party to the UNFCCC, without yet coming under legally binding emission limitation commitments under the Kyoto Protocol. Moreover, many analysts have speculated that the likelihood of the Kyoto Protocol entering into force in its current form is slim. Its entry-into-force requires ratification by at least 55 countries whose collective CO2 emissions in 1990 accounted for at least 55 percent of the world total. This means entry-into-force without ratification by the United States is, while technically possible, politically unlikely. The United States, on the other hand, has stated that “meaningful participation” by developing countries in the Protocol process is a precondition for its ratification. [24]

(3) Become Party to the UNFCCC as a non-Annex I country:

If Turkey’s petition for removal from Annex I is accepted and it becomes a Party to the UNFCCC as a non-Annex I country, it will not yet have to limit or reduce its emissions, although it will assume certain commitments. These mainly consist of: developing and disseminating national inventories of GHG emissions; implementing programs containing measures to address emissions and to facilitate adaptation to climate change; taking climate change into account in national economic and environmental plans and promoting and cooperating in technology transfer, exchange of information, and education/training/public awareness related to climate change. [24]

At the same time, being a non-Annex I developing country, Turkey would benefit from technology and financial resource transfers to be provided by Annex I countries through various mechanisms including Joint Implementation; GEF project funding; and various capacity building programs offered by UN agencies, bilateral donors, and multilateral development banks. [24]

(4) Become Party to the UNFCCC as a non-Annex I country and Party to the Kyoto Protocol:

If Turkey’s petition for removal from Annex I is accepted such that it accedes to the UNFCCC as a non-Annex I country, and ratifies the Kyoto Protocol, it will not have a binding commitment to limit or reduce its emissions at this point. However, it is expected that, if and when the Kyoto Protocol enters into force, developing countries will eventually be expected to take on future emission limitation commitments, particularly given the pressure placed on them by industrialized countries (e.g., Australia, Canada, EU countries, Japan, and the United States) for engaging in a “meaningful participation.” Meanwhile, as a non-Annex B developing country, Turkey would be eligible to participate in the Clean Development Mechanism (CDM) as a host to emission mitigation projects, in which Annex B countries would invest. The benefits of hosting such projects are technology transfer and a share of the resource rent arising from the difference in marginal abatement costs between the investor and the host country. [24]

If Turkey's energy consumption and CO_2 emissions are projected based on the energy consumption patterns in 1992 and compared to the projections based on the consumption patterns in1996, which is the actual case, it can be realized that if Turkey had not considered policy change regarding global warning since 1992, the CO_2 emissions would be 20% higher in 2010. [25]

5. TURKEY AND OTHER OECD COUNTRIES

5.1. LAND AREA AND POPULATION

The world population, which was about 5.7 billion in 1995, is expected to reach almost 7 billion in 2010 and 7.7 billion in 2020 with continuing increases in the period beyond. The increase over 30 years (1990-2020) is roughly equal to the size of the world's population in 1950. The total population of OECD countries as a share of world population is forecast to decline from almost 19 per cent in 1995 to about 16 per cent by 2020. At the same date, China, India and Africa could each have more population than the total of OECD member countries. Turkey has a much greater land area than any OECD European Member and already ranks second in this group after Germany with its 62.6 million populations in 1997 and will have the largest population in the year 2020. [23]

Turkey has the highest population growth rate of all IEA countries. Between 1990 and 1999, the average annual population growth rate was around 1.5 %. The population estimation of the State Institute of Statistics is given in Table 5-1. Total population is expected to exceed 83 million in 2022. [23]

Table 5-1: Population Growth by Years (by million) [23]

Year	1999	2000	2005	2010	2022
Population(million)	64,3	65,300	69,828	74,115	83,421

Population growth rates are projected to fall in all OECD countries. Turkey is one of the few members who will continue to experience population growth but the rate of growth will continue to slow significantly in the coming decades. The growth rate was 1.7 per cent in 1995, and will move to 1.2 per cent in 2010 and 0.8 per cent in 2020. In fact, all population projections are based on three key factors: fertility rates (rather than birth rates), life expectancy and migration. Fertility rates (average number of children a woman would have during childbearing ages) are at, or below replacement rates (2 children) in most OECD countries. Turkey is at present one of the exceptions but its fertility rate will reach a replacement level by 2005. There will be no difference with other OECD countries (Table 5-3). [23]

Table 5-2: Total Population and Growth Rate Indicators (by million) [23]

	Total		**Average annual growth rate**		
	1995	**2000**	**2010**	**2020**	**(1995-2020)**
USA	263	275	297	321	0.80
Japan	126	127	127	124	-0.06
EU	370	375	375	371	0.01
Turkey	61	66	75	83	1,24
Other OECD	262	277	304	326	0,97
Total OECD	1.082	1.120	1.178	1.225	0.50
ChinaHongKong	1.227	1.291	1.395	1.494	0.80
India	936	1.022	1.189	1.327	1,41
Indonesia	198	213	240	264	1,16
Brasil	162	175	199	221	1,25
Russia	147	146	143	140	-0.20
Other Asia	617	681	807	924	1,63
Other LatinAmr.	223	241	276	311	1,34
Middle East-	871	1.013	1.298	1.584	2,42
Other Countries	229	232	242	252	0.33
Total non-OECD	4.610	5.014	5.789	6.517	1,39
Total World	5.692	6.134	6.967	7.742	1,24

Table 5-3: Fertility Rates (10 most populous OECD countries) [23]

	1990-1995	**2025-2030**
USA	2.1	2.1
Japan	1.5	2.0
Mexico	3.2	2.1
Turkey	2.8	2.1
Germany	1.3	2.0
France	1.8	2.0
United Kingdom	1.8	2.0
Italy	1.3	2.0
Spain	1.2	2.0
Canada	1.9	2.1
Source: World Population Projections		

5.2. LIFE EXPECTANCY

Life expectancy at birth is projected to increase by 4 to 5 years in most OECD countries. In Turkey, life expectancy will increase more rapidly, in part due to reductions in infant mortality rates. Accordingly, the overall life expectancy in Turkey of almost 67 years in 1995 will rise to around 73 years in the 2020s. [23]

5.3. MIGRATION RATES

According to OECD estimates, immigration rates, which are relatively high in several OECD countries, are projected, to fall quite quickly, with only the United States, Canada and Australia projected to continue receiving immigrants after 2010. In the 2020s net migration rates are assumed in all OECD countries, including Turkey, to be zero. For many members, this will certainly depend on governments' migration policies. If they deem it opportune, immigration could help mitigate some problems, which are likely to arise from the ageing of populations and the shrinking of labor forces over the coming decades. [23]

5.4. LABOUR FORCE

Populations in OECD countries are getting older due to slowing population growth and increased lifespan. The effects of population ageing will mainly be observed with the fall of the working-age population (defined as 15 to 64 years). By the 2020s, the size of the working-age population will become smaller at a rate of more than 1/2 per cent per year. Regional labor market imbalances might be possible in many OECD countries. Turkey will be once again an exception because it is a fairly youthful nation and its population increase will provide sufficient growth of labor force (Table 5-4). [23]

The share of the over 65's in total population (elderly share) (Table 5.5) and their ratio to the working-age population will rise in most OECD countries particularly after 2010.

Table 5-4: Working Age Population (average annual increase) 10 most populous OECD countries [23]

Population aged 15 to 64 (working age population)			
	1990-2000	**2000-**	**2010-2020**
World	1.7	1.6	1.2
Total OECD	0.7	0.5	0.0
OECD-Europe	0.5	0.2	-0.2
USA	0.9	0.9	0.1
Japan	0.0	-0.5	-0.8
Mexico	2.5	2.2	1.5
Turkey	2.2	2.0	1.1
Germany	0.1	-0.5	-0.8
France	0.4	0.4	-0.4
United Kingdom	0.2	0.2	-0.3
Italy	-0.1	-0.4	-0.8
Spain	0.3	-0.2	-0.5
Canada	1.1	0.8	0.0
Source: World Population Projections / The World Bank (1994)			

Total number of dependent persons (children and elderly) in relation to the working-age population (total dependency ratio), which will remain rather constant between 1990 and 2010, will considerably rise after 2010. Accordingly, the burden of the working age population will increase significantly in the future. In Turkey, this ratio is less important than in most OECD countries because the proportion of old age persons is low and will remain comparatively low in the future [23]

The existence of ageing populations in many OECD countries will have effects on the economy that go well beyond the labor market. Consumption, saving, investment and capital accumulation patterns will change. People will have to be prepared to work longer, and to save more during their working life. Governments will need to adopt a courageous reform agenda to take action on pensions, health care, education and training to support the attainment of skills and productivity. [23]

Table 5-5: Population Sub-Groups (Population aged 65 and over as a per cent of total population.) [23]

	1. Population aged 65 and over				**2. Total dependency ratio**			
	1990	2000	2010	2020	1990	2000	2010	2020
Total OECD	12.9	13.9	15.6	18.9	51.2	50.7	50.6	56.8
OECD-Europe	13.7	14.7	16.4	19.5	50.9	50.4	50.6	57.1
USA	12.6	12.5	13.6	17.5	51.7	52.0	50.5	57.4
Japan	11.9	16.5	21.1	25.6	43.5	47.2	56.7	67.8
Mexico	3.7	4.3	5.3	7.2	71.6	61.5	50.2	45.5
Turkey	4.0	5.5	6.1	7.7	65.2	54.0	51.9	45.6
Germany	14.9	16.2	20.2	22.5	45.3	46.7	50.0	57.3
France	13.8	15.5	16.3	20.2	51.1	52.8	51.2	59.6
United	15.7	15.9	17.0	19.7	52.9	54.0	52.3	58.3
Italy	14.8	17.9	20.6	23.6	45.5	47.8	51.5	58.8
Spain	13.2	16.2	17.6	20.1	49.3	45.3	46.9	52.7
Canada	11.3	12.3	13.8	18.2	47.5	48.3	47.5	56.3
1. Population aged 65 and over as a per cent of total population.								

5.5. URBANIZATION

Turkey, due to its age-structure, will not experience the same difficulties. Its problems will be concentrated on another issue: rapid urbanization. Although today the proportion of the urban population in Turkey is at the same level with many OECD countries (70 per cent), the urban population growth rate has been considerably higher than the OECD average. This rapid growth, as in many countries expected to be accompanied by an increase in the size and number of mega cities. The urbanization process constitutes a formidable fiscal and organizational challenge, due to the combination of population needs for employment, health, education, housing and transport, with the demands of the business community for services and infrastructure. Environmental problems are also very important. All these tasks need to be addressed by public and private sectors' co-operation. The challenges include the provision of various public goods, innovations in projects and finance of urban infrastructure and local community involvement in the setting of priorities and the design of urban programs. The other side of the coin shows the emergence of one of the most important markets of the world with the advantages of modern consumption patterns needed for fast growth. [23]

Table 5-6: Urban Population [23]

As % of total population			**Average annual growth rate (%)**
	1980	**1995**	**1980-95**
Turkey	42	62.5	4.8
High income economies	75	75	0.7
*S*ource : World Development Report - 1997 and SPO (Turkey)			

5.6. TECHNOLOGY

Technological change and demographic prospects are crucial parts of the overall picture over the period to the year 2020. No doubt, human capital and technological change will be the engine of economic development in the future. It is very difficult to predict technological development. [23]

This is why, neither the OECD report nor this study include any forecasts in the technological field. However, when we consider that the state of current technological change would have been unimaginable in 1970s, we continue to have great expectations for the future. In this context, major roles could be played by information technology, biotechnology and advanced materials. For instance, advances in microelectronics would accelerate worldwide communications, transforming the existing industrial structures and social relations. Biotechnology could create great advances in agricultural productivity, health care and environmental remediation. Advanced material might revolutionize aerospace, automobiles, electronics and construction. [23]

Technological change has two dimensions: innovation and technology diffusion. The main issue for all countries is the capacity to manage these dimensions and consequently to have the ability to promote sustained economic development. It includes not only the capacity of institutional actors, but also that of the system itself to address the challenges relating to several technological problems: organization of research and development, university research capacity, utilization of information technology, assimilation of imported technology, modern enterprise management, identification and protection of intellectual property rights.

Developed OECD countries are entering the period over 2020 with significant advantages of well-developed technology and know-how. This is important for their sustained economic growth, which will increasingly depend on cost-reducing and productivity-enhancing innovations, coupled with new product developments. No doubt, most new technology will continue to be generated by these countries. However OECD countries will face new pressures both from the rapid changes in technology in prospect and new stronger competitors. Today knowledge is diffused rapidly and an increasing number of countries create more receptive conditions to attract global business with high technology. Furthermore, in several OECD countries R&D expenditures have declined as a share of GDP in absolute terms, mainly due to economic slowdown. The governmental support for R&D risks also suffering from continued budget restrains in the future. As some developing countries have started to rely more and more on their own technological resources and public R&D investments have also risen steeply to support technology upgrading, the technology gap between them and the OECD area will certainly be narrowed. [23]

Although the amount of resources dedicated to research and development are at low levels compared to the OECD average, Turkey has a rapidly developing network of institutions in the public and private sectors, whose activities initiate, import, modify and diffuse new technologies. The percentage of spending on R&D by the private sector has been increasing (The percentage of the gross spending on R&D carried out by the industry from 1990 to 1995 has increased from 27.4 to 30.8). This is a sign of gradual convergence towards the pattern of developed OECD countries. [23]

There is a high degree of concentration of research in Turkish universities. Almost 74 per cent of all the national total researchers belong to higher education institutions. Moreover, the number of higher education researchers in Turkey is increasing at a very high rate exceeding most OECD countries. [23]

Energy R&D spending by the Turkish government in 1999 totaled 1,406 billion Turkish lira, or 0.002% of the country’s GDP. Government spending on energy R&D is thought to represent more than two-thirds of the total, the rest being made up by business R&D expenditure. Hence, overall energy R&D efforts as a percentage of GDP are much lower in Turkey than in other IEA countries. The trends in government energy R&D spending, in nominal terms, show an increase until 1997 and a decrease afterwards. The fall in spending is magnified when the data are converted into constant dollars, because of flaring inflation in the last three years. [7]

The patterns of government spending on R&D are erratic. No clear set of R&D spending priorities emerges from the breakdown in Figure 24: while research on fossil fuels seemed very important in 1990 and 1995, in one year research focused on oil and gas, and in another year coal research was favored. In 1999, on the other hand, renewable attracted more research funding than before. It is noteworthy, though, that the erratic pattern in government energy R&D spending conforms to the general pattern of R&D spending in Turkey, and with the development of the Turkish economy in general. However, the high R&D expenditure for 1997 was due mostly to Turkish refineries' (TUPRAS) R&D projects On 13 December 2000, the Supreme Council for Science and Technology, which is chaired by the prime minister, mandated the Scientific and Technical Research Council of Turkey (TUBITAK) to draw up an "Energy Technologies R&D Program and Action Plan". Work was launched on 5 January 2001 by the first meeting of a study group comprising a wide variety of experts and scholars from all concerned institutions. [7]

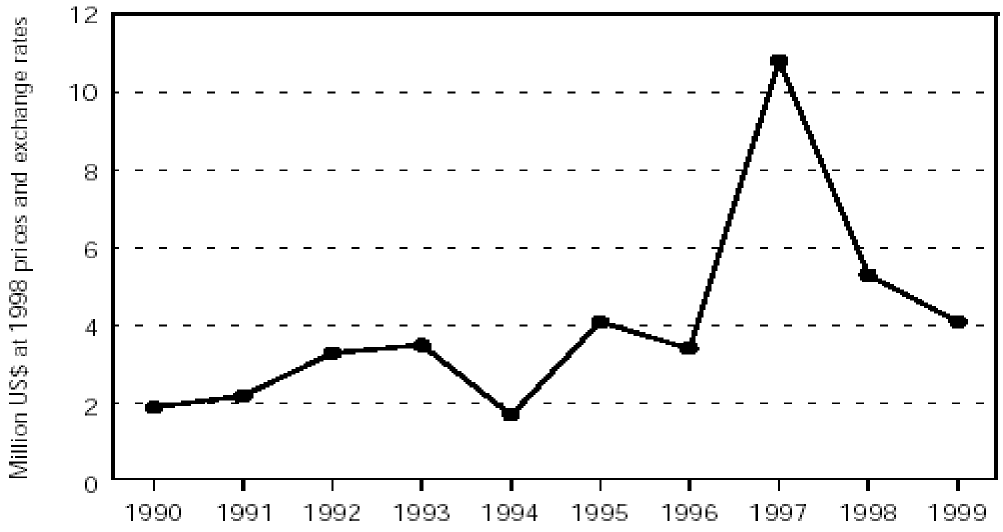


Figure 5-1: Total Turkish Government Energy R&D Spending, 1990-1999[7]

