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Report on Resource Adequacy Plan (Generation) for West Bengal (2025-26 to 2035-36) (Version 2.0)

December, 2025

Government of India
Ministry of Power
Central Electricity Authority

Contents

Disclaimer

This Resource Adequacy Study for the state of West Bengal has been conducted based on data and inputs provided by the West Bengal State Power Department. 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 West Bengal 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 a Resource Adequacy (RA) study with a planning horizon up to FY 2034-35, based on the data provided by West Bengal State Power Department 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 2035-36, incorporating the latest data furnished by the State and planning assumptions. The RPO requirement for the state has also been assessed in accordance with the RPO trajectory specified in the Ministry of Power's Office Memorandum dated 20th October, 2023.

The electrical energy requirement and peak electricity demand for West Bengal, as furnished by West Bengal, are projected to increase with a CAGR of 5.46% and 5.38% respectively from 2025-26 to 2035-36. However, as per mid-term review of 20th EPS projections, the electricity energy requirement and peak electricity demand for West Bengal is projected to increase with a CAGR of 5.21% and 4.16% respectively from 2025-26 to 2035-36. The study has been done considering the demand projections furnished by West Bengal, as these projections are on the higher side as compared to the mid-term review projections. 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 West Bengal, based on existing contracted capacity and planned capacity additions, indicates that the available capacity may be insufficient to meet the projected electricity demand. In particular, the total unserved energy in the year 2035-36 is estimated to be approximately 62,487 MUs, accounting for around 48% of the projected electrical energy requirement for that year.

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 an 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, variation in 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 West Bengal along with RPO constraints for Solar, Wind 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 59,647 MW which consists of 13,263 MW from coal; 1,866 MW from hydro; 20,928 MW from solar; 7,545 MW from wind; 4,732 MW from Distributed Renewable Energy (DRE) source; 5,440 MW from Storage (6 hr); 3,636 MW from Storage (4 hr) and 2,237 MW from SToA/MToA. This 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 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 West Bengal based on inputs furnished by West Bengal. 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, variation in 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 had conducted the RA study for the state up to FY 2034-35, based on data furnished by the state 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 West Bengal as on 31st March, 2024, is given in Fig. 1.

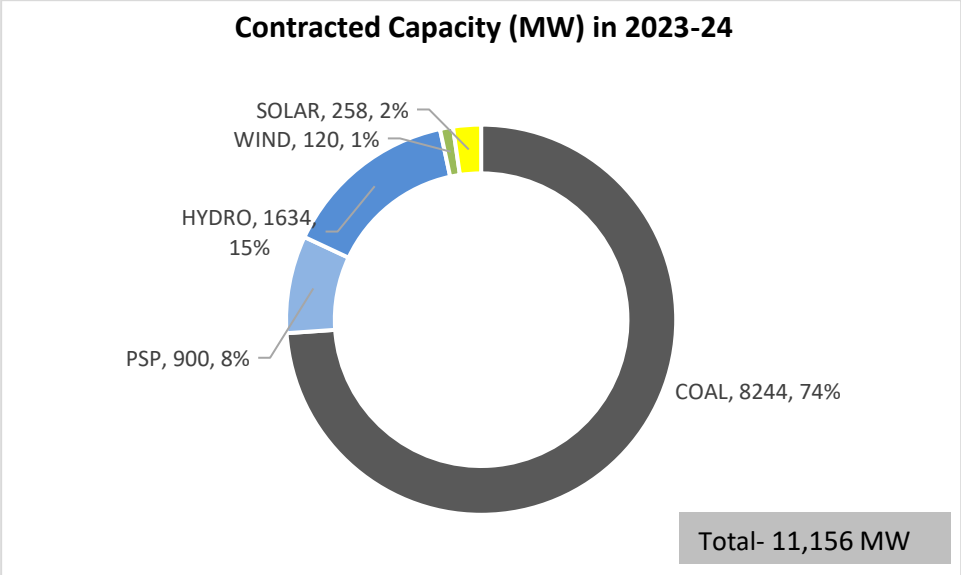

Figure 1: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2024

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 furnished by the State

	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)	70607	77056	82589	88574	94340	100528	105791	111356	117250	123486	132402
Year on Year Growth		10.38%	9.13%	7.18%	7.25%	6.51%	6.56%	5.23%	5.26%	5.29%	5.32%
Peak Electricity Demand Projections (MW)	13306	14492	15506	16593	17657	18788	19756	20770	21862	23008	24757
Year on Year Growth		10.85%	8.91%	7.00%	7.01%	6.41%	6.41%	5.15%	5.13%	5.26%	5.24%

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	HYDRO	WIND	SOLAR	HYBRID	PSP	BATTERY	DRE	STOA
2024-25	8244	1634	220	371	0	900	0	829	4620
2025-26	8244	1634	293	928	250	900	0	1267	5000
2026-27	8244	1634	1639	9412	950	900	1133	1746	3076
2027-28	8244	1634	3140	10341	2060	900	1590	2288	2708
2028-29	12017	1634	4140	10741	2060	900	1590	2880	207
2029-30	12446	1634	5140	10741	2060	1400	1590	3541	236
2030-31	12739	1724	6140	10741	2060	1400	1590	4141	263
2031-32	12938	1724	7140	11143	2060	1650	2004	4794	355
2032-33	13402	1724	8140	11837	2060	1650	2308	5507	729
2033-34	13589	1724	9140	12712	2060	1900	2463	6283	970
2034-35	14148	1724	10140	14167	2060	1900	3219	7255	1062

***** *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 contract addition

FY	Thermal		Hydro	Wind		Solar	
	Planned	Additional	Planned	Planned	Additional	Planned	Additional
2024-25				100		113	
2025-26				73		557	
2026-27				346	1000	584	7900
2027-28				501	1000	929	
2028-29		3773			1000	400	
2029-30		429			1000		
2030-31		293	90		1000		
2031-32		199			1000		403
2032-33		764			1000		694
2033-34		187			1000		875
2034-35		558			1000		1455

FY	Storage		Hybrid	DRE	Yearly STOA
	Planned	Additional	Planned	Additional	Additional
2024-25				829	4620
2025-26			250	438	5000
2026-27	10	1123	700	479	3076
2027-28		457	1110	542	2708
2028-29				592	207
2029-30	500			661	236
2030-31				599	263
2031-32	250	414		654	355
2032-33		304		713	729
2033-34	250	155		776	970
2034-35		756		972	1062

**Requirement is for a particular year*

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

3.1 Present Power Scenario in West Bengal

The power supply position for West Bengal from 2020-21 to 2024-25 is given in Table 4.

Table 4: Power Supply Position of West Bengal

Power Supply Position						
Year	**Energy required (MU)**	**Energy supplied (MU)**	**Gap (MU)**	**Peak Demand (MW)**	**Peak Met (MW)**	**Demand not met (MW)**
2020-21	51644	51544	100	8846	8846	0
2021-22	54001	53945	56	9089	9087	2
2022-23	60348	60274	74	10125	9900	225
2023-24	67576	67490	86	11626	11626	0
2024-25	71180	71085	95	12645	12640	5

As per the data provided by West Bengal, as of March 2025, the total contracted capacity of West Bengal is 10,943 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 27 %.

The fuel-wise contracted capacity as on 31st March, 2025 is given in Table 5 and Fig. 2.

