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Report on Resource Adequacy Plan (Generation) for Haryana (2026-27 to 2035-36) (Version 2.0)

December, 2025

Government of India
Ministry of Power
Central Electricity Authority

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Disclaimer

This Resource Adequacy Study for the state of Haryana has been conducted based on data and inputs provided by Haryana Power Purchase Centre (HPPC), Haryana. The Haryana Power Purchase Centre (HPPC) is a joint forum created and owned by Haryana's Discoms, responsible for procuring power, managing tariffs etc. The findings, analysis and conclusions presented in this report are contingent upon the accuracy, completeness and timeliness of the information furnished by the State. 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 the state of Haryana 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 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.

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

To support the state in fulfilling this requirement, CEA, initially carried out a Resource Adequacy (RA) study with a planning horizon up to FY 2034-35, based on the data provided by HPPC, Haryana 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 State and planning assumptions being in line with the RPO trajectory as notified by Ministry of Power gazette notification dated 20th October, 2023.

The electrical energy requirement and peak electricity demand for Haryana, as per the revised 20th Electric Power Survey (EPS), are projected to increase with a CAGR of 4.5% and 3.1% respectively from 2025-26 to 2035-36. 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 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 Haryana, based on existing contracted capacity and planned capacity additions, indicates that the available capacity will not be sufficient to meet the projected electricity demand. Further, the state, with its existing and planned Renewable Energy (RE) based capacity, may be unable to fulfill its Renewable Purchase Obligation targets.

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

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

The Resource adequacy studies have projected likely optimal capacity mix for future years till 2035-36 which shall be able to meet anticipated demand reliably at every instance. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 43,426 MW which consists of 11,270 MW from Coal; 569 MW from Gas; 1,545 from Nuclear; 119 MW from Biomass; 4,028 MW from Hydro; 3,375 from Wind; 10,437 MW from Solar; 6,493 MW from Distributed Renewable Energy (DRE) source (71 MW of DRE Biomass, 11 MW of DRE Hydro and 6,411 MW of DRE Solar) and 5,308 MW from Energy Storage System (comprising of 100 MW from Tehri PSP; 676 MW of integrated BESS from Hybrid; 150 MW from SECI assured peak hybrid BESS and 4,382 MW from Energy Storage System). This capacity shall be able to meet the projected demand with prescribed reliability criteria while complying with the stipulated Renewable Purchase Obligation (RPO) 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, Ministry of Power vide notification dated 20th October, 2023, had notified the RPO trajectory for the states/Discoms. Based on the trajectory specified, hydro, wind and other (solar, biomass etc.) RPO quantum in million units (MUs) has been calculated to find additional quantum of renewable capacity that the states/Discoms have to contract in addition to the existing/planned capacity to meet their RPO targets.

To support the state in fulfilling the Resource Adequacy Guidelines and complying with the Renewable Purchase Obligation (RPO) notification, CEA has carried out the RA study for the state of Haryana based on inputs furnished by HPPC. 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 state 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 state up to FY 2034-35, based on data furnished by the utility and in accordance with the RPO trajectory specified in the Ministry of Power's Office Memorandum dated 20th October, 2023.

2.0 Highlights of the Previous RA Study (Up to FY 2034-35)

1. In the earlier Resource Adequacy (RA) study, financial year 2023-24 had been considered as the base year, and the study covered the period from 2024-25 to 2034-35. The fuel-wise contracted capacity of Haryana as on 31st March 2024, is given in Fig. 1.

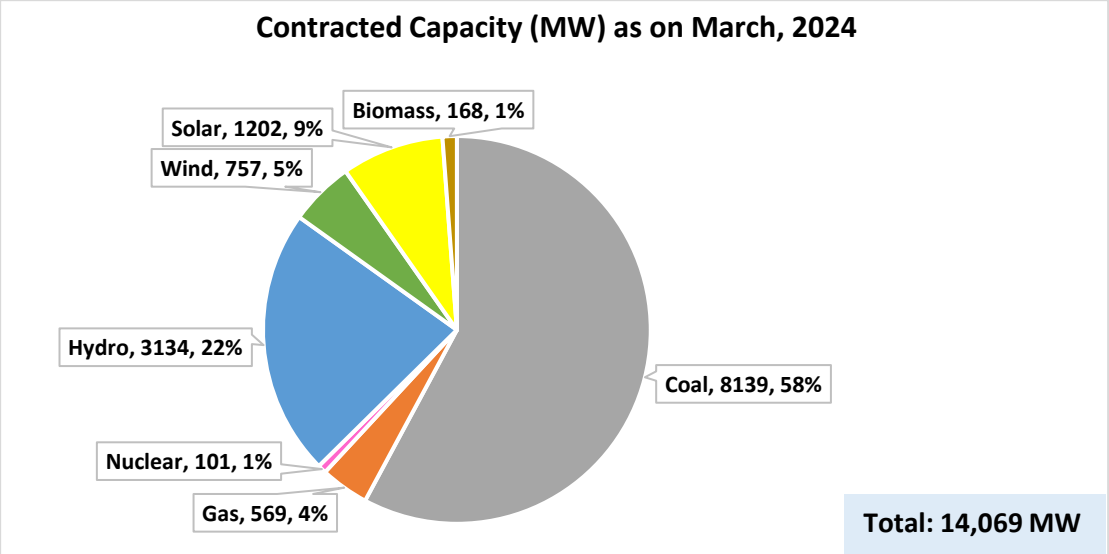


Figure 1: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2023

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	2034-35
Electrical Energy Projections (MU)	66926 (63983*)	71821	77217	82981	89050	95486	103176	108782	114636	120805	127306	134157
Year on Year Growth			7.51%	7.46%	7.31%	7.23%	8.05%	5.43%	5.38%	5.38%	5.38%	5.38%
Peak Electricity Demand Projections (MW)	13546 (13088*)	14411	15335	16337	17380	18478	19744	20648	21644	22688	23782	24930
Year on Year Growth			6.41%	6.53%	6.38%	6.32%	6.85%	4.58%	4.82%	4.82%	4.82%	4.82%

** Actual Demand Observed in FY 2023-24*

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

Table 2: Source-wise projected capacities

Year	Coal	Gas	Nuclear	Biomass	Hydro	Wind	Solar	Storage	DRE	STOA*
2024-25	8972	569	101	215	3299	1279	2184	100	843	3603
2025-26	8972	569	101	215	3973	1279	2184	100	1269	3834
2026-27	8972	569	101	215	4176	1679	3084	2274	1754	4084
2027-28	8972	569	451	215	4301	2079	3984	2295	2300	4345
2028-29	9772	569	1151	215	4330	2479	4884	2295	2915	3903
2029-30	10893	569	1501	215	4330	2879	5784	2295	3634	3615
2030-31	11477	569	1501	215	4330	3279	6684	2295	4258	3569
2031-32	12146	569	1501	215	4487	3679	7584	2295	4935	3432
2032-33	12688	569	1501	215	4487	4079	8484	2849	5674	3010
2033-34	13235	569	1501	215	4487	4479	9384	3371	6477	2659
2034-35	13537	569	1501	215	4487	4879	10284	3864	7351	2574

*****_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

FY	Coal		Nuclear	Hydro		Solar	
	Planned	**Additional**	**Planned**	**Planned**	**Additional**	**Planned**	**Additional**
2024/25	833			135	30	982	
2025/26				283	391		
2026/27				18	184		900
2027/28			350		126		900
2028/29	800		700		29		900
2029/30		1121	350				900
2030/31		584					900
2031-32		669			157		900
2032/33		543					900
2033/34		547					900
2034/35		302					900
TOTAL	**1633**	**3766**	**1400**	**436**	**917**	**982**	**8100**
FY	**Wind**		**Storage**		**Biomass**	**DRE**	**Yearly STOA**
	Planned	**Additional**	**Planned**	**Additional**	**Planned**	**Additional**	**Additional**
2024/25	523		100		48	843	3603
2025/26						426	3834
2026/27		400		2174		484	4084
2027/28		400		22		547	4345
2028/29		400				615	3903
2029/30		400				719	3615
2030/31		400				623	3569
2031-32		400				678	3432
2032/33		400		554		738	3010
2033/34		400		522		804	2659
2034/35		400		493		874	2574
TOTAL	**523**	**3600**	**100**	**3765**	**48**	**7351**	

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

3.1 Present Power Scenario in Haryana

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

Table 4: Power Supply Position of Haryana

Power Supply Position						
Year	**Energy required (MU)**	**Energy supplied (MU)**	**Gap (MU)**	**Peak Demand (MW)**	**Peak Met (MW)**	**Demand not met (MW)**
2024-25	70,149	70,120	30	14,662	14,662	0
2023-24	63,983	63,636	348	13,088	12,844	244
2022-23	61,451	60,945	506	12,768	12,768	0
2021-22	55,499	55,209	290	12,120	12,120	0
2020-21	53,161	53,108	53	10,982	10,982	0

As per the data provided by HPPC, Haryana, as of November 2025, the total contracted capacity of Haryana is 16,994 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is around 40%. The fuel-wise contracted capacity as on November 2025, is given in Table 5 and Fig. 2.

