

Table 1: Socio-economic Indicator for Selected Countries (2008)

Country	Population (Million)	GDP (at 2000 USD ppp)/Capita	Total Primary Energy Supply (kgoe)/Capita	Electricity Consumption (kWh)/Capita
India	1139.97	724.4	540	566
China	1325.64	1963.3	1600	2453
Japan	127.69	40459.5	3880	8072
Germany	82.12	25513.6	4080	7148
US	304.53	38558.7	7500	13647
Sri Lanka	20.16	1198.9	440	409

Source: IEA, 2010, Key World Energy Statistics, pp. 48-57

Table 2: Per Capita GSDP and Electricity Consumption in the States and Country (2006/07)

State	Electricity (kWh)/Capita	GSDP (Rs)/Capita	State	Electricity (kWh)/Capita	GSDP (Rs)/Capita
Andhra Pradesh	802	30485	Manipur	195	18746
Arunachal Pradesh	299	20601	Meghalaya	547	30660
Assam	175	21607	Mizoram	250	24680
Bihar	91	9600	Nagaland	173	26863
Jharkhand	659	23361	Orissa	665	19407
Goa	2098	92010	Punjab	1506	42984
Gujarat	1331	50282	Rajasthan	591	21979
Haryana	1208	47613	Sikkim	533	28307
Himachal Pradesh	872	42391	Tamil Nadu	1080	48468
J & K	759	24625	Tripura	179	20628
Karnataka	806	35818	Uttar Pradesh	341	16756
Kerala	441	37372	Uttaranchal	707	30362
Madhya Pradesh	582	19650	West Bengal	397	29440
Chhatisgarh	935	24921	Delhi	1417	76087
Maharashtra	975	44634	India	672	31605

Source: TEDDY 2010 and Wikipedia

All of the energy sources that we use, except geothermal and nuclear energies, are derived initially from solar energy.

The fossil fuels (coal, oil, and natural gas) are derived from organisms (primarily ocean plankton) that grew over several hundreds of millions of years, storing the solar energy which reached the earth's surface. Renewable energies (hydro, biomass, and wind) are also directly or indirectly derived from the energy of our sun. Solar energy, though technically not renewable, is normally classified as such because it is effectively inexhaustible on any practical timescale. Nuclear energy is derived from uranium nuclei contained in the earth. This element was formed in heavy stars and was scattered in space when those stars died. Uranium nuclei were present in the dust from which the solar system was formed about 4.5 billion years ago. The earth formed

by accretion of such dust and some thermal energy due to this process still remains. However, most of the thermal energy contained in the earth comes from the decay of radio-active nuclei present in the earth and initially produced in stars (Ngo and Natowitz, 2009).

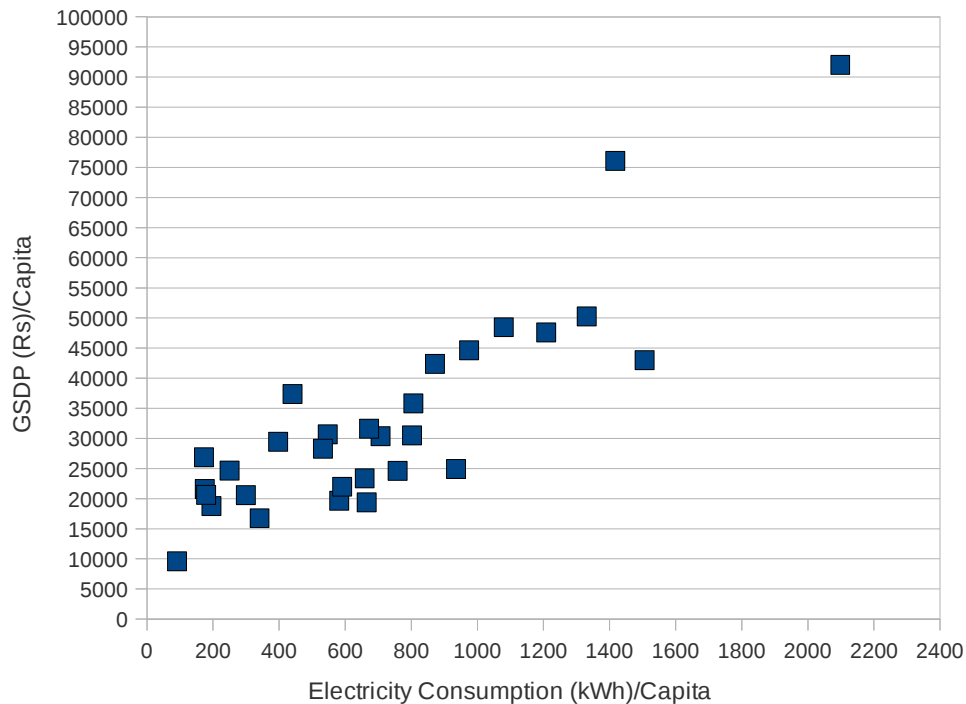


Figure 1: Per Capita Electricity Consumption and GSDP in the States and Country (2006/07)

