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Report on Resource Adequacy Plan (Generation) for UPPCL, Uttar Pradesh (2026-27 to 2035-36) (Version 2.0)

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Government of India
Ministry of Power
Central Electricity Authority

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Disclaimer

This Resource Adequacy Study for the utility Uttar Pradesh Power Corporation Limited (UPPCL) has been carried out based on the data and inputs provided by the utility. The findings, analysis and conclusions presented in this report are contingent upon the accuracy, completeness and timeliness of the information furnished by the utility. 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 UPPCL, Uttar Pradesh, in fulfilling this requirement.

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

Executive Summary

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

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

The Government of India has gazette-notified the Renewable Consumption Obligation (RCO) trajectory up to 2029-30 vide gazette notification dated 27th September 2025, which mandates that a specified portion of electrical energy consumption must be met from renewable energy sources.

To support the Utility in fulfilling this requirement, CEA, initially carried out a Resource Adequacy (RA) study with a planning horizon up to FY 2033-34, based on the data provided by the utility and in compliance with the RPO trajectory specified in the Ministry of Power's gazette notification dated 20th October, 2023. This study has now been updated and extended to cover the period up to FY 2035-36, incorporating the latest data furnished by the utility and planning assumptions being in line with the RCO trajectory as notified by Ministry of Power vide gazette notification dated 27th September, 2025.

The electrical energy requirement and peak electricity demand for Uttar Pradesh, as per the projections furnished by the utility, are projected to increase with a CAGR of 7.1% and 6.9% respectively from 2025-26 to 2035-36. For satisfying resource adequacy i.e. meeting the electricity demand reliably and at affordable cost, the Utility needs to methodically plan its capacity expansion either by investing in new generation or by procuring power. In view of the reduction in cost of solar panels and newer technology options like energy storage systems, planning for long term optimal generation capacity mix gains tremendous importance so as the future generation capacity mix is cost effective as well as environment friendly.

The study for UPPCL, based on existing contracted capacity and planned capacity additions, indicates that the available capacity will not be sufficient to meet the projected electricity demand. The total unserved electrical energy in the year 2035-36 is expected to be about 63,977 MU, which is about 21% of the projected annual electrical energy requirement during the year 2035-36.

Further, UPPCL, with its existing and planned Renewable Energy (RE) based capacity, may be unable to fulfill its Renewable Consumption Obligation targets.

To find out the least cost option for generation capacity expansion for the period 2026-27 to 2035-36, generation expansion study has been carried out with the objective to minimize the total system cost of generation including the cost of anticipated future investments while fulfilling all the technical constraints associated with various power generation technologies. Additionally, reliability study has been carried out to determine the probability of unmet demand and hours by implementing the variation in demand, RE generation and forced outage of thermal generators (coal/ lignite) etc.

Generation capacity expansion pathways have been considered for the long-term study based on the yearly capacity addition plans of the utility, along with RCO constraints. The Renewable capacities have been assessed in view of adherence to the RCO trajectory gazette notified by the Ministry of Power, considering the fungibility among different sources.

The Resource adequacy studies have projected likely optimal capacity mix for future years till 2035-36 which shall be able to meet anticipated demand reliably at every instance. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 1,34,749 MW which consists of 35,313 MW from Coal; 549 MW from Gas; 613 from Nuclear; 1,498 MW from Biomass; 5,247 MW from Hydro; 10,546 from Wind; 29,883 MW from Solar; 300 MW from Hybrid; 800 MW from Complementary Solar tied up with MPPMCL in the months of May to October for UPPCL; 4,010 MW from FDRE; 13,938 MW from Energy Storage System (comprising of 887 MW of 2 hour ESS and 13051 MW of 4 hour ESS). This capacity shall be able to meet the projected demand with prescribed reliability criteria while complying with the stipulated RCO targets of excluding DRE from 2028-29 onwards. The additional energy storage requirement could be met from power tie up from PSPs or a combination of PSP and BESS.

This capacity shall be able to meet the projected demand with prescribed reliability criteria while complying with the stipulated RCO targets.

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 capacity is available round-the-clock to reliably serve the electricity demand, under various scenarios. This naturally translates into the need for ensuring adequate reserve margin which could cater to varying levels of demand and supply conditions in the grid. In the wake of high RE generation, it is important to understand demand-supply situation in the grid precisely due to high seasonality and intermittency in RE generation. Resource Adequacy exercise may also help in assessment of capacity requirement to be tied up or contracted on long term, medium term, and short-term basis.

Further, the Ministry of Power vide notification dated 27th September 2025, had notified the RCO trajectory for the states/Discoms. Based on the trajectory specified, hydro, wind and other (solar, biomass, etc.) RCO quantum in million units (MUs) has been calculated to find additional quantum of renewable capacity that the states/Discoms have to contract in addition to their existing/planned capacity to meet their RCO targets.

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

Earlier, CEA had conducted the RA study for the Utility up to FY 2033-34, based on data furnished by the utility and in accordance with the RPO trajectory specified vide Ministry of Power notification dated 20th October, 2023.

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

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

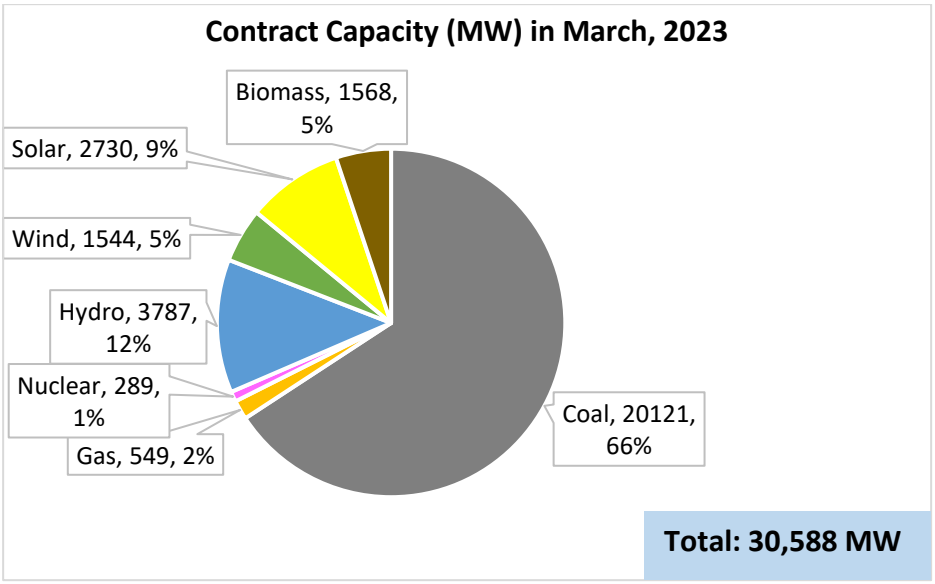


Figure 1: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2023

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

Table 1: Peak electricity demand and electrical energy projections as per 20th EPS Report

	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34
Electrical Energy Requirement Projections (MU)	162297 (148791*)	173262 (165090*)	185390	198367	212738	227111	243009	260020	278222	296306	315566
Year on Year Growth		6.8%	7.0%	7.0%	7.2%	6.8%	7.0%	7.0%	7.0%	6.5%	6.5%
Peak Electricity Demand Projections (MW)	28737 (28704*)	30605 (30618*)	32595	34713	36970	39373	41932	44657	47560	50651	53943
Year on Year Growth		6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%

** Actual Electricity Demand*

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

Table 2: Source-wise projected capacities

Year	Coal	Gas	Nuclear	Biomass	Hydro	Wind	Solar	Storage (MW/MWh)	DRE	STOA*
2024-25	25763	549	289	1629	4127	2630	3169	0/0	1450	5538
2025-26	25653	549	289	1629	4227	4030	3779	0/0	3050	7000
2026-27	30680	549	289	1629	4845	4830	11779	0/0	4650	4544
2027-28	32881	549	289	1629	5095	5630	19779	3535.4/14141.7	6250	1212
2028-29	33571	549	289	1629	5345	6430	27779	6061.1/24244.6	7850	166
2029-30	33461	549	451	1629	5595	8230	31392	9187/36748	8560	0
2030-31	33351	549	451	1629	5595	9030	36849	13610.8/54443.2	10177	0
2031-32	34050	549	451	1629	5595	9830	41740	17202.8/68811.2	11979	0
2032-33	35624	549	451	1629	5595	10630	46514	20341.5/81366.1	13917	0
2033-34	36807	549	451	1629	5595	11430	48779	25437/101748.3	16057	0

***** *The SToA/MToA value represents the peak power requirement in MW and it was recommended that this requirement may be met through power procurement from the market or through bilateral agreements.*

