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Energy Consumption and Distribution

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ABSTRACT : *For as long as the global economy continues to operate on the basis of the limited energy and material supplies, its future prospects will be bleak. There are two incontrovertible reasons for this. Firstly, supply of fossil and mineral resources are limited; and secondly, the processes in which these resources are used inevitably also overstretch, damage and even destroy those limited planetary resources on which our lives depend: water, land and atmosphere. With respect to energy consumption, this second reason has become literally a burning issue.*

The fundamental economic reality of fossil fuels is that such fuels are found only in a relatively small number of locations across the globe, yet are consumed everywhere. The economic reality, by contrast, is that solar resources are available, in varying degrees, all over the world. Fossil fuel and solar resource use are thus poles apart – not just because of the environmental effects, but also because of the fundamentally different economical, logical and differing political, social and cultural consequences. These differences must be acknowledged if the full spectrum of opportunity for solar resources is to be exploited.

Therefore, this study concentrates on solar power as a renewable source of energy. It has many benefits compared to fossil fuels. It is clean and green, non-polluting and everlasting energy. For this reason it has attracted more attention than other alternative sources of energy in recent years. Many energy economists say that solar energy is going to play an increasingly important role in all our lives. To highlight the importance of such a source of energy becomes not only important but also inevitable.

Keywords: *Energy, power, Distribution, Consumption, Solar Power*

I. INTRODUCTION

Energy is a key infrastructure, which is the backbone and prime mover of the economic development of any country because it is required for all the sectors of economy which include agriculture, industries, service, information and technology, transport and others. Economic growth too is driven by energy in the form of finite resources such as coal, oil and gas or in renewable forms such as solar, hydro, wind and biomass, or its converted form, electricity.

Modern economists believe that an index of energy could be used as an index of capital because in "economic parlance, energy caters both to the direct consumption and the production of goods: as consumer goods, their consumption tends to vary with changes in income and consumer preferences; as an input in production, their availability and increasing quantities are a sine qua non of rising national income" [1].

Therefore, the availability of quality power in the required quantity is one of the most important determinants in the success of the country's development [2]. In addition providing adequate and affordable electric power is essential for economic development, human welfare and higher standard of living. India being a developing country with increasing population makes power the critical infrastructure. Hence, the study needs to know the real picture of power sector performance and its challenges therefore; power scenario of India has been examined.

II. REVIEW OF LITERATURE

There are divergent opinions regarding the application of energy as well as renewable source of energy. Accordingly different persons including scientists, technocrats, economists etc. view it from multiple angles. It is in this background, an attempt has been made to review the literature to understand the varied perspectives on conventional energy scenario, power development and its present position, renewable energy in general terms and solar energy in particular.

Anjaiah (2007) has highlighted in his intra-regional analysis, some economic issues pertaining to disparities in infrastructural facilities among the Indian states and union territories. But the infrastructure has wide spectrum such as roads and buildings, transport, tele-communication, power supply, banking and insurance services etc. Therefore, he has made an attempt to concentrate on power (electricity) issues such as production, supply and demand shortages and some other issues among the States. He has pointed out the reasons for the disparities among regions which is worth attention [3].

Vandana S. (2002) has stated that the conventional energy sources of the world like coal and petroleum are dwindling fast. Energy crisis have made us aware that and our total dependence on only one form of energy is not a wise step. The author has felt the need to tap additional sources of energy, to sustain satisfactory growth rate of our country. And she has mentioned that the ultimate solution of the energy crisis will be through the discovery of methods of harnessing the non –conventional energy sources. The extraction and utilization of non-conventional energy will not only help in meeting energy demands, but also help in their development [4].

Narasaiah M.L (2004) has focused on energy demand and supply of future in India. He has mentioned that the growing climate concerns would require massive reductions in fossil fuel use at the time when demand for energy is soaring. A shift to renewable energy sources such as solar energy and wind power holds great promise for meeting future energy demands without adverse ecological consequence, as per the author [5].

Chinnammai & Sasikala (2008) have, in their paper, highlighted the increasing energy pattern in India, characteristics of the energy in rural and urban areas, its impact on women, the various solar energy appliances available and

have empirically found out that solar energy can enhance the role of women. They have also forwarded various possible approaches to facilitate the sustenance of solar energy in India. By reaping the benefits of using solar energy appliances the increasing energy pattern, characteristics of household energy in rural and urban areas, its impact on women [6].

