



**Report on  
Resource Adequacy Plan  
(Generation) for  
JBVNL (Jharkhand)  
(2025-26 to 2035-36)  
(Version 2.0)**

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**Government of India  
Ministry of Power  
Central Electricity Authority**

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## Disclaimer

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

In accordance with the Resource Adequacy Guidelines dated 28<sup>th</sup> 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 JBVNL 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 Distribution Licensee.

## 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 requirements.

As per the Resource Adequacy Guidelines dated 28<sup>th</sup> 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 20<sup>th</sup> October 2023, which mandates that a specified portion of energy consumption must be met from renewable energy sources.

To support the Distribution Licensee 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 JBVNL and in compliance with the RPO trajectory specified in the Ministry of Power's Office Memorandum dated 20<sup>th</sup> 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 Distribution Licensee and planning assumptions. The RPO requirement has also been assessed in accordance with the gazette notified trajectory specified in the Ministry of Power's Office Memorandum dated 20<sup>th</sup> October, 2023.

The electrical energy requirement and peak electricity demand for JBVNL, as furnished by JBVNL, are projected to increase with a CAGR of 5.21% and 5.38% respectively from 2025-26 to 2035-36. The study has been done considering the demand projections furnished by JBVNL. For satisfying resource adequacy i.e., meeting the electricity demand reliably and at affordable cost, the Distribution Licensee 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 JBVNL, based on existing contracted capacity and planned capacity additions, indicates that the available capacity may not be sufficient to meet the projected future demand. In particular,

with existing and planned capacities only, the quantum of unserved energy in 2035-36 is projected to be 1585 MUs which is approximately 5% of total projected electrical energy requirement in 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 an 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, 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 JBVNL along with RPO constraints 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 meet anticipated demand reliably at every instance. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 14,768 MW which consists of 3,928 MW from coal; 341 MW from hydro; 4,398 MW from solar; 2,000 MW from wind; 1,081 MW from Distributed Renewable Energy (DRE) source; 747 MW from 6 Hour Energy Storage system and 2,274 MW from 4 Hour Energy Storage system is projected to be required by 2035-36. 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 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 on long term, medium term, and short-term basis.

Further, Ministry of Power vide notification dated 20<sup>th</sup> 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 Distribution Licensee in fulfilling the Resource Adequacy Guidelines and complying with the Renewable Purchase Obligation (RPO) notification, CEA has carried out the RA study for JBVNL (Jharkhand) based on inputs furnished by JBVNL. 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, RE generation, and forced outage of thermal capacities. The study also assesses the Planning Reserve Margin (PRM) required by the Distribution Licensee to account for the aforementioned uncertainties, ensuring that electricity demand is reliably met throughout the year.

Prior to this, CEA had conducted the RA study for the Distribution Licensee up to FY 2033-34, based on data furnished by JBVNL and in accordance with the RPO trajectory specified in the Ministry of Power’s Office Memorandum dated 20<sup>th</sup> October, 2023.

## 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 2023-24 to 2033-34. The fuel-wise contracted capacity of JBVNL as on 31<sup>st</sup> March, 2023, is given in Fig. 1.

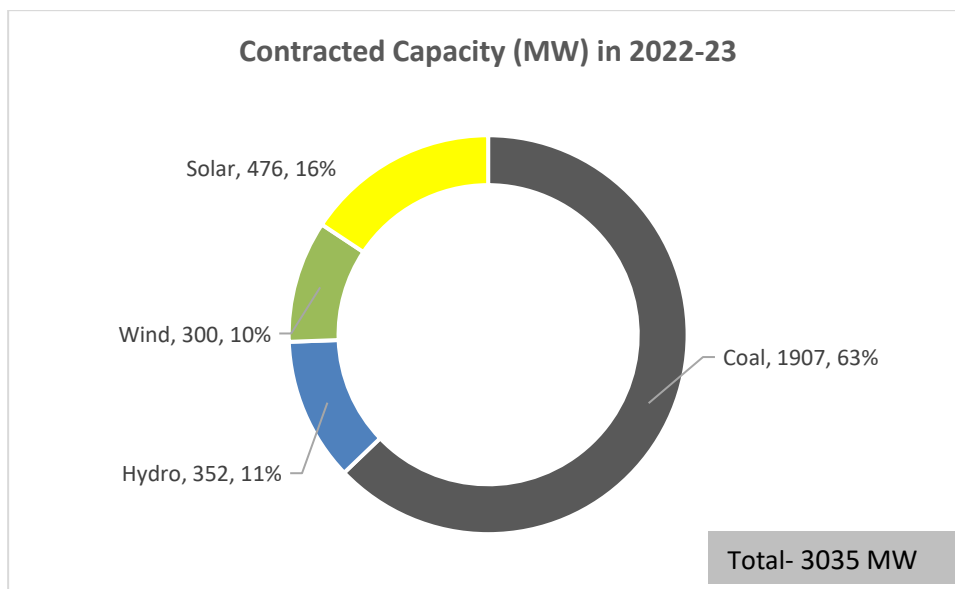


Figure 1: Fuel-wise Contracted Capacity (in MW) as on 31<sup>st</sup> March, 2023

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

Table 1: Electrical energy and Peak electricity demand projections as per 20<sup>th</sup> EPS Report

	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34
<b>Electrical Energy Projections (MU)</b>	15678	16675	17737	18895	20079	21314	22730	23805	24843	25926	27057
<b>Year on Year Growth</b>		6.36%	6.37%	6.53%	6.27%	6.15%	6.64%	4.73%	4.36%	4.36%	4.36%
<b>Peak Electricity Demand Projections (MW)</b>	2614	2784	2967	3165	3369	3582	3827	4014	4196	4386	4585
<b>Year on Year Growth</b>		6.50%	6.57%	6.67%	6.45%	6.32%	6.84%	4.89%	4.53%	4.53%	4.53%

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 capacity projections

Year	Coal	Hydro	Wind	Solar	Storage	DRE	Total	SToA/MToA*
2024-25	3619	352	700	976	0	196	5843	0
2025-26	4299	352	900	1226	0	292	7069	0
2026-27	4438	352	1100	1476	0	399	7765	40
2027-28	4438	372	1300	1726	0	519	8355	0
2028-29	4438	372	1500	1976	0	651	8937	0
2029-30	5798	372	1700	2226	149	801	11046	0
2030-31	5798	372	1850	2369	293	932	11613	0
2031-32	5798	372	2000	2519	426	1070	12184	0
2032-33	5798	372	2150	2669	554	1218	12761	0
2033-34	5798	372	2300	2819	700	1377	13366	0

\*The SToA/MToA value represents the peak power 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	Thermal	Hydro	Solar		Wind		Storage	Yearly SToA/MToA	DRE	Total (in MW)	
	Planned	Additional	Planned	Additional	Planned	Additional	Additional	Additional	Additional	Planned	Additional
2023-24	176	0	250	0	200	0	0	0	0	626	0
2024-25	1536	0	250	0	200	0	0	0	196	1986	196
2025-26	680	0	250	0	200	0	0	0	292	1130	292
2026-27	139	0	250	0	200	0	0	40	399	589	439
2027-28	0	20	250	0	200	0	0	0	519	450	539
2028-29	0	0	250	0	200	0	0	0	651	450	651
2029-30	1360	0	250	0	200	0	149	0	801	1810	950
2030-31	0	0	0	143	0	150	144	0	932	0	1369
2031-32	0	0	0	150	0	150	133	0	1070	0	1503
2032-33	0	0	0	150	0	150	129	0	1218	0	1647
2033-34	0	0	0	150	0	150	146	0	1377	0	1823
<b>Total</b>	<b>3891</b>	<b>20</b>	<b>1750</b>	<b>593</b>	<b>1400</b>	<b>600</b>	<b>700</b>	<b>40</b>	<b>7455</b>	<b>7041</b>	<b>9409</b>

### 3.0 RA Study for JBVNL (Jharkhand) (from 2025-26 to 2035-36)

#### 3.1 Present Power Scenario

The power supply position for the state of Jharkhand from 2020-21 to 2024-25 is given in Table 4:

Table 4: Power Supply Position of Jharkhand

Power Supply Position						
Year	Energy required (MU)	Energy supplied (MU)	Gap (MU)	Peak Demand (MW)	Peak Met (MW)	Demand not met (MW)
2024-25	15203	15126	77	2295	2292	3
2023-24	14408	13858	550	2193	2020	173
2022-23	13278	12288	990	2253	1918	335
2021-22	11148	10590	558	1887	1611	276
2020-21	9953	9675	278	1651	1527	124

*Note: The power supply position (PSP) indicated in the table above is for the state of Jharkhand as a whole as separate data is not available for JBVNL.*

As per the data provided by JBVNL, as of March 2025, the total contracted capacity of JBVNL is 3,097 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 39%.

