South Asia NGO Capacity Building for Poverty Reducing Sustainable Energy Solutions Project

ENERGY FOR SUSTAINABLE DEVELOPMENT

Report On Energy Overview in India with Emphasises on Energy Security

INDIA

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CHAPTER-1

BACKGROUND

India, with a population of slightly more than one billion people living in 25 states, is the second most populous country in the world, behind China. At a growth rate of 1.6% per annum, the country's population is projected to grow to 1.16 billion by the year 2010. India has a land area of 2,973,190 square kilometers, or slightly more than one third that of the United States, and is bordered by Pakistan to the west, Bhutan, China, and Nepal to the north, Bangladesh to the east, and the Indian Ocean to the south.

The Indian economy uses a variety of energy sources, both commercial and non-commercial. Fuel wood, animal waste and agricultural residue are the traditional or `non-commercial' sources of energy that continue to meet the bulk of the rural energy requirements even today. However, the share of these fuels in the primary energy supply has declined from over 70% in the early 50's to a little over 30% as of today. The traditional fuels are gradually getting replaced by the "commercial fuels" such as coal, lignite, petroleum products, natural gas and electricity.

At the time of Independence, the country had a very poor infrastructure in terms of energy production and supply. The per capita consumption of energy was abysmally low and the access to energy was very inadequate for the common people. The economy was dependent largely on the non-commercial sources of energy for meeting the requirements of the households and on animal and human energy in case of agriculture and transport. During the 50 years that followed Independence, the demand for energy, particularly for commercial energy, registered a high rate of growth contributed largely by the changes in the demographic structure brought about through rapid urbanization, need for socio-economic development and the need for attaining and sustaining self reliance in different sectors of the economy.

Over the years, the high rate of growth of energy demand could be sustained primarily through increased dependence on commercial energy sources such as coal, oil, natural gas and electricity. However, the energy supply system that has developed over the years has tended to depend more and more on non-renewable energy resources, the availability of which is severely limited. Moreover, development of some of these energy resources is beset with serious environmental implications. To some extent, subsidized prices of certain forms of energy also led to end-use inefficiencies and, therefore, an increase in the gross energy demand. All these factors have raised questions about the long-term sustainability of such an energy supply system. Moreover, with the rapid increase in demand for petroleum products, the country has become a heavy importer of oil. The present trends indicate that in the absence of adequate measures of demand management, the country may have to resort to import of other forms of energy as well and this has raised issues of long-term energy security of the country.

CHAPTER-2

ENERGY SUMMARY AND PRESENT RESOURCES

THE PRIMARY ENERGY RESOURCE ENDOWMENT

India is not endowed with large primary energy reserves in keeping with her large geographical area, growing population and increasing final energy needs. The energy scene in India is very different from developed countries and is a complex picture of various sources of energy meeting a variety of demands, presenting a formidable problem in analysis. India annually consumes about three percent of the world's total energy. The country is the world's sixth largest energy consumer, and is in fact a net energy importer. India's year 2000 energy consumption by fuel is shown in Table 1and Renewable energy potential in Table 2.

Table 1: India's Energy Consumption by Fuel (Year 2000)

Fuel	Usage (PJ)
Coal	7,048
Petroleum	4,347
Natural Gas	950
Hydroelectric	834
Nuclear	179
Non-Hydro Renewables	11
Total	13,368

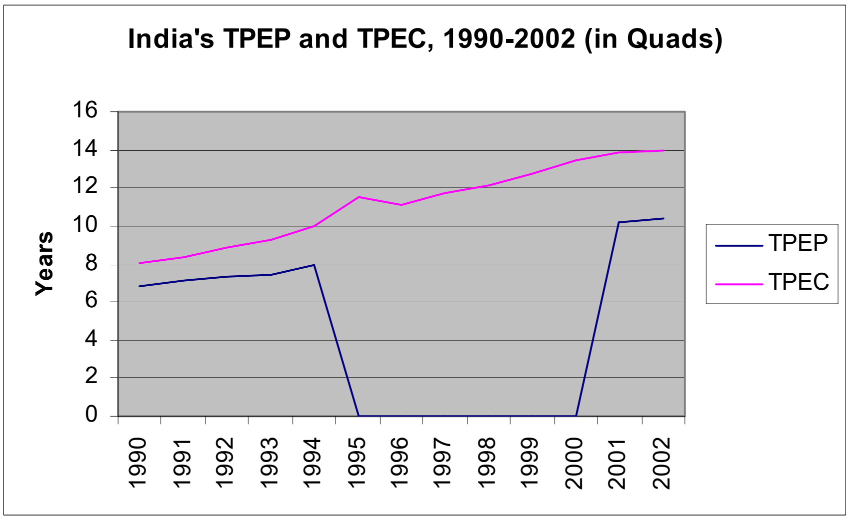
Source: DOE/EIA

As far as non-commercial or traditional sources are concerned, fuel-wood is the major source. The present estimate of fuel-wood use in the household sector is around $160x10^6$ tonnes and accounts for 65% of the total non-commercial energy use in the households. The annual availability of wet dung is estimated at $960x10^6$ tonnes. The consumption of dung cakes is presently estimated at $80x10^6$ tonnes on an annual basis. The annual yield of crop residues is placed at around $370x10^6$ tonnes of which nearly $45x10^6$ tonnes are used in the household sector.

PRESENT STATUS OF DEVELOPMENT OF ENERGY RESOURCES

An historical summary of India's Total Primary Energy Production (TPEP) and Consumption is shown in chart- (see annex 1).

Despite increases in energy use in India, consumption on a per capita basis is still low in relation to other countries. In 2000, India's per capita consumption was just above 13.3 GJ against a world average of 69 GJ and a U.S. average of 370 GJ.



Total primary energy production and consumption, draft, error in TPEP

OIL

Exploration and Reserve

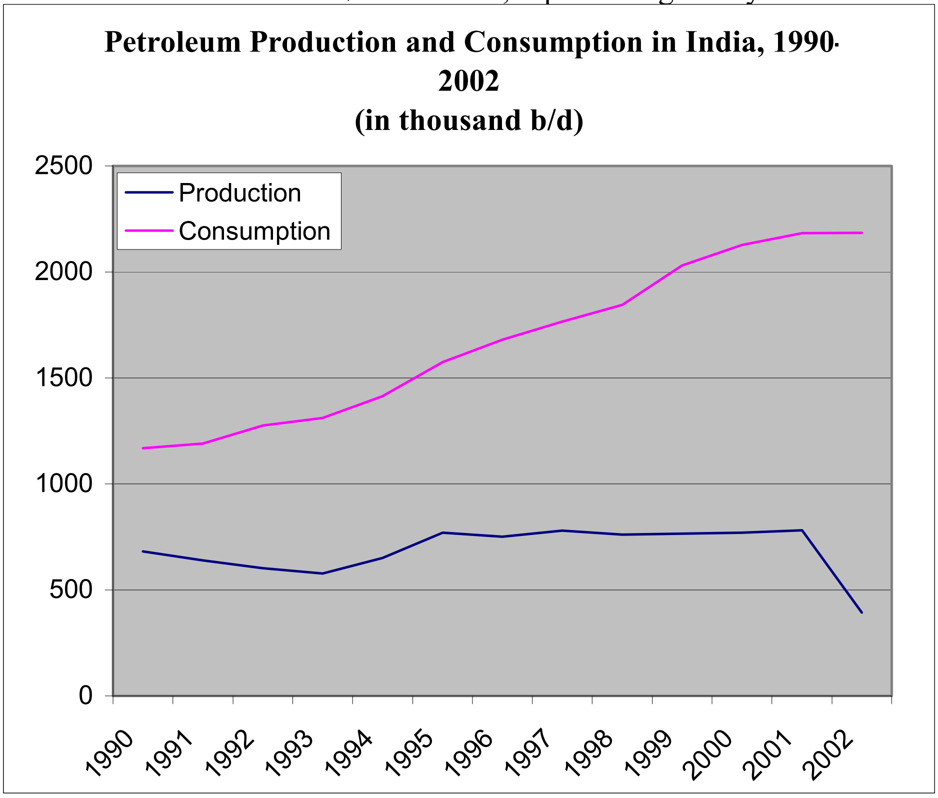
India's crude oil reserves are currently estimated at 4.7 billion barrels. However, India has not yet been thoroughly examined for possible oil deposits, as exploration has taken place in only about one-quarter of India's 26 sedimentary basins. Offshore basins cover approximately 380,000 square kilometers, while onshore basins cover 1.34 million square kilometers. These basins may contain as much as 30 billion tons of hydrocarbon reserves.

Wary of a growing reliance on imported oil, the government announced the New Exploration Licensing Policy (NELP) in 1997, which opened the door to involvement by foreign energy companies. Prior to this policy, exploration was strictly limited to Indian enterprises. Foreign firms were initially hesitant to bid on oil exploration rights, and as a result no bids were received from foreign energy companies till 1999. However, by early 2000 India had awarded 25 oil exploration blocks. The government of India forecasts that oil reserves will be depleted by 2012 under present consumption and production patterns. It is hoped that increased exploration and enhanced recovery practices will extend India's reserves. However, some experts take the position that India's easy-to-reach reserves have already been tapped.

Production and Consumption

Nearly 30% of India's energy needs are met by oil, and more than 60% of that oil is imported. Given strong growth in oil demand, oil consumption is projected to climb to 3.1 million barrels per day (b/d) by 2010. The Indian government is encouraging increased production of petroleum to reduce its dependence on imported oil.

The cost of oil imports in 2001 was estimated at $11.5 billion, representing nearly one-fifth of total imports. It is expected that by 2010 almost three-quarters of India's oil and gas needs will be met by imports. (see annex 2).



NATURAL GAS

Exploration and Reserves

India's natural gas reserves are currently estimated at 22.9 trillion cubic feet (tcf). The area northwest of Mumbai in the Arabian Sea, 110-200 kilometers off the coast, is India's major natural gas producing region; the Bombay High, Heera, Panna, South Bassein, Neelam, Bombay L-II, and Bombay L-III fields are in this area. The region is also rich in crude oil.

There are additional gas off the east coast, in the Bay of Bengal, which includes the Krishna-Godavari and Kaveri Basins. The Krishna-Godavari Basin is home to the Ravva Field while the Kaveri Basin contains the PY-1, PY-3, and KH-3 fields. These, combined, account for less than five percent of India's production of natural gas, however. An area off the Andaman and Nicobar Islands, also in the Bay of Bengal, has shown promise for holding what could be the country's largest reserves of coal bed methane.

Production and Consumption

Natural gas has experienced the fastest rate of increase of any fuel in India's primary energy supply. It now supplies about 7% of India's energy, with that share expected to double by 2020. Natural gas demand is growing at about 6.5% per year and is forecast to rise to 1.3 tcf (1360 PJ) per year by 2005 and 1.8 tcf (1900 PJ) per year by 2010.

Power generation, fertilizers, and petrochemicals production are industries that have been turning to natural gas as an energy feedstock. Natural gas will become a bigger part of the energy picture for India, primarily as a way to reduce dependence on foreign oil. The environmental benefits of its absence of sulfur dioxide and reduced levels of carbon dioxide and nitrogen oxide (compared to coal) are also appealing to a country increasingly struggling with environmental concerns. India's natural gas consumption is currently met entirely with domestic production. However, demand for natural gas likely will soon outstrip the country's ability to produce it. India will have to begin importing natural gas within a few years to supply new gas-fired power plants proposed by its government. (see annex 3)

COAL

Reserves and Mining

India's has huge coal reserves, about 7% of the world's total; at the current level of production and consumption, India's coal reserves would last nearly three centuries. Overall, hard coal resources total almost 214 billion tonnes as of January 2001. Of this amount, 84 billion tonnes are proven recoverable reserves of anthracite and bituminous coal, with another 28 billion tonnes of lignite reserves. A summary of India's coal reserves is shown in Table5.

Table 5: India's Coal Reserves as of January 2001 (in millions metric tonnes)

Coal Type	Proven	Indicated	Inferred	Total
Coking	14931	11557	1231	27720
prime coking	3279	634	n/a	4821
medium coking	10307	10103	1030	21330
blendable/semi-coking	437	820	201	1459
Non-Coking	61728	69660	34818	166205
Total	76659	81217	36049	193925

n/a - not applicable
note: components may not add to total due to rounding
Source: India Ministry of Coal

India's coal deposits occur mostly in the east central part of the country. A map with the locations of these reserves is shown in Figure 1.

Production and Consumption

India is the third largest coal-producing country in the world behind China and the United States and accounts for about 7.5% of the world's annual coal production. India is also the world's third-greatest coal consuming country, again behind China and the United States, and accounts for about 8% of the world's annual coal consumption.

Nearly three quarters of India's electricity and two-thirds of its commercial energy comes from coal. In all, India depends on coal for more than half of its total energy needs, and the demand for coal has been steadily increasing over the past decade.

Even though India is able to satisfy most of its country's coal demand through domestic production, less than 5% of its reserves are coking coal used by the steel industry. As a result, India's steel industry imports coking coal, mainly from Australia & New Zealand to meet about 25% of its annual needs- (see annex 4).

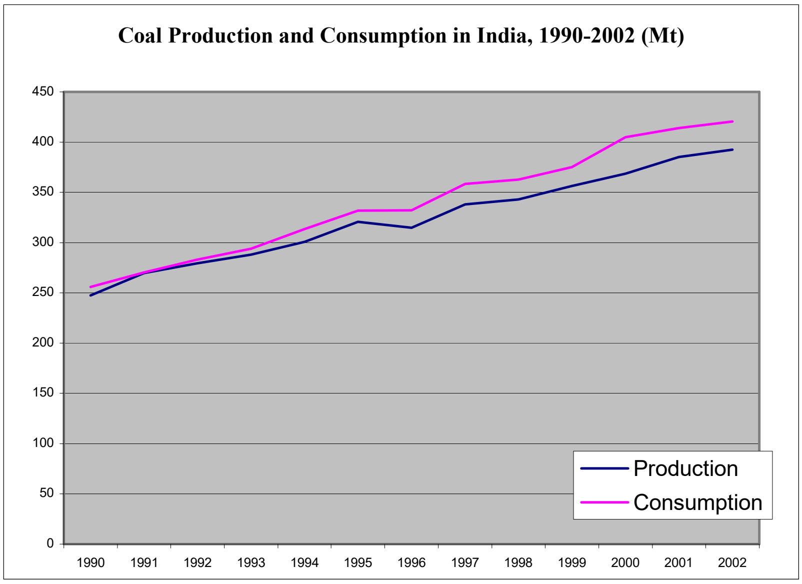


Figure 1: India's Coal Reserves

Source: DOE/EIA

NUCLEAR

The Atomic Energy Commission oversees India's nuclear power industry. India has 14 nuclear reactors in operation at six facilities with a combined generating capacity of 2,720 MWe, all operated by the government-owned Nuclear Power Corp. of India Ltd. (NPCIL), which is run as an independent company under the Atomic Energy Commission. NPCIL wants to boost capacity to 7,300 MWe by 2007, and by 2020 the goal is to have 20,000 MWe worth of capacity online, representing 7-10% of total electricity generating capacity. A summary of India's nuclear power plants is shown in Table 7.

Table 7: Operating Nuclear Power Plants in India (as of October 2002)

Power Plant	**Owner**	**Location**		**No. of Units**	**Total Capacity (MWe)**
		City	**State**		
Rajasthan	NPCIL	Rawatbhata	Rajasthan	4	740
Kaiga	NPCIL	Kaiga	Karnataka	2	440
Kakrapar	NPCIL	Kakrapar	Gujarat	2	440
Narora	NPCIL	Narora	Uttar Pradesh	2	440
Madras	NPCIL	Madras	Tamil Nadu	2	340
Tarapur	NPCIL	Tarapur	Maharashtra	2	320

Source: NPCIL

The outlook is improving for India's nuclear power industry. India has sufficient uranium reserves (currently about 34,000 tonnes, though only 44% are economically exploitable) for its nuclear energy programme. The average capacity factor for India's nuclear power plants has been trending upwards during the past several years and now stands at about 85%. In 1999, NPCIL declared it’s first-ever dividend (profits are returned to the Indian government), but the nuclear industry still is heavily reliant on government funding. Government spending on new projects for the current five-year plan (1997-2002), at $193.5 million, is five times the level during the previous five-year plans.

HYDROELECTRIC AND OTHER RENEWABLE ENERGY

Hydroelectric sources, by far, are the predominant source of new renewable energy in India. India's 10th five-year plan, which runs through 2007, calls for 10% of all new electric generating capacity to come from renewable energy sources, and almost all of this will be hydroelectric. Of the other forms of renewable energy, wind and biomass are the most likely to have any significant input to India's power generating mix. The Indian Renewable Energy Development Agency (IREDA), which is a part of the Ministry of Non-Conventional Energy Sources (MNES), oversees development of these non-hydro renewable energy sources.

Hydroelectric Power

There are twenty river basins, major and minor, in India. The largest of these, in terms of area, is that of India's largest and longest river, the Ganges (known in India as the Ganga) and its major tributary the Yamuna.

India has vast hydroelectric resources. Some estimates place the hydroelectric potential as much as 150,000 MWe, with another 90,000 MWe possible for pumped storage capacity. About one-fifth of India's total electricity generation now comes from hydroelectric power plants.

In addition to these Indian government-owned entities, many of the state-owned SEBs also own electricity-generating assets. The largest of these is the Andhra Pradesh SEB, whose hydroelectric assets are nearly equal in total capacity to those of BBMB. Other SEBs with large amounts of hydroelectric capacity are Tamil Nadu, Kerala, and Maharashtra, whose Koyna facility is presently the largest hydroelectric power plant in India.

There is a huge amount of additional hydroelectric generating capacity that could come online in about the next ten years; at least 30 projects of more than 100 MWe are in the construction stage and many more than that are in various stages of planning. In particular, the Narmada River and its tributaries are undergoing rapid development; the Narmada Valley Development Plan envisions 30 large dams, more than 100 medium-size dams, and about 3,000 small dams. If all of these are built, the river system would in effect be transformed into a series of lakes. The largest of these are the Sardar Sarovar and Indira Sagar (also known as the Narmada Sagar) hydroelectric facilities, both currently nearing completions.

India is also actively pursuing smaller hydroelectric power generation opportunities. More than 1,400 MWe of generating capacity is now online that consists of hydroelectric facilities of 25 MWe and less, with about another 500 MWe in construction stages.

Solar Power

Most parts of India get 300 days of sunshine a year, which makes the country a very promising place for solar energy utilization. So far, photovoltaic (PV) generation has been limited to very small installations, but throughout the country there are more than 750,000 of them, generating a total of about 58 MWe. Most of these are stand-alone installations, for applications such as pumping water for irrigation, but there are 17 grid-interactive PV installations that supply a total of about 1.4 MWe to the electricity grid during daylight hours. PV is thought to have promise in isolated rural areas, where access to electricity via power lines is not available.

