

Chapter-I

Overview of Power Sector

India's power sector is well diversified and evolving with changes in market dynamics. The demand for electricity in the country has increased rapidly and is expected to increase further in the years to come. In order to meet the increasing demand for electricity, the electricity supply chain has undergone a phase of transformation to competitiveness. This chapter provides an overview of the developments made in the electricity supply chain over the years and the new policy initiatives undertaken to address some of the key challenges faced by the sector.

1. Generation

The sources of electricity generation in India can be broadly classified into conventional and non-conventional. The conventional sources of power generation are thermal (coal, lignite, natural gas, and oil), hydro and nuclear power, whereas non-conventional sources of power generation (renewable energy sources) include solar, wind, agricultural and domestic waste, etc. Table-1(a) and Figure-1(a) show the installed electricity generation capacity in India by different sources.

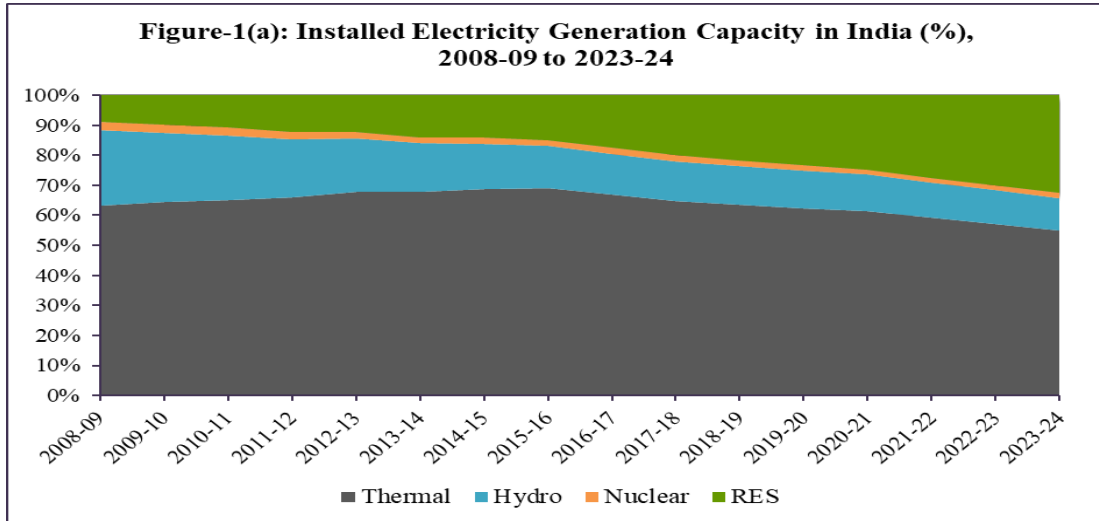
**Table-1(a): Installed Electricity Generation Capacity in India (GW),
2008-09 to 2023-24**

Year	Thermal	Hydro	Nuclear	RES*	Total
2008-09	93.73	36.88	4.12	13.24	147.97
2009-10	102.45	36.86	4.56	15.52	159.40
2010-11	112.82	37.57	4.78	18.45	173.63
2011-12	131.60	38.99	4.78	24.50	199.88
2012-13	151.53	39.49	4.78	27.54	223.34
2013-14	168.26	40.53	4.78	34.99	248.55
2014-15	188.90	41.27	5.78	38.96	274.90
2015-16	210.68	42.78	5.78	45.92	305.16
2016-17	218.33	44.48	6.78	57.24	326.83
2017-18	222.91	45.29	6.78	69.02	344.00
2018-19	226.28	45.40	6.78	77.64	356.10
2019-20	230.60	45.70	6.78	87.03	370.11
2020-21	234.73	46.21	6.78	94.43	382.15
2021-22	236.11	46.72	6.78	109.89	399.50

2022-23	237.27	46.85	6.78	125.16	416.06
2023-24	243.22	46.93	8.18	143.64	441.97

Source: CEA, *Growth of Electricity Sector in India, various issues.*

* RES includes Small Hydro Project (≤ 25 MW)



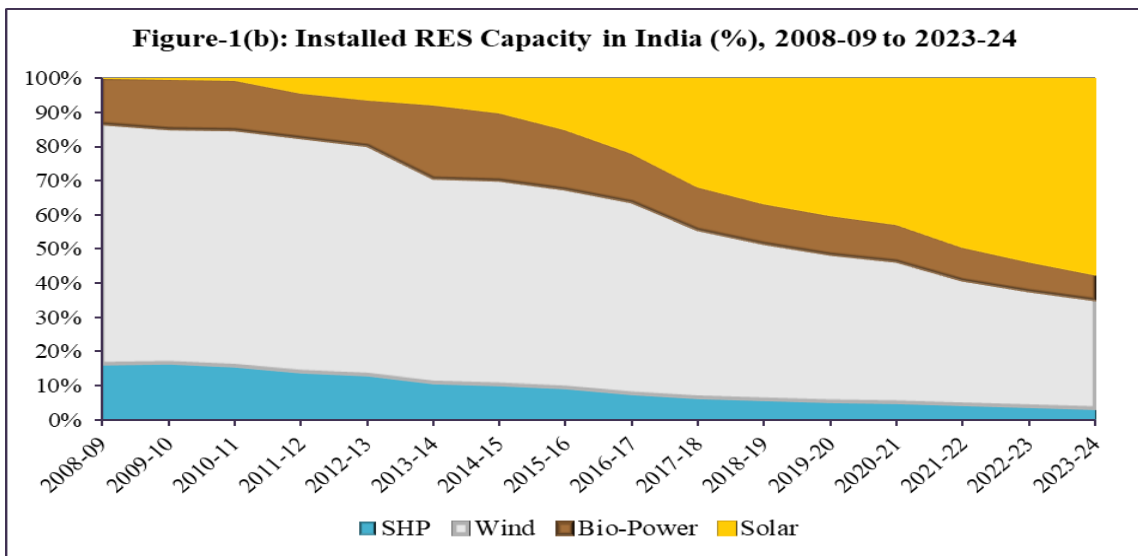
As can be observed from Figure-1(a), thermal is a major source of electricity generation in India, contributing 55% of the total capacity of generation in 2023-24, followed by renewable energy sources (RES) with 32.5%, hydro (10.6%) and nuclear (1.9%). While the share of thermal-based generation capacity in the total installed capacity gradually decreased from 63.3% in 2008-09 to 55% in 2023-24, the share of renewables-based generation capacity increased about four times, i.e., from 8.9% to 32.5% during this period. The CAGR of total installed electricity generation capacity was about 7.6% during the period as compared to 17.2% in RES and 5.4% in all other sources.