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

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

	COAL		**HYDRO**		**WIND**		**SOLAR**	
Year	**Planned Contracts**	**Additional Requirement**	**Planned Contracts**	**Additional Requirement**	**Planned Contracts**	**Additional Requirement**	**Planned Contracts**	**Additional Requirement**
2024-25	2739	0	340	0	622	0	225	0
2025-26	0	0	100	0	1400	0	610	0
2026-27	0	5027	368	250	0	800	0	8000
2027-28	0	2312	0	250	0	800	0	8000
2028-29	800	0	0	250	0	800	0	8000
2029-30	0	0	0	250	0	1800	0	3613
2030-31	0	0	0	0	0	800	0	5457
2031-32	0	699	0	0	0	800	0	4891
2032-33	0	1574	0	0	0	800	0	4774
2033-34	0	1183	0	0	0	800	0	2265
	Nuclear		**Distributed RE**		**TOTAL**		**Storage**	
Year	**Planned Contracts**	**Additional Contracts**	**Planned Contracts**	**Additional Requirement**	**Planned contracts**	**Additional Requirement**	**Planned contracts**	**Additional Requirement**
2024-25	0	0	1450	0	**5376**	**0**	0	0/0
2025-26	0	0	1600	0	**3710**	**0**	0	0/0
2026-27	0	0	1600	0	**1968**	**14077**	0	0/0
2027-28	0	0	1600	0	**1600**	**11362**	0	3535/14141
2028-29	0	0	1600	0	**2400**	**9050**	0	2525/10102
2029-30	162	0	0	710	**162**	**6373**	0	3125/12503
2030-31	0	0	0	1617	**0**	**7874**	0	4423/17695
2031-32	0	0	0	1801	**0**	**8191**	0	3591/14367
2032-33	0	0	0	1938	**0**	**9086**	0	3138/12554
2033-34	0	0	0	2140	**0**	**6388**	0	5095/20382

3.0 RA Study of UPPCL (from 2026-27 to 2035-36)

3.1 Present Power Scenario in Uttar Pradesh

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

Table 4: Power Supply Position of Uttar Pradesh

Power Supply Position						
Year	**Energy required (MU)**	**Energy supplied (MU)**	**Gap (MU)**	**Peak Demand (MW)**	**Peak Met (MW)**	**Demand not met (MW)**
2024-25	1,65,090	1,64,786	304	30,618	30,618	0
2023-24	1,48,791	1,48,287	504	28,704	28,284	420
2022-23	1,44,251	1,43,050	1,201	27,369	26,589	780
2021-22	1,29,448	1,28,310	1,138	24,965	24,795	170
2020-21	1,24,367	1,23,383	984	23,797	23,747	50

As per the data provided by the utility, as of January 2026, the total contracted capacity of UPPCL is 35,995 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is around 29%. The fuel-wise contracted capacity as on January 2026, is given in Table 5 and Fig. 2.

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

Source	Contracted Capacity (MW)	Percentage
Coal	25137	69.8%
Gas	549	1.5%
Nuclear	370	1%
Biomass + Bagasse + Slop + MSW	1498	4.2%
Hydro + Small Hydro	3948	11%
Wind	1556	4.3%
Solar	2937	8.2%
Total	**35995**	**100%**

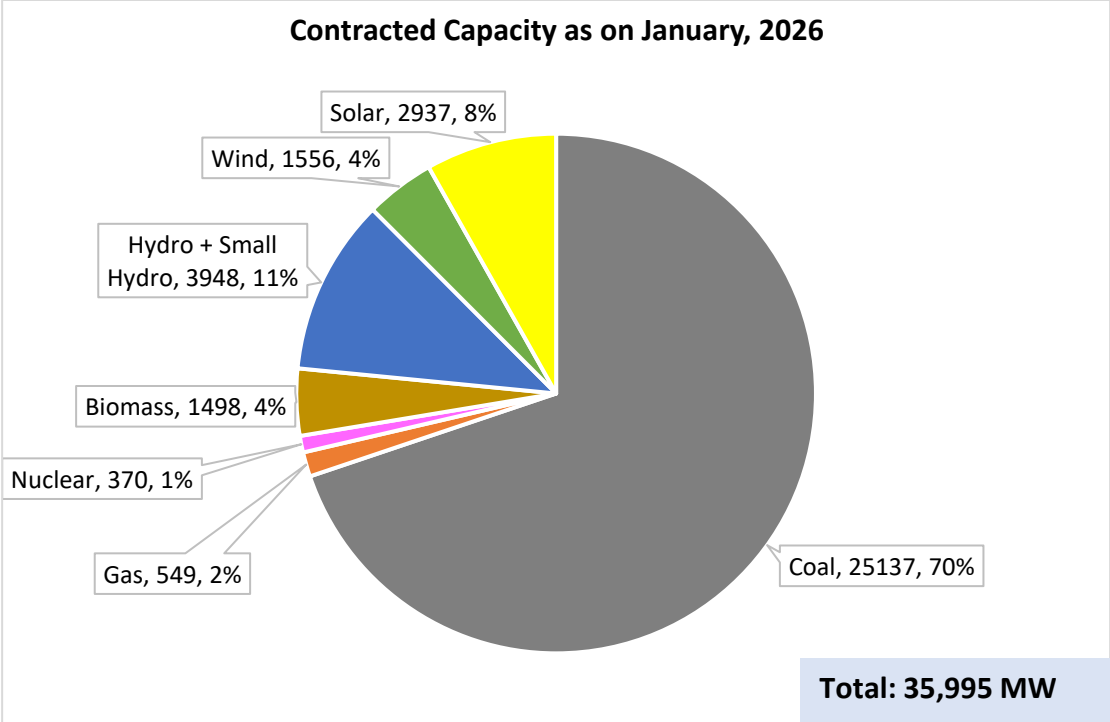


Figure 2: Fuel-wise Contracted Capacity (in MW) as on January, 2026

3.2 Demand Analysis of the FY 2024-25

The hourly demand pattern for 2024-25 was analyzed, and it was observed that UPPCL experiences its highest annual electricity demand during the months of June and July, with the annual peak electricity demand specifically occurring in June during night period. Higher electricity demand is generally observed during the non-solar (evening) hours across most months. While overall demand varies seasonally, with higher levels in summer and comparatively lower levels in winter, the evening peak pattern remains consistent throughout the year. The month-wise average hourly demand observed for the year 2024-25 is shown in Fig. 3.

