Report on
Resource Adequacy Plan
(Generation) for
Bihar
(2026-27 to 2036-37)

July, 2026

Bihar State Power (Holding) Company Limited (BSPHCL)
Energy Department, Govt of Bihar

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DISCLAIMER

BSPHCL has been actively carrying out the RA study on behalf of both the DISCOMs (North Bihar Power Distribution Company Ltd.-NBPDCL & South Bihar Power Distribution Company Ltd-SBPDCL). in association with Central Electricity Authority (CEA). In December, 2025/January 2026, CEA distributed the STELLAR Model, along with the GAMS software, to all states, to empower them to carry out RA studies using the STELLAR Model to maintain uniformity in long-term country-level planning. Using the STELLAR Model, BSPHCL has completed this study covering the fiscal years from 2026-27 to 2036-37.

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). BSPHCL has conducted this study and prepared the report to fulfill this requirement.

The findings, analysis and conclusions presented in this report are contingent upon the accuracy, completeness and timeliness of the information furnished by BSPHCL. Any discrepancies or limitations in the data may affect the study's outcomes accordingly.

CEA has vetted the report in fulfillment of the requirement stipulated under the aforesaid Guidelines. The vetting has been done solely based on data, inputs and assumptions provided by BSPHCL. Any change in the data, inputs or assumptions by BSPHCL may lead to change in the Study/Plan. 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 BSPHCL.

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 undertake a Resource Adequacy Plan (RAP) with a 10-year planning horizon, LT-DRAP, to meet its own peak electricity demand and electrical energy requirements. 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 gazette-notified the Renewable Energy 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 state in fulfilling this requirement, CEA, initially carried a Resource Adequacy (RA) study with a planning horizon up to FY 2035-36, based on the data provided by BSPHCL and in compliance with the RPO trajectory specified in the Ministry of Power's Office Memorandum dated 20th October, 2023. This study has now been updated and extended to cover the period up to FY 2036-37, incorporating the latest data and planning assumptions. The RCO requirement for the State has also been assessed in accordance with the recent gazette notified trajectory.

The electrical energy requirement and peak electricity demand are projected to increase at a CAGR of 7.34% and 7.50% respectively from 2026-27 to 2036-37. 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 capacity or by procuring power. In view of the reduction in cost of solar panels and newer technology options like Battery Energy Storage Systems, planning for long term optimal generation capacity mix gains tremendous importance so as the future generation capacity mix is cost effective as well as environment friendly.

To identify the least-cost generation capacity expansion pathway for the period 2026-27 to 2036-37, Generation Capacity Expansion Study has been carried out with the objective of minimizing the total system cost of electricity generation, including the cost of anticipated future investments, while satisfying all technical, operational, and policy constraints associated with various power generation technologies. The study also ensures compliance with the Renewable Consumption

Obligation (RCO) notified by the Ministry of Power. 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 Bihar along with RCO constraints for Solar, Wind and DRE technologies. The Renewable capacities have been assessed in view of adherence to RCO 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 2036-37 which will meet the projected electricity demand reliably at every instance. Based on the study, the likely total projected contracted capacity for the year 2036-37 is around 39,375 MW which consists of 14,694 MW from coal; 144 MW from biomass; 1,713 MW from hydro; 11,450 MW from solar; 5,910 MW from wind; 4,964 MW from Storage (3418 MW PSP, 1546 MW BESS) and 500 MW from MToA/SToA arrangement. The MToA/SToA capacity is required during non-solar hours of peak demand months viz. from May to September. In addition, the DRE installed capacity required in 2036-37 is of the order of 3,802 MW. The projected capacity shall be able to meet the projected electricity demand with prescribed reliability criteria.

1.0 Introduction

Ministry of Power has notified Electricity (Amendment) Rules 2022, in December 2022. Rule 16 (I) of the said rules stipulates that "A guideline for assessment of resource adequacy during the generation planning stage (one year or beyond) as well as during the operational planning stage (up to one year) shall be issued by the Central Government in consultation with the Authority". Accordingly, the Resource Adequacy Guidelines have been notified in June, 2023, by Ministry of Power in consultation with Central Electricity Authority.

Resource Adequacy is generally defined as a *mechanism to ensure that there is an adequate supply of generation resources to serve expected demand reliably at least cost*. A key aspect of resource adequacy planning is to ensure that adequate generation capacities are available round-the-clock to reliably serve demand, under various scenarios. This naturally translates into the need for ensuring adequate reserve margin which could cater to varying levels of demand and supply conditions in the grid. In the wake of high RE generation, it is important to understand demand-supply situation in the grid precisely due to high seasonality and intermittency in RE generation. Resource Adequacy exercise also helps in assessment of generation capacity requirement to be tied up or contracted in long term, medium term, and short-term basis.

Further, Ministry of Power vide notification dated 27th September, 2025, had notified the Renewable Energy Consumption Obligation (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 the existing/planned capacity to meet their RCO targets.

The study recommends an optimal resource mix up to the year 2036-37, 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 electricity demand on a 24x7 basis, considering variations in electricity 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.

Prior to this, CEA jointly with BSPHCL had conducted the RA study for the state up to FY 2035-36, based on data and inputs furnished by BSPHCL.

2.0 Highlights of the Previous RA Study (Up to FY 2035-36)

1. In the earlier Resource Adequacy (RA) study, financial year 2024-25 was considered as the base year, and the study covered the period from 2025-26 to 2035-36. The fuel-wise contracted capacity of Bihar as on 31st March, 2025, is given in Fig. 1.

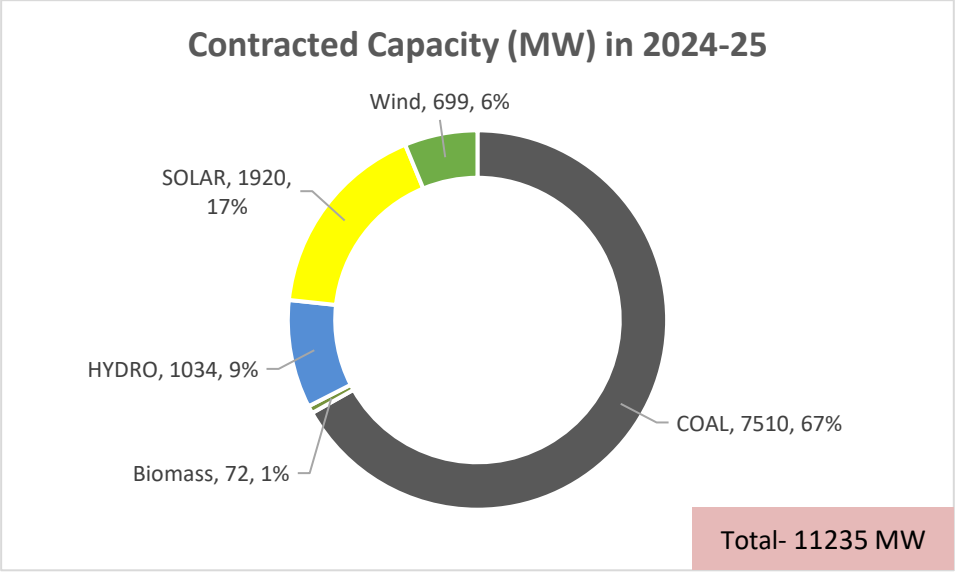


Figure 1: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2025

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

Table 1: Peak electricity demand & electrical energy projections as per BSPHCL

	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
Electrical Energy Projections (MU)	52518	56181	60030	63218	66383	69214	71966	74629	78517	82461	86337
Year on Year Growth		6.97%	6.85%	5.31%	5.01%	4.26%	3.98%	3.70%	5.21%	5.02%	4.70%
Peak Electricity Demand Projections (MW)	8878	9602	10366	11002	11615	12159	12643	13165	13810	14458	15233
Year on Year Growth		8.16%	7.96%	6.14%	5.57%	4.68%	3.98%	4.13%	4.90%	4.69%	5.36%

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

Table 2: Source-wise projected capacities

YEAR	COAL	BIOMASS	HYDRO	WIND	SOLAR	Storage (PSP/BESS)	DRE	SToA/ MToA*
2025-26	8632	72	1251	699	2257	115	0	0
2026-27	8632	72	1391	1349	5473	1365	1237	294
2027-28	8632	72	1423	2581	6004	1490	1615	570
2028-29	8782	72	1469	3231	6499	1551	2010	737
2029-30	9582	72	1469	3881	6870	1714	2436	343
2030-31	11182	72	1469	4531	7513	2049	2540	0
2031-32	12622	72	1693	5181	7517	2049	2641	0
2032-33	12622	72	1693	5281	8480	2632	2738	0
2033-34	12622	72	1693	5281	9733	3639	2881	0
2034-35	12622	72	1693	5281	11194	4770	3026	0
2035-36	12622	72	1693	5281	13025	5290	3168	0

