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Global Energy: Need, Present Status, Future Trend and key Issues

By Md. Nasir Uddin MM Rashid, MG Mostafa, Belayet H, SM Salam & NA Nithe
International Islamic University Malaysia, Malaysia

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Traditional sources of energy e.g. firewood and vegetable wastes, animal power, wind, sun and the traditional ways of using these sources could not match with the increased energy demand. Commercial energy sources: coal, oil and gas are presently playing the dominant role. But the reserves of these sources are finite. New and renewable energy sources like: hydro, nuclear, solar, wind, hydrogen, synthetic oils etc. are also contributing to meet the rising global energy demand but the contribution of these sources is still very limited..

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GLOBALENERGYNEEDPRESENTSTATUSFUTURETRENDANDKEYISSUES

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Global Energy: Need, Present Status, Future Trend and key Issues

Md. Nasir Uddin[α], MM Rashid [σ], MG Mostafa[ρ], Belayet H[ω], SM Salam[¥] & NA Nithe[§]

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Electricity is the most preferred from of energy to meet the end use. The growth rate of electricity is the highest and is likely remain so in the coming years. The paper primarily discusses, in brief, the global energy need, present status, future trend and the key issues involved with energy development that have to be confronted in meeting the sustainable development as well as to achieve the Millennium Development Goals (MDGs).

I. Introduction

Energy is the capacity to do work. It is an essential element to produce the goods and services required for higher quality of life. Energy in various forms is needed to grow food crops to cook food, to produce clothes, to build houses, construct roads and bridges, for transportation, for lighting and even to compute and send information and signals in the present day of information and communication technology. All these activities need sources of energy to perform the desired activities.

The primary energy sources are geographically unevenly distributed. Economic development depends on the available opportunities. Availability of final energy increases or widens the choices or opportunities. The explosion of global population and the economic activities have created tremendous pressure on the commercial sources. Use of fossil fuels is causing global warming and environmental degradation. The cost of large-scale use of renewable energy sources is still economically prohibitive.

Energy affects health and environment. Global warming and climatic change and the environmental pollution are linked with energy. Commercial sources are finite. The question of sustainable development as such is a challenge before the world community.

Wide disparities exist among states and among communities within a state. “Today, citizens of the ten wealthiest countries are at least 75 times richer than those who live in the ten poorest ones, and the chasm is widening” [1]. Millennium Development Goals (MDGs) have been set to reduce poverty, hunger, and diseases to half by 2015 [Annex- I]. Energy is linked with the fulfillment of MDGs [2].

Comprehensive assessment and analyses with knowledge and wisdom from the perspective of present and future global and regional needs are essential to address energy related issues.

II. Energy

The universe constitutes of two fundamental things: matter and energy. These are inter- convertible. The dynamic universe is evolving at the expense of energy. The paper deals with human centered energy only. Lots of works are and have to be carried out in order to maintain and improve quality of life. Without energy no work can be done.

a) Energy Terms

While the subject is being explored further, the meaning and perceptions of some (the reaming ones may be seen at Annex – II) of the terms that are often used in energy domain should be clear. Some of these terms are discussed below[3].

Energy System: may be defined as all the activities starting form the exploration of the primary energy sources to the end use including processing, transportation, conversion, distribution etc. The Fig.1 shown below helps to understand the energy system [4].

Author α σ ρ: Department of Mechatronics Engineering, International Islamic University Malaysia, Kuala Lumpur, Malaysia.
e-mail: nasir.u@live.iium.edu.my
Author ω ¥ §: Department of Electrical & Electronics Engineering, ADUST, BUET, I&E, Dhaka, Bangladesh.

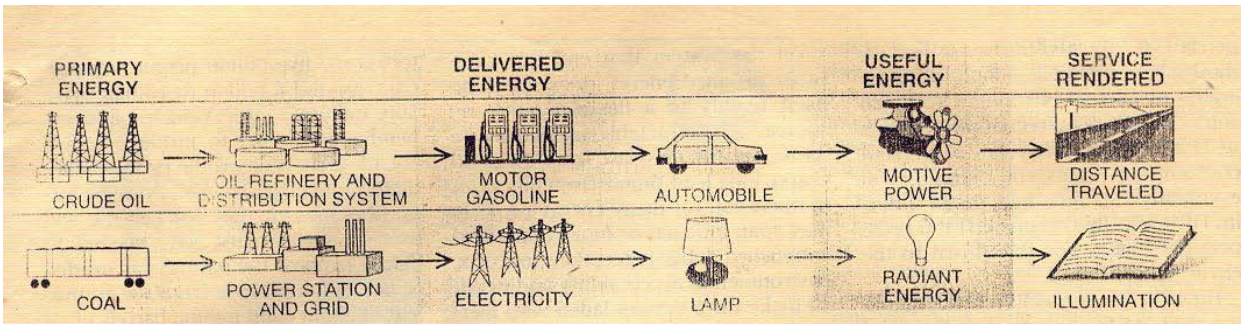


Fig. 1: Energy System, Source: p.22 Scientific American, September 1990

Energy Services: are used to describe consumer benefits, which include: lighting, air- conditioning, refrigeration, cooking, transportation, providing motive power etc.

Energy Chain: includes activities that link the primary energy to deliver energy services.

Energy Security: may be defined as the national policy actions assuring the availability of all energy forms at affordable prices and in sufficient quantities for a reasonable future period (30 to 50 years, depending on many factors).

Energy Intensity: is the ratio of the quantity of energy consumed for producing unit of gross domestic product.

Commercial Energy: is the energy that is subject to a commercial transaction and thus can be accounted for. Biomass: is the organic non-fossil material oil or gas of biological origin, which constitutes an exploitable energy resource.

Primary Energy: is the energy extracted directly from nature e.g. crude oil, hard coal, natural gas, wood, solar-wind-hydro power, uranium (as we receive from nature) etc.

Final Energy: is the energy delivered to the customer often after processing e.g. electricity, gasoline, diesel, coal, gas, compressed natural gas etc. The primary and final energy situation of France shown in Fig.2 may help in clearing the ideas behind the terminology [5].

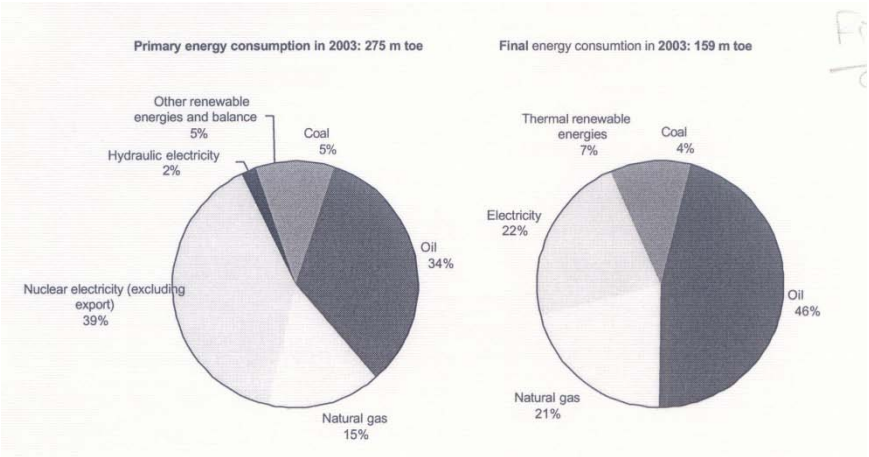


Fig. 2 : Primary and Final Energy , Source: [5]

Reserves : are those occurrences of energy sources or minerals that are identified and measured as economically and technically recoverable with current technology and prices [5].

Resources : are those occurrences of energy sources or minerals with less certain geological and/or economic/technical recoverability characteristics, but that are considered to become potentially recoverable with foreseeable economic and technological development.

b) Sustainable Development

The world community committed (Agenda 21) for achieving human centered Sustainable Development at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. More than 175 states are now parties to this programme [6].