Table-1(b) shows the installed RES capacity from various sources, and Figure-1(b) shows the share of different sources in the installed RES capacity. As can be observed from the figure, solar constitutes about 57% of total RES capacity in India, followed by wind (31.9%), bio-power (7.6%) and small hydropower (3.5%) in 2023-24. The share of solar in the total RES installed capacity has increased considerably from less than 1% in 2008-09 to 57% in 2023-24.

Table-1(b): Installed RES Capacity in India (GW), 2008-09 to 2023-24

Year	SHP	Wind	Bio-Power	Solar	Total RES
2008-09	2.16	9.34	1.74	0.00	13.24
2009-10	2.60	10.65	2.26	0.01	15.52
2010-11	2.91	12.81	2.70	0.03	18.45
2011-12	3.41	16.90	3.26	0.94	24.50
2012-13	3.64	18.49	3.73	1.69	27.54
2013-14	3.80	21.04	7.51	2.63	34.99
2014-15	4.06	23.35	7.81	3.74	38.96
2015-16	4.27	26.78	8.11	6.76	45.92
2016-17	4.38	32.28	8.30	12.29	57.24
2017-18	4.49	34.05	8.84	21.65	69.02
2018-19	4.59	35.63	9.24	28.18	77.64
2019-20	4.68	37.69	10.02	34.63	87.03
2020-21	4.79	39.25	10.31	40.09	94.43
2021-22	4.85	40.36	10.68	54.00	109.89
2022-23	4.94	42.63	10.80	66.78	125.16
2023-24	5.00	45.89	10.94	81.81	143.64

Source: CEA, Growth of Electricity Sector in India, various issues.



The Electricity Act of 2003 liberalised the process of electricity generation by shifting towards a license-free regime, which has resulted in increased competition in the generation segment with the share of private players witnessed a significant increase in total electricity generation.

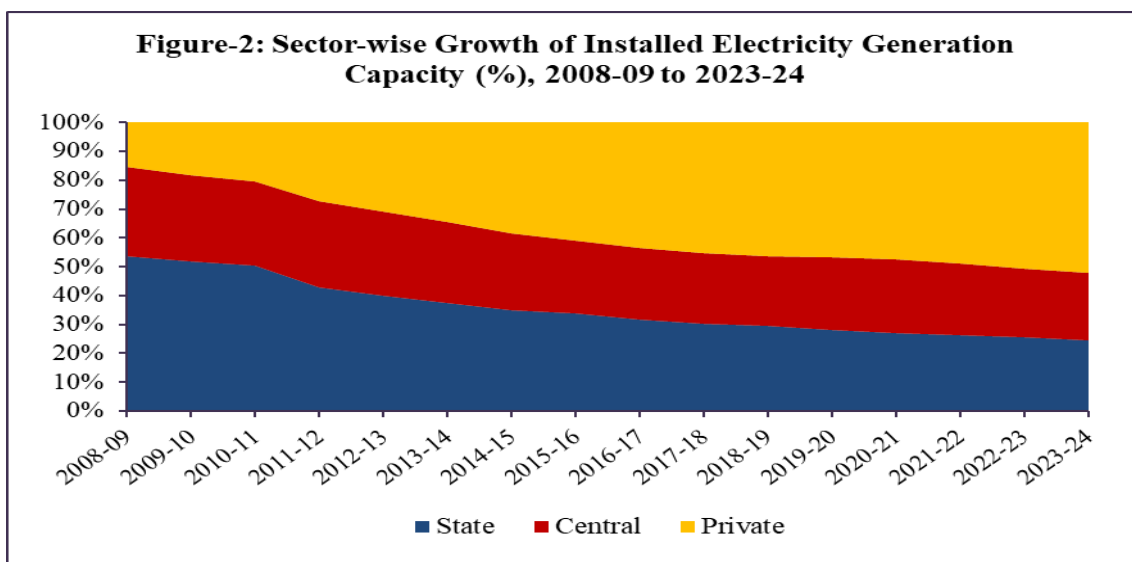
The players in the electricity generation segment can be divided into three types based on ownership and operations, i.e., (i) Central public sector undertakings, (ii) State public sector undertakings/State Electricity Boards, and (iii) Private sector companies.

