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Report on Resource Adequacy Plan (Generation) for Tata Power Delhi Distribution Limited (TPDDL, Delhi) (2025-26 to 2035-36) (Version 2.0)

March, 2026

Government of India
Ministry of Power
Central Electricity Authority

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Disclaimer

This Resource Adequacy Study for the Tata Power Delhi Distribution Limited (TPDDL), Delhi, has been conducted based on data and inputs provided by the utility. The findings, analysis and conclusions presented in this report are contingent upon the accuracy, completeness and timeliness of the information furnished by the discom. Any discrepancies or limitations in the data may affect the outcomes of the study accordingly.

In accordance with the Resource Adequacy Guidelines dated 28th June 2023, each Distribution Licensee is mandated to prepare a Resource Adequacy Plan (RAP) for a 10-year horizon, referred to as the Long-Term Distribution Licensee Resource Adequacy Plan (LT-DRAP), which shall be vetted and validated by the Central Electricity Authority (CEA). CEA has facilitated this study and prepared the report solely to assist TPDDL in fulfilling this requirement.

It is expressly stated that the responsibility for the implementation of the study's recommendations, ensuring the adequacy of electricity resources, and undertaking any related actions including financial implications, if any, rests entirely with the Discom.

Executive Summary

Ministry of Power had notified the Electricity (Amendment) Rules in December, 2022. As per Rule 16 of the Electricity (Amendment) Rules, Ministry of Power, has notified Resource Adequacy (RA) Guidelines. According to these Guidelines, Central Electricity Authority (CEA) is entrusted with the responsibility of preparing the Long-Term National Resource Adequacy Plan (LT-NRAP). Further, each Distribution Utility is required to carry out a Long-Term Distribution Licensee Resource Adequacy Plan (LT-DRAP) to reliably meet its peak electricity demand and electrical energy requirement.

As per the Resource Adequacy Guidelines dated 28th June 2023, each Distribution Licensee shall prepare a Resource Adequacy Plan (RAP) with a 10-year planning horizon, LT-DRAP, to meet its own peak electricity demand and electrical energy requirement. This plan shall be vetted/validated by CEA to leverage the benefits of national-level optimization for the Distribution Licensees. The LT-DRAP shall be prepared by the Distribution Licensees on an annual rolling basis, factoring in the already contracted capacity and optimizing the requirement for additional capacity.

Government of India has notified the Renewable Purchase Obligation (RPO) trajectory up to 2029-30 vide gazette notification dated 20th October 2023, which mandates that a specified portion of energy consumption must be met from renewable energy sources.

To support the discom in fulfilling this requirement, CEA, initially carried a Resource Adequacy (RA) study with a planning horizon up to FY 2033-34, based on the data provided by TPDDL and in compliance with the RPO trajectory specified in the Ministry of Power's Office Memorandum dated 20th October, 2023. This study has now been updated and extended to cover the period up to FY 2035-36, incorporating the latest data furnished by the discom and planning assumptions. The RPO requirement for the discom has been assessed in accordance with the trajectory specified in the Ministry of Power's Office Memorandum dated 20th October, 2023.

The electrical energy requirement and peak electricity demand for Tata Power Delhi Distribution Limited (TPDDL), Delhi, are projected to increase with a CAGR of 3.52% and 4.2% respectively from 2025-26 to 2035-36. However, as per 20th EPS projections, the electricity energy requirement and peak electricity demand for TPDDL is projected to increase with a CAGR of 4.10% and 4.04% respectively from 2025-26 to 2031-32. The study has been done considering the demand projections of the Discom. For satisfying resource adequacy i.e., meeting the electricity demand reliably and at affordable cost, the Discom needs to methodically plan its capacity expansion either by investing in new generation or by procuring power. In view of the reduction in cost of solar panels and newer technology options like Battery Energy Storage Systems, planning for long term optimal generation capacity mix gains tremendous importance so as the future generation capacity mix is cost effective as well as environment friendly.

The study for TPDDL carried out based on existing contracted capacity and planned capacity additions (excluding banking/STOA/MTOA arrangements), indicates that the available capacity may be insufficient to meet the projected electricity demand. In particular, the total unserved energy in the year 2035-36 is estimated to be approximately 655 MU, accounting for around 4% of the projected annual electrical energy requirement for that year.

To find out the least cost option for generation capacity expansion for the period 2025-26 to 2035-36, generation expansion study has been carried out with the objective to minimize the total system cost of generation including the cost of anticipated future investments while fulfilling all the technical constraints associated with various power generation technologies. Additionally, reliability study has been carried out to determine the probability of unmet demand and hours by implementing the variation in demand, variation in RE generation and forced outage of thermal generators (Coal/ Lignite) etc.

Generation capacity expansion pathways have been considered for the long-term study based on the yearly capacity addition plan of TPDDL along with RPO targets for Solar, Wind and DRE technologies. The Renewable capacities have been assessed in view of adherence to RPO notified by Ministry of Power, considering the fungibility among different sources.

The Resource adequacy studies have projected likely optimal capacity mix for future years till 2035-36 which shall be able to reliably meet anticipated demand. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 6,940 MW which consists of 1524 MW from coal; 27 MW from biomass; 451 MW from gas; 63 MW from nuclear; 529 MW from hydro; 1600 MW from solar; 50 MW from wind; 510 MW from hybrid; 601 MW from Distributed Renewable Energy (DRE) source; 400 MW from FDRE; 885 MW from Storage and 300 MW of MTOA/STOA arrangement. This capacity shall be able to meet the projected demand with prescribed reliability criteria.

1.0 Introduction

Ministry of Power has notified Electricity (Amendment) Rules 2022, in December 2022. Rule 16 (I) of the said rules stipulates that *"A guideline for assessment of resource adequacy during the generation planning stage (one year or beyond) as well as during the operational planning stage (up to one year) shall be issued by the Central Government in consultation with the Authority"*. Accordingly, the Resource Adequacy Guidelines have been notified in June, 2023, by Ministry of Power in consultation with Central Electricity Authority.

Resource Adequacy is generally defined as a mechanism to ensure that there is an adequate supply of generation resources to serve expected demand reliably at least cost. A key aspect of resource adequacy planning is to ensure that adequate generation capacities are available round-the-clock to reliably serve electricity demand, under various scenarios. This naturally translates into the need for ensuring adequate reserve margin which could cater to varying levels of demand and supply conditions in the grid. In the wake of high RE generation, it is important to understand demand-supply situation in the grid precisely due to high seasonality and intermittency in RE generation. Resource Adequacy exercise may also help in assessment of capacity requirement to be tied up or contracted in long term, medium term, and short-term basis.

Further, Ministry of Power vide notification dated 20th October, 2023, had notified the RPO trajectory for the states/Discoms. Based on the trajectory specified, hydro, wind and other (solar, biomass etc.) RPO quantum in million units (MUs) has been calculated to find additional quantum of renewable capacity that the states/Discoms have to contract in addition to the existing/planned capacity to meet their RPO targets.

To support the discom in fulfilling the Resource Adequacy Guidelines and complying with the Renewable Purchase Obligation (RPO) notification, CEA has carried out the RA study for TPDDL based on inputs furnished by TPDDL. The study recommends an optimal resource mix up to FY 2035-36, taking into account technical and financial parameters associated with various capacities. It aims to optimize long-term power procurement while ensuring resource adequacy to meet demand on a 24x7 basis, considering variations in demand, variations in RE generation, and forced outage of thermal capacities. The study also assesses the Planning Reserve Margin (PRM) required by the discom to account for the aforementioned uncertainties, ensuring that demand can be reliably met throughout the year.

Prior to this, CEA had conducted the RA study for the discom up to FY 2033-34, based on data furnished by TPDDL.

2.0 Highlights of the Previous RA Study (Up to FY 2033-34)

1. In the earlier Resource Adequacy (RA) study, financial year 2022-23 had been considered as the base year, and the study covered the period from 2024-25 to 2033-34. The fuel-wise contracted capacity of TPDDL as on 31st March, 2023, is given in Fig. 1.

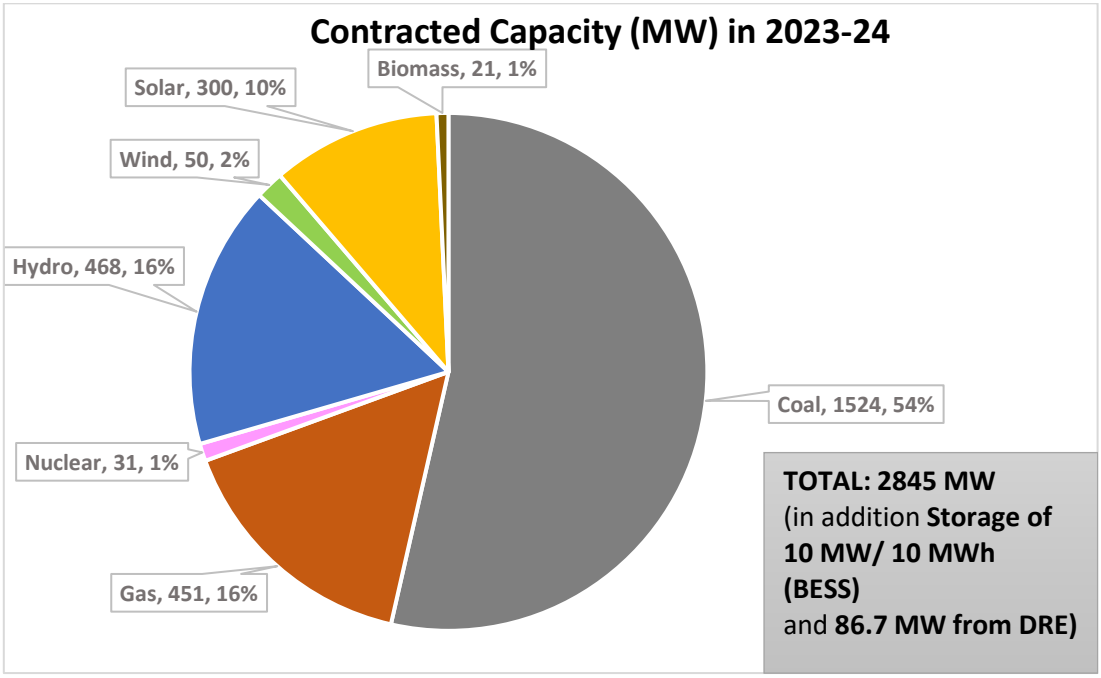


Figure 1: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2023

2. The peak electricity demand and electrical energy projections that had been considered in the study is given in Table 1.