The World Commission on Environment and Development defines sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (p.8.); also "as a process of change in which the exploitation of resources, the

direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potentials to meet human needs and aspirations" (p.46). In broad sense the report notes, "the strategy for sustain able development aims to promote harmony among human beings and between humanity and nature" [7].

c) Energy Forms

There are different forms of energy, gas, coal, oil, hydro, nuclear, electricity, light, heat, potential, kinetic etc. The selection or suitability of the form will depend on the end use. Electricity is the most preferred form.

III. Energy Need

a) Population Growth

It took about 600 thousand years (form early Java man) for the human population to cross the limit of 1 billion around 1800 AD, but the same increased by 4 billions in just 55 years (from 2.48 billions in 1950 to 6.46 billions in 2005). The 2nd and the 5th billion were added to the global population in just 123 and 13 years respectively [8].

The population growth is much more significant in the developing countries (90% growth is taking place in this region) than the developed world [8]. This trend will remain so in the coming years. The world population, though the growth rate is declining due to fall in reproduction and fertility rates, is expected to rise to 10.1 billion by 2050 [8]. More energy will therefore be needed for the expanding global population.

b) Quality Living

A full grown person needs about 2200 kilocalorie of energy per day, which is generated through food intakes. Human beings are the only bio-species, which presently consume on the average about 75 gigajoule of energy which, is about **22 times** more energy than what is required for living. The excess amount is required to maintain the life style and the standard of living. The urge for better living is a universal human instinct. Easy availability of plentiful and affordable different forms of energy allows many people to enjoy unprecedented comfort, mobility and productivity. Consequently the quality of living is improving and the energy consumption rate per person is also increasing.

The desire for the improvement of quality of life is universal. The effect of globalization, particularly the, electronic media and information and communication technology has strengthened this urge of better life. Energy is needed to fulfill this urge.

c) Knowledge Explosion

The ever expanding knowledge and understanding of physical laws and chemical behavior of matter, the application of more and more sophisticated technology in production and services led to the previously unthinkable living standard (at least for those living in the developed world), higher life expectancy and a consequent sharp rise of global population. The world knowledge is doubling every five years as more and more persons are engaged in research and development works [9].

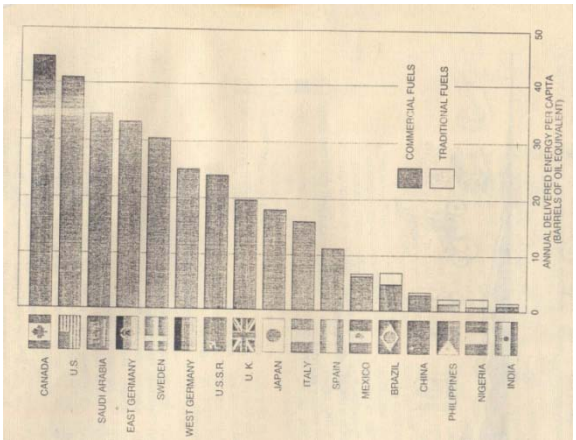
d) Demographic Transition

Just over 100 years ago 95 % of the USA population were engaged in agriculture and food related activities. The percentage has dropped to 5% now [9]. The process of urbanization and social transition is a logical trend to support the changed economic activities. This trend is true for the developing world as well. Besides, people living in areas with lesser economic opportunities have a general tendency of migration to areas of better economic opportunities.

e) Disparities

Wide disparities exist among the states as well as within communities or groups of a state. The world's richest 500 hundred individuals have a combined income greater than that of the poorest 416 million [10]. The 2.5 billion people living on less than 2$ a day and comprising 40% of the global population –account for only 5% of the global income while the richest 10% mostly living in developed countries account for 54%. More than 1 billion people live in acute poverty and hunger with less than 1$ a day [11].

The disparity in energy consumption between developed and developing countries is actually a reflection of economic development status [Fig.3]. Ensuring energy availability and affordability to the population at large living in rural areas of the developing world is one of the important challenges which has to be addressed. This is required for removing disparities and ensuring sustainable growth. About 2 billion global populations do not have access to even electricity. These people live almost entirely on traditional energy sources.



Source: p.23 Scientific American, September 1990

Fig. 3 : Disparity in Energy Consumption between Developed and Developing Countries

f) Consumption Limit and Conservation

There is still (although there was and still there is an effort in some developed countries like to limit the energy consumption rate to 1500 watt per capita) no limit set or established for the human consumption of energy. Efforts are on for quite some time to conserve energy sources by improving efficiency and avoiding wastage. But the savings due to conservation measures are largely offset by the growing demand.

g) MDGs

"When we consider The Millennium Development Goals….. such as the eradication of poverty and hunger, universal access for fresh water, and improved health care – it is quickly evident that the availability of energy overall, and electricity in particular is central to our ability as an international community to deliver on each of these goals" [12]. The fulfill ment of MDGs are closely linked with availability and affordability of final energy sources. Please see Annex-III [13].

h) Energy-Economy Linkage

The economy is directly linked with energy. The global economy is expanding and will continue to expand. So the energy demand will also increase. Among the different forms of energy electricity is the most preferred form and it will remain so in the coming years. The Fig.4 shows the changes in gross domestic product, population, primary energy use and electricity use by region for the period 1971 to 1997 [14]. The figure reveals how the economic growth is linked with energy particularly electricity. The energy demand growth of developing regions in the Asia and Pacific regions, specifically of China is clearly significant.

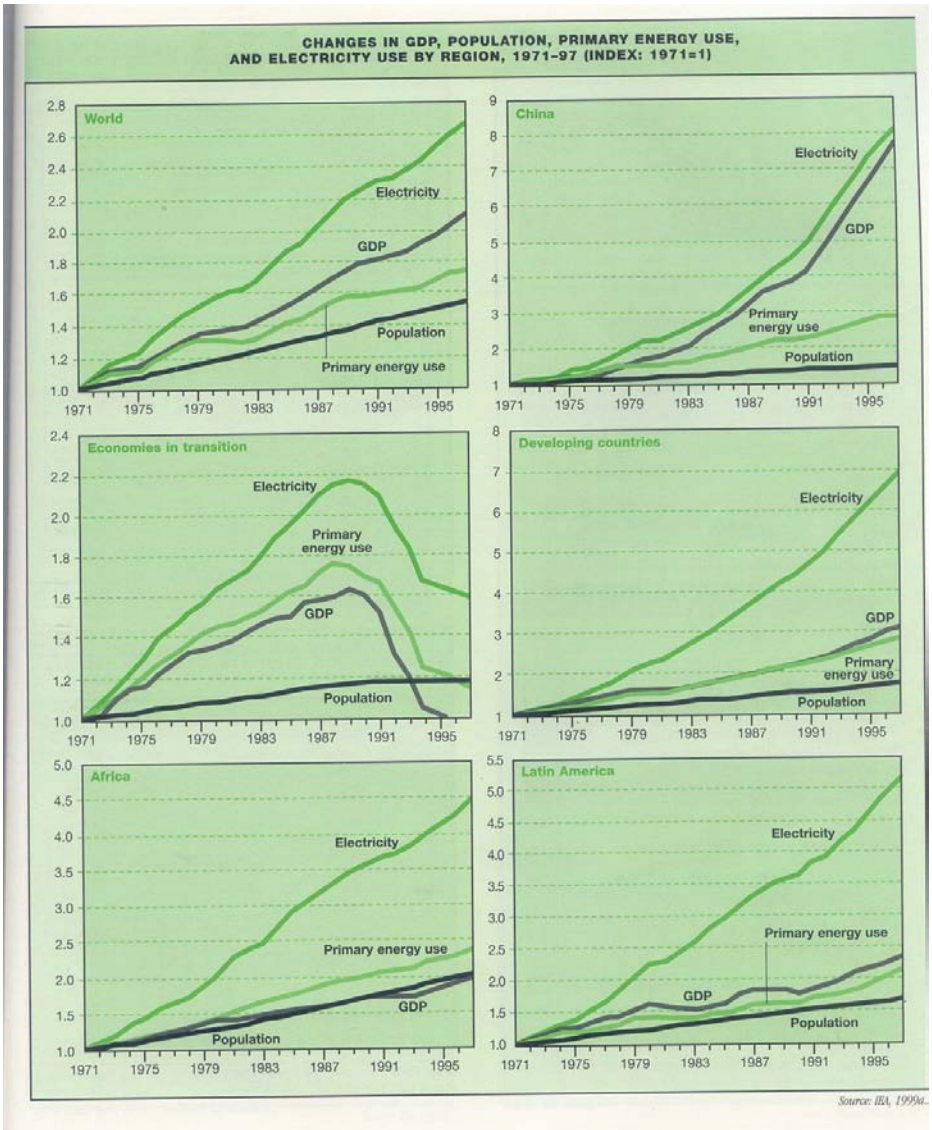


Fig. 4 : Changes in Gross Domestic Product, Population, Primary Energy Use and Electricity Use by Region for the Period 1971 to 1997, Source:[23]

i) Driving Force

The prime driving force is economy and market forces. The rate of growth and energy supply scenario as well as the relative share of the constituting energy sources may, however, be affected or changed due to geopolitical situation and the technological inventions and innovations. The growth rates may also be affected by country's regulatory framework and environmental considerations.

