REPORT ON
RESOURCE ADEQUACY PLAN
FOR THE STATE OF
ASSAM
(2024-25 to 2029-30)

GOVERNMENT OF INDIA
MINISTRY OF POWER
CENTRAL ELECTRICITY AUTHORITY

Executive Summary

The electricity demand for the State of Assam is increasing with a CAGR of 6.19 % from 2023-24 to 2031-32 as forecasted by 20th EPS. The projections of APDCL also indicate that electricity demand may increase with a CAGR of 1.87 % from 2023-24 to 2029-30. For satisfying resource adequacy i.e., meeting the electricity demand reliably and at affordable cost, the State need to methodically plan its capacity expansion either by investing 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 electricity demand typically remains similar from the month of January to March. April onwards, it starts increasing and peaks around monsoon months of August and September. The demand during the months of January, February and March is significantly lower compared to rest of the year. The peak electricity load is generally observed during night hours.

Ministry of Power had notified Electricity (Amendment) Rules in December, 2022. As per Rule 16 of the Electricity (Amendment) Rules, Ministry of Power has notified Resource Adequacy guidelines. As per the Resource Adequacy (RA) Guidelines, Central Electricity Authority is entrusted to prepare Long Term-National Resource Adequacy Plan (LT-NRAP). Further Distribution Utility need to carry out LTDRAP (Long term Discoms Resource Adequacy Plan) to meet the utility peak and energy requirement reliably.

The Government of India has recently notified new Renewable Purchase Obligation (RPO) trajectory till 2029-30 which ensure certain amount of energy consumption to be met from renewable energy sources. While carrying out the RA Studies, it was ensured that RPO is met.

With the existing and planned capacity, the hourly generation dispatch analysis has been carried out to assess the hourly demand supply position till 2029-30 for Assam based on inputs received from APDCL. It was found that the state's existing contracted capacity along with capacity addition plans for conventional as well as renewable energy sources may not be adequate to meet projected demand.

To find out the least cost option for generation capacity expansion for the period 2023-24 to 2029-30, long-term study for the State of Assam was 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.

Reliability analysis was also carried out with varying demand, RE Generation and forced outage of coal-based capacities. Based on the study, the likely contracted capacity of the state of Assam is 7,371 MW which comprises of 1206 MW from Coal, 771 MW from Gas, 1546 MW from Hydro, 241 MW from Wind, 2502 MW from Solar and 1105 MW from Short term/Market based contracts.

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 order dated 22nd July 2022 had notified the RPO trajectory for the states. Based on the trajectory specified the 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 have to contract in addition to its existing/planned capacity to meet their RPO targets.

Resource Adequacy studies has been carried out for Assam based on the inputs received from APDCL and to fulfill the RPO trajectory. The study suggests the optimal resource mix till 2030 taking into account all technical and financial parameters associated with capacities. The study optimizes power purchase on a long-term basis while evaluating resource adequacy for meeting the demand 24 X 7 considering variation in demand, RE generation and forced outages of thermal capacities. The study has also assessed the requirement of Planning Reserve margin for Assam for catering to above highlighted uncertainties so that demand can be met reliably throughout the year.

2.0 Assam RA Study

2.1 Present Power Scenario in Assam

As of March, 2023, the total contracted capacity for Assam is 2,430 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 44 %.
The fuel-wise contracted capacity as of March, 2023 is given in Table and Figure below:

Table 1 Fuel-wise Contracted Capacity as on March, 2023

Source	Contracted Capacity (MW)	Percentage (%)
Coal	585	24.1
Gas	771	31.7
Hydro	760	31.3
Solar	214	8.8
Wind	100	4.1
Total	2430	100