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

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

Table 3: Year-wise planned and additional capacity contracts

	Coal	Hydro	Wind		Solar	
Year	Planned Contracts	Planned Contracts	Planned Contracts	Additional Requirement	Planned Contracts	Additional Requirement
2025-26	1122	217	0	0	337	0
2026-27	0	140	0	650	716	2500
2027-28	0	32	582	650	0	531
2028-29	150	46	0	650	0	495
2029-30	800	0	0	650	0	371
2030-31	1600	0	0	650	0	643
2031-32	1440	224	0	650	0	4
2032-33	0	0	0	100	0	964
2033-34	0	0	0	0	0	1252
2034-35	0	0	0	0	0	1462
2035-36	0	0	0	0	0	1830
Total	**5112**	**659**	**582**	**4000**	**1053**	**10052**
	Distributed RE#	**Storage (PSP/BESS)**		**Total**		**SToA /MToA***
Year	Additional Requirement	Planned Contracts	Additional Contract	Planned Contracts	Additional Contract	Additional Contract
2025-26	0	115	0	1791	0	0
2026-27	1237	50	1200	906	5587	294
2027-28	378	125	0	739	1559	570
2028-29	395	0	0	196	1540	737
2029-30	425	0	363	800	1809	343
2030-31	104	0	406	1600	1803	0
2031-32	101	0	0	1664	755	0
2032-33	98	0	509	0	1671	0
2033-34	143	0	1126	0	2521	0
2034-35	145	0	1200	0	2807	0
2035-36	142	0	195	0	2167	0
Total	**3168**	**290**	**5000**	**7696**	**22219**	

*#inclusive of Planned DRE of 255 MW; *Requirement is for a particular year*

3.0 Resource Adequacy Study for Bihar (from 2026-27 to 2036-37)

3.1 Present Power Scenario in Bihar

3.1.1 Power Supply Position

The power supply position for Bihar from 2021-22 to 2025-26 is given in Table 4:

Table 4: Power Supply Position of Bihar

Power Supply Position						
Year	**Energy required (MU)**	**Energy supplied (MU)**	**Gap (MU)**	**Peak Demand (MW)**	**Peak Met (MW)**	**Demand not met (MW)**
2021-22	36216	35761	455	7154	6490	664
2022-23	39545	38762	783	7852	6631	1221
2023-24	41514	40918	596	8049	7420	629
2024-25	44393	44217	176	8078	7852	226
2025-26	47440	47425	15	8597	8594	3

The data in Table 4 indicates that over the past five years, Bihar's electrical energy requirement and peak electricity demand have increased at a Compound Annual Growth Rate (CAGR) of 6.98% and 4.70%, respectively. Peak electricity demand in 2026-27 (till June 2026) has been 9,068 MW.

As on 31st March 2026, the total contracted capacity of Bihar (excluding DRE) is 12,065 MW. Out of the total contracted capacity, the share of non-fossil fuel-based contracted capacity 35.8 %. The fuel-wise contracted capacity as on 31st March, 2026 is given in Table 5 and Fig. 2.

Table 5: Fuel-wise Contracted Capacity as on 31st March 2026

Source	**Contracted Capacity (MW)**	**Percentage**
Coal	7743	64.2%
Biomass	43.9	0.4%
Hydro	1356.1	11.2%
Wind	699.2	5.8%
Solar	2107.1	17.5%
BESS	45.4	0.4%
PSP	70	0.6%
Total	**12064.7**	**100%**
Solar DRE	312	
Total with DRE	**12376.7**	

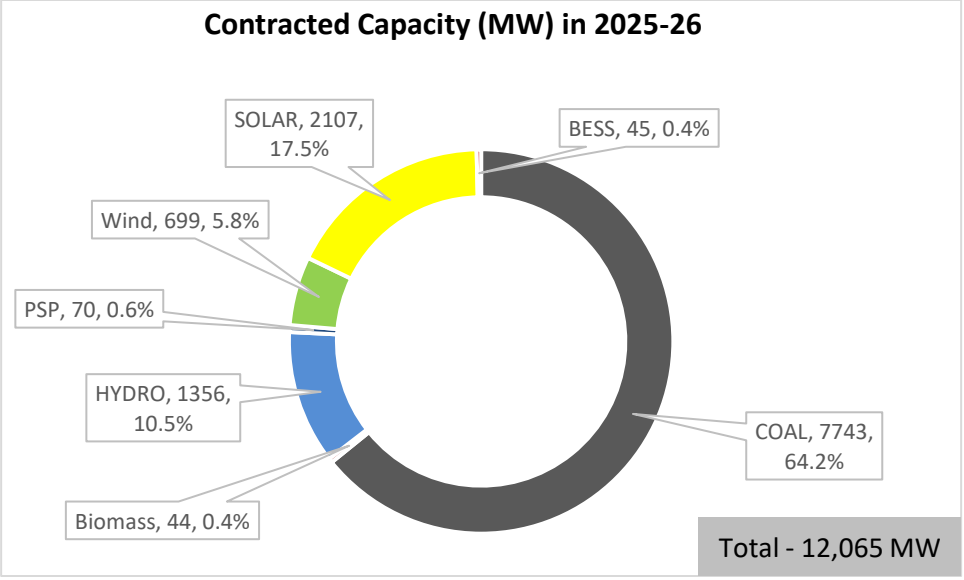


Figure 2: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2026

3.1.2 Challenges in Power Supply

Bihar has been experiencing seasonal load swings, with electricity demand peaking during the summer and monsoon months from April to September. Maintaining an optimal power supply position during this high-demand period presents a critical operational challenge for Bihar's Discoms – North Bihar Power Distribution Company Limited (NBPDCL) and South Bihar Power Distribution Company Limited (SBPDCL) – on account of two major systemic bottlenecks:

i) Reduced generation availability, arising from significant shortfalls or outages in long-term tied-up generation plants, as well as delays in the commissioning of tied-up thermal generating stations; and

ii) Lower market clearances, characterized by extremely low clearing rates on the Power Exchange(s) during peak demand hours, and correspondingly high market clearing prices.

Bihar's power portfolio relies heavily on thermal generation, with thermal tie-ups accounting for about 64% of the State's total power portfolio. Significant availability shortages – arising mainly from forced outages, coupled with delays in commissioning of tied-up generating units – have compelled Bihar's Discoms to arrange power through alternate modes, posing a continuing challenge to the power security of the State.

To bridge these supply gaps, the Power Management Cell of Bihar State Power (Holding) Company Limited (BSPHCL) has been utilizing multiple procurement platforms, including securing allocation from the unallocated quota of central generating stations, short-term power procurement through the DEEP (Discovery of Efficient Energy Price) e-tendering portal, and purchases from the Power Exchange(s), in order to maintain power adequacy.

Power Procurement Arrangements: FY 2024-25

To offset the power deficit projected for FY 2024-25, BSPHCL arranged power through allocations from the Ministry of Power's (MoP) unallocated quota and through short-term bilateral contracts procured on the DEEP portal. Details are given below:

Table 6: Allocation from Unallocated Quota of Central Generating Stations by MoP (FY 2024-25)

S. No.	Source	Allocated Quantum (MW)	Period	Duration
1	Barh II	97	30-03-2024 to 30-09-2024	RTC
2	Barh I	80	30-03-2024 to 30-09-2024	RTC
3	Farakka I & II	302.36	01-07-2024 to 31-03-2025	RTC

Table 7: Procurement from DEEP e-Tendering Portal (FY 2024-25)

S. No.	Period	Duration	Quantum (MW)
1	01-06-2024 to 30-06-2024	RTC	350
2	01-07-2024 to 31-07-2024	RTC	350
3	01-08-2024 to 31-08-2024	RTC	700
4	01-09-2024 to 30-09-2024	RTC	550

Power Procurement Arrangements: FY 2025-26

Table 8: Allocation from Unallocated Quota of Central Generating Stations by MoP (FY 2025-26)

S. No.	Unallocated Power Pool / Region	Allocated (MW)	Duration	Period
1	Southern Regional Pool	250	RTC	25-05-2025 to 30-06-2025
2	Western Regional Pool	250	RTC	01-07-2025 to 30-09-2025
3	Farakka STPP I & II	329.36	RTC	01-04-2025 to 30-09-2025

Table 9: Procurement from DEEP e-Tendering Portal (FY 2025-26)

S. No.	Period	Time Block	Quantum (MW)
1	01-07-2025 to 31-07-2025	00:00–02:00	75
		19:00–24:00	60
2	01-08-2025 to 31-08-2025	00:00–02:00	75
		19:00–24:00	60
3	01-09-2025 to 30-09-2025	00:00–02:00	75
		19:00–24:00	60

Further, on account of the delay in commissioning of Unit #2 of the Buxar Thermal Power Station, Bihar had to procure additional power during peak and night hours for the period April 2026 to September 2026, through the DEEP e-tendering portal, as detailed below.

Table 10: Power Procurement Necessitated by Delay in Commissioning of Buxar TPP Unit #2 (Apr'26–Sep'26)

S. No.	Month	Time Block	Quantum (MW)
1	Apr-26	00:00–02:00	75

		19:00–24:00	174
2	May-26	00:00–03:00	250
		19:00–24:00	773
3	Jun-26	00:00–04:00	50
		19:00–24:00	683
4	Jul-26	00:00–05:00	740
		19:00–24:00	953
5	Aug-26	00:00–05:00	852
		19:00–24:00	953
6	Sep-26	00:00–02:00	582
		19:00–24:00	953

Dependence on Power Exchange(s) and Clearance Constraints

To mitigate peak electricity demand requirements arising from power shortages (forced outages) on an as-and-when basis, Bihar's Discoms rely heavily on procurement from the Power Exchange(s). However, owing to demand surges and reduced availability on the Power Exchange(s) during Bihar's peak demand hours – 00:00–03:00 Hrs. and 19:00–24:00 Hrs. – clearance rates as low as 1% have been witnessed over the past years.