The demand of energy will therefore continue to rise to fulfill the growing economic needs of expanding global population and for meeting other global and the United Nations' goals discussed in the preceding paragraphs.

IV. Evolution of Energy Scenario

a) Evolution

The 'use of oxen multiplied the power available to a human being by a factor of 10. The invention of the vertical wheel increased productivity by another factor of 6; the steam engine by another order of magnitude'[14].

The energy scenario with the consequent growth of types and quantities of primary energy sources actually evolved over the years as the world economy evolved with technological inventions and innovations. The scientific knowledge and the technology also affected the transition of economic activities from predominantly agricultural to production sector during post industrial revolution period and now to service sectors. This evolution is shown in the Fig. 5 [4].

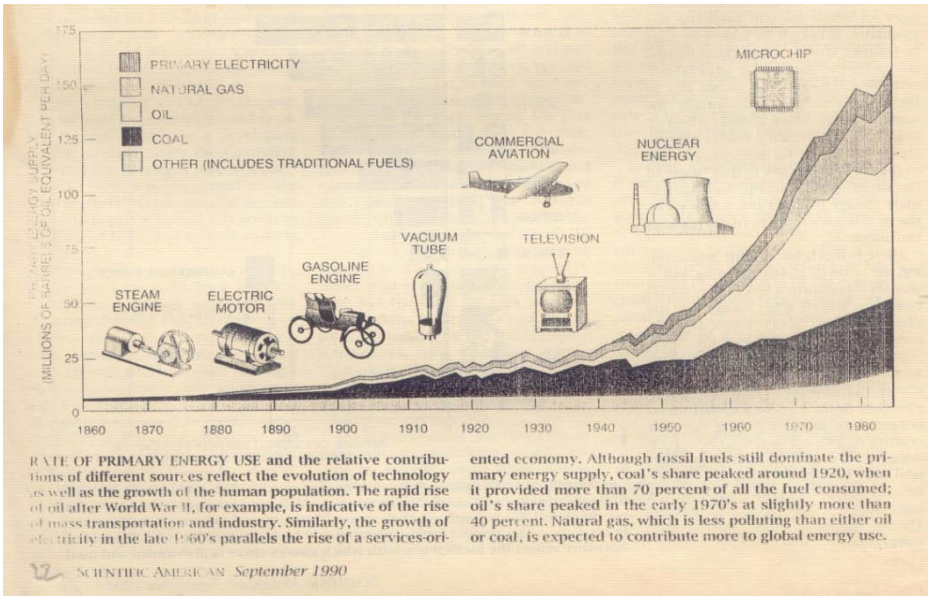


Fig. 5 : Evolution of Energy, Source: [4]

Motor vehicles and airplanes reduced transportation time and the cost. Recent explosion of information and communication technology (ICT) resulted electronic speed in exchange of data and information. The barrier of distances has greatly been reduced. The earth is becoming smaller and smaller.

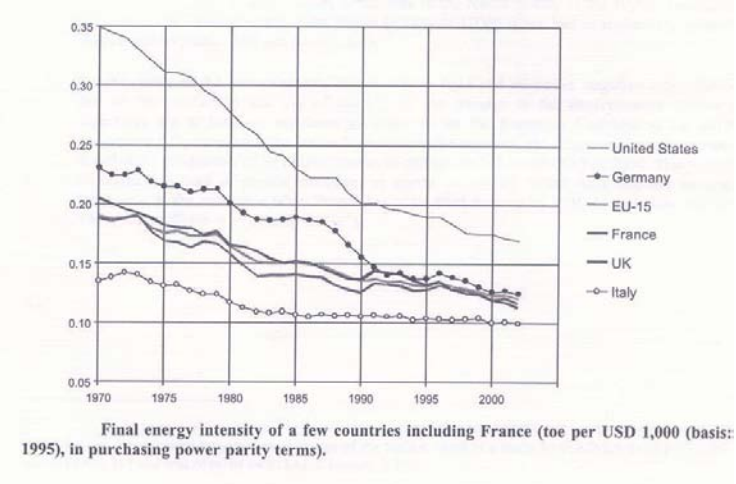
b) Resource Constraints

It may be seen that the use of traditional fuels remained static since 1880 as the industrial revolution started. The fossil fuels dominated and still dominate the primary energy supply. Coal's share peaked around 1920, when it provided more than 70% of all fuel consumed; oil's share peaked in the early 1970's at slightly more than 40% [4]. In the recent background of price hike of oil the share of gas, which is the least polluting, is increasing fast. The share of coal may also peak as the gas and oil reserves are stressed and the prices of these two sources compared to coal are escalating.

The fissile or nuclear sources however remained largely untapped. There are issues of safety, safeguards, proliferation and waste management. But the principal reason appears to be geo-politics.

c) Energy Intensity

The energy intensity is decreasing globally particularly in developed countries as the economy is gradually shifting from predominantly production oriented to service oriented activities. The increased efficiency of the energy systems also contributes to this end. Yet the rate of expansion is higher than the effect of decline due to the lessened energy intensity. This may be seen at Fig. 6.



Final energy intensity of a few countries including France (toe per USD 1,000 (basis: 1995), in purchasing power parity terms).

Fig. 6 : Final Energy Intensity of a few Countries, Source: [5]

v. Present Status

a) Energy Sources

The energy sources are usually categorized into: primary, final and commercial groups.

i. *Primary Sources*

The **primary energy** sources consists of the following –

- Traditional sources (fire woods, vegetable wastes etc.);
- Commercial sources or the fossil fuels (coal, oil and gas);
- Renewables (solar, wind, tide, geothermal etc.) and
- Nuclear/Fissile sources (Uranium and Thorium)

ii. *Final Sources*

The **final energy** sources are processed oil, coal, gas, heat, light, radiation, electricity etc. The most important and preferred one of the final energy sources is **electricity**.

iii. *Commercial Sources*

The commercial sources: oil, gas and coal are presently the dominant types of energy sources. The trend will continue in the coming years (at least in the next 2 to 3 decades). The energy use pattern is primarily dependent on the demand and supply situation (profit) and the market forces. The regulatory frame works and the environmental effects of the use of these source influence the use. The geopolitical situation also affects the energy scenario. The reserves are **maturing** i.e. the discovery now fails to match with the consumptions rate.

b) Energy Reserves and Resources

Nature took more than 3 million years to produce the fossil fuels. The fossil fuels are now being depleted at a rate that is 100,000 times faster than they are being formed [4]. This is not sustainable. The reserves depend on various factors: available technology, demand and the economic cost. The **Fig. 7** reproduced below will help in understanding the dynamics of energy reserve and resource situations.

