सत्यमेव जयते

Report on Resource Adequacy Plan (Generation) for Assam (2025-26 to 2035-36) (Version 3.0)

Government of India
Ministry of Power
Central Electricity Authority

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Disclaimer

This Resource Adequacy Study for the state of Assam has been conducted based on data and inputs provided by the Assam Power Distribution Company Limited (APDCL). The findings, analysis and conclusions presented in this report are contingent upon the accuracy, completeness and timeliness of the information furnished by APDCL. 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 APDCL 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 APDCL.

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 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 utility in fulfilling this requirement, CEA, in collaboration with the State, initially conducted a Resource Adequacy (RA) study with a planning horizon up to FY 2034-35, based on the data received from the State 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 utility has also been assessed in accordance with the recent gazette notified trajectory.

The study has been done considering the demand projections furnished by APDCL. The demand projections include a PSP pumping demand of 5.256 BU, which has not been taken into account for the calculation of Renewable Purchase Obligation of the State The electricity energy requirement and peak demand for Assam is projected to increase with a CAGR of 11.2% and 9.9% respectively from 2025-26 to 2035-36. Further, a Business as Usual (BAU) scenario has also been carried out. The electricity energy requirement and peak demand in the BAU scenario are increasing with a CAGR of 8.6% and 6.3% respectively. 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 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.

The study has been carried out for Assam considering the existing contract capacity and planned capacity addition data. It was found that the state likely contracted capacity may not be sufficient to meet the projected demand. Further, the total unserved energy in the year 2035-36 is expected to be about 21.4 BU which is about 58% of the annual projected energy demand during the year 2035-36.

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 with an objective to minimize the total system cost of generation including the cost of anticipated future investments while fulfilling all the technical/financial constraints associated with various power generation technologies. Additionally, reliability study has been carried out to determine the probability of unmet demand and hours by implementing the variation in demand, RE and forced outage of thermal generators (Coal/ Lignite) etc.

Generation capacity expansion pathways have been considered for the long-term study based on the yearly capacity addition plans of the Assam along with RPO constraints for solar and wind 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 is 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 16,816 MW which consists of 4073 MW from coal, 408 MW from gas, 1399 MW from hydro, 1100 MW from wind, 6954 MW from solar, 673 MW from Distributed Renewable Energy (DRE) source and 2206 MW from 4hour Storage. Further, in addition to this, 941 MW of MToA/SToA arrangement will be required. 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 in 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 utility 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 Assam based on inputs furnished by APDCL. 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 outages 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 inputs from APDCL 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 has been considered as the base year, and the study covered the period from 2024-25 to 2034-35. The fuel-wise contracted capacity by APDCL as on 31st March, 2024 is given in Fig. 1.

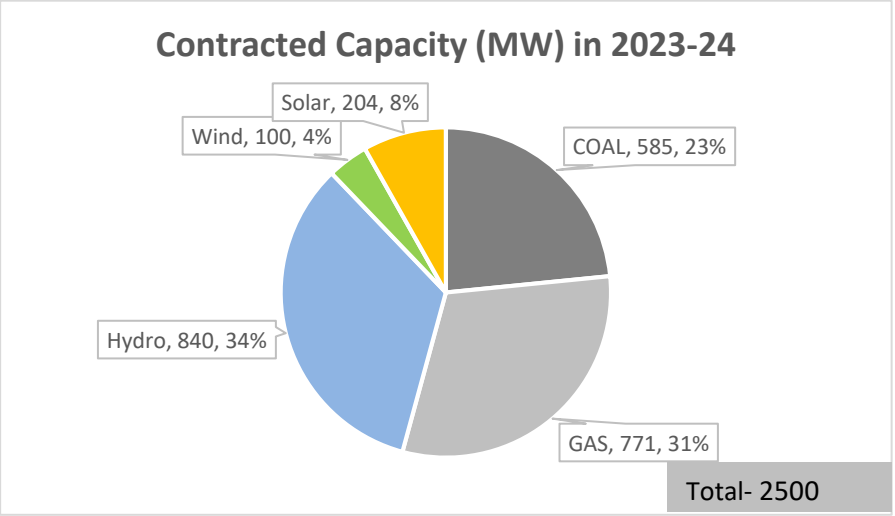


Figure 1 Contract Capacity 2023-24

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

Table 1: Peak electricity demand & electrical energy projections

	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)	13455	14419	15408	16466	17595	18802	20092	21470	22943	24517	26199
Year on Year Growth		7.16%	6.86%	6.87%	6.86%	6.86%	6.86%	6.86%	6.86%	6.86%	6.86%
Peak Electricity Demand Projections (MW)	2753	2942	3144	3359	3590	3836	4099	4380	4681	5002	5345
Year on Year Growth		6.87%	6.87%	6.84%	6.88%	6.85%	6.86%	6.86%	6.87%	6.86%	6.86%

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

Table 2: Source wise projected capacities

Year	Coal	Gas	Hydro	Wind	Solar	DRE	Storage (4Hrs)	SToA/MToA	Total
2024/25	585	771	840	100	204	165	0	1405	**4070**
2025/26	1280	771	1168	100	304	247	0	590	**4460**
2026/27	1280	771	1168	150	554	339	0	843	**5105**
2027/28	1434	771	1168	200	954	443	0	951	**5921**
2028/29	1734	771	1168	250	1354	560	0	926	**6762**
2029/30	1734	771	1168	300	1754	690	0	1239	**7656**
2030/31	1775	771	1168	350	2154	819	50	1465	**8552**
2031/32	1952	771	1168	400	2554	963	279	1329	**9415**
2032/33	2124	771	1168	450	2804	1122	481	1262	**10182**
2033/34	2301	771	1168	500	3054	1299	718	1170	**10981**
2034/35	2499	771	1168	550	3304	1495	915	1139	**11842**

*****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	Coal		SOLAR		Storage (4 Hrs)	Wind	Hydro	DRE	Total		SToA/MToA
	Planned	Additional	Planned	Additional	Additional	Additional	Planned	Additional	Planned	Additional	Additional*
2024/25	165	0	0	0	0	0	0	165	**165**	**165**	1405
2025/26	530	0	100	0	0	0	328	82	**958**	**82**	590
2026/27	0	0	0	250	0	50	0	92	**0**	**392**	843
2027/28	154	0	150	250	0	50	0	104	**304**	**404**	951
2028/29	300	0	150	250	0	50	0	116	**450**	**416**	926
2029/30	0	0	150	250	0	50	0	130	**150**	**430**	1239

FY	Coal		SOLAR		Storage (4 Hrs)	Wind	Hydro	DRE	Total		STOA/MTOA
	Planned	Additional	Planned	Additional	Additional	Additional	Planned	Additional	Planned	Additional	Additional*
2030/31	0	41	150	250	50	50	0	129	**150**	**520**	1465
2031/32	0	177	150	250	229	50	0	144	**150**	**850**	1329
2032/33	0	172	0	250	202	50	0	160	**0**	**834**	1262
2033/34	0	177	0	250	237	50	0	177	**0**	**891**	1170
2034/35	0	198	0	250	197	50	0	196	**0**	**891**	1139
Total	**1149**	**765**	**850**	**2250**	**915**	**450**	**328**	**1495**	**2327**	**5875**	

**Requirement is for a particular year*

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

3.1 Present Power Scenario in Assam

The current power supply position for Assam is shown in Table 4:

Table 4: Power Supply Position of Assam

Power Supply Position						
Year	**Energy required (MU)**	**Energy supplied (MU)**	**Gap (MU)**	**Peak Demand (MW)**	**Peak Met (MW)**	**Demand not met (MW)**
2021-22	10,844	10,825	19	2126	2121	5
2022-23	11,465	11,465	0	2379	2376	3
2023-24	12,445	12,341	104	2413	2413	0
2024-25	12,843	12,837	6	2812	2687	125

The data in the table indicates that over the past four years, Assam's energy demand and peak demand have increased at a Compound Annual Growth Rate (CAGR) of 5.80% and 9.77%, respectively.

As of March 2025, the total contracted capacity for Assam is 2504 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 46 %.

