Electricity Consumption and Its Sources in India: An Overview

[1]Mouneshwari G, [2]H H Bharadi

[1]PhD Research Scholar, [2]Professor
Department of Studies in Economics
Karnatak University
Dharwad. Karnataka State, India.

***Abstract*- India is one of the fastest-growing economies in the world, and its energy demand has been rising rapidly. Electricity consumption has been increasing steadily over the past few decades due to various factors such as population growth, urbanization, and industrialization. This paper provides an overview of the current state of electricity consumption and its sources in India.**

India's electricity sector is characterized by a mix of different energy sources, including coal, natural gas, hydroelectric, nuclear, and renewable energy sources such as wind, solar, and biomass. Coal remains the dominant source of electricity generation, accounting for around 70% of total electricity generation. However, the government is actively promoting the use of renewable energy sources to reduce the country's dependence on fossil fuels and to mitigate the adverse impacts of climate change.

Despite efforts to increase the share of renewable energy, the growth in electricity demand has outpaced the growth in renewable energy installations. India faces several challenges in the electricity sector, including power shortages, transmission and distribution losses, and inadequate infrastructure. To meet the growing demand for electricity, the government has initiated several programs and policies to promote the use of renewable energy, such as the National Solar Mission and the National Wind Mission.

Overall, India's electricity consumption is expected to continue to grow in the coming years, driven by economic development and rising population. However, the country's energy mix is likely to shift towards renewable energy sources, as the government continues to prioritize the development of renewable energy infrastructure and technologies. the study analyses the electricity consumption, with the objective of understanding the current scenario and predicting future outcomes. The analysis is based on the data collected from various sources, including the Central Electricity Authority (CEA) and the International Energy Agency (IEA) and Reserve Bank of India,

Using simple statistical tools percentage change, growth rate an overview of the electricity consumption patterns in India is present, the paper concludes with recommendations for policymakers to promote sustainable energy sources and improve the efficiency of the power sector in India.

***Keywords*: Electricity, Energy Resources, Consumption, Energy Demand, Power Generation.**

Introduction

India, as one of the fastest-growing economies in the world, has witnessed a rapid increase in electricity consumption in recent years. With a population of over 1.3 billion, India faces the daunting task of providing reliable and affordable electricity to all its citizens. However, the country's electricity sector faces several challenges, including an inadequate power infrastructure, high transmission and distribution losses, and a heavy reliance on non-renewable sources of energy. In this context, an analysis of electricity consumption and its sources in India is crucial to understand the country's energy landscape and identify potential solutions to address its energy challenges. This analysis can shed light on the key drivers of electricity demand, the sources of energy used for electricity generation, and the policies and initiatives aimed at promoting renewable energy and energy efficiency.

Electricity consumption and its sources in India have been the focus of numerous studies in recent years, given the country's rapid economic growth and rising demand for energy. This review of literature provides a summary of some of the key findings and insights from relevant studies on this topic.

One of the earliest studies on electricity consumption in India was conducted by Ghosh and Ghosh (2003), who analysed the trends and patterns of electricity consumption across different sectors of the Indian economy from 1971 to 2001. The study found that the growth rate of electricity consumption had increased significantly over the years and was particularly high in the industrial sector. They also found that the main sources of electricity generation were thermal and hydroelectric power plants, with a relatively small contribution from other renewable sources.

Another study by Singh and Sharma (2011) focused on the drivers of electricity consumption in India, analysing data from 1970 to 2007. They found that economic growth, urbanization, and population were the main factors driving electricity consumption in the country. They also found that the industrial sector was the largest consumer of electricity, followed by the household and commercial sectors.
A more recent study by Kumar and Yadav (2019) analysed the trends in electricity consumption and its sources in India from 1985 to 2016. The study found that the growth rate of electricity consumption had increased significantly, with the industrial sector being the main contributor to this growth. They also found that thermal power plants were the main source of electricity generation, followed by hydroelectric and renewable sources.
Several studies have also focused on the potential for renewable energy sources in India. A study by Agnihotri et al. (2017) analysed the potential of solar energy in India and found that the country had significant potential for solar energy generation, with the potential to meet a significant portion of its electricity demand. Another study by Thakur and Pathak (2020) analysed the potential of wind energy in India and found that wind energy had significant potential to meet a significant portion of the country's electricity demand.
While there have been several studies conducted on electricity consumption and sources in India, there is a lack of comprehensive analysis that takes into account both the demand and supply side of electricity. Additionally, there is a need for research that focuses on the regional and sectoral variations in electricity consumption and sources in India. Therefore, a research gap exists in identifying the determinants of electricity consumption and sources in India and analysing the regional variations in these determinants.