The fuel-wise contracted capacity as on 31<sup>st</sup> March, 2025 is given in Table 5 and Fig. 2.

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

Source	Contracted Capacity (MW)	Share (%)
Coal	1888	61
Hydro	341	11
Wind	300	10
Solar	476	15
DRE	92	3
<b>Total</b>	<b>3097</b>	<b>100</b>

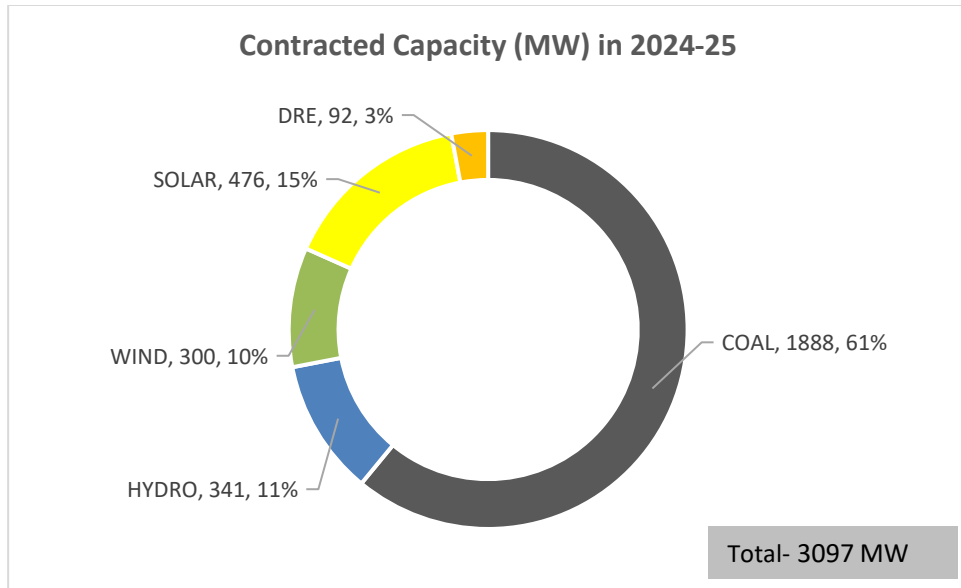


Figure 2: Fuel-wise Contracted Capacity (in MW) as on 31<sup>st</sup> March, 2025

### 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 JBVNL is typically during the month of April. The Distribution Licensee witnesses peak electricity demand predominantly during non-solar hours. The month-wise average hourly demand observed for the year 2024-25 is shown in Fig. 3.