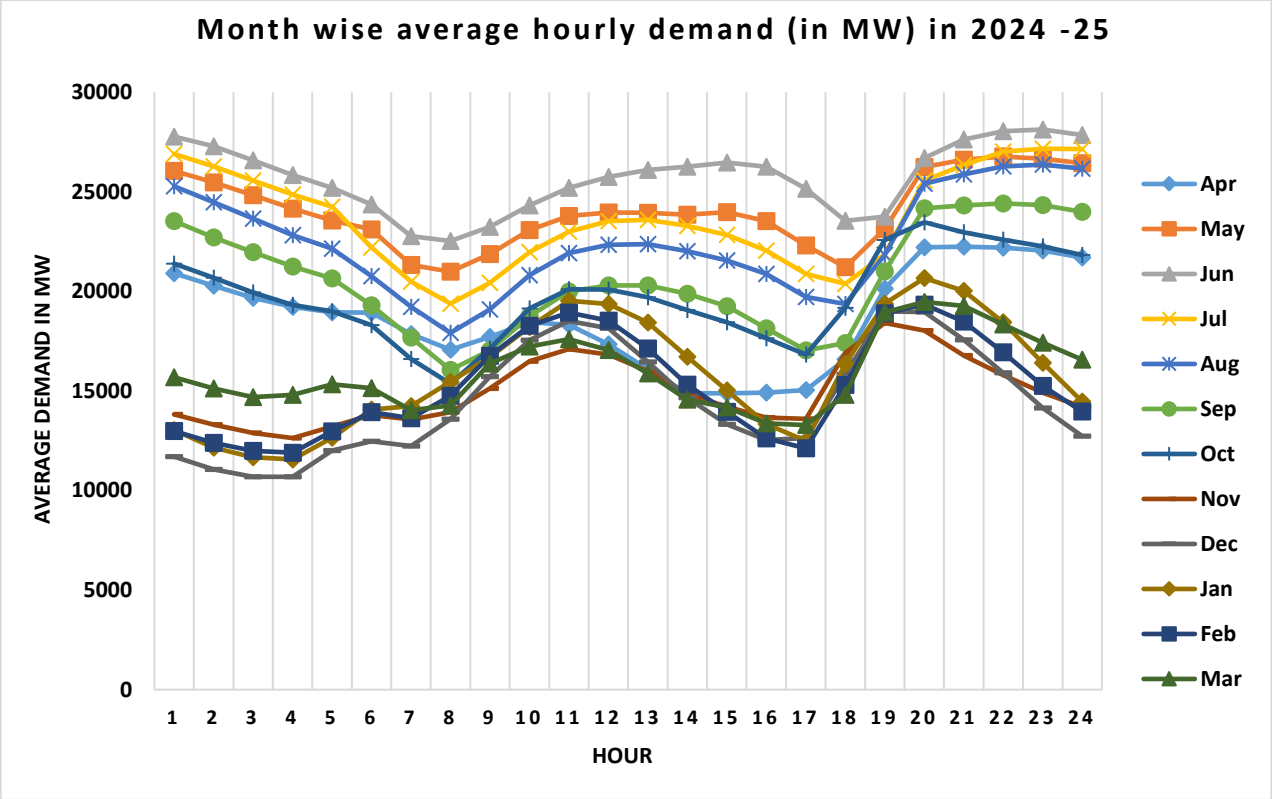


Figure 3: Month-wise Average Hourly Demand Variation for 2024-25

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

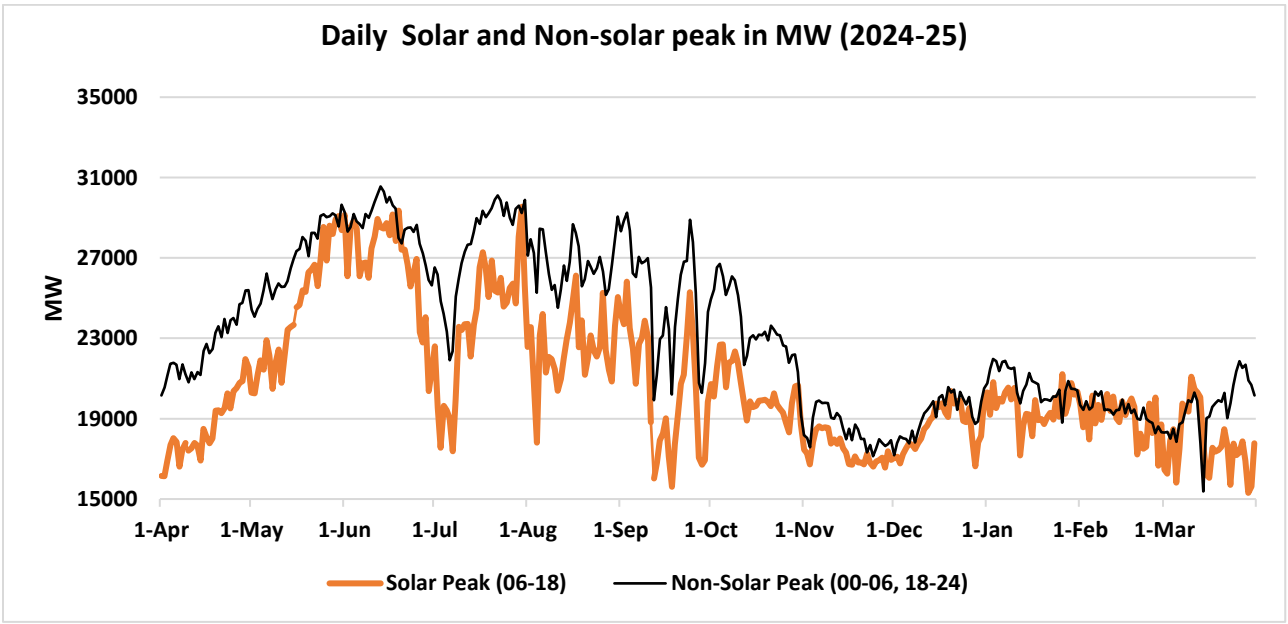


Figure 4: Solar and non-solar peak in MW for the year 2024-25

The hourly demand pattern of 2024-25 was analysed for finding out the number of occurrences of the peak and near peak demand. Such instances are critical for study purpose as it is necessary to ensure resource adequacy during such instances with an optimal mix of long-term, medium-term and short-term contracts. Frequency Distribution of hourly demand profile for 2024-25 is shown in Fig. 5.

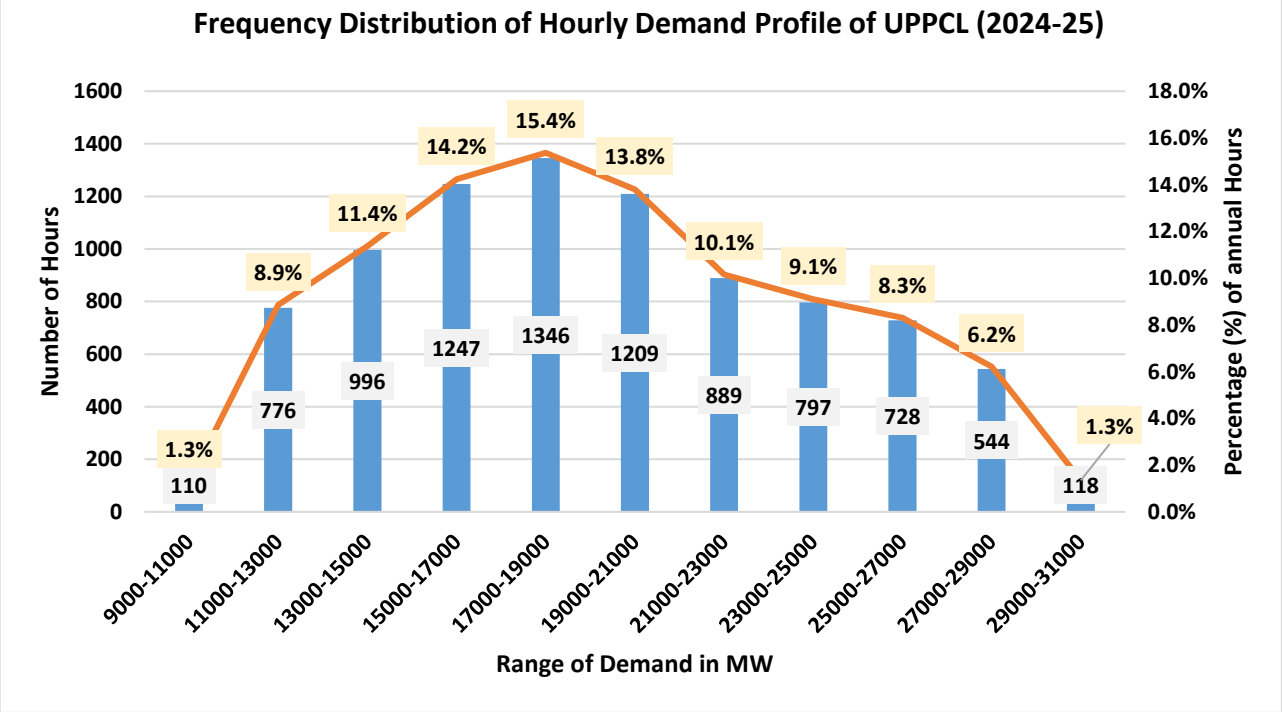


Figure 5: Frequency Distribution of hourly demand profile of 2024-25

4.0 Principles of Generation Planning

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

The major aspects considered in the planning process are:

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

4.1 Generation Expansion Planning Tool -ORDENA

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

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

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

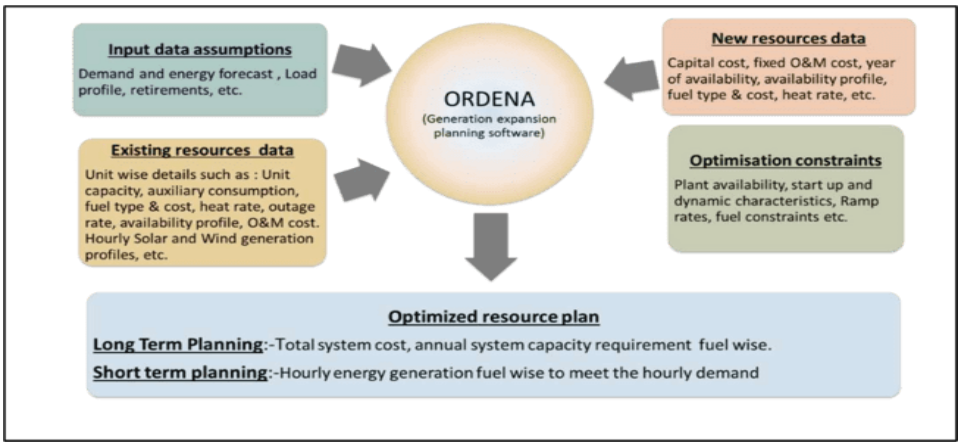


Figure 6: Schematic Diagram

5.0 Reliability Analysis

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

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

Mega Watt hours (MWh). The metric can be normalized (i.e., divided by total system energy requirement) to create a Normalized Energy Not Served (NENS) metric.

Monte Carlo /Stochastic simulation has been used to factor-in the uncertainty associated with various generation resources and demand. It is an approach which is used to predict the probability of a variety of outcomes when the potential for random variables is present, as compared to deterministic modelling of economic dispatch model. Monte Carlo simulation helps in analysing the randomness associated with RE energy resource, demand pattern changes and forced outages of plant. A large no. of random samples of these variables is simultaneously simulated to ascertain system reliability indices (i.e. Loss of load probability LOLP & Energy Not Served (ENS)) & the system robustness in case of above variation of system parameters.

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

5.1 Variation in electricity demand

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

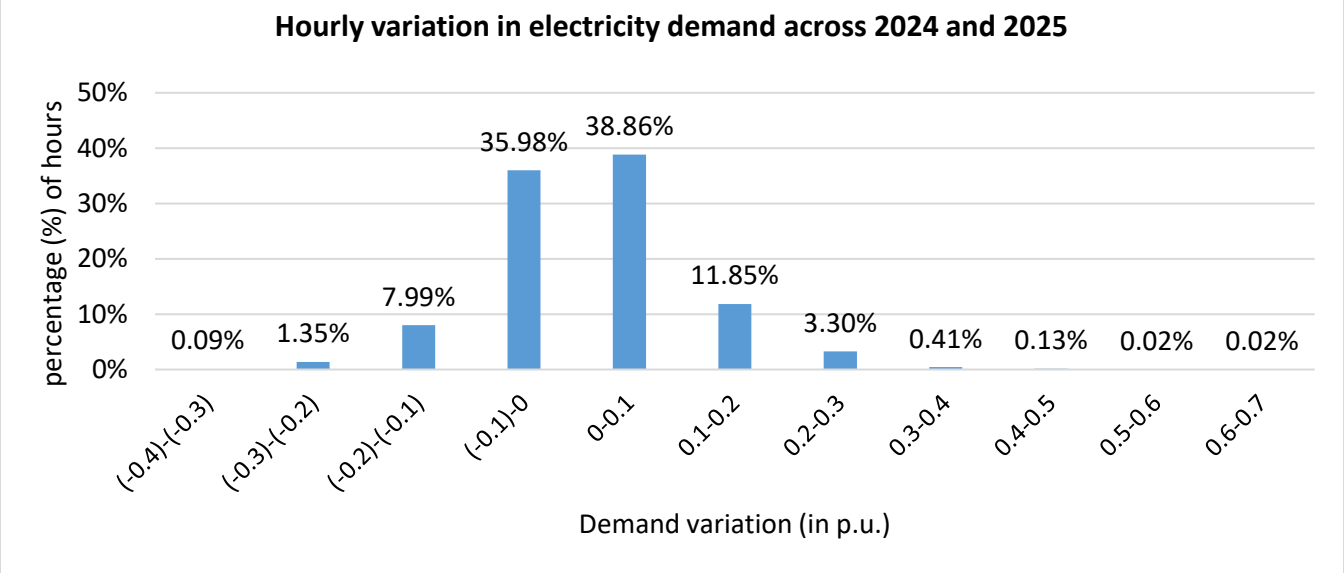


Figure 7: Hourly Variation in electricity demand across years

It can be observed that the hourly demand typically varies within ±10% for ~75% of instances. This variation is primarily due to temperature, weather parameter or any random outages of transmission line and generating units etc. This variation has been captured in the reliability study

by incorporating a variation of ±10% in the projected hourly demand for the future years by introducing a random variable (with normal distribution) for demand as per observed behavior over the years.