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	590	23%
Gas	771	31%
Hydro	839	34%

Wind	100	4%
Solar	204	8%
Total	**2504**	**100.0%**

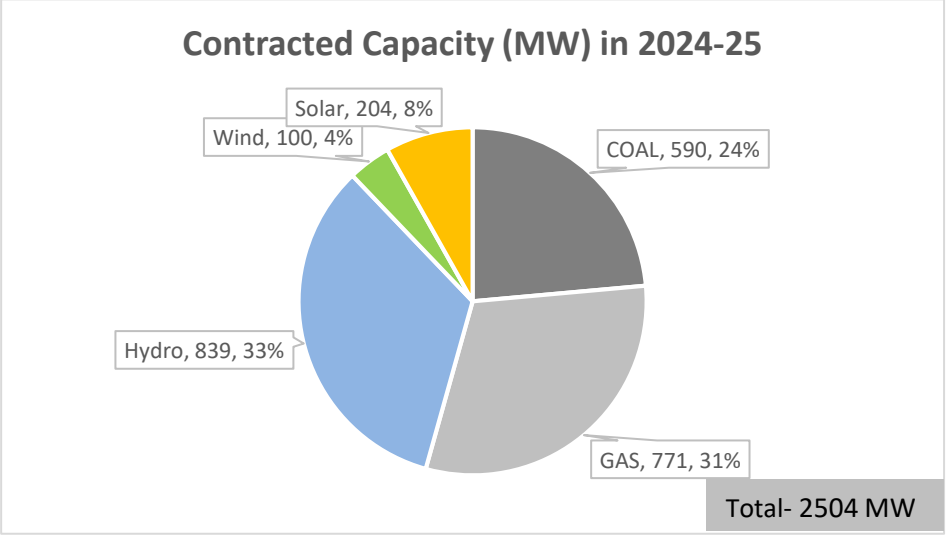


Figure 2: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2025

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 State of Assam is during the months from July to September. Assam witnesses peak demand during non-solar hours.

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

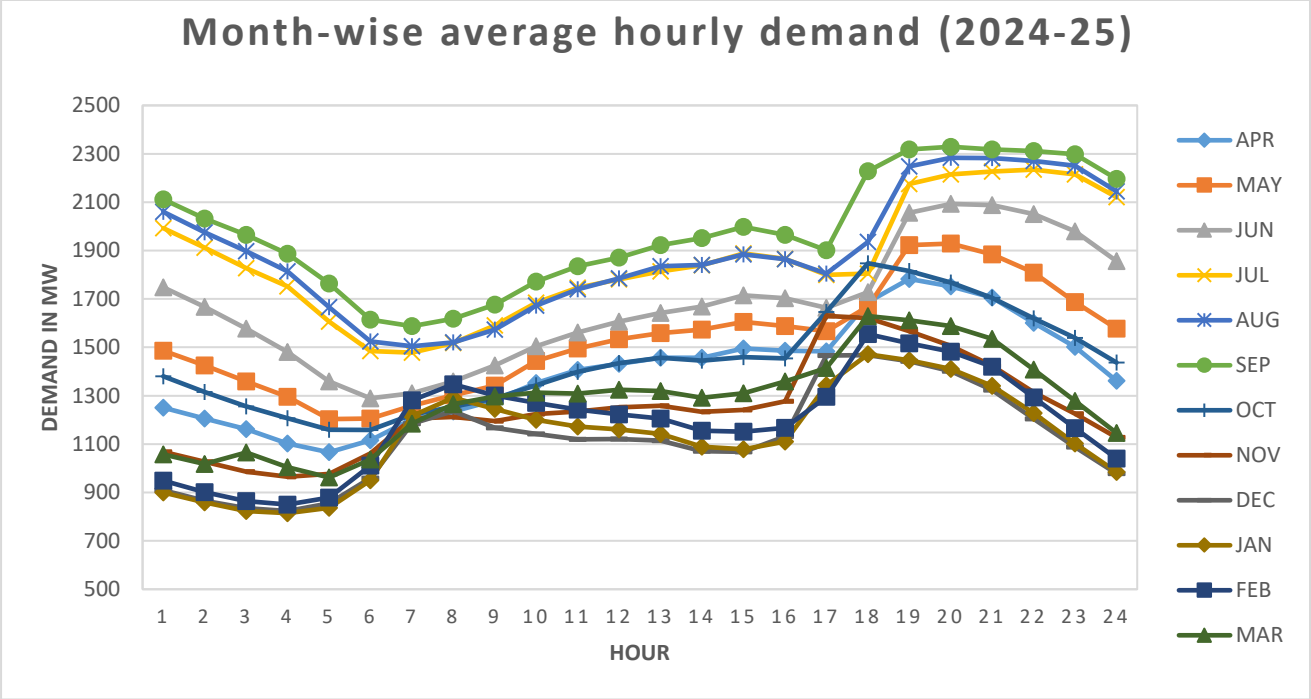


Figure 3: Average Hourly Demand Variation (Month-wise) for 2024-25

From the hourly demand data of 2024-25 the daily peak during solar hours (06:00 to 18:00 hrs) and non-solar hours are plotted in Fig. 4.

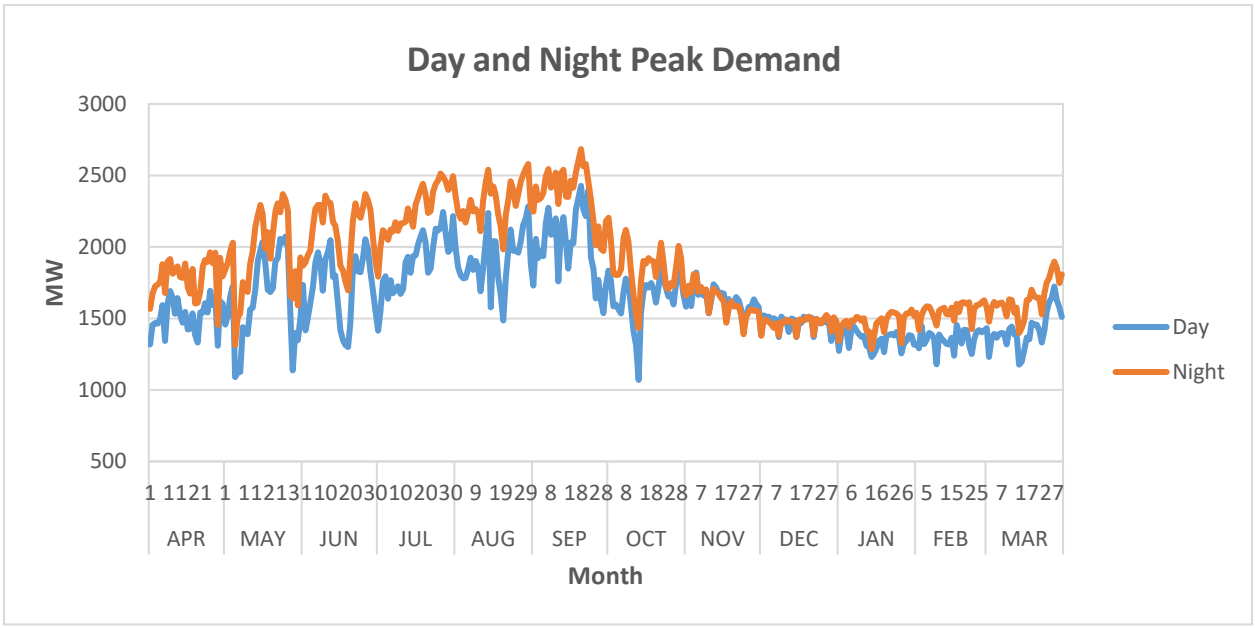


Figure 4: Day and Night Peak in MW for the year 2024-25

Daily peak occurs in Assam 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.