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

Source	**Contracted Capacity (MW)**	**Percentage**
Coal	9670	56.9%
Gas	569	3.3%
Nuclear	123	0.7%
Biomass	119	0.7%
Hydro	3722	21.9%
Wind	895	5.3%
Solar	1574	9.3%
DRE Biomass	68	0.4%
DRE Hydro	11	0.1%
DRE Solar	42	0.2%
BESS from Hybrid plant	150 MW/75 MWh	0.9%
PSP	50	0.3%
TOTAL	**16994**	100.0%

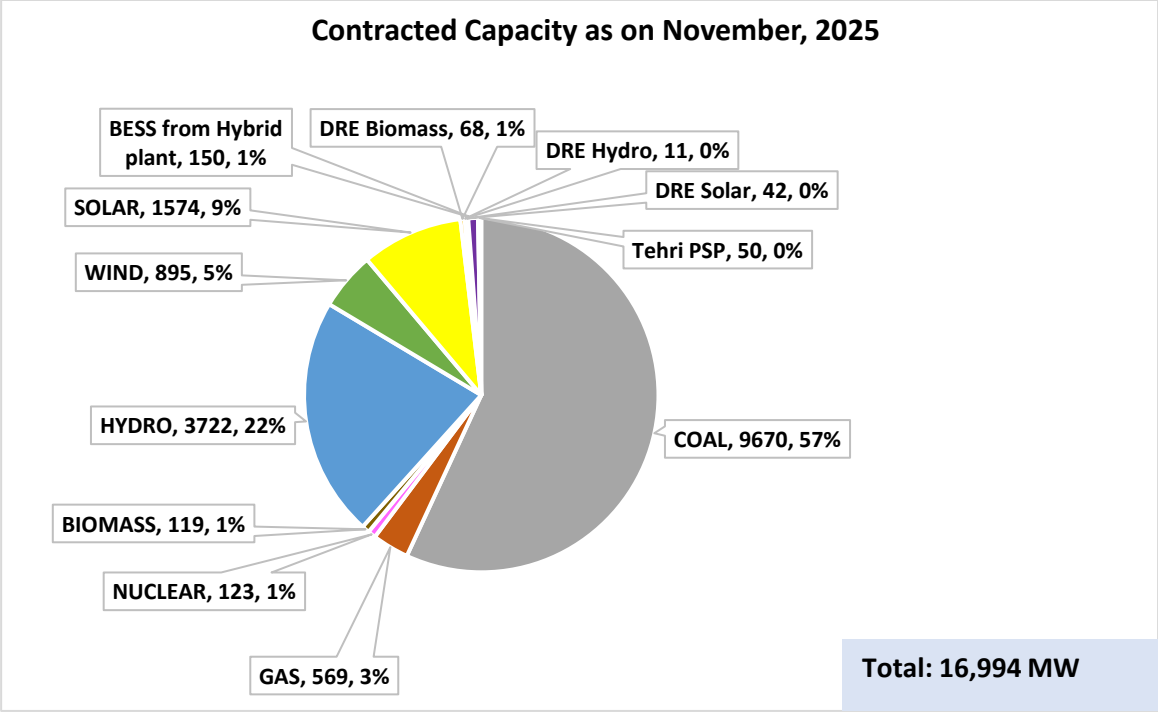


Figure 2: Fuel-wise Contracted Capacity (in MW) as on November, 2025

3.2 Demand Analysis of the FY 2024-25

The hourly demand pattern for 2024–25 was analyzed, and it was observed that Haryana experiences its highest annual electricity demand during the months of June and July, with the annual peak electricity demand specifically occurring in June during noon period. The peak electricity demand is predominantly observed during the solar hours, however, in the months of April and May, the peak electricity demand is observed in non-solar hours. The month-wise average hourly demand observed for the year 2024-25 is shown in Fig. 3.