The sector-wise growth of installed generation capacity is shown in Table-2 and Figure-2. The total installed generation capacity increased at a CAGR of 7.6% from 2008-09 to 2023-24. During this period, the share of the state sector in the total installed generation capacity declined from 54% to 24%, and the share of the central sector declined from 31% to 24%, while the share of the private sector increased significantly from 15% to 52%.

Table-2: Sector-wise Growth of Installed Electricity Generation Capacity, 2008-09 to 2023-24

Year	Installed Generation Capacity (GW)			
	State	Central	Private	Total
2008-09	79.31	45.78	22.88	147.97
2009-10	82.91	47.48	29.01	159.40
2010-11	87.42	50.76	35.45	173.63
2011-12	85.92	59.68	54.28	199.88
2012-13	89.13	65.36	68.86	223.34
2013-14	92.27	68.13	84.87	245.26
2014-15	95.08	72.52	104.12	271.72
2015-16	101.79	76.30	124.00	302.09
2016-17	103.97	80.26	142.62	326.85
2017-18	103.97	84.52	155.51	344.00
2018-19	105.08	86.60	164.43	356.10
2019-20	103.32	93.48	173.31	370.11
2020-21	103.87	97.51	180.77	382.15
2021-22	104.85	99.00	195.64	399.50
2022-23	105.73	100.05	210.28	416.06
2023-24	107.67	104.45	229.85	441.97

Source: CEA, Growth of Electricity Sector in India, various issues.

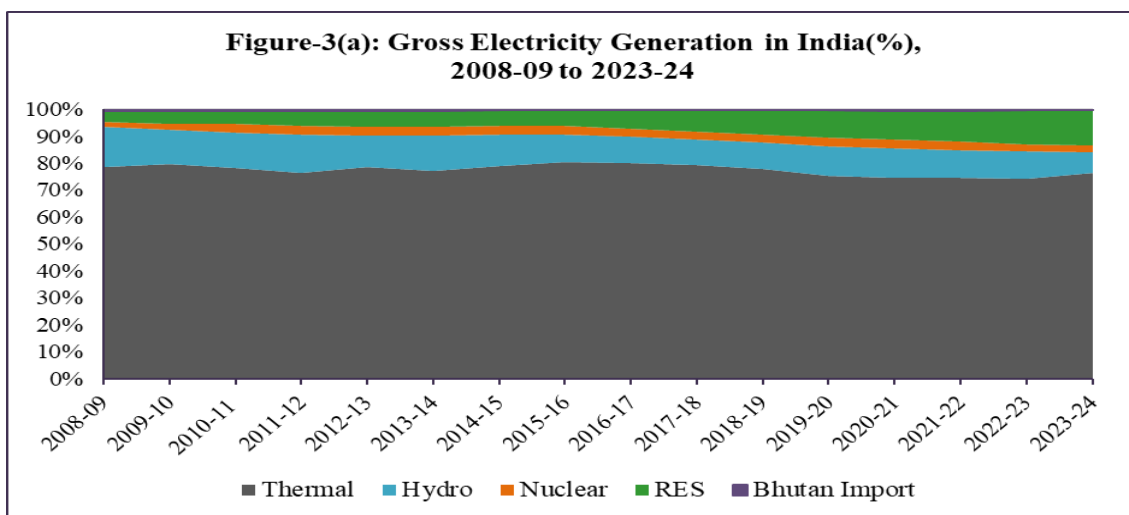


Source-wise gross electricity generation in India is shown in Table-3(a) and Figure-3(a). It can be observed from the table that gross electricity generation in India has increased from 747.07 BU in 2008-09 to 1739.09 BU in 2023-24, at a CAGR of about 5.8%. The growth in gross electricity generation is low compared to the growth in annual installed electricity generation capacity (7.6%). This may be primarily due to an increase in capacity from RES with a relatively low utilization factor.

Table-3(a): Gross Electricity Generation in India (BU), 2008-09 to 2023-24

Year	Thermal	Hydro	Nuclear	RES	Bhutan Import	Total
2008-09	588.28	110.10	14.93	27.86	5.90	747.07
2009-10	640.21	104.06	18.64	36.95	5.40	805.26
2010-11	665.00	114.30	26.30	41.15	5.60	852.35
2011-12	708.43	130.51	32.29	51.23	5.30	927.76
2012-13	760.45	113.72	32.87	57.45	4.80	969.29
2013-14	792.05	134.85	34.23	59.62	5.60	1026.35
2014-15	877.94	129.24	36.10	61.79	5.00	1110.07
2015-16	943.01	121.38	37.41	65.78	5.20	1172.78
2016-17	994.22	122.31	37.66	81.87	5.64	1241.70
2017-18	1037.06	126.12	38.35	101.84	4.78	1308.15
2018-19	1072.00	135.00	37.70	126.76	4.40	1375.86
2019-20	1044.45	155.67	46.38	138.32	5.81	1390.63
2020-21	1032.51	150.30	43.03	147.25	8.77	1381.86
2021-22	1114.71	151.63	47.11	170.90	7.49	1491.85
2022-23	1206.39	162.10	45.86	203.56	6.74	1624.65
2023-24	1326.55	134.05	47.94	225.83	4.72	1739.09

Source: CEA, Growth of Electricity Sector in India, various issues



Of all the sources, electricity generation from thermal (mainly coal) continues to play a dominant role in the energy mix of the country, with a share of about 76% in 2023-24. Though the relative share of thermal continues to be the highest, it has shown a declining trend over the last few years, mainly because of the increasing emphasis on renewable energy sources. The share of electricity generated from RES in the total generation has increased about four times, i.e., from 3.7% in 2008-09 to 13% in 2023-24.