Table 1: Peak electricity demand and electrical energy projections as per the utility

	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34
TPDDL Energy Projections (in MU)	10980	11459	11790	12145	12486	12816	13157	13525	13945	14349
Year on Year Growth	-	4.4%	2.9%	3.0%	2.8%	2.6%	2.7%	2.8%	3.1%	2.9%
TPDDL Peak Demand Projections (MW)	2357	2484	2580	2683	2785	2887	2994	3108	3205	3298
Year on Year Growth	-	5.4%	3.9%	4.0%	3.8%	3.7%	3.7%	3.8%	3.1%	2.9%

3. To meet the above projected peak electricity demand and electrical energy requirement reliably, the source-wise projected capacity (in MW) as outlined in the previous report is given in Table 2.

Table 2: Source-wise projected capacities (MW)

Year	COAL	GAS	NUCLEAR	BIOMASS	HYDRO	WIND	SOLAR	HYBRID	BATTERY	DRE	FDRE	STOA*
2024/25	1524	451	31	21	468	50	300	0	10	87	0	341
2025/26	1524	451	31	21	687	50	300	0	10	95	0	453
2026/27	1524	451	31	21	707	50	300	510	25	250	0	230
2027/28	1524	451	31	27	715	50	300	510	25	315	0	250
2028/29	1524	451	31	27	715	50	300	510	25	382	200	280
2029/30	1524	451	31	27	736	50	300	510	25	453	200	300
2030/31	1524	451	31	27	736	50	300	510	25	465	200	325
2031/32	1531	451	31	27	736	50	300	510	25	478	200	355
2032/33	1553	451	31	27	736	50	300	510	25	493	200	370
2033/34	1631	451	31	27	736	50	300	510	25	507	200	400

*****_The STOA/MTOA value represents the yearly requirement in MW and it was recommended that this requirement may be met through power procurement from the market or through bilateral agreements._

4. The year-wise planned and additional capacity contract addition (in MW) for the above tabulated cumulative capacity is given in Table 3.

Table 3: Year-wise planned and additional capacity contract addition

FY	COAL	BIOMASS	HYDRO	HYBRID	FDRE
	Additional Requirement	**Planned Contracts**	**Planned Contracts**	**Planned Contracts**	**Planned Contracts**
2024-25	0	0	0	0	0
2025-26	0	0	219*	0	0
2026-27	0	0	20	510	0
2027-28	0	6	8	0	0
2028-29	0	0	0	0	200
2029-30	0	0	21.45	0	0
2030-31	0	0	200	0	0
2031-32	7	0	0	0	0
2032-33	22	0	0	0	0
2033-34	78	0	0	0	0

FY	Distributed RE		STORAGE	Total	
	Planned contracts	Additional Requirement	Planned contracts	Planned Contracts	Additional Requirement
2024-25	0	0	0	0	0
2025-26	9	0	0	228	0
2026-27	1	154	15	546	154
2027-28	1	64	0	15	64
2028-29	1	66	0	201	66
2029-30	1	70	0	22.45	70
2030-31	0	12	0	200	12
2031-32	0	13	0	0	20
2032-33	0	15	0	0	37
2033-34	0	14	0	0	92

***** *Hydro capacity includes 200 MW of Medium Term-Cross Border from FY 25-26 to FY 29-30 for the month of June to October*

3.0 RA Study for TPDDL (from 2025-26 to 2035-36)

3.1 Present Power Scenario in TPDDL

The power supply position for TPDDL from 2020-21 to 2024-25 is given in Table 4:

Table 4: Power Supply Position of TPDDL

Power Supply Position*						
Year	**Energy required (MU)**	**Energy supplied (MU)**	**Gap (MU)**	**Peak Demand (MW)**	**Peak Met (MW)**	**Demand not met (MW)**
2021-22	9490	9490	0	2105	2105	0
2022-23	20696	20695	0	2229	2229	0
2023-24	10742	10742	0	2214	2214	0
2024-25	11527	11527	0	2481	2481	0

***** *Data furnished by the discom.*

As per the data provided by TPDDL, as of March 2025, the total contracted capacity of TPDDL is 3,085 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 36 %. The fuel-wise contracted capacity as on 31st March, 2025 is given in Table 5 and Fig. 2.

Table 5: Fuel-wise Contracted Capacity as on March 2025

Source	Contracted Capacity (MW)	Percentage
Coal*	1524	49.4%
Gas	451	14.6%
Biomass	21	0.7%
Nuclear	63	2.0%
Hydro	480	15.6%
Solar	400	13.0%
Wind	50	1.6%
DRE	86	2.8%
Storage	10	0.3%
Total	**3085**	100%

* The allocation from Sasan UMPP is 136 MW for April, 64 MW for May to October, and 26 MW for November to March. These figures have been accounted for in the study

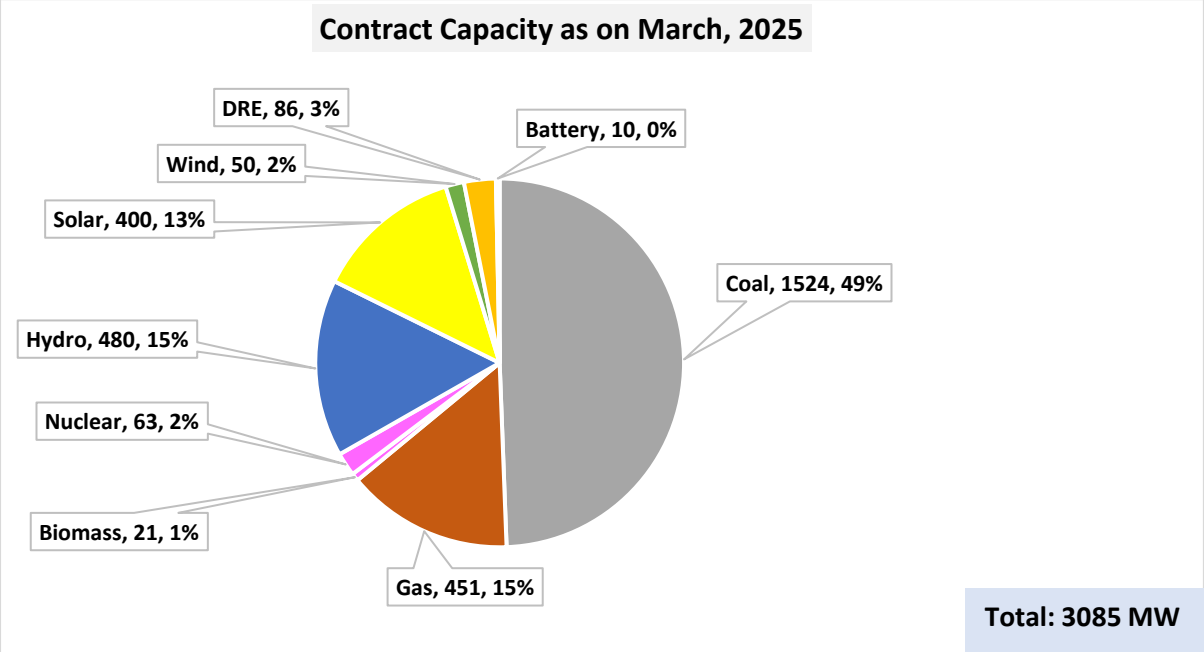


Figure 2: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2025

3.2 Demand Analysis of the FY 2024-25

Hourly demand pattern of 2024-25 was analyzed and it was observed that the peak demand season for TPDDL is typically during the summer months viz May, June and July. Peak electricity demand occurs during solar hours. The month-wise average hourly demand observed for the year 2024-25 is shown in Fig. 3.

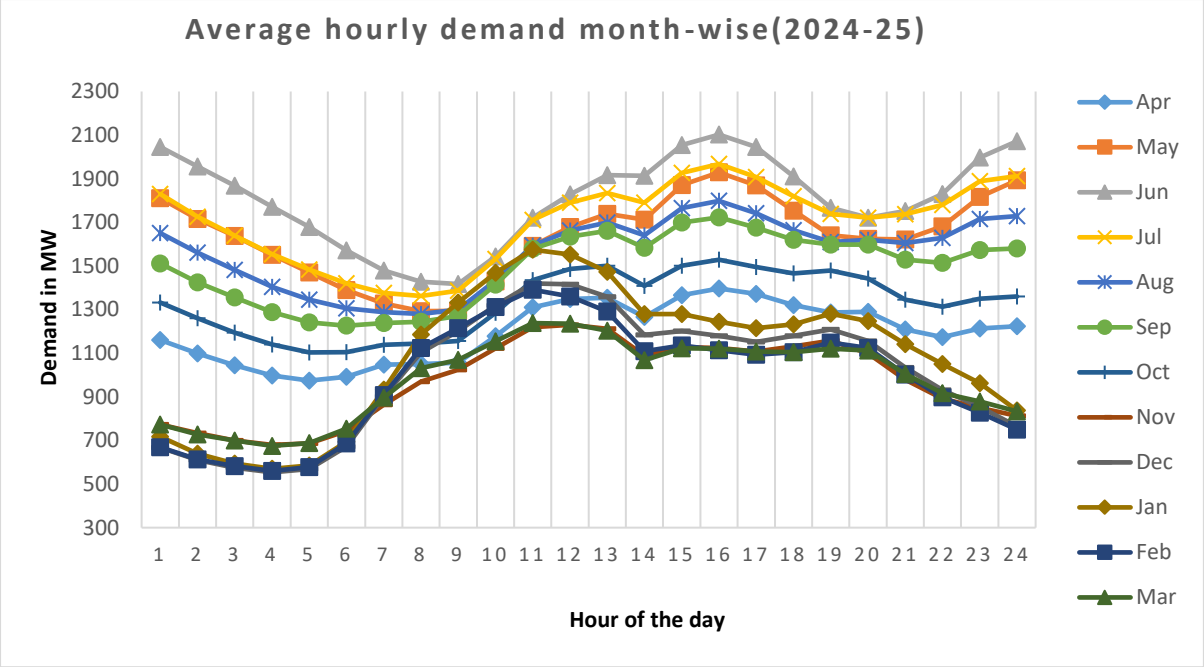


Figure 3: Average Hourly Demand Variation (Month-wise) for 2024-25

From the hourly demand data of 2024-25, the daily peak during solar hours and non-solar hours are plotted in Fig. 4.