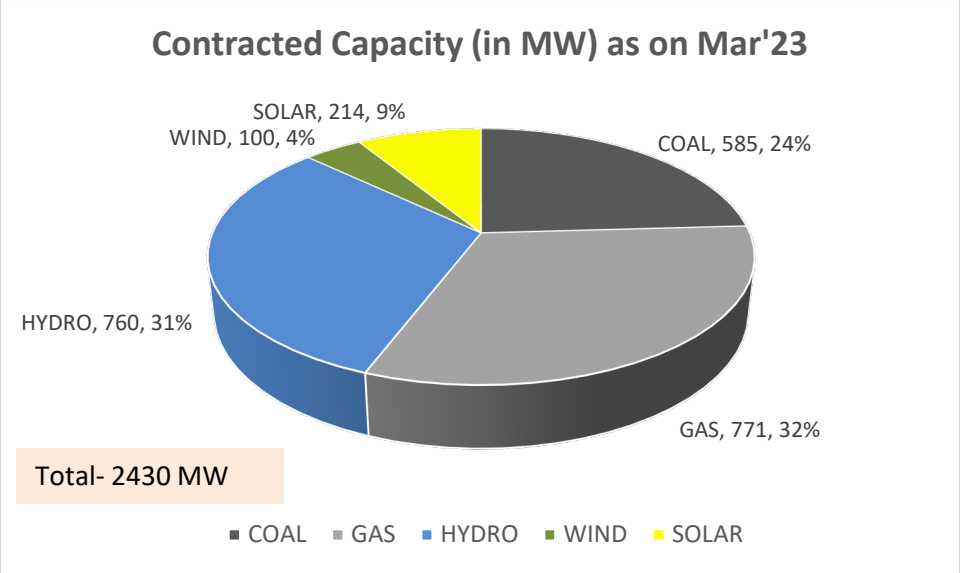


Figure 1 Fuel-wise Contracted Capacity (in MW) as on Mar 2023

2.2 Demand Analysis (2019-20)

In absence of recent demand data and demand distortion due to Covid-19, hourly demand pattern of 2019-20 was analyzed and it was observed that the peak demand season for Assam is during the months of August and September. The Demand during the months from January to

March remains significantly low as compared to other months which reflects the effect of seasonality in demand.

Assam witnesses peak demand during night hours. The day and night peak demand typically remains same for the months of November to March.

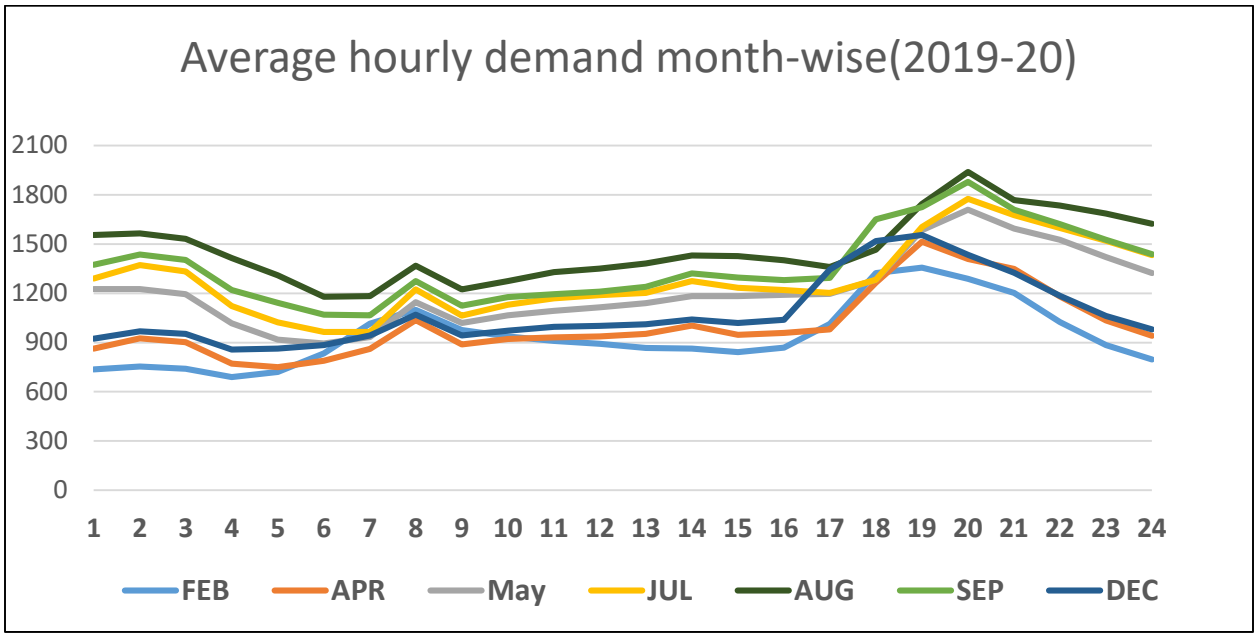


Figure 2 Average Hourly Demand Profile (MW)