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

Source	**Contracted Capacity (MW)**	**Percentage**
Coal	7964	73
Hydro	1438	13
PSP	900	8
Wind	220	2
Solar	388	4
DRE	33	0.03
Total	**10943**	**100**

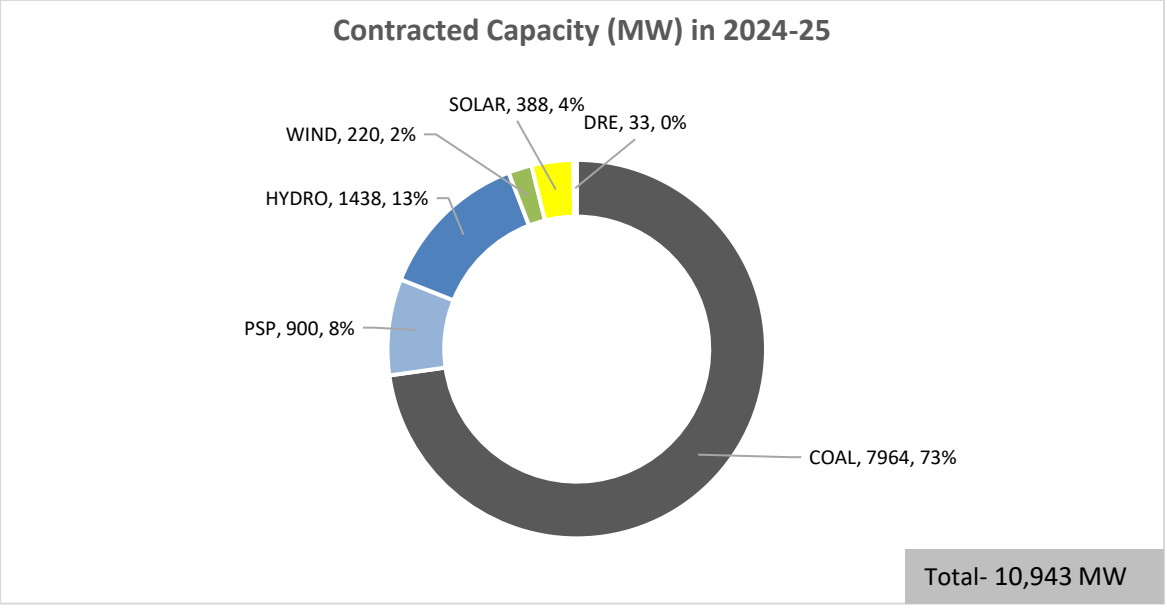

Figure 2: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2025

3.2 Demand Analysis of the FY 2024-25

Hourly demand pattern of 2024-25 was analyzed and it was observed that the peak demand season for the State of West Bengal is typically during the months from April to June. West Bengal witness peak electricity demand during non-solar hours.

The month-wise average hourly demand observed for the year 2024-25 is shown in Fig. 3.

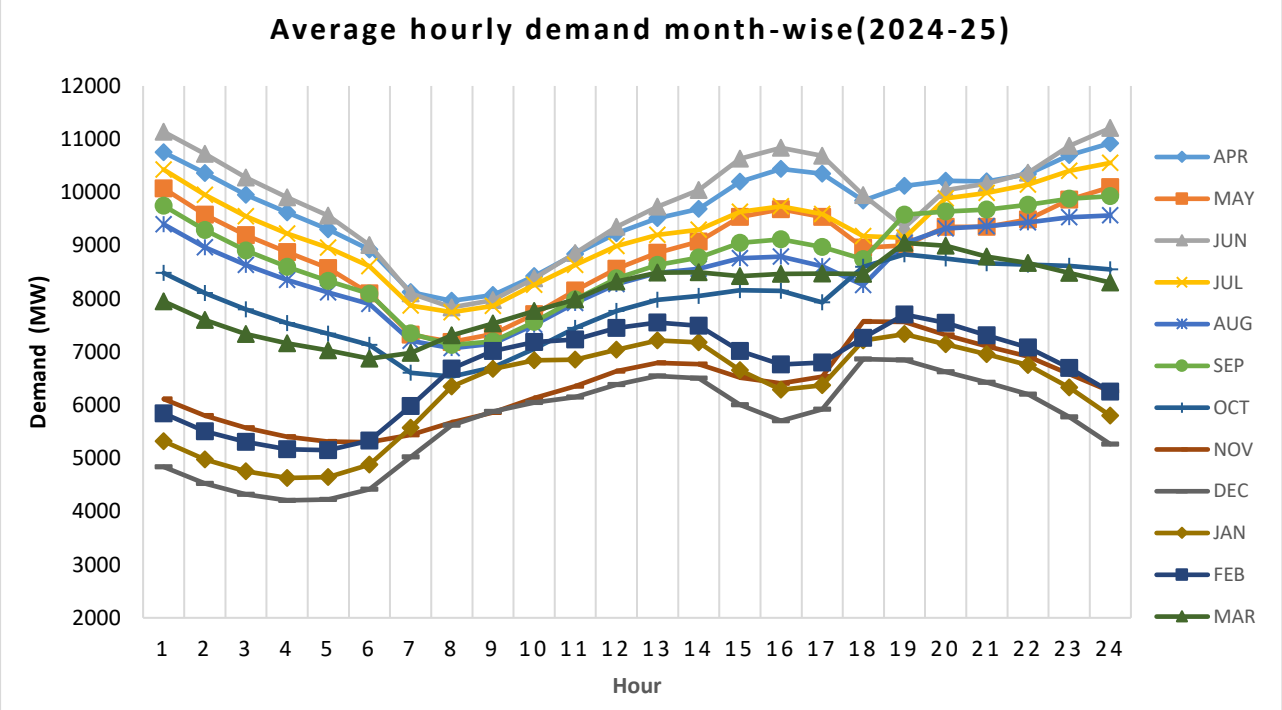

Figure 3: Average Hourly Demand Variation (Month-wise) for 2024-25

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

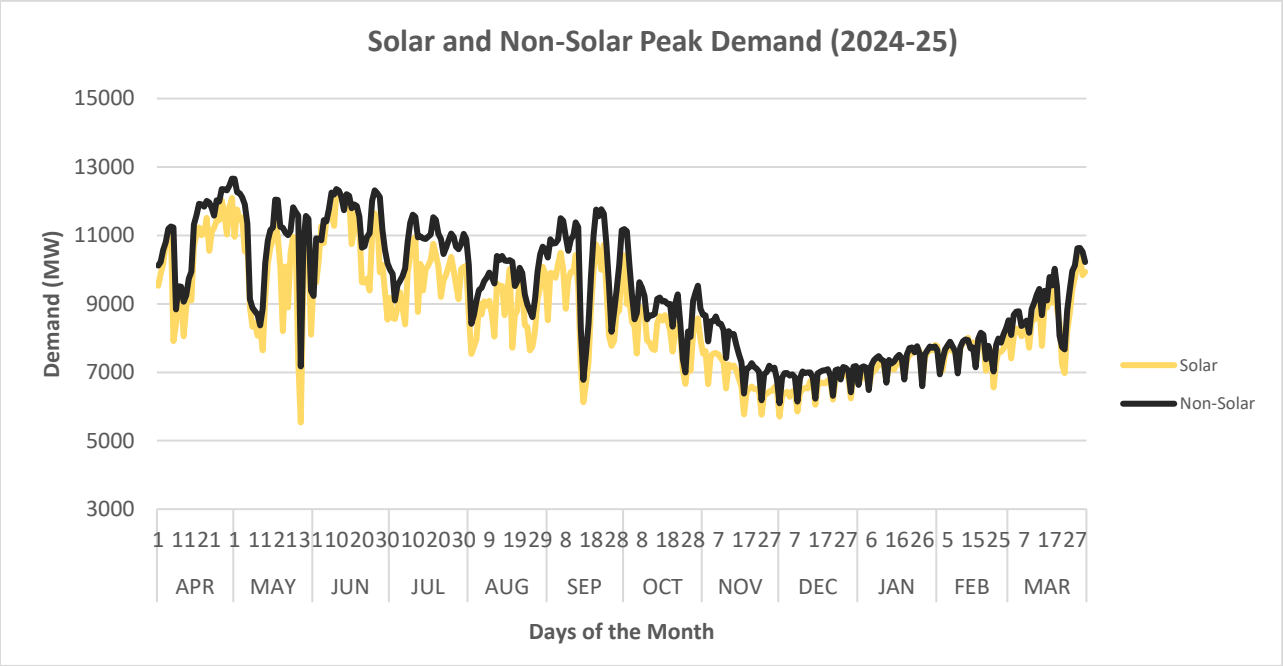

Figure 4: Solar and non-solar peak in MW for the year 2024-25

The hourly demand pattern of 2024-25 was analysed for finding out the number of occurrences of the peak and near peak electricity 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.