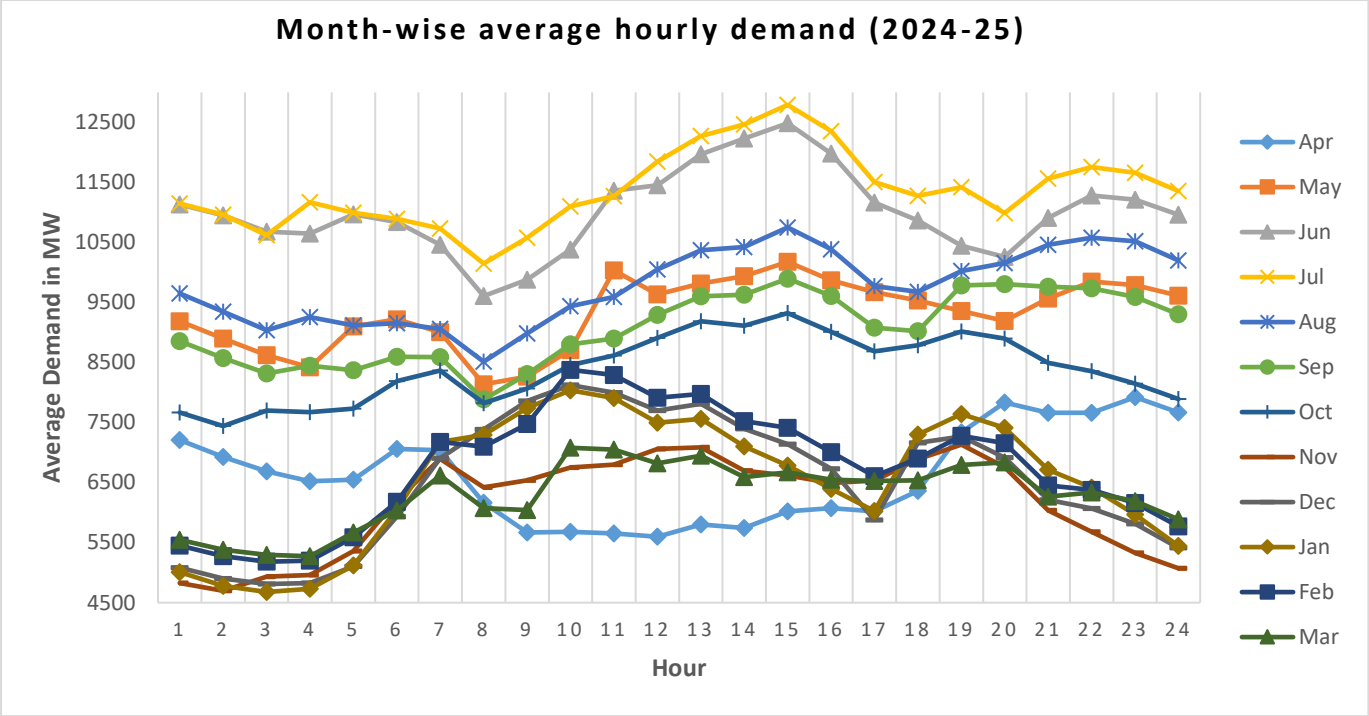


Figure 3: Month-wise Average Hourly Demand Variation for 2024-25

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

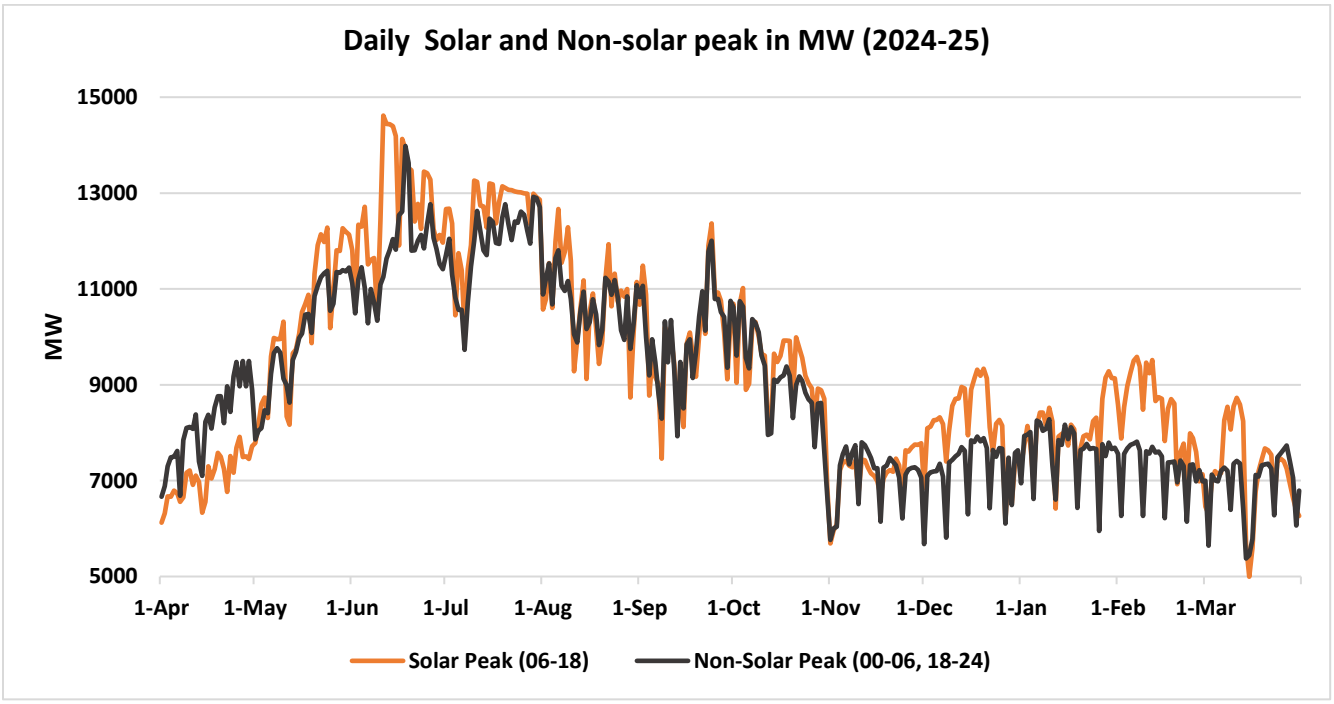


Figure 4: Solar and non-solar peak in MW for the year 2024-25

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.

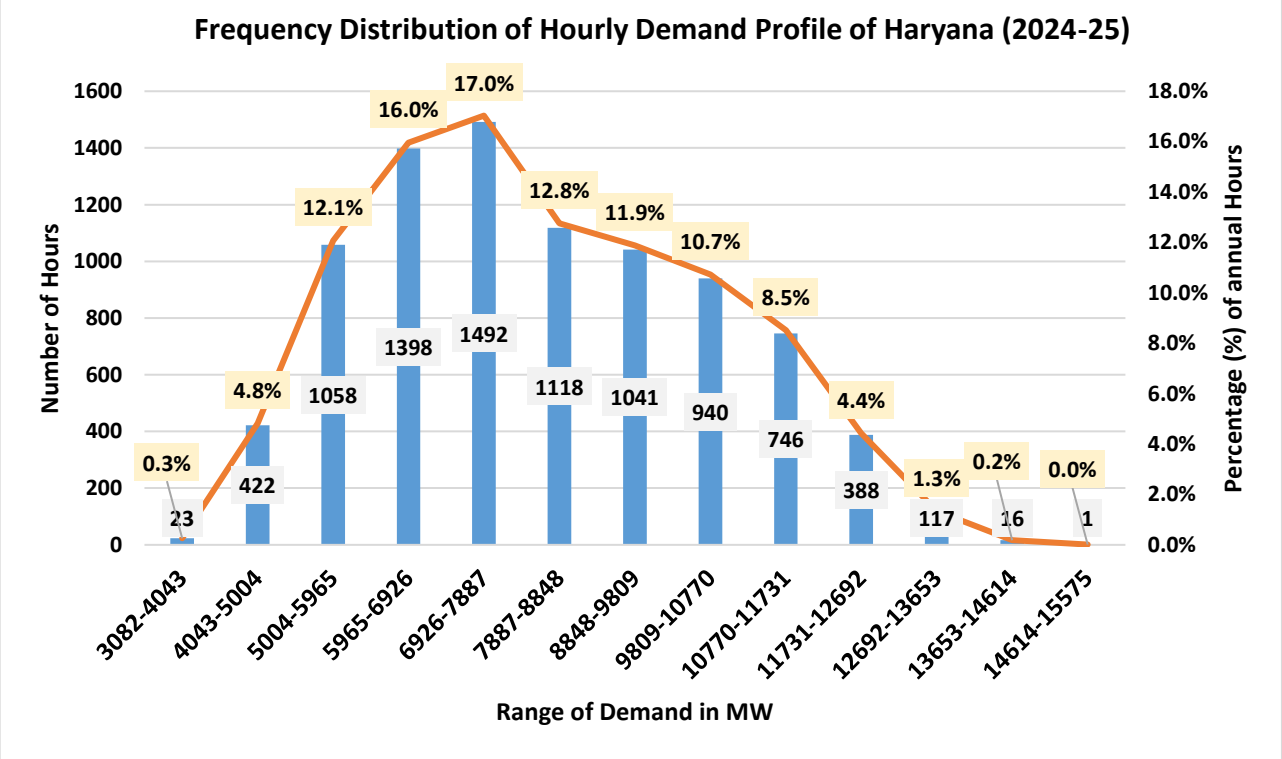


Figure 5: Frequency Distribution of hourly demand profile of 2024-25

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.

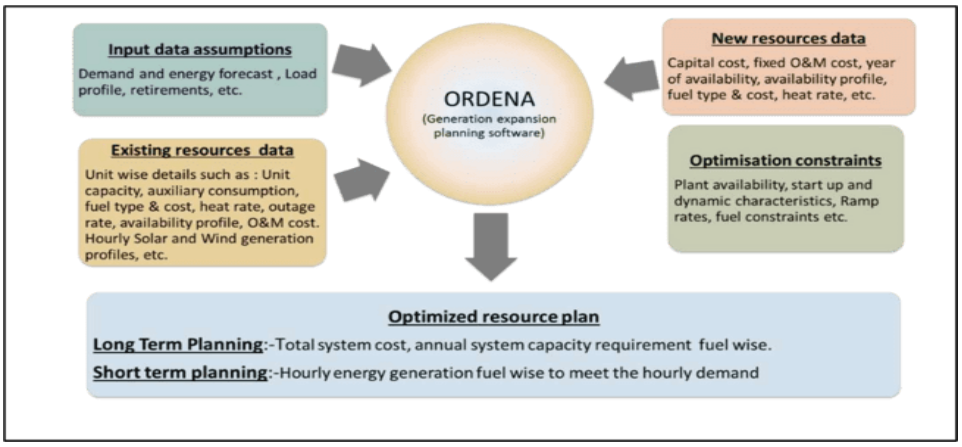


Figure 6: Schematic Diagram

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.