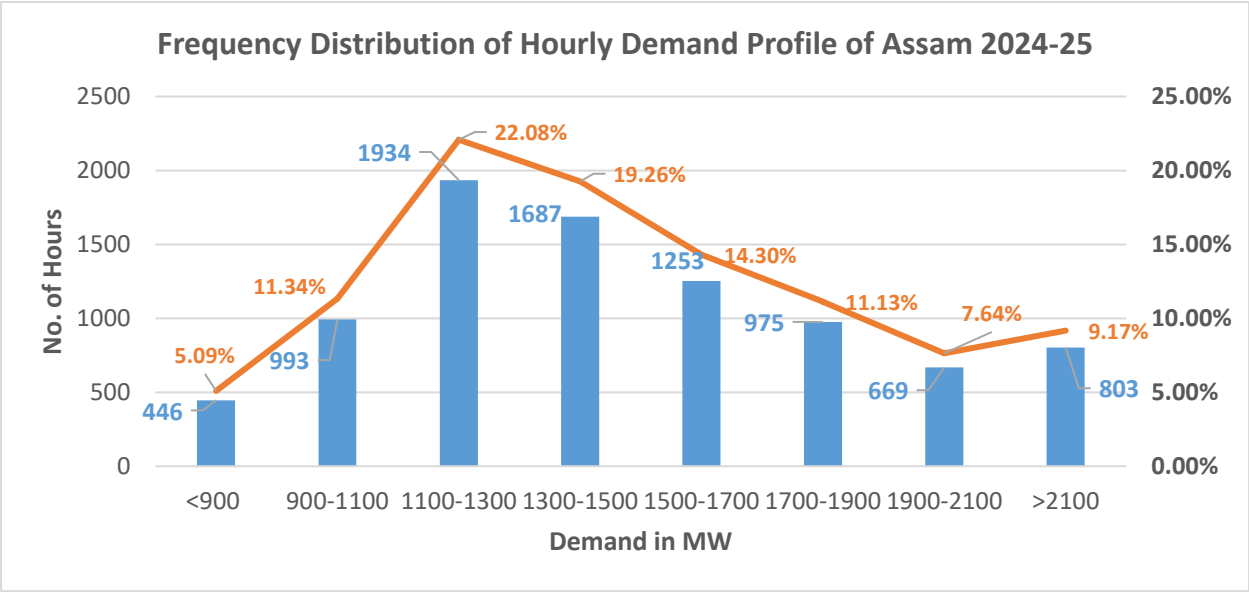


Figure 5: Frequency Distribution of Hourly Demand Profile of 2024-25

3.3 Future demand assessment

As per APDCL, key factors driving high demand in Assam are as follows:

1. **Accelerated Peak Demand Growth**

   As intimated by APDCL, Peak demand increased from 2,100 MW (FY 2021-22) to 2,800 MW (FY 2024-25). It is expected to reach 6,153 MW by FY 2032-33.

   APDCL intimated that the increase in peak demand over the last five years is attributable to:

   a. Consumer Base Expansion: Addition of approximately 15 lakh new consumers across all categories with connected load increasing by 2,100 MW. This expansion in the consumer base has directly led to an increase in electricity demand.
   b. RDSS Implementation: Enhanced electrification, reduction in system constraints, network expansion, and quality power supply under the Revamped Distribution Sector Scheme has led to increased power demand.
   c. Economic Growth: State's GSDP has grown at 8-9% annually driven by infrastructure projects (Asom Mala, Act East Policy), industrial estates, logistics parks, and expansion in petroleum, tea, and tourism sectors leading to higher industrial power consumption.

2. Upcoming Projects and Infrastructure development in Assam

As intimated by APDCL, Commercial, HT Industries and Bulk Supply categories are expected to see exceptional growth.

a. **Commercial Sector**: 11 Five Star Hotels, Data Centers and other commercial infrastructure are likely to set up in Assam in near future.
b. **HT Industrial Sector**: Major industrial projects include TATA Semiconductor facility, OIL and NRL expansion projects are likely to come up in Assam.
c. Further under the Advantage Assam 2.0 initiative, manufacturing industries with aggregate demand of approximately 400 MW are being established.
d. Based on their preliminary assessments of power requirements these projects are expected to add 1000 MW to the demand over and above demand as per the projected trajectory
e. **Bulk Supply Sector**: Renovation and construction of government schools, colleges and institutional infrastructure development is being done. This may increase energy demand in this category.

Furthermore, two Pumped Storage Projects (2×900 MW each) are likely to be set up in Assam for which the charging power will be given by APDCL. The charging power will be given in the off-peak time which falls in the day hours. As such, the PSPs will increase the demand in off peak hours by 1800 MW.

It is pertinent to mention that during the preparation of 20th Electric Power Survey (EPS), the demand forecast for Assam was undertaken based on data submitted by the State of Assam, which was duly agreed to by the State. The 20th EPS figures for energy requirement and peak demand are given in Table 6.

Table 6: Electrical Energy requirement and peak demand as per 20th EPS

FY	Electrical Energy requirement (MU)	Peak Electricity Demand (MW)
2024-25	13454	2689
2025-26	14279	2861
2026-27	15151	3045
2027-28	16079	3240
2028-29	17069	3449
2029-30	18183	3683
2030-31	19230	3905
2031-32	20285	4128

It may be noted that in FY 2024-25 the gross demand for State of Assam was 2812 MW while the demand met was 2687 MW. Projection of electrical energy requirement and peak demand as per APDCL is given in Table 7 and 8.

Table 7: Projection of electrical energy requirement and peak demand as per APDCL

FY	Energy requirement (MU)	Peak Demand (MW)
2025-26	14314	3030
2026-27	16421	3469
2027-28	18693	3927
2028-29	20577	4304
2029-30	22538	4704
2030-31	24969	5178
2031-32	27521	5676
2032-33	30077	6153
2033-34	33385	6759
2034-35	36638	7297
2035-36	40593	7969

Table 8: Category-wise Projection of electrical energy requirement and peak demand as per APDCL

	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
ENERGY CONSUMPTION (MUs)											
1. Domestic	5294	5577	5875	6190	6521	6870	7237	7624	8032	8462	8915
2. Commercial	1920	2393	2905	3362	3869	4484	5166	5873	6766	7658	8763
3. Public lighting	22	22	23	23	24	25	25	26	26	27	28
4. Public Water Works	217	241	268	297	330	366	406	451	501	556	617
6. LT Industries	136	147	159	171	184	199	214	231	249	269	290
7. HT Industries	2675	3418	4205	4841	5533	6389	7316	8223	9421	10521	11936
8. Railway Traction	131	157	188	226	271	325	390	468	561	673	808
9. Bulk Supply	914	1264	1624	1872	2134	2472	2827	3139	3595	3949	4453
10. Open Access Excl. Rly.											
11.EV Charging	22	26	35	42	48	55	61	68	74	83	92
12. Others	71	72	66	63	61	59	57	55	53	50	46
Total (Energy Consumption)	**11402**	**13316**	**15348**	**17087**	**18975**	**21243**	**23700**	**26157**	**29280**	**32248**	**35948**
T&D losses -MU	**2912**	**3105**	**3345**	**3490**	**3563**	**3726**	**3821**	**3920**	**4105**	**4390**	**4645**
T&D losses -in %	**20.35**	**18.91**	**17.89**	**16.96**	**15.81**	**14.92**	**13.88**	**13.03**	**12.30**	**11.98**	**11.44**
Energy Requirement - MU	**14314**	**16421**	**18693**	**20577**	**22538**	**24969**	**27521**	**30077**	**33385**	**36638**	**40593**
Annual Load Factor	**0.54**	**0.54**	**0.54**	**0.55**	**0.55**	**0.55**	**0.55**	**0.56**	**0.56**	**0.57**	**0.58**
Peak Load - MW	3030	3469	3927	4304	4704	5178	5676	6153	6759	7297	7969

Based on the revised data submitted by APDCL, the electricity demand forecast has been done under two scenarios- Optimistic scenario and Business as Usual. In both scenarios, the additional electricity demand due to two upcoming Pumped storage plants (2x900 MW) in Assam have not been considered.

In business-as-usual scenario, emphasis has been given to the past growth trends in Energy requirement and Peak electricity demand.

In the optimistic scenario, complete realization of targets in various categories as stated by APDCL has been assumed.

Revised projections for Peak Demand and Energy requirement (excluding PSP) for the State of Assam as considered for carrying out the studies are given in Table 9.

