Report On
Resource Adequacy Plan
For the State of
Jharkhand (JBVNL)

Government of India
Ministry of Power
Central Electricity Authority

Contents

Executive Summary

Ministry of Power had notified Electricity (Amendment) Rules in December, 2022. As per Rule 16 of the Electricity (Amendment) Rules, Ministry of Power has notified Resource Adequacy guidelines. As per the Resource Adequacy (RA) Guidelines, Central Electricity Authority is entrusted to prepare Long Term-National Resource Adequacy Plan (LT-NRAP). Further Distribution Utility need to carry out LTDRAP (Long term Distribution Licensee Resource Adequacy Plan) to meet the utility peak and energy requirement reliably.

The Government of India has recently notified new Renewable Purchase Obligation (RPO) trajectory till 2029-30 which ensure certain amount of energy consumption to be met from renewable energy sources. RPO requirement for Jharkhand (JBVNL) has been assessed in compliance with new RPO trajectory.

The electricity demand for the State of Jharkhand (JBVNL) is increasing with a CAGR of 6.39 % from 2023-24 to 2029-30 as forecasted by 20th EPS. The projections of Jharkhand (JBVNL) also indicate that electricity demand may increase with a CAGR of 4.98 % from 2023-24 to 2029-30. For satisfying resource adequacy i.e., meeting the electricity demand reliably and at affordable cost, the State need to methodically plan its capacity expansion either by investing 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.

To find out the least cost option for generation capacity expansion for the period 2023-24 to 2033-34, long-term study for the State of Jharkhand (JBVNL) was carried with an objective to minimize the total system cost of generation including the cost of anticipated future investments while fulfilling all the technical/financial constraints associated with various power generation technologies.

The study was carried out considering existing capacity, planned capacity & capacity required to fulfil the Renewable Purchase Obligations (RPO). It was found that the state's likely contracted capacity is sufficient to meet projected demand primarily due to the significant addition of coal capacity.

The electricity demand for JBVNL is maximum during the month of April. The electricity demand is observed to have morning and evening peaks during the winter months (October to March). The peak electricity load is generally observed during non-solar hours.

Generation capacity expansion pathways have been considered for the long-term study based on the yearly capacity addition plans of the state along with RPO constraints. 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 2033-34 to meet anticipated demand reliably at every instance while meeting Renewable Purchase Obligations (RPO).

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 20th October 2023 had notified the RPO trajectory for the states. Based on the trajectory specified the 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 have to contract in addition to its existing/planned capacity to meet their RPO targets.

Resource Adequacy studies has been carried out for Jharkhand (JBVNL) based on the inputs received from Jharkhand (JBVNL) while fulfilling RPO trajectory. The study suggests the optimal resource mix till 2033-34 taking into account all technical and financial parameters associated with capacities. The study optimizes power purchase on a long-term basis while evaluating resource adequacy for meeting the demand 24 X 7 considering variation in demand, RE generation and forced outages of thermal capacities. The study has also assessed the requirement of Planning Reserve margin for Jharkhand (JBVNL) for catering to above highlighted uncertainties so that demand can be met reliably throughout the year.

2.0 Jharkhand (JBVNL) RA Study

2.1 Present Power Scenario in Jharkhand (JBVNL)

As of March 2023, the total contracted capacity for Jharkhand (JBVNL) is 3035 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 37%.

The fuel-wise contracted capacity as of March 2023 is given in Table and Figure below:

Table 1 Fuel-wise Contracted Capacity as of March 2023

Source	Contracted Capacity (MW)	Percentage
Coal	1907	63%
Hydro	352	11%
Wind	300	10%
Solar	476	16%
Total	**3035**	100%

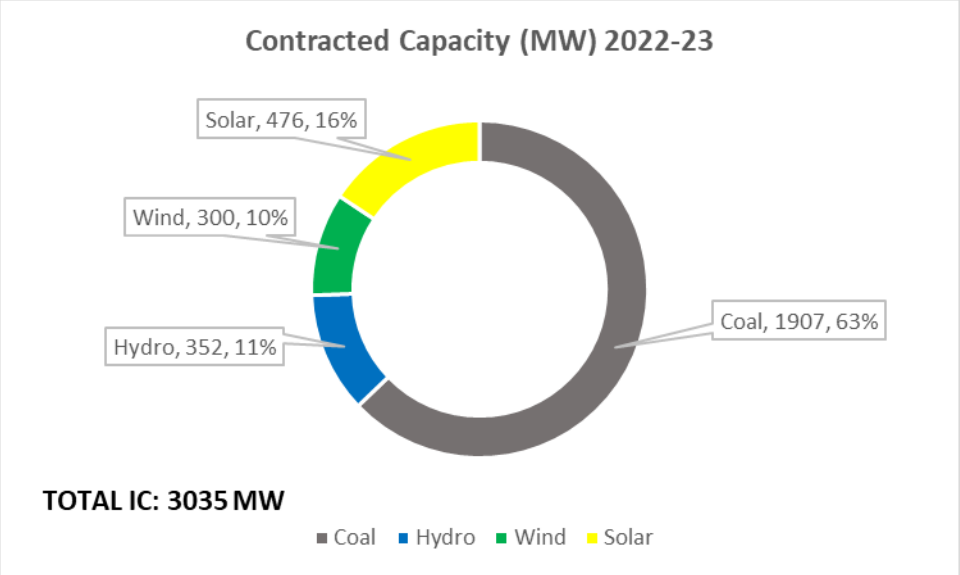


Figure 1 Fuel-wise Contracted Capacity (in MW) as of Mar 2023

2.2 Present Demand Analysis (2022-23)

Hourly demand pattern of 2022-23 was analyzed (as shown in Figure 2) and it was observed that the peak demand season for Jharkhand (JBVNL) is during the months of April. Jharkhand (JBVNL) witnesses peak demand during night hours.

