GROWTH AND STRUCTURE OF INDIAN ENERGY SECTOR, CHALLENGES AND REFORMS

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The present study on the growth and structure of Indian energy sector looked at various parameters that influence the growth, production and consumption levels of different energy sources. The production and consumption of different energy sources of India from the period 1970-2005 has been thoroughly examined ,linear trends of different energy sources has revealed that there is wide gap between production and consumption of energy in India. The study also looked upon trends in percentage showing electricity, petroleum coal and natural gas consumption in different sector of the economy such as industrial, agriculture, transport and commercial usage. Sect oral analyses of major energy sources have been carefully examined. Trends in import dependency and its implications on the energy mix have also been studied. The trends found in the production and consumption of major energy sources will help in visualizing this energy outlook in the coming decades.

Economic growth of the country is strongly linked with the growth and beneficial structural changes in the energy sector. All sectors of economy and all sections of society depend upon energy. Energy is the most significant input for economic growth. The changes in the growth pattern and structure of energy sector affect the social, economic, and environmental dimensions of development. The trends in this sector will reveal weather sufficient quantity of energy at affordable prices is available to meet the present and future needs of India (Planning commission 2007).

Studies reveal that energy sector in India has received a high priority in the planning process. It has also received a high priority in allocation of public funds for its growth. This is evident from the fact that allocation of public funds in the energy sector has risen from fifteen percent in the Third Five Year plan to twenty seven percent in the Tenth Five Year plan. The study of growth and structure will also reveal weather performance of this sector is satisfactory or not. Is the

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growth in different sectors of energy is good enough to keep pace with the demand of various consuming sector under the tremendous pressure of rapidly growing population. The trends in growth and structure may help in evolving integrated energy approach to meet the policy goals of economic efficiency, sustainable development and energy security.

With expected GDP growth of 9% by the end of the Eleventh Five-Year Plan, the energy demand is expected to grow at 5.5% due to sustained economic growth, rise in income levels and increased availability of goods and services. India's incremental energy demand for the next decade has been projected to be among the highest in the world. Despite increases in energy use in India, the current per capita commercial primary energy consumption in India is about 455 kgoe (kilograms of oil equivalent) per year till 2005, which is well below that of developed countries. (MOC,2004)

Demand and supply scenario

In this paper demand and supply scenario of different sources of energy, their production and consumption trends giving different implications have been analyzed. The data collected for the present study has been taken from the year 1970-2005 (*i.e.* about three and half decades).

India is relatively well endowed with both exhaustible and renewable energy resources. Coal, oil, and natural gas are the three primary commercial sources of energy. There has been a significant change in the pattern of supply and consumption of energy, over the years. The share of commercial fuels (coal, lignite, oil, natural gas, hydropower, wind power, nuclear power) in the total energy supply in India has risen from 41% in 1970-71 to approximately 70% in 2003-04, despite the dominance of the traditional fuels in the energy sector in India. (Ninth Five Year Plan 1997-02)

The Indian energy sector is complex due to the co-existence of widely varying pattern of consumption amongst different sections of society. In the residential sector, much of the energy demands in the rural household continue to be fulfilled by traditional fuels such as firewood, crop residue, and dung, while urban households use modern fuels like LPG (liquefied petroleum gas) and electricity to-

meet their needs. In the industry sector, most of the large industries have adopted technologies that compare with the best in the world, while small units continue to function with very inefficient and outdated technologies.

India's Present Energy Mix

If we closely look at India's present energy mix, we find that there are large disparities in the country's energy consumption pattern.

Table 1
India's present energy Mix (2005)

Coal	51 percent
Oil	36 percent
Natural gas	9 percent
Hydroelectricity	2.1 percent
Nuclear energy	1.5 percent
Renewable	0.07 percent

Source: Planning Commission 2006

Table 1 reveals that in India's energy mix structure the coal is dominant energy source. India depends on coal for more than half of its total energy needs, followed by oil (*i.e.* 36 percent). The least used source is of renewable (*i.e.* 0.07 percent). It clearly shows that India depends on coal and oil for its major energy requirements.

India's oil consumption is also increasing. Out of total consumption of oil nearly 75 percent of oil is imported. Currently India is the sixth largest consumer of oil and will shortly become the fourth largest consumer. India's demand for oil is expected to increase at 2.9 percent annually. (Planning Commission 2006).

The situation relating to gas is very grim. India's demand for gas is expected to rise to 125 bcm in coming 15-20 years from present 49 billion cubic meters in 2005-06. The production from existing field and discoveries would be 52 bcm leaving a gap of 75 bcm to be filled through new domestic discoveries and from imports (Ministry of Petroleum and Natural Gas 2006).