Table 9: Revised projections for Peak Electricity Demand and Energy requirement

Summary of revised demand projections in both scenarios				
Peak Electricity Demand (MW)				
FY	**20th EPS**	**APDCL**	**Optimistic-Revised Projections**	**BAU -Revised Projections**
2025-26	2861	3030	3067	2997
2026-27	3045	3469	3407	3195
2027-28	3240	3927	3831	3404
2028-29	3449	4304	4225	3623
2029-30	3683	4704	4668	3855
2030-31	3905	5178	5166	4099
2031-32	4128	5676	5624	4356
2032-33		6153	6143	4627
2033-34		6759	6697	4913
2034-35		7297	7299	5215
2035-36		7969	7951	5533

Electrical Energy Requirement (MU)				
FY	**20th EPS**	**APDCL**	**Optimistic-Revised Projections**	**BAU -Revised Projections**
2025-26	14279	14314	14489	13709
2026-27	15151	16421	15853	14694
2027-28	16079	18693	17379	15732
2028-29	17069	20577	19089	16823
2029-30	18183	22538	21004	17970
2030-31	19230	24969	23153	19165
2031-32	20285	27521	25206	20426
2032-33		30077	27551	21727
2033-34		33385	30241	23100
2034-35		36638	33313	24505
2035-36		40593	36811	26006

4.0 Principles of Generation Planning

The objective of the 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 purpose of generation planning studies is not to predict or forecast the future, but a collaborative effort to understand and explore the key factors and relationships shaping the future of the power sector. Planning is therefore an activity encompassing balancing demand and supply at all instances of time and at all locations, which makes it a regular ongoing process.

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
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 were 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 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.

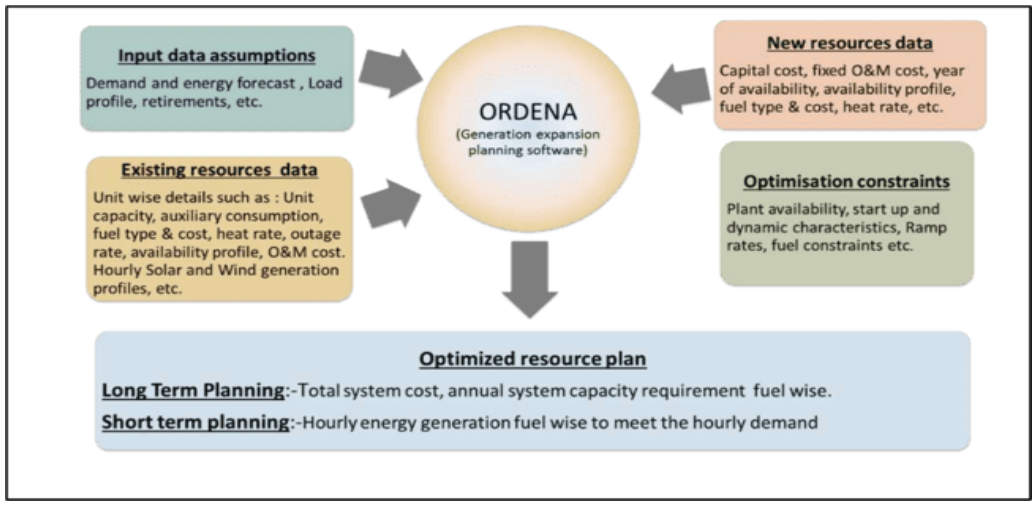


Figure 6: Schematic Diagram

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 load) 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 expressed as a certain percent of peak load forecast of the system.

5.1 Demand variation

The variation in demand pattern for last two years have been analyzed. The hourly demand variation for consecutive years (i.e., 2023-24 and 2024-25) has been analyzed. The Demand pattern variation of 2023-24 and 2024-25 is shown in Fig. 7.

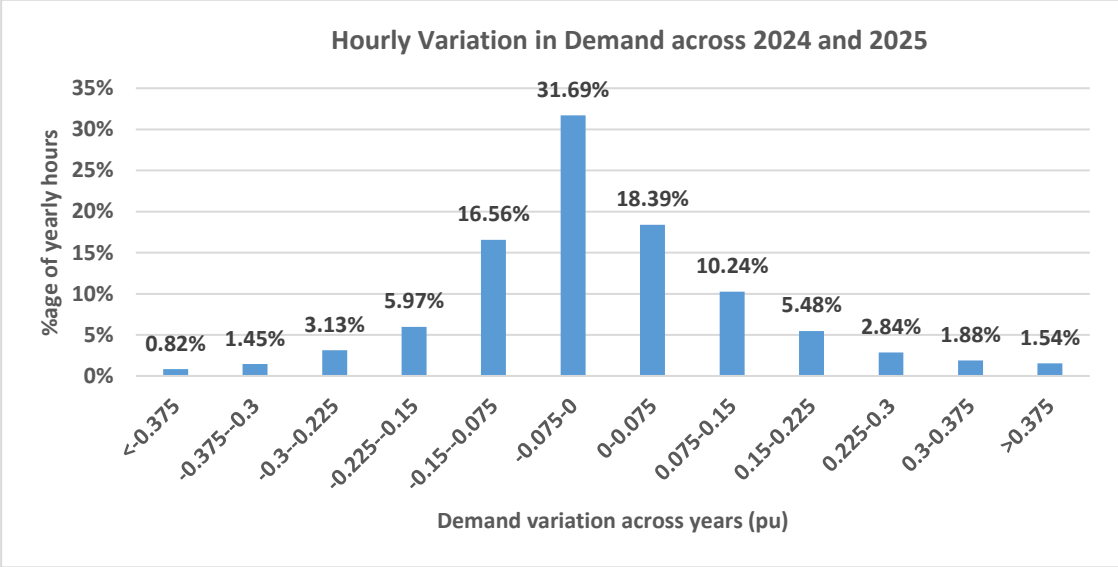


Figure 7: Hourly Variation in Demand across years

It can be observed that the hourly demand typically varies within ±7.5% for ~50% of instances. This variation is primarily due to temperature, weather parameter or any random outages of transmission line and generation units etc. This variation has been captured in the reliability study by varying the projected hourly demand for the future years by varying ±7.5% by introducing a random variable (with normal distribution) for demand as per observed behavior over the years.

5.2 RE variation

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 % and wind generation has been varied by ± 60% 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 are 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 Assam, furnished by APDCL is given in Table 10.

Table 10: Future Demand Projection as provided by utility

	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
APDCL Peak Demand Projections (in MW)	3067	3407	3831	4225	4668	5166	5624	6143	6697	7299	7951
Year on Year Growth		11%	12%	10%	10%	11%	9%	9%	9%	9%	9%
Energy Requirement (in MU)											
APDCL Energy Projections (in MU)	14489	15853	17379	19089	21004	23153	25206	27551	30241	33313	36811
Year on Year Growth		9%	10%	10%	10%	10%	9%	9%	10%	10%	11%

In addition to the above demand, PSP pumping demand of (2628 MU) corresponding to 900 MW of load for 8 hrs (off-peak) pumping has also been considered for the year 2031-32 and 2033-34 each. Consequently, the final electrical energy demand considered for the study is show in Table 11.

Table 11: Final energy demand considered

Total Energy Requirement (in MU)											
	2025-26	**2026-27**	**2027-28**	**2028-29**	**2029-30**	**2030-31**	**2031-32**	**2032-33**	**2033-34**	**2034-35**	**2035-36**
APDCL Energy Projections (in MU)	14489	15853	17379	19089	21004	23153	27834	30179	35497	38569	42067

The peak demand has been taken as per the figures in Table 10.

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 referred from National Electricity Plan 2023 (Vol I Generation).

iv) The capital costs of candidate plants for coal, wind, solar, and battery 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 APDCL. The same is summarised in Table 12 and details are furnished in Annexure.

Table 12: Source wise planned capacity addition

FY	COAL	HYDRO	Battery (MW/ MWh)
2025/26	200	246	-
2026/27	-	314	25/100
2027/28	154	-	-
2028/29	300	-	-
2029/30	-	-	-
Total	**654**	**560**	**25/100**

vi) **Renewable Purchase Obligation (RPO) trajectory**: Ministry of Power 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 13.

Table 13: 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. 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 14.

Table 14: 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*

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 15.

Table 15: 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**	210.1	176.8	4243.8	152.1	4782.7
2.	**2026-27**	312.3	212.4	4960.4	214.0	5699.2
3.	**2027-28**	425.8	246.8	5785.6	286.8	6744.9
4.	**2028-29**	563.1	271.1	6690.5	372.2	7895.0
5.	**2029-30**	731.0	279.4	7618.3	472.6	9101.2
6.	**2030-31**	10013.9			521.0	10534.8
7.	**2031-32**	11279.8			567.1	11846.9
8.	**2032-33**	12687.5			619.9	13307.4
9.	**2033-34**	14288.7			680.4	14969.1
10.	**2034-35**	16240.0			749.5	16989.5
11.	**2035-36**	18313.7			828.3	19142.0

As indicated in Table 16, the state will not be able to meet its RPO requirements with its existing and envisaged future capacity additions.