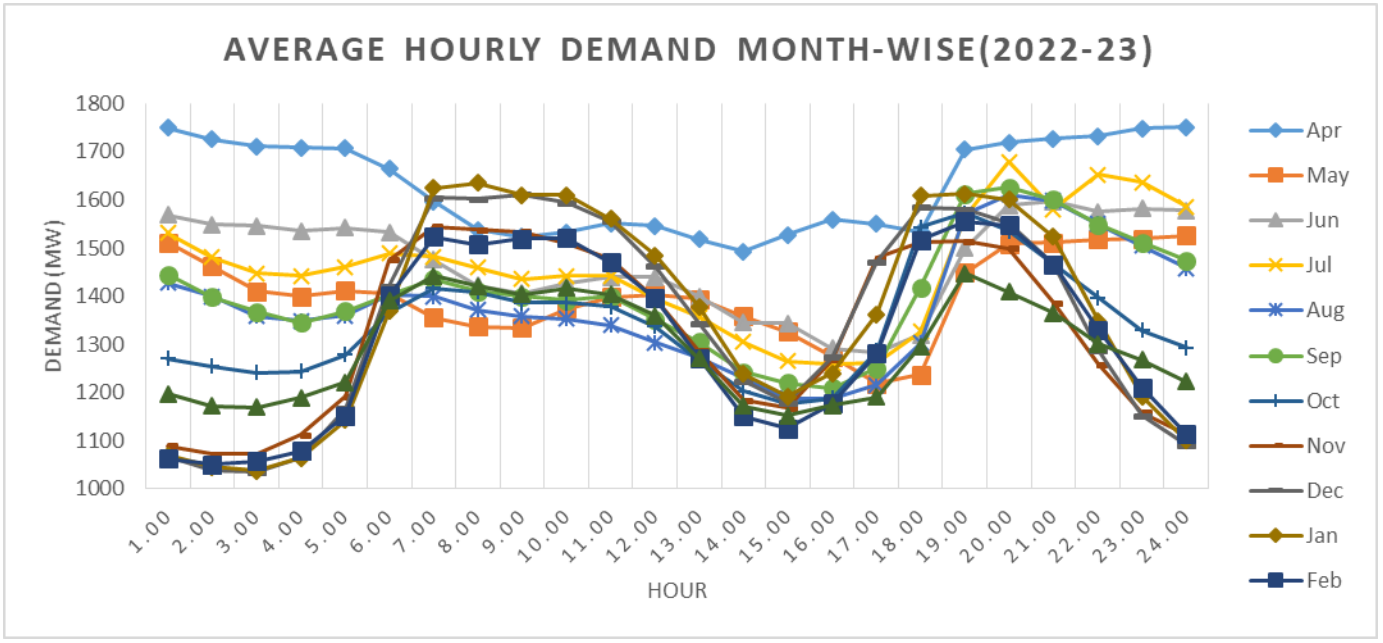


Figure 2 Average Hourly Demand Variation (Month-wise) of Jharkhand (JBVNL) for 2022-23

As seen in Figure 3, Jharkhand (JBVNL) has peak in night hours in almost every month of the year.

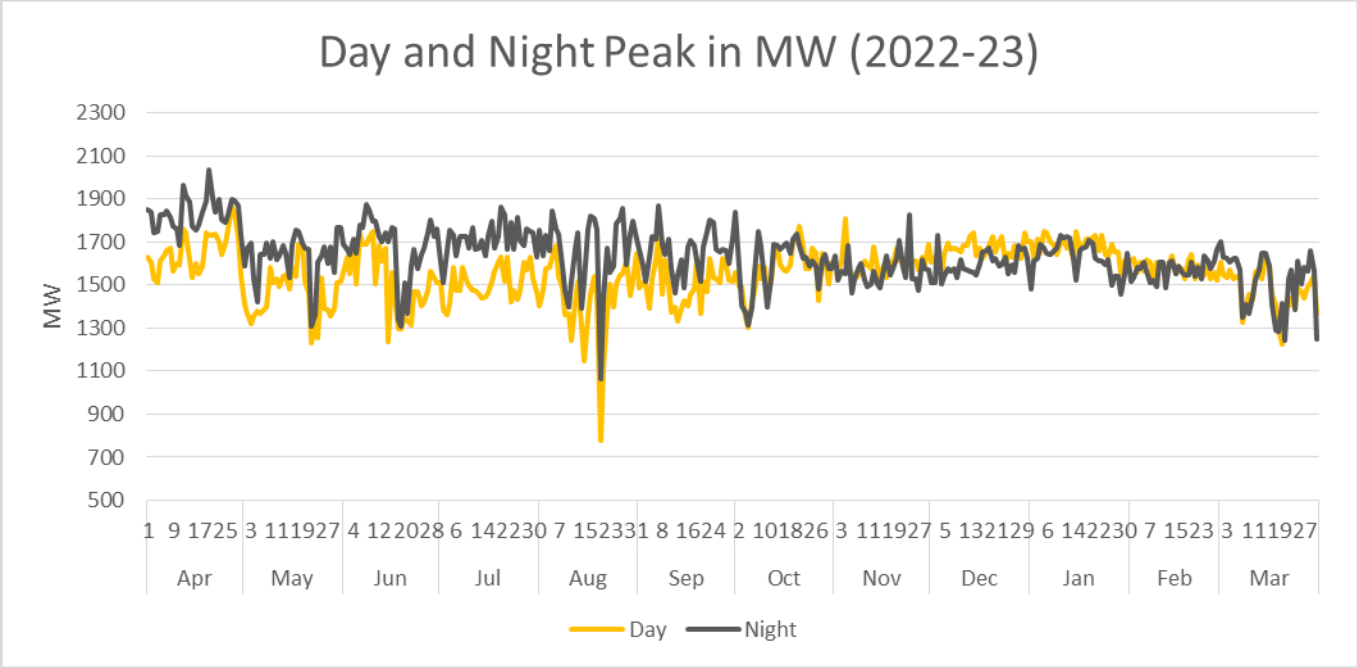


Figure 3 Day and Night Peak in MW of Jharkhand (JBVNL) (2022-23)

The hourly demand pattern of 2022-23 was analysed (Figure 4) 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.

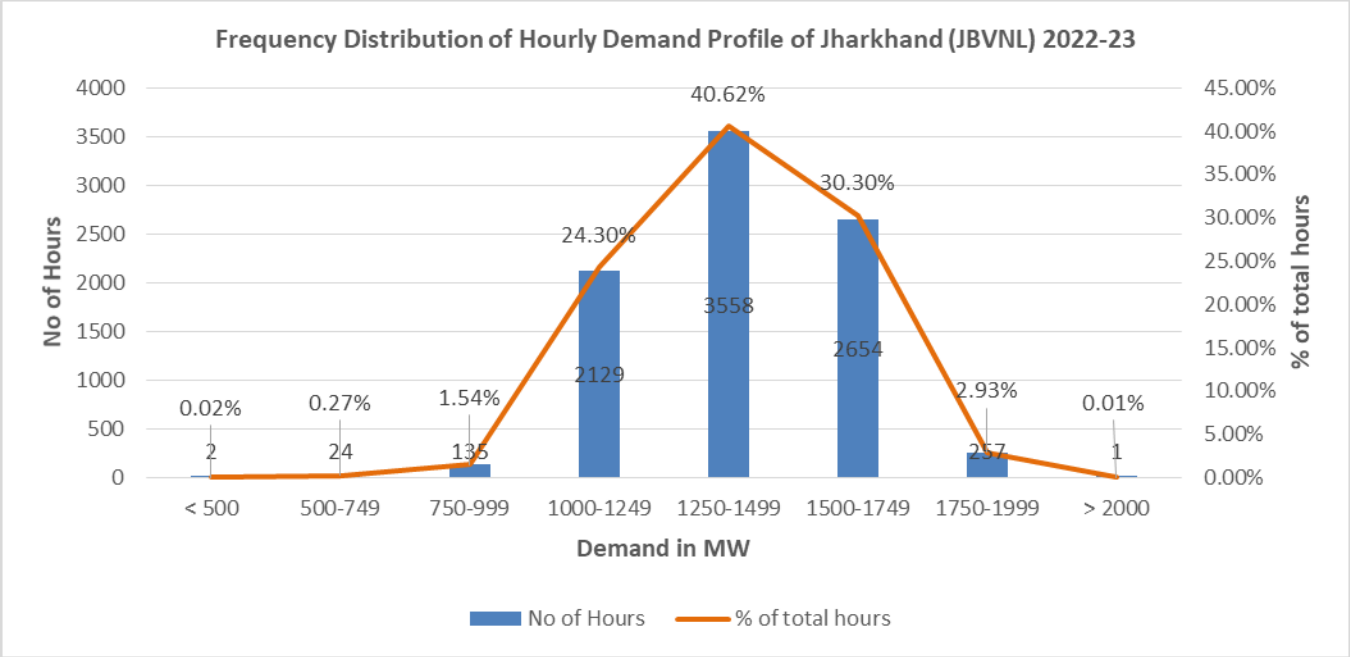


Figure 4 Frequency Distribution of Hourly Demand Profile of Jharkhand (JBVNL) 2022-23

3.0 Inputs/Assumptions for the Study

i) Peak and Energy Demand for the State of Jharkhand (JBVNL) as furnished by the utility, were compared with the 20th EPS (Electric Power Survey) projections. The Demand estimation by Jharkhand (JBVNL) was found to be lower than projected by 20th EPS as shown in Figure 5. Therefore, the Studies have been carried out using 20th EPS projections.

