JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Consumption of Electricity Energy Resources and Strategic Policy Issues and Options Ahead in India

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Abstract

In this era of modernization and globalization, the demand for energy sources is continuously rising. The study mainly focuses on the growing consumption of energy sources in India. The study covers the data from 1970 to 2018, which has been calculated from the energy statistics reports by the CSO government of India. The data revealed that the consumption of crude oil was 18.38 million tons, and it increased to 251.93 tonnes in 2017-18. The per capita consumption had also increased from 4,336 mega joules in 1970-71 to 23,355 mega joules in 2017-18. The data also revealed the percentage share energy consumption in different sectors of the economy from 1979-80 to 2017-18. So with the growing energy demand, supply constraints stay behind energy crises. To fulfill the energy demand, there is a need for a stable and long term policy that gives visibility and builds up investor confidence.

Keywords: Energy Consumption, energy intensity, crude oil, lignite, electricity.

Introduction

The increasing size of the economy has increased demand for energy sources. India is a populist country that's why it is a highly energy consuming economy. In the traditional societies, energy sources were wood fuels and coal, and their usage was very limited. Those were used for cooking and heating until the gradual transition to the industrial age. In the industrial age, energy has become essential for almost all aspects of human activities. This transition has become significant for energy usage both as input to the production sector and to compliment most of the final industrial goods, whose demand requires energy either oil, gas, electricity and other energy products. The growth of modern and industrial age aggravated by a rising urban population, industrial progress, and technological progress has increased the demand for energy resources. The growth of competitive market systems and international economic relations has led to the development of energy markets. Energy plays both sides role as final good in the household sector and as input in the industrial or production. Electricity is one of the most safe and reliable sources of energy. It has become a central point to measure the quality of life as everything we do depends upon it one way or another. On the domestic front, it lights the houses, buildings, and streets/pathways, etc.; protects the human beings from unbearable heat/cold; and empowers them to run machine/equipment used in the fields, industries, homes, offices, etc. Electric power has also become the most critical input for raising production, bringing speed and automation across all major sectors of an economy - agriculture, industry, transport, communications, business/commerce, etc. Electricity can be generated from various energy resources such as oil, coal, hydro, natural gas, nuclear, wind, solar, and stored hydrogen. Most of these inputs, particularly coal, oil, and natural gas, are not only exhaustible, scarce and depleting, but these inputs

are also subject to the price shocks, supply interruptions, and causing severe pollution (Government of India, 2015; 2017). All these factors demand optimum uses of these energy inputs, which, in turn, require proper planning and strategy for electricity production, transmission, and distribution. Further for the planning and optimal uses of electricity, an integrated and updated database of electricity production and consumption is not only necessary but also demands a scientific analysis of various competing inputs, technological up-gradations, and alternative uses. The electricity sector in India has grown significantly during the post- independence period. Its installed generation capacity was only 1360 MW in 1947, which has risen to 173626 MW in 2010. Soon after independence, India adopted the planning model for allocating its scarce resources to the development priorities.

Energy Sources Supplying Electricity:

Energy can be derived mainly from two sources: renewable and non-renewable sources. These are the two crucial sources of energy for human consumption in the world today. The renewable energy sources are Solar energy-Photovoltaic conversion, Thermal energy Hydroelectric power, Wind energy, Power from biomass, Ocean energy- wave energy, marine currents, ocean thermal energy conversion, tidal energy (Sukhatme, 2014) while non- renewable energy sources are nuclear energy and fossil fuels such as coal and lignite, natural gas and petroleum.