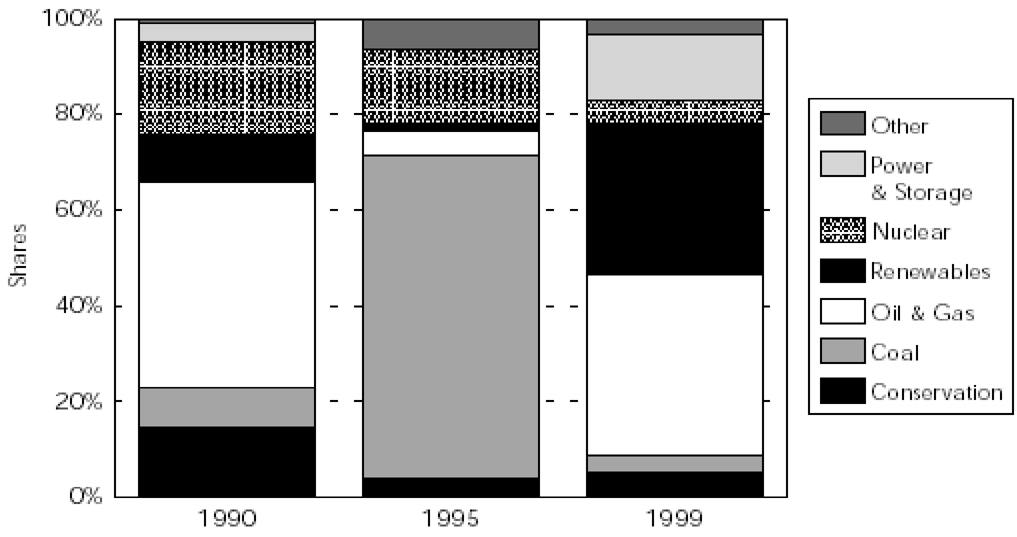


Figure 5-2: Breakdown of Turkish Government Energy R&D Expenditures 1990, 1995 and 1999 [7]

Through foreign trade and investment links, the business community in Turkey is able to get easy access to spillovers from foreign research and development activities. Turkey's liberalization program in foreign trade has increased and is expected to further increase such spillover effects. [23]

A country's capacity to absorb new technologies through foreign trade and foreign direct investment is closely associated with the skill and educational levels of its labor force. Turkey's "human resource development" efforts and in particular the eight year compulsory education introduced in 1997, are expected to have a positive effect on the level of creativity and skill of the Turkish work force of the 2020s. [23]

Due to the important role that information technology plays in integration into the global economy, it is crucial for national economies to have a proper infrastructure. Although its information technology market is still at a low level when compared with the developed OECD countries, Turkey stands to be one of the countries with the strongest average growth in information technology markets both in the OECD and the non-OECD world. [23]

Furthermore, Turkey has been among the 29 initial participants of the World Trade Organization (WTO) Ministerial Declaration on Trade Information Technology

Products (ITA) which was agreed at the first World Trade Organization (WTO) Ministerial Conference on 13 December 1996 in Singapore. The ITA that aims to eliminate customs duties and other duties and charges on information technology products by the year 2000 is expected to further develop the information technology market in the next decades. [23]

Information technologies also play an important role in transportation. Till now, transport systems have evolved with an emphasis on individual modes: maritime, road, rail or aviation. However the differences between modes of transport in the national regulatory framework, administrative procedures and in the assignment of liabilities for cargoes raise transaction and logistics costs significantly and impede the ability of firms to provide more rapid and reliable delivery. Consequently there are now new demands for improved transport efficiency and productivity. Increased use of technology seems to be the key in this regard. Information technology that is now available to companies enables more responsive, efficient and reliable transport. For instance the existing Intelligent Transport Systems (ITS) provides a truck driver with the possibility to determine whether or not a chosen route is congested; with Global Positioning Systems (GPS), the firm waiting for the product being transported knows exactly where the shipment is and when it will arrive. More improvements in container management, facilities in seaports or ITS technologies in freight vehicles are expected in the future. [23]

For improved performance, well-connected services between modes of transport can be developed. The evolution of container trade indicates the increase in international intermodal shipments and the connection between maritime and the land-based transport systems, whether rail or road. The increase of road-rail transport systems is also revealing (over the last 10 years almost 75 per cent use of intermodal transport needs increasing technological developments allowing transport equipment to be adopted for use in other modes but also a comprehensive change in the present framework of infrastructural policies, regulations and the management of operations. Of course, different transport modes are not necessarily substitutes for one another, since each has distinct advantages over others, according to the type of cargo, the distance to be traveled, the location of the pick-up and drop-off sites, the degree of traffic congestion, taxes and prices for using it, and particularly the existence or lack of infrastructure and the quality of infrastructure. [23]

5.7. GEOGRAPHY

Turkey is at the crossroads of existing and planned multimodal intercontinental transportation links. It is at the epicenter of road, railway, maritime, inland waterways and air transportation interconnecting Europe, Caucasus, Central Asia, Northern Africa and the Middle East. Creating an efficient and cost effective outlet to major markets, Turkey is a key transportation terminal at a point of regional and international convergence. [23]

Besides corridor 4 (Berlin / Nurnberg - Prag - Budapest - Constanta / Thessaloniki / Istanbul), several other priority road and railway corridors within the Pan-European Transportation System involve Turkey through corridor 4 to Istanbul, such as:

- 7 (Danube),
- 8 (Durres - Tirana - Skopje - Sofia - Varna),
- 9 (Helsinki - Chisinau - Bucharest - Dimitrovgrad - Alexandroupoli),
-10 branch B (Nis - Sofia).

This system aims to develop a Europe-wide transport policy based on co-coordinated infrastructure development, harmonization of national transport regulations, border crossing facilitation and an expanded research effort. Turkey is also the eastern gateway of Trans-European Networks (Tens) particularly designed for European Union members and included in one of the four Pan-European Transportation Areas (PETRAs). [23]

TRACECA (Transport Corridor Europe - Caucasus - Asia) project, launched in 1993 with a view to developing a transport corridor on the West -East axis from Europe, across the Black Sea, through the Caucasus and Caspian Sea to Central Asia, shall bring out the importance of the East Black sea Highway as the practical over-land connection of the project. This highway is also an integral part of the Black Sea Ring Corridor Concept which follows the Black Sea coastline, enhanced with railway and maritime links. Invariably, Turkey is on the path natural prolongation of the ECO (Economic Co-operation Organization) transportation network as well as of Mediterranean, North Africa and the Middle East. Moreover two of the three corridors envisaged within the framework of ESCAP (Economic and Social Commission for Asia and Pacific) to link Central Asia to Europe pass pass through Turkey. [23]

Trans-European Motorway (TEM) shall, in the south of Turkey, continue on to Iraq and other Middle Eastern countries. Completion of the southeastern section of the motorway shall provide better access to the Middle East. [23]

The building of deep seaports and receiving terminals in the Mediterranean and the Black Sea, construction of a rail tube tunnel crossing through the Bosporus, building of a transcontinental bridge over the Dardanelles, completion of the Kars - Tbilisi railway (as a complementary part of TRACECA), and extension of TEM motorways in the eastern and south eastern direction, building of international airports at metropolitan and tourist centers as well as the production and trade centers in Anatolia, Will position Turkey in 2010 and 2020 at the regional and intercontinental control panel of multimodal transportation. Consequently Turkey, envisaged as an energy bridge and terminal of the future, also forms the transportations backbone of three major continents in a fashion reminiscent of the historical silk route for the 21st century. [23]

6. TURKEY IN 2023

6.1. MAIN DRIVERS OF CHANGE

6.1.1. Increasing energy consumption

Turkish energy consumption has risen dramatically over the past 20 years. From just 1.0 quadrillion Btu (quads) in 1980, Turkey's domestic energy consumption has more than tripled, reaching a level of 3.2 quads in 2000. Although this is still low relative to similar-sized countries such as Germany (14.0 quads), France (10.4 quads), and Poland (3.7 quads), Turkey's upward trend may mean it will meet or even surpass these countries at some point in the future.

6.1.2. Environmental Problems

We must meet European environmental standards: Air pollution and wastes are one of the most important problems for Turkey. As energy demand will increase pollution is increase as the same amount. Transportation of energy: especially from Bosporus.

6.1.3. Development of Energy programs in the world

Since all other countries developing themselves and trying to develop new technologies for better life standards and to be powerful we must do the same way.

6.1.4. Climate Change, Air & Water & Marine Pollution

6.1.5. Renewable Energy Sources

Must be developed for clean energy technologies.

6.2. POWERFUL SIDES OF TURKEY

6.2.1. The Geographical position of Turkey makes it very important in the international arena since Turkey is located between the counties possessing rich oil and natural gas resources and the countries that need them. Transportation of these energy resources to the West through Turkey is an appropriate alternative due to economical and technical reasons as well as the political ones.

In the aftermath of the Cold War, Turkey has moved from the periphery of Europe to the epicenter of a new political and economic reality called Eurasia. This region, broadly defined to include Central Asia, the Caucasus and the Black Sea countries, attracts increasing attention not only because it constitutes one of the world's most potentially important energy-producing regions, but because it is also a crucial trade and transport corridor linking East and West. The prospective weight of the East is expected to increase in the global political, economic and environmental scene and the performance of the western economies may increasingly depend on the policies and performances of the new actors.

6.2.2. Turkey’s cultural, historic and ethnic ties with the newly independent states in Caucasus and Central Asia enabled her to establish very close political, cultural and economic links with them. We share the same concerns for stability and welfare of the region, for the consolidation of their independence and security as well as for progress in democracy.

6.2.3.The participation of foreign and local private capital and investment have been greatly encouraged by the Governments through the Built-Operate-Transfer (BOT), Built-Operate (BO) and Transfer of Operating Rights (TOOR) models. Auto-production is also allowed for private sector. BOT/BO programs were created to allow private investors to build and run new generating plants for 20-30 years.

6.2.4. Turkey will be an exception because it is a fairly **youthful nation** and its population increase will provide sufficient growth of labor force in the next 20 year.

It is not just the availability of technology but rather **management methods** that are also important in development. Both large scale and small and medium scale Turkish enterprises have been displaying a remarkably strong performance in management. The existing work force and the young team leaders of projects have been instrumental in this achievement.

6.2.5. The number of **higher education researchers** in Turkey is increasing at a very high rate exceeding most OECD countries.

6.2.6. Turkey's geography -- a rectangular plateau peninsula surrounded on three sides by seas -- is highly conducive to hydroelectric power generation; Turkey has about 1% of the total world hydroelectric potential.

6.2.7. We have good lignite & natural gas reserves. We must develop our technology in this manner.

6.2.8. New technological developments on the production of electricity and fuel from sun energy.

6.2.9. Because of the geographical position Turkey is more attractive for the foreign investors.

6.2.10. Liberalization of the energy sector market. The shift to a more knowledge-intensive, competitive economy also requires an important contribution from governments. This contribution is essentially indirect, creating conditions which foster technical, commercial and organizational innovation. In other words, the efficiency of the economy depends primarily on establishing policy co-ordination to bring together the finance, science and technology, employment, education and training and regulatory functions of governments. A better balance is particularly needed between the importance of rewarding innovation, thus encouraging entrepreneurial risk-taking, and the maximization of social and economic benefits, avoiding the abuse of market power which directly threatens the creation, distribution and commercialization of innovation.

6.2.11. Energy save potential is very high in Turkey.

6.2.12. Clean and Renewable energy potential is one of the most important powerful sides of Turkey.

6.2.13. We have potential also in Electro-mechanical industry.

6.2.14. Technological developments in the world provide the use of rich mines such as Borate, H and Thorium, which are the some of the most important strategically sources for Turkey.

6.2.15. Rich land potential for green area.

6.2.16. Different kind of energy sources is also another powerful side of Turkey.

6.3. POOR SIDES

6.3.1. Population growth along with rapid urbanization, are likely to increase energy demand substantially in the world over the next decades.

6.3.2. Prior to Turkey's recent severe economic difficulties**,** the country's energy consumption had been growing much faster than its production, making Turkey a rapidly growing energy importer. Assuming that the Turkish economy and energy demand return to a rapid growth path, Turkey will require billions of dollars worth of investments in coming years.

6.3.3. Turkey’s economic policies have encouraged energy waste.

6.3.4. Turkey is not a party to the U.N. Framework Convention on Climate Change (UNFCCC) or the Kyoto Protocol, meaning the country has no binding requirements to cut carbon emissions by the 2008-2012 periods as most other IEA countries have. However, Turkey has established a National Climate Coordination Group (NCCG) to carry out the national studies in line with those conducted by all countries of the UNFCC. [24]

6.3.5. No co-operation with industry on Research & Development to demonstrate and deploy new technologies that is relevant to the Turkish market. And also encouragement of government for research is not sufficient.

6.3.6. Poor relationships with our neighbors: We have to improve our relationship with our neighbors.

6.3.7. Non-stable government politic. This provides the foreign to invest money in Turkey.

6.3.8. Limited amount of oil and natural gas reserves.

6.3.9. We don't use energy efficiently. Most of the energy is wasted.

6.3.10. Turkey must develop more technological & economical transportation ways for development. Since, the expansion, dissemination and diversification of the infrastructure and technology of transportation and telecommunications will mark the world economy in 2020. The interrelated factors of deeper economic integration and ensuing transactions, evolving trade and investment links, increasing capital flows, and growing demand for energy will require improved transportation and advanced telecommunications. As far as transport facilities are concerned, improved transport infrastructure and services coupled with the application of information technologies could reduce global transport costs and bring about greater opportunities for international trade, investment, finance and tourism. Accordingly, transportation will definitely play a major role in the years to come.

6.4. VISION FOR 2023

6.4.1. To meet energy demand using domestic energy resources as the highest priority. In the next 20 year this will occur by mixing of public, private and foreign capital. New and renewable energy sources must be improved.

6.4.2. Future energy facilities would have no environmental impact. Conventional pollutants would be captured and either disposed of or converted to marketable co-products. There would be no solid or liquid discharges.

6.4.3. Emissions of carbon dioxide and other greenhouse gases must be reduced by new technologies. The captured carbon would be recycled into useful products.

6.5. TARGETS TO REACH OUR VISION

6.5.1. In Turkey most of energy is consumed by industry. Because of the non-stable economy in Turkey many plant could not develop themselves by technological developments in the world. In all manufacturing plants production technologies must be chosen with respect to their efficient and conventional energy usage.

6.5.2. Governmental & foreign investments must be done and energy centers must be started to operate.

6.5.3. We must develop our renewable energy sources by adding new and renewable sources (geothermal energy, solar energy, wind energy, biomass etc.)

6.5.4. To live in a healthy environment emission must be decreased to the OECD levels. In 1997, the Third Conference of the Parties to the UNFCCC adopted the Kyoto Protocol to the Convention, which brought more specific quantified emissions limitation and reduction commitments. The key objective of the Protocol is for Annex B countries to achieve reductions of six GHGs by at least 5% below 1990 levels between of 2008-2012. If Turkey signs and ratifies the UNFCCC as an Annex I and II country, it will come under the following key, but legally non-binding commitments: [24]

Adopt national policies and measures to limit its anthropogenic GHG emissions with the objective of returning to 1990 emission levels;

- Periodically communicate detailed information on these policies and measures, as well as national inventories of GHG emissions, to the UNFCCC Secretariat;

- Provide Financial resources, including technology transfer, to help non-Annex I countries meet the costs of complying with their Convention obligations;

If Turkey becomes a Party to the UNFCCC as an Annex I country and Ratifies the Kyoto Protocol as well, it will automatically be included in Annex B of the Protocol, and as such, will have to negotiate a ‘quantified emission limitation or reduction commitment’. As an Annex B Party to the Protocol, it will then come under legally binding obligations to limit or reduce its GHG emissions by the amount it negotiates, and with a view to the ultimate goal of reducing overall Annex B emissions by at least 5% below 1990 levels in the period 2008-2012. [24]

6.5.5. Research and development strategies must be developed. Government and private sector must work closely to each other. Funds for research must be increased. There are no stable spending on research and development in Turkey. From the following figure one can see the governmental energy R&D spending in past years:

In fact a wide array of activities can be classified as energy RD&D, at least in part. There are some less obvious ones: [34]

- Military R&D, which has energy 'spin-offs' (for instance, relating to improved aircraft engine performance, which subsequently leads to improved natural gas-fired turbines) may be important but is usually excluded.

- Research into catalysts and materials science.

- New chip designs, which improve battery life for various applications.

- Fiber optic research, which permits utilities to deliver cable television to homes.

- Research into portable fuel cells to power laptop computers.
- Space agency investments in photovoltaic cells used in communication satellites.
- Long-term research into beaming solar power from space to terrestrial receivers for electricity generation.
- Government-funded programmed to accelerate the deployment of efficient heat pumps - which can be justified on conservation or energy generation grounds (for example, in district heating schemes in Sweden).
- Government-funded research into reducing traffic bottlenecks.
- Research into consumer attitudes towards 'green power'.
- Automobile industry research.
- Research into carbon cycle modeling.

6.5.6. Since, most of energy is wasted before usage we should try to increase the number of well-trained personnel.

6.5.7. We must concentrate on the developing technologies.

6.5.8. Coal is the largest domestic energy source in Turkey. But some of them are not operated efficiently. We must continue to restructure of coal mining sector and privatization of viable mines.