Table 16: Renewable Energy Deficit/Surplus

FY	RE Generation required to meet RPO		RE Generation available/met (From existing/ planned contracts)		RPO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2025/26	4782.7	33.01	3408	24%	-9%
2026/27	5699.2	35.95	4340	27%	-9%
2027/28	6744.9	38.81	4412	25%	-13%
2028/29	7895.0	41.36	4498	24%	-18%
2029/30	9101.2	43.33	4598	22%	-21%
2030/31	10534.8	45.5	4647	20%	-25%
2031/32	11846.9	47	4693	19%	-28%
2032/33	13307.4	48.3	4746	17%	-31%
2033/34	14969.1	49.5	4807	16%	-34%
2034/35	16989.5	51.0	4876	15%	-36%
2035/36	19142.0	52.0	4955	13%	-39%

7.0 Outcome of the model

7.1 Unserved Energy Projections

Initially, the study is conducted considering only the existing and planned capacity contracts. The projected total unserved energy for the year 2035-36 is about 21 BU. The year-wise likely unserved energy with the planned capacities is given in Fig 8.

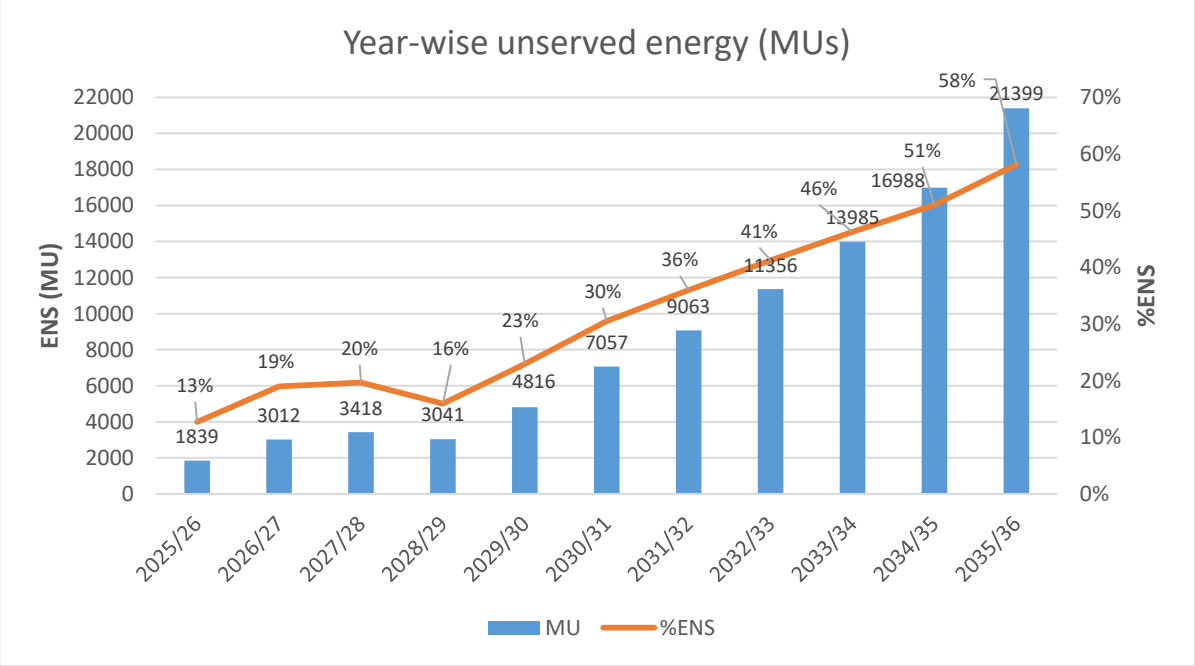


Figure 8: Yearly likely unserved energy (in MU) with the existing and planned capacities

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 demand. Details are shown in Fig. 9.

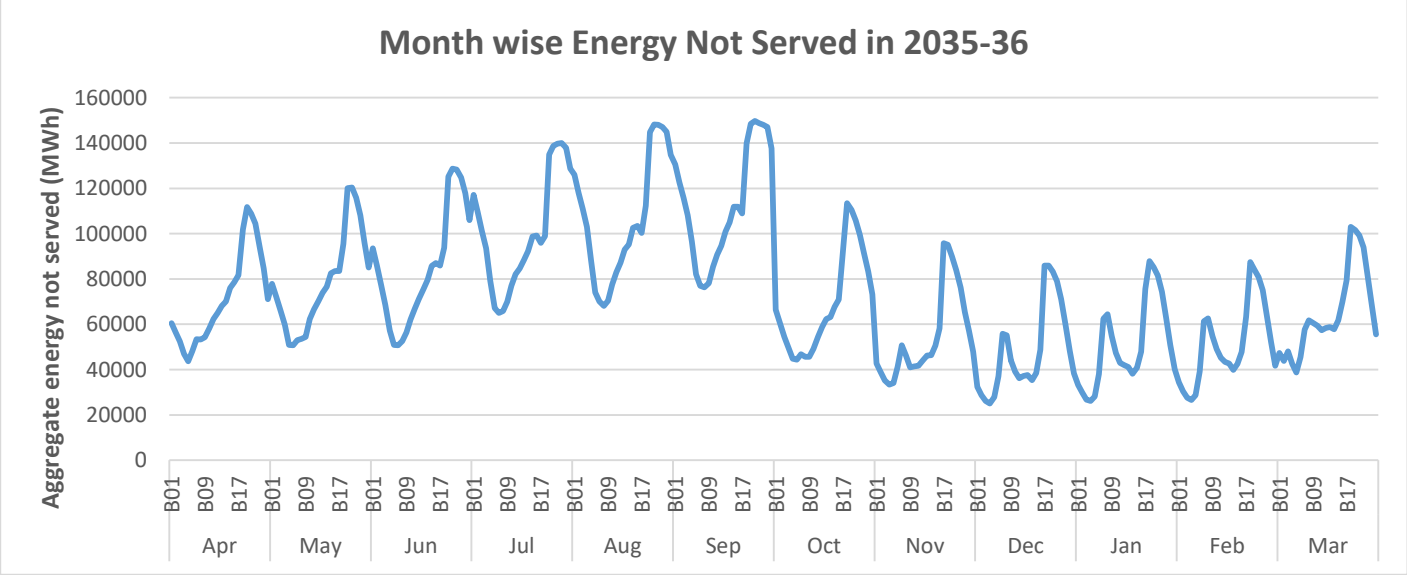


Figure 9: Block-wise Unserved Energy Pattern MWh (2035-36)

The unmet demand occurs mainly during non-solar hours throughout the year.

7.2 Investment options to meet the unserved energy

To meet this unserved energy, energy investment options (i.e., candidate capacities) are given to the model to find the least cost optimal capacity mix required to meet the demand with RPO obligations. The capacity projections for APDCL are given in Table 17.

Table 17: Year-wise contracted capacity projections (in MW)

Year	Coal	Gas	Hydro	Wind	Solar	Storage* (4 Hr)	DRE	SToA/MToA
2025/26	790	771	1085	100	204	0	124	950
2026/27	790	606	1399	200	729	25	175	950
2027/28	944	606	1399	300	1254	25	234	950
2028/29	1244	606	1399	400	1804	695	304	950
2029/30	1908	606	1399	500	2354	695	385	837
2030/31	2153	606	1399	600	2954	857	425	950
2031/32	2736	606	1399	700	3604	857	462	950
2032/33	2873	606	1399	800	4304	1246	505	950
2033/34	3447	606	1399	900	5054	1330	555	950
2034/35	3695	606	1399	1000	6004	1717	611	950
2035/36	4073	408	1399	1100	6954	2206	675	941

