ITES
Part of the UK-India Net Zero Innovation Virtual Centre

Mapping Indian Network Operators

DISCOM challenges in their pathway to supply zero emission electricity

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CATAPULT Energy Systems

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1 Introduction

India is accelerating deployment of renewable energy, driven not only by sustainability concerns but also by the potential for cost-effective solutions to meet the country's development needs. The interim RE adoption targets is set at 500 GW of non-fossil generation capacity, to be achieved by 2030. This includes energy systems in decentralised formats, typically rooftop solar plants.

The seemingly low cost of wind and solar projects masks the underlying structural costs that renewable energy imposes on grids when scaled up. The unpredictable and intermittent nature of electricity generated from renewable sources, in contrast to the stable flow from traditional fossil fuel generation, requires fundamental changes in grid investment and operation. India's response to this challenge involves better coordination of power flow between its state-run grids. By increasing energy trade between state utilities, surplus power in one region can offset deficits in others, creating a more stable and reliable supply of renewable energy that can replace polluting fossil fuels. In addition, various mission mode programmes have also been taken up by the Government of India such as 5 million tonnes of green hydrogen, 30% mobility to be transformed to EVs and much more by 2030 which will further push the requirement of RE for sustainable operation of these new assets.

Currently, the electricity generation in India is not entirely carbon-free as most of the country's power- generating capacity still relies on fossil fuels such as coal and crude oil.

Installed Generation Capacity (Fuel wise) as on 31.03.2023

Category	Installed Generation Capacity (MW)	% of share in Total
Fossil Fuel		
Coal	2,05,235	49.30%
Lignite	6,620	1.60%
Gas	24,824	6%
Diesel	589	0.10%
Total Fossil Fuel	**2,37,269**	**57.7%**
Non-Fossil Fuel		
RES (Incl. Hydro)	**1,72,010**	**41.30%**
Hydro	46,850	11.30%
Wind, Solar & Other RE	**1,25,160**	**30.1 %**

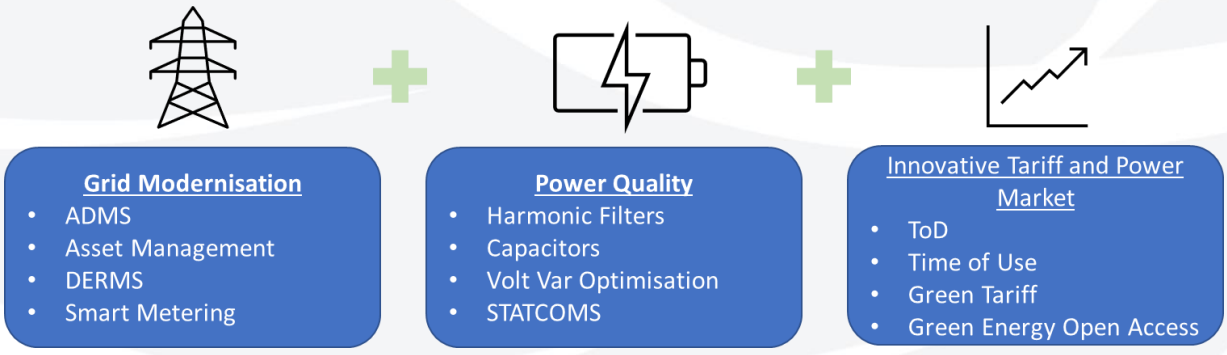
Wind	42,633	10.2 %
Solar	66,780	16.1 %
Biomass Power and Cogeneration	10,248	2.5 %
Waste to Energy	554	0.10%
Small Hydro Power	4,944	1.2 %
Nuclear	**6,780**	**1.60%**
Total Non-Fossil Fuel	**1,78,790**	**43%**
Total Installed Capacity (Fossil Fuel & Non-Fossil Fuel)	**4,16,059**	**100%**

Installed Generation Capacity (Fuel wise) as on 31.03.2023

Therefore, not only adoption of EVs but powering those EVs with RE will be essential to reduce the carbon footprint of the road transportation sector, which forms 14% of the energy-related direct (Scope- 1) carbon dioxide (CO2) emissions. Moreover, the integration of these renewable resources, electric vehicles, and energy storage systems etc. in the low voltage grid will lead to operational complexity for grid operators as mentioned below:

- Increased power losses and overloading situations with the installation of EVCS
- Increase in fault current value of lines and feeders
- Harmonic distortion in the distribution network with the increased installations of EVCS and RTPV

Considering these issues with RE and EV integration in the network, the distribution companies need to focus on grid modernisation and load balancing to support the flexibility and robustness of the grid for ensuring reliable as well as quality power supply up to tail ends.



Focus area for utilities to integrate generation and demand resources in the low voltage grid

2 Need of the study

Innovating for Transport and Energy Systems (ITES) is a landmark, government-backed collaboration between the UK and India. It is designed to fast-track sustainable transport and drastically reduce emissions through market-driven UK-India innovation.

ITES carries out joint research into specific sustainable transport issues and enabling the piloting, support and scale up of new sustainable solutions. To achieve decarbonisation of the transport sector, it is essential to also decarbonise the electricity systems that power electric vehicles.