In case of hydroelectricity, nuclear energy and renewable the situation is equally grim. The sources have not been fully exploited

and the self-sufficiency in case of energy matters is still not likely to be achieved.

Analysis of Growth Rates of different Energy Sources

Under the present heading, the in-depth study of growth, production and consumption of four important energy sources *i.e.* coal, oil, natural gas and electricity has been done on the following lines.

Coal

Coal has been the most important component of India's energy source from a long time. It accounts for nearly 50% of the total energy supply. The developments of core infrastructure sectors like power, steel, cement are dependent on coal. About 75% of the coal in the country is consumed in the power sector. (Planning Commission 2002).

The domestic demand for coal has been estimated to grow from 340. 1 MT (million tones) in 2002-03 to 460. 5 MT (million tones) by 2006-07 and 620 MT by 2011-12. As against this demand, the availability of indigenous coal has been estimated to grow from 341. 3 MT in 2002-03 to 405 MT in 2006-07 and 515 MT in 2011-12 thereby leaving a gap of 55 MT in 2006-07 and this gap is expected to increase to 105 MT in 2011-12. (MOC 2005)

India has huge coal reserves and its share stands at about 7 percent of the world's total. According to the estimates of experts, with the current level of production and consumption, coal reserves would last to nearly about three centuries. (Planning Commission 2006).

Table 2
Growth Rates of Production & Consumption of Coal from 1970-2005

(In Thousand Tones)

Year	Production (in thousand tones)	Growth rates of Production	Consumption (in thousand tones)	Growth rates of Consumption
1970	76430	-	71230	-
1971	76140	-0.379	74060	0.973
1972	80110	5.214	78180	5.563

1973	81490	1.722	77660	-0.665
1974	91350	12.099	85580	10.198
1975	102660	12.380	92160	7.688
1976	105010	2.289	100100	8.615
1977	104560	-0.428	103780	3.676
1978	105250	0.659	100150	-3.497
1979	106840	1.510	105530	5.371
1980	119020	11.400	109310	3.581
1981	131240	10.267	121010	10.703
1982	137530	4.792	130130	7.536
1983	147539	7.277	137290	5.502
1984	155277	5.244	141450	3.030
1985	162336	4.546	155530	9.954
1986	175290	7.979	166840	7.271
1987	192551	9.847	179209	7.413
1988	208820	8.449	192115	7.201
1989	215724	3.306	203424	5.886
1990	228131	5.751	213360	4.884
1991	248805	9.062	232330	8.891
1992	258616	9.062	241750	8.891
1993	266785	3.158	256320	6.026
1994	277080	3.858	269174	5.014
1995	295561	6.669	284037	5.521
1996	308720	4.452	298620	5.134
1997	320221	3.725	306824	2.747
1998	315689	-1.415	313476	2.168
1999	322168	2.052	315047	0.501
2000	336643	4.492	341220	8.307
2001	352601	4.740	349740	2.496
2002	367290	4.165	361745	3.482
2003	389204	2.966	379405	4.881
2004	412952	6.101	404691	6.664
2005	437079	5.842	407013	0.573
CAGR	-	5.35	-	5.45

Source: Office of the Coal Controller, Ministry of Coal 2005-06
*Coal includes lignite also.

The overall analysis of table 2 clearly reveals that overall compound annual growth rate under the present study period *i.e.* 1970-2005 of coal production and coal consumption is respectively 5.35 percent and 5.45 percent indicating that coal consumption is growing at a faster pace as compared to coal production.

Maximum growth rate of coal production is in the year 1975 and 1974 *i.e.* 12.38 and 12.09 percent respectively. Maximum growth rate of coal consumption is in the year 1981 *i.e.* 10.70 percent whereas the least consumption growth rate in this category is in the year 1978 when it become negative *i.e.* -3.49 percent.

Growth rates of production of coal also become negative in the following years; 1971 growth rate -0.37 percent; 1977 growth rate -0.42 percent; 1998 growth rate -1.41 percent.

The production of coal in the measure of thousand tones in the last 36 years of study always remained higher than consumption except during the year 2000.

Table 3
Trends in percentage share of Coal consumption by different industries from period 1970-2005

	70-71	80-81	90-91	00-01	05-06
Electricity	18.54	34.90	53.29	74.13	73.26
Steel Casting	18.99	19.22	14.48	9.00	8.74
Cement	4.94	4.34	4.88	4.49	4.24
Railways	21.87	10.80	2.45	0.00	-
Paper	0.38	1.96	1.32	0.79	0.63
Cotton@	2.03	1.80	1.21	0.30	0.07
Others	33.23	26.97	22.34	11.27	13.04

Source: Calculated by the author from the data of Ministry of Coal 2005-06
@ Includes Jute, Bricks, Colliery, and fertilizers coal for soft cake.