Objective:
The objective of this study is to conduct a comprehensive analysis of electricity consumption and its sources in India. The study will aim to identify the determinants of electricity consumption and sources and analyse the regional variations in these determinants. Specifically, the objectives of the study are:
1. To analyse the consumption of electricity sector wise and sources of electricity in India, including conventional and renewable sources, and their regional distribution.
2. To estimate the future demand for electricity in India and identify the potential sources to meet this demand.

Overall, the study will provide insights into the current state of electricity consumption and sources in India and inform policy decisions for a sustainable and efficient electricity sector.

Methodology:
The research design for this study is a descriptive research design, and this is the appropriate design for this study because it seeks to describe the trends and patterns of electricity consumption in India and the sources of electricity generation.
The data for this study will be collected from secondary sources, 1. Central Electricity Authority, Annual Report, 2. Ministry of New and Renewable Energy, Government of India. Academic journals, and other publicly available sources. The data will be collected and analysed using a systematic approach to ensure that the information is reliable and valid. The data analysis for this study will be conducted using descriptive statistics, including frequencies, percentages, and measures of central tendency then growth rate. The data will be analysed using statistical software to ensure that the results are accurate and reliable.

Discussion
Electricity Consumption in India:
India is the second most populous country in the world, and as a result, it has a massive demand for electricity. In recent years, the country has made significant strides in increasing its electricity generation and improving access to electricity for its citizens. However, India still faces challenges in meeting the growing demand for electricity, particularly in rural areas.
According to data from the Central Electricity Authority, the total electricity consumption in India increased from 24.121 petajoule in 2011-12 to 33.508 2021-22, representing a compound annual growth rate (CAGR) of 2.94 %. However, the growth rate has been slowing down in recent years, with consumption increasing by just 3% in 2020 compared to the previous year.
The industrial sector is the largest consumer of electricity in India, accounting for around 41% of total consumption in 2020. The residential sector is the second-largest consumer, accounting for around 25.67 percent, followed by the commercial sector at 8.31 percent and agriculture at 17.52 percent. when we look at the compound annual growth rate (CAGR) sector wise, industrial sector accounted for 8 percent, agriculture sector 5 percent, domestic and commercial had 7 percent compound annual growth rate (CAGR)
The table below shows the consumption of electricity by sector in India from 2001-02 to 2019-20

Table 1: Consumption of Electricity by Sectors in India
(In percentage)

Year	Industry	Agriculture	Domestic	Commercial	Traction and railways	Others
2001	33.27	25.33	24.71	7.49	2.51	6.68
2002	33.85	24.88	24.55	7.49	2.59	6.64
2003	34.51	24.13	24.86	7.81	2.55	6.13
2004	35.63	22.93	24.77	8.13	2.46	6.07
2005	36.80	21.92	24.30	8.73	2.41	5.84
2006	37.58	21.73	24.36	8.83	2.37	5.14
2007	37.74	20.75	24.09	9.30	2.21	5.91
2008	37.81	19.79	23.78	9.78	2.06	6.78
2009	38.64	19.62	23.84	9.89	2.03	5.97
2010	39.26	19.00	24.38	9.69	2.02	5.65
2011	44.87	17.95	21.79	8.33	1.81	5.25
2012	44.40	17.89	22.29	8.83	1.71	4.88
2013	43.97	17.47	22.86	8.49	1.78	5.42
2014	44.11	17.81	22.92	8.26	1.71	5.20
2015	42.30	17.30	23.86	8.59	1.66	6.29
2016	41.28	18.33	23.99	9.22	1.61	6.50
2017	41.71	17.74	24.35	8.35	1.55	6.31
2018	42.91	17.64	23.82	8.12	1.56	5.96
2019	42.69	16.93	24.74	8.50	1.53	5.61
2020	41.09	17.52	25.67	8.31	1.51	5.89
CAGR	8%	5%	7%	7%	4%	6%