Energy used can be broadly divided into commercial and non-commercial form. Commercial energy, i.e. traded in the market, includes coal, oil, gas, electricity and in some cases biomass. Non-commercial energy includes mostly biomass that is used for cooking, predominantly by the rural communities. Accurate and more recent data on non-commercial energy use in the country is not available. In 2000, India's energy mix was 65% commercial and 35% non-commercial (TEDDY 2010, pp 2). Considering the stage of transformation, energy can also be classified as primary (coal, crude oil, natural gas, water, geothermal, wind, solar heat, biomass, etc.), secondary (steam, chilled water, petrol, diesel, biogas, hydro-electricity, solar electricity, etc.) and tertiary type (electricity). Primary energy sources are those that present prior to any human-induced modification. Higher energy sources are obtained from the transformation of lower sources.

Higher form of energy has advantages of cleanliness, ease of operation and control, and obviously expensive. A number of political, economic, social, technological, legal and ecological factors play a critical role in ensuring access to and use of right quantity and quality of energy by the people.

According to the Dy Chairman, Planning Commission (2006), the present energy scenario in India is not satisfactory.

The power supply position prevailing in the country is characterised by persistent shortages and unreliability and also high prices for industrial consumer. There is also concern about the position regarding petroleum products. We depend to the extent of 70 percent on imported oil, and this naturally raises issues about energy security. These concerns have been exacerbated by recent movements in international oil prices. Electricity is domestically produced but its supply depends upon availability of coal, exploitation of hydro power sources and the scope for expanding nuclear power, and there are constraints affecting each source.

In this paper an attempt has been made to study the energy scene of the country in the context of ensuring energy security and sustainable development of the people. In the next section, available energy resources of the country is presented. In Section 3, energy used by different sectors is discussed. In Section 4, the supply and demand side problems of energy are covered and possible strategies for energy security are suggested. Last section provides some concluding remarks.

2. Energy Resources of India

India has all the possible sources of energy. These include all forms of non-renewable and renewable energy sources. However, the energy sources are not uniformly distributed. Table 3 indicates the energy sources in major locations of the country.

According to BP Statistical Review of World Energy, India has the third largest proven coal reserves totaling 58600 million Ton, and the country's reserve-to-production ratio (R/P) is 105. In 2008/09, the coal and lignite production in the country was 525 million Ton (TEDDY 2010, pp 4-5).

The total oil reserve in the country was estimated to be 786 million Ton in 2004-05. The proven reserve-to-production ratio was 23 in 2004-05 (Planning Commission 2006). In 2009-10 the crude oil production was 33.67 million Ton (TEDDY 2010, pp 86). In 2009-10, 79% of the country's consumption was imported. The crude oil import bill amounting to Rs 3753 billion in 2009/10 put a huge burden on the economy.

Table 3: Key Location of Energy Sources

Energy Source	Key location	Remark
Coal	Jharkhand, Odisha, Chhatisgarh, West Bengal, Andhra Pradesh, Madhya Pradesh, Maharashtra	Jharkhand, Odisha and Chhatisgarh constitute 69% of total reserve as on 1 April 2010
Oil	Onshore: Assam, Nagaland, Gujarat, Rajasthan Offshore: Andhra Pradesh, Tamil Nadu, Bombay High	94% of onshore production from the four states in 2009-10.
Gas	Assam, Nagaland, Gujarat, Andhra Pradesh, Tamil Nadu, Rajasthan, Tripura	89% of gas production from Assam, Nagaland, Gujarat, Andhra Pradesh, Tamil Nadu
Hydro-electricity	All the regions of India	76% identified capacity in North-eastern and Northern region
Electricity (hydro and thermal)	All the regions of India	Thermal power plants are concentrated in coal rich states
Uranium and Thorium	Uranium in Jharkhand and Rajasthan Thorium in coastal Odisha, Kerala, Andhra Pradesh and Tamil Nadu	
Wind Energy	Karnataka, Gujarat, Tamil Nadu, Rajasthan, Maharashtra, Kerala, Madhya Pradesh, Andhra Pradesh, Odisha, West Bengal	77% of gross potential in Karnataka, Gujarat, Tamil Nadu, Rajasthan and Maharashtra
Biomass Energy	All the regions of India	
Solar Energy	All the regions of India	More prominent in Rajasthan desert because of cheap land availability
Geothermal Energy	Chhatisgarh, Jammu and Kashmir, Madhya Pradesh	
Biogas Energy	All the regions of India	