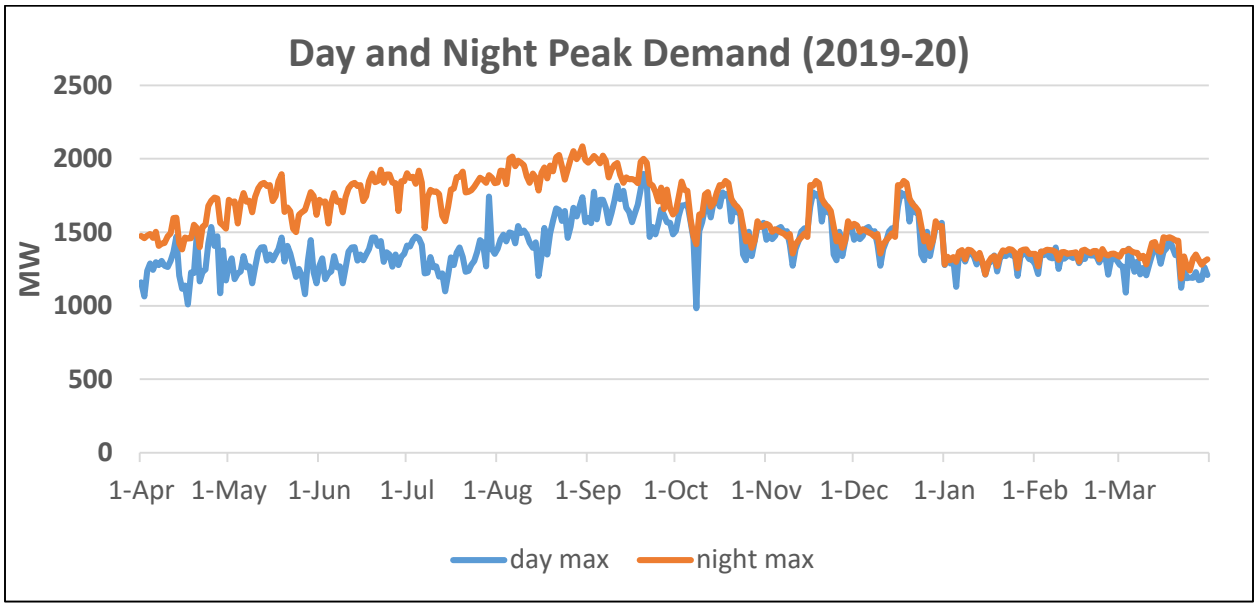


Figure 3 Day and Night Peak in MW of Assam (2019-20)

3.0 Inputs/Assumptions for the Study

i) Peak and Energy Demand for the state of Assam has been taken as per 20th EPS Projections. The Demand estimation furnished by APDCL were lower than projected by 20th EPS and actual demand recorded in 2022-23. Therefore, the Studies have been carried out using 20th EPS projections.

Table 2 Future Demand Projection by 20th EPS

	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30
Energy Projections (MU)	12679	13454	14279	15151	16079	17069	18183
Year on Year Growth	-	6.11 %	6.13 %	6.11 %	6.13%	6.16%	6.53%
Peak Demand Projections (MW)	2526	2689	2861	3045	3240	3449	3683
Year on Year Growth	-	6.45 %	6.40 %	6.43 %	6.40%	6.45%	6.78%

Table 3 Future Demand Projection by APDCL

	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30
Energy Projections (MU)	10804	11006	11212	11422	11636	11855	12077
Year on Year Growth	-	1.87%	1.87%	1.87%	1.87%	1.88%	1.87%
Peak Demand Projections (MW)	2419	2600	2792	2969	3151	3366	3612
Year on Year Growth	-	7.5%	7.4%	6.3%	6.1%	6.8%	7.3%

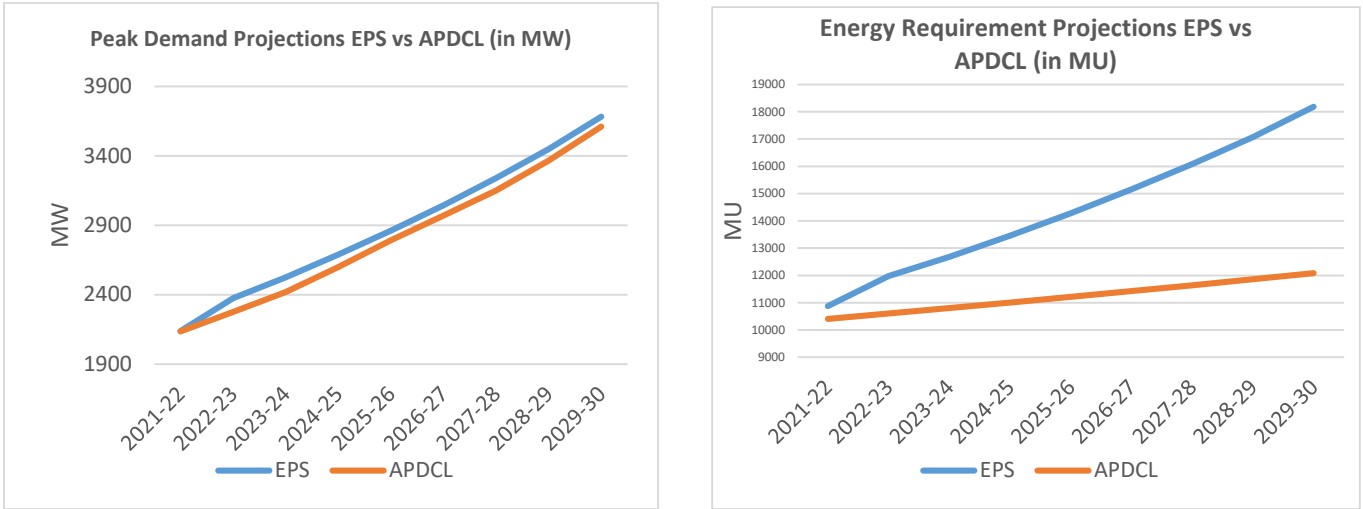


Figure 4 Comparison of Energy Requirement and peak Demand Projections of EPS vs APDCL

ii) Future demand profile for the year 2029-30 has been projected using the demand profile for the year 2019-20 as the base profile with the demand of March 2020 replaced with that of March 2019, to take care of the demand distortion due to Covid-19.