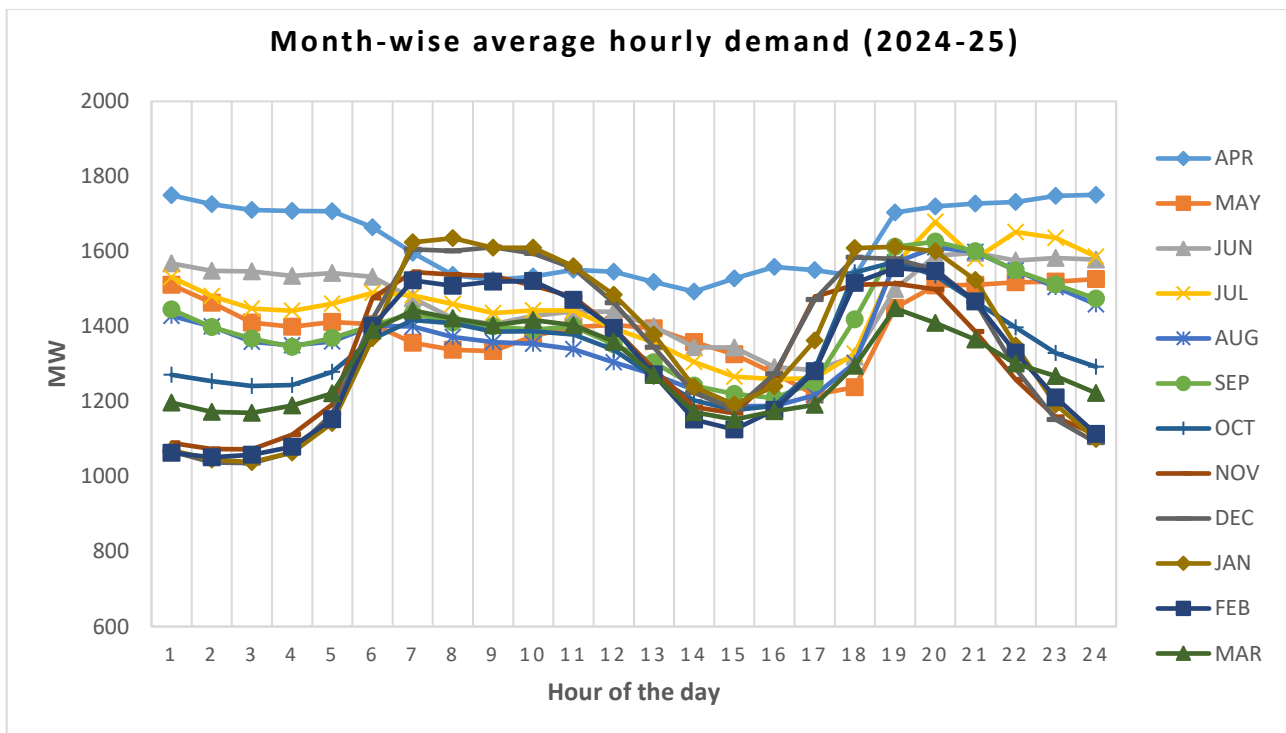


Figure 3: Month-wise average Hourly Demand Variation for 2024-25

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

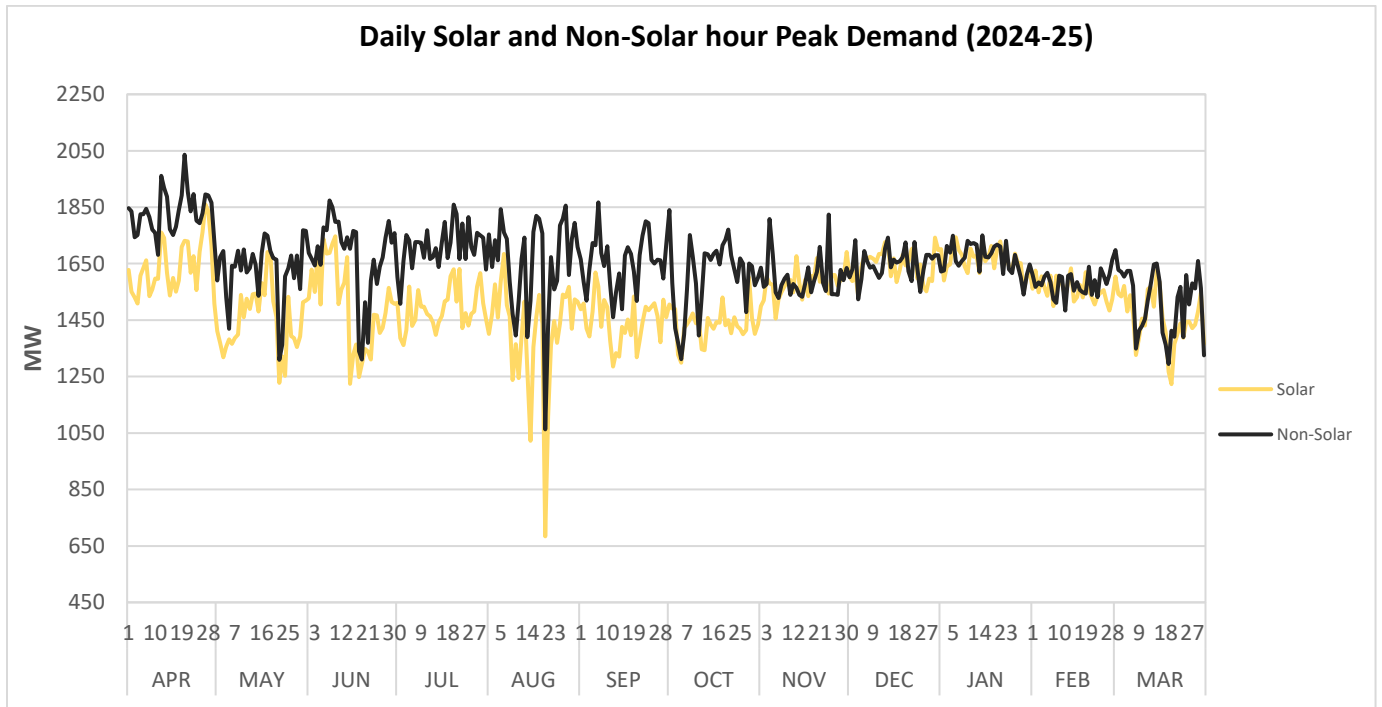


Figure 4: Solar and non-solar peak in MW for the year 2024-25

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.

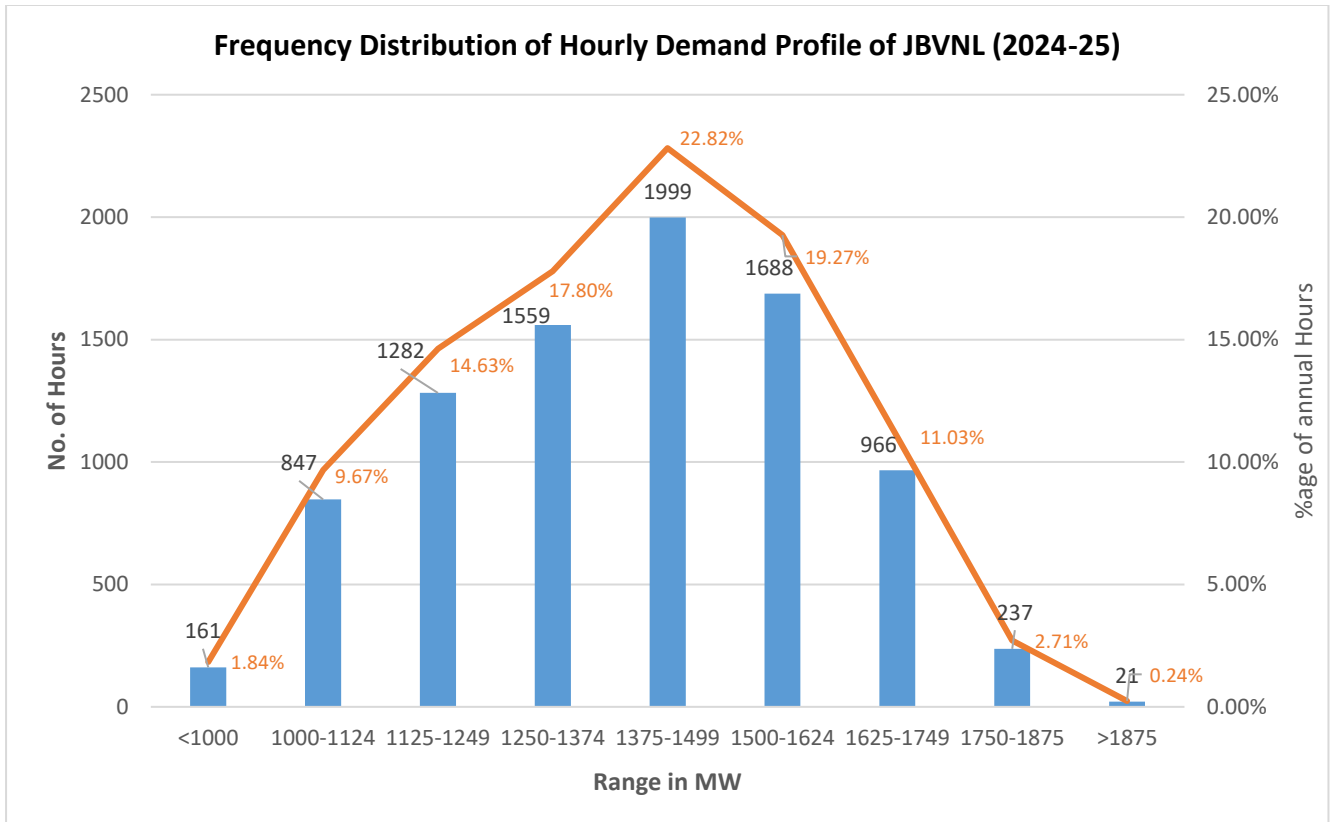


Figure 5: Frequency Distribution of Hourly Demand Profile of 2024-25

#### 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.

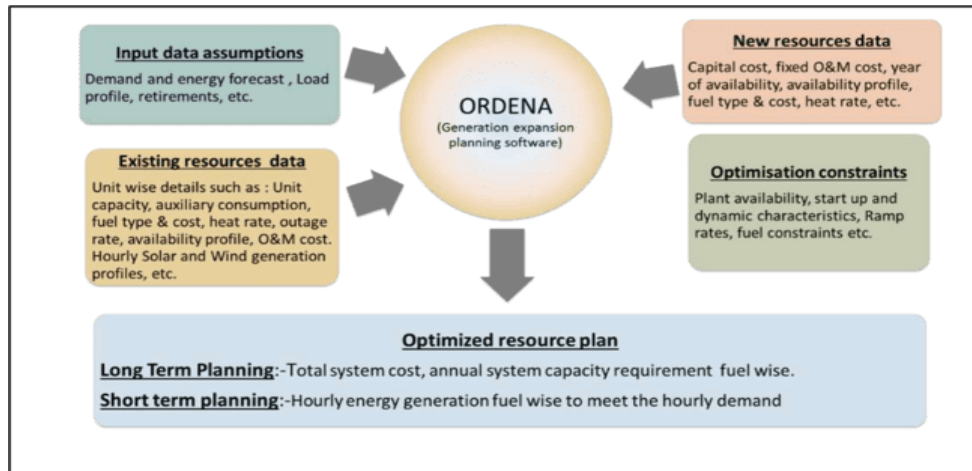


Figure 6: Schematic Diagram

## 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 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 plant. A large no. of random samples of these variables is simultaneously simulated to ascertain system reliability indices (i.e. Loss of load probability, LOLP and Energy Not Served, ENS) and the system robustness in case of 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 electricity demand pattern for last two years viz. 2023-24 and 2024-25 has been analyzed (considering 2023-24 as the base year). The demand pattern variation across 2023-24 and 2024-25 is shown in Fig. 7.