Coal, part of fossil fuels - is the mainstay of India's energy sector, accounting for over 50 percent of primary commercial energy supply in 2010–11 (Planning Commission, 2013). It has also been predicted that the share of coal will further increase to 57 percent over the next ten years (Planning Commission, 2013). India has accessible coal reserves of 118 billion tonnes, enough to last for over 100 years of the country's present energy needs (Bhargava, 2014). These coal stocks are large enough to fulfill the foreseeable energy needs of the Indian economy. At present, nearly one-third of India's electricity generated found to be coal-based. India is the third-largest producer of hard coal after China and the U.S. However, coal reserves in India are generally of low quality with high ash content, and it is also unevenly distributed. Further, state must augment imports of coal from other counties (Kaur, 2016). Petroleum Products and Natural Gas- Petroleum products and natural gas are two other fossil fuels used for producing commercial energy in India. Domestic production of crude oil and natural gas is not adequate to meet India's energy requirements. For instance, more than 60 percent of India's oil needs (around 1.4 million barrels per day) has been imported from other countries. Demand for petroleum products in India grew at an annual rate of 4.15 per cent during 2007-12, whereas the scope for raising domestic production is very limited. Moreover, consumption of LPG in India has also increased from 10.85 million tonnes in 2006-07 to 15.36 million tonnes in 2011-12; grew @ 7.21 percent per annum. Further, oil prices in the world markets are highly volatile and high also. In India, the targeted production of both oil and gas could not be achieved.

India has made little headway with building solar thermal power plants at the moment 50 MW plant using parabolic through concentrators located near Jaisalmer, Rajasthan, 1 MW plant using parabolic through concentrators built by IIT Bombay at the solar energy center in Gurgaon, 2.5 MW plant based on the central tower concept at Bikaner, Rajashthan. Only the first plant is operational. In contrast, several solar thermal power plants are in operation in the world, principally in the USA and Spain. Currently, the largest plant in the world is at lvanpah, California, USA. It has a capacity of 392 MW and is just becoming operational. It is based on the central tower concept and expected to generate about 1 million MWh per year (Sukhatme, 2014).

Data Sources and Methodology

The study covers the annual data of consumption of energy resources, per capita consumption, and consumption in different sectors of the economy from 1970 to 2018. The data has been taken and calculated from the annual energy statistics reports of various issues of the central statistics office (CSO), the Government of India.

Section I

1.1 Growth of Consumption of Energy Sources in India

As the size of the economy is increasing, the demand for energy is also growing. India has a large population, and it highly consumes the energy resources. Before 1991 economic reforms, the consumption of

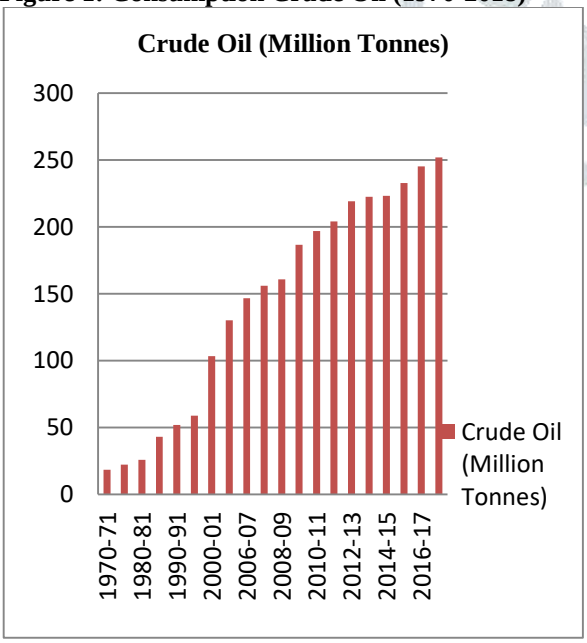
energy resources was not much, but after the economic reforms, energy consumption has risen due to globalization, privatization, and liberalization. In 1970-71 the consumption of crude oil was 18.38 million tons, which increased to 51.77 million tones in 1990-91 and further increased to 251.93 tonnes in 2017-18. The consumption of Lignite was 3.39 million.