Table 2 Future Demand Projection by 20th EPS

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

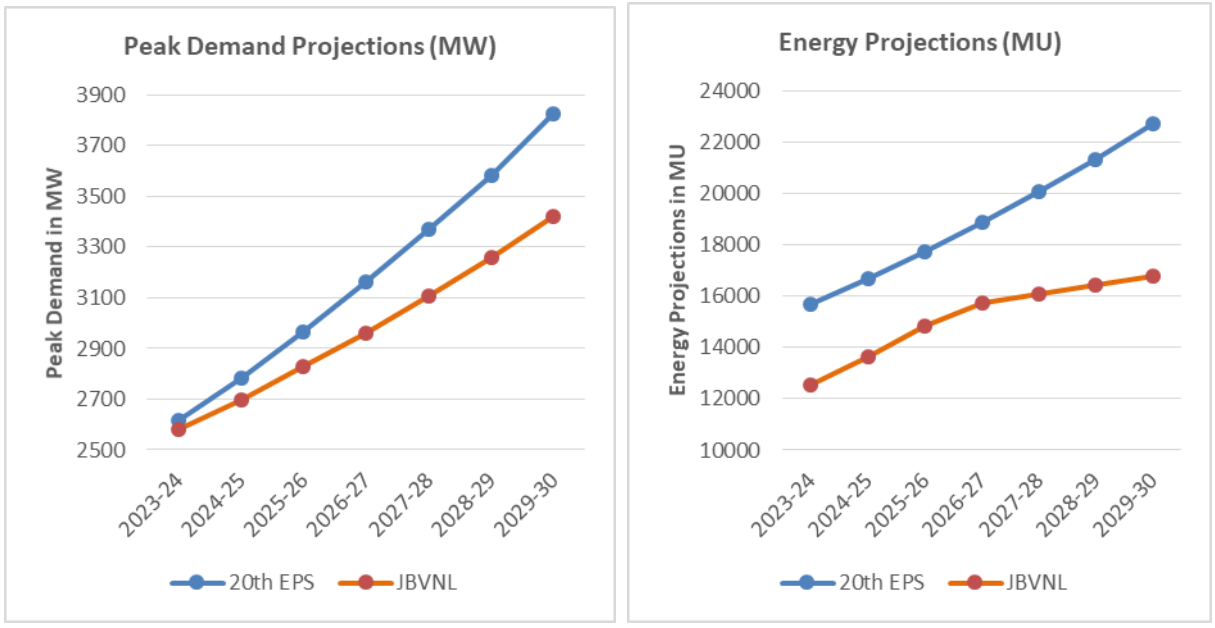


Figure 5 Comparison of Energy Requirement and peak Demand Projections of 20th EPS vs Jharkhand (JBVNL)

ii) Future demand profile for the year 2033-34 has been projected using the demand profile for the year 2022-23 as the base profile.

iii) The actual solar and wind generation profiles and CUFs have been referred from National Electricity Plan.

iv) Capital cost of candidate plants for Coal, Wind, Solar, Battery and PSP have been referred from National Electricity Plan.

v) Existing & Planned Capacity: As per the information received from Jharkhand (JBVNL). (List of Planned Thermal is attached in **Annexure-I**)

Table 3 Year on Year source wise Planned capacity addition (in MW)

FY	COAL	WIND	SOLAR	TOTAL
2023/24	176	200	250	626
2024/25	1536	200	250	1986
2025/26	680	200	250	1130
2026/27	139	200	250	589
2027/28	0	200	250	450
2028/29	0	200	250	450
2029/30	1360	200	250	1810
TOTAL	**3891**	**1400**	**1750**	**7041**

vi) **Renewable Purchase Obligation (RPO) trajectory**: Ministry of Power 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. 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 increase beyond 2029-30. Therefore, the RPO trajectory is assumed to rise steadily beyond 2029-30 and hence, RPO targets till 2033-34 are given below:

*Table 4 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)	(6)	(5)	(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%	33.10%	3.9%	41.36%
6.	2029-30	3.48%	1.33%	34.02%	4.5%	43.33%
7.	2030-31	40.50%			5.0%	45.50%
8.	2031-32	41.50%			5.5%	47.00%
9.	2032-33	42.30%			6.0%	48.30%

10.	2033-34	43.00%	6.5%	49.50%

*Trajectory for RPO till 2029-30 as per MoP RPO order notified in October,2023. After 2029-30, RPO targets assumed based on anticipated RE capacity requirement on national level given in National Electricity Plan (Vol-I Generation)

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 tabulated below:

*Table 5 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)	(6)	(5)	(7)
1	**2024-25**	112	63	4561	250	4987
2	**2025-26**	257	216	5009	372	5855
3	**2026-27**	372	253	5657	510	6793
4	**2027-28**	492	285	6353	663	7793
5	**2028-29**	629	303	7055	831	8815
6	**2029-30**	791	302	7733	1023	9849
7	**2030-31**	9641			1190	10831
8	**2031-32**	10310			1366	11676
9	**2032-33**	10967			1556	12522
10	**2033-34**	11634			1759	13393

*Considering the fungibility aspect of RPO targets among Wind, Hydro and other RE generation

Accordingly, the additional source wise MW requirement considering the fungibility aspects in the RPO has been estimated by the model as tabulated below:

Table 6 As per RPO trajectory, Jharkhand needs to add/contract following additional capacity (MW).

FY	HYDRO	WIND	SOLAR	DRE	TOTAL (in MW)
2024/25	0	0	0	196	**196**
2025/26	0	0	0	96	**96**
2026/27	0	0	0	108	**108**
2027/28	20	0	0	119	**139**
2028/29	0	0	0	132	**132**
2029/30	0	0	0	150	**150**
2030/31	0	150	143	131	**424**
2031/32	0	150	150	138	**438**
2032/33	0	150	150	148	**448**
2033/34	0	150	150	159	**459**
TOTAL	**20**	**600**	**593**	**1377**	**2589**

4.0 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 very 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 load) 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 are 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 expressed as a certain % of peak load forecast of the system.

4.1 Demand variation:

The variation in demand pattern of Jharkhand (JBVNL) for last 5 years has been analyzed. The hourly demand variation for consecutive years (i.e., 2021-22 and 2022-23) has been analyzed. The Demand pattern variation of 2021-22 and 2022-23 is shown below.