iii) The actual hourly solar and wind generation profiles and CUFs of Southern Region have been considered for the Study.

iv) Capital cost of candidate plants for Coal, Battery and PSP have been referred from National Electricity Plan.

v) Existing & Planned Capacity: As per the information received from APDCL, 785 MW of Hydro Power is planned till 2025-26.

vi) RPO trajectory: In order to meet its Renewable Purchase Obligation (RPO), as per RPO trajectory notified by the Ministry vide order dated 22nd July, 2022, Assam's requirement to add/contract additional renewable capacity (MW) has been assessed as below.

Table 4 Total Energy required to meet RPO (MU) as per MoP order dated 22.07.2022

	2023-24	**2024-25**	**2025-26**	**2026-27**	**2027-28**	**2028-29**	**2029-30**
Wind	203	331	480	650	841	1051	1262
Hydro	84	145	211	273	346	428	513
Other RPO	3146	3548	4022	4524	5054	5580	6104

Table 5 Generation eligible for RPO (MU) as per existing and planned capacity addition*

	2023-24	**2024-25**	**2025-26**	**2026-27**	**2027-28**	**2028-29**	**2029-30**
Wind	0	0	0	0	0	0	0
Hydro	211	1031	1504	1504	1504	1504	1504
Other RPO	2204	2204	2204	2204	2204	2204	2204

Table 6 Surplus/Shortfall (-) in RPO Generation considering Fungibility for Hydro RPO and Other RPO (MU)

	2023-24	**2024-25**	**2025-26**	**2026-27**	**2027-28**	**2028-29**	**2029-30**
Wind	-76	0	0	0	0	0	-271
Hydro	0	554	813	581	317	24	0
Other RPO	-942	-790	-1006	-1739	-2533	-3352	-3900

Additional capacity to be contracted by Assam to meet RPO is given below:

Table 7 As per RPO trajectory, Assam needs to add/contract following additional capacity (MW).

	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	Total
Wind	39.37	0.00	0.00	0.00	0.00	0.00	101.26	**140.62**
Large + Small Hydro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Solar + Other RE	597.23	0.00	0.00	416.93	455.10	471.60	347.51	**2288.37**

4.0 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 very 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.

In addition to the above two metrics, the Planning Reserve Margin (PRM) is a predominant metric used to ensure adequacy of generation resources in the system. PRM in a power system is expressed as certain percentage of peak load forecast of the system.

4.1 Demand variation:

The variation in demand pattern of Assam for last 2 years has been analyzed. The hourly demand variation for consecutive years (i.e. 2021-22 and 2022-23) has been analyzed.

The variation in demand 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 ±5% by introducing a random variable (with normal distribution) for demand as per the observed behavior over the years.

4.2 RE variation

In the Long-term capacity expansion planning studies, a particular profile for Solar and Wind Plants are considered based on the observed solar and wind generation data to determine the optimal capacity mix. However, due to intermittent nature of these sources the generation from these non-dispatchable sources may vary across years. As per the analyses carried out based on historical generation data, solar generation and wind generation has been varied by 5% to incorporate the variation in these generation sources and plan for requisite measures to mitigate such behavior.

4.3 Forced Outage of Thermal Generators

The forced outage rate of thermal generators of APDCL were observed for previous years and it was observed that average forced outage rate is typically at 10% with ±5% variation. The same has been incorporated in the model.

Based on the variation reliability studies are carried out to ascertain robustness of the system. The LOLP & EENS of the system is within specified range.

5.0 Results of the study

5.1 Unserved Energy Projections

The study was carried out considering existing capacity, planned capacity & capacity required to fulfil the RPO obligations. It was observed that the total unserved energy in the year 2029-30 is about 1581 MU. The yearly likely unserved energy with the planned capacities is given below.