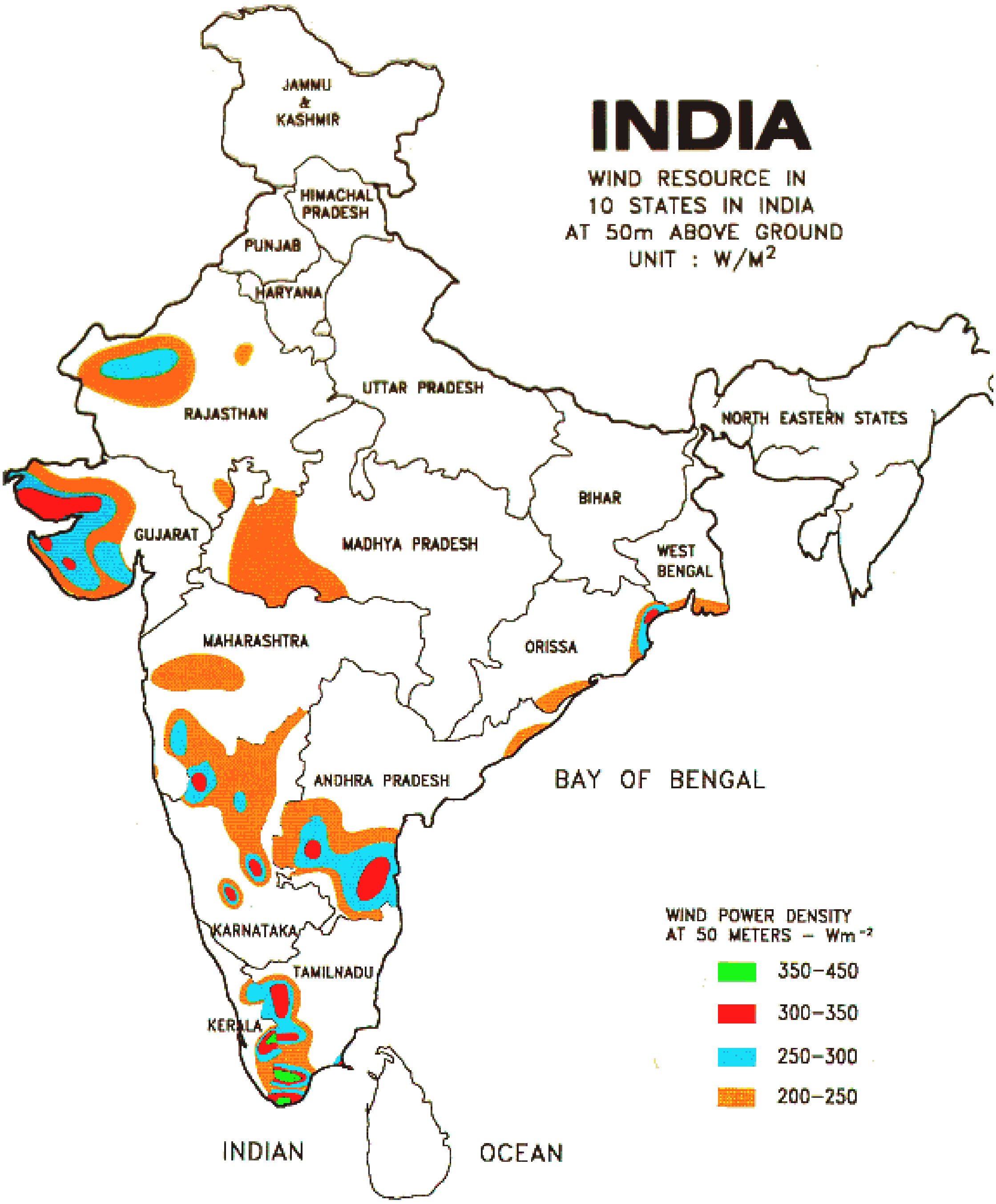
The Indian government is also promoting direct use of solar energy, in the form of solar water heaters and solar cookers. The cookers are large parabolic reflector-based systems that are meant to meet the needs of small, isolated communities, but so far they have not found widespread acceptance. Solar water heaters are doing better, and have seen use at hotels, hospitals, textile mills and other industries, and dairies. There has also been some use in individual residences. Nearly 500,000 square meters of conventional solar flat plate collectors are now in use throughout India.

Wind Power

India has abundant wind resources to harness for power generation. Strong seasonal winds blow across the Indian subcontinent April through September. The Ministry of Non-Conventional Energy Sources (MNES) has estimated that the gross wind power potential of India is about 45,000 MWe and has identified more than 200 sites suitable for wind power facilities. Southern India in particular has excellent wind resources, with the states of Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Madhya Pradesh, Maharashtra, and Rajasthan having the highest potential. A map of India's Wind Resources is shown in Figure 3.

India ranks fourth in the world in the global wind power makret; in 2005 was installed 1430 MWe of windpower in India, bringing the total capacity above MWe. Almost all of the capacity located in the southern half of the country. India's wind power generation is mostly not yet making use of the most modern large-scale technology; wind power farms in India are made up of smaller units.

Figure 3: India's Wind Resources

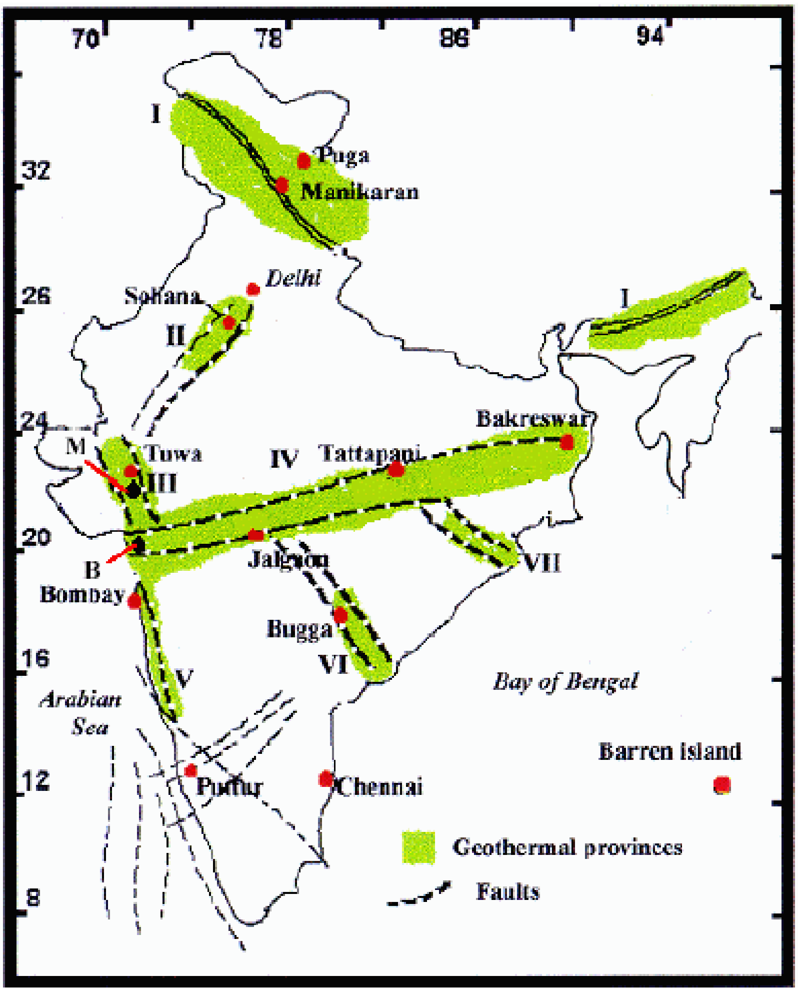


Source: Ministry of Non-Conventional Energy Sources (MNES)

Geothermal Power

There are seven main geothermal regions in India, which contain a total of about 400 thermal springs. The major geothermal area is the Son-Narmada-Tapi (SONATA) rift zone, which follows the Narmada river valley from Gujarat into Madhya Pradesh, and then continues into eastern India. An additional place of interest is Barren Island in the Andaman Islands, which has the only active volcano on the Indian subcontinent. A map of India's geothermal regions is shown in Figure 4.

Figure4: Geothermal Regions of India



KEY: I - Himalaya; II - Sohana; III - Cambay; IV - SONATA; V - West Coast;
VI - Godavari; VII - Mahanadi; M - Mehmadabad; B – Billimora
Source: Indian Institute of Technology

The state of Gujarat seems to be the hub for geothermal activities in India. The Gujarat state government passed a resolution theoretically aimed at creating incentives for geothermal and other forms of renewable energy, but any actual effect has been minimal and there remain significant financial barriers. Despite this, there are some geothermal pioneers. Geothermal energy in India is at present mostly being used for direct heating applications such as heating of bathing pools and drying of agricultural produce. For power generating purposes, the overall geothermal potential of India is about 10,000 MWe. The Geological Survey of India (GSI) has developed an atlas identifying more than 300 potential sites for generating power.

Biomass

The Ministry of Non-Conventional Energy Sources (MNES) estimates India's electricity potential from biomass at nearly 20,000 MWe, with 16,000 MWe from biomass and 3,500 MWe from cogeneration (i.e., combined heat and power) plants using bagasse from sugar mills. About 40 cogeneration projects capable of generating 280 MWe and 30 biomass projects capable of generating 140 MWe have been commissioned. Nearly 500 MWe of additional generating capacity is under construction.

Besides its use for power generation, biomass is also a large component of the energy mix in poor households. These include firewood, agricultural residues and cow dung, and are used mainly for heating and cooking.

CHAPTER-3

CURRENT ENERGY SCENARIO

(A) COMMERCIAL SOURCES OF ENERGY:

The GDP and energy consumption for the country are growing at about 6% during the last 20 years and the trend is expected to continue. The energy- GDP elasticty, which was about 1.6 in the decade 1950-60 has currently stabilized around unity. Infact, according to the estimates by the 10th plan, the elasticity for primary commercial energy, for the period 1990-2000 was less than unity. Furthermore, the per capita energy consumption is two and a half times lower as compared to China and 5 times lower as compared to the world average. Thus to catch up with the world, the per capita energy consumption in India should grow at a faster pace than the world average[1]

India's commercial energy consumption is indeed growing faster than world commercial energy consumption. India is the sixth largest consumer of commercial energy in the world. The country's energy consumption has grown at 4.9% (CAGR) over the period 1990-2000 vis-à-vis world energy consumption growth of 1% (CAGR) over the same period. Growth of the economy has been the principal driver of energy consumption[2]. Average GDP growth during FY99-FY04 was about 6% with average commercial energy consumption growth during the period FY 00 –FY04 was about 4 %.

The world primary energy mix is dominated by oil & gas, but India's commercial primary energy mix is dominated by coal, owing to coal's availability in abundance at a lower cost, relative to the other energy sources. However, gas, owing to its non-polluting nature and ease of use as compared to oil, is expected to gain significance and have a larger share in the energy mix. Presently coal (including lignite) and oil account for 48% and 47% respectively in the commercial energy mix. India's current import dependence stands at around 19% of the total primary energy consumption[3]. Energy imports largely consists of oil imports as India imports 70% of crude oil requirements (about 16% of total energy consumption). The total oil import bill in FY03 was about US$ 17.6 billion[4], accounting for about 28.6% of the country's total imports. In the recent years, the country has been largely importing crude oil, as it has become more or less self-sufficient in refined oil products owing to substantial

(1) [1] Hydrocarbon Vision 2025

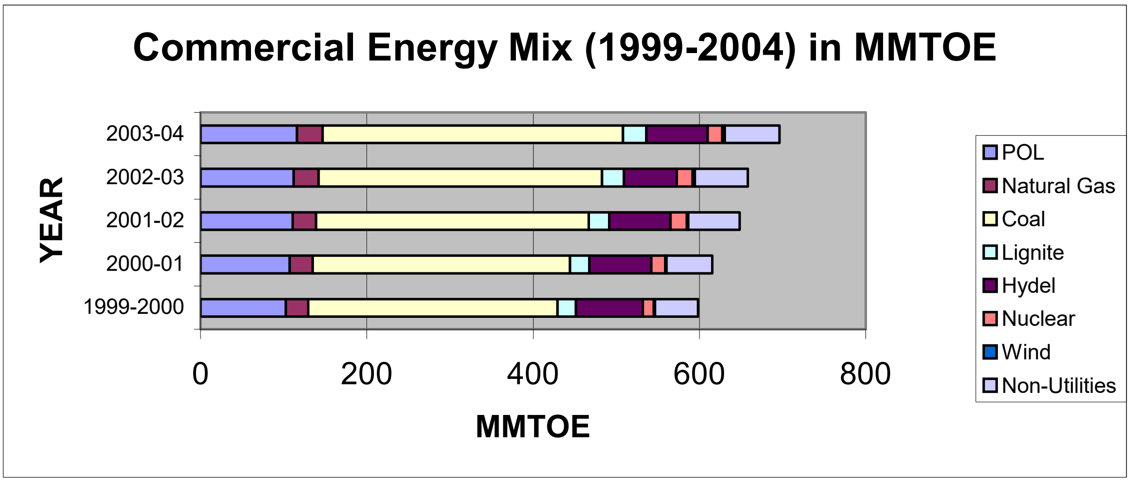
(2) [2] figures to be confirmed

(3) [3] Steering Committee report on Energy the 10 th FYP

(4) [4] Economic Survey, 2003-04,GOI

increase in domestic refining capacity. The share of imported primary energy in total energy is likely to increase.

Commercial Energy Mix (1999-2004):



DRAFT. Source: MoPNG, MNES, 1 Mtoe = 41.86 PJ

As India ranks sixth in the world in terms of energy demand accounting for 3.5 per cent of world commercial energy demand in 2001. With a gross domestic product (GDP) growth of 8 per cent set for the Tenth Five-Year Plan, the energy demand is expected to grow at 5.2 per cent. Although, the commercial energy consumption has grown rapidly over the last two decades, a large part of India's population does not have access to it. At 12 GJ, the per capita energy consumption is also low even compared to some of the developing countries. The Tenth Plan strategy for the sector includes increasing the production of coal and electricity, accelerated exploration for hydrocarbons, equity oil abroad, introduction of reforms through restructuring/deregulation of the energy sector to increase efficiency, demand management through introduction of energy efficient technologies/processes and appliances. In order to have an integrated energy, approach and to meet the policy goals of economic efficiency, energy security, energy access and environment, the establishment of institutional links and coordinating mechanisms has been proposed.

(B) NON-COMMERCIAL ENERGY RESOURCES

More than 60 per cent of Indian households depend on traditional sources of energy like fuel wood, dung and crop residues for meeting their cooking and heating needs. Out of the total rural energy consumption, about 65 per cent is met from fuel wood. Fuel wood consumption during 2001-02 is estimated at 223 million tonnes (TENTH FIVE YEAR PLAN 2002-07) of which 180 million tonnes is for household consumption and the balance for cottage industry, big hotels etc. The consumption of animal dung and agro-waste is estimated at 130 million tonnes, which does not include the wet (fresh or green) dung used for biogas plants. It is assumed that the wet dung used as manure is being diverted to biogas plants as these plants, in addition to providing cleaner fuel, also supply enriched organic manure.

Even though there has been an impressive increase in the availability of the two petroleum based domestic fuels- liquefied petroleum gas (LPG) and kerosene (SKO), they do not appear to have made any significant dent in the pattern of fuel consumption in the rural areas. To some extent, the biogas programme has made progress in rural areas and about 3.2 million plants had already been installed by August 2001. The National Council for Applied Economic Research (NCAER), Delhi, estimated the likely availability of gas from these plants during 2001-02 at 1,360 million cubic meters. The renewable energy potential in India is shown in the table 5:

Table-5 RENEWABLE ENERGY POTENTIAL

New and Renewable Sources of Energy-Potential and Achievement as on 31.3.2004

Source/Technology	Potential	Achievement
Biogas Plants	120 lakh (12 million)	36.50 lakh (3.65 million)
Improved Chulhas	1,200 lakh (120 million)	339 lakh (33.9 million)
Wind	45,000 MW	2,483MW
Small hydro	15,00MW	1,603 MW
Biomass power/Cogeneration	19,500 MW	613MW
Biomass Gasifies		58MW
Solar PV	20 MW/sq.km	151MWp*
Waste to Energy	170 mill. sq.m for landfill gas	41.50MWe
Solar Water Heating	140 mill. sq.m Collector Area	0.8 mill m2 sq.m Collector Area

*of this 75MWp SPV products have been exported but the estimates regarding the energy mix for the last five years are given below for the commercial sources of energy in figure 5 & 6 changed over a period of time.

Whereas the commercial energy mix for the last ten years as given table 6 shows increasing trend for the use of Pol products as estimated for the last five years also shows our high dependency on the imports of Pol products for meeting the energy needs of the country.

India is highly dependent on coal, lignite and oil and gas, which account for 95 per cent of commercial energy Mix. Coal and Lignite form 48 per cent whereas Oil and Gas account for 47 percent of total commercial energy mix.

The planners and policy makers of the Indian economy in recent years have envisaged a faster growth rate of the economy in the years to come, which might in turn result in a higher growth in consumption of petroleum products. The high rate of economic growth is likely to be accompanied by an increasing per capita income and changes in life styles. This will also affect the energy demand. In view of the rising awareness of environment protection and conservation, the future growth in the energy sector must consider such concerns and develop in an environment friendly manner. At the same time, the overall energy intensity of the economy is expected to continue to decline on account of progressive substitution of primary non-commercial energy sources by the more efficient commercial energy sources and adoption of more efficient technologies, etc. The key issues facing a developing country such as India which have energy implications are, therefore, rising population, need for economic growth, access to adequate commercial energy supplies, the financial resources need to achieve this, rational energy policies regime, improvements in energy efficiency of both the energy supply and consumption, technological upgrading, a matching R & D base and environment protection. The factors driving energy demand upwards are economic growth accompanied by growth in urban and rural population. In addition, there may be the following factors that affect the demand:

- Price of Oil Products
- Environment considerations
- Increase in efficiency of use

The population of the country is likely to exceed 1315×10^6 by the end of the year 2019-20. Based on the present trends available in the rate of urbanization, the share of urban population is projected to increase from 25.38% in 1990-91 to 43% in the year 2020. The growth in GDP and its structural changes will have an effect on the demand for energy and the energy supply mix in future. The high rate of economic growth is likely to be accompanied by an increasing per capita income and changes in life styles. This will have an effect on the energy demand as well.

According to the planning commission the projected requirement of commercial energy is estimated at about 412 Mtoe (17,700 PJ) and 554 Mtoe (23,700 PJ) in the terminal years of the Tenth and Eleventh Plans respectively. Based on the inputs of various working groups, the commercial energy demand during the Tenth Plan and Eleventh Plan is estimated to grow at an average rate of 6.6 per cent and 6.1 per cent respectively. **Table 8** indicates the estimated energy demand in the terminal years of the Tenth and Eleventh Plans. However, the demand may be less by 5 per cent and 10 per cent during 2006- 07 and 2011-12 respectively due to increasing use of information technology (IT) and prevalence of e-commerce, which will mainly affect the demand of energy in transport sector.