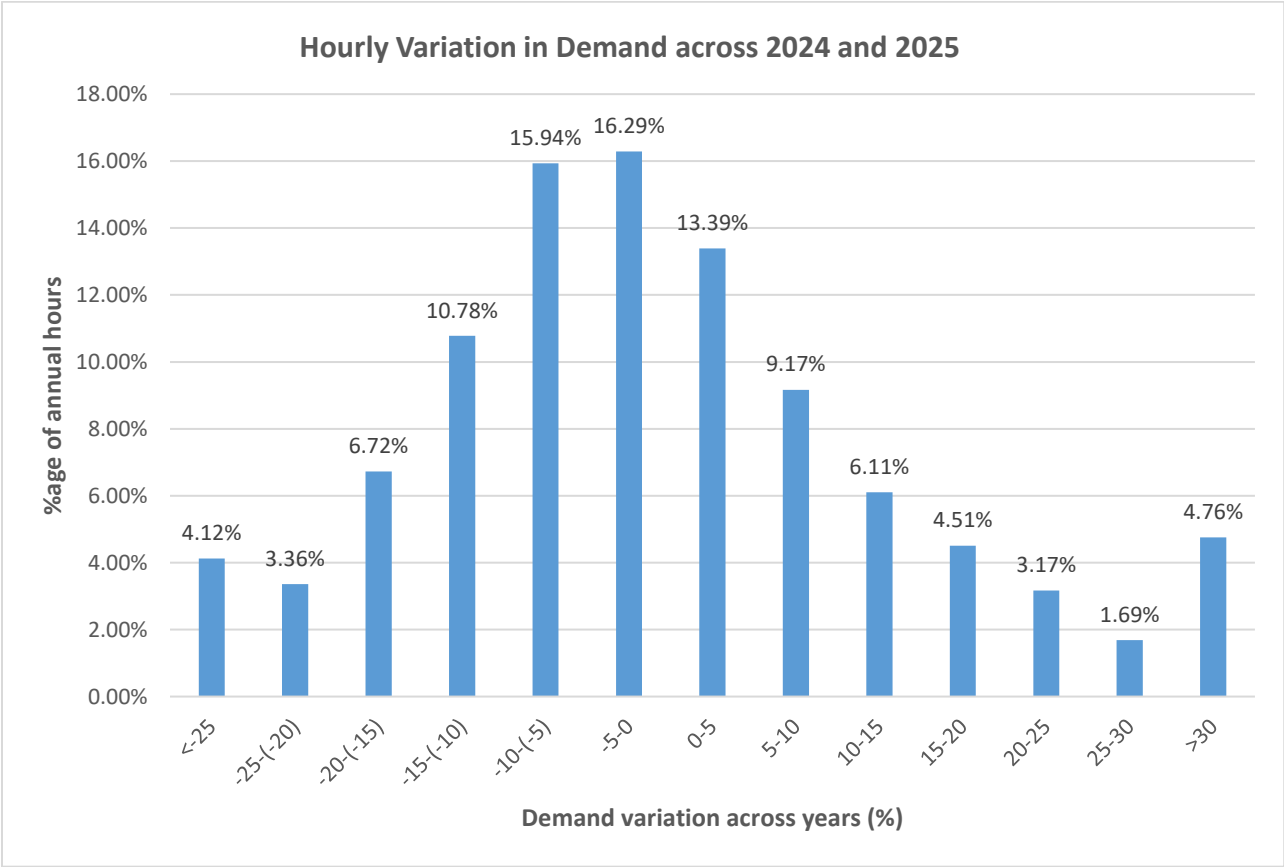


Figure 7: Hourly Variation in electricity demand across years

It can be observed that the hourly demand typically varies within  $\pm 10\%$  for  $\sim 55\%$  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  $\pm 10\%$  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  $\pm 10\%$  and  $\pm 50\%$  respectively to incorporate the variation in these generation sources and plan for requisite measures to mitigate such behavior.

## 5.3 Forced Outage of Thermal Generators

The average forced outage rate of thermal generators is typically 10% with  $\pm 5\%$  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 requirements of JBVNL furnished by JBVNL has been considered for the study and is given in Table 6.

Table 6: Electricity demand projections as per JBVNL

	Peak Electricity Demand		Electrical Energy Requirement	
	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth
<b>2025-26</b>	2967		17737	
<b>2026-27</b>	3165	6.67%	18895	6.53%
<b>2027-28</b>	3369	6.45%	20079	6.27%
<b>2028-29</b>	3582	6.32%	21314	6.15%
<b>2029-30</b>	3827	6.84%	22730	6.64%
<b>2030-31</b>	4014	4.89%	23805	4.73%
<b>2031-32</b>	4196	4.53%	24843	4.36%
<b>2032-33</b>	4386	4.53%	25926	4.36%
<b>2033-34</b>	4585	4.54%	27057	4.36%
<b>2034-35</b>	4792	4.51%	28233	4.35%
<b>2035-36</b>	5010	4.55%	29461	4.35%

- 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 in CEA.
- iv) The capital cost of candidate plants for coal, solar, wind 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 JBVNL. The same is summarised in Table 7 and details are furnished in Annexure.

Table 7: Source-wise planned capacity addition

Fig.in MW

FY	Thermal	Solar
2025-26	680	0
2026-27	1360	100
<b>Total</b>	<b>2040</b>	<b>100</b>

- vi) **Renewable Purchase Obligation (RPO) trajectory:** Ministry of Power vide gazette notification dated 20<sup>th</sup> 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 (%) as per MoP order

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	27.35	1.5	29.91
2.	2025-26	1.45	1.22	28.24	2.1	33.01
3.	2026-27	1.97	1.34	29.94	2.7	35.95
4.	2027-28	2.45	1.42	31.64	3.3	38.81
5.	2028-29	2.95	1.42	33.1	3.9	41.36
6.	2029-30	3.48	1.33	34.02	4.5	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. Further, the DRE percentage has been assumed to be 4.5 % beyond 2029-30. Hence, the suggested trajectory of Renewable Purchase Requirement 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	27.35	1.50	29.91
2.	2025-26	1.45	1.22	28.24	2.10	33.01
3.	2026-27	1.97	1.34	29.94	2.70	35.95
4.	2027-28	2.45	1.42	31.64	3.30	38.81
5.	2028-29	2.95	1.42	33.10	3.90	41.36
6.	2029-30	3.48	1.33	34.02	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	46.50			4.50	51.00
12.	2035-36	47.50			4.50	52.00

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	257.2	216.4	5008.9	372.5	5855.0
2.	2026-27	372.2	253.2	5657.2	510.2	6792.8
3.	2027-28	491.9	285.1	6353.0	662.6	7792.7
4.	2028-29	628.8	302.7	7054.9	831.2	8815.5
5.	2029-30	791.0	302.3	7732.7	1022.8	9848.9
6.	2030-31	9760.0			1071.2	10831.3
7.	2031-32	10558.3			1117.9	11676.2
8.	2032-33	11355.7			1166.7	12522.4
9.	2033-34	12175.5			1217.6	13393.1
10.	2034-35	13130.0			1270.6	14400.6
11.	2035-36	13994.0			1325.7	15319.7

As indicated in Table 11 and 11(a), the Distribution Licensee with its existing and envisaged future capacity additions will not be able to meet its RPO requirements from the year 2025-26 onwards.

Table 11: Renewable Energy (excluding DRE) Deficit/Surplus

FY	RE Generation required to meet RPO		RE Generation available/met (From existing/ planned contracts)		RPO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	
2025-26	5482.5	30.91	2375	13.39	-17.52
2026-27	6282.6	33.25	2536	13.42	-19.83
2027-28	7130.1	35.51	2536	12.63	-22.88
2028-29	7986.4	37.47	2536	11.90	-25.56
2029-30	8826.1	38.83	2536	11.16	-27.67
2030-31	9760.0	41.00	2536	10.65	-30.35
2031-32	10558.3	42.50	2536	10.21	-32.29
2032-33	11355.7	43.80	2536	9.78	-34.02
2033-34	12175.5	45.00	2536	9.37	-35.63
2034-35	13130.0	46.50	2536	8.98	-37.52
2035-36	13994.0	47.50	2536	8.61	-38.89

Table 11(a): DRE Deficit/Surplus

FY	DRE required to meet RPO		DRE available/met (From existing/ planned contracts)		RPO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	
2025-26	372.5	2.10	117	0.66	-1.44
2026-27	510.2	2.70	117	0.62	-2.08
2027-28	662.6	3.30	117	0.58	-2.72
2028-29	831.2	3.90	117	0.55	-3.35
2029-30	1022.8	4.50	117	0.52	-3.98
2030-31	1071.2	4.50	117	0.49	-4.01
2031-32	1117.9	4.50	117	0.47	-4.03
2032-33	1166.7	4.50	117	0.45	-4.05
2033-34	1217.6	4.50	117	0.43	-4.07
2034-35	1270.6	4.50	117	0.41	-4.09
2035-36	1325.7	4.50	117	0.40	-4.10

## 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 1585 MUs which is about 5% of the projected electrical energy requirement in 2035-36. The year-wise likely unserved energy with the existing and planned capacities is given in Fig 8.

