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Viability of power distribution in India – Challenges and Way Forward

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ABSTRACT

Energy is a key component for economic growth as well as for human development. India is the third-ranking electricity generator in the world but ranks 106th in terms of per capita consumption. Specifically, the distribution of power is the most important link in the value chain of the power sector since it is the cash register for the entire sector. In India, electricity is a concurrent subject shared between the Central and State Governments. While the generation of power has been deregulated since 2003, the supply of power to the consumers is generally carried out by Government-owned power Distribution Companies (DISCOMs). In this paper, the authors analyze the financial distress of DISCOMs in India, and explain how the supply-demand mismatch due to over-ambitious demand projections, the fixed and energy charges of thermal power plants, and the excess procurement of "must-run" renewable sources together contribute to the high cost of power procurement that drives the financial stress faced by DISCOMs. The authors support their assertion with a study of nine DISCOMs supplying electricity to 155 million people in three States and propose policy recommendations for a turnaround of such DISCOMs which can be rolled out with suitable modifications across India.

1. Introduction[1]

While India accounts for 18 percent of the World's population, it consumed only six (6) percent of the World's primary energy in 2017 (BP, 2020; IEA, 2019). World Bank (2017) has documented the link between energy (SDG 7) on the one hand and 125 of the 169 targets related to the 17 SDGs on the other. After the adoption of the 2030 Agenda, India ratified the Paris Agreement on October 2, 2016 and is committed *inter alia* to "*increase the generation capacity of non-fossil fuel-based sources to 40 percent of all sources by 2030 through the transfer of technology and low-cost international finance including from Green Climate* Fund" (Fragkos et al., 2018; Lok Sabha, 2017a; Parikh et al., 2018; Sokolowski, 2019; UNFCCC, 2015).

Renewable Energy (RE) sources (excluding, large hydro projects) generated 10 percent of the 1389 TWh of electricity generated in India while coal-fired Thermal Power Plants (TPPs) continue to generate 72 percent of the 1389 TWh of electricity generated by utilities in India during FY 2019–20 (NPP, 2020). To increase the generation of power by

Abbreviations: ACS, Average Cost of Supply; APERC, Andhra Pradesh Electricity Regulatory Commission; APEPDCL, Eastern Power Distribution Company of Andhra Pradesh Limited; APSPDCL, Southern Power Distribution Company of Andhra Pradesh Limited; ARR, Average Revenue Realized; AT&C, Aggregate Technical and Commercial; BESCOM, Bangalore Electricity Supply Company Limited; CAGR, Compounded Annual Growth Rate; CEA, Central Electricity Authority; CERC, Central Electricity Regulatory Commission; CESC, Chamundeshwari Electricity Supply Corporation Limited; CGS, Central Generating Station; CIL, Coal India Limited; CPCB, Central Pollution Control Board; DISCOM, Power Distribution Company; ECR, Energy Charge Rate; EPS, Electric Power Survey; FC, Fixed Charges; FGD, Flue Gas Desulfurizer; GENCO, Power Generating Station; GESCOM, Gulbarga Electricity Supply Company Limited; GOI, Government of India; HESCOM, Hubli Electricity Supply Company Limited; IPP, Independent Power Producer; KERC, Karnataka Electricity Regulatory Commission; KSEBL, Kerala State Electricity Board Limited; MESCOM, Mangalore Electricity Supply Company Limited; MoEF&CC, Ministry of Environment, Forest and Climate Change in the Government of India; MOP, Ministry of Power in the Government of India; NTPC, National Thermal Power Corporation Limited; PFC, Power Finance Corporation Limited; PGCIL, Power Grid Corporation of India Limited; RE, Renewable Energy; REC, Rural Electrification Corporation Limited; RPO, Renewable Purchase Obligation; SCCL, Singareni Collieries Company Limited; SDGs, Sustainable Development Goals; SERCs, State Electricity Regulatory Commissions; SGS, State Generating Station; SR, Southern Region; TANGEDCO, Tamil Nadu Generation and Distribution Corporation Limited; TPPs, Thermal Power Plants; TSERC, Telangana State Electricity Regulatory Commission; TSNPDCL, Northern Power Distribution Company of Telangana Limited; TSSPDCL, Southern Power Distribution Company of Telangana Limited.

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RE sources that have practically zero variable costs, all Grid-connected RE sources in India enjoy "must-run" status, requiring RE to be dispatched first as long as it is available (CERC , 2010; Shidore and Busby, 2019). However, 49 percent of the total RE capacity in India as on March 31, 2020, is concentrated in India's Southern Region (SR) which consists of five States (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Telangana) and the Union Territory of Puducherry (CEA, 2020a). The total population of this region is 268 million (20 percent of the entire country) and the total power generation capacity installed in this region as on March 31, 2020, is 112 GW (CEA, 2020a; MoH&FW, 2019).

As shown in Figs. 1 and 2, RE sources account for 38 percent of the total installed generation capacity in the SR and produce 21 percent of the electricity generated (CEA, 2020a, 2020b; NPP, 2020). Since the share of renewables will continue to increase steadily to meet India's Nationally Determined Contribution (NDC), this paper focusses on the power sector in South India which is well ahead of the rest of India not only in RE integration but also in ensuring 100 percent energy access, thanks to relatively more efficient but financially-stressed DISCOMs (Saubhagya, 2020).

While this paper focusses on the cost of power procurement which forms more than 80 percent of the total expenditure of these DISCOMs, the authors are also studying the internal operations of the DISCOMs whose efficiency can also be improved to ensure their viability.

The paper is divided into five sections. Following the introduction, the second section explains the key drivers of the financial stress faced by DISCOMs all over India while the third section focusses on the power sector in the Southern Region (SR). The fourth section describes the structure of power procurement costs in India which account for more than 80 percent of the total cost base of the DISCOMs. Finally, the authors conclude the paper with certain policy recommendations to enhance the viability of the DISCOMs which can be implemented on a pilot basis in SR and then extended across India with suitable modifications.

2. Background

To develop a path for DISCOM reforms in India, it is important to understand the functioning of India's power sector which is included in the "concurrent" list of subjects in the Indian Constitution with overlapping jurisdictions for the Centre and the States (Singh, 2006). As per the Electricity Act, 2003, "*the Central Government shall, from time to time, prepare the National Electricity Policy and tariff policy, in consultation with the State Governments and the Authority for development of the power system based on optimal utilization of resources such as coal, natural gas, nuclear substances or materials, hydro and renewable sources of energy* (India Code, 2020)." Planning for the sector is done by the Central Electricity Authority, an agency of the Government of India (GOI). It carries out various functions including the preparation of a National Electricity Plan for the country once in 5 years as per the National Electricity Policy.