Table 8: Estimated Energy Demand*As per planning commission estimates:

Primary Fuel Unit Demand (in Original Units) and demand in (Mtoe)

Primary Fuel Unit		**Demand (in Original Units)**		**Demand (Mtoe)**	
		2006-07	**2011-12**	**2006-07**	**2011-12**
Coal	mt	460.50	620.00	190.00	254.93
Lignite	mt	57. 79	81.54	15.51	22.05
Oil	mt	134.50	172.47	144.58	185.40
Natural gas	BCM	47.45	64.00	42.70	57.60
Hydro Power	BKwh	148.08	215.66	12.73	18.54
Nuclear Power	BKwh	23.15	54.74	6.04	14.16
Wind Power	BKwh	4.00	11.62	0.35	1.00
Total Commercial Energy				411. 91	553.68
Non-Commercial Energy				151 .30	170.25
Total Energy Demand				563.21	723.93

mt : Million Tonnes; BCM : Billion Cubic Meter; Bkwh : Billion kilo watt hour

CHAPTER-4

ENERGY SECURITY AND GROWING IMPORT DEPENDENCY OF INDIA

Energy consumption in India is expected to have more than doubled by 2020 to meet development aspirations. Like many other developing countries, India also is a net importer of energy. 70 per cent of crude requirements are being met through import primarily from the Middle East. The import of crude oil is estimated to increase from the present level of about 85 Mt per annum (PA) to 151 Mt p.a. during the tenth plan period. The demand for gas is also growing at a faster rate. Due to geo-political tensions oil prices are highly volatile. The inelasticity of oil demand and the rising oil import bill has been the focus of serious concern due to the pressure it places on scarce foreign exchange resources and also because it is largely responsible for energy supply shortages. During the first oil embargo, India's import bill rose by over 50 per cent, while the adverse impact of the 1990-91 Gulf War, which caused a huge Balance of Payment (BOP) deficit, pushing up the inflation to an all-time high of 13 per cent, resulting in to slowing down the economic growth of India.

In one set of projections for future energy supply in India estimates is given in Table 11.

Table 11: Primary energy supply: baseline scenario (PJ)

	1990	2000	2010	2020
Coal	3850	7145	10508	15516
Indigenous	3850	7145	10508	15167
Imports	—	—	—	349
Oil	2416	4245	7553	10723
Indigenous	1410	1592	1774	1955
Imports	1006	2653	5759	8768
Gas	480	1002	1909	3478
Indigenous	480	1000	667	533
Imports	—	2	1242	2945
Hydro*	249	324	625	917
Nuclear	24	31	25	12
Total commercial energy	**7019**	**12747**	**20600**	**30646**
Crop residue	763	763	763	763
Fuel-wood	3134	3134	3134	3134
Animal waste	1314	1227	1113	939
Total traditional energy	**5211**	**5124**	**5010**	**4836**

**energy in electricity generated*

It would be observed from the figures projected that oil demand and supply would almost quadruple during the period 1990 and 2020. However, based on current indications of increases in indigenous production, the level of imports in the same period would increase to eight times the 1990 levels. This poses a major challenge not only in terms of ensuring a diversification of sources to minimize the possibility of disruptions in supply arising out of various factors but also in terms of ensuring that the lifeline of supply remains uninterrupted. Analysts are not particularly concerned about the possibility of large-scale hostilities disrupting the supply of oil physically, but the dangers of terrorist actions in several spots could create serious repercussions for major importers of oil such as India. Another major concern, of course, arises out of larger changes that could take place in the global oil market. This would really be in the nature of sudden fluctuations in prices, such as those that were experienced in 1973/74 and 1979/80. More recently, at the start of this decade, the Gulf War resulted in nervousness and sudden price increase in the world market, which for a major oil importer like India would have serious economic impacts if repeated.

NEED FOR SUBSTAINABLE ENERGY SECURITY IN INDIA

One of the key areas of concerns now is related to security of energy supplies. With a high dependence on imports, the vulnerability to external shocks is high. The high level of imports also results in a continuous strain on the country's foreign exchange reserves. Energy covers the entire gamut of energy resources– primary, secondary, commercial, non-commercial, renewable and non-conventional. However, the focus of energy security seems at represent only on oil, because the world is supposed to be running out of oil. In fact, it has been the discovery of oil and, more recently gas that has brought the concept of energy security to the fore in energy policymaking. Over 40 per cent of the total world energy consumed is based on oil. Over 50 per cent of India's energy is based on oil and gas, of which over 70 per cent is imported. This percentage is expected to steadily increase in view of the growing requirements of oil, especially in transport sector, and the stagnating indigenous oil production. At present, the major import of India's oil is from West Asia. Liquefied Natural Gas (LNG) is also being used to meet the rapidly increasing power demand in the country. Growing reliance of India on imported oil from West Asia and gas has raised serious policy issues of energy security that need to be carefully examined.

In one point of view for considering energy security with particular reference to oil, it needs to be noted that international markets to trade oil have now become well defined, and price signals are efficiently maintained. Nevertheless, any restriction on oil supplies would be very damaging to the world economy, especially to oil importing developing countries like India. The increases have serious repercussions on India's energy security. Most of India's oil imports are shipped across the Indian Oceans via tankers. Question of safety of shipping and the Sa Lanes of Communications (SLOC) has been the subject of considerable attention for the country security analysts. West Asia region is very volatile, with most of the Gulf States involved in territorial disputes with one another.

But the challenge of energy security requires consideration on various fronts. While many actions have to be taken– e.g., efforts at a more purposeful policy for production of Alternate Fuels (hydrocarbons) and promotion of renewable sources of energy would help– a much larger view of economic initiatives and actions would serve India's interests far better.

Firstly, overall economic policy has to accept the reality that the scarcity of commercial energy resources and oil, in particular, in India is an important factor, which should influence the structure of the Indian economy. Consequently, continuing the expansion of those activities, which are highly energy intensive, needs careful consideration, whereby a preference for imports rather than local manufacture would be desirable. In essence, energy security would be ensured by replacing oil imports at the margin with imports of oil- or energy-using products instead.

At another level, fuel substitution initiatives which reduce dependence on oil imports and favour greater use of indigenous energy resources should be preferred. Some of these changes would occur naturally if there is an import premium attached to prices of crude oil and oil products. However, this would presuppose efficiency and market responsive supply of other forms of energy- this, unfortunately, is not the case. In fact, in the case of electricity supply, given the enormous problems in the state electricity boards, failures of supply lead to the installation of captive power generation units using large quantities of petroleum products. This is also true for diesel pump-sets that are used in preference to electric pump-sets in rural areas, which generally receive very poor quality power.

Macro policies and market-based instruments should be used effectively for ensuring high levels of energy security as mentioned above. There is also a need for institutional initiatives and innovation such as empowering *panchayats* and municipal bodies for effective decisions and actions in the energy sector. Efforts to improve the efficiency of energy use, conversion of waste material into useful energy, and the installation of renewable energy devices would only take place if local institutions are strong enough to bring about a change in these directions. The 73rd and 74th amendments to the Constitution of India provided the framework and rationale for involving local institutions in development decisions and actions. However, very little follow-up has taken place in terms of providing local bodies with abilities to take effective action. Governments at the center and the states need to urgently build capacity in local institutions for attaining an energy path, which is sustainable and relevant for the endowment of resources at the local level. Combined with rational pricing of electricity, local initiatives, particularly in rural areas, can reduce our dependence overall on growing imports of oil and oil products.

Another issue to be considered is that of developing a technology policy for the energy sector that rests on a vision of the kind of energy supply and consumption desired related to security and other considerations, which India should be aiming at over the next 30–40 years and beyond. Technology development cannot be isolated from developments in the rest of the world, but India clearly has priorities that are unique to its own situation. For instance, the commercialization of coal gasification technology would open up a new era in the use of indigenous coal in every sector of the Indian economy. Similarly, the use of fly ash for commercial purposes would provide hundreds of tonnes of useful material that could alter the construction sector in the country substantially. Similarly, with the endowment of renewable energy resources available to us, the development of sophisticated renewable energy technologies would serve the interests of India in a sustainable manner, besides preserving a social system that has shown unique strengths for thousands of years. The advent of modern information technology and the possibility of decentralized forms of energy production could provide the basis for realizing the Gandhian dream of development that is village-centered and village-based. Through the building blocks of such development, the country would also be able to attain a high level of energy security. Although the importance of energy for India's development in the new global economy is now being increasingly recognized, the linkage of energy policy to every aspect of national policy, including foreign policy and national security, has not been adequately studied and articulated. Moreover, recognizing that India's economic problems are complex and multidimensional, it is necessary that a multi-dimensional integrated energy policy is formulated and implemented. This becomes even more necessary because current trends in international energy markets show a movement towards the formation of mergers of large oil companies, which will control and dictate policy vis-à-vis production and prices. Therefore, energy-dependent countries like India have to devise individual strategies to protect not only the security of their oil supplies, but also to keep their access to low cost energy options open.

While all-out efforts are being made to intensify the exploration of indigenous oil reserves, substitution of oil with indigenous energy sources with alternative fuels should also be a key element of India's integrated energy policy. Large investments are needed for this purpose, which are not always available. This dependence needs to be brought down by greater use of domestic resources especially non-conventional energy sources that have enormous potential. Currently, these sources contribute only about 3% to the total capacity. Enhancing energy security would require a host of measures, foremost among which is the issue of a strategic petroleum reserve for the country. This is particularly significant in the light of spiralling oil prices. In addition, strategic reserves provide a cushion against temporary disruptions.

Fuel cells, hydrogen technologies and renewable sources are the future energy sources. Hydrogen has been called the 'Freedom Fuel' and a major initiative has been launched by US and other developed countries for ushering in a fossil fuel free hydrogen economy. India doesn't want to lag behind, as with its strong hydrogen and fuel cell R&D foundation and expertise it has scope for taking up a major programme for hydrogen energy, as the alternative to fossil fuel economy. It is felt that through the systematic push in this area of frontier technological development, demonstration and implementation, the country would be able to attain the goal of sustainable energy security for all.

RENEWABLE ENERGY TECHNOLOGIES

Renewable energy sources offer viable options to address the energy security concerns in a country. Today India has one of the highest potential for the effective use of renewables. There is significant potential in India for generation of power from renewable energy sources, such as wind, small hydro, biomass, and solar energy. Therefore a special emphasis has been laid on the generation of grid quality power from renewable sources of energy.

In the past 10–12 years, the capacity of small hydro projects up to 3 MW (megawatt) has increased four-fold from 63 MW to 240 MW. India is the largest producer of cane sugar. There exists an established potential of 19,500 MW, including 3,500 MW of exportable surplus power from bagasse-based cogeneration in sugar mills and 16,000 MW of grid quality power from other biomass resources. The total installed capacity in the country as on 31 December 2002 was 468 MW. Grid-interactive solar photovoltaic power projects aggregating to 2.490 MW have so far been installed and other projects of 0.8 MW capacity are under installation. The wind power development in the country has been going up, as a result of a mix of fiscal incentives and promotional measures. Consequently, generation from wind power projects is rapidly increasing.

CHAPTER-5

Overview of Indian renewable energy programme and Government policy on renewable energy

Though renewable energy technologies (RETs) such as biogas plants and improved cookstoves had been available in India since the late 1940s, the programme itself was initiated on a very moderate scale in the wake of energy crisis of 1973. Government of India set up a high-powered CASE (Commission for Additional Sources of Energy) in the Department of Science and Technology, to draw up plans for achieving a harmonious transition from an economy based on non-renewable hydrocarbons to one based on renewable energy resources. The Commission was set up on the lines of the Space Commission and Atomic Energy Commission, and to begin with, its mandate was to promote R&D activities in the field of renewable energy.

To provide focused attention to this sector, a separate Department of Non-Conventional. Energy Sources (DNES) was created in 1982, under the Ministry of Energy, at par with Departments of Coal and Power. After a decade, in 1992, the Department was upgraded to the status of a Ministry, naming it as the Ministry of Non-Conventional Energy Sources (MNES) to increase the deployment of RE technologies. This was done primarily to give more autonomy and focus in decision-making and allocation of more resources for renewable energy promotion. Today India is in a unique position of having a dedicated Ministry for Non-Conventional Energy Sources (MNES). The Ministry is the nodal agency of the Government of India for all matters concerning the promotion of non-conventional/renewable energy. The span of its activities covers policy making, planning, promotion and co-ordination of various demonstration and commercial programmes, designing and implementing fiscal and financial incentives, creation of industrial capacity, promotion of R&D and technology development, intellectual property protection, human resource development and international relations. The ministry also deals with emerging areas; such as, fuel cells, electric vehicles, ocean energy and hydrogen energy. All multilateral and bilateral Government to Government linkages related to renewables are enacted through this Ministry. In order to provide concessional financial support to the renewable energy sector, the Ministry (MNES) has set up under its fold a financial institution, viz., Indian Renewable Energy Development Agency Ltd. (IREDA). Plan-wise outlay and actual expenditure for MNES is given below.

The following specific items have been assigned to the Ministry:

- Commission for Additional Sources of Energy (CASE)
- Integrated Rural Energy Programme (IREP).
- Research and development of biogas and programme relating to biogas units.
- Programme relating to improved cook stoves (chulhas) and R & D thereof.

- Mini-micro hydel projects below 3 MW (now upgraded to 25 MW) capacity and geothermal energy.
- Solar photovoltaic devices, including their development production and application.
- Tidal energy, wave and ocean thermal energy.
- Indian Renewable Energy Development Agency

MNES also administers the state nodal agencies by providing targets and supervising them, as well as providing finance, either allocated as subsidies or through funding of other schemes and projects/ programmes. It also supports national level RE conferences, seminars and training/capacity building.

Till mid 1993, the MNES was organized broadly on the basis of technology; individual divisions within the Ministry, which looked after one single technology, such as, solar PV, wind mills or improved cookstoves. The individual technologies were promoted through design and development support and through the establishment of large-scale demonstration programmes, e.g., the national programmes for biogas development, cookstoves dissemination, and wind energy. Through these programmes, a RET manufacturing base was created. The RET devices were procured by the government, either for demonstration projects (as for wind energy and for SPV community-lighting and power plant programmes), or for subsidized sales to consumers. A number of technology-support centres were created to promote technological up gradation by manufacturers, and to certify the quality of devices procured by the government. The devices and the subsidies were channeled to consumers through SNA (State Nodal Agencies) that were responsible for after-sales service and consumer support. To streamline its working, the MNES was restructured in 1993, with an aim to adopt an integrated approach. Divisions were reorganized on the basis of applications of technologies through horizontal integration of various subjects and research areas. The restructured MNES now has three main divisions:

1. Rural Energy Division

Rural Energy Group I.
Rural Energy Group I deals with biogas, improved cookstoves, biomass (production and utilization), Urjagram (energy village project) and the IREP (Integrated Rural Energy Programme).

Rural Energy Group II.
Rural Energy Group II deals with PV lighting, water pumping; solar thermal applications (rural); and human and animal energy.

2. Urban and Industrial Energy Division
Overview of Indian renewable energy programme
This division looks after domestic energy and process heating, passive architecture, urban/municipal wastes, industrial wastes, and energy conservation.

3. Power Division
This division deals with the wind energy, small hydro, bioenergy, and cogeneration, and solar energy (only grid-connected solar applications). In the new scheme, much greater reliance is placed on developing market linkages and promoting commercialization by involving private sector, rather than public investment, and providing more fiscal and tax

incentives. Under the New Strategy and Action Plan of 1993, the following, two-pronged Action Plan was devised:

- High priority accorded to generation of grid quality power from wind energy, small hydropower, bio-energy and solar energy.
- Rural energisation programme is promoted through: electrification of villages through photovoltaic and biomass gasifier power systems
- Supply of solar lanterns to unelectrified households
- Use of solar water heating systems
- Rural energy programmes viz. National Project on Biogas Programme production of energy from agricultural waste, etc.
- Currently, a three-fold strategy has been pursued by the government for promotion of RE sources through private sector involvement. These include:
  - providing budgetary resources by government for demonstration projects,
  - promote development agency (like, IREDA) and other financial institutions for commercially viable projects, with private sector participation; and
  - mobilize external assistance from international and bilateral agencies.
- Promoting private investment through fiscal incentives, tax holidays, depreciation allowance, and facilities for wheeling and banking of power for the grid and the remunerative returns for the power provided to the grid.
- The emphasis has shifted from direct financial incentives (e.g., capital subsidies) to indirect fiscal incentives (e.g. low interest loans, financing packages for consumers, reduced tariff and taxes, viable power-purchase prices, etc.). This has stimulated private-sector investment in wind and SPV power plants, and has encouraged RET manufacturers and financing intermediaries to address the needs of consumers in their product design and system development. The current policy environment has been successful in creating one of the largest and most diverse renewable energy programmes in the world, with a broad technological base and creation of large human capacity, in terms of up-gradation of knowledge, skills development, training of managers, designers, engineers, supervisors, technicians and local artisans and entrepreneurs etc.

The RETs (renewable energy technologies), such as, biogas plants and improved cookstoves have been available in India since the late 1940s, though the renewable energy programme started in earnest only after the creation of CASE (Commission on Additional Sources of Energy) in 1980, and then the DNES (Department of Non-conventional Energy Sources) in September, 1982. Programmes of DNES during 1980s were focused on the development, dissemination, and demonstration of various RETs. The programme was driven by direct Government subsidies. However, investment in RET promotion was low in comparison to those for conventional energy sources. The cumulative government expenditure for the renewable energy sector between 1980 and 1992 totaled only Rs. 11.55 billion, as compared to Rs. 812 billion for the power sector, Rs 335 billion for the petroleum sector, and Rs. 158.5 billion for coal sector (GOI 1996). In the Eighth Plan (1992-97), allocations for renewable energy were about 0.8% of the total funds allocated for the energy sector (GOI 1996).

During the early 1990s, it was realized that faster diffusion of renewable energy sources required greater reliance on commercialization through fiscal rather than financial incentives involving the private sector- the role of the DNES had to change from that of an implementing organization to one facilitating the rapid commercial application of renewables. Partly as a result of this, the DNES was converted into a full-fledged Ministry (Ministry of Non-Conventional Energy Sources- MNES) in July 1992. Even since, the thrust of the programmes has been on market development in order to facilitate and catalyze commercialization resulting in several-fold increase in the diffusion of RETs. India is perhaps, the only country in the world with an independent ministry for promotion of RETs.