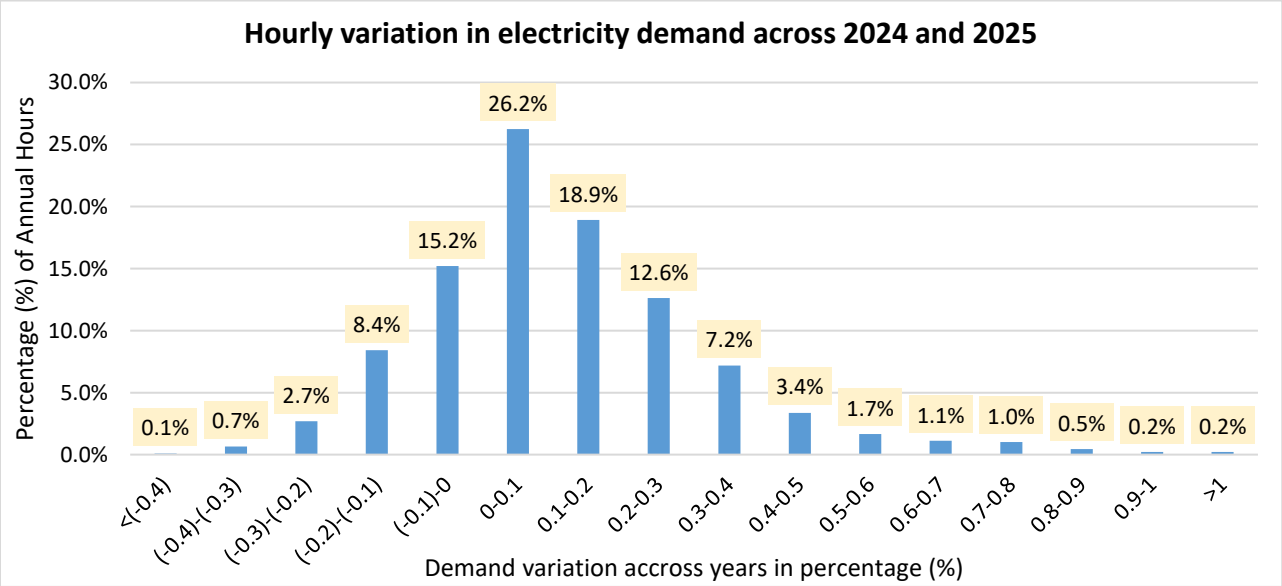


Figure 7: Hourly Variation in electricity demand across years

It can be observed that the hourly demand typically varies within ±20% for ~69% of instances. This variation is primarily due to temperature, weather parameter or any random outages of

transmission line and generating units etc. This variation has been captured in the reliability study by incorporating a variation of ±20% 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 Haryana is considered as projected in the revised 20th EPS has been considered for the study and are given in Table 6:

Table 6: Electricity demand projections as per the revised 20th EPS

Year	Peak Electricity Demand		Electrical Energy Requirement	
	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth
2025-26	15,616		71,804	
2026-27	16,100	3%	76,158	6%
2027-28	16,800	4%	80,574	6%
2028-29	17,514	4%	85,151	6%
2029-30	18,173	4%	89,547	5%
2030-31	18,749	3%	93,616	5%
2031-32	19,267	3%	97,469	4%
2032-33	19,759	3%	1,01,259	4%
2033-34	20,181	2%	1,04,747	3%
2034-35	20,548	2%	1,07,998	3%
2035-36	21,127	3%	1,11,042	3%

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 capacity addition

Fig.in MW

FY	Thermal	Nuclear	Hydro	Solar	Wind	DRE Solar	DRE Biomass	PSP	Hybrid integrated 2 hours BESS
2026-27	0	22	43	1148	1175	108	3	50	568
2027-28	0	0	76	365	505	0	0	0	109
2028-29	0	0	53	0	0	0	0	0	0
2029-30	1600	350	134	0	0	0	0	0	0
2030-31	0	350	0	0	0	0	0	0	0
2031-32	0	0	0	0	0	0	0	0	0
2032-33	0	700	0	0	0	0	0	0	0
2033-34	0	0	0	0	0	0	0	0	0
2034-35	0	0	0	0	0	0	0	0	0
2035-36	0	0	0	0	0	0	0	0	0
Total	**1600**	**1422**	**306**	**1513**	**1680**	**108**	**3**	**50**	**677**

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

Table 8: Renewable Purchase Obligation (RPO) trajectory (%) as per MoP order

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

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

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

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	2024-25	0.67%	0.38%	27.35%	1.50%	29.91%
2.	2025-26	1.45%	1.22%	28.24%	2.10%	33.01%
3.	2026-27	1.97%	1.34%	29.94%	2.70%	35.95%
4.	2027-28	2.45%	1.42%	31.64%	3.30%	38.81%
5.	2028-29	2.95%	1.42%	33.10%	3.90%	41.36%
6.	2029-30	3.48%	1.33%	34.02%	4.50%	43.33%
7.	2030-31	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%

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

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

Sl. No.	Year	Wind renewable energy (MU)	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	**2025-26**	1041.16	876.01	20277.41	1507.88	23702.46
2.	**2026-27**	1500.31	1020.51	22801.62	2056.26	27378.70
3.	**2027-28**	1974.06	1144.15	25493.57	2658.94	31270.72
4.	**2028-29**	2511.95	1209.14	28184.95	3320.89	35218.42
5.	**2029-30**	3116.22	1190.97	30463.75	4029.60	38800.54
6.	**2030-31**	37914.29			4680.78	42595.06
7.	**2031-32**	40449.62			5360.79	45810.41
8.	**2032-33**	42832.68			6075.56	48908.24
9.	**2033-34**	45041.15			6808.55	51849.69
10.	**2034-35**	46979.23			7559.88	54539.10
11.	**2035-36**	48858.40			8328.14	57186.54

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 11 Renewable Energy Deficit/Surplus

FY	RE Generation required to meet RPO (excluding DRE)		RE Generation (excluding DRE) available or to be met from existing and planned contracts		RE Generation Surplus (+)/ Deficit (-) (excluding DRE)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	22195	30.91%	21557	30.02%	-0.89%
2026-27	25322	33.25%	28185	37.01%	3.76%
2027-28	28612	35.51%	30912	38.36%	2.85%
2028-29	31906	37.47%	31089	36.51%	-0.96%
2029-30	34771	38.83%	31564	35.25%	-3.58%
2030-31	37914	40.50%	31564	33.72%	-6.78%
2031-32	40450	41.50%	31564	32.38%	-9.12%
2032-33	42833	42.30%	31564	31.17%	-11.13%
2033-34	45041	43.00%	31564	30.13%	-12.87%
2034-35	46979	43.50%	31564	29.23%	-14.27%
2035-36	48858	44.00%	31564	28.43%	-15.57%

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

Table 12 Distributed Renewable Energy (DRE) Deficit/Surplus

FY	DRE Generation required to meet RPO		DRE generation available or met from existing and planned contracts		DRE Generation Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	1508	2.10%	231	0.32%	-1.78%
2026-27	2056	2.70%	376	0.49%	-2.21%
2027-28	2659	3.30%	376	0.47%	-2.83%
2028-29	3321	3.90%	376	0.44%	-3.46%
2029-30	4030	4.50%	376	0.42%	-4.08%
2030-31	4681	5.00%	376	0.40%	-4.60%
2031-32	5361	5.50%	376	0.39%	-5.11%
2032-33	6076	6.00%	376	0.37%	-5.63%
2033-34	6809	6.50%	376	0.36%	-6.14%
2034-35	7560	7.00%	376	0.35%	-6.65%
2035-36	8328	7.50%	376	0.34%	-7.16%

As indicated in the tables above, the utility will not be able to meet its RPO requirements from the year 2028-29 onwards, based on the existing and planned contracts. Further, the utility will not be able to meet its RPO requirements from DRE as well.

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 by HPPC, 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 3900 MU. The year-wise likely unserved electrical energy with the planned capacities is given in Figure 8.