Source: TEDDY 2010

According to the 2008 BP Statistical Energy Survey, in 2007, India had proven natural gas reserves of 1.05 trillion cubic meters, 0.59% of the world total (mbendi, 2010). In 2009-10 the natural gas production was 47.57 BCM (TEDDY 2010, pp 89). The proven reserve-to-production ratio is 22. Based on the discoveries made in recent years, the possibility of having large gas reserve in the sedimentary basins of the country appears to be high.

The estimated deposits of uranium and thorium in the country are respectively 70,000 Ton and 360,000 Ton. Since available uranium is of poor quality (0.06 to 0.07% of the ore) the reactors are designed to take advantage of large thorium deposits. The country has a plan to develop 20000 MW of nuclear capacity by 2020 and 63000 MW by 2032. It is expected that by 2050, 25% of electricity will be coming from nuclear power plants (TEDDY 2010, pp 122).

India has large potential for renewable energy exploitation. However, there is a wide gap between the potential and actual utilisation (Table 4). Technological constraints, high cost of production, weak institution and policy measures are coming in the way of large scale use of renewable energy.

Table 4: Renewable Energy Potential and Actual Achievement

Renewable Energy	Potential	Actual Installed Capacity (as on 31 March 2010)
Wind Power	45,195 MW	11, 807 MW
Bio-power and Bagasse Based Co-generation Power Project	21,881 MW	2,199 MW
Large Hydro Power (>25 MW)	1,48,701 MW	32,128 MW (Developed) 14,225 MW (Under Construction)
Small Hydro Power	15,000 MW	2,735 MW
Solid and Liquid Waste from Urban Areas	2,700 MW	12 MW
Biogas	12 million	4.2 million
Solar Water Heating	140 million m ²	3.53 million m ²
Solar PV System	50 MW/km ²	120 MW
Ocean Thermal Energy Conversion (OTEC)	300,000 MW	-
Wave Energy	40,000 MW	-
Tidal Energy	8,000 MW	-

Source: TEDDY 2010, pp 177, 188-190, 308

As on 30th June 2011, the country has a total installed electricity generating capacity of 176,990 MW, besides a grid connected captive capacity of 19,509 MW. Out of it, 115,650 MW is thermal (96,743 of coal fired, 17,706 MW of gas fired and 1200 MW of oil fired) power plants. Balance is contributed by nuclear (4780 MW), hydro-electric (38,106 MW) and renewable energy sources (18,455 MW) including small hydro, biomass gasifiers, urban and industrial waste power and solar. Based on the sources of primary energy for electricity production, the installed capacity mix of coal, hydro, gas, diesel, nuclear and renewable energy are 55%, 21.5%, 10%, 0.7%, 2.7% and 10% respectively (CEA, 2011).

Out of total generation of 766 Billion Units (BU) in 2009-10, the generation mix of thermal, hydro and nuclear sources were respectively 640.5 BU (84%), 106.6 BU (14%) and 18.6 BU (2%). The supply constrained demand of electricity had an energy deficit of 9.9% and peak power deficit of 12.6% in 2009/10 in the country. The state-wise electric energy and electric power deficit during 2008/09 are shown in Figure 2 and Table 5 (TEDDY 2010, pp 167-170).