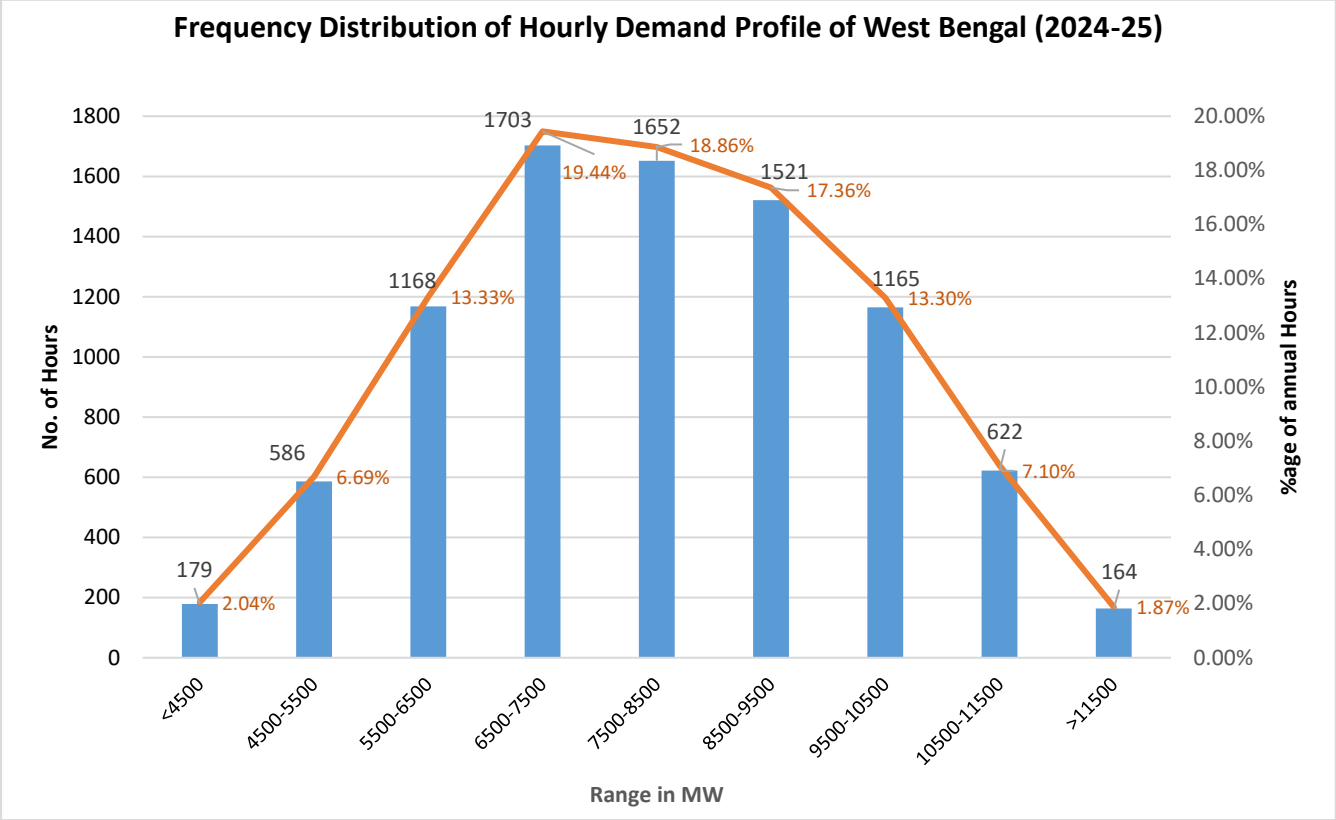

Figure 5: Frequency Distribution of Hourly Demand Profile of 2024-25

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.

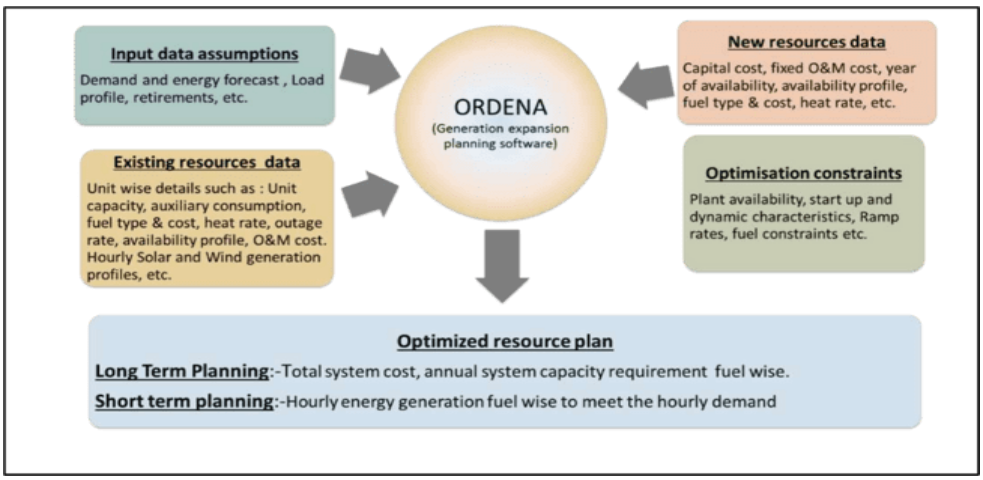

Figure 6: Schematic Diagram

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 electrical energy requirement) to create a Normalized Energy Not Served (NENS) metric.

Monte Carlo /Stochastic simulation has been used to factor-in the uncertainty associated with various generation resources and demand. It is an approach which is used to predict the probability of a variety of outcomes when the potential for random variables is present, as compared to deterministic modelling of economic dispatch model. Monte Carlo simulation helps in 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) and 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. 2023-24 and 2024-25 (considering 2023-24 as the base year) has been analyzed. The demand pattern variation across 2023-24 and 2024-25 is shown in Fig. 7.

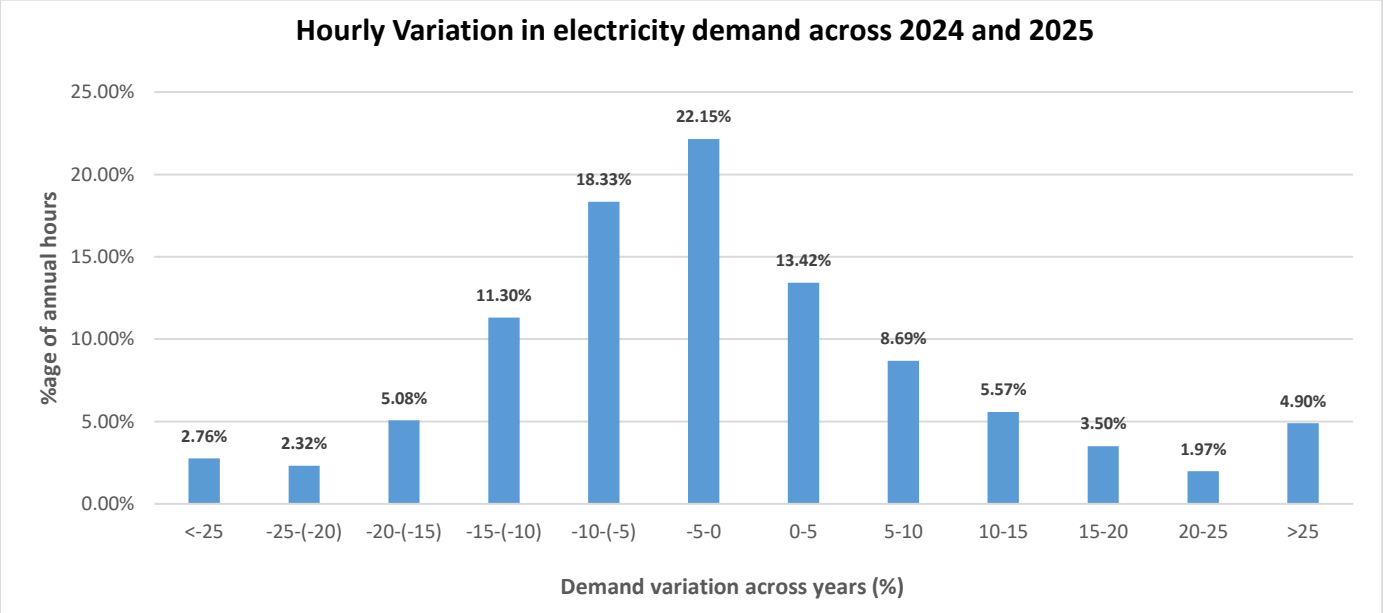

Figure 7: Hourly Variation in electricity demand across years

It can be observed that the hourly demand typically varies within ±10% for ~62% 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 ± 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 requirement of West Bengal as per the state and mid-term review of 20th EPS Report is given in Table 6.