Table-3(b) and Figure-3(b) provide details of renewable electricity generation in India from various sources from 2015-16 onwards. As can be observed from the figure, total renewable electricity generation increased from 65.78 BU in 2015-16 to 225.83 BU in 2023-24 at a CAGR of 16.7%. Solar generation increased significantly from 7.45 BU in 2015-16 to about 115.98 BU in 2023-24 at a CAGR of 40.9%.

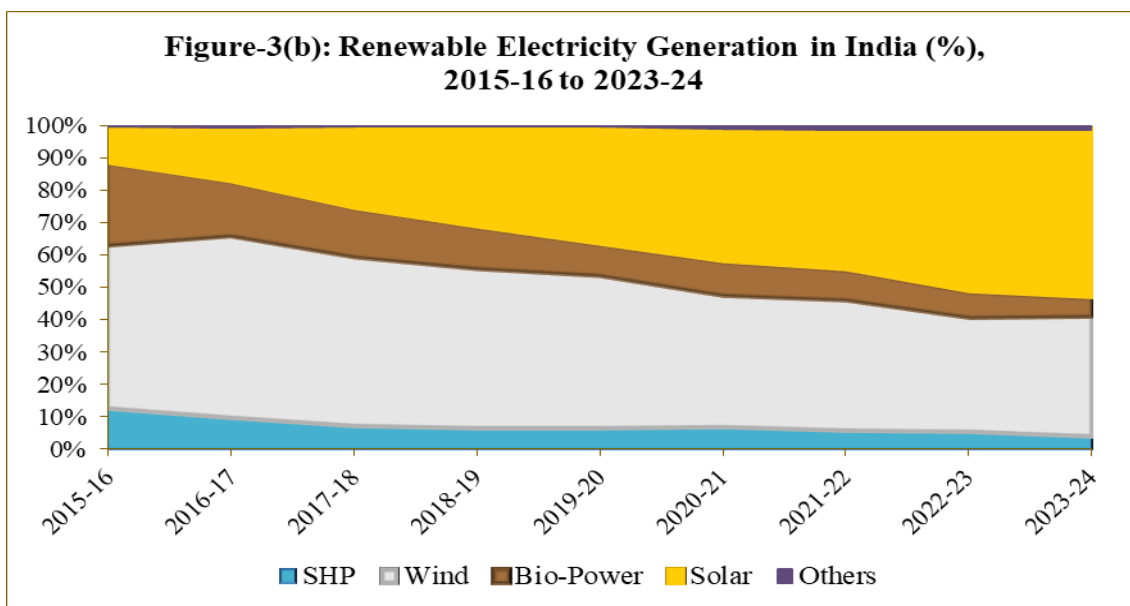
**Table-3(b): Renewable Electricity Generation* in India (BU),
2015-16 to 2023-24**

Year	SHP	Wind	Bio-Power	Solar	Others	Total RES
2015-16	8.36	33.03	16.68	7.45	0.27	65.78
2016-17	8.16	46.01	13.69	13.80	0.57	82.22
2017-18	7.69	52.67	15.25	25.87	0.36	101.84
2018-19	8.70	62.04	16.33	39.27	0.43	126.76
2019-20	9.45	64.65	13.74	50.13	0.37	138.34
2020-21	10.26	60.15	14.82	60.40	1.62	147.25
2021-22	10.46	68.64	16.06	73.48	2.27	170.91
2022-23	11.17	71.81	16.02	102.01	2.53	203.55
2023-24	9.49	83.39	13.57	115.98	3.42	225.83

Source: CEA, Report of Renewable Generation

* Excluding Large Hydro





As per the announcement made by the Hon'ble Prime Minister at the COP26 Summit in Glasgow in November 2021, the Government of India has set an ambitious target for the enhancement of non-fossil fuel energy capacity to 500 GW by 2030. The commitment regarding non-fossil fuel energy capacity is proposed to be met mainly from the installation of solar and wind power capacities. This will enable diversification of India's energy mix with the increasing share of renewable resources.

The Energy Conservation (Amendment) Act, 2022 notified on October 20, 2023 mandates the minimum share of non-fossil energy consumption for designated consumers, effective from April 1, 2024. As per the notification, all electricity distribution licensees and all other designated consumers who are open access consumers or captive users to the extent of consumption of electricity from sources other than distribution licensee shall utilize a minimum percentage of energy consumption from different types of non-fossil sources as a percentage of their total share of energy consumption.

