

Report on
Resource Adequacy Plan
(Generation)
for
Madhya Pradesh
(2025-26 to 2036-37)

February, 2026

Government of India
Ministry of Power
Central Electricity Authority

Contents

Disclaimer ii

Executive Summary iii

1. Introduction 1

2. Highlights of Previous RA study (2024-25 to 2034-35) 2

3. RA Study for Madhya Pradesh (2025-26 to 2036-37) 4

3.1 Present Power Scenario in Madhya Pradesh 4

3.2 Analysis of Electricity Demand 5

4. Inputs/Assumptions for the Study 7

5.0 Reliability Analysis 10

6.0 Results of the study 13

6.1 Unserved Energy Projections 13

6.2 Scenario 1: Considering RCO trajectory in line with MoP Regulation 15

6.3 Scenario 2: Considering RPO trajectory in line with MPERC Regulation 25

7.0 Conclusions 34

Assumptions for Resource Adequacy Studies for the state of Madhya Pradesh 36

Disclaimer

This Resource Adequacy study for the state of Madhya Pradesh has been conducted based on data and inputs provided by the MPPMCL. The findings, analysis and conclusions presented in this report are contingent upon the accuracy, completeness and timeliness of the information furnished by MPPMCL. 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 MPPMCL 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 any financial implications etc., rests entirely with MPPMCL.

Executive Summary

The electricity demand for the State of Madhya Pradesh is projected to increase with a CAGR of 5.7 % from 2025-26 to 2036-37 as per the projections of MPPMCL. For satisfying resource adequacy i.e., meeting the electricity demand reliably and at affordable cost, the State needs 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 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.

Agrarian nature of the state economy and seasonality contributes to the seasonal and diurnal variation of the electricity demand. The electricity demand generally starts increasing from the month of October and is maximum during the month of January. The demand during the months of November, December, January and February is significantly higher compared to rest of the year. The lowest electricity demand is generally in the month of July. The peak electricity demand is generally observed during morning hours in winter season and evening hours in summer season.

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 prepare LT-DRAP (Long term Distribution Licensee Resource Adequacy Plan) to reliably meet the peak electricity demand and electrical energy requirement.

Ministry of Power, Government of India has notified RCO till 2029-30 which ensure certain amount of energy consumption to be met from renewable energy sources. However, MPSERC has notified an alternative trajectory for the state of Madhya Pradesh which mandate slightly lower obligation percentage compared to the one notified by Ministry of Power recently in September 2025.

Madhya Pradesh has also planned for Agricultural load shifting during solar hours for higher absorption of Renewable energy, achieving the twin objectives of cost efficiencies and energy transition. The resource adequacy studies for the period (2025-26 till 2036-37) to assess the hourly generation dispatch with the existing and planned capacity have been carried out to assess the hourly demand supply gap till 2036-37 for Madhya Pradesh based on inputs received from MPPMCL. It was found that the state's likely contracted capacity along with the trajectory of the banking arrangement is not sufficient to meet capacity addition requirement for conventional as well as renewable energy sources to meet projected electricity demand.

To find out the least cost option for generation capacity expansion for the period 2025-26 to 2036-37, long-term study for the State of Madhya Pradesh 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 has been carried out considering existing capacity, planned capacity and capacity required to fulfil the Renewable Consumption Obligations (RCO). It was observed that the total unserved energy in the year 2036-37 is expected to be about 19.3 BU which is about 9.6 % of annual energy requirement during the year 2036-37 and primarily observed in the months from November to March. The Resource adequacy studies have projected likely optimal capacity mix for future years till 2036-37 which is able to reliably meet the anticipated electricity demand.

Generation capacity expansion pathways have been considered for the long-term study based on the yearly capacity addition plans of the state along with RCO constraints for RE technologies. In this regard, two scenarios have been included in the RA Studies based on two different RCO trajectories. In one scenario, the Renewable capacities have been assessed in view of adherence to RCO notified by Ministry of Power in September 2025 considering the fungibility among different sources. The RCO beyond 2030 has been extended till 2036-37 based on the trend of anticipated RE capacity addition plan beyond 2030. While in another scenario, the Renewable capacities have been assessed in view of adherence to Renewable Obligations notified by MPERC considering the fungibility among different sources.

The planned addition in nuclear, coal, RE capacity and storage capacity in the respective years has been considered in the studies. The results of the studies indicate that MP may have to procure and plan for substantial investments in RE capacity and Energy Storage System for achieving energy transition towards cleaner energy sources along with coal capacity procurement to meet energy requirement during high demand and low RE availability season in the terminal years of the study.

1. 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.

Resource Adequacy is generally defined as a mechanism to ensure that there is an adequate supply of generation resources to reliably serve projected electricity demand 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 electricity demand and supply conditions in the grid. In the wake of high RE generation, it is important to understand the 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 27th September, 2025, had notified the source wise minimum share of consumption of non-fossil sources (renewable energy) by designated consumers till the year 2029-30. Based on the trajectory specified, hydro, wind solar and other (biomass etc.) RCO quantum in million units (MUs) has been calculated to find the additional quantum of renewable capacity that the state has to contract in addition to its existing/planned capacity to meet the RCO targets.

Resource Adequacy studies have been carried out for Madhya Pradesh based on the inputs received from MPPMCL along with adherence with RCO trajectory corresponding to the relevant scenario. The study suggests the optimal resource mix till 2036-37 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 24x7 considering variation in demand, variation in RE generation and forced outage of thermal capacities. The study has also assessed the requirement of Planning Reserve margin for Madhya Pradesh for catering to above highlighted uncertainties so that the electricity demand can be met reliably throughout the year.

2. Highlights of Previous RA study (2024-25 to 2034-35)

As of August 2024, the total contracted capacity for Madhya Pradesh was 22,840 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC was 44.4 %. The fuel-wise contracted capacity as on August 2024 is given in Table and Figure below:

Table 1: Fuel-wise Contracted Capacity as on August 2024

Source	Contracted Capacity (MW)	Percentage
Coal	12646	55.4%
Gas	50	0.2%
Nuclear	586	2.6%
Hydro	3406	14.9%
Solar	3523	15.4%
Wind	2585	11.3%
Bioenergy	43	0.2%
Total	22840	100.0%

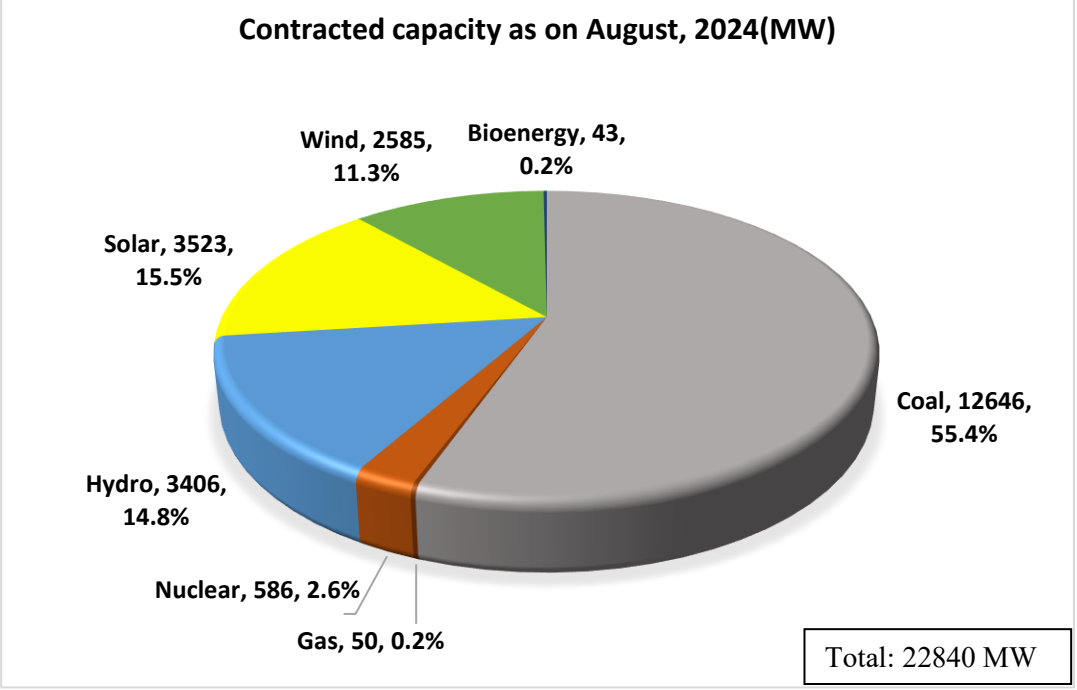


Figure 1 Fuel-wise Contracted Capacity (in MW) as on August 2024

Demand profile for the future years was projected using the hourly demand pattern for the year 2022-23 as the base profile. The year-wise anticipated agricultural load shift was superimposed on the demand pattern to arrive at the final demand pattern of the particular year.

The peak electricity demand and electrical energy projections as per MPPMCL had been considered in the study, which is given in Table 2.

Table 2: Peak electricity demand and Electrical Energy Requirement Projections

	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35
Electrical Energy Projection (MU)	101533	107918	116075	123087	131566	138071	144498	150985	157562	164168	170768
YoY Growth	-	6.29%	7.56%	6.04%	6.89%	4.94%	4.65%	4.49%	4.36%	4.19%	4.02%
Peak Electricity Demand Projection (MW)	19098	20289	21802	23047	24686	25906	27113	28256	29573	30820	32068
YoY Growth	-	6.24%	7.46%	5.71%	7.11%	4.94%	4.66%	4.22%	4.66%	4.22%	4.05%

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 3.

Table 3 Year-wise capacity projections (in MW)

	Coal	Nuclear	Gas	Bio-mass	Hydro	Wind	Solar		Storage (4 hrs.)	Banking	STOA/ MTOA
							Annual	Complim Entary			
Aug'24	12646	586	50	43	3406	2585	3523	0	0	1800	-
2024-25	12646	586	50	43	3518	3438	6870	0	0	1800	1700
2025-26	12646	586	50	43	3561	3438	9870	0	1377	1500	1700
2026-27	12978	586	50	43	3745	4238	12917	0	2911	1200	1700
2027-28	12978	586	50	43	3745	5038	13964	2000	4437	1000	1700
2028-29	16406	586	50	43	3745	5438	15770	2400	4437	900	1700
2029-30	19356	586	50	43	3745	5838	17942	2800	5473	800	1700
2030-31	19516	586	50	43	3745	6238	20326	3200	6119	700	1800
2031-32	20316	586	50	43	3745	6638	22283	3600	7422	600	1900
2032-33	21016	586	50	43	3745	7038	24046	4000	8684	500	2000
2033-34	21716	586	50	43	3745	7438	26119	4500	10007	500	2100
2034-35	22016	1286	50	43	3745	7838	28009	5000	11493	500	2200

3. RA Study for Madhya Pradesh (2025-26 to 2036-37)

3.1 Present Power Scenario in Madhya Pradesh

As of March 2025, the total contracted capacity for Madhya Pradesh is 24,565 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based capacity is around 47%. The fuel-wise contracted capacity as on March 2025 is given in Table and Figure below:

Table 4: Fuel wise contracted capacity

Source	Contracted Capacity (MW) as on March 2025	Contracted Capacity (MW) as on August 2024
Coal	12865	12646
Gas	50	50
Nuclear	586	586
Hydro	3408	3406
Solar	4435	3523
Wind	3179	2585
Bioenergy	42	43
Total	**24565**	**22840**

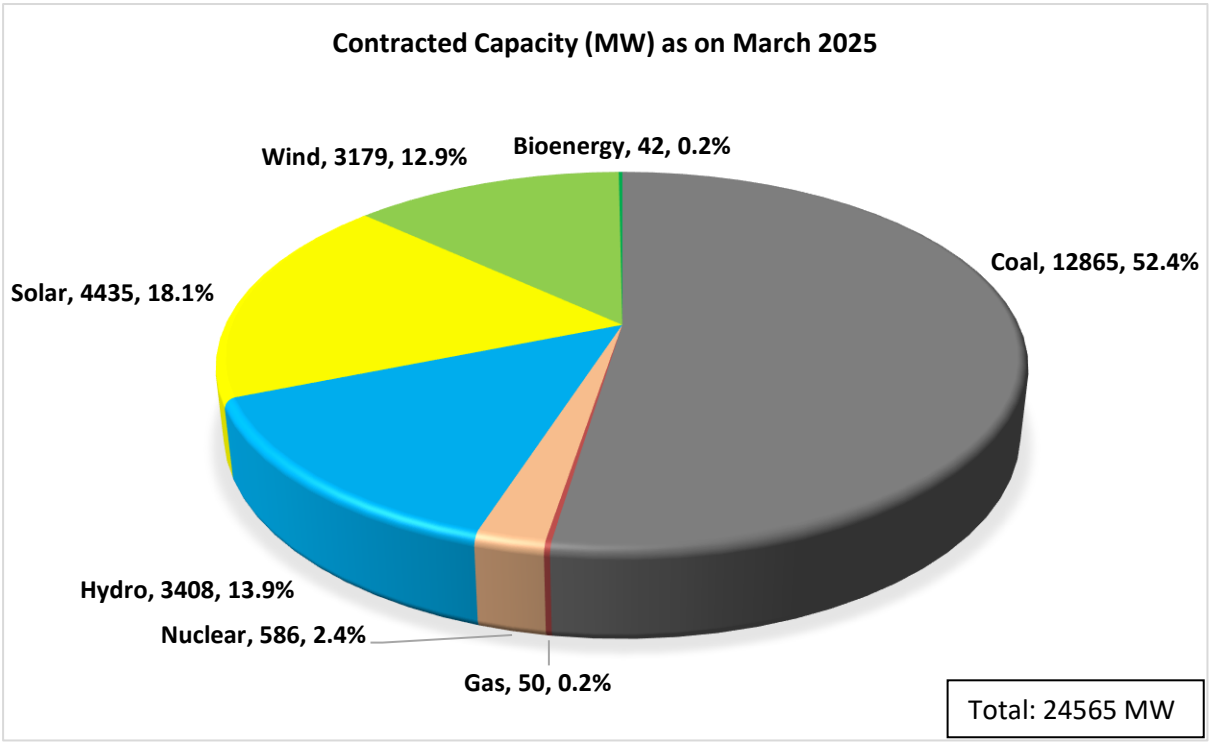


Figure 2: Fuel-wise Contracted Capacity (in MW) as on March 2025

3.2 Analysis of Electricity Demand

Hourly electricity demand pattern of 2024-25 was analyzed for carrying out the RA studies. The analysis of the day-averaged hourly electricity demand for Madhya Pradesh reveals a distinct seasonal pattern across the year. The average daily electricity demand remains relatively high during the winter and early spring months, peaking approximately at more than 17,000 MW. From November to March, the demand consistently stays above 10,000 MW, indicating a clear high-demand period likely driven by increased agricultural activity during the rabi season and moderate climatic conditions. Peak demand season for Madhya Pradesh is during the winter months in December, January and February.

In contrast, the demand declines significantly from June to September, reaching its lowest level in August (around 9,200 MW), marking the low-demand period that coincides with the monsoon season when irrigation load decreases. The months of April, May, and October represent transitional periods between these two extremes, showing intermediate demand levels of around 11,000 –13,000 MW.

Overall, Madhya Pradesh exhibits two distinct continuous demand groups: a high-demand period from November to March and a low-demand period from June to September, reflecting the combined influence of agricultural cycles and seasonal temperature variations on electricity consumption.

