Chapter-I

Overview of Power Sector

The Indian power sector is one of the most diversified in the world. The entire electricity supply chain has undergone a phase of transformation in the process of advancing reforms in the sector. This chapter provides an overview of the developments made in the electricity supply chain over the years and the new policy initiatives to address some of the key challenges faced by the sector.

1. Generation

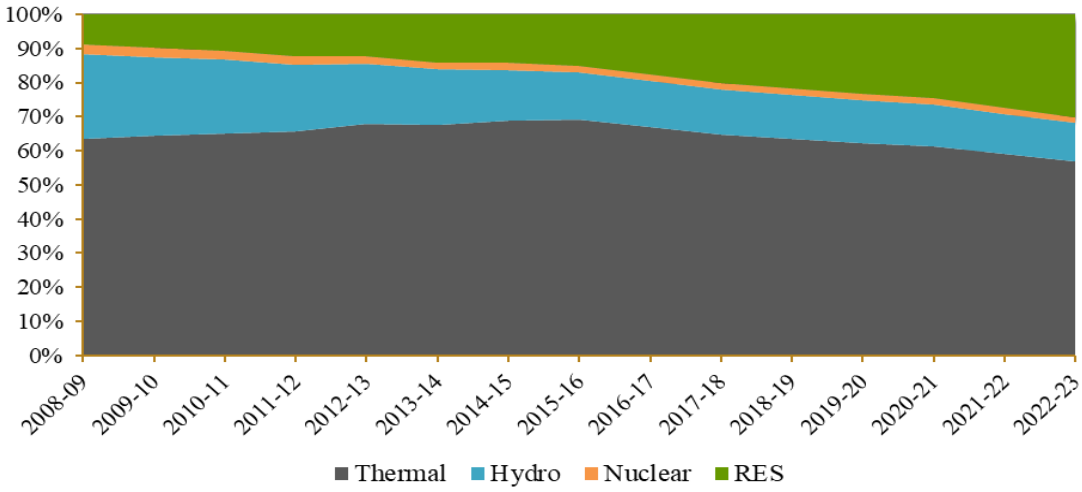
The sources of electricity generation in India can be broadly classified into conventional and non-conventional. The conventional sources of power generation are thermal (coal, lignite, natural gas, and oil), hydro and nuclear power, whereas non-conventional sources of power generation (renewable energy 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 2022-23

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

Source: CEA, Growth of Electricity Sector in India, various issues.
*** RES includes Small Hydro Project (≤ 25 MW)*

Figure-1(a): Installed Electricity Generation Capacity in India (%), 2008-09 to 2022-23



As may be observed from Figure-1(a), thermal is a major source of electricity generation in India, contributing 57% of the total capacity of generation in 2022-23, followed by renewable energy sources (RES) (30.1%), hydro (11.3%) and nuclear (1.6%). However, the share of thermal-based generation capacity in the total installed capacity has gradually come down from 63.3% in 2008-09 to 57% in 2022-23. During this period, the share of hydro-based generation capacity also decreased from 24.9% to 11.3%, whereas renewables-based generation capacity witnessed an increase from 8.9% to 30.1%. The CAGR of total installed electricity generation capacity was about 7.7% during the period as compared to 17.4% in RES and 5.7% 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 around 53.4% of total RES capacity in India, followed by wind (34.1%), bio-power (8.6%) and small hydropower (4%) in 2022-23. Though the capacity from all the sources increased over the years, the relative share of solar increased considerably from less than 1% in 2008-09 to about 53% in 2022-23.