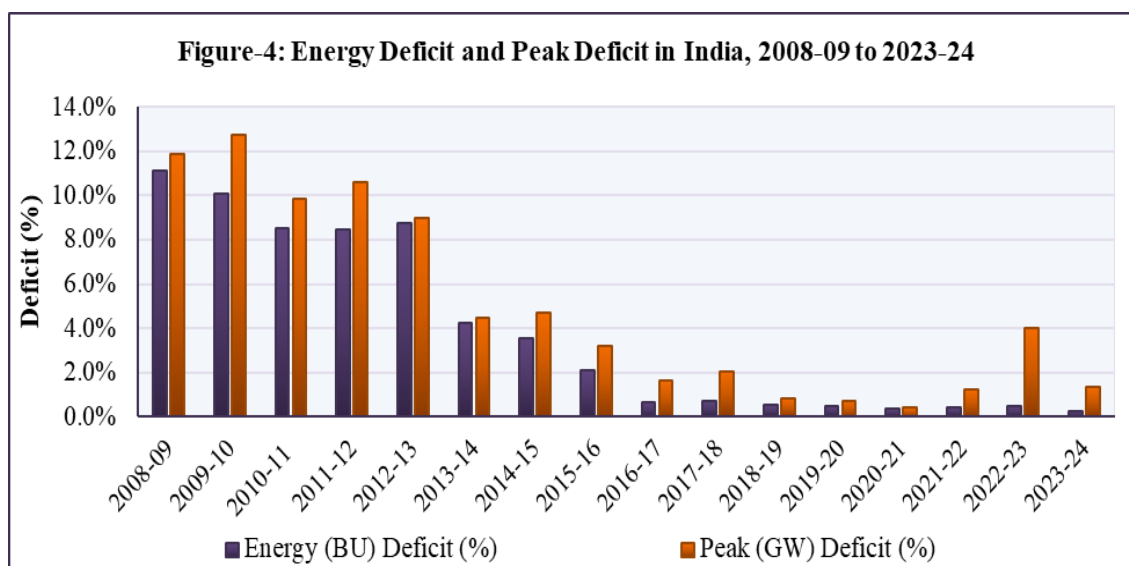
The increase in installed electricity generation capacity over the years (as shown in Table-1(a)) has had a positive impact on the power supply position. Both energy requirement and peak demand increased from 777.04 BU and 109.81 GW, respectively, in 2008-09 to 1626.13 BU and 243.27 GW, respectively, in 2023-24 (Table-4). An increase in the installed capacity resulted in a decrease in the energy and peak deficit

from 11.1% and 11.9%, respectively, in 2008-09 to about 0.3% and 1.4%, respectively, in 2023-24 (Figure-4).

Table-4: Power Supply Position in India, 2008-09 to 2023-24

Year	Energy (BU)			Peak (GW)		
	Requirement	Availability	Deficit (%)	Requirement	Availability	Deficit (%)
2008-09	777.04	691.04	11.1%	109.81	96.79	11.9%
2009-10	830.59	746.64	10.1%	119.17	104.01	12.7%
2010-11	861.59	788.36	8.5%	122.29	110.26	9.8%
2011-12	937.20	857.89	8.5%	130.01	116.19	10.6%
2012-13	995.56	908.65	8.7%	135.45	123.29	9.0%
2013-14	1002.26	959.83	4.2%	135.92	129.82	4.5%
2014-15	1068.92	1030.79	3.6%	148.17	141.16	4.7%
2015-16	1114.41	1090.85	2.1%	153.37	148.46	3.2%
2016-17	1142.93	1135.33	0.7%	159.54	156.93	1.6%
2017-18	1213.33	1204.70	0.7%	164.07	160.75	2.0%
2018-19	1274.60	1267.53	0.6%	177.02	175.53	0.8%
2019-20	1291.01	1284.44	0.5%	183.80	182.53	0.7%
2020-21	1275.53	1270.66	0.4%	190.20	189.40	0.4%
2021-22	1379.81	1374.02	0.4%	203.01	200.54	1.2%
2022-23	1513.50	1505.91	0.5%	215.89	207.23	4.0%
2023-24	1626.13	1622.02	0.3%	243.27	239.93	1.4%

Source: CEA



2. Transmission

Transmission sector is having a natural monopoly, as it involves high sunk costs in investing in the infrastructure needed to transmit electricity, such as transmission lines. Due of these characteristics, non-public entities face entry barriers, and private investments are allowed in transmission projects only after the approval from CERC. Although the transmission market is largely dominated by the public sector, there are many lines, including High-Voltage Direct Current (HVDC) lines owned by private players. As on 31.3.2024, CERC granted approval for Inter-state transmission licence to 107 entities (Annexure-I).

CERC notified the Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022 on 7.6.2022. These regulations simplify the process of connectivity and access to the grid for facilitating open access and competition in the power sector. The Regulations also specify that each State shall have a General Network Access (GNA) to ISTS. The States shall be able to schedule power under long term or medium-term or short-term contracts based on its own assessment of merit order on day ahead basis within GNA quantum. Any drawal beyond GNA shall be with additional charges and the GNA once granted shall remain valid until relinquished. Connectivity grantees shall be deemed to have been granted GNA, equal to the quantum of Connectivity from the start date of Connectivity. The Regulations also feature the concept of Temporary GNA as open access to ISTS granted to an eligible buyer or an entity on behalf of buyer for a time period of one block up to eleven months.

The growth of transmission system (transmission lines and transformation capacity) in India during 2008-09 to 2023-24 is shown in Table-5 and Figure-5.