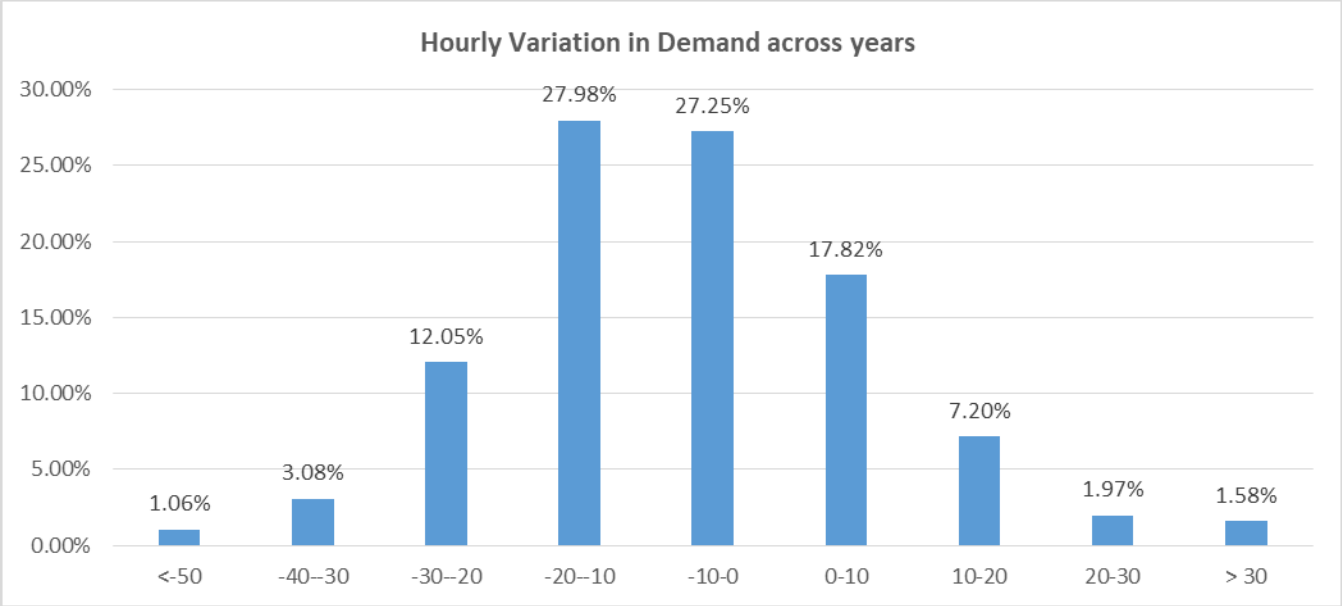


Figure 6 Hourly Variation in Demand across years

It can be observed that the hourly demand typically varies ±20% for 80% of instances. This variation is primarily due to temperature, weather parameter or any random outages of transmission line and generation units etc. This variation has been captured in the reliability study by varying the projected hourly demand for the future years by varying ±20% by introducing a random variable (with normal distribution) for demand as per observed behavior over the years.

4.2 RE variation

In the Long-term capacity expansion planning studies, a particular profile for Solar and Wind Plants are considered based on the observed solar and wind generation data to determine the optimal capacity mix. However, due to intermittent nature of these sources the generation from these non-dispatchable sources may vary across years. As per the analyses carried out based on historical generation data, solar generation and wind 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.

4.3 Forced Outage of Thermal Generators

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

Based on these variations, reliability studies are carried out to ascertain robustness of the system. The LOLP & EENS of the system is within specified range.

5.0 Results of the study

5.1 Unserved Demand Projections

The study was carried out considering existing capacity and planned capacity only. It was observed that the unserved energy in the year 2033-34 is zero. This is expected due to significant planned coal capacity tie ups envisaged by the utility in future years.

5.2 Capacity Mix Projection

The study was carried out considering existing capacity, planned capacity and additional capacity required to fulfil the RPO obligations.

The year wise capacity projections for Jharkhand (JBVNL) are given below:

Table 7 Year-wise contracted capacity projections (in MW)

Year	COAL	HYDRO	WIND	SOLAR	Storage	DRE	Total	STOA
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 projected contracted capacity mix, year-wise is given in the figure below:

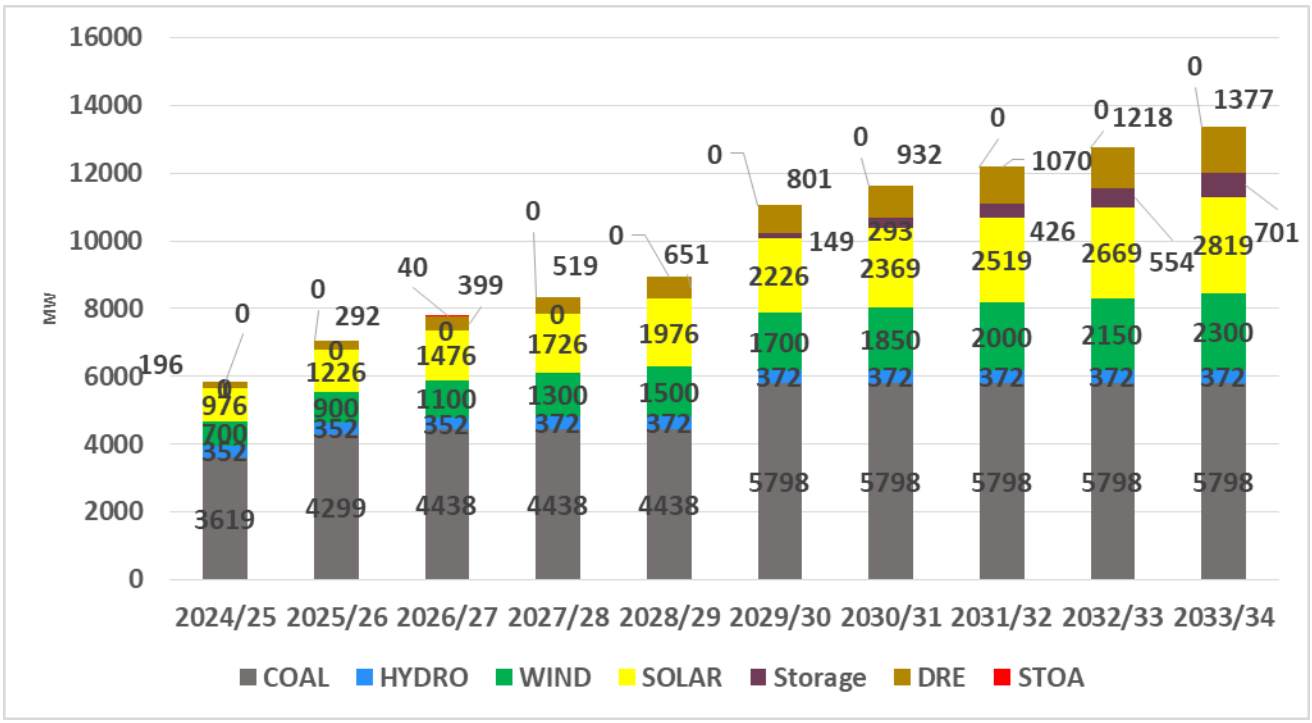


Figure 7 Projected Contracted Capacity Mix Year-wise (MW) for Jharkhand (JBVNL)

As per the Resource Adequacy studies, the total projected contracted Capacity for the year 2033-34 is 13,366 MW which consists of 5798 MW from Coal, 372 MW from Hydro, 2819 MW from Solar, 2300 MW from Wind, 700 MW of Storage, 1377 MW from DRE. This IC shall be able to meet the projected demand with prescribed reliability criteria.

The Reliability studies have been carried out to adhere to the reliability criteria of LoLP and NENS as provided in NEP (0.2% and 0.05% respectively). The PRM for the state of Jharkhand (JBVNL) has been assessed as 28.8%. In addition, the projected/contracted capacity fulfils the stipulated Renewable Purchase Obligation and aforementioned reliability criteria.