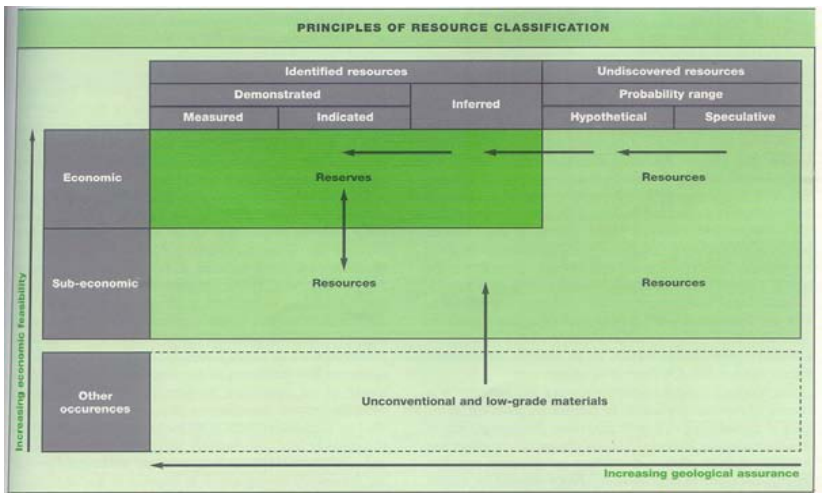


Fig. 7 : Principles of Reserve & Resource Classification, Source: [23]

i. *Fossil and Nuclear Fuels*

The summary of the world fossil fuels and nuclear fuel reserves are shown in **Table-2** .The nuclear source in the table does not include the fissile materials that exist in seawater. It may be noted that nuclear source is still very much untapped. The proper use of this source may ease the global energy supply situation for transition to a pseudo infinite source like fusion source.

Table-2 : Summary of Global Fossil & Nuclear Sources, Source: [23]

SUMMARY OF GLOBAL FOSSILE AND FISSILE RESOURSES (THOUSANDS OF EXAJOULES)

Resource	Consumed by end 1998	Consumed in 1998	Reserves	Resources	Resource base[a]	Additional occurrences
Oil	5.14	0.14	11.11	21.31	32.42	45
Conventional	4.85	0.13	6.00	6.07	12.08	
Unconventional	0.29	0.01	5.11	15.24	20.35	45
Gas	2.38	0.08	14.88	34.93	49.81	930
Conventional	2.35	0.08	5.45	11.11	16.57	
Unconventional	0.03	0.00	9.42	23.81	33.24	930
Coal	5.99	0.09	20.67	179.00	199.67	
Fossile total	**13.51**	**0.32**	**46.66**	**235.24**	**281.89**	**975**
Uranium						
Open cycle in thermal reactors[b]	n.e.	0.04	1.89	3.52	5.41	7.1[c]
Closed cycle with fast reactors[d]	—	—	113	211	325	426[b]
Fossile and fissile total[e]	**n.e.**	**0.36**	**48**	**446**	**575**	**1,400**

n.e. Not estimated. — Negligible.
a. Sum of reserves and resources. b. Calculated from the amount in tonnes of uranium, assuming 1 tonne = 589 terajoules (IPCC, 1996a). c. Does not include uranium from seawater or other fissile materials. d. Calculated assuming a 60-fold increase relative to the open cycle, with 1 tonne = 35,340 terajoules. e. All totals are rounded.
Source: Author's calculations from previous chapter tables.

ii. *Renewable Energy Sources*

The summary of the global potential of renewable sources is shown in **Table-3.** The share of these sources in the global energy demand is likely to remain low key because of many technical and economic reasons. But this is undoubtedly a vast untapped area.

Table-3 : Summary of the Renewable Energy Potential, Source: [23]

SUMMARY OF THE RENEWABLE RESOURCE BASE (EXAJOULES A YEAR)

Resource	Current use[a]	Technical potential	Theoretical potential
Hydropower	9	50	147
Biomass energy	50	>276	2,900
Solar energy	0.1	>1,575	3,900,000
Wind energy	0.12	640	6,000
Geothermal energy	0.6	5,000	140,000,000
Ocean energy	n.e.	n.e.	7,400
Total	**56**	**>7,600**	**>144,000,000**

n.e. Not estimated.
a. The electricity part of current use is converted to primary energy with an average factor of 0.385. *Source: Author's calculations from previous chapter tables.*

c) Geographical Distribution, Production and Replenishments

The world fossil fuels are geographically very much unevenly distributed. Some countries like Japan, France, Italy etc. are largely dependent on imported energy sources and others like Middle East Russia sell the excess energy[15]. This necessitated a flourishing worldwide trade in energy commodities. The distribution networks [pipe lines for gas and oil, processing facilities for CNG, LPG, oil distillates, transmission and distribution lines] had to be developed and are still required to be developed to deliver desired forms of energy to the customers or users.

i. *Oil*

The global distribution of oil and the flow of the sources from the producing to consuming regions are shown in **Figs.8 & 9** respectively. The oil production or demand in different years is shown in **Fig. 10.** The replenishments of the sources in USA and in the world are shown in **Fig. 11** and **Fig.12** respectively.

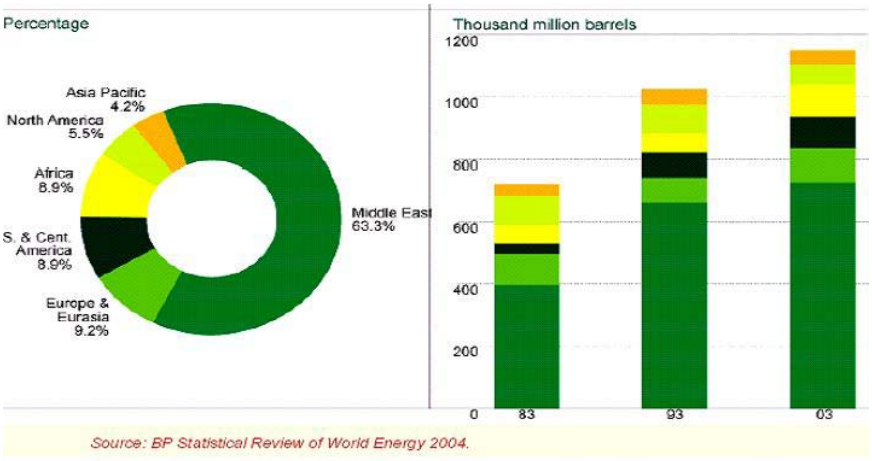


Fig. 8 : Oil Energy Reserve & Geographical Distribution

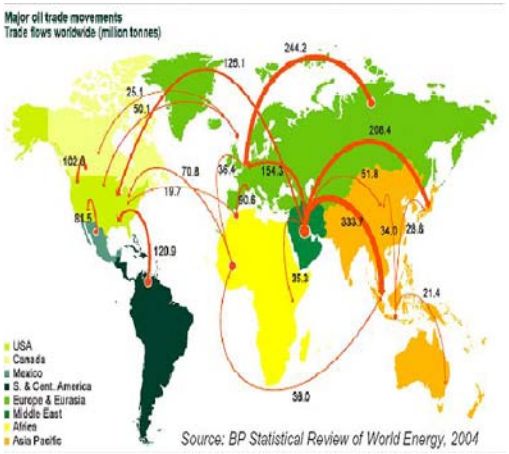


Fig. 9 : Global Oil Trade

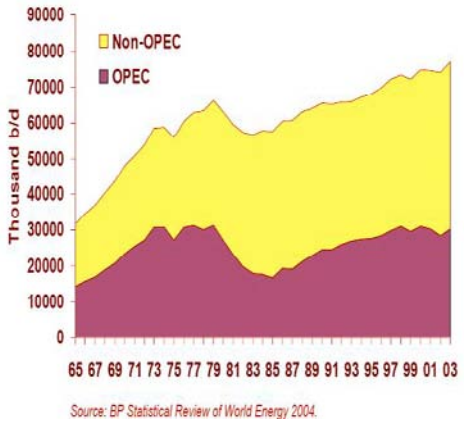


Fig. 10 : Oil Demand Scenario

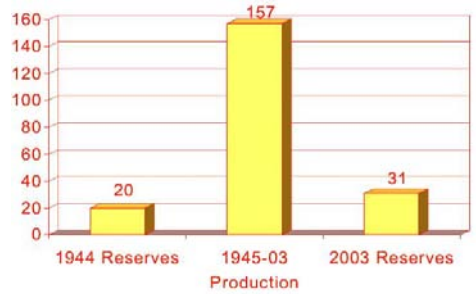


Fig. 11 : U.S.Oil Production& Replenishment

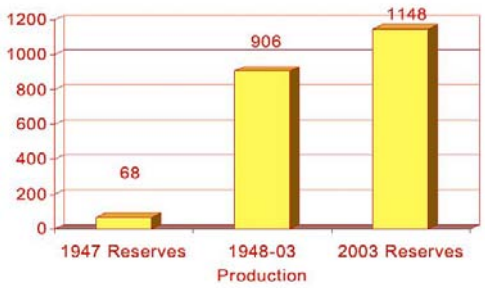


Fig. 12 : World Oil Production & Replenishment

Source: [21]

ii. *Gas*

The global gas reserves and the gas producing regions are shown in **Fig.13**. The gas production or demand in different years is shown in **Fig.14.** The replenishments of the sources in USA and in the world are shown in **Fig.15** and **Fig.16** respectively.