This study aims to undertake a study to map the challenges faced by the Indian electricity network operators (DISCOMs), in their pathways to supply zero emission electricity to their network and support India's target to achieve net zero emissions by 2070.

3 Project tasks and activities

This study has been structured into four major tasks, as highlighted below.

- Providing overview of DISCOMs in India
- Selecting high priority DISCOMs
- Status of decarbonisation activities of selected DISCOMs
- Major challenges and way forward

Further sections provide an overview of the approach followed for executing the above-listed tasks, activities undertaken corresponding to each task and key findings in line with the objective of the study.

3.1 Task 1 - Overview of DISCOMs in India

The aim of this task is to present a high-level overview of power utility companies operating in India, particularly in regard to their ownership structure (whether they are publicly or privately owned), the types and number of consumers they serve, and the proportion of renewable energy sources in their energy mix. This overview will be used to prioritise the DISCOMs and narrow down the list of companies to focus on for a thorough analysis of their path towards achieving net zero emissions.

3.1.1 Approach followed

This task provides As-Is evaluation of DISCOMs to identify DISCOMs of higher priority. A list of data items was compiled in consultation with ESC team, and secondary research was used to populate the database. This initial screening enabled us to gain insights into the operational and market performance of DISCOMs located in major states and UTs.

3.1.2 Activities undertaken

There are more than 70 DISCOMs in India, including both public and private sector companies. For the purpose of this study, 50 (fifty) DISCOMs located in major states and UTs (in consultation with the ESC team) have been considered. Below is the list of states/UTs and corresponding DISCOMs for which the first level of data (explained later) has been collected.

State	Name of DISCOM
Andhra Pradesh	(APEPDCL)-Eastern Power Distribution Company of Andhra Pradesh Limited
	(APSPDCL) Southern Power Distribution Company of A.P Limited
	(APCPDCL) Central Power Distribution Corporation of A.P. Ltd

Delhi	BSES Yamuna Power Ltd
	BSES Rajdhani Power Limited (BRPL)
	Tata Power Delhi Distribution Limited (TPDDL)
Maharashtra	Maharashtra State Electricity Distribution Company Limited (MSEDCL)
	Brihanmumbai Electric Supply & Transport (BEST) Undertaking
	Adani Electricity Mumbai Limited
	Tata Power Company Limited
Punjab	Punjab State Power Corporation Limited (PSPCL)
Karnataka	Bangalore Electricity Supply Company Limited (BESCOM)
	Chamundeshwari Electricity Supply Corporation Limited (CHESCOM)
	Gulbarga Electricity Supply Company Limited (GESCOM)
	Hubli Electricity Supply Company Limited (HESCOM)
	Mangalore Electricity Supply Company Limited (MESCOM)
Haryana	Dakshin Haryana Bijli Vitran Nigam Limited (DHBVNL)
	Dakshin Haryana Bijli Vitran Nigam Limited (UHBVNL)
Telangana	Telangana State Northern Power Distribution Company Limited (TSNPDCL)
	Telangana State Southern Power Distribution Company Limited (TSSPDCL)
Rajasthan	Ajmer Vidyut Vitran Nigam Limited (AVVNL)
	Jaipur Vidyut Vitran Nigam Limited (JVVNL)
	Jodhpur Vidyut Vitran Nigam Limited (JdVVNL)
Tamil Nadu	Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO)
Gujarat	Dakshin Gujarat Vij Company Limited (DGVCL)
	Madhya Gujarat Vij Company Limited (MGVCL)
	Paschim Gujarat Vij Company Limited (PGVCL)
	Uttar Gujarat Vij Company Limited (UGVCL)
	Torrent Power Ahmedabad
	Torrent Power Surat
West Bengal	West Bengal State Electricity Distribution Company Limited (WBSEDCL)
	Calcutta Electric Supply Corporation Limited (CESCL)
	India Power Corporation Limited (IPCL)
Kerala	Kerala State Electricity Board Limited (KSEBL)
Odisha	TP Central Odisha Distribution Limited (TPCODL)

	TP Northern Odisha Distribution Limited (TPNODL)
	TP Western Odisha Distribution Limited (TPWODL)
	TP Southern Odisha Distribution Limited (TPSODL)
Madhya Pradesh	Madhya Pradesh Madhya Kshetra Vidyut Vitaran Company Limited (MPMaKVVCL)
	Madhya Pradesh Paschim Kshetra Vidyut Vitaran Company Limited (MPPaKVVCL)
	Madhya Pradesh Poorv Kshetra Vidyut Vitaran Company Limited (MPPoKVVCL)
Uttar Pradesh	Dakshinanchal Vidyut Vitran Nigam Limited (DVVNL)
	Kanpur Electricity Supply Company Limited (KESCO)
	Madhyanchal Vidyut Vitran Nigam Limited (MVVNL)
	Paschimanchal Vidyut Vitran Nigam Limited (PVVNL)
	Purvanchal Vidyut Vitran Nigam Limited (PuVVNL)
	Noida Power Company Limited (NPCL)
Bihar	North Bihar Power Distribution Company Limited (NBPDCL)
	South Bihar Power Distribution Company Limited (SBPDCL)
Jharkhand	Jharkhand Bijli Vitran Nigam Limited (JBVNL)

List of focus States/UTs and corresponding DISCOMs

The first level of data items collected for the above-mentioned DISCOMs have been presented in the table below.