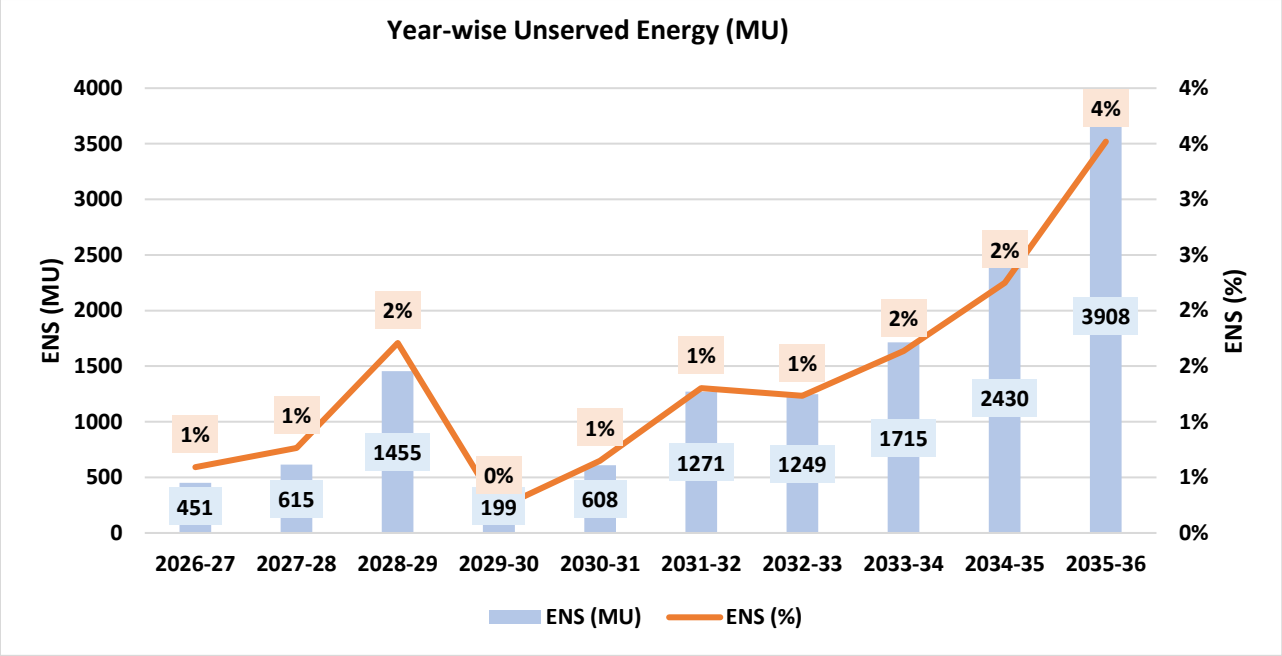


Figure 8 Year-wise likely unserved electrical energy (in MU) with the existing and planned capacities

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

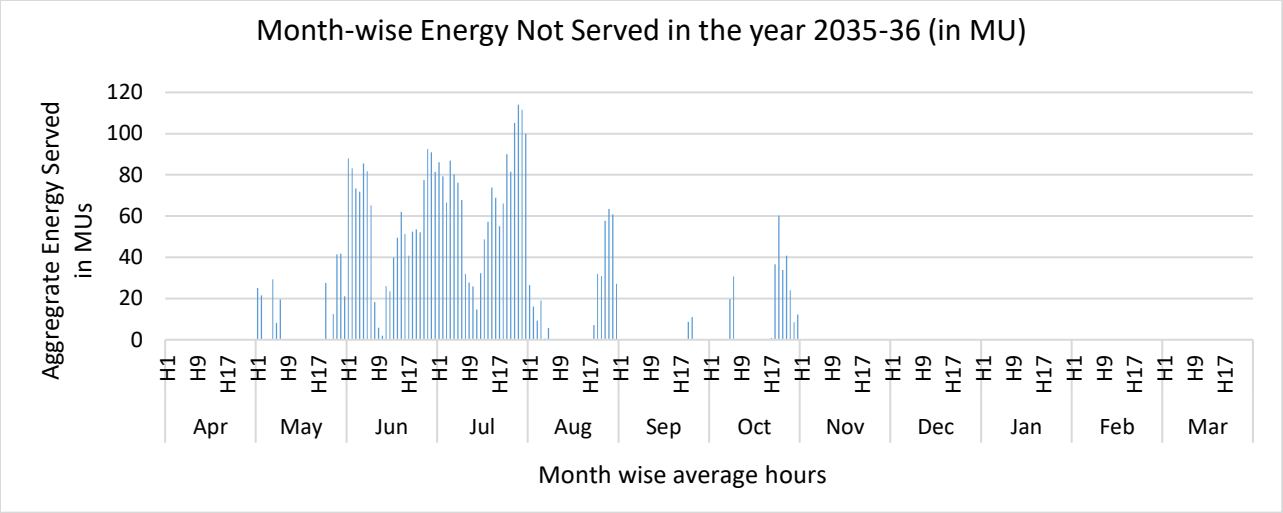


Figure 9 Block-wise Unserved Electrical Energy Pattern GWh (2035-36)

The unmet demand occurs during the months from May to October primarily in non-solar hours and throughout the day during high demand months i.e. June and July. To meet unserved energy, the utility needs to tie up additional capacity.

7.2 Investment options to meet the unserved energy

To meet unserved electrical energy, candidate capacities have been given to the model to find the least cost optimal capacity mix required to meet the demand in compliance with the Renewable Purchase Obligation. The capacity projection for the utility is tabulated below:

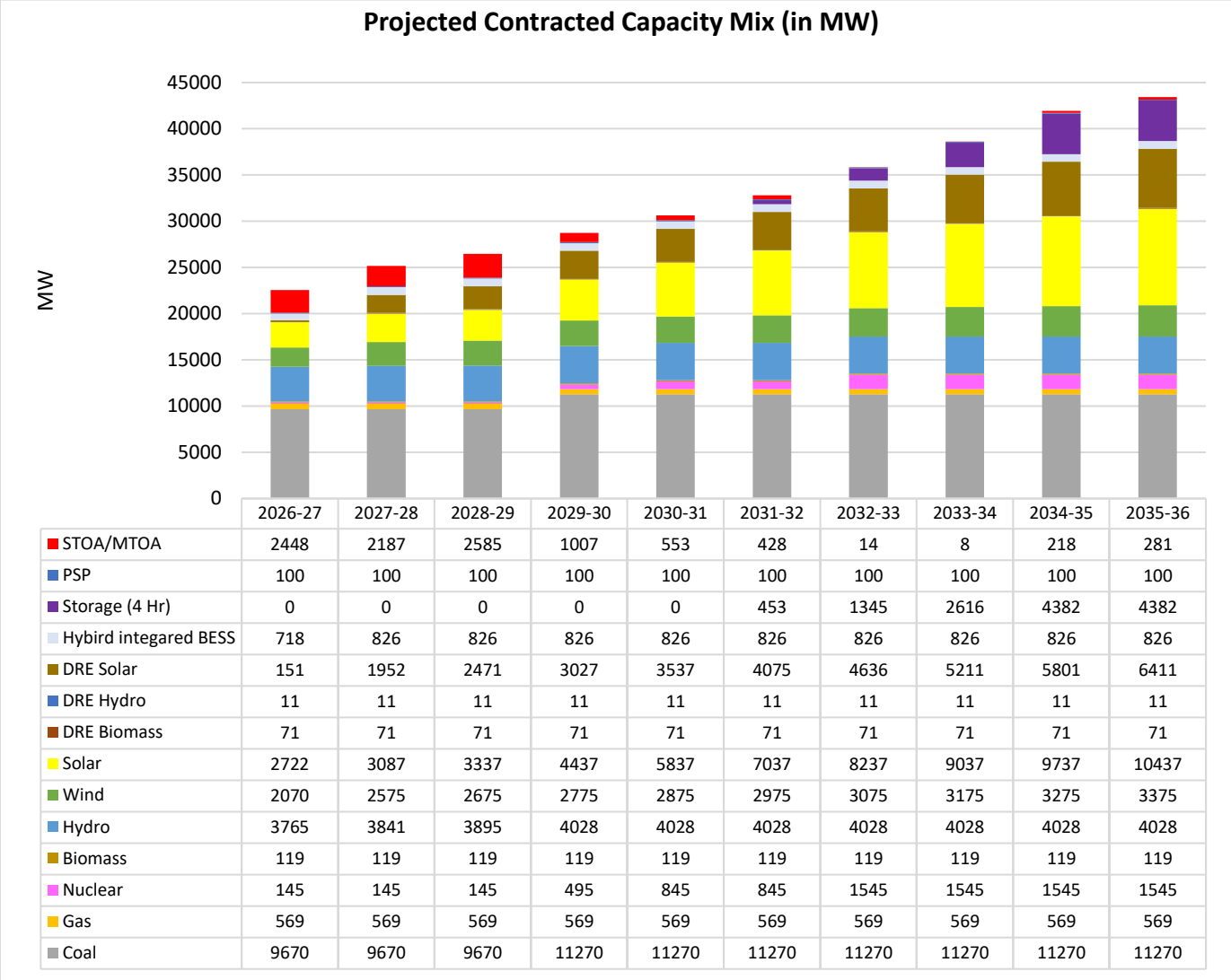
Table 13: Year-wise contracted capacity projections (existing, planned, to be tied up) (in MW)