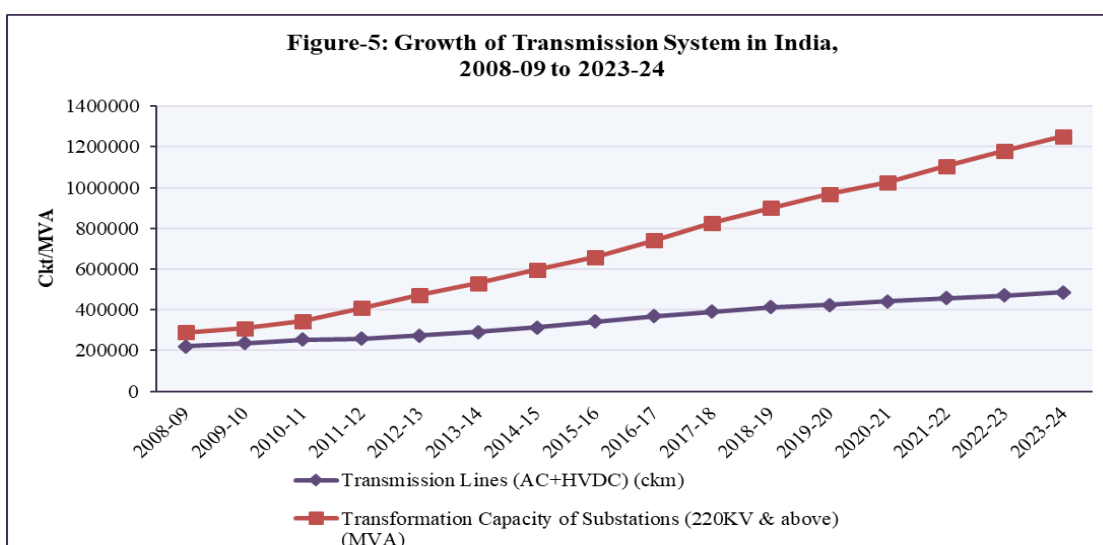
Table-5: Growth of Transmission System in India, 2008-09 to 2023-24

Year	Transmission Lines (AC+HVDC) (ckm)	Transformation Capacity of Substations (220KV and above) (MVA)
2008-09	220794	288615
2009-10	236467	310052
2010-11	254536	345513
2011-12	257481	409551



2012-13	274588	473216
2013-14	291336	530546
2014-15	313437	596100
2015-16	341551	658949
2016-17	367851	740765
2017-18	390970	826958
2018-19	413407	899663
2019-20	425071	967893
2020-21	441821	1025468
2021-22	456716	1104450
2022-23	471341	1180352
2023-24	485544	1251080

Source: CEA, Monthly Reports



It can be observed from Table-5 that bulk transmission (transmission lines 220 kV & above) has increased from 2.21 lakh ckm in 2008-09 to 4.85 lakh ckm in 2023-24. During the period, the transformation capacity of sub-stations has also increased from 2.89 lakh MVA to 12.51 lakh MVA. The CAGR in the transmission lines and transformation capacity of sub-stations was 5.4% and 10.3%, respectively.

Table-6 provides the data on annual transmission charges (transmission charges applicable for transmission lines owned by PGCIL and other ISTS licensees) for the period from 2011-12 to 2023-24. The annual transmission charges increased at a CAGR of 14.88% during the period. There are various reasons for increase in annual transmission charges, like the growth of transmission lines (especially at higher voltage levels), waiver of transmission charges for inter-state renewable energy generators, and relinquishment of long-term access (LTA).

Table-6: Annual Transmission Charges, 2011-12 to 2023-24

Year	Transmission Charges as on 31 st March (₹ Crore)
2011-12	8743
2012-13	12797
2013-14	15118
2014-15	17680
2015-16	22476
2016-17	27383
2017-18	31405
2018-19	35599
2019-20	39285
2020-21	41051
2021-22	41696
2022-23	46800
2023-24	46203

Source: Grid-India

In March 2023, the Ministry of Power brought out a detailed Plan titled “Transmission System for Integration of over 500 GW RE Capacity by 2030” in consultation with States and other stakeholders. The planned transmission system is expected to provide visibility to the RE developers about the potential generation sites and scale of investment opportunities.

3. Distribution

Distribution is the last leg in the electricity supply chain and assumes significant importance in the overall performance of the sector. State Electricity Distribution Companies (DISCOMs)/State Electricity Boards (SEBs) own the majority of the distribution segment in the electricity supply chain. In order to boost competition and make the sector more efficient, the Government is emphasizing the importance of a well-performing distribution sector and has been focusing on the improvement of the financial health of the distribution utilities. This is necessary to meet the goal of providing people a reliable and good-quality power and universal access to electricity. To meet this goal, it is required to increase rural electrification, reduce aggregate technical and commercial (AT&C) losses incurred while distributing electricity, ensuring financial viability of DISCOMs, and encourage private sector participation.

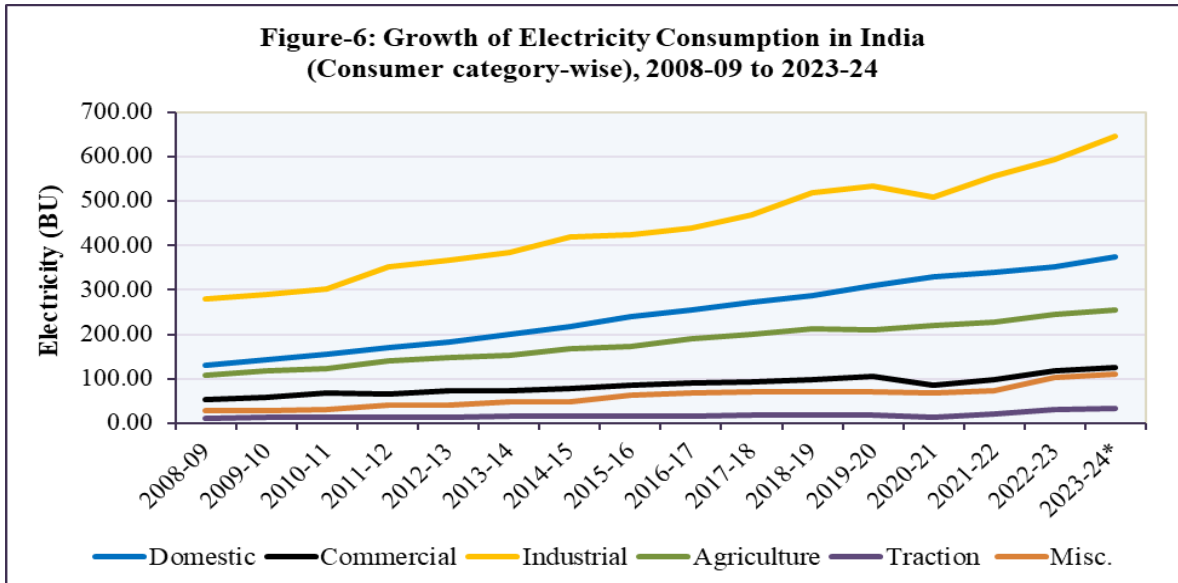
The growth in electricity consumption (consumer category-wise) is provided in Table-7 & Figure-6. The total electricity consumption increased from 611.29 BU in 2008-09 to 1543 BU in 2023-24 at a CAGR of 6.4%. During the period, per capita consumption of electricity in India has increased from 734 kWh to 1395 kWh. Despite this considerable growth, the level of per capita electricity consumption in India is low as compared to the international average of around 3358 kWh for 2021 (latest available).