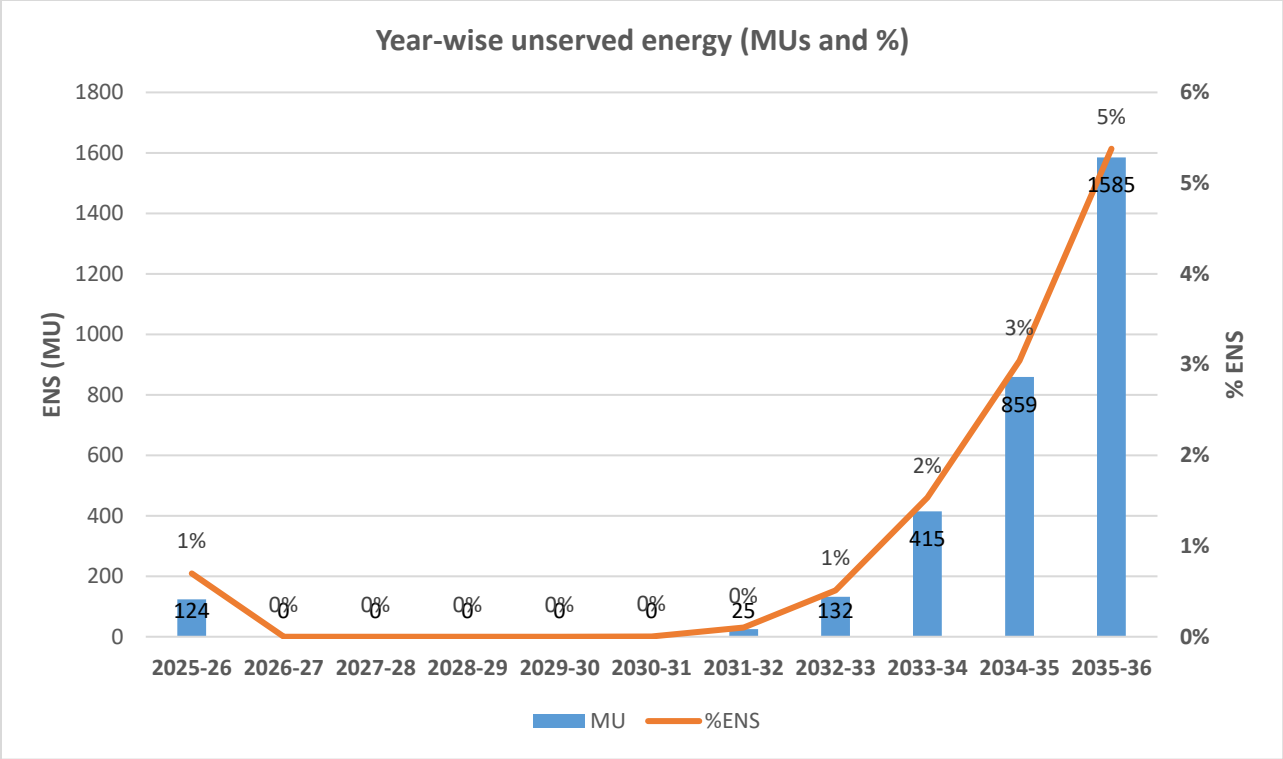


Figure 8: Yearly likely unserved energy (in MU) with the existing and planned capacities

The study has also analyzed the daily and monthly pattern of unserved energy in the year 2035-36, it can be seen that contracted capacity (present and planned) is unable to meet the demand. Details are shown in Fig. 9.

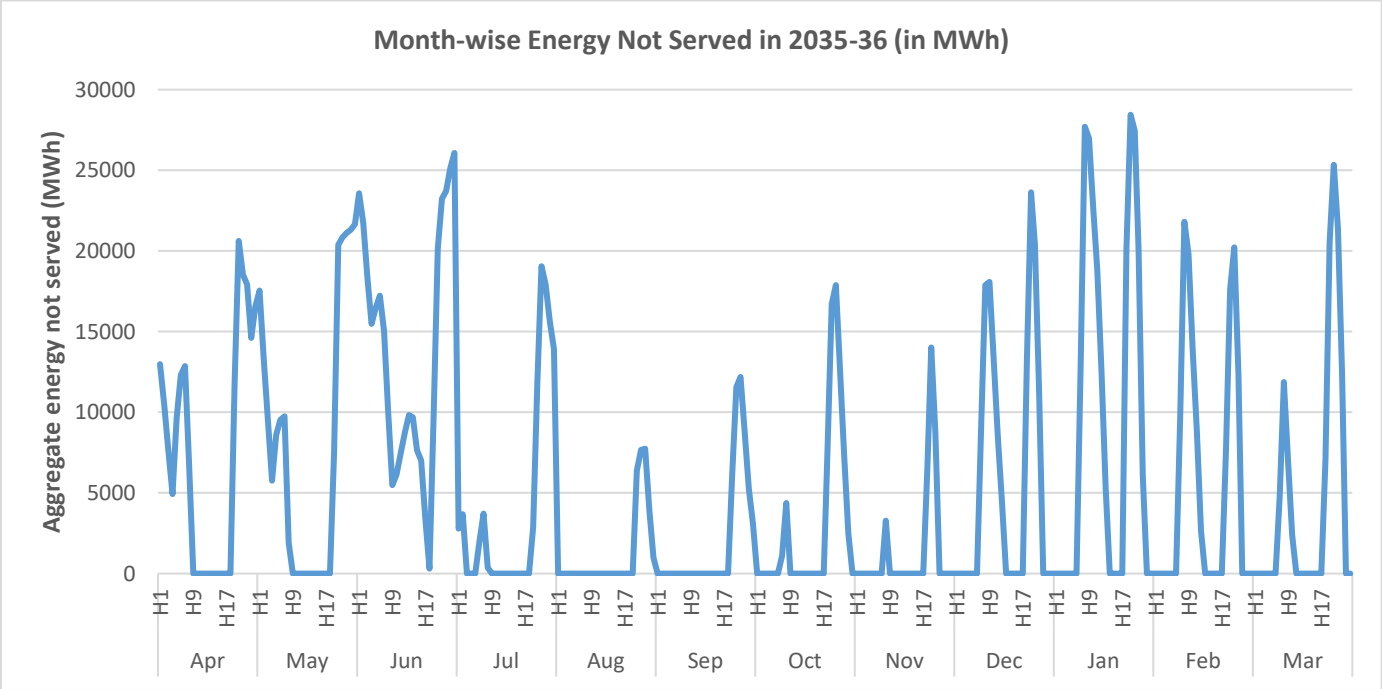


Figure 9: Block-wise Unserved Energy Pattern MWh (2035-36)

## 7.2 Investment options to meet the unserved energy

As the Distribution Licensee's existing and planned capacity contracts may not be sufficient to meet the electrical energy demand, investment options (i.e., candidate capacities) have been given to the model to find the least cost optimal capacity mix required to meet the projected electricity demand while fulfilling the RPO obligations. Based on the outcome of the study, the capacity projections (existing, planned, to be tied up) for JBVNL are given in Table 12.