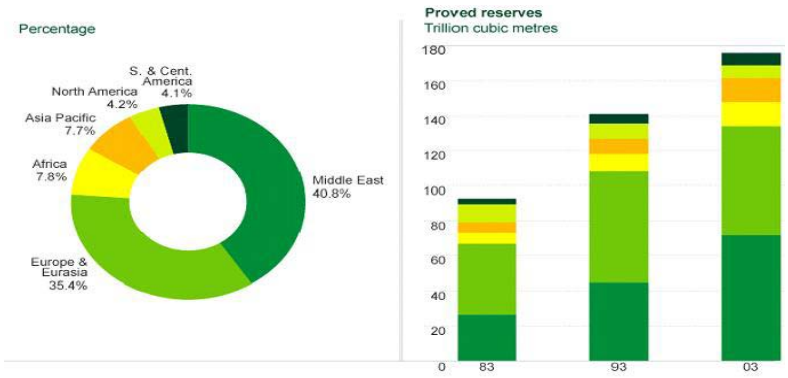


Fig. 13 : Gas Energy Reserve & Geographical Distribution, Source: [21]

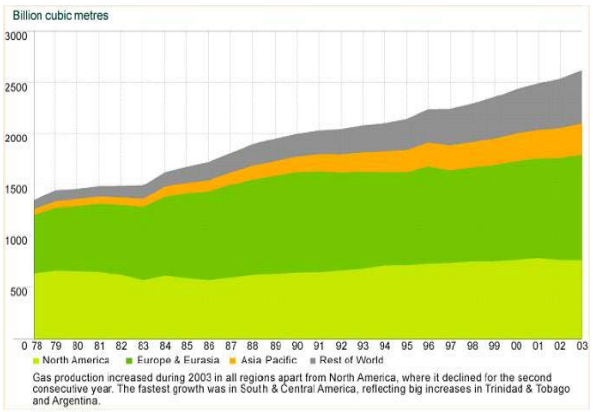


Fig. 14 : Gas Demand Scenario

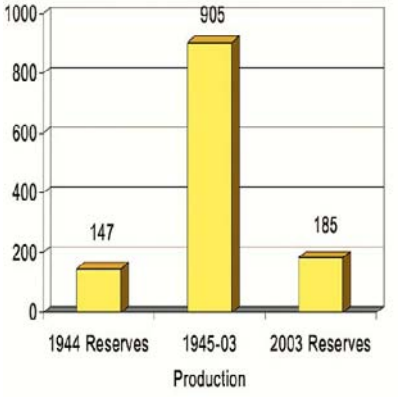


Fig. 15 : U.S. Gas Production & Replenishment

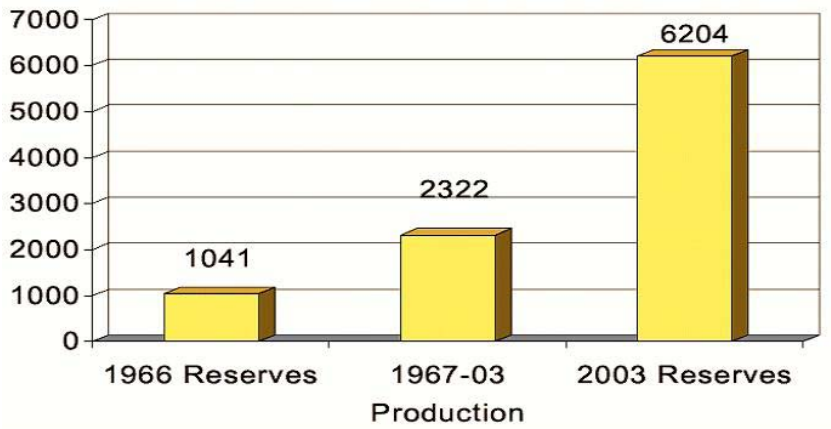


Fig 16 : World Gas Oil Production & Replenishment, Source: [21]

iii. *Coal*

The global estimated reserves and resource of coal and the distribution shown at **Tables 4 & 5** respectively.

Table 4 : World Estimated Coal Reserve

ESTIMATED COAL RESERVES (MILLIONS OF TONNES)				
Region	Bitumi-nous (incl. anthracite)	Sub-bitumi-nous	Lignite	Total (exajoules)
North America	115,600	103,300	36,200	6,065
Latin America and Caribbean	8,700	13,900	200	533
Western Europe	26,300	600	47,700	1,178
Central and Eastern Europe	15,400	5,500	10,700	744
Former Soviet Union	97,500	113,500	36,700	4,981
Middle East and North Africa	200	20	0	6
Sub-Saharan Africa	61,000	200	< 100	1,465
Pacific Asia	900	1,600	5,100	10
South Asia	72,800	3,000	2,000	1,611
Centrally planned Asia	62,700	34,000	18,600	2,344
Pacific OECD	48,100	2,000	41,600	1,729
Total	**509,200**	**277,600**	**198,900**	**20,666**

Source: WEC, 1998.

Table 5 : World Estimated Coal Resource

ESTIMATED COAL RESOURCES (BILLIONS OF TONNES OF COAL EQUIVALENT)			
Region	Hard coal	Soft coal/ lignite	Total (exajoules)
North America	674	201	25,638
Latin America and Caribbean	37	2	1,143
Western Europe	337	11	10,196
Central and Eastern Europe	106	14	3,516
Former Soviet Union	3,025	751	110,637
Middle East and North Africa	1	1	58
Sub-Saharan Africa	181	< 1	5,303
Pacific Asia	7	5	352
South Asia	84	1	2,491
Centrally planned Asia	429	35	13,595
Pacific OECD	139	67	6,030
Total	**5,021**	**1,089**	**178,959**

Note: Includes reserves. *Source: BGR, 1998.*

Source: [23]

VI. Electricity

a) Growth Trend

Electricity as stated earlier is the most preferred form of energy. The electricity demand is growing at much faster rate compared to other final energies. Yet, 2 billion people or every 2nd person out of the 6 persons of the world do not have any access to electricity. 'Energy analysts are looking at the pace and price of progress-at a time when electricity demand is rising ever higher' [16]. The world net electricity production and the past trend of growth as well as the contribution of different sources are shown in the Fig.17.

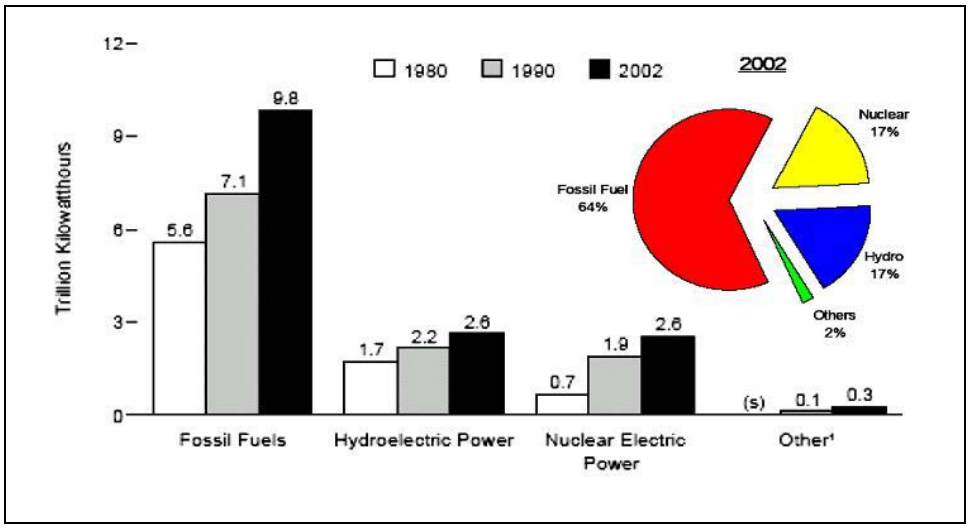


Fig. 17 : World Electricity Production & Growth Rate, Source: [21]

b) Investment Outlook

The World Energy Investment Outlook of the International Energy Agency EIA projects an investment of $16 trillion (about 1% of the global GDP) over the period 2001-2030 to meet primary energy demand growth of 1.7% and electricity demand of 2.4%. Electricity will require 60% of the total investment. Compared to the estimated annual investment of $410 billion in 2000, it will rise $ 550 billion in the current decade and to $630 billion during 2021 to 2030 [16]. The summary of electricity investment, as projected is shown in Fig.18. The cumulative investment in energy by fuel is shown in Fig. 19.