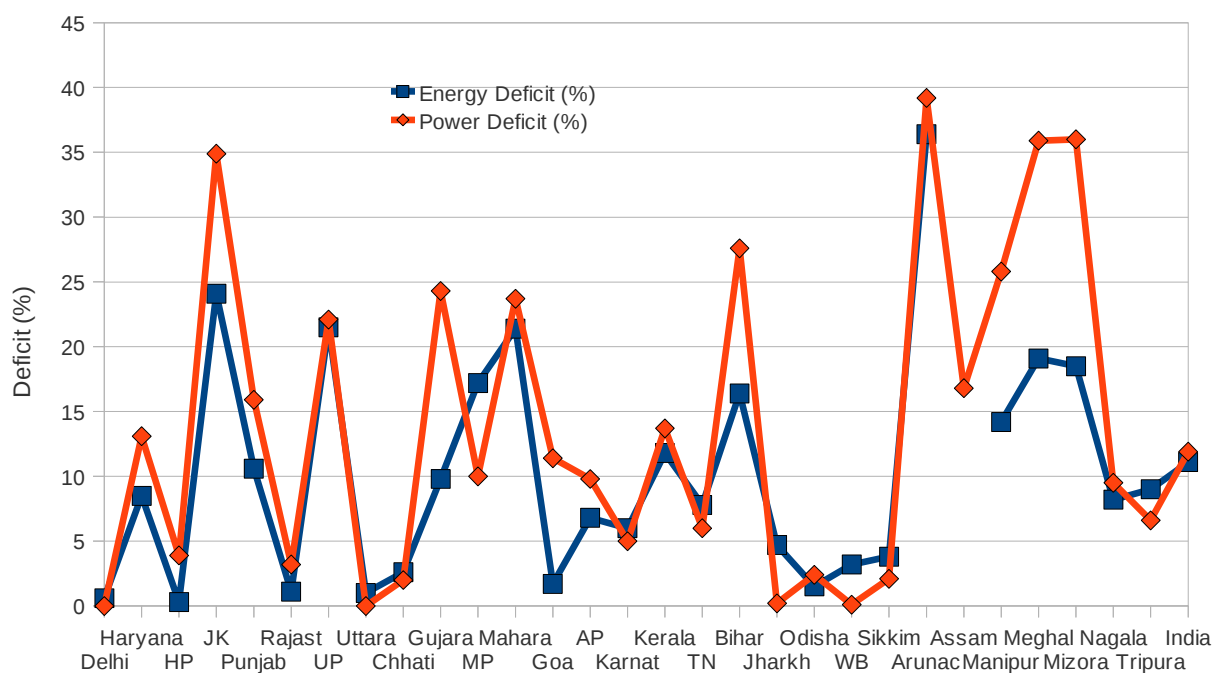


Figure 2: Percentage Electric Power and Energy Deficit in 2008/09

Table 5: Electricity Supply Position in Different States (2008/09)

State	Peak Demand (MW)	Power Deficit (%)	Energy Available (MU)	Energy Deficit (%)
Delhi	4036	0	22273	0.6
Haryana	5511	13.1	26625	8.5
Himachal Pradesh	1055	3.9	6241	0.3
JK	2120	34.9	8698	24.1
Punjab	8690	15.9	37238	10.6
Rajasthan	6303	3.2	37388	1.1
Utar Pradesh	10587	22.1	54309	21.5
Uttarakhand	1267	0	7765	1
Chhatisgarh	2887	2	14475	2.6
Gujarat	11841	24.3	60851	9.8
Madhya Pradesh	7564	10	34841	17.2
Maharashtra	18049	23.7	95761	21.4
Goa	466	11.4	2754	1.7
Andhra Pradesh	11083	9.8	66673	6.8
Karnataka	6892	5	40578	6
Kerala	3188	13.7	15562	11.8
Tamil Nadu	9799	6	64208	7.8
Bihar	1842	27.6	8801	16.4
Jharkhand	889	0.2	5110	4.7
Odisha	3062	2.4	20214	1.5
West Bengal	5387	0.1	30290	3.2
Sikkim	97	2.1	330	3.8
Arunachal Pradesh	130	39.2	271	36.4
Assam	958	16.8		
Manipur	128	25.8	477	14.2
Meghalaya	457	35.9	1386	19.1
Mizoram	100	36	269	18.5
Nagaland	95	9.5	436	8.2
Tripura	167	6.6	728	9
India	109809	11.9	691042	11.1

Source: TEDDY 2010, pp 167-170

3. Energy Use

The total commercial energy use in India in 2007/08 was 272.4 MTOE. Energy use in industry, transport, residential and commercial, agriculture, other energy use and non-energy use (fertiliser, petrochemical, etc.) were respectively 47%, 15%, 14%, 7%, 8% and 9% (TEDDY 2010, pp 3). In 2008, India's energy intensity of 0.14 kgoe/USD PPP is lower than that of China (0.2 kgoe/USD PPP) and US (0.19/USD PPP) (IEA, 2010).

The commercial energy consumption in India is highly dependent on coal. It contributes to about 53% in 2008-09. In the same year, the contribution of oil and gas were respectively 33% and 8%. Balance is from nuclear, hydro and other renewable energy sources.