	Coal	Gas	Nuclear	Biomass	Hydro	Wind	Solar	DRE Biomass	DRE Hydro	DRE Solar	Hybrid integrated BESS*	Energy Storage (4 hours)	PSP	STOA/ MTOA@
2026-27	9670	569	145	119	3765	2070	2722	71	11	151	718	0	100	2448
2027-28	9670	569	145	119	3841	2575	3087	71	11	1952	826	0	100	2187
2028-29	9670	569	145	119	3895	2675	3337	71	11	2471	826	0	100	2585
2029-30	11270	569	495	119	4028	2775	4437	71	11	3027	826	0	100	1007
2030-31	11270	569	845	119	4028	2875	5837	71	11	3537	826	0	100	553
2031-32	11270	569	845	119	4028	2975	7037	71	11	4075	826	452	100	428
2032-33	11270	569	1545	119	4028	3075	8237	71	11	4636	826	1344	100	14
2033-34	11270	569	1545	119	4028	3175	9037	71	11	5211	826	2615	100	8
2034-35	11270	569	1545	119	4028	3275	9737	71	11	5801	826	4381	100	218
2035-36	11270	569	1545	119	4028	3375	10437	71	11	6411	826	4381	100	281

*150 MW/ 75 MWh of SECI-Assured Peak Power-Hybrid BESS and Hybrid integrated 2-hour BESS of 568 MW (in 2026-27) that will be augmented by 109 MW from 2027-28

@ The SToA/MToA value represents the year-wise peak power requirement

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	2448	2187	2585	1007	553	428	14	8	218	281
PSP	100	100	100	100	100	100	100	100	100	100
Storage (4 Hr)	0	0	0	0	0	453	1345	2616	4382	4382
Hybird integared BESS	718	826	826	826	826	826	826	826	826	826
DRE Solar	151	1952	2471	3027	3537	4075	4636	5211	5801	6411
DRE Hydro	11	11	11	11	11	11	11	11	11	11
DRE Biomass	71	71	71	71	71	71	71	71	71	71
Solar	2722	3087	3337	4437	5837	7037	8237	9037	9737	10437
Wind	2070	2575	2675	2775	2875	2975	3075	3175	3275	3375
Hydro	3765	3841	3895	4028	4028	4028	4028	4028	4028	4028
Biomass	119	119	119	119	119	119	119	119	119	119
Nuclear	145	145	145	495	845	845	1545	1545	1545	1545
Gas	569	569	569	569	569	569	569	569	569	569
Coal	9670	9670	9670	11270	11270	11270	11270	11270	11270	11270

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 43,426 MW which consists of 11,270 MW from Coal; 569 MW from Gas; 1,545 from Nuclear; 119 MW from Biomass; 4,028 MW from Hydro; 3,375 from Wind; 10,437 MW from Solar; 6,493 MW from Distributed Renewable Energy (DRE) source (71 MW of DRE Biomass, 11 MW of DRE Hydro and 6,411 MW of DRE Solar) and 5,308 MW from Energy Storage System (comprising of 100 MW from Tehri PSP; 676 MW of integrated BESS from Hybrid; 150 MW from SECI assured peak hybrid BESS and 4,382 MW of 4 hour Energy Storage System). This capacity shall be able to meet the projected demand with prescribed reliability criteria while complying with the stipulated Renewable Purchase Obligation (RPO) targets from 2026-27 onwards. The additional energy storage requirement could be met from power tie up from PSPs or a combination of 2 hr/4 hr BESS. Based on the planned capacity addition, the Planning Reserve Margin works out to about 5%. Capacity mix required by 2035-36 is shown in Figure 9.

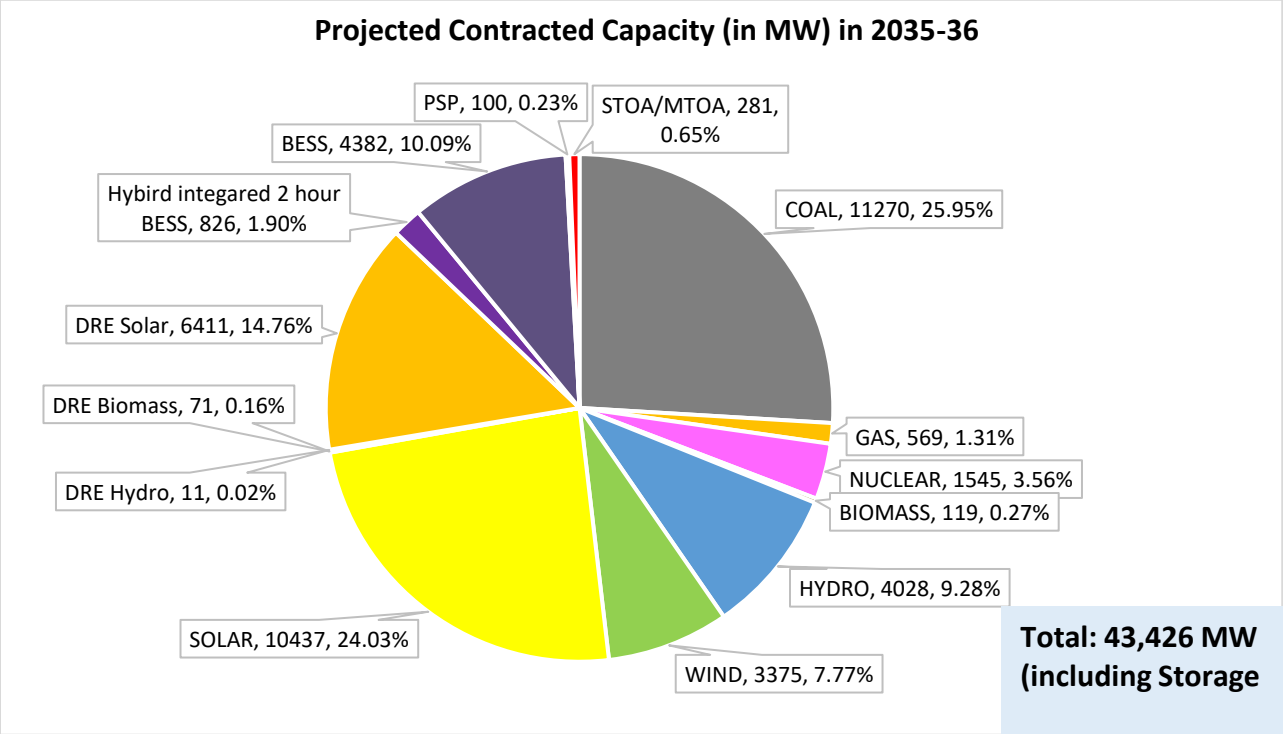


Figure 9: Contracted Capacity Mix in 2035-36

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

As per the study, the state likely needs to contract the following capacities (planned and additional) every year till 2035-36 to meet its demand reliably as shown in Table 14.

Table 14: Year-wise Capacity Addition (in MW)

	Coal	Nuclear	Hydro	Wind		Solar	
	Planned Contracts	Planned Contracts	Planned Contracts	Planned Contracts	Additional Contracts	Planned Contracts	Additional Contracts
2026/27	-	22	43	1175	-	1148	-
2027/28	-	-	76	505	-	365	-
2028/29	-	-	53	-	100	-	250
2029/30	1600	350	134	-	100	-	1100
2030/31	-	350	-	-	100	-	1400
2031/32	-	-	-	-	100	-	1200
2032/33	-	700	-	-	100	-	1200
2033/34	-	-	-	-	100	-	800
2034/35	-	-	-	-	100	-	700
2035/36	-	-	-	-	100	-	700
TOTAL	**1600**	**1422**	**306**	**1680**	**800**	**1513**	**7350**
	PSP	**Hybrid integrated BESS**	**Energy Storage System (4 hr)**		**DRE Biomass**	**DRE Solar**	
	Planned Contracts	Planned Contracts	Additional Contracts		Planned Contracts	Planned Contracts	Additional Contracts
2026/27	50	568	-		3	108	-
2027/28	-	109	-		-	-	1801
2028/29	-	-	-		-	-	519
2029/30	-	-	-		-	-	556
2030/31	-	-	-		-	-	510
2031/32	-	-	453		-	-	538
2032/33	-	-	892		-	-	561
2033/34	-	-	1270		-	-	576
2034/35	-	-	1765		-	-	590
2035/36	-	-	-		-	-	610
TOTAL	**50**	**677**	**4382**		**3**	**108**	**6261**

In addition to above, the year-wise STOA/MTOA requirement as outlined in Table 13, also needs to be tied up.