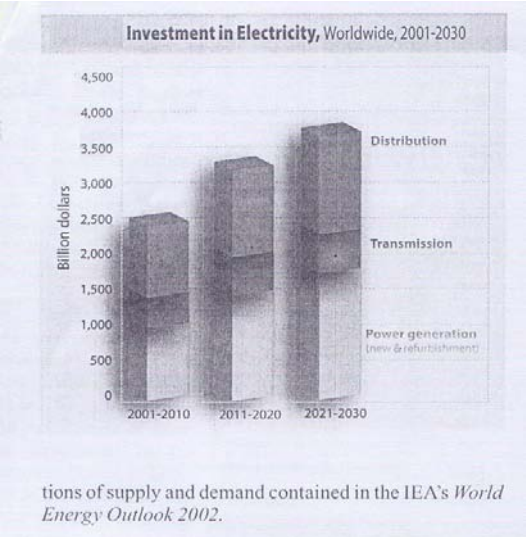


Fig. 18 : World Investment in Electricity Source: [18]

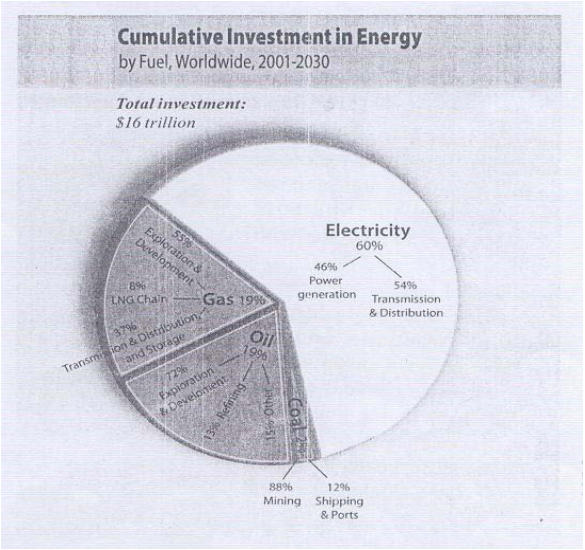


Fig. 19 : World Cumulative Investment in Energy Source: [18]

The fuel wise generation of electricity is shown in Table-6.

Table 6 : World Electricity Balance, Source: [18]

Electricity Balance,* Worldwide, 2000-2030

	2000	2010	2020	2030	Average annual growth 2000-2030 (%)
Gross generation (TWh)	15,391	20,037	25,578	31,524	2.4
Coal	5,989	7,143	9,075	11,590	2.2
Oil	1,241	1,348	1,371	1,326	0.2
Gas	2,676	4,947	7,696	9,923	4.5
Hydrogen-fuel cells	0	0	15	349	n.a.
Nuclear	2,586	2,889	2,758	2,697	0.1
Hydro	2,650	3,188	3,800	4,259	1.6
Other renewables	249	521	863	1,381	5.9
Own use and losses (Mtoe)	235	304	388	476	2.4

*Includes transport, agriculture and non-specified uses of electricity.

c) Supply Reliability

Uninterrupted and quality power supply at an affordable price is a key component for smooth economic growth of a country. In industrialized countries, consumers demand 100% reliability, while the power supply systems in developing countries suffer frequent disruptions as well as poor quality (voltage and frequency fluctuations). The cost burden of the disruptions is enormous.

The electricity blackouts make headlines in Europe and North America. But such blackouts are common in any developing countries. The reliability of electricity supply,therefore, was highlighted as a priority issue in the Sydney World Energy Congress of September 2004 [Annex-V].

VII. Future Trend

a) Market Forces

The development of energy industry depends on many factors: economy, advances in technology related to energy production, distribution and consumption, policy decisions, regulations and environmental effects and global demand and supply position. The key is profit and market force. This is also dependent on geo-political dynamics. Recently unthinkable price hike took place in oil sector. The oil price, which dipped to $10.29 in December 1998 remained stable between $ 20 to 30 for a certain period and then, crossed $ 70 in August 2005.

b) Energy Outlook

i. USA

The energy trend is presented from the overview of the Annual Energy Outlook 2005 document published by Energy Information Administration of the USA [24]. The overview presented the historical growth (from 1970 to 2003) of energy prices and projections for the period up to 2025 [Fig.20], delivered energy consumption by sectors [Fig. 21], energy consumption by fuel [Fig. 22], energy use per capita and per dollar of GDP [Fig.23], electricity generation by fuel [Fig. 24], total energy production and consumption [Fig.25], energy production by fuel [Fig. 26] and the projected CO2 emissions by sector of fuels [Fig. 27].