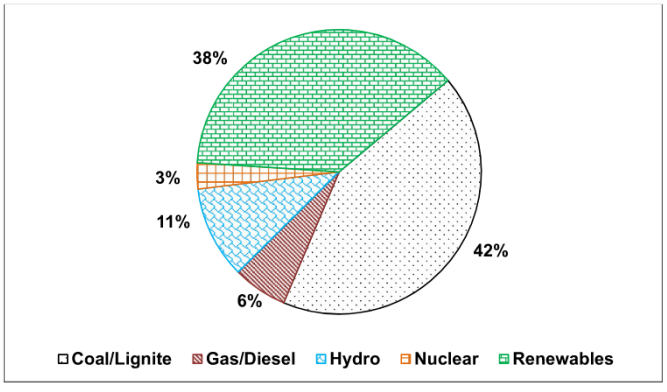

Fig. 1. Electricity generation capacity in the Southern Region as on March 31, 2020 (112 GW).

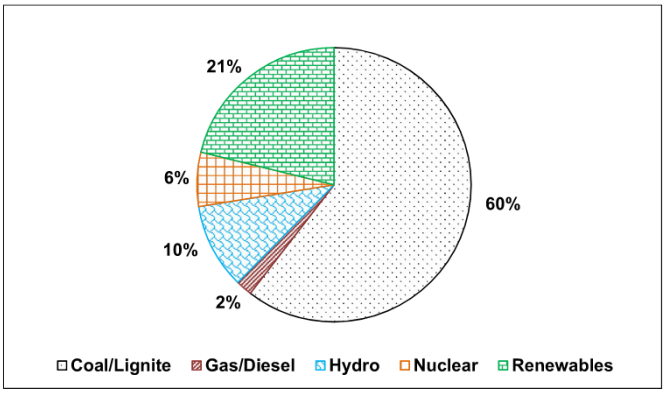

Fig. 2. Electricity generation in the Southern Region during FY 2019–20 (316 TWh).

Every five years, the Government of India constitutes an "Electric Power Survey Committee" to forecast the State-wise electricity demand of the country. The latest in the series of Electric Power Survey (EPS) Reports is the 19th EPS report, which was published in January 2017, while the previous 18th EPS report was brought out in December 2011 (CEA, 2011a; 2017a). The 18th EPS report includes the detailed projections for the year-wise electricity demand for each State for the years 2012–13 to 2021–22 (CEA, 2011a). The 19th EPS Report contains detailed forecasts for year-wise electricity demand for each State for the period 2016–17 to 2026–27. As shown in Fig. 3, GOI had grossly over-estimated the electricity demand in the country in the 18th EPS to such an extent that the gap between the projected and actual peak demand was 40 GW in 2016–17 and as high as 62 GW in 2019–20 (CEA, 2011a; 2020d). This vast gap between GOI's projections in the 18th EPS report and the actual peak demand is because the Government assumed (in the 18th EPS report) that peak electricity demand would grow at a Compounded Annual Growth Rate (CAGR) of 8.50 percent during the period 2011–12 to 2016–17 while the actual CAGR of peak demand during this period was only 4.18 percent (Lok Sabha, 2017b). In the 19th EPS published in January 2017, GOI reduced the projected CAGR growth rates of peak demand to 6.88 percent between 2016–17 and 2021–22 and 5.77 percent from 2021–22 to 2026–27. While GOI moderated the demand growth in the 19th EPS, the gap between the forecast and actual value of peak demand still reached a level of 17 GW by 2019–20 (CEA, 2017a, 2020d). This is because GOI made these optimistic projections for peak demand in the 19th EPS report knowing fully well that the actual All-India peak demand between 2010–11 and 2015–16 increased at a CAGR of only 4.63 percent (CEA, 2011b, 2016a). The projections in the 18th EPS led to explosive growth in the installed generation capacity in the country between 2011–12 and 2016–17. When actual demand fell short of projections, it led to financial stress for

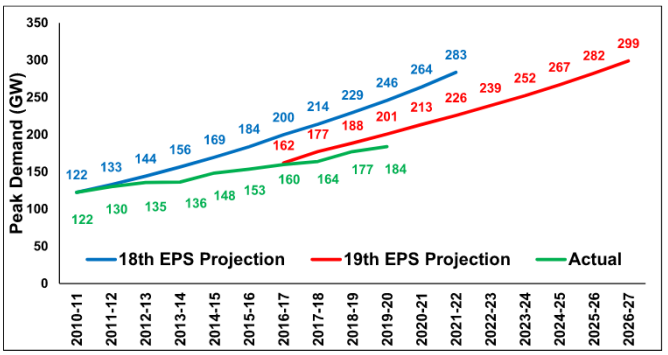

Fig. 3. EPS projections & actual peak demand in India.

the DISCOMs which had signed Power Purchase Agreements (PPAs) with Power Generation Companies (GENCOs) based on these projections (CEA, 2011a; 2011b; 2012, 2013; 2014, 2015; 2016a, 2017a; 2017b, 2018; 2019a, 2020d).

Similarly, the projections for the peak demand in the SR states for 18th EPS also went haywire (CEA, 2017a). As shown in Fig. 4, GOI had grossly over-estimated the electricity demand in the SR in the 18th EPS to such an extent that the gap between the projections and actual levels of peak demand which was 15 GW in 2016–17 increased to 17 GW in 2019–20 (CEA, 2011a; 2020d). While GOI moderated the demand growth in the 19th EPS, the gap between the forecast and actual value of peak demand in the SR still increased to 2.4 GW by 2019–20 less than four years after the projections were published (CEA, 2017a, 2020d).

Based on the projections in the 18th EPS, the DISCOMs in SR also signed cost-plus PPAs for 25 years with Central and State GENCOs as well as Independent Power Producers (IPPs) and facilitated the installation of TPPs as well as RE power plants. These TPPs were also financed by GOI-controlled power finance corporations like PFC Ltd. and REC Ltd as well as public sector banks controlled by GOI. The RE developers were also granted several concessions in addition to "must-run" status since South India has a natural advantage in both solar and wind energy potential.