Table1: Growth of Consumption of Energy Sources in India

Year	Crude Oil (Million Tonnes)	Lignite (Million Tonnes)	Coal (Million Tonnes)	Natural Gas (Billion Cubie Meters)	Electricity (GWh)
1970-71	18.38	3.39	71.23	0.65	43,724.00
1975-76	22.28	3.03	92.16	1.13	60,246.00
1980-81	25.84	5.1	109.31	1.52	82,367.00
1985-86	42.91	7.68	155.53	4.95	123,099.00
1990-91	51.77	14.2	213.36	12.77	190,357.00
1995-96	58.74	22.3	284.04	18.09	277,029.00
2000-01	103.44	24.82	339.31	27.86	316,600.00
2005-06	130.11	30.34	433.26	31.03	411,887.00
2006-07	146.55	30.8	462.32	30.79	455,748.00
2007-08	156.1	34.65	502.83	31.48	500,774.00
2008-09	160.77	31.75	549.57	32.99	553994.71
2009-10	186.55	34.43	585.3	48.34	612644.99
2010-11	196.99	37.69	589.87	52.02	694392.00
2011-12	204.12	41.89	642.64	60.68	785194.00
2012-13	219.21	46.01	688.75	53.91	824300.99
2013-14	222.5	43.9	724.18	48.99	874208.57
2014-15	223.24	46.94	821.85	46.95	948521.82
2015-16	232.86	42.21	836.73	47.85	1001190.68
2016-17	245.36	43.16	837.22	50.78	1061182.64
2017-18 (P)	251.93	45.82	896.34	52.83	1130243.84

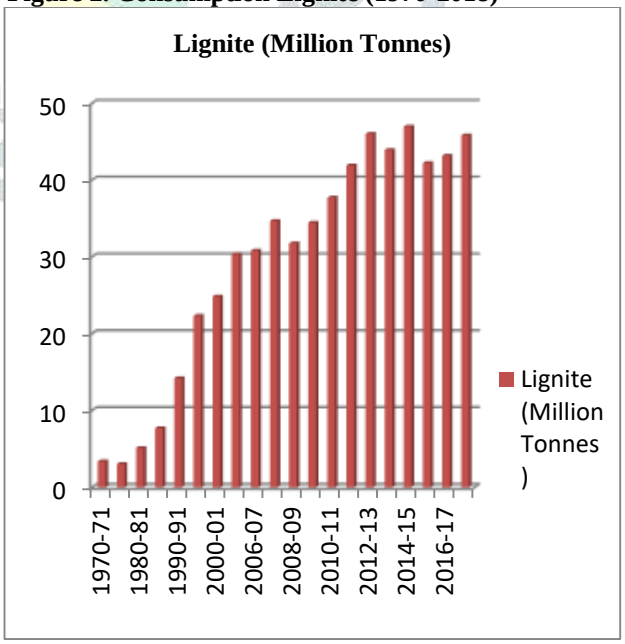
Source: CSO, Energy Statistics of various issues

Figure 1: Consumption Crude Oil (1970-2018)



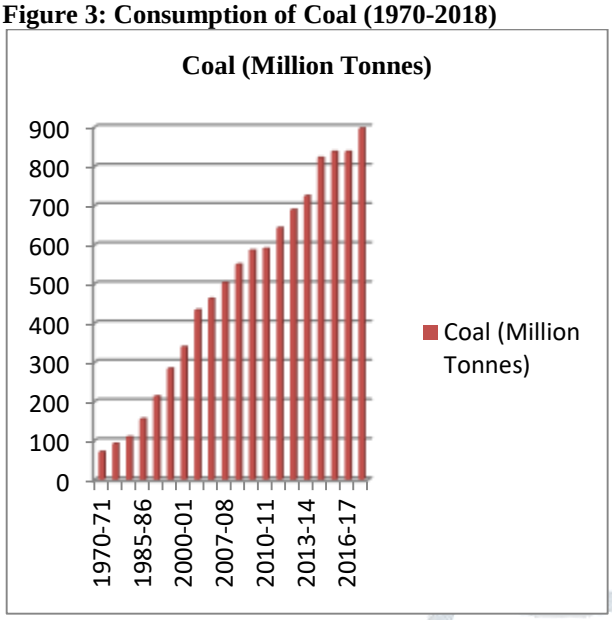
Source: CSO, Energy Statistics of various issues

Figure 2. Consumption Lignite (1970-2018)