Policy and Institutional Frameworks:

Till July 14, 1993, the MNES (and earlier, the DNES) was organized on the broad basis of technology. Individual technologies were promoted through design and development support, and through the establishment of large-scale demonstration programme, e.g., the centrally sponsored National programme for biogas development (NPBD), cookstoves dissemination, and wind energy. The household biogas plants was essentially meant for the Indian villages, almost 575,000 in numbers spread/scattered throughout the country, with socio-cultural diversities, and some of them in very far-flung regions. Therefore, to be effective, the programmes required highly decentralized approach for implementation. In view of this, drawing from the practical experience and feed-back of NGOs already involved in implementation in their respective area of operations, the NPBD incorporated “Multi-Model and Multi-Agency” approach for promotion of household biogas plants. This approach also gave both qualitative and quantitative results and created positive impact. Almost the same approach (as NPBD) was followed in the case of promotion and implementation of improved cook stoves (ICS), under the centrally sponsored scheme of DNES-know MNES, known as National Programme of Improved Cook Stoves (NPICS. The large-scale demonstration programme backed by R&Ds and incentives to manufactures in ‘Wind Energy” and other RETs, a sustainable manufacturing base for quality RET design and production was created. Due to training programmes and to some extent back-up, follow-up and post-installation support-cum-service, , gradually qualitative product was delivered and serviced to the ‘End Users’, especially in the case of household biogas plants by grassroots NGOs.

The RET devices were procured by the government, either for demonstration projects (as for wind energy and for SPV community-lighting and power plant programmes), or for onward (subsidized) sales to consumers. As technology-support centres were created in universities to promote technological up-gradation by manufacturers, and to certify the quality of devices procured by the government. The devices and the subsidies were channeled to consumers through state-level nodal agencies, which were also responsible for after-sales service and consumer support.

This policy regime was successful in the creating a fairly large and diversified manufacturing base, and an infrastructure (technology-support groups and facilities, as well as the nodal agencies) to support RET design, development, testing, and deployment. However, commercial demand for RET devices remained limited, in spite of the subsidies. This was largely because of a combination of low reliability of the devices, the lack of remunerative tariffs for RET-generated electricity, and a lack of consumer-desired features (in terms of the services and the financial commitments) in the design and sales-package.

In order to give the required focus and more thrust on commercialization, market orientation, and to have greater involvement of the private sector, NGOs, civil society and micro-level people’s institutions (MLIPs), like CBOs, SHGs, Micro Finance Groups (MFGs) and panchayats MNES was restructured in 1993 on the basis of end-use applications of technologies through horizontal integration of various technologies. Based on the “Learning Curve” from the past one decade, the restructured MNES now has sectoral groups of (a) rural energy, (b) urban/ industrial energy, and (c) power generation. Through the restructuring, emphasis shifted towards policies, planning and institutional linkages to promote RETs within each sector. Each such sector now consists of integrated programmes to serve different energy needs; for instance, cooking energy is now comprehensively dealt with, under the rural energy group rather than individual technologies being implemented separately.

The change in the structure has resulted in significant changes in the focus of the programmes. For instance, till 1992, the biogas programme had traditionally been the single largest programme within the renewable sector, accounting for over half of the funds allocated. All other individual programmes had received less than 10% of the funds. In terms of numbers achieved, however, the dissemination of improved cookstoves has been the largest programme (Table). Currently, the rural energy division has the largest financial allocation with the inclusion of both biogas and cookstove programmes.

The restructuring has also led to a shift from direct financial incentives (e.g., subsidies) to indirect fiscal incentives (e.g., low-interest loans, financing packages for consumers, reduced tariffs and taxes, viable power-purchase prices). This has stimulated private-sector investment in wind and Solar PV power plants, as well as encouraged RET manufacturers and financing intermediaries to address the needs of consumers in their product design. The resulting growth of the RET market has been impressive. Table 1 shows RET penetrations till 1993 (before the restructuring), and till end-1995. Significant increases have occurred in the use of RETs in wind-energy generation, Solar PV domestic lighting (particularly solar lanterns, which were earlier not even a part of the national programmes) and water pumping, and family-sized biogas plants as a result of the market-based commercialization of RET deployment.

WindEnergy: About the technology

Wind energy is one of the clean, renewable energy sources that hold out the promise of meeting a significant portion of energy demand in the direct, grid-connected modes as well as stand-alone and remote ’niche’ applications (for instance water pumping, desalination, and telecommunications) in developing countries like India.

The wind power in many countries is already competitive with fossil power (capital cost, 40 million rupees per MW) when external/social costs are also accounted for. International organizations estimates that wind power will become competitive in a short time frame (2005-2010)) with both fossil and nuclear in a narrow economic sense, without taking into account it’s competitive advance in external or social costs.

Two perspectives inform the economics of grid-connected wind power. The first is that of public authorities or energy planners, making assignments of different energy sources. Here the focus is on levelized cost in, for example, Rs/kWh. Such calculations do not include factors determined by society or governments, such as inflation or taxation. The second perspective is that of the private or utility investor, where inflation, interest rates, the taxation system, amortization period, etc. must be included. Consequently, the economics of wind energy differs greatly from country to country. Here the focus is on cash flow in each project, on payback time, and present value of the investment.

The generation cost from wind energy is basically determined by the following parameters:

- total investment cost, which comprises-
  - cost of wind turbines,
  - project preparation costs, and
  - cost of the infrastructure;
- as well as-
- operation and maintenance cost;
- average wind speed at the particular site;
- availability;
- technical lifetime;
- amortization period; and
- real interest rate.

Solar Thermal: About the technology

Energy in the form heat is one of the main energy requirements in domestic, agricultural, industrial and commercial sectors of our economy. From an end-use point of view, solar thermal energy finds its application in areas as diverse as listed below.

- Water heating for domestic and industrial applications
- Process heating for industrial applications
- Drying
- Refrigeration and air conditioning
- Cooking
- Architecture
- Water desalination and water purification
- Water pumping
- Power generation.

India is one of the few countries with plenty of sunshine with an annual average insulation varying from 4-7 kWh per m^2/day with 250-300 clear sunny days per year.

Various types of solar thermal devices are now available in the country these includes solar water heaters, solar cookers, solar stills, solar dryers etc. apart from these devices, solar energy is also being used particularly in the colder areas of the country for space heating by including solar passive features in the buildings; and for agriculture by utilizing solar greenhouses.

Water heating

Most of solar water heaters have a collector for solar energy collection and heating water and an insulated water storage for storing hot water. The collector and storage are connected by pipes. A solar water heater serves the functions of collecting solar energy, utilizing this energy to heat water and storing hot water. The circulation of water in the system is possible due to the density difference (thermo-siphon water heaters) or by utilizing a pump (forced circulation water heaters).

In India, solar thermal systems are used for heating water for domestic and industrial purposes. In the industrial sector, these systems pre-heat boiler feed water and also supply direct process heat. The resultant savings are mainly in terms of boiler fuel. In the domestic sector, solar water heating systems often replace electric water heaters (geysers). The small capacity systems (up to 2,000 liter per day) can work on natural circulation or thermo-siphon principle. However, for larger capacity systems, pumps with necessary controls are required to circulate water and such systems are designated as 'forced flow' systems. Wider use of solar water heaters not only saves substantial amount of electricity but also reduces the peak load demand significantly. Approximately, use of 1,000 solar domestic water heaters (2000 m^2 of collector area) can contribute to a peak load shaving of 1 MW. The cumulative installed collector area in the country in 1998/99 was 450,000 m^2 and has doubled since.

The cost of solar water heater could be reduced by merging the collector and storage into one component. This concept is used in a collector-cum-storage system. It essentially consists of a thin metal water tank, insulated on three sides and having glass grazing on the fourth side to collect solar energy.

Cooking

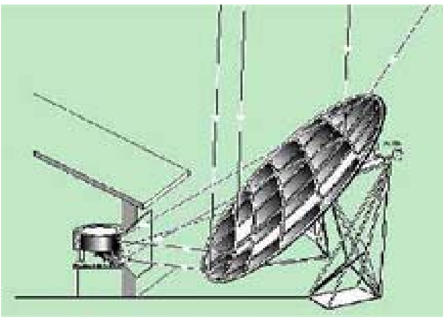
In India, in the household sector, the bulk of energy is spent on cooking. Although in the urban households, there is a gradual shift from fuelwood to LPG (liquefied petroleum gas), 32.7% (as per 1991 census) of the urban poor still use fuelwood. According to 1991 census, about 30% of urban population uses gas and another 30% uses firewood and wood chips, whereas in rural sector, about 78% of the population rely on firewood and agricultural wastes & residues. As per the NCAER (National Council of Applied Economic Research) survey conducted in 1978/79, cooking accounted for 85.2% of the total energy consumed in the rural domestic sector. Therefore, the cooking with solar energy appears to be one of the most desirable options, in combination with biogas and ICS. At the micro level, a solar cooker would facilitate financial savings for the consumer, while at the macro level it would help in conserving of precious natural resources like fuelwood. Moreover, cooking through solar cookers helps in abating the greenhouse effect. Of the many types of solar cookers, the box type solar cooker has reached the commercialization stage. Since 1981-82, around 4,62,000 solar cookers have been sold in the country. The number of solar cookers sold in the country during the year 1995-96 is more than 40,000. Now the parabolic cooker with glazed aluminum sheet strips (which gives very high reflective efficiency) and can provide much higher temperature than the box-type cookers, has also started showing some promise.

✦ Community solar cooker (Scheffler)

The solar cooker system, developed by W. Scheffler, ULOG Group of Switzerland, has the advantage of cooking food inside the kitchen itself. This is the latest in community solar cooker designs. Its special features are as follows.

- A battery of parabolic (dish shaped) cookers that reflects sunlight in to the kitchen and then on to a secondary reflector which is located below.
- The cooker's temperature can be regulated as easily as in conventional cooking.
- It can be used to boil, fry, and bake.
- Unlike other parabolic dishes, this one is flexible, with a curvature that can be seasonally adjusted.
- Maximum temperature: 450°C.
- Capacity: 70–80 meals per day.

- Cooking time: 1–12 hours for each dish.



Schematic diagram of the scheffler concentrating cooker

Scheffler concentrating cookers with a view of kitchen
Image source: Annual Report 1998–99,
Ministry of Non-Conventional Energy Sources, Govt. of India, p. 47

Power generation

It was decided by the MNES (Ministry of Non-conventional Energy Sources) that the first megawatt-size solar thermal power plant in India should be taken up as an R&D-cum-demonstration project, with an objective of replication of such plants in future. The emphasis was on optimum utilization of indigenous know-how and transfer of technology. It was further concluded that parabolic trough type collectors were more promising compared to the central receiver type, mainly because of the California experience. Considering the objective of ultimately commercializing the technology and taking into account the proven ness of the 30-MW unit size over the 10-MW unit size, it was decided to go in for the former.

The proposed 140-MW integrated power plant, the capacity of solar-alone plant is 35 MW and balance 105 MW is based on naphtha. Upon examination of the available data for different proposed sites, Jodhpur (in Rajasthan state) was found to be the most appropriate site for such a venture. Using a baseline case of a coal-fired 140-MW power station, the marginal cost of the solar plant has been estimated at US$ 83 million (about $2,400 per kW). The RSEB (Rajasthan State Power Corporation Ltd), a recently established concern wholly owned by the state government, will implement the project. The approximate total cost is US$ 280 million, to be financed by a combination of GEF (Global Environment Facility) grant, loans (from commercial organizations and bilateral agencies), and equity. The GEF and KfW (a German Government development bank) funding are in place. Once installed, the plant will operate autonomously as an IPP and will sell power to the grid based on a PPA (power purchase agreement) with the RSEB. An ICB (International Competitive Bidding) is expected shortly.

Process heat

- **Industrial applications**

The annual compounded growth rate of commercial energy consumption in India has been around 5.5% during 1992–97. However, the per capita energy consumption still remains less than 10% of the levels achieved in the industrialized market economies. Indeed, to maintain a reasonable industrial growth, the country must have a sustainable energy supply. But the state of affairs in the field of energy reveals a disturbing picture. Persistent energy shortages loom dangerously as demand continues to outstrip supply. The situation becomes more alarming due to the fact that the continued burning of fossil fuels endangers the climate through such phenomena as the global warming.

Major portion of thermal energy requirements in the Indian industrial sector lies in the temperature range of 100°C to 250°C that corresponds to the medium temperature range of solar thermal systems. This is supplied either as high temperature pressurized water or as low pressure steam. These medium temperature requirements are presently met primarily by combustion of fossil fuels like coal, lignite, and fuel oil. There are 22 major industries (dairy, food processing, textiles, hotel, edible oil, chemical, marine chemicals, bulk drug, breweries, distilleries, etc.), where boilers supply process heat either in the form of steam or hot air up to a temperature of 150°C.

Solar thermal systems could be employed to meet this demand in a complementary role. It is estimated that about 60% of thermal energy consumed in industry is used for processing of end products. Even if only 10% of this requirement is met through solar thermal systems, this will lead to savings of about 292,400 liters of furnace oil per year and reduction in the resultant carbon dioxide.

Water desalination and purification

Solar ponds located in arid regions, where abundant brackish water is available, may be excellent sources of energy for water desalination. There are two reasons for this– first, the solar pond can provide the thermal energy required for the process; and second, the pond can be a repository for the concentrated waste brine, disposal of which often prove to be a difficult problem, particularly with anti-pollution laws becoming stricter every day.

In places such as arid zones and desert areas, where there is a high degree of solar radiation, fresh water is most lacking. With the development of low temperature multi effect, multi stage, flash desalination systems, it can be stated that technical constraints associated with the utilization of solar energy with respect to the desalination sub-system have been solved. This is also true from the point of view of the economic considerations. However, economic feasibility of solar desalination based on current energy prices can only be achieved with an extremely low cost yet reliable solar collector and storage system, such as a solar pond. A solar pond– coupled to an energy-efficient, low temperature, multi-effect, multi-stage, flash desalination system offers the highest potential for producing potable water on a large scale, at competitive costs compared to the existing fossil-fuel-powered desalination systems, for the locations where salt/bittern is available cheaply. The concentrated waste brine, left after desalination, can be recycled into the solar pond. If the concentrated brine is substantial, it can be used to `breed' additional solar ponds, thereby solving the problem of waste disposal on the one hand and providing more energy on the other hand.

✦ **Solar pond desalination systems in industrial environment**

The solar pond desalination system offers a viable option for producing fresh water for the industries located in water-scarce regions like arid zones, deserts, and coastal areas. These are the areas where salt/bittern as well as wasteland are available in plenty along with abundant supply of solar radiation. Therefore, a solar pond desalination system becomes very cost-effective and competitive compared to a conventional system like the RO (reverse osmosis). Indeed, solar pond technology can be used in salt farms for increasing the yield of salt along with fresh water production.

✦ **Solar pond desalination systems for drinking water supply**

Solar pond desalination systems can also be used to solve the drinking water problems in areas where fresh water is scarce, such as the Kutch region in Gujarat states. Here, the groundwater is depleting so rapidly that water levels fall by 1–1.5 m in a year. In many coastal areas, the ingress of subsoil salinity had reached 30 km inland from the coast. It is feared that the economic activities in the Kutch region would become unsustainable in the near future on account of salinity ingress, water scarcity, etc. According to one estimate, by 2021, Kutch will need a total of 194 million litters of drinking water daily. At present, the daily availability of drinking water is to the tune of 70 million liters only. Keeping in view the vast deposits of natural salt that Kutch is endowed with and its long coastal shores, solar pond desalination systems could prove to be very beneficial. This technology is especially appropriate for this region because its main inputs, namely, salt/bittern and clay, are available in abundance here. Thus, the solar pond technology could prove to be the most cost-effective by utilizing locally available materials for conversion of brackish/sea water into pure and soft drinking water.

Similarly, a solar pond water desalination system could also be used to meet drinking water requirements of the Army and the Border Security Force, stationed at Indo-Pak border, all along the Great Rann of Kutch.

SMALL HYDRO POWER: ABOUT THE TECHNOLOGY

Small or mini–micro hydro power is one of the earliest known renewable energy sources, in existence in the country since the beginning of the 20th century. In fact much before that, the technology was used in Himalayan villages in the form of waterwheels to provide motive power to run devices like grinders. References to mechanical energy extraction have been found from as early as twelfth century.

SHP (small hydro power) technology was introduced in India shortly after the commissioning of the world's first hydroelectric installation at Appleton, USA in 1882. The 130 kW plant at Darjeeling in the year 1897 was the first SHP installation in the country. A few other power houses belonging to that period such as Shivasundaram in Mysore (2 mw, 1902), Galgoi in Mussoorie (3 mw, 1907), and Chaba (1.75 mw, 1914) and Jubbal (50 kW, 1930) near Shimla are reported to be still functioning properly.

Most of these power houses utilized the high head available at the sites, and impulse turbines were generally preferred in such conditions. Initially, the development of SHP was restricted to small hilly streams in the Himalayan region lacking alternative sources of power. Later, between 1930 and 1950, some low head SHP installations came up on a number of canals on the Ganga. The major impediment to SHP stations in the early stages was that high voltage transmission lines had not been developed, resulting in heavy line losses wherever the load centres were spaced far apart.

Hydro power development was stepped up only after Independence, by which time the technology for large hydro was available and efforts of all state governments/state electricity boards were mainly on the large multi-purpose projects. During the earlier Five-Year Plans did give priority to rural electrification; no comprehensive plans were drawn for the development of SHP. It was only during the Eighth Five-Year Plan that the MNES (Ministry of Non-conventional Energy Sources) proposed that the status of SHP be upgraded and additional funds be allocated for this purpose. The total installed capacity of SHP projects in India is 144.28 MW while another 241.87 MW is under construction. The achievements of each state with respect to installed capacity under SHP projects are shown in Table 1.

Classification of small hydro power systems

The globally accepted classification for hydro is in terms of power output, but the norms vary from country to country. In India, a hydro power plant of capacity lower than 15 MW is termed ’small hydro’. The Central Electricity Authority further classifies small hydro schemes as follows.

- **Depending on the capacity**

Size	**Unit size**	**Installation**
Micro	up to 100 kW	100 kW
Mini	101–1000 kW	2000 kW
Small	1001–6000 kW	15 000 kW

- **Depending on the head**

Ultra	low head	below 3 meters
Medium	head	from 30–75 meters
High	head	above 75 meters

Benefits of small hydro

The biggest advantage of SHP (small hydro power) is that it is the only ’clean’ and renewable source of energy available round the clock. It is free from many issues and controversies that continue to ’hound’ large hydro, like the submergence of forests, siltation of reservoirs, rehabilitation and relocation, and seismological threats. Other benefits of small hydro are user-friendliness, low cost, and short gestation period.

In addition to these obvious benefits, SHP contributes numerous economic benefits as well. It has served to enhance economic development and living standards especially in remote areas with limited or no electricity. In some cases, rural dwellers have been able to manage the switch from firewood for cooking to electricity, thus limiting deforestation and also cutting down on carbon emissions. On the macro level, rural communities have been able to attract new industries– mostly related to agriculture– owing to their ability to draw power from SHP stations. In countries like South Africa, China, and Nepal, rapid SHP development has also enthused small, local manufacturers to support these hydro power plants.