This reduced availability, both on the Power Exchange(s) and under tied-up power generation arrangements, poses a significant challenge to the core mandate of a distribution utility, namely, ensuring 24x7 power supply to the consumers.

Delay in Commissioning of Tied-Up Thermal Generating Stations

A review of the historical commissioning schedule of Bihar's existing and upcoming tied-up thermal generating units indicates substantial and recurring delays vis-à-vis the originally scheduled Commercial Operation Date (COD), as summarized below.

Table 11: Delay in Commissioning of Thermal Generating Stations from which capacity had been tied up

Sl No.	Generating Station	Unit	Installed Capacity (MW)	Bihar's Share (MW)	Scheduled COD	Actual / Tentative COD	Delay (Y-M-D)
1	North Karanpura	I	660	297	07-05-2019	01-03-2023	3Y 9M 24D
		II	660	297	07-11-2019	20-03-2024	4Y 4M 13D
		III	660	297	07-05-2020	15-06-2025	5Y 1M 8D
2	Barh Stage-I	I	660	401	21-02-2010	12-11-2021	11Y 8M 21D
		II	660	401	21-12-2010	01-08-2023	12Y 7M 10D
		III	660	401	21-10-2011	01-07-2025	13Y 8M 11D
3	Barh Stage-II	IV	660	576	14-01-2013	08-03-2016	3Y 1M 24D
		V	660	576	14-11-2013	18-02-2016	2Y 3M 5D
4	Bhartiya Rail Bijlee Co. Ltd.	I	250	25	21-01-2011	15-01-2017	5Y 11M 26D
		II	250	25	21-07-2011	10-09-2017	6Y 1M 22D
5	Barauni TPS	IX	250	250	15-06-2020	01-11-2021	1Y 4M 17D
6	Darlipali Stage-I	I	800	161	17-06-2018	01-03-2020	1Y 8M 14D
		II	800	161	17-12-2018	01-09-2021	2Y 8M 15D

7	Kanti Bijlee Utpadan Nigam Ltd.	I	195	145	12-10-2012	18-03-2017	4Y 5M 4D
		II	195	145	12-01-2013	01-07-2017	4Y 5M 18D
8	Nabinagar Stage-I	I	660	547	31-05-2017	06-09-2019	2Y 3M 7D
		II	660	547	30-11-2017	23-07-2021	3Y 7M 22D
		III	660	547	31-05-2018	01-06-2022	4Y 0M 2D
9	Buxar TPS	I	660	561	01-07-2023	14-11-2025	2Y 4M 13D
		II	660	561	01-01-2024	30-07-2026	2Y 4M 14D

Commissioning delays of the thermal stations range from about one year to over thirteen years relative to the originally scheduled CoD, with several units under Barh Stage-I and North Karanpura reflecting the most protracted slippages. Such delays directly constrain the availability of contracted capacity.

Forced Outages: NTPC Barh Stage-I TPP

In addition to commissioning delays, Barh Stage-I TPP has exhibited persistently low availability on account of recurring forced outages. The month-wise outage duration for FY 2024-25, FY 2025-26 and FY 2026-27 (April–June) is presented below.

Table 12: Forced Outage Duration – Barh Stage-I (FY 2024-25)

Unit	Affected Qty. (MW)	Total Outage (Hrs.)	Duration (Ex-Bus)
Unit 1	361	2,823	3 Months 26 Days
Unit 2	361	1,312	1 Month 24 Days

Table 13: Forced Outage Duration – Barh Stage-I (FY 2025-26)

Unit	Affected Qty. (MW)	Total Outage (Hrs.)	Duration (Ex-Bus)
Unit 1	361	2,641	3 Months 20 Days
Unit 2	361	1,638	2 Months 8 Days
Unit 3	361	1,339	1 Month 25 Days

Table 14: Forced Outage Duration – Barh Stage-I (FY 2026-27, April–June)

Unit	Affected Qty. (MW)	Total Outage (Hrs.)	No. of Days (Ex-Bus)
Unit 1	361	313	13
Unit 2	361	460	19
Unit 3	361	207	9

The persistence and scale of forced outages at Barh Stage-I across three consecutive years indicate a structural, rather than transient, availability constraint from this station, and warrant explicit treatment as a derated/reduced-availability resource in the resource adequacy assessment for Bihar. The matter has been repeatedly taken up by Bihar with NTPC.

3.2 Demand Analysis of the FY 2025-26

Hourly demand pattern of 2025-26 was analyzed and it was observed that the peak demand season for State of Bihar is typically during the months from May to September. Bihar witness peak electricity demand during non-solar hours.

The month-wise average hourly demand observed for the year 2025-26 is shown in Fig. 3.

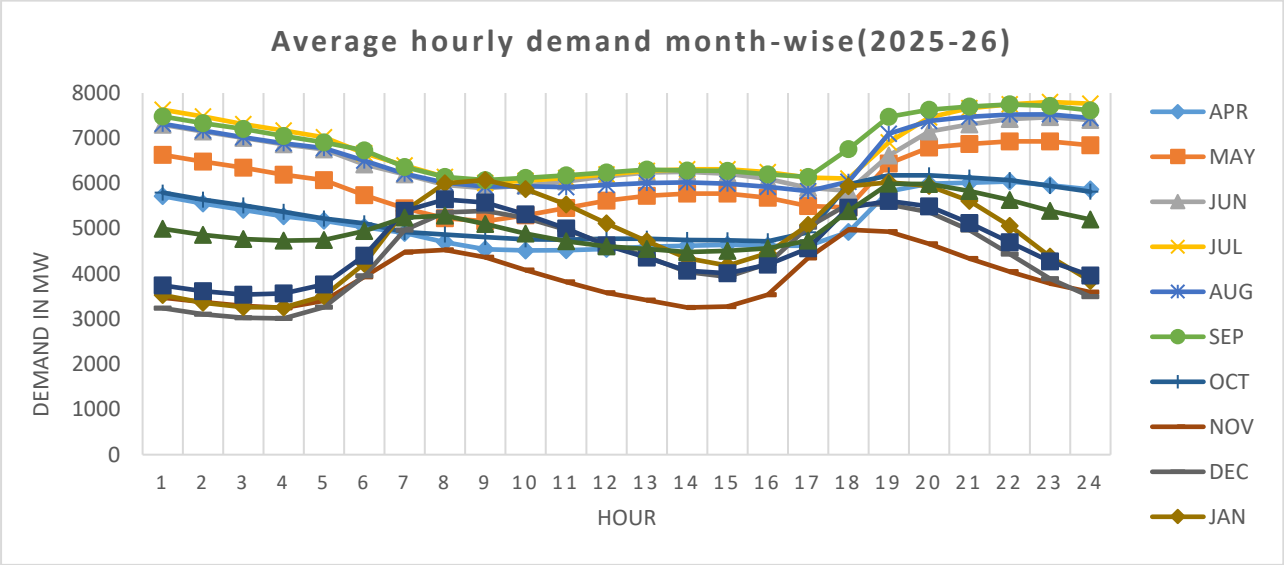


Figure 3: Average Hourly Demand Variation (Month-wise) for 2025-26

From the hourly demand data of 2025-26, the daily peak electricity demand during solar hours (06:00 to 18:00 hrs) and non-solar hours are plotted in Fig. 4.

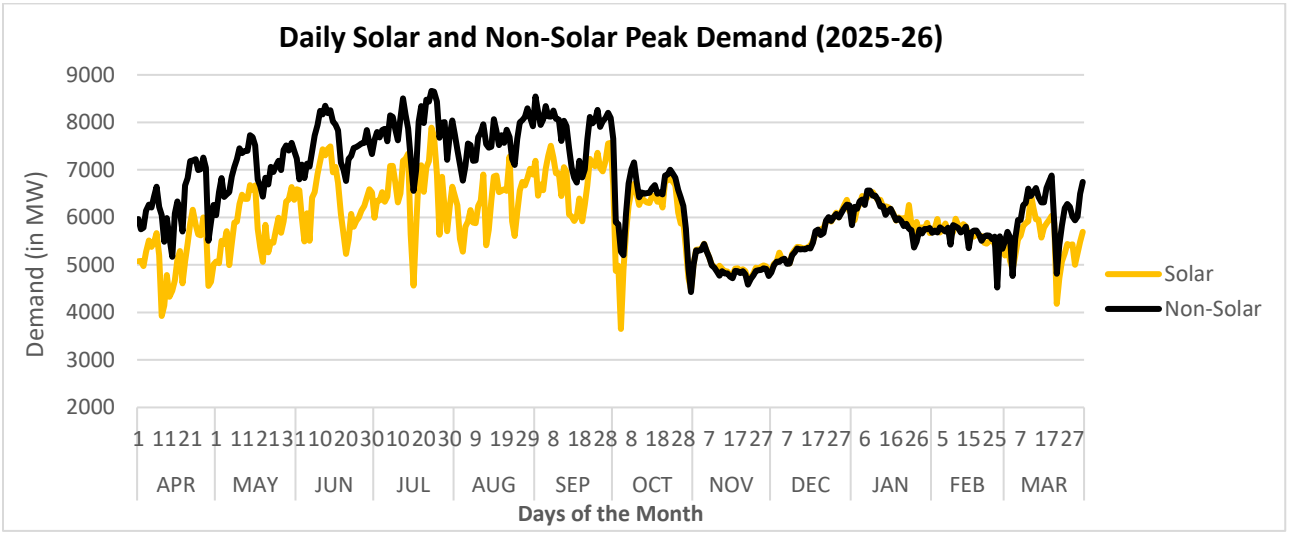


Figure 4: Solar and non-solar hour peak demand in MW for the year 2025-26

The hourly demand pattern of 2025-26 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 2025-26 is shown in Fig. 5.