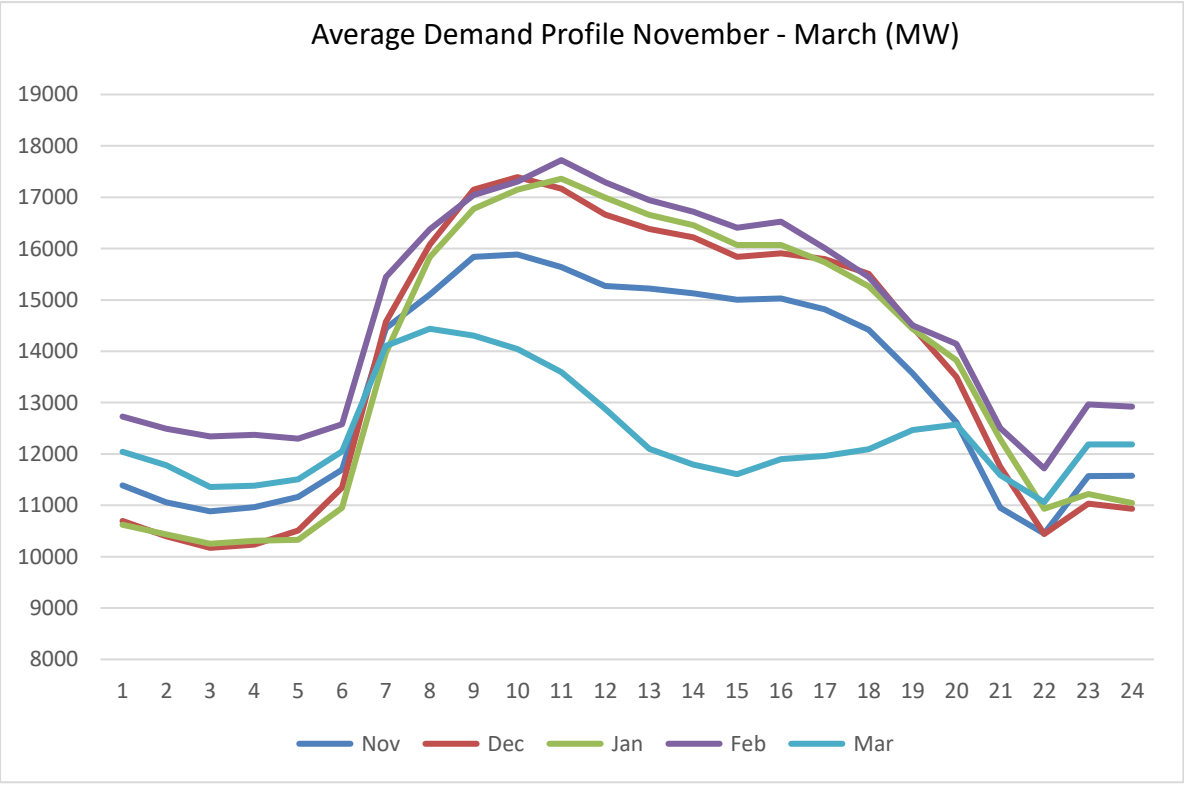


Figure 3: Average Demand Profile for November to March 2024-2025

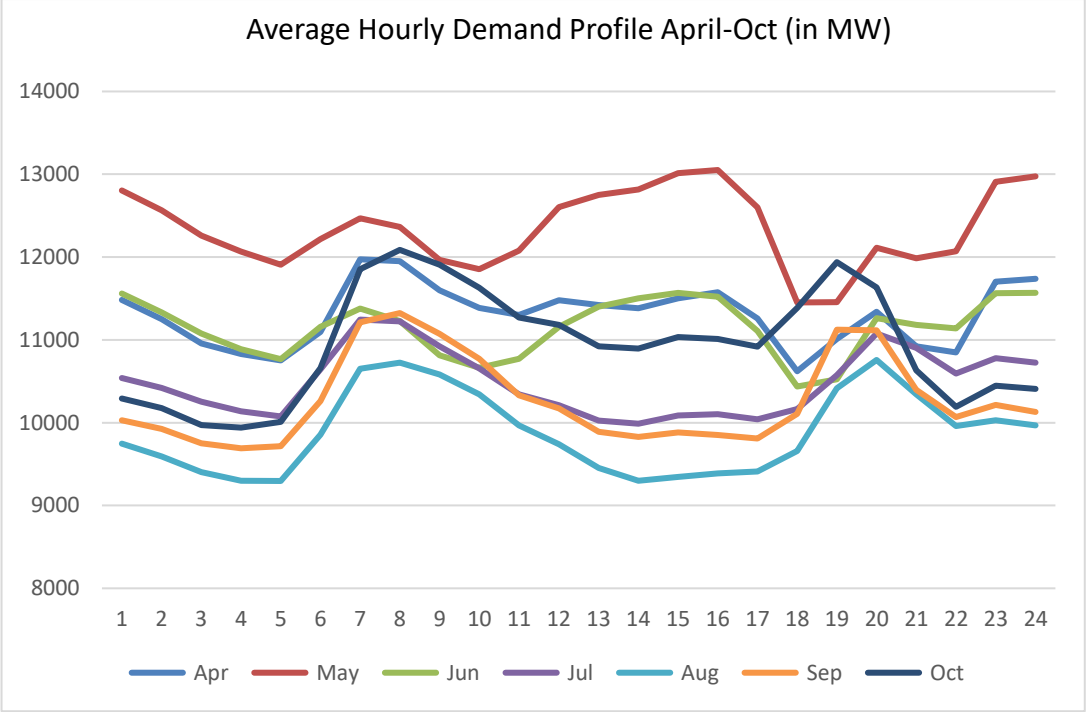


Figure 4: Average Hourly Demand Profile for April to October for 2024-2025

Optimal utilization of resources through short-term contracts like banking or STOA as currently practiced for managing the seasonal variation in demand is one of the effective ways for ensuring resource adequacy in periods of high electricity demand. MPPMCL has informed that Madhya Pradesh has planned for agricultural load shifting during solar hours which has been incorporated in future load pattern of the state.

Hours

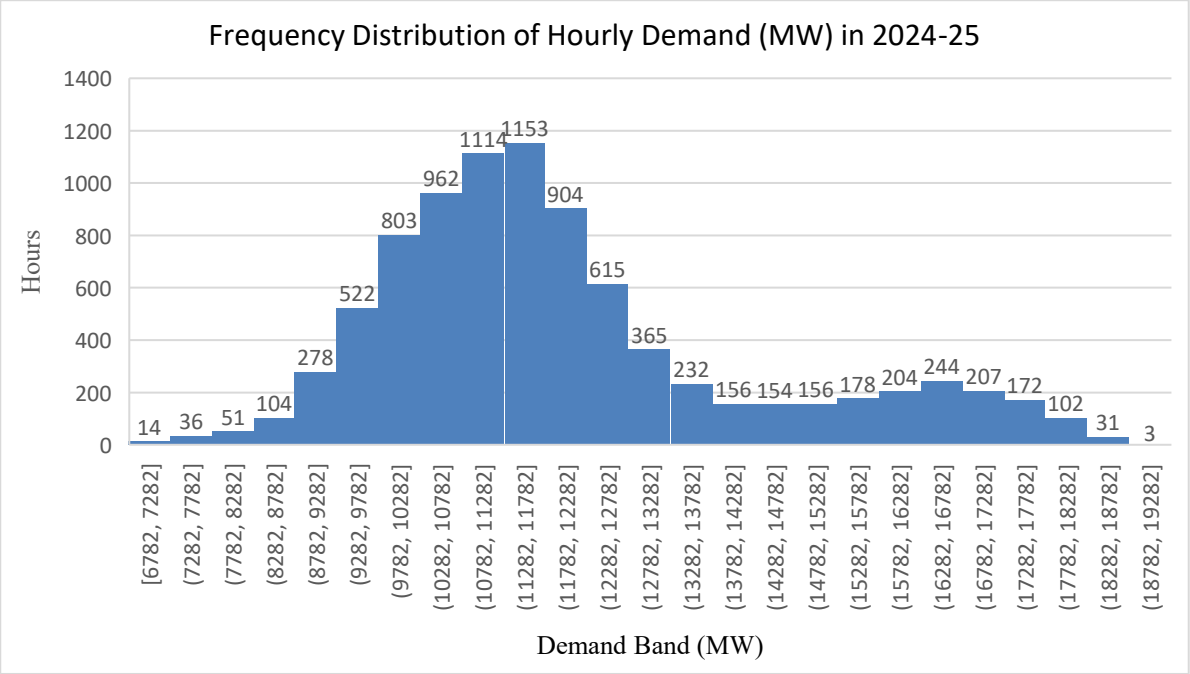


Figure 5: Frequency Distribution of Hourly Demand 2024-25

The frequency distribution of the demand indicates that maximum instances of demand were concentrated in the band of 8,500-13,500 MW for almost 80% of the time. The demand was higher >14000 MW for about 18% of the time which typically occur during the winter months.

The daily non-solar (night peak) and solar (day peak) demand (shown below) for Madhya Pradesh from April 2024 to March 2025 shows clear seasonal variations and a consistent difference between day and night peaks. The peak demand is significantly higher in winter months and happens during day hours while there is insignificant difference in day and night peak during rest of the year.

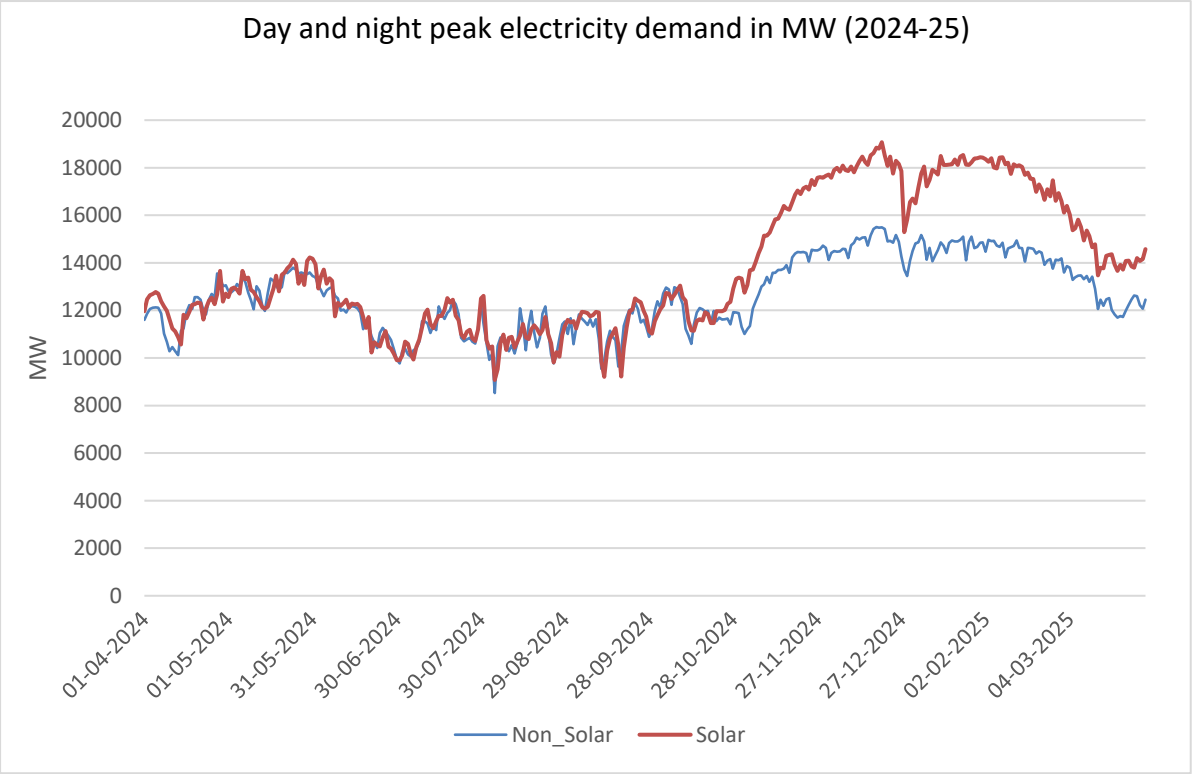


Figure 6: Day and Night Peak in MW (2024-25)

4. Inputs/Assumptions for the Study

i) Peak electricity demand and electrical energy requirement for the state of Madhya Pradesh has been taken as per the latest projections of MPPMCL. The electrical energy requirement of the State is expected to increase at a CAGR of 5.7% till 2036-37. Electricity demand projection by MPPMCL is given in Table 5.

Table 5: Peak electricity demand and Electrical Energy Requirement Projections

	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
Electrical Energy requirement Projection (MU)	109151	116842	123437	130680	138011	145643	153884	162920	174051	183007	191805	200849
YoY Growth	-	7.0%	5.6%	5.9%	5.6%	5.5%	5.7%	5.9%	6.8%	5.1%	4.8%	4.7%
Peak electricity	20647	21847	23106	24437	25780	27150	28652	30277	32294	33725	35093	36418

Demand Projection (MW)												
YoY Growth	-	5.8%	5.8%	5.8%	5.5%	5.3%	5.5%	5.7%	6.7%	4.4%	4.1%	3.8%

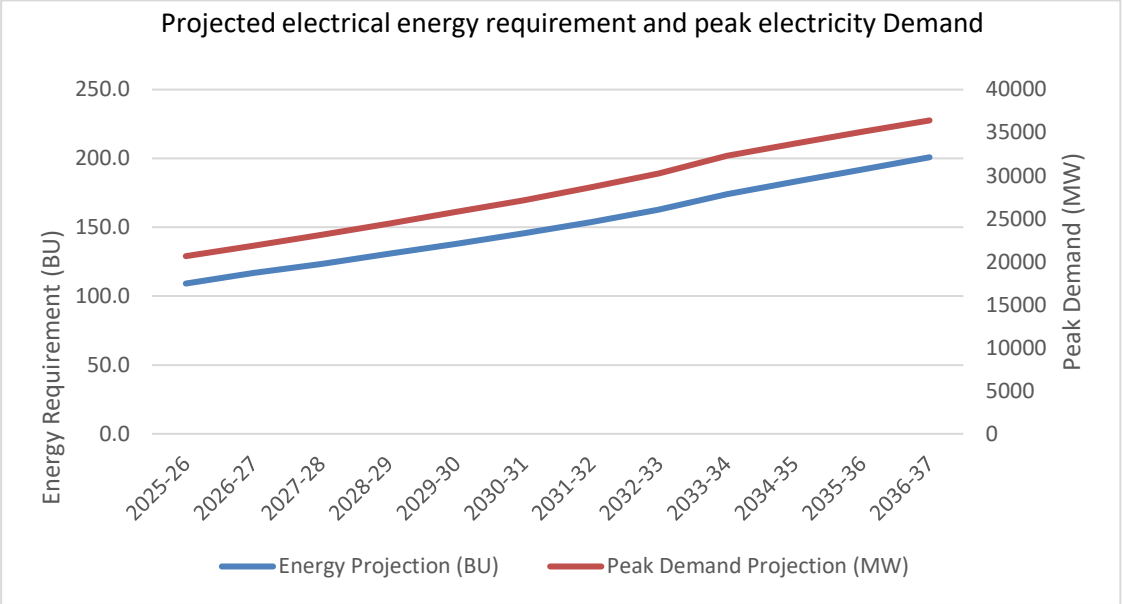


Figure 7: Electrical Energy Requirement (in Billion Units) and Peak Electricity Demand (in MW) Projections of MP as per MPPMCL

ii) Electricity Demand Projections as per 20th Electric Power Survey (EPS) Report is given in Table 6.