Sl. No.	Data items collected
1	Map of area served
2	Number of consumers served
3	Consumer Mix (Residential, Commercial, Industrial and Agricultural)
4	Ownership Structure (Private / Public)
5	Energy Sales (MU)
6	Percentage of RE in Electricity Generation mix
7	Peak Demand (MW) – State
8	Peak Demand Met (MW) – State
9	Peak Deficit (MW) – State
10	Energy Demand (MU) – State
11	Energy demand Met (MU) – State
12	Energy Deficit (MU) - State

DISCOMs Data Collection Overview

Populated database has been appended as Annexure 1: Overview of DISCOMs in India at the end of this report.

3.1.3 Key findings

- RTPV and EV implementation – show the states which is moving faster towards RTPV and EV implementation
- EV Tariff – special EV tariff (ISGF report on EV tariff)
- Green Tariff – Green tariff by Maharashtra and Tamil Nadu (helps in procurement of green energy for EV charging)
- Peak demand increase – peak demand increase aligned with EV increase and how RTPV can help in meeting the peak demand

3.2 Task 2 - Selection of high priority DISCOMs

Towards making the study more meaningful, it was decided to undertake a detailed analysis of a few select DISCOMs, shortlisted on a certain criterion. The primary objective of this activity was to identify DISCOMs which are better prepared in terms of decarbonising the electricity system and achieving India's net zero emission targets.

Following set of holistic parameters were considered while shortlisting the high priority DISCOMs.

- **Operational competence –** The primary factor is whether a DISCOM is being managed professionally or not. We employed two proxy indicators - annual rating assigned to DISCOMs (by government) as well as their technical losses. Good rating and low loss levels indicate a better managed utility, with greater propensity to undertake technical interventions.
- **Energy sales –** High energy sales, indicate demand as well as consumer presence, providing a good catchment for EV as well as rooftop PV penetration. Higher sales indicate a large set of consumers, invariably having transportation needs (EVs – buses and private vehicles and charging stations) as well as households for PV rooftops. In addition, consumer type was looked into to ensure a decent share of commercial and industrial loads.
- **Renewable energy portfolio –** The third set of parameters gauged the existing as well as targets of RE (both centralised as well as decentralised plants). We checked for policy support mechanisms including SARAL rating (checks state's preparation towards rooftop PV), RPO levels and targets, existence of net-metering policy as well as declaration of green tariff. Some of these factors were not available at a DISCOM level, as such, we used State specific data points.

- **EV portfolio –** The next set of parameters focused upon the EV sector. These included existing and targeted share of EV in total vehicles sold (separately for PVs and CVs), share of EV energy as part of total energy sales and the number of EV charging stations. In addition, EV support measures like subsidies and tax incentives were also looked into. Most of these factors were not available at a DISCOM level, as such, we used state specific data points.
- **Appropriate representation –** The aforementioned parameters would have led to selection of a number of DISCOMs, making it difficult to undertake an in-depth analysis. This might have led to inadequate representation of certain states/ areas/ DISCOMs. Therefore, few other filters were employed. These included area profile (rural/ urban/ mix), load type, DISCOM ownership, spatial location, and the intent of the local government (in terms of planned investments in the RE and EV space).

Six DISCOMs were shortlisted in the first round of shortlisting. Geographical diversity has also been taken into consideration while coming out with the initial list.

Zones	West	North	East	South	West	Central
DISCOMs	MSEDCL (Maharashtra)	DHBVN (Haryana)	SBPDCL (Bihar)	BESCOM (Karnataka)	JVVNL (Rajasthan)	PVVNL (UP)
Operational Aspects						
DISCOM Rating	C-	A+	C-	C-	C	C
AT&C Loss	18%	14%	33%	13%	19%	27%
Market Size						
Sales	1,05,000 MU	26,000 MU	18,800 MU	30,000 MU	22,000 MU	33,500 MU
C&I Share	43%	42%	29%	30%	Moderate	25%
Profile	Industrial	Urban	Mix	Urban	Urban	Mix
RE / Solar Aspects						
RTPV Targets (State)	4,700 MW	1,600 MW	1,000 MW	2,300 MW	2,300 MW	4,300 MW
RTPV Cap (State)	1,400 MW	418 MW	31MW	416 MW	835 MW	259 MW
SARAL Rating (State)	A+	A	B	A++	A+	B+
NM Policy	Y	Y	Y	Y	Y	Y

RPO Level	11%	10%	-	23%	18%	11%
Green Tariff	Y	Y	-	Y	-	Y
EV / EVCS related aspects						
EV Policy/ Targets	Subsidies; targets; tax incentives	Subsidies; 100% E-Bus by 2030	Incentives for E2W,3W, 4W, E-Bus	500 EV-Buses; 100% E3W	E2W- 15%, E3W- 30%, E4W-5%	E2W,4W, Bus - Exemption on regn fee; 15% rebate on road tax
Registered EV (State)[1]	2,53,000	60,000	1,37,951	2,03,968	1,55,209	4,98,526
EVCS Installed	Existing - 49 Target of 2375 EVCS by 2025	5	-	11	-	-
EV Sale (kWh) (State)	91k	12k	7k	62k	22K	36K

Above are the operational, market, RE and EV related data items captured for the initially shortlisted 6 DISCOMs.