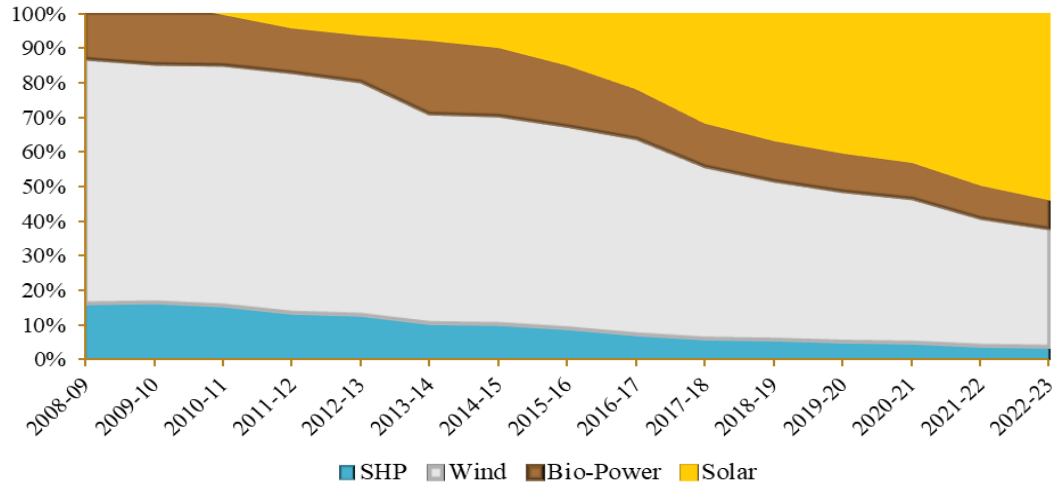
Table-1(b): Installed RES Capacity in India (GW), 2008-09 to 2022-23

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

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

Figure-1(b): Installed RES Capacity in India (%), 2008-09 to 2022-23



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

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

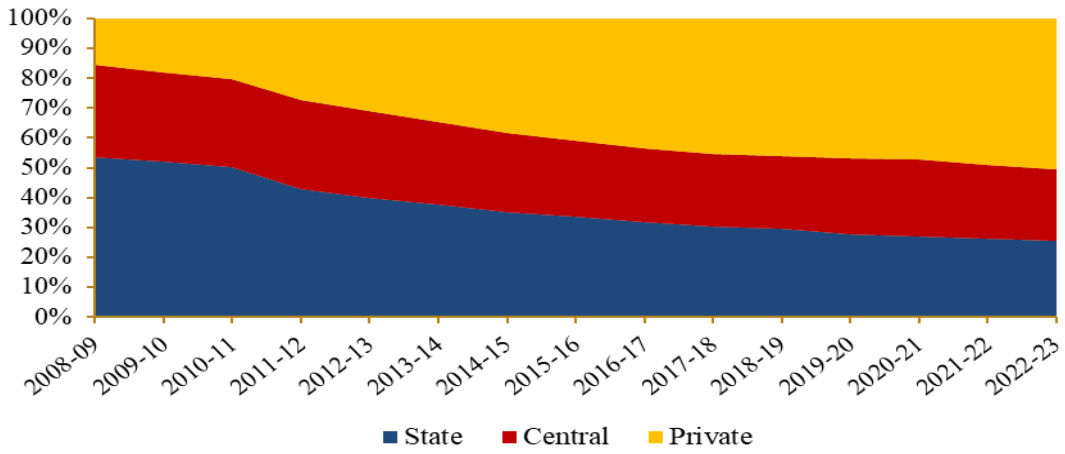
The sector-wise growth of installed generation capacity is shown in Table-2 and Figure-2. It can be observed from the table that the CAGR of total installed generation capacity was about 7.7% during the period from 2008-09 to 2022-23. During the period, the share of the state sector in the total installed generation capacity declined from 54% to 25%, and the share of the central sector declined from 31% to 24%, whereas the share of the private sector increased significantly, i.e., from 15% to 51%.

Table-2: Sector-wise Growth of Installed Electricity Generation Capacity, 2008-09 to 2022-23

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

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

Figure-2: Sector-wise Growth of Installed Electricity Generation Capacity (%), 2008-09 to 2022-23