The Times of India (2008) has discussed Eco-friendly solar signals to direct traffic in Delhi which is now looking at installing solar-powered traffic signals at major intersections in the city. With this, traffic jams caused by signals rendered non-functional due to power failure or heavy rain may soon become a thing of the past. The traffic police are also installing inverters for back up at major points. The technology is expensive – and maintenance is high. With right research and development in this field experts feel that a futuristic technology, solarization, is an efficient means [7].

III. METHODOLOGY

The present study is empirical, based on secondary sources of data. The framework of the analysis has been constructed from the data collected through secondary sources. Secondary data, regarding net availability of power, distribution of power supply under state and all-India level have been collected from administrative reports, planning commission reports, books etc. These data have been used to highlight and substantiate the theoretical aspects of the solar power distribution. An attempt has been made to focus on the solar power sector growth and distribution in India.

IV. OBJECTIVES OF THE STUDY

To study the real picture of power sector performance and its challenges and
To analyse power scenario in India.

V. RESULT AND DISCUSSION

1.1 Indian Scenario

India is both a major energy producer and a consumer. India currently ranks as the world's seventh largest energy producer, accounting for about 2.49 percent of the world's total annual energy production. It is also the world's fifth largest energy consumer, accounting for about 3.45 percent of the world's total annual energy consumption in 2004. Since independence, the country has seen significant expansion in the total energy use with a shift from non-commercial to commercial sources. The share of commercial energy in total primary energy consumption rose from 59.7 percent in 1980-81 to 72.6 percent in 2006-07.

Table: 1 Demand and Supply of Primary Energy in India (In Mtoe #)

	1960-61	**1970-71**	**1980-81**	**1990-91**	**2000-01**	**2006-07**	**2011-12**
Domestic production of Commercial Energy	36.78	47.67	75.19	150.01	207.08	259.56	435
Demand of Commercial Energy	42.82	60.33	99.82	181.08	296.11	390.93	546
Non-Commercial Energy	74.38	86.72	108.48	122.07	136.64	147.56	169
Total Primary Energy Demand	117.20	147.05	208.30	303.15	432.75	538.49	715
Net Imports	**6.04**	**12.66**	**24.63**	**31.07**	**89.03**	**131.37**	**111**

Source: Planning commission Government of India'2008 Note: # Mtoe = million tonne of oil equivalen

i. Domestic production of commercial energy includes coal, lignite, oil, natural gas, hydro power, nuclear power and wind power.
ii. Net imports include coal, oil and LNG imports.

It must be noted, however, that India's per capita energy consumption is one of the lowest in the world. India consumed 455 kgoe per person of primary energy in 2003, which is around 26 percent of world average of 1750 Kgoe in that year. As compared to this, per capita energy consumption in China and Brazil was 1147 Kgoe and 1232 Kgoe, respectively [8].

Table: 1 shows the trend of primary energy demand and supply between 1960-61 and 2006-07 and projected requirement for 2011-12. While total primary energy demand registered 117.20 million tonne of oil equivalent (Mtoe) in 1960-61, it increased to 538.49 Mtoe during 2006-07. It has been projected to increase to 715 Mtoe in 2011-12. From the table it is observed that the net imports is on the rise; it can be inferred that India is not self sufficient in meeting our country's total energy demands.

The demand for energy, particularly for commercial energy, has been growing rapidly with the growth of the economy, changes in the demographic structure, rising urbanization, socio-economic development, and the desire for attaining and sustaining self-reliance in some sectors of the economy. The demand for commercial energy has increased to 390.93 mtoe during the period 1960-61 to 2006-07, it is projected to further the increase to 54.6 mtoe in 2011- 12. Non-

commercial energy resources include the traditional fuels such as wood; cow dung, crop residue, and biogas constitute a significant quantity of total primary energy demand. A large share of this fuel is used by the households, particularly in rural areas, for meeting their cooking and heating needs.