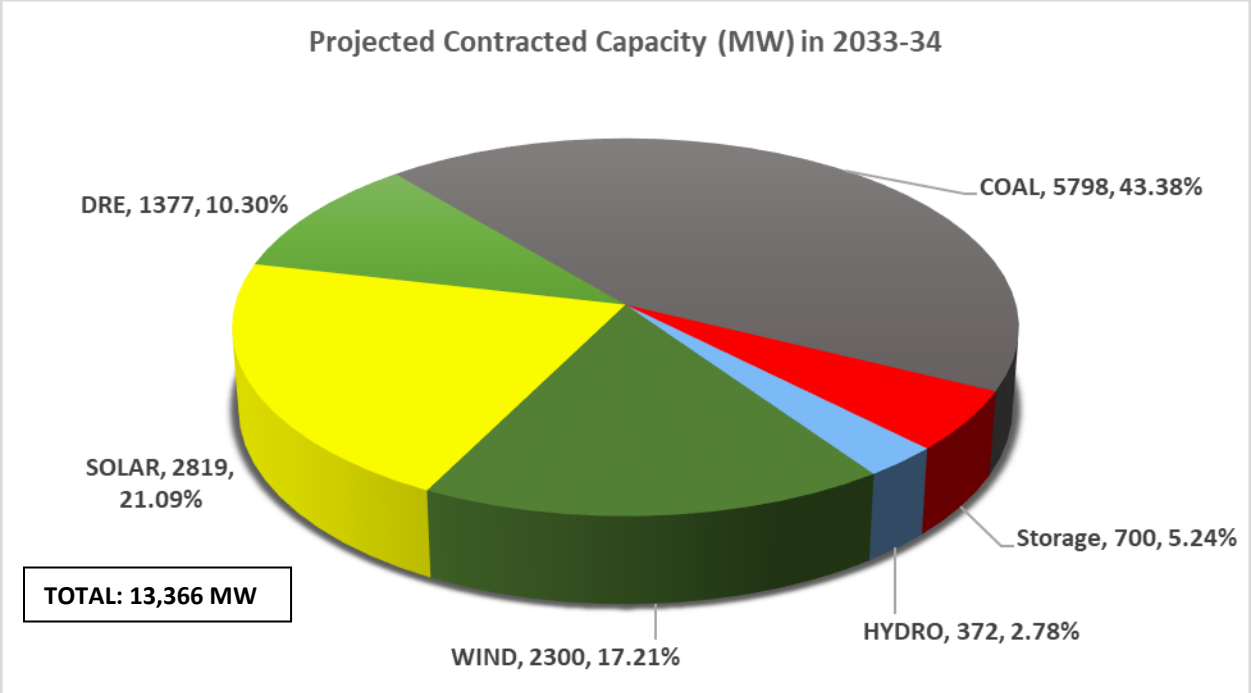


Figure 8 projected Capacity Mix in 2033-34 with 28.8% PRM

The share of non-fossil fuel-based capacity in the generation mix is projected to increase to around 51.4 % by 2033-34 from 37% in 2022-23 with higher contribution from non-fossil fuel-based capacities in alignment with RPO trajectory.

The projected generation mix for the state is shown in Figure 9 & 10 below:-

It is seen that the share of non-fossil generation will increase to around 50% by FY 34.

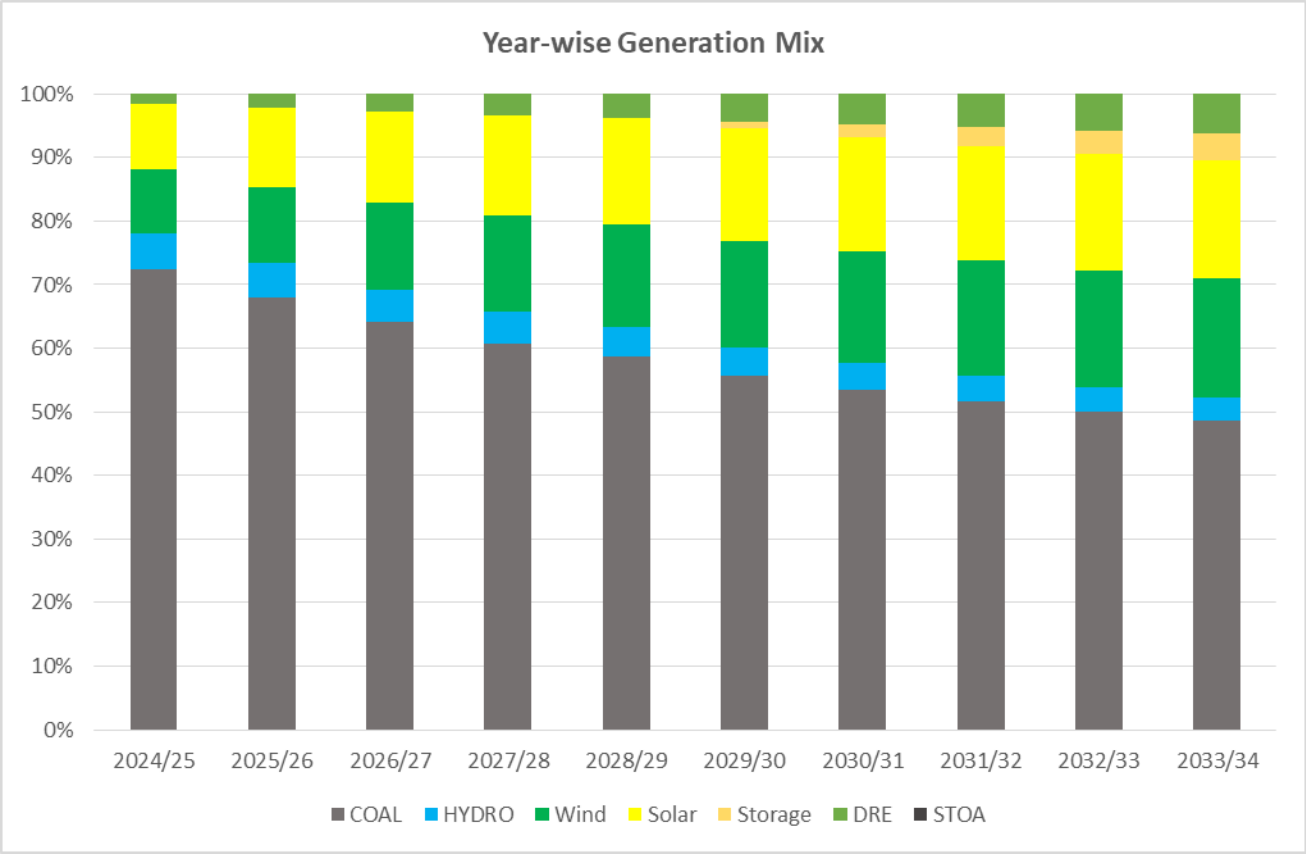
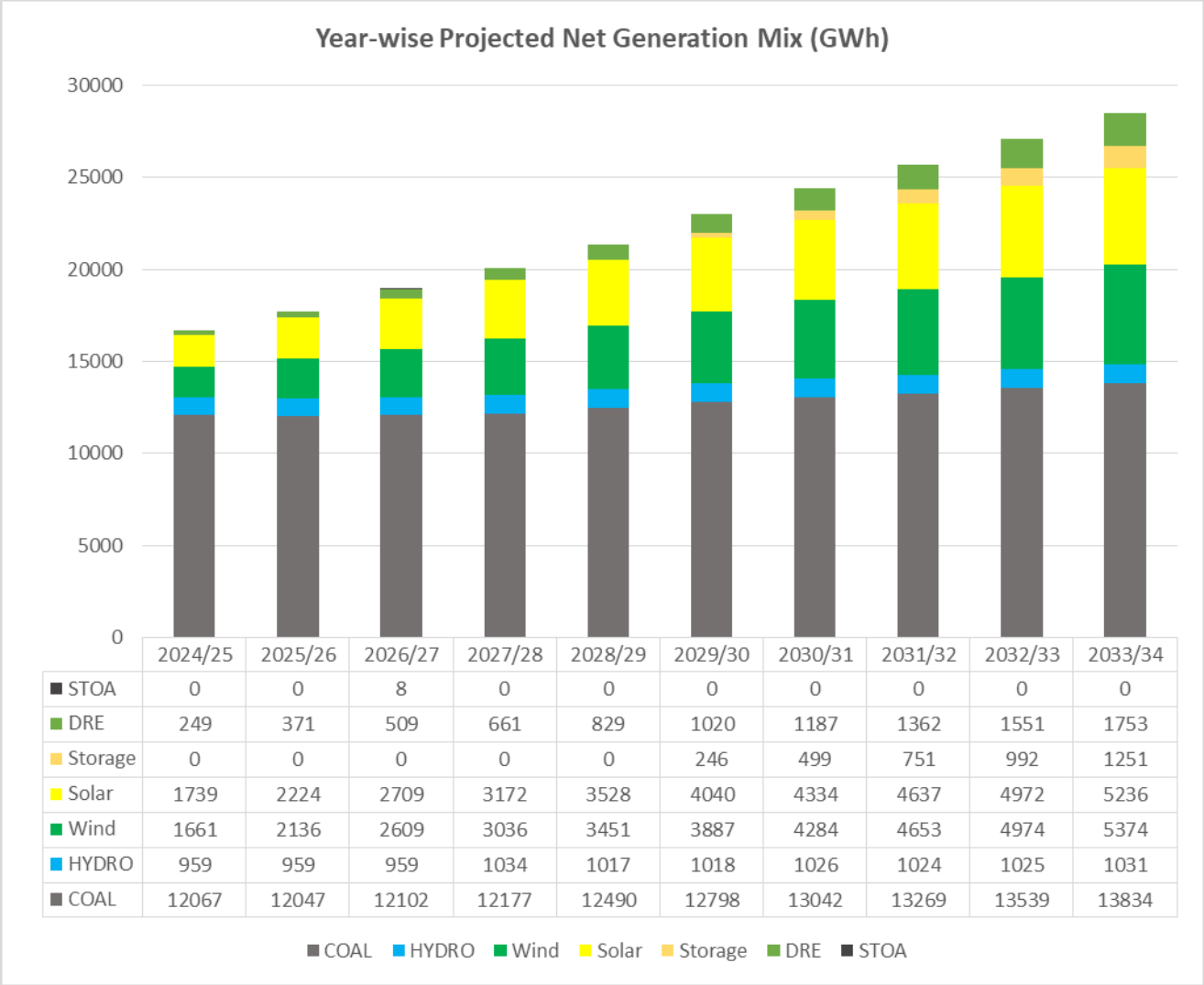