Table 6: Electricity demand projection

Year	Projections by West Bengal				Projections as per Mid-term review of 20th EPS			
	Peak Electricity Demand		Electrical Energy Requirement		Peak Electricity Demand		Electrical Energy Requirement	
	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth
2025-26	14017		75780		13053		75598	
2026-27	14780	5.44%	79984	6.97%	13838	6.01%	80131	6.00%
2027-28	15598	5.53%	84482	6.85%	14316	3.46%	85096	6.20%
2028-29	16465	5.56%	89252	5.31%	15043	5.07%	90402	6.24%
2029-30	17384	5.58%	94313	5.01%	15746	4.67%	95660	5.82%
2030-31	18294	5.23%	99312	4.26%	16412	4.23%	100785	5.36%
2031-32	19254	5.25%	104598	3.98%	17040	3.83%	105765	4.94%
2032-33	20269	5.27%	110190	3.70%	17689	3.81%	110956	4.91%
2033-34	21344	5.30%	116102	5.21%	18324	3.59%	116139	4.67%
2034-35	22478	5.31%	122355	5.02%	18929	3.30%	121220	4.38%
2035-36	23677	5.34%	128969	4.70%	19620	3.65%	125645	3.65%

Projections as per the state have been considered in the study.

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, wind and hydro generation profiles and CUFs have been considered as per the data available in CEA.

iv) The capital cost of candidate plants for coal, solar, wind 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 West Bengal. The same is summarised in Table 7 and details are furnished in Annexure.

Table 7: Source-wise planned capacity addition

Fig.in MW

FY	HYDRO (Conventional/Small)	Thermal	Solar	Wind	PSP	Battery (MW/MWh)
2025-26	338	48	539	73	-	-
2026-27	-	-	589	351	-	10/40
2027-28	-	-	849	501	-	-
2028-29	-	-	200	-	-	-
2029-30	-	-	-	-	500	-
2030-31	90	-	-	-	0	-
2031-32	-	-	-	-	250	-
2032-33	-	-	-	-	0	-
2033-34	-	-	-	-	250	-
Total	**428**	**48**	**2177**	**925**	**1000**	**10/40**

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 (%)

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. Further, the DRE percentage has been assumed to be 4.5% 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.	**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**	41.00			4.50	45.50
8.	**2031-32**	42.50			4.50	47.00
9.	**2032-33**	43.80			4.50	48.30
10.	**2033-34**	45.00			4.50	49.50
11.	**2034-35**	46.50			4.50	51.00
12.	**2035-36**	47.50			4.50	52.00

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: Renewable Energy (excluding DRE) in MUs required to meet RPO

Sl. No.	Year	Wind renewable energy (MU)	Hydro renewable energy	Other renewable energy	Total renewable energy
1.	**2025-26**	1098.8	924.5	21400.3	23423.6
2.	**2026-27**	1575.7	1071.8	23947.2	26594.7
3.	**2027-28**	2069.8	1199.6	26730.1	29999.6
4.	**2028-29**	2632.9	1267.4	29542.4	33442.7
5.	**2029-30**	3282.1	1254.4	32085.3	36621.7
6.	**2030-31**	40717.9			40717.9
7.	**2031-32**	44454.2			44454.2
8.	**2032-33**	48263.2			48263.2
9.	**2033-34**	52245.9			52245.9
10.	**2034-35**	56895.1			56895.1
11.	**2035-36**	61260.3			61260.3

Table 11: Renewable Energy (excluding DRE) Deficit/Surplus

FY	RE Generation required to meet RPO		RE Generation available/met (From existing/ planned contracts)		RPO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	23423.6	30.91	8641	11.40	-19.51
2026-27	26594.7	33.25	10410	13.01	-20.24
2027-28	29999.6	35.51	12946	15.32	-20.19
2028-29	33442.7	37.47	12207	13.68	-23.79
2029-30	36621.7	38.83	13264	14.06	-24.77
2030-31	40717.9	41.00	13639	13.73	-27.27
2031-32	44454.2	42.50	13639	13.04	-29.46
2032-33	48263.2	43.80	13639	12.38	-31.42
2033-34	52245.9	45.00	13639	11.75	-33.25
2034-35	56895.1	46.50	13639	11.15	-35.35
2035-36	61260.3	47.50	13639	10.58	-36.92

Table 11(a): DRE Deficit/Surplus

FY	DRE required to meet RPO		DRE available/met (From existing/ planned contracts)		RPO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	1591.4	2.10	40	0.05	-2.05
2026-27	2159.6	2.70	40	0.05	-2.65
2027-28	2787.9	3.30	40	0.05	-3.25
2028-29	3480.8	3.90	40	0.04	-3.86
2029-30	4244.1	4.50	40	0.04	-4.46
2030-31	4469.0	4.50	40	0.04	-4.46
2031-32	4706.9	4.50	40	0.04	-4.46
2032-33	4958.6	4.50	40	0.04	-4.46
2033-34	5224.6	4.50	40	0.03	-4.47
2034-35	5506.0	4.50	40	0.03	-4.47
2035-36	5803.6	4.50	40	0.03	-4.47

As indicated in Table 11 and 11 (a), the state with its existing and envisaged future capacity additions will not be able to meet its RPO requirements from the year 2025-26 onwards.

7.0 Outcome of the model

7.1 Unserved Energy Projections

Initially, the study has been carried out considering only the existing and planned capacity contracts. The projected total unserved energy (ENS) for the year 2035-36 is about 62,487 MUs which is about 48% of the energy demand in 2035-36. The year-wise likely unserved energy with the existing and planned capacities is given in Fig 8.

