सत्यमेव जयते

Report on Resource Adequacy Plan (Generation) for Nagaland (2025-26 to 2035-36)

(Version 2.0)

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Government of India
Ministry of Power
Central Electricity Authority

Contents

Disclaimer

This Resource Adequacy Study for the state of Nagaland has been conducted based on data and inputs provided by the Nagaland Power Department. The findings, analysis and conclusions presented in this report are contingent upon the accuracy, completeness and timeliness of the information furnished by Nagaland. 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 Nagaland 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 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 requirement.

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 peak 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 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 2031-32, based on the data available with CEA and NERPC and in compliance with the RPO trajectory specified in the Ministry of Power's Office Memorandum dated 22nd July 2022. This study has now been updated and extended to cover the period up to 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 recent gazette notified trajectory.

The electrical energy requirement and peak electricity demand for Nagaland, as furnished by Nagaland, are projected to increase with a CAGR of 7.94% and 8.60% respectively from 2025-26 to 2035-36. However, as per mid-term review of 20th EPS projections, the electrical energy requirement and peak electricity demand for Nagaland is projected to increase with a CAGR of 5.28% and 4.29% respectively from 2025-26 to 2035-36. The study has been done considering the demand projections as per the mid-term review of 20th EPS projections, as these projections are more aligned with the past growth trend of peak electricity demand and electrical energy requirement of the state. 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 technology options like battery energy storage systems, planning for long term optimal generation capacity mix gains tremendous importance so that the future generation capacity mix is cost effective as well as environment friendly.

The study for Nagaland, based on existing contracted capacity and planned capacity additions, indicates that the available capacity may be insufficient to meet the projected future demand. In particular, the total unserved energy in the year 2035–36 is estimated to be approximately 90 MU, accounting for around 5% 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 planning 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, 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 Nagaland along with RPO constraints for solar 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 reliably meet the anticipated electricity demand at every instance. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 714 MW which consists of 79 MW from coal, 76 MW from gas, 254 MW from hydro, 219 MW from solar, 47 MW from Distributed Renewable Energy (DRE) source, 29 MW from Wind and 10 MW from Biomass. In addition to the above, 61 MW from Storage (BESS or PSP) and 17 MW from MToA/SToA arrangement is projected to be required by 2035-36. This capacity shall be able to meet the projected 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 Nagaland based on inputs furnished by Nagaland. 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 24×7 basis, considering variations in demand, RE generation, and forced outage of thermal capacities. The study also assesses the Planning Reserve Margin (PRM) required by the state to account for the aforementioned uncertainties, ensuring that demand can be reliably met throughout the year.

Prior to this, CEA had conducted the RA study for the state up to 2031-32, based on data available with CEA and in accordance with the then RPO trajectory specified in the then Ministry of Power's Office Memorandum dated 22nd July 2022.

2.0 Highlights of the Previous RA Study (Up to FY 2031–32)

1. In the earlier Resource Adequacy (RA) study, financial year 2022-23 had been considered as the base year, and the study covered the period from 2023-24 to 2031-32. The fuel-wise contracted capacity by Nagaland as on 31st March, 2023 is given in Fig. 1.

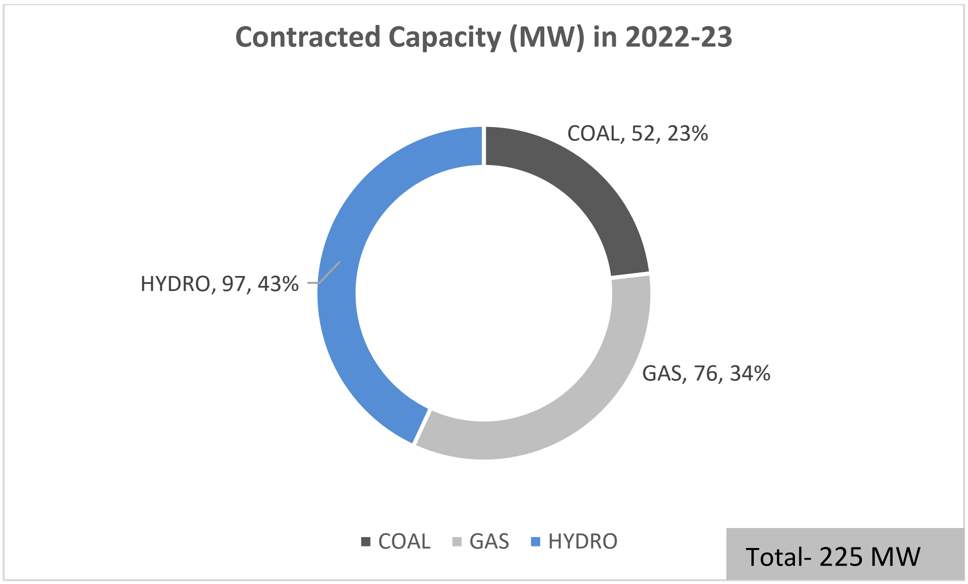

Figure 1: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2023

2. The peak electricity demand and electrical energy projections as per the 20th EPS report that had been considered in the study is given in Table 1.

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

	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
Electrical Energy Projections (MU)	953	997	1041	1088	1134	1182	1228	1272	1299
Year on Year Growth		4.62%	4.41%	4.51%	4.23%	4.23%	3.89%	3.58%	2.12%
Peak Electricity Demand Projections (MW)	171	179	187	195	204	213	221	230	235
Year on Year Growth		4.68%	4.47%	4.28%	4.62%	4.41%	3.76%	4.07%	2.17%

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

Table 2: Source-wise projected capacities

Year	Coal	Gas	Hydro	Solar	SToA/MToA *	Total
2023-24	52	76	129	26	0	**283**
2024-25	52	76	173	26	0	**327**
2025-26	52	76	173	26	0	**327**
2026-27	52	76	173	26	0	**327**
2027-28	52	76	263	26	0	**417**
2028-29	52	76	263	26	0	**417**
2029-30	52	76	263	26	0	**417**
2030-31	52	76	263	26	4	**421**
2031-32	52	76	263	26	7	**424**

*****_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	Hydro	Solar	Total	SToA/MToA
	Planned	Planned	Planned	Additional*
2023-24	32.4	25	**57.4**	0
2024-25	17	0	**17**	0
2025-26	15	0	**15**	0
2026-27	0	0	**0**	0
2027-28	90	0	**90**	0
2028-29	0	0	**0**	0
2029-30	0	0	**0**	0
2030-31	0	0	**0**	4
2031-32	0	0	**0**	7

*_Requirement is for a particular year_

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

3.1 Present Power Scenario in Nagaland

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

Table 4: Power Supply Position of Nagaland

Power Supply Position						
Year	**Electrical Energy required (MU)**	**Electrical Energy supplied (MU)**	**Gap (MU)**	**Peak Electricity Demand (MW)**	**Peak Met (MW)**	**Demand not met (MW)**
2020-21	826	822	4	160	155	5
2021-22	852	851	1	173	153	20
2022-23	926	873	53	168	167	1
2023-24	921	921	0	174	174	0
2024-25	938	938	0	189	188	1

The data in Table 4 indicates that over the past five years, Nagaland's electrical energy requirement and peak electricity demand have increased at a Compound Annual Growth Rate (CAGR) of 3.23% and 4.25%, respectively.