6.5.9. Privatization is also playing an important role to reach our vision. The participation of foreign and local private capital and investment has been greatly encouraged by the Governments through the Built-Operate-Transfer (BOT), Built-Operate (BO) and Transfer of Operating Rights (TOOR) models. Auto-production is also allowed for private sector. BOT/BO programs were created to allow private investors to build and run new generating plants for 20-30 years. Through the TOOR model, operating rights for some of the Turkish Electricity Generation and

Transmission Company's (TEAS) generating plants and Turkish Electricity Distribution Company's (TEDAS) distribution facilities are currently being transferred to the private sector in order to increase efficiency, reduce operational costs and cover additional investments. [6]

6.5.10. Employers, employees and students should be informed and trained. Energy efficiency courses should be involved with the Engineering and Architecture Faculties' program. [21]

6.5.11. Innovative foreign energy conservation studies should be followed and applied into the national energy sector's contract, and information banks should be established to give information in the subject. [21]

6.6. TECHNOLOGICAL ACTIVITY AREAS

6.6.1. Electricity Production & Delivery

According to 1997 year data's 61.8 % of the electricity is produced from fossil fuels. 66.7 % of the lignite, 48.4 % of the natural gas, 10.1 % of the hard coal and 7 % of the oil is consumed for electricity. The difference between production and consumption in electricity is named as system leakages. In thermal centrals consumed energy is 8 % of the total produced energy. In Turkey and also in many European countries one of the most important problems is the leakage of electricity by delivery. [3]

It is nearly 2.5 times greater in Turkey with respect to the other OECD countries. As a disadvantage, Turkey has an increasing trend in electricity leakage. In the year of 1990 it was 9 %, in 1998 it was 15.8% but it was increased to 20.15% in 2001. [25]

Firstly, thermal centrals must be modernized for efficient electricity manufacturing. In thermal central where pulverized coal is used, efficiency is 35 % whereas it is 41 % in fluidized bed centrals. In coal gasification systems it is nearly 39 %. Efficiency is 55 % in natural gas centrals that are only producing electricity. However, it is nearly 85-90% in cogeneration centrals by using heat. [3]

In Turkey besides technological inefficiency most of the leakage resulted from uncontrolled inspection. Especially in rural areas many people use electricity by illegally. Moreover, the Government must support R&D studies.

6.6.2. Industry

MENR has published regulations whose aim is to increase industrial energy efficiency. Energy consumption by industry is 35 % of the total consumption. According to these regulations, the following precautions should be taken into account by industries [21]:

(a) Fuels and existing combustion systems should be used efficiently;

(b) Heating and cooling should be provided efficiently;

(c) Heat insulation should be done appropriately to the standards. Heat producer, distributor and user units should be isolated, and heat losses should be decreased;

(d) Waste heat should be recovered;

(e) Carnot cycle efficiencies of industrial plants should be increased;

(f) Electrical blackouts should be prevented;

(g) The use of cogeneration plants should be encouraged;

(h) Automatic control should be implemented in power plants;

(i) Air pollution emissions should be decreased and the impact on the environment of energy wastes should be minimized.

According to the studies conducted by Turkish State Statistics Institute (DIE) in 1992 and 1995, on the basis of the results obtained from approximately 1200 of these manufacturers, their total energy consumption of the places of employment, which annually consume 500 toes or above, constitute 75% of the industrial energy consumption of Turkey. Table 5 indicates the industrial subsectoral energy consumption and the share of the cost of energy production of Turkey. [21]

Table 6-1: Industrial Sub sector Energy Consumption and Share of The Cost of Energy Production of Turkey [7]

Industrial subsector energy consumption and the share of the cost of energy production of Turkey

Industry	Total energy (toe)	Rate of industrial consumption (%)	Rate of energy in total cost (%)
Iron/steel	4,863,328	34.9	11.5 and 48
Metals (except iron)	312,947	2.3	6.2 and 47.4
Ceramics	627,789	4.5	32.5
Cement	2,736,165	19.7	55
Glass	234,898	1.7	22–42
Paper and cellulose	468,823	3.4	9–30
Textile and woven	822,305	5.9	8–10
Petro chemical	606,423	4.6	28.5
Main chemicals	308,138	2.2	24
Chemical fertilizer	718,962	5.2	40
Petrol refineries	406,006	2.9	4
Dye, varnish	7149	0.05	1.6
Medicine	17,693	0.12	1.5
Soap, cleaners	41,190	0.3	2.1
LPG	34,082	0.24	1
Others	558,000	4	–
Forest products and furniture	72,143	0.52	6
Metal furniture	41,251	0.3	4
Flour products	8132	0.06	4
Tea	72,053	0.52	3.5
Sugar	415,759	2.99	8.5
Oil	137,731	0.99	3.7–6
Vegetable and fruit industry	65,762	0.47	6.44
Tobacco/beverage	107,287	0.77	0.7–6
Total	13,923,448	100	

As can be seen in the table, the iron and steel sectors take a large share (35%) of this consumption. In this sector, when the cost of the energy is investigated, this share breaks down into 48% in the iron and steel sector, 32.5% in the ceramics industry and 55% in the cement industry. On the basis of the cost of the energy, the share of the metal and soil industry, out of the total value of Turkey ranges from 11% to 55%. [21]

Coal is also used in industrial processes, primarily for steel making and cement manufacturing. Both uses can release air pollutants. The Clean Coal Technology Program demonstrated new ways to use coal directly in the blast furnaces of steel mills, rather than converting it to coke (the coking process releases pollutants which, unless captured, can become harmful air emissions). Another Clean Coal project tested a new type of scrubber for a cement kiln that used previously discarded dust from the kiln as a chemical to absorb sulfur dioxide and chlorine emissions before they escaped into the atmosphere. [21]

6.6.3. Construction of Buildings

Overall, buildings account for about 36 percent of primary energy use, 9 with substantial variation among countries. With global population increasing by 85 million per year, and urban populations in developing countries increasing by over 60 million per year, the correspondingly large number of buildings and modern appliances that these people will require will have a major impact on future energy use. These buildings will have lifetimes of typically 50 to 80 years; thus, delays in improving their energy efficiency will lock in energy waste and unnecessary expense for many decades. In addition, several hundred million households worldwide lack power and running water. For about one-third of the world’s population, cooking and in some cases heating is fueled by firewood, charcoal, or agricultural residues. [35]

Approximately one third of primary energy is consumed in non-industrial buildings such as dwellings, offices, hospitals, and schools where it is utilized for space heating and cooling, lighting and the operation of appliances. In terms of the total energy end use, this consumption is comparable to that used in the entire transport sector. Hence energy use in buildings represents a major contributor to fossil fuel use and carbon dioxide production. Following uncertainties in energy supply and concern over the risk of global warming, many countries have now introduced target values for reducing energy consumption in buildings. Overall, these are aimed at reducing energy consumption by between 15-30%. To achieve such a target, international co-operation, in which research activities and knowledge can be shared, is seen as an essential activity. [35]

In recognition of the significance of such energy use, the International Energy Agency has established an Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS). The function of ECBCS is to undertake research and provide an international focus for building energy efficiency. Tasks are undertaken through a series of annexes that are directed at energy saving technologies and activities that support their application in practice. Results are also used in the formulation of international and national energy conservation policies and standards. ECBCS undertakes a diverse range of activities both through its individual annexes and through centrally organized development and information exchange. ECBCS countries are free to choose which Annexes to take part in. Activities usually take the form of a 'Task Shared' Annex in which each country commits an agreed level of effort.

Occasionally an Annex may be either jointly or part jointly funded. More informal activities take place through Working Groups. [35]

Advanced building design techniques and associated technologies and appliances available today can cut in half the energy consumption of buildings in the United States and other OECD countries. Savings typically pay for the incremental cost of these more-efficient buildings in less than seven years. Techniques to achieve these savings include use of high-performance wall insulation, infiltration controls, advanced window technology (such as low-emissive coatings, high-molecular-weight-gas-filled glazing), increasing use of natural lighting and ventilation, reducing heating and cooling loads, and installing high-efficiency heating, cooling, and lighting equipment. The best results come from incorporating specifications for building envelope, equipment, controls, operations, and surrounding environment into a “whole building” framework. Similar or better energy performance improvements are feasible in the developing and transition countries. [36]

6.6.4. Transportation

The level of economic development and the development of the transport system varies significantly between Central Europe and Turkey. Per capita transport activity in Turkey is low compared to the other countries in the group and its infrastructure; especially rail is much less developed. [37]

Most of energy produced is consumed for transportation. (Nearly 22 %) In Turkey highways does 95 % of transportation, railways are 4 %, marine way is % 0, 1 and airway is % 0,9. In Turkey, one of our problems is that many people use their own cars for transportation. This cause to: [13]

- Air pollution
- Traffic jam
- Energy consumption

To solve this problem we must develop total transportation such as railways & marine ways. Besides energy consumption is also in minimum level for railways.

Table 6-2: Energy consumption per person by transportation type [13]

Transportation type	Energy consumption
Highway(personal cars)	567 kcal/person km
Highway(bus)	155 kcal/person km
Railway	48 kcal/person km

From the research and development studies some new technologies have been developed for transportation:

- High Efficiency Conventional Vehicles
- Electrical Vehicles
- Fuel cell

- Biodiesel
- Vehicles use hydrogen as fuel
- Speed train

Table 6-3: Energy consumption for load delivery by transportation type [13]

Transportation type	Energy consumption
Highway (truck)	921 kcal/ton km
Marine way	169 kcal/ton km
Railway	61 kcal/ton km

6.6.5. Heat

Energy consumption for heating is too high in Turkey because buildings have almost no insulation. Average consumption for heating in dwellings is above 200kWk/m2 per year. In addition, almost no building has passive solar techniques and solar energy cannot meet a significant part of their heat energy requirements despite the fact that Turkey has plenty of solar energy. For example, daily total global solar energy is about 30000kJ/m2 and sunshine duration is 10 h in summer and about 9000kJ/m2 and 3 h in winter, in Trakya (north-west of Turkey) [13]

In the residential/commercial sector, more than 80% of the energy consumed is used for heating. Energy use per unit of building area could be reduced by nearly half – according to an EIEI study carried out based on questionnaires in 1997– through the application to all buildings of the new Heat Insulation Standards on building envelopes, issued in 1999 (effective in June 2000). While existing buildings require 200-250 kWh/m2, the new standards could bring requirements down to 100-150 kWh/m2. At current rates of building stock turnover, the estimated energy efficiency gains could take several decades to materialize. [7]

6.6.6. Lightening

And electricity used for lighting in developing countries could be reduced 40 percent or more through use of more efficient lighting technologies—products that are already available and cost effective. A large technical, policy, and analytical base exist for improving building and appliance efficiency. [36]

7. TECHNOLOGICAL DEVELOPMENTS

7.1. COAL TECHNOLOGIES

Clean coal technologies are a family of new technological innovations that are environmentally superior to the technologies in common use today. Most are the products of research that has been conducted over the last 20 years or more. Clean coal technologies can be new combustion processes - like fluidized bed combustion and low-NOx burners - that remove pollutants, or prevent them from forming, while the coal burns. Clean coal technologies can be new pollution control devices - like advanced scrubbers - that clean pollutants from flue gases before they exit a plant's smokestack. Still other clean coal technologies can convert coal into fuel forms that can be cleaned before being burned. For example, a clean coal plant may convert coal into a gas that has the same environmental characteristics as clean-burning natural gas. [6]

Clean Coal Technology Program including innovative technologies in four major technology categories:

7.1.1. Advanced Pollution Controls

These devices could be installed on existing power plants or built into new facilities. Their purpose was to provide more effective and/or lower cost ways to reduce sulfur dioxide and nitrogen emissions. Examples of these devices included: [6]

SO2 control systems: These devices remove sulfur dioxide pollutants from the combustion gases after they exit the boiler. The Clean Coal Technology Program tested two basic versions of this technology: One worked inside the existing ductwork of a power plant. These devices are suitable for smaller, older plants with limited space for adding equipment. Typically these devices can reduce sulfur pollutants by 50 to 70%. For larger plants with the available space, the Clean Coal Technology Program tested advanced flue gas desulphurization technologies, or scrubbers. These devices are typically built as separate modules and can reduce sulfur pollutants by more than 90%. In the Clean Coal program, the advanced scrubbers were designed to remove the sulfur in an environmentally safe, solid powder rather than the difficult-to-handle sludge of older technologies.

NOx control technology: These devices reduce emissions of nitrogen oxides (NOx). Three basic categories were tested:

(1) New combustor designs (low-NOx burners) that retard the formation of nitrogen oxides by carefully controlling the way coal burns. These devices reduce NOx by 37 to 68%;

(2) "Reburning" technology where natural gas or coal is burned above the main combustion zone in such a way that nitrogen oxide pollutants are broken down into harmless molecular nitrogen before they leave the boiler. Reburning can reduce NOx emissions by 50 to 67%; and

(3) Scrubbing systems that inject ammonia or urea into combustion flue gases to remove nitrogen oxide pollutants. Non-catalytic technologies can reduce NOx by 30 to 50% while selective catalytic systems can eliminate 80 to 90%+ of NOx.

Several Clean Coal Technology projects combined both sulfur and nitrogen pollutant controls.

7.1.2. **Combustion:**

Fluidized bed combustors remove pollutants inside the boiler no scrubber or post-combustion sulfur and nitrogen controls are needed. Fluidized beds suspend solid fuels on upward-blowing jets of air during the combustion process. The result is a turbulent mixing of gas and solids. The tumbling action, much like a bubbling fluid, provides more effective chemical reactions and heat transfer. The technology burns fuel at temperatures of 1,400 to 1,700 °F, well below the threshold where nitrogen oxides form (at approximately 2,500 ° F, the nitrogen and oxygen atoms in the combustion air combine to form nitrogen oxide pollutants). The mixing action of the fluidized bed results brings the flue gases into contact with a sulfur-absorbing chemical, such as limestone or dolomite. More than 95 percent of the sulfur pollutants in coal can be captured inside the boiler by the sorbent. [38]

Pressurized fluidized-bed combustion (PFBC) builds on earlier work in atmospheric fluidized-bed combustion technology. Atmospheric fluidized bed combustion is crossing over the commercial threshold; with most boiler manufacturers currently offering fluidized bed boilers as a standard package. This success is largely due to the Clean Coal Technology Program and the Energy Department's Fossil Energy and industry partners' R&D. The popularity of fluidized bed combustion is due largely to the technology's fuel flexibility - almost any combustible material, from coal to municipal waste, can be burned - and the capability of meeting sulfur dioxide and nitrogen oxide emission standards without the need for expensive add-on controls. [27]

A 2nd generation pressurized fluidized bed combustor, currently under development, uses "circulating fluidized-bed" technology and a number of efficiency enhancement measures. Circulating fluidized-bed technology has the potential to improve operational characteristics by using higher air flows to entrain and move the bed material, and recalculating nearly all the bed material with adjacent high-volume, hot cyclone separators. The relatively clean flue gas goes on to the heat exchanger. This approach theoretically simplifies feed design, extends the contact between sorbent and flue gas, reduces likelihood of heat exchanger tube erosion, and improves SO2 capture and combustion efficiency. [27]

A major efficiency enhancing measure for 2nd generation pressurized fluidized bed combustor is the integration of a coal gasifier (carbonizer) to produce a fuel gas. This fuel gas is combusted in a topping combustor and adds to the combustor's flue gas energy entering the gas turbine, which is the more efficient portion of the combined cycle. The topping combustor must exhibit flame stability in combusting low-Btu gas and low-NOx emission characteristics. To take maximum advantage of the increasingly efficient commercial gas turbines, the high-energy gas leaving the topping combustor must be nearly free of particulate matter and alkali/sulfur content. Also, releases to the environment from the pressurized fluid bed combustion system must be essentially free of mercury, a soon-to-be regulated hazardous air pollutant. [27]

To reduce cost and carbon dioxide emissions, new sorbents are being evaluated. Sorbent utilization has a major influence on operating costs, and carbon dioxide emissions streams can result in the production and use of alkali-based sorbents. [27]

With all these features, 2nd generation pressurized fluidized bed combustion is expected to achieve a 52 percent fuel-to-electricity efficiency level and have near-zero NOx, SO2, and particulate emissions. Market entry is projected for 2008. [27]

7.1.3. Gasification Combined Cycle

Coal gasification offers a much more efficient way to generate electricity than conventional coal-burning power plants.

Coal gasification represents the next generation of coal-based energy production. With the first pioneering coal gasification power plants now operating in the United States and other nations, coal gasification is gaining increasing acceptance as a way to generate extremely clean electricity and other high-value energy products. Rather than burning coal directly, coal gasification reacts coal with steam and carefully controlled amounts of air or oxygen under high temperatures and pressures. [27]

The heat and pressure break apart the chemical bonds in coal's complex molecular structure, setting into motion chemical reactions with the steam and oxygen to form a gaseous mixture, typically hydrogen and carbon monoxide. (Gasification, in fact, may be one of the best ways to produce clean-burning hydrogen fuel in the future.) [27]

Pollutant-forming impurities and greenhouse gases can be separated from the gaseous stream. As much as 99% of sulfur and other pollutants can be removed and processed into commercial products such as chemicals and fertilizers. Unreacted solids can be collected and marketed as a co-product such as slag (used, for example, in road building). The primary product, fuel-grade coal-derived gas, rivals natural gas in environmental quality. [27]

The basic gasification process can also be applied to virtually any carbon-based feedstock - such as biomass, petroleum coke, municipal waste, or blends of these fuels. [8] Gasification is particularly suitable to treat industrial wastes but there are some problems with municipal solid wastes related to their heterogeneity. [38]

In a conventional plant, heat from the coal furnace is used to boil water, creating steam for a steam-turbine generator. By contrast, a gasification- based power plant uses the hot, high-pressure coal gases exiting a gasifier to power a gas turbine (in the same manner as natural gas). Hot exhaust from the gas turbine is then fed into a conventional steam turbine, producing a second source of power. This dual, or **"combined cycle"** arrangement of turbines - a configuration not possible with conventional coal combustion - offers major improvements in power plant efficiencies. [27]

Today's conventional combustion plants are typically 33-35% efficient (fuel-to-electricity). Coal gasification offers the prospects of boosting efficiencies to 45-50% in the short-term and potentially to nearly 60% with technological advancements.