Consequently, the total installed generation capacity in the SR as on March 31, 2020, increased to 112 GW while the peak demand in FY 2019–20 was only 54 GW. Even after discounting the generation capacity of the variable and intermittent RE sources (42 GW as on March 31, 2020), the capacity of the conventional generation sources alone (70 GW) in the SR was 30 percent higher than the peak demand of 54 GW during FY 2019–20 (CEA, 2020a).

This yawning gap due to consistently over-optimistic projections of economic growth (and consequently, electricity demand growth) is one of the key reasons for the financial stress on the DISCOMs in the SR today. Therefore, it is not surprising that GOI has asserted that one of the reasons for the slower pace of solar energy across India due to the *"unwillingness of (State-owned) DISCOMS to procure solar power"* (Lok Sabha, 2019).

3. Power sector in Southern Region

In the first round of power sector restructuring carried out in India, the Government-owned State Electricity Boards were unbundled into generation, transmission, and distribution companies (Sharma et al., 2005). Except in two States (Odisha and Delhi) and in the cities of Ahmedabad, Mumbai, and Kolkata (which have historically had private sector distribution companies), the DISCOMs continue to function as State-owned monopolies in their respective license areas (Kundu and Mishra, 2011; Mukherjee et al., 2017). For example, though the State of Andhra Pradesh (A.P), Karnataka and Telangana have nine DISCOMs operating within distinct geographic (license) areas, they are controlled by their respective State Governments which appoints the Board of Directors including the Chairperson and the Managing Director. However, Tamil Nadu and Kerala are exceptions in South India since the generation and distribution functions are centralized in one company TANGEDCO (Tamil Nadu Generation and Distribution Corp. Ltd.) while KSEBL (Kerala State Electricity Board Ltd.) still operates all three functions (generation, transmission, and distribution) in the power sector.

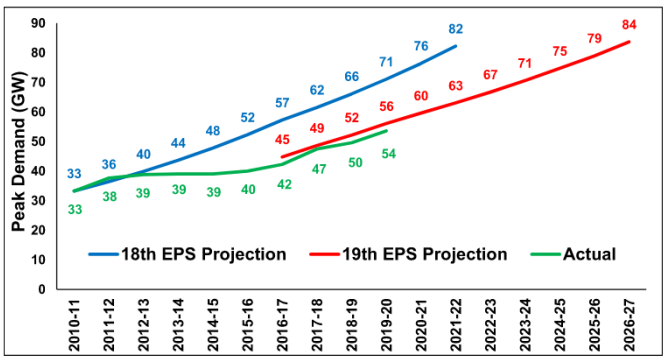

Fig. 4. EPS projections & actual peak demand in the southern region.

This paper focusses on the nine DISCOMs in three SR States (A.P, Karnataka, and Telangana) which are exclusively engaged in the last-mile distribution of electricity to 155 million people (MoH&FW, 2019). The weighted average costs of power procurement in these States are shown in Table 1, while the salient features of the nine DISCOMs (all State Government-owned) are summarized in Tables 2 and 3.

The billing efficiencies (proportion of energy procured that is billed to the consumers) of these nine (9) SR DISCOMs is in the range of 80–96 percent while their collection efficiencies (proportion of billed amount collected) is in the range of 80–100 percent (APEPDCL, 2019; APSPDCL, 2019; BESCOM, 2019; CESC, 2019a; 2019b; 2019c; GESCOM, 2019; HESCOM, 2019; MESCOM, 2019; PFC, 2020). As a result, the Aggregate Technical & Commercial (AT&C) losses (the proportion of the net input energy for which no revenue could be collected during the period) of seven (out of nine) DISCOMs in the SR are significantly lower than the National Average of 22.01 percent during FY 2018–19 (PFC, 2020). Despite their satisfactory performance on several key performance parameters, the total losses (un-audited) of these nine (9) SR DISCOMs during FY 2018–19 was Rs.189.83 Billion though the losses would have been much higher if not for the profits of Rs.9.68 Billion booked by the five (5) Karnataka DISCOMs (Table 2).

To some extent, these losses are due to the subsidized and unmetered supply of power to agriculture and rural domestic consumers as per Government policies as another measure towards public welfare (Tables 2 and 3). For example, the Government of Karnataka mandates the provision of 40 units of free power per month to households in rural areas, and 7 h of free power per day to Irrigation Pump (IP) sets below 10 HP capacity (KERC, 2020a). In some of the DISCOMs catering to rural areas in Karnataka, the unmetered power supply is above 40 percent of the total electricity supplied by the DISCOM (Table 2). Similar policies for rural consumers exist in Andhra Pradesh and Telangana as well. In Andhra Pradesh, 7 h of free power is supplied to agricultural consumers per day which are proposed to be extended to 9 h. Further, Telangana is the first state in India to provide 24 h of free power to agricultural consumers, while there is no limitation in the capacity of IP sets in Andhra Pradesh and Telangana (APERC, 2020; The Economic Times, 2017).

Being first movers in the renewable arena, the initial solar and wind power costs were high although they came down subsequently (MoF , 2017). However, due to the 25-year PPAs signed with IPPs producing high-cost RE, DISCOMs in the SR continue to incur significant financial impacts due to the procurement of excess RE at higher weighted-average costs compared to the power available from CGS (Table 1). These enhanced costs have created financial distress for the DISCOMs in the SR due to the must-run status imposed by the Grid Code for which these DISCOMs are not compensated today (Kanitkar et al., 2020). The opportunity costs of procuring excess RE by the DISCOMs in these three States over and above the Renewable Power Obligations (RPOs) mandated by their respective State Electricity Regulatory Commissions (SERCs) are shown in Tables 4 and 5 are explained in the following sections.

3.1. Karnataka

Electricity distribution in Karnataka is carried out by five Government-owned DISCOMS – Bangalore Electricity Supply Company Ltd. (BESCOM), Chamundeshwari Electricity Supply Corporation Ltd. (CESC), Gulbarga Electricity Supply Company Ltd. (GESCOM), Hubli Electricity Supply Company Ltd. (HESCOM), and Mangalore Electricity Supply Company Ltd. (MESCOM). These five DISCOMs serve 25.3

1Table 1
Weighted average cost of power procurement during FY 2018–19 (Rs./kWh) (**Data Sources:** APERC, 2018; KERC , 2018a; TSERC , 2018a).