Table 6: 20th Electric Power Survey Projections for Madhya Pradesh

	2025-26	**2026-27**	**2027-28**	**2028-29**	**2029-30**	**2030-31**	**2031-32**	**2036-37**
Electrical Energy requirement Projection (MU)	118751	128844	137111	145662	155770	162540	168854	217218
Peak electricity Demand Projection (MW)	20024	21592	22826	24091	25596	26564	27386	33708

The electricity demand for the State of Madhya Pradesh is projected to increase with a CAGR of 5.64 % from 2025-26 to 2036-37 as per the projections of 20th EPS. The electrical energy requirement estimates provided by 20th EPS are slightly higher compared to projections of MPPMCL while the peak demand projections of MPPMCL are higher compared to 20th EPS projections.

iii) Electricity demand profile for the future years has been projected using the hourly demand pattern for the year 2024-25 as the base profile. The year-wise anticipated agricultural load shift has been superimposed on the demand pattern to arrive at the final demand pattern of the particular year.

iv) The actual solar and wind generation profiles and CUFs provided by MPPMCL including that of ISTS connected RE capacity located in high CUF areas have been considered for the Study. The upcoming wind CUF has been considered about 32%, while upcoming solar CUF in the range of 27-28%. The CUF of solar PV rooftop (DRE) has been considered in the range of 19%. If the capacity is tied up from lower CUF solar plants, the capacity requirement will accordingly increase.

v) Capital cost of candidate plants for Coal, Wind, Solar, Battery and PSP have been assumed from the recent technology cost trends and provided in Annexure.

vi) RCO trajectory: The following RCO trajectory has been considered for the studies:

Table 7: RCO Trajectory considered in the study

Year	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
(%) RE Consumption.	33%	36%	39%	41%	43%	45.5%	46.5%	47.5%	48.5%	49.5%	50.5%	51.5%

vii) Existing and Planned Capacity: As per the information received from MP Planning Cell, a total of 2x615 MW of thermal capacity (Mahan) in 2027-28, 63.8 MW share from NTPC's LARA TPP each in 2027-28 and 2028-29, 660 MW of Amarkantak replacement and 660 MW Satpura Replacement Thermal project are also planned in FY 2029-30 and FY 2030-31 respectively. Also, surrendered power (332 MW) from NTPC Mouda I & II will be available from FY 2026-27. MPPMCL has also planned for procuring its share in Sipat Phase-III (160 MW) from 2030-31 along with planned procurement of 800 MW from NTPC Gadarwara Ph-II TPP (2032-33). MPPMCL has also informed that they have planned procurement of 4900 MW from different projects on TBCB route in different years in a phased manner from 2028-29 in 2032-33.

viii) It is also envisaged that MP may get allocation of 700 MW from upcoming Chutka Nuclear Power Plant (2x700 MW) likely to be commissioned in 2034-35 and 2035-36 based on information received from NPCIL and MPPMCL.

ix) MP has also informed that the state is also looking for storage capacity procurement for integrating higher quantum of RE sources. In this regard, MP has planned procurement of 500 MW from PSP on complementary basis (November-April) with UP to be available from 2031-32 and 1190 MW BESS to be available in 2027-28 and 2028-29 in phases.

x) According to the data provided by MPPMCL, an additional 8,564 MW of solar and 1,600 MW of wind is planned which are likely to be commissioned between 2025-26 and 2028-29. MPPMCL has also planned for installation of solar rooftop and solar pumps to the tune of 2,130 MW and 794 MW respectively by 2036-37.

xi) MPPMCL is also exploring opportunities to install Solar PV on complementarity basis with different states due to effect of seasonality in Demand. In this regard, MPPMCL has planned Morena Solar Park-2 (800 MW) on Complementary basis with UP. MP will be drawing power during November-April (6 months) and UP will be drawing power in the

remaining six months. MPPMCL needs to identify other States/Discoms having demand complementarity with MP for setting up such capacity.

xii) The annual STOA/MTOA limit has been restricted till 1000 MW in the initial years and gradually increased to 1500 MW till 2036-37 as per the submission from MPPMCL.

xiii) The annual Wind Capacity addition is limited to 400 MW from 2028-29 till 2033-34. The annual Wind Capacity addition limit is increased till 500 MW beyond 2033-34 based on the submission of MPPMCL.

xiv) MPPMCL has submitted that MP has been allocated hydro power to the tune of 453 MW from Lower Subansiri Lower HEP (105 MW), Rangit HEP IV (16 MW), Teesta HEP VI (45 MW), Ratle HEP (31 MW), Amahata Hydro (3.8 MW) and Dibang HEP (252 MW). Therefore, capacity addition from hydro has been considered limited to 453 MW for the studies till 2036-37. No additional Hydro capacity addition other than the planned procurement has been considered in the study. However, additional hydro capacity may be considered in future revisions of the study if additional hydropower is tied up by the State. Any update with regard to Hydro capacity addition from upcoming hydro projects can be incorporated in the next LT-DRAP version as the exercise of LT-DRAP needs to be carried out annually. The deficit on account of HPO if any, can be met through fungibility from other RE resources as provided in MoP notification dated 27th September 2025.

xv) Details provided by MP for the planned banking arrangements till 2028-29 have also been considered.

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 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 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 analyzing 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 Normalized Energy Not Served, NENS) and the system robustness in case of variation of system parameters.

5.1 Variation in Electricity Demand

The variation in electricity demand pattern of MPPMCL for last two years has been analyzed. The hourly demand variation for consecutive years (i.e. 2023-24 and 2024-25 considering 2023-24 as the base year) has been analyzed. The demand pattern variation across the years is shown below.

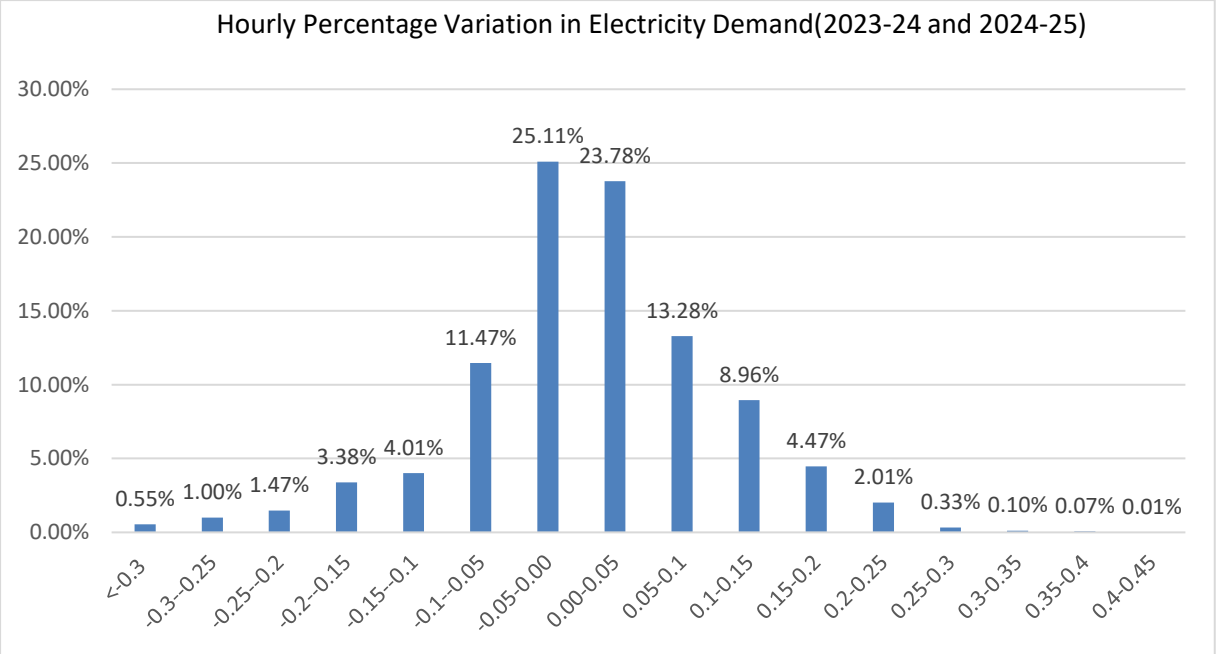


Figure 8 Hourly Percentage Variation in Electricity Demand across 2023-24 and 2024-25

The year-on-year variation in electricity demand between FY 2023–24 and FY 2024–25 shows a strongly centered and nearly symmetric distribution around zero, indicating that overall demand patterns between the two years were largely similar. More than 48% of all observations fall within the narrow range of ±5% variation, suggesting that nearly half of the time blocks experienced minimal change in demand. 73% of values lie within ±10% variation, while over 87% remain within ±15% variation, highlighting a highly stable demand trend across the system. Larger deviations beyond ±20% are quite less (about 4% of total observations), and extreme changes beyond ±30% are almost negligible (less than 1%).

Overall, the variation distribution confirms a stable, well-balanced, and consistent year-to-year demand profile, with only marginal shifts likely arising from local climatic, operational, or consumption behavior factors.

5.2 Variation in RE

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.

5.3 Forced Outage of Thermal Generators

The forced outage rate of thermal generators of MPPMCL were observed for previous years and it was observed that average planned outage rate is typically at 10% with ±5% variation. The same has been incorporated in the model.

Based on the variation reliability studies are carried out to ascertain robustness of the system. The LOLP and EENS of the system is within specified range.

6.0 Results of the study

6.1 Unserved Energy Projections

Initially the study has been carried out considering only the existing and planned capacity addition to analyze the demand supply gap in future years. The existing and planned capacity is not sufficient to meet the projected electricity demand and the year wise unserved energy considering only the existing and planned capacity is shown below:

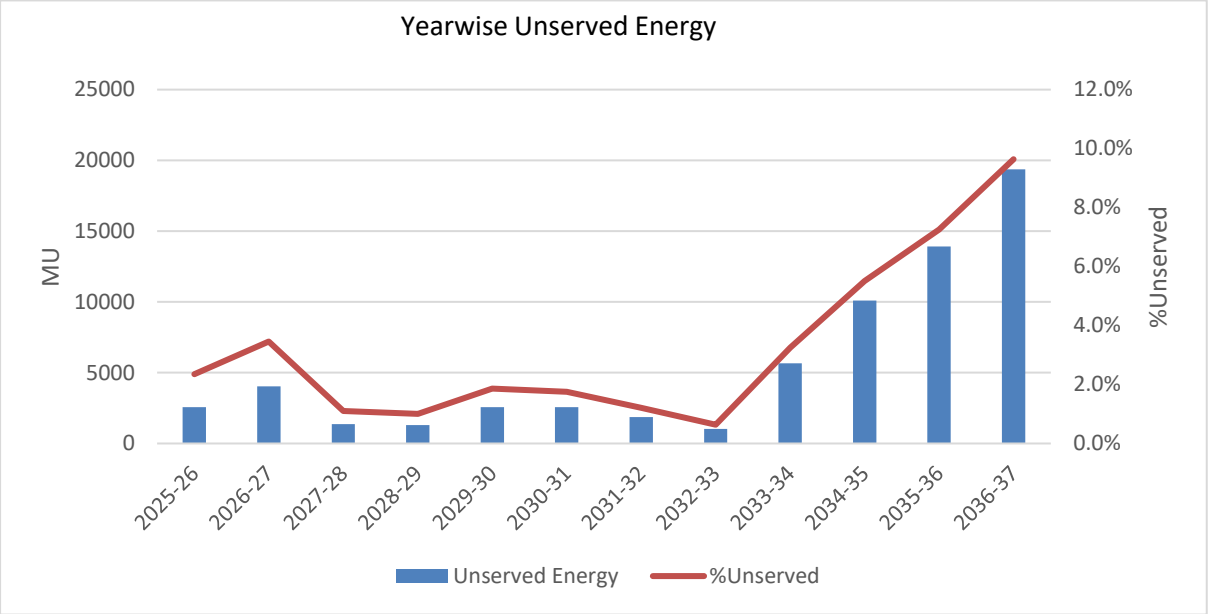


Figure 9: Year-wise unserved energy

The analysis of monthly unserved energy from FY 2026-27 to FY 2036-37 highlights clear seasonal and temporal variations in supply adequacy. During the years 2026-27 to 2032-33, the State experiences moderate energy deficits, primarily between November and February, with monthly unserved energy of about 600-700 MU in December and January. This reflects seasonal demand surges and limited reserve margins during the winter period.

A marked improvement is observed in FY 2031-32 and FY 2032-33, when unserved energy reduces sharply across most months, indicating improved capacity availability and generation reliability with anticipated capacity addition from thermal resources. However, from FY 2033–34 onwards, the trend reverses and the system again begin to face significant shortfalls. By FY 2036-37, the capacity deficit intensifies, with unserved energy rising sharply across almost all months—exceeding 3500 MU during December–February and 1300-1700 MU even during April–June. Even in monsoon months, marginal deficits of about 30-800 MU during July–September indicates that system may experience capacity shortfall even in the low demand season with existing and additional capacity procurement plans.

A comparison of FY 2027-28 and FY 2036-37 further illustrate this deterioration in supply adequacy. In 2027-28, unserved energy was largely confined to the winter months (October–February), with moderate deficits ranging from 180 to 250 MU, and negligible shortages

during the monsoon. By 2036-37, the magnitude and spread of deficits increase sharply across almost all months, with December–February showing the most pronounced shortfalls (~3500 MU). Even months such as April–June and October–November, which earlier showed lower deficits, reflect a substantial rise in unmet demand.

The comparison clearly indicates that while supply in 2027-28 was largely sufficient for most of the year, by 2036-37 the energy deficit becomes both deeper and more widespread, signaling a rising capacity requirement.

If this pattern continues, the total unserved energy by FY 2036-37 is estimated at around 19,300 MU, underscoring the need for timely capacity augmentation, enhanced generation flexibility, and demand-side management. Strengthening supply during solar and evening peak hours will be essential to maintain reliability and meet future demand sustainably.

Table 8: Heatmap for Unserved Energy (in Million Units) for years from 2026-27 to 2036-37

Low UnservedEnergy: High Unserved Energy:

Month	April	May	June	July	August	September	October	November	December	January	February	March
2026-27	565.9	407.8	193.6	36.6	4.5	5.6	112.2	613.4	578.5	727.2	546.0	247.0
2027-28	286.5	112.1	21.5	10.9	0.0	0.0	19.9	178.8	246.0	249.0	190.1	47.7
2028-29	288.0	93.1	20.2	12.2	0.0	0.0	16.4	138.5	246.1	247.9	196.0	48.3
2029-30	345.7	123.7	23.9	17.2	0.0	0.0	17.8	251.2	558.5	609.1	528.5	88.6
2030-31	350.1	127.5	25.8	18.9	0.0	0.0	13.7	225.3	613.3	663.5	451.5	67.3
2031-32	268.4	75.0	24.2	11.7	0.0	0.0	0.0	56.6	500.3	574.4	305.3	50.0
2032-33	110.8	39.7	17.9	2.1	0.0	0.0	0.0	25.0	346.3	325.5	138.6	30.9
2033-34	562.5	324.0	156.1	37.9	0.0	0.0	14.0	431.3	1275.7	1567.1	1171.3	113.6
2034-35	983.9	753.7	504.5	116.3	7.5	6.9	39.6	976.1	2050.4	2347.5	1908.6	391.2
2035-36	1308.7	1078.1	804.1	373.1	26.5	15.2	66.1	1471.8	2635.1	2930.8	2462.1	746.6
2036-37	1760.9	1539.1	1251.5	785.9	54.9	28.2	269.3	2202.1	3427.4	3720.0	3034.0	1287.1

The study also reflects that there is substantial deficit in meeting RCO obligations to the extent of about 10,900 MU by 2029-30 considering all existing and planned RE capacity addition.

6.2 Scenario 1: Considering RCO trajectory in line with MoP Regulation

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. MoP has recently revised the previous RPO in September 2025 notification to be referred now as RCO notification. As per the recent Renewable Consumption Obligation (RCO) notification, energy consumption from nuclear power sources has been excluded in calculation of Renewable Consumption Obligations. In line with the recent notification, the studies have been carried out based on the trajectory mentioned in the RCO notification till 2030. 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 RCO trajectory is assumed to rise steadily beyond 2029-30. The following RCO trajectory has been considered till 2036-37.

Table 9: Renewable consumption Obligation (RCO) trajectory considered for the study

Sl. No.	Year	Wind renewable energy (%)	Hydro renewable energy (%)	Other renewable energy (%)	Distributed renewable energy (%)	Total renewable energy (%)
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
7	2030-31	41.0			4.5	45.5
8	2031-32	42.0			4.5	46.5
9	2032-33	43.0			4.5	47.5
10	2033-34	44.0			4.5	48.5
11	2034-35	45.0			4.5	49.5
12	2035-36	46.0			4.5	50.5
13	2036-37	47.0			4.5	51.5

As the existing and planned capacity is not sufficient to meet the projected electricity demand along with Renewable Obligations, candidate capacities have been given to the model to find the least cost optimal capacity mix required to meet the projected electricity demand. It has been assumed that candidate capacity required for meeting projected electricity demand can only be commissioned/procured as early as 2028-29. The capacity requirement for meeting any deficit arising during 2026-27 or 2027-28 can be met through power markets/ short-term bilateral contracts. The following is observed on the basis of the study:

i. MP has been planning for DRE installation through PM Surya Ghar Muft Bijli Yojana (Solar

PV Rooftop) and PM Kusum schemes for installation of additional 9,290 MW of solar capacity by 2036-37 including 2,130 MW of solar rooftop and 794 MW installation of solar pumps. The same has been considered as planned capacity addition and would contribute as DRE for fulfillment of RCO. The tentative plan of capacity addition via solar rooftop and solar pumps is given at Annexure. The capacity procurement plans of MP in DRE are sufficient to suffice for meeting the DRE requirement as per RCO notification till 2029-30 and beyond as per the assumed RCO trajectory.

ii. For fulfilling the requirement of Storage, BESS candidate capacity has been considered to be available from 2028-29 onwards assuming the storage (BESS) capacity gets commissioned as early as in 2028-29. Similarly, PSP candidate capacity has been assumed to be available as early as 2029-30.

iii. MPPMCL has also submitted that it is planning for installation of solar PV on complementary basis for meeting its higher demand during Rabi season (Q3 and Q4) and sharing the same capacity with other states having high demand during summer season (Q1 and Q2) like UP, Punjab, Haryana etc. The solar complementary plans have also been considered in the studies assuming installation of such capacity to the tune of 12,000 MW by 2036-37.

iv. The STOA/MTOA requirement can be fulfilled through power procurement from market or bilateral agreements and has been limited to 1000-1500 MW across years as per the anticipated power procurement from exchanges as furnished by MPPMCL considering the liquidity available in the market.

v. The STOA/MTOA value reflects the peak value requirement in terms of MW.

vi. The quantum of RCO deficit across the years with existing and planned capacity procurement is given below:

Table 10: Renewable Consumption Obligation (RCO) Compliance

	2025-26	**2026-27**	**2027-28**	**2028-29**	**2029-30**	**2030-31**	**2031-32**	**2032-33**	**2033-34**	**2034-35**	**2035-36**	**2036-37**
RCO (%)	**33.0%**	**36.0%**	**38.8%**	**41.4%**	**43.3%**	**45.5%**	**46.5%**	**47.5%**	**48.5%**	**49.5%**	**50.5%**	**51.5%**
Energy Req. from RE sources (BU)	35.0	40.9	46.7	52.8	58.4	64.9	70.1	75.9	82.9	88.1	93.4	99.9
Energy Available from Tied-up RE (BU)	26.5	35.3	43.5	46.4	47.5	48.3	49	49.5	50.1	51.3	51.8	52.4
Surplus/Deficit (BU)	-8.5	-5.6	-3.2	-6.4	-10.9	-16.6	-21.1	-26.4	-32.8	-36.8	-41.6	-47.5

vii. The capacity projections for Madhya Pradesh on the basis of Resource Adequacy Studies are given below:

Table11: Year Wise Capacity Projections (in MW)

Year	Coal	Gas	Nuclear	Biomass	Hydro	Wind	Solar		Storage		Banking	STOA
							Annual	CMPL	PSP (6 hrs)	BESS (4 hrs)		
2025-26	12865	50	586	42	3408	3179	5236	0	0	0	3600	1250
2026-27	13269	50	586	42	3533	3179	9999	0	0	0	1500	1250
2027-28	14563	50	586	42	3609	4779	13411	0	0	0	1500	1250
2028-29	15527	50	586	42	3609	5179	14706	4300	0	3250	1500	1250
2029-30	16347	50	586	42	3609	5579	14848	7800	963	4440	0	1250
2030-31	17517	50	586	42	3609	5979	15681	9590	963	4572	0	1250
2031-32	19117	50	586	42	3609	6379	17664	9590	1463	4572	0	1250
2032-33	21417	50	586	42	3609	6779	19715	10077	1463	5322	0	1250
2033-34	21061	50	586	42	3609	7179	21912	10279	2477	6072	0	1250
2034-35	21339	50	936	42	3861	7679	22904	10420	2477	6822	0	1500
2035-36	21804	50	1286	42	3861	8179	24878	10661	2816	7572	0	1500
2036-37	22477	50	1286	42	3861	8679	26449	12337	3835	7690	0	1500

The projected capacity mix, year-wise is given in the figure below:

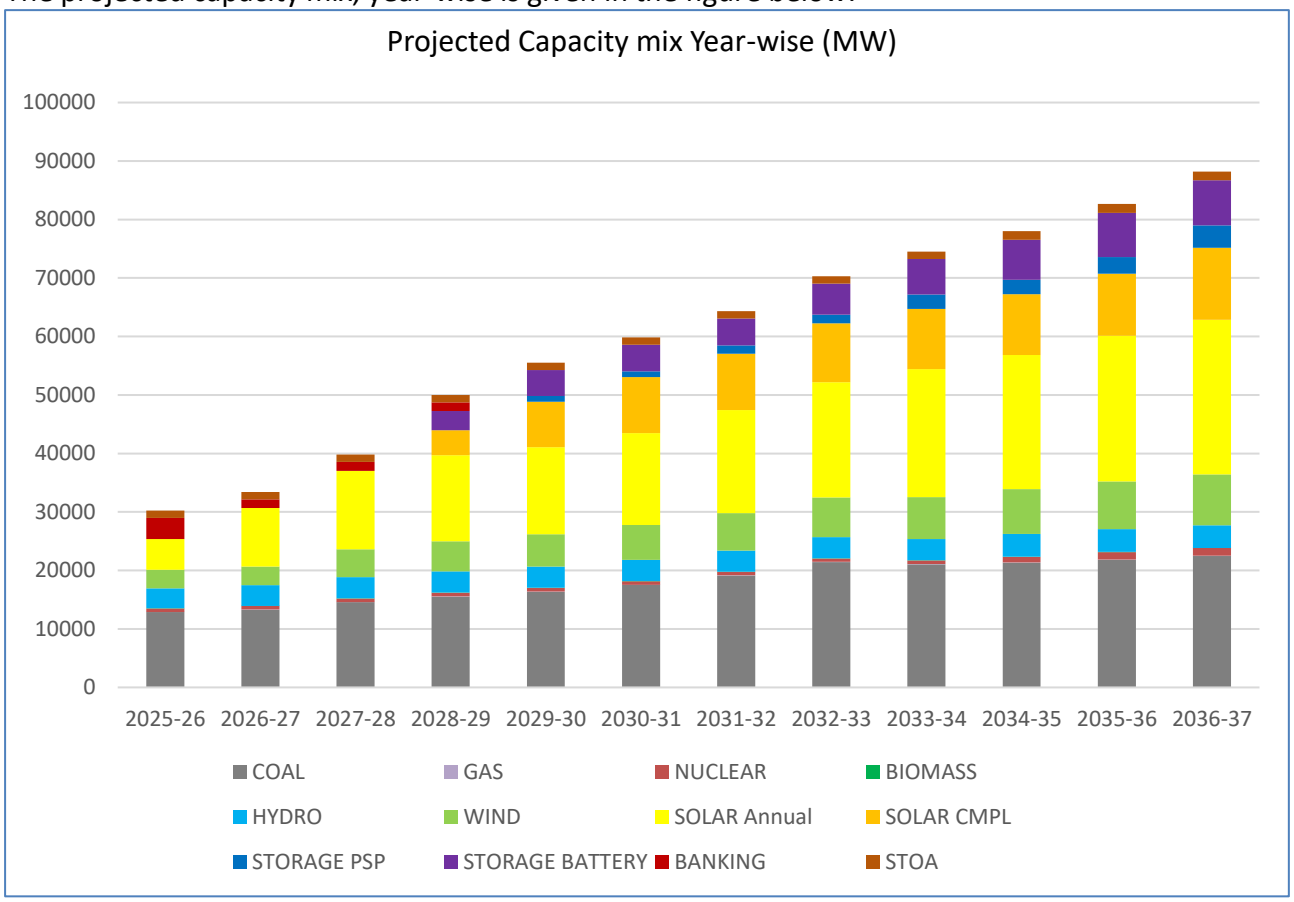


Figure 10: Projected Capacity Mix Year-wise (in MW)

The projected capacity mix indicates a clear transition toward renewable and flexible generation sources over the assessment period. The share of coal-based capacity in the contracted capacity continues to decrease to about 25 % till 2036-37 from 52% in 2025-26, due to significant likely

addition of RE based capacities especially Solar PV. This trend of capacity requirement signals a gradual shift from conventional to clean alternatives in future.

Between FY 2026-27 and FY 2036-37, total installed capacity in the State increases substantially, primarily driven by solar, wind, and storage capacity addition.

- Coal capacity increases from 12,865 MW in FY 2025-26 to 22,477 MW in FY 2036-37, with planned capacity additions between 2028-29 to 2032-33 and additional requirement of capacity in terminal years of study of about 1900 MW by 2036-37.
- Solar capacity exhibits the most significant growth, reinforcing the State's trajectory towards renewable integration and RCO compliance with likely additional requirement of about 10,500 MW (annual) and 11,500 MW of solar on complementary basis.
- Wind capacity also shows steady expansion—from 3,179 MW in FY 2025-26 to 8,679 MW in FY 2036-37 with planned addition of 1,600 MW and additional capacity requirement in later years—complementing solar generation during non-solar hours.
- The total storage requirement for integration of RE and ensuring resource adequacy is about 11.5 GW/51.4 GWh by 2036-37 which can be met from combination of BESS and PSP technologies.
- Hydro capacity remains constant at 3,609 MW from 2027-28 till 2033-34 and is increased to 3,861 with the planned addition of 252 MW from Dibang HEP in 2034, providing essential base and peaking support. The hydro capacity addition in future, other than the planned procurement, has not been considered due to limited visibility of capacity procurement by the state from planned hydro capacities at national level. Hydro capacity procurement plans of the state can be updated in future versions of the study, if made available.

For enabling higher penetration of RE and providing balancing mechanism, energy storage system viz. both Pumped Storage Plants (PSP) and BESS will be required. MP has already planned power procurement of 500 MW (6 hrs) from PSP on complementary basis and 1190 MW (2 hrs) from BESS. The results reveal total capacity requirement of BESS and PSP to the extent of 7,690 MW and 3,835 MW respectively by 2036-37 indicating strong emphasis on system flexibility and storage.

The visibility of Banking capacity (representing inter-regional/inter-state energy exchange arrangements) is limited till 2028-29 to the extent of 1500 MW.

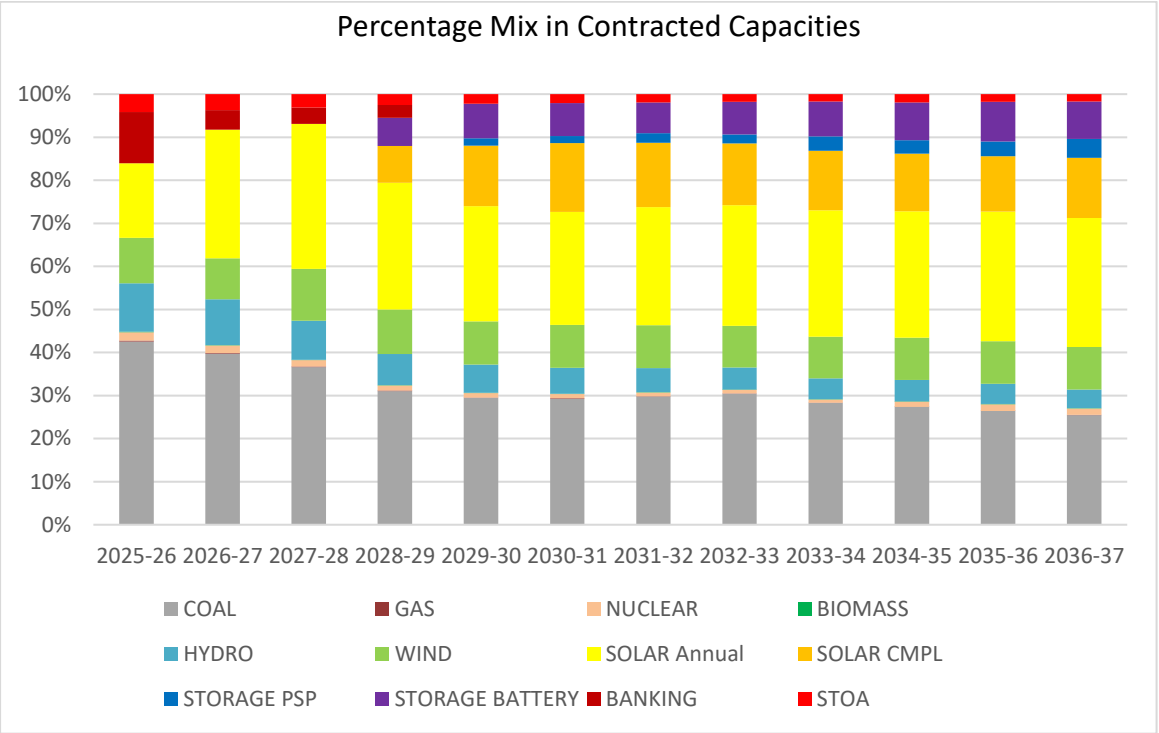


Figure 11: Projected Mix of contracted Capacity Year-wise

The percentage mix in contracted capacities is likely to shift substantially towards non-fossil fuel resources from fossil fuel resources currently (2025-26) resulting in energy transition towards clean resources for the state. The coal and gas capacities are likely to reduce to around 26% by 2036-37.

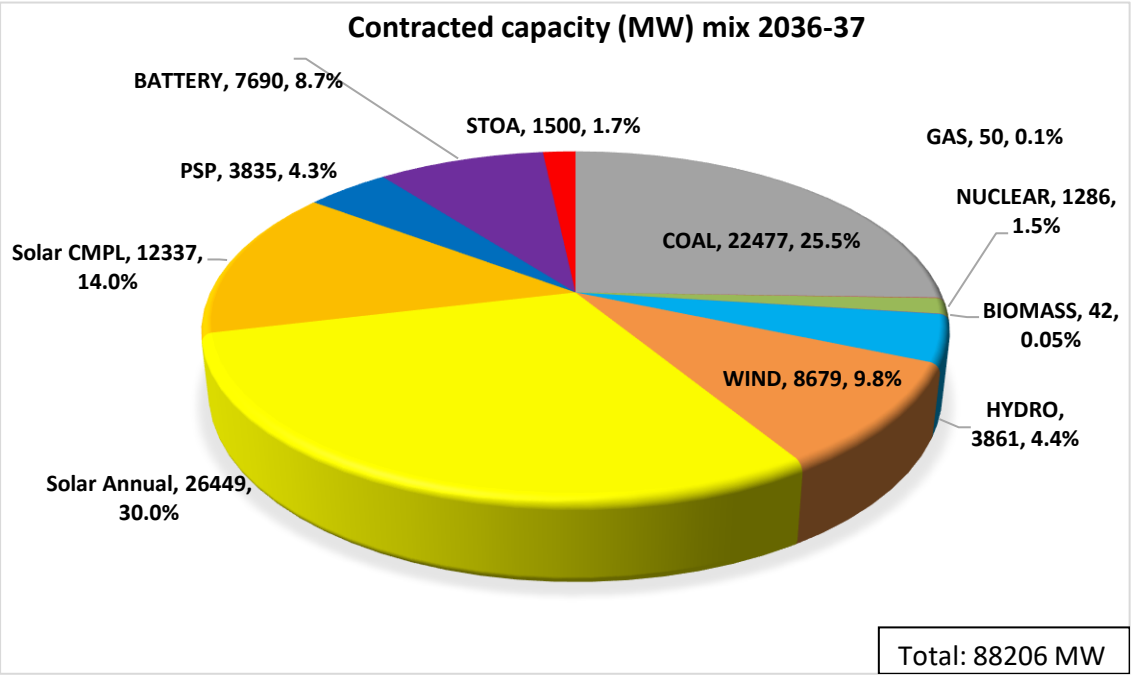
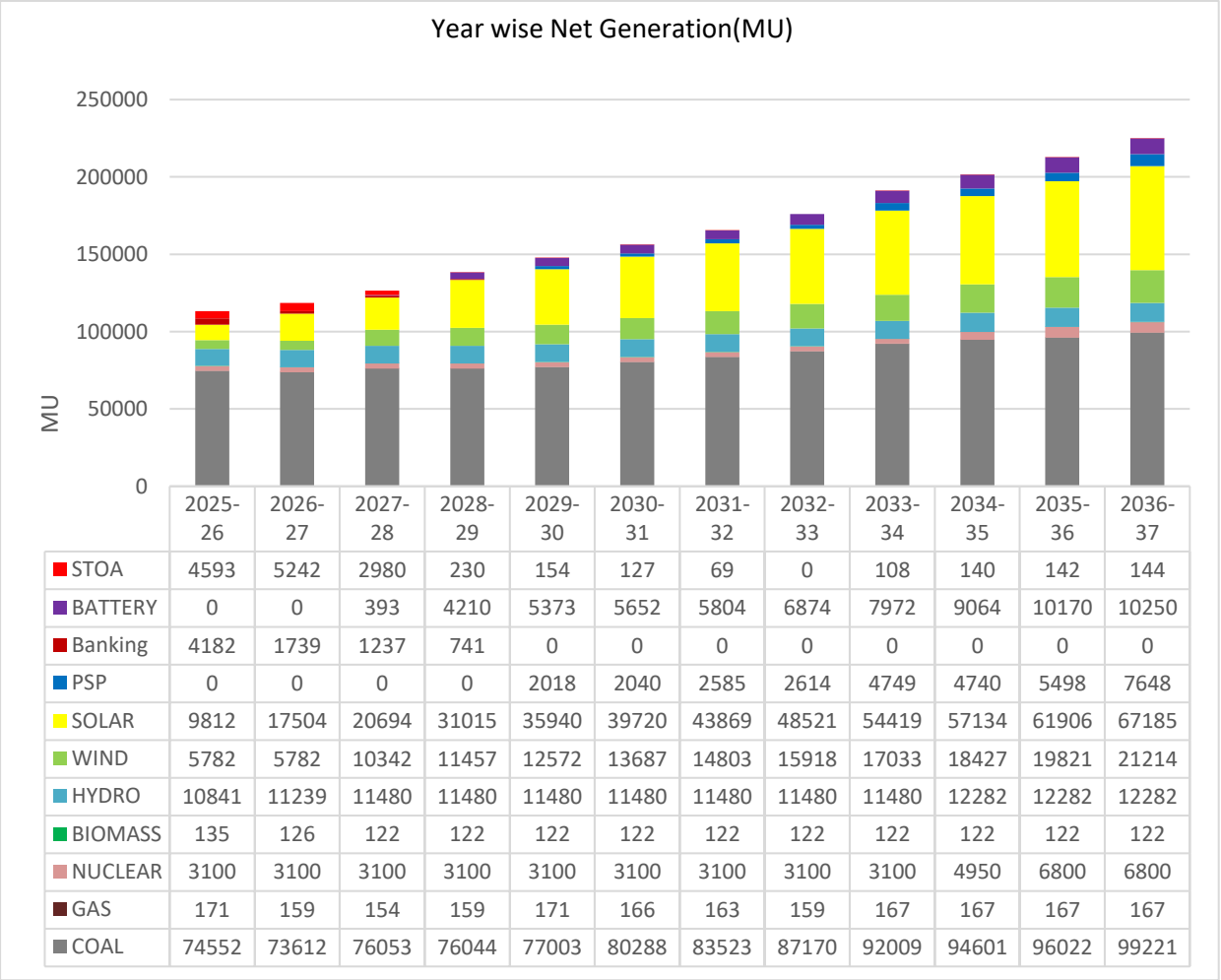


Figure 12: Contracted Capacity Mix in 2036-37

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 Madhya Pradesh has been assessed as 8.9%. In addition, the projected/contracted capacity fulfils the stipulated Renewable Consumption Obligations.