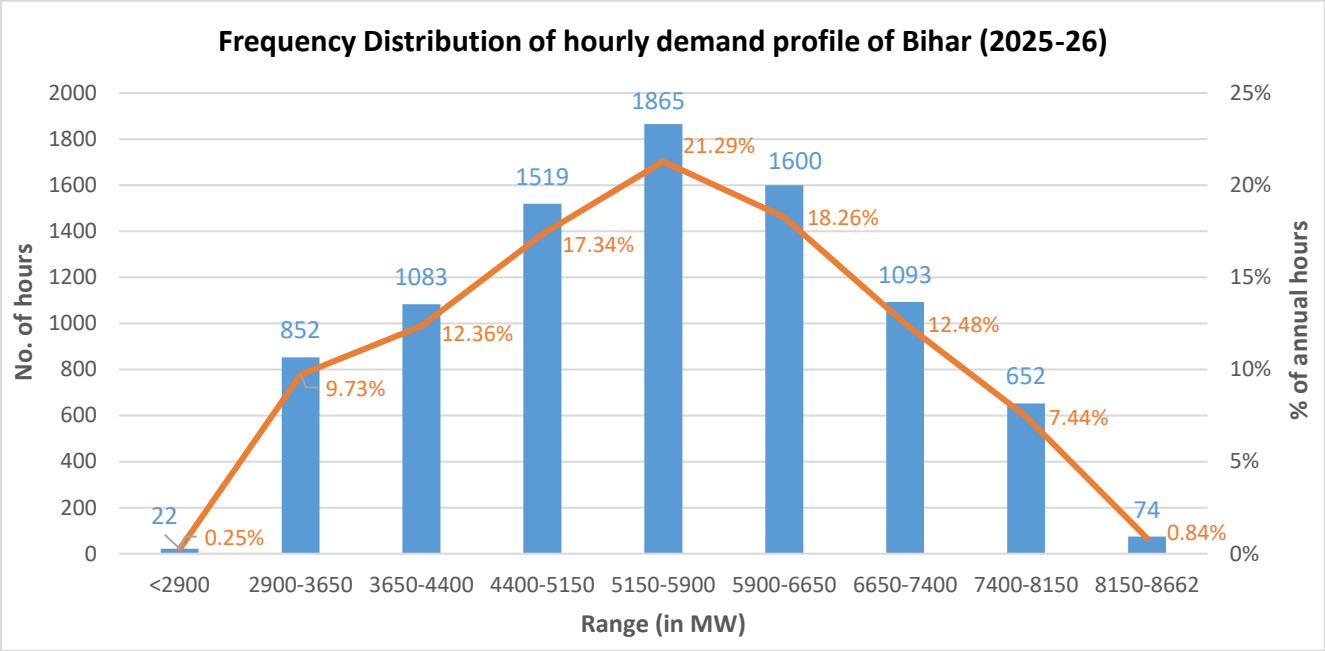


Figure 5: Frequency Distribution of Hourly Demand Profile of 2025-26

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 RCO 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 – STELLAR

Central Electricity Authority (CEA) has successfully developed an indigenously built generation expansion planning tool that integrates long-term capacity planning, economic dispatch, and reliability analysis into a unified framework. Named “STELLAR” (Strategic Expansion for Long-Term Load Adequacy and Resilience), the tool represents a significant advancement in power system modelling and planning. STELLAR is a state-of-the-art optimisation model framework specifically designed to support long-term decision-making in the electricity sector, with a focus on ensuring resource adequacy, operational resilience, and cost-effective system evolution in line with India's energy transition goals.

STELLAR serves as a comprehensive and robust platform for long-term generation and transmission planning, supporting informed policymaking and investment strategies in India's evolving power sector. The salient features of STELLAR include representative-day modelling, co-optimisation of energy and ancillary services, demand response modelling, and reliability modelling.

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

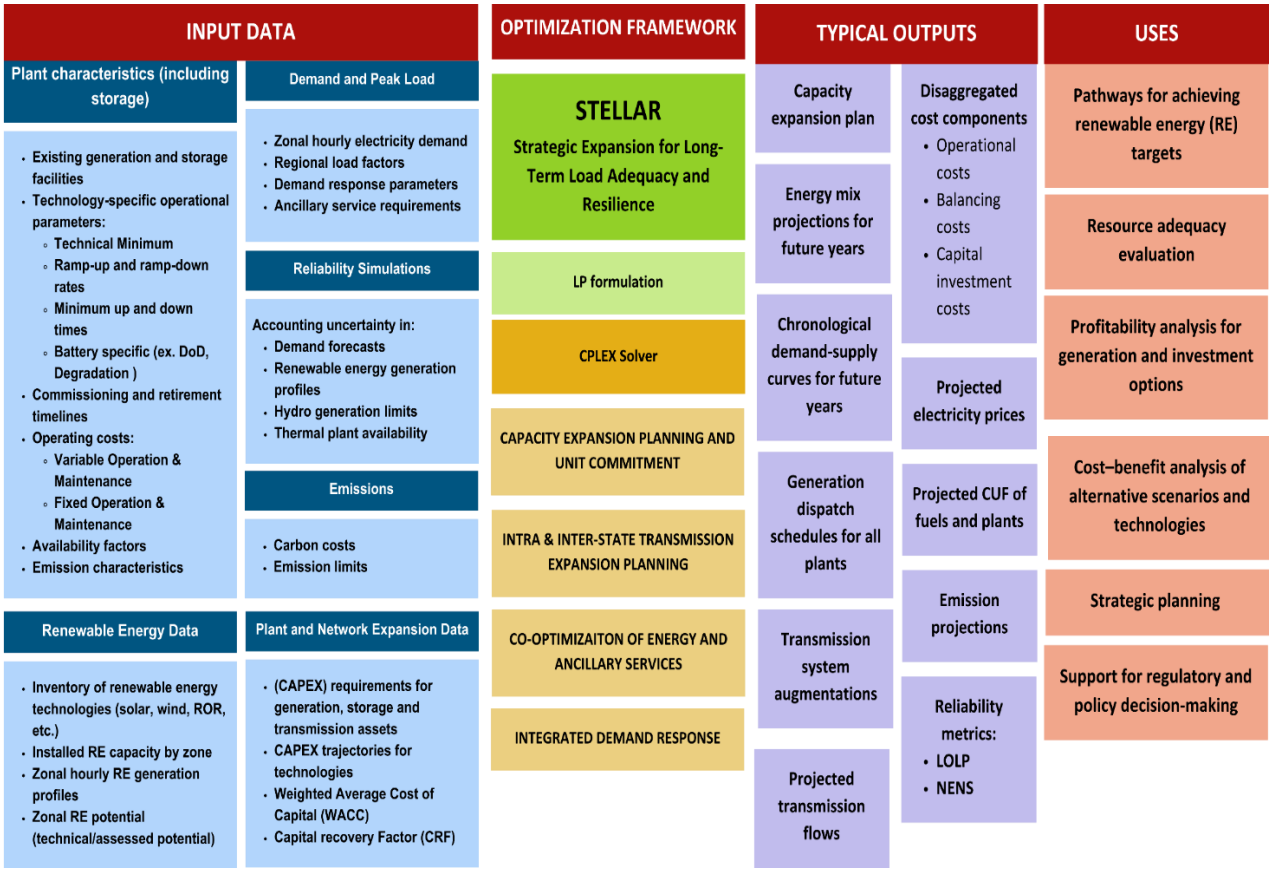


Figure 6: STELLAR Schematic Diagram

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 Demand variation

The variation in demand pattern for last two years viz. 2024-25 and 2025-26 (considering 2024-25 as the base year) has been analyzed. The demand pattern variation across 2024-25 and 2025-26 is shown in Fig. 7.