Higher efficiencies translate into better economics and inherent reductions in greenhouse gases. [27]

Gas from coal is not only a clean fuel but also a rich source of chemicals. One of the primary products of coal gasification is hydrogen, the cleanest of all fuels. Coal-derived gas can also be recombined into liquid fuels, including high-grade transportation fuels, and a variety of petrochemicals. In contrast to conventional combustion, carbon dioxide exits a coal gasifier in a concentrated stream rather than diluted in a high volume of flue gas. This allows the carbon dioxide to be captured more easily and used for commercial purposes or sequestered. [27]

Historically, industry's interest in gasification has been to produce fuels, chemicals and fertilizers. Gasification is used today in refineries and chemical plants, but for electric power generation, the technology is still in the demonstration phase. [27]

In DOE's original Clean Coal Technology Program, utilities built and operated two successful coal gasification power plants (near Tampa, FL, and West Terre Haute, IN). The program is also cost-sharing another gasification power project in Kentucky now in the design phase. Each project, although designed to eventually operate commercially, is intended as a first-of-a-kind test of different gasifiers, cleanup systems, and applications. Another Clean Coal Technology gasification project is operating at Kingsport, TN, producing coal gas that is chemically recombined into industrial-grade methanol and other chemicals. [27]

Largely because of the environmental and efficiency benefits demonstrated in the Clean Coal Technology Program, several companies have announced plans to use coal gasification as the basis for future power plants. Current gasification-based power plants are estimated to cost about $1200 per kJ, compared to conventional coal plants at around $900 per kilowatt. [27]

DOE's Fossil Energy program is cost sharing with industry an effort that, if successful, will "leapfrog" today's state-of-the-art. The Vision 21 program is intended to lead to a new concept for coal-based energy production in which modular plants could be configured to produce a variety of fuels and chemicals depending on market needs with virtually no environmental impact outside the plant's "footprint."[27]

At test facilities in Wilsonville, AL, the National Energy Technology Laboratory in West Virginia and Pennsylvania, and several industry sites, research is underway to: [27]

- Develop revolutionary technologies (e.g., membranes) to separate oxygen from air for the gasification process and to separate hydrogen and carbon dioxide from coal gas;

- Improve gasifier designs to make them more durable and capable of handling a variety of carbon-based feedstock’s;

- Develop advanced gas cleaning technologies that can capture virtually all of the ash particles, sulfur, nitrogen, alkali, chlorine, and hazardous air pollutants; and Develop ways to minimize solid wastes and recycle them as commercial products.

- With the President's Clean Coal Power Initiative ($2 billion over the next 10 years), a means now exists for these high-potential, but still high-risk, technologies to move out of laboratory- and pilot-scale development and into major engineering tests as a precursor to commercial use.

These systems depart from coal combustion altogether. Instead, coal is turned into a gas, which can be cleaned of its impurities, virtually to same levels as natural gas. Then the gas is burned in a gas turbine to generate one source of electricity. Exhaust from the gas turbine is hot enough to boil water, creating steam to drive a steam turbine and generate a second source of electricity. This "combined cycle" technology offers a new technological approach for increasing power plant fuel efficiencies. Initial gasification-based plants could boost efficiencies by as much as 20% over conventional coal-burning power plants, and improved versions might eventually double today's efficiencies.

Gasification combined cycle technologies are among the cleanest ways to generate electricity from coal. As much as 95 to 99% of the sulfur and nitrogen known chemical processes can remove impurities in the coal gas. These pollutants can be converted into useable products, such as chemicals and fertilizers.

7.1.4. Kaline Cycle

Kaline cycle, where the standard Rankine cycle used in power generation employs a single working fluid, namely water, the Kaline cycle operates by using a mixture of two or more working fluids, varying their ratio in different parts of the cycle, It is claimed that the only significant change required by a conventional generating plant is in the condensing process, where a system to change the composition of the working fluid before and after condensation is required.

Significant increases in system efficiency claimed (10% or more) by tailoring the cycle to suit the specific system. [39]

7.2. RENEWABLE TECHNOLOGIES

7.2.1. Photovoltaic Cell

Photovoltaic (PV) cells are devices that convert sunlight to electricity, bypassing thermodynamic cycles and mechanical generators. PV stands for photo (light) and voltaic (electricity), whereby sunlight photons free electrons from common silicon. The phenomenon was first discovered in the 18th century. The photovoltaic cells were developed at Bell Labs in 1950 primarily initially for space applications. The Hubbell telescope utilizes solar panels for its energy requirements. [40]

The US Department of Energy during the Carter administration spent 500 million dollars developing this technology. Costs have dropped since then and currently, solar cells have proved to be cost effective. Other than space satellites, the photovoltaic cells are being used in rural health clinics for refrigeration, water pumps for irrigation and for small-scale power generation. [40]

Solar cell is also being used in developing countries. Solar panels can power a 17" b/w TV, a radio or a fan. Some electric lighting systems provide sufficient current for up to 10 hours of lightning each evening. Locally produced car batteries can provide up to 5 nights of energy for an 8 J DC fluorescent light. [40]

The new Mazda 929 uses solar cells to activate a fan to ventilate the car when the car is idle and parked during a sunny hot day. [9]

The use of silicon crystals in the Photovoltaic cells makes it expensive. First of all, silicon crystals are currently assembled manually. Secondly, silicon purification is difficult and a lot of silicon is wasted. In addition, the operation of silicon cells requires a cooling system, because performance degrades at high temperatures. However, it has convinced analysts that solar cells will become a significant source of energy by the end of the century. [9]

Research is underway for new fabrication techniques, like those used for microchips. Alternative materials like cadmium sulfide and gallium arsenide are at an experimental stage. Reduction of cost will depend the economies of scale. [41]

Oil companies for example, are aware of the renewed interest in solar power. They are diversifying their holdings in other forms of energy. Today, the chemical giant Exxon is the second largest producer of solar cells. [41]

7.2.2. Solar thermal

With solar thermal electrical technologies, sunlight is focused on to a receiving station to heat a fluid. This fluid can be used to raise steam for electricity generation. Existing designs are uneconomical but continuing R&D (especially on the heat engines for generating electricity and improvements in the costs and reliability of tracking systems), together with the potential for economies of scale, could improve the competitiveness of the technology. One drawback is that solar power plants cover a large surface area and will therefore probably be limited to desert regions. [39]

In solar hot water heating systems, heat-transfer fluid (such as water or antifreeze) flows through the tubes of solar collectors, where it is heated by the sun and then transfers the heat to the household water. Typically, a solar water heating system has a back-up conventional heating system in the event of heavy or unusual hot water requirements during the year, but some homeowners opt to use solar hot water as the sole source for hot water. The size of the system will vary from household to household and will depend on several factors including: the number of people living in the house, the number of bathrooms, and household hot water needs. [39]

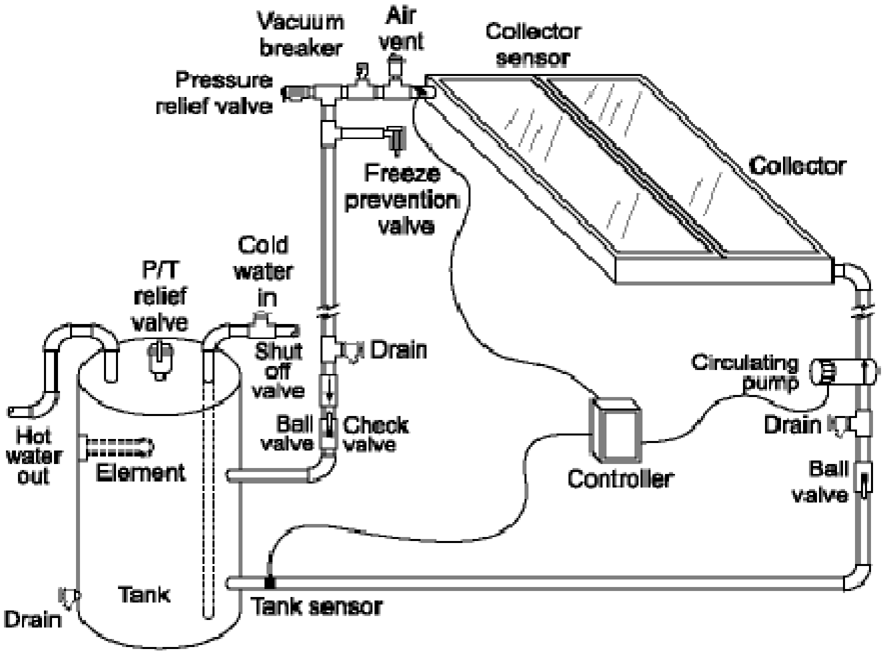


Figure 7-1: A typical active solar hot water system configuration [18]

Solar water heating systems for homes have two primary parts: a solar collector and a storage tank. (See Figure 7-1) The most common collector is called a flat-plate collector that is mounted on the roof of the home. The collector consists of a thin, flat, rectangular box with a transparent cover that faces the sun. Small tubes run through the box and carry the fluid to be heated. The tubes are attached to an absorber plate, which is painted black to absorb the heat. As heat builds up in the collector, it heats the fluid passing through the tubes. The storage tank then holds the hot liquid. The storage tank can be either a modified water heater, or larger well-insulated tank. Systems that use fluids other than water usually heat the water by passing it through a coil of tubing in the tank (i.e. a heat exchanger), which is full of hot fluid. Solar water heating systems can be either active or passive. The most common systems are the active systems that rely on pumps to move the liquid between the collector and the storage tank. Passive systems rely on gravity and the tendency for water to naturally circulate as it is heated. [18]

Solar hot water heaters can also characterize by direct (open loop) and indirect (closed loop) systems. Direct systems use a heat transfer fluid (water or diluted antifreeze) in the collector that collect the heat from the sun and then transfer the heat to the household water. Indirect systems simply circulate the household water through the solar collector where it absorbs the heat from the sun. [18]

7.2.3. Wind Energy

Wind power is now the world's fastest growing energy source. It increased by 33% from 1994 to 1995. On-shore wind energy schemes have been deployed in many countries with high wind regimes (8 m/s on average). Public acceptability, however, has proven to be a problem. One way of overcoming this is to mount wind turbines in offshore locations. Although this technology is approaching maturity, further R&D is required to reduce generating costs. [39]

7.2.4. Wave Energy

Prototype shoreline wave energy devices based on the oscillating water concept have been successfully deployed on a small scale in several countries. Further R&D is needed on the performance of such schemes at larger scale (especially on the turbines). A totally new concept designed by a Dutch group has been successfully tested. It differs from conventional wave energy technology in the sense that it is under the surface of the ocean where it is more protected and uses the huge swell of waves in the ocean. According to calculations, the world has 20 000 kilometers of suitable ocean coastline and each kilometer could generate 48 megawatts. [39]

7.2.5. Biomass

Biomass is a term for all organic material that stems from plants (including algae, trees and crops). Biomass is produced by green plants converting sunlight into plant material through photosynthesis and includes all land- and water-based vegetation, as well as all organic wastes. Biomass has always been a major source of energy for mankind and is presently estimated to contribute of the order 10– 14% of the world’s energy supply. [42]

Biomass is the plant material derived from the reaction between CO_2 in the air, water and sunlight, via photosynthesis, to produce carbohydrates that form the building blocks of biomass. Typically photosynthesis converts less than 1% of the available sunlight to stored, chemical energy. The solar energy driving photosynthesis is stored in the chemical bonds of the structural components of biomass. If biomass is processed efficiently, either chemically or biologically, by extracting the energy stored in the chemical bonds and the subsequent 'energy' product combined with oxygen, the carbon is oxidized to produce CO_2 and water. The process is cyclical, as the CO_2 is then available to produce new biomass. [42]

Biomass can be converted into three main types of product:

- Electrical/heat energy,
- Transport fuel,
- Chemical feedstock.

Researchers characterize the various types of biomass in different ways but one simple method is to define four main types, namely:

- Woody plants,
- Herbaceous plants/grasses,
- Aquatic plants,
- Manures.

Within this categorization, herbaceous plants can be further subdivided into those with high- and low-moisture contents. Apart from specific applications or needs, most commercial activity has been directed towards the lower moisture-content types, woody plants and herbaceous species and these will be the types of biomass investigated in this study. Aquatic plants and manures are intrinsically high-moisture materials and as such, are more suited to 'wet' processing techniques. Based primarily upon the biomass moisture content, the type of biomass selected subsequently dictates the most likely form of energy conversion process. High moisture content biomass, such as the herbaceous plant sugarcane, lends itself to a 'wet/aqueous' conversion process, involving biologically mediated reactions, such as fermentation, while a 'dry' biomass such as wood chips, is more economically suited to gasification, pyrolysis or combustion. Aqueous processing is used when the moisture content of the material is such that the energy required for drying would be inordinately large compared to the energy content of the product formed. [42]

7.2.6. Hydrogen and Fuel Cells

Many policy makers, energy analysts, environmental organizations and industry leaders have asserted that hydrogen is the fuel of the future. Its attraction is that it is both inexhaustible and clean (its combustion produces only water). However, the technology is not yet advanced enough for hydrogen to be commercial – particularly in the areas of production and storage. [5]

Hydrogen is the most abundant element in the universe – although little exists as a free gas on Earth. Currently hydrogen is produced mainly from fossil fuels for industrial purposes in petroleum refining, chemical production, metal manufacturing and electronics production. [5]

Hydrogen is an energy carrier, not an energy source, and must be produced. Two production routes are available: conversion of hydrocarbon by partial oxidizing or reforming, and electrolysis of water by electricity the electricity can be produced by a variety of inputs including fossil, nuclear or solar plants. Other routes are possible, for example, thermal dissociation of water at high temperatures. Currently, 98% of hydrogen is produced from hydrocarbons, with the production cost approximately five times the cost of the hydrocarbons used to produce hydrogen. The thermal power of hydrogen per unit of volume is very low compared to natural gas, LPG, gasoline or diesel. While the thermal power of hydrogen per unit of mass is very high (119995 kJ/kg of H_2 liquid compared to 43338 kJ/kg for jet fuel A_1), hydrogen has to be liquefied at very low temperature (-253^{o}C). [5]

The principle of fuel cell was first discovered in 1839 by Sir William R. Grove, a British jurist and physicist, who used hydrogen and oxygen as fuels catalyzed on platinum electrodes. A fuel cell is defined as an electrochemical device in which the chemical energy stored in a fuel is converted directly into electricity. A fuel cell consists of an electrolyte material, which is sandwiched in between two thin electrodes (porous anode and cathode). Specifically, a fuel cell consists of an anode—to which a fuel, commonly hydrogen, is supplied—and a cathode—to which an oxidant, commonly oxygen, is supplied. The oxygen needed by a fuel cell is generally supplied by feeding air. The two electrodes of a fuel cell are separated by an ion-conducting electrolyte. All fuel cells have the same basic operating principle. An input fuel is catalytically reacted (electrons removed from the fuel elements) in the fuel cell to create an electric current. The input fuel passes over the anode (negatively charged electrode) where it catalytically splits into electrons and ions, and oxygen passes over the cathode (positively charged electrode). The electrons go through an external circuit to serve an electric load while the ions move through the electrolyte toward the oppositely charged electrode. At the electrode, ions combine to create by-products, primarily water and CO2. Depending on the input fuel and electrolyte, different chemical reactions will occur. The main product of fuel cell operation is the DC electricity produced from the flow of electrons from the anode to the cathode. The amount of current available to the external circuit depends on the chemical activity and amount of the substances supplied as fuels and the loss of power inside the fuel cell stack. The by-products of fuel cell operation are heat, water in the form of steam or liquid water, and CO2 in the case of hydrocarbon fuel. [43]

Hydrogen as a fuel is championed because, theoretically, it can be derived from totally renewable sources, such as solar energy. Hydrogen, moreover, creates absolutely no air pollution when it burns. Finally, hydrogen fuel is the optimal fuel to use in a fuel cell since it will cause the slowest degradation of the elements of the fuel cell. The disadvantages of hydrogen are that it must be transported and stored under extreme pressure, up to 2,000 PSI. Two somewhat related consequences of this are an entire new distribution and storage infrastructure must be built, an undertaking of massive, nearly incalculable expense, and since hydrogen is highly flammable, an explosive hazard is created and an infrastructure must be created to counter and prepare against. [41]

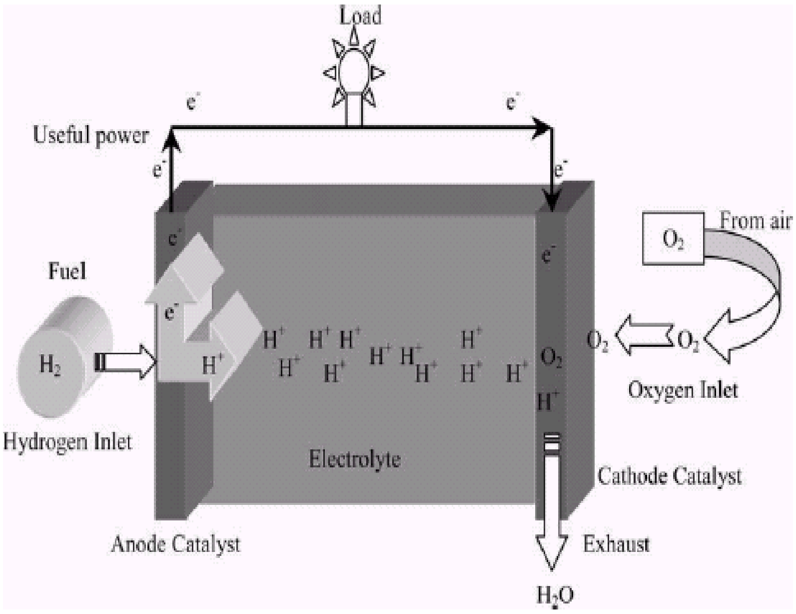


Figure 7-2: Typical fuel cell configuration. [34]

They come in all sizes, and will be used for everything from micro-appliances to tools and appliances, to home power units, to car power units, to building power units, to utility power plants. Fuel cells will power ships at sea and colonies in space. [41]

7.2.6.1) Proton-exchange membrane fuel cell: The PEMFC uses a solid polymer membrane as its electrolyte. This membrane is an electronic insulator, but an excellent conductor of protons (hydrogen cations). The ion-exchange membrane used to date is fluorinated sulfonic acid polymer such as Nafion resin manufactured by Du Pont, which consist of a fluorocarbon polymer backbone, similar to Teflon, to which are attached sulfonic acid groups. The acid molecules are fixed to the polymer and cannot “leak” out, but the protons on these acid groups are free to migrate through the membrane. The solid electrolyte exhibits excellent resistance to gas crossover. With the solid polymer electrolyte, electrolyte loss is not an issue with regard to stack life. Typically the anode and cathode catalysts consist of one or more precious metals, particularly platinum (Pt) supported on carbon.