As of March 2025, the total contracted capacity for Nagaland is 231 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 45 %. 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	52	22%
Gas	76	33%
Hydro	103	45%
Total	**231**	**100.0%**

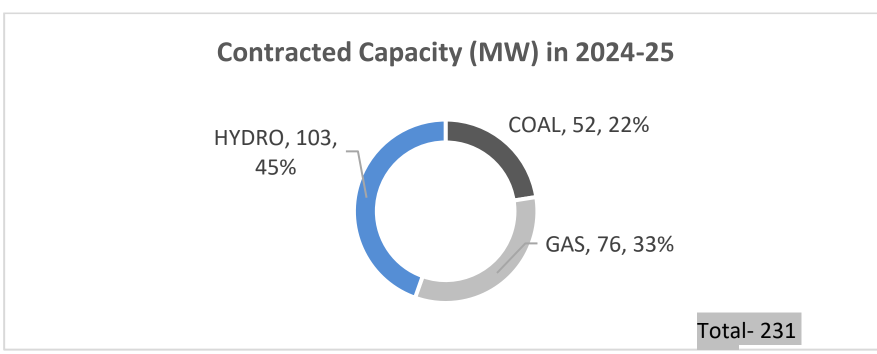

Figure 2: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2025

3.2 Demand analysis of the year 2024-25

Hourly demand pattern of 2024-25 was analyzed and it was observed that the peak demand season for State of Nagaland is typically during the months July to September. Nagaland witnesses peak demand during non-solar hours. The month wise average hourly demand observed for the year 2024-25 is shown in Fig. 3.

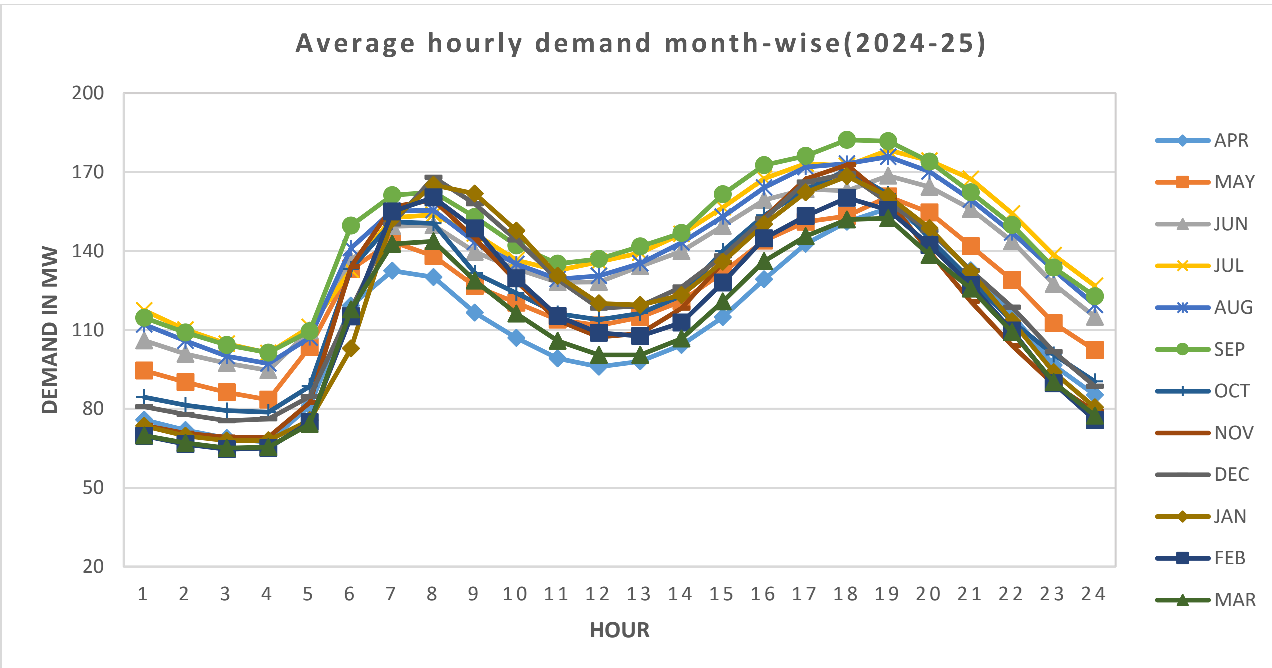

Figure 3: Average Hourly Demand Variation (Month-wise) for 2024-25

From the hourly demand data of 2024-25, the daily peak during solar hours (05:00 to 17:00 hrs) and non-solar hours are plotted in Fig. 4.

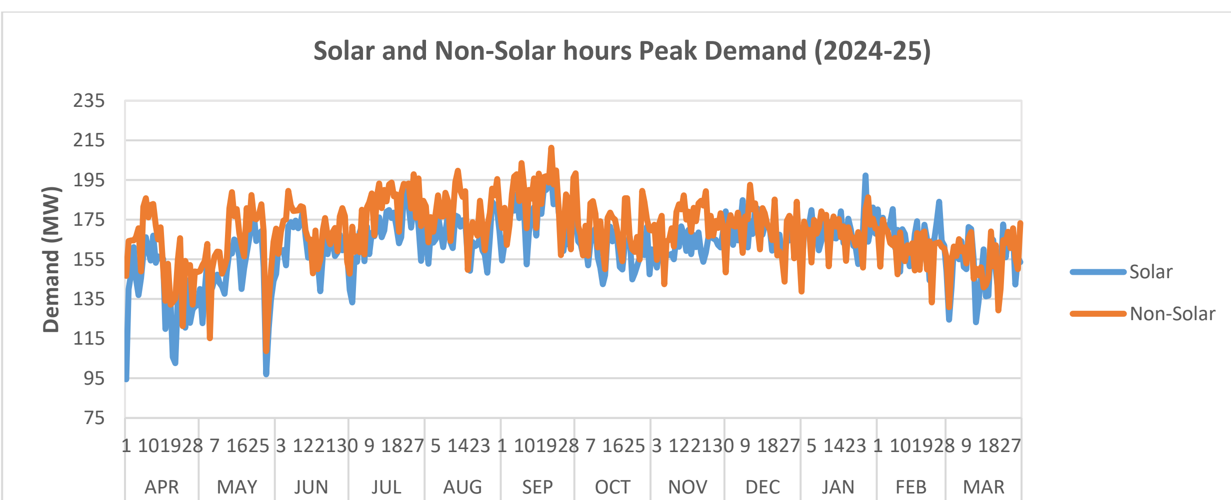

Figure 4: Solar and non-solar peak in MW for the year 2024-25

Daily peak occurs in Nagaland during non-solar hours in almost every month of the year.