5.2 Variation in RE Generation

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

5.3 Forced Outage of Thermal Generators

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

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

6.0 Inputs/Assumptions for the Study

i) The peak electricity demand and electrical energy requirements of Uttar Pradesh is considered as per the projections furnished by the utility and are given in Table 6:

Table 6: Electricity demand projections as furnished by the utility

Year	Peak Electricity Demand		Electrical Energy Requirement	
	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth
2026-27	33,934		1,61,670	
2027-28	36,377	7.2%	1,73,456	7.3%
2028-29	38,851	6.8%	1,86,257	7.4%
2029-30	41,570	7.0%	2,00,133	7.5%
2030-31	44,480	7.0%	2,15,203	7.5%
2031-32	47,594	7.0%	2,29,815	6.8%
2032-33	50,688	6.5%	2,45,397	6.8%
2033-34	53,982	6.5%	2,61,961	6.7%
2034-35	57,491	6.5%	2,79,565	6.7%
2035-36	61,228	6.5%	2,98,240	6.7%

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

iii) The actual solar and wind generation profile has been considered as per the inputs from the utility. The hydro generation profiles is as per the data available with CEA.

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

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

Table 7: Source-wise planned contract capacity addition (in MW)

	Coal	Nuclear	Hydro	Solar	Wind	Hybrid	Complementary Solar*	FDRE	Storage (MW/ MWh)	DRE
2026-27	615	81	182	2030	2345	-	-	-	-	1673
2027-28	-	-	340	2110	-	300	-	4010	250/1000	-
2028-29	-	-	-	-	-	-	800	-	-	-
2029-30	267	-	101	-	-	-	-	-	-	-
2030-31	267	-	51	1000	-	-	-	-	-	-
2031-32	1500	-	-	-	-	-	-	-	-	-
2032-33	-	81	385	-	-	-	-	-	-	-
2033-34	-	81	-	-	-	-	-	-	-	-
2034-35	-	-	241	-	-	-	-	-	-	-
2035-36	-	-	-	57	-	-	-	-	-	-
Total	**2649**	**243**	**1299**	**5197**	**2345**	**300**	**800**	**4010**	**250/1000**	**1673**

*The complementary solar capacity of 800 MW implies that the contracted solar power will be utilised by UPPCL during the months of May to October, while the same capacity will be utilised by MPPMCL, Madhya Pradesh, during the remaining months of the year.

vi) Renewable Consumption Obligation (RCO) trajectory: Ministry of Power vide gazette 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 as given in Table 8.

Table 8: Renewable Consumption Obligation (RCO) trajectory as per the MoP order

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	2024-25	0.67%	0.38%	27.35%	1.5%	29.91%
2.	2025-26	1.45%	1.22%	28.24%	2.1%	33.01%
3.	2026-27	1.97%	1.34%	29.94%	2.7%	35.95%
4.	2027-28	2.45%	1.42%	31.64%	3.3%	38.81%
5.	2028-29	2.95%	1.42%	33.1%	3.9%	41.36%
6.	2029-30	3.48%	1.33%	34.02%	4.5%	43.33%

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

Table 9: Renewable Consumption Obligation (RCO) trajectory (in %) considered for the study

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	2024-25	0.67%	0.38%	27.35%	1.50%	29.91%
2.	2025-26	1.45%	1.22%	28.24%	2.10%	33.01%
3.	2026-27	1.97%	1.34%	29.94%	2.70%	35.95%
4.	2027-28	2.45%	1.42%	31.64%	3.30%	38.81%
5.	2028-29	2.95%	1.42%	33.10%	3.90%	41.36%
6.	2029-30	3.48%	1.33%	34.02%	4.50%	43.33%
7.	2030-31	40.50%			5.00%	45.50%
8.	2031-32	41.50%			5.50%	47.00%
9.	2032-33	42.30%			6.00%	48.30%
10.	2033-34	43.00%			6.50%	49.50%
11.	2034-35	43.50%			7.00%	50.50%
12.	2035-36	44.00%			7.50%	51.50%

As per the notification dated 27th September 2025, Ministry of Power had notified the RCO trajectory for Designated Consumers/Discoms. For all the designated consumers, the Renewable Consumption Obligation shall exclude electricity consumed from Nuclear Power Sources. The Adjusted Electrical Energy Requirement (MU) after excluding Nuclear Power Sources is tabulated below:

Table 10: Adjusted Electrical Energy Requirement (MU)

	Electrical Energy Requirement (MU)	Nuclear Energy (MU)	Adjusted Electrical Energy Requirement (MU)
2026-27	1,61,670	2,420	1,59,250
2027-28	1,73,456	2,420	1,71,035
2028-29	1,86,257	2,420	1,83,836
2029-30	2,00,133	2,420	1,97,713
2030-31	2,15,203	2,420	2,12,783
2031-32	2,29,815	2,420	2,27,395
2032-33	2,45,397	2,854	2,42,542
2033-34	2,61,961	3,289	2,58,672
2034-35	2,79,565	3,289	2,76,276
2035-36	2,98,240	3,289	2,94,951

Based on the trajectory specified and adjusted electrical energy computed in table above, RCO quantum in million units (MUs) from hydro, wind, other (solar, biomass, etc.) and Distributed Renewable Energy (DRE) has been calculated and is tabulated in Table 11.

Table 11: Total Electrical Energy required to meet RCO (MU)

Sl. No.	Year	Wind renewable energy (MU)	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	**2026-27**	3137	2134	47679	4300	57250
2.	**2027-28**	4190	2429	54116	5644	66379
3.	**2028-29**	5423	2610	60850	7170	76035
4.	**2029-30**	6880	2630	67262	8897	85669
5.	**2030-31**	86177			10639	96816
6.	**2031-32**	94369			12507	106876
7.	**2032-33**	102595			14553	117148
8.	**2033-34**	111229			16814	128043
9.	**2034-35**	120180			19339	139519
10.	**2035-36**	129778			22121	151900

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

Table 12: Renewable Energy Deficit/Surplus

FY	RE Generation required to meet RCO (excluding DRE)		RE Generation (excluding DRE) available or to be met from existing and planned contracts		RE Generation Surplus (+)/ Deficit (-) (excluding DRE)
	(MU)	(%)	(MU)	(%)	(%)
2026-27	52951	33.25%	38560	24.21%	-9.04%
2027-28	60735	35.51%	65408	38.24%	2.73%
2028-29	68884	37.47%	66989	36.44%	-1.03%
2029-30	76772	38.83%	67348	34.06%	-4.77%
2030-31	86177	40.50%	69534	32.68%	-7.82%
2031-32	94369	41.50%	69534	30.58%	-10.92%
2032-33	102595	42.30%	70897	29.23%	-13.07%
2033-34	111229	43.00%	70897	27.41%	-15.59%
2034-35	120180	43.50%	71832	26.00%	-17.50%
2035-36	129778	44.00%	71941	24.39%	-19.61%

Similarly, the year-wise total renewable energy for Distributed Renewable Energy (DRE) met from the existing and planned addition in DRE (i.e., 1673 MW) along with the deficit is shown in table below:

Table 13: Distributed Renewable Energy (DRE) Deficit/Surplus

FY	DRE Generation required to meet RCO		DRE generation available or met from existing and planned contracts		DRE Generation Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2026-27	4300	2.70%	2137	1.34%	-1.36%
2027-28	5644	3.30%	2137	1.25%	-2.05%
2028-29	7170	3.90%	2137	1.16%	-2.74%
2029-30	8897	4.50%	2137	1.08%	-3.42%
2030-31	10639	5.00%	2137	1.00%	-4.00%
2031-32	12507	5.50%	2137	0.94%	-4.56%
2032-33	14553	6.00%	2137	0.88%	-5.12%
2033-34	16814	6.50%	2137	0.83%	-5.67%
2034-35	19339	7.00%	2137	0.77%	-6.23%
2035-36	22121	7.50%	2137	0.72%	-6.78%

As indicated in the tables above, the utility will not be able to meet its RCO requirements, based on the existing and planned contracts.

7.0 Outcomes of the Study

7.1 Unserved Energy Projections

Initially, the study has been carried out considering only the existing and planned capacity contracts of UPPCL, and does not include any banking arrangements or short-term contracts. From the study, it has been observed that the existing and planned capacity contracts (excluding the banking arrangements or short-term contracts) may not be sufficient to meet the demand reliably. The total unserved electrical energy for the year 2035-36 would be around 63,977 MU. The year-wise likely unserved electrical energy with the planned capacities is given in Figure 8.