Table-7: Growth of Electricity Consumption in India (Consumer category-wise) (BU), 2008-09 to 2023-24

Year	Domestic	Commercial	Industrial	Agriculture	Traction	Misc.	Total
2008-09	130.06	53.54	279.66	107.78	11.81	28.45	611.29
2009-10	144.25	59.30	290.26	119.32	12.41	27.71	653.24
2010-11	156.02	68.72	301.26	123.39	13.09	29.93	692.40
2011-12	171.10	65.38	352.29	140.96	14.21	41.25	785.19
2012-13	183.70	72.79	365.99	147.46	14.10	40.26	824.30
2013-14	199.84	74.25	384.42	152.74	15.54	47.42	874.21
2014-15	217.41	78.39	418.35	168.91	16.18	49.29	948.52
2015-16	238.88	86.04	423.52	173.19	16.59	62.98	1001.19
2016-17	255.83	89.83	440.21	191.15	15.68	68.49	1061.18
2017-18	273.55	93.76	468.61	199.25	17.43	70.83	1123.43
2018-19	288.24	98.23	519.20	213.41	18.84	72.06	1209.97
2019-20	308.75	106.05	532.82	211.30	19.15	70.03	1248.09
2020-21	330.81	86.95	508.78	221.30	14.67	67.70	1230.21
2021-22	339.78	97.12	556.48	228.45	21.94	73.00	1316.76
2022-23	353.16	117.23	593.90	243.85	30.03	102.15	1440.31
2023-24*	375.00	125.00	645.00	255.00	33.00	110.00	1543.00

* Estimated

Source: CEA, Growth of Electricity Sector in India, various issues.



As per the latest available report by Power Finance Corporation Ltd (PFC) namely ‘Report on Performance of State Power Utilities- 2022-23’, the average all-India AT&C losses were about 15.41% in FY 2022-23². Majority of these losses can be attributed to Transmission and Distribution Losses, which correspond to electricity produced but not paid for.

The electricity tariffs charged by the DISCOMs are not cost-reflective for various reasons. The DISCOMs sell electricity below cost or provide for free/subsidized rates for agriculture and domestic consumers. These tariffs for residential and agricultural consumers are subsidized by overcharging industrial and commercial users. Average cost of supply and average revenue of all state power utilities for the period from 2008-09 to 2022-23 is provided in Table-8 and Figure-7.

The all-India average cost of supply and average revenue (without subsidy) increased from ₹3.40/kWh and ₹2.63/kWh respectively in 2008-09 to ₹7.11/kWh and ₹5.53/kWh, respectively, in 2022-23. Here the average revenue includes revenue from operations, regulatory income, revenue grants under UDAY and other income. The gap between the cost of supply and revenue has increased from ₹0.77/kWh to ₹1.58/kWh during the period. The revenue as percentage of cost of supply varied between 77% to

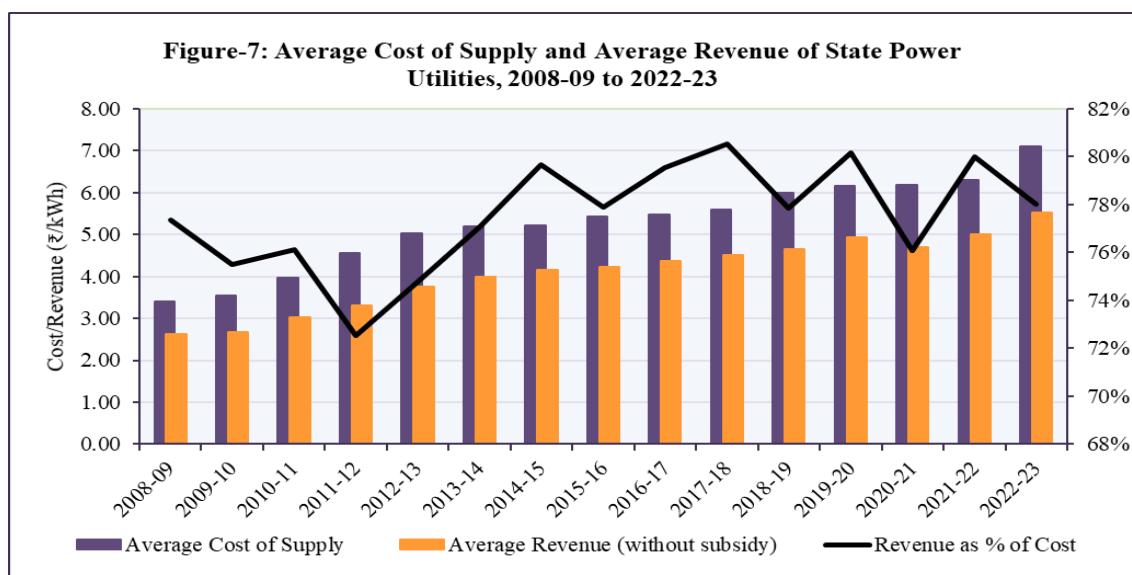
² As per the revised methodology for calculation of AT&C losses notified by CEA.