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

Year	Coal	Hydro	Wind	Solar	Storage (6 Hr)	Storage (4 Hr)	DRE	SToA/MToA
<b>2025-26</b>	2568	341	300	476	0	0	304	640
<b>2026-27</b>	3928	341	470	2375	0	1279	416	0
<b>2027-28</b>	3928	341	640	2577	0	1627	540	0
<b>2028-29</b>	3928	341	810	2920	0	1871	678	0
<b>2029-30</b>	3928	341	980	2967	234	1871	834	0
<b>2030-31</b>	3928	341	1150	3261	361	1871	873	0
<b>2031-32</b>	3928	341	1320	3473	454	1871	912	0
<b>2032-33</b>	3928	341	1490	3673	557	1871	951	0
<b>2033-34</b>	3928	341	1660	3886	664	1871	993	0
<b>2034-35</b>	3928	341	1830	4118	746	1871	1036	0
<b>2035-36</b>	3928	341	2000	4398	747	2274	1081	0

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

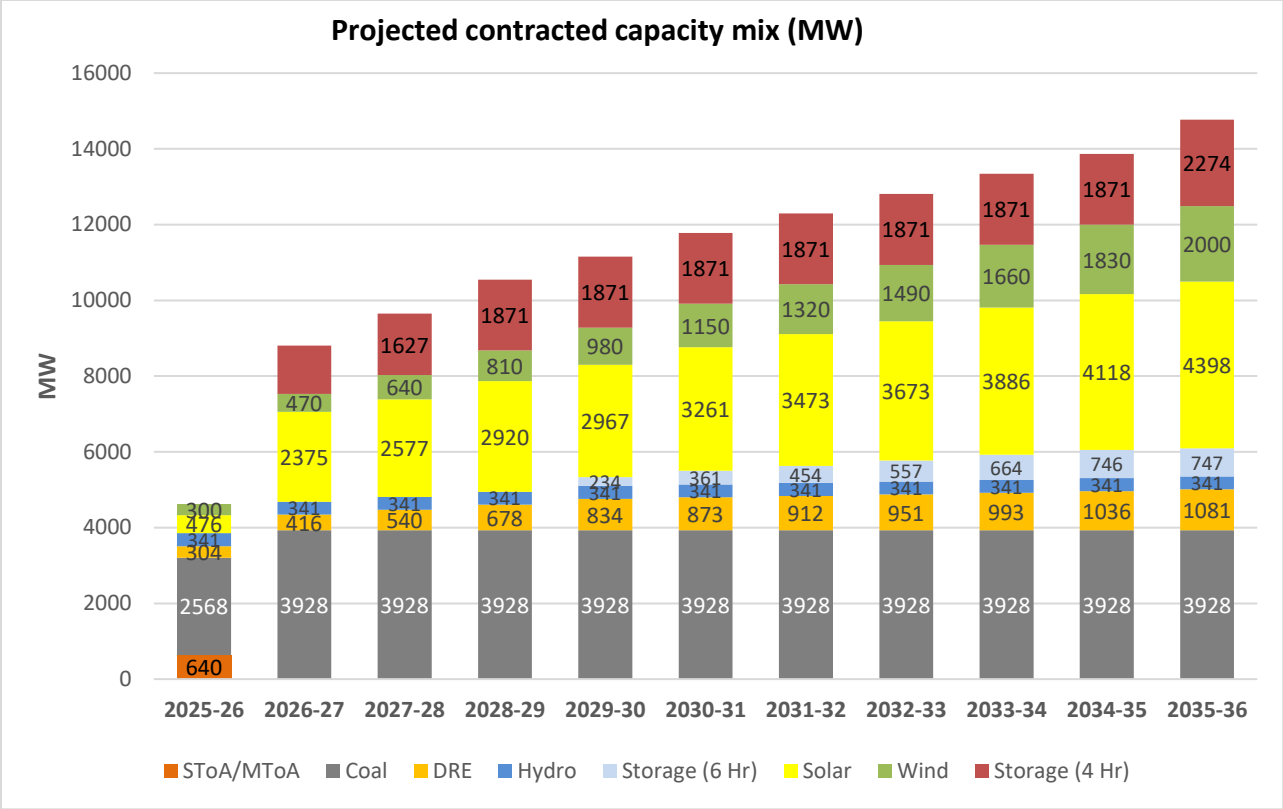


Figure 10: Year-wise Projected Contracted Capacity Mix (MW)

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 Not-Served Energy (NENS) remaining within the permissible limits of 0.2% and 0.05%, respectively (as specified in the National Electricity Plan (NEP)).

The Resource adequacy studies have projected likely optimal capacity mix for future years till 2035-36 which shall be able to reliably meet the projected electricity demand. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 14,768 MW which consists of 3,928 MW from coal; 341 MW from hydro; 4,398 MW from solar; 2,000 MW from wind; 1,081 MW from Distributed Renewable Energy (DRE) source; 747 MW from 6 Hour Energy Storage system and 2,274 MW from 4 Hour Energy Storage system. This capacity shall be able to meet the projected electricity demand with prescribed reliability criteria and to comply with the stipulated Renewable Purchase Obligation (RPO) targets. The storage requirement can be met through PSP or a

combination of PSP and BESS. Based on the capacity addition, the planning reserve margin works out to ~20%. Capacity mix required by 2035-36 is shown in Figure 11.

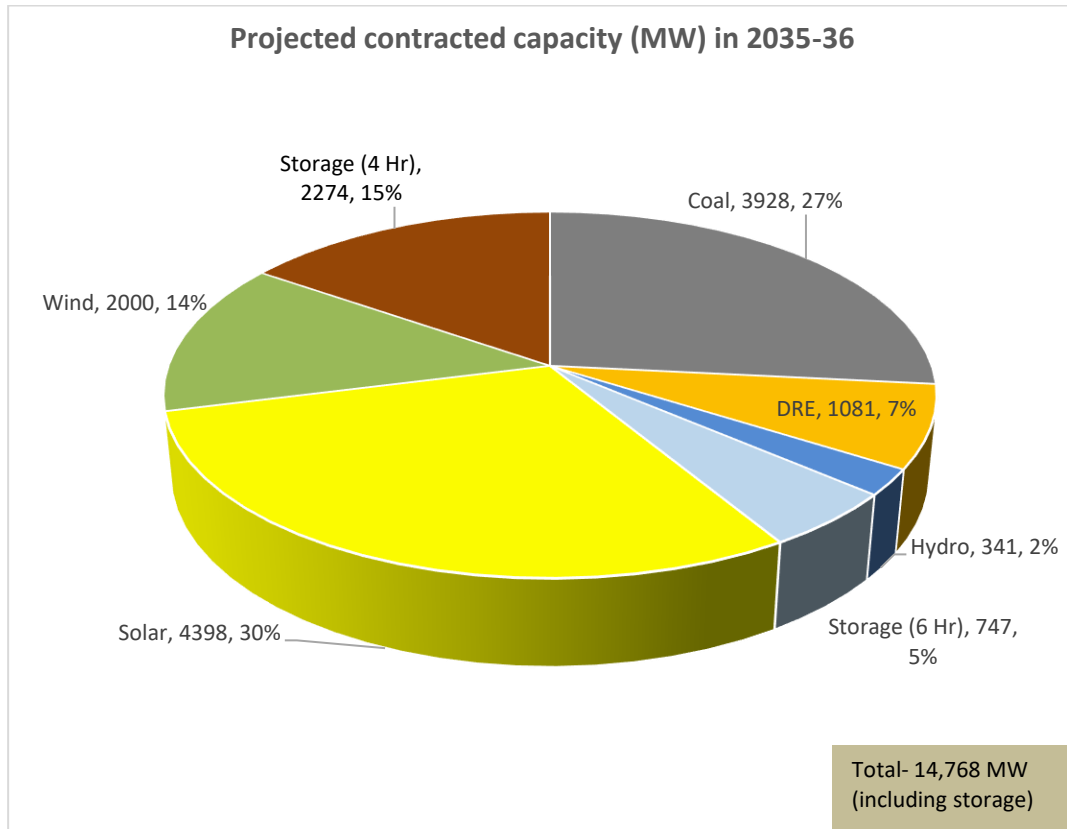


Figure 11: Contracted Capacity Mix in 2035-36

It is important to note that any deviations in the commissioning schedule of the planned capacity could result in a situation where the Distribution Licensee 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 Distribution Licensee’s power demand reliably.