Even though SHP has had an early start, the pace of growth in this sector has been very slow vis-à-vis large hydro. This can be attributed to the rapid pace of industrialization after Independence which required huge amounts of power and necessitated the installation of large multi-purpose power projects. However, with growing consciousness and concern about the environment, the focus shifted towards the development of small, user-friendly, and decentralized power projects with low gestation periods. Multifaceted impetus is being provided by various agencies in the sector; for instance World Bank credit through the Indian Renewable Energy Development Agency (IREDA) and the Hilly Hydro Project (HHP) funded by United Nations Development Programme–Global Environment Facility (GEF). The Ministry of Non-conventional Energy Sources (MNES) is offering, through its normal budget, a host of incentives for surveys, investigations, preparation of detailed project reports, and execution of projects. With these new and exciting developments, small hydro power in India is poised to make a big splash; quite like wind power generation has made waves in the past five years

BIOGAS: ABOUT THE TECHNOLOGY

When any organic matter, such as bovine (cattle and buffalo) dung, crop residue and kitchen waste is fermented in the absence of oxygen, biogas is generated which contains combustible methane (55- 65%) along with carbon dioxide, and traces of other gases. This gas can serve as a convenient fuel that can be used for a variety of applications, such as cooking, lighting, and motive power. The slurry that comes out of biogas plant after the gas is produced can be used as organic manure in the fields to augment soil fertility. Thus, biogas technology produces fuel as well as fertilizer, while only one of these is possible if dung is used in its original form.

Biogas production is a chemical process occurring in stages during which different bacteria act upon the organic matter resulting in the formation of methane and acids. The main factors that influence biogas production are pH (level of acidity) of the feedstock and the temperature. It is well established that a biogas plant works optimally at pH level of 7 or just above (neutral solution) and a temperature of 30- 35^{o} C. In low temperatures, bacteria activity slows down resulting in substantial decrease in gas generation, ceasing completely below 10^{o}C.

Carbon-nitrogen ratio (C/N) of the feed material is also an important factor and should be in the range of 20:1 to 30:1. Bovine (cattle and buffalo) has a C-N ratio of 25:1 and is considered ideal for maximum gas production. Solid concentration in the feed material is also crucial to ensure sufficient gas production, as well as easy mixing and handling; 8-12% (average 10%) of total solids (TS) is the normal value required. Fresh bovine (cattle and buffalo) dung has a solid concentration of about 20% and therefore, it is recommended that this dung is mixed with water in a ratio of 1:1 to attain the desired level of total solids (TS). One kilogram of fresh cattle dung produces about 40 liters (0.04 m^3) of biogas in 40 days HRT (Hydraulic Retention Time) built in the plains of northern India. A family size biogas plant (two cubic meters-2 m^3 capacity) requires 50 kg of fresh dung and equal amount of water to produce 2,000 liter (2 m^3) of gas per day. This amount of gas is sufficient to meet the daily cooking requirement of an average size family consisting of five to six members.

Hydraulic Retention Time (HRT)– the number of days the feed material is required to remain in the digester to begin gas production– is the most important factor in determining the volume of the digester which in turn determines the cost of the plant; the larger the retention period, higher the construction cost. In India, the different HRTs are recommended for three different temperature zones.

Zone	Average ambient temperature	HRT (days)	Approximate regions
I	>20^{o}C	30	Andhra Pradesh, Goa, Karnataka, Ketala, Maharashtra, Tamil Nadu, Pondicherry and Andaman & Nicobar Islands
II	15-20^{o}C	40	Bihar, Gujrat,Haryana, Jammu region of J&K, Madhya Pradesh, Orrisa, Punjab, Rajasthan, Uttar Pradesh and West Bengal
III	<15^{o}C	55	Himanchal Pradesh, North-eastern states, Sikkim, Kashmir region of J&K, and hill districts of UP

GASIFIER: ABOUT THE TECHNOLOGY

Biomass materials such as firewood and agro residues essentially contain carbon, hydrogen, and oxygen along with some moisture and ash. Direct combustion of biomass is generally inefficient and smoky and cannot be easily controlled. Under controlled conditions characterized by low oxygen supply and high temperatures, most biomass materials can be converted into a gaseous fuel known as producer gas, which comprises carbon monoxide, hydrogen, carbon dioxide, methane, and nitrogen. This gas has a lower calorific value (1000–1200 kcal/Nm^3 equivalent to 4.2-5 MJ/Nm^3) compared to natural gas or liquefied petroleum gas, but can be burnt with high efficiency and good degree of control without emitting smoke. Each kilogramme of air-dry biomass (10% moisture content) yields about 2.5 Nm^3 of producer gas. In energy terms, the conversion efficiency of the gasification process is in the range of 60%–70%. Usage of gasifiers instead of conventional direct burning devices will lead to savings of a minimum of 50% fuel.

For thermal applications, the technology has been well proven and gasifier systems are already working in the field. The capacity installed so far covers a wide range of applications at different capacities. The gasifier range is from 30 $kW_{(t)}$ to 500 $kW_{(t)}$.

Gasifier designs

The gasifier is essentially a chemical reactor, where several thermo-chemical processes such as pyrolysis, combustion, and reduction take place. Depending on the movement of gases relative to the fuel bed, the various gasifier designs can be classified as updraft, down-draft and cross-draft gasifiers. Traditional down-draft gasifiers had throats or choke plates in order to reduce the tar content of the gases, but throat-less designs are limited. Advanced designs such as fluidized bed systems, high-pressure gasifiers, or designs with tar recycling are yet to be perfected. Gasifier designs are usually fuel specific, with the fuel type, moisture content, ash content, fuel pellet size, etc. affecting the performance. Certain biomass fuels such as rice husk have the tendency to form slag at high temperatures, and hence may require very different designs.

Advantages of gasification

Conversion of solid biomass into combustible gas offers all the advantages associated with using gaseous and liquid fuels such as clean combustion, compact burning equipment, high thermal efficiency, and a good degree of control. In locations where biomass is already available at reasonable low prices (e.g. rice mills, coffee/corn processing units, sugar mills, etc.) or in applications utilizing fuelwood (e.g. institutional cooking, silk reeling units, etc), gasifier systems offer definite economic advantages. These are made especially attractive with the incentives offered by the MNES (Ministry of Non-conventional Energy Sources) at present.

Advantages of using producer gas

- Reduces firewood consumption by at least 50% in many large stoves
- Saves LPG in large-scale cooking
- Saves LDO (Light diesel oil) and furnace oil in boiler applications
- Replaces up to 80% of diesel oil in diesel generator sets operated in dual fuel mode

Application of the technology

✦ **Steam generation**

Small-sized "baby boilers" are used at present in many small industries like food processing industries.

- Boilers can be retrofitted easily to burn producer gas
- Installation of gasifier can replace inefficient wood/ biomass burning boilers, if the user does not want to change to efficient boilers.
- Users of LDO and furnace oils can shift to firewood /wood waste briquettes at specific sites where biomass is available at low cost

✦ **Institutional/large-scale cooking**

- Fuelwood is presently used in large quantities for cooking in hostels, hospitals, hotels, marriage parties, and sweet shops
- Thermal efficiency of large stoves using firewood is often low (approximately 10%) and necessitates the use of large quantities of firewood
- Use of gasifier reduces fuelwood consumption by about 50%, similar to what is possible with changes to efficient stoves.
- Power delivered can be varied over a large range making cooking faster
- Depending on the availability of biomass and space, LPG users can shift to firewood/biomass briquettes

✦ **Silk reeling industry**

Large cottage basin units for silk reeling in south India use large quantities of firewood

- Thermal efficiencies of cottage basin ovens are often very low (10%–14%)
- Use of gasifiers can reduce firewood consumption by 50%, similar to the effect of conversion to efficient boilers
- Clean flue gas obtained by burning producer gas can be used for drying of pupae (silkworm)
- Producer gas can also be used for stifling of cocoons to kill pupae

✦ **Crematoriums**

- Currently, about 400 kg of fuelwood is required for every cremation
- Annually about 2.44 million tonnes of fuelwood is consumed
- Pollution of rivers like the Ganga and the Yamuna along the banks of which dead bodies are burnt:
- air pollution due to large quantities of biomass usage
- water pollution due to throwing of under-burnt bodies into the rivers
- Gasifiers can reduce fuel consumption drastically
- Gasifiers would be sentimentally acceptable alternatives for cremation, as the body is burnt in flames
- Gasifiers can alleviate pollution problems to a large extent

✦ **Drying**

- Present methods of drying cash crops like cardamom, tea, and areca nut using firewood are very inefficient
- Usage of gasifiers can reduce fuel consumption by at least 50%
- Flue gases obtained by burning producer gas can be used either directly or indirectly (by employing a compact plate-fin heat exchanger) for drying or curing of various items including fruits, vegetable, fish, and other food products.

✦ **Power generation**

▪ Producer gas can be cleaned to a high degree (approximately 50 mg/Nm^3 tar/dust with simple equipment

▪ Existing diesel engine sets can be easily converted to operate on dual (diesel + producer gas) fuel mode

Diesel replacement possible up to 80%, even with large variation of load.

CHAPTER

ENERGY AND POVERTY

The challenge of making renewable energies accessible and affordable for sustainable development and poverty alleviation is recognized. An enormous amount of work is yet to be done. The current state of informed opinion concerning energy and poverty has been summarized by many agencies and a new consensus has emerged:

- Approximately two billion people do not have access to “modern” forms of energy such as electricity, and liquid fuels.
- “Modern” forms of energy are a necessary input for economic development and the elimination of poverty. The substitution of inanimate energy for human energy has proven to be an essential element in removing drudgery, and increasing well-being. But improved forms of energy are not sufficient conditions for development. Many ‘complementary inputs’ are also required including “end-use” technology to convert energy into useful outputs such as illumination, milling, pumping, transport, communications.
- Conventional modern forms of energy (fossil fuels, and electricity) will remain the fuel of first choice for many poor people for many years to come, while traditional biomass fuels will remain the main fuel of necessity.
- Biomass fuels are not always “renewable” as sometimes they are harvested renewably and sometimes “mined” destructively.
- Poor people need energy for many tasks (lighting, cooking, mechanical power, heating and cooling, communication) and they require multiple fuels (electricity is not enough). Women and children usually form the majority of poor people in any community; and women are usually major users and suppliers of energy resources in marginalized communities.
- Poor people already pay cash for improved energy services particularly for the convenience of electric lighting and radios. Beyond this, the additional income to pay for modern energy services will usually be associated with investment in sustainable (profitable) and productive energy end use activities.

- The fuels and technology traditionally available to poor people results in very low energy conversion efficiency. However this efficiency can be improved both domestically and in commercial and institutional uses through changes in technology.
- The energy supply sectors of many developing countries are in the process of being restructured to attract private capital. This poses both a threat and an opportunity for poor people. As energy supplies are delivered on a more commercial basis, their availability to reduce. However “un-packaging” energy supply systems opens up opportunities for the private sector to supply energy services to poor people who would do not have access under current arrangements.
- Funds from tax revenues, aid agencies and charities are unlikely to be able to provide energy services directly to any but the smallest fraction of poor people. This means that market mechanisms will have to provide the finance for improved energy services, but their extent and effectiveness will have to be massively expanded to meet current unmet needs and the needs of growing populations.
- The State has a vital role to play in providing the "enabling environment" that is necessary for the private sector to supply improved energy services to poor people. Subsidies (including aid) may well be essential, but they need to be applied with great care so that they may make markets rather than destroy them.

ENERGY, POVERTY AND GENDER

Gender analysis of poverty is not so much about whether women suffer more from poverty than men, but rather about how gender differentiates the social processes leading to poverty, and the escape routes out of destitution. An understanding of the causal processes leading to poverty has important policy implications: it raises questions about whether it can be assumed, as is often done, that the kinds of policies that can strengthen the position of poor men will have much the same impact on poor women.

Current efforts in gender and energy:

Over the last two decades, gender issues have attained increased prominence in the debate on sustainable energy development. International programs, such as ENERGIA, UNDP, and Winrock, are helping to bring critical issues of gender equality and efficiency to the table (see Annex 1). Policy researchers and development practitioners have begun building a body of evidence and experience that links attention to gender in energy policy and projects to equitable, efficient and sustainable outcomes in development. Despite these developments, the importance of bringing a gender perspective to energy policy analysis and design is still not widely understood, nor have the lessons for development been fully integrated by donors or national policy makers. While many are sympathetic, gender is still commonly viewed predominantly as a political agenda and given this, not central to questions of efficiency or project effectiveness. Current efforts on gender and energy focus on:

- Building up a body of evidence and experience linking attention to gender in energy policy and projects to equitable, efficient and sustainable outcomes in energy and development;
- Advocacy in national and international arenas on the importance of bringing a gender Perspective to policy analysis and design;

- Capacity building and assistance to energy programs, policy and projects in integrating a gender perspective; and
- Creating networks and institutions at the national, regional and international levels to support these efforts.

There has been virtual exclusion of women's needs. Traditional energy policies have inadequately addressed the role of energy as an input to development and have largely ignored the critical role women play in energy systems, particularly in rural areas. Insufficient access to modern energy and existing patterns of energy use, processing, and collection affect women and men differently. Concerns about gender and energy arise out of the recognition that men and women have different roles, activities and responsibilities in society determined on the basis of their sex. Although ''gender'' is about men *and* women, much of the discussion concerning gender and energy tends to focus on women because in most rural and many poor urban households, energy supply as well as its utilization for domestic purposes, like cooking is women's responsibility; and hence it is the women who carry the heaviest burdens because of energy poverty. Men also suffer from energy poverty, but the resulting hardships, drudgery and diminished opportunities are generally greater for women. Also, in most developing countries, the largest energy programmes are aimed at rural electrification but implicit in these programmes and policies is the assumption that the benefits of electricity are gender neutral. Clearly this is not the case; women use energy quite differently from men. Electrification saves women's time and labor, improves their health, and potentially provides income and security. Potential contributions of women in energy have also been ignored till now.

Women need opportunities to speak for themselves about what they want. However, the set up in energy institutions is primarily male dominated. More females are needed in energy management in order to establish good connections with community women. Although, merely increasing the number of women professionals do not ensure genderised outcome. They need a clear mandate. Overall, male energy planners and policy-makers need to be sensitized to gender issues so that they can understand and support special measures designed to encourage women's participation in the design and implementation of energy policies.

Why Gender and Energy in India?

This question makes sense in the light of the precaution that can be observed in India with respect to energy services, the unbalance between men and women in the access, use, and control of resources, and the general poverty level. While in India the main source of energy still is based in fossil fuels and biomass, structural adjustments of the energy sector in these countries aim to re-articulate themselves in the global demands of privatization, without addressing need for access to energy of the poor parts of the population. Women face this situation with a biased perspective since when compared to men, for them there are additional barriers of a social, political, economical and cultural type, that impede that the process of development will unfold itself in terms of equality. Only on a few occasions, do they find themselves in positions that allow participation in decision making with respect to programmes or projects in the field of energy, while generally in rural areas women are the ones dedicating their time to collecting fuel wood to prepare food for all the family, making them the main consumers of household energy.

The gender perspective seeks not only to involve more women in development projects but also aims to even existing inequities in social relationships through actions that take into account women's disadvantaged situation. It has been realized that energy projects that are sensitive to gender and engage a wider participation of women and men, are not only more efficient and sustainable, but can also support women and men's social empowerment providing the necessary tools for improving their quality of life. This is why efforts are directed to mainstream the gender perspective in institutional policies.

We need to develop gender sensitive indicators to measure quantitative and qualitative progress of gender equity in projects in India.

Purpose of a gender approach in energy planning:
Understanding of how women should be involved in development has evolved over time. Current preference is to think not in terms of special or separate programmes for women, but in terms of gender. There are still a number of different positions, however, that can be taken regarding the reason for and purpose of a gender approach in energy planning.

CHAPTER-6

NATIONAL RENEWABLE ENERGY POLICY- AND IMPLEMENTATION STRATEGIES IN INDIA

The government is keen on increasing the share of RE in country’s installed power generation capacity by an additional 10% or 12,000 MW by 2012. A draft of the RE policy statement has been submitted by MNES for approval. In effect, around one tenth of the 120,000 MW expansion in energy generation capacity planned for the country by the Central Electricity Authority (CEA) for the 11th plan (2007-2012) is expected to come from the RE sector. As a part of the long-term vision, this Policy Statement seeks to set out the major application areas and near term targets for the period up to the end of the Eleventh Five Year Plan, in the year 2012. The major application areas are:

- Minimum rural energy needs
- Decentralized energy supply for agriculture, industry, commercial and household sector in rural and urban areas
- Grid quality power generation and supply

In formulating the goals and the strategies for these application, major objectives are to: enhance the diversity and security of energy supplies through the optimum utilization of indigenous resources; promote private-sector participation and competitiveness; enhance the substitution of fossil fuels and augmentation of energy supply, support local and global environmental protection; facilitate enhanced local participation, specially of women and NGOs; and generate employment, particularly in rural areas.

The medium-term goals, up to the end of the eleventh Five Year Plan in 2012, envisage coverage of 30 million households through improved chulhas; setting up of additional 3 million family size biogas plants; deployment of 5 million solar lanterns and 2 million solar home lighting systems; electrification by renewables of at least one quarter of the 18,000 villages that could not be electrified through conventional means; deployment of solar water heating systems in one million homes; and contribution by renewable of at least 10% of the new power capacity addition projected for the period up to 2012.

NEW POLICY THRUST TO RENEWABLE IN INDIA

India's energy scenario calls for the effective management of all available resources in order to attain national objectives. A well-balanced fuel mix, in which all energy resources are appropriately utilized, is essential for sustainable development. A lot still remains to be done if renewables are to be brought within the ambit of national energy planning processes. The cornerstone of our policy to promote renewables will have to be the conservation of our finite fossil fuels resources, principally coal and oil, and exploitation of our abundant natural, non-depletable resources, such as hydro, solar, wind and biomass. Such a pathway is also environmentally benign, allows equitable use of our resources, and is sustainable.

The Government, therefore, envisions a central role for renewables in the energy sector during this century. It is anticipated that about 100,000 MW of electricity supply to the grid could be sourced competitively from renewables at that time. Within this long-term vision, a goal of adding from renewables about 12,000 MW, or 10% of the incremental power generating capacity, is envisaged in the medium-term, for the period up to the year 2012. It is also expected that about 4,500 villages, or 25% of the 18,000 villages not considered economically viable for extension of grid electricity, would get electrified through renewables by that year.

It is recognized that accelerated renewable energy development and diffusion in the country would require a coordinated strategy and approach that stimulates markets and private capital mobilization through policies that provide renewable energy with a level playing field; selective and targeted investments for provision of minimum energy needs and in the development of human resources, technologies and indigenous production capacity; and, provision of direct and indirect incentives to promote commercialization and market development. The aim would be to promote the competitive delivery of renewable energy services, and attract enhanced investments, both domestic and foreign, to this sector. Balanced development could create up to one million jobs in manufacturing and entrepreneurship towards installation, maintenance and servicing. Priority would need to be accorded within each application area to mature products that are close to commercialization, and emphasis given to product development with a view to improve efficiency and reliability, and reduce costs. Renewed thrust would have to be accorded to R&D to keep pace with international technological trends and market requirements. Effective implementation of the strategy and achievement of the goals would be crucially dependent on the creation of a suitably supportive enabling environment encompassing the following dimensions: -

- Technology Development and Deployment
- Quality Assurance
- Fiscal and Promotional Incentives
- Credit Infrastructure
- Legislative and Regulatory Support
- Human Resources Development
- Institutional Development

Strategic legislative and regulatory support is critical for accelerated development of renewable energy based power generation. Accordingly, the existing electricity legislation would need to be reviewed and suitably amended to incorporate the following proposals:-

States would be encouraged to integrate renewables as a supply side option in their power development programmes. The functions of the State Electricity Regulatory Commissions to explicitly provide for the determination of a prescribed minimum quantity of energy generated from renewable sources within the overall purchase plans of transmission and distribution utilities.