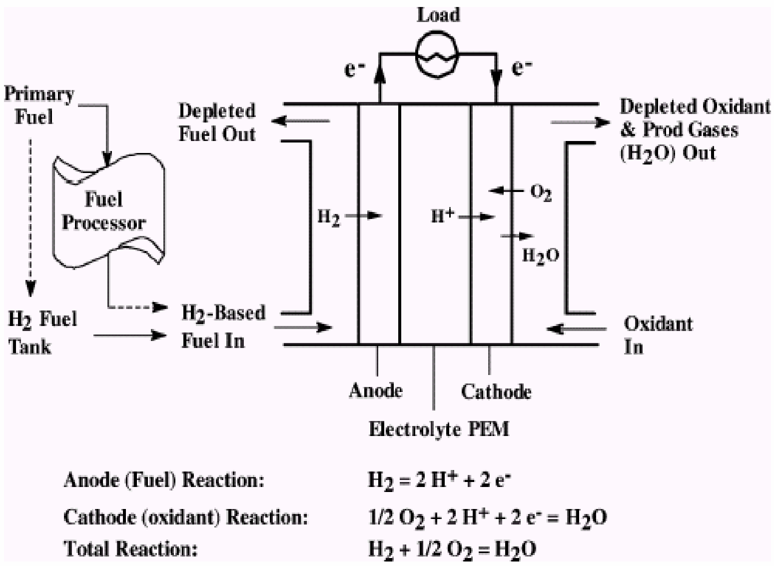


Figure 7-3: Concept of Proton-Exchange Membrane Fuel Cell System [34]

Because of the limitation on the temperature imposed by the polymer and water balance, the operating temperature of PEMFC is less than 120°C, usually between 70 and 90°C. PEMFC technology is primarily suited for residential/ commercial (business) and transportation applications. PEMFC offers an order of magnitude higher power density than any other fuel cell system, with the exception of the advanced aerospace AFC, which has comparable performance. [43]

7.2.6.2. Phosphoric acid fuel cell: The PAFC uses liquid, concentrated phosphoric acid as the electrolyte. The phosphoric acid is usually contained in a Teflon bonded silicon car- bide matrix. The small pore structure of this matrix preferentially keeps the acid in place through capillary action. Some acid may be entrained in the fuel or oxidant streams and addition of acid may be required after many hours of operation. Platinum supported on porous carbon is used on both the anode (for the fuel) and cathode (for the oxidant) sides of the electrolyte. PAFC operates at 180–220°C, typically around 200°C. [34]

The relative stability of concentrated phosphoric acid is high compared to other common acids, which enables PAFC operation at the high end of the acid temperature range of up to 220ºC.

In addition, the use of concentrated acid of nearly 100% minimizes the water vapor pressure and therefore water management in PAFC is not difficult, unlike PEMFC. PAFC power plant designs can achieve 40–45% fuel-to-electricity conversion efficiencies on a lower heating value basis (LHV). PAFC has a power density of 160–175 W/ft^2 of active cell area. Turnkey 200kW plants are now available and have been installed at more than 70 sites in the United States, Europe, and Japan. Operating at about 200°C (400°F), the PAFC plant also produces heat for domestic hot water and space heating. PAFC is the most mature fuel cell technology in terms of system development and is already in the first stages of commercialization. It has been under development for more than 20 years and has received a total worldwide investment in the development and demonstration of the technology in excess of $ 500 million. The PAFC was selected for substantial development a number of years ago because of the belief that, among the low-temperature fuel cells, it was the only technology, which showed relative tolerance for reformed hydrocarbon fuels and thus could have widespread applicability in the near term. [43]

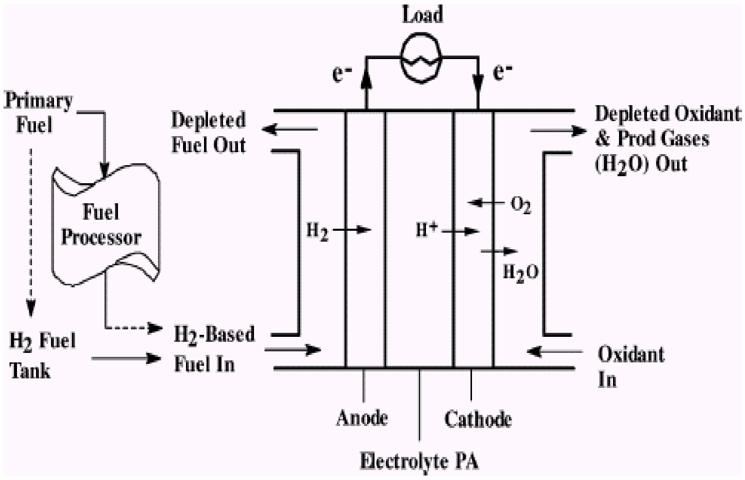


Figure 7-4: Concept of Phosphoric Acid Fuel Cell [34]

7.2.6.3 Alkaline fuel cell: AFC uses aqueous solution of potassium hydroxide (KOH) as its electrolyte. The electrolyte is retained in a solid matrix (usually asbestos), and a wide range of electro catalysts can be used, including nickel, metal oxides, spinals, and noble metals electrode. The operating temperatures of AFC can be higher than PAFC by using concentrated KOH (85%) for high-temperature AFC at up to 250ºC, or lower by using less concentrated KOH (35–50%) for low-temperature AFC at <120º C. The fuel supply for AFC is limited to hydrogen; CO is a poison; and CO2 reacts with KOH to form K2CO3, thus changing the electrolyte. [43]

AFC concept has been described since 1902 in a US patent but Francis T. Bacon at Cambridge, England did not demonstrate them till the 1940s and 1950s. Since 1960s AFC has been used in space applications that took man to the moon with the Apollo missions. However, the requirements of pure H2 and the sensitivity to CO2 appear to be among the major factors limiting the widespread application of AFC. The alkaline fuel cell is being phased out in the US where its only use has been in space vehicles.

However, it should be noted that AFC has its advantages of being simple in design and less expensive (electrolyte materials), and may have some applications where its disadvantages (require pure H2, sensitive to CO2) are not an issue such as with regenerative fuel cells involving water [43].

7.2.6.4 Molten carbonate fuel cell:

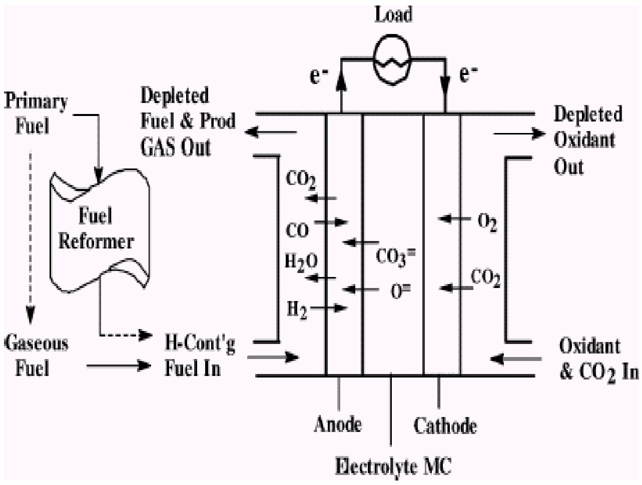


Figure 7-5: Concept of Molten Carbonate Fuel Cell [34]

The MCFC uses a molten carbonate salt mixture as its electrolyte. The composition of the electrolyte varies, but usually consists of lithium carbonate and potassium carbonate (Li_2CO_3–K_2CO_3). At the operating temperature of about 650ºC (1200ºF), the salt mixture is liquid and a good ionic conductor. The electrolyte is suspended in a porous, insulating and chemically inert ceramic ($LiA1O_2$) matrix. At the high operating temperatures in MCFCs, noble metals are not required for electrodes; nickel (Ni) or its alloy with chromium (Cr) or aluminum (Al) can be used as anode, and nickel oxide (NiO) as cathode. The cell performance is sensitive to operating temperature. A change in cell temperature from 650 ºC to 600ºC results in a drop in cell voltage of almost 15%. MCFCs operate at higher temperatures, around 650ºC; they are candidates for combined-cycle applications, in which the exhaust heat is used to generate additional electricity. When the waste heat is used, total thermal efficiencies can approach 85%. [43]

The disadvantages of MCFC are that the electrolyte is corrosive and mobile, and a source of CO_2 is required at the cathode to form the carbonate ion. [43]

7.2.6.5. Solid oxide fuel cell: SOFC uses a ceramic, solid-phase electrolyte, which reduces corrosion considerations and eliminates the electrolyte management problems, associated with the liquid electrolyte fuel cells. To achieve adequate ionic conductivity in such a ceramic, however, the system must operate at high temperatures in the range of 650–1000ºC, typically around 800–1000ºC (1830°F) in the current technology. The preferred electrolyte material, dense yttrium (Y_2O_3)-stabilized zirconium (ZrO_2) is an excellent conductor of negatively charged oxygen (oxide) ions at high temperatures. The SOFC is a solid-state device and shares certain properties and fabrication techniques with semiconductor devices. The anode of SOFC is typically a porous nickel–zirconium ($Ni–ZrO_2$) cermet (cermet is the ceramic–metal composite) or cobalt–zirconium ($Co–ZrO_2$) cermet, while the cathode is typically magnesium (Mg)-doped lanthanum manganate or strontium (Sr)-doped lanthanum manganate $LaMnO_3$. At the operating temperature of 800–1000ºC, internal reforming of most hydrocarbon fuels should be possible, and the waste heat from such a device would be easily utilized by conventional thermal electricity generating plants to yield excellent fuel efficiency. On the other hand, the high operating temperature of SOFC has its own drawbacks due to the demand and thermal stressing on the materials including the sealants and the longer start-up time. Because the electrolyte is solid, the cell can be cast into various shapes such as tubular, planar, or monolithic. SOFCs are currently being demonstrated in a 160kW plant. They are considered to be state-of-the-art fuel cell technology for electric power plants and offer the stability and reliability of all-solid-state ceramic construction. Operation up to 1000ºC (1830ºF) allows more flexibility in the choice of fuels and can produce better performance in combined-cycle applications. Adjusting air and fuel flows allows the SOFC to easily follow changing load requirements. Like MCFCs, SOFCs can approach 50–60% (LHV) electrical efficiency, and 85% (LHV) total thermal efficiency. [43]

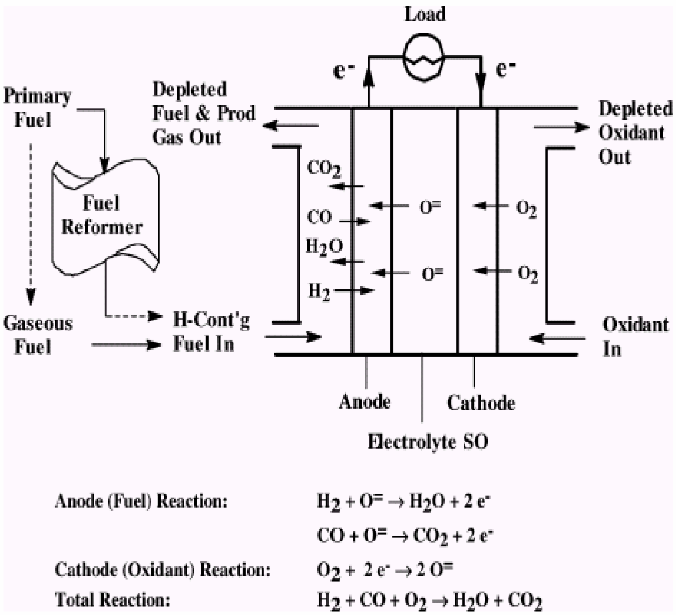


Figure 7-6: Concept of Solid Oxide Fuel Cell [34]

They come in all sizes, and will be used for everything from micro-appliances to tools and appliances, to home power units, to car power units, to building power units, to utility power plants. Fuel cells will power ships at sea and colonies in space. Fuel cells today are expensive to manufacture and depend on ongoing technological innovations to ensure their eventual economic viability. For example, unless you want to run a fuel cell on hydrogen fuel, you will have to process your fuel through a "reformer." This device reformulates non-hydrogen fuels such as gasoline, methane, etc., to turn them into hydrogen. [43]

This problem is being overcome but progress is slow. Reformers are still very expensive. Some of the higher temperature fuel cells can actually directly process non-hydrogen fuels, methane, gasoline and ethanol, without using the reformer. This can degrade and destroy lower temperature fuel cells, as well as high-temperature fuel cells using earlier technologies. And high temperature fuel cells that can directly process non-hydrogen fuels are still expensive, too. [43]

Fuel cells are intrinsically much more energy-efficient, and could achieve as high as 70–80% system efficiency (including heat utilization) in electric power plants using solid oxide fuel cells (SOFC, versus the current efficiency of 30–37% via combustion), and 40–50% efficiency for transportation using proton-exchange membrane fuel cells (PEMFC) or solid oxide fuel cells (versus the current efficiency of 20–35% with internal combustion (IC) engines). The technical discussions will focus on fuel processing for fuel cell applications in the 21st century. The strategies and options of fuel processors depend on the type of fuel cells and applications. Among the low-temperature fuel cells, proton-exchange membrane fuel cells require H2 as the fuel and thus nearly CO-free and sulfur-free gas feed must be produced from fuel processor. High-temperature fuel cells such as solid oxide fuel cells can use both CO and H2 as fuel, and thus fuel processing can be achieved in fewer steps. Hydrocarbon fuels and alcohol fuels can both be used as fuels for reforming on-site or on-board. Alcohol fuels have the advantages of being ultra-clean and sulfur-free and can be reformed at lower temperatures, but hydrocarbon fuels have the advantages of existing infrastructure of production and distribution and higher energy density. Further research and development on fuel processing are necessary for improved energy efficiency and reduced size of fuel processor. More effective ways for on-site or on-board deep removal of sulfur before and after fuel reforming, and more energy-efficient and stable catalysts and processes for reforming hydrocarbon fuels are necessary for both high-temperature and low temperature fuel cells. In addition, more active and robust (non-pyrophoric) catalysts for water–gas-shift (WGS) reactions, more selective and active catalysts for preferential CO oxidation at lower temperature, more CO-tolerant anode catalysts would contribute significantly to development and implementation of low-temperature fuel cells, particularly proton-exchange membrane fuel cells. In addition, more work is required in the area of electrode catalysis. [43]

By far the greatest research interest throughout the world has focused on Proton Exchange Membrane and Solid Oxide cell stacks. PEMs are a well-advanced type of fuel cell that is suitable for cars and mass transportation if they can be made cost competitive. Their efficiency is around 50%, which is better than any internal combustion engine. Efforts made by DLR, a German aerospace research body, has resulted in a reduction of the amounts of noble metal catalyst needed in PEMFCs and DMFCs to less than 0.05 mg/sqcm by engineering extremely thin reactive layers [11]. A thin layer tends to be more efficient since it promotes reaction and allows the passage of product water. As for the future development of SOFCs, having efficiency around 70% with a heat conversion possibility, it is mainly concerned with reducing their operating temperature since expensive high temperature alloys are used to house the fuel cell. The reduction in the temperature will therefore allow the use of cheaper structural components such as stainless steel. A lower temperature will also ensure greater overall system efficiency and a reduction in the thermal stresses in the active ceramic structures, leading to a longer expected lifetime of the system, and making possible the use of cheaper interconnect materials such as ferritic steels, without protective coatings. In the DLR's process, Ceramics that are currently being developed, by researchers around the world, to replace the actual yttria-stabilized zirconium (YSZ) include scandium-stabilized zirconium (ScSZ), samarium-doped ceria, gadolinium-doped ceria (Gd-doped CeO_2), $Ba_2In_2O_5$, in addition to perovskite ceramic such as $BaCe0.9Gd0.1O_3$, $CaAl0.7Ti0.3O_3$ and $SrZr0.9Sc0.1O_3$ [12]. Doped lanthanum gallate, in particular (SrMg)–doped $LaGaO_3$, appears to show promise as an SOFC solid electrolyte. New ways are also sought to deposit electrolyte film very thinly in order to minimize ohmic losses and reduce costs. A range of ceramic perovskite that includes the oxide of lanthanum compounded with gallium scandium, indium and aluminum for cathode material purposes, are also produced. [34]

The energy industry is also getting serious about hydrogen. Both Shell and BP have established core hydrogen divisions within their companies. Exxon Mobil is teaming up with GM and Toyota to develop fuel cells. Texaco has become a major investor in hydrogen storage technology. [41]

7.2.6.6. Fuel Cells for electric power plants:

Figure 7-6 shows the components of fuel cell systems for electric power plants. Fuel cell systems can be grouped into three sections: fuel processor, generator (fuel cell stack), and power conditioner (DC/AC inverter). In the fuel processor, a fuel such as natural gas or gasoline is processed in several steps to produce hydrogen. The hydrogen-rich fuel and oxygen (air) are then fed into the generator section to produce DC electricity and reusable heat. The generator section includes a fuel cell stack which is a series of electrode plates interconnected to produce the required quantity of electrical power. The output DC electricity from fuel cell is then converted to AC electricity in the power conditioning section where it also reduces voltage spikes and harmonic distortions. The power conditioner can also regulate the voltage and current output from the fuel cells to accommodate variations in load requirements [43].