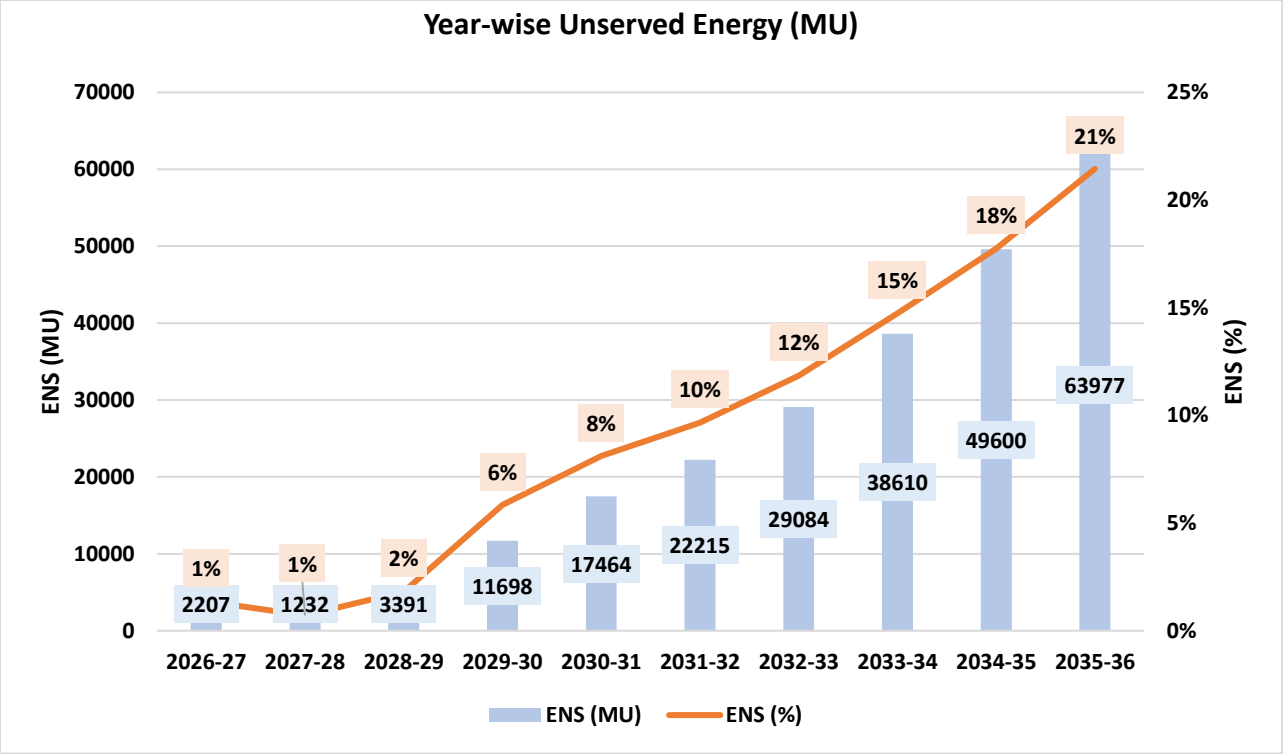


Figure 8 Year-wise likely unserved electrical energy (in MU) with the existing and planned capacities

The study has also analyzed the daily and monthly pattern of unserved electrical energy in the year 2035-36 as shown in Figure 9.

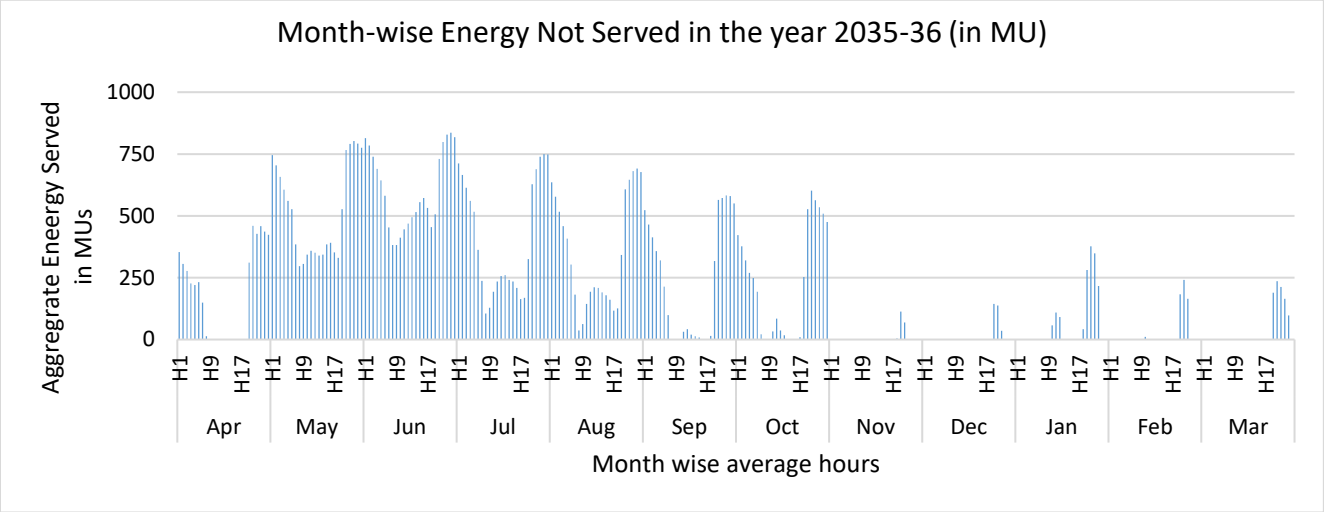


Figure 9 Block-wise Unserved Electrical Energy Pattern GWh (2035-36)

The unmet demand primarily occurs during the non-solar hours and throughout the day in high demand months i.e. May to July. To meet unserved energy, the utility needs to tie up additional capacity (including the banking arrangements thereof).

7.2 Investment options to meet the unserved energy

Candidate capacities have been given to the model to find the least cost optimal capacity mix required to meet the demand keeping in view the compliance of Renewable Consumption Obligation. The capacity projection for the utility is tabulated below:

Table 14: Year-wise contracted capacity projections (existing, planned, to be tied up) (in MW)

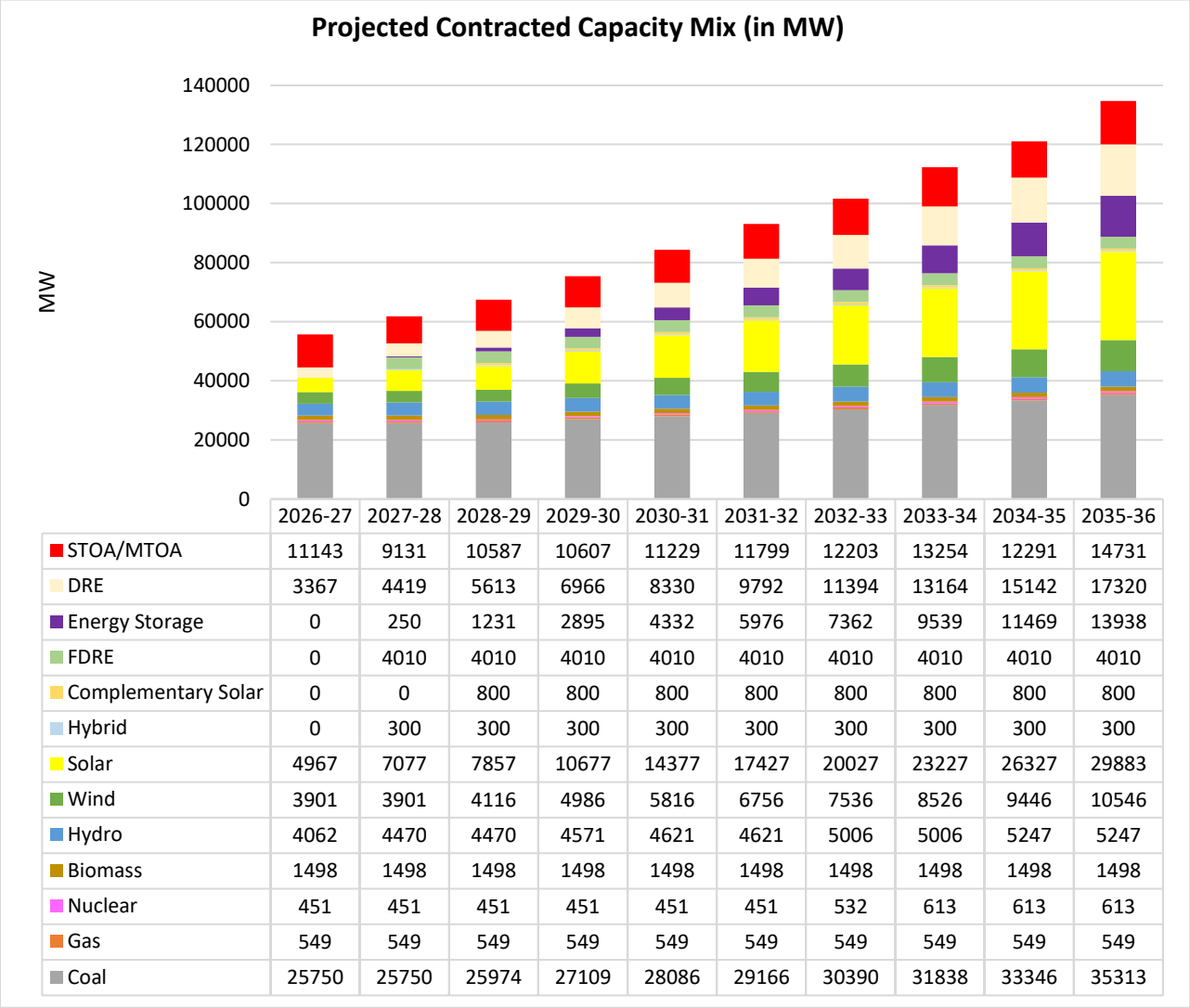
	Coal	Gas	Nuclear	Biomass	Hydro	Wind	Solar	Hybrid	Com-plementary Solar *	FDRE	Energy Storage MW/ MWh	DRE	STOA/ MTOA@
2026-27	25750	549	451	1498	4062	3901	4967	0	0	0	0/0	3367	11143
2027-28	25750	549	451	1498	4470	3901	7077	300	0	4010	250/1000	4419	9131
2028-29	25974	549	451	1498	4470	4116	7857	300	800	4010	1230/4922	5613	10587
2029-30	27109	549	451	1498	4571	4986	10677	300	800	4010	2894/11578	6966	10607
2030-31	28086	549	451	1498	4621	5816	14377	300	800	4010	4331/16765	8330	11229
2031-32	29166	549	451	1498	4621	6756	17427	300	800	4010	5975/22959	9792	11799
2032-33	30390	549	532	1498	5006	7536	20027	300	800	4010	7362/28361	11394	12203
2033-34	31838	549	613	1498	5006	8526	23227	300	800	4010	9538/37066	13164	13254
2034-35	33346	549	613	1498	5247	9446	26327	300	800	4010	11469/44102	15142	12291
2035-36	35313	549	613	1498	5247	10546	29883	300	800	4010	13937/53977	17320	14731