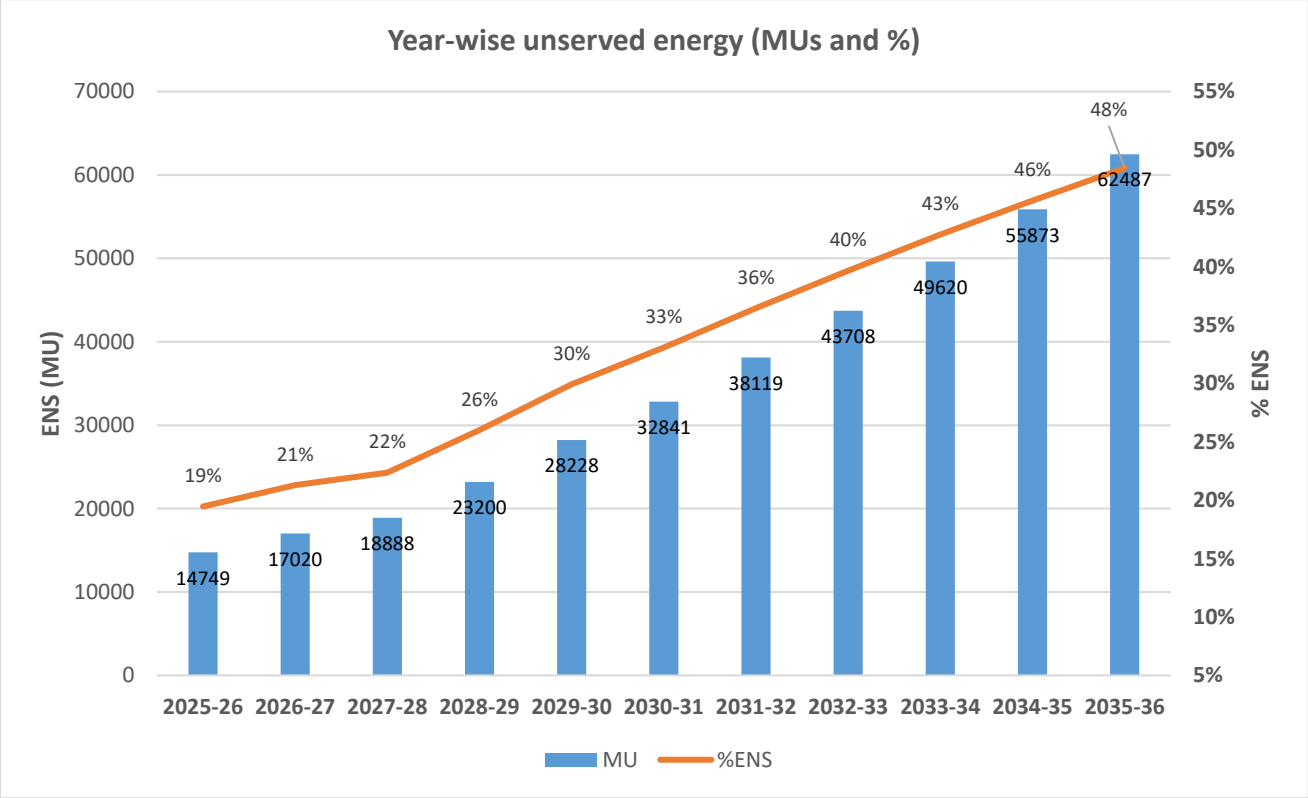

Figure 8: Yearly likely unserved energy (in MU) with the existing and planned capacities

The study has also analyzed the daily and monthly pattern of unserved energy in the year 2035-36, it can be seen that contracted capacity (present and planned) is unable to meet the demand. Details are shown in Fig. 9.

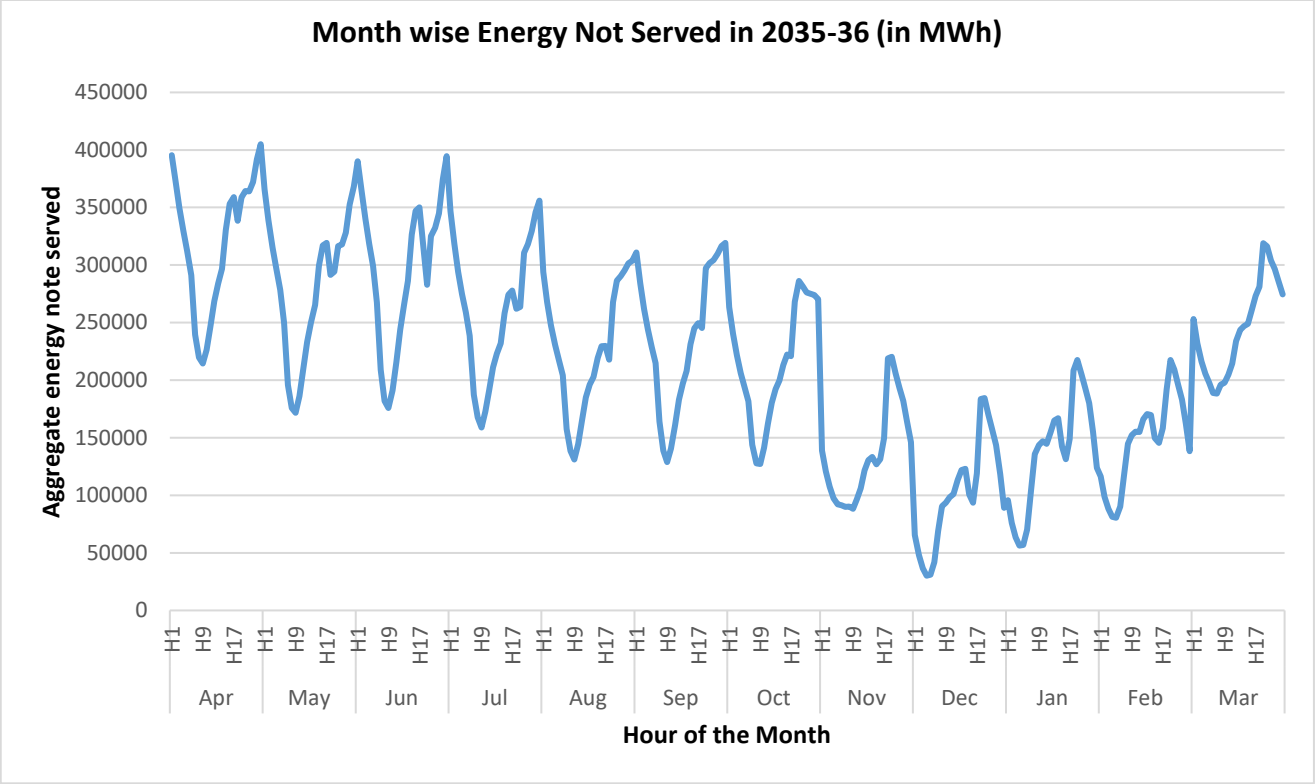

Figure 9: Block-wise Unserved Energy Pattern MWh (2035-36)

From the above figure, it can be seen that unserved energy is high during high demand season viz. April to June and is typically observed during non-solar hours.

7.2 Investment options to meet the unserved energy

To meet the unserved energy, energy investment options (i.e., 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 RPO obligations. The capacity projections (existing, planned, to be tied up) for West Bengal are given in Table 12.

Table 12: Year-wise contracted capacity projections (in MW)

Year	Coal	Hydro	Wind	Solar	Storage (6 Hr)	Storage (4 Hr)	DRE	SToA/MToA
2025-26	8012	1776	293	927	900	0	1298	4200
2026-27	8012	1776	1344	5517	2567	10	1761	4200
2027-28	8012	1776	2545	10366	4102	10	2273	4200
2028-29	8012	1776	3245	11566	4440	10	2838	4200
2029-30	9612	1776	3545	12666	4940	10	3461	3254
2030-31	11212	1866	4245	14248	4940	10	3644	2095
2031-32	11571	1866	4995	14931	5190	10	3838	2301
2032-33	12212	1866	5745	16097	5190	221	4043	2266
2033-34	12639	1866	6445	17317	5440	831	4260	2312
2034-35	13059	1866	7145	18928	5440	1976	4490	2323
2035-36	13263	1866	7545	20928	5440	3636	4732	2237