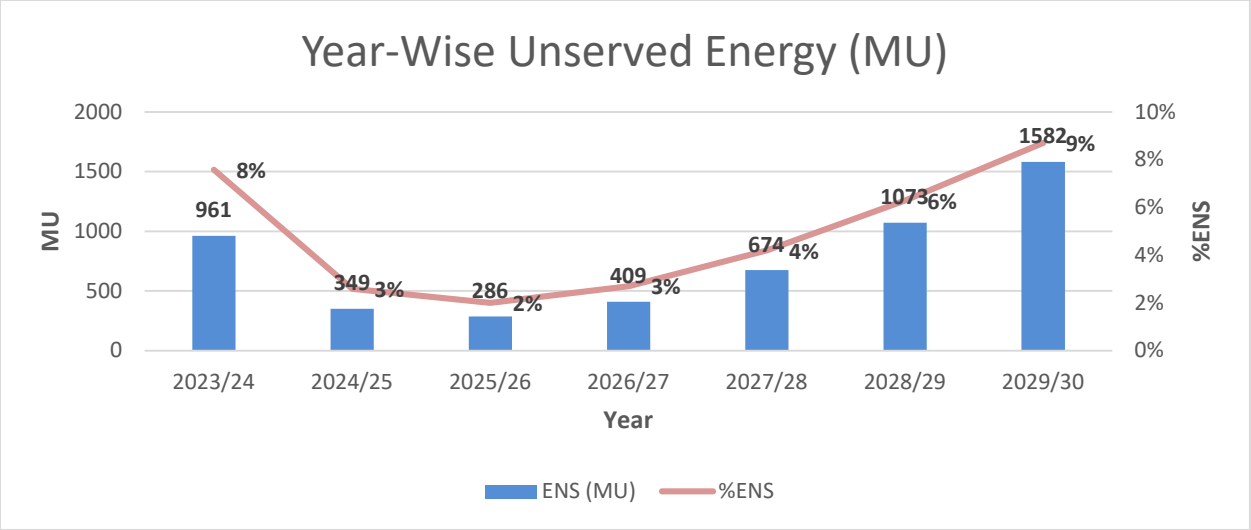


Figure 5 Yearly likely unserved energy with the planned capacities for Assam (in MU)

The study has also analyzed the Daily and monthly pattern of unserved energy in the year 2029-30, it can be seen that the unserved energy coincides with low hydro availability months when the contracted capacity (present and planned) is unable to meet the demand.

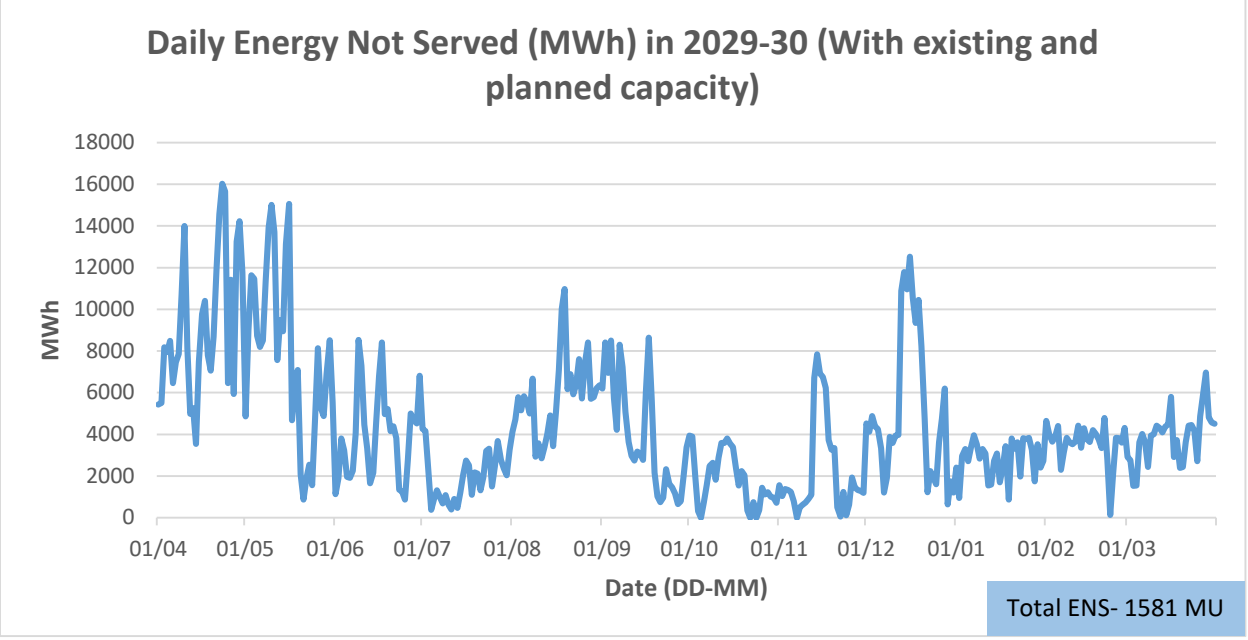


Figure 6 Daily Unserved Energy Pattern MU (2029-30)

5.2 Capacity Mix Projection

To meet the unserved energy, energy investment options (candidate capacities) is given to the model to find the least cost optimal capacity mix required to meet the demand. The following is observed:

i) There is requirement of Coal-based capacity 2027/28 onwards.
ii) The STOA/MTOA requirement can be fulfilled through power procurement from markets or bilateral agreements.
iii) The STOA/MTOA value reflects the peak value requirement in terms of MW.