Figure 9 Projected Generation Mix (%)



	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34
STOA	0	0	8	0	0	0	0	0	0	0
DRE	249	371	509	661	829	1020	1187	1362	1551	1753
Storage	0	0	0	0	0	246	499	751	992	1251
Solar	1739	2224	2709	3172	3528	4040	4334	4637	4972	5236
Wind	1661	2136	2609	3036	3451	3887	4284	4653	4974	5374
HYDRO	959	959	959	1034	1017	1018	1026	1024	1025	1031
COAL	12067	12047	12102	12177	12490	12798	13042	13269	13539	13834

Figure 10 Year-wise projected net generation mix (in GWh)

5.3 Capacity contract requirement for future

It has been found out in the studies that Jharkhand (JBVNL) needs to contract following capacities (planned and additional) per year till 2033-34 to meet its demand reliably while ensuring fulfilment of its RPO obligations.

FY	Thermal	Hydro	SOLAR		Wind		Storage	Yearly STOA	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
Total	3891	20	1750	593	1400	600	700	40	7455	7041	9409

Table 8 Year-wise Capacity Addition for Jharkhand (JBVNL) (in MW)

5.4 Projected Coal Capacity utilization

The coal capacity PLF is expected to remain in the range of 25%-38 % for the years till 2034 ensuring higher absorption of higher renewable energy.

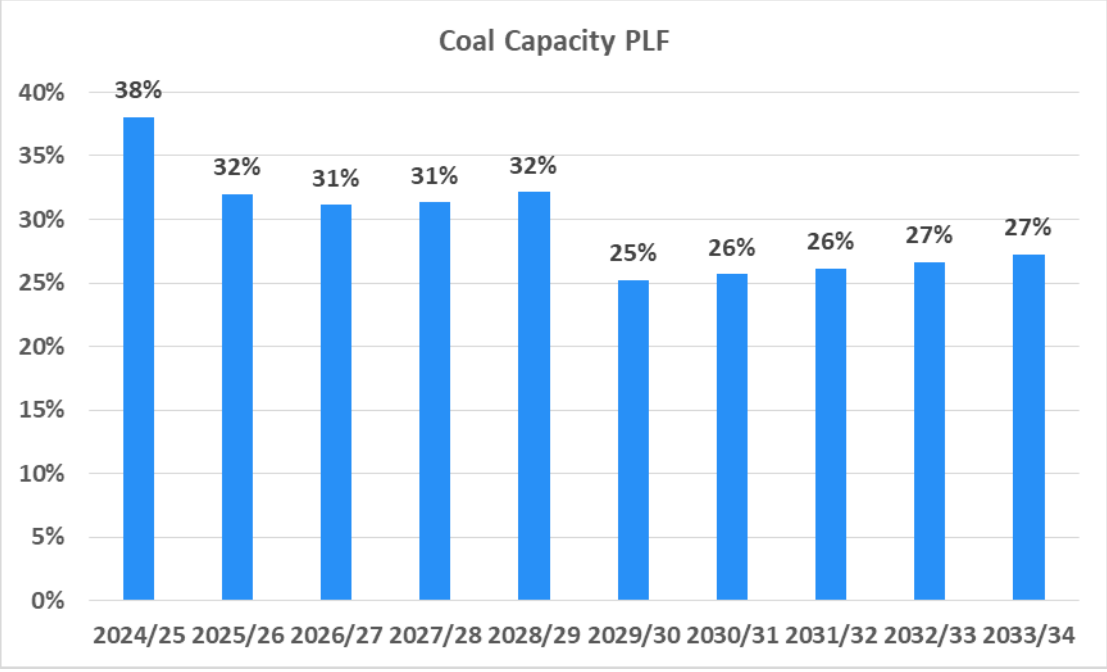


Figure 11 Year-wise coal capacity PLF for Jharkhand (JBVNL) (in %)

Based on the information received from the utilities of the planned future tie ups of coal based capacity. It is seen from the studies that the state is likely to have surplus coal based generation available after meeting the projected hourly demand (as shown in Figure 12). This indicates that the state may look for banking / medium term bilateral agreements with other states to optimize utilization of these likely surpluses.