Source: Ministry of Power, Govt. of India. Compiled by the Author

As the table shows, the industrial sector has consistently been the largest consumer of electricity, accounting for around 40% of total consumption throughout the period. However, the share of consumption by the residential sector has been increasing over time, from around 24% in 2001 to 25% in 2020. The share of consumption by the agriculture sector has been decreasing 25.33 percent in 2001 to 17.52 percent in 2020, while the commercial sector has seen a slight increase in its share of consumption.

Sources of Electricity in India:

India's electricity generation mix is dominated by coal, which accounts for a significant portion of the country's greenhouse gas emissions. However, in recent years, India has made significant strides in diversifying its electricity generation mix and increasing the share of renewable energy sources.

Table 2: Sources of Electricity in India (in Percentage)

year	coal	Lignite	Gas	diesel	nuclear	hydro	renewable sources	Total
2018	191.09	6.36	24.94	0.64	6.78	45.40	74.08	349.29
2019	198.49	6.76	24.94	0.51	6.78	45.40	85.91	368.79
2020	199.86	6.26	24.96	0.51	6.78	45.80	91.15	375.32
2021	203.19	6.62	24.90	0.51	6.78	46.51	10.49	299.00
2022	203.78	6.62	24.81	0.59	6.78	4.69	120.90	368.16

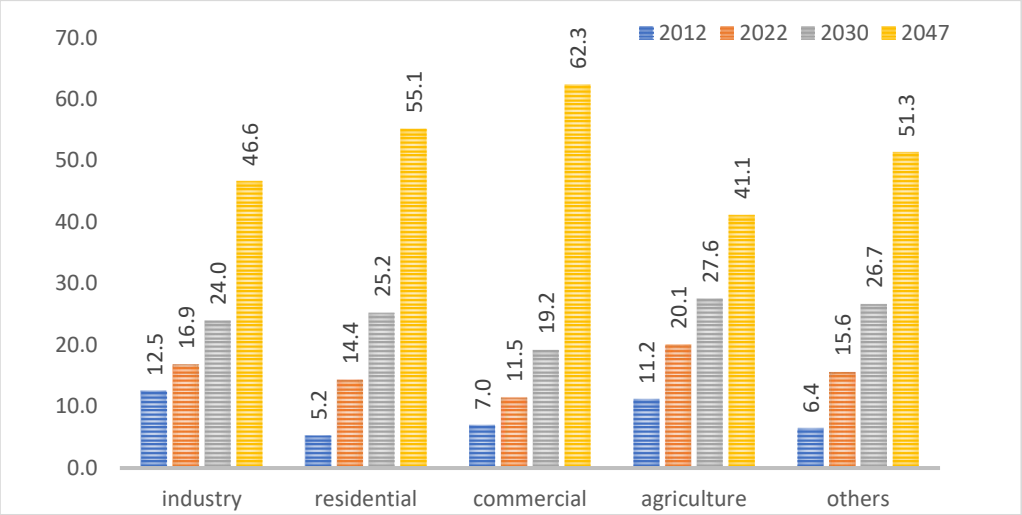
2023	205.90	6.62	25.04	0.59	7.48	46.85	130.89	423.36
Share in % 2023	48.63	1.56	5.91	0.14	1.77	11.07	30.92	100.00

Source: central electricity authority, Govt. of India. Compiled by the Author

As shown in Table 2, coal is still the primary source of electricity in India, accounting for 48.63 % of electricity generation in 2023. However, the share of renewable energy sources g 30.92% in 2023. Hydroelectric power also plays a significant role in India's electricity mix, accounting for 11.07% of generation in 20223.

Projected Electricity demand in various sectors (MW).