The projected gross generation mix for the state is shown in Figure 10 and 11.

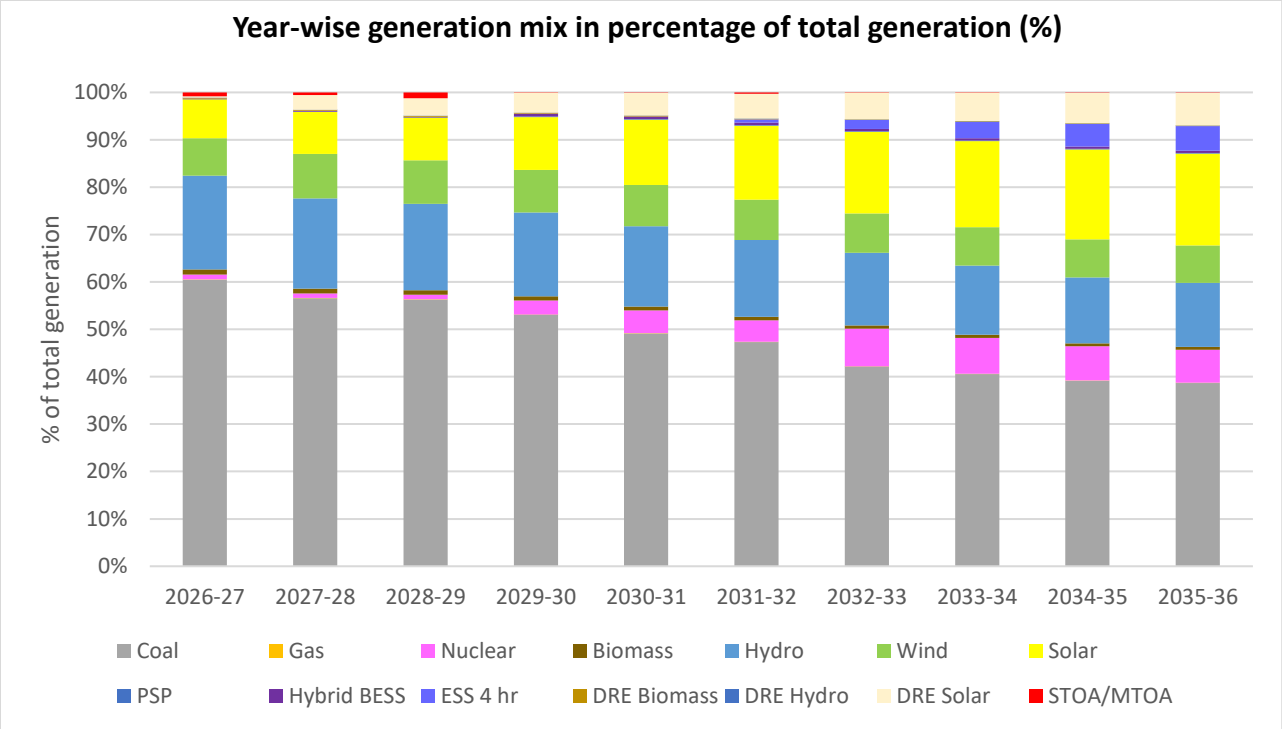
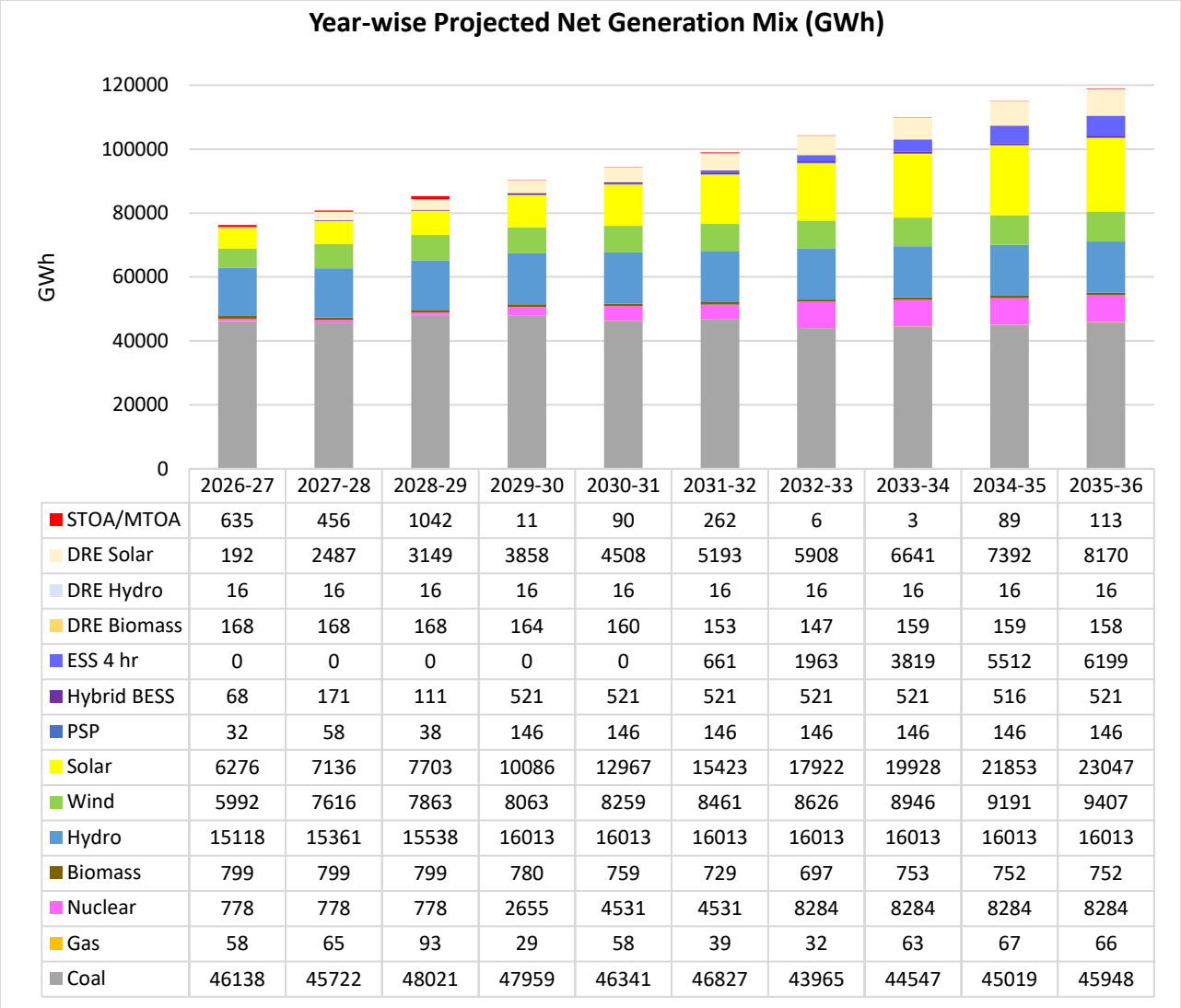


Figure 10: Year-wise projected net generation mix (in %)



	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
STOA/MTOA	635	456	1042	11	90	262	6	3	89	113
DRE Solar	192	2487	3149	3858	4508	5193	5908	6641	7392	8170
DRE Hydro	16	16	16	16	16	16	16	16	16	16
DRE Biomass	168	168	168	164	160	153	147	159	159	158
ESS 4 hr	0	0	0	0	0	661	1963	3819	5512	6199
Hybrid BESS	68	171	111	521	521	521	521	521	516	521
PSP	32	58	38	146	146	146	146	146	146	146
Solar	6276	7136	7703	10086	12967	15423	17922	19928	21853	23047
Wind	5992	7616	7863	8063	8259	8461	8626	8946	9191	9407
Hydro	15118	15361	15538	16013	16013	16013	16013	16013	16013	16013
Biomass	799	799	799	780	759	729	697	753	752	752
Nuclear	778	778	778	2655	4531	4531	8284	8284	8284	8284
Gas	58	65	93	29	58	39	32	63	67	66
Coal	46138	45722	48021	47959	46341	46827	43965	44547	45019	45948

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

7.3 Surplus Coal Capacity

Generally, surplus capacity is available with the state 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 Haryana is expected to have a minimum surplus coal-based capacity ranging between 300 MW to 1700 MW during the period from August to March and April to May. This surplus capacity may be banked or shared with other states whose demand profile complements that of Haryana.