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

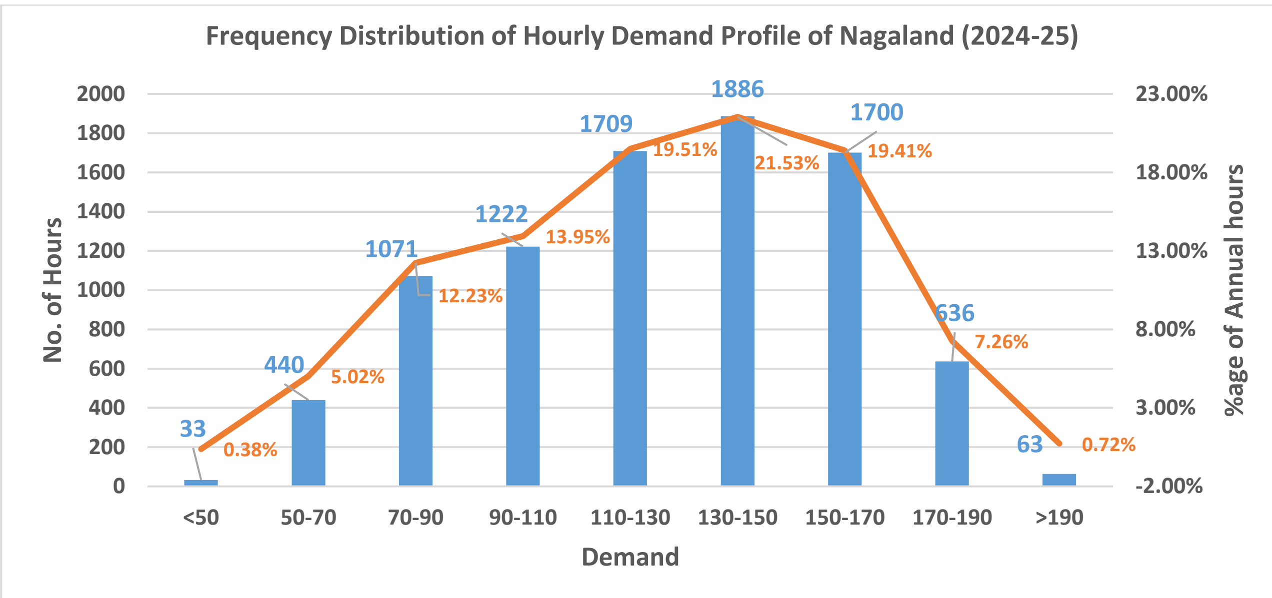

Figure 5: Frequency Distribution of Hourly Demand Profile of 2024-25

4.0 Principles of Generation Planning

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

i) To supply 24x7 reliable power to the consumers
ii) To achieve objectives of all policies of the Government of India such as RPO trajectory, RE capacity addition 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 generation expansion planning model namely ORDENA. ORDENA is a mixed integer linear optimization program that minimizes the Net Present Value (NPV) of investment and operating costs subject to several constraints. The major constraints include balancing electricity supply and demand, resource supply limits, planning and operating reserve limits, and policy targets. These constraints are met considering a broad portfolio of conventional generation, renewable generation, and storage.

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

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

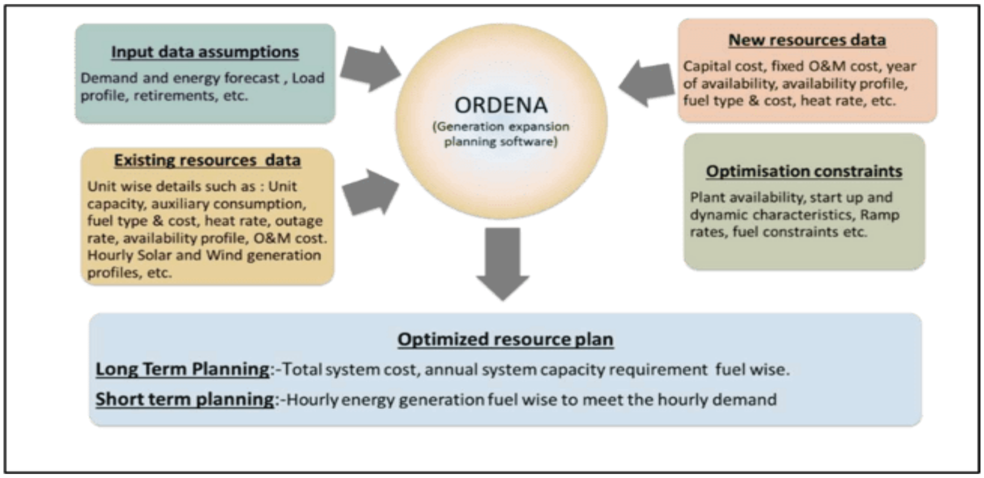

Figure 6: Schematic Diagram

5.0 Reliability Analysis

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

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

Monte Carlo /Stochastic simulation has been used to factor-in the uncertainty associated with various generation resources and demand. It is an approach which is used to predict the probability of a variety of outcomes when the potential for random variables is present, as compared to deterministic modelling of economic dispatch model. Monte Carlo simulation helps in analysing the randomness associated with RE energy resource, demand pattern changes and forced outages of plant. A large no. of random samples of these variables are 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. 2023-24 and 2024-25 has been analyzed. The demand pattern variation across 2023-24 and 2024-25 is shown in Fig. 7.

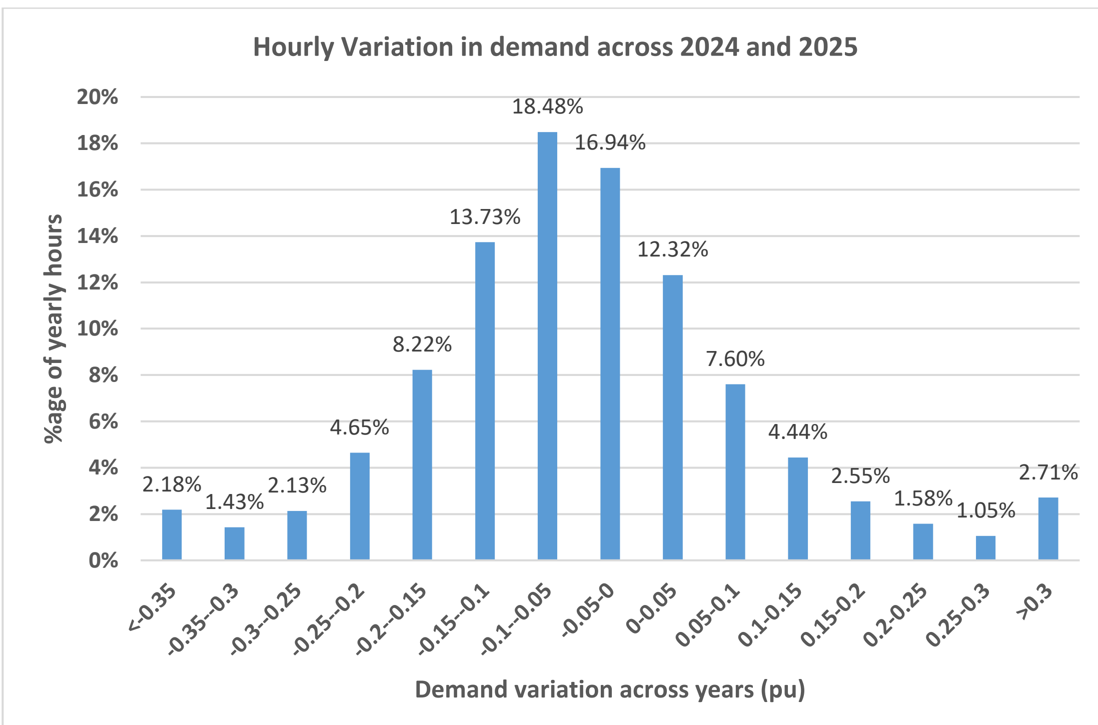

Figure 7: Hourly Variation in Demand across years

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 is considered based on the observed solar 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 hydro based generation has been varied by ± 10% 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 Nagaland, as per the mid-term review of 20th EPS is given in Table 6.

