

ELECTRICITY GENERATION AND CONSUMPTION IN INDIA: AN OVERVIEW**Sajna S N¹ and Dr. A. Seilan²**

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ABSTRACT

Electricity generation and consumption in India are pivotal to the nation's economic growth and social development. As one of the fastest-growing economies in the world, India faces a dual challenge: meeting the increasing demand for electricity while ensuring sustainable and efficient energy production. The country's electricity generation mix has evolved significantly, incorporating diverse sources such as coal, hydro, natural gas, wind, and solar power. With ambitious targets set under the National Solar Mission and other initiatives, India aims to achieve 450 GW of renewable energy capacity by 2030. Consumption patterns reflect India's socio-economic diversity, with urban areas experiencing higher per capita consumption compared to rural regions. Industrial sectors are the largest consumers, followed by residential and agricultural uses. The disparities in access to electricity remain a critical issue, with efforts underway to enhance rural electrification and improve grid connectivity. Despite significant progress, challenges persist, including infrastructural deficits, energy losses during transmission, and the need for regulatory reforms. The implementation of smart grid technologies and energy-efficient practices is essential to optimize consumption and minimize waste. Furthermore, the impact of climate change necessitates a transition towards cleaner energy sources, fostering innovation and investment in sustainable technologies.

Key Words : *installed capacity of electricity generation, gross generation of electricity, transmission losses, per-capita energy consumption, energy intensity.*

Introduction

Energy is the basic building block of economic development. Economic growth is energy-intensive, so it is widely acknowledged that energy, especially electricity is essential to this process (Ross Ferguson, William Wilkinson and Robert Hill 2000). Energy (specifically electricity) plays a major role as an input into the production of goods and services, and in determining economic growth and the development of a nation (Asafu-Adjaye, 2000). An economy's production and consumption processes depend heavily on electricity, making it a vital factor. Electricity is the most flexible form of energy that constitutes one of the vital infra-structural inputs in socio-economic development. India's economy is the fastest-growing in the world; hence it has a vast and growing need on energy resources. Electricity infrastructure and production are important for a developing economy like that of India, which with a population of 1.2 billion and an area of 3.29 million km², is the 7th largest country in the world.

Electricity, as an energy carrier, has been the most-consumed energy source by end-use sectors in India. Between 2008-09 and 2017-18, among all the commercial sources of energy, electricity recorded highest compound annual growth rate (CAGR) of 5.71%. This reflects that fact that India's electricity sector has witnessed significant growth over the years, encompassing all consumer sectors. India's electricity

demand is expected to continue to grow, due to increased economic expansion, urbanization, and access to electrical appliances.

By 2030, the total electricity demand in the country (excluding Transmission and Distribution losses) is projected to be 2,060 – 2,699 Tera Watt-hour (TWh). The utility level demand including Transmission and Distribution losses would likely be in the range of 2,039-2,454 TWh (Raghav Pachouri, Shubham Thakare, and Sonam Sinha 2023).

Scope and Objective of the Study

The present study is undertaken to find out the production and consumption of electricity in India. It also covers the analysis of aspects related to the installed capacity of electricity generation in India, gross generation of electricity, year-wise availability of electricity, year-wise consumption of electricity, sector-wise consumption of electricity, electricity generated (from utilities), distributed, sold and transmission losses, per-capita energy consumption and energy intensity.

Methodology of the Study

The study is based on secondary data for ten years from 2010-11 to 2019-20; collected from reports of Central Electricity Authority, Government of India; and Energy Statistics India - 2021 published by National Statistical Office, Ministry of Statistics and Programme Implementation, Government of India.

Discussion

Installed Capacity of Electricity Generation

Generating and providing reliable power at competitive prices in a sustainable manner by optimising the use of multiple energy resource with innovative eco-friendly technologies has been at the core of policy planning in India. The installed capacity of electricity generation in utilities (private companies, cooperative organisations, local or regional authorities, nationalized undertakings or governmental organizations which produce, transmit and distribute electric energy) and non-utilities (an independent power producer owns facilities to generate electric power for sale to utilities and end users) is analysed in table 1 and 2.