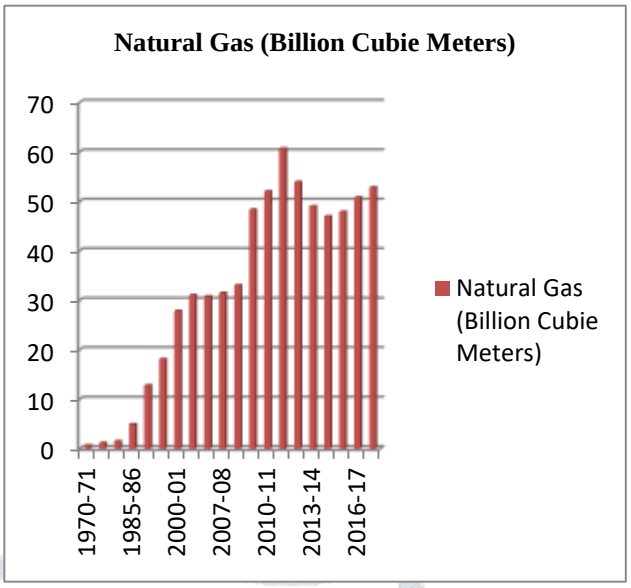
Source: CSO, Energy Statistics of various issues

Figure 3: Consumption of Coal (1970-2018)



Source: CSO, Energy Statistics of different years

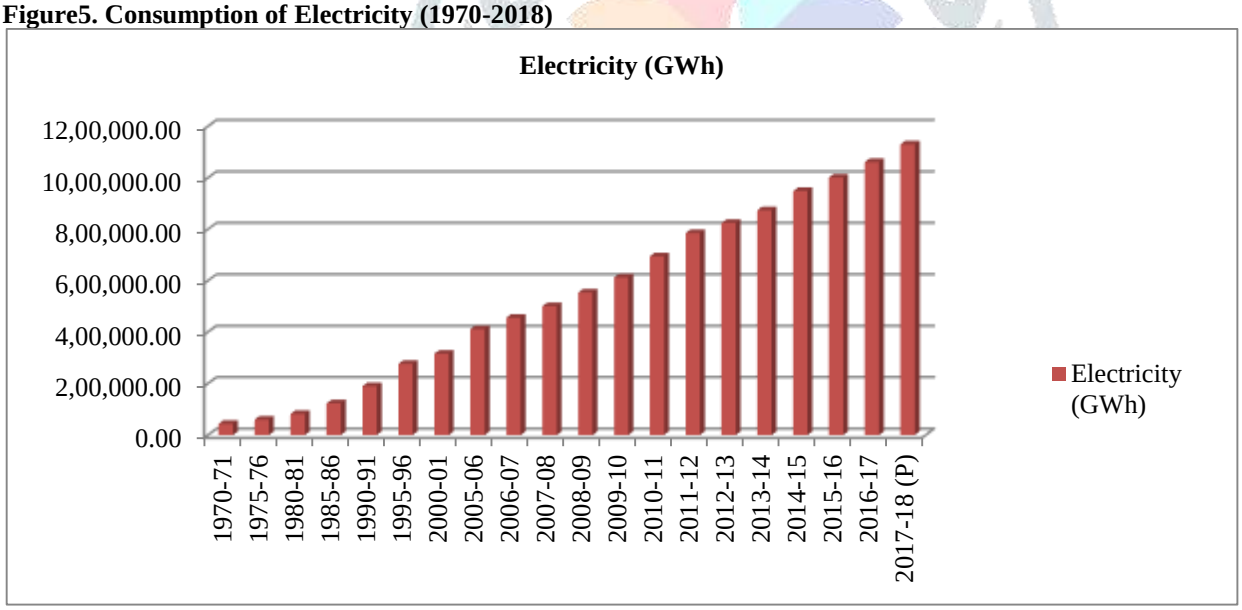
Figure 4: Consumption of Natural gas (1970-2018)



Source: CSO, Energy Statistics of different years

tones in 1970 which increased to 14.2 million tonnes in 1990-91 and 45.82 million tonnes in 2017-18. In the case of coal, the consumption was 71.23 million tones in 1970-71, which increased to 213.36 million tones in 1990-91 and further increased to 896.34 million tones in 2017-18. Consumption of natural gas was 0.65 billion cubie meters in 1970-71, increased to 12.77 billion cubie meters in 1990-91 and further it increased to 52.83 billion cubie meters. Consumption of electricity was 43724.00 Gwh, which increased to 190357.00 Gwh and further, increased to 1130243.84 Gwh.