Table 6: Demand Projections as per the mid-term review of 20th EPS

	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
Peak Demand Projections (in MW)	200	213	224	236	248	256	264	274	284	293	304
Growth rate		6.60%	5.36%	5.41%	4.93%	3.49%	2.78%	3.81%	3.64%	3.46%	3.45%
Energy Projections (in MU)	1051	1121	1195	1276	1355	1419	1476	1550	1625	1700	1759
Growth rate		6.58%	6.67%	6.71%	6.21%	4.73%	4.00%	5.03%	4.84%	4.65%	3.45%

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

iii) The actual solar and hydro generation profiles and CUFs have been referred from National Electricity Plan 2023 (Vol I: Generation).

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

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

Table 7: Source wise planned capacity addition (MW)

FY	HYDRO (Conventional/Small)	Thermal	Solar	DRE	Wind	Biomass
2025-26	29	-	-	10	-	-
2026-27	-	-	99	5	-	-
2027-28	-	27	-	32	29	-
2028-29	5.7	-	-	-	-	10
2029-30	8.1	-	-	-	-	-
2030-31	24	-	-	-	-	-
2031-32	-	-	-	-	-	-
2032-33	-	-	-	-	-	-
2033-34	-	-	-	-	-	-
2034-35	-	-	-	-	-	-
2035-36	84	-	-	-	-	-
Total	**150.8**	**27**	**99**	**47**	**29**	**10**

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

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

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

Further, in view of the country's energy transition goals as well as the long-term net zero target of 2070, it is estimated that the share of RE generation in the generation mix will continue to proportionally increase beyond 2029-30. Therefore, the RPO trajectory is assumed to rise steadily beyond 2029-30. However, the DRE percentage has been assumed to be constant from 2029-30 onwards. Further, being a hilly state, the DRE percentage for Nagaland has been taken as half of the percentage what other states are obliged to meet. Hence, the suggested trajectory of Renewable Purchase Requirement up to 2035–36 is given in Table 9.

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

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Distributed renewable energy*	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	**2024-25**	0.67	0.38	28.10	0.75	29.91
2.	**2025-26**	1.45	1.22	29.29	1.05	33.01
3.	**2026-27**	1.97	1.34	31.29	1.35	35.95
4.	**2027-28**	2.45	1.42	33.29	1.65	38.81
5.	**2028-29**	2.95	1.42	35.05	1.95	41.36
6.	**2029-30**	3.48	1.33	36.27	2.25	43.33
7.	**2030-31**	43.25			2.25	45.5
8.	**2031-32**	44.75			2.25	47
9.	**2032-33**	46.05			2.25	48.3
10.	**2033-34**	47.25			2.25	49.5
11.	**2034-35**	48.75			2.25	51.0
12.	**2035-36**	49.75			2.25	52.0

** For Hilly states, DRE Percentage is half of the percentage what other states are obliged to meet.*

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

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

Sl. No.	Year	Wind renewable energy (MU)	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	**2025-26**	15.2	12.8	307.9	11.0	347.1
2.	**2026-27**	22.1	15.0	350.6	15.1	402.8
3.	**2027-28**	29.3	17.0	397.9	19.7	463.9
4.	**2028-29**	37.6	18.1	447.1	24.9	527.6
5.	**2029-30**	47.1	18.0	491.4	30.5	587.0
6.	**2030-31**	613.6			31.9	645.6
7.	**2031-32**	660.3			33.2	693.5
8.	**2032-33**	713.7			34.9	748.6
9.	**2033-34**	767.7			36.6	804.3
10.	**2034-35**	829.0			38.3	867.2
11.	**2035-36**	875.2			39.6	914.7

As indicated in Table 11, the state with its existing and envisaged future capacity additions will not be able to meet its RPO requirements from the year 2032-33 onwards.

Table 11: Renewable Energy Surplus/Deficit

FY	RE Generation required to meet RPO		RE Generation available/met (From existing/ planned contracts)		RPO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	347.1	33.01	360	34	1
2026-27	402.8	35.95	511	46	10
2027-28	463.9	38.81	610	51	12
2028-29	527.6	41.36	652	51	10
2029-30	587.0	43.33	665	49	6
2030-31	645.6	45.5	713	50	5
2031-32	693.5	47	713	48	1
2032-33	748.6	48.3	713	46	-2
2033-34	804.3	49.5	713	44	-6
2034-35	867.2	51.0	713	42	-9
2035-36	914.7	52.0	882	50	-2

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 90 MUs which is about 5% of the projected electrical energy requirement in 2035-36. The year-wise likely unserved energy with the planned capacities is given in Fig 8.

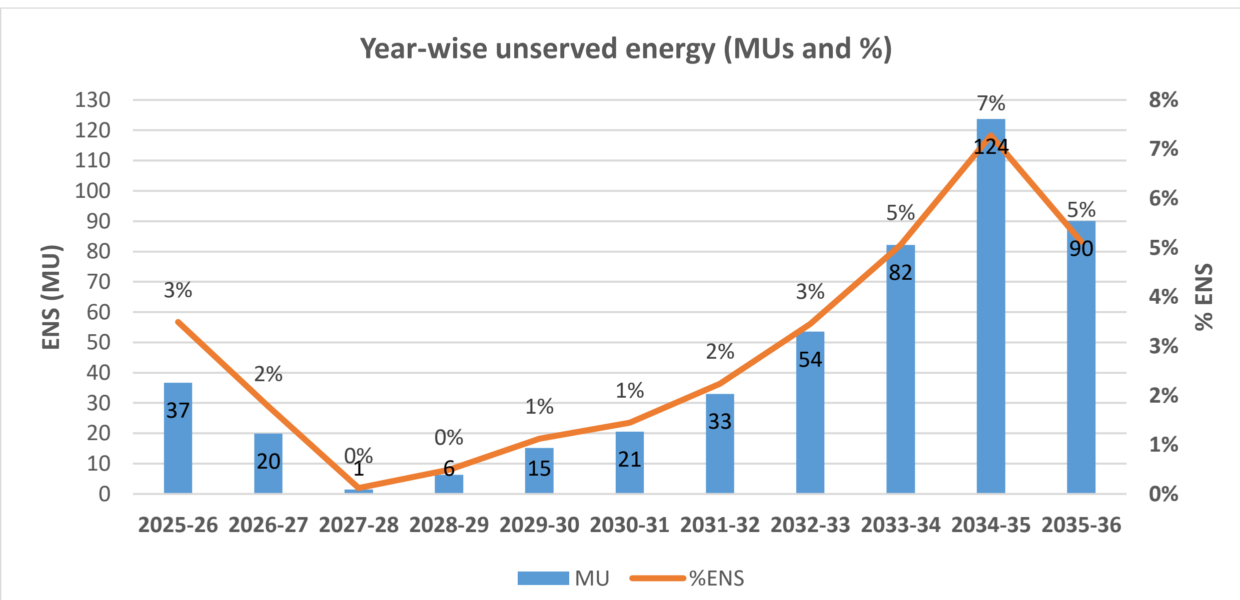

Figure 8: Yearly likely unserved energy (in MU) with the existing and planned capacities

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 projected electricity demand. Details are shown in Fig. 9.