The capacity projections for Assam are given below:

Table 8 Year-wise capacity projections (in MW)

	COAL	GAS	HYDRO	WIND	SOLAR	STOA/MTOA
2023-24	585	771	840	139	811	962
2024-25	585	771	1252	139	811	790
2025-26	585	771	1546	139	811	733
2026/27	585	771	1546	139	1228	950
2027/28	927	771	1546	139	1683	862
2028/29	1045	771	1546	139	2155	998
2029/30	1206	771	1546	241	2502	1105

The projected capacity mix, year-wise is given in the figure below:

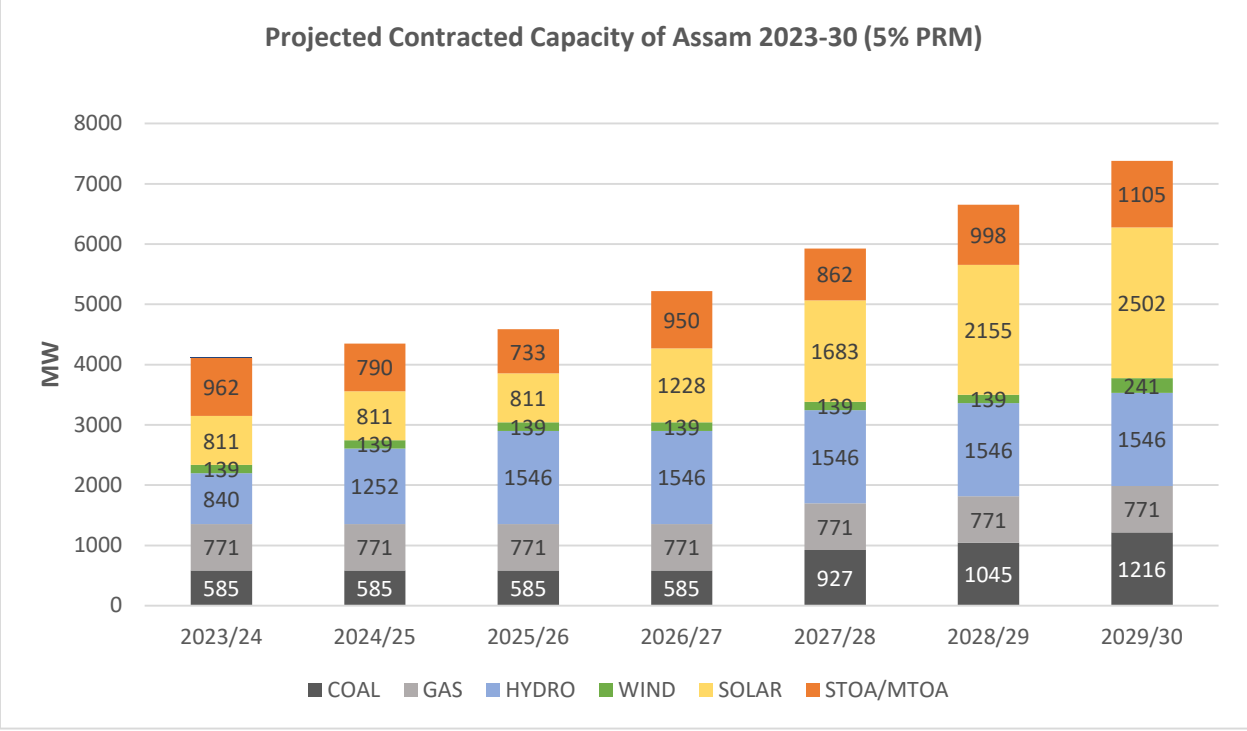


Figure 7 Projected Capacity Mix Year-wise (MW) for Assam

As per the Resource Adequacy studies, the total projected Capacity for the year 2029-30 is 7,371 MW which consists of 1216 MW from Coal, 771 MW from Gas, 1546 MW from Hydro, 241 MW from Wind, 2502 MW from Solar and 1105 MW from STOA. This IC shall be able to meet the projected demand with prescribed reliability criteria.

The Reliability studies have been carried out to adhere to the reliability criteria of LoLP and NENS as provided in NEP (0.2% and 0.05% respectively). The PRM for the state of Assam has been assessed as 5%. In addition, the projected/contracted capacity fulfils the stipulated Renewable Purchase Obligation.