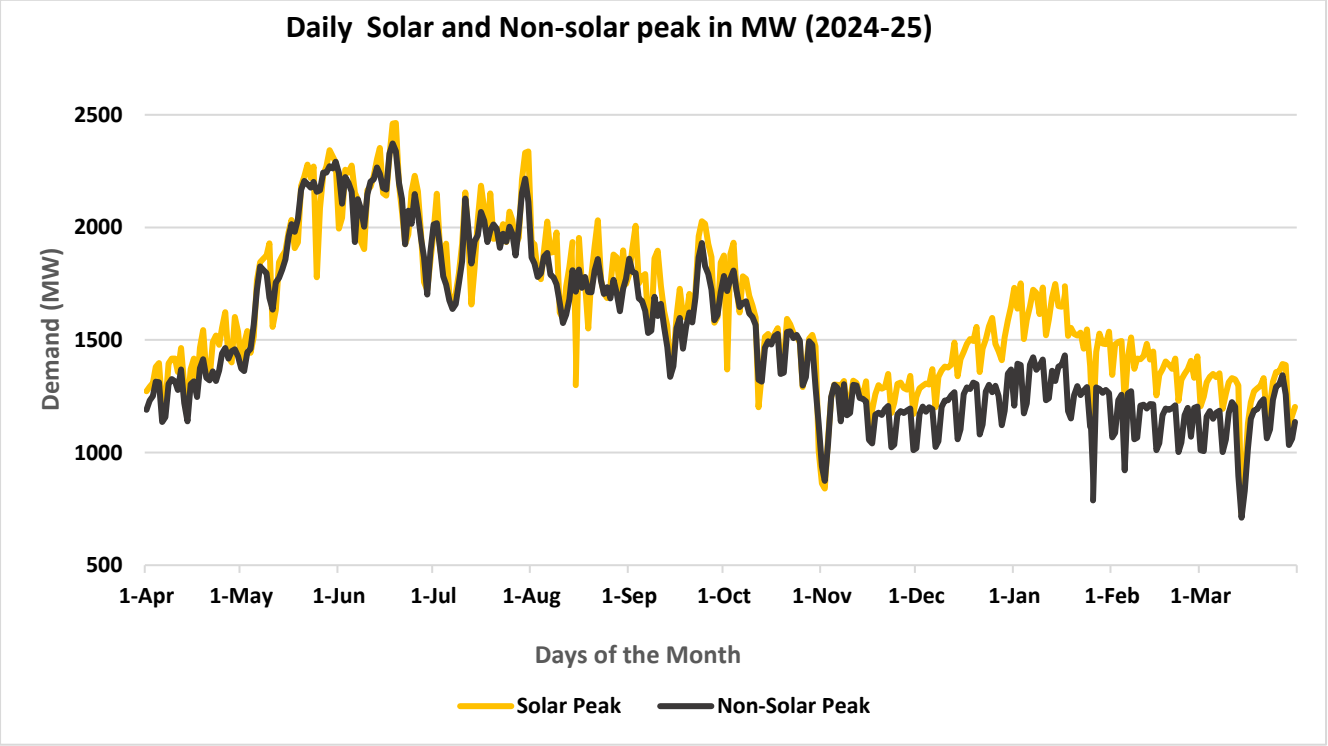


Figure 4: Solar and non-solar peak in MW for the year 2024-25

The hourly demand pattern of 2024-25 was analysed for finding out the number of occurrences of the peak and near peak demand. Such instances are critical for study purpose as it is necessary to ensure resource adequacy during such instances with an optimal mix of

long-term, medium-term and short-term contracts. Frequency Distribution of hourly demand profile for 2024-25 is shown in Fig. 5.

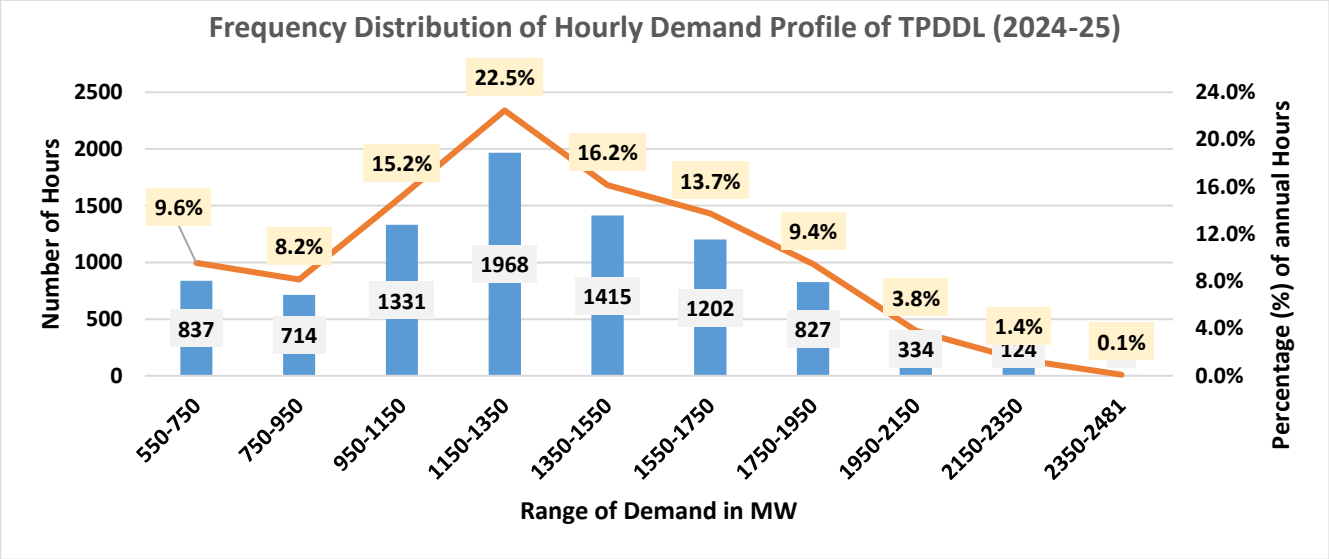


Figure 5: Frequency Distribution of Hourly Demand Profile of 2024-25

4.0 Principles of Generation Planning

The objective of Generation Planning process is to obtain an optimal generation capacity mix in the least cost manner to meet the electricity demand at every instance of time while ensuring the most efficient use of resources.

The major aspects considered in the planning process are:

i) To supply 24x7 reliable power to the consumers
ii) To achieve objectives of all policies of the Government of India such as RPO trajectory, RE capacity addition plan etc.
iii) To achieve sustainable development.
iv) To fulfil desired operational characteristics of the system such as reliability and flexibility.
v) Most efficient use of resources.
vi) Fuel availability

4.1 Generation Expansion Planning Tool -ORDENA

The studies have been carried out using a generation expansion planning model namely ORDENA. ORDENA is a mixed integer linear optimization program that minimizes the Net Present Value (NPV) of investment and operation costs subject to several constraints. The major constraints include balancing electricity supply and demand, resource supply limits, planning and operating reserve limits, and policy targets. These constraints are met considering a broad portfolio of conventional generation, renewable generation, and storage.

ORDENA has a reliability module to determine the trustworthiness of the system using Monte Carlo simulations. The software is also capable of carrying out hourly/sub-hourly economic generation dispatch considering all the technical constraints associated with various generation technologies.

The schematic diagram of the software is given in Fig. 6.

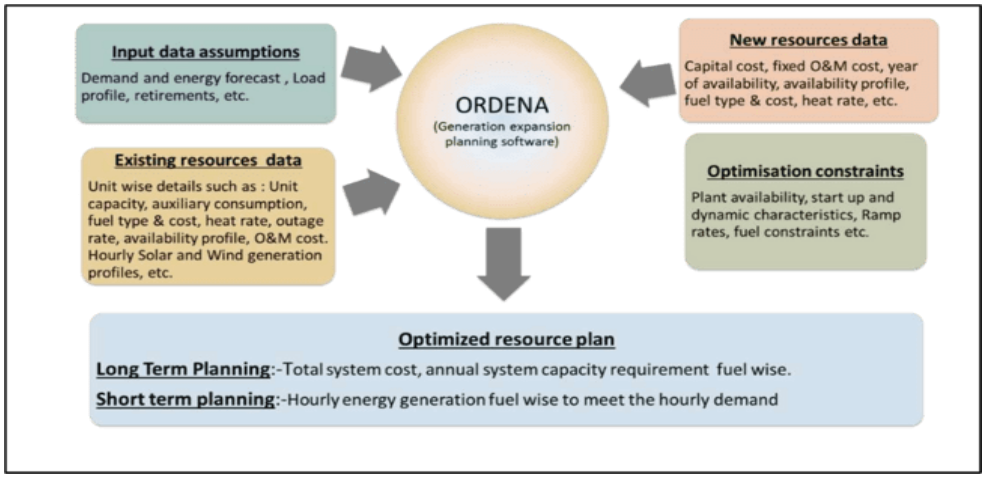


Figure 6: Schematic Diagram

5.0 Reliability Analysis

One of the main criteria of resource adequacy studies is to determine the reliability of the system to meet the demand adequately at every instance of time. This reliability is measured via two indices i.e. LOLP (Loss of Load Probability) and EENS (Expected Energy Not Served). These indices have been defined in resource adequacy guidelines as below:

- **Loss of Load Probability (LOLP)**: Measure of the probability that a system's load may exceed the generation and firm power contracts available to meet that load in a year. E.g., 0.0274 % probability of load being lost.
- **Expected Energy Not Served (EENS):** Expected amount of energy (MWh) that may not be served for each year within the planning period under study. It is a summation of the expected number of megawatt hours of demand that may not be served for the year. This is an energy-centric metric that considers the magnitude and duration of energy being not served, calculated in Mega Watt hours (MWh). The metric can be normalized (i.e., divided by total system electrical energy requirement) to create a Normalized Energy Not Served (NENS) metric.