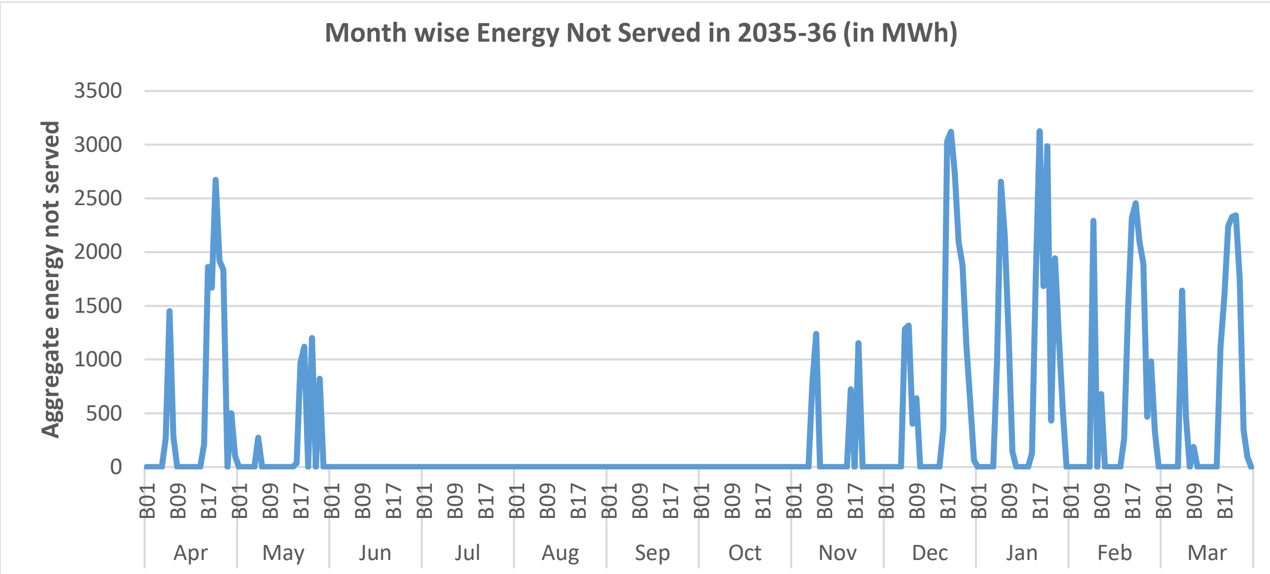

Figure 9: Block-wise Unserved Energy Pattern MWh (2035-36)

From the above figure, it can be seen that unserved energy is high during low hydro availability months viz. December to April.

7.2 Investment options to meet the unserved energy

To meet this 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 with RPO obligations. The capacity projections for Nagaland are given in Table 12.

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

Year	Coal	Gas	Hydro	Solar	DRE	Wind	Biomass	Storage	SToA/MToA
2025-26	52	76	132	0	10	0	0	0	26
2026-27	52	76	132	99	15	0	0	0	32
2027-28	79	76	132	99	47	29	0	0	19
2028-29	79	76	138	99	47	29	10	0	23
2029-30	79	76	146	99	47	29	10	0	29
2030-31	79	76	170	99	47	29	10	0	26
2031-32	79	76	170	119	47	29	10	2	31
2032-33	79	76	170	149	47	29	10	22	31
2033-34	79	76	170	179	47	29	10	41	31
2034-35	79	76	170	219	47	29	10	61	32
2035-36	79	76	254	219	47	29	10	61	17

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

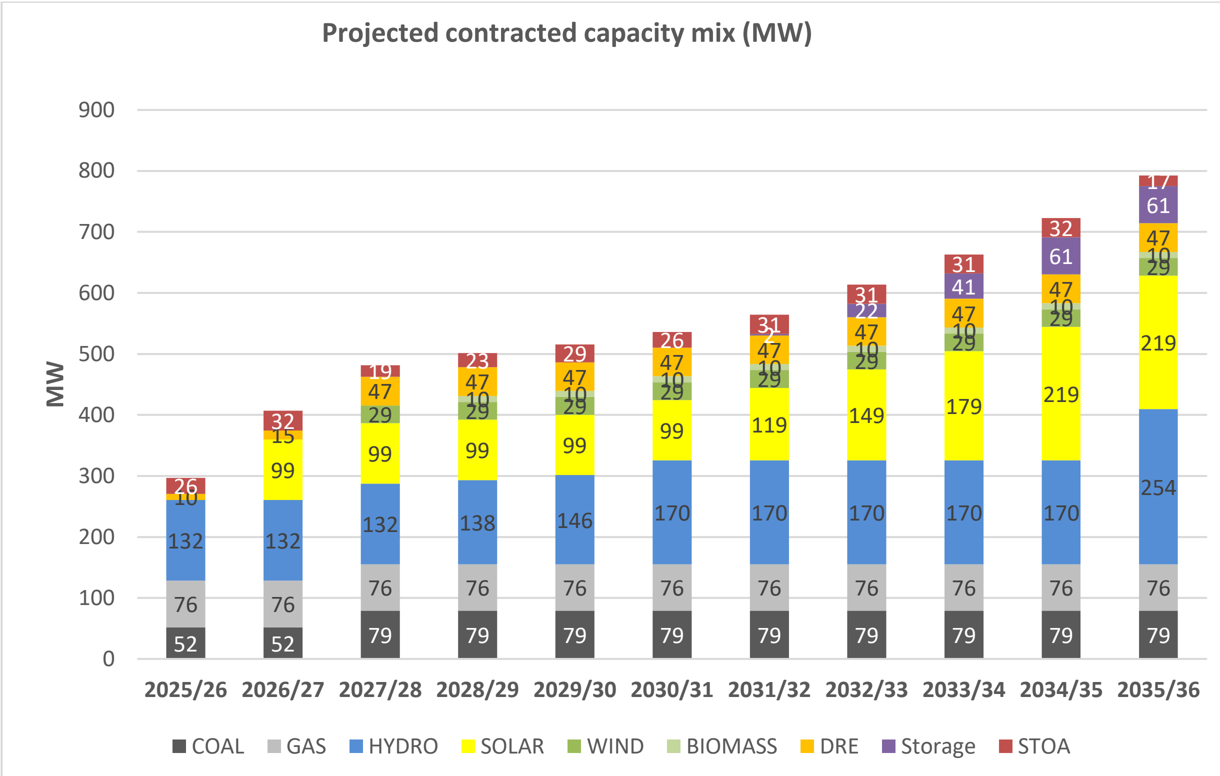

Figure 10: Projected Contracted Capacity Mix Year-wise (MW)

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 (NEP)).