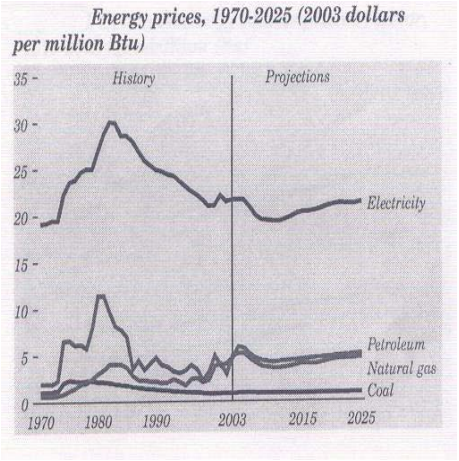


Fig. 20 : Energy Prices & Projection

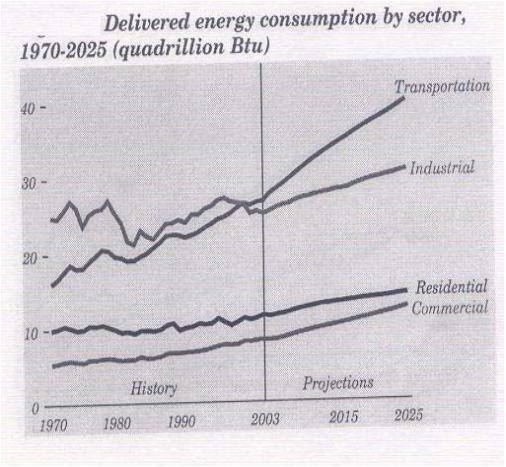


Fig. 21: Delivered Energy Consumption

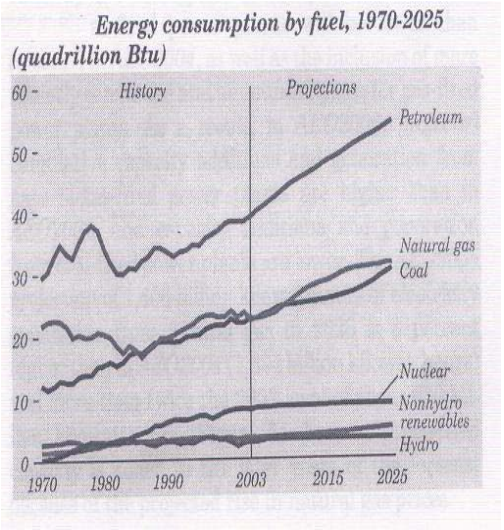


Fig. 22 : Energy Consumption by Fuel

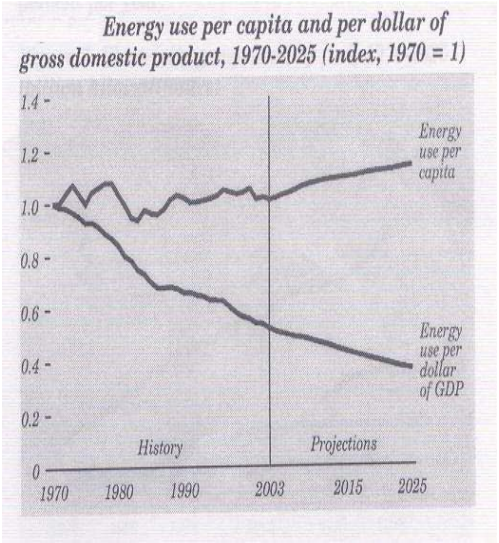


Fig. 23 : Energy Use per Capita & per Dollar of GDP

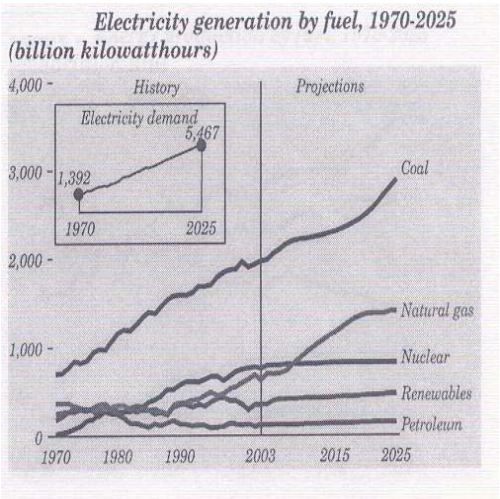


Fig. 24 : Electricity Generation by Fuel

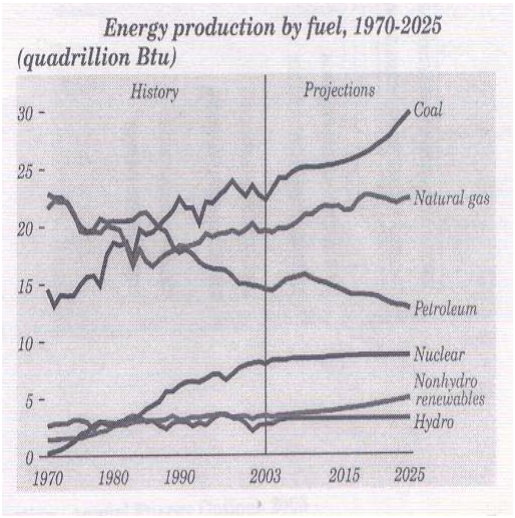


Fig. 25 : Total Energy Production & Consumption

Source: [24]

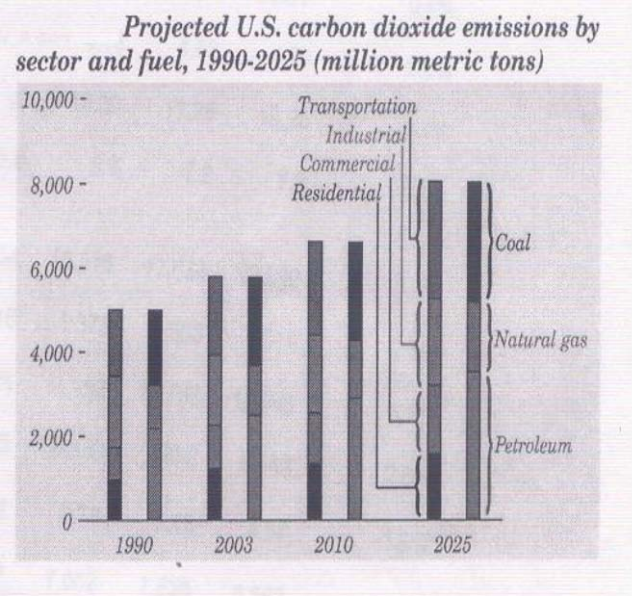


Fig. 26 : The Projected CO_2 Emission by Sectors of Fuels, Source: [24]

The summary of the overview is shown in Table7. The energy trend presented above is designed for the USA. The oil price forecast for the coming years ($ 28.50 in 2020 and $30.31 in 2025) from the present day perspectives appears to be highly optimistic. But there must have been in depth analyses behind these optimistic forecasts. The information throws light on future energy trend.

Table-7 : EIA/DOE Energy Forecast

Total energy supply and disposition in the *AEO2005* reference case: summary, 2002-2025

Energy and economic factors	2002	2003	2010	2015	2020	2025	Average annual change, 2003-2025
Primary energy production (quadrillion Btu)							
Petroleum	14.71	14.38	15.41	14.31	13.83	12.82	-0.5%
Dry natural gas	19.48	19.58	20.97	21.33	22.48	22.42	0.6%
Coal	22.70	22.66	25.10	25.56	27.04	29.90	1.3%
Nuclear power	8.14	7.97	8.49	8.62	8.67	8.67	0.4%
Renewable energy	5.79	5.89	6.85	7.13	7.57	8.10	1.5%
Other	1.12	0.93	0.97	0.78	0.77	0.82	-0.5%
Total	**71.94**	**71.42**	**77.79**	**77.73**	**80.35**	**82.73**	**0.7%**
Net imports (quadrillion Btu)							
Petroleum	22.64	24.10	28.61	33.10	36.87	41.11	2.5%
Natural gas	3.59	3.32	5.06	7.19	8.08	8.87	4.6%
Coal/other (- indicates export)	-0.47	-0.43	-0.14	0.19	0.25	0.58	NA
Total	**25.75**	**26.99**	**33.53**	**40.47**	**45.21**	**50.55**	**2.9%**
Consumption (quadrillion Btu)							
Petroleum products	38.41	39.09	44.84	48.07	51.30	54.42	1.5%
Natural gas	23.59	22.54	26.11	28.69	30.73	31.47	1.5%
Coal	21.98	22.71	24.95	25.71	27.27	30.48	1.3%
Nuclear power	8.14	7.97	8.49	8.62	8.67	8.67	0.4%
Renewable energy	5.79	5.89	6.85	7.13	7.57	8.10	1.5%
Other	0.07	0.02	0.03	0.07	0.05	0.04	4.1%
Total	**97.99**	**98.22**	**111.27**	**118.29**	**125.60**	**133.18**	**1.4%**
Petroleum (million barrels per day)							
Domestic crude production	5.74	5.68	6.02	5.49	5.21	4.73	-0.8%
Other domestic production	3.60	3.38	3.59	3.77	4.00	4.10	0.9%
Net imports	10.54	11.24	13.37	15.40	17.11	19.11	2.4%
Consumption	19.71	20.00	22.98	24.67	26.32	27.93	1.5%
Natural gas (trillion cubic feet)							
Production	19.03	19.13	20.49	20.85	21.97	21.91	0.6%
Net imports	3.50	3.24	4.94	7.02	7.89	8.66	4.6%
Consumption	22.98	21.95	25.44	27.96	29.95	30.67	1.5%
Coal (million short tons)							
Production	1,105	1,083	1,238	1,270	1,345	1,488	1.5%
Net imports	-23	-18	-9	3	7	20	NA
Consumption	1,066	1,095	1,229	1,273	1,352	1,508	1.5%
Prices (2003 dollars)							
World oil price (dollars per barrel)	24.10	27.73	25.00	26.75	28.50	30.31	0.4%
Domestic natural gas at wellhead (dollars per thousand cubic feet)	3.06	4.98	3.64	4.16	4.53	4.79	-0.2%
Domestic coal at minemouth (dollars per short ton)	18.23	17.93	17.30	16.89	17.25	18.26	0.1%
Average electricity price (cents per kilowatthour)	7.4	7.4	6.6	6.9	7.2	7.3	-0.1%
Economic indicators							
Real gross domestic product (billion 2000 dollars)	10,075	10,381	13,084	15,216	17,634	20,292	3.1%
GDP chain-type price index (index, 2000=1.000)	1.041	1.060	1.218	1.373	1.563	1.814	2.5%
Real disposable personal income (billion 2000 dollars)	7,560	7,734	9,594	11,192	12,783	14,990	3.1%
Value of manufacturing shipments (billion 1996 dollars)	5,067	5,105	6,165	6,850	7,633	8,469	2.3%
Energy intensity (thousand Btu per 2000 dollar of GDP)	**9.73**	**9.47**	**8.51**	**7.78**	**7.13**	**6.57**	**-1.6%**
Carbon dioxide emissions (million metric tons)	**5,751**	**5,789**	**6,627**	**7,052**	**7,520**	**8,062**	**1.5%**