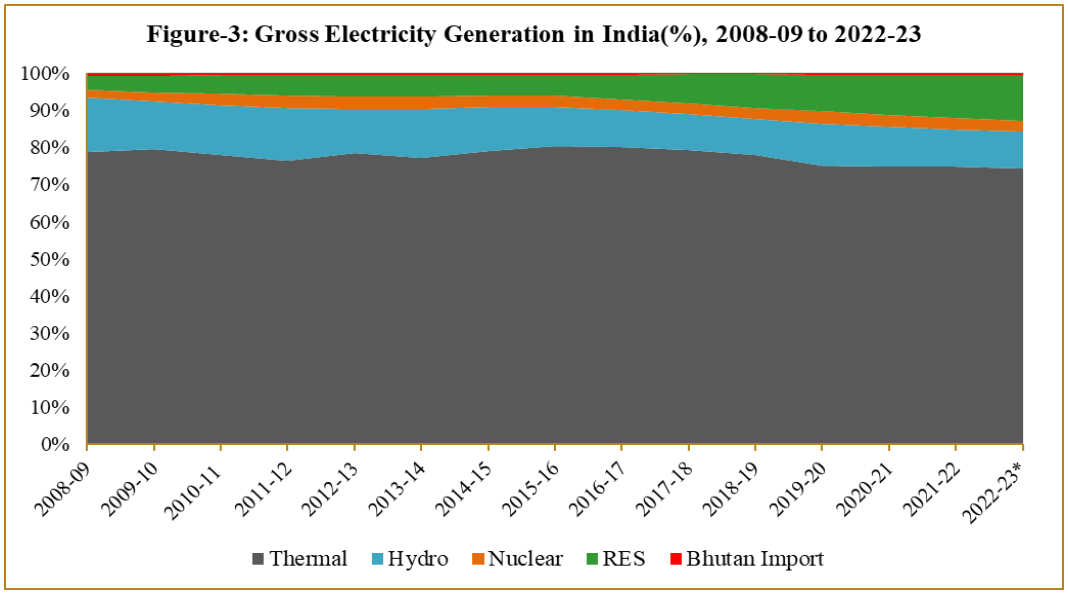
Source-wise gross electricity generation in India is shown in Table-3(a) and Figure-3. As may be observed from the table, gross electricity generation in India has increased from 747.07 BU in 2008-09 to 1624.47 BU in 2022-23, at a CAGR of about 5.7%. The growth in gross electricity generation is low as compared to the growth in annual installed electricity generation capacity (7.7%). This may be primarily due to an increase in capacity from RES with a low utilization factor.

Table-3(a): Gross Electricity Generation in India (BU), 2008-09 to 2022-23

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*	1206.21	162.10	45.86	203.55	6.74	1624.47

**Provisional.*

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



*Provisional

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 74% in 2022-23. Though its relative share continues to be the highest, it has shown a declining trend over the last few years, mainly because of increasing emphasis on renewable energy sources. The amount of electricity generated from RES increased from 3.7% in 2008-09 to 12.5% in 2022-23.

Table-3(b) provides details of renewable electricity generation in India from various sources. As can be observed from the figure, total renewable electricity generation increased from 65.78 BU in 2015-16 to 203.55 BU in 2022-23 at a CAGR of 17.5%. Solar generation increased significantly from 7.45 BU in 2015-16 to about 102 BU in 2022-23 at a CAGR of 45.3%.

Table-3(b): Renewable Electricity Generation* in India (BU), 2015-16 to 2022-23

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	7.67	46.00	14.16	13.50	0.21	81.55
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