State	Solar	Non-Solar (Wind, Bioenergy, Captive & Small Hydro)	Central Generating Station or CGS (Coal/Lignite)	CGS (Nuclear)	CGS (Combined)	State Generating Station or SGS (Coal/Lignite)	SGS (Hydro)
Andhra Pradesh	4.25	4.72	3.74	3.10	**3.63**	3.95	1.46
Karnataka	4.60	3.54	3.80	3.66	**3.78**	4.30	0.85
Telangana	5.58	5.59	3.19	3.24	**3.19**	4.17	4.62

Table 2
Overview of DISCOMs in the States of Andhra Pradesh, Karnataka, and Telangana in comparison to All India during FY 2018–19.

DISCOM	Net Profit/ Loss (Rs. Billion)	AT&C Losses (%)	ACS-ARR Gap (Rs/ kWh)	Peak Demand (GW)	Energy Billed						
					Free or Subsidized Electricity (%)	Domestic (%)	Commercial (%)	Industry (%)	Agriculture (%)	Others (%)	Un-metered (% of Total Sales)
APSPDCL	−76.80	29.66	2.23		*	24.86	8.06	28.60	32.27	6.21	*
APEPDCL	−42.52	18.47	2.16		*	27.29	8.87	36.59	19.87	7.38	*
Andhra Pradesh	**−119.32**	**25.67**	**2.20**	**9.45**	*	**25.73**	**8.35**	**31.48**	**27.80**	**6.63**	*
BESCOM	0.84	15.92	0.64		26.77	25.39	17.50	20.66	0.16	9.52	25.97
CESC	−2.09	15.78	−0.07		47.49	15.68	7.59	14.35	1.78	13.11	44.90
GESCOM	3.48	14.48	−0.03		49.95	15.28	5.64	17.78	1.65	10.00	49.95
HESCOM	6.89	10.55	0.51	**12.87**	59.29	12.57	5.72	12.66	3.01	6.75	56.84
MESCOM	0.56	10.74	−0.67		33.65	28.41	14.43	16.15	0.99	6.73	20.48
Karnataka	**9.68**	**14.62**	**0.34**		**39.16**	**20.70**	**12.25**	**17.57**	**1.18**	**9.15**	**36.88**
TSNPDCL	−30.51	28.74	1.72		*	17.36	3.69	12.04	50.49	16.42	*
TSSPDCL	−49.67	16.03	1.31		*	18.77	11.52	27.18	29.28	13.26	*
Telangana	**−80.19**	**19.99**	**1.44**	**10.81**	*	**18.35**	**9.18**	**22.65**	**35.62**	**14.20**	*
All-India Avg.	**−496.23**	**22.01**	**0.77**	**177.02**	*	**28.01**	**9.07**	**29.00**	**22.44**	**11.48**	*

Note.
[a]Andhra Pradesh: Profit/(Loss) figures are based on the audited Annual Reports of the DISCOMs (APEPDCL, 2019; APSPDCL, 2019); AT&C losses, ACS-ARR gap and Energy Billed data are based on PFC (2020); Peak Demand from CEA (2019a).
[b]Karnataka: Profit/(Loss), and AT&C losses data are based on the audited Annual Reports of the DISCOMs (BESCOM, 2019; CESC, 2019; GESCOM, 2019; HESCOM, 2019; MESCOM, 2019); Energy Billed data are based on DISCOMs tariff filings with KERC and their audited Annual Reports (BESCOM, 2019; CESC, 2019; GESCOM, 2019; HESCOM, 2019; KERC, 2020; MESCOM, 2019); ACS-ARR gap is based on PFC (2020); Peak Demand from CEA (2019); AT&C losses data for Karnataka State are based on the weighted average values extracted from PFC (2020).
[c]Telangana: Profit/(Loss) on accrual basis, AT&C losses, ACS-ARR gap and Energy Billed data are based on PFC (2020); Peak Demand from CEA (2019a).
[d]All India: Profit/(Loss) on accrual basis, AT&C losses, ACS-ARR gap and Energy Billed data are based on PFC (2020); Peak Demand from CEA (2019a).
[e]. *Free/Subsidized electricity supply to the rural domestic and agriculture consumer is largely unmetered, but could not be computed for want of data.

million consumers. The peak demand and energy requirement in the State during FY 2018–19 was 12.87 GW and 71.76 TWh respectively (BESCOM, 2019; CEA, 2019a, 2019c; CESC, 2019; GESCOM, 2019; HESCOM, 2019; MESCOM, 2019). As shown in Table 3, the Ministry of Power has rated these DISCOMs higher than most other DISCOMs in the SR due to their superior performance on several key parameters (MoP, 2019).

During the year FY 2018–19, the Karnataka Electricity Regulatory Commission (KERC) directed the five Karnataka DISCOMs to procure 3513 GWh of solar power to meet their respective Solar RPO targets @ 6 percent of the total non-hydro power procured (KERC, 2018g). As shown in Table 4, these five DISCOMs procured 58,554 GWh of input electrical energy (excluding large hydro) during FY 2018–19 to meet the demand in their respective license areas. Of this, solar power procured by the five DISCOMs accounted for 6995 GWh which amounts to 12 percent of the total non-hydro power procured by them. This exceeds the Solar RPO quantum by 3482 GWh. Further, the weighted-average cost of solar power procured by these DISCOMs was Rs.4.60 per kWh, which was Rs.0.82 per kWh higher than the tariff of Rs.3.78 per kWh charged by CGS supplying almost one-third of the total power to Karnataka during FY 2018–19 (KERC , 2018a). Therefore, the Karnataka DISCOMs could have saved Rs.2.85 Billion by procuring 3482 GWh of power from CGS instead of solar power (Table 4).

Besides, Karnataka DISCOMs purchased 11,135 GWh of non-solar power (19 percent of the total non-hydro energy) @weighted average tariff of Rs.3.54 per kWh. While these DISCOMs were mandated to procure only 6445 GWh of non-solar power to meet their non-solar RPO obligations as per KERC's mandate (@7 percent for GESCOM, 9.5 percent for HESCOM, 12 percent for BESCOM and CESC, and 13 percent for MESCOM respectively), they have procured 4690 GWh of non-solar power over and above their non-solar RPOs. Since the tariff of non-solar power was Rs.0.24 kWh less than the CGS tariff of Rs.3.78 kWh, the Karnataka DISCOMs have saved Rs.1.13 Billion by procuring 4690 GWh of non-solar power over and above their non-solar RPO. Put together, the five Karnataka DISCOMs have incurred Rs.1.72 Billion of excess costs to procure 8172 GWh of RE during FY 2018-19 beyond their RPO. A shown in Tables 4 and 5, these excess costs are primarily due to the procurement of 3482 GWh of excess solar power over and above their RPOs. These details are summarized in Tables 4 and 5 (BESCOM, 2019; CESC, 2019; KERC , 2018).