**BESS or PSP or combination thereof*

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

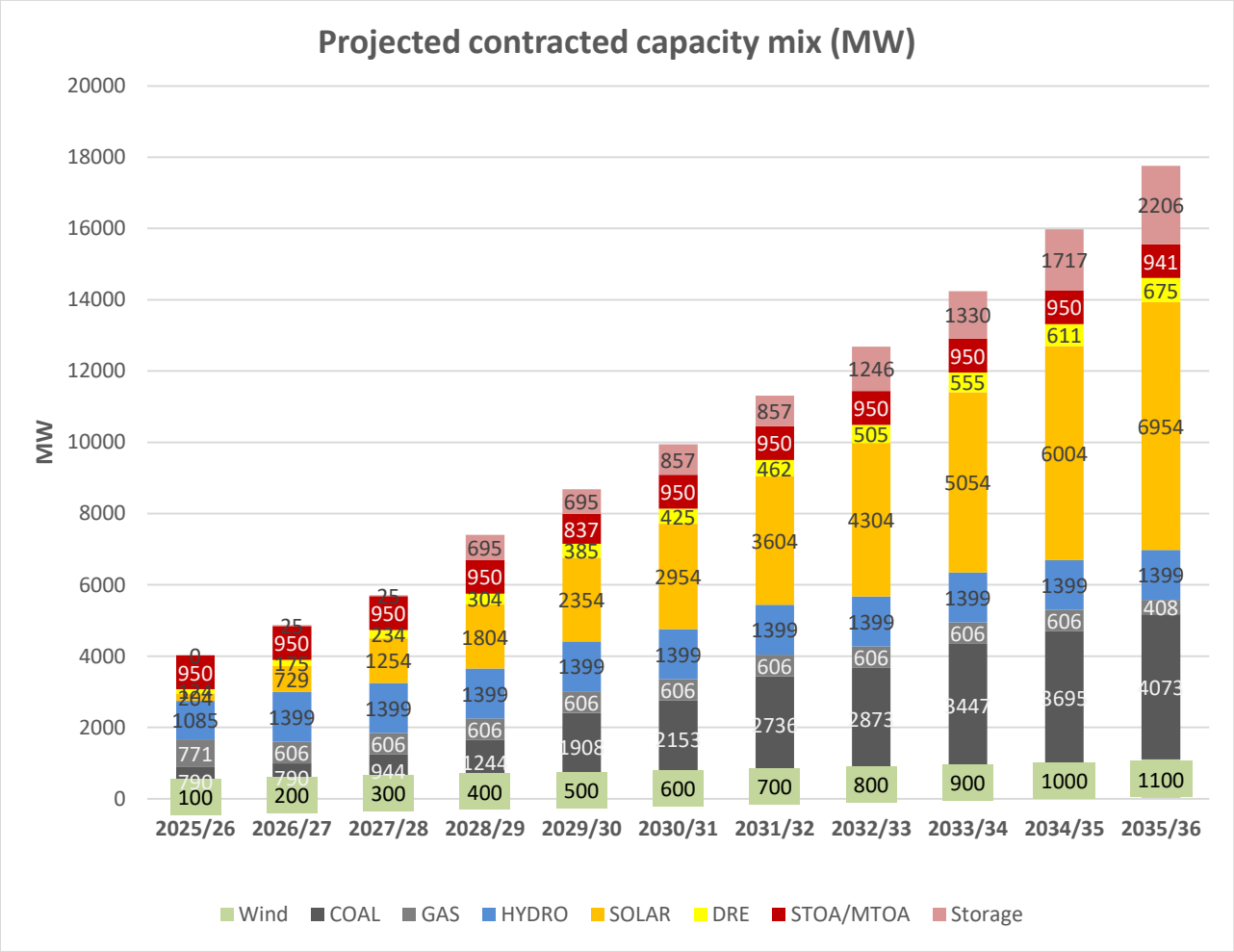


Figure 10: Projected Contracted Capacity Mix Year-wise (MW)

The SToA/MToA requirement can be fulfilled through power procurement from markets 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 generation capacity for the year 2035-36 is around 14,610 MW which consists of 4,073 MW from coal, 408 MW from gas, 1,399 MW from hydro, 1,100 MW from wind, 6,954 MW from solar and 675 MW from Distributed Renewable Energy (DRE) sources. In addition, 2,206 MW from Storage (4 Hrs) is projected to be

required by 2035-36. Furthermore, 941 MW of MToA/SToA arrangement will be required. This capacity is inclusive of the planning reserve margin of 5% for non-solar hours and 16% for Solar hours and shall be able to meet the projected demand with prescribed reliability criteria and to comply with the stipulated Renewable Purchase Obligation (RPO) targets. Capacity mix required by 2035-36 is shown in Figure 11.

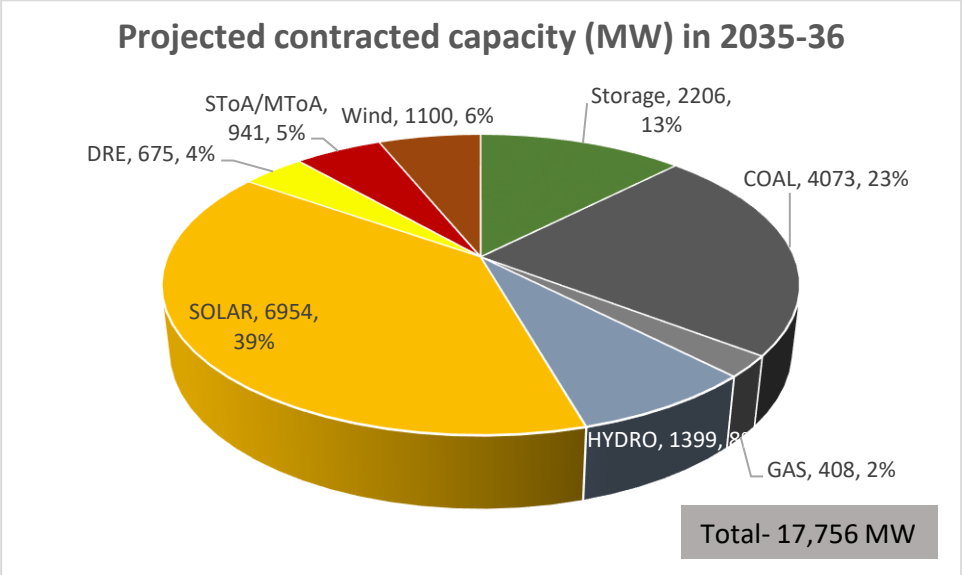


Figure 11 Contracted Capacity Mix in 2035-36

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 demand and 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 utility needs to contract the following capacities (planned and additional) per year till 2035-36 to meet its demand reliably as shown in Table 18.

Table 18: Year wise Capacity Addition (in MW)

FY	Coal		Storage (4 Hrs)		Solar	Wind	Hydro	DRE	Total	
	Planned	Additional	Planned	Additional	Additional	Additional	Planned	Additional	Planned	Additional
2025/26	200	0	0	0	0	0	246	124	**446**	**224**
2026/27	0	0	25	0	525	100	314	50	**339**	**675**
2027/28	154	0	0	0	525	100	0	59	**154**	**684**
2028/29	300	0	0	670	550	100	0	70	**300**	**1390**
2029/30	0	664	0	0	550	100	0	82	**0**	**1396**
2030/31	0	245	0	162	600	100	0	39	**0**	**1146**

FY	Coal		Storage (4 Hrs)		Solar	Wind	Hydro	DRE	Total	
	Planned	Additional	Planned	Additional	Additional	Additional	Planned	Additional	Planned	Additional
2031/32	0	583	0	0	650	100	0	38	**0**	**1371**
2032/33	0	137	0	389	700	100	0	43	**0**	**1369**
2033/34	0	573	0	84	750	100	0	49	**0**	**1556**
2034/35	0	248	0	387	950	100	0	56	**0**	**1741**
2035/36	0	379	0	489	950	100	0	64	**0**	**1982**
Total	**654**	**2829**	**25**	**2181**	**6750**	**1000**	**560**	**675**	**1239**	**13435**