492.8 MT of coal and 32.4 MT of lignite were produced in India in 2008-09. In the same year, 37.9 million Ton of non-cooking coal and 21.08 MT of cooking coal were imported from Australia, Indonesia and South Africa. Simultaneously, India exported 1.7MT of coal to Bangladesh, Bhutan and Nepal. About 78% of coal is consumed by power sector. Balance is used mostly by cement (4%) and steel plants (18%).

156 MT of oil was consumed in the country in 2007-08. 75% of oil consumption was imported which accounted for 23.4% of total import bill and 6.3% of GDP of the country. Bulk of it is used in the transport sector.

32 billion cubic meter (BCM) of gas was consumed in the country in 2008-09. Out of it 65% was used for power generation. 24.3% of total gas consumed in the country is imported.

501,977.09 GWh of electricity was sold in the country with a connected load of 3,50,056 MW among 17,27,03,600 consumers in 2007-08 (Table 6, Figure 3). In December 2010, the per capita electricity consumption in the country stood at 612 kWh (Wikipedia).

Table 6: Characteristics of Electricity Use in India (2007-08)

Consumer Segment	Electricity Consumed (%)	Connected Load (%)	Number of Consumers (%)
Domestic	24.1	38.3	77.2
Commercial	9.3	10.9	10.4
Industrial	37.7	27.7	2.2
Public Lighting	1.2	0.8	0.8
Traction	2.2	1.1	1.1
Agriculture	20.8	18.9	9.2
Public Works	2.3	1.2	1.2
Miscellaneous	2.3	1.1	1.1

Source: TEDDY 2010, pp 163-164

As on 31 March 2008, out of 593732 villages in the country, 82.3% villages have been electrified. Similarly as on 31 November 2008, out of 138,271,559 rural households in the country, 44% of them are electrified (Table 7 and Figure 4) (TEDDY 2010, pp 174-176).

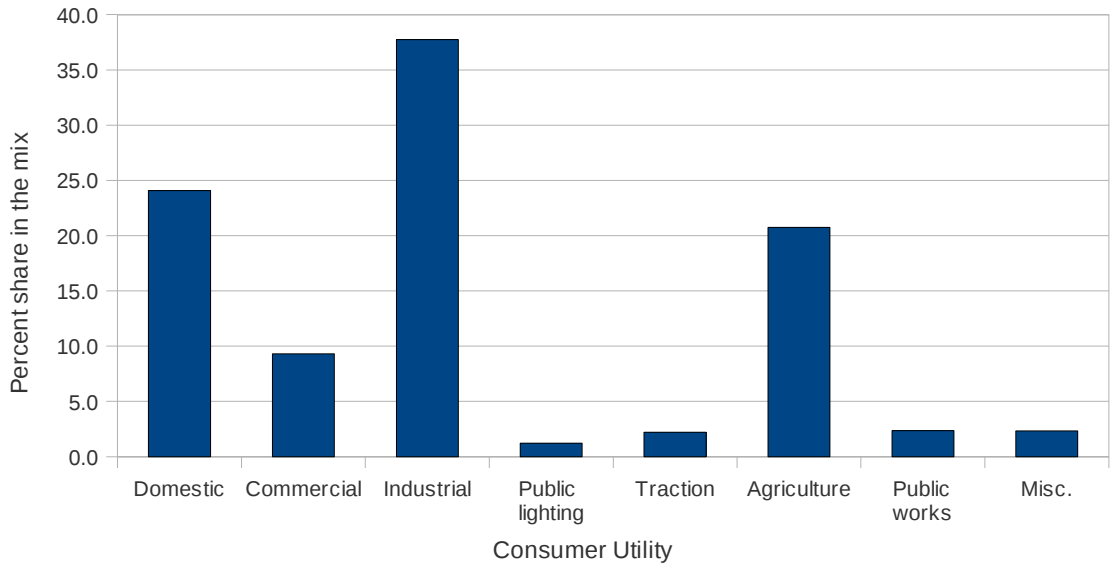


Figure 3: Electricity Sales to Ultimate Consumer Utilities (2007-08)