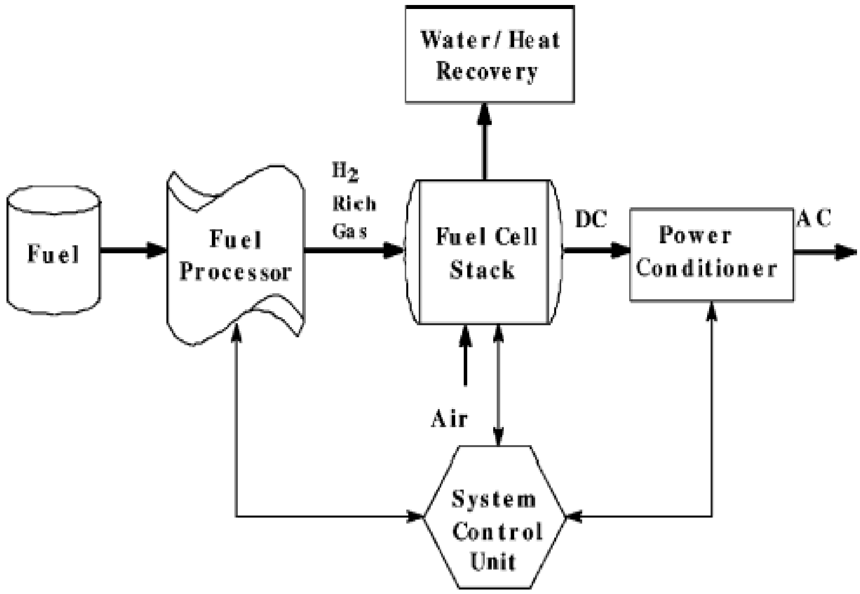


Figure 7-7: The Components of Fuel Cell Systems for Electric Power Plants [34]

Figure 7-7 illustrates different paths of electricity generation from hydrocarbon-based solid, liquid and gaseous fuels by conventional technologies and new technologies based on fuel cells. [43]

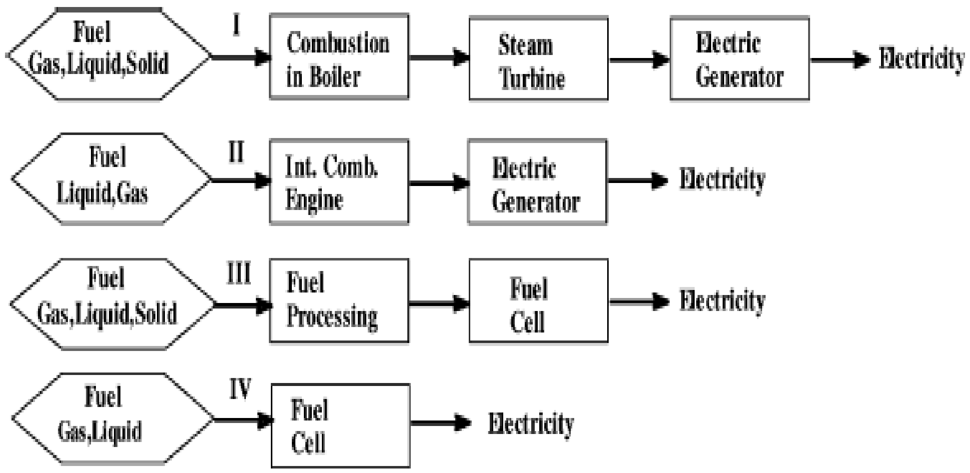


Figure 7-8: Different Paths of Electricity Generation from Hydrocarbon-based solid, liquid and gaseous fuels [34]

7.2.6.7. Fuel Cells for Transportation

Currently, the typical overall fuel efficiency of gasoline-powered cars is only around 12%, and the overall fuel efficiency of diesel-powered vehicles is better, at around 15%. These numbers, however, indicate that the majority of the energy is wasted. Therefore, new powering mechanisms (that are more efficient and clean) are also being explored by many auto manufacturers. Fundamentally, the theoretical upper limit of efficiency in the current IC engines is set by a thermodynamic (Carnot) cycle based on combustion, and this must be overcome by using different conversion devices. Fuel cells hold tremendous potential in this direction. Fuel cell-powered cars are expected to be two to three times more efficient than the gasoline and diesel engines. There is a great potential for the widespread applications and there is a fundamental need in view of sustainable development. [43]

7.2.6.8. Fuel Cells for Residential and commercial sectors

While centralized electric utilities will continue to be the major generators of electricity in the near future, there are application markets where small fuel cells can serve as convenient generators for residential homes and commercial buildings. The general advantages for such applications include high-energy efficiency, low noise, low emissions of pollutants, and low greenhouse gas emissions. For this type of applications using PEMFC, however, catalytic fuel processing should consider non-pyrophoric catalysts for the water–gas-shift reaction, as indicated recently. The general principle of fuel processing is the same for most applications, and the fuel processor typically includes the components of fuel reforming, water–gas-shift, and CO clean up. The fuels, however, would preferably be those that have existing infrastructure in the distribution network such as natural gas. For residential applications, in addition to natural gas, propane gas or LPG is also a potential fuel for on-site reforming for fuel cells [43].

What can be done for the future of hydrogen and fuel cells?

- It is important to avoid creating confusion between the challenges of hydrogen and those of fuel cells. Clearly, there are links between the future of fuel cells and the potential of hydrogen. But the challenges and the timing are different. Separate, but linked, program may be valuable for each. [5]

- It would be a mistake to focus the hydrogen economy only on the transport sector. Clearly this is the most "popular" potential market for hydrogen and fuel cells, but at the same time the least probable in the medium/long-term. Other markets such as power generation seem more realistic even if it would require significant delays. [5]

- A specific focus has to be pursued on R&D on fuel cells. Technology improvements may contribute to increase competitiveness of fuel cells in power generation beyond what is anticipated in the WEO – although, considering the hurdles, perhaps well short of the more optimistic projections. [5]

- Hydrogen generation is a key challenge where technological breakthroughs are required. Improvement in reforming technology as well as electrolysis or thermal dissociation may have a significant impact on the present market of

- Hydrogen as well on new power generation market and perhaps in the longer-term on transportation. [5]

- A portfolio strategy is likely to be more effective than a single fuel focus. Thus, future energy systems should be designed in such a way as to be robust enough to include hydrogen (with its well-recognized and considerable benefits) as well as other (currently more economic and practical) alternatives. [5]

According to ANNEX I followings needs to be done; [5]

- Transportation: (1) Reduction of fuel cell costs; (2) Hydrogen storage in vehicles, direct methanol fuel cells or onboard hydrogen production from carbon-based energy carriers; (3) Infrastructure (a "systems" approach from hydrogen production, distribution, storage and use to ensure a reliable and convenient infrastructure)

- Stationary applications: (1) Reduction of fuel cell costs; (2) System integration; (3) Infrastructure

Areas of further analysis: (1) Life cycle analysis (well-to-wheel) of cost and environmental impact (some publications already available); (2) Resource constraints (natural gas as source for hydrogen?); (3) Platinum group metal requirements (some publications already available); (4) Deployment policies and strategies, especially for infrastructure; (5) Economic analysis of various technology configurations from fuel supply to end-use sectors taking into account different policy scenarios. [5]

7.3. SOLID WASTE MANAGEMENT

7.3.1. Solid Waste Management by Gasification:

Combustion, gasification and pyrolysis are the thermal conversion processes available for the thermal treatment of solid wastes. As shown in Fig. 7-9, different products are gained from the application of these processes and different energy and matter recovery systems can be used to treat these. Gasification can be broadly defined as the thermo chemical conversion of a solid or liquid carbon-based material (feedstock) into a combustible gaseous product (combustible gas) by the supply of a gasification agent (another gaseous compound). The thermo chemical conversion changes the chemical structure of the biomass by means of high temperature. The gasification agent allows the feedstock to be quickly converted into gas by means of different heterogeneous. [38]

The combustible gas contains CO2, CO, H2, CH4, H2O, trace amounts of higher hydrocarbons, inert gases present in the gasification agent, various contaminants such as small char particles, ash and tars. [38]

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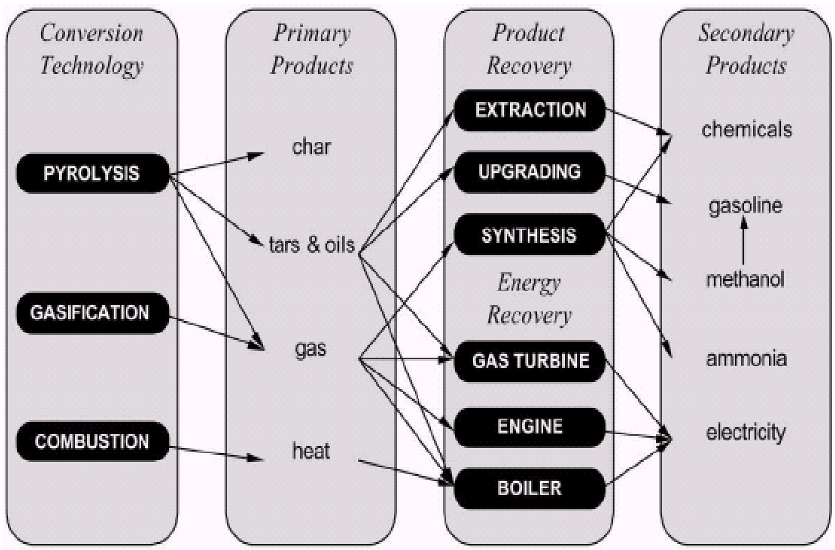

Fig. 1. Thermal conversion process and products (Bridgwater, 1994a).

Figure 7-9: Thermal Conversion Process and Products [38]

Direct gasification occurs when an oxidant gasification agent is used to partially oxidize the feedstock. The oxidation reactions supply the energy to keep the temperature of the process up. If the process does not occur with an oxidizing agent, it is called indirect gasification and needs an external energy source (Figure 7-9 and 7-10) Steam is the most commonly used indirect gasification agent, because it is easily produced and increases the hydrogen content of the combustible gas.

Pyrolysis is an indirect gasification process with inert gases as the gasification agent. As shown in Figure, resulting from the gasification process and varying with the temperature at which the process is carried out, the three major output fractions are:

1. A combustible gas;

2. A liquid fraction (tars and oils); and

3. A char, consisting of almost pure carbon plus inert material originally present in the feedstock.

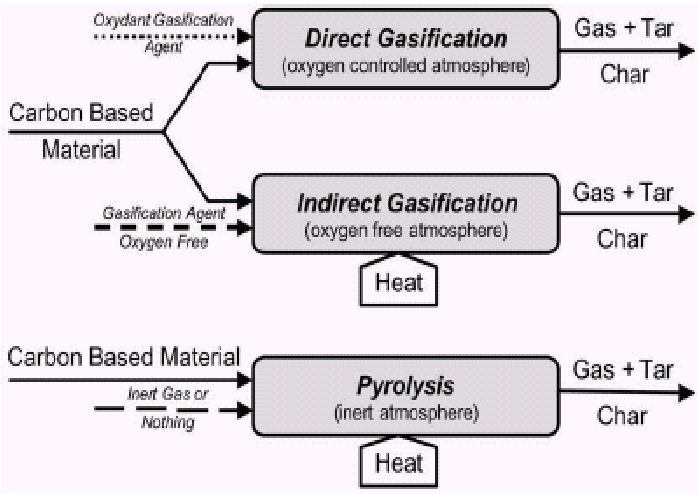

Figure 7-10: Gasification and Pyrolysis Processes [38]

Typically, a gasification system is made up of three fundamental elements: (1) the gasifier, useful to produce the combustible gas; (2) the gas cleanup system, necessary to remove harmful compounds from the combustible gas; (3) the energy recovery system. The system is completed with suitable sub-systems useful to control environmental impacts (air pollution, solid wastes production, and wastewater). [38]

For a correct and efficient gasification process, a sufficiently homogeneous carbon-based material is required. Therefore many kinds of waste cannot be treated in the gasification process and for certain types an extensive pre-treatment is required (refuse derived fuel). Instead there are several types of waste that are directly suitable for the process; they are: paper mills waste, mixed plastic waste, forest industry waste and agricultural residues. [38]

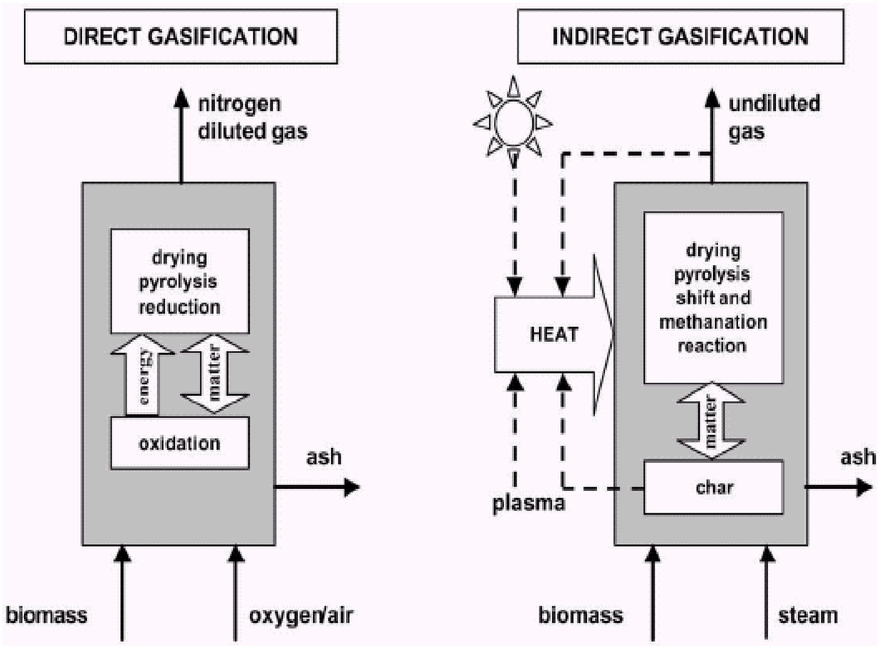

Figure 7-11: Direct and Indirect Gasification Processes [38]

7.3.2. Biomass conversion into fuel gas using circulating fluidized bed technology:

Circulating fluidized bed technology has been used in coal combustion and the catalytic/petroleum industry for more than two decades with great success; unfortunately it still lacks practical application in the biomass gasification. CFB conversion of biomass could be expected to be characterized by: i) acceptance of a wide variety of biomass feeds; ii) flexible scale-up from small to large capacity up to 10– 50MW thermal input; iii) available utilization of the existing power plant capacity, and thus low specific investment cost, considering the features of CFB technology, viz. i) high heat and mass transfer intensity; ii) high thermal capacity per unit of sectional area; iii) relatively easy scale-up; iv) easy control of temperature to keep the temperature profile ideal; v) flexibility with regard to feed rate and its composition. If these expectations could be met, CFB conversion of biomass for fuel gas will be a promising alternative to bioenergy industry. [44]