The table 3 reveals that the power sector is the largest growing consumer of the coal energy. The share of coal consumption is growing at a very faster pace *i.e.* it has increased from 18.54 percent in the year 1970-71 to 73.26 percent in the year 2005-06. The second largest consumer of coal is steel casting sector. However, the percentage share of coal consumption in this sector has starting falling from 14.48 percent in 1990-91 to 8.74 percent in the year 2005-06.The cement industry share in coal consumption has almost remain steady *i.e.* its consumption hovered around 4 to 5 percent. Interesting highlight in this analysis is that railway sector which was earlier consuming a major chunk of coal *i.e.* 21.87 percent in 1970-71 has almost stopped consuming coal from the year 2000-01. The sector has switched over to other sources of energy primarily diesel

and power. Paper, cotton and other consumers have also shown declining trend.

Table 4
Trends in Coal production, import and import dependency (Thousand Tones)

	1970-71	1975-76	1980-81	1985-86	1990-91	1995-96	2000-01	2005-06
Production	71240	92170	109320	155536	214987	284043	325440	432271
Imports	Nil	Nil	550	2030	4900	8870	20930	36869
Total	71240	92170	109870	15756	219887	292913	346378	469140
Import dependency	Nil	Nil	0.50%	1.28%	2.23%	3.03%	6.04%	7.85%

Source: Calculated by the author from the data of Ministry of Coal 2005-06

Table 4 clearly shows that import of coal commenced from the year 1980-81, in which 550 thousands tones of coal was imported. Secondly the imports of coal has grown many fold *i.e.* around 63 times in the year 2005-06 from 1980-81 onwards. No doubt, the production of coal has increased to 432271 thousand tones up to the year 2005-6 but at the same time the coal import dependency has also increased. Import dependency was 0.50 percent in the year 1980-81 but it has risen up to 7.8 percent in the year 2005-06.

However, the rising trend in coal production and import dependency also indicates that Indian economy has been passing through fast developing phase. The rising trend in coal production and import dependency is mainly due to rapid growth of the power sector, which is the largest consumer of coal as compared to other sectors of the economy.

Policy reforms and outlook of coal sector

Two committees, namely the Committee on Integrated Coal Policy (Chari Committee and Geetakrishnan Committee) was set up in the initial reform period (1996-2000) by government of India to give recommendation for improvement of this sector. Unfortunately, the recommendations remain only partially implemented. Coal price has been decontrolled but the restructuring is still being debated. Captive mining in India has been allowed in steel, cement and power sector (TERI 2005).

The current import policy has allowed the free import of coal under general license by consumers according to their requirements. An

overseas wing named as "Coal Videsh" has been formed to create an overseas reserve of high grade coking and non-coking coal.

The coal sector needs further deregulation to encourage greater competition. Further institutional reforms are needed in coal companies to improve efficiency and productivity. There is a need for adopting environmental friendly practices in coal mining. International mining practices through joint ventures need further encouragement. Grading and pricing of coal may be based on gross calorific value rather than the currently used "useful heat value".

Petroleum

Production of petroleum is also increasing significantly. Nearly 30 percent of India's energy needs have been met by oil, and more than 70 percent of that oil is imported. India is currently the world's eighth-greatest oil consuming country. (Planning Commission 2005).

Round about 76% of India's petroleum requirement is met through imports, which is a major factor of worry for the Indian economy. (Teddy 05-06). The gap between the production and consumption is increasing for which the economy has to take remedial measures. The petroleum sector has registered a 5% decline in its production in 2005-06 as compared to previous year.

In 2006 the total length and capacity of crude petroleum pipeline in India were about 3971 km and 28.5 MT, respectively, from various supply centers to demand centers. In a major move the aim of which is to enhance energy security of country, the government has been considering setting up strategic oil reserves for the past few years. It has been proposed to build a strategic reserve with a capacity of about 5MT at three locations in the country, namely Mangalore (1.5MT), Visakhapatnam (1.0MT), and Padur near Udipi (2.5MT). (Teddy 2005-06).