Note: For the year 2026-27, though the projected electricity demand is being met, the likely RCO deficit of the utility from RE based sources (non-DRE) will be around 14,390 MU. Accordingly, to meet the RCO targets (non-DRE) for the year 2026-27, the utility may endeavor short-term contract, or any other appropriate mechanisms deemed suitable by the utility.

*The complementary solar capacity of 800 MW implies that the contracted solar power will be utilised by UPPCL during the months of May to October, while the same capacity will be utilised by MPPMCL, Madhya Pradesh during the remaining months of the year.

@ The SToA/MToA value represents the year-wise peak power requirement and banking arrangement.

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



	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
STOA/MTOA	11143	9131	10587	10607	11229	11799	12203	13254	12291	14731
DRE	3367	4419	5613	6966	8330	9792	11394	13164	15142	17320
Energy Storage	0	250	1231	2895	4332	5976	7362	9539	11469	13938
FDRE	0	4010	4010	4010	4010	4010	4010	4010	4010	4010
Complementary Solar	0	0	800	800	800	800	800	800	800	800
Hybrid	0	300	300	300	300	300	300	300	300	300
Solar	4967	7077	7857	10677	14377	17427	20027	23227	26327	29883
Wind	3901	3901	4116	4986	5816	6756	7536	8526	9446	10546
Hydro	4062	4470	4470	4571	4621	4621	5006	5006	5247	5247
Biomass	1498	1498	1498	1498	1498	1498	1498	1498	1498	1498
Nuclear	451	451	451	451	451	451	532	613	613	613
Gas	549	549	549	549	549	549	549	549	549	549
Coal	25750	25750	25974	27109	28086	29166	30390	31838	33346	35313

2

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

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

Reliability studies have been conducted based on the projected capacity for the year 2035-36. The analysis confirms that the projected capacity meets the reliability criteria specified in the National Electricity Plan (NEP), with the Loss of Load Probability (LoLP) and Normalised Energy Not Served (NENS) remaining within the permissible limits of 0.2% and 0.05%.

The Resource adequacy studies have projected likely optimal capacity mix for future years till 2035-36 which shall be able to meet anticipated electricity demand reliably. Based on the study, the likely

total projected contracted capacity for the year 2035-36 is around 1,34,749 MW which consists of 35,313 MW from Coal; 549 MW from Gas; 613 from Nuclear; 1498 MW from Biomass; 5,247 MW from Hydro; 10,546 from Wind; 29,883 MW from Solar; 300 MW from Hybrid; 800 MW from Complementary Solar tied up with MPPMCL in the months of May to October to UPPCL; 4010 MW from FDRE; 13,938 MW from Energy Storage System (comprising of 887 MW of 2 hour ESS and 13051 MW of 4 hour ESS). The additional energy storage requirement could be met from power tie up from PSPs or a combination of PSP and BESS. This capacity shall be able to meet the projected demand with prescribed reliability criteria.

Based on this capacity addition, the Planning Reserve Margin works out to about 7%. Capacity mix required by 2035-36 is shown in Figure 9.

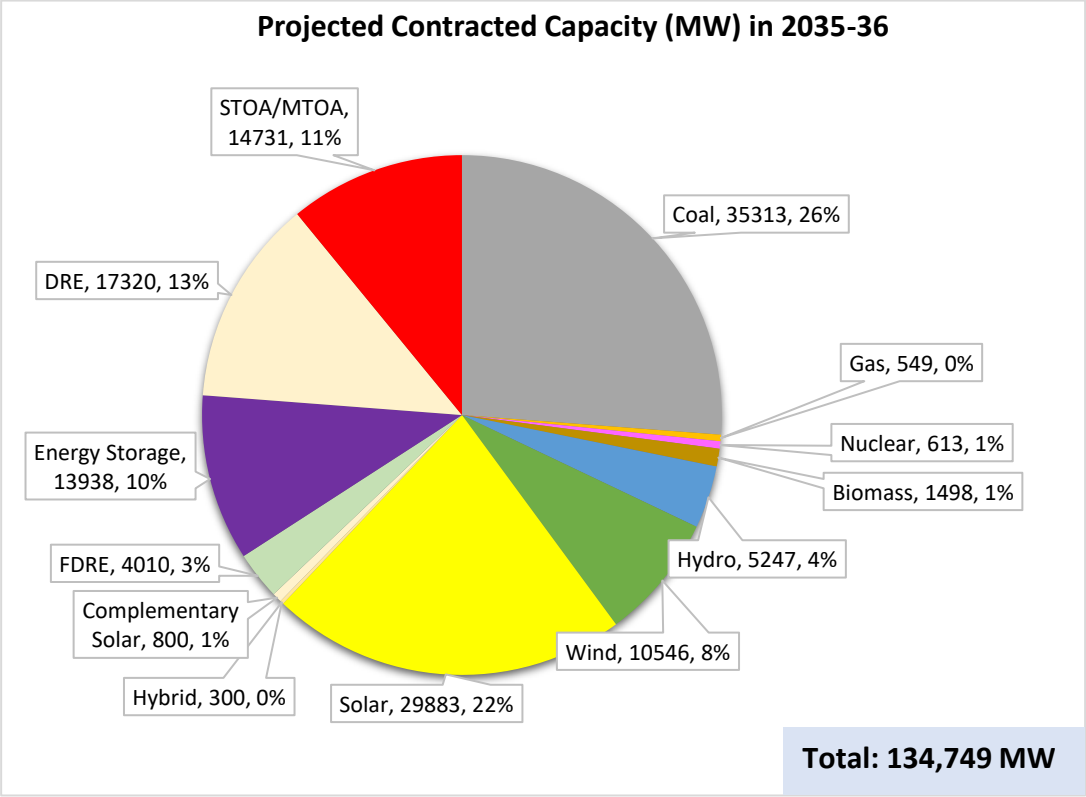


Figure 9: Contracted Capacity Mix in 2035-36

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

As per the study, the utility likely needs to contract the following capacities (planned and additional) every year till 2035-36 to meet its demand reliably as shown in Table 15.

Table 15: Year-wise Capacity Addition (in MW)

	Coal			Nuclear	Hydro	Solar		Complementary Solar *
	Planned Contracts	Additional Contracts	Retirement assumed	Planned Contracts	Planned Contracts	Planned Contracts	Additional Contracts	Planned Contracts
2026-27	615	0	0	81	114	2030	0	0
2027-28	0	0	0	0	408	2110	0	0
2028-29	0	224	0	0	0	0	780	800
2029-30	267	3607	-2740	0	101	0	2820	0
2030-31	267	710	0	0	51	1000	2700	0
2031-32	1500	0	-420	0	0	0	3050	0
2032-33	0	1225	0	81	385	0	2600	0
2033-34	0	1448	0	81	0	0	3200	0
2034-35	0	1508	0	0	241	0	3100	0
2035-36	0	1967	0	0	0	57	3500	0
TOTAL	**2649**	**10688**	**-3160**	**243**	**1299**	**5197**	**21750**	**800**
	Wind		**Hybrid**	**FDRE**	**DRE**		**Energy Storage (MW/MWh)**	
	Planned Contracts	Additional Contracts	Planned Contracts	Planned Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts
2026-27	2345	0	0	0	1673	1693	0	0/0
2027-28	0	0	300	4010	0	1053	250/1000	0/0
2028-29	0	215	0	0	0	1194	0	980/3922
2029-30	0	870	0	0	0	1353	0	1664/6656
2030-31	0	830	0	0	0	1364	0	1437/5186
2031-32	0	940	0	0	0	1462	0	1643/6194
2032-33	0	780	0	0	0	1602	0	1386/5402
2033-34	0	990	0	0	0	1770	0	2176/8705
2034-35	0	920	0	0	0	1977	0	1930/7035
2035-36	0	1100	0	0	0	2178	0	2468/9874
TOTAL	**2345**	**6645**	**300**	**4010**	**1673**	**15647**	**250/1000**	**13687/52977**

*The complementary solar capacity of 800 MW implies that the contracted solar power will be utilised by UPPCL during the months of May to October, while the same capacity will be utilised by MPPMCL, Madhya Pradesh during the remaining months of the year.