The consumption of 147.56 Mtoe of non-commercial energy in 2006-07 includes consumption of fuel wood, dung, and agricultural waste. It is projected to be at 169 Mtoe in 2011-12. From the table it is observed that there is a constant increase in demand for primary energy. Pattern of consumption also disturbs the power sector scenario; sudden increase in one sector's consumption level affects another sector. Nowadays domestic sector consumption of power is ever increasing due to increasing standard of living, increase in population and impact of globalization on social, economic and cultural stages of development. The next section has analyzed the distribution of consumption pattern of electricity in India. Table 2 indicates that consumption pattern of power by domestic, commercial, industry, railway traction, agriculture and others. The total utilization of power by industry has come down from 58.4 percent in 1980-81 to 45 percent in 1990-91. It further declined to 34 percent in 2000-01. There could be various reasons for this declining consumption of power. Many industries have switched to alternative sources of fuel while many others have established independent power producing plants.

Table: 2 Consumption Pattern of Electricity in India (In Percent)

Year	Domestic	Commer -cial	Industry	Railway Traction	Agricul -ture	Others	Total
1980-81	11.2	5.7	58.4	2.7	17.6	4.4	100
1981-82	11.6	5.8	58.8	2.8	16.8	4.2	100
1982-83	12.7	6.1	55.4	2.8	18.6	4.4	100
1983-84	12.9	6.4	55.8	2.6	17.8	4.5	100
1984-85	13.6	6.1	55.2	2.5	18.4	4.2	100
1985-86	14.0	5.9	54.5	2.5	19.1	4.0	100
1986-87	14.2	5.7	51.7	2.4	21.7	4.3	100
1987-88	15.2	6.1	47.5	2.5	24.2	4.5	100
1988-89	15.5	6.2	47.1	2.3	24.3	4.6	100
1989-90	16.9	5.4	46.0	2.3	25.1	4.3	100
1990-91	16.0	5.9	45.0	2.2	26.4	4.5	100
1991-92	17.3	5.8	42.0	2.2	28.2	4.5	100
1992-93	18.0	5.7	40.9	2.3	28.7	4.4	100
1993-94	18.2	5.9	39.6	2.3	29.7	4.3	100
1994-95	18.5	6.1	38.6	2.3	30.5	4.0	100
1995-96	18.7	6.1	37.8	2.3	30.9	4.2	100
1996-97	19.7	6.2	37.2	2.4	30.0	4.5	100
1997-98	20.3	6.5	35.4	2.3	30.8	4.7	100
1998-99	21.0	6.4	33.9	2.4	31.4	4.9	100
1999-2000	22.2	6.3	34.8	2.6	29.2	4.9	100
2000-01	23.9	7.1	34.0	2.6	26.8	5.6	100

Source: Buddhadeb Ghosh & Prabir De, India Infrastructure Database 2005, Vol.II, Book well, New Delhi, pp1087 to 1089.

Large industries are setting up their own captive power plants, instead of depending upon the inadequate and often undependable public utilities. However, consumption of power by agricultural sector in the total utilization of power has increased considerably over the years from 17.6 percent in 1980-81 to 26.8 percent in 2000-01. Increase in energized pump sets over the years and the promise made by most of the State Governments to provide free electricity for the farmers are considered to be the main reason for growth in the consumption of power by agricultural sector.

Table: 3 State Wise Consumption Pattern of Electricity in 2007– 2008 (In Mu)

Sl. No	State /UT	Domestic	Commer -cial	Industry	Agricul -ture	Railway Traction	Miscel- laneous	Total
1.	Andhra Pradesh	10679	2737	15383	15241	1209	3613	48861
2.	Arunachal Pradesh	48	10	77	0	0	35	170
3.	Assam	992	331	834	20	0	369	2544
4.	Bihar	1700	372	1103	659	385	175	4394
5.	Chattishgarh	1883	359	5150	1459	696	1066	10613
6.	Delhi(DVB)	7142	5008	2832	37	148	1161	16328
7.	Goa	602	160	1590	39	0	157	2548
8	Gujarat	7565	3534	20238	10946	588	1364	44236
9	Haryana	3477	1144	4990	7335	442	872	18260
10	Himachal Pradesh	1051	247	3100	27	0	595	5020