- Decentralized/ off-grid generation and distribution of electricity not to be constrained by intrusive regulation.
- Guidelines to State Electricity Regulatory Commissions (SERCs) for incorporating 'preferential' prices for renewables based on the avoided cost of negative externalities associated with fossil-fuel-based generation of electricity.
- Wheeling and banking for grid connected power projects to be encouraged to accelerate commercialization and stimulate investments.
- Model agreements and contracts for purchase and sale of renewable based electricity to be prepared to secure timely revenue streams.

Increasing commercialization of the renewable energy sector will create additional demand on capital. Budgetary resources will be insufficient to meet the investment requirements of an accelerated programme. New means of mobilization of resources, careful targeting and restructuring of subsidies will be required to generate additional resources and make effective use of them. A National Renewable Energy Fund (NREF) could be established by charging a cess, in the form of a `sustainability tax', in the coal and hydrocarbon sectors. The Fund could be utilized to support proposed preferential prices for renewables and for providing interest subsidy, where required, through the credit infrastructure.

A new thrust is being given to consolidate the progress made so far in India, remove constraints, bottlenecks for accelerated utilization and venture in new directions across the entire spectrum of renewable energy, with special emphasis on generation of grid quality power. In order to take a long term view, and to realise the full potential of renewables, a Renewable Energy Policy Statement is being formulated to put in place an appropriate policy, institutional, financial and technical framework for accelerated development of renewables in the country. Having already achieved a leadership position, India has the potential to truly emerge as a major global player in this sector in the coming decades.

ENERGY BUDGET ALLOCATION & FOREIGN EXCHANGE REQUIREMENTS

The plan-wise budget allocation during the plans and different ministries in the total budget outlay is given below in table 9.The share of total energy in the plan expenditure is increasing in all the plans indicates the need and development of the sector.

Table 9: Plan expenditure (million rupees) and the share of total energy

Plan expenditure (million rupees) and share of total energy

Five year plan	Plan expenditure	Total energy
First(1951-56)	19,600	3,861.2 (19.7%)
Second (1956-61)	46,700	3,310.8 (12.4%)
Third (1961-66)	85,800	15,873.0 (18.5%)
Fourth (1969-74)	157,800	33,453.6 (21.2%)
Fifth (1974-79)	394,300	99,363.6 (25.2%)
Sixth (1980-85)	1,092,900	307,104.9 (28.1%)
Seventh(1985-90)	2,202,200	621,020.4 (28.2%)
Eighth (1992-97)	4,341,000	1,150,365.0 (26.5%)
Ninth Plan (1997-02)	8,592,000	2,223,750.0 (25.9%)
Tenth Plan (2002 -07)	15,256,390	4,039,270.0 (26.5%)

An expenditure at current prices at the base year of the respective plans.

c Outlay
d data obtained from Economic Survey 2003/04

Note
Figures in parentheses are percentages

Sources
New Delhi; Planning Commission, Government of India.
New Delhi; Planning Commission, Government of India.

India is emerging as a large importer of crude and is planning to import LNG during the Tenth Plan period as per evaluation of composition of our trade account. If the present trend continues, India's oil import dependency is likely to grow beyond the current level of 70 per cent. The estimates regarding the percentage share of POL and coke, coal and briquettes shown **in table 10** and also the Imports (thousand tonnes) of crude oil and petroleum products: 1990/91 to 2003/04 **in table 11.**

Table 10: Imports of Pol, Coke, coal and Briquettes in total imports
% Share in total imports

	2000-2001	**20001-02 (April-Oct)**	**2002-03 (April-Oct)**	**2003-04 (April-Feb)**
POL	32.8*	29.3	29.9	26.7
Coke, Coal & Briquettes	2.2*	2.1	2.00	1.8

*weights have been worked out on the basis of value on (2000-01) (April-Oct)
**Source: Economic Survey

To reduce the dependency the future strategies should focus on increasing exploration activities to enhance the level of recoverable reserves of the country. The country is not self-sufficient in oil and oil products. As a result, the import dependence of the country for oil has been increasing over time. In addition to POL imports, there have been imports of superior quality coal for use in the steel industry.

CHAPTER-7

POVETY ALLEVATION THROUH RENEBWABLE ENERGY IN INDIA

Energy-poverty linkages

Poverty is multi-dimensional. In a wider sense, it is deprivation, which may be traced to five interrelated clusters of disadvantages: physical weakness (lack of strength, under-nutrition, ill health, disability, high ratio of dependants to active adults); isolation (physical remoteness, ignorance, lack of access to information or knowledge); income poverty (lack of income and wealth); vulnerability (increased exposure to contingencies, danger of becoming more deprived); and powerlessness (inability to cope, adapt, and choose). Energy in itself is a near basic human need depending on its use in a given place and has enormous potential in addressing poverty in its many dimensions.

Energy projects can contribute to poverty reduction at the macro and micro levels with their impact being apparent at the supply end or at the point of consumption. *Energy poverty linkages at the point of energy supply:* At the macro level, energy projects contribute to poverty alleviation primarily through resource savings on account of energy efficiency gains, forex savings/earnings and increase in tax revenues due to employment. These resources can be invested in poverty alleviation programmes. Projects that promote efficiency in energy supply may also lower the price of energy, making it more affordable. Backward linkages of energy development (iron and steel, transport etc.) will also induce economic growth. However, for such benefits to flow to the poor, appropriate pro-poor policies and strategies need to be in place. At the project site, there will be a direct impact on poverty through employment created during the construction and operation of the project. Those in the vicinity of the project will feel the environmental (e.g. air pollution) and social (e.g. displacement of people from project site) impact.

Energy poverty linkages at the point of consumption

Projects that provide access to energy, increase its reliability, and/or improve its affordability can result in poverty alleviation at a micro level. There are four major consumers of energy: households, agriculture, industry/commercial, and transport. Each of these sectors depends on energy for a variety of uses, and energy consumption in these sectors can in turn, impact poverty in many ways as discussed below. At a macro level, energy consumption indirectly impacts on poverty through the trickle-down effects of energy-induced growth.

ENERGY CONSUMPTION IN HOUSEHOLDS

Households use energy for a variety of purposes: cooking, lighting, water heating, and space conditioning. The provision of superior energy sources such as electricity and LPG, has important economic and social implications because they have significant monetary and non-monetary benefits compared to traditional fuels. The rural poor spend considerable time collecting fuel wood: as deforestation increases the distance travelled to gather fuelwood is progressively increasing. Providing the rural poor with modern forms of energy would therefore, also contribute to arresting forest degradation. Apart from increasing the time spent on collection, fuelwood shortages induce households to adopt different kinds of coping strategies: households may be compelled to substitute fuelwood with inferior biomass fuels which lead to increased air pollution, and increased tending time or they may cook less often. Damage to health associated with the use of traditional fuels has important gender and long-term implications with women and young children being the most affected due to their predominant role in the collection and combustion of traditional fuels. The incidence of disease has obvious economic implications in terms of reduced productivity and increased expenditure treatment.

Being connected to electricity makes it possible for the poor to spend longer hours studying or employed in other activities that can contribute to their capabilities. Energy is also an important input in the provision of such social infrastructure as street lighting, piped water, television, and better-equipped hospitals and schools.

ENERGY CONSUMPTION IN AGRICULTURE

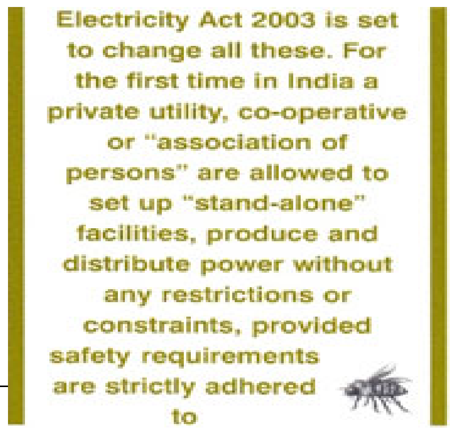
Agriculture is the main source of livelihood for most people in the rural areas of developing countries. The sector's dependence on energy has risen rapidly as agricultural activities have become modernized and mechanized. Direct uses of energy range from land preparation, sowing, irrigation, fertilizer application, harvesting, and transport to agro industries. Energy in agriculture can contribute to poverty reduction directly in at least three ways. It may reduce the cost of energy by making available cheaper, more efficient and convenient options such as electricity, thereby benefiting farmers dependent on groundwater. Second, it may augment farm income through an increase in the gross cropped area either due to an increase in cropping intensity or area (net) under cultivation. Third, farm employment may increase as the gross cropped area goes up. Thus, the landed poor and also the landless benefit as employment opportunities increase. The growth of agro-based industries in rural areas would also create employment opportunities.

ENERGY CONSUMPTION IN INDUSTRY

The industrial sector is the largest consumer of energy; it is the basic input. Providing energy in an energy-deficient area can thus promote industrial growth by encouraging new industries or allowing enhanced capacity utilization in existing industries. This will lead to the creation of employment opportunities in the area and also set off a multiplier effect on output and employment throughout the economy. At the same time, however, as the scale and spread of industrial activity rises, environmental risks may get aggravated in the absence of appropriate safeguards**.**

Rural energy- state of the art

Lack of access to affordable energy contributes in a major way to the relatively low- income levels and poor quality of life in India's rural areas. Rural people need energy for lighting, cooking, and to some extent space heating, especially in very cold and mountainous region in the domestic sector; for water lifting and



transportation in agriculture; and in small and medium enterprises.

Rural households account for 75 percent of the total energy consumed. Biomass fuels provide 85-90 percent of the domestic energy. Cooking is the largest energy consuming end-use, and accounts for nearly 90 percent of the household energy. Lighting and space heating consume the rest. Biomass (wood, animal dung, crop residue) is used in outdated, inefficient cook-stoves (with only 10 per cent efficiency), while inefficient devices fuelled by kerosene are used for lighting.

In 2001, India's rural areas consumed 180 million tonnes of fuelwood. Considering that only a third of households even in electrified villages have electricity connections, it is estimated that there are 70-80 million households in the country that are not served by grid electricity. These homes are totally dependent on kerosene for lighting. An unreliable power supply, even to electrified homes, compels villagers to use kerosene lamps.

The agriculture sector comes next. Three activities in the sector account for most of the energy used: land preparation, harvesting, and irrigation (water lifting and transportation). Animate energy (human and draught power) caters to over one-third of the total energy consumed.

An estimated 16 million electric and 6 million diesel pumps are currently being operated in the agriculture sector of the country. Diesel oil and electricity are the major sources of energy for irrigation, with the estimated consumption for each being 8 MMT and 127 TWh, respectively, in 2001-2002. The share of oil and electricity in the final energy consumption of the agricultural sector has increased steadily over the years. It now accounts for 30 percent of the overall demand for electric power, mostly for water lifting, which is provided by the erratic grid power supply interspersed by human and animal power. Poor quality and insufficient power supply reduces the efficiency of the electric pumps, affecting agricultural yield.

Inefficiency in the small-scale industry in rural India is a major reason behind high energy consumption and high levels of pollutants generated at the source, which leaves adverse effects on the environment. The overall consumption of energy is low when compared to the rest of the energy requirement in the rural sector. The small enterprises sector is an important engine of the economy, stimulating the development of technical skills and providing employment to the local population.

Rural industries such as small-scale foundries and brick kilns are energy-intensive and use fuel wood to fulfill their energy requirements. Cottage enterprises draw from the grid where it is available, but benefits are restricted owing to poor connectivity.

Since a large number of rural settlements are geographically scattered, they consume very small quantities of electricity. Extending the grid, therefore, may not be viable, while energy generation using local, renewable resources will be. Decentralized energy production and distribution may also provide opportunities for rural development and encourage local institutions to manage their own energy needs. Interventions that harness renewable sources such as the sun, wind, water, and geothermal energy can facilitate energy access in off-grid areas, and improve the quality of life, benefit the economy, and reduce environmental stress. Renewable energy technologies have applications in all fields that affect rural life, and can be used effectively to complement the main grid or on a stand-alone basis for energy generation.

New Paradigms in Rural Electrification

There is a shortfall of about 15,000-20,000 MW of electricity in the country. India requires about 140,000 MW of additional capacity by 2010 with an estimated outlay of Rs 55,000 million. Shortage of electricity affects the overall growth of the economy. But, with any problems in the national grid, rural areas are affected the most, as state utilities give priority to urban areas. Rural consumers are given a lower priority because of the subsidy syndrome!

Electricity Act 2003 is set to change all these. For the first time in India a private utility, cooperative or "association of persons" are allowed to set up "stand-alone" facilities, produce and distribute power without any restrictions or constraints, provided safety requirements are strictly adhered to. Under the Act:

- No license is needed for "stand-alone generation and distribution of power" in rural areas.
- Connectivity can be taken from the main grid to facilitate excess power utilization and availability during shortages.
- Convergence for operations is possible: electricity distribution/cable networking/internet/ telecom.

Information communication technology (IT) can be used to transform the energy scenario in villages, provided an appropriate system is designed, put together and implemented.

National Electricity Policy

Electricity Act 2003 paves the way for introducing IT in villages and provides for a policy regime. Acting under the provisions of Section 3 of the Act, the Central government notified the National Electricity Policy on February 12, 2005. The main objectives of the policy are given below:

- Provide access to electricity for all households by 2010.
- Make power available on demand by 2012. Overcome energy and peaking shortages and make available five percent spinning reserve.
- Supply reliable and quality power of specified standards in an efficient manner and at reasonable rates.
- Increase per capita availability of electricity to over 1,000 units by 2012.
- Set a minimum lifeline consumption of 1 unit/household/day as a merit good by year 2012.
- Create a role for panchayats, local authorities, NGOs and other franchisees in the operation and maintenance, and cost recovery by rural utilities through appropriate arrangements.

Institutional Framework

Some time ago, the Rural Electricity Supply Technology (REST) mission was set up in the Ministry of Power. The goal of this mission is to accelerate the completion of electrification of all villages by 2007 and all households by 2012 through technology options, innovative financing, and grassroots institutional arrangements to provide affordable and reliable power supply to

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rural areas and effecting implementation through distributed generation.

The objectives of the REST mission are to:

- Identify technology and feasible size of fuel generating units locally available.
- Adopt technologies for setting up a local distribution network.
- Access the funds required
- Promote cost-effective technologies and methodologies.
- Plan and formulate schemes for adoption and implementation

The Program Base

The recently launched RGGVY provides the programme base for rural electrification. Under the RGGVY, projects could be financed with the Government of India capital subsidy for provision of:

- Rural Electricity Distribution Backbone (REDB) of 33/11 kV (or 66/11 kV) sub-stations of adequate capacity and lines in blocks where these do not exist.
- Creation of Village Electrification Infrastructure (VEI): that is electrification of un-electrified villages, un-electrified habitations, and provision of distribution transformers of appropriate capacity in electrified villages/habitation(s).
- Decentralized Distributed Generation (DDG) and supply for villages where grid connectivity is either not feasible or not cost-effective, provided it is not covered under the program of the Ministry of Non-Conventional Energy Sources (MNES) for providing electricity from alternative energy sources under their remote village electrification program of 25,000 villages.

REDB, VEI and DDG would cater to the requirement of agriculture and other activities including irrigation pump-sets, small and medium industries, Khadi and Village Industries (KVI), cold chains, healthcare, education and IT. According to the architects of the Yojana (planning) this would facilitate overall rural development, employment generation and poverty alleviation.

In the management of rural distribution, NGOs, users associations, cooperatives or individual entrepreneurs, and Panchayati Raj Institutions (PRI) would be associated. The "franchisees" arrangement could be introduced for a system beyond and including feeders from substation or from and including distribution transformer(s).

Business Plan for Rural Electrification

The RGGVY, however, seems to be more like another fund-and-figure government scheme backed by a high level of subsidy to be administered by a consortium of Central Government’s public undertakings led by the Rural Electrification Corporation (REC). The only added feature is the provision for franchisees for managing rural distribution.

A business plan for rural electrification should make it sustainable and commercially viable in the long run. Only then investments can be attracted. What we are looking at is not just powering a few bulbs and pumps in villages but the dynamic growth and diversification of the rural economy that "depends critically on the easy availability of reliable power."

A rural electrification business plan should be structured on investment models built around "stand-alone" facilities as envisaged in the Electricity Act. Such a model would design a "stand-alone product/service module;" can/survey to assess demand profile and select potential villages/village clusters for establishing the module; work out a pricing strategy appropriate to the village/cluster; identify technology and feasible sizes of generating units based on locally available fuel/renewable source; establish a strategy for "hybrid" generation mix; and prepare a detailed project report (DPR) for decentralized generation/distribution and implementation.

A rural energy system (RES) that would comprise reconfigured district energy utilities (DEU) would host this business model. These small utilities would involve PRI and local entities in key roles including communication, awareness/support building, managing key and related functions such as distribution, delivery, metering, meter reading, billing and collection and water accessing. The "stand-alone module" would be used to generate power and distribute electricity in a specified area without connecting to the grid as part of the rural distribution network. This business model would attract substantial investment.

Renewable energy would be at the core of such a business model. PRIs would provide the political base, REC the programme base and the distribution utilities the operation/market base. Expertise of professionals, the private sector and NGOs should be liberally drawn upon for this purpose. Energy and the Irrigation Management Transfer Mechanism could be an effective tool for achieving linkages and the much-needed people's participation.

Enterprise-cum-Investment Opportunities

Rural electrification as an engine of *Bharat Nirman* cannot come about through mere government schemes, however well-intentioned they may be.

Investment opportunities in the RES under the above model are significant on account of the following factors:

- Ambitious targets for installed capacity adopted by the government for the Energy Plan 2012.
- Vast un-served or poorly served populations willing to spend money on quality and reliable energy services.
- Hundreds of thousands of "stand-alone" DG facilities to be established in villages that have been declared "electrified" and those yet to see electricity.
- The 12,000 MW target for renewable energy set for year 2012.
- Global clean climate initiatives announced by many developed countries and most RES investments being eligible for carbon credit under CDM

These physical targets and potentials translate themselves into an investment need of several billion dollars over the next 10 years.