Final selection

Below listed 4 Discoms are shortlisted for further assessment, based on the detailed discussions with ESC team -

- JVVNL (Jaipur)
- PVVNL (Uttar Pradesh)
- MSEDCL (Maharashtra)
- SBDCL (Bihar)

3.3 Task 3 - Status of decarbonisation activities of selected DISCOMs

India has pledged to raise the proportion of non-fossil-fuel sources in its installed capacity of electric power to 40% by 2030 as part of its Intended Nationally Determined Contributions (INDCs). To achieve this goal, solar energy is being considered as a primary source. The Indian Government has set a target of attaining

[1] Number of overall registered electric vehicles in the state as of now, Source: VAHAN Sewa Dashboard, VAHAN SEWA| DASHBOARD (parivahan.gov.in)

100 GW of solar power capacity in the country by 2022, with a specific aim of generating 40 GW of power from rooftop solar (RTS), of which 4000MW in the residential sector.

On December 30, 2015, the Indian Government gave its approval for the "Grid Connected Rooftop and Small Solar Power Plants Program," which aimed to establish 4,200 MW of rooftop solar (RTS) plants across the nation by 2019-20. On February 19, 2019, the Indian Government approved Phase-II of the "Grid Connected Rooftop and Small Solar Power Plants Program," with a target of achieving a cumulative capacity of 40 GW of rooftop solar (RTS) plants by 2022. As part of the implementation of the MNRE Rooftop Solar Phase-II Program, DISCOMs and their local offices have been designated as nodal points. This is because DISCOMs play a crucial role in expanding RTS, as they have direct access to end-users, provide approval for installation, manage the distribution network, and serve as the billing interface with rooftop owners.

This task provides a summary of the measures and initiatives implemented by four shortlisted DISCOMs to decrease the carbon footprint in their networks. It includes their objectives for achieving decarbonisation in the power sector, as well as plans to support net-zero targets and reduce emissions from transportation. The focus of this overview includes solar rooftop installations, the purchase and planned purchase of renewable energy, and efforts to promote the adoption of electric vehicles through the installation of charging infrastructure.

3.3.1 MSEDCL (Maharashtra)

MSEDCL, Maharashtra is taking several steps to decarbonise the electricity system in India and accommodate the adoption of electric vehicles. Some of the measures undertaken by MSEDCL are highlighted in the table below.

Parameters	Response
Energy demand (2030)	NA
Peak Load (2030)	NA
RTS Installation	MSEDCL participated in the Grid Connected Rooftop Solar Program with an initial target of 25 MW and MNRE allocated 100 MW[2] for FY 2021-22. The program will continue up to 2030 and MNRE will sanction the target on a

[2] https://solarrooftop.gov.in/grid_others/phase2SanctionList

	year-on-year basis. MESDCL also empaneled agencies for implementation of RTS -II Program all over the state through a transparent e-tendering process. The consumer has been provided with the option to select the agency for installation of RTS. The installed capacity of Rooftop Solar in MSEDCL area has reached up to 873 MW[3] by 30.11.2021.
Share of RE in power procurement	MSEDCL is actively promoting the use of renewable energy sources such as solar, wind, and hydroelectricity. In 2021, MSEDCL signed a power purchase agreement with a 250 MW wind energy project in Gujarat to supply renewable energy to Maharashtra. Furthermore, the company has also signed PPAs with solar power plants and is encouraging the installation of rooftop solar panels in residential and commercial buildings. By increasing the share of renewable energy in its energy mix, MSEDCL is reducing its carbon footprint and contributing towards India's goal of achieving 450 GW of renewable energy capacity by 2030. MSEDCL has also invited bids to procure 225 MW of power from decentralised solar projects under the Pradhan Mantri - Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) program. The last day to submit the bids is April 28, 2023. The utility will enter into a power purchase agreement with the successful bidders for 25 years from the commercial operation date of the projects.
EVCI Support	As per the recent Press Order, for continued promotion of Electric Vehicles (EV) in the State, MERC has approved lower Fixed/Demand Charges for EV category to ensure that tariff for EV Charging Stations is close to Average Cost of Supply (ACoS), with an effective variable charge of Rs. 7.25 per unit and demand charges of Rs.75 per kVA per month at LT voltage level for FY2023-24. Additionally, users are also eligible for Load Factor (LF) and Power Factor (PF) incentives/penalties as applicable, besides Time-of-Day (ToD) tariffs, which will further reduce tariffs. Further, consumers may take separate connection under this category for charging of EVs. For more details, please check https://www.eqmagpro.com/wp-content/uploads/2023/04/Press-Release-MSEDCL-