Table 5
Growth Rates of Production & Consumption of Petroleum from 1970-2005 (in "000 tones)

Year	Production (in thousand tones)	Growth rates of Production	Consumption (in thousand tones)	Growth rates of Consumption	Gap
1970	6822	-	18379	-	(11557)
1971	7299	6.992	20042	9.048	(12743)
1972	7321	0.301	19328	-3.562	(12007)
1973	7189	-1.803	20958	8.43	(13769)
1974	7684	6.85	21094	0.648	(13410)
1975	8448	9.942	22283	5.636	(13835)
1976	8898	5.326	22995	3.195	(14097)
1977	10763	20.959	24898	8.275	(14135)
1978	11633	8.083	25974	4.321	(14341)
1979	11766	1.143	27474	5.775	(15708)
1980	10507	-10.700	25836	-5.962	(15329)
1981	16194	54.125	30146	16.682	(13952)
1982	21063	30.066	33156	9.984	(12093)
1983	26020	23.534	35263	6.354	(9243)
1984	28990	11.414	35556	0.830	(6566)
1985	30168	4.063	42190	18.657	(12022)
1986	30480	1.034	45699	8.317	(15219)
1987	30357	-0.403	47754	4.496	(17397)
1988	32040	5.544	48803	2.196	(16763)
1989	34087	6.388	51942	6.43	(17855)
1990	33021	-3.127	51772	-0.327	(18751)
1991	30346	-8.100	51423	-0.674	(21077)
1992	26950	-11.190	53482	4.004	(26532)
1993	27026	0.282	54296	1.522	(27270)
1994	32239	19.28	56534	4.121	(24295)
1995	35167	9.082	58741	3.903	(23574)
1996	32900	-6.446	62870	7.029	(29970)
1997	33858	2.911	65166	3.651	(31308)
1998	32722	-3.355	68538	5.174	(35816)
1999	31949	-2.362	85964	25.425	(54015)
2000	32426	1.493	103444	20.334	(71018)
2001	32032	-1.215	107274	3.702	(75242)
2002	33044	3.159	112559	4.926	(79515)
2003	33373	0.995	121841	8.246	(88468)
2004	33981	1.821	127117	4.380	(93136)
2005	32190	-5.270	130109	2.353	(97919)
CAGR	-	1.051	-	1.057	

Sources: Ministry of Petroleum & Natural Gas, 2005-06

From the analysis of yearly growth rates of production and consumption of petroleum for the period 1970-2005, we can conclude that compound growth rate of petroleum production is 1.051 percent whereas the compound growth rate of petroleum consumption is 1.057 percent. Further analysis of the table reveals that maximum growth rate of petroleum production is in the year 1977 i.e., 20.959 percent and thereafter in the year 1994 i.e., 19.288 percent. The yearly growth rates of production of petroleum indicate many fluctuations. There is negative yearly growth of production of petroleum in around 11 years and the maximum negative growth is in the year 1992 *i.e.* -11.19 percent.

Similarly, the analysis of consumption side indicates that there are wide fluctuations in the yearly growth rates of consumption. The growth rates for the period 1970 to 2005 hovered around 0 percent to 25-percent. During the year 1972, 1980, 1990 and 1991 the growth rate shows negative trend i.e., -3.562, -5.962, -0.327, -0.674 respectively. Maximum yearly growth rate of consumption is in the year 1999 i.e., 25.425 percent whereas the minimum yearly growth of consumption rate is in the year 1980 when it becomes -5.962 percent. Consumption is higher than production for all the years of study period. Consumption-production gap has increased from 11557 thousand tones to 97919 thousand tones from 1970 to 2005.

ONGC (Oil and Natural Gas commission) had made 10 hydrocarbon discoveries. Oil India limited had made 5 discoveries and has successfully drilled the well in Makum in Tinsukla district of Assam.Cairn energy has made one of the biggest discovery in Rajasthan with an estimated reserve of 3.6 billion barrels of oil and other products (Ministry of Petroleum & Natural Gas, 2005).

Table 6
Trends in percentage share of petroleum products consumption sector wise from period 1970-2005(high and light diesel oil)

	90-91	2000-01	2005-06
Transportation	86.32	64.83	61.91
Plantation	1.54	18.62	17.28
Power Generation	1.50	6.94	6.33
Industry	10.24	9.41	8.40
Private sale	-	0.05	5.40

Source: Calculated by the author from the data of Ministry of Petroleum & Natural Gas, 2005-06

Table 6 reveals that largest consumer of petroleum product is transportation. However, the percentage share of consumption has fallen *i.e.* from 86.32 percent in 1990-91 to 61.91 percent in the year 2005-06. Contrary to this percentage share of petroleum products consumption has increased in the plantation sector from 1.54 percent in 1990-91 to 18.62 percent in 2000-01. In case of industry and power generation, the percentage share of petroleum products consumption has shown a declining trend.