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

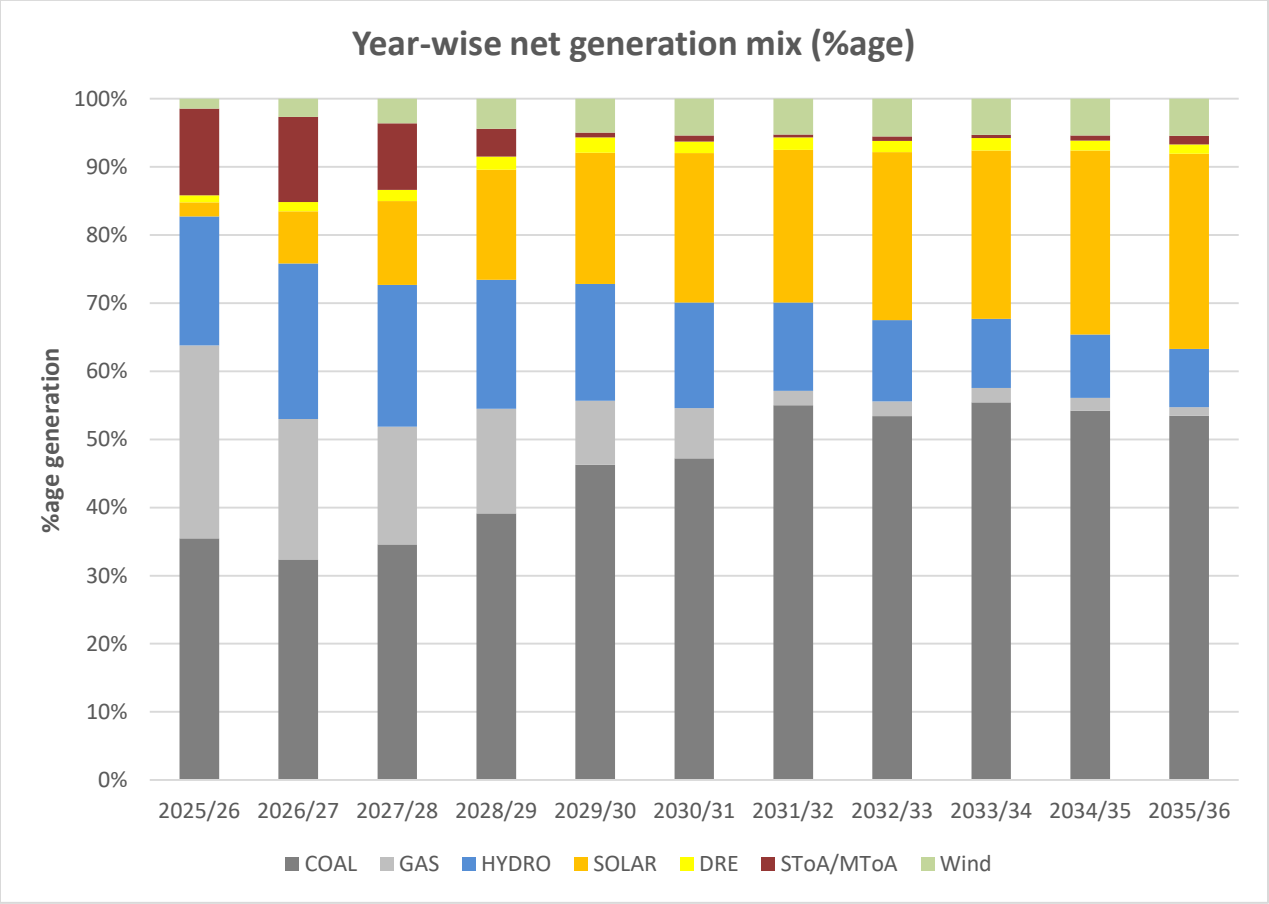


Figure 12 Year-wise projected net generation mix (in %)

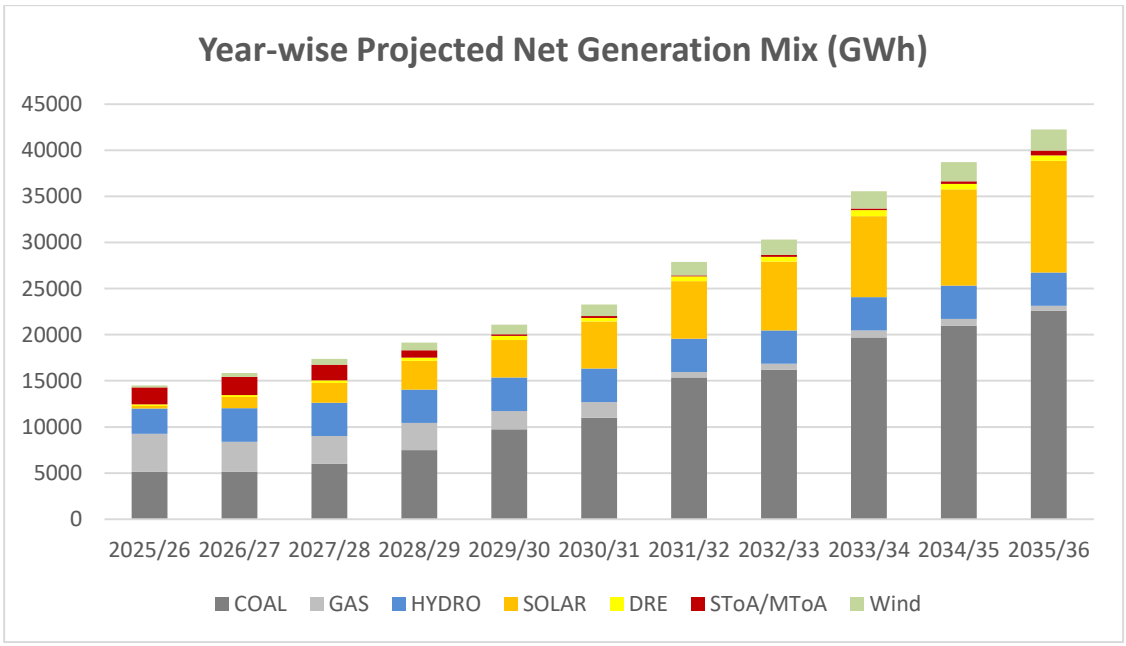


Figure 13: Year-wise projected net generation (in GWh)

7.3 Coal Capacity Performance

The coal capacity PLF is expected to remain in the range of around 61% - 78% for the years till 2036 ensuring higher absorption increasing contracts from renewable energy. Coal capacity PLF is shown in Figure 14.

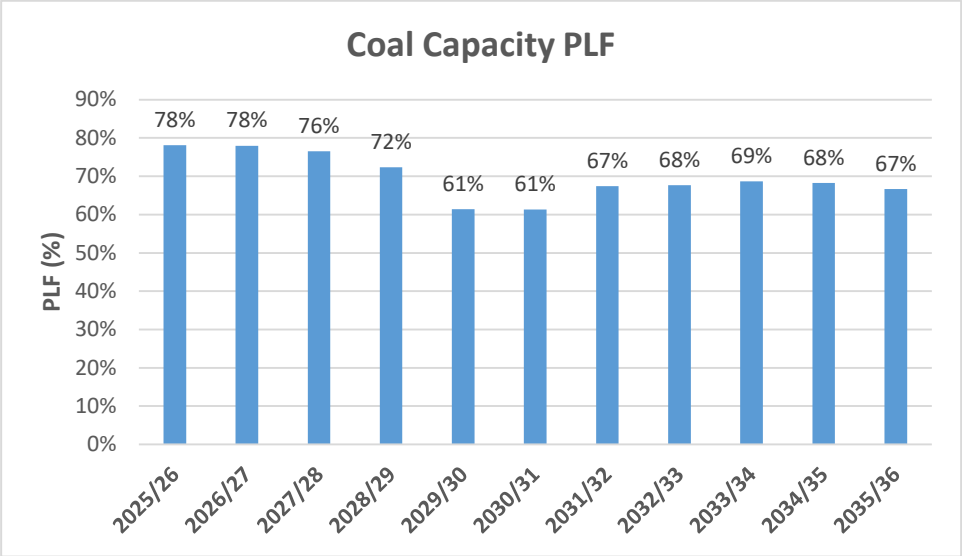


Figure 14: Year-wise coal contracts PLF (in %)

7.4 Day-wise Surplus Coal Capacity (in MW)

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. This capacity can be shared with other states/ Discoms and reduce the fixed cost burden on the utilities resulting in reduction in the cost for the consumer. The state has likely surplus capacity of more than 200 MW available during the whole year except in the months of August and September as shown below which can be shared with other states/ Discoms.