As per the Resource Adequacy studies, the likely total projected contracted capacity for the year 2035-36 is around 714 MW which consists of 79 MW from coal, 76 MW from gas, 254 MW from hydro, 219 MW from solar, 47 MW from Distributed Renewable Energy (DRE) source, 29 MW from Wind and 10 MW from Biomass. In addition to the above, 61 MW from Storage (BESS or PSP) and 17 MW from MToA/SToA arrangement is projected to be required by 2035-36. This capacity is inclusive of the planning reserve margin (which works out to 12%) and shall be able to meet the projected demand with prescribed reliability criteria and complies with the stipulated Renewable

Purchase Obligation (RPO) targets. Projected contracted capacity required by 2035-36 is shown in Figure 11.

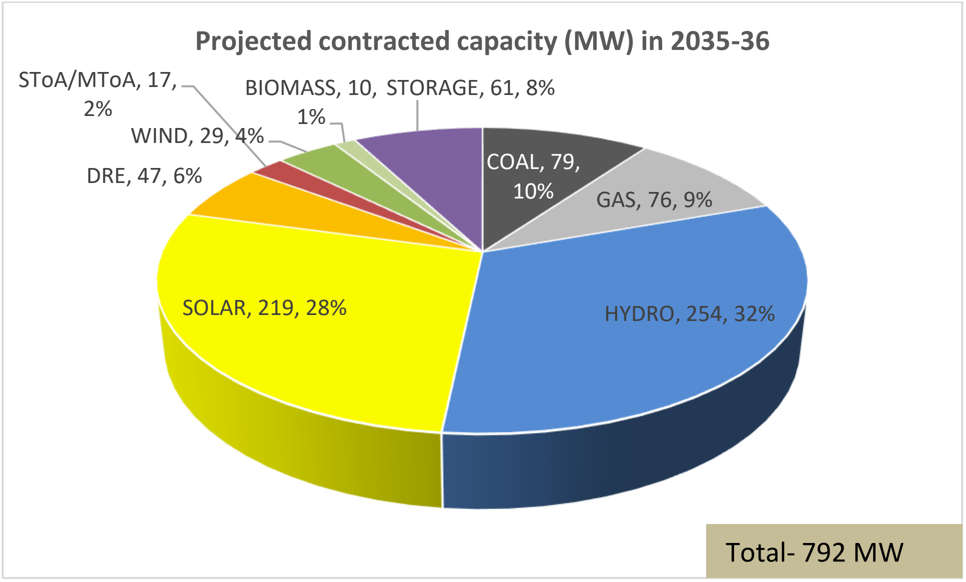

Figure 11: Projected Contracted Capacity Mix in 2035-36

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)

FY	Coal	Solar		Hydro	Wind	Biomass	Storage	DRE	Total		SToA/MToA *
	Planned	Planned	Additional	Planned	Planned	Planned	Additional	Planned	Planned	Additional	Additional
2025-26	0	0	0	29	0	0	0	10	**39**	**0**	26
2026-27	0	99	0	0	0	0	0	5	**104**	**0**	32
2027-28	27	0	0	0	29	0	0	32	**88**	**0**	19
2028-29	0	0	0	6	0	10	0	0	**16**	**0**	23
2029-30	0	0	0	8	0	0	0	0	**8**	**0**	29
2030-31	0	0	0	24	0	0	0	0	**24**	**0**	26
2031-32	0	0	20	0	0	0	2	0	**0**	**22**	31
2032-33	0	0	30	0	0	0	20	0	**0**	**50**	31
2033-34	0	0	30	0	0	0	19	0	**0**	**49**	31
2034-35	0	0	40	0	0	0	20	0	**0**	**60**	32
2035-36	0	0	0	84	0	0	0	0	**84**	**0**	17

Total	**27**	**99**	**120**	**151**	**29**	**10**	**61**	**47**	**363**	**181**

*Yearly requirement

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

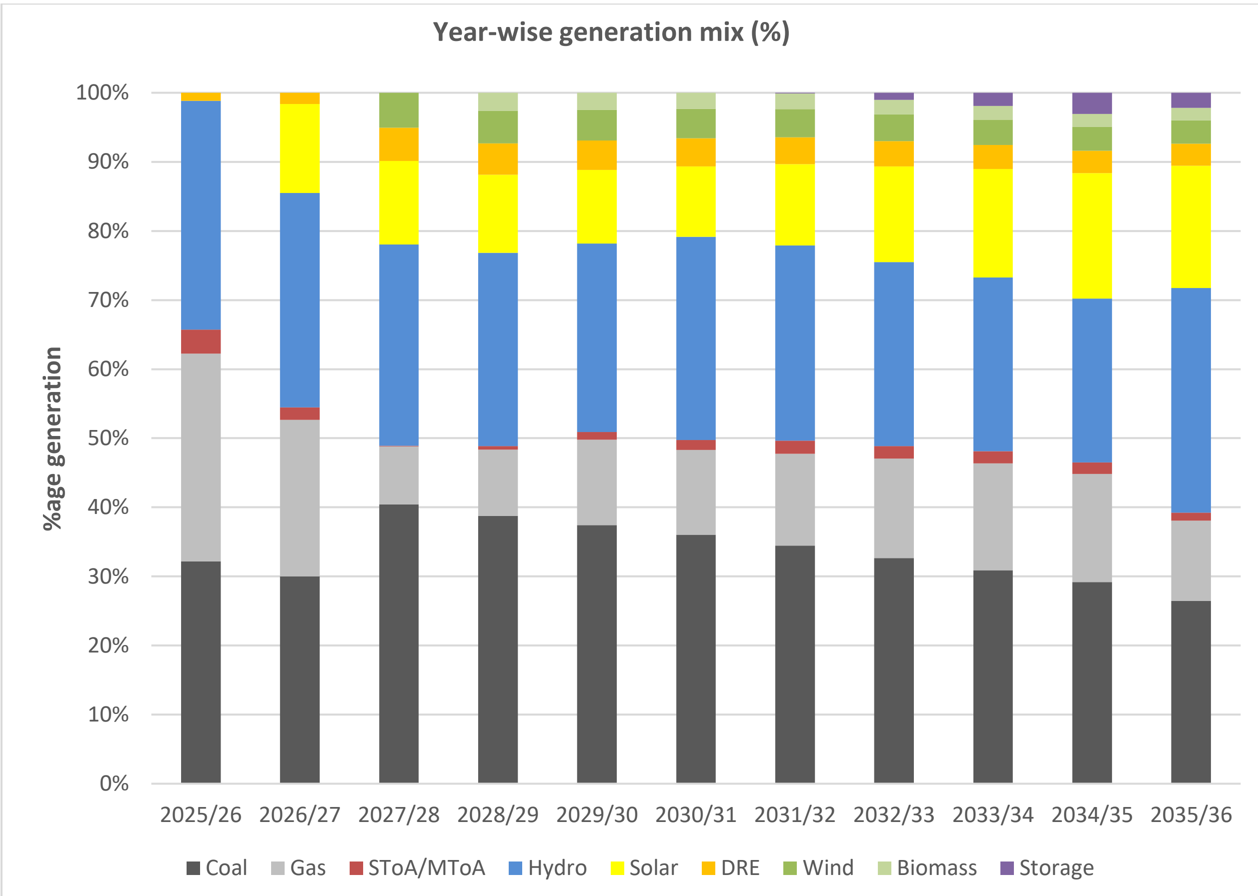

Figure 12: Year-wise projected net generation mix (in %)