3.2. Telangana

Electricity distribution in Telangana is performed by two DISCOMS Northern Power Distribution Company of Telangana Limited (TSNPDCL) and Southern Power Distribution Company of Telangana Limited (TSSPDCL) with a total consumer strength of 14.7 million (TSNPDCL, 2019; TSSPDCL, 2019). The peak demand and energy requirement in the State during FY 2018–19 was 10.81 GW and 66.48 TWh respectively (CEA, 2019a, 2019c). Though the overall AT&C losses of Telangana DISCOMs (19.99 percent) are lower than the All-India average of 22.01 percent, they have still incurred a financial

Table 3
Cost of Power Procurement, Consumer Tariffs, Ratings, Subsidies and Unpaid dues of DISCOMs in the state of Andhra Pradesh, Karnataka, and Telangana during FY 2018–19.

DISCOM	Ratings by MoP	Total Power Procurement Cost (Rs. Billion)	Power Procurement Cost as a percentage of Total Expenditure	Unpaid dues to the GENCOs (Rs. Billion)	Subsidy received from State Government (Rs. Billion)	Weighted Average Consumer Tariff				
						Domestic (Rs/kWh)	Commercial (Rs/kWh)	Industry (Rs/kWh)	Agriculture (Rs/kWh)	Others (Rs/kWh)
APSPDCL	**B+**	254.57	81		50.78	3.78	9.00	6.94	1.48	4.44
APEPDCL	**A**	135.8	83		11.15	3.69	8.72	6.45	1.75	3.59
Andhra Pradesh		**390.37**	**82**	**30.01**	**61.93**	**3.74**	**8.88**	**6.72**	**1.53**	**4.14**
BESCOM	**A+**	187.14	86		22.69	5.90	9.49	8.24	3.70	6.90
CESC	**A**	30.68	73		14.16	5.61	9.43	7.92	5.43	5.99
GESCOM	**A**	39.49	76		16.97	6.60	9.50	8.43	5.63	6.08
HESCOM	**B**	66.65	79		30.77	6.57	9.62	8.73	6.03	6.20
MESCOM	**A+**	22.23	73		6.29	6.22	9.18	8.14	5.28	6.08
Karnataka		**346.20**	**81**	**36.37**	**90.88**	**6.08**	**9.47**	**8.28**	**5.04**	**6.47**
TSNPDCL	**B**	90.09	85		35.01	3.60	8.56	7.77	1.71	5.00
TSSPDCL	**B+**	206.40	84		11.50	4.67	9.82	7.85	1.23	6.60
Telangana		**296.49**	**84**	**57.07**	**46.51**	**4.36**	**9.58**	**7.83**	**1.44**	**5.68**

Note.
[a]Andhra Pradesh: Data on power procurement costs and subsidy grants are based on the audited Annual Reports of the DISCOMs (APEPDCL, 2019; APSPDCL, 2019); Data on weighted average consumer tariffs are computed from sales & revenue figures of the DISCOMs as approved by APERC (2018).
[b]Karnataka: Data on power procurement costs and subsidy grants are based on the audited Annual Reports of the DISCOMs (BESCOM, 2019; CESC, 2019a, 2019b; 2019c; HESCOM, 2019; MESCOM, 2019); GESCOM data related to subsidy grants from the State Government has been obtained through RTI (GESCOM, 2020); Data on weighted average consumer tariffs are computed from the sales & revenue figures of the DISCOMs as approved by KERC (2018b; 2018c; 2018d; 2018e; 2018f).
[c]Telangana: Power procurement cost and subsidy grants data are based on PFC (2020); Data on weighted average consumer tariffs are computed from sales & revenue figures of the DISCOMs as approved by TSERC (2018a).
[d]Total unpaid dues by the State DISCOMs towards GENCOs as on March 2020 are based on Praapti (2020)..
[e]Ratings of the DISCOMs are indicated by the Ministry of Power (MoP, 2019).

Table 4
Financial Impact of Solar Power Procurement in excess of the respective Solar RPOs by the DISCOMs in Andhra Pradesh, Karnataka, and Telangana during FY 2018–19.

State	Total Electricity Procured (GWh)	Electricity procured from Hydro Sources (GWh)	Electricity procured Excl. Hydro (GWh)	Solar Units		Weighted Average Tariff (Rs./kWh)		Difference in Cost (Rs. Billion)
				RPO mandate (GWh)	Actual Procurement (GWh)	Solar	CGS (combined)	
	1	2	3	4 (a)	5 (a)	6 (a)	7(a)	(8) = {5(a)-4(a)}* {6(a)-7(a)}/1000
Andhra Pradesh	61,543	2500	59,043	2362	7272	4.25	**3.63**	**3.04**
Karnataka	70,149	11,595	58,554	3513	6995	4.60	**3.78**	**2.85**
Telangana	68,458	1687	66,771	3559	6008	5.58	**3.19**	**5.85**

Table 5
Financial Impact of Non-Solar Power Procurement in excess of the respective Non-Solar RPOs by the DISCOMs in Andhra Pradesh, Karnataka, and Telangana during FY 2018–19.

State	Total Electricity Procured (GWh)	Electricity procured from Hydro Sources (GWh)	Electricity procured Excl. Hydro (GWh)	Non-Solar Units		Weighted Average Tariff (Rs./kWh)		Difference in Cost (Rs. Billion)
				RPO mandate (GWh)	Actual Procurement (GWh)	Non-Solar	**CGS (combined)**	
	1	2	3	4 (a)	5 (a)	6 (a)	**7(a)**	(8) = {5(a)-4(a)}* {6(a)-7(a)}/1000
Andhra Pradesh	61,543	2500	59,043	4133	8383	4.72	**3.63**	**4.63**
Karnataka	70,149	11,595	58,554	6445	11,135	3.54	**3.78**	**−1.13**
Telangana	68,458	1687	66,771	447	514	5.59	**3.19**	**0.16**

Source for Table 4 and 5: APERC , 2017; 2018; BESCOM, 2019; CESC, 2019; GESCOM, 2019; HESCOM, 2019; KERC, 2018, MESCOM, 2019; TSERC , 2018a; 2018b; TSTRANSCO, 2020.