Monte Carlo /Stochastic simulation has been used to factor-in the uncertainty associated with various generation resources and demand. It is an approach which is used to predict the probability of a variety of outcomes when the potential for random variables is present, as compared to deterministic modelling of economic dispatch model. Monte Carlo simulation helps in analysing the randomness associated with RE energy resource, demand

pattern changes and forced outages of generating plant. A large number of random samples of these variables is simultaneously simulated to ascertain system reliability indices (i.e. Loss of load probability LOLP & Energy Not Served (ENS)) & the system robustness in case of above variation of system parameters.

Planning Reserve Margin (PRM): To meet the prescribed standard of LOLP / NENS conditions, sufficient reserve margins need to be maintained in the system for adequately addressing the demand and supply variations. Planning Reserve Margin (PRM) is the predominant metric used to ensure adequacy of generation resources in the system. PRM in a power system is generally expressed as a certain percent of the projected peak electricity demand.

5.1 Variation in Electricity Demand

The variation in demand pattern for last two years viz. 2023-24 and 2024-25 (considering 2023-24 as the base year) has been analyzed. The demand pattern variation across 2023-24 and 2024-25 is shown in Fig. 7.

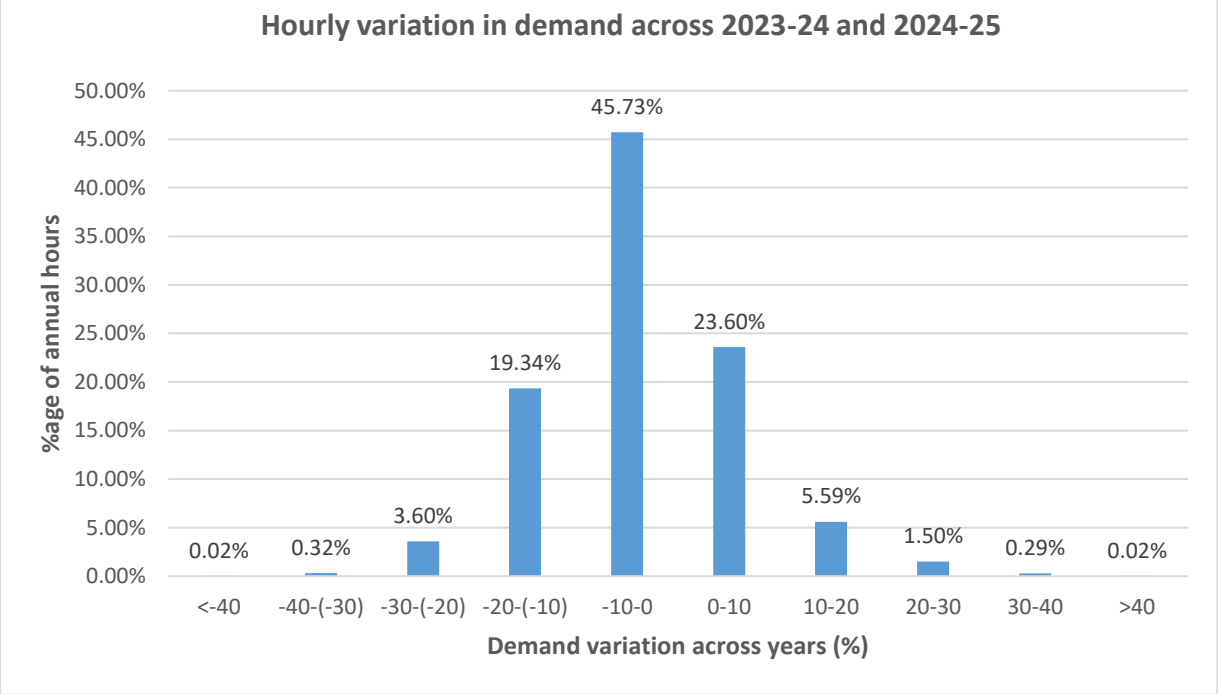


Figure 7: Hourly Variation in electricity demand across years

It can be observed that the hourly demand typically varies within ±10% for ~69% of instances. This variation is primarily due to temperature, weather parameter or any random outages of transmission line and generating units etc. This variation has been captured in the reliability study by incorporating a variation of ±10% in the projected hourly demand for the future years by introducing a random variable (with normal distribution) for demand as per observed behavior over the years.

5.2 Variation in RE

In the Long-term capacity expansion planning studies, a particular profile for Solar and Wind is considered based on the observed generation data to determine the optimal capacity mix. However, due to intermittent nature of these sources, generation from these non-dispatchable sources may vary across years. As per the analyses carried out based on historical generation data, solar and wind-based generation has been varied by ± 10% and ± 50% respectively to incorporate the variation in these generation sources and plan for requisite measures to mitigate such behavior. Hydro based generation has also been varied by ± 5%.

5.3 Forced Outage of Thermal Generators

The average forced outage rate of thermal generators is typically 10% with ±5% variation. The same has been incorporated in the model.

Based on these variations, reliability studies have been carried out to ascertain robustness of the system.

6.0 Inputs/Assumptions for the Study

i) The peak electricity demand and electrical energy requirement as per TPDDL and 20th EPS Report is given in Table 6.

Table 6: Electricity demand projection

Year	Projections by TPDDL, Delhi				Projections as per 20th EPS Report			
	Peak Electricity Demand		Electrical Energy Requirement		Peak Electricity Demand		Electrical Energy Requirement	
	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth
2025-26	2562		11836		2554		11808	
2026-27	2670	3.3%	12255	3.5%	2663	4.09%	12304	4.03%
2027-28	2782	4.2%	12688	3.5%	2779	4.17%	12825	4.06%
2028-29	2899	4.2%	13138	3.5%	2901	4.21%	13375	4.11%
2029-30	3021	4.2%	13603	3.5%	3047	4.79%	14037	4.72%
2030-31	3148	4.2%	14079	3.5%	3151	3.30%	14514	3.29%
2031-32	3280	4.2%	14571	3.5%	3250	3.05%	14975	3.08%
2032-33	3418	4.2%	15081	3.5%	-	-	-	-
2033-34	3561	4.2%	15609	3.5%	-	-	-	-
2034-35	3711	4.2%	16156	3.5%	-	-	-	-
2035-36	3867	4.2%	16721	3.5%	-	-	-	-

Projections as per the utility has been considered in the study.

ii) Future demand profile till the year 2035-36 has been projected using the demand profile for the year 2024-25 as the base profile.

iii) The actual solar, wind and hydro generation profiles and CUFs have been considered as per data available with CEA.

iv) The capital cost of candidate plants for coal, solar, and battery/PSP technologies is detailed in the Annexure and are in alignment with current market trends and recent price discovery.

v) The planned capacity has been considered based on the tie-up information as furnished by TPDDL. The same is summarised in Table 7 and details are furnished in Annexure.

Table 7: Source-wise planned capacity addition

Fig.in MW

FY	HYDRO	Hybrid	2h_Storage	DRE	FDRE
2025-26	-	-	-	25	-
2026-27	-	510	50	40	-
2027-28	228	-	50	38	-
2028-29	-	-	100	28	400
2029-30	21	-	100	22	-
2030-31	-	-	100	-	-
2031-32	-	-	-	-	-
2032-33	200	-	-	-	-
2033-34	-	-	-	-	-
2034-35	-	-	-	-	-
2035-36	-	-	-	-	-
Total	**449**	**510**	**400**	**153**	**400**

vi) **Renewable Purchase Obligation (RPO) trajectory**: Ministry of Power vide gazette notification dated 20th October, 2023, had notified the source wise minimum share of consumption of non-fossil sources (renewable energy) by designated consumers, till the year 2029-30 as given in Table 8.

Table 8: Renewable Purchase Obligation (RPO) trajectory (%)

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	2024-25	0.67	0.38	28.11	1.50	29.91
2.	2025-26	1.45	1.22	29.29	2.10	33.01
3.	2026-27	1.97	1.34	31.29	2.70	35.95
4.	2027-28	2.45	1.42	33.29	3.30	38.81
5.	2028-29	2.95	1.42	35.04	3.90	41.36
6.	2029-30	3.48	1.33	36.27	4.50	43.33

Further, in view of the country's energy transition goals as well as the long-term net zero target of 2070, it is estimated that the share of RE generation in the generation mix will continue to proportionally increase beyond 2029-30. Therefore, the RPO trajectory is assumed to rise steadily beyond 2029-30 and the DRE percentage has been assumed to be 4.50 % beyond 2029-30. Hence, the suggested trajectory of Renewable Purchase Requirement for TPDDL up to FY 2035-36 is given in Table 9.

Table 9: Renewable Purchase Obligation (RPO) trajectory (in %) considered for the study

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	2024-25	0.67	0.38	28.11	1.50	29.91
2.	2025-26	1.45	1.22	29.29	2.10	33.01
3.	2026-27	1.97	1.34	31.29	2.70	35.95
4.	2027-28	2.45	1.42	33.29	3.30	38.81
5.	2028-29	2.95	1.42	35.04	3.90	41.36
6.	2029-30	3.48	1.33	36.27	4.50	43.33
7.	2030-31	41.00			4.50	45.50
8.	2031-32	42.50			4.50	47.00
9.	2032-33	43.80			4.50	48.30
10.	2033-34	45.00			4.50	49.50
11.	2034-35	46.00			4.50	50.50
12.	2035-36	47.00			4.50	51.50

Based on the trajectory specified, RPO quantum in million units (MUs) from hydro, wind, other (Solar, biomass etc.) and distributed renewable energy (DRE) is calculated and given in Table 10.