[3] https://www.mahadiscom.in/ismart/media/SoP%20Rooftop%20Solar.pdf

	English_compressed.pdf MSEDCL has offered an additional concessional rate of INR 4.5 per unit for non-peak hours (10pm to 6am) of EV charging. MSEDCL is actively promoting the adoption of electric vehicles in Maharashtra. In 2020, the company signed an MoU with Mahindra Electric Mobility Ltd to promote the adoption of electric vehicles and set up electric vehicle charging infrastructure across the state. Furthermore, the company is also setting up EV charging stations in collaboration with various public and private sector partners. The power utility firm has prepared a roadmap for setting up a total of 500 EVCS close to its substations in various districts of Maharashtra over the next 2 years. MSEDCL has also announced setting up of 18 EVCS in Mumbai Metropolitan Region (MMR) for public – 4 in Greater Mumbai, 6 in Thane, 4 in Navi Mumbai and 4 in Panvel. MSEDCL has also developed an app named 'Power App' for electric vehicle users. Consumers can locate the nearest charging station, self-charge their vehicles, and make payments with the help of this app. This app displays information about MSEDCL's charging stations as well as private charging stations.
Demand Side Flexibility	MSEDCL with support from the Government of Maharashtra and Maharashtra Industry, Trade and Investment Facilitation Cell has installed EV billing meter in six charging stations operated by Magenta Power which will be extended on EV corridors also. This will facilitate in harnessing EV flexibility in future with smart charging and V2G getting implemented. Similarly, to ensure demand side flexibility, MSEDCL introduced TOD tariff which facilitates both the consumers and utility to optimise their load and efficient load management respectively.
Other Measures	Upgrading transmission and distribution infrastructure: MSEDCL is upgrading its transmission and distribution infrastructure to support the integration of renewable energy sources into the grid. The company has installed a 220 KV substation in Solapur and is currently constructing a 400 KV substation in Aurangabad. These substation upgrades will help in increasing the capacity and reliability of the power grid in Maharashtra. Furthermore, MSEDCL is

	also deploying energy storage systems, demand response programs, and microgrids to improve the efficiency and reliability of the power system. **Green Power Tariff** The Maharashtra Electricity Regulatory Commission (MERC) has also allowed a 'Green Power Tariff' of ₹0.66 (~$0.009)/kWh[4] to be levied on consumers (including extra high voltage, high voltage, and low voltage categories) opting for 100% green energy. **Off-grid solar powered irrigation pumps:** The Government of Maharashtra has targeted deployment of 1,00,000 nos. of Off-Grid Solar Powered Ag pumps in phase wise manner under "Mukhyamantri Saur Krushi Pump Yojana" within 03 years vide GR dated 1st Jan 2019. • First Phase – 25000 • Second Phase – 50000 • Third Phase – 25000

MSEDCL Decarbonisation and EV Adoption Initiatives

Overall, MSEDCL is taking several steps to decarbonise the electricity system in Maharashtra and promote the adoption of electric vehicles. These steps will help in reducing carbon emissions, improving energy efficiency, and promoting sustainable development in the state.

3.3.2 PVVNL (Uttar Pradesh)

As stated earlier, Government of India, on 19th Feb. 2019, has approved phase II of Grid Connected Rooftop and Small Solar Power Plants Programme". UP has been given a target of 60 MW for the residential sector, a very ambitious project requiring a rooftop space of 600 million sq. meters.

Parameters	Response
Energy demand (2030)	NA
Peak Load (2030)	NA
RTS Installation	Under Phase-II of RTS installation scheme, MNRE allocated the target of 12 MW[5] grid connected solar rooftop capacity.

[4] MERC order in reply to a petition filed by TATA Power, more on https://www.mercomindia.com/consumers- 100-renewables-green-power-tariff

[5] https://solarrooftop.gov.in/grid_others/phase2SanctionList

	As of December 2021, over 4,000 consumers have installed solar panels under this scheme.
Share of RE in power procurement	The long-term trajectory of minimum quantum of purchase of Renewable power from various renewable sources has been targeted at 15% in FY2023-24[6].
EVCI Support	As per the petition submitted to UP ERC on 09.01.2023[7], EV charging tariff at LT Public Charging Stations (PCS) has been set at INR 7.7/unit with TOD, whereas at HT PCS, it is set at INR 7.3/unit with TOD. The lowest EV charging tariff for domestic consumers will be INR 3.5/unit after subsidy with fixed charges of INR 55/kW/month. For more details, please check the link below: https://pvvnl.org/pvvnl_tenders/uploads/news/c9556d_PVVNL_FY2023-24_English.pdf
Demand Side Flexibility	UP is the first state to implement P2P trading of roof top solar which provides flexibility prosumers and consumers to supply and procure RE power locally at preferential rates and came out with implementation guidelines for commercial scaling up of P2P trading thereby facilitating in providing flexibility to the distribution grid. Similarly, UPPCL implemented DR pilot programme to aid DISCOMs in peak demand management for select consumer categories. Consumers, primarily commercial ones, with a minimum contract demand of 500 kVA were shortlisted and information regarding the DR event was provided in advance to voluntary participants through social media platforms like WhatsApp. The result was a successful load reduction of 3 MW during the DR event. The objectives of identifying target sections for DR projects and consumer categories and demonstrating a test intervention with select consumer categories were achieved. TOD tariff has also been introduced for facilitating both utilities and consumers for load balancing and optimisation of electricity bill.