The key to the success of the RES initiatives under the Electricity Act and the REST mission are the Rural Electricity Supply Provider (RESP) and Technology Provider. RESP could be enterprises/cooperatives owned and operated by consumers through rural franchisees/NGOs/ panchayats or an independent power producer with generation facilities for sale to the "captive users" or private entrepreneurs/corporate entities. The technology provider would be a key player involved in selecting the technology options, the local RESP, training and imparting skills to handle the generation and distribution system, preparation of the DPR, facilitate/assist in arranging funds, selection of area of operation, billing and collection management, and to monitor recoveries.

- Investment-oriented;
- Sustainable and commercially viable;

- Enterprise-driven;
- Technology-friendly;
- Capable of generating jobs on an incremental basis;
- Inclusive; and
- A part of a growth strategy aimed at abating poverty and advancing prosperity.

The plan and the model suggested in this article fulfill all these requirements and can make rural electrification a true catalyst for rural development. Corporate endeavors such as ITC's 'e-Choupal' have demonstrated that models and modules envisaged above could be structured and sustained on a long-term basis.

A vast number of small, medium and micro enterprises that would start under this business plan would need mentoring and incubation as RESP and technology providers. This task is cut out for donor agencies and corporates who can contribute to revolutionizing the rural economy and pave the way for Bharat Nirman by participating in the "growth strategy for rural India, which is home to 72 percent of the Indian population and 75 percent of its poor."

It is in facilitating this task the Government of India should address itself with the active involvement of state governments, PRIs, donor agencies, the corporate sector and NGOs.

Case study: Poverty and Energy in Pura Village

Pura village in Kunigal taluk in the state of Karnataka, India, was one of the earliest villages to be studied exhaustively for its energy consumption patterns (Ravindranath et al., 1979; ASTRA, 1982; UNDP, 1995). In 1977, it had a population of 357 in 56 households who consumed about 3000kWh of electricity per day for the following activities:

- Agricultural operations (with ragi which is a minor millet & rice as the main crops),
- Domestic activities (grazing livestock, cooking, gathering fuel-wood and fetching water for domestic use, particularly drinking),
- Lighting, and
- Industry (pottery, flour mill, and coffee shop).

The sources of energy for these activities were fuelwood, human beings, kerosene, bullocks, and electricity, in the order of energy derived. Energy derived from fuelwood dominated the source set (89%) and domestic activities out-ranked all the others (91%) in terms of energy used. Several features of the patterns of energy consumption in Pura are significant (Batliwala, 1995):

- What is conventionally referred to as *commercial* energy (i.e., kerosene and electricity in the case of Pura) accounted for a mere 3 per cent of the inanimate energy used in the village, with the remaining 97 per cent coming from fuelwood. Further, fuelwood must be viewed as a *non-commercial* source, since only about 4 per cent of the total fuelwood requirement of Pura was purchased as a commodity, with the rest gathered at zero private cost.

- *Animate* sources (human beings and bullocks) only accounted for about 8 per cent of the total energy, but the real significance of this contribution is revealed by the fact that these animate sources represented 77 per cent of the energy used in Pura's agriculture. In fact, this percentage would have been much higher were it not for the operation of four electrical pump-sets in Pura, which accounted for 23 per cent of the total agricultural energy.

- Virtually all of Pura's energy consumption came from traditional renewable sources - thus, agriculture was largely based on human beings and bullocks, and domestic cooking utilized 19 per cent of the human energy and 80 per cent of the total inanimate energy (entirely fuelwood).
- This pattern of dependence on renewable resources, although environmentally sound, was achieved at an exorbitant price: levels of agricultural productivity were low, and large amounts of human energy were spent on fuelwood gathering (on the average, about two to six hours spent travelling four to eight kilometres per day per family to collect about 10 kilograms fuelwood).
- Fetching water for domestic consumption also utilized a great deal of human energy (an average of one to five hours travelling up to six kilometers per day per household) to achieve an extremely low *per capita* water consumption of 17 liters per day.
- Of the human energy for domestic activities, 46 per cent was spent on grazing livestock (5 to 8 hours/day/household), a crucial source of supplementary household income.
- Women provided the major part of human labour (53 per cent), especially in gathering fuel (42 per cent), fetching water (80 per cent), grazing livestock (15 per cent), and agriculture (44 per cent). Their labour contributions were vital to the survival of families, a point now well established in the global literature, but still neglected by planners and policy-makers.
- Similarly, children contributed a crucial share of the labour for gathering fuelwood (25 per cent), fetching water (14 per cent), and grazing livestock (33 per cent). The critical importance of children's labour contributions in poor households has significant implications for population and education policies and programmes - but again, largely ignored.
- Only 25 per cent of the houses in the "electrified" village of Pura had domestic connections for electric lighting; the remaining 75 per cent depended on kerosene lamps, and of these lamps, three quarters were open-wick type.
- A very small amount of electricity (30 kWh/day), flowed into Pura, and even this was distributed in a highly in-egalitarian way- 65 per cent going to the four irrigation pump-sets of three landowners, 28 per cent to illuminate 14 out of 56 houses, and the remaining 7 per cent to a single flour-mill owner.

Since the Pura study, many studies of rural energy consumption patterns have been conducted in developing countries (e.g., Barnett et al., 1982; Nkonoki and Sorenson, 1984; Smith, 1986). The specific numbers vary, depending upon region, agro-climatic zone, proximity to forests, availability of crop residues, prevalent cropping pattern, etc., but the broad features of Pura's energy consumption pattern outlined here were generally validated.

CHAPTER-8

ENERGY CONSERVATION

Introduction:

Energy conservation has received attention in India since the mid 70s. The impact of energy conservation efforts are felt at a very low pace as the commercial energy consumption per capita is low in the country and efficient end use devices are costly. Recent rapid increase in energy demand, mainly in the industrial and the service sectors has created a renewed awareness about the economic advantage of energy conservation.

Structural changes in the economy has led to expansion of the industrial base in the country, and subsequently the increase in demand for energy. Electricity generation sector has not expanded at a desirable level. This has also supported a renewed effort on energy conservation.

The energy conservation efforts in India have to be viewed in terms of coal and lignite being the long-term sustainable local energy resources. Small resources of petroleum and natural gas will be exhausted shortly and in the medium and long-term the import of oil will increase. The shortage of energy and increasing tariff trends, dictates that every socially responsible individuals should conserve energy as much as possible. That will in turn reduce the load on National Utility Services as well as the economic burden. This effort required are:

Public awareness on energy types,
Utilization Methods,
Source of wastage,
Maintenance procedure,
Change of habits, and
Replacement of inefficient gadgets

Energy Policy

India follows an energy policy which is divided into short term, medium term and long term measures. These can be summarized as follows:

Short term

- maximize returns from the assets already created in the energy sector.
- initiate measures for reducing technical losses in production, transportation and end-use of all forms of energy.
- initiate action to reduce the energy intensity of the different consuming sectors of the economy and promote conservation and demand management through appropriate organizational and fiscal measures.
- initiate steps for meeting fully the basic energy needs of the rural and urban households, so as to reduce the existing inequities in energy use.
- maximize satisfaction of demand for energy from indigenous resources.

Medium-Term

- initiate steps towards progressive substitution of petroleum products by coal, lignite, natural gas and electricity so as to restrict the quantum of oil imports to the 1991 level.
- initiate action for accelerated development of all renewable energy resources, especially the available hydro-electric potential.
- promote programmes to achieve self-reliance in the energy sector.
- initiate appropriate organizational changes in the case of different energy sub-sectors consistent with the overall energy strategy.

Long-Term

- promote an energy supply system based largely on renewable sources of energy
- promote technologies of production, transportation and end-use of energy that are environmentally benign and cost effective.

These policy elements were built on the hypothesis that foreign and private investments would be forthcoming at desired levels. As lack of procedures to fulfill accountability norms have resulted in poor response from investors, the performance is not in conformity with the laid down policy.

The efforts are made to educate individuals to conserve energy and thereby help the country at large.

Different Energy Sources

- Common Energy sources used in a home are:
- Electricity
- Liquid petroleum gas
- Kerosene
- Coal (Nowadays Coal usage by Individuals is negligible)

The Environment

House is a fixed factor in energy consumption. A properly designed house would provide ample light in the daytime and thus energy consumption for light in daytime would be near zero. By using proper material for construction and the right direction of windows, Energy requirement for Air-conditioning (cooling) and heating can be reduced drastically. Solar energy can be used in the design to either keep the house cool in summer/or Heat in winter.

In India, generally houses are not designed to be Energy efficient - if so it is rather accidental than a well-focused design concept. One cannot change the house design drastically after building. However if one is planning to purchase a house or relocate a house, one can look for energy efficient design.

If one is planning for constructing a house, he has the freedom to design energy efficient house, in consultation with Energy Experts.

Certain gadgets like Water Tank Level indicators really help not only to save electricity but also help to avoid water wastage (overflow) by blind pumping. These gadgets really help to save energy and give indication and timely warning about water availability.

The wastage Factors

- Insulation
- Faulty wiring
- Over rated heating gadgets
- Improper fittings
- Wrong placement
- Negligence in usage
- Wrong habits
- Improper usage
- Improper ventilation
- Negligence toward maintenance

Locating and Saving Energy losses

Locating the source of wastage will help us to plug the wastage and find alternatives and corrective action required

Electricity Usage

- Lighting is the most common use of electricity. Lighting contributes to about 20 to 25 % of electricity consumption in a household.
- Air Conditioning could contribute 40 to 70% of consumption in a household in summer months.
- Water heating in winter for taking bath could contribute to 30 to 40% of consumption.
- Room heating using electric room heater could contribute 30 to 50% of electric consumption in winter
- Well designed Refrigerator consumes around 10%
- Television is responsible for about 5% of electric consumption.
- Less than 5 to 15% of consumption is from other gadgets like Press for ironing and other miscellaneous gadgets
- The percentage of consumption share depends on life style and family size and number of hours utilized in each function.
- Especially in the Air-conditioned Rooms, It is a good idea to use double glass properly fitted window. The window cost may double but in the long run energy saving would make it economical. Doors of good insulating material are recommended. There should be no leaks through doors and windows.
- If a new house being constructed, hollow bricks may be used. One can consider insulating walls by using double walled insulating material.
- Choose the proper colour to obtain maximum reflection or absorption of heat energy. Surface finish can be designed to obtain proper reflection/absorption characteristics. Using properly design fan and humidity control may reduce number of hours/days Air-conditioning needs to be used in summer.
- Think and adopt methods to reduce volume of the living room. This will result in saving energy, as the requirement of energy will be reduced both in summer and winter.

Saving Energy in Kitchen

Kitchen is the center of cooking activity-requiring energy for all activities.

- Utensils like Kadhai (deep frying pan) and Tawa (plat or very shallow pan for making Indian bread) get deposits due repeated use of oil, giving them a layer of bad conductor. This results in gas wastage. The deposits need to be removed regularly.
- Use proper size of burner. A right utensil for the right job saves gas usage. Utensils with flat bottom get heated faster but are not suitable for deep frying.
- Switching on gas when not required and leaving it on with utensil on gas waiting for vegetable to be cut etc. would result in gas waste. Moreover, cooking excess quantities of food than required, results in the consumption of excess energy.
- The use of refrigeration to save the food from getting spoiled should be avoided, as ultimately a major percentage of this excess old food goes to dustbin, after consuming considerable amount of energy.
- Leaving the water tap open or opening the tap more than required with full force results in water and energy wastage as the water has to be pumped using 'Electric Energy'.
- Using 'Pressure Cooker' or cooking under pressure by closing the lid of utensil saves considerable energy and time.
- Exhaust fan in the kitchen if too big would create vacuumed in the kitchen resulting in cool air to be sucked in from outside and flow over cooking utensils on the gas, delay in delivering heat within utensil.
- Pre-heating of oven should be avoided to save energy.

Liquid Petroleum Gas

- At present Liquid Petroleum Gas (LPG), which is bottled liquefied natural gas is exclusively used in Kitchen in India for cooking. Today it is the most economical fuel. An average family uses one gas cylinder of 14.5 Kg per month.
- The use of Liquid Petroleum Gas (LPG), being comparatively clean and convenient fuel, can be extended to water heating, running generators at home and also as a stand by power supply system.

Saving Energy in Bathrooms

- Washing machine should be used with full load should be used, as less energy is consumed with one full load than two half load- this will also save time.
- Using shower requires less water and less hot water, which could result in big saving.
- Lots of energy could go wasted through leaking hot water tap.
- Generally pipes from storage heater to taps go through wall. In winter the wall becomes cold and lot of energy gets wasted while water is getting delivered through such pipes. Pipes should be insulted and should be fixed closer to the water heater.
- Another aspect of storage heater is while the hot water is drawn, cold water fills the tank cooling the hot water. While 25 liters water may be heated to say 80 degree Celsius, but a bucket of 25 liters when filled may be 50 to 60 degree Celsius or less depending on temperature of inlet water. The solution may lie in using pre-heated water from solar heater or simply use an instant heater as it does not store much water. Energy is not wasted in heating excess water. Hot Water should be drawn when needed and not in advance as the water would cool down fast in winter.
- The best choice in low-flow shower heads is one with a temporary shut-off button that allows for turning off the water while lathering up without having to readjust the temperature when the water is again turned on.

- Turn off the water while shampooing or soaping up. Use a brush or washcloth to get rid of stubborn dirt quickly.
- Whenever water is heated, the loss of heat depends on area of surface exposed to air, the conductivity of vessel and also the difference between water temperature and atmosphere temperature. 35% of energy is last through walls in case of Air conditioning and heating and 25% through roof. Only 45% of energy is utilized in that case.

House Wiring and Lights

- House electric wiring should be fault free, equipped with proper fuse and over load protection. The wire rating should be at least twice the load otherwise the wires carrying current will become hot and lose energy and would be in danger of catching fire and may result in short circuit.
- The consumption by way of lighting though not very high is a common function and is required through out the year as bare minimum for today’s norms of the society. Therefore the cumulative effect could be substantial.
- Areas not used can be lighted with lower wattage bulbs to save the energy. Gadgets like TV should be switched off when not being watched. Many new technologies are coming up for lightning before using and investing on them, one must calculate their economy. Some times it is not possible to recover the additional cost in the life time of the lightning gadget.
- CFL lamps of appropriate wattage are good solution at this stage.
- Using electronic regulators instead of resistance type may save energy.

Maintenance & Safety

- Keep the electric wiring in good health change any wire getting hot. Use good quality of plugs and sockets to avoided loose contact. Clean bulbs and tube lights regularly as the dust deposited over them can cut out as much as 50% of light.
- Leaking pipes especially hot water pipes and fault taps need to be attended urgently. Water leakage from flush could empty the overhead tank in few hours.
- The geyser should be cleaned every year to remove salt and scaling. Scaling and deposits result in delayed heating and energy wastage.

Using more efficient gadgets

A Sure way of reducing the wastage is to use more efficient gadgets especially like Air - Conditioner, Water heater, TV and light bulbs.

Tips for Using Refrigerator/Freezer

- The refrigerator temperature should be set between 36 and 40 degrees Fahrenheit, and the freezer temperature should not be lower than 0 degrees Fahrenheit.
- The refrigerator doors should be opened as seldom as possible and should be closes quickly after placing of keeping the things. Do not remove and keep putting things with the door open for more than required time. When telephone bill rings close the fridge before attending to the call.
- Cool the foods to room temperature before placing them in the refrigerator unless otherwise noted in the recipe. But don't leave food out so long at room temperature to

avoid growing of salmonella, botulism or other nasty food poison. Don't leave food out on for longer than 30 minutes.

- Defrost the manually-operated switch refrigerators when the frost is ¼ inch thick.
- If the second refrigerator in the house is not needed for some time, then unplug it and have the door removed.
- The condenser coils should be kept clean.
- The freezer portion should be kept full. This will help in retaining cold air when opening and closing the door. The freezer works more efficiently when full than when nearly empty. Therefore, plastic containers like old milk jugs with water in them may be placed in the freezer to take up empty space.
- It should be ensured that foods are covered before putting them in the refrigerator. Otherwise the moisture in them will evaporate, making the refrigerator use more energy.
- It should be ensured that everything is taken out the first time while opening the freezer door. This will help to eliminate unnecessary door openings.

Range/Oven

- Only use pots and pans that fit the heating units.
- Use a flat bottom pan with a tight fitting lid.
- Don't preheat the oven unless the recipe calls for it.
- You do not always have to preheat when you are broiling.
- Use a timer and try to avoid opening the oven door before the food is done.
- Plan meals ahead so that several foods can be cooked at one time.
- Use a pressure cooker, instead of oven- it can save energy and shorten cooking time.

Microwave

- Microwave may be used when reheating leftovers, for saving energy.
- Microwave may be used to thaw out foods when time does not permit natural thawing.
- Microwave oven may be used in place of the conventional oven whenever possible in the summer because the microwave does not heat up the kitchen.

Easy Cooking Tips

Some easy energy-saving tips in the kitchen are given below:

- "Smaller is better". Smaller pans need less energy to heat up. Smaller ovens use less energy than larger ones.
- The pan size should match the size of the element on the electric cook-top.
- It should be ensured that the pan covers the burner without going more than an inch beyond it.
- If a burner is larger than the pan, one not only pays to heat but also the pan and at the same time the air over the uncovered part of the burner, leading to inefficiency.
- Microwaves use less energy than full-size ovens.
- Cleaning those metal burner pans under the burners and keeping them bright and shiny, will enable to reflect the heat better back up to the pan.
- The pots should be kept covered when ever they can be and the water will boil faster.

- Using the least amount of water will take less time and energy to bring it to a boil. Keeping the lowest possible heat setting to let the water boiling, steaming, simmering, or whatever recipe calls for will result in conservation of energy.
- If an electric cook-top is used, the burner should be turned off right before finishing cooking. The heat of the switched-off burner could be used while it continues to cools down and releases the heat.
- The flame on the gas burner should be blue, as a yellow flame means the gas is not burning efficiently. In such case, either the burners should be self-cleaned or the gas company should be called or checking the fault and rectification.
- Frozen food should be defrosted after taking out from refrigerator before cooking; either by just running it under the warm water until its ready or inside the microwave oven.
- The oven should be pre-heat in the minimum amount of time. In fact, while breads and pastries need a preheated oven other foods may not.
- After turning on the oven light it should be looked through the window in the door instead of opening the door to check if the food is done. Every time the oven door is opened the temperature comes down and the food takes longer to cook and the heat is wasted. For the same reason, peaking under the lids on the stove-top should be avoided.
- The foil should not be placed on the racks or block the flow of air in the oven any other way. To keep that air flowing, pans should be staggered on the upper and lower racks if more than one pan is used at a time.
- The food should not be overcooked. This can be done by setting the timer and if cooking meat then it is advisable to use a 'Meat Thermometer'.
- If self-cleaning feature you are going to used on the oven, this feature should be started right after the food or something else is cooked so the oven starts out already hot. However, it should not be used more than once a month and the ventilation fan is on when cleaning the oven is undertaken.
- The microwave will work more efficiently if the inside surfaces are clean.
- Only microwave-safe serving dishes should be used for cooking, and not any other dishes inside the microwave for cooking.