A few experiences to improve fuel gas production technology by means of the combination of pyrolysis process and gasification process in separated reactor are availably referable; however they cause the consequence of complicating experimental system. The starting point for our concept is, on the contrary, using the same reactor to incorporate pyrolysis, gasification, and combustion process. In detail, the concept combines and integrates the following well-known processes: i) partial oxidation, ii) fast pyrolysis (with an instantaneous drying), iii) gasification, and iv) tar cracking, as well as v) a shift reaction. The fuel is dried inside the feeding pipe and afterwards led to the fast pyrolysis section. In the fast pyrolysis section, the heat from partial oxidation reaction will pyrolyze the fuel with the assistance of bed material. The volatiles and most of char from the fast pyrolysis section are led to the gasification section, where oxidation air and gasification steam (the ratio is controlled, based on the requirements) are added together. In the gasification section part of the char from the pyrolysis process is oxidized and part of the remains gasified at the chosen temperature. The tar content is dramatically reduced, due to cracking thermally and catalytically in the section above gasification. Finally the gas passes by the shift reaction section and there the gas composition is adjusted. Bed material (sands and some additives) and the remaining un-gasified char are carried out by the fuel gas flow to enter into the cyclone, where particles are separated from the gaseous flow, and subsequently are re-circulated to the bottom section of the riser. The circulating bed material and burning formed flue gas act as a heat carrier from the combustion to the fast pyrolysis section, and then to the gasification zone. The cyclone can be taken as a gas conditioner, as coarse particles carried out with the gas are mostly removed therein. The concept, in itself, assures only un-gasified char from gasification is burned in the combustion section, and pyrolysis volatiles do not participate in the burning in the reactor. The volatiles are not subjected to oxidation and therefore can to the greatest degree guarantee the calorific value of the final product gas, which is very important where the product gas is used as fuel for power generation. Furthermore, in our concept all the char formed from the pyrolysis process is subjected to the gasification reaction prior to oxidation, not vice versa, and therefore char gasification conversion could occur to a maximum degree. This concept could lead to the minimization of the size of CFB biomass conversion system and also to the improvement of the gas quality as well as productivity. [44]

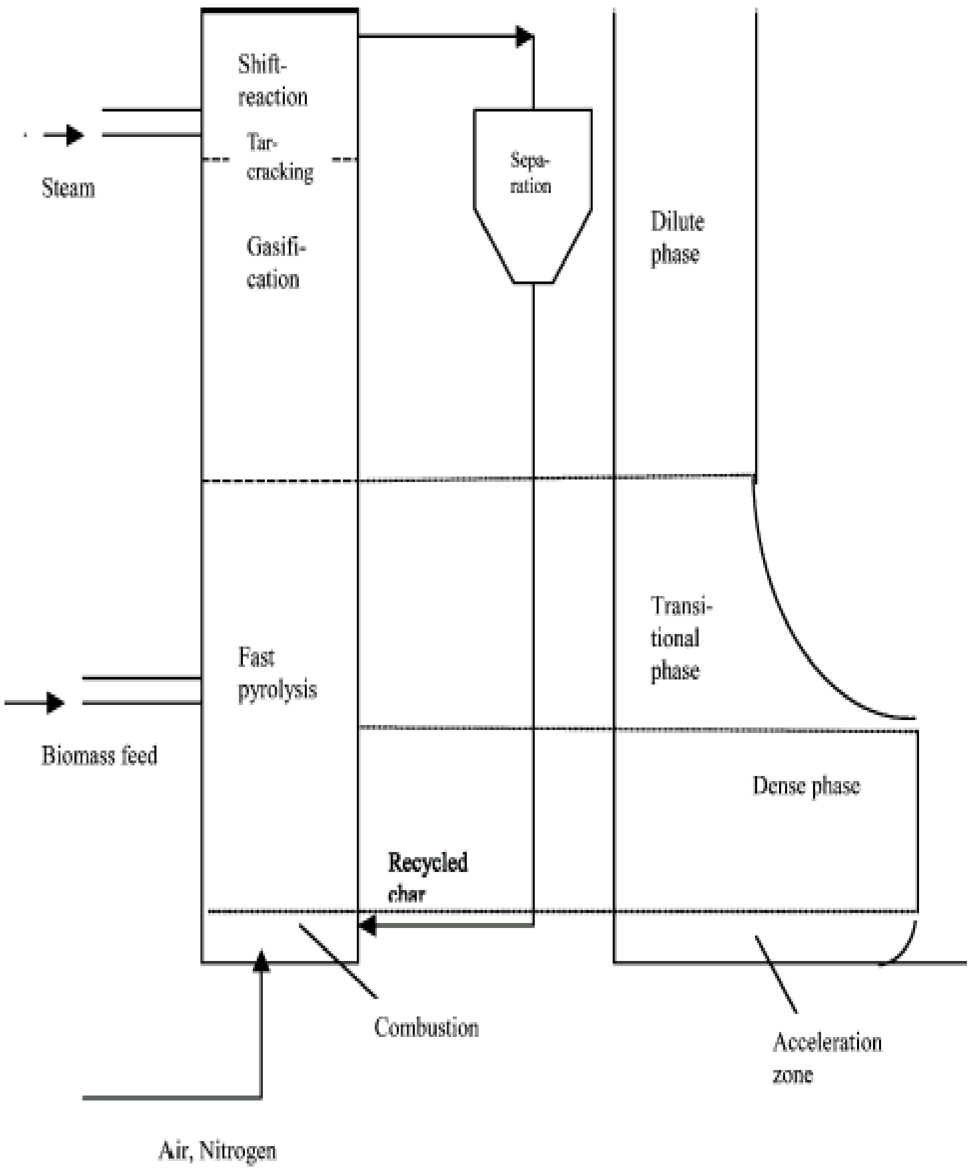

Figure 7-12: Modeling determination of CFB riser. [44]

The innovative concept for biomass conversion using CFB technology appears quite promising despite the fact that preliminary experimental results are not very satisfactory. Some solutions should be made as required to remove those physical constraints of CFBGs and afterwards more experiments are needed to validate. [44]

Table 7-1: Technical Data for CFB Biomass Conversion System [44]

Items	Data
Inner diameter of riser (mm)	83
Height of riser (m)	6
Cyclone efficiency	95% above
Maximum thermal capacity (kW)	100
Fluidising medium	Air nitrogen and steam
Biomass fuel staging	2–3 feeding points
Preheating capacity	12 kW
Circulation rate (kg/h)	45–180

7.4. BIODIESEL:

Biodiesel is a fuel with similar properties to kerosene but is derived either from vegetable oil or animal fat. Unlike fossil fuels, biodiesel can, in principle, be produced and consumed indefinitely, and its use need not irreversibly add carbon dioxide to the atmosphere. [45]

Biodiesel is one product of the chemical reaction of an alcohol with a vegetable oil or animal fat (the other product being glycerol). The alcohol is assumed to be methanol. Biodiesel is then a mixture of methyl esters of different fatty acids. A typical biodiesel molecule contains between 13 and 23 carbon atoms, approximately twice as many hydrogen atoms, and two oxygen atoms. Note that the molecules in biodiesel are very similar to the molecules in kerosene, and, from the point of view of chemistry and physics, the two fuels are similar in all respects. [45]

Biodiesel production begins with pressing the crop, which yields a liquid oil fraction to be converted and a first by-product, oil cake, used as cattle feed. After filtering, esterification provides a low-cost way to transform the large-branched molecule structure of the extracted oils into smaller, straight-chained molecules similar to the hydrocarbons in the diesel boiling range. During esterification, the addition of a monovalent alcohol, usually methanol, replaces the trivalent alcohol glycerin, which gives methyl ester and releases glycerin; a second by-product used in the pharmaceutical and cosmetics industries. [45]

Currently, fuel for aviation turbine engines is extracted from fossil resources, primarily crude oil. Molecules in the fuel are hydrocarbons, with a typical molecule containing between 9 and 16 carbon atoms and approximately twice as many hydrogen atoms. The exact mix of molecules depends both on the origin of the crude oil and on the extraction process. This leads to fuels with different properties. Three fuels are widely recognized for use in commercial aviation turbines; Jet A, Jet A-1 (both referred to as aviation kerosene) and Jet B (referred to as wide-cut fuel). American Society defines all three fuels for Testing and Materials standard ASTM D 1655.

Biodiesel has been in use for some years as a fuel for trucks and buses. In the US, the total consumption for the year 2000 was approximately twenty million gallons.3 A20% biodiesel/80% fossil diesel blend (called B20) can be used in any diesel engine vehicle, regardless of age, without any need for modification (although, in a small minority of cases, rubber hoses and seals perish and must be replaced). The use of this fuel even has a number of technical advantages. It prolongs engine life and reduces the need for maintenance (biodiesel has better lubricating qualities than fossil diesel). It is safer to handle, being less toxic, more biodegradable, and having a higher flash point. It reduces some exhaust emissions (although it may, in some circumstances, raise others [6]). The technical disadvantages of biodiesel/fossil diesel blends include problems with fuel freezing in cold weather, reduced energy density, and degradation of fuel under storage for prolonged periods. One additional problem is encountered when blends are first introduced into equipment that has a long history 385 of pure hydrocarbon usage. Hydrocarbon fuels typically form a layer of deposits on 386 the inside of tanks, hoses, etc. Biodiesel blends loosen these deposits, causing them to block fuel filters. However, this is a minor problem, easily remedied by proper filter maintenance during the period following introduction of the biodiesel blend. [45]

8. TURKEY ENERGY POLITICS

The Turkish energy policy is mainly concentrated on assurance of energy supply, reliably, sufficiently, in time, in economic and clean terms and in a way to support and orientate the target growth and social developments. In the frame of these subjects, energy planning studies of the country, taking into account of short, medium and long term policies and measures, have been carried on by the MENR. The government focused its efforts on improvement of domestic production by utilizing public, private and foreign sources and increasing efficiency by rehabilitation and acceleration of existing construction programs to initiate new investments on reasonable accounts. [46]

Turkey is an energy importing country because domestic fossil reserves are limited and insufficient. Therefore, the Turkish government's investment needs in the energy sector for the period 2002–2015 will be around 65 billion US dollars, and of this, about 82% is total planning investments. A major dilemma now faced by Turkey is how to invest in new electric power capacity, while at the same time, adhering to foreign debt ceilings under lending rules set by the International Money Fund (IMF). Therefore, Turkey has to adopt new long-term energy strategies to reduce the share of fossil fuels and to increase the share of renewable in primary energy consumption. [47]

Every five years, in Turkey, the State Planning Organization (SPO) prepares a Development Plan with the assistance of expert organizations for all sectors including the energy sector. In this regard, Turkish energy policy is mainly concentrated on the assurance of the energy supply: reliably and economically. They also consider the environmental impact and attempt to balance targeted growth and social developments.

In this context, existing energy policies may be summarized as follows [21]:

- planning energy research and development activities to meet the aforementioned requirements;
- meeting long term demand using public, private, domestic and foreign capital
- developing existing sources of energy, while encouraging research on new sources;
- adding new and renewable sources (geothermal energy, solar energy, wind energy, biomass etc.) as soon as possible to help meet the energy requirements;
- taking into consideration supply costs of energy imports;
- diversifying energy supplies and avoiding a single source or country;
- meeting energy demands as much as possible through indigenous sources;
- implementing measures for energy efficiency, preventing wastes and minimizing the losses in energy production, transmission, distribution and consumption;
- protecting the environment and public health in the process of meeting energy requirements.

Securing finance for energy projects by implementing the BOT, BO and Transfer of Operating Right (TOOR) models [6].

To make use of Turkey's geopolitical location to establish the country as a pivotal transit area for international oil and gas trade ("Eurasia energy corridor"). [7]

The energy sector in Turkey is mainly state-owned, and the Government is heavily involved in the management and corporate decisions of the State Economic Enterprises (SEEs). The Government has generally maintained prices below the level at which the SEEs could make the necessary investments, and as a consequence, most of the SEEs have been dependent upon the capital endowment by the treasury and state guarantees for investments. This pricing policy has had an increasingly negative impact on the economy. It has increased the budget deficit, and thus fueled inflation, and has encouraged the inefficient use of energy, accelerating the growth in energy demand and imports. It has also led to shortages in investment capital to secure energy supply, to improve the functioning of the enterprises and to protect the environment. The aim of the long term Generation–Investment Plan is to solve the energy problems of Turkey in the period 1997–2020. Turkey has to adopt new long term energy strategies to reduce the share of fossil fuels in the primary energy consumption. In recent years, the development of alternative energy sources has been a major focus of the research effort in Turkey. The additional generation capacity for the period of 1997–2020 will require huge investments. Public investments require the contribution of foreign capital because of financial problems. [7]

Today the world has changed dramatically and so have the policies and priorities of Turkey. The global situation now calls for less government intervention and ownership in some sectors, which have been mainly dominated by the state. In Turkey, energy and natural resources like oil and coal are among these sectors where the State is increasingly becoming reluctant to get involved in the operation and maintenance of these installations. In other words, the State is trying to withdraw itself from these sectors, as it should. [6]

Private investment is the only way to rebalance the situation. In the long run, Turkey can only gain from private and foreign investment. Along with finance, private-sector involvement can bring market-oriented skills, access to advanced technology, and usually faster build-up of supply capacity than would be the case under public-sector management. [7]

For the Technology, Research and Development the Government should: [4]

- Avoid large fluctuations in R&D annual spending.
- Strengthen Tübitak’s coordinating role.
- Continue to encourage private R&D.

- Continue to step up acquisition of R&D data and assessment of private sector activities, in order to maximize the effectiveness of R&D nationwide.

- In close liaison with the private sector, continue to encourage R&D in energy efficiency and the most cost-effective renewable energy sources, especially in the area of applied research.

- Enhance the international orientation of R&D program, in particular towards the EU and the IEA.

In the electricity area the government should: [4]

- Move toward a reform of the electricity pricing system as soon as possible, in order to ensure that prices cover the full cost of supplies and progressively eliminate regional and customer cross- subsidies.

- Issue a stable and coherent legal and commercially realistic framework for BOT/BOO projects and the transfer of TEAS and TEDAS facilities. In parallel, enunciate a view of the long-term evolution and structure of the electricity supply industry.

- Unbundled the accounts of electricity companies to guarantee transparency in costs and prices.

- Corporate state companies, if they are not privatized.

- Establish an independent regulator to handle regulatory and pricing issues for both state-owned and private companies.

- Enhance conditions for competition in electricity generation and distribution, particularly those related to auto production and grid access.

- Progressively withdraw from generation planning, shifting this function to TEAS and successor companies.

- Strengthen the independent organizational structures needed to ensure the safety of facilities related to the nuclear power program. Continue efforts toward gaining public acceptance.

8.1. PRIVATIZATION

The participation of foreign and local private capital and investment has been greatly encouraged by the Governments through the Built-Operate-Transfer (BOT), Built-Operate (BO) and Transfer of Operating Rights (TOOR) models. Auto-production is also allowed for private sector. BOT/BO programs were created to allow private investors to build and run new generating plants for 20-30 years. Through the TOOR model, operating rights for some of the Turkish Electricity Generation and Transmission Company's (TEAS) generating plants and Turkish Electricity Distribution Company's (TEDAS) distribution facilities are currently being transferred to the private sector in order to increase efficiency, reduce operational costs and cover additional investments. [6]

8.1.1. BUILT OPERATE TRANSFER (BOT) MODEL

Turkey was among the first countries to introduce the BOT system in 1984, through the Electricity Act (Law No. 3096). The BOT system is not restricted to electricity or energy projects; it is also used for other infrastructure investment such as motorways, bridges, tunnels or water treatment plants. [7]

Under this model, private investors build and operate power plants. After remaining in private ownership for a number of years corresponding to the economic lifetime of the investment (15 to 20 years), these power plants are transferred to state ownership. [7]

Table 8-1: BOT Power Plants in Turkey, December 2000 [7]

	Number of Plants	*Installed Capacity (MW)*	*Average Generation (GWh)*
HYDRO POWER PLANTS			
In service	16	846	3,220
Under construction	4	293	1,074
Agreements signed	17	1,814	6,134
HYDRO TOTAL	**37**	**2,953**	**10,428**
THERMAL POWER PLANTS			
In service	4	1,445	10,600
Under construction	0	0	0
Agreements signed	2	470	3,000
THERMAL TOTAL	**6**	**1,915**	**13,600**
WIND POWER PROJECTS			
In service	2	17	50
OVERALL TOTAL	**45**	**4,885**	**24,078**

Source: MENR.

To increase the number of successful BOT energy projects, the Turkish government sought to eliminate the concession classification. Among its initiatives was an amendment to the BOT law that eliminated energy projects from the list of BOT projects classified as concessions. Turkey's Constitutional Court overruled this amendment as unconstitutional in 1996. In its ruling, the Constitutional Court established that generation, transmission and distribution of electricity constitute a public service and that they were therefore subject to public-law government concessions. [7]

To reduce the share of State finance for energy investment and introduce private capital, the "built-operate-transfer" model has been practiced in Turkey since 1984 and as of June 1997, five hydro-power plants with a capacity of 74 MW and a gas-fired plant with capacity 253 MW have been completed and taken into service in the context of the BOT model.