(un-audited) loss of Rs.80.19 Billion during FY 2018–19 (Table 2) (PFC, 2020). This is largely due to the high cost of power procurement which roughly accounted for 84 percent of their total expenditure (Table 3). Besides, the procurement of 2516 GWh of RE over and above TSERCs RPO mandate was also done at an extra cost of Rs.6.01 Billion during FY 2018–19 (Tables 4 and 5) (TSERC , 2018a; 2018b; TSTRANSCO, 2020).

3.3. Andhra Pradesh

Electricity distribution in Andhra Pradesh (AP) is performed by two DISCOMS – Southern Power Distribution Company of A.P. Ltd. (APSPDCL, 2019) and Eastern Power Distribution Company of A.P. Ltd. (APEPDCL, 2019) with a total consumer strength of 16.4 million while the peak demand and energy requirement in the state during FY 2018–19 was 9.45 GW and 63.86 TWh, respectively (APERC, 2019; CEA, 2019a, 2019c). The overall AT&C loss of the A.P. DISCOMs (25.67 percent) are higher than the All-India average of 22.01 percent and they have also incurred a financial loss of Rs.119.32 Billion during FY 2018–19 (Table 2) (APEPDCL, 2019; APSPDCL, 2019; PFC (2020)) (Table 2). This is mainly due to the high cost of power procurement (82 percent of total expenditure) and the procurement of 9160 GWh of RE over and above the APERCs RPO mandate at an incremental cost of Rs. 7.67 Billion (compared to the average CGS tariff) during FY 2018–19 (Tables 3–5) (APERC , 2017).

4. Power procurement costs

The electricity tariffs for industrial consumers in India are amongst the highest in the World (on a PPP basis) due to rampant cross-subsidization, even as the reliability of power supplies needs further improvement (Subramanian, 2017). Specifically, the weighted-average industrial tariff in Karnataka (Rs.8.28/kWh) is significantly higher than that in the United States (Rs.5.21/kWh) (EIA , 2020; KERC, 2018b, 2018c; 2018d, 2018e, 2018f). While the electricity subsidy is a burden on the state budgets, industries and commerce in India are handicapped since their competitiveness is eroded by the high input costs which hamper their ability to enhance job creation even under normal conditions (Table 3).

As per the National Tariff Policy, the long-and medium-term Power Purchase Agreements (PPAs) with the CGS and SGS includes two-part tariff to facilitate merit order dispatch (CERC, 2016a). Merit order principle is a method of ranking the stations for dispatch of energy as per the ascending order of their variable costs (MoP , 2018a). So, one part is the fixed cost/charges which are fixed by the concerned regulator (on an annual or 5-year basis) and the other part is the variable cost which is the energy charge. The structure of these costs is explained in this section.

4.1. Fixed charges

As per the tariff regulations issued by Central Electricity Regulation Commission (CERC) under the Electricity Act, CERC determines the tariff of generating stations governed by section 62 of this Act (CERC, 2019b; India Code, 2020). For all such stations, the annual Fixed Charges (FC) determined by the concerned regulator consists of (a)Return on equity; (b)Interest on loan and working capital; (c)Depreciation; and (d)Operation and Maintenance (O&M) cost. Barring a few exceptions where tariff-based bidding was conducted by the power procurers to ascertain a competitive tariff, the vast majority of the TPPs in India are governed by section 62 of the Electricity Act, 2003, and the determination of annual FC as above.

In a scenario, if "X" quantum of power from a plant (either from SGS/CGS) is not purchased despite its availability, then the DISCOMs must pay the full annual FC to that power plant as per the regulatory order in tune with the PPAs. During FY 19, the total FC borne by the nine SR DISCOMs was Rs.244.58 Billion (APERC, 2018; KERC, 2020a, 2020b; 2020c, 2020d, 2020e; TSERC , 2018a). However, due to the must-run status of RE and high RE influx in the SR, some of the well-furnished TPPs having the state-of-art super-critical technology (and equipped with the latest environmental protection technologies) are largely under-utilized, thereby swelling up their FC per unit (Srikanth et al., 2020). For example, the annual FC of the Kudgi and Yermarus TPPs during FY 2018–19 were Rs. 48.05 Billion and Rs. 25.82 Billion, respectively (NTPC, 2020, RPCL, 2019). However, during FY 2019–2020, the PLFs of these two modern TPPs declined from 41 to 22 percent (Kudgi) and 6 to 3 percent (Yermarus) (NPP, 2020). This is because the CAGR of energy requirement in the SR during the years FY 2015–16 to FY 2019–20 was only 4.58 percent compared to a projection of 7.42 percent in the 18th EPS (CEA, 2011a; 2016b; 2020c). Consequently, the 18th EPS (published in December 2011) over-estimated the electrical energy requirement in the SR during FY 2019-20 by as much as 28.51 percent (CEA, 2011a; 2020c). While CEA (2017a) toned down the 18th EPS projections, the 19th EPS (published in January 2017) also over-estimated the electrical energy requirement in the SR during FY 2019-20 by 9.26 percent (CEA, 2020c). However, the PPAs for the most modern TPPs in SR, viz., Kudgi (3 × 800 MW), and Yermarus (2 × 800 MW) TPPs were signed by the DISCOMs in SR based on the projections made in the 18th EPS. While these modern and efficient TPPs with super-critical technology commenced their commercial operations in 2017/2018, they are grossly under-utilized (FY 2019–20 PLFs of 22 percent for Kudgi and 3 percent for Yermarus). Since these two TPPs have approved annual FCs (Rs.74 Billion in FY 2018–19) which have to be paid on the "take or pay" principle, the DISCOMs in SR can reduce their losses by maximizing their offtake from these TPPs while the excess RE produced in the SR can be transmitted to other States who are unable to fulfill their RPOs. This will not only reduce the average tariffs in SR but will also enable the RE GECNOs to avoid getting backed down despite their "must-run" status as per India's electricity Grid Code (Table 1) (CEEW, 2018; CERC, 2010). Further, the inter-state transmission of energy is also incentivized by exempting solar and wind energy sources from payment of transmission charges and losses for using the Inter-State Transmission System (ISTS) for 25 years from the date of commercial operation (CERC, 2016a, 2019a).