Table 7

Trends in percentage share of petroleum products consumption sector wise from period 1970-2005(furnance and low sulphur oil)

	90-91	2000-01	2005-06
Transportation	4.87	2.80	2.08
Plantation	2.06	2.61	3.11
Power Generation	25.09	18.76	15.75
Industry	67.39	64.00	63.58
Private sale	-	11.35	14.84

Source: Calculated by the author from the data of Ministry of Petroleum & Natural Gas, 2005-06

Table 7 reveals that largest consumer of petroleum product is industry. However, the percentage share of consumption has fallen *i.e.* from 67.39 percent in 1990-91 to 63.58 percent in the year 2005-06. Contrary to this percentage share of petroleum products consumption has increased in the plantation sector from 2.06 percent in 1990-91 to 3.11 percent in 2005-06. In case of industry and power generation, the percentage share of petroleum products consumption has shown a declining trend.

Table 8

Trends in Petroleum production, import and import dependency (Thousand Tones)

	1970-71	1975-76	1980-81	1985-86	1990-91	1995-96	2001-01	2005-06
Production	6822	8448	10507	30168	33021	35167	32426	32190
Imports	11683	13683	16248	14616	20699	27342	74097	99409
Total	18505	22072	26755	44784	53720	62509	106523	131599
Import dependency	63.13%	61.72%	60.73%	32.63%	38.53%	43.74%	69.56%	75.54%

Source: Calculated by the author from the data of Ministry of Petroleum and Natural Gas 2005-06

The table 8 shows that in 1970's India is dependent on import of petroleum for more than its 60% requirements whereas after 1970's the import dependency shows a declining trend and in 1985's India is dependent on import of petroleum only for its 32.63 percent requirements. After ward, its import dependency again shows a rising trend that is mainly due to the rapid growth in industrial and domestic sector. The table shows that in 1970 the total requirement of petroleum is 18,505 thousand tones whereas in 2005 the requirement of petroleum has reached at 1, 31,599 thousand tones. The import dependency ratio was 69.56% in 2000-01 and 75.54% in 2005-06.

Another reason for higher imports is that since 1993, private investors have been allowed to import and market liquefied petroleum gas (LPG) and kerosene freely. However, to curtail import of petroleum products, the refining sector has been opened to private and foreign investors. Among the refineries expected to come in the next five years, the most significant is the export oriented RPL (Reliance Petroleum Limited) refinery with a capacity of 29 MTPA. In the 11th Five Year Plan, it is expected that another 85.99 MTPA of refining capacity will be added (Planning Commission 2006).

Regarding the improvements in fuel quality so as to make it eco-friendly the National Auto Fuel Policy 2003, provides the timeliness for introduction of Euro III and IV grade fuels across the entire country by 2010.

Gas

India's consumption of natural gas has risen faster than any other fuel in the recent years. Core sectors of the economy are shifting towards natural gas for their fuel requirements.

Approximately 70 percent of total natural gas is used for energy purposes whereas the remaining 30percent portion is used in fertilizer and petrochemical industries. (Teddy 2005).

India's natural gas consumption has been entirely met through domestic production in past. However, in the last 4-5 years there has been a lot unmet demand of natural gas in the country, which is mainly required for the core sectors of the economy. To bridge this

gap, apart from encouraging domestic production, the import of LNG (Liquid natural gas) is being considered as one of the possible solutions for India's expected gas shortages. Several LNG terminals are planned in the country. Two LNG terminals have already been commissioned (1) Petro net LNG terminal of 5MTPA (Million tones per annum) at Dahej and (2) LNG import terminal at Hazira. In addition, an agreement has been reached with Iran for import of 5MTPA of LNG. (MOPNG, 2005)

Use of natural gas as a domestic fuel is likely to increase further in the future period. Use of CNG (Compressed natural gas) is also expected to increase in future due to extensive use of the same in the transport sector.

In order to meet the existing short fall and the projected demand of natural gas in the country one of the option available is to import LNG (Liquefied natural gas). To encourage the use of LNG, it has been placed under Open General License (OGL) list and 100 percent foreign direct investments have been permitted.

Apart from LNG ((Liquefied natural gas), several cross border pipe lines have been proposed to fulfill the growing demand of natural gas. The countries of origin of these pipe lines are Iran, Myanmar, Bangladesh and Turkmenistan. The most talked about international pipe line is the 2600 kilometers overland pipeline connecting south parafield in Iran with the HBJ (Hazira-Bijapur-Jagdishpur) pipeline in India via Pakistan (MOPNG,2005)

In the case of domestic pipeline network, the infrastructure is limited and is present only in few regions of the country. GAIL is the sole company involved in lying down of pipelines.