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

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

Year	Coal	Wind	Solar		Storage (6 Hr)	Storage (4 Hr)	DRE	Total		SToA/ MToA*
	Planned Contracts	Additional Contracts	Planned Contracts	Additional Requirement	Additional Contracts	Additional Contracts	Additional Contracts	Planned Contracts	Additional Contracts	Additional Contracts
2025-26	680	0	0	0	0	0	212	680	212	640
2026-27	1360	170	100	1799	0	1279	112	1460	3361	0
2027-28	0	170	0	202	0	348	124	0	844	0
2028-29	0	170	0	343	0	244	138	0	894	0
2029-30	0	170	0	47	234	0	156	0	607	0
2030-31	0	170	0	295	127	0	39	0	631	0
2031-32	0	170	0	212	93	0	38	0	513	0
2032-33	0	170	0	200	103	0	40	0	513	0
2033-34	0	170	0	213	108	0	41	0	532	0
2034-35	0	170	0	232	82	0	43	0	527	0
2035-36	0	170	0	280	0	403	45	0	898	0
<b>Total</b>	<b>2040</b>	<b>1700</b>	<b>100</b>	<b>3823</b>	<b>747</b>	<b>2274</b>	<b>988</b>	<b>2140</b>	<b>9532</b>	<b>640</b>

\*Yearly requirement

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

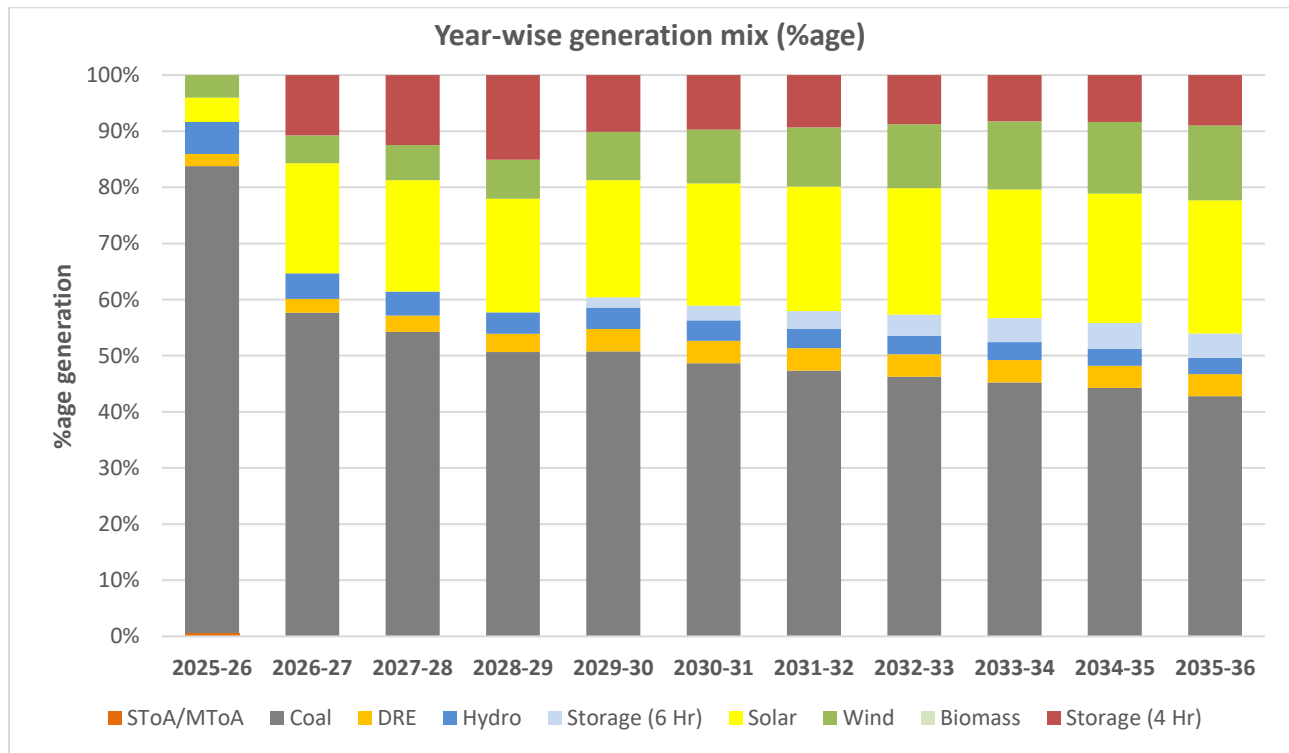


Figure 12: Year-wise projected net generation mix (in %)

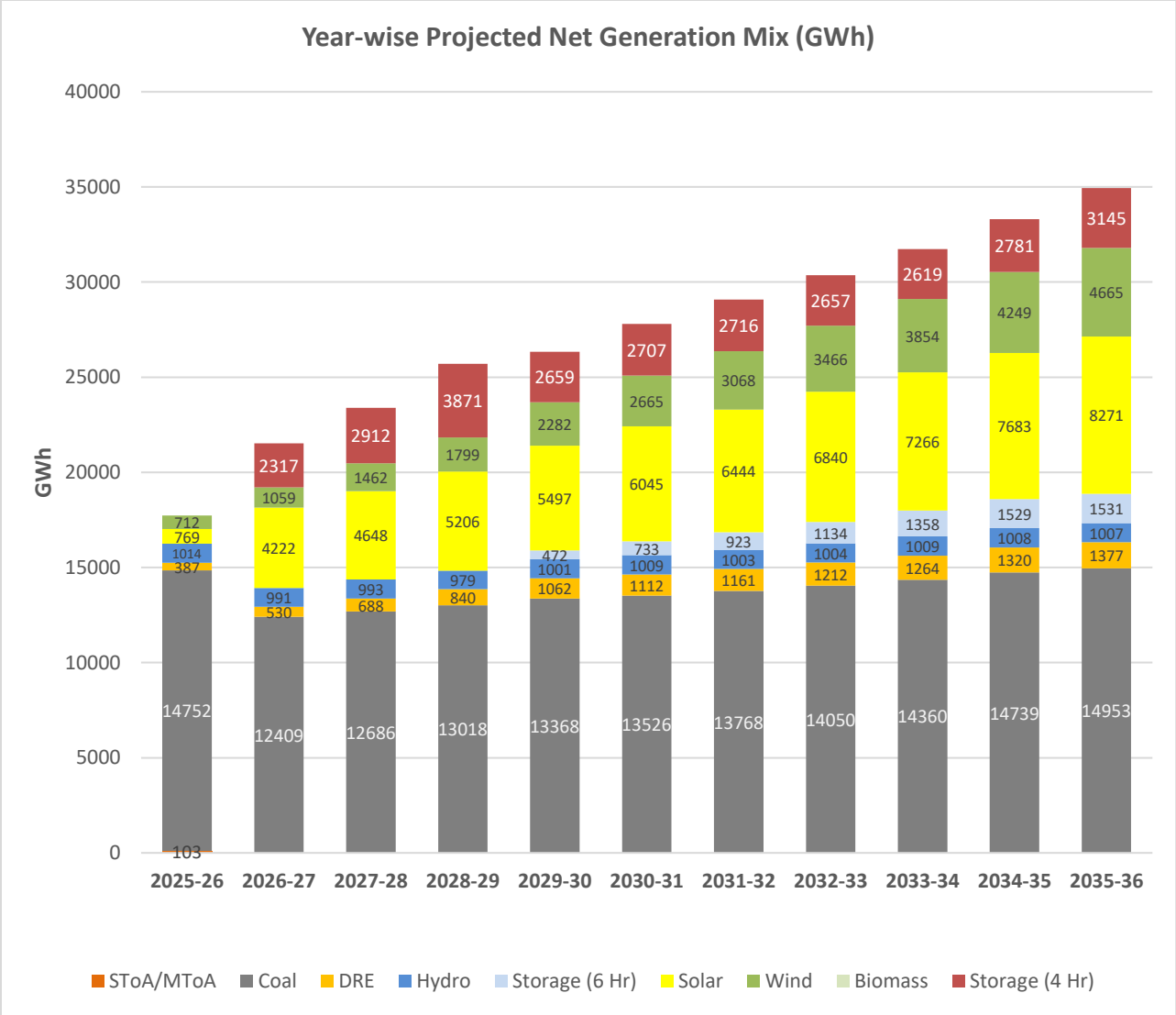


Figure 13: Year-wise projected net generation (in GWh)

7.3 Surplus Coal Capacity

Generally, surplus capacity is available with the Distribution Licensee 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 JBVNL is expected to have a minimum surplus coal-based capacity of 200 MW during the period from July to December and from February to March. This surplus capacity may be banked or shared with other states whose demand profile complements that of JBVNL.