Source: CEA, Report of Renewable Generation
** Excluding Large Hydro*

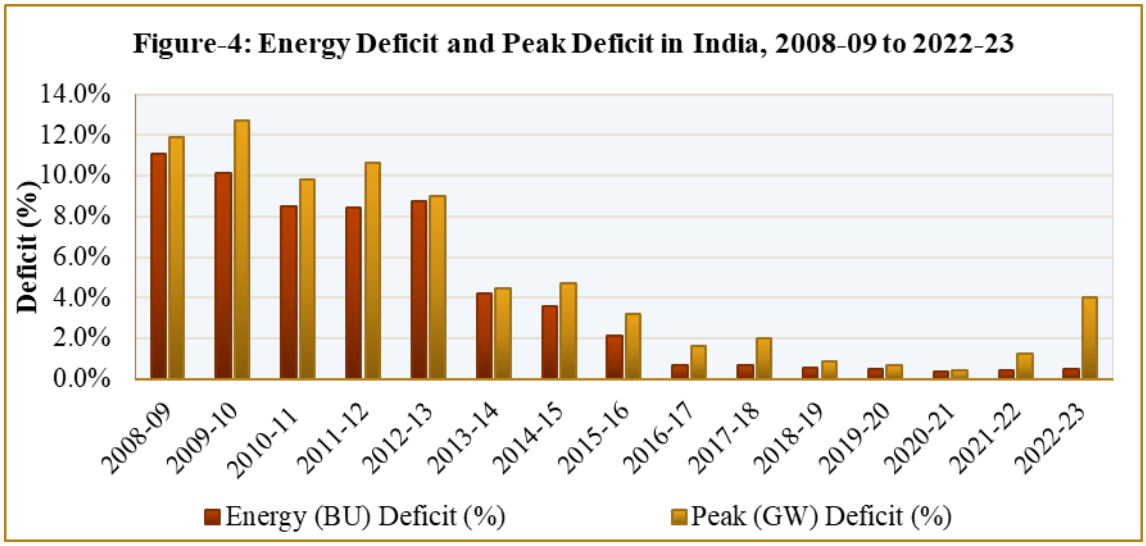
As per the announcement made by the Hon'ble Prime Minister in COP26 Summit at Glasgow in November 2021, Government of India has set an ambitious target for enhancement of non-fossil fuel energy capacity to 500 GW by 2030. The commitment regarding non-fossil fuel energy capacity is proposed to be met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

The increase in installed electricity generation capacity, as shown in Table-1, 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 1511.85 BU and 215.81 GW, respectively, in 2022-23 (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 0.5% and 4.0%, respectively in 2022-23 (Figure-4).

Table-4: Power Supply Position in India, 2008-09 to 2022-23

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	1511.85	1504.26	0.5%	215.89	207.23	4.0%

Source: Ministry of Power



2. Transmission

The transmission sector was opened for private investments in 1998. The Central Transmission Utility (CTU) is the nodal agency for providing medium-term (3 months to 5 years) and long-term (exceeding 7 years) access (the right to use the inter-state transmission system) typically required by a generating station or a trader acting on the generating station's behalf. The PGCIL has been responsible for inter-state transmission and development of the national grid, and acts as the CTU. The RLDCs are the nodal agencies for grant of short-term open access (upto 3 months). National Load Despatch Centre (NLDC) is the nodal agency providing transmission access to the power exchanges.

Open Access refers to the right to generators of electricity [Captive Power Plants[2] (CPP)/Independent Power Producers (IPP)] and bulk consumers[3] to sell the generated electricity at a certain transmission surcharge and to access the transmission and distribution networks of any generator without any discrimination by the distribution/transmission line owners. The principle of open access is based on the premise that while it is uneconomical to lay down multiple transmission lines in the

[2]*Captive Power refers to generation from a unit set up by industry for its own consumption*
[3] *Bulk consumers are consumers with power requirement of 1MW or above*

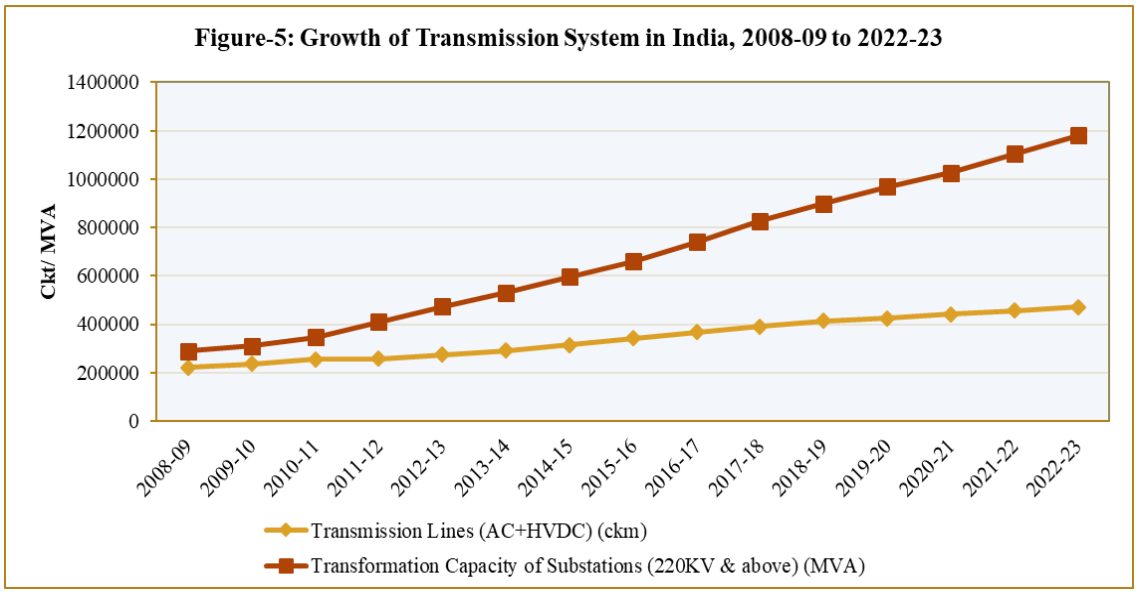
same region because of the large sunk costs involved, it is still best to give consumers a choice to decide which firm's electricity they want to consume.