Table 10: Total Energy required to meet RPO (MU)

Sl. No.	Year	Wind renewable energy (MU)	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	**2025-26**	171.62	144.39	3466.65	248.55	3906.93
2.	**2026-27**	241.42	164.21	3834.46	330.87	4405.52
3.	**2027-28**	310.87	180.18	4223.97	418.72	4924.37
4.	**2028-29**	387.56	186.55	4603.40	512.37	5433.70
5.	**2029-30**	473.37	180.92	4933.68	612.12	5894.02
6.	**2030-31**	5772.28			633.54	6405.82
7.	**2031-32**	6192.88			655.72	6848.60
8.	**2032-33**	6605.69			678.67	7284.36
9.	**2033-34**	7024.20			702.42	7726.62
10.	**2034-35**	7431.61			727.01	8158.61
11.	**2035-36**	7858.93			752.45	8611.38

The year-wise total renewable energy, excluding DRE, met from the existing and planned capacity along with the surplus/deficit is shown in Table 11 (a).

Table 11 (a): Renewable Energy Surplus/Deficit

FY	RE Generation required to meet RPO (excluding DRE)		RE Generation excluding DRE available or met from existing and planned contracts		RE Generation Surplus (+)/ Deficit (-) (excluding DRE)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	3783	31.96%	3058	25.84%	-6.12%
2026-27	4240	34.60%	4392	35.84%	1.24%
2027-28	4715	37.16%	4758	37.50%	0.34%
2028-29	5178	39.41%	7210	54.88%	15.47%
2029-30	5588	41.08%	6202	45.59%	4.51%
2030-31	5772	41.00%	6202	44.05%	3.05%
2031-32	6193	42.50%	6202	42.56%	0.06%
2032-33	6606	43.80%	6503	43.12%	-0.68%
2033-34	7024	45.00%	6503	41.66%	-3.34%
2034-35	7432	46.00%	6503	40.25%	-5.75%
2035-36	7859	47.00%	6503	38.89%	-8.11%

Similarly, the year-wise total renewable energy for Distributed Renewable Energy (DRE) met from the existing and planned capacity along with the surplus/deficit is shown in Table 11(b).

Table 11 (b): Distributed Renewable Energy (DRE) Surplus/ Deficit

FY	DRE Generation required to meet RPO		DRE generation available or met from existing and planned contracts		DRE Generation Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	249	2.10%	142	1.20%	-0.90%
2026-27	331	2.70%	193	1.58%	-1.12%
2027-28	419	3.30%	242	1.90%	-1.40%
2028-29	512	3.90%	277	2.11%	-1.79%
2029-30	612	4.50%	305	2.24%	-2.26%
2030-31	634	4.50%	305	2.17%	-2.33%
2031-32	656	4.50%	305	2.10%	-2.40%
2032-33	679	4.50%	305	2.02%	-2.48%
2033-34	702	4.50%	305	1.96%	-2.54%
2034-35	727	4.50%	305	1.89%	-2.61%
2035-36	752	4.50%	305	1.83%	-2.67%

As indicated in the tables above, the Discom will not be able to meet its RPO requirements for the years from 2032-33 to 2035-36 based on the existing and planned contracts. Further, the discom will not be able to meet its RPO requirements from DRE for the years from 2025-26 to 2035-36.

7.0 Outcome of the model

7.1 Unserved Energy Projections

Initially, the study has been carried out considering only the existing and planned capacity contracts. The projected total unserved energy (ENS) for the year 2035-36 is about 655 MUs which is about 4% of the electrical energy requirement in 2035-36. The year-wise likely unserved energy with the existing and planned capacities is given in Fig 8.

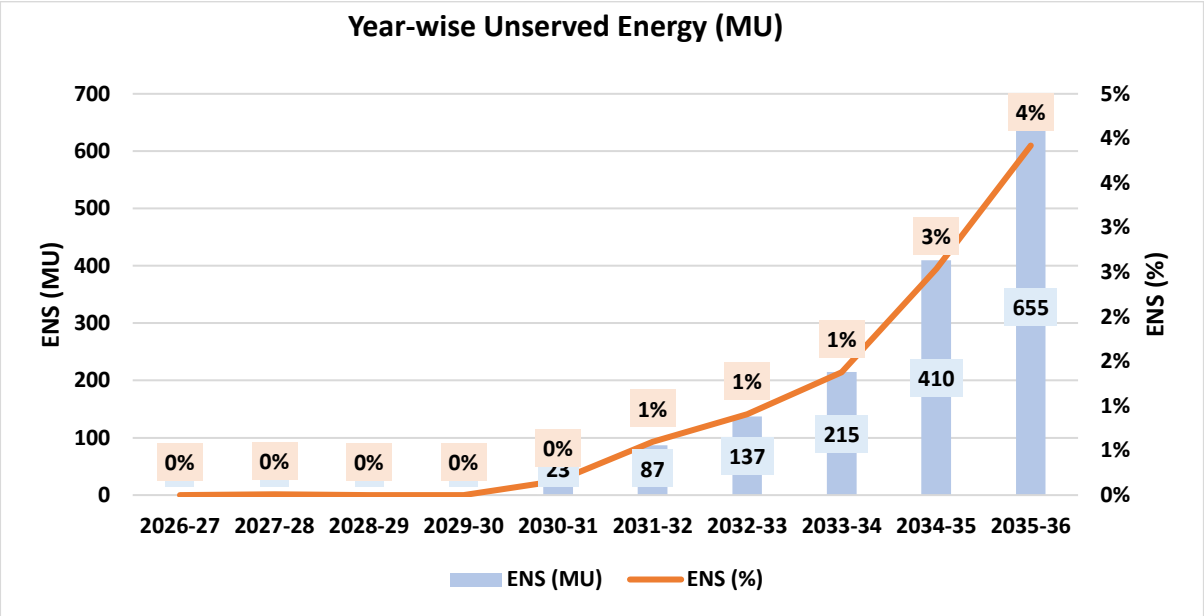


Figure 8: Yearly likely unserved energy (in MU) with the existing and planned capacities

The study has also analyzed the daily and monthly pattern of unserved energy in the year 2035-36 and it can be seen that contracted capacity (present and planned) is unable to meet the electricity demand.

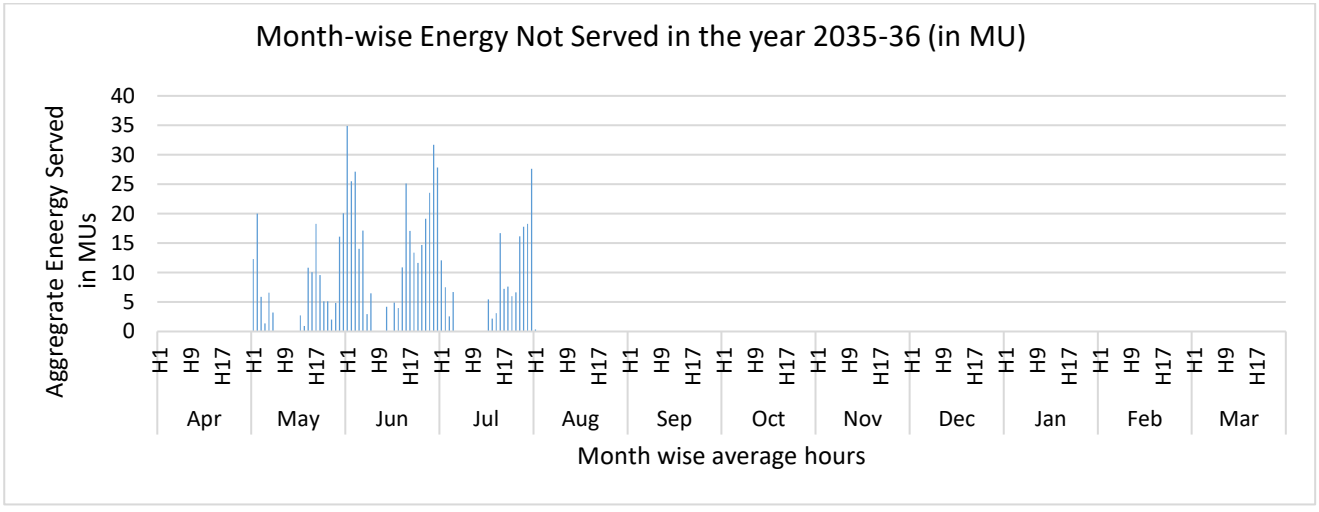


Figure 9: Block-wise Unserved Energy Pattern MU (2035-36)

From the above figure, it can be seen that unserved energy is high during high demand season viz. May to July and is typically observed during both solar and non-solar hours.