Table 1: Year-wise Installed Capacity of Electricity Generation in Utilities

(in Mega Watt = 10^3 Kilo Watt)

Year	Thermal	Hydro	Nuclear	RES*	Total
2010 - 11	1,12,824	37,567	4,780	18,455	1,73,626
2011 - 12	1,31,603	38,990	4,780	24,503	1,99,877
2012 - 13	1,51,530	39,491	4,780	27,542	2,23,344
2013 - 14	1,68,255	40,531	4,780	34,988	2,48,554
2014 - 15	1,88,898	41,267	5,780	38,959	2,74,904
2015 - 16	2,10,675	42,783	5,780	45,924	3,05,162
2016 - 17	2,18,330	44,478	6,780	57,244	3,26,833
2017 - 18	2,22,907	45,293	6,780	69,022	3,44,002
2018 - 19	2,26,279	45,399	6,780	77,642	3,56,100

2019 - 20	2,30,600	45,699	6,780	87,028	3,70,106
CAGR 2010-11 to 2019-20 (%)	8.27	2.20	3.96	18.81	8.77

Source : Central Electricity Authority.

Note: * RES= Renewable Energy Sources excluding Hydro

Year-wise installed capacity of electricity generation from utilities (table 1) reveals that electricity generated from thermal sources was 112824 MW in the year 2010-11 which increased to 230 600 MW in the year 2019-20. During the same period the electricity generated from nuclear sources increased from 4780 MW to 6780 MW, electricity generated from hydro energy sources increased from 37567 MW to 45699 MW and electricity generated from other renewable energy sources increased from 18455 MW to 87028 MW. During the year 2010-11 to 2019-20 the electricity generation through renewable energy sources showed a growth rate of 18.81%, the thermal source grew by 8.27%, nuclear sources by 3.96% and hydro source by 2.2%. Overall, the installed capacity of electricity generation from utilities increased by 8.77% to 370106 MW in 2019-20 over 173626 MW in 2010-11.

Table 2 : Year-wise Installed Capacity of Electricity Generation in Non-utilities

(in Mega Watt = 10^3 x Kilo Watt)

Year	Thermal	Hydro	RES*	Total
2010 - 11	33,821	57	567	34,444
2011 - 12	38,456	48	872	39,375
2012 - 13	39,535	67	1,124	40,726
2013 - 14	40,935	64	1,259	42,258
2014 - 15	43,291	65	1,301	44,657
2015 - 16	46,853	59	1,368	48,279
2016 - 17	50,031	65	1,433	51,529
2017 - 18	53,155	51	1,726	54,933
2018 - 19	72,037	103	3,067	75,207
2019 - 20	74,707	108	3,185	78,000
CAGR 2010-11 to 2019-20 (%)	8.25	6.62	18.84	8.52

Source : Central Electricity Authority.

Note: * RES= Renewable Energy Sources excluding Hydro

Year-wise installed capacity of electricity generation from non utilities (table 2) shows that the electricity generated from thermal sources remained at 33821MW in the year 2010-11; it increased to 74707 in 2019-20, similarly the electricity generated during this period from hydro sources increased from 57 MW to 108 MW and the electricity generated from other renewable sources increased from 567 MW to 3185 MW.

During the years 2010-11 to 2019-20 the electricity generation through renewable energy sources increased by 18.84%, thermal sources by 8.125% and hydro sources by 6.62%. On the whole, the installed capacity of

electricity generation from non-utilities increased by 8.52% to 78000 MW in 2019-20 over 34444 MW in 2010-11.

Gross Generation of Electricity

The total amount of electricity produced by firms before deducting losses or internal use is referred to as the gross generation of electricity. This assessment sheds light on the electrical industry's total capacity and production capabilities.