The growth of the transmission system (transmission lines and transformation capacity) in India during 2008-09 to 2022-23 is shown in Table-5 and Figure-5.

Table-5: Growth of Transmission System in India, 2008-09 to 2022-23

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

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 4.71 lakh ckm in 2022-23. During the period, the transformation capacity of sub-stations has also increased from 2.89 lakh MVA to 11.80 lakh MVA. The CAGR in the transmission lines and transformation capacity of sub-stations was 5.6% and 10.6%, 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 2022-23. The annual transmission charges increased at a CAGR of 16.48% 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 2022-23

Year	Transmission Charges as on 31st 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

Source: GRID-INDIA

Transmission sector is having a natural monopoly, as is involves high sunk costs in investing in the infrastructure needed to transmit electricity, such as transmission lines. Because 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 31.3.2023, 85 Inter-state transmission licensees have been granted approval by CERC (Annexure-I).

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 1403.40 BU in 2022-23 at a CAGR of 6.1%. During the period, per capita consumption of electricity in India has increased from 734 kWh to 1327 kWh (provisional). Despite this considerable growth, the level of per capita electricity consumption in India is low as compared to the international average of around 3577 kWh for 2022.

Table-7: Growth of Electricity Consumption in India (Consumer category-wise) (BU), 2008-09 to 2022-23

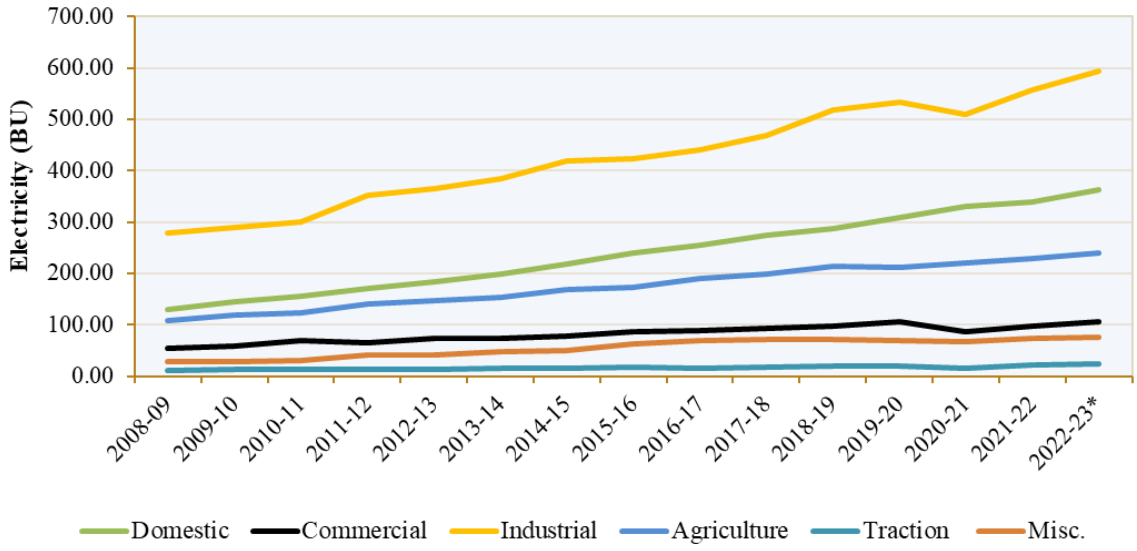
Year	Domestic	Commercial	Industrial	Agriculture	Traction	Misc.	Total
2008-09	130.06	53.54	279.66	107.78	11.81	28.45	611.29
2009-10	144.25	59.30	290.26	119.32	12.41	27.71	653.24