11	Jammu & Kashmir	1399	213	950	271	0	1197	4030
12	Jharkand	1346	225	8701	67	891	158	11387
13	Karnataka	6207	3614	11105	10844	22	2443	34235
14	Kerala	5624	1910	3198	241	109	708	11791
15	Madhya Pradesh	4943	1174	7516	7536	1541	882	23591
16	Maharashtra	15389	6476	29034	12676	2024	2332	67931
17	Manipur	118	13	9	1	0	58	197
18	Megalaya	212	39	508	1	0	134	893
19	Mizoram	116	9	2	0	0	52	179
20	Nagaland	127	10	13	0	0	33	183
21	Orissa	3313	705	6020	172	523	565	11299
22	Punjab	6349	1849	10558	10022	110	999	29887
23	Rajasthan	4464	1530	7407	8145	297	1816	23658
24	Sikkim	61	42	89	0	0	68	260
25	Tamil nadu	13006	6286	21114	10717	516	1314	52953
26	Tripura	220	41	65	24	0	48	398
27	Uttar Pradesh	13704	4089	8591	6200	653	4294	37532
28	Uttarakhand	1163	712	2288	300	9	263	4736
29	West Bengal	7001	3160	11335	1110	944	2698	26248
Total (States)		**119901**	**45999**	**183799**	**104090**	**11107**	**29469**	**494363**
Total (UTs)		**1017**	**686**	**5625**	**94**	**0**	**191**	**7614**
ALL INDIA		**120918**	**46685**	**189424**	**104184**	**11107**	**29660**	**501977**

Source: All India Electricity Statistics General Review 2009 by CEA

The same trend is seen in the domestic sector too. Consumption of power by domestic sector in the total utilization of power has increased from 11.2 percent in 1980-81 to 16.0 percent in 1990-91. It further increased to 23.9 percent in 2000-01. Growth and availability of various electronic goods for a quality living is considered to be the main reason for growth in consumption of power by domestic sector. But the growth seen in the consumption of power by commercial sector was very marginal. Consumption of power by commercial sector was 5.7 percent in the total utilization of power in 1980-81 and it increased to 5.9 percent in 1990-91 and 7.1 percent in 2000-01.

Table 3 clearly shows that out of 5, 01,977 million units (MU) total consumption, Industrial category accounted for 1, 89,424 MU, followed by Domestic sector for 1, 20, 918 MU. Of the total power consumption, other categories that is Agriculture consumed 1, 04184, Commercial accounted for 46,685, Railway consumed 11,107 and miscellaneous was about in terms of consumption 29,660. From the above table, there is a high rate of consumption in all sectors of some States. This gives a picture of the density of population, industrial, and infrastructural development of the Country.

The table further reveals that Maharastra is the leading state in the consumption of electricity by the following sectors, 15389 MU by domestic, 6476 MU by commercial, 29034 MU by industrial sector and 12676 MU by agricultural sector and followed by TamilNadu which consumed the high level of electricity at the rate of 13006 MU by domestic sector, 6286 MU by commercial sector, 21114 MU by industrial sector and 10717 MU by agricultural sector.

On the other hand, Arunachal Pradesh and Sikkim has shown the lowest consumption of electricity in India, because of their population and energy utility, at the rate of 48MU by Domestic sector, 10 MU by commercial sector, 77MU by industrial sector and 61 MU by Domestic sector, 42 MU by commercial sector, 89 MU by industrial sector respectively.

It is evident from the discussions above that India and TamilNadu are short of all energy resources and that coal will dominate India's energy basket. We need to expand our resources through research and development in the field of exploration of alternative sources of energy, energy saving techniques and usage of renewable sources of energy etc.

The environmental impact of various energy options is also a growing concern owing to widespread use of energy. It is necessary that the demand of energy in the country is met in an environment-friendly and sustainable manner. Therefore it is the need of the hour to pay much attention on renewable resources which are economical in long run and eco-friendly. Within renewable energy, solar power could be important for attaining energy independence as well as green house gas-free energy system in the long run.

The Sun is our nearest star and it is the source of energy for life on Earth. It is about 150 million km away a distance which sunlight cover in 8 minutes. The Sun is about 3, 00,000 times heavier than Earth. The energy output, solar constant is about 3.8 X 10^{33} ergs / sec. within forty minutes of the sun shining on the Earth, the Sun will have given off as much energy as the entire world population will use in a year. Only about one percent of this energy put out by the Sun is harnessed and utilized by earth's inhabitants.