Table 3 : Year-wise Gross Generation of Electricity from Utilities

(Giga Watt hour= 10^6 Kilo Watt hour)

Year	Thermal	Hydro	Nuclear	RES*	Total
2010-11	6,64,822	1,14,416	26,266	39,245	8,44,748
2011-12	7,08,427	1,30,511	32,287	51,226	9,22,451
2012-13	7,60,454	1,13,720	32,866	57,449	9,64,489
2013-14	7,92,054	1,34,848	34,228	65,520	10,26,649
2014-15	8,77,941	1,29,244	36,102	73,563	11,16,850
2015-16	9,43,013	1,21,377	37,414	65,781	11,67,584
2016-17	9,93,516	1,22,378	37,916	81,548	12,35,358
2017-18	10,37,146	1,26,123	38,346	1,01,839	13,03,455
2018-19	10,72,314	1,34,894	37,813	1,26,759	13,71,779
2019-20 (P)	10,42,838	1,55,769	46,472	1,38,337	13,83,417
CAGR 2010-11 to 2019-20 (%)	5.13	3.49	6.54	15.03	5.63

Source : Central Electricity Authority.

Note: * RES= Renewable Energy Sources excluding Hydro

Gross generation of electricity from utilities reveals that (table 3) electricity generation from thermal sources increased from 664822 GW in 2010-11 to 1042838 GW in 2019-20 with 5.13% increase; During the same period the electricity generation from hydro sources increased from 114416 GW TO 155769 GW with 3.49% increase; electricity generation from nuclear sources increased from 26266 GW to 46472 GW with 6.54% increase and the electricity generation from renewable energy sources increased from 39245 GW to 138337 GW with 15.03% increase.

The gross electricity generation from utilities from all sources taken together was 844748 GW in 2010-11 which increased to 1383417 GW in 2019-20, this has grown by 5.63% in the last 10 years.

Table 4 : Year-wise Gross Generation of Electricity from Non-Utilities

(Giga Watt hour= 10^6 x Kilo Watt hour)

Year	Thermal	Hydro	RES*	Total
2010-11	1,19,846	149	922	1,20,917
2011-12	1,33,079	131	1,178	1,34,388

2012-13	1,42,141	118	1,750	1,44,010
2013-14	1,46,957	129	1,903	1,48,988
2014-15	1,59,256	145	2,656	1,62,057
2015-16	1,66,216	110	2,046	1,68,372
2016-17	1,69,625	144	2,277	1,72,046
2017-18	1,77,337	112	2,328	1,79,777
2018-19	2,09,130	270	3,674	2,13,074
2019-20 (P)	2,10,869	280	3,851	2,15,000
CAGR 2010-11 to 2019-20(%)	5.81	6.53	15.36	5.92

Source : Central Electricity Authority.

Note: * RES= Renewable Energy Sources excluding Hydro

Gross generation of electricity from non-utilities during 2010-11 to 2019-20 shows that (table 4) generation of electricity from thermal sources has increased from 119846 GW to 210869 GW with 5.81% increase, electricity generation from hydro sources has increased from 149 GW to 280 GW with 6.53% increase and electricity generation from renewable energy sources increased from 922 GW to 3851 GW with 15.36% increase. Gross electricity generation from non-utilities was 120917 GW in 2010-11 which increased to 215000 GW in 2019-20, this has grown by 5.92% in the last ten years.

Availability of Electricity

Availability of electricity typically refers to the total amount of electricity generated and supplied over a series of years. This data helps in understanding trends, planning infrastructure, and addressing energy needs.

Table 5 : Year-wise Availability of Electricity

(in Giga Watt hour = 10⁶ Kilo Watt hour)

Year	Gross Electricity Generated from Utilities	Consumption in Power Station Auxiliaries	Net Electricity Generated from Utilities	Purchases from Non-Utilities + Net Import from Other Countries	Net Availability (For Supply)
2010-11	8,44,748	52,952	7,91,796	19,839	8,11,635
2011-12	9,22,451	56,499	8,65,952	15,514	8,81,466
2012-13	9,64,489	64,109	9,00,380	20,849	9,21,229
2013-14	10,26,649	70,161	9,56,488	17,948	9,74,436
2014-15	11,16,850	76,268	10,40,582	13,773	10,54,355
2015-16	11,67,584	79,302	10,88,282	15,947	11,04,228
2016-17	12,35,358	81,044	11,54,314	8,977	11,63,290
2017-18	13,03,455	82,148	12,21,307	11,198	12,32,505
2018-19	13,71,779	83,386	12,88,393	19,291	13,07,685
2019-20	13,83,417	84,795	12,98,621	12,554	13,11,176

CAGR 2010-11 to 2019-20 (%)	5.63	5.37	5.65	-4.96	5.47
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Source : Central Electricity Authority.