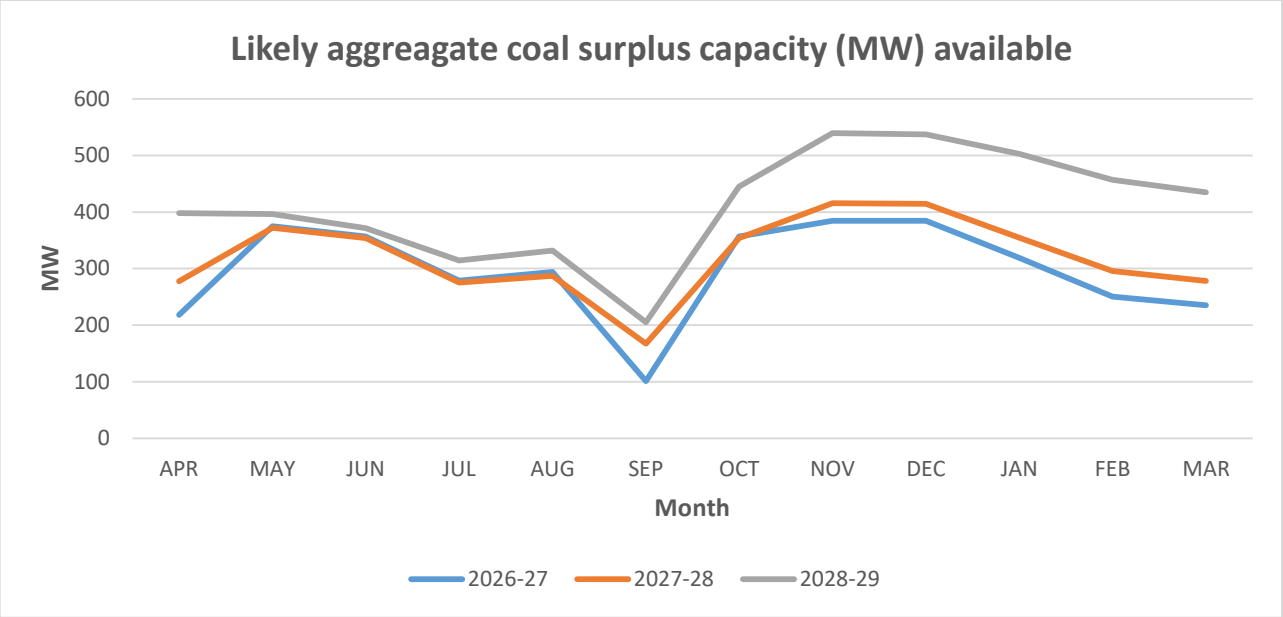


Figure 15: Surplus Coal Capacity Year-wise (MW)

7.5 Business-as-usual (BAU) Scenario

In view of the higher rate of growth of electricity demand, a low to moderate demand growth rate scenario has also been considered. The demand projections considered in the scenario are given in Table 19.

Table 19: Demand Projections (in MW)

	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
APDCL Peak Demand Projections (in MW)	2997	3195	3404	3623	3855	4099	4356	4627	4913	5215	5533
Year on Year Growth		7%	7%	6%	6%	6%	6%	6%	6%	6%	6%
Energy Requirement (in MU)											
APDCL Energy Projections (in MU)	13709	14694	15732	16823	17970	19165	20426	21727	23100	24505	26006
Year on Year Growth		7%	7%	7%	7%	7%	7%	6%	6%	6%	6%

In addition to the above demand, a PSP pumping demand of (2628 MU) corresponding to 900 MW of load for 8 hrs (off-peak) pumping has also been considered from the year 2031-32 and 2033-34.

Consequently, the final energy demand considered for the study is given in Table 20.

Table 20: Total Electrical Energy Requirement

Total Energy Requirement (in MU)											
	2025-26	**2026-27**	**2027-28**	**2028-29**	**2029-30**	**2030-31**	**2031-32**	**2032-33**	**2033-34**	**2034-35**	**2035-36**
APDCL Energy Projections (in MU)	13709	14694	15732	16823	17970	19165	23054	24355	28356	29761	31262

The capacity projections for APDCL are given in the Table 21.

Table 21: Capacity projections (in MW)

Year	COAL	GAS	HYDRO	WIND	SOLAR	Storage (4 Hr)	DRE	SToA/MToA
2025/26	790	771	1085	100	204	0	117	800
2026/27	790	606	1399	200	604	25	162	800
2027/28	944	606	1399	300	1004	25	212	800
2028/29	1244	606	1399	400	1354	234	267	800
2029/30	1560	606	1399	500	1754	234	330	750
2030/31	1764	606	1399	600	2154	234	352	800
2031/32	2265	606	1399	700	2554	234	375	1047
2032/33	2548	606	1399	800	2954	294	399	1050
2033/34	2973	606	1399	900	3254	294	424	1033
2034/35	3147	606	1399	1000	3579	460	450	1029
2035/36	3423	408	1399	1100	3904	667	477	1050

8.0 Conclusions

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

1. The study has been done based on the hourly load pattern of the year 2024-25. It has been observed that the peak demand season is typically from August to September with peak demand occurring during non-solar hours.
2. The study has considered energy requirement projections as per the projections of APDCL, which envisages that the annual energy requirement of the state is likely to grow at a CAGR of 11.2% while the peak demand for the utility is likely to grow at a CAGR of 9.9% for the period of 2025-26 to 2035-36.
3. Assam is likely to witness energy deficit ranging from 1.8 to 21.4 BUs in different years from 2025-26 to 2034-35 with the existing and planned capacity addition only.
4. The state is likely to have unserved energy in coming years and need to contract fossil-based capacities for meeting energy requirements other than the planned capacities. Additional coal-based capacities of about 2,829 MW have to be tied-up by the year 2035-36. In addition to this, the state shall have a likely requirement of MToA/ SToA ranging from around 837 to 950 MW in different years as outlined in the report. The SToA/MToA requirement can be fulfilled through power procurement from markets or bilateral agreements. The SToA/MToA value reflects the peak value requirement and seasonal banking requirements in terms of MW.

5. The projected capacity and generation mix outlined in the report meet the utility's RPO requirements for the years 2025-26 to 2035-36.
6. The Planning Reserve Margin (PRM) for Assam for Non-solar and Solar hours has been assessed at 5% and 16% respectively. Further, the study indicates year-wise short-term/medium-term/bilateral requirements inclusive of the PRM capacity to meet the demand optimally.
7. The current capacity mix of the utility has 46% of contracted capacity from non-fossil fuel sources which is likely to increase to 65% in 2035-36.
8. It is likely that APDCL may have surplus capacity available during all the months except August and September which can be shared with other utilities/states through banking / bilateral arrangements including Pushp portal.
9. The above figures are based on the higher demand projects as per APDCL. Considering the Business as Usual (BAU) Scenario, the capacity mix in 2035-36 will include 3,423 MW coal, 408 MW Gas, 1,399 MW Hydro, 1,100 MW Wind, 3,904 MW Solar, 667 MW Storage, 477 MW DRE and 1050 MW through MToA/SToA.
10. 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, States are strongly encouraged to adopt scientific tools and robust methodologies for demand forecasting.
11. 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.

****

Annexure

Planned Future Contracted (MW) considered in the study

Sr. No.	Tied capacity name	Type of generation	Expected COD	APDCL share (in MW)
1.	Shakti Scheme	Thermal	2025-26	200
2.	Shakti Scheme	Thermal	2028-29	300
3.	Talcher	Thermal	2027-28	154
4.	Subansiri	Hydro	2025-26	188
5.	Subansiri	Hydro	2026-27	78
6.	Punatsangchhu-II	Hydro	2025-26	58
7.	Punatsangchhu-II	Hydro	2026-27	116
8.	Lower Kopili	Hydro	2026-27	120
9.	APDCL Solar	Solar	2027-28	500
10.	OTPC BESS	Battery	2025-26	25

Plant retirements considered in the study

Sr. No.	Capacity name	Type of generation	Retirement year	APDCL share (in MW)
1.	Agartala GT	Gas	2035-36	59
2.	Assam Gas based	Gas	2035-36	164
3.	Namrup	Gas	2035-36	139

Assumption for Resource Adequacy Studies

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

RE CUF considered

Hydro	Wind	Solar	DRE
44-48 %	22%	19%	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	-	-	-	-
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 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	11.5 Cr	19.54 Lakh	4	25
Solar	5 Cr	1 % of Capex	0.5	25
Wind(Onshore)	8 Cr	1% of Capex	1.5	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