Figure5. Consumption of Electricity (1970-2018)



Source: CSO, Energy Statistics of various issues

1.2 Trends in Per Capita Energy Consumption and Energy intensity in India (1970-2018)

The per capita energy consumption and intensity of energy has increased over the years. The data in table 2 revealed that Energy consumption was 2390 peta joules in 1970-71 which has

Table 2: Trends in Energy Consumption in India

Year	Energy Consumption in peta joules	Mid year population (in million)	GDP* (Rs. Crore)	per capita energy consumption (in mega joules)	Energy intensity per rupee
1970-71	2390	551	517148	4336	0.1284

1975-76	3026	617	596428	4902	0.1409
1980-81	3645	688	695361	5296	0.1456
1985-86	5319	766	894041	6943	0.1653
1990-91	6850	852	1193650	8037	0.1594
1995-96	8772	940	1529453	9337	0.1593
2000-01	11355	1035	2030710	10972	0.1553
2005-06	14074	1118	2844942	12591	0.1374
2006-07	15216	1134	3120029	13418	0.1355
2007-08	18392	1148	3402716	14141	0.1325
2008-09	20264	1161	4154973	20047	0.1557
2009-10	22329	1175	4464081	21829	0.1597
2011-12	23910	1220	8736329	19599	0.2737
2012-13	25167	1235	9213017	20378	0.2732
2013-14	25806	1251	9801370	20629	0.2633
2014-15	27539	1267	10527674	21735	0.2616
2015-16	28337	1283	11369493	22087	0.2492
2016-17	29207	1299	12298327	22484	0.2375
2017-18	30735	1316	13179857	23355	0.2332

Source: CSO, Energy Statistics various issues

*GDP is estimated at 1999-2000 prices from 1970-71 to 2006-07, at 2004-05 prices from 2007-08 to 2009-10, at 2011-12 prices from the year 2011-12 to 2017-18.

increased to 6850 peta joules in 1990-91 and 30735 peta joules in 2017-18. Population has also increased during this time-period. It was 551 million in 1970-71, which increased to 852 million in 1990-91, and further it increased to 1316 million. GDP had also increased from Rs.517148 crore in 1970-71 to 1193650 crore in 1990-91 and further it increased to 13179857 crore in 2017-18. Further Consumption of per capita energy has also increased 4336 mega joules in 1970-71 to 8037 mega joules in 1990-91, and further, it increased to 23355 mega joules in 2017-18. Energy intensity was 0.1284 per rupee in 1970-71 which increased to 0.1594 per rupee and further it increased to 0.2332 per rupee.

1.3 Growing Electricity Consumption in Different Sectors of India

India's electricity consumption is continuously growing from many years. In 1979-80 the total electricity consumption was 85334 MU which increased to 374670 MU in 2001-02 and 852903 in 2012-13. In case of consumption by the different sectors of the economy, then the industrial sector is one which is dominating other sectors for many years. Though its share has decreased even then, it is consuming more than other sectors. In 1979-80 its share was 62.35%, which decreased to 45.89% in 2006-07 and 44.87% in 2012-13.

In the case of the domestic sector, the consumption is increasing. It was 9.85% in 1979-80, which increased to 21.12% in 2005-06 and 21.79% in 2012-13. The consumption in the agriculture sector firstly increases from 15.76% in 1979-80 to 26.65% in 1996-97 after that it start to decrease and still it is decreasing. It was 18.84% in 2006-07 and 17.95% in 2012-13. On commercial sector electricity consumption has increased from 5.46% in 1979-80 to 7.65% in 2006-07 and 8.33% in 2012-13. Misc or other uses has also increased from 3.89% in 1979-80 to 5.75% in 2001-02 to 5.25% in 2012-13.