Analysis about the year wise available of electricity in India (table 5) reveals that in the year 2019-20 gross electricity generated from utilities stood at 1383417 GWh; after deducting the consumption of electricity in power stations which is 84795 GWh, then net electricity generated from utilities remained at 1298621 GWh, electricity purchased from non-utilities and net import from other countries amounts to 12554 GWh this when added makes net availability of electricity for supply in India as 1311176 GWh. The net availability of electricity for supply increased from 811635 GWh in 2010-11 to 1311176 GWh in 2019-20, thus recording a compound annual growth rate of 5.47% during this period.

Consumption of Electricity

Consumption of electricity refers to the total amount of electricity used by end-users, including households, businesses, and industries. The study of consumption patterns of energy in any economy is vital to understand how final demand drives energy use or consumption.

Table 6 : Year-wise Consumption of Electricity in Physical Units and Energy Units

Year	Electricity in Physical Units (GWh)	Electricity in Energy Units (Petajoules)
2010-11	6,94,392.00	2500
2011-12	7,85,194.00	2827
2012-13	8,24,300.99	2967
2013-14	8,74,208.57	3147
2014-15	9,48,521.82	3415
2015-16	10,01,190.68	3604
2016-17	10,61,182.64	3820
2017-18	11,23,426.86	4044
2018-19	12,09,971.63	4356
2019-20 (P)	12,91,493.75	4649
CAGR 2010-11 to 2019-20 (P)(%)	7.14	7.14

Source : Central Electricity Authority

Note : GWh = Giga Watt hour = 10^6 x Kilo Watt hour

Data pertaining to the year-wise consumption of electricity in India in physical units and energy units (table 6) shows that, it has increased from 694392 GWh (22620 penta joules) in 2010-11 to 1291493 GWh (32514 penta joules). The consumption of electricity has increased by 7.14% during these years.

Sector-wise Consumption of Electricity

Sector-wise electricity consumption explains the amount of electricity consumed by different sectors of an economy.

Table 7 : Consumption of Electricity – Sector-wise

(in Giga Watt Hour = 10⁶ Kilo Watt Hour)

Year	Industry	Agriculture	Domestic	Commercial	Traction & Railways	Others	Total
2010-11	2,72,589	1,31,967	1,69,326	67,289	14,003	39,218	6,94,392
2011-12	3,52,291	1,40,960	1,71,104	65,381	14,206	41,252	7,85,194
2012-13	3,65,989	1,47,462	1,83,700	72,794	14,100	40,256	8,24,301
2013-14	3,84,418	1,52,744	1,99,842	74,247	15,540	47,418	8,74,209
2014-15	4,18,346	1,68,913	2,17,405	78,391	16,177	49,289	9,48,522
2015-16	4,23,523	1,73,185	2,38,876	86,037	16,594	62,976	10,01,191
2016-17	4,40,206	1,91,151	2,55,826	89,825	15,683	68,493	10,61,183
2017-18	4,68,613	1,99,247	2,73,545	93,755	17,433	70,834	11,23,427
2018-19	5,19,196	2,13,409	2,88,243	98,228	18,837	72,058	12,09,972
2019-20	5,51,362	2,28,172	3,10,151	1,03,883	19,577	78,348	12,91,494
% share in 2019-20 (%)	42.69	17.67	24.01	8.04	1.52	6.07	100.00
CAGR 2010-11 to 2019-20 (%)	8.14	6.27	6.96	4.94	3.79	7.99	7.14

Source : Central Electricity Authority.

Consumption of electricity by various sectors in India (table 7) reveals that in the year 2019-20, of the total consumption of electricity, industrial sector accounted for the largest share (42.69%) followed by domestic sector (24.01%), agricultural sector (17.67%), commercial sector (8.04%), traction and railways (1.52%) and other sectors (6.07%).

Electricity Generated, Distributed, Sold, and Transmission Losses

Electricity generated, distributed, sold, and transmission losses describe the lifecycle of electricity from production to delivery and the inefficiencies along the way. These aspects are crucial for understanding energy efficiency, the financial health of utilities, and planning improvements in the power infrastructure.