The share of non-fossil fuel-based capacity in the generation mix is projected to increase to around 53% by 2036-37 with higher contribution from non-fossil fuel-based capacities in alignment with RCO trajectory. The contribution of STOA/dependence on market in the generation mix for meeting peak demand requirement remains quite low, typically in range of 0.1-4.6% in different years. The dependence on STOA is limited to 0.1% in 2036-37 on energy basis.



	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
STOA	4593	5242	2980	230	154	127	69	0	108	140	142	144
BATTERY	0	0	393	4210	5373	5652	5804	6874	7972	9064	10170	10250
Banking	4182	1739	1237	741	0	0	0	0	0	0	0	0
PSP	0	0	0	0	2018	2040	2585	2614	4749	4740	5498	7648
SOLAR	9812	17504	20694	31015	35940	39720	43869	48521	54419	57134	61906	67185
WIND	5782	5782	10342	11457	12572	13687	14803	15918	17033	18427	19821	21214
HYDRO	10841	11239	11480	11480	11480	11480	11480	11480	11480	12282	12282	12282
BIOMASS	135	126	122	122	122	122	122	122	122	122	122	122
NUCLEAR	3100	3100	3100	3100	3100	3100	3100	3100	3100	4950	6800	6800
GAS	171	159	154	159	171	166	163	159	167	167	167	167
COAL	74552	73612	76053	76044	77003	80288	83523	87170	92009	94601	96022	99221

Figure 13: Year-wise projected generation mix (in Million Units or GWh)

6.2.1 Capacity contract requirement for future

It has been found out in the studies that Madhya Pradesh needs to contract following capacities (planned and additional) per year till 2036-37 to meet its demand reliably along with planned and existing capacities.

Table 12: Year wise Capacity Addition for Madhya Pradesh (in MW)

Year	Coal		Nuclear		Solar Annual		Solar Complementary	
	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts
2025-26	72	0	0	0	801	0	0	0
2026-27	332	0	0	0	4763	0	0	0
2027-28	1294	0	0	0	3412	0	0	0
2028-29	964	0	0	0	726	569	800	3500
2029-30	530#	0	0	0	142	0	0	3500
2030-31	1460	0	0	0	160	673	0	1790
2031-32	1600	0	0	0	179	1804	0	0
2032-33	2300#	0	0	0	203	1848	0	487
2033-34	-420*	64	0	0	228	1969	0	202
2034-35	-420*	700	350	0	257	735	0	141
2035-36	0	463	350	0	290	1684	0	241
2036-37	0	673	0	0	327	1244	0	1676

Year	BESS		PSP		Wind		Hydro	
	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts
2025-26	0	0	0	0	0	0	0	**0**
2026-27	0	0	0	0	0	0	125	0
2027-28	750@	0	0	0	1600	0	76	0
2028-29	440@	2500	0	0	0	400	0	0
2029-30	0	750	0	963	0	400	0	0
2030-31	0	132	0	0	0	400	0	0
2031-32	0	0	500	0	0	400	0	0
2032-33	0	750	0	0	0	400	0	0
2033-34	0	750	0	1014	0	400	0	0
2034-35	0	750	0	0	0	500	252	0
2035-36	0	750	0	339	0	500	0	0
2036-37	0	118	0	1018	0	500	0	0

***SGTPS Birsinghpur (4x210 MW) is proposed to be retired in 2033-34 and 2034-35 by MP**
@Likely to be commissioned in Oct 2028 and Oct 2029, 2hrs Storage.
 # Considering expiry of Contracts with DVC (100 MW) in 2032-33 and PFCCL(290 MW) in 2029-30

6.2.2 Generation Dispatch on Peak Demand Day

It is quite important from resource adequacy perspective to assess the quantum of availability of resources on the critical days like maximum energy demand day, maximum peak demand

day or maximum RE day. The studies have analyzed all such critical instances and observed that the projected capacity mix by 2036-37 would be able to meet demand at all instances reliably. The generation dispatch during peak demand days is shown below:

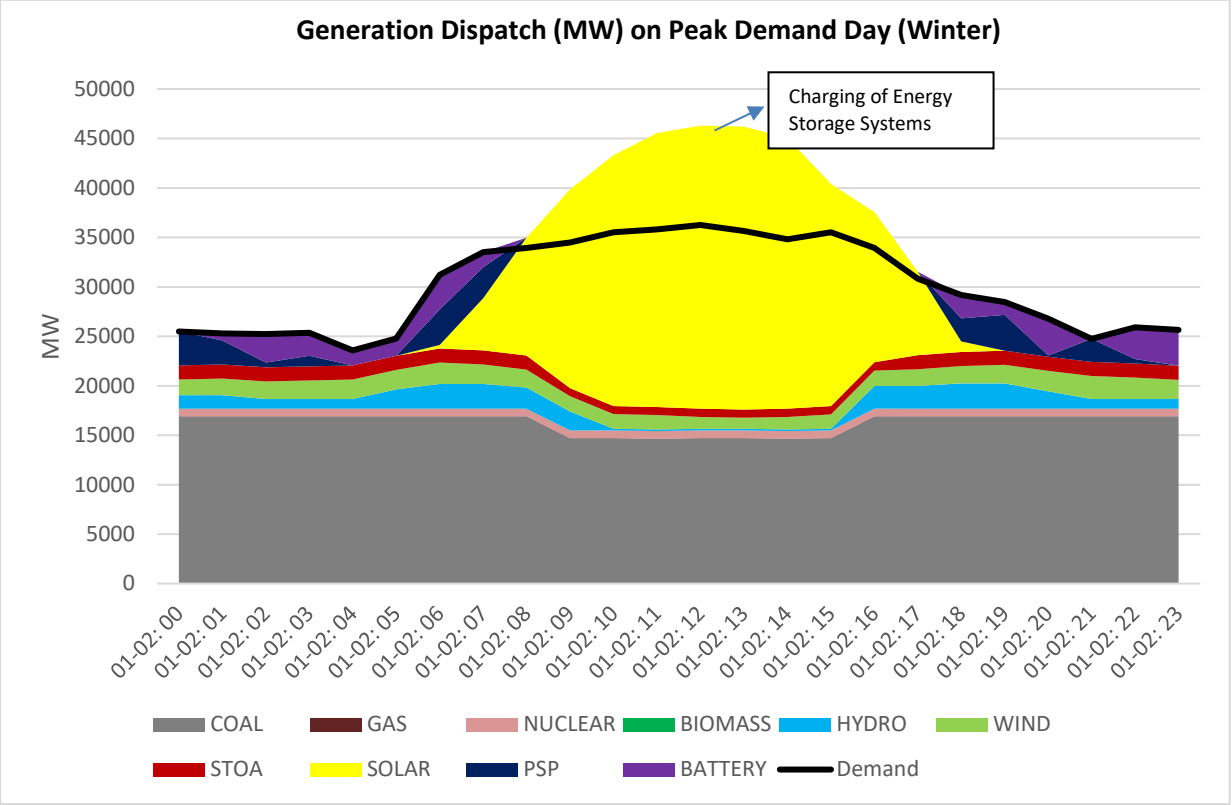


Figure 14: Generation Dispatch on peak Demand Day for year 2036-37 in MW

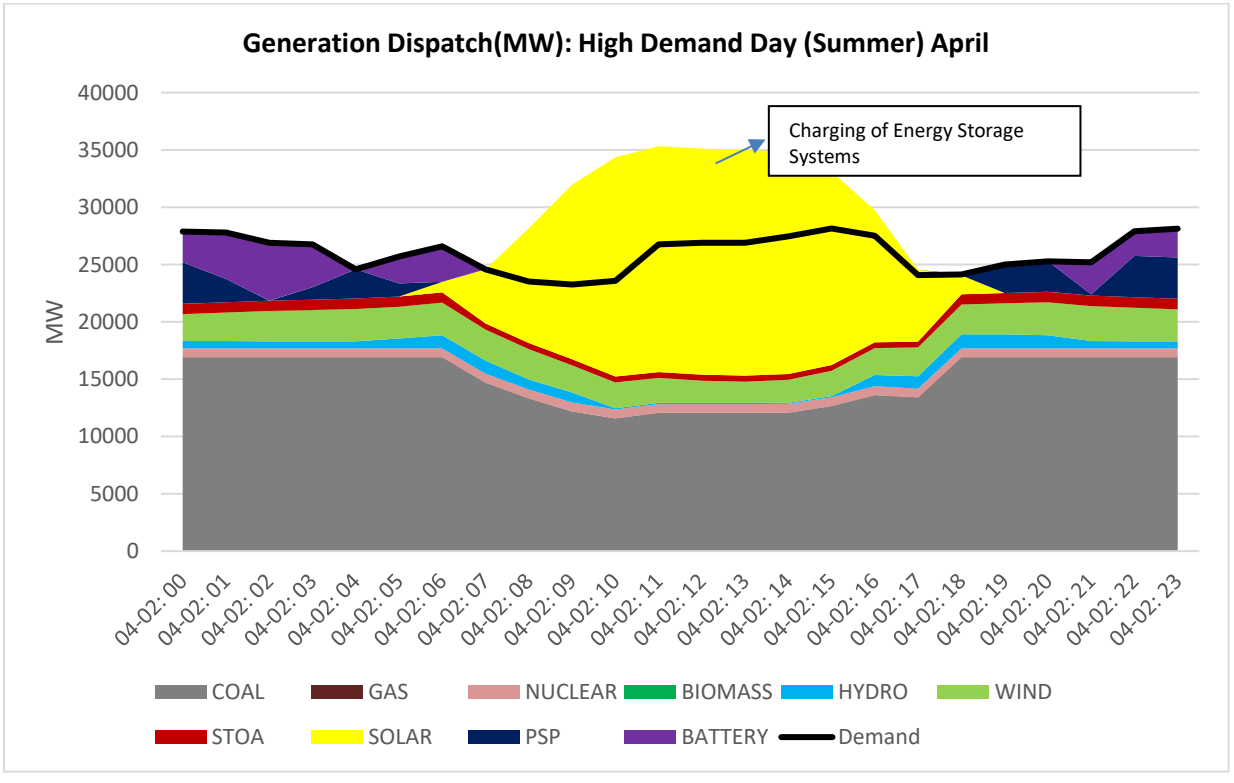


Figure 15: Generation Dispatch on High Demand Day (Summer) April for year 2036-37

6.2.3 Surplus Coal Capacity

Based on studies, the State will be having surplus coal capacity in monsoon months. The surplus capacity available with MP during low demand season (Monsoon) can be shared through banking arrangements or shared with other states through bilateral agreements / Pushp portal, thereby reducing the fixed cost burden on the utility, resulting in a reduction in the cost for the consumer or made available on PUSHP/ DEEP portal.

6.2.4 Energy Storage Requirement

The combined storage requirement is about 11.5 GW/51.4 GWh by 2036-37 comprising a mix of PSP and BESS. PSP is more economical source for providing longer duration storage and ensuring grid stability, however it has longer gestation period compared to BESS. The year-wise storage requirement from 2028-29 onwards is given in the figure below.

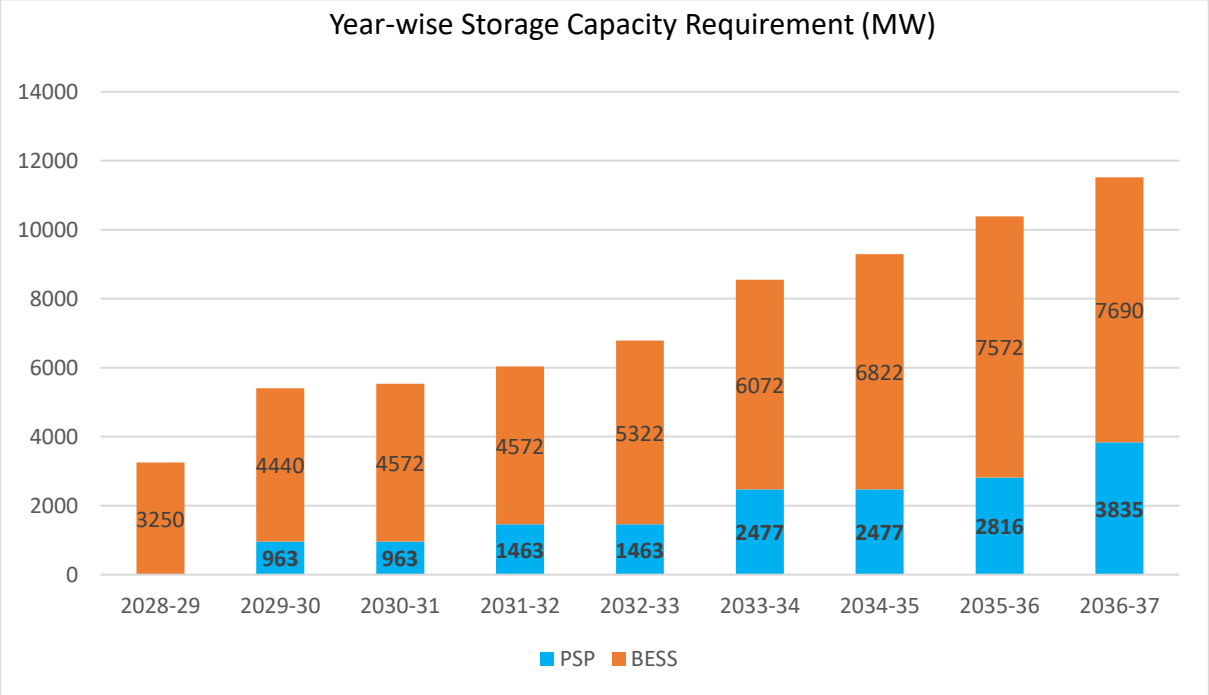


Figure 16: Year wise Storage Capacity requirement (in MW)

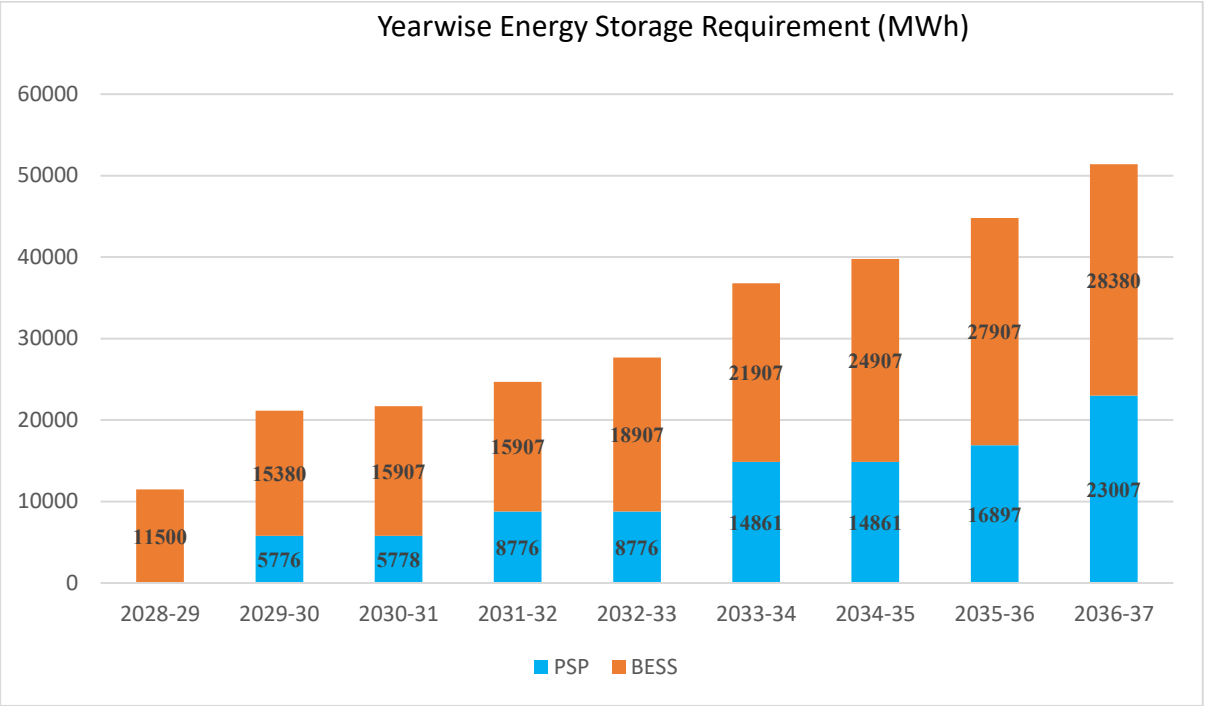


Figure 17: Year Wise Energy Storage requirement (in MWh)

It has been found while analyzing the generation dispatches that four-hour duration storage may be required for fulfillment of demand during non-solar hours for majority of the days in the initial years of the study. There is requirement of storage for meeting morning peak demand in high demand months. However, the storage duration required for meeting morning demand is less (about 2 hours) compared to the night hours.