Table 3: Percentage increase in Electricity Consumption in India (MU), Utilities and Non-Utilities

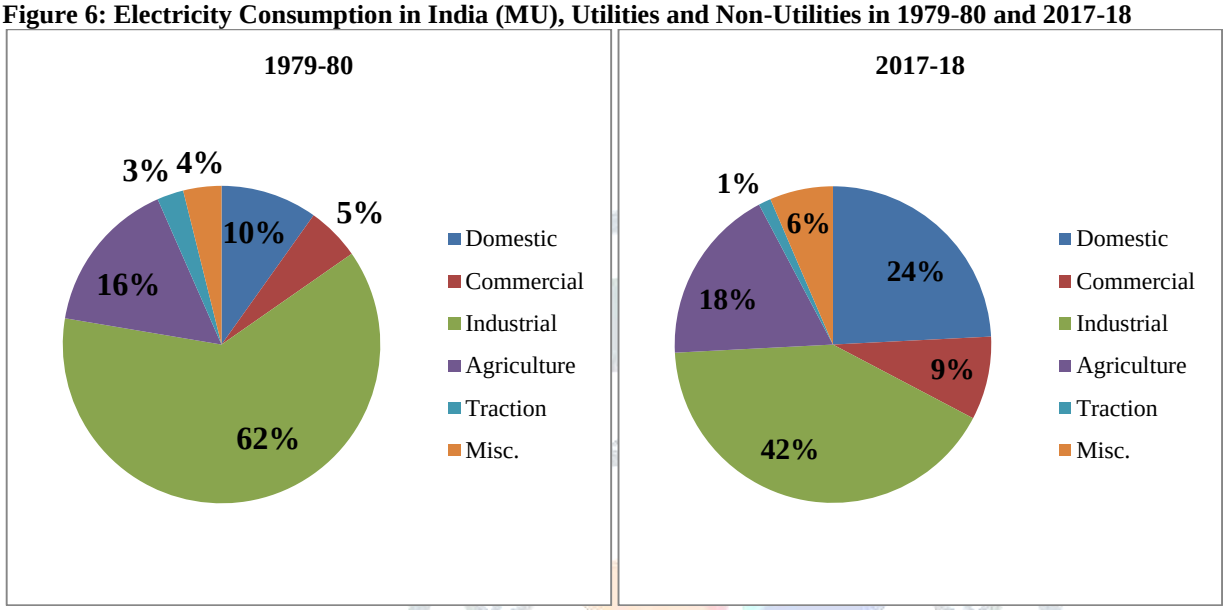
Year	Domestic	Commercial	Industrial	Agriculture	Traction	Misc.	Total
1979-80	9.85	5.46	62.35	15.76	2.7	3.89	100
1989-90	15.16	4.89	51.45	22.58	2.09	3.83	100
1991-92	15.51	5.2	47.94	25.33	1.96	4.06	100
1996-97	17.53	5.56	44.17	26.65	2.09	4.01	100
2001-02	21.27	6.44	42.57	21.8	2.16	5.75	99.99
2006-07	21.12	7.65	45.89	18.84	2.05	4.45	100
2011-12	21.79	8.33	44.87	17.95	1.81	5.25	100
2012-13	21.79	8.33	44.87	17.95	1.81	5.25	100
2016-17	24.11	8.46	41.48	18.01	1.48	6.45	100

2017-18	24.2	8.51	41.48	18.08	1.27	6.47	100

Source: Calculated from CSO, Energy Statistics various issues

Figure 6 shows the comparison of the consumption of electricity in different sectors of the economy in 1979-80 and 2018-19. The data showed that the share of domestic consumption had been increased over the years from 10.00 percent in 1979-80 to 24.00 percent in 2017-18. Commercial consumption has been increased from 5.00 percent to 9.00 percent. The consumption in industrial sector has been decreased from 62.00 percent to 42.00 percent, which shows that the industries has not developed much in India over this time period which leads to falling in consumption of electricity in the industrial sector. In the Agriculture sector the consumption increases from 16.00 percent to 18.00 percent. The shares of misc. have been increased from 4.00 percent to 6.00 percent.