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

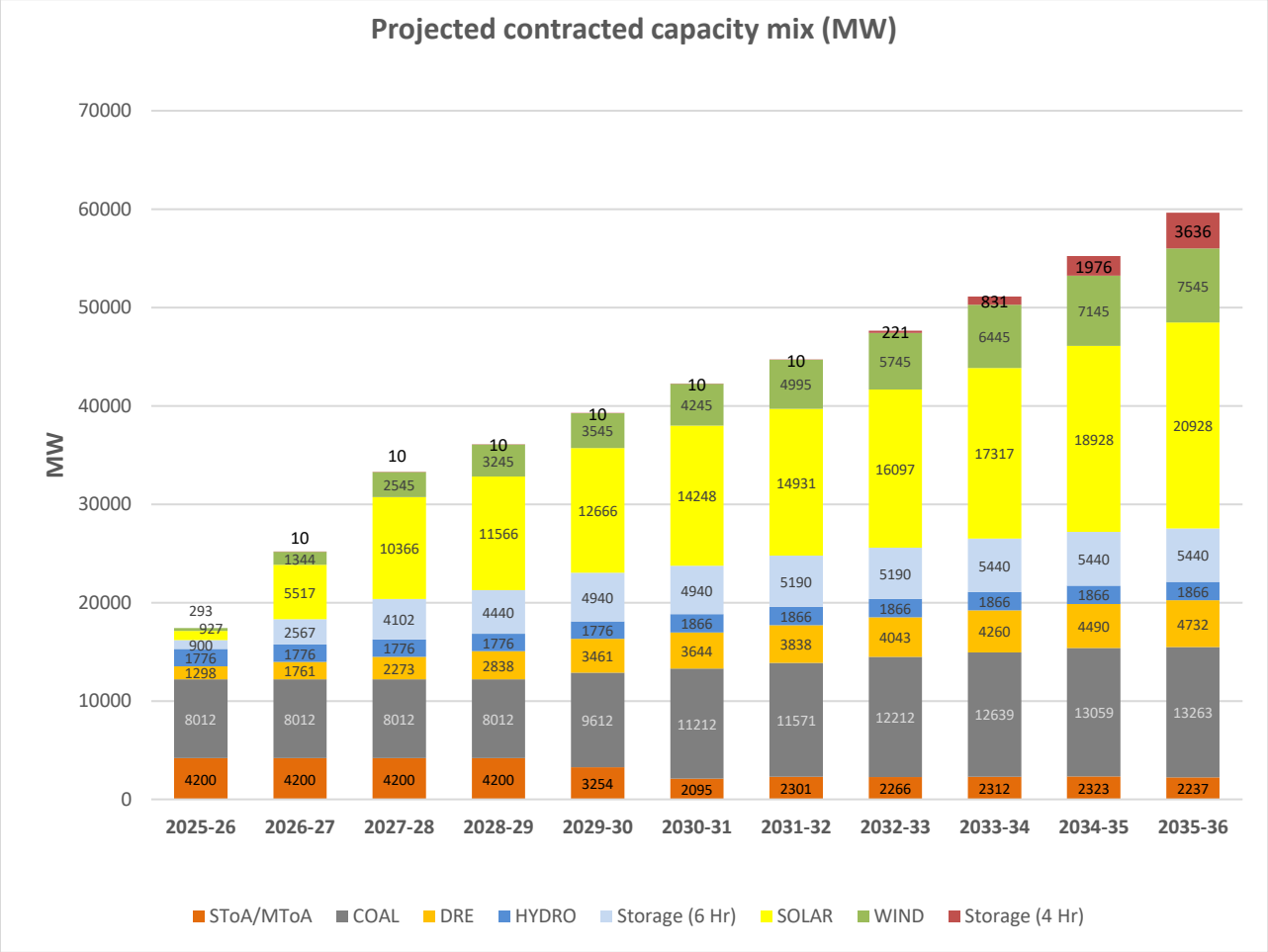

Figure 10: Year-wise Projected Contracted Capacity Mix (MW)

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 Not-Served Energy (NENS) remaining within the permissible limits of 0.2% and 0.05%, respectively (as specified in the National Electricity Plan).

As per the resource adequacy studies, the likely total projected contracted capacity for the year 2035-36 is around 59,647 MW which consists of 13,263 MW from coal; 1,866 MW from hydro; 20,928 MW from solar; 7,545 MW from wind; 4,732 MW from Distributed Renewable Energy (DRE) source; 5,440 MW from Storage (6 Hr); 3,636 MW from Storage (4 Hr) and 2,237 MW from SToA/MToA. This capacity shall be able to meet the projected demand with prescribed reliability criteria and to comply with the stipulated Renewable Purchase Obligation (RPO) targets. Based on the capacity addition, the planning reserve margin works out to 6%. The storage requirement can be met from PSP or a combination of PSP and BESS. Capacity mix required by 2035-36 is shown in Figure 11.

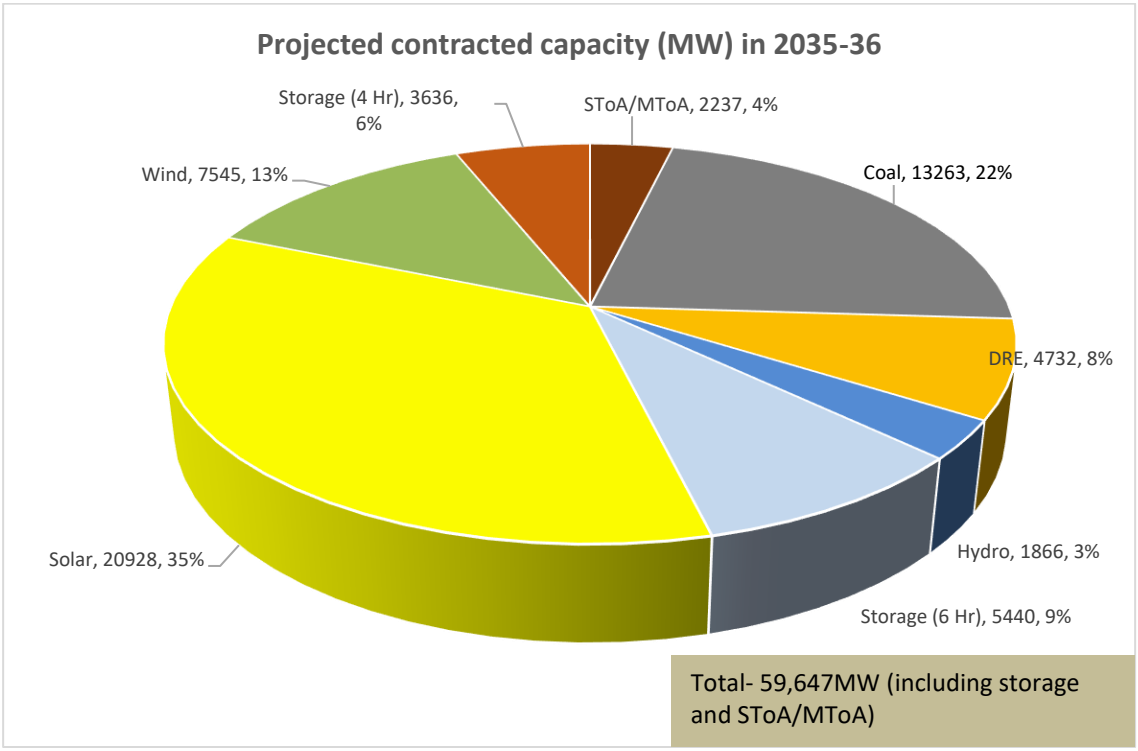

Figure 11: Contracted Capacity Mix in 2035-36

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 13.

Table 13: Year-wise Capacity Addition (in MW)

	Coal		**Hydro**	**Solar**		**Wind**	
Year	Planned Contracts	Additional requirement	Planned Contracts	Planned Contracts	Additional Requirement	Planned Contracts	Additional Requirement
2025-26	48	0	338	539	0	73	0
2026-27	0	0	0	589	4000	351	700
2027-28	0	0	0	849	4000	501	700
2028-29	0	0	0	200	1000	0	700
2029-30	0	1600	0	0	1100	0	300
2030-31	0	1600	90	0	1582	0	700
2031-32	0	359	0	0	683	0	750
2032-33	0	641	0	0	1165	0	750
2033-34	0	426	0	0	1219	0	700
2034-35	0	420	0	0	1610	0	700
2035-36	0	205	0	0	2000	0	400
Total	**48**	**5251**	**428**	**2177**	**18359**	**925**	**6400**

	DRE	**Storage (6 hours)**		**Storage (4 hours)**		**Total**		**SToA/ MToA***
Year	Additional Requirement	Planned Contracts	Additional Requirement	Planned Contracts	Additional Requirement	Planned Contracts	Additional Requirement	Additional Requirement
2025-26	1265	0	0	0	0	998	1265	4200
2026-27	463	0	1667	10	0	950	6830	4200
2027-28	512	0	1535	0	0	1350	6747	4200
2028-29	565	0	338	0	0	200	2603	4200
2029-30	622	500	0	0	0	500	3622	3254
2030-31	183	0	0	0	0	90	4065	2095
2031-32	194	250	0	0	0	250	1986	2301
2032-33	205	0	0	0	211	0	2972	2266
2033-34	217	250	0	0	610	250	3172	2312
2034-35	229	0	0	0	1145	0	4105	2323
2035-36	243	0	0	0	1660	0	4507	2237
Total	**4700**	**1000**	**3540**	**10**	**3626**	**4588**	**41876**	

*Yearly requirement

The projected gross generation mix for the state is shown in Figure 12 and 13.