4.2. Variable costs

The variable costs of TPPs are almost entirely dependent on the price of coal, freight charges, and the specific consumption of coal in the TPP. While the specific consumption of coal is based on the efficiency of the TPP, the other two costs are in the hands of GOI since GOI-controlled companies produce more than 94 percent of the coal in India and more than 87 percent of the coal produced in India is supplied to TPPs (Coal Controller, 2019).

As per CERC's tariff regulations, the computation of energy charges based on the landed cost of fuel includes all cost components up to the delivery point of the generating stations (CERC, 2019b). Further, these energy charges are directly passed through in the retail tariff based on the formula specified for Energy Charge Rate (ECR) in the Tariff Regulations and the DISCOMs can only verify the bills or claims of the energy charge rate while making payment (CERC, 2019b). This approach for allowing pass-through of the landed cost of fuel is based on the premise that the fuel cost is beyond the control of the GENCOs as these were administered prices earlier. While coal prices were decontrolled by the GOI several years back, in practice the Ministry of Coal which appoints all the Directors in GOI-controlled Coal India Ltd (that produces 83 percent of the coal produced in India) continues to control coal prices through the directors on the board of Coal India Ltd. (CIL) who are all appointed by the GOI which controls 69 percent of the shares of CIL (CIL, 2020; Coal Controller, 2019). Similarly, Singareni Collieries Company Ltd. (SCCL) which produces 8.77 percent of the coal produced in India is owned jointly by the GOI and the State Government of Telangana sets its coal prices at a level higher than the CIL coal price for the same grade of coal (Coal Controller, 2019).

CERC (2019c) has analyzed the energy charges between FY 2009–10 and FY 2016–17 and discovered that the following cumulative cost escalations have been imposed on the TPPs in the form of energy charges:

- Coal Cost: 82 percent hike
- Taxes & Duties on coal: 219 percent hike

- Coal Transportation (Railway freight): 60 percent hike
- Taxes & Duties on Transportation: 340 percent hike

Cumulatively, these cost increases by GOI-controlled monopolies (CIL, SCCL, and Indian Railways) have hiked coal costs supplied to the TPPs by 82 percent between 2009–10 and 2016–17 and are entirely passed through to the DISCOMs as energy charges (CERC, 2019c). Unfortunately, the DISCOMs have been unable to recover these escalated costs from their end consumers through commensurate tariff hikes since a large portion of the consumers in the three states (Andhra Pradesh, Karnataka, and Telangana) have to get subsidized or free electricity (under the norms set by the respective State Electricity Regulatory Commissions) as per the welfare policies of the respective State Governments. While GOI has recently amended various Laws to permit commercial coal mining, not a single coal block has been allotted for commercial mining to date (PIB , 2020). Therefore, the DISCOMs have no choice but to bear the energy charges imposed by Government monopolies (CIL, SCCL, and Indian Railways) which are all controlled by the Central Government. Further, the GENCOs are also forced to increase their energy charges by at least Rs. 0.20 per unit due to the differences between the grade of coal received from the GOI monopolies compared to the grade of coal they have paid for (SRPC, 2019).

Besides, frequent backing down of TPPs to accommodate "must-run" renewables has also impacted the efficiency of these plants, requiring higher use of coal to produce the same quantum of electricity as well as increasing the O&M costs of the TPPs due to higher wear and tear of the machinery (Srikanth, 2018). These costs are not being factored in our computation for want of data.

4.3. Future cost projections

The DISCOMs are already burdened with high annual FCs for their TPPs whose PLFs are already at an all-time low. Following CERC's (2019b) tariff regulations, India's largest GENCO "NTPC Ltd." has already filed petitions to hike the fixed charges of its TPPs in SR. Specifically, NTPC has asked CERC to increase the total FC of three of its TPPs in the SR during the ongoing 5-year control period (FY 2019–20 to FY 2023–24) by eight (8) percent over the total FC during the last 5-year control period (FY 2014–15 to FY 2018–19) (CERC, 2016b, 2016c; 2016d, 2017a,b; NTPC, 2019).

Further, the Ministry of Environment, Forest and Climate Change (MoEF&CC) has revised the emission standards for all TPPs with retrospective effect. As per the revised standards, installation of an expensive Flue Gas Desulfurizer (FGD) is mandatory for both existing and new plants even if the ambient air concentrations of SO_2 around the TPPs in the SR is significantly lower than the applicable ambient air quality standards (MoEF, 2009; MoEF&CC (Ministry of Environment Forest and Climate Change), 2015; NTPC, 2019c, 2019d). The Ministry of Power (MoP) in the Central Government has already directed CERC to review and approve any increase in cost for the installation and operation of these FGDs as a pass-through in the generation tariff (MoP, 2018). Since the aforesaid increase of eight (8) percent in the total FC projected by NTPC during the ongoing 5-year control period (FY 2019–20 to FY 2023–24) did not consider the estimated capital investment of Rs. 34 Billion required for the installation of FGDs in the three TPPs (indicated above) (CERC, 2018), the annual FC of these TPPs is projected to increase further. These increases in the annual FC will again be passed through to the DISCOM in the form of higher generation tariffs which they will have to recover from their consumers or the respective State Governments (in the form of subsidies) if they have to avoid losses. MoEF&CC must review their mandate to all TPPs using domestic low-sulfur (<0.7 percent) coal to install FGDs since the minimum stack height of TPPs in India was fixed by the Central Pollution Control Board (CPCB) based on the meteorological conditions prevalent in a tropical country like India to ensure that the ground-level air concentrations of SO_2 are compliant with the National ambient air quality standards (CPCB, 1985).

5. Conclusions and policy implications

While the per capita electricity consumption in India has increased at a CAGR of 4.8 percent in the last 12 years (FY 2006–07 to FY 2018–19), India appears to be tripping up on the third pillar, namely "affordability" which is a critical part of SDG 7 (CEA, 2019b; United Nations, 2020). As a result, the annual per capita electricity consumption in India in 2017 (947 kWh) was only 30 percent of the World's per capita consumption of 3152 kWh (IEA, 2019). Further, Oswald et al. (2020) have exposed the large inequality in energy footprints across the World by documenting the fact that "*the bottom half of the global population consumes less than 20 percent of the final energy footprints which is less than what top 5 percent of income ladder consumes annually*."