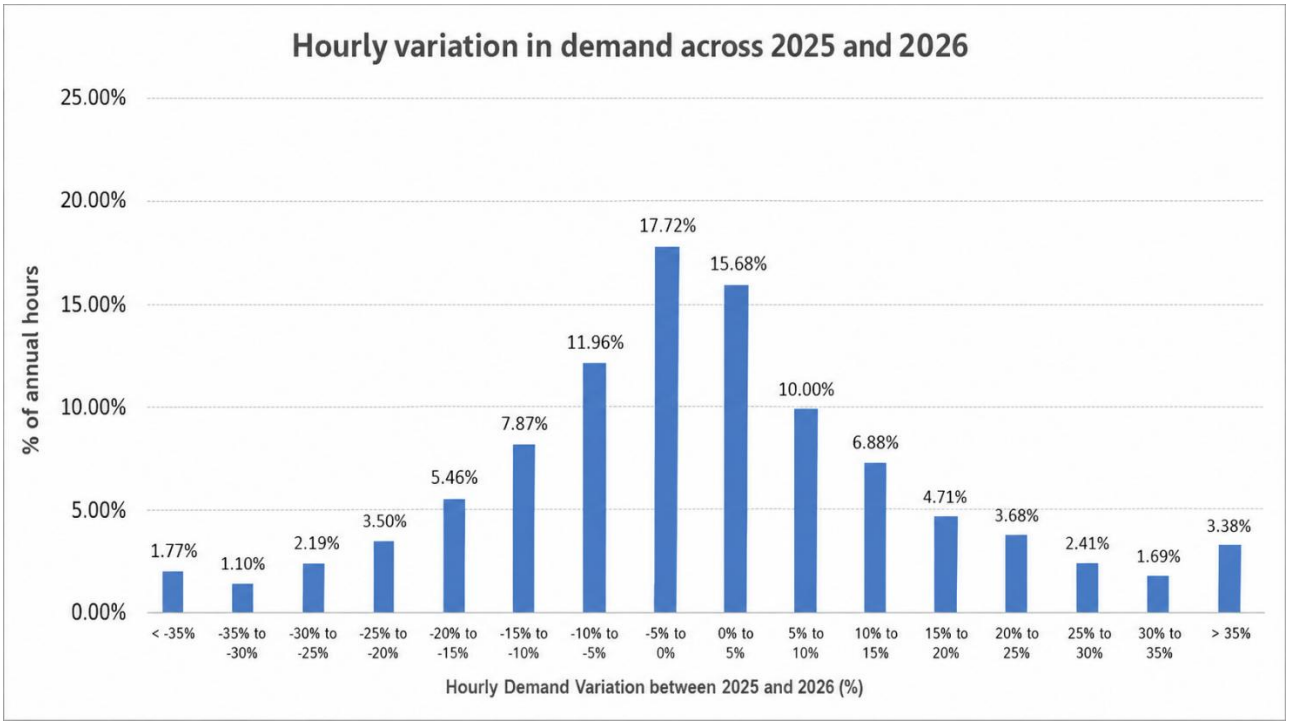


Figure 7: Hourly Variation in electricity demand

It can be observed that the hourly demand typically varies within ±10% for ~55% of instances. This variation is primarily due to temperature, weather parameter or any random outages of transmission line and generating units etc. This variation has been captured in the reliability study by incorporating a variation of ±10% in the projected hourly demand for the future years by introducing a random variable (with normal distribution) for demand as per observed behavior over the years.

5.2 Variation in RE

In the Long-term capacity expansion planning studies, a particular profile for Solar and Wind is considered based on the observed generation data to determine the optimal capacity mix. However, due to intermittent nature of these sources, generation from these non-dispatchable sources may vary across years. As per the analyses carried out based on historical generation data, solar and wind-based generation has been varied by ± 10% and ±30% 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

iii) The peak electricity demand and electrical energy requirement of Bihar considered in the study is given in Table 15.

Table 15: Electricity demand projections

Year	Demand Projections			
	Peak Electricity Demand		Electrical Energy Requirement	
	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth
2026-27	9237	-	51275	-
2027-28	10041	8.70%	55395	8.04%
2028-29	10878	8.34%	59718	7.80%
2029-30	11747	7.99%	64262	7.61%
2030-31	12654	7.72%	69103	7.53%
2031-32	13592	7.41%	74240	7.43%
2032-33	14580	7.27%	79654	7.29%
2033-34	15616	7.11%	85318	7.11%
2034-35	16698	6.93%	91246	6.95%
2035-36	17829	6.77%	97458	6.81%
2036-37	19033	6.75%	104089	6.80%

iv) Future demand profile till the year 2036-37 has been projected using the demand profile for the year 2025-26 as the base profile.

v) The actual solar, wind and hydro generation profiles and CUFs have been referred from the data available with BSPHCL.

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

vii) The planned capacity has been considered based on the tie-up information available with BSPHCL. The same is summarised in Table 16 and details are furnished in Annexure.

Table 16: Source-wise planned capacity addition

Fig.in MW

FY	COAL	HYDRO (Conventional/Small)	Solar	Wind	PSP	BESS
2026-27	561	23	510	270	-	185
2027-28	-	-	690	280	-	815
2028-29	-	13	300	332	-	-
2029-30	1760	50	-	-	600	-
2030-31	2230	117	-	-	600	-
2031-32	-	154	-	-	460	-

2032-33	-	-	-	-	460	-
2033-34	800	-	-	-	-	-
2034-35	800	-	-	-	-	-
2035-36	800	-	-	-	-	-
Total	**6951**	**357**	**1500**	**882**	**2120**	**1000**

viii) **Renewable Energy 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 17.

Table 17: Renewable Energy Consumption Obligation (RCO) trajectory (%)

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.	2025-26	1.45	1.22	28.24	2.1	33.01
2.	2026-27	1.97	1.34	29.94	2.7	35.95
3.	2027-28	2.45	1.42	31.64	3.3	38.81
4.	2028-29	2.95	1.42	33.1	3.9	41.36
5.	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 shall at least remain 43.33% beyond 2029-30. Further, the DRE percentage has also been assumed to be constant at 4.5% beyond 2029-30. Hence, the suggested trajectory of Renewable Consumption Requirement up to FY 2036-37 is given in Table 18.

Table 18: Renewable Energy Consumption Obligation (RCO) trajectory (in %) considered for the study

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Total renewable energy (without DRE)	Distributed renewable energy
(1)	(2)	(3)	(4)	(5)	(3) + (4) +(5)	(6)
1.	2026-27	1.97	1.34	29.94	33.25	2.70
2.	2027-28	2.45	1.42	31.64	35.51	3.30
3.	2028-29	2.95	1.42	33.10	37.47	3.90
4.	2029-30	3.48	1.33	34.02	38.83	4.50
5.	2030-31	38.83			38.83	4.50
6.	2031-32	38.83			38.83	4.50
7.	2032-33	38.83			38.83	4.50
8.	2033-34	38.83			38.83	4.50
9.	2034-35	38.83			38.83	4.50

10.	2035-36	38.83	38.83	4.50
11.	2036-37	38.83	38.83	4.50

Based on the trajectory specified, RCO quantum in million units (MUs) from hydro, wind and other (Solar, biomass etc.) is calculated and given in Table 19.

Table 19: Total Energy required to meet RCO (other than DRE) [in MU]

Sl. No.	Year	Wind renewable energy (MU)	Hydro renewable energy	Other renewable energy	Total renewable energy w/o DRE
(1)	(2)	(3)	(4)	(5)	(3) + (4) +(5)
1.	2026-27	1010.12	687.09	15351.74	17048.94
2.	2027-28	1357.18	786.61	17526.98	19670.76
3.	2028-29	1761.68	848.00	19766.66	22376.33
4.	2029-30	2236.32	854.68	21861.93	24952.93
5.	2030-31	26832.69			26832.69
6.	2031-32	28827.39			28827.39
7.	2032-33	30929.65			30929.65
8.	2033-34	33128.98			33128.98
9.	2034-35	35430.82			35430.82
10.	2035-36	37842.94			37842.94
11.	2036-37	40417.76			40417.76

As indicated in Table 20, the state with its existing and envisaged future capacity additions will not be able to meet its RCO requirements from the year 2026-27 onwards.

Table 20: Renewable Energy (other than DRE) Deficit/Surplus

FY	RE Generation required to meet RCO [excluding DRE]		RE Generation available/met (From existing/ planned contracts) [excluding DRE]		RCO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2026-27	17048.94	33.25	11119.83	21.69	-11.56
2027-28	19670.76	35.51	12899.07	23.29	-12.22
2028-29	22376.33	37.47	14167.42	23.72	-13.75
2029-30	24952.93	38.83	14633.30	22.77	-16.06
2030-31	26832.69	38.83	14906.17	21.57	-17.26
2031-32	28827.39	38.83	15476.09	20.85	-17.98
2032-33	30929.65	38.83	15476.09	19.43	-19.40
2033-34	33128.98	38.83	15476.09	18.14	-20.69
2034-35	35430.82	38.83	15476.09	16.96	-21.87
2035-36	37842.94	38.83	15476.09	15.88	-22.95
2036-37	40417.76	38.83	15476.09	14.87	-23.96

The electricity demand furnished by Bihar represents the electricity demand recorded on the grid (the drawl from the grid) and reflects the net demand after accounting for energy consumed by

prosumers from behind-the-meter generation. The same has been considered as input to the STELLAR model.

Requirement of DRE has been considered exogenously. Considering the current Distributed Renewable Energy (DRE) capacity and anticipated increase in DRE, the Renewable Compliance Obligation (RCO) targets of MoP, along with its anticipated achievements, are outlined in Table 21, where Solar Rooftop Generation as per RCO trajectory has been considered, which has then been utilized in calculating the RCO.