5.5 Projected Aggregate Surplus generation for Jharkhand (JBVNL)

Surplus generation is likely to be available with the state due to RE availability, Demand variation etc. The pattern of surplus capacities for Jharkhand (JBVNL) has been observed as shown below. This capacity can be shared with other states and reduce the fixed cost burden on the utilities resulting in reduction in the cost for consumer. Jharkhand (JBVNL) has likely surplus capacity available during the day time in the range of 1300-3200 MW for 2026-27 as shown below which can be shared with other states / utilities.

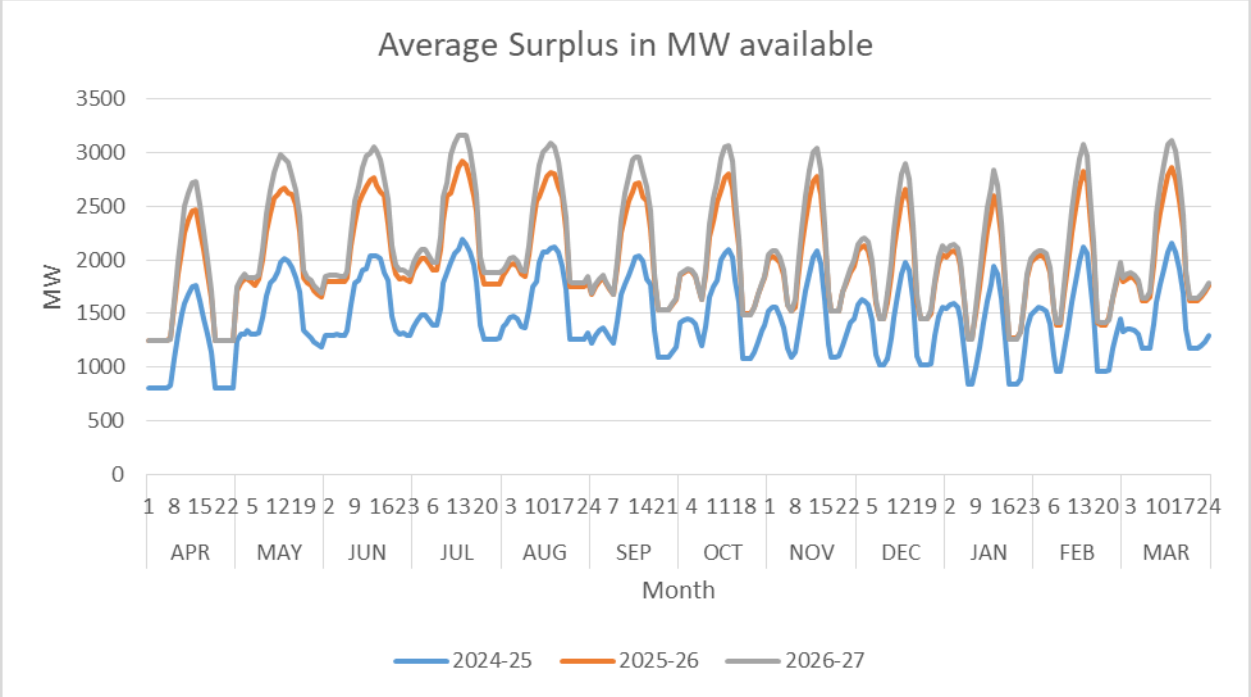


Figure 12 Average Surplus Coal generation Year-wise (MW)

6.0 Alternate Resilient Scenario Analysis

In view of the recent surge in Power demand during the year 2023-24 and capacity addition being delayed compared to the envisaged timelines, it was realized that a stress scenario may be assessed to comprehend such situations arising in the future and prepare the utilities for navigating such challenging situations optimally so as to fulfil their consumer end demand reliably.

The following cases were considered simultaneously in the Alternate Resilient scenario:

- Peak and Energy Demand- 5% increase compared to the EPS demand
- 70% of RPO requirement is ensured to be met with the delayed capacity addition plan
- Capacity Addition being delayed from their anticipated year as follows:

Table 9 Time Delay in commissioning of contracted capacity

Contracted Capacity Type	Years Delayed
Hydro	2
Nuclear	2
Renewable Energy Capacity	1
Coal	1

6.1 Capacity Mix Projections

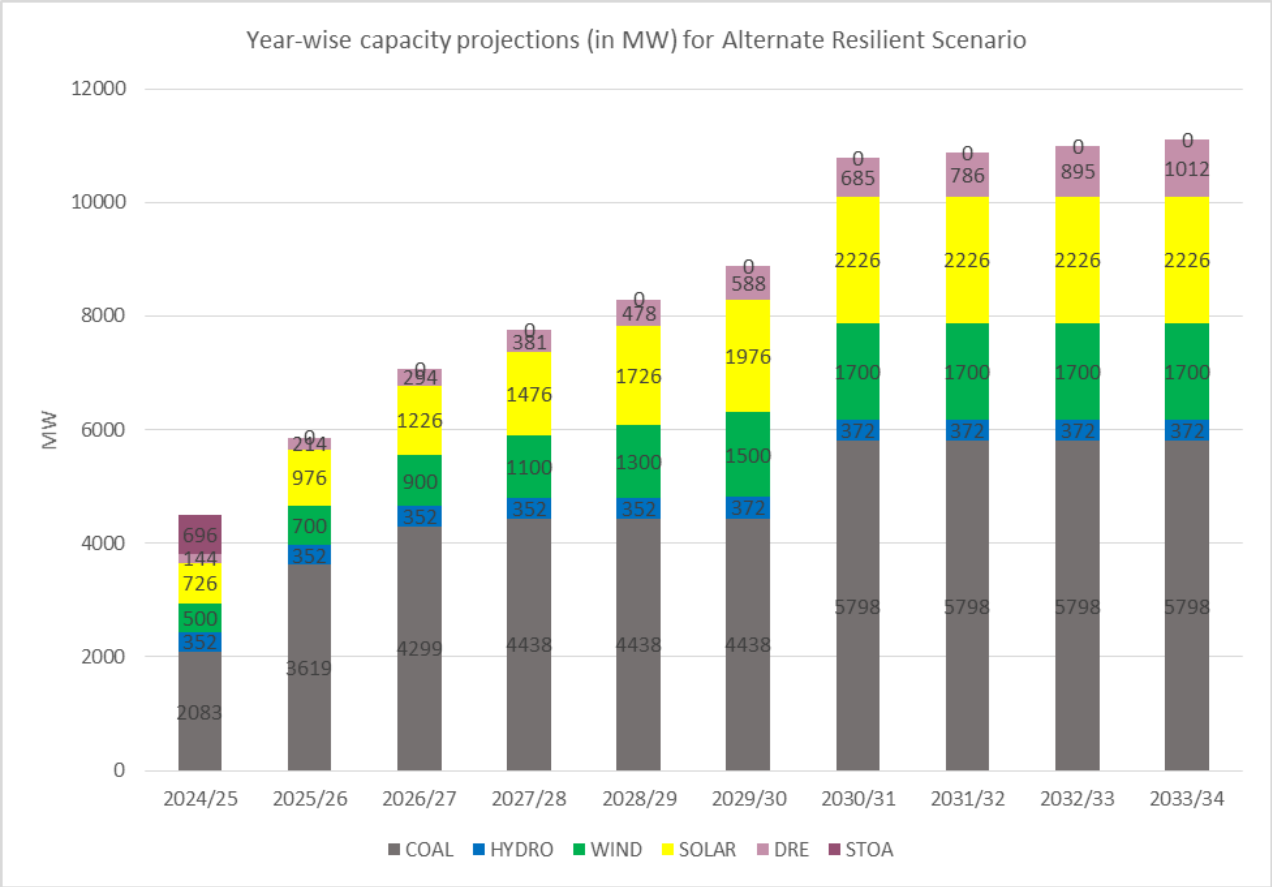


Figure 13: Year-wise capacity projections (in MW) for Alternate Resilient Scenario

In the Alternate Resilient Scenario, the total projected contracted Capacity for the year 2033-34 is 11,108 MW which consists of 5798 MW from Coal, 372 MW from Hydro, 2226 MW from Solar, 1700 MW from Wind, 1012 MW from DRE. This IC shall be able to meet the projected demand with prescribed reliability criteria.