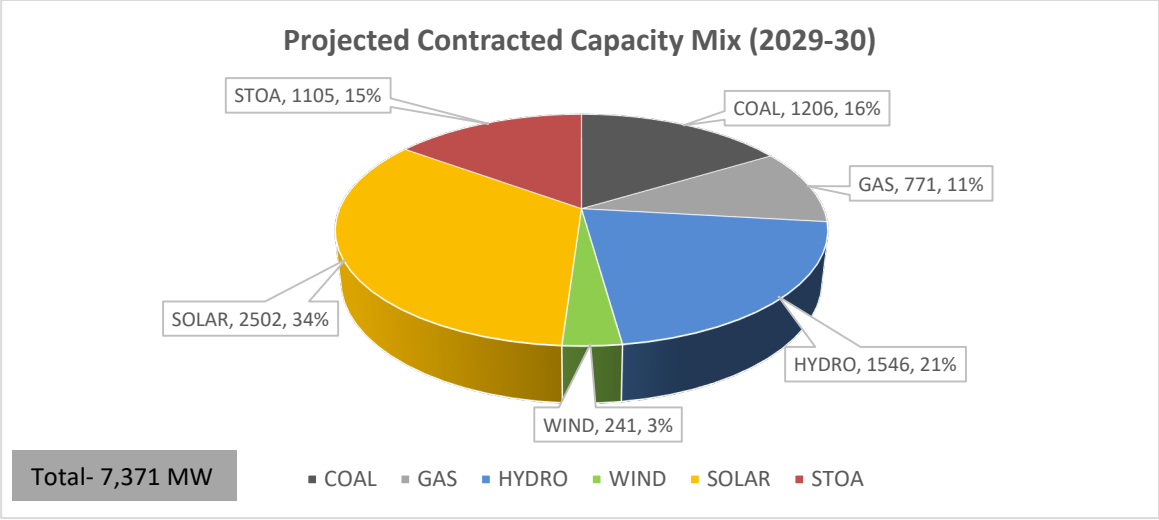


Figure 8 Contracted Capacity Mix in 2029-30 with 5% PRM

The share of non-fossil fuel-based capacity in the total contracted capacity is projected to increase to around 58.23% in 2030 from 44 % in 2022-23 with higher contribution from non-fossil fuel-based capacities in alignment with RPO trajectory.

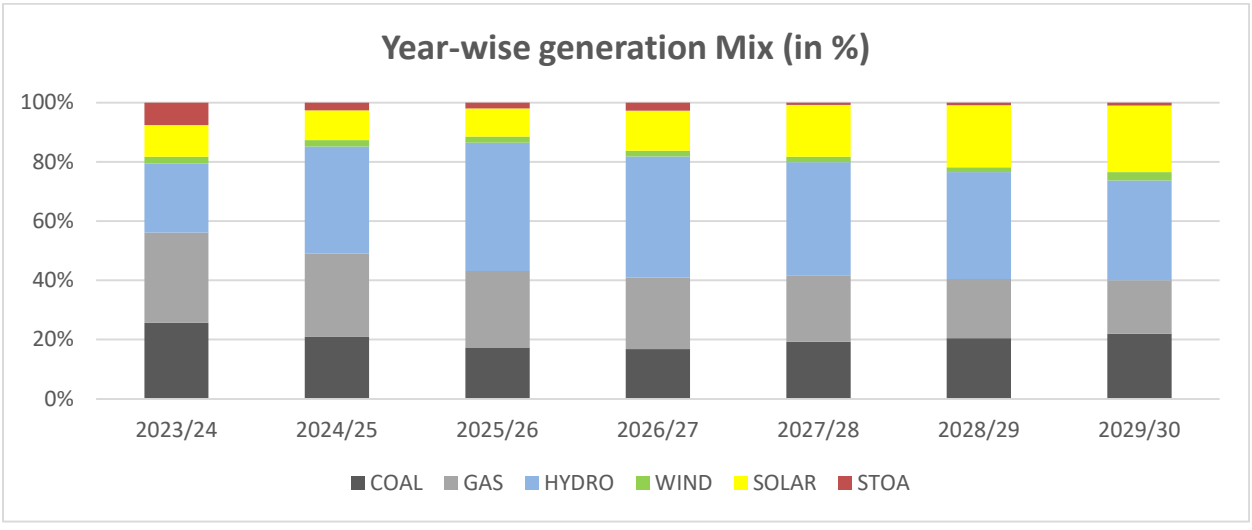
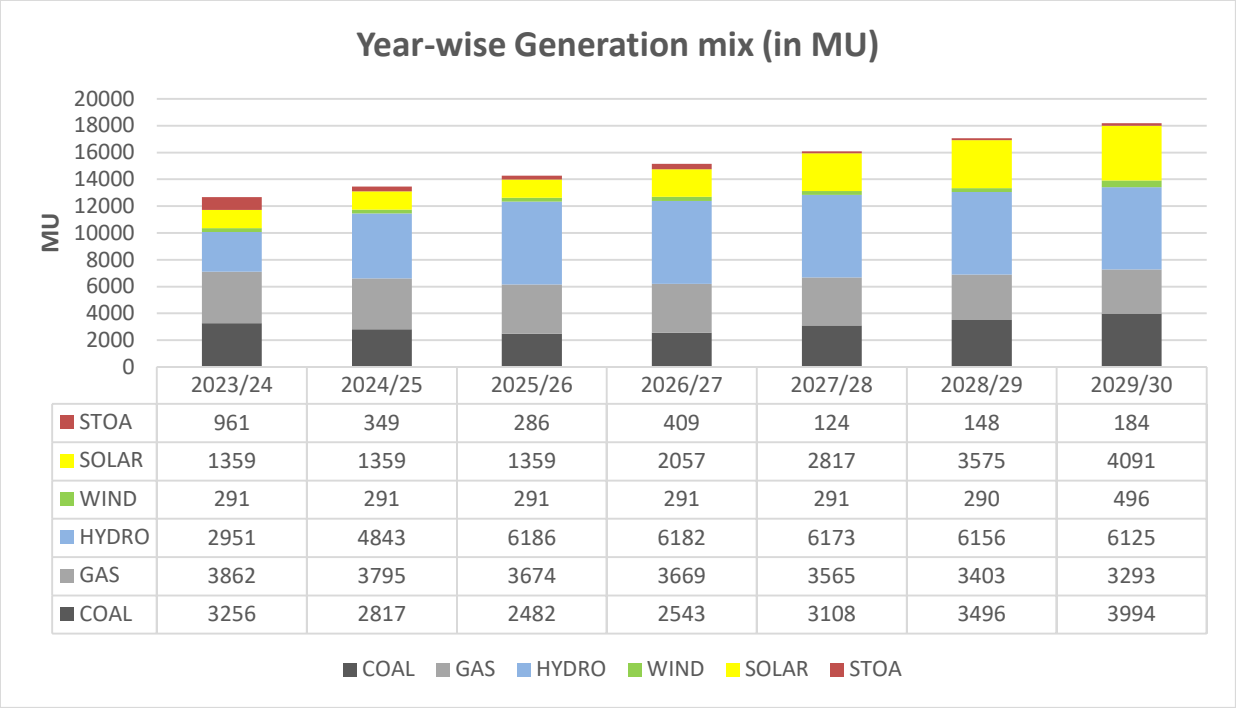