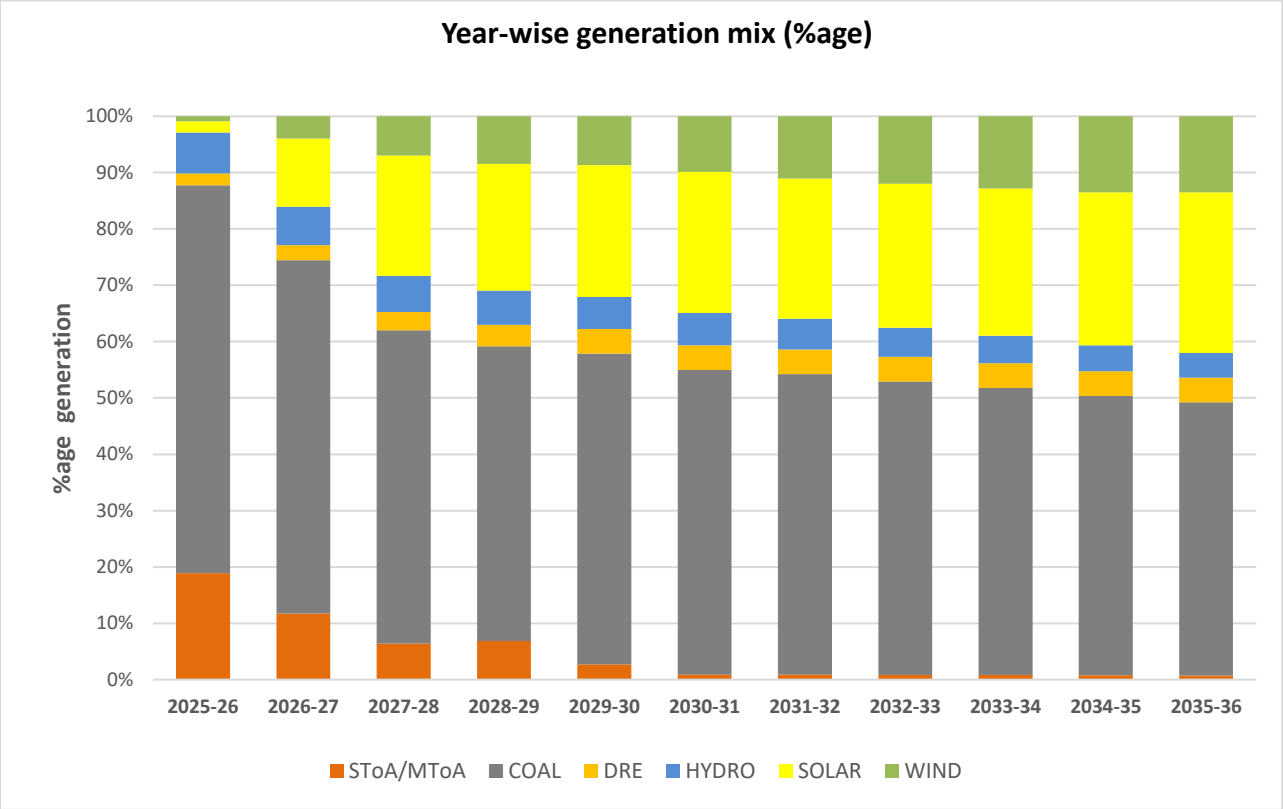

Figure 12: Year-wise projected net generation mix (in %)

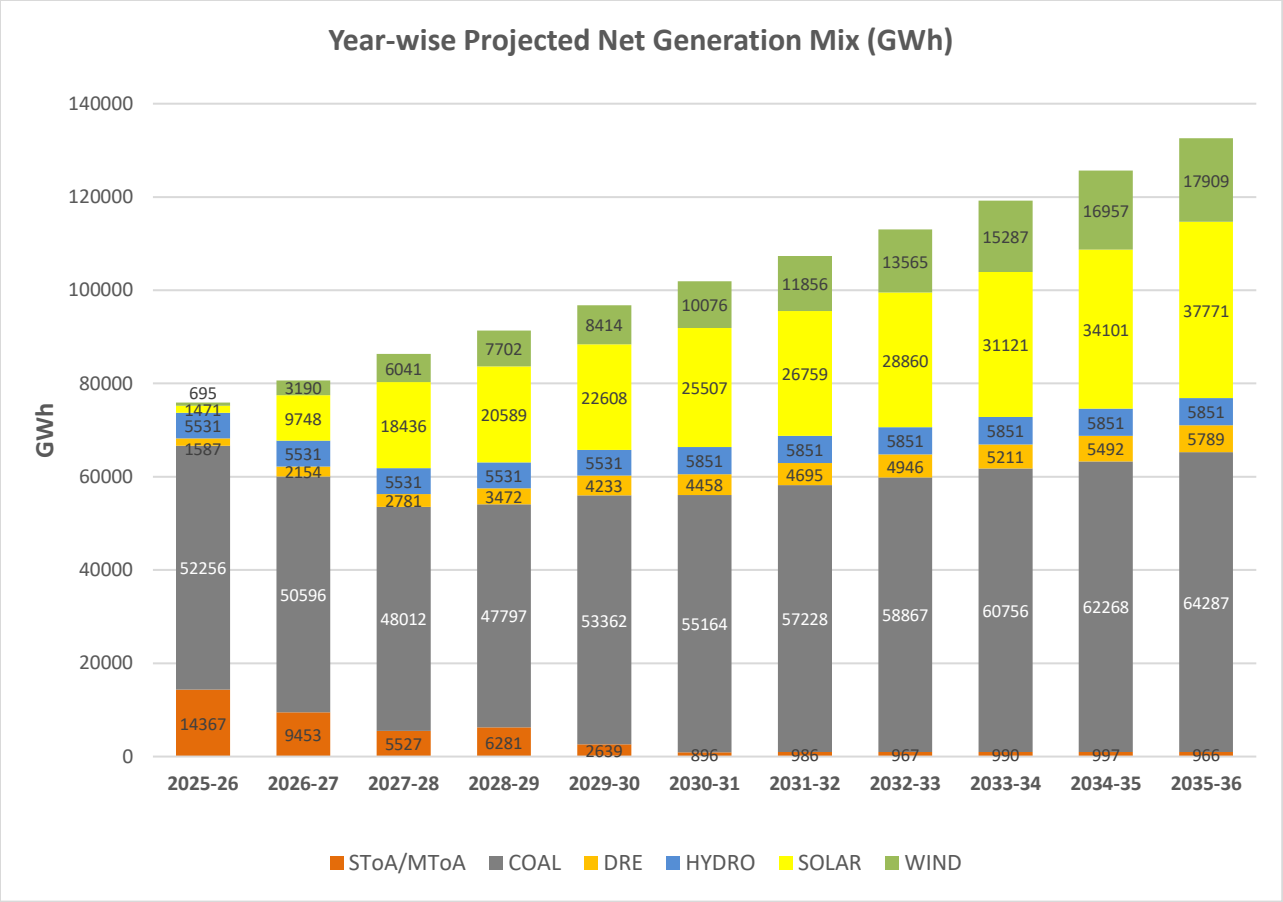

Figure 13: Year-wise projected net generation (in GWh)

7.3 Surplus Coal Capacity (in MW)

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 14. From the figure below, it is observed that West Bengal is expected to have a minimum surplus coal-based capacity ranging between 630 MW and 1250 MW during the period from November to January. This surplus capacity may be banked or shared with other states whose demand profile complements that of West Bengal.