[6] https://puvvnl.up.nic.in/Download/Tariff%20Order%20for%20FY%202022-23.pdf

[7] https://pvvnl.org/pvvnl_tenders/uploads/news/c9556d_PVVNL_FY2023-24_English.pdf

Other Measures	**Green Power Tariff** UPERC has computed the Green Energy Tariff payable by opting consumers as Rs. 0.54 per kWh[8]. This Tariff will be applicable for all the opting consumers except domestic and agriculture consumers. This Tariff will be in addition to the regular Tariff as approved by the Commission. The DISCOM has sanctioned INR 20 Cr. for repairing, maintaining, and strengthening Noida's power infrastructure. While INR 5.25 Cr. will be spent on strengthening damaged cables, poles and new air circuit breakers among others, INR 3 Cr. will be spent on increasing the capacity of existing distribution transformers. In rural areas, work on cable repairs and transformer ramp-up will be undertaken in Dadri and Jewar[9].

MSEDCL Decarbonisation and EV Adoption Initiatives

The table above highlights the RPO trajectory directed by UPERC.

Minimum quantum of purchase from renewable energy sources as % age of total energy consumed (in kWh)			
Financial Year	**Non-Solar**	**Solar**	**Total**
2019-2020	6	2	8
2020-2021	8	3	11
2021-2022	9	4	13
2022-2023	9	5	14
2023-2024	10	5	15

RPO trajectory as per UPERC regulations (%)

3.3.3 JVVNL (Rajasthan)

Rajasthan is one of the largest states in India and has a high potential for renewable energy generation, particularly solar and wind power. Rajasthan has a target of achieving 30 GW of solar power capacity by 2025, of which 10 GW is to be installed by DISCOMs. The state has already installed 5,726 MW of solar power capacity, as of January 2022, which is about 20% of the state's total installed capacity. Rajasthan has

[8] https://puvvnl.up.nic.in/Download/Rate%20Schedule%20for%20FY%202022-23.pdf

[9] https://timesofindia.indiatimes.com/city/noida/discom-sanctions-rs-20-crore-for-power-infra-upgrade-in- noida/articleshow/98529726.cms

a total wind power capacity of 4,281 MW, as of January 2022. As of January 2022, Rajasthan had a total installed capacity of 28,302 MW, of which 24.2% was from renewable sources. The state aims to increase this share to 50% by 2025.

In recent years, Rajasthan DISCOMs (Distribution Companies) have undertaken several measures to decarbonise their electricity supply and increase the use of renewable energy sources.

Parameters	Response
Energy demand (2030)	154 TWh
Peak Load (2030)	28 GW
RTS Installation	As of September 2021, JVVNL had installed a rooftop solar capacity of 45.13 MW across the state. Under the net metering scheme, consumers could install solar panels on their rooftops and feed excess power back into the grid, earning credits for the power generated. Additionally, the JVVNL had also signed agreements with several private companies and organisations to install rooftop solar systems in various parts of the state.
Share of RE in power procurement	The RERC has revised the RPO target for financial years (FY) 2021 to 2024 and included hydropower purchase obligation under the non-solar RPO. It has specified 8.50% solar RPO while non-solar RPO included 8.90% wind, 0.90% biomass, and 0.18% hydropower purchase obligations for FY 2021-22. For FY 2022-23, the solar RPO is set at 9.50%, wind at 9.10%, biomass at 1%, and hydropower purchase obligations at 0.35%. The total RPO target for FY 2023-24 is 21.66%. Of this, 10.50% is allocated to solar, 9.4% to wind, 1.1% to biomass, and 0.66% to hydropower.
EVCI Support	RERC clarified that if solar RPO compliances stood at 80% or above, DISCOMs could cover the shortfall by excess non-solar power consumed over the non-solar RPO target for that year. If non-solar RPO compliance reaches 80% or above, the shortfall could be met with excess solar, or hydropower consumed above that year's solar RPO or hydropower purchase obligation. If the hydropower purchase compliance stood at 80% or above, DISCOMs could cover the deficit through excess