Figure 1: Electricity Demand in India



The Above the diagram shows the electricity demand for the various sector, one important point recognized by all sectors demand for electricity increase the day by day. hence all sectors are going to increase electricity by doubled the amount as compared to the present demand in 2023. Industrial sector demand for electricity was 12.5 percent it will increase upcoming days by 24.0 percent, residential sector demand for electricity in 2012 was 5.2 percent and it will increase 55.1 percent in 2047, Commercial sector in 2012 was 7.0 percent it will increase 63.3 percent this is highest electricity demand as a compared to the other sectors. Then agriculture sector in 11. 1 percent 2012 it will increase by 41. 1 percent in 2047.

Table 3: Per Capita Availability, Requirement, and Installed Capacity of Electricity

Year	Per Capita Availability of Electricity* (KWh)	AAGR	Installed Capacity of Electricity (MWh)	AAGR	Electricity Requirement (net core unit)	AAGR
2012-13	750.8		223344		99811	
2013-14	793.1	5.63	245394	9.87	100226	0.42
2014-15	851.8	7.40	271722	10.73	106892	6.65
2015-16	901.4	5.82	298060	9.69	111441	4.26
2016-17	938.1	4.07	326849	9.66	114293	2.56
2017-18	978.1	4.26	330580	1.14	119215	4.31
2018-19	1028.9	5.19	356100	7.72	127456	6.91
2019-20	1042.6	1.33	370106	3.93	129101	1.29
2020-21	1031.4	-1.07	382151	3.25	127553	-1.20
2021-22	1115.3	8.13	399497	4.54	137981	8.18

Source: RBI

As we can see from the table, the per capita availability of electricity has increased from 750.8 kWh in 2012-13 to an estimated 1,115.5 kWh in 2021-22, which is a significant improvement. However, the per capita requirement has also

increased during the same period, from 99811 kWh to an estimated 137981 kWh in 2021. This indicates that there is still a large gap between the electricity supply and demand in India.

To address this gap, India has been increasing its installed capacity of electricity generation steadily. The installed capacity has increased from 223344 MW in 2012-13 to 399497 MW in 2021-22, which is a more than three-fold increase. This shows that India is making significant progress in meeting the growing electricity demand of its population.

Table 4: Region/category -wise energy generation in India

Regions/Categories	Monitored capacity (in gigawatt	Generation target (2022-23)
Northern Region		
Thermal	51.57	273.55
Nuclear	1.62	9.35
Hydro	19.70	76.24
Total	72.88	359.14
Western Region		
Thermal	96.39	502.79
Nuclear	1.84	14.16
Hydro	7.39	15.46
Total	105.62	532.41
Southern Region		
Thermal	49.54	246.54
Nuclear	3.32	19.82
Hydro	11.75	30.51
Total	64.61	296.87
Eastern Region		
Thermal	36.06	221.96
Hydro	5.99	20.10
Total	42.05	242.06
Northeastern Region		
Thermal	2.45	12.56
Hydro	2.03	8.34
Total	4.48	20.90
Bhutan Imp. Region	0.00	8.00
India Region		
Thermal	236.01	1257.39
Nuclear	6.78	43.32
Hydro	46.85	150.66
Bhutan Imp.	0.00	8.00
Total	289.64	1459.37

Source: Ministry of Power, Govt. of India

As we can see from the table, the western region has the largest monitored capacity, followed by the Southern region. The northern, eastern regions have almost similar installed capacity, while the northeastern regions have a lower installed capacity.

In terms of power generation, coal continues to be the dominant source, accounting for around 70% of the total electricity generated in India, followed by renewable energy sources such as wind, solar, and hydroelectric power. The following table shows the region-wise electricity generation in India.

As we can see from the table, the western region has the highest electricity generation, followed by the northern and southern regions. The north-eastern region has the lowest electricity generation. It is worth noting that the data provided is for the year 2022-23 till December and may not represent the current scenario.