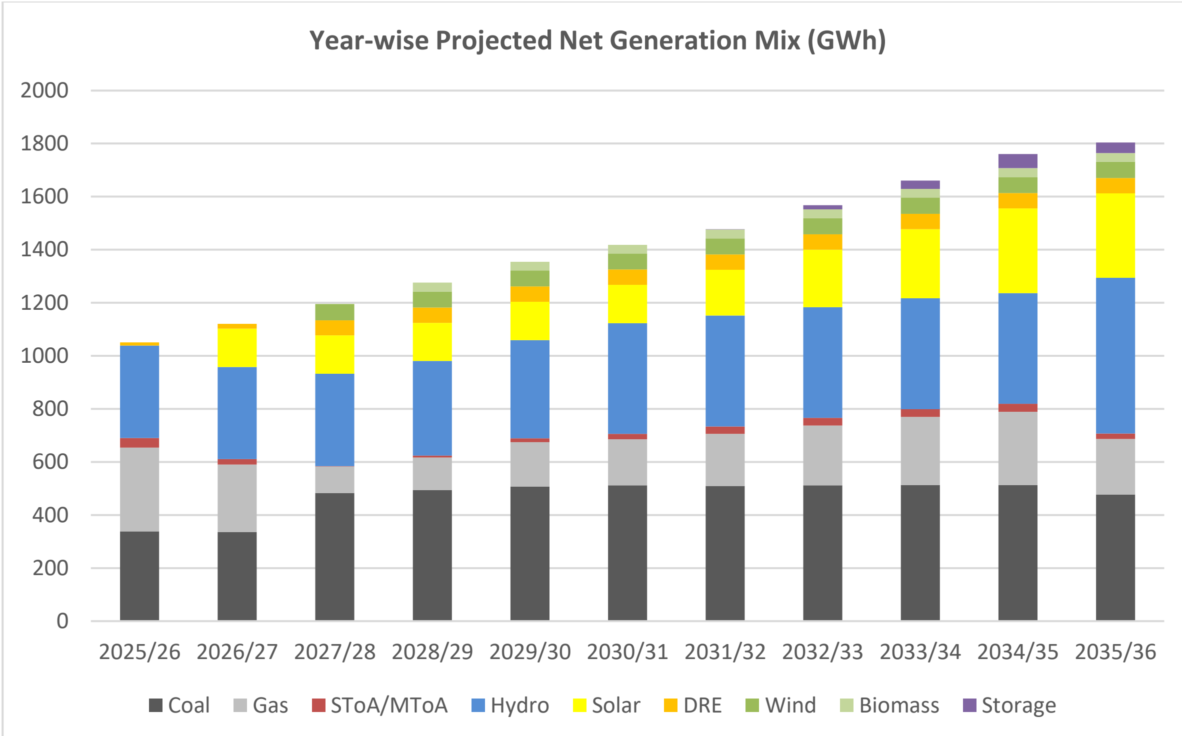

Figure 13: Year-wise projected net generation (in GWh)

7.3 Coal Capacity Performance

The coal capacity PLF is expected to remain in the range of around 73% - 78% till 2035-36. Year-wise Coal capacity PLF is shown in Figure 14.

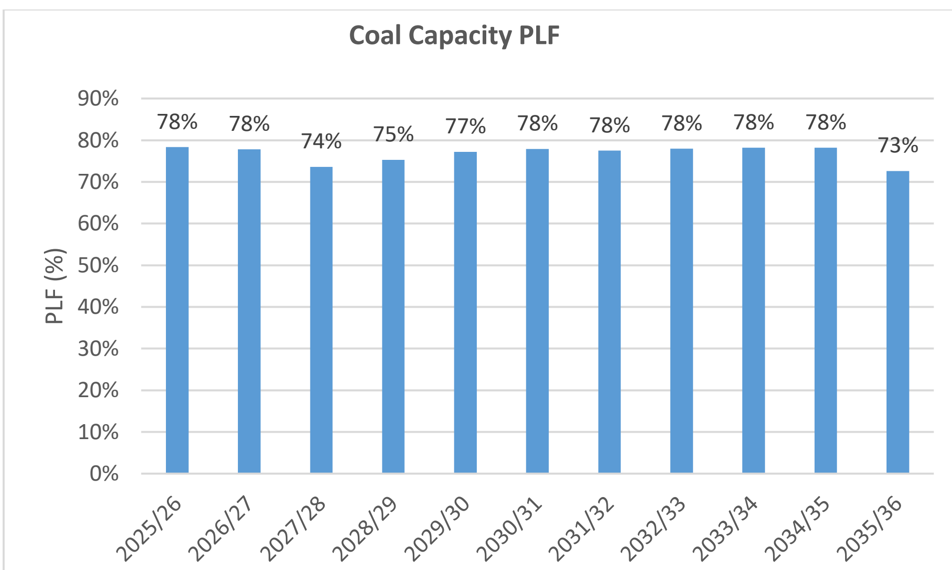

Figure 14: Year-wise coal contracts PLF (in %)

7.4 Day-wise Surplus Coal Capacity (MW)

Generally, surplus capacity is available with the state due to RE availability, Demand variation etc. The pattern of surplus capacities has been observed as shown in Figure 15. However, as can be seen from the figure below, the spikes indicate that surplus is not available for longer periods of time, hence, it cannot be shared/banked with other states/utilities.