Table 21: Renewable Energy from DRE

FY	DRE required to meet RCO		DRE available/met (From existing/ planned contracts)		RCO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2026-27	1353	2.70%	1960	3.91%	1.21%
2027-28	1797	3.30%	2144	3.94%	0.64%
2028-29	2304	3.90%	2634	4.46%	0.56%
2029-30	2878	4.50%	3248	5.08%	0.58%
2030-31	3095	4.50%	3248	4.72%	0.22%
2031-32	3325	4.50%	3248	4.39%	-0.11%
2032-33	3568	4.50%	3248	4.10%	-0.40%
2033-34	3822	4.50%	3248	3.82%	-0.68%
2034-35	4087	4.50%	3248	3.58%	-0.92%
2035-36	4365	4.50%	3248	3.35%	-1.15%
2036-37	4662	4.50%	3248	3.13%	-1.37%

The existing and planned DRE tie-up capacities along with the RCO trajectory of DRE for Bihar up to 2036-37 are as follows:

Table 22: Existing/Planned DRE capacities and RCO projections (in MW)

Year	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
Cumulative YoY DRE Capacity available (MW)	1598	1748	2148	2648	2648	2648	2648	2648	2648	2648	2648
Capacity required to fulfill RCO (MW)	1103	1465	1879	2347	2524	2712	2909	3116	3333	3560	3802
Surplus/Deficit	495	283	269	301	124	-64	-261	-468	-685	-912	-1154

In order to meet the deficit and hence fulfill the RCO obligations, the state needs to tie-up an additional 1154 MW of DRE capacity by 2036-37.

7.0 Outcome of the model

7.1 Investment options to meet the unserved energy and ensure RCO compliance

To help the state in meeting the projected electricity demand, candidate capacities have been given to the model to find the least cost optimal capacity mix required to meet the electricity demand while fulfilling the RCO obligations. The capacity projections (existing, planned, to be tied up) for Bihar are given in Table 23.

Table 23: Year-wise contracted capacity projections (in MW)

Year	Coal	Biomass	Hydro	Wind	Solar	PSP	BESS 4h	SToA/MToA
2026-27	8304	44	1379	969	2617	70	231	956
2027-28	8304	44	1379	1849	6269	541	1046	1459
2028-29	8304	44	1392	2781	6738	541	1046	1500
2029-30	10064	144	1442	3313	7252	1141	1046	-
2030-31	12294	144	1559	3313	7909	1741	1046	-
2031-32	12294	144	1713	3313	8562	2201	1046	-
2032-33	12294	144	1713	3510	9398	2661	1046	-
2033-34	13094	144	1713	4110	9892	2661	1046	-
2034-35	13894	144	1713	4710	10456	2661	1046	-
2035-36	14694	144	1713	5310	11018	2918	1046	-
2036-37	14694	144	1713	5910	11450	3418	1546	500

The year-wise projected contracted capacity mix is given in Figure 8.

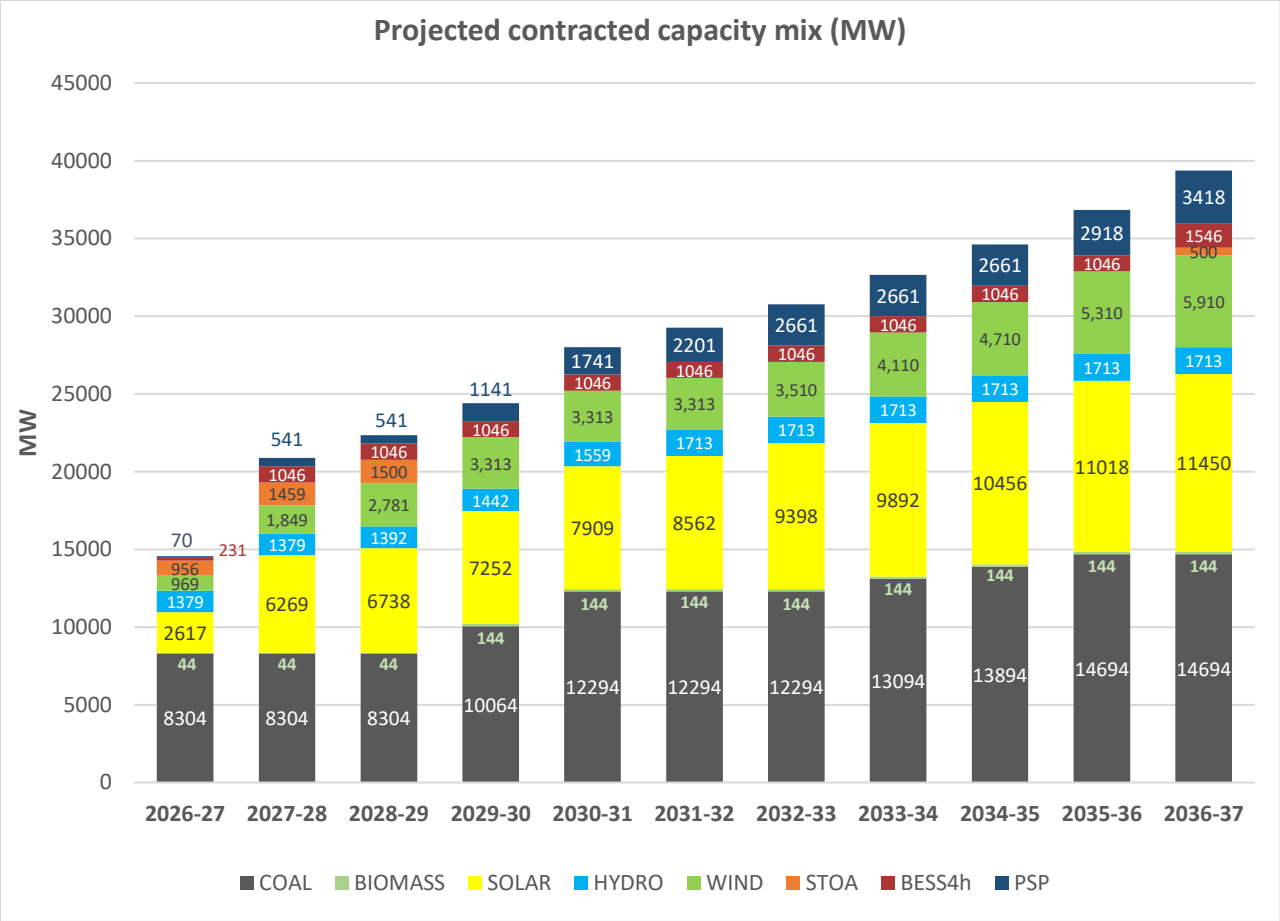


Figure 8: Year-wise Projected Contracted Capacity Mix (MW)

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 and is only required during non-solar hours of peak demand months viz. from May to September.

Reliability studies have been conducted based on the projected capacity for the year 2036-37. The analysis confirms that the projected capacity meets the reliability criteria specified in the National Electricity Plan (NEP), with the Loss of Load Probability (LoLP) and Not-Served Energy (NENS) remaining within the permissible limits of 0.2% and 0.05%, respectively (as specified in the National Electricity Plan (NEP)).

As per the resource adequacy studies, the likely total projected contracted capacity for the year 2036-37 is around 39,375 MW which consists of 14,694 MW from coal; 144 MW from biomass; 1,713 MW from hydro; 11,450 MW from solar; 5,910 MW from wind; 4,964 MW from Storage (PSP/BESS) and 500 MW from SToA/MToA arrangement. This capacity shall be able to meet the projected demand with prescribed reliability criteria and to comply with the stipulated Renewable

Energy Consumption Obligation (RCO) targets. Based on the capacity addition, the planning reserve margin works out to be about 4%. Capacity mix required by 2036-37 is shown in Figure 9.

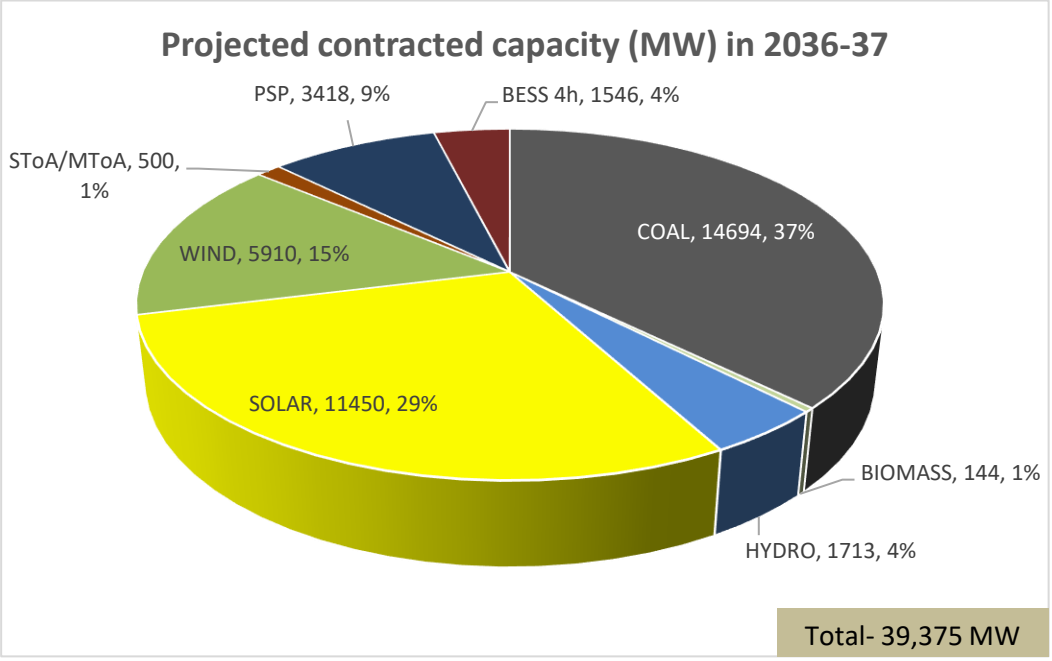


Figure 9: Contracted Capacity Mix in 2036-37

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 2036-37 to meet its demand reliably as shown in Table 24.