Energy supply in India 2023

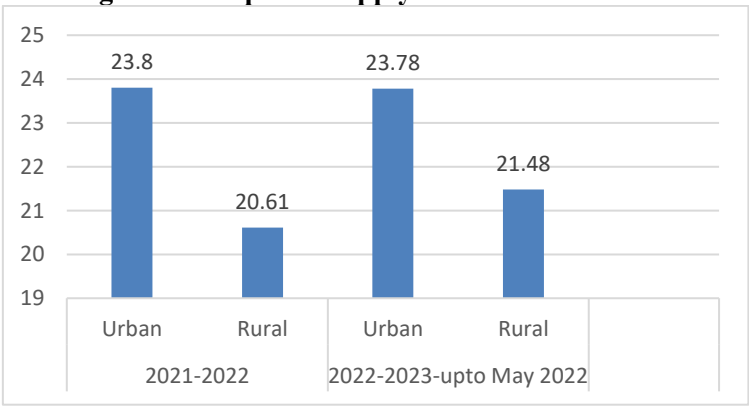
Source: Centre Electricity authority govt of india:

Region	energy necessity (Gigawatt)	Accessibility (Gigawatt)	surplus /deficit (-) Gigawatt	Peak demand (Gigawatt)	accessibility (Gigawatt)	surplus /Deficit (-) Gigawatt
Northern	490.77	482.13	(-)8.64	80.5	77.26	(-)3.24
Western	489.79	523.90	34.11	77.28	73.78	(-)3.24
Southern	396.82	423.81	26.99	65.19	60.36	(-) 4.8
Eastern	191.99	195.61	3.62	31.06	27.56	(-)3.50
North-Eastern	20.51	21.23	0.71	3.91	3.70	(-)0.21
All India	1589.87	1646.67	56.80	229.02	230.3	1.72

Energy is a basic input in all production process in the economy. While Energy demand, Energy supply, energy efficiency, energy generation, and availability of energy sources are indicated to the developmental economy in the country. As we can see above the table shows the large gap between the energy supply and energy demand in the all-regions. although northern region energy requirement is 490. 77 gigawatts but availability of energy is 482.13 only its leads to the energy deficit.

India is full fill the gap between the energy supply and energy demand because India's energy demand is 2229.02-Gigawatt availability is 230.3 gigawatt, it shows the India is surplus in the energy installed capacity therefore which is indicated to the India is fastest growing country in the world.

Average hours of power supply rural and urban in India



Source: LSUQ (Lok Sabha unstarred question no. 1964, Dated on 28.07.2022.

The implementation of the rural electrification projects remained given top attention. The initiative includes, among other things, steps to increase power production, electrify rural areas and small-town energizing houses as soon as possible and enhancing irrigation sets of pumps. It is the State's obligation to electrify rural areas. Governments, state electricity agencies, and distribution businesses that own & run the State's distribution network. Plans for rural electrification are Priorities are developed and put into action by the State Governments. based on their determination and the availability of funds and other resources inputs.

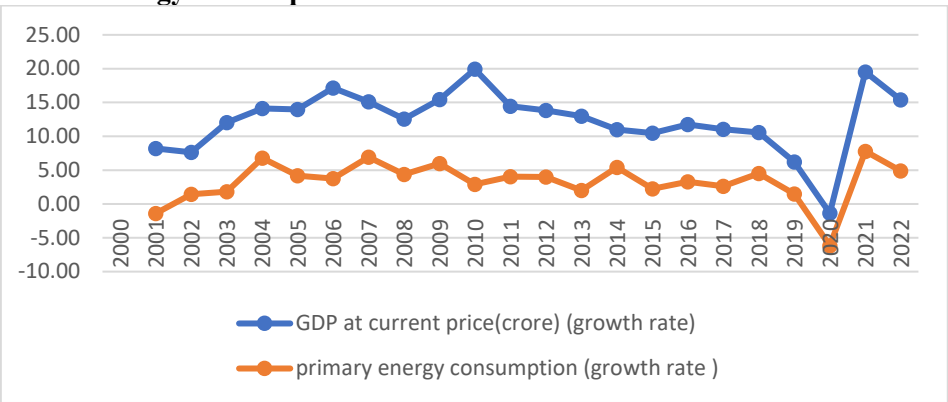
The Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) initiative of the Government of India provides the financing for the rural electrification program, with financial institutions like REC Ltd. supplementing this funding.

According to the current definition of village electrification, which was updated in February 2004, "a village would be declared as electrified if Electricity is provided to public places like Schools, Panchayat Office, Health Centres, Dispensaries, and Community Centres." At least 10% of all residences are electrified and there are centres, etc. how many homes there are in the community.