There is a need to set up to a well-knit domestic natural gas pipeline network for the development of natural gas markets in the country.

It is suggested that further attractive terms should be offered to investors for the construction of liquefied natural gas (LNG) import facilities. Regarding gas pricing it is suggested that uniform method for determining gas process should be followed. So far, market determined and administered pricing co-exist in this sector.

Table 9
Growth Rates of Production & Consumption of natural gas from 1970-2005 (in million Cubic meters)

Year	Production (in million cubic meters)	Growth rates of Production	Consumption (in million cubic meters)	Growth rates of Consumption
1970	1445	-	647	-
1971	1535	6.228	718	10.973
1972	1565	1.954	771	7.381
1973	1713	9.456	762	-1.167
1974	2041	19.147	951	24.803
1975	2368	16.021	1126	18.401
1976	2428	2.533	1381	22.646
1977	2839	16.927	1464	6.010
1978	2812	-0.951	1711	16.871
1979	2767	-1.600	1681	-1.753
1980	2358	-14.781	1522	-9.458
1981	3851	27.316	2222	45.992
1982	4936	28.175	2957	33.078
1983	5961	20.765	3401	15.015
1984	7241	21.472	4141	21.758
1985	8134	12.332	4950	21.758
1986	9853	21.133	7075	42.929
1987	11467	16.380	7968	12.621
1988	13217	15.261	9250	16.089
1989	16988	28.531	11172	20.778
1990	17998	5.945	12766	14.267
1991	18645	3.594	14442	13.128
1992	18060	-3.137	16116	11.591
1993	18335	1.522	16340	1.389
1994	19468	6.179	17337	6.101
1995	22642	16.303	18091	4.349
1996	23256	2.711	18632	2.990
1997	26401	13.523	21513	15.462
1998	27428	3.890	22489	4.536
1999	28446	3.711	26885	19.547
2000	29477	3.624	27860	3.626
2001	29714	0.804	28037	0.635

2002	31389	5.637	29964	6.873
2003	31962	1.825	30906	3.143
2004	31763	-0.622	30775	-0.423
2005	32202	1.382	31325	1.787
CAGR		10.79		13.42

Sources: Ministry of Petroleum & Natural Gas, 2005-06

The table 9 reveals that compound annual growth rate of production of gas is 10.79 percent where as compound annual growth rate of consumption of gas is 13.42 percent that clearly indicates that consumption of gas is rising at a higher rate than its production.

The maximum yearly growth rate of the production of natural gas is in the year 1989 i.e; 28.531 percent. From the period 1980 to 1987, the growth rate of production of natural gas has many fluctuations i.e; growth rate hovered around 15 percent to 28 percent approximately. The yearly growth rates of production of natural gas are negative in the years 1978, 1979, 1980 and 1992 when these are -0.951 percent, -1.600 percent, -14.781 percent and -3.137 percent respectively.

The maximum yearly growth rate of consumption of natural gas is in the year 1986 and minimum is in the year 1980 when these are 42.929 percent and -9.458 percent respectively. However, the consumption pattern of yearly growth rates of natural gas again shows very wide fluctuations in consumption pattern.

Electricity

It is a fact that India's need for power is growing at an exponential rate. India is currently ranked sixth in the world in terms of total installed electricity generating capacity and accounts for about 3.3 percent of the world total. About three quarters of India's generating capacity is thermal-electric power plants, while slightly less than one quarter is hydroelectric, about 2 percent is nuclear and the remaining 1 percent is non-hydro renewable. (Planning Commission 2005).

The total installed capacity under the utilities in India increased to 124287.17 MW (megawatts) in 2006 from 118425.70 MW in 2005. The overall electricity generation in country, which was 513 BU in

2001-02 has risen 617 BU in 2005-06 at rate of 4.7 percent. (CEA 2006).

Amongst all regions, the western region had the maximum installed capacity of captive power plants (1 MW and above) to the tune of 6214.93 MW followed by the southern region (5339.13MW), Northern region (3603.23 MW), Eastern region (3598.11 MW) and north-eastern region (347.15MW) during 2004-05 (CEA 2006).