	solar or non- solar energy consumed beyond their specified RPO. Electric Vehicle charging station tariff has been kept at INR 6/unit for LT PCS with INR 40/month of sanctioned connected load. For HT PCS, the tariff is INR 6/unit with INR 135/kVA/month. The TOD rebate of 15% will be applicable additionally for off-peak hours (12am – 6am) and surcharge of 5% during peak hours (6am to 10am). For more information, please check the link: https://jmkresearch.com/wp-content/uploads/2022/09/RERC-issued-retail-tariff-order-for-FY-2023.pdf In order to promote the usage of electric vehicles in the state, Rajasthan Transport and Road Safety Department notified "The Rajasthan Electric Vehicle Policy" dated August 31, 2022, effective from Sep 1st, 2022, for a period of 5 years. The policy targets 15% new E2W registrations, 30% new E3W registrations, 5% new E4W registrations, and phased transition to E-buses. JVVNL has also been nominated as the State Nodal Agency to support the deployment of public EV charging stations across the State.
Demand Side Flexibility	The demand response pilot implemented by JVVNL was designed with a demand-bidding-to-the-market mechanism where consumers could submit demand bids directly to the energy market. 17 commercial consumers participated on voluntary basis and the aggregator was tasked with sending DR signals to the consumers via phone call, SMS, and e-mail. The consumer then acknowledged the signal and confirmed the load curtailment as per the bids. A field team was assigned to observe the oad curtailment on a real-time basis through the DR portal. In addition, ToD tariff was introduced to provide flexibility on the distribution grid through better load management

Other Measures	JVVNL had proposed a budget of INR 651 Cr. for sub-transmission and distribution works[10]. JVVNL also proposed investment for separation of agriculture and non- agriculture feeders, strengthening and augmentation of sub-transmission & distribution infrastructure in rural areas and Rural electrification.

Rajasthan DISCOMs Renewable Energy Measures

Rajasthan DISCOMs are taking several measures to increase the share of renewable energy sources and reduce carbon emissions.

3.3.4 SBDCL (Bihar)

Bihar DISCOMs have been increasing their share of renewable energy in their power mix. In FY 2020- 21, Bihar State Power Holding Company Limited (BSPHCL), one of the state-run DISCOMs, procured around 1800 million units of renewable energy, which accounted for around 13.4% of its total power procurement. This was a significant increase from the previous year, when it procured around 1300 million units of renewable energy, accounting for around 9.8% of its total procurement. Bihar based DISCOMs have undertaken various measures to decarbonise the electricity sector.

Here are some of the measures taken by SBDCL.

Parameters	Response
Energy demand (2030)	53638.12 MU
Peak Load (2030)	10461 MW
RTS Installation	As of March 2023, SBDCL has installed a rooftop solar capacity of 25 MW across the state.
Share of RE in power procurement	Total RPO targets for SBDCL for 2021-22 were 14.25% (Solar RPO – 6.75% and Non-Solar RPO – 7.5%). Total of 1073.60 MU had been targeted. However, total of 0.17% RPO target has been achieved[11].
EVCI Support	Energy charges for LT EV charging has been fixed at INR

[10] https://india-re-navigator.com/public/tender_uploads/utility_rooftop_wind_policy-619f7cf328106.pdf

[11] https://sbpdcl.co.in/(S(pexbt3kgmtkndly15nbmfnew))/Tariff_Regulation_PDF/193/K.%203298/TARIFF-ORDER_NB-SB-FY-21-22%20(1).PDF

	7.15/unit and HT EV charging at INR 6.45/unit[12]. In case the consumer uses the electricity supply for charging his own electric vehicle at his premises, the tariff applicable shall be asper the category of such premises. Electricity consumption for other facilities and purposes at Charging Station such as office, restaurant, restrooms, convenience stores, public amenities, etc., shall be charged at tariff applicable to Non-Domestic Category.
Demand Side Flexibility	SBPDCL has introduced ToD tariff for ensuring better load management and facilitating consumers with options for electricity bill optimisation.
Other Measures	In order to reduce collection losses and increase network efficiency, SBDCL is undertaking strengthening and capacity addition of electricity distribution infrastructure, physical feeder segregation, feeder improvement program for network strengthening, name and shame campaign to control power theft and several consumer awareness programs.

SBDCL Action Plan

RAG Rating

Selected DISCOMs	MSEDCL	PVVNL	JVVNL	SBDCL
Rooftop Solar Installation	Active RTS installations	Low RTS installations	Limited RTS installations	Low RTS installations
Renewable Purchase Obligations	High RPO trajectory	High RPO trajectory	High RPO trajectory	High RPO trajectory
	High RPO achieved	Limited RPO achieved		Low RPO achieved
EVCI Support	EV Concessional Tariff	Concessional EV Tariff	Concessional EV Tariff	Concessional EV Tariff

[12] https://sbpdcl.co.in/(S(4oihfjjbrnapfuzwjaezedse))/Tariff_Regulation_PDF/233/K.%204950/FINAL%20TARIFF%20SCHEDULE%20FOR%20FY%202022-23.PDF

	EVCS Installations	Limited EVCS Installation	State Nodal Body for EVCS support	Limited EVCS support
Demand Side Flexibility	TOD Tariff	Guidelines on P2P trading of roof top solar	Demand response pilot for commercial and industrial customers	TOD tariff
	Installation of EV billing meter	TOU tariff pilot implementation framework	TOD Tariff	
		Manual DR pilot for commercial consumers		
		TOD Tariff		
Other Measures	Grid Modernisation measures undertaken	Green Power Tariff proposed	No green tariff	No green tariff
	Green Power Tariff	Distribution Network Upgradation	Limited network enhancements	Limited grid infrastructure enhancements
	Off-grid solar irrigation pumps	Net metering	Net metering	Net metering
	Net metering			

RAG Performance Indicators

3.4 Task 4 – Major challenges & way forward

In order to understand the challenges faced by DISCOMs in terms of integrating RE & EV loads and the measures taken by them to address these challenges, a two-pronged strategy was adopted. At the first stage, data pertaining to DISCOMs' operations, including RE & EV aspects, were collated from public platforms. This provided an overview of its activities.