Solar power can be harnessed in two ways, in the form of heat (or thermal energy), and in the form of light energy. The light rays of solar energy are harnessed for power generation through solar cells and are called Solar Photovoltaic (SPV) systems, where light is directly converted into electricity using silicon (solar) cells. The electricity thus generated can be used for lighting or other electrical applications [9].

1.2 Indian Scenario of Solar Energy

India was among the first countries in the world to have launched a major programme for renewable energy in the 1970s. During the Fifth Five-Year Plan (1975-80), a specific provision was made for Research and Development (R&D) on new and renewable sources of energy. During the Sixth Five-Year Plan (1980-85), a separate Department of Non-conventional Energy Sources (DNES) was set up in 1982. The programmatic emphasis of the DNES during the 1980s was on the development, dissemination, and demonstration of various Renewable Energy Technologies (RETs). The programme was led by government subsidies.

During the Seventh Five-Year Plan (1985-90), this programme was further intensified and major advances were made in areas such as solar thermal and solar photovoltaic among others. The renewable energy programme in India got a major boost when the DNES was upgraded to a full-fledged Ministry of Non-conventional Energy sources (MNES) in 1992. Around this time, it was realized that faster diffusion of renewable energy sources required great reliance on commercialization through fiscal rather than financial incentives involving the private sector. Thus, after the formation of the Ministry, the thrust of the programme has been on market development in order to facilitate and catalyze commercialization. India is probably the only country in the world with an independent ministry for the promotion of RETs in the energy economy of the country [10].

1.3 Progress of Solar Energy in India

In the area of solar energy, India has today achieved a leading position in the world in the development and use of technology. It is the second largest manufacturer in the world of crystalline silicon modules. Solar device based industrial production has touched a level of 7 MW/year.

The next section has assessed the usage of various levels of solar power in India.

Table: 4 Achievement of Solar Device in India (1996 To 2010)

Source/ systems	Units	Achievement up to 1996	Achievement up to 2005	Achievement up to 2007.	Achievement up to 2010.
I. Solar thermal Systems					
(i). Solar Water Heater	Sq.m	3,64,354	1 million collector area	2 .15 million collector area	3.25 million collector area
(ii.)Solar Cookers	Nos.	4,06,642	5,75,000	6,20,000	6,00,072
II.Solar Photovoltaic Systems					
(i) SPV Lantern	Nos	81,059	5,60,295	5,85,001	7,92,285.
(ii) SPV Street lights	Nos	32,870	54,795	69,549	88,297.
(iii) SPV Home lights	Nos	37,359	3,42,607	3,63,399	5,50,743.
(v)SPV Pumps	Nos	1,820	6818	7,068	7,247
III. SPV Power plants					
(a) Grid connected		-	-	2.12 MW	10.28 MW
(b) Stand alone		909.3 KWp	1566 KWp	2.18 MW	2.39 MW

Source: Annual reports of MNES, Government of India' 1996, 2005, 2007&2010.

Table 4 shows the cumulative achievements of solar device installed from 1996 to 2010. There were 3, 64,354 sq.m area covered by Solar water heaters and 4, 06,642 solar cookers were utilized in the country. This achievement rate has increased progressively by the policy of the government of India.

This apparently reveals with the current status of solar device installation. During 2010, 3.25 million sq.m areas have been covered by solar water heater devices installation. In the same year, 6, 00,072 lakh solar cookers have been distributed for usage. Under solar photovoltaic programme 792,285 numbers of solar lanterns, 88,297 numbers of solar street lighting systems and 5, 50,743 numbers of solar home lighting have installed. Besides these achievements 7247 numbers of solar water pumping installed for the benefit of agrarian society. More than 12.67 MW have so far been installed for voltage support for weak grids, for peak load saving and as diesel saving. This shows solar device technology not only entered into heating and lighting but also it extends its possibility in the area of water pumping and power producing through grid and off-grid.

VI. CONCLUSION

It can be seen that the solar energy technology is a natural endowment available freely and abundantly in the nature. At the time of increasing energy crisis, its full utilization will not only benefit the people but also helps to preserve the environment. Besides, it will be a contributing factor for improving the quality of life. Definitely, in future solar energy technology will become more popular and the development of this energy will drastically reduce the consumption of

commercial sources of energy like electricity, petrol, diesel, kerosene, natural gas etc. which in turn protects the environment and makes pollution free society.

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