Table 24: Year-wise Capacity Addition (in MW)

	Coal	Biomass	Hydro	Wind		Solar	
Year	Planned Contracts	Planned Contracts	Planned Contracts	Planned Contracts	Additional Requirement	Planned Contracts	Additional Requirement
2026-27	561	-	23	270	-	510	-
2027-28	-	-	-	280	600	690	2962
2028-29	-	-	13	332	600	300	169
2029-30	1760	100	50	-	532	-	514
2030-31	2230	-	117	-	-	-	657
2031-32	-	-	154	-	-	-	653
2032-33	-	-	-	-	197	-	835
2033-34	800	-	-	-	600	-	495
2034-35	800	-	-	-	600	-	563
2035-36	800	-	-	-	600	-	562
2036-37	-	-			600		433
Total	**6951**	**100**	**357**	**882**	**4329**	**1500**	**7843**
	PSP		**BESS**		**TOTAL**		**SToA /MToA***
Year	Planned contracts	Additional Requirement	Planned Contracts	Additional Requirement	Planned Contracts	Additional Requirement	Additional Requirement
2026-27	-	-	185	-	1549	-	956
2027-28	-	471	740	-	1710	4033	1459
2028-29	-	-	75	-	720	769	1500
2029-30	600	-	-	-	2510	1046	-
2030-31	600	-	-	-	2947	657	-
2031-32	460	-	-	-	614	653	-
2032-33	460	-	-	-	460	1032	-
2033-34	-	-	-	-	800	1095	-
2034-35	-	-	-	-	800	1163	-
2035-36	-	258	-	-	800	1420	-
2036-37	-	500	-	500	-	2033	500
Total	**2120**	**1229**	**1000**	**500**	**12910**	**13901**	

*Yearly requirement

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

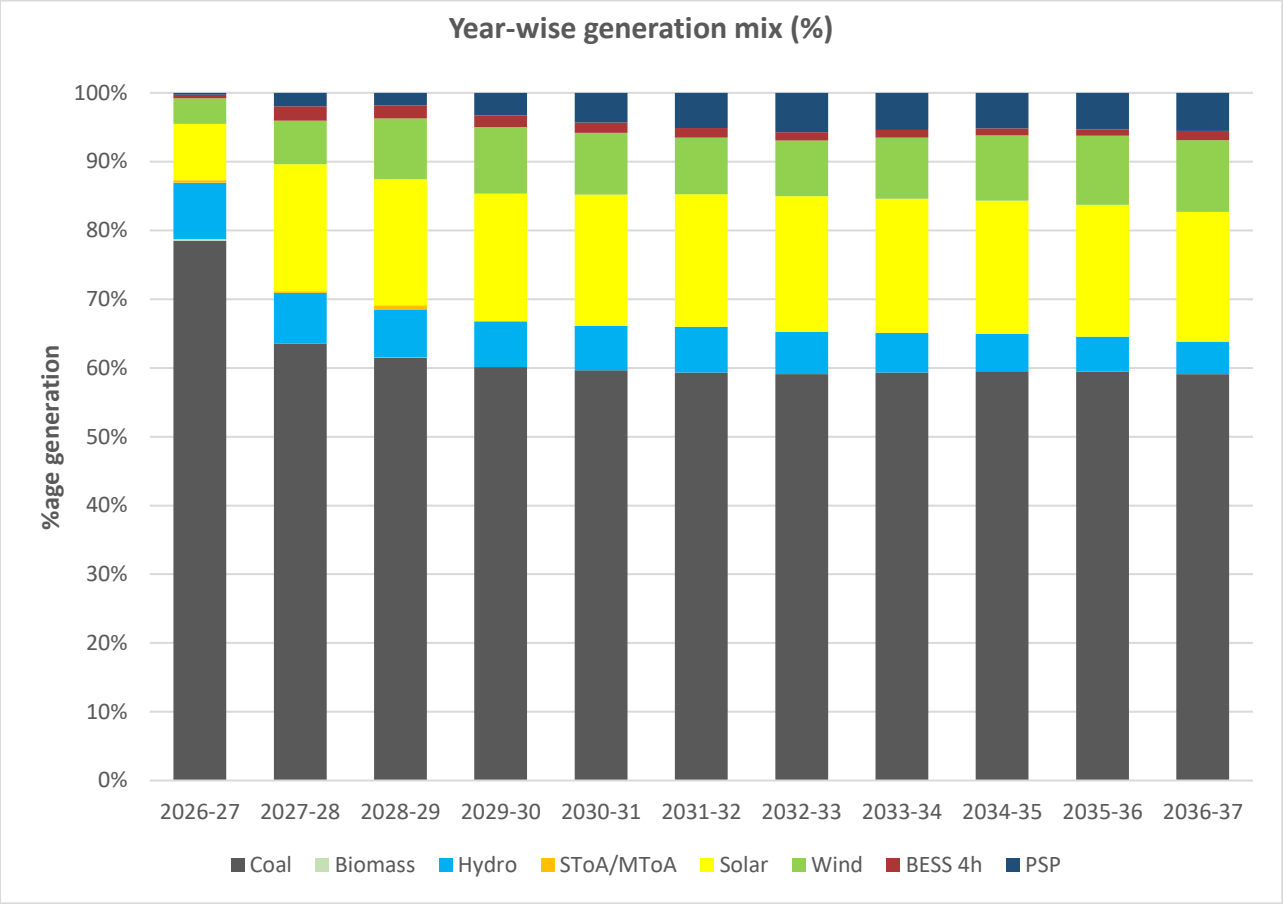
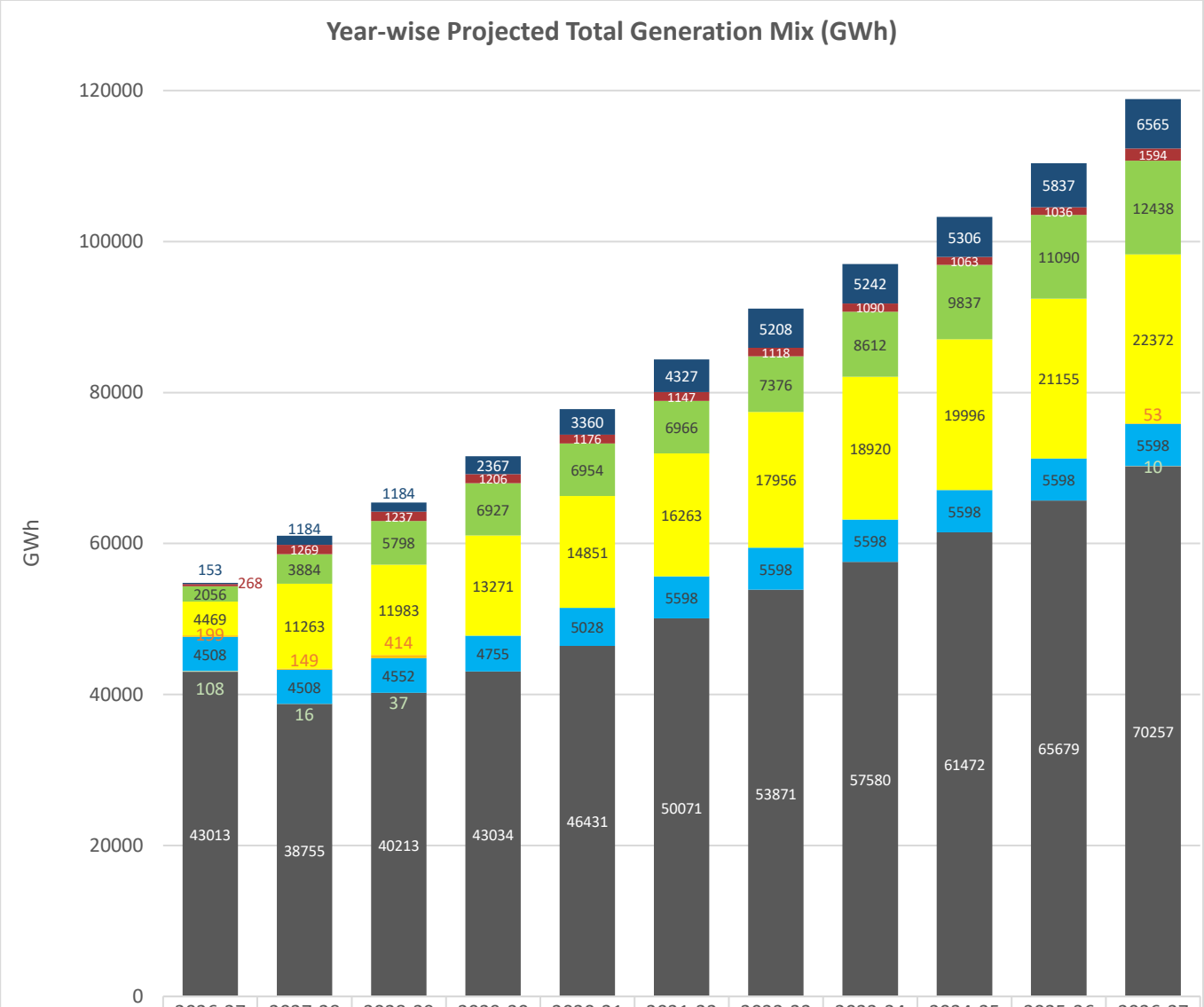