Table 8-2: BOT Projects Eligible for Treasury Guarantee [7]

Start of Operation	*Fuel Type*	*No.*	*Project*	*Capacity (MW)*
2001	Wind	1	Kocadag-I	50
		2	Canakkale	30
		3	Bozcaada	10
		4	Mazy-I	39
		5	Intepe	30
		6	Mazy-II	90
		7	Mazy-III	40
		8	Akhisar	30
		9	Kocadag-II	26
2002	Natural Gas	10	Eskisehir	199
		11	Karadeniz Eregli	206
		12	Kirklareli	75
		13	Yalova 25	306
	Geothermal	14	Germencik	25
	Hydro	15	Yukari Akcay	2
		16	Aryt	9
		17	Pamuk	20
		18	Keklicek	17
	Wind	19	Bandyrma	15
		20	Datca	29
		21	Cesme	12
		22	Aksihar	12
		23	Yalykavak	8
		24	Gökceada	5
		25	Kapydag	35
		26	Belen	34
	Hydro	27	Susehri HEPP	12
		28	Aksu-Akdeniz HEPP	6
		29	Mursal HEPP	7

Sources: US Department of Energy, Tebahaber.

The construction of the 180 MW Esenyurt Natural Gas (NG) fired plant has started. Construction of two Liquefied Natural Gas (LNG) fired plants with 480 MW capacities each in Marmara Ereglisi is in process with a total investment cost of 1.2 billion US dollars. [33]

Five HPPs with a total capacity of 770 MW are under construction, including the 672 MW Birecik Dam and HPP. At present a number of projects using the BOT model are being evaluated. [33]

In parallel, our Ministry has recently completed planning studies for thermal power plants using natural gas and imported hard coal to be realized under the "built-operate-own" model up to the year 2010, with a total installed capacity of 10.7 GW and costing some 10 billion US dollars. [33]

8.1.2. BUILT OPERATE OWN (BOO) MODEL

(Law No. 4283) Under the BOO arrangement, investors do not transfer ownership of the plant to the government at the end of the contract period but maintain their ownership. The BOO Law was enacted in July 1996, and in 1997, a tendering round was opened to collect bids for BOO projects. However, in December 1999, the Centre for the Development of State Enterprises filed a lawsuit against the BOO Law. The case is still pending. [7]

Table 8-3: BOO Power Plant Projects in Turkey, 2000 [7]

Name	*Fuel Type*	*Location*	*Installed Capacity (MW)*
Adapazari	Natural gas	Adapazari	770
Gebze	Natural gas	Gebze	1,540
Ankara	Natural gas	Ankara	770
Aliaga	Natural gas	Izmir	1,540
Iskenderun	Imported coal	Iskenderun	1,210
Total capacity			**5,830**

Source: MENR.

8.1.3. TRANSFER OF OPERATING RIGHTS (TOOR)

TOOR allows private-sector operation of energy infrastructure, but not private-sector ownership. Under this concept, the MENR transfers rights to operate electricity infrastructure in a region for 20 or 30 years. In Turkey, TOOR is used for thermal generating plants and distribution/retailing operations. Like the BOT system, the TOOR model is based on the 1984 Electricity ACT (Law No: 3096) and was initiated under the Privatization Law of 1994 (Law No.4046) and Law No.4047 of the same year. [7]

Table 8-4: TOOR Power Plants in Turkey, 2000 [7]

Name	*TOOR Estimated Value (million $)*	*Installed Capacity (MW)*	*Annual Production (GWh)*
Cayirhan	185	620	4,030
Kangal	125	457	2,970
Orhaneli	90	210	1,365
Çatalagzi	75	300	1,950
Tunçbilek	100	429	2,789
Yatagan	160	630	4,095
Yeniköy	100	420	2,730
Kemerköy	150	630	4,095
Soma	255	1,034	6,721
Total	**1,240**	**4,730**	**30,745**

Source: MENR.

The principal objective of the TOOR model is refurbishment and increased operational efficiency of the equipment. The Ministry of Energy and NATURAL Resources expects that through the transfers, plant availability and capacity factor will increase. An increase in total generation capacity of 5000 GWh is expected for the eight power plants in the first year after transfer, with additional increases of 9000 GWh each year as of the second year. The MENR hopes that after 20 years, power generation will increase by 175 TWh. This cannot be achieved through efficiency increases alone and will require additional capacity investment. [7]

Private sector investments are also inevitable. Therefore, BOT, BOO and privatization would be suitable models to solve the energy problems of Turkey in the near future. [33]

8.2. ELECTRICITY LAW

The 'Electricity Market Law' No.4628, published in the Official Gazette dated 3 March 2001 was enacted with the aim of unbundling electricity market activities, of enabling progress towards a liberalized electricity market and the provision of fair and transparent market regulation. [12]

In summary, the new law includes the following key elements:

- An autonomous Energy Market Regulatory Authority, governed by a board;
- A new licensing framework for market participants;
- An energy market, comprising bilateral contracts between market participants;
- An ‘eligible consumer’ concept, with eligible consumers free to choose their suppliers
- A transition mechanism to be implemented over a two-year program in the case of electricity.

In addition, all over the world, energy sector investments are gradually being undertaken by the private sector and Turkey is also following this global trend. It is important to ensure that this transition will be smooth and effective. The purpose of this law is to ensure the formation of an electricity market which is financially strong, transparent and operates in accordance with the provisions of private law in a competitive environment, while achieving a stable supply of adequate, low-cost, and environmentally-friendly electricity of good quality and ensuring autonomous regulation and supervision of the market. The main objective of the law is to create a competitive electricity market with the great majority of the participants in the market being private investors and most of the assets used to supply electricity being privately owned. The role of the state will be greatly reduced. [12]

8.3. ENERGY TAXATION

Turkey’s main tax on oil products is the fuel consumption tax (FCT). To alleviate the effects of oil price fluctuations and the pronounced exchange rate fluctuations of the Turkish lira against the dollar on domestic oil prices, the government linked this tax to a pre-existing mechanism, called the Fuel Price Stabilization Fund (FPSF), as of 5 February 2000. [7]

The FPSF was established through Decree No 98/10745 of 1 July 1998. The purpose of this fund is to stabilize domestic oil prices. The Fuel Price Stabilization Fund is financed through a compensatory FPSF tax. The tax rate fluctuates and is inversely proportional to developments in international oil prices and the Exchange rate of the Turkish lira against the dollar. The tax does not apply to fuels used in generating electricity. Ex-refinery ceiling prices are now linked to CIF Mediterranean product prices. The ceiling price changes if the rolling seven-day average of the import price rises or falls more than 3%. When end-user oil product prices do not rise as rapidly as crude oil prices, payments are made from the FPSF to reimburse refiners' and retailers' revenue shortfalls. The fund is financed through the FPSF tax, especially during periods of low oil prices when the tax rate is high. [7]

Through this change, oil product prices were linked to international market prices and short-term fluctuations were limited to a price band. Ex-refinery prices, distributor and retailer margins are also indexed to the U.S. dollar in order to protect refineries, distributors and retailers, as well as tax revenues, from the effects of inflation. The purpose of this measure was to enhance price stability and predictability, as well as to eliminate the economic disadvantage of the inland refineries caused by transportation. Refineries, distributing companies and retailers are free to compete below the ceiling price. In 1999 and early 2000, the FPSF tax was applied only to diesel, and the rate was very low (about 1% of the end-user price). The reason for this was the high volatility of crude oil prices at the time. By applying this low-rate tax, the government tried to relieve the burden on ultimate consumers. [7]

In January 1996, Turkey signed the Customs Union Agreement with the EU. Therefore, customs duties are applied only to oil product imports from non-EU countries. [7]

9. CONCLUSION

The economic and political achievements of the Turkish nation under the Turkish Republic are today assets that will enable us to move forward at an ever-increasing pace. Our society has gone through a fundamental transformation in every sphere of life. This transformation has made Turkey a modem, secular, democratic country with a strong economic base, and a model state for many other nations. We have come a long way since the early days of the Republic, and as a nation we are forever indebted to the founder of our Republic, Kemal Atatürk. The creativity and the decisiveness of his reforms, his faith in the Turkish youth to whom he entrusted the future of Turkey are the basic values that will guide Turkey as it moves into the next millennium as one of the most youthful nations of the world which will serve to generate, once again, the creativity that characterized the foundation of the Turkish Republic. Turkey with its large, dynamic, young, educated and internationally experienced population; with its huge agricultural production capacity; and with its highly diversified and strong industrial output, is bound to become one of the most influential economies of the world.

We can say that energy demand is increasing both for Turkey and the other countries of the world by population growth. Every country is seeking new ways of economical and environmental friendly energy supply. In terms of Turkey for the next millennium its positive sides are much more than the poor ones. Firstly, Turkey is a transit country between Europe and Middle East and he must use this property intelligently. The country will sustain a high rate of economic development throughout the next two decades however at the moment economic instability of our country is one of its most important poor sides. Since investors could not be courageous to invest money for their projects. We must try to finalize this economic instability and encourage both foreign and local capital. As we all know the driving force behind globalization has been the reduction of national and regional barriers to trade and foreign direct investment, the liberalization of domestic and international financial markets, major improvement in transport, production and communication technologies, as well as closer links between OECD and non-OECD economies.

The main principles of Turkish energy policies must be:

- Meeting demand-making use of domestic sources in the first place as much as possible in all energy types.
- Developing existing sources while accelerating studies on new sources.
- Adding new and renewable sources as soon as possible to the energy supply cycle.
- Source diversification and avoiding dependence on a single source or country in energy importation.
- Meeting demand in the medium and long terms through public, private and foreign capital contribution.

Projections for Turkey indicate a continuing increase in demand for energy, especially for electricity, in the next two decades. According to the government's long-term investment plans, energy consumption will nearly quadruple by 2020. Lignite and hydropower will see the largest growth in production. Turkey has limited reserves of oil and natural gas, but proven reserves of lignite in the order of 8.4 billion tones. Combustible renewable, especially wood, and the country's watercourses, especially the Euphrates and Tigris rivers, are other important indigenous energy resource. Turkey's geography -- a rectangular plateau peninsula surrounded on three sides by seas -- is highly conducive to hydroelectric power generation. Hydroelectric power plants in Turkey currently account for about 40% of Turkey's electricity demand. By the year 2010, Turkey is planning to exploit two thirds of its hydro-potential, aiming to increase hydro production to about 80000GWh/yr. By 2020 this will rise to 110000GWh/yr, and by 2023 it could be 120000GWh/yr, in time to celebrate the 100th anniversary of the Turkish Republic. To reach these capacities economic hydroelectric generating plants planning or under construction must be accelerated consistent with the protection of the riverine environment. Periodically the economic potential of hydropower must be reevaluated. Besides its hydropower, preliminary studies indicate that the country has an average 2,640 sunshine hours annually, with an average solar intensity of 3.6 kWh/m2 per day. Especially in the southern part of the country the government must encourage people to use sun collectors. By using solar collectors we can also save energy. It is clear that renewable energy sources play very important role to supply energy demand of the next millennium. Nowadays, energy from biomass is most popular in the world. However for Turkey the importance of biomass is indisputable since the traditional biomass fuel wood, charcoal; crop residues and dung are still primary cooking fuels for some parts of Turkey. Also, there are many wind power plant project under the evaluation of MENR. The goal is for wind power to represent about 2% of installed electric power capacity in 2005. Solar energy and wind energy capacity of Turkey must speed the investments of both local and private capital in these areas.

Turkey has also borate; thorium and uranium resources, which are the largest known deposits in the world, are under state monopoly. At the moment there is no technology in Turkey to operate these mines. Our main scope must be the development of new technologies for operation of these mines.

The government oil accounts for the largest share of demand in Turkey. Natural gas demand also has been increasing very rapidly since its use instead of coal and oil increasing day by day. It is nearly evident that during the coming years, the abundant oil and natural gas reserves of the Caspian Sea region will be tapped and marketed to the world. The development of this sector will prove that Turkey is and will remain the safest and most economic route for trade in Caspian energy resources. Therefore, Turkey will be an energy terminal, not just for Europe, but for the other regions as well. In March 2002, Turkey signed a $300 million deal with Greece to extend an Iranian natural gas pipeline to Greece. The pipeline will go 125 miles inside Turkey and cross the Dardanelles Straits into Greece.

In line with growing awareness across the world, Turkey has been devoting due attention to environmental regulation and policy in order to address its own problems on the one hand, and to be an active member of the international community on the other. Turkey lacks an integrated energy-environment strategy that presents policymakers with clear means of evaluating the various policy and investment options. Furthermore, Turkey is currently assessing its choices vis-à-vis the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. In order to develop its negotiating position, it has to be able to assess the cost-effectiveness of options for greenhouse gas (GHG) mitigation and their impact on Turkey's overall strategy for developing its energy sector. We must:

- Increase the resources for the Ministry of the Environment and strengthen collaboration with the Ministry of Health on air quality issues.

- Strengthen the mandate and the capability for inspection and verification of compliance of the agency or agencies responsible for the application and enforcement of air pollution legislation.

- Establish additional regional branches to address environmental issues in the provinces.

Industry sector is the main consumer of energy in Turkey. So, CO2 emissions from industry are also in the maximum levels with respect to other energy consumed sectors. Existing coal power plants must retrofitted with flue gas desulphurization (FGD) and electrostatic precipitation (ESP) equipment. Besides we make efforts to increase the energy efficiency and the environmental performance of new coal plants through early adoption of advanced, clean coal technologies. The government must continue to harmonize standards and regulations for environmental quality with those of the EU and other international bodies. The government should develop an implementation strategy that allows it to assume a greenhouse gas emissions target no later than the second commitment period of the Kyoto Protocol. And it must strengthen collaboration agreements with neighboring countries to limit energy-related pollution. In particular, we should seek agreements with countries bordering the Black Sea to reduce marine pollution, increase the inspection and verification of safety and environmental regulations in tankers, and consider raising standards and increase resources for port authorities.

Privatization models of BOO, BOT and TOOR are also too important for Turkey energy supply for next millennium. By these models the participation of foreign and local private capital and investment has been greatly encouraged by the Governments. In such an environment, private investment is often the only way to rebalance the situation. In the long run, Turkey can only gain from private, and foreign, investment.

As I finalize one can see that the energy demand of Turkey is increasing like all other countries in the world. When I started to write this thesis the 2nd Gulf War had not been started. Now the war was finalized and we can see that America has its power also in Iraq borders. Restarting the oil industry is key to the U.S. plans for rebuilding Iraq. Iraq has more proven oil reserves than any other country except Saudi Arabia, and before the war it was pumping around 2.8 million barrels a day, or 3 percent of global supplies. It needed around 300,000 barrels a day for domestic use, by some estimates, and the rest was exported. Oil and gas pipelines from Iraq are important for our country energy supply. We must develop new strategies by taking care of these circumstances that Turkey has facing.

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APPENDIX

A. Installed generating capacity and annual electricity output at end 1999

	Installed capacity MW	Annual output GWh
Cape Verde Islands	3	5
Egypt (Arab Rep.)	15	25
Morocco	N	1
Somalia	N	N
South Africa	N	N
Total Africa	**18**	**31**
Canada	125	193
Costa Rica	46	75
Guadeloupe	1	2
Jamaica	3	5
Mexico	3	8
United States of America	2 251	4 488
Total North America	**2 429**	**4 771**
Argentina	14	35
Brazil	18	30
Chile	25	45

Uruguay	N	N
Total South America	**57**	**110**
China	253	450
India	1 081	1 900
Indonesia	1	2
Japan	83	376
Korea (Republic)	7	6
Philippines	N	N
Sri Lanka	3	5
Taiwan, China	N	N
Thailand	N	N
Turkey	9	21
Total Asia	**1 437**	**2 760**
Austria	35	60
Belgium	9	13
Czech Republic	5	8
Denmark	1 771	3 029
Estonia	N	N
Finland	18	49
France	18	36
Germany	4 445	7 400
Greece	107	160

Ireland	67	187
Italy	232	403
Latvia	1	2
Luxembourg	10	15
Netherlands	408	645
Norway	13	25
Poland	3	4
Portugal	53	88
Romania	N	N
Russian Federation	5	8
Spain	1 539	3 750
Sweden	215	369
Switzerland	3	3
Ukraine	24	25
United Kingdom	344	897
Total Europe	**9 325**	**17 176**
Iran (Islamic Rep.)	10	17
Israel	7	14
Jordan	2	3
Total Middle East	**19**	**34**
Australia	9	28
New Caledonia	3	5

New Zealand	36	39
Total Oceania	**48**	**72**
TOTAL WORLD	**13 333**	**24 954**

OECD-Europe: Austria, Belgium, the Czech Republic, Denmark, Finland, Prance, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom

OECD-non Europe: Australia, Canada, Japan, Mexico, New Zealand, the Republic of Korea, the United States.

BACKGROUND

She was born in Edirne in 1978. She was studied high school in I.Murat Lisesi in Edirne. In 1994 she was entered to the Chemical Engineering Department of Middle East Technical University. In 1999 she was graduated from the university and started to work in Eczacıbası Pharmaceuticals as a Dissolution and Stability Specialist. She lived two years in Lüleburgaz within this period. And also in this period she was started to her master degree. In 2002 she was started to work in Labkim Kimyasal Urunler San. ve Tic. A.S. as a Sales Executive. She is still working in this company.