In addition to above, the year-wise STOA/MTOA requirement as outlined in Table 14, also needs to be tied up.

The projected net generation mix for the Utility is shown in Figure 10 and 11.

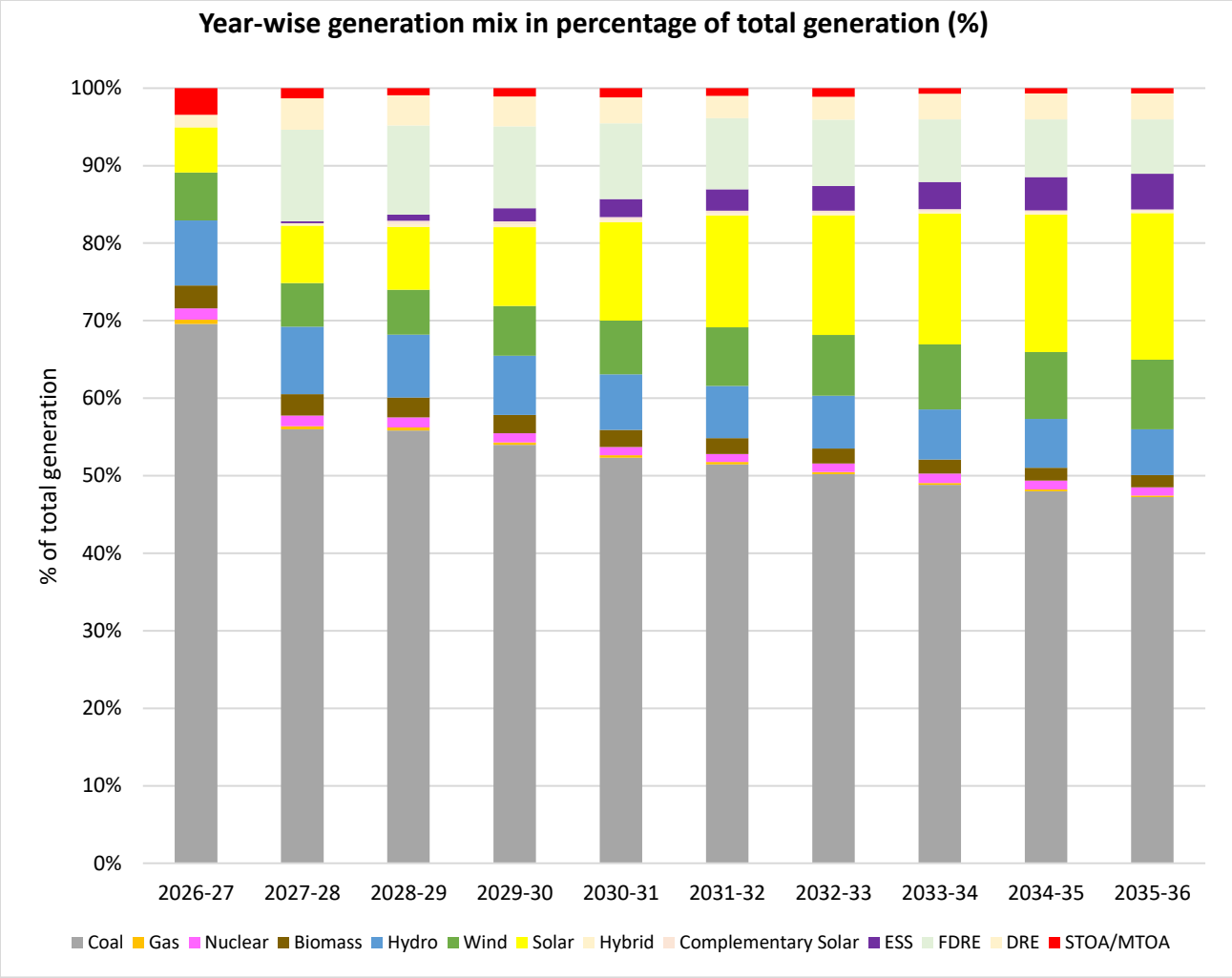
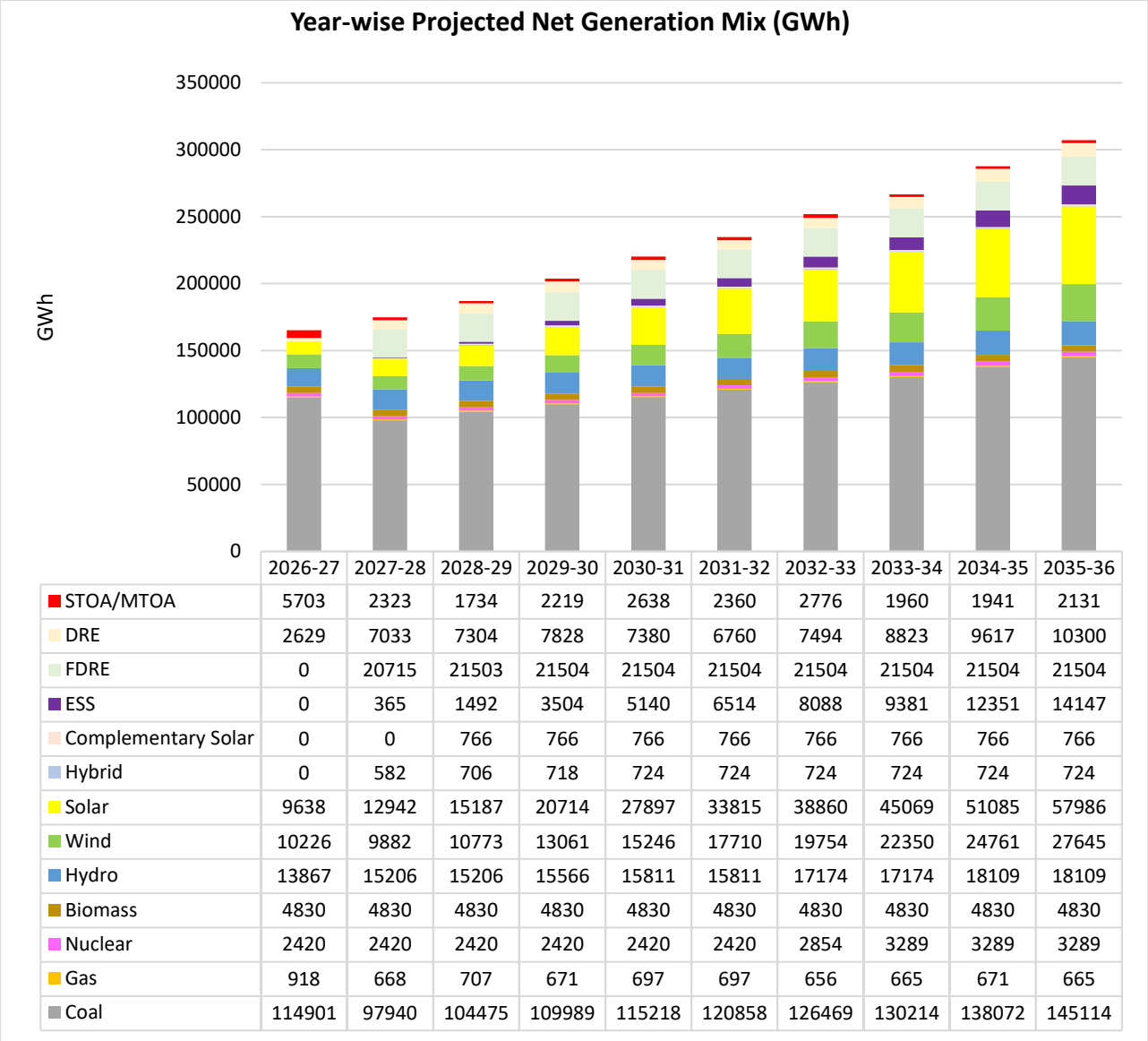


Figure 10: Year-wise projected net generation mix (in %)



	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
STOA/MTOA	5703	2323	1734	2219	2638	2360	2776	1960	1941	2131
DRE	2629	7033	7304	7828	7380	6760	7494	8823	9617	10300
FDRE	0	20715	21503	21504	21504	21504	21504	21504	21504	21504
ESS	0	365	1492	3504	5140	6514	8088	9381	12351	14147
Complementary Solar	0	0	766	766	766	766	766	766	766	766
Hybrid	0	582	706	718	724	724	724	724	724	724
Solar	9638	12942	15187	20714	27897	33815	38860	45069	51085	57986
Wind	10226	9882	10773	13061	15246	17710	19754	22350	24761	27645
Hydro	13867	15206	15206	15566	15811	15811	17174	17174	18109	18109
Biomass	4830	4830	4830	4830	4830	4830	4830	4830	4830	4830
Nuclear	2420	2420	2420	2420	2420	2420	2854	3289	3289	3289
Gas	918	668	707	671	697	697	656	665	671	665
Coal	114901	97940	104475	109989	115218	120858	126469	130214	138072	145114

Figure 11: Year-wise projected net generation (in GWh)

7.3 Surplus Coal Capacity

Generally, surplus capacity is available with the Utility due to variation in electricity demand, RE availability etc. The pattern of surplus capacities has been observed as shown in Figure 12. From the figure below, it is observed that the utility is expected to have a minimum surplus coal-based capacity ranging between 4575 MW to 7500 MW during the period from November to April in 2027-28. This surplus capacity may be banked or shared with other Utility/states whose demand profile complements that of the utility.