Table 8 : Electricity Generated (from Utilities), Distributed, Sold and Transmission Losses

(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 (%)
2010-11	7,91,796	19,839	8,11,635	6,17,098	1,94,537	23.97
2011-12	8,65,952	15,514	8,81,466	6,73,068	2,08,398	23.64
2012-13	9,00,380	20,849	9,21,229	7,08,997	2,12,232	23.04
2013-14	9,56,488	17,948	9,74,436	7,51,908	2,22,528	22.84
2014-15	10,40,582	13,773	10,54,355	8,14,250	2,40,105	22.77
2015-16	10,88,282	15,947	11,04,228	8,63,364	2,40,864	21.81
2016-17	11,54,314	8,977	11,63,290	9,14,093	2,49,197	21.42
2017-18	12,21,307	11,198	12,32,505	9,73,131	2,59,375	21.04
2018-19	12,88,393	19,291	13,07,685	10,37,518	2,70,167	20.66
2019-20 (P)	12,98,621	12,554	13,11,176	10,44,648	2,66,527	20.33
CAGR 2010-11 to 2019-20 (%)	5.65	-4.96	5.47	6.02	3.56	

Source : Central Electricity Authority.

Analysis regarding electricity generated, distributed, sold and loss in transmission (table 8) reveals that, in the year 2019-20 net electricity generated from utilities amounts to 1298621 GWh and electricity purchased from non-utilities and net import from other countries was 12554 GWh. Thus the net electricity available for supply was found to be 1311176 GWh; of which 266527 GWh was lost in transmission and distribution, and finally 1044648 GWh electricity was sold to ultimate consumers and other countries.

Per-Capita Energy Consumption and Energy Intensity

Per-Capita Energy Consumption measures the average amount of energy consumed by each individual within a country over a certain period, typically measured annually. It is calculated by dividing the total energy consumption of the region by its population. Per-capita energy consumption provides insight into energy usage patterns and is an important metric for both economic planning and sustainability assessments.

Energy Intensity is a measure of the amount of energy required to produce a unit of economic output. It is usually expressed as the amount of energy consumed per unit of Gross Domestic Product (GDP), often in terms of energy used per unit of currency.

Table 9: Per-Capita Energy Consumption and Energy Intensity

Year	Energy Consumption in petajoules	Mid year population (in Million)	GDP at 2011-12 prices (Rs. crore)	Per Capita Energy Consumption (in Megajoules)	Energy Intensity (Megajoules perrupee)
2011-12	23996	1220	8736329	19669	0.2747
2012-13	25676	1235	9213017	20790	0.2787AA
2013-14	26166	1251	9801370	20916	0.2670
2014-15	27710	1267	10527674	21871	0.2632
2015-16	28517	1283	11369493	22227	0.2508
2016-17	29397	1299	1,23,08,193	22630	0.2388
2017-18	30993	1314	1,31,44,582	23587	0.2358
2018-19	32639	1327	1,40,03,316	24596	0.2331
2019-20	32514	1341	1,45,69,268	24246	0.2232
CAGR 2011-12 to 2019-20((P) (%)	3.87	1.19	6.60	2.65	-2.56

Source : India Energy Statistics – 202, MoSPI Government of India.

Note :Energy Intensity = Amount of energy consumed for producing one unit of Gross Domestic Product.

GDP estimates are at base 2011-12 price as per the National Accounts Divisions's, NSO, MoSPI First Revised Estimates released on 29.01.2021

Mid-Year (as on 1st October) population has been taken from population projections for India and states 2011 – 2036; Report of the Technical Group on Population Projections, November, 2019, National Commission on Population, Ministry of Health & Family Welfare

Conclusion

Electricity generation and consumption in India are crucial to the country's development and sustainability. As India struggles to meet its expanding energy demands, it is critical to shift to a more diverse and cleaner energy mix, with a strong emphasis on renewable energy. Addressing issues like as infrastructure shortages, energy losses, and unequal access is critical to guaranteeing consistent electricity for all populations. By encouraging innovation and implementing efficient methods, India may establish a balanced strategy that promotes economic growth while emphasizing environmental responsibility, preparing ways for an energy future that is sustainable.

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