In the later years of the study (2033-34 to 2036-37), it has been observed that requirement of long duration storage (6 hours) i.e. PSP is higher compared to shorter duration storage for meeting evening, night and morning demand surge. By 2036-37, storage is being utilized for meeting morning peak demand for almost entire year. Additionally, it has been found that solar may be the most economical source for charging of storage during day hours. The option of charging storage through wind may not result in optimal utilization of storage due to high seasonality and unreliability in wind power generation. The charging of storage through Thermal energy may be costly and would depend on the availability of thermal resources for extra generation required for charging of storage.

6.3 Scenario 2: Considering RPO trajectory in line with MPERC Regulation

MPPMCL has informed that MPERC has issued RPO regulations 2021 for ensuring a certain quantum of electricity to be procured by Obligated entities from Renewable energy resources as percentage of their total annual procurement of electrical energy. MPPMCL has submitted the RPO trajectory in line with MPERC regulation and extended the trajectory till 2036-37. MPPMCL has further submitted that one scenario based on the RPO Trajectory as per MPERC may be carried out to assist them in formulating their Resource Adequacy Plan.

Table 13: Renewable Power Obligation (RPO) Trajectory furnished by MPPMCL

	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
Total RPO	30.97%	32.72%	34.51%	36.30%	37.89%	38.87%	39.88%	40.93%	42.01%	43.14%	44.30%	45.50%
Energy Storage Obligation	1.00%	1.50%	2.00%	2.50%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%

As the existing and planned capacity is not sufficient to meet the projected electricity demand along with Renewable Obligations, candidate capacities have been given to the model to find the least cost optimal capacity mix required to meet the projected electricity demand. It has been assumed that candidate capacity required for meeting future demand can only be commissioned/procured as early as 2028-29. The capacity requirement for meeting any deficit arising during 2026-27 or 2027-28 can be additionally met through power markets/ short-term bilateral contracts. The following is observed on the basis of the study:

i) The requirement of capacity from Solar PV in the results includes the capacity requirement for fulfillment of RPO for DRE (Distributed Renewable Energy) which can be achieved through Solar rooftop and solar pumps installations facilitated by Government schemes. MP has been planning for DRE installation through PM Surya Ghar Muft Bijli Yojana (Solar PV Rooftop) and PM Kusum schemes for installation of additional 9290 MW of solar capacity by 2027-28. The same has been considered as planned capacity addition and would contribute as DRE for fulfillment of RPO. The tentative plan of capacity addition via solar rooftop and solar pumps is given at Annexure.

ii) For fulfilling the requirement of Storage, BESS candidate capacity has been considered to be available 2028-29 onwards assuming the storage (BESS) capacity gets commissioned as early as in 2028-29. Similarly, PSP candidate capacity has been assumed to be available as early as 2029-30.

iii) MPPMCL has also submitted that it is planning for installation of solar PV on complementary basis for meeting its higher demand during Rabi season (Q3 and Q4) and sharing the same capacity with other states having high demand during summer season (Q1 and Q2) like UP, Punjab. The solar complementary plans have also been considered in the studies assuming installation of such capacity to the tune of about 11,000 MW by

2036-37.

iv) The STOA/MTOA requirement can be fulfilled through power procurement from markets or bilateral agreements and have been limited to 1000-1500 MW across years as per the anticipated power procurement from exchanges as furnished by MPPMCL considering the liquidity available in the market.

v) The STOA/MTOA value reflects the peak value requirement in terms of MW.

vi) The quantum of RPO deficit across the years with existing and planned capacity procurement is given below:

Table 14: Renewable Power Obligation (RPO) Compliance

	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
RPO (%)	30.97%	32.72%	34.51%	36.30%	37.89%	38.87%	39.88%	40.93%	42.01%	43.14%	44.30%	45.50%
Energy Req. from RE sources (BU)	33.8	38.2	42.6	47.4	52.3	56.6	61.4	66.7	73.1	78.9	85.0	91.4
Energy Available from Tied-up RE (BU)	26.5	35.3	43.5	46.4	47.5	48.3	49	49.5	50.1	51.3	51.8	52.4
Surplus/Deficit (BU)	-7.3	-2.9	0.9	-1	-4.8	-8.3	-12.4	-17.2	-23	-27.6	-33.2	-39

vii) The capacity projections for Madhya Pradesh are given below:

Table 15: Year Wise Capacity Projections (in MW)

Year	Coal	Gas	Nuclear	Biomass	Hydro	Wind	Solar		Storage		Banking	STOA
							Annual	CMPL	PSP	BESS		
2025-26	12865	50	586	42	3408	3179	5236	0	0	0	3600	1250
2026-27	13269	50	586	42	3533	3179	9999	0	0	0	1500	1250
2027-28	14563	50	586	42	3609	4779	13411	0	0	0	1500	1250
2028-29	15527	50	586	42	3609	5079	14137	4300	0	3250	1500	1250
2029-30	16747	50	586	42	3609	5379	14279	7800	458	4490	0	1250
2030-31	17917	50	586	42	3609	5679	14439	8565	458	4490	0	1250
2031-32	19517	50	586	42	3609	5979	14618	8565	958	4490	0	1250
2032-33	21817	50	586	42	3609	6279	16821	8691	958	4490	0	1250
2033-34	22147	50	586	42	3609	6579	18639	9560	1484	5290	0	1250
2034-35	21922	50	936	42	3861	6979	20896	10316	2280	6090	0	1500
2035-36	22452	50	1286	42	3861	7379	22829	10316	2506	6890	0	1500
2036-37	22977	50	1286	42	3861	7779	24684	11706	3368	7690	0	1500

The projected capacity mix, year-wise is given in the figure below:

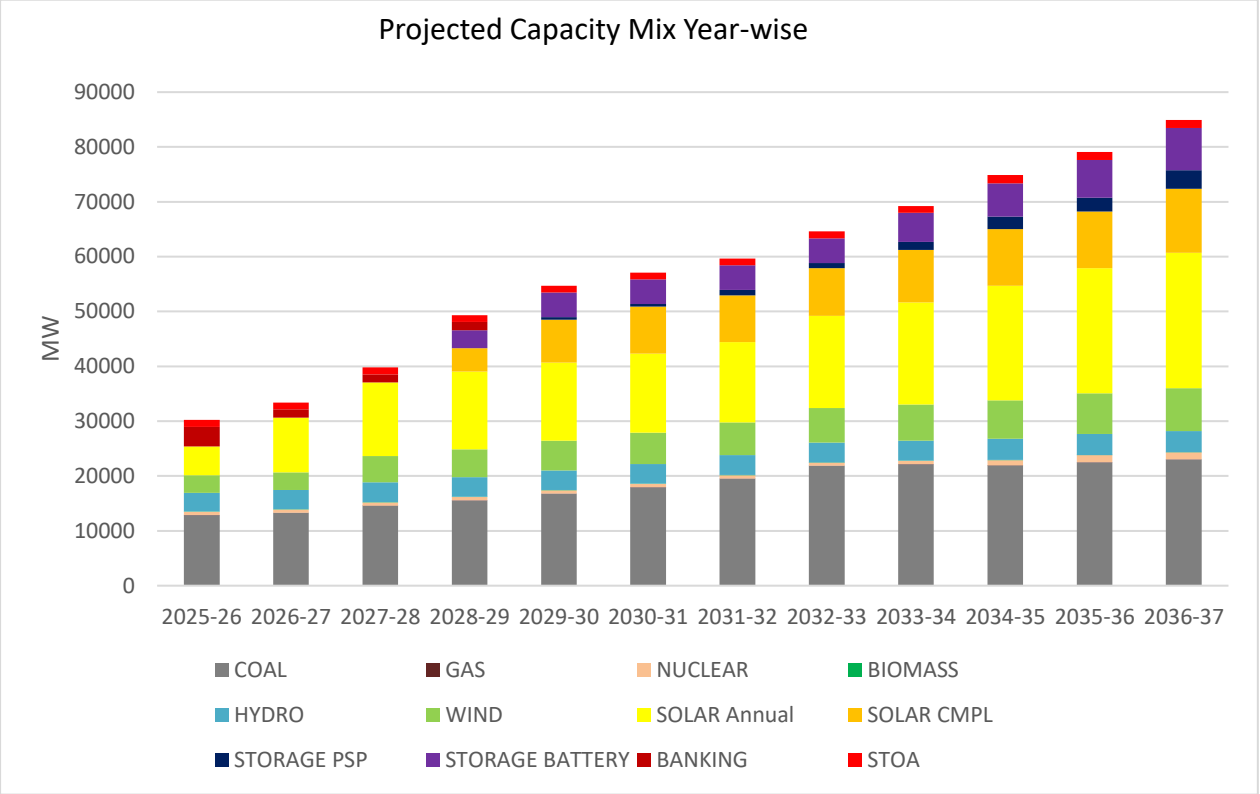


Figure 19: Projected Capacity Mix Year-wise (in MW)

The projected capacity mix indicates a clear transition toward renewable and flexible generation sources over the assessment period. The coal-based capacity which constitutes to form the dominant share in contracted capacity presently is likely to reduce to about 27% by 2036-37 which signals a gradual shift from conventional to clean alternatives.

Between FY 2027–28 and FY 2036-37, total installed capacity in the State increases substantially, primarily driven by solar, wind, and energy storage capacity addition.

- Coal capacity increases from 12865 MW in FY 2025-26 to 22,977 MW in FY 2036-37, with planned capacity additions between 2028-29 to 2032-33 and additional requirement of capacity in terminal years of study of about 2400 MW by 2036-37.
- There is likely requirement of about 36 GW of solar capacity by 2036-37. Solar capacity exhibits the most significant growth, reinforcing the State's trajectory toward renewable integration and RPO compliance with likely additional requirement of about 8800 MW of annual solar and 11000 MW of solar capacity on complementary basis.
- Wind capacity also shows steady expansion, from 3,179 MW in 2025-26 to 7,779 MW in 2036-37 with planned addition of 1600 MW and additional capacity requirement in later years—complementing solar generation during non-solar hours.
- Hydro capacity remains constant at 3,609 MW from 2027-28 till 2033-34 and is increased to 3,861 with the planned addition of 252 MW from Dibang HEP by 2034-35, providing essential base and peaking support. The hydro capacity addition in

future other than the planned procurement has not been considered due to limited visibility of capacity procurement by the state from planned hydro capacities at national level. Hydro capacity procurement plans of the state can be updated in future versions of the study if made available.

- The total storage requirement is about 11 GW/48.6 GWh by 2036-37 which can be met from combination of BESS or PSP technologies.

For ensuring higher penetration of RE as per RPO trajectory and providing balancing mechanism, storage capacity of both Pumped Storage Plants (PSP) and BESS will be required. MP has already planned power procurement of 500 MW from PSP and 1190 MW from BESS. The results reflect additional capacity requirement of BESS and PSP to the extent of 6500 MW and 2843 MW respectively by 2036-37 indicating strong emphasis on system flexibility and storage.

The visibility of Banking capacity (representing inter-regional/inter-state energy exchange arrangements) is limited till 2028-29 to the extent of 1500 MW.

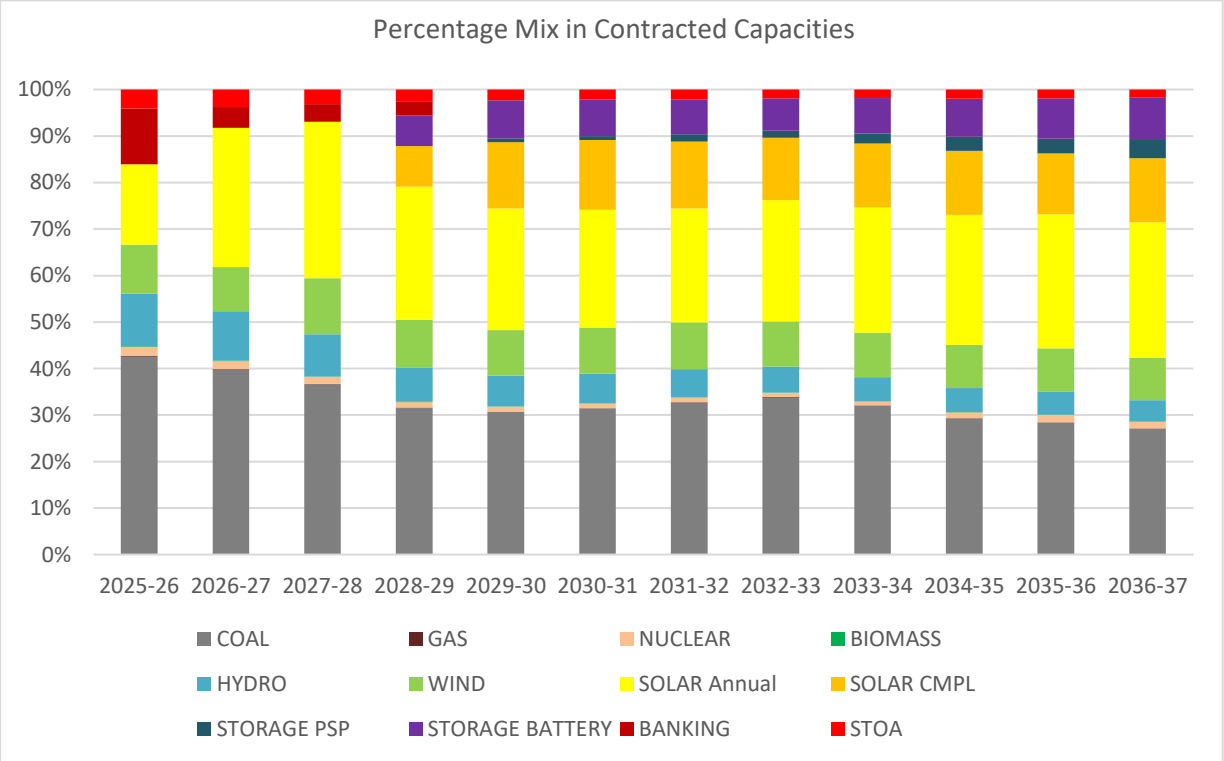


Figure 20: Projected Mix of contracted Capacity Year-wise

The percentage mix in contracted capacities is likely to shift substantially towards non-fossil fuel resources from fossil fuel resources currently (2025-26) resulting in energy transition towards clean resources for the state. It is anticipated that contribution of fossil fuel sources in the capacity mix may decrease to about 27% by 2036-37 from 53% as on March 2025.
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 Madhya

Pradesh has been assessed as 8.2%. In addition, the projected/contracted capacity fulfils the stipulated Renewable Purchase Obligation.