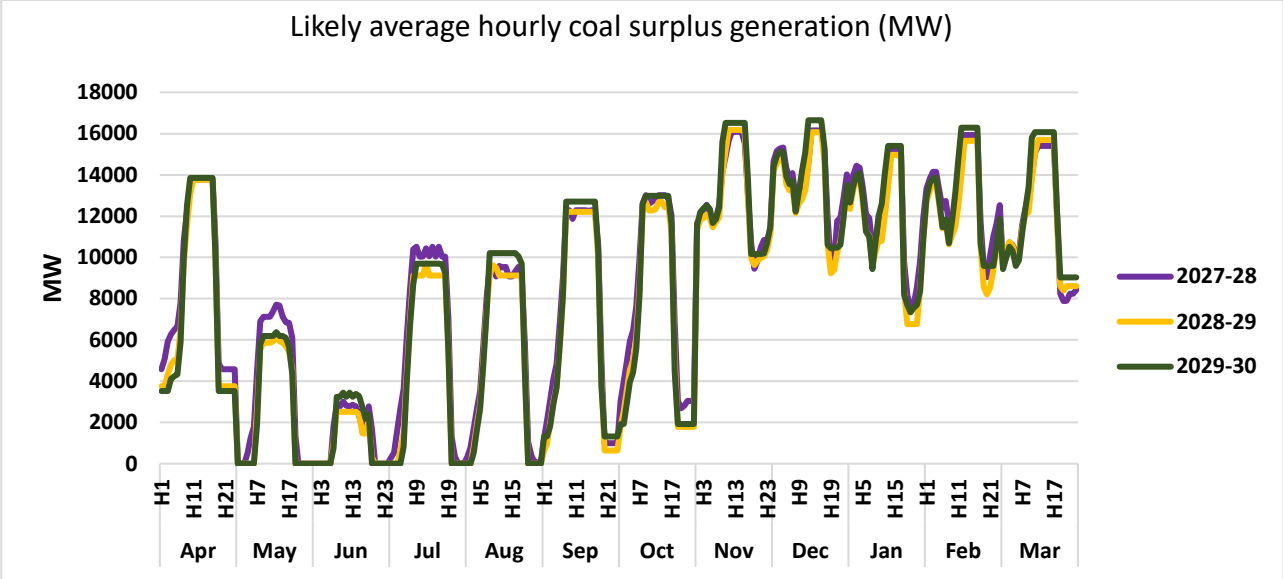


Figure 12: Surplus Coal Capacity Year-wise (MW)

8.0 Conclusions

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

1. The study has been carried out considering electrical energy requirement and peak electricity demand projections as furnished by the utility, which envisages that the annual electrical energy requirement and peak electricity demand is likely to grow at a CAGR of 7.1% and 6.9 % respectively for the period of 2025-26 to 2035-36.
2. It has been observed that the peak demand season in the state is typically from June to July with peak demand occurring during non-solar hours.
3. UPPCL is likely to witness energy deficit ranging from 1200 MUs to 64000 MUs in different years from 2026-27 to 2035-36 with the existing and planned capacity addition only. The deficit may reduce depending upon the capacity tie up, banking arrangement etc.
4. The likely total projected contracted capacity for the year 2035-36 is around 1,34,749 MW which consists of 35,313 MW from Coal; 549 MW from Gas; 613 from Nuclear; 1498 MW from Biomass; 5,247 MW from Hydro; 10,546 from Wind; 29,883 MW from Solar; 300 MW from Hybrid; 800 MW from Complementary Solar tied up with MPPMCL in the months of May to October to UPPCL; 4010 MW from FDRE; 13,938 MW from Energy Storage System (comprising of 887 MW of 2 hour ESS and 13,051 MW of 4 hour ESS).
5. In order for the Utility to fulfill its Renewable Purchase Obligation, the Utility, in addition to the existing and already planned contracts, needs to tie up around 6,645 MW of wind-based

capacity contracts, around 21,750 MW of solar-based capacity contracts by 2035-36 and 15,647 MW of DRE (year wise details may be referred at Table 15) along with the energy storage requirement as outlined. The additional energy storage requirement could be met from power tie up from PSPs or a combination of PSP and BESS. The projected capacity and generation mix outlined in the report meet the RCO targets of the Utility from 2027-28 onwards for RE based sources (except DRE) and RCO targets from DRE based sources are met from 2026-27 onwards. For the year 2026-27, though the projected electricity demand is being met, the likely RCO deficit of the utility from RE based sources (non-DRE) will be around 14,390 MU. Accordingly, to meet the RCO targets (non-DRE) for the year 2026-27, the utility may endeavor short-term contract, or any other appropriate mechanisms deemed suitable by the utility.

6. As per studies, the utility is expected to have a minimum surplus coal-based capacity ranging between 4,575 MW to 7,500 MW during the period from November to April. This surplus capacity may be banked or shared with other Utility/states whose demand profile complements that of UPPCL.
7. The Planning Reserve Margin (PRM) for UPPCL has been assessed as ~ 7 %. Further, the study indicates year-wise short-term/medium-term/bilateral requirements inclusive of the PRM capacity to meet the demand optimally.
8. Timely commissioning of planned capacities is critical for ensuring that the Utility meets its projected peak electricity demand and electrical energy requirements reliably. Any deviation from the planned schedule may lead to resource shortfalls and could significantly increase the cost of reliably meeting the electricity demand.

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Annexure

Details of upcoming capacities considered in the study

Generator	Technology	Capacity Tie up (MW)	COD
Ghatampur TPP/ NLC JV U-3	Coal	615	2026-27
Rajasthan Atomic Power Station (RAPS) Unit-8	Nuclear	81	2026-27
Subansiri Lower	Hydro	114 (of 182 allocated)	2026-27
Kiru	Hydro	84	2027-28
Pakaldul	Hydro	90	2027-28
Subansiri Lower	Hydro	68 (of 182 allocated)	2027-28
Vishnugad Pipalkoti	Hydro	166	2027-28
Planned Solar Morena (May-Oct)	Complementary Solar	800	2028-29
Singrauli Stage-III U-8, 800 MW	Coal	267	2029-30
Tapovan Vishnugad	Hydro	101	2029-30
Singrauli Stage-III U-9, 800 MW	Coal	267	2030-31
URI-I Stage-II	Hydro	51	2030-31
DBFOO	Coal	1500	2031-32
Dibang	Hydro	385	2032-33
Gorakhpur HAVP (GHAVP) U-1	Nuclear	81	2032-33
Gorakhpur HAVP (GHAVP) U-2	Nuclear	81	2033-34
Sawalkot	Hydro	241	2034-35

Details of retiring capacities considered in the study

Generator	Technology	Capacity Retired (MW)	Retirement Year
Anpara A	Coal	630	2029-30
Anpara B	Coal	1000	2029-30
Harduaganj-A	Coal	110	2029-30
Obra B	Coal	1000	2029-30
Parichha B Ext-I	Coal	420	2031-32

Assumption for Resource Adequacy Studies

1. Electricity Demand & peak requirement: As per the projections of by the utility.
2. Demand Profile: Based on hourly demand profile of 2024-25.
3. Existing & Planned Capacity: As per the information shared by the utility and available with CEA.
4. Cost parameters: based on information in National Electricity Plan as well as the current market trends and recent price discovery.

RE CUF considered

Hydro	Wind	Solar	DRE Solar
~37%-38%	29.9%	22.2%	14.58%

Technical Parameters

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical . (%)
Coal/ Lignite	Existing/Planned	85	1	55
	Candidate	88	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 hourly generation profile	100	-
Solar	Existing/Planned		-	-
	Candidate		-	-
Wind	Existing/Planned		-	-
	Candidate		-	-
Pumped storage	Existing/Planned	95	50	-
	Candidate		50	-
BESS	Candidate	98	NA	-

Technology	Type	Heat Rate (MCal/MWh)		Aux. Consumption (%)
		At max loading	At min loading	
Coal	Existing/ Planned	2300 to 2879	2438 to 3052	7.0
	Candidate (SC & USC)	2060 to 2125	2183 to 2253	6.5
Gas	Existing	2000 to 2900	2260 to 3277	2.5
Nuclear	Existing/ Planned	2777	2777	10
	Candidate	2777	2777	10
Biomass	Existing/ Planned	4200	4450	8
	Candidate	4200	4450	8

Technology	Type	Heat Rate (MCal/MWh)		Aux. Consumption (%)
		At max loading	At min loading	
Hydro	Existing/ Planned	-	-	0.7
	Candidate	-	-	0.7
Pumped Storage Projects	Existing/ Planned	-	-	Round trip efficiency 80 %
	Candidate	-	-	
BESS	Candidate	-	-	Round trip efficiency 88 %

Transmission Parameters

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

Financial Parameters

Following cost parameters have been assumed:

Resource	Capex* (in ₹/MW)	Fixed O&M Cost (in ₹/MW)	Construction Time (in years)	Amortization /Life time (in years)
Coal	12 Cr	30 Lakh	4	25
Solar	4.5 Cr	1 % of Capex	1	25
Battery Energy Storage System (4-Hour)	5 Cr to 3.6 Cr	5.9 Lakh	1	15
PSP	6 Cr	30 Lakh	4	40