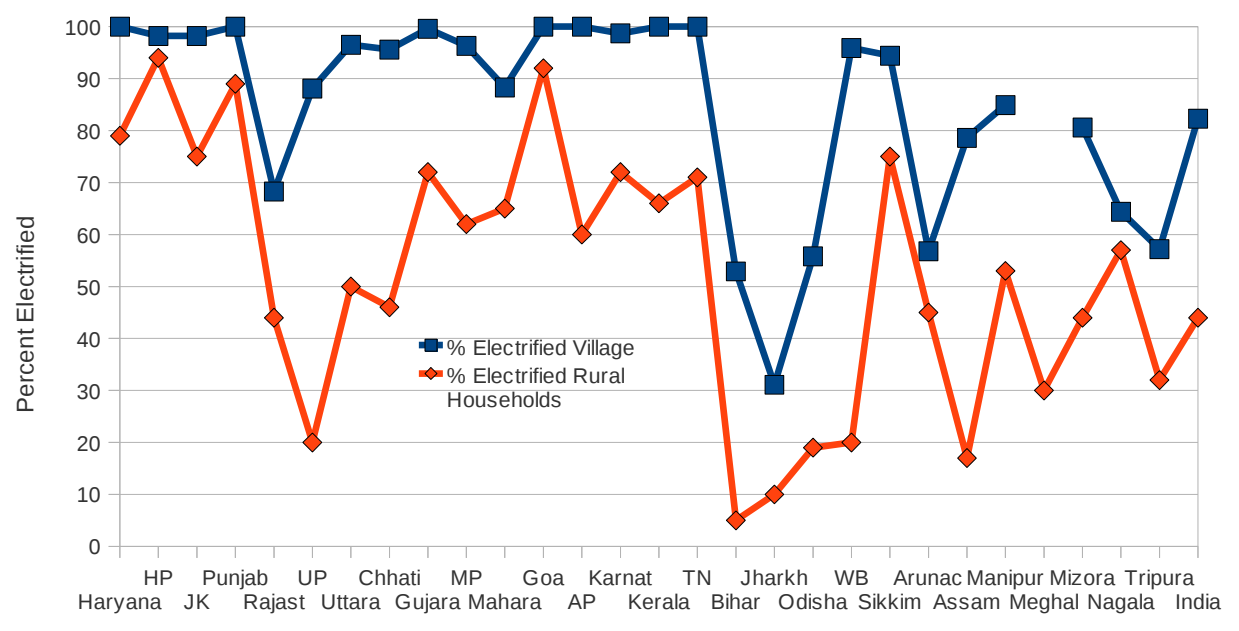


Figure 4: Extent of Village and Rural Household Electrified

Table 7: Extent of Village and Rural Household Electrified (March 2008)

State	% Electrified Village	% Electrified Rural Households	State	% Electrified Village	% Electrified Rural Households
Haryana	100	79	Kerala	100	66
Himachal Pradesh	98.2	94	Tamil Nadu	100	71
J&K	98.2	75	Bihar	52.9	5
Punjab	100	89	Jharkhand	31.1	10
Rajasthan	68.3	44	Odisha	55.8	19
Utar Pradesh	88.1	20	West Bengal	95.9	20
Uttarakhand	96.5	50	Sikkim	94.4	75
Chhatisgarh	95.6	46	Arunachal Pradesh	56.8	45
Gujarat	99.6	72	Assam	78.6	17
MP	96.3	62	Manipur	84.9	53
Maharashtra	88.3	65	Meghalaya		30
Goa	100	92	Mizoram	80.6	44
Andhra Pradesh	100	60	Nagaland	64.4	57
Karnataka	98.7	72	Tripura	57.2	32
			India	82.3	44

Source: TEDDY 2010, pp 174-176

4. Supply and Demand Side Factors of Energy Management in India

The per capita energy consumption in India in 2006 was 510 kgoe against 5416 kgoe for high income countries (World Bank, 2009). Energy consumption in India has been continuously increasing over the years. There is a large gap between actual demand and supply-constrained demand for energy in the country. A host of supply side and demand side factors influence the energy sector.

A. Supply-side Factors

Reliable and adequate supply of both commercial and non-commercial energy at an affordable price is a complex issue. It is difficult to develop appropriate supply-side strategies in the absence of reliable data, which often is the case for non-commercial energy. An analysis of factors affecting non-commercial energy cannot be neglected, since it constitutes a significant part of our energy mix. Although, no reliable recent data is available, against a commercial energy consumption of 191.6 MTOE in 2000-01 in the country; the non-commercial energy consumption was 80 MTOE in domestic sector and 23.5 MTOE in unorganised, small and cottage industries.

The commercial energy sector in India is highly dependent on fossil fuels. In 2007-08, about 89% of total primary energy supply is contributed by coal, oil and gas.

Although India has large coal reserve, it is faced with poor quality (high ash content and low calorific value), inefficient and expensive mining, environmental restrictions and poor labour relation. The environmental