Notes: Quantities are derived from historical volumes and assumed thermal conversion factors. Other production includes liquid hydrogen, methanol, supplemental natural gas, and some inputs to refineries. Net imports of petroleum include crude oil, petroleum products, unfinished oils, alcohols, ethers, and blending components. Other net imports include coal coke and electricity. Some refinery inputs appear as petroleum product consumption. Other consumption includes net electricity imports, liquid hydrogen, and methanol.
Source: AEO2005 National Energy Modeling System, run AEO2005.D102004A.

Energy Information Administration / Annual Energy Outlook 2005

ii. *World*

The summary of the UNDP World Assessment report (2000) about the energy projections up to 2100 are shown at **Annex- IV [17].** The UNDP projections may be compared and verified with the EIA/DOE energy outlook.

iii. *Energy System Integration and Cooperation*

The word is moving though slowly towards cross –boundary integration of energy distribution networks of electrical grids and gas and oil pipelines. Such integration is likely to make energy systems more efficient, accessible and affordable. The EU countries in the past has taken and are taking steps towards this direction. But for the developing countries will require more transparency, understanding, consensus of people and parties at stake for energy system integration. The actions have to be based mutual trust, cooperation and ethics.

VIII. Bangladesh Perspective

a) Energy Status

Bangladesh is the most densely populated country (among the comparable sized ones) of the

world. Population wise (about146 million) it is the eighth largest country with an area of only 147570 sq kms. The impor- tance of energy, particularly electricity is recognized in the Constitution (Article - 16) [19]. Yet, more than 66% of the people do not have access to electricity. Besides the electrical supply system suffers from frequent load shedding and low quality. The per capita energy consumption rate is also very low. The Table-8 shows energy scenario of some selected countries and the regions. Most of the people (79.9%) living in the rural areas depend mostly on primary energy sources.

Table 8 : Energy Scenario of Some Selected Regional Countries and Economic Areas

Sl. No.	Country	+Traditional Fuel Consumption (% of total) 2002	+Per Capita Electricity Consumption (kwh/yr.	Installed Capacity (Mega Watt)	Electricity Access to Population (%)
1.	Bangladesh	61.6	140	4710	40
2.	Bhutan	87.8	241	445	30
3.	India	20	561	112,058	56
4.	Nepal	-	63	522	40
5.	Pakistan	-	479	17,953	56
6.	Sri Lanka	41.6	354	1,615	64
9.	China	5.3	1484		
10.	Malaysia	1.5	3234		
11.	Iran	0.1	2,075		
12.	OECD	3	8615		
13.	High Income	4.5	10,198		
14.	Middle Income	17	1,653		
15.	Developing	24.5	1,155		
16.	Low Income	42.2	399		
17	World	7.6	2456		40

+Source: UNDP Human Development Report 2005

b) Energy Sources

The country has very little energy reserves even compared to South Asian countries [Table-9]. The most important commercial energy source is gas (very high quality). Gas is used for production of 89 % of electricity of the country [20]. The rationality may be assessed.

Table 9 : Energy Reserve Base of South Asian Countries

Sl.No.	Country	Population Million	Oil Reserve (GigaTons)	Gas Reserve (Trillion m3)	Hydro Potential 10^{12} watt hr/Yr.	Coal Giga Tons
1.	Bangladesh	145	0.007	0.3	2	2.5
2.	Bhutan	2	-	-	70	-
3.	India	1085	0.671	0.77	660	84
4.	Nepal	28	-	-	158	-
5.	Pakistan	164	0.026	0.75	130	2
6.	Srilanka	20	-		8	-
7.	World	6465	295	502	13945	5579

Source : Oil and Gas Journal, World Energy Council (Energy & Power, p.9, 01.02.05)

c) Energy Management

The country has notified the Energy Policy in 1995[22]. Several energy studies have been carried out since 1975. But the recommendations of the national policy or the studies are not duly reflected in the policy decisions of energy development. Consensus on the energy reserve-resources (particularly on gas) is lacking. The coordination of the activities of the interdependent energy and consumer sectors is also weak.

The energy demand and supply issues, as these are closely linked with sustainable development [Agenda 21], are required to be routinely studied and assessed with due depth from the energy security perspectives. The Japanese, South Koreans, French, Malaysian national energy policies may be examined for guidance. The uniqueness of Bangladesh in the context of geo-socio-economic situation are also required to be critically and routinely examined. Such studies may help in achieving smooth and sustainable development as

well as to fulfill the country's constitutional obligations (Articles 16 and 19).

ix. Key Issues

The issues that are confronted by the world community were elaborately discussed in the World Energy Conference held in Sydney, Australia in September 2004.

a) Goal

While the message of the World Energy Council (WEC) Conference held in September 1989 in Montreal, Canada was "Find **more energy or perish";** the key issue of the last WEC Conference held in Sydney was **energy sustainability**. But the achievement of sustainable development in energy sector demands that the access and security of supply is ensured while avoiding environmental impacts, which would compromise future social and economic development.

b) Focal Areas

The increase in energy prices and supply disruptions and their effects on different energy development aspects were subjects of discussions and redress. The conclusions of the Sydney World Congress are given in **Annex-V.** Some of the key conclusions are highlighted below: -

- All energy options must be open
- More pragmatic market reform
- Reliability of electricity supply
- Regional integration of energy supply
- Research and development
- Climate change
- Public trust and understanding
- Energy security
- Energy accessibility and affordability

c) MDGs and Sustainable Development

Particularly the accessibility and affordability of the useful forms of final energy are essential to fulfill the millennium development goals (MDGs). World is very much diverse. Each country, particularly the developing one, has its unique socio-politico- geo-economic position. The unique features shall have to be taken into consideration by the policy makers for achieving the sustainable development.

d) Global Consensus

Global consensus and cooperation among the states are needed to resolve global warming and climatic changes and environmental pollution issues and for more future friendly use of fissile and renewable sources.

x. Conclusion

Energy is essential for continued human development and economic growth. It 'is central to achieving the interrelated economic, social, and environmental aims of sustainable human development'.

Electricity and final energies are not accessible or affordable to more than 2 billion people who live in acute poverty and deprivation. The energy need of this deprived group has to be addressed in order to achieve the MDGs.

Energy will be needed in much larger quantities in the coming years to meet the need of the expanding global population as well as to meet the growing need of goods and services are required for better quality of life. But the reserves of the commercial sources are finite.

"Much of the world's energy…. is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to remain substantially the same".

Proper understanding and consensus among the parties at stakes on national energy issues from the country's energy reserve/resource base and socio-geo-economic condition are essential for energy security and sustainable development. The planned energy mix has to be optimized in the context of the national needs and aspirations and global perspectives.

Comprehensive assessments and analyses with knowledge and reliable data and actions with wisdom will be necessary to address energy related issues. This is essential for a more stable and livable world, particularly in this age of globalization and information and communication technology and expanding global unrest and terrorism.

The goal is of course achievable if the ethics based strong commitment, mutual trust and active support and cooperation of the world leaders and the multinational economic-giants could be ensured.

xi. Annexes

Annex-I: Millennium Development Goals
Annex-II: Glossary-selected terminology
Annex-III: Matrix of Energy and the Millennium Development Goals
Annex-IV: Summary of three Energy Development Cases in 2050 and 2100 compared with 1990
Annex-V: Conclusions of World Energy Congress, Sydney, Australia, 5-9 September 2004

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