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*	362.00	105.10	595.00	240.80	25.00	75.50	1403.40

* Estimated

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

Figure-6: Growth of Electricity Consumption in India (Consumer category-wise), 2008-09 to 2022-23



** Estimated*

As per the latest available 'Report on Performance of State Power Utilities-2021-22' published by Power Finance Corporation Ltd (PFC), the average all-India AT&C losses were about 16.42% in 2021-22[4]. More than 90% of these losses can be attributed to Transmission and Distribution Losses, which correspond to electricity produced but not paid for.

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

The electricity tariffs charged by the DISCOMs are not cost reflective for various reasons. The DISCOMs sell electricity below cost or provide electricity at free/subsidized rates for agriculture and domestic consumers. The 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 has been provided for the period from 2008-09 to 2021-22 in Table-8 and Figure-7.

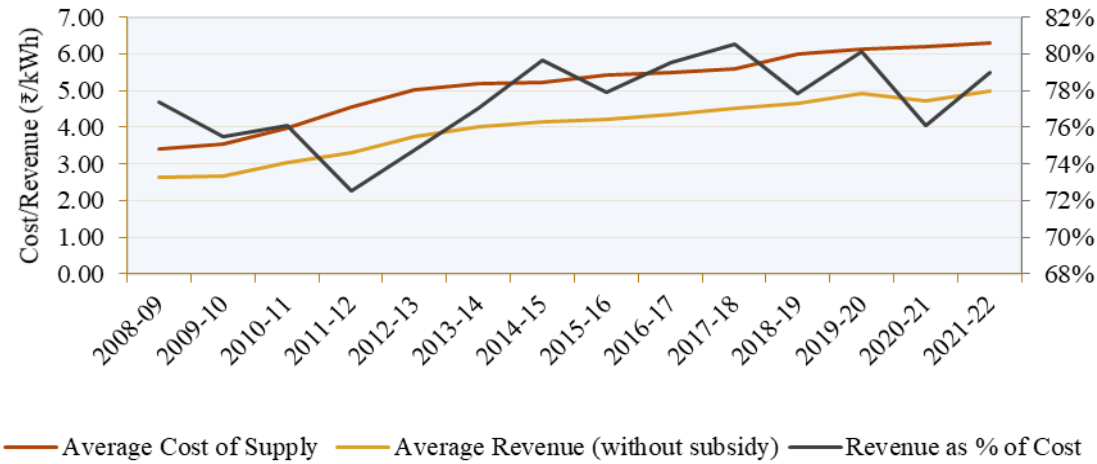
The all-India average cost of supply and average revenue (without subsidy) increased from ₹3.40/kWh and ₹2.63/kWh respectively in 2008-09 to ₹6.29/kWh and ₹4.98/kWh, respectively, in 2021-22. Here the average revenue includes revenue from operations, regulatory income, revenue grants under UDAY and other income. The gap between the cost of supply and revenue has increased from ₹0.77/kWh to ₹1.31/kWh during the period. The revenue as percentage of cost of supply varied between 76% to 81% during the recent five years, which indicates that the average revenue was about 21% 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 2021-22

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	6.19	4.71	1.48	76%
2021-22	6.29	4.98	1.31	79%

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

Figure-7: Average Cost of Supply and Average Revenue of State Power Utilities, 2008-09 to 2021-22



Due to some of the legacy issues, the DISCOMs are financially stressed with huge operational losses and outstanding debt. Due to which, DISCOMs 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.

The Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya Scheme) was launched in September 2017, 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 of sub-transmission and distribution network, and also 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.

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