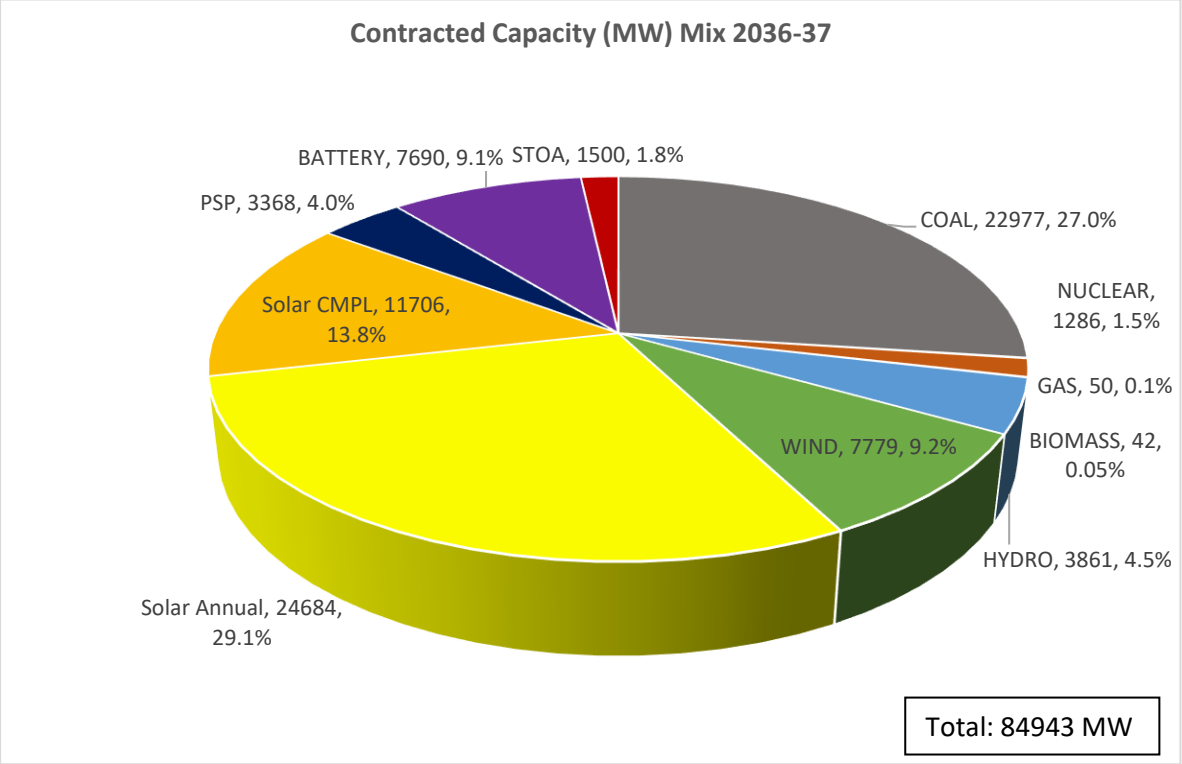
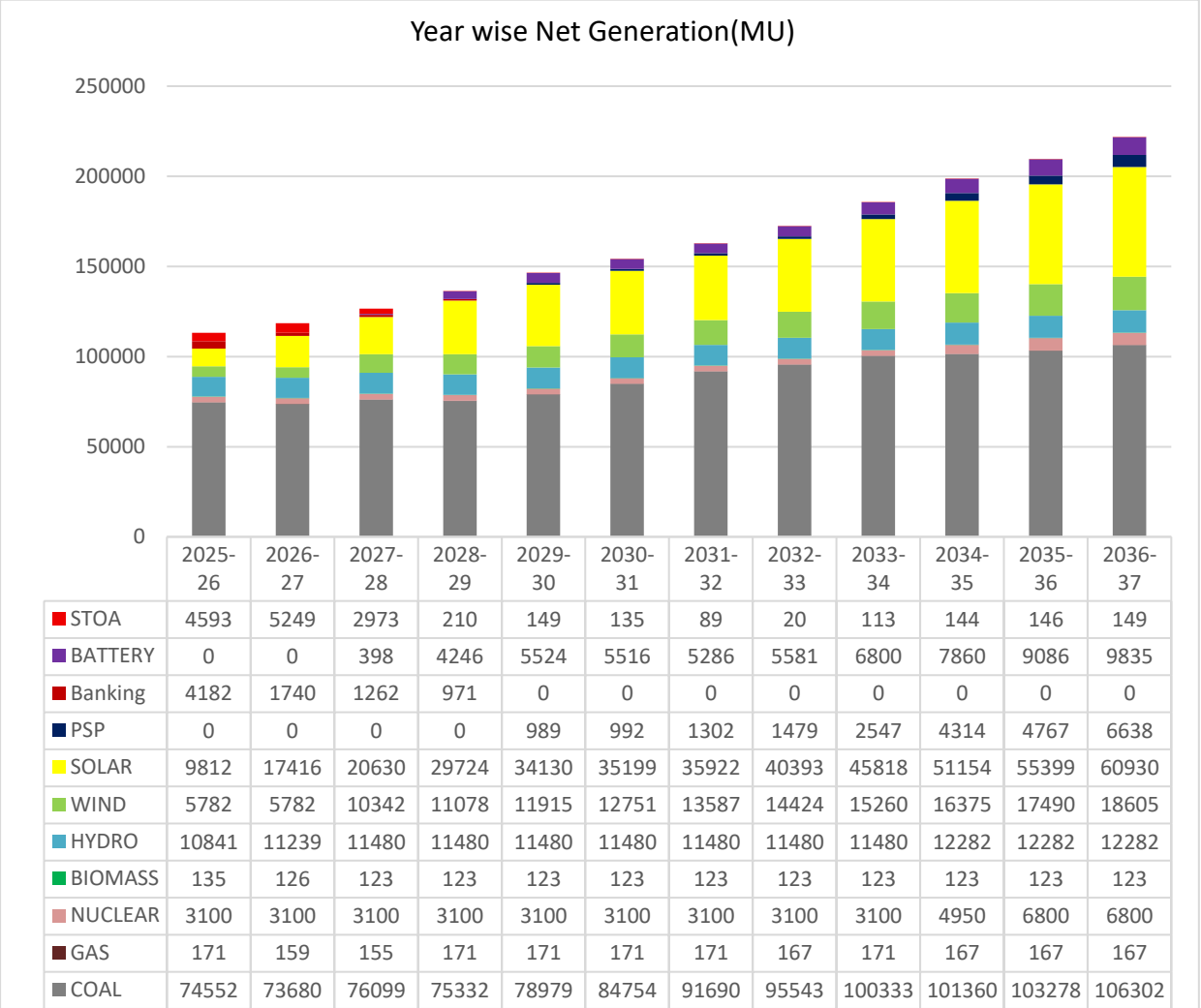


Figure 21: Contracted Capacity Mix in 2036-37

The share of non-fossil fuel-based capacity in the generation mix is projected to increase to around 48% by 2036-37 with higher contribution from non-fossil fuel-based capacities in alignment with RPO trajectory. The contribution of STOA/dependence on market in the generation mix for meeting peak demand requirement remains quite low typically in range of 0.1- 4.6% in different years. The dependence on STOA is limited to 0.1% in 2036-37 on energy basis.



	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
STOA	4593	5249	2973	210	149	135	89	20	113	144	146	149
BATTERY	0	0	398	4246	5524	5516	5286	5581	6800	7860	9086	9835
Banking	4182	1740	1262	971	0	0	0	0	0	0	0	0
PSP	0	0	0	0	989	992	1302	1479	2547	4314	4767	6638
SOLAR	9812	17416	20630	29724	34130	35199	35922	40393	45818	51154	55399	60930
WIND	5782	5782	10342	11078	11915	12751	13587	14424	15260	16375	17490	18605
HYDRO	10841	11239	11480	11480	11480	11480	11480	11480	11480	12282	12282	12282
BIOMASS	135	126	123	123	123	123	123	123	123	123	123	123
NUCLEAR	3100	3100	3100	3100	3100	3100	3100	3100	3100	4950	6800	6800
GAS	171	159	155	171	171	171	171	167	171	167	167	167
COAL	74552	73680	76099	75332	78979	84754	91690	95543	100333	101360	103278	106302

Figure 22: Year-wise projected generation mix (in Million Units or GWh)

6.3.1. Capacity contract requirement for future

It has been found in the studies that Madhya Pradesh needs to contract following capacities (planned and additional) per year till 2036-37 to meet its demand reliably along with fulfilment of its RPO as notified by MPERC.

Table 16: Year wise Capacity Addition for Madhya Pradesh (in MW)

Year	Coal		Nuclear		Solar annual		Solar complementary	
	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts
2025-26	72	0	0	0	801	0	0	0
2026-27	332	0	0	0	4763	0	0	0
2027-28	1294	0	0	0	3412	0	0	0
2028-29	964	0	0	0	726	0	800	3500
2029-30	530[#]	400	0	0	142	0	0	3500

2030-31	1460	0	0	0	160	0	0	765
2031-32	1600	0	0	0	179	0	0	0
2032-33	2300[#]	0	0	0	203	2000	0	126
2033-34	-420*	750	0	0	228	1590	0	869
2034-35	-420*	195	350	0	257	2000	0	756
2035-36	0	530	350	0	290	1643	0	0
2036-37	0	525	0	0	327	1528	0	1390

Year	BESS (4 hrs)		PSP (6 hrs)		Wind		Hydro	
	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts
2025-26	0	0	0	0	0	0	0	**0**
2026-27	0	0	0	0	0	0	125	0
2027-28	750[@]	0	0	0	1600	0	76	0
2028-29	440[@]	2500	0	0	0	300	0	0
2029-30	0	800	0	458	0	300	0	0
2030-31	0	0	0	0	0	300	0	0
2031-32	0	0	500	0	0	300	0	0
2032-33	0	0	0	0	0	300	0	0
2033-34	0	800	0	527	0	300	0	0
2034-35	0	800	0	796	0	400	252	0
2035-36	0	800	0	226	0	400	0	0
2036-37	0	800	0	862	0	400	0	0

*SGTPS Birsinghpur (4x210 4 MW) is proposed to be retired in 2033-34 and 2034-35 by MP
@Likely to be commissioned in Oct 2028 and Oct 2029, 2hrs Storage.
Considering expiry of Contracts with DVC (100 MW) in 2032-33 and PFCCL(290 MW) in 2029-**30**

6.3.2 Generation Dispatch on Peak Demand Day

It is quite important from resource adequacy perspective to assess the quantum of availability of resources on the critical days like maximum energy demand day, maximum peak demand day or maximum RE day. The studies have analyzed all such critical instances and observed that the projected capacity mix by 2036-37 would be able to meet demand at all instances reliably. The generation dispatch during peak demand days is shown below:

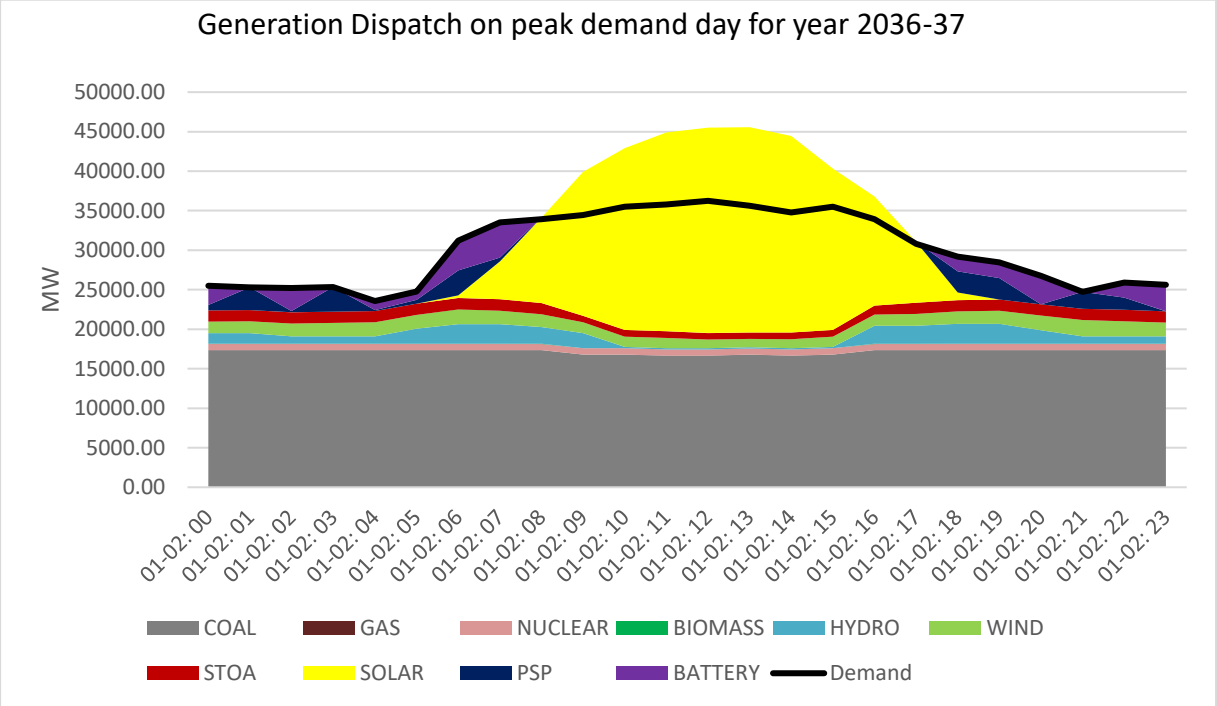


Figure 22: Generation Dispatch on peak Demand Day for year 2036-37 in MW for whole 24 hours

6.3.3 Surplus Coal Capacity

Based on studies, the State will be having surplus coal capacity in monsoon months. The surplus capacity available with MP during low demand season (Monsoon) can be shared through banking arrangements or shared with other states through bilateral agreements / Pushp portal, thereby reducing the fixed cost burden on the utility, resulting in a reduction in the cost for the consumer or made available on PUSHP/ DEEP portal.

6.3.4 Storage Requirement

The combined storage requirement is about 48.6 GWh by 2036-37 comprising a mix of PSP and BESS. PSP is more economical source for providing longer duration storage and ensuring grid stability, however it has longer gestation period compared to BESS. The year-wise storage requirement from 2028-29 onwards is given in the figure below.

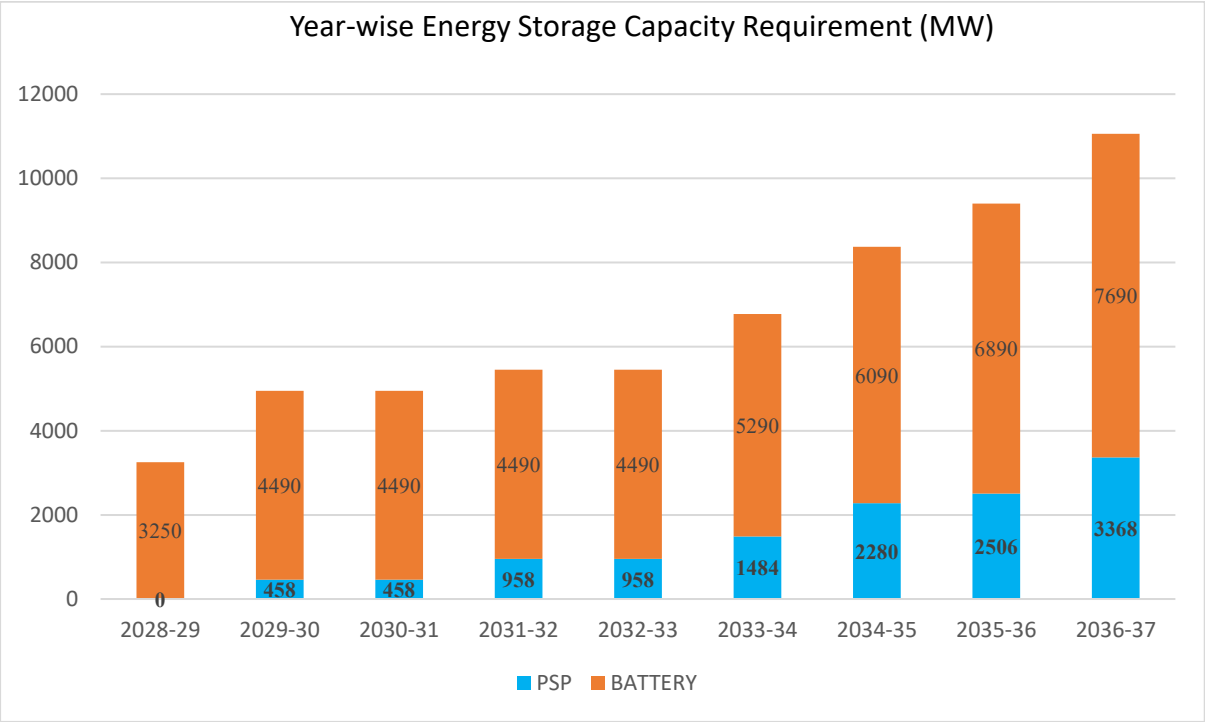


Figure 25: Year wise Storage requirement (in MW)