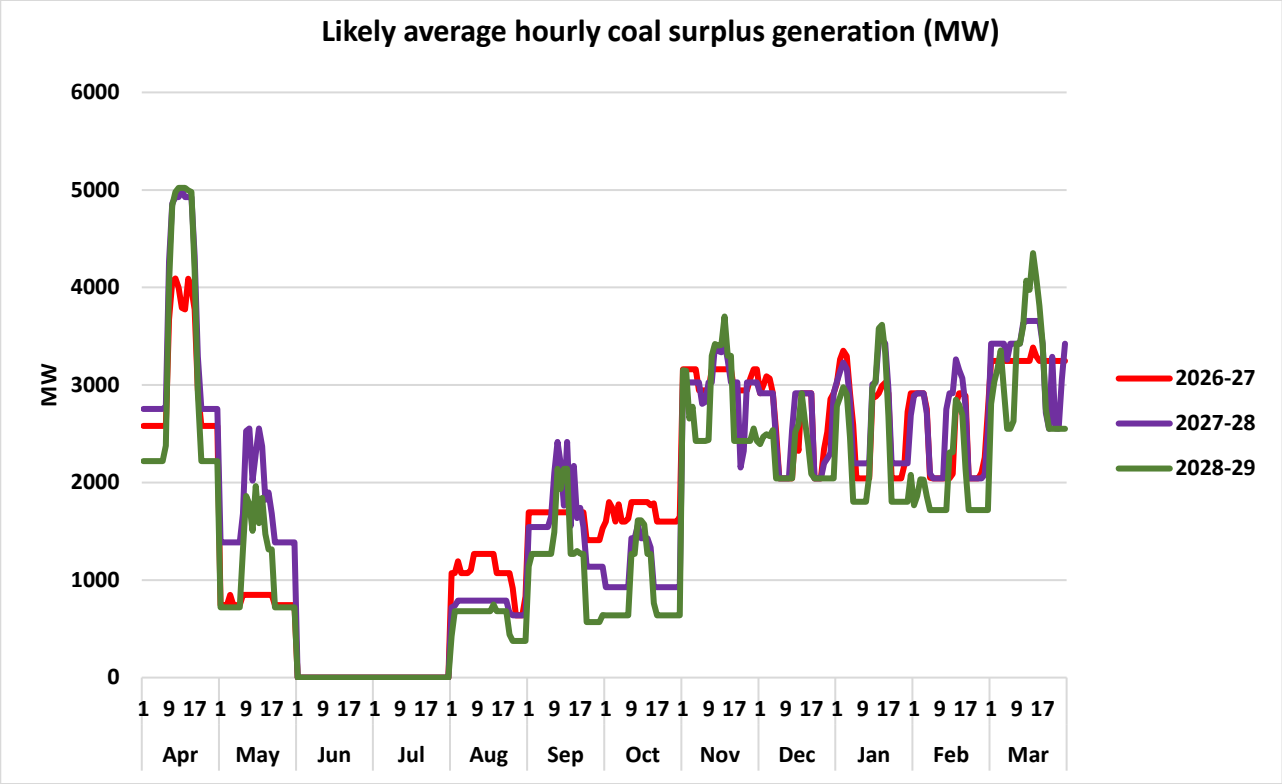


Figure 12: Surplus Coal Capacity Year-wise (MW)

8.0 Conclusions

Based on the Resource Adequacy studies of Haryana 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 per the revised 20th EPS projections, which envisages that the annual electrical energy requirement and peak electricity demand of the state is likely to grow at a CAGR of 4.5% and 3.1 % 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 solar hours.
3. Haryana is likely to witness energy deficit ranging from 200 MUs to 3900 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 43,426 MW which consists of 11,270 MW from Coal; 569 MW from Gas; 1,545 from Nuclear; 119 MW from Biomass; 4,028 MW from Hydro; 3,375 from Wind; 10,437 MW from Solar; 6,493 MW from Distributed Renewable Energy (DRE) source (71 MW of DRE Biomass, 11 MW of DRE Hydro and

6,411 MW of DRE Solar) and 5,308 MW from Energy Storage System (comprising of 100 MW from Tehri PSP; 676 MW of integrated BESS from Hybrid; 150 MW from SECI assured peak hybrid BESS and 4,382 MW from Energy Storage System). This capacity shall be able to meet the projected demand with prescribed reliability criteria while complying with the stipulated Renewable Purchase Obligation (RPO) targets.

5. In order for the state to fulfill its Renewable Purchase Obligation, the state, in addition to the existing and already planned contracts, needs to tie up approximately 800 MW of wind-based capacity contracts, 7350 MW of solar-based capacity contracts and 6261 MW of Distributed Renewable Energy (DRE) solar-based capacity by 2035-36 (refer Table 14) 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 2 hr/4 hr BESS. The projected capacity and generation mix outlined in the report meet the state's RPO requirements for the years 2026-27 to 2035-36.
6. As per studies, the state is expected to have a minimum surplus coal-based capacity ranging between 300 MW and 1700 MW during the period from August to March and April to May. This surplus capacity may be banked or shared with other states whose demand profile complements that of Haryana.
7. The Planning Reserve Margin (PRM) for Haryana has been assessed as ~ 5 %. 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 state 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 state’s power demand.

****

Annexure

Details of upcoming capacities considered in the study

Generator	Technology	Capacity Tie up (MW)	COD
Tehri PSP	PSP	50	2026-27
Rajasthan Atomic Power Plant (RAPP) Unit-8	Nuclear	22	2026-27
2 hr BESS from Hybrid	BESS	568	2026-27
Solar from Hybrid	Solar	1148	2026-27
Wind from Hybrid	Wind	1175	2026-27
Subansiri HEP	Hydro	43	2026-27
Kiru HEP	Hydro	37	2027-28
Pakaldul HEP	Hydro	39	2027-28
2 hr BESS from Hybrid	BESS	109	2027-28
Solar from Hybrid	Solar	365	2027-28
Wind from Hybrid	Wind	505	2027-28
Kwar HEP	Hydro	35	2028-29
Vishnugad Pipalkoti	Hydro	18	2028-29
DCRTTP Unit-3 YNR	Coal	800	2029-30
Durgapur (DVC)	Coal	200	2029-30
Koderma (KTPS-II DVC)	Coal	300	2029-30
Raghunathpur (RTPS-II DVC)	Coal	300	2029-30
NPCIL Gorakhpur Haryana (Unit-1)	Nuclear	350	2029-30
Ratle HEP	Hydro	21	2029-30
Sunni Dam HEP	Hydro	42	2029-30
Tapovan Vishnugad HEP	Hydro	57	2029-30
URI-II HEP	Hydro	13	2029-30
NPCIL Gorakhpur Haryana (Unit-2)	Nuclear	350	2030-31
NPCIL Gorakhpur Haryana (Unit-3)	Nuclear	350	2032-33
NPCIL Gorakhpur Haryana (Unit-4)	Nuclear	350	2032-33

Assumption for Resource Adequacy Studies

1. Electricity Demand & peak requirement: As per the projections of revised 20th EPS.
2. Demand Profile: Based on hourly demand profile of 2024-25.
3. Existing & Planned Capacity: As per the information shared by the state.
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
Generator specific PLF ~38%	28%	25%	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	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)	4.98 Cr to 3 Cr	5.9 Lakh	1	15
PSP	6 Cr	30 Lakh	4	40