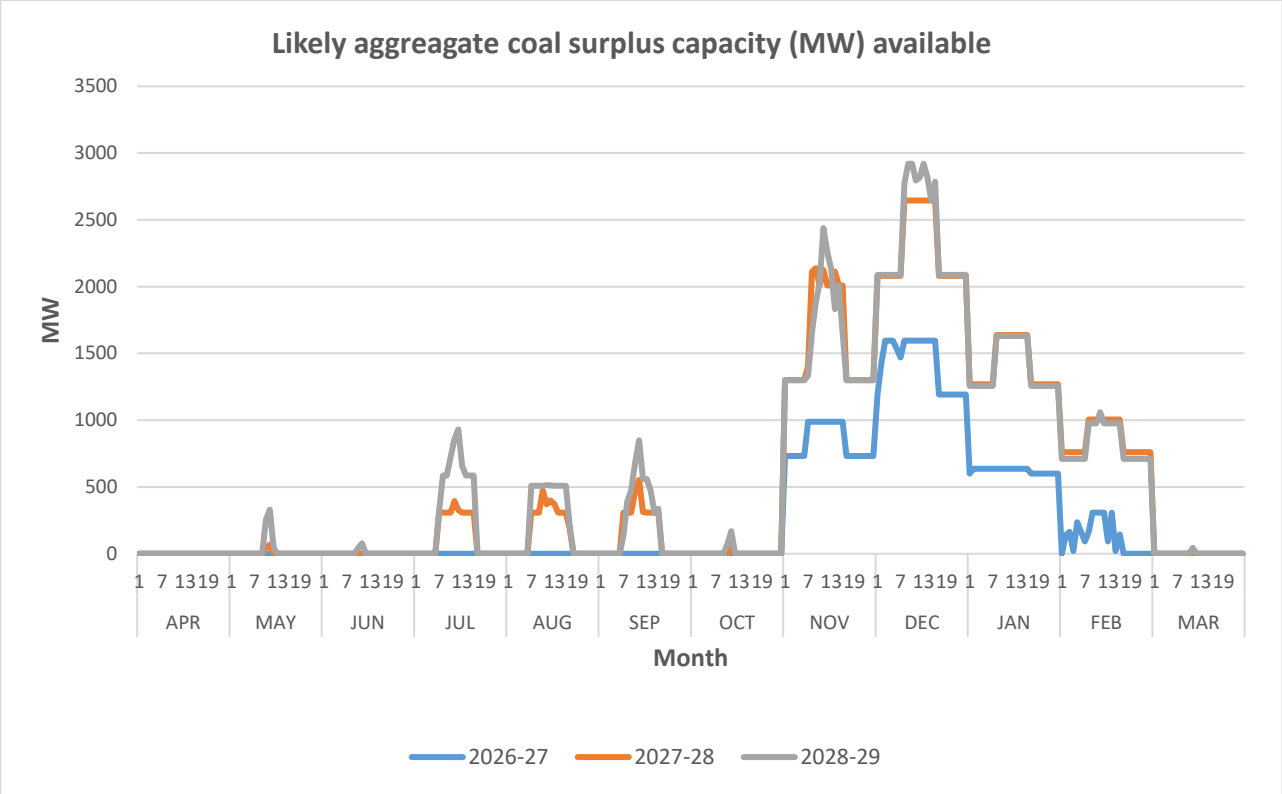

Figure 14: Surplus Coal Capacity Year-wise (MW)

8.0 Conclusions

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

1. The study has considered energy requirement projections as per the projections furnished by West Bengal, which envisages that the annual electrical energy requirement and peak electricity demand of the state for the period 2025-26 to 2035-36 is likely to grow at a CAGR of 5.46% and 5.38% respectively. It has been observed that the peak demand season is typically from April to June with peak demand occurring during non-solar hours.

2. West Bengal, with its existing and planned capacity addition only, is likely to witness energy deficit ranging from 14,749 to 62,487 MUs in different years from 2025-26 to 2035-36. The state will need to contract additional Coal, Solar, Wind-based and Energy Storage capacities beyond those already planned.

3. As per the studies, the likely total projected contracted capacity for the year 2035-36 is around 59,647 MW which consists of 13,263 MW from coal; 1,866 MW from hydro; 20,928 MW from solar; 7,545 MW from wind; 4,732 MW from Distributed Renewable Energy (DRE) source; 5,440 MW from Storage (6 Hr); 3,636 MW from Storage (4 Hr) and 2,237 MW from SToA/MToA. The storage requirement can be met from PSP or a combination of PSP and BESS.

4. In addition to the existing and already planned contracts, the state needs to tie up approximately 5,251 MW of Coal-based; 18,359 MW of Solar; 6,400 MW of Wind; 4,700 MW of DRE; 3,540 MW of 6-Hour Energy Storage System and 3,626 MW of 4- Hour Energy Storage System by 2035–36 (refer Table 13). Additionally, there will be a requirement for Medium-Term Open Access (MToA) and Short-Term Open Access (SToA) ranging from around 2,095 to 4,200 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). The projected capacity and generation mix outlined in the report meet the state's RPO requirements for the years 2026-27 to 2035-36.
5. As per studies, the state is expected to have a minimum surplus coal-based capacity ranging between 630 MW and 1250 MW during the period from November to January. This surplus capacity may be banked or shared with other states whose demand profile complements that of West Bengal.
6. The Planning Reserve Margin (PRM) for West Bengal has been assessed at 6%. Further, the study indicates year-wise short-term/medium-term/bilateral requirements inclusive of the PRM capacity to meet the demand optimally.
7. 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.

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Annexure

Details of upcoming considered in the study

Sl. No.	Tied capacity name	Type of generation	Expected COD	West Bengal's share (in MW)
1.	Barh STPP	Thermal	2025-26	6.73
2.	North Karanpura	Thermal	2025-26	41.38
3.	Solar	Solar	2025-26	539
4.	Solar	Solar	2026-27	589.5
5.	Solar	Solar	2027-28	849
6.	Solar	Solar	2028-29	200
7.	Wind	Wind	2025-26	73
8.	Wind	Wind	2026-27	351
9.	Wind	Wind	2027-28	501
10.	Turga	PSP	2029-30	500
11.	Turga	PSP	2031-32	250
12.	Turga	PSP	2033-34	250
13.	BESS	BESS	2026-27	10
14.	Punatsangchhu	Hydro	2025-26	338
15.	Teesta Intermediate	Hydro	2030-31	90

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 2024-25.
3. Existing & Planned Capacity: As per the information shared by the state.
4. Cost parameters: based on information in National Electricity Plan.

RE CUF considered

Hydro	Wind	Solar (existing)	Solar (planned)	DRE
35 %	24%	18%	23.5	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

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical. (%)
Hydro	Existing/Planned/ Candidate	As per available hourly generation profile	100	-
Solar	Existing/Planned		-	-
	Candidate		-	-
Wind	Existing/Planned		-	-
	Candidate		-	-
Pumped storage	Existing/Planned	95	50	-
	Candidate		50	-
Battery Energy Storage	Candidate	98	NA	-

Technology	Type	Heat Rate (MCal/MWh)		Aux. Consum. (%)	Min. online time (hr)	Min. offline time (hr)
		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
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	-	-	Round trip efficiency 80 %	-	-
	Candidate	-	-		-	-

Technology	Type	Heat Rate (MCal/MWh)		Aux. Consum. (%)	Min. online time (hr)	Min. offline time (hr)
		At max loading	At min loading			
Battery Energy Storage	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)	O&M Fixed Cost (in ₹/MW)	Construction Time (in years)	Amortization /Life time (in years)
Coal	12 Cr	30 Lakh	4	25
Solar	4.5 to 4.0 Cr	1 % of Capex	0.5	25
Wind	7.5 Cr	1 % of Capex	1	25
Battery Energy Storage System (4-Hour)	4.98 Cr to 2.92 Cr	5.9 Lakh	1	14
PSP (6 Hour)	6 Cr	30 Lakh	4	40