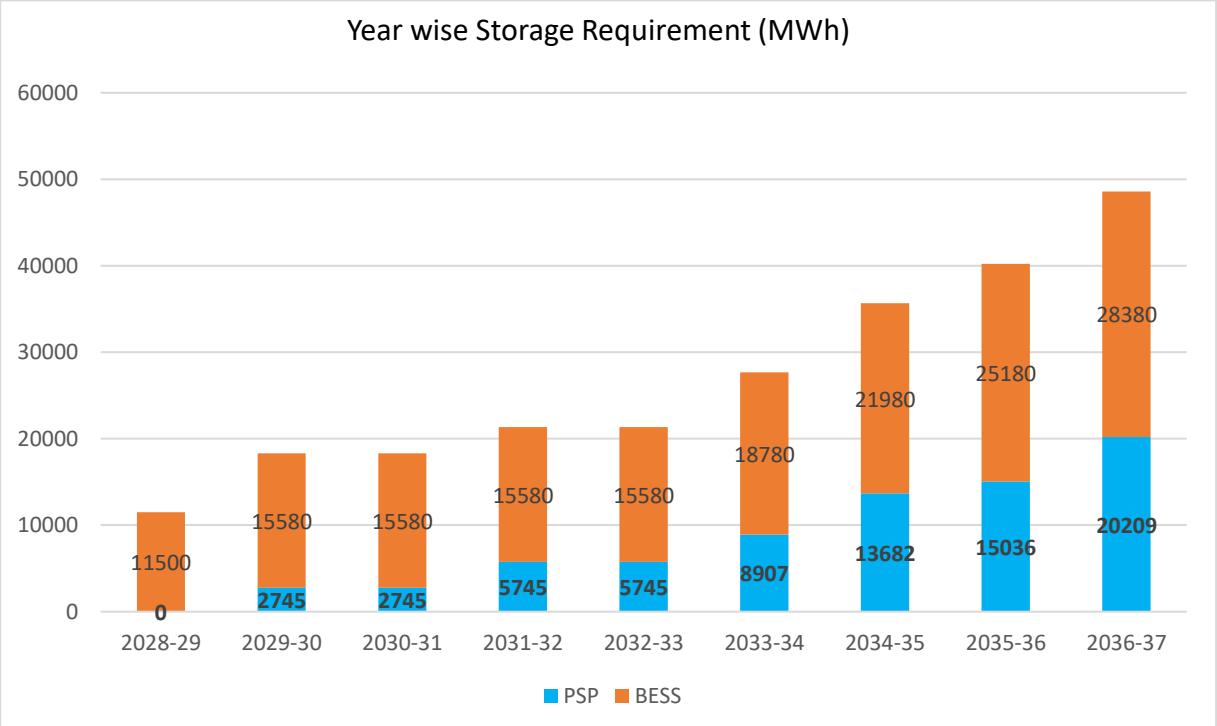


Figure 26: Year Wise Storage requirement (in MWh)

It has been found while analyzing the generation dispatches that four-hour duration storage may be required for fulfillment of demand during non-solar hours for majority of the days in the initial years of the study. There is even requirement of storage for meeting morning peak demand in high demand months. However, the storage duration required for meeting

morning demand is less (about 2 hours) compared to the night hours.

In the terminal years of the study (2035-36 to 2036-37), it has been observed that with higher penetration of RE sources in the energy mix in later years of study, there is higher requirement of long duration storage (6 hours) i.e. PSP compared to shorter duration storage for meeting evening, night and morning demand surge. Additionally, it has been found that solar may be the most economical source for charging of storage during day hours. This may lead to higher absorption of renewable energy required for meeting the RPO targets. The optionality of charging storage through wind may not result in optimal utilization of storage due to high seasonality and unreliability in wind power generation. The charging of storage through Thermal energy may be costly and would depend on the availability of thermal resources for extra generation required for charging of storage.

7.0 Conclusions

1. The study evaluates the resource adequacy of Madhya Pradesh using latest demand projections furnished by MP Power Management Company Limited (MPPMCL). These projections exceed the demand forecasts reported in the 20th Electric Power Survey (EPS) Report. As per MPPMCL, the projected peak electricity demand and electrical energy requirement in 2036-37 is 36418 MW and 200.8 BU.
2. Madhya Pradesh's present capacity mix derives approximately 53% of installed capacity from fossil-fuel sources. The winter months (November–February) constitute the state's peak-demand season. The analysis employs the hourly load profile for the year 2024–25.
3. Under existing and planned capacity additions, the State may experience an energy deficit ranging from roughly 1,100 MU to 19,000 MU in various years between FY 2025-26 and FY 2036-37. Madhya Pradesh is currently short of meeting its Renewable Consumption Obligations (RCO) and therefore must secure additional renewable capacity to satisfy these obligations. The projected capacity and generation mix has been modelled to achieve the RCO and other specified non-fossil obligations by 2030, in accordance with the Ministry of Power's notification. 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.
4. The Government of Madhya Pradesh is proactively promoting Distributed Renewable Energy (DRE) through schemes such as PM Surya Ghar Muft Bijli and PM KUSUM. In addition, the State plans complementary solar procurement- developing solar capacity that can be optimally deployed during the Rabi peak and shared with states facing summer deficits (for example Uttar Pradesh, Bihar, West Bengal and Punjab). As per the studies, Solar PV capacity is likely to exhibit the most significant growth, reinforcing the State's trajectory toward renewable integration and RCO compliance. The total solar installed capacity is likely to be about 39 GW by 2036-37 including planned DRE capacity addition of about 9 GW as per the studies.
5. As per the studies, the total projected contracted capacity for the year 2036-37 is around

88,206 MW comprising of 22,477 MW from Coal; 50 MW from Gas; 1286 MW from Nuclear; 42 MW from Biomass; 3,861 MW from hydro; 38,787 MW from Solar; 8,679 MW from Wind; 3,835 MW from PSP; 6500 from BESS(4 hrs) and 1190 MW from BESS (2hrs); 1500 MW from Short Term Open Access(STOA).

6. Storage requirements have been estimated from the projected renewable additions and the demand profile. The total storage requirement for integration of RE and ensuring resource adequacy is about 11.5 GW/51.4 GWh by 2036-37. These requirements may be satisfied by a combination of Pumped Storage Projects (PSP) and Battery Energy Storage Systems (BESS), depending on availability and contractual arrangements.
7. Short-term open access (STOA) imports are projected to constitute about 0.1–4.6% of total electrical energy needs; while the energy share is limited, STOA is important during winter peak periods to meet end-consumer demand. In capacity (MW) terms, STOA reflects peak requirements within the capacity mix.
8. Madhya Pradesh is likely to register surplus coal capacity during the months of May-September when demand is relatively low. Such surpluses can be exported to complementary states—reducing the State's fixed-cost burden—or traded on power exchanges. In this regard, MP is also planning for solar power procurement on complementarity basis with states having high demand during summer season.
9. The results indicate that the percentage mix in contracted capacities is likely to shift substantially towards non-fossil fuel resources from fossil fuel resources currently (2025-26) resulting in energy transition towards clean resources for the state. The fossil fuel-based capacities are likely to reduce to around 26% by 2036-37 from 53% in March, 2025.
10. Correspondingly, the share of non-fossil fuel-based capacity in the generation mix is projected to increase to around 53% by 2036-37 with higher contribution from non-fossil fuel-based capacities in alignment with objectives of energy transition towards clean energy.
11. The capacity projections in this report are sensitive to assumptions on the timing of planned additions and the pace of demand growth. The system could become stressed if demand outpaces MPPMCL projections, if project commissioning is delayed, or if very old thermal units are retired earlier than anticipated. In particular, the State may face deficits during high-demand months over the next two years owing to insufficient capacity tie-ups for that near-term horizon.
12. Updates to planned hydro capacity additions from upcoming projects may be incorporated in subsequent annual LT-DRAP exercises. Deficits attributable to the Hydro Purchase Obligation (HPO) may be mitigated through fungibility with other renewable resources, as provided in the Ministry of Power's October 20, 2023 notification.
13. Since LT-DRAP is prepared on an annual, rolling basis, the long-term projections for contracted capacities should be revised periodically with improved visibility of demand forecasts, load patterns, project timelines, market conditions for renewables, and storage-technology developments.

Annexure

Assumptions for Resource Adequacy Studies for the state of Madhya Pradesh

- Peak electricity demand electrical energy requirement: As per MPPMCL projections.
- Demand Profile: Based on hourly demand profile of 2024-25
- Existing & Planned Capacity: As per the information received from MP Planning Cell
- Cost parameters: Based on information received from MP Planning Cell
- Agricultural Load shifting as per projections of MPPMCL.

RE CUF considered

Existing Hydro PLF	Planned Hydro PLF	Biomass CUF	Existing Solar CUF	ISTS Solar CUF	DRE CUF	Existing Wind CUF (MP)	Planned ISTS Wind CUF	Small Hydro CUF
35 %	35 %	30 %	22%	27 %	19 %	21 %	32 %	18%

RPO Trajectory (In line with MoP Notification dated 27th September 2025)

Year	2025-26	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2035-36	2036-37
RE consumption (%)	33.00%	36.00%	38.80%	41.40%	43.30%	45.50%	46.5%	47.50%	48.50%	49.50%	50.50%	51.50%

Technical Parameters

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical. (%)
Coal/ Lignite	Existing/Planned	85	1	55
	Candidate	85	1	55
Gas	Existing	90	5	40
Nuclear	Existing/Planned	68	Const. Load	-
Biomass	Existing/Planned	60	2	50
Hydro	Existing/Planned/ Candidate	As per available	10	-
	Existing/Planned		-	-

Solar	Candidate	hourly generation profile	-	-
Wind	Existing/Planned		-	-
	Candidate		-	-
Pumped storage Plants	Existing/Planned	95	10	-
	Candidate		10	-
Battery Energy Storage System	Candidate	98	-	-

Technology	**Type**	**Heat Rate (MCal/MWh)**		**Aux. Consumption (%)**	**Minimum online time**	**Minimum offline time**
		At max loading	At min loading		(hr)	(hr)
Coal	Existing/ Planned	2300 to 2879	2438 to 3052	7.5	6	4
	Candidate (SC & USC)	2060 to 2125	2183 to 2253	6.5	6	4
Biomass	Existing/ Planned	4200	4450	8	6	4
	Candidate	4200	4450	8	6	4
Hydro	Existing/ Planned	-	-	0.7	-	-
Pumped Storage Plant	Existing/ Planned/ Candidate	-	-	Round trip efficiency 80 %	-	-
Battery Energy Storage System	Candidate	-	-	Round trip efficiency 85%	-	-

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 2024-25 till 2036-37 (at price level of 2024/25):

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 to 4.1 Cr	1 % of Capex	1	25
Wind (Onshore)	7.5 Cr	1% of Capex	2	25
Pumped Storage	6 Cr	5 % of Capex	4	40
Battery Energy Storage (4-Hour)	4.99 Cr in 2025-26 to 3.0 Cr in 2036-37	6 Lakhs/MW	0.5	15

* All the Capex figures are on actual basis at the cost/price level of 2024-25.

The variable cost of candidate coal plants has been considered as Rs 2.0/kWh at price/cost level of 2024/25.

**Solar Cost is assumed to reduce from Rs 4.5 Cr/MW in 2024-25 to Rs 4.1 Cr/MW in 2036-37.

Capacity Addition Program (Figures in MW)

Name of Project	SCOD	Capacity (MW)	MP Share (MW)	Year wise Capacity Addition program (MW)											
				2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
MPPGCL - Amarkantak Replacement Unit	Nov-29	1x660	660					660							
MPPGCL - Satpura Replacement Unit	Nov-30	1x660	660						660						
Sub-Total (MPPGCL)			**1320**	**0**	**0**	**0**	**0**	**660**	**660**	**0**	**0**	**0**	**0**	**0**	**0**
NHPC Lower Subansiri HEP U-1	Feb-26	1x250	13	13											
NHPC Lower Subansiri HEP U-2	Jan-26	1x250	13	13											
NHPC Lower Subansiri HEP U-3	Mar-26	1x250	13	13											
NHPC Lower Subansiri HEP U-4	Mar-26	1x250	13	13											
NHPC Lower Subansiri HEP U-5	Jun-26	1x250	13		13										
NHPC Lower Subansiri HEP U-6	Jun-26	1x250	13		13										
NHPC Lower Subansiri HEP U-7	Sep-26	1x250	13		13										
NHPC Lower Subansiri HEP U-8	Sep-26	1x250	13		13										
NHPC Teesta HEP VI (Sikkim)	Dec-27	4x125	45			45									
NHPC Rangit HEP IV (Sikkim)	Dec-25	3x40	16	16											
NHPC Ratle HEP	Dec-27	4x205+1x30	31			31									
Amahata Hydro Unit 4	Feb-26	3.8	3.8	3.8											
NHPC Dibang HEP	Apr-34	12x240	252										252		
Sub-Total (Hydro)			**453**	**72**	**53**	**76**	**0**	**0**	**0**	**0**	**0**	**0**	**252**	**0**	**0**
NTPC Lara STPS, Raigarh U-3	Nov-27	1x800	63.8			63.8									
NTPC Lara STPS, Raigarh U-4	Sep-28	1x800	63.8				63.8								
NTPC Sipat Stage-III	Nov-29	1x800	160					160							
NTPC/NPC JV Anushakti Vidyut Nigam Ltd-Chutka Unit-1	Jun-32	1x700	350								350				

NTPC/NPC JV Anushakti Vidyut Nigam Ltd-Chutka Unit-2	Nov-32	1x700	350								350				
NTPC Gadarwara Phase-II	Nov-32	2x800	800								800				
Sub-Total (Central Sector)			**1788**	**0**	**0**	**64**	**64**	**160**	**0**	**0**	**1500**	**0**	**0**	**0**	**0**
PFCCL MTPP (up to 31.01.2030)	Nov-25		72	72											
Mahan Energen, Unit-1	Apr-27	1x660	615			615									
Mahan Energen, Unit-2	Oct-27	1x660	615			615									
DBFOO (Existing Plants)	Nov-28	900	900				900								
DBFOO Unit-I (New)	Nov-30	1x800	800						800						
DBFOO Unit-II (New)	Apr-31	1x800	800							800					
DBFOO Unit-III (New)	Nov-31	1x800	800							800					
DBFOO Unit-IV (New)	Apr-32	1x800	800								800				
DBFOO Green Shoe Unit	Nov-32	1x800	800								800				
Sub-Total (IPP)			**6202**	**0**	**0**	**1230**	**900**	**0**	**800**	**1600**	**1600**	**0**	**0**	**0**	**0**
Solar Projects - NHPC, Rajasthan (SBE23)	Sep-26		320		320										
Solar Projects - RUMS,ASN	Feb-26		216	216											
Solar Projects - RUMS,ASN	Feb-26		149	149											
CPSU Phase-II Scheme (NTPC ISTS	Feb-26		500	500											
CPSU Phase-II Scheme(SECI) ISTS	Sep-26		500		500										
Solar Projects - Kusum A	Feb-26		347	347											
Solar Projects - Kusum A	Dec-26		1404		1404										
Solar Projects - Kusum C	Dec-26		1171		1171										
Sky Power	Nov-25		50	50											
MPPGCL Solar	Nov-25		7	7											
UVNL (Proposed) KUSUM C	Oct-27		3300			3300									
Morena Solar Park-1	Jul-28	600	600				600								

Morena Solar Park-2 (November-April, Complementary basis with UP)	Nov-28	800	800				800								
Solar Projects			**9364**	**1269**	**3395**	**3300**	**1400**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Wind Tender	Oct-27		1600			1600									
Non-solar projects			**1600**	**0**	**0**	**1600**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Grand Total			**20726**	**1341**	**3447**	**6270**	**2364**	**820**	**1460**	**1600**	**3100**	**0**	**252**	**0**	**0**

Storage Planned	**Contracted Capacity (MW/MWh)**	**Expected Year**
BESS through Morena-1 Solar Project	440 MW/880 MWh	Oct 2028
BESS through VGF	750 MW/1500 MWh	Oct 2027
Pumped Storage	500 MW/3000 MWh	2031-32

- Summary of Year-wise Solar Rooftop and solar Pumps Installations Plans

Source	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
Solar Roof Top	630	704	786	879	981	1096	1225	1368	1528	1707	1906	2130
Solar Pumps	171	196	226	260	299	343	395	454	522	600	691	794