80% during the recent five years, which indicates that the average revenue was about 22% lower than the average cost of supply and this gap is financed through budgetary support as subsidy by the Government.

Table-8: Average Cost of Supply and Average Revenue of State Power Utilities, 2008-09 to 2022-23

Year	Average Cost of Supply (₹/kWh)	Average Revenue (without subsidy) (₹/kWh)	Revenue Gap (₹/kWh)	Revenue as % of Cost
2008-09	3.40	2.63	0.77	77%
2009-10	3.55	2.68	0.87	75%
2010-11	3.98	3.03	0.95	76%
2011-12	4.55	3.30	1.25	73%
2012-13	5.03	3.76	1.27	75%
2013-14	5.19	4.00	1.19	77%
2014-15	5.21	4.15	1.06	80%
2015-16	5.43	4.23	1.20	78%
2016-17	5.48	4.36	1.12	80%
2017-18	5.60	4.51	1.09	81%
2018-19	6.00	4.65	1.35	78%
2019-20	6.15	4.93	1.22	80%
2020-21	6.21	4.77	1.44	77%
2021-22	6.29	5.01	1.28	80%
2022-23	7.11	5.53	1.58	78%

Source: PFC, Report on The Performance of State Power Utilities.



Due to some of the legacy issues, the DISCOMs are financially stressed with huge operational losses and outstanding debt. DISCOMs, therefore, find it difficult to supply adequate power at affordable rates. To improve their financial health, several

policy initiatives have been taken by the Union Government during the last few years, which include implementation of Ujwal DISCOM Assurance Yojana (UDAY, launched in 2015), Integrated Power Development Scheme (IPDS, launched in 2014), National Smart Grid Mission (NSGM launched in 2015), etc. UDAY is being implemented in various States for the financial turnaround and revival of the DISCOMs through four initiatives (i) improving operational efficiencies of DISCOMs; (ii) reduction of cost of power purchase; (iii) reduction in interest cost of DISCOMs; and (iv) enforcing financial discipline on DISCOMs through alignment with State finances.

The IPDS works with the objectives of reducing AT&C losses, establishment of IT enabled energy accounting/auditing system, improvement in billed energy based on metered consumption and improvement in collection efficiency and the scheme is focused on urban areas. The Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY, launched in 2014) is centred on improving distribution and electrification in rural areas. The scheme includes the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) as a key component of the rural electrification initiative. NSGM was launched in 2015 to plan and monitor implementation of policies and programmes related to Smart Grid in India. NSGM scheme was extended till 31st March 2024 with focus on: (i) completing ongoing sanctioned projects, (ii) training and capacity building, (iii) technical assistance to utilities and (iv) handholding of DISCOMs on their Smart Grid Distribution preparedness, etc.

The Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya Scheme) was launched in September 2017, with the objective to provide free electricity connections to all households, for above poverty line (APL) & poor families in rural areas and poor families in urban areas. All DISCOMs, including Private Sector DISCOMs, State Power Departments and Renewable Energy Cooperative Societies shall be eligible for financial assistance under the scheme in line with DDUGJY.

These schemes have helped the DISCOMs in strengthening and augmenting sub-transmission and distribution network, as well as IT enablement. These schemes have supported in achieving the goal of providing universal electricity access to the

households enabling significant improvement in availability of power supply in both rural and urban areas.

The Ministry of Power has launched the Revamped Distribution Sector Scheme (RDSS) dated 20.07.2021, with the aim to provide reform-based result-linked financial assistance to DISCOMs to strengthen the supply infrastructure. Main objectives of the scheme include: (i) Reduction of AT&C losses to pan-India levels of 12-15% by FY 2024-25; (ii) Reduction of ACS-ARR gap to zero by FY 2024-25; (iii) improvement in the quality, reliability and affordability of power supply to consumers through a financially sustainable and operationally efficient distribution sector; and (iv) modernization of the DISCOMs through technology enhancement in the areas of asset management, customer experience and business operations. RDSS assist DISCOMS to improve their operational efficiencies and financial sustainability by providing result-linked financial assistance to DISCOMS to strengthen supply infrastructure based on meeting pre-qualifying criteria and achieving basic minimum benchmarks.

Electricity (Late Payment Surcharge and Related Matters) Rules, 2022 provide relief to the DISCOMS, as well as electricity consumers and at the same time Generating companies also get the benefit from assured monthly payments, which will help the whole power sector to become financially viable.

The amendment in the Electricity Rules, 2005 notified on 26.07.2023 put in place additional measures to improve financial health of DISCOMs by streamlining the process of accounting, reporting, billing and payment of subsidy by States to the Distribution Companies.