It is noted that in this scenario, to meet the increase in envisaged demand in view of delayed commissioning of capacity planned / required to meet RPO , the state still has sufficient capacity planned with which the demand may be met.

7.0 Conclusion

Based on the RA study results, the following observations are made:-

1. The study was carried for assessing the resource adequacy of Jharkhand (JBVNL) based on the demand projections by 20th Electric Power Survey report (The demand projections by Jharkhand (JBVNL) are lower compared to the demand projections report by 20th Electric Power Survey (EPS)).
2. The current capacity mix in Jharkhand (JBVNL) has 63% of IC from fossil fuel sources.
3. The study is based on the hourly load pattern of the year 2022-23. The peak demand month is April.
4. The state has sufficiently surplus coal based capacity planned such that in order to meet the projected demand. Jharkhand (JBVNL) is likely to not witness energy deficit throughout the period of study i.e. from 2023-24 to 2033-34 with the existing and planned capacity addition. However, Jharkhand (JBVNL) is deficit in fulfilment of its Renewable Purchase Obligations (RPO) as per the MOP notification dated 20th October 2023 and needs to contract additional renewable capacities. The projected capacity and generation mix fulfils the RPO obligation.
5 The coal capacity PLF is expected to remain in the range of 25%- 38% for the years till 2033-34 ensuring higher absorption of higher renewable energy. The coal based utilization increases to 35-76% in alternate resilient scenario i.e. if the demand increases and/or the planned capacity tie ups are delayed.
6 In the Alternate Resilient Scenario, the contracted capacity requirement decreases from 13,366 MW to 11,108 MW because only 70% of the Renewable Purchase Obligation (RPO) is assumed to be fulfilled.
7 Further, Jharkhand (JBVNL) has likely surplus capacity available in the range of 1300-3200 MW for 2026-27 as shown below which can be shared with other states.

Annexure-I

Future Contracted/Approved Capacity (MW) of Central and State Sector (Thermal)

SR. NO	POWER PLANT	JHARKHAND (JBVNL)'S SHARE (MW)	TYPE OF GENERATION	EXPECTED COD/ REMARK
1	Patratu Vidyut urja Uthpadan	2040 MW	THERMAL	U-1 & U-2: FY 2024-25 U-3: FY 2025-26
2	North Karanpura Thermal Power	352 MW	THERMAL	U-2: FY 2023-24 U-3: FY 2024-25
3	Darlipali thermal Power Plant phase II	79 MW	THERMAL	FY 2026-27
4	NTPC Nabinagar Phase 2	60 MW	THERMAL	FY 2026-27
5	Patratu Vidyut urja Uthpadan Phase II	1360 MW	THERMAL	FY 2029-30
	TOTAL	**3891 MW**		

Assumption for Resource Adequacy Studies for the state of Jharkhand (JBVNL)

1. Electricity Demand & peak requirement: As per 20th Electric Power Survey
2. Demand Profile: Based on hourly demand profile of 2022-23
3. Existing & Planned Capacity: As per the information received from JHARKHAND (JBVNL)
4. Future Capacity addition: based on RPO trajectory
5. Cost parameters: based on information in National Electricity Plan

RE CUF considered

Hydro PLF Existing & Planned	Solar CUF Existing & Planned	Wind CUF Existing & Planned
31%	18% & 22%	27%

Technical Parameters

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical. (%)	Start -up time (hr)		
					Hot	Warm	Cold
Coal/ Lignite	Existing/Planned	85	1	55	2	5	10
	Candidate	88	1	55	2	5	10
Gas	Existing	90	5	40	1.5	2	3
Nuclear	Existing/Planned	68	Const. Load	-	-	-	-
Biomass	Existing/Planned	60	2	50	2	4	8
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	-	-	-	-
Battery Energy Storage	Candidate	98	NA	-	-	-	-

Technology	Type	Heat Rate (MCal/MWh)		Aux. Consum. (%)	Min. online time (hr)	Min. offline time (hr)	Start-up fuel consumption (MCal/MW)		
		At max loading	At min loading				Hot	Warm	Cold
Coal	Existing/ Planned	2300 to 2879	2438 to 3052	7.0	6	4	600	1000	1800
	Candidate (SC & USC)	2060 to 2125	2183 to 2253	6.5	6	4	600	1000	1800
Gas	Existing	2000 to 2900	2260 to 3277	2.5	4	3	30	50	90
Nuclear	Existing/ Planned	2777	2777	10	6	4	-	-	-
	Candidate	2777	2777	10	-	-	-	-	-
Biomass	Existing/ Planned	4200	4450	8	6	4	600	1000	1800
	Candidate	4200	4450	8	6	4	600	1000	1800
Hydro	Existing/ Planned	-	-	0.7	-	-	-	-	-
	Candidate	-	-	0.7	-	-	-	-	-
Pumped Storage	Existing/ Planned	-	-	pump efficiency 80 %	-	-	-	-	-
	Candidate	-	-		-	-	-	-	-

Battery Energy Storage	Candidate	-	-	Round trip losses 12%	-	-	-	-	-

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 in the year 2021-2022:

Resource	Capex* (in ₹/MW)	O&M Fixed Cost (in ₹/MW)	Construction Time (in years)	Amortization /Life time (in years)
Coal	8.34 Cr	19.54 Lakh	4	25
Hydro~	6 Cr to 20 Cr	2.5% of Capex	5 to 8	40
Solar**	4.5 Cr to 4.1 Cr	1 % of Capex	0.5	25
Wind(Onshore)	6 Cr	1% of Capex	1.5	25
Wind(Offshore)	13.7 Cr	1% of Capex	1.5	25
Biomass	9 Cr	2% of Capex	3	20
Pumped Storage	3 Cr to 8 Cr	5 % of Capex	7	40
Battery Energy Storage (2-Hour)	5.13 Cr to 3.13 Cr	1 % of Capex	0.5	14
Battery Energy Storage (4-Hour)	8.22 Cr to 4.72 Cr	1 % of Capex	0.5	14
Battery Energy Storage (5-Hour)	9.77Cr to 5.51 Cr	1 % of Capex	0.5	14
Battery Energy Storage (6-Hour)	11.31 Cr to 6.30 Cr	1 % of Capex	0.5	14

* All the Capex figures are on actual basis at the cost level of 2021-22 i.e., inflation is not considered while calculating capex.

~ The Capex values of Hydro and PSS candidates are considered as per the project cost details furnished by the respective developers for state and private sector plants and as per RCEs done periodically by CEA for central sector plants.

**Solar Cost is assumed to reduce from Rs 4.5 Cr/MW in 2021-22 to Rs 4.1 Cr/MW in 2029-30.