Nevertheless, India's power sector is awash in generation capacity since the maximum demand of 184 GW in FY 2019–20 (even before the COVID-19 lockdown) was 62 GW lesser than that projected for FY 20 in the 18th Electric Power Survey (EPS) and 17 GW lesser than that projected in the 19th EPS published in January 2017 (CEA, 2011a; 2017a; 2020d). As a result, the All-India PLF of TPPs in India has dipped to an all-time low of 56 percent in FY 2019–20 and is projected to drop even lower due to the COVID-19 crisis which will leave a severe impact on India's economic development (NPP, 2020).

Power distribution is the most vital link in the entire power value chain and the sustainability of DISCOMs is critical for the entire power sector. However, even the better-performing DISCOMs in the SR are exhibiting financial distress primarily due to the high cost of power procurement caused by a combination of several factors, including the large supply-demand mismatch caused by over-optimistic projections of power demand and the consequent oversubscription to thermal capacity through long term PPAs coupled with the unmetered (or subsidized) electricity sales to agriculture and low-income households in rural areas. This eventually translates into payment delays to GENCOs (Rs. 123.45 Billion being the combined dues of the nine SR DISCOMs to the GENCOs as on March 2020) as well as inadequate investments in the maintenance and upgradation of power system infrastructure (Praapti, 2020). Finally, this financial stress affects the provision of affordable power supply to all Indians which is a prerequisite to the attainment of Sustainable Development Goal 7 (United Nations, 2020).

The situation of the DISCOMs after the COVID-19 crisis is likely to be grim since they have to pay Billions of rupees in fixed charges to the GENCOs with whom they have signed long-term PPAs even as electricity demand falls below the projected figures in the 19th EPS due to this crisis. While each DISCOM has to improve its operational efficiency with the active participation of the State Government, GOI can also facilitate the viability of the DISCOMs by incorporating suitable amendments in the Electricity Act, Tariff Policy, and the Grid Code to implement the following recommendations:

- Announce a moratorium on fresh investments in TPPs and RE sources during the next two years till the nationwide peak demand exceeds 70 percent of the conventional generation capacity in the country (65 percent during FY 2019–20).

The proposed moratorium may be applied only to fresh investments in TPPs and RE plants other than those power plants where more than 50 percent of the sanctioned expenditure has already been incurred. However, work on hydro and nuclear power plants must be continued since they are crucial for India's long-term carbon-free energy security.

- Direct the CERC to amend its tariff regulations (2019–24) by reducing the guaranteed, post-tax Return on Equity (ROE) for GENCOs from the current level of 15.5 percent to 12 percent (CERC, 2019c).

This reduction in post-tax ROE by 3.5 percent is justified to revive the economy and jobs growth caused by the COVID-19 crisis since the Reserve Bank of India (RBI) has reduced its policy repo rate (with a knock-on impact on lending rates by banks) from 7.5 percent (April 2015) to 4 percent today (RBI, 2015; 2020). While this will reduce the margins of the GENCOs, it will also reduce the cost of power procurement for the DISCOMs since even the better-performing DISCOMs are unable to recover the relentless cost increases in generation tariffs and fixed cost compensation for backing down modern power plants due to the unprecedented supply-demand mismatch.

Alternatively, GOI-controlled NTPC Ltd. (which supplied 20 percent of the power generated by utilities and 18 percent of the combined generation by utilities and non-utilities during FY 2018–19) can be directed by GoI to bear a part of the DISCOM burden by a voluntary reduction in fixed charges in return for increasing the offtake from their under-utilized TPPs (MoSPI, 2020; NTPC, 2019h).

- Permit DISCOMs to implement merit order dispatch for RE sources once the RPOs are fulfilled at the State level since the DISCOMs in the three States studied (AP, Karnataka, and Telangana) are suffering losses of Rs.15.42 Billion (in FY 2018–19) by procuring RE at higher costs even after complying with their respective RPOs while 17 out of the 28 States in the country are unable to meet even 60 percent of their respective RPOs (Lok Sabha, 2020).
- Compensate the States for backing down their TPPs to accommodate any RE that they absorb over and above their respective RPOs till the time India's Power Grid can freely transmit excess RE from the SR to other States through the "Green Energy Corridors" (Kanitkar et al., 2020; Lok Sabha, 2020).
- Reduce energy charges by directing CIL and SCCL to supply "washed" coal containing less than 34 percent ash to all TPPs located more than 500 km from the coal mines so that the landed cost of coal (on a calorific value basis) is lesser than that of raw coal supplied to TPPs today (MoEF, 2014). This will not only have a knock-on effect on the energy charges of the TPPs but will also have a positive impact on CO_2 emissions from India's energy sector.
- Direct GOI-controlled PGCIL to voluntarily reduce the inter-state transmission charges to optimize procurement of low-cost power by all DISCOMs in the country which is crucial to ensure affordability of power to all Indians in tune with SDG 7.
- Develop a transition path for TPPs to comply with new environmental norms since India's power sector is not in a position to invest Rs.674 Billion for FGDs during the next two years to upgrade 167 GW of TPP capacity (CEEW, 2019; Financial Express, 2020). A gradual transition path is critical since such investments will increase tariffs by Rs.0.62–0.93 per kWh which will be a heavy burden on all consumers who will continue to bear the economic brunt of the COVID crisis for the next two years (Krishnan et al., 2019).

As explained in this paper, the Government of India is following a silo-based approach towards the fixation of tariffs/charges in various sectors of the electricity value chain though these sectors (coal, railways, inter-state power transmission) as well as all key policies related to the coal, railways, and power sectors are controlled by GoI. Specifically, the electricity demand projections, coal prices, freight charges for coal transportation, levies on coal and railway freight, the National Tariff Policy, the Grid Code (with must-run status for RE irrespective of the merit order), cost-plus tariffs and the rate of return for Government GENCOs and Transmission utilities, are all regulated by GoI directly or indirectly. This silo-based approach is imposing a financial burden on the DISCOMs resulting in high tariffs for consumers. While the State Governments must work with the DISCOMs to improve their internal business processes, the Central and State Governments must work together and develop an integrated approach for India's power sector to ensure its sustainable development.

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CRediT authorship contribution statement

Soumya Deep Das: Investigation, Methodology, Formal analysis, Data curation, Writing - original draft. **R. Srikanth:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Funding acquisition, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Further reading

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