Figure 6: Electricity Consumption in India (MU), Utilities and Non-Utilities in 1979-80 and 2017-18



Source: Calculated from CSO, Energy Statistics various issues

Section II

2.1 Electricity Generated (from Utilities), Distributed, Sold and Lost in India

Further, if we look at the trends of net electricity generated, net electricity availability for supply, purchases from non utilities +net imports from other countries, and loss and transmission the data revealed that all these variables has risen during the time period 1970-71 to 2016-17(Table 4). Net Electricity generated from utilities has been increased from 52965 GWh in 1970-71 to 244725 GWh in 1990-91 further increased to 1151971 GWh in 2016-17. In case of purchases from non utilities +net import from other courtiers, the trends show that it was 66 GWh in 1970-71, and increased to 2216 Gwh in 1990-91 and increased to 13773 GWh in 2016-17. Net Electricity available for supply was 53031 Gwh in 1970-71 and it increased to 246941 in 1990-91 and further increased to 1168317 Gwh in 2016-17. Electricity sold to ultimate consumers and other countries has also been increased from 43724 Gwh in 1970-71 to 190420 Gwh 1990-91 to 919483 GWh in 2016-17. Loss in transmission and distribution was 9307 Gwh in 1970-71, increased to 56521 GWh in 1990-91 and further rise to 248834 GWh in 2016-17.

Table 4: Electricity Generated (from Utilities), Distributed, Sold and Lost in India

(in Giga Watt hour =106 Kilo Watt hour)

Year	Net Electricity Generated from utilities	Purchases from non utilities+ net import from other countries	Net electricity available for supply	Sold to ultimate consumers& other countries	Loss in transmission & distribution	Loss in transmission & distribution (%)
1970-71	52965	66	53031	43724	9307	17.55
1975-76	74675	121	74796	60246	14550	19.45
1980-81	103,614	120	103734	82367	21367	20.60

1985-86	157193	107	157300	123106	34194	21.74
1990-91	244725	2216	246941	190420	56521	22.89
1995-96	352657	3784	356441	277078	79363	22.27
2000-01	466272	5596	471868	316795	155073	32.86
2005-06	581849	10345	592194	412096	180098	30.41
2006-07	627077	11931	639008	455964	183044	28.65
2007-08	677095	12685	689780	502267	187513	27.18
2008-09	699053	13487	712540	527564	184976	25.96
2009-10	746576	15359	761934	569723	193795	25.38
2010-11	792466	16989	809455	617097	194537	23.97
2011-12	865965	19839	811506	673068	208398	23.64
2012-13	900380	20849	921229	708997	212232	23.04
2013-14	956488	17948	974436	751908	222528	22.84
2014-15	1040582	13773	1054355	814250	240105	22.77
2015-16	1088282	15947	1104228	863364	240864	21.81
2016-17	1151971	16345	1168317	919483	248834	21.30

Source: CSO, Energy Statistics of different years

Section III

3.1 Strategic Policy Issues and Suggestions

Based on preceding analysis and discussion, it has been found that rising energy needs of the growing Indian economy and its strategic sectors cannot be met by the public utilities alone, although the public utilities must have a dominant and commanding role. The private sector must be involved in the generation and distribution of modern means of energy (electricity, oil, LPG, etc.). For this, there is a need to rethink and reformulate new energy policy by involving all stakeholders (producers, consumers, distributors, etc.). It has been noticed that India's rising energy needs could not be fulfilled by utilizing domestic resources only like coal, oil, hydro, uranium, and other renewable resources. India has to look outside the world to produce more energy by importing more coal, oil, uranium, solar power, and related machinery and technology. The country must ensure electricity trading with neighbor countries, particularly with Pakistan, Bangladesh, and Myanmar instead of natural gas supply as these countries have enough storage of natural gas.

However, heavy reliance on imported energy will not only involve high costs of the final output, but also put stress on scarce foreign exchange and, in turn, impinges adversely on India's energy security in the future. In the long-run, the Indian government must augment and rely upon her domestic sources of energy. However, a few critical inputs and technology such as nuclear, solar, wind, and clean coal technology should be allowed to import at the earliest. Further, passing of Energy Conservation Act of 2001 must be implemented at the earliest by adhering to energy consumption norms, energy performance standards, new buildings to follow 'energy conservation code' and by display energy consumption labels at each product and public places.