India's energy supply is growing year over year as a result of upgraded transmission networks that have demonstrated the availability of reliable electricity throughout the country. Over the years, the transmission system has been expended for the removal of electricity for the removal of power from the generating station to the load centre. Beginning in 1992,

area grids were gradually integrated. On December 31, 2013, our nation attained "ONE NATION ONE GRID ONE FREQUENCY."
In 2021–2022, the number of hours of energy supplied to urban and rural regions per day increased by 23.8 and 20.61 hours, respectively, and by 23.78 and 21.48 hours, respectively, in 2022–2023.

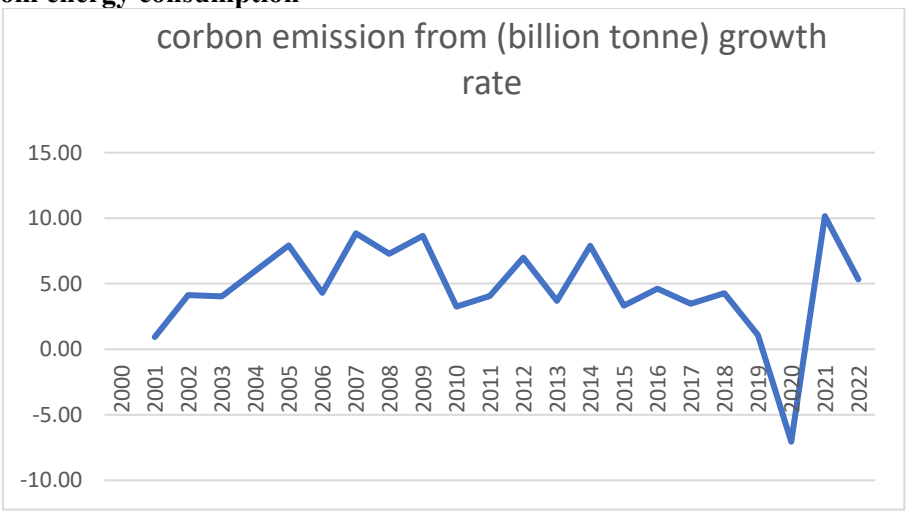
Relationship between the energy consumption and GDP



Source : BP world statical world review 2021-22 and Economic survey 2022-23 Statistical Appendix .

Many studies it has been found out that many developed and developing countries have consumed higher energy consumption due to achieving economic growth and GDP. While India since 2000 to 2022 India is accomplishing a advanced Growth rate in GDP as well as in primary energy consumption. Above the figure presents the growth rate of the energy consumption and GDP since Frome the 2000 to 2022, as we seen figure shows the important point when energy consumption increase GDP also increase and energy consumption is decrees GDP also decrees, therefore positive relationship between the energy consumption and economic growth.

Corbon emission from energy consumption



Source: BP world statical world review 2021-22

Above the diagram shows the corban emission growth rate in India. The carbon emission is increasing the year by year because increasing energy consumption. However highest carbon emission derives from energy sources in India because India's electricity generation dependence on the fossil fuel in order to these sources produced the carbon emission in the atmosphere.
The result of the correlation Metrix shows the positive correlation between the energy consumption and co2 emission. In 2001 carbon emission were 0.959 billon tones it was increased to the 8.85 billon tones in 2007 because increased energy consumption in the country, although it was reached the negative point -7.05 billon tones in 2020 because coved pandemic during this period restriction in many activities, e.g. mobility, economic bustle, construction and manufacturing, plunged the global energy demand. although in the country it was again increased 10.16 billon tones in 2021 over the year.

Conclusion:
In conclusion, electricity consumption in India has increased significantly in recent years, driven by the country's rapid economic growth and urbanization. India has a diverse mix of energy sources, including coal, renewable energy, and nuclear power. However, coal continues to dominate the energy mix and remains a significant contributor to air pollution and greenhouse gas emissions. The government has taken steps to increase the share of renewable energy in the energy mix and improve energy efficiency. Still, there is a need for more significant investments in clean energy technologies and infrastructure to meet the growing demand for electricity while also addressing environmental concerns. Overall, a transition towards a sustainable energy system is necessary to ensure energy security, mitigate climate change, and improve public health.

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