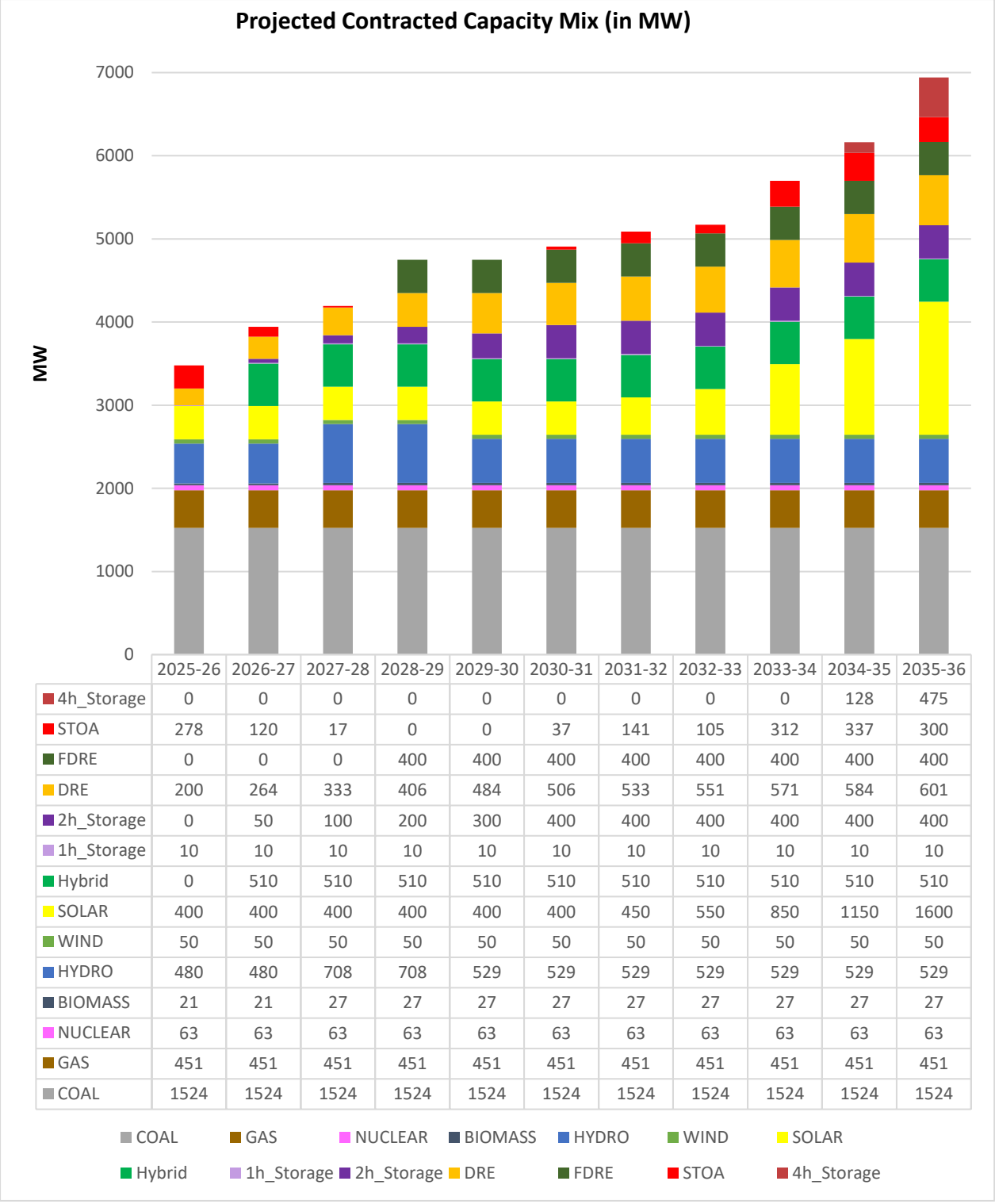
7.2 Investment options to meet the unserved energy

To meet this unserved energy, investment options (i.e., candidate capacities) have been given to the model to find the least cost optimal capacity mix required to meet the electricity demand while fulfilling the RPO obligations. The capacity projections (existing, planned, to be tied up) for TPDDL are given in Table 12.

Table 12: Year-wise contracted capacity (existing, planned, to be tied up) projections (in MW)

Year	COAL	GAS	NUCLEAR	BIO-MASS	HYDRO	WIND	SOLAR	Hybrid	1h Storage	2h Storage	4h Storage	DRE	FDRE	STOA
2025-26	1524	451	63	21	480	50	400	0	10	0	0	200	0	278
2026-27	1524	451	63	21	480	50	400	510	10	50	0	264	0	120
2027-28	1524	451	63	27	708	50	400	510	10	100	0	333	0	17
2028-29	1524	451	63	27	708	50	400	510	10	200	0	406	400	0
2029-30	1524	451	63	27	529	50	400	510	10	300	0	484	400	0
2030-31	1524	451	63	27	529	50	400	510	10	400	0	506	400	37
2031-32	1524	451	63	27	529	50	450	510	10	400	0	533	400	141
2032-33	1524	451	63	27	529	50	550	510	10	400	0	551	400	105
2033-34	1524	451	63	27	529	50	850	510	10	400	0	571	400	312
2034-35	1524	451	63	27	529	50	1150	510	10	400	128	584	400	337
2035-36	1524	451	63	27	529	50	1600	510	10	400	475	601	400	300

The projected year-wise contracted capacity mix is given in Figure 10.



	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
4h_Storage	0	0	0	0	0	0	0	0	0	128	475
STOA	278	120	17	0	0	37	141	105	312	337	300
FDRE	0	0	0	400	400	400	400	400	400	400	400
DRE	200	264	333	406	484	506	533	551	571	584	601
2h_Storage	0	50	100	200	300	400	400	400	400	400	400
1h_Storage	10	10	10	10	10	10	10	10	10	10	10
Hybrid	0	510	510	510	510	510	510	510	510	510	510
SOLAR	400	400	400	400	400	400	450	550	850	1150	1600
WIND	50	50	50	50	50	50	50	50	50	50	50
HYDRO	480	480	708	708	529	529	529	529	529	529	529
BIOMASS	21	21	27	27	27	27	27	27	27	27	27
NUCLEAR	63	63	63	63	63	63	63	63	63	63	63
GAS	451	451	451	451	451	451	451	451	451	451	451
COAL	1524	1524	1524	1524	1524	1524	1524	1524	1524	1524	1524

Figure 10: Year-wise Projected Contracted Capacity Mix (MW)

The SToA/MToA requirement can be fulfilled through power procurement from market or bilateral agreements. The SToA/MToA value reflects the peak value requirement and seasonal banking requirements in terms of MW.

Reliability studies have been conducted based on the projected capacity for the year 2035-36. The analysis confirms that the projected capacity meets the reliability criteria specified in the

National Electricity Plan (NEP), with the Loss of Load Probability (LoLP) and Normalised Energy Not Served (NENS) remaining within the permissible limits of 0.2% and 0.05% respectively.

As per the resource adequacy study, the likely total projected contracted capacity for the year 2035-36 is around 6,940 MW which consists of 1524 MW from coal; 27 MW from biomass; 451 MW from gas; 63 MW from nuclear; 529 MW from hydro; 1600 MW from solar; 50 MW from wind; 510 MW from hybrid; 601 MW from Distributed Renewable Energy (DRE) source; 400 MW from FDRE; 885 MW from Storage and 300 MW of MTOA/STOA arrangement. This capacity shall be able to meet the projected demand with prescribed reliability criteria and to comply with the stipulated Renewable Purchase Obligation (RPO) targets. The storage requirement can be met from PSP, combination of 1 hr/2 hr/4 hr BESS or combination of PSP and BESS. Based on the capacity addition, the planning reserve margin works out to be about 4.5%. Projected Contracted Capacity required in 2035-36 is shown in Figure 11.

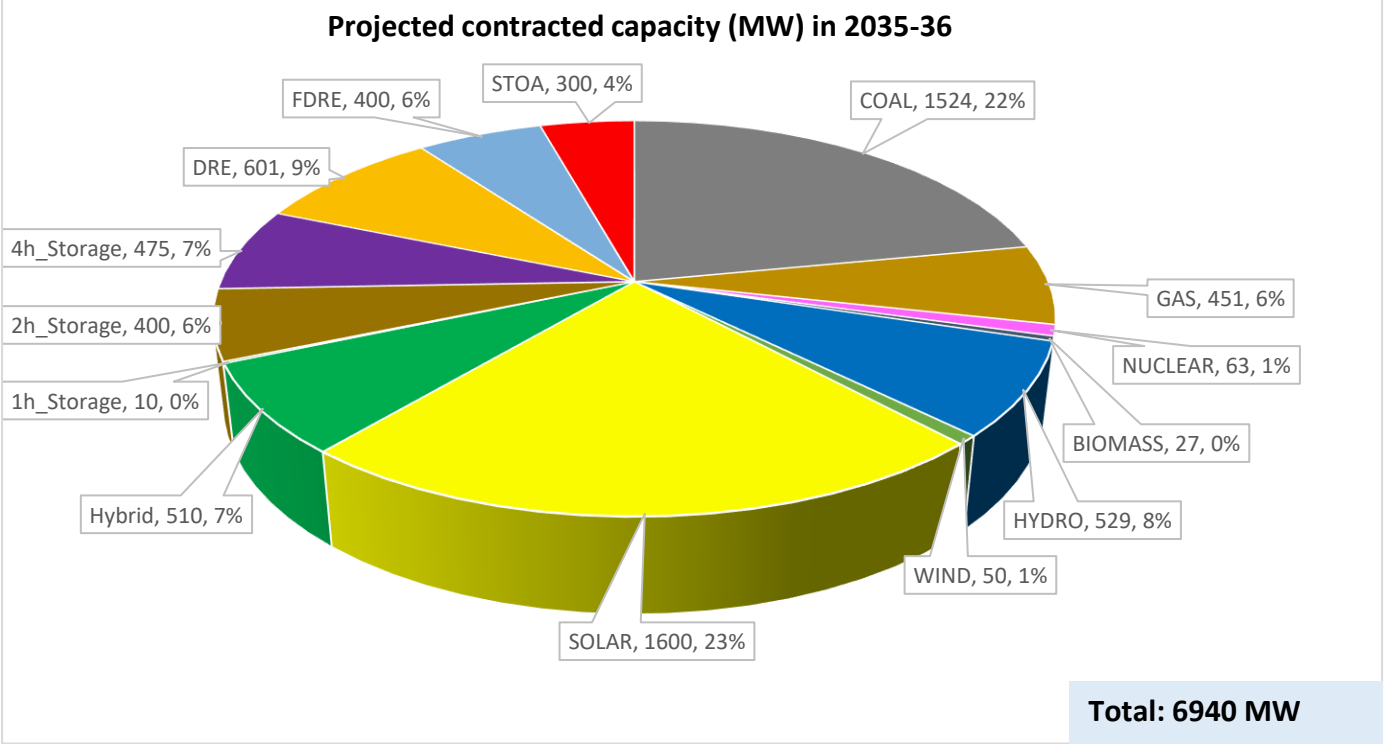


Figure 11: Contracted Capacity Mix in 2035-36

It is important to note that any deviations in the commissioning schedule of the planned capacity could result in a situation where the discom is unable to meet the projected peak electricity demand and electrical energy requirements identified in this study with the available resources. Such changes may also lead to an increase in the cost of meeting the discom's power demand reliably.