Figure 10: Year-wise projected generation mix (in %)



	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
PSP	153	1184	1184	2367	3360	4327	5208	5242	5306	5837	6565
BESS 4h	268	1269	1237	1206	1176	1147	1118	1090	1063	1036	1594
Wind	2056	3884	5798	6927	6954	6966	7376	8612	9837	11090	12438
Solar	4469	11263	11983	13271	14851	16263	17956	18920	19996	21155	22372
SToA/MToA	199	149	414								53
Hydro	4508	4508	4552	4755	5028	5598	5598	5598	5598	5598	5598
Biomass	108	16	37								10
Coal	43013	38755	40213	43034	46431	50071	53871	57580	61472	65679	70257

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

8.0 Conclusions

Based on the Resource Adequacy studies of Bihar up to the year 2036-37, the following conclusions may be drawn:

1. The study has been done based on the hourly electricity demand pattern of the year 2025-26. It has been observed that the peak demand season is typically from May to September with peak demand occurring during non-solar hours.
2. The study has considered electrical energy and peak electricity requirement projections as per the projections available with BSPHCL (Bihar), which envisages that the annual energy requirement of the state is likely to grow at a CAGR of 7.34% while the peak electricity demand for the state is likely to grow at a CAGR of 7.50% for the period of 2026-27 to 2036-37.
3. The state is projected to face unserved energy in the coming years and will need to contract additional solar, wind and storage capacities beyond those already planned. In addition to the existing and already planned contracts, the state needs to tie up approximately 7,843 MW of solar-based capacity, 4329 MW of wind-based capacity and 1729 MW of Storage (1229 MW PSP and 500 MW BESS) by 2036–37 (refer Table 24). Additionally, there will be a requirement for Medium-Term Open Access (MToA) and Short-Term Open Access (SToA) ranging from around 500 MW to 1500 MW in different years, as detailed in the report. These MToA/SToA needs can be met through power procurement from market or through bilateral agreements. The MToA/SToA values represent peak electricity demand requirements as well as seasonal banking needs, expressed in terms of megawatts (MW) and is only required during non-solar hours of peak demand months viz. from May to September. To fulfil the RCO obligations for Distributed Renewable Energy (DRE), the state needs to tie-up an additional 1154 MW of DRE capacity by 2036-37.
4. As per the resource adequacy studies, the likely total projected contracted capacity for the year 2036-37 is around 39,375 MW which consists of 14,694 MW from coal; 144 MW from biomass; 1,713 MW from hydro; 11,450 MW from solar; 5,910 MW from wind; 4,964 MW from Storage (3418 MW PSP, 1546 MW BESS) and 500 MW from SToA/MToA arrangement. This capacity shall be able to meet the projected demand with prescribed reliability criteria and to comply with the stipulated Renewable Energy Consumption Obligation (RCO) targets. In addition, the DRE installed capacity required in 2036-37 is of the order of 3,802 MW.
5. LT-DRAP was also verified against the coincident peak requirement to be met by Bihar at the time of national peak, as provided for in the Long-term National Resource Adequacy Plan (LT-NRAP) published by CEA for the period from 2026-27 to 2035-36. It was found that the planned capacity for FY 2026-27 and FY 2027-28 is adequate to meet the coincident peak demand while maintaining the required national level PRM.

6. The Planning Reserve Margin (PRM) for Bihar has been assessed at about 4%. Further, the study indicates year-wise short-term/medium-term/bilateral requirements inclusive of the PRM capacity to optimally meet the demand.
7. The State is setting up PSP capacity through Private Sector. As the gestation period of PSP is about four-five years, advance action should be taken by the State towards development of PSP capacity in the State. As peak demand of the state is in non-solar hours, energy storage system will be a good option to meet the peak electricity demand in non-solar hours.
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.
9. Bihar is suggested to periodically review the progress of all the under construction/planned projects and accordingly plan alternate sources of baseload/firm power for the intervening period in case of slippages in the planned capacity.
10. It is likely that the state may have surplus capacity, which can be shared with other utilities/states through banking/bilateral arrangements, including the PUShP portal.
11. Accurate demand assessment is fundamental to capacity expansion modelling and directly impacts the Resource Adequacy (RA) study outcomes. To achieve realistic and data-driven results, DISCOMs are strongly encouraged to adopt scientific tools and robust methodologies for demand forecasting.

****

Annexure

Details of upcoming considered in the study

Sl. No.	Tied capacity name	Type of generation	Expected COD	Bihar's share (in MW)
1.	Buxar TPP (SJVNL)	Thermal	2026-27	561
2.	Nabinagar St-II U-I &II	Thermal	2029-30	960
3.	Pirpainti U-I	Thermal	2029-30	800
4.	Pirpainti U-II & U-III	Thermal	2030-31	1600
5.	NTPC Darlipali Stage – II	Thermal	2030-31	150
6.	Nabinagar St-II U-III	Thermal	2030-31	480
7.	Planned Coal U 1	Thermal	2033-34	800
8.	Planned Coal U 2	Thermal	2034-35	800
9.	Planned Coal U 3	Thermal	2035-36	800
10.	Kurichu (Run of River)	Hydro	2026-27	23
11.	Tala (Run of River)	Hydro	2028-29	13
12.	Heo HEP	Hydro	2029-30	15.74
13.	Tato-I HEP	Hydro	2029-30	15.07
14.	Rangit	Hydro	2029-30	19
15.	Arun-III	Hydro	2030-31	116.7
16.	Dibang HEP	Hydro	2031-32	104
17.	Kalai II Hydro	Hydro	2031-32	50
18.	Planned Solar	Solar	2026-27	510
19.	Planned_Solar	Solar	2027-28	690
20.	Planned_Solar	Solar	2028-29	300
21.	GSS(BESS) Standalone	BESS	2026-27	125
22.	Kajra Phase II BESS (BSPGCL)	BESS	2026-27	60.25
23.	Acme Hybrid-SECI IX	BESS	2027-28	75
24.	SECI (BESS) Tranche XV	BESS	2027-28	100
25.	SECI BESS (FDRE)	BESS	2027-28	190
26.	SJVN (BESS) Standalone	BESS	2027-28	450
27.	GREENKO U-I	PSP	2029-30	600
28.	GREENKO U-II	PSP	2030-31	600
29.	Sun Petrochemicals Pvt Ltd. U-I	PSP	2031-32	460
30.	Sun Petrochemicals Pvt Ltd. U-II	PSP	2032-33	460
31.	PM-Kusum and others	DRE	2026-27	1286
32.	BREDA and DISCOM	DRE	2027-28	150
33.	BREDA and DISCOM	DRE	2028-29	400
34.	BREDA and DISCOM	DRE	2029-30	500

Assumption for Resource Adequacy Studies

1. Electricity Demand & peak requirement: As per information furnished by the State.
2. Demand Profile: Based on hourly demand profile of 2025-26.
3. Existing & Planned Capacity: As per the information shared by the state.
4. Cost parameters: based on information in LT-NRAP.

RE CUF considered

Hydro	Wind	Solar (existing)	Solar (planned)	DRE
38 %	27%	19%	24%	14%

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 Plants	Existing/Planned	95	50	-
	Candidate		50	-
Battery Energy Storage System	Existing/Candidate	98	NA	-

Technology	Type	Heat Rate (MCal/MWh)		Auxiliary Consum. (%)	Min. online time (hr)	Min. offline time (hr)
		At max loading	At min loading			
Coal	Existing/ Planned	2300 to 2879	2438 to 3052	7.0	6	4
	Candidate (SC & USC)	2060 to 2125	2183 to 2253	6.5	6	4
Gas	Existing	2000 to 2900	2260 to 3277	2.5	4	3

Technology	Type	Heat Rate (MCal/MWh)		Auxiliary Consum. (%)	Min. online time (hr)	Min. offline time (hr)
		At max loading	At min loading			
Nuclear	Existing/ Planned	2777	2777	10	6	4
	Candidate	2777	2777	10	-	-
Biomass	Existing/ Planned	4200	4450	8	6	4
	Candidate	4200	4450	8	6	4
Hydro	Existing/ Planned	-	-	0.7	-	-
	Candidate	-	-	0.7	-	-
Pumped Storage	Existing/ Planned	-	-	pump efficiency 80 %	-	-
	Candidate	-	-		-	-
Battery Energy Storage	Candidate	-	-	Round trip losses 12%	-	-

Transmission Parameters

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

Financial Parameters

Following cost parameters have been assumed:

Resource	Capex* (in ₹/MW)	O&M Fixed Cost (in ₹/MW)	Construction Time (in years)	Amortization /Life time (in years)
Coal	12 Cr	30 Lakh	4	25
Solar	4.32 Cr to 4 Cr	1 % of Capex	1	25
Wind	7.5 Cr	1 % of Capex	2	25
Battery Energy Storage (4-Hour)	4.8 Cr to 3.6 Cr	1% of Capex	1	15
Pumped Storage	5 Cr	30 Lakh	4	40