Energy Audit

- The energy audit can be done by self or by taking the help of an electric engineer. As a first step, a chart is made of all gadgets including bulbs etc along with the wattage. As a second step, the time for their utilization in a day is noted down. After this, the wattage and time in hours are multiply to get individual Kilowatt hour used by an individual item. The total consumption of the day can be ascertained by adding Kilowatt hour used by each item for any household or office or industry.
- Gadgets with auto cut-outs like geyser, air-conditioners, ovens etc, consume energy during the time these gadgets are in use and not the time for which they remained on.
- If scientific and more accurate study are required then it advisable to ask a qualified technician or consultant to do the 'Energy Audit"

CHAPTER-9

BIO-DIESEL

INTRODUCTION:

The global oil price has crossed $ 60 a barrel at a time (2004-05) when demand for crude oil exceeds 125 million metric tonnes (mmt) that India needs to feed the economy. These makes every one extremely vulnerable to the vagaries of the of the global oil market. There is immediate need to embark on initiatives to scrutinize energy sources. Energy alternative is needed to power the nations growing need. The data for past five years indicates that the gap between domestic supply and demand of crude oil has been increasing. This has lead to an increase in crude oil import burden. India consumes about nine mmt of petrol and 47 mmt of diesel and the crude oil import bill in the region being Rs. 1,10,000 crore.(11 billion)

Diesel forms the biggest chunk (35 percent) of total petroleum product consumption in India. The Table 1 indicates the sector– wise consumption of diesel.

Table1.

	SECTOR	**DIESEL (TRANSPORT FUEL) CONSUMPTION**
1	Road Transport & Agriculture	73-75%
2	Railways	4-5%
3.	Manufacturing industry (captive power generation) & power utilities	13-14%
4	Other end uses	5%

(Source: Fuelling India's Growth-Vision 2030, PetroFed Publication)

Secondly about 70% of India's population lives in villages, a majority of which has practically remained outside the reach of the economic development that has transformed lifestyles of a small segment of urban population to the levels comparable to developed countries. Majority of population in rural areas doesn't have adequate income generating opportunities, and also, either do not have access to adequate energy for their livelihood or have to rely on polluting energy sources to the detriment of the environment, and to their own social and economic development. Scarcity of energy for productive and income generating activities has perpetuated poverty in rural areas, kept villages under developed, resulting in exodus of youth to slums in metropolises. Even in the so-called 'electrified villages', 70% of the rural households have no access to electricity since they cannot afford to pay for connectivity from the poles. The rest 30%, who have been connected to the grid, also suffer due to bad quality as well as chronic shortages of electricity, which at times can be just 4 to 6 hrs in the night when they may not need it.

The challenge therefore is to provide affordable, reliable and quality energy in the rural areas, especially for income generating activities, which can transform the life of the poor. One solution to this challenge is to shift the energy paradigm away from centralized fossil-fuelled power plants towards clean and cost-effective solutions based on decentralized renewable energy sources available locally. Oil from plants such as Pongamia and Jatropha, that can run diesel engines to provide power for a range of income generating activities such as rice milling, water pumping, operation of agricultural equipments and transport, is one such energy that holds the key to such a transformation, either in the form of bio-oil or bio-diesel, seen as great future possibility for India. Using this clean renewable energy technology in place of fossil fuels also eliminates carbon dioxide emissions, the main source of global warming. It is advocated country–wide that bio-fuels are more competitive mainly due to the surge in oil prices.

Bio-diesel is an eco-friendly, alternative diesel fuel prepared from domestic renewable resources i.e. vegetable oils (edible or non- edible oil) and animal fats. These natural oils and fats are made up mainly of triglycerides. These triglycerides show striking similarity to petroleum derived diesel and are called "Bio-diesel".

India's Initiative

Conscious of the advantages, Government of India (GoI) is now working towards evolving a national policy on Bio-fuels as environmentally friendly energy source and reduce dependence on import of diesel. The Government has launched an ambitious programme to blend fossil Diesel with Bio-Diesel in the coming years. To implement GoI targets and policies, several government-owned bodies, research organizations and petro-product companies are working with farmers and entrepreneurs to cultivate/ collect oil seeds, extract oil and produce Bio-diesel. Jatropha has been identified as the ideal plant for production of Bio-diesel and large-scale farming is being encouraged across the country. In this effort, some of the Indian NGOs, especially with strong grass-roots base or linkages have staring promoting bio-oil crops, mainly the cultivation of Jatropha crop with the active participation of local farmers.

A National Mission on Bio-diesel was launched in April 2003 based on the recommendations of the Planning Commission of India.

- Jatropha Curcas ("Jatropha") was identified as the energy crop that could be grown in over 5 million hectares of waste lands across India.
- By the year 2006, all diesel sold was to be blended with 2.6 million tonnes of Bio-diesel[5].
- The Bio-diesel production target for the year 2012, is 13 million tonnes to blend 20% of all diesel.
- Specific wasteland and forest regions have been identified to cultivate Jatropha.

Realizing the urgency and a great need for the producing Bio-diesel in adequate quantities the Govt. of India has constituted National Oil Seed & Vegetable Oil Development (NOVOD) who have been continuously working towards goal since inception.

(5) [5] A substitute for Diesel, based on vegetable oils

State-wise area undertaken by NOVOD for Jatropha Plantation

State	Area (hectare)
Andhra Pradesh	44
Bihar	10
Chhatisgarh	190
Gujarat	240
Haryana	140
Karnataka	80
Madhya Pradesh	260
Maharashtra	150
Mizoram	20
Rajasthan	275
Tamil Nadu	60
Uttaranchal	50
Uttar Pradesh	200

Economics (as per Planning Commission Report on Bio-fuels, 2003):

ACTIVITIES	Rate (Rs/ Kg)	Quantity (Kg)	Cost (Rs)
SEED	5.00	3.28	16.40
Cost of collection & oil extraction	2.36	1.05	2.48
Less cake produced	1.00	2.23	(-)2.23
Trans-etherification	6.67	1.00	6.67
Less cost of glycerin produced	40 to 60	0.095	(-) 3.8 to 5.7
Cost of Bio-diesel per kg			19.52 to 17.62
Cost of Bio-diesel per liter (Sp. Gravity 0.85)			19.52 to 14.98

National Oilseed and Vegetable Oil Development Board (NOVOD) are making the following efforts in the areas of bio-fuels:

- Systematic state/region wise survey for identification of superior trees and superior seeds.
- Maintenance of record on seeds/trees. Samples of high yield to be sent to National Bureau of Plant Genetic Resources (NBPGR) for accession and cryo-preservation.

NOVOD has also developed improved Jatropha seeds, which have oil contents up to 1.5 times of ordinary seeds. However, being in short supply, initially these improved Jatropha seeds would be supplied only to Agricultural Universities for multiplication and development. After multiplication these would be supplied to different states for further cultivation. This programme is likely to take 3- 4 years. It is also working for development of multi-purpose post-harvest technology tools like- decorticator and de-huller, which would further improve oil recovery.

Technical Feasibility

Technology for use of oils as bio-fuels to power diesel engines is old and well proven. It gained momentum world over due to increasing environmental concerns related to fossil fuels with several initiatives in EU and US countries to increase use of bio-diesel (name given to vegetable oils that are processed and used to substitute diesel). Although a variety of oils are being considered as diesel substitutes in EU and US programmes, the focus in India is on non-edible oils due to high demand for and price of edible oils. Several varieties of oil-bearing seed trees are found in India but experts have zeroed in on to a few species for producing oil. This includes **Pongamia, Jatropa, Mahua and Neem.**

Although there are over 20 different types of oil seeds that could be used to produce Bio Diesel, of which several already grow in the wild abundantly, Government prefers cultivation of Jatropha, one major reason being its potential for rural employment and wasteland farming.

Although technology is well proven and demonstrated, access to credit is still a major problem for the rural poor, who otherwise could turn into entrepreneurs raising plantations, setting up oil extraction facilities, generating power and running small-scale industries in villages. Although India has a well developed rural banking infrastructure, the link between the renewable energy and banking sectors is yet to be consolidated. Banks still perceive lending to this sector risky.

Sources of Bio-diesel

All trees bearing oil (TBO) seeds, both edible and non-edible have the potential to be a source of bio-diesel. Among edible oils seeds Soya-bean, Sunflower and Mustard oil etc are source of bio-diesel. Edible seeds can't be used for bio-diesel production in the country, as its indigenous production does not meet India’s current demand. Thus, India would focus on non edible oils like Jatropha Curcas, Pongemia Pinnata, Neem etc. Among non-edible TBO, Jatropha Curcas has been identified as the most suitable seed for India.

The reasons for Jatropha Curcas as the most suitable Tree Borne Oilseed (TBO) for production of bio-diesel in India, both in view of the non-edible oil available from it and its presence throughout the country. The capacity of Jatropha Curcas to rehabilitate degraded or dry lands, from which the poor mostly derive their sustenance, by improving land's water retention capacity, makes it additionally suitable for up-gradation of land resources. Presently, in some Indian villages, farmers are extracting oil from Jatropha. After settling and decanting it they are mixing the filtered oil with diesel fuel. So far the farmers have not observed any damage to their machinery.

The oil needs to be converted to bio-diesel through a chemical reaction- trans-esterification. This reaction is relatively simple and does not require any exotic material. IOC (R&D) has been using a laboratory scale plant of 100 kg/day capacity for trans-esterification; designing of larger capacity plants is in the offing. These large plants are useful for centralized production of bio-diesel. Production of bio-diesel in smaller plants of capacity e.g. 5 to 20 kg/day may also be started at decentralized level in villages.

Employment potential (as per Planning Commission report on bio-fuels, 2003)

Likely demand of petro diesel by 2006-07 will be 52 MMT and by 2011-12 it will increase to 67 MMT. By 2011-12, for 20% blend with Petro-diesel, the likely demand for bio-diesel would be 13.4 MMT. To meet the requirement of 2.6 MMT of bio-diesel, plantation of Jatropha would have to be done on 2.2- 2.6 million ha area. The 11.2- 13.4 million ha of land should be covered by 2011- 12 for 20% bio-diesel blending. It will generate following number of jobs in the following areas.

Traditionally tribals and women collect seeds from the forest and dry lands and they could get more income by collecting the seeds.

Year	No. of jobs in plantation	In maintenance	Operation of BD units
2006-07	2.5 million	0.75 million	0.10 million
2011-12	13.0 million	3.9 million	0.30 million

Agencies & Institutes working in the field of bio-diesel

- National Oil seeds and Vegetable Oil Board, Gurgaon
- PCRA- Petroleum Conservation Research Association (MOP&NG)
- IOC (R&D) Centre, Faridabad
- Delhi College of Engineering
- Indian Institute of Technology, Delhi
- Indian Institute of Petroleum, Dehradun

- Downstream National Oil Companies
- Indian Institute of Chemical Technology, Hyderabad
- Center for Science and Industrial Research
- Ministry of Non-Conventional Energy Sources
- Central Pollution Control Board
- Bureau of Indian Standards
- Indian Renewable Energy Development Agency
- Environment Protection Training & Research Institute– Hyderabad

States, which have made some lead in India:

Uttaranchal: Uttaranchal Bio-fuel Board (UBB) has been constituted as a nodal agency for bio-diesel promotion in the state. The board has undertaken Jatropha plantation in an area of 1 lakh hectare. UBB has established Jatropha Gene Bank to preserve high yielding seed varieties and plans to produce 100 million liters of bio-diesel.

Andhra Pradesh: Government of Andhra Pradesh (GoAP) has encouraged Jatropha plantation in 10 rain shadow districts of AP. Task force for it has been constituted at district and state level. GoAP proposed Jatropha cultivation in 15 lakh (1.5 million) acres in next 4 years. Initial target is 2 lakh (200,000) acres. Irrigation is to be dovetailed with Jatropha cultivation. 90% drip subsidy is proposed. Jatropha cultivation is to be taken up only in cultivable lands with existing farmers. Crop and yield insurance is proposed.

Chhattisgarh: In the state 6 lakh (600,000) saplings of Jatropha have been planted with the involvement of State's Forest, Agriculture, Panchayat and Rural Development Departments. As per the Deputy Chairman, State Planning Board, the state has the target to cover 1 million hectare of land under Jatropha plantation. Ten reputed bio-diesel companies, including the UK-based D1 Oils, have offered to set up Jatropha oil-extraction units and to buy the produce from farmers in Chhattisgarh. Companies like Indian Oil, Indian Railways and Hindustan Petroleum have each deposited Rs. 10 lakh (1 million) as security for future MoUs with the state government.

Haryana: Farmers in Haryana have formed NGOs and cooperatives for promotion of Jatropha plantation. These NGOs and cooperatives are raising nurseries for Jatropha plantation and supplying saplings to others for further cultivation. They have been blending directly Jatropha Oil into diesel fuel and successfully using this blend in their tractors and diesel engines without any problems. These NGOs and cooperatives are also organizing the practical demonstration of this usage in their demonstration workshops. They are organizing local seminars, workshops and conferences etc. to promote the usage of Jatropha oil. NGOs have also printed some booklets on Jatropha plantation.

Current usages and trails of bio-diesel in India

1. Shatabadi Express was run on 5% blend of bio-diesel from Delhi to Amritsar on 31st December 2002 in association with IOC.
2. Field trials of 10% bio-diesel blend were also done on Lucknow-Allahabad Jan Shatabdi Express.
3. HPCL is also carrying out field trials in association with BEST.
4. Bio-Diesel blend from IOC (R&D) is being used in buses in Mumbai as well as in Rewari, in Haryana on trial basis.

5. CSIR and Daimler Chrysler have jointly undertaken a successful 5,000 km trial run of Mercedes cars using bio-diesel as fuel.
6. NOVOD has initiated test run by blending 10% bio diesel in collaboration with IIT, Delhi in Tata Sumo & Swaraj Mazda vehicles.

Need for Government intervention: Rural populations are yet to benefit from this promising technology, which has tremendous potential to make a significant contribution to the economic well being of people. In fact, this technology combines two important objectives of governments and international donors- providing income generating opportunities to the poor and access to clean energy (including electricity) with a view to reduce emissions and improve the environment.

Progressive Government policies and enabling regulatory and business environment can encourage farming and post-harvest activities around the production of Bio Diesel. Government controls use of forest resources, viz. collection of oil seeds from trees situated in forest areas. Further, present regulatory controls over use of chemicals such as Methanol need to be relaxed in order to facilitate establishment of trans-esterification plants[6]. Government's involvement will increase the commitments of other stakeholders and catalyze the development of the Bio Diesel industry.

(6) [6] SVO has to be trans esterified to produce Bio Diesel

CONCLUSIONS

Several policies as suggested by the Indian Planning Commission to steer the energy sector onwards development goals (some of which are already in place and others need to be facilitated) include:

- **Building a regulatory framework** that would lay a road map for restructuring/deregulating the energy sector allowing for competitive forces to determine prices and permit open access to all the players;
- **Accelerating the exploration of hydrocarbons**;
- **Rationalizing duty structure** to encourage efficient refining, marketing, and distribution system;
- **Assessing the infrastructure support**– viz., raw materials, power, transportation including port facilities, construction facilities, etc. – in the light of possible production capacities in other public/private sectors that would be required for implementation of development plans;
- **Suggesting measures for progressive improvement** of products standards to ensure cleaner and greener environment;
- **Evolving policy measures** for energy conservation measures through the demand-side management;
- **Suggesting suitable measures for effecting improvement** in the formulation of coal and lignite projects, and minimizing time and cost over-runs in their implementation;
- **Suggesting measures for effective implementation of environmental management plans**;
- **Evolving appropriate policies and institutional arrangements** by which power generated by non-utility/captive plants could be optimally utilized;
- **Exploring avenues for tapping the potential for renewables in India** as an alternative fuel option to alleviate energy security concerns.

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ANNEXURE

Annex 1: India's TPEP and TPEC, 1990-2002 (in Quads)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
TPEP	6.82	7.16	7.33	7.49	8.00	9.48	8.75	9.17	9.37	9.59	9.81	10.21	10.41
TPEC	8.02	8.39	8.86	9.24	9.97	11.49	11.15	11.76	12.17	12.74	13.48	13.84	13.98

Source: DOE/EIA

Annex 2: Petroleum Production and Consumption in India, 1990-2002 (in thousand b/d)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Production (total)*	682	639	602	578	651	770	751	780	761	765	770	782	819
Production (Crude Oil only)	660	615	561	534	590	704	651	675	661	653	646	642	665
Consumption	1,168	1,190	1,275	1,311	1,413	1,575	1,681	1,766	1,844	2,031	2,127	2,184	2,185

* includes crude oil, natural gas plant liquids, other liquids, and refinery processing gain
Source: DOE/EIA

Annex 3: Dry Natural Gas Production and Consumption in India, 1990-2002 (in tcf)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Production	0.40	0.45	0.48	0.53	0.59	0.63	0.70	0.72	0.76	0.75	0.79	0.85	0.88
Consumption	0.40	0.45	0.48	0.53	0.59	0.63	0.70	0.72	0.76	0.75	0.79	0.85	0.88

note: "dry" gas means gas with condensates removed
Source: DOE/EIA

Annex 4: Coal Production and Consumption in India, 1990-2002 (in millions of short tons)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Production	247.6	269.9	279.5	288.1	300.8	320.6	314.9	338.1	343.1	356.3	368.9	385.2	392.6
Anthracite	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Bituminous	*232.0*	*252.3*	*262.1*	*269.8*	*279.5*	*296.2*	*290.0*	*312.6*	*317.5*	*331.5*	*342.2*	*357.8*	*367.9*
Lignite	*15.6*	*17.6*	*17.4*	*18.3*	*21.3*	*24.4*	*24.8*	*25.4*	*25.5*	*24.8*	*26.7*	*27.4*	*24.7*
Consumption	255.8	270.5	283.0	294.1	313.6	331.9	332.2	358.5	362.9	375.4	405.0	413.9	420.6

n/a - not applicable
note: components may not add to total due to rounding
Source: DOE/EIA

Annex 6: Estimated Energy Demand*As per planning commission estimates:

Primary Fuel Unit Demand (in Original Units) Demand (MTOE)

mt: Million Tonnes; BCM: Billion Cubic Meter; Bkwh: Billion kilo watt hour

Primary Fuel	Unit	Demand (in Original Units)		Demand (MTOE)	
		2006-07	**2011-12**	**2006-07**	**2011-12**
Coal	mt	460.50	620.00	190.00	254.93
Lignite	mt	57.79	81.54	15.51	22.05
Oil	mt	134.50	172.47	144.58	185.40
Natural gas	BCM	47.45	64.00	42.70	57.60
Hydro Power	BKwh	148.08	215.66	12.73	18.54
Nuclear Power	BKwh	23.15	54.74	6.04	14.16
Wind Power	BKwh	4.00	11.62	0.35	1.00
Total Commercial Energy				411.91	553.68
Non-Commercial Energy				151.30	170.25
Total Energy Demand				563.21	723.93