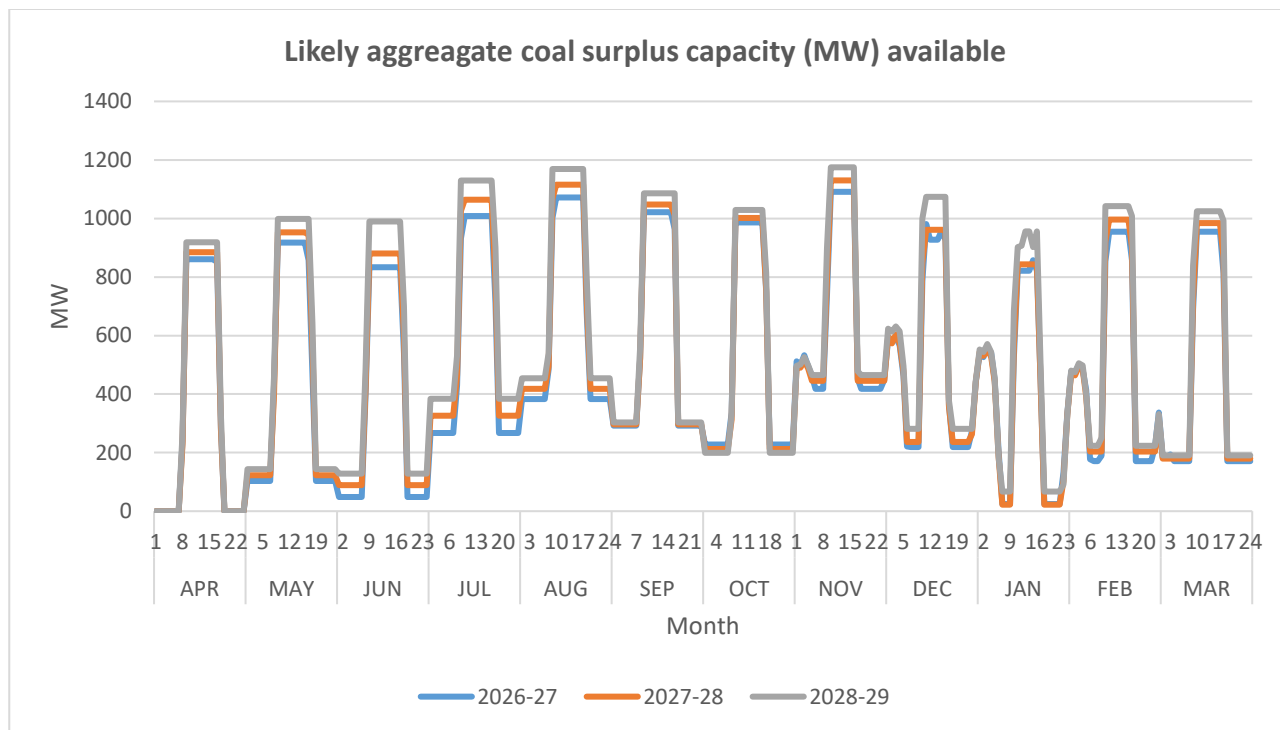


Figure 14: Surplus Coal Capacity Year-wise (MW)

## 8.0 Conclusions

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

1. The study has considered electrical energy and peak demand requirement projections as per the projections furnished by JBVNL, which envisages that for the Distribution Licensee, the annual electrical energy requirement is likely to grow at a CAGR of 5.21% while the peak electricity demand is likely to grow at a CAGR of 5.38% for the period of 2025-26 to 2035-36. The projected peak electricity demand and electrical energy requirement in 2035-36 is 5,010 MW and 29,461 MU respectively. It has been observed that the peak demand season is typically in April with peak demand typically occurring during non-solar hours.
2. JBVNL, with its existing and planned capacity addition only, is likely to witness energy deficit ranging from 25 to 1585 MUs in different years from 2031-32 to 2035-36.
3. To meet the projected electricity demand, the Distribution Licensee will need to contract additional solar, wind and storage capacities beyond those already planned. In addition to the existing and already planned contracts, the Distribution Licensee needs to tie up approximately 3,823 MW of solar-based capacity, 1700 MW of wind-based capacity and 3,021 MW of Energy

Storage System by 2035–36 (refer Table 13). The energy storage requirement can be met through PSP or a combination of PSP and BESS.

4. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 14,768 MW which consists of 3,928 MW from coal; 341 MW from hydro; 4,398 MW from solar; 2,000 MW from wind; 1,081 MW from Distributed Renewable Energy (DRE) source; 747 MW from 6 Hour Energy Storage system and 2,274 MW from 4 Hour Energy Storage system. This capacity shall be able to meet the projected electricity demand with prescribed reliability criteria and to comply with the stipulated Renewable Purchase Obligation (RPO) targets. The storage requirement can be met through PSP or a combination of PSP and BESS.
5. As per studies, the Distribution Licensee is expected to have a minimum surplus coal-based capacity of 200 MW during the period from July to December and from February to March. This surplus capacity may be banked or shared with other states/ Distribution Licensees whose demand profile complements that of JBVNL.
6. The Planning Reserve Margin (PRM) for JBVNL has been assessed at ~20 %. Further, the study indicates year-wise short-term/medium-term/bilateral requirements inclusive of the PRM capacity to meet the demand optimally.
7. Timely commissioning of planned capacities is critical for ensuring that the Distribution Licensee 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 Distribution Licensee’s power demand.

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### Details of upcoming capacities/retirements considered in the study

Sl. No.	Tied capacity name	Type of generation	Expected COD	JBVNL's share (in MW)	Remarks
1.	Patratu Unit 1	Thermal	2025-26	680	
2.	Patratu Unit 2 and 3	Thermal	2026-27	1360	
3.	Solar	Solar	2026-27	100	

### Assumption for Resource Adequacy Studies

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

### RE CUF considered

Hydro	Wind	Solar (existing)	Solar (planned)	DRE
35 %	27%	18%	21%	14%

### Technical Parameters

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical . (%)
<b>Coal/ Lignite</b>	Existing/Planned/ Candidate	85	1	55
		88	1	55
<b>Hydro</b>	Existing/Planned	As per available hourly generation profile	100	-
<b>Solar</b>	Existing/Planned/ Candidate		-	-
<b>Wind</b>	Existing/Planned/ Candidate		-	-
<b>Pumped storage</b>	Candidate		95	50
		50		-
<b>Battery Energy Storage</b>	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
Hydro	Existing/Planned	-	-	0.7	-	-
		-	-	0.7	-	-
Pumped Storage	Candidate	-	-	Round trip efficiency 80 %	-	-
		-	-		-	-
Battery Energy Storage System	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 to 4.0 Cr	1 % of Capex	0.5	25
Wind	7.5 Cr	1 % of Capex	1	25
Battery Energy Storage System (4-Hour)	4.98 Cr to 2.92 Cr	5.9 Lakh	1	14
PSP	6 Cr	30 Lakh	4	40