As per the study, the discom likely needs to contract the following capacities (planned and additional) every year till 2035-36 to reliably meet its electricity demand as shown in Table 13.

Table 13: Year-wise likely Capacity Addition (in MW)

FY	BIOMASS	HYDRO	SOLAR	DRE	
	Planned Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts
2025-26	0	0	0	25	0
2026-27	0	0	0	40	24
2027-28	6	228	0	38	31
2028-29	0	0	0	28	45
2029-30	0	21.45	0	22	56
2030-31	0	0	0	0	22
2031-32	0	0	50	0	27
2032-33	0	200	100	0	18
2033-34	0	0	300	0	20
2034-35	0	0	300	0	13
2035-36	0	0	450	0	17
Total	**6**	**449**	**1200**	**153**	**273**
FY	**Hybrid**	**FDRE**	**2h_STORAGE**	**4h_STORAGE**	**STOA/MTOA***
	Planned Contracts	Planned Contracts	Planned Contracts	Additional Contracts	(Annual Requirement)
2025-26	0	0	0	0	278
2026-27	510	0	50	0	120
2027-28	0	0	50	0	17
2028-29	0	400	100	0	0
2029-30	0	0	100	0	0
2030-31	0	0	100	0	37
2031-32	0	0	0	0	141
2032-33	0	0	0	0	105
2033-34	0	0	0	0	312
2034-35	0	0	0	128	337
2035-36	0	0	0	347	300
Total	**510**	**400**	**400**	**475**	

**The STOA/MTOA requirement is for a particular year.*

The projected gross generation mix for the discom is shown in Figure 12 and 13.

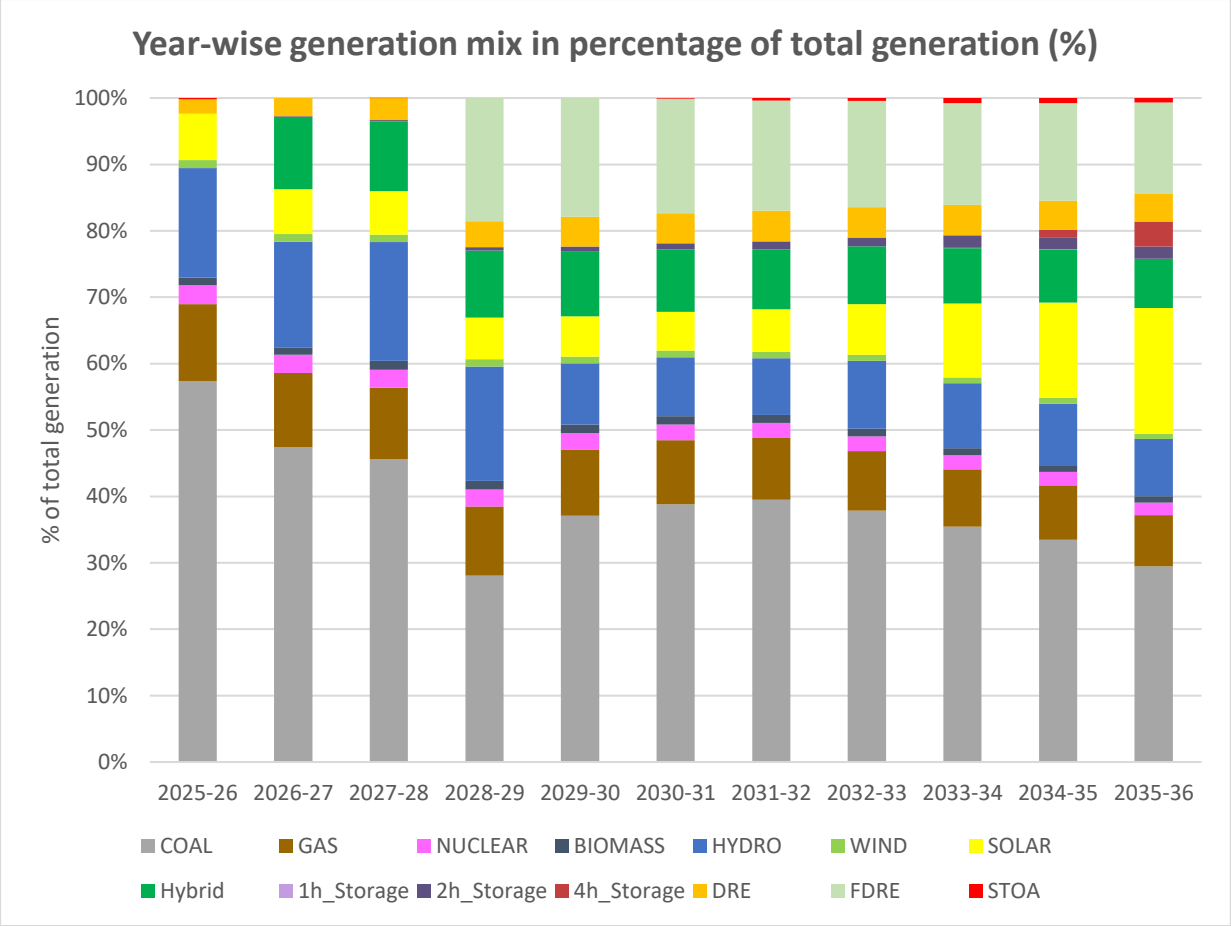
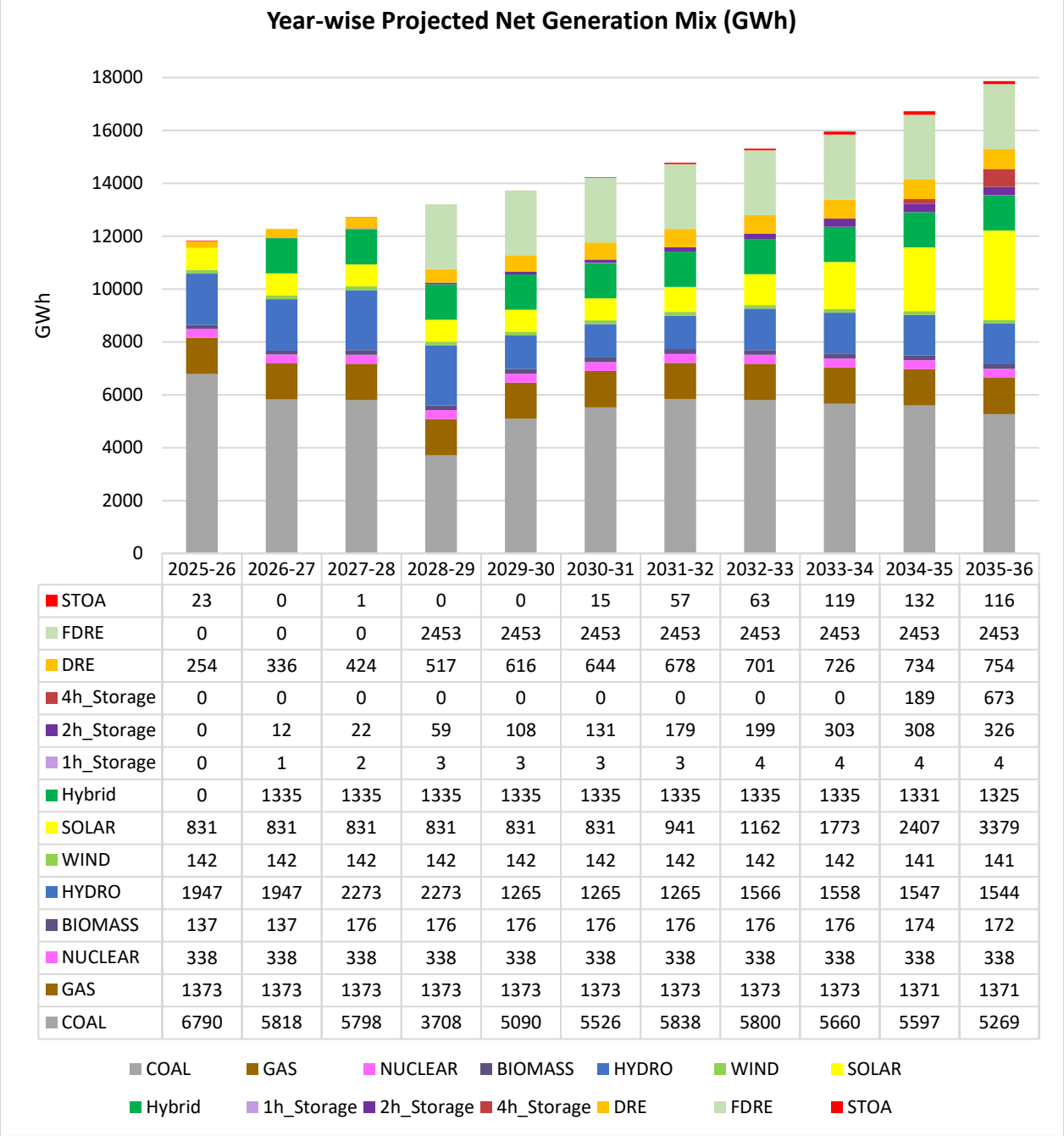


Figure 12: Year-wise projected net generation mix (in %)



	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
STOA	23	0	1	0	0	15	57	63	119	132	116
FDRE	0	0	0	2453	2453	2453	2453	2453	2453	2453	2453
DRE	254	336	424	517	616	644	678	701	726	734	754
4h_Storage	0	0	0	0	0	0	0	0	0	189	673
2h_Storage	0	12	22	59	108	131	179	199	303	308	326
1h_Storage	0	1	2	3	3	3	3	4	4	4	4
Hybrid	0	1335	1335	1335	1335	1335	1335	1335	1335	1331	1325
SOLAR	831	831	831	831	831	831	941	1162	1773	2407	3379
WIND	142	142	142	142	142	142	142	142	142	141	141
HYDRO	1947	1947	2273	2273	1265	1265	1265	1566	1558	1547	1544
BIOMASS	137	137	176	176	176	176	176	176	176	174	172
NUCLEAR	338	338	338	338	338	338	338	338	338	338	338
GAS	1373	1373	1373	1373	1373	1373	1373	1373	1373	1371	1371
COAL	6790	5818	5798	3708	5090	5526	5838	5800	5660	5597	5269

Figure 13: Year-wise projected net generation (in GWh)

7.3 Surplus Coal Capacity

Generally, surplus capacity is available with the discom due to variation in electricity demand, RE availability etc. The pattern of surplus capacities has been observed as shown in Figure 14. From the figure below, it is observed that TPDDL is expected to have a surplus coal-based capacity available during winter months namely November to March of around 550-700 MW for 2028-29. This surplus capacity may be banked or shared with other states whose demand profile complements that of TPDDL.