Table 10
Growth Rates of Production & Consumption of electricity from 1970-2005 (in gigawat per hours)

Year	Production (in gigawat hours)	Growth rates of Production	Consumption (in gigawat hours)	Growth rates of Consumption	Gap
1970	53031	-	43724	-	9307
1971	57925	9.228	47073	7.659	10852
1972	61326	5.871	49088	4.28	12238
1973	63189	3.037	50246	2.359	12943
1974	66199	4.763	52632	4.748	13567
1975	74796	12.986	60246	14.466	14550
1976	83087	11.084	66639	10.616	16448
1977	85818	3.286	69255	3.925	16563
1978	96703	12.683	77293	11.606	19410
1979	98200	1.548	78084	1.023	20116
1980	103734	5.635	82367	5.485	21367
1981	113928	9.827	90245	9.564	23683
1982	121305	6.475	95589	5.921	25716
1983	130122	7.268	102344	7.066	27778
1984	145393	11.735	114068	11.455	31325
1985	157300	8.189	123099	7.917	34201
1986	173325	10.187	135952	10.441	37373
1987	187873	8.393	145613	7.106	42260
1988	205942	9.617	160196	10.014	45746
1989	228784	11.091	175419	0.502	53365
1990	246941	7.936	190357	8.815	56584
1991	269136	8.987	207645	9.081	61491
1992	282384	4.922	220674	6.274	61710
1993	303681	7.541	238569	8.109	65112
1994	329255	8.421	259629	8.827	69626
1995	356441	8.256	277029	6.701	79412
1996	371395	4.195	280146	1.125	91249
1997	394989	6.352	296749	5.926	98240
1998	421479	6.706	309734	4.375	111745
1999	453205	7.527	312841	1.003	140364

2000	471868	4.118	316600	1.201	155268
2001	488802	3.588	322459	1.85	166343
2002	502656	2.834	339598	5.315	163058
2003	535031	6.44	360937	6.283	174094
2004	561709	4.986	386134	6.98	175575
2005	590172	5.067	415299	7.553	174873
CAGR		7.54		7.00	

Source: Central Electricity Authority 2005-06

Table 10 gives yearly and compound annual growth rates or production and consumption of electricity during 1970-2005. The above table reveals the growth rate of production of electricity in maximum in the 1975 *i.e.* 12.96 percent and the minimum growth rate in the same sector is in the year 1979 *i.e.* 1.54 percent. On the consumption side under the study period, (1970-2005) all the yearly growth rates are positive. The maximum growth is in the year 1975 *i.e.* 14.466 percent and minimum in the year 1999 when it is only 1.003 percent.

The overall compound average growth rate n production and consumption of electricity is 7.54 and 7.00 percent respectively. The gap between production and consumption in electricity as shown in table is due to the transmission and distribution losses and theft in electricity by certain sectors.

Table 11
Trends in percentage share of electricity consumption sector wise from period 1970-2005

Sectors	1970-71	1980-81	1990-91	2000-01	2005-06
Industry	67.64%	58.36%	44.24%	33.99%	35.89%
Domestic	8.78%	11.22%	16.80%	23.88%	24.89%
Agriculture	10.23%	17.59%	26.43%	26.76%	23.04%
Commercial	5.88%	5.68%	5.87%	7.12%	8.37%
Transport	3.12%	2.75%	2.16%	2.59%	2.51%
Others	4.34%	4.39%	4.49%	5.64%	5.29%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Calculated by the author from the data of Central Electricity Authority 2005-06

Analysis of table 11 shows that the major portion of electricity has been consumed by industry and domestic sector. Industry and domestic sector have dominance over the other sectors. However, the

share of industry sector shows declining trend, its share for the year 1970-71 was 67.64%, which declined to 35.89 % in 2005-06. The share of consumption in agriculture sector shows increasing trend. Its share has risen from 10.23% in 1970-71 to 23.04% in 2005-06. Again, transport sector is showing a declining trend. Commercial sector is showing an increasing trend in consumption of electricity sector. The consumption share of domestic sector has increased from 8.78 percent in 1970-71 to 23.88 percent in 2000-01 and further to 24.89 percent in 2005.

Table 12

Trends in Electricity production, import and import dependency (Giga watt-hours)

	1970-71	1975-76	1980-81	1985-86	1990-91	1995-96	2001-01	2005-06
Production	52965	74675	103164	157193	244725	352657	466272	580841
Imports	66	121	120	107	2216	3786	559	9331
Total	53031	74796	103734	157300	246941	365441	471868	590172
Import dependency	0.12%	0.16%	0.11%	0.07%	0.089%	1.06%	0.187%	0.158%

Source: Calculated by the author from the data of Central Electricity Authority, 2005-06.