Considering the benefits of conservation and energy efficiency, the state should take steps to implement strictly the provisions of Energy Conservation Act, 2001 (effective from March 01, 2002) in the state. This act in fact provides for institutionalizing and strengthening delivery mechanisms for energy efficiency programs in the country and provides a framework for the much-needed coordination between various government entities. It also provides a legal framework and a regulatory mechanism at the central and state government levels. The bureau of energy efficiency (BEE) in the state must be strengthened, and its recommendations are made mandatory and legally enforceable. LED bulbs/tubes should be low priced and made compulsory across the industrial and street lighting system at the initial stage. Later on, the application of LED lighting is made compulsory across all lighting arrangements. Further, strict measures must be introduced to reduce power theft in the state. The electricity meters of general/industrial consumers should be shifted out of their premises and the task should be accomplished in a time bound manner. Disciplinary action should be taken against the erring employees who helped the consumers to indulge in the theft. Moreover, application of new technologies like electronic meters, remote control of transformers, remote meter reading, and HVDS system for AP/Industries must be introduced.

3.2 Sustainability Issues

A sustainable energy system can only be achieved if the technical and economic governance structures support each other. There is a wide range of options that can be explored.

- **Decentralization of electricity production**: Electricity networks might be put an end to at all. Customers can become self- reliant with respect to electricity. They may either depend on the energy sources like natural gas or hydrogen for the home production of electricity. As another option, sustainable energy production from wind and solar cells might cover most local needs. Self-dependent customers make their own decisions about consumption and production of electricity according to their objectives. Under these circumstances, the technical complimentarily will be low because production and consumption of electricity are physically at the same location. This is the most reaching case of the decentralization energy system.
- **Network intelligence:** Network might become sharper by developing inbuilt capabilities to operate within secure technological boundaries while maintaining the highest transport capacity. Under these circumstances, no centralized system operation is necessary.
- **Generation Based Incentive (GBI) as a bridge mechanism**: Till such time the utility pay-out for RE power is superior to the marginal cost of conventional power, GBI could act as a bridge instrument, with or without any other mechanism is available. For example, if AD can decrease the costs partially, the GBI could bring it down further to meet the utility's cost of procuring other power source. Also the GBI is also an output /performance-linked incentive and hence has very limited possibilities of misuse.
- **Network morphology:** like the internet, electricity networks can be activated in tiny, semi-independent units that are interconnected by a backbone. The energy web or the Micro Grid concepts are examples of this approach. The Micro Grid structure assumes an aggregation of loads and micro source operating as a single system providing both power and head.
- **Bundling of RE power with cheaper conventional power**: As long as the unallocated quota for conventional power is available, it must be used to bundle with RE power to incentivize procures for buying RE. This has no financial impact on the Government and offers benefits related to timely payments, secured power purchase agreements, and generators receive the full tariff for RE, and hence do not need any additional incentives.
- A**ccelerated Depreciation (AD):** Alternatives such as AD may be continued with advancement in the design of the mechanism such that operational performance gets incentivized. Further, specific tools through which the tax credits can be passed on to individual / institutional investors will help broad-base the class of beneficiary investors, resulting in enhanced investments. The mechanism would, however, necessitate supplementary support from other mechanisms to bring tariff parity with the alternative sources, also because not all classes of investors can benefit from it.
- **Viability Gap Funding (VGF):** The current model of VGF for solar projects is unique. It is a high initial cost option, with part of the payments being deferred to ensure performance. As such, it is a hybrid of VGF and GBI and still requires significant initial outlays, with no exceptional gains. The mechanism seems inferior to most other mechanisms.

There is a need for a stable and long term policy (3 years), which gives visibility and builds up investor confidence. There is a need to establish new high voltage grid sub-stations and upgrade the old ones along with augmentation of 11 kV and LT lines so that the last-end consumers should not suffer from low voltage fluctuations. Further, MVAR shunt capacitors are made compulsory. The establishment of a 400 kV sub-station with 1000 MVA capacity in 2012-13 in the state is the right step. Moreover, women are the primary stakeholders in the energy resources' management and conservation, especially for domestic users. A comprehensive policy on domestic energy must be evolved to create a portfolio of energy options. Apart from electricity and biomass sources, non-biomass sources of energy, including solar and wind for small producers, should be promoted.

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