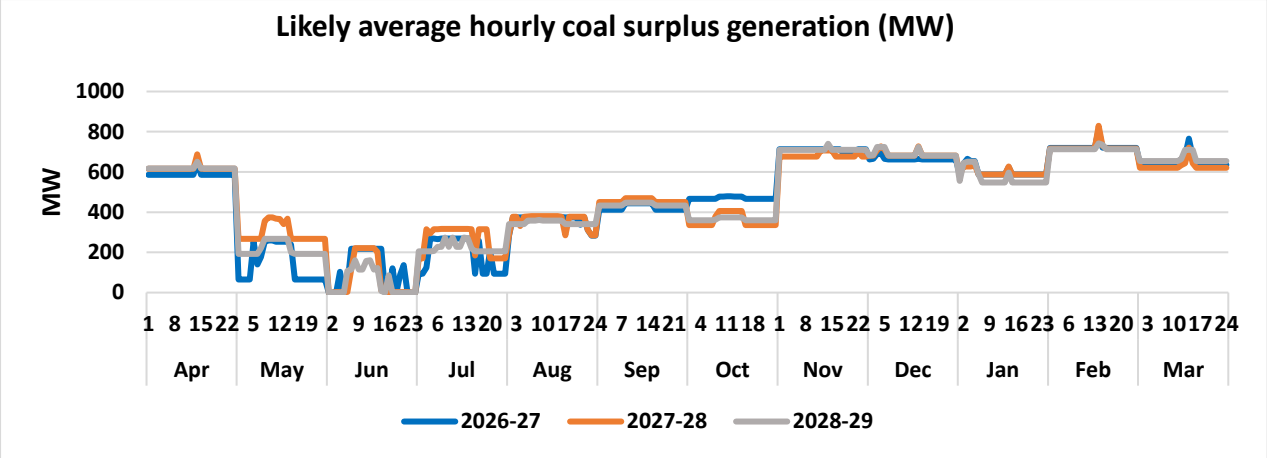


Figure 14: Surplus Coal Capacity Year-wise (MW)

8.0 Conclusions

Based on the Resource Adequacy studies of TPDDL up to the year 2035-36, the following conclusions may be drawn:

1. The study has been carried out considering electricity demand projections as per the utility, which envisages that the annual electrical energy requirement of the utility is likely to grow at a CAGR of 3.5% while the peak electricity demand for the discom is likely to grow at a CAGR of 4.2% for the period of 2025-26 to 2035-36. It has been observed that the peak demand season is typically from May to July with peak demand occurring during solar hours.
2. TPDDL, with its existing and planned capacity addition only, is likely to witness energy deficit ranging from 23 to 655 MUs in different years from 2030-31 to 2035-36.
3. As per the resource adequacy study, the likely total projected contracted capacity for the year 2035-36 is around 6,940 MW which consists of 1524 MW from coal; 27 MW from biomass; 451 MW from gas; 63 MW from nuclear; 529 MW from hydro; 1600 MW from solar; 50 MW from wind; 510 MW from hybrid; 601 MW from Distributed Renewable Energy (DRE) source; 400 MW from FDRE; 885 MW from Storage and 300 MW of MTOA/STOA arrangement is projected to be required by 2035-36. This capacity shall be able to meet the projected demand with prescribed reliability criteria and to comply with the stipulated Renewable Purchase Obligation (RPO) targets. The storage requirement can be met from PSP, combination of 2 hr/4 hr BESS or a combination of PSP and BESS.
4. As per the study, the discom is expected to have a surplus coal-based capacity available during winter months namely November to March of around 550-700 MW for 2028-29. This surplus capacity may be banked or shared with other states whose demand profile complements that of TPDDL.

5. The Planning Reserve Margin (PRM) for TPDDL has been assessed at about 4.5%. Further, the study indicates year-wise short-term/medium-term/bilateral requirements inclusive of the PRM capacity to optimally meet the demand.
6. The current capacity mix of TPDDL has 64% of contracted capacity from fossil fuel sources. The share of fossil fuel-based capacity is likely to reduce to 28 % in 2035-36. In 2035- 36, the RE based generation (that includes hydro, solar, hybrid, biomass and DRE) capacity are likely to constitute around 68% of the total installed capacity.
7. Timely commissioning of planned capacities is critical for ensuring that the discom meets its projected peak electricity demand and electrical energy requirements reliably. Any deviation from the planned schedule may lead to resource shortfalls and could significantly increase the cost of reliably meeting the discom's power demand.

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Annexure

Details of upcoming generation projects considered in the study

Sr. No.	Tied capacity name	Type of generation	Expected COD/ Remark	TPDDL share (in MW)
1.	Medium Term Hydro*	Hydro	2027-28	200
2.	Vishnugad Pipalkoti		2027-28	20
3.	Pakal Dul HEP		2027-28	8
4.	Tapovan Vishnugad		2029-30	21.45
5.	Long Term Hydro**		2032-33	200
6.	TPREL	Hybrid(Solar)	2026-27	170
7.	TPREL	Hybrid(Wind)	2026-27	340
8.	FDRE	FDRE	2028-29	400
9.	Biomass-TWE (TOWMCL)	Biomass	2027-28	6
10.	Distributed Renewable Energy (DRE)	Solar DRE	2025-26	25.3
11.			2026-27	40
12.			2027-28	38
13.			2028-29	28
14.			2029-30	22
15.	BESS	Storage 2h	2026-27	50
16.	BESS	Storage 2h	2027-28	50
17.	BESS	Storage 2h	2028-29	100
18.	BESS	Storage 2h	2029-30	100
19.	BESS	Storage 2h	2030-31	100

* 200 MW of Medium Term from FY 2027-28 to FY 2031-32.

** 200 MW Long Term Hydro from 2032-33 for the months of May to September.

List of Hydro based plants considered for likely retirement in the study period

Sr. No.	Tied capacity name	Type of generation	Retirement year as per TPDDL	TPDDL Share (MW)
1.	NVNNL/Kameng	Hydro	2029-30	200
2.	Hydro MT	Hydro	2032-33	200

Assumption for Resource Adequacy Studies

1. Electricity Demand & peak requirement: As per the projections of TPDDL.
2. Demand Profile: Based on hourly demand profile of 2024-25.
3. Existing and Planned Capacity: As per the information shared by the discom.
4. Cost parameters: based on information in National Electricity Plan.

RE CUF considered

Hydro	Hybrid	Solar (existing)	Wind	Solar (planned)	DRE
38 %	35%	23%	32%	24%	14.5%

Technical Parameters

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical. (%)
Coal/ Lignite	Existing/Planned	85	1	55
	Candidate	88	1	55
Gas	Existing	90	3	40
Nuclear	Existing/Planned	68	Const. Load	-
Biomass	Existing/Planned	60	2	50
Hydro	Existing/Planned/ Candidate	As per available hourly generation profile	100	-
Solar	Existing/Planned		-	-
	Candidate		-	-
Wind	Existing/Planned		-	-
	Candidate		-	-
Pumped storage	Existing/Planned	95	50	-
	Candidate		50	-
BESS	Candidate	98	NA	-

Technology	Type	Heat Rate (MCal/MWh)		Aux. Consum. (%)	Min. online time (hr)	Min. offline time (hr)
		At max loading	At min loading			
Coal	Existing/ Planned	2300 to 2879	2438 to 3052	7.0	6	4
	Candidate (SC & USC)	2060 to 2125	2183 to 2253	6.5	6	4
Gas	Existing	2000 to 2900	2260 to 3277	2.5	4	3
Nuclear	Existing/ Planned	2777	2777	10	6	4
	Candidate	2777	2777	10	-	-
Biomass	Existing/ Planned	4200	4450	8	6	4
	Candidate	4200	4450	8	6	4
Hydro	Existing/ Planned	-	-	0.7	-	-
	Candidate	-	-	0.7	-	-
Pumped Storage Plant	Existing/ Planned	-	-	Round trip efficiency 80 %	-	-
	Candidate	-	-		-	-
BESS	Candidate	-	-	Round trip efficiency 88%	-	-

Transmission Parameters

A single node has been considered for the purpose of study with all generating units and demand connected to the node. No transmission bottleneck has been considered for the study. Interstate ATC limit has not been considered in the study.

Financial Parameters

Following cost parameters have been assumed:

Resource	Capex* (in ₹/MW)	O&M Fixed Cost (in ₹/MW)	Construction Time (in years)	Amortization /Life time (in years)
Coal	12 Cr	30 Lakh	4	25
Solar	4.5 Cr	1 % of Capex	1	25
Battery Energy Storage System (4-Hour)	4.98 Cr to 3.00 Cr	5.9 Lakh	1	15
PSP	6 Cr	30 Lakh	4	40