Table 12 shows that from the period of 1970-1985 the import dependency of India for electricity was very negligible. It slightly increased during 1990-91 to 1995-96, but declined again afterwards. During the period 1970-71 the requirement of electricity is 53,031 giga watt hours which has increased to 5,90,172 giga watt hours in 2005-06..

The power sector needs are mainly met through power sector linkages with Bhutan and Nepal. In Bhutan, power from the Chukha Hydro Electric Project is being supported to India through a 220 KV DC line as well as a separate 220 KV lines from Chukha to Bispasa. Power from the Kurichhu Hydro Electric Power Project is being supplied in India through 132 KV Geylegphug-Salaskali line (CEA, 2006).

Recent development and reforms in the power sector

In compliance with the provisions of National Electricity Act 2003, the national tariff policy has been announced by central government. Broadly the aim of this policy is to attract investment, promote

competition and efficiency, ensure electricity to consumers at reasonable rates and promote transparency and consistency in regulatory framework.

The electricity regulatory commission legislation has been enacted. The Central Electricity Regulatory Commission (CERC) was setup with the main objective of regulating the central power generation units. Private investment in power generation has also been allowed. The government has also enacted Electricity Act 2003, which seeks to bring about a qualitative transformation of the electricity sector. The central government has recently issued the Rural Electrification Policy in August 2006.The code for energy conservation should be made mandatory. The guidelines and the code suggested by Bureau of Energy Efficiency should be implemented. More efforts should be made for exchange of electric power from its neighbouring countries for supply of surplus power. Adequate consistent quality coal supply to thermal power sector should be ensured. Efforts that are more consistent are needed to control the transmission and distribution losses.

Table 13
Linear Trend: Total period from 1970-71 to 2005-06

Equ. No.	Dependent variable	Regression Coff.	R^2	Adj R^2	CAGR
1	Coal Prod.	10237.13 (33.93)	.97	.97	5.35
2	Coal Cons.	10048.707 (32.412)	.96	.96	5.45
3	Pet. Pro.	906.59 (11.35)	.79	.78	1.05
4	Pet. Con.	2928.859 (14.396)	.85	.85	1.05
5	Gas Pro.	1046.20 (25.92)	.95	.95	10.79
6	Gas Con.	1000.037 (20.65)	.92	.92	13.42
7	Elec. Pro.	15640.90(23.94)	.94	.94	7.54
8	Elec. Con.	10701.191 (28.579)	.96	.95	7.00

Source : Calculated by the author from the data of Ministry of Coal, Ministry of Petroleum & Natural Gas & Central Electricity Authority

Using the regression technique we have computed linear trend of variables like (1) Coal production (2) Coal consumption (3) Petroleum production (4) Petroleum consumption (5) Natural gas production (6) Natural gas consumption (7) Electricity production (8) Electricity consumption for the period from 1970 to 2005. The

results of linear trend are presented in the table in their respective equations. It can observed from the table that adjusted R^2 explains 98 percent variation in total primary energy production, 79 percent variation in petroleum production, 95 percent variation in gas production, 95 percent variation in electricity production and 97 percent variation in coal production due to the time a factor.

From the table 13 it is evident that 't' ratios of all variables during the period of study are significant. It is also found that the annual consumption growth rate in coal, petroleum, gas and electricity is always higher as compared to compound annual production growth rate in the same sectors of energy.

The entire period of study reveals that India continue to experience an energy supply shortfall. The gap has widened in the major energy sector. Rising oil demand and India's inability to raise oil production has led to major dependence of oil import from the middle east. There is a need of diversification of sources of oil imports. The oil prices fluctuations necessitates measures to reduce oil dependency by taking suitable measures to reduce demand and by developing alternatives to oil such as biofuel, natural gas and renewable energy. The import of gas and LNG (Liquefied Natural Gas) are likely to increase in the coming years. The import energy dependency implies vulnerability to external price shocks and supply disturbances, which threaten the energy security of the country. Urgent need of the nation is to reduce its dependency on the imported energy sources so that better energy security environment is created.

Some of the strategies that can be used to meet future challenges to this energy security are :

- Development of energy efficiency and conservation code.
- Building stockpiles of different energy sources.
- Diversification of energy supply sources.
- Effective measure for demand restraint.
- Development of fuel switching strategies.
- Shifting to less energy intensive modes of transport such as better design of vehicle, use of CNG, bio and synthetic fuel.
- The measures to increase the use of renewable sources *i.e.* solar, wind, biomass and nuclear.
- Reducing subsides on oil products and power tariffs.

- Encouraging private sector participation in power generation and reduce transmission and distribution losses.

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