As a next step, which was a primary in nature, a semi-structured questionnaire was administered to DISCOM officials in order to ascertain their preparedness towards low-carbon future. This included discussions with their officials as well.

The development of a sustainable energy transition ecosystem at distribution level will require integration of distributed renewable energy sources and flexible demand resources which poses many challenges as non-linear loads has the capability to generate harmonics thereby requiring installation of harmonic filters capacitors etc. into the grid for ensuring grid reliability. In addition, with integration of these resources there will be load enhancement which will also require strengthening of the grid to cater the increased demand. To identify the various challenges for the utilities, the project team has carried out detailed discussion with concerned person of each of the selected utilities as mentioned below:

DISCOM	Name of the Official	Designation
JVVNL, Rajasthan	PK Gupta	Superintendent Engineer (Commercial)
	Neha Sikka	EV Champion, Rajasthan
SBPDCL, Bihar	Raj Kumar	Chief Engineer (O&M)
PVVNL, Uttar Pradesh	Rajeev Maheshwari	Superintendent Engineer (Technical)
MSEDCL, Maharashtra	Aarti Kulkarni	Executive Engineer

Challenges Identification for Selected Utilities

Based on the discussion, we have identified the challenges and categorised them into different types as mentioned below:

Types of challenges	Decarbonisation of transport sector	Power quality improvement	Reduction of carbon content in network	Harnessing flexibility of EVs
Technical Challenges	Assessment of Grid upgradation requirement not carried out across the network to cater the additional demand	Absence of Power Quality Meters as mandatory instrument in PCS	Grid upgradation requirement assessment based of hosting capacity of VRE in the distribution grid	Maturity of V2G technology
	No feeder level load flow studies undertaken to	Absence of detailed power quality	Harmonic distortion and	Absence of smart grid technology

	assess the impact of EV integration in the grid	studies by DISCOMs w.r.t integration of VRE and EV	installation of harmonic filters	implementation by DISCOMs like EMS and system wide integration to realise full benefits of flexibilities harnessed by EVS
	Increased power losses and overloading situations	Thermal stress on distribution assets by nonlinear loads leading to asset failure		
Operational Challenges	The capacity of distribution transformers as well as the conductors need to be enhanced to support the increased load	Absence of standard power quality monitoring mechanism	Absence of real time monitoring and limited generation forecasting owing to their distributed nature	No market design principles established for V2G, Peer-to-Peer trading etc
	No Standard Operating Procedure for operation of grid for the public charging stations (PCS) leading to asset failures at the site e.g. transformers	Generation of harmonics and absence of regular monitoring	Intermittent nature leading to inefficient load balancing	No standard operating procedure including scheduling and Accounting procedure for V2G and Peer to Peer trading
	Increase in load and absence of	Uncontrolled EV charging	Increase in operational	Absence of state- wide

	TOU tariff not facilitating load shifting	can significantly reduce the power quality of low voltage networks	burden due to application processing, connectivity, metering, and billing	smart metering to implement these market services
	Lack of technical skill sets			Lack of institutional skills and capacities
Financial Challenges	High investment cost including dedicated transformer and 11 kV feeder for PCS	High investment requirement for grid upgradation with harmonic filters, capacitors etc.	High cost of operation for RE based PCS due to high investment and low utilisation rates	High cost of technology and limited financing due to absence of standard market design and regulatory guidelines
	Low utilisation rates due to limited EV penetration leading to negative RoI		High cost of RE procurement from the open market	
Regulatory Challenges	No provision for pass through of cost of setting up charging infrastructure to the DISCOM's consumer base through electricity tariff	Non enforcement of measures for maintaining power quality in the network and absence of associated incentives and penalties	Absence of Green Power Tariff for green energy procurement except MSEDCL which has come out with Green Power Tariff of INR 0.66/kWh	Absence of Time of Use tariff/Time of Day tariff with reference to EV consumers

			over and above normal tariff	
	Irregularity in tariff hike proposed by DISCOMs making it difficult for DISCOMs to pursue additional investment			Absence of regulatory guidelines for V2G, Peer-to-Peer trading etc.
				Lack of skill and capacity building

Categorised Challenges Identified from Discussions

Considering the challenges mentioned above, it is recommended to carry out deep dive analysis of specific DISCOMs in terms of grid upgradation assessment, feeder level harmonic studies, policy and regulatory support including framework for ToU tariff, V2G pilot and identification of pre-requisite technologies and market design to support the implementation etc. to suggest specific measures for each of the challenges identified.

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