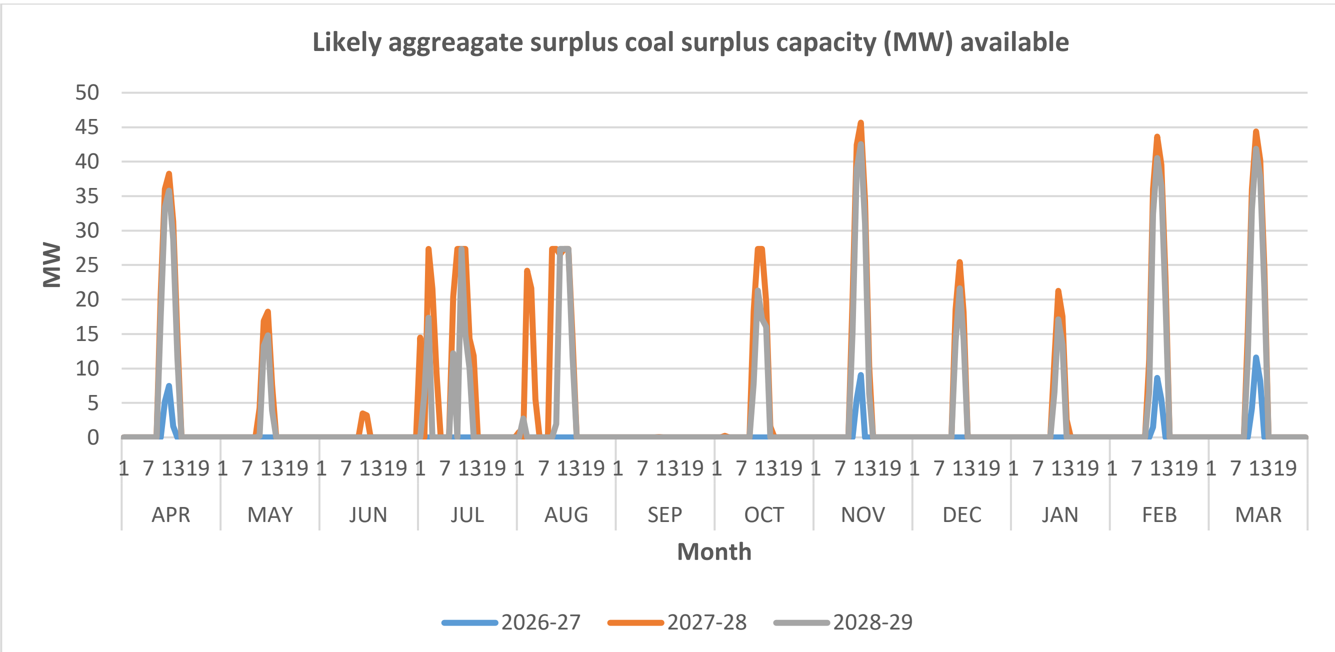

Figure 15: Surplus Coal Capacity Year-wise (MW)

8.0 Conclusions

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

1. The study has been done based on the hourly electricity demand pattern of the year 2024-25. It has been observed that the peak demand season is typically from July to September with peak demand occurring during non-solar hours.

2. The study is based on peak electricity demand and electrical energy requirement projections as per the Mid-term review of 20th EPS, which envisages that the electrical energy requirement of the state is likely to grow at a CAGR of 5.28% while the peak electricity demand for the state is likely to grow at a CAGR of 4.28% for the period of 2025-26 to 2035-36.

3. Considering only the existing and planned capacity addition, Nagaland is likely to witness energy deficit ranging from 1.4 MU to 124 MU in different years from 2025-26 to 2035-36. Hence, the State will need to contract additional solar-based and storage capacity in beyond those already

planned. Specifically, approximately 120 MW of solar-based capacity and 61 MW of Storage (BESS or PSP) is projected to be required by 2035–36. Additionally, there will be a requirement for Medium-Term Open Access (MToA) and Short-Term Open Access (SToA) ranging from around 17 MW to 32 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 demand requirements as well as seasonal banking needs, expressed in terms of megawatts (MW). The projected capacity and generation mix outlined in the report, meets the state's RPO requirements for the years 2025-26 to 2035-36.

4. The Planning Reserve Margin (PRM) for Nagaland has been assessed as 12%. Further, the study indicates year-wise short-term/medium-term/bilateral requirements inclusive of the PRM capacity to meet the demand optimally.
5. Timely commissioning of planned capacities is critical to ensuring that the state can meet the projected peak demand and energy requirements identified in this study. 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

Planned Future Contracted (MW) considered in the study

Sl. No.	Tied capacity name	Type of generation	Expected COD	Nagaland share (in MW)
1.	Tuli TPP	Thermal	2027-28	27
2.	Lower Subansiri	Hydro	2025-26	29
3.	Narzai	Small hydro	2028-29	4.2
4.	Dzuna	Small hydro	2028-29	1.5
5.	Lower Likimro	Small hydro	2029-30	8.1
6.	Zungki	Hydro	2030-31	24
7.	Lower Tizu	Hydro	2035-36	42
8.	Tizu Valley	Hydro	2035-36	24
9.	Lower Doyang	Hydro	2035-36	18
10.	Solar DRE	DRE	2025-26	10
11.	Solar DRE	DRE	2026-27	5
12.	Solar DRE	DRE	2027-28	32
13.	Solar	Solar	2026-27	99
14.	Wind	Wind	2027-28	29
15.	Biomass	Biomass	2028-29	10

Assumption for Resource Adequacy Studies

1. Electricity Demand & peak requirement: As per mid-term review of 20th EPS.
2. Demand Profile: Based on hourly demand profile of 2024-25.
3. Existing & Planned Capacity: As per the information shared by the state.
4. Cost parameters: based on information in National Electricity Plan.

RE CUF considered

Hydro	Wind	Solar	DRE
44-48 %	24%	18%	14%

Technical Parameters

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical . (%)	Start -up time (hr)		
					Hot	Warm	Cold
Coal/ Lignite	Existing/Planned	85	1	55	2	5	10
	Candidate	88	1	55	2	5	10
Gas	Existing	90	5	40	1.5	2	3
Nuclear	Existing/Planned	68	Const. Load	-	-	-	-

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical . (%)	Start -up time (hr)		
					Hot	Warm	Cold
Biomass	Existing/Planned	60	2	50	2	4	8
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)	Start-up fuel consumption (MCal/MW)		
		At max loading	At min loading				Hot	Warm	Cold
Coal	Existing/ Planned	2300 to 2879	2438 to 3052	7.0	6	4	600	1000	1800
	Candidate (SC & USC)	2060 to 2125	2183 to 2253	6.5	6	4	600	1000	1800
Gas	Existing	2000 to 2900	2260 to 3277	2.5	4	3	30	50	90
Nuclear	Existing/ Planned	2777	2777	10	6	4	-	-	-
	Candidate	2777	2777	10	-	-	-	-	-
Biomass	Existing/ Planned	4200	4450	8	6	4	600	1000	1800
	Candidate	4200	4450	8	6	4	600	1000	1800
Hydro	Existing/ Planned	-	-	0.7	-	-	-	-	-
	Candidate	-	-	0.7	-	-	-	-	-
Pumped Storage	Existing/ Planned	-	-	pump efficiency	-	-	-	-	-

	Candidate	-	-	80 %	-	-	-	-	-
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	11.5 Cr	19.54 Lakh	4	25
Solar	5 Cr	1 % of Capex	0.5	25
Battery Energy Storage (2-Hour)	5.13 Cr to 3.13 Cr	1 % of Capex	0.5	14
Battery Energy Storage (4-Hour)	8.22 Cr to 4.72 Cr	1 % of Capex	0.5	14
Battery Energy Storage (5-Hour)	9.77Cr to 5.51 Cr	1 % of Capex	0.5	14
Battery Energy Storage (6-Hour)	11.31 Cr to 6.30 Cr	1 % of Capex	0.5	14