Figure 9 Year-wise projected generation mix (in %age)



	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30
STOA	961	349	286	409	124	148	184
SOLAR	1359	1359	1359	2057	2817	3575	4091
WIND	291	291	291	291	291	290	496
HYDRO	2951	4843	6186	6182	6173	6156	6125
GAS	3862	3795	3674	3669	3565	3403	3293
COAL	3256	2817	2482	2543	3108	3496	3994

Figure 10 Year-wise projected generation mix (in GWh)

5.3 Day-wise Surplus Capacity Assam (MW)

The surplus coal capacity (average MW) available for Assam for the period 2024-25, 2025-26 and 2026-27 is given in the figure below. This is calculated as the difference between the maximum dispatch in MW during the year and the dispatch in a particular two-hourly block.

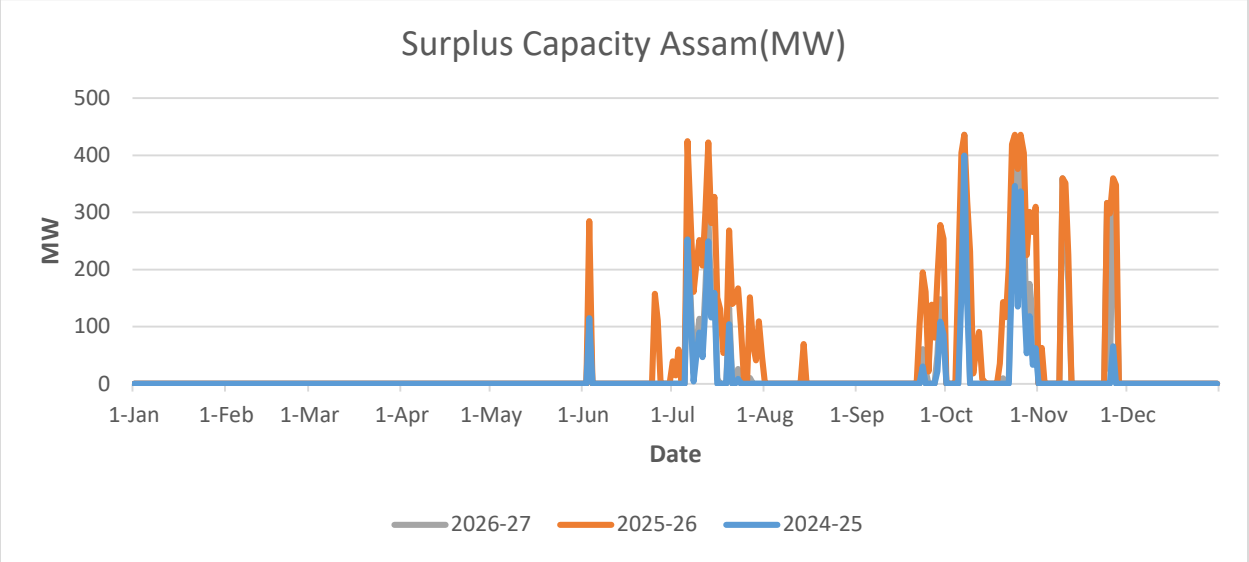


Figure 11 Surplus Coal Capacity Year-wise (MW)

It can be seen from the above graph that the surplus coal capacity is substantial during the months of July, September, October and November for Assam for the all the three years, as compared to the other months, with the maximum surplus being around 430 MW for the year 2026-27.

5.4 Coal Capacity Performance

The coal capacity PLF is expected to remain in the range of 40%- 67% for the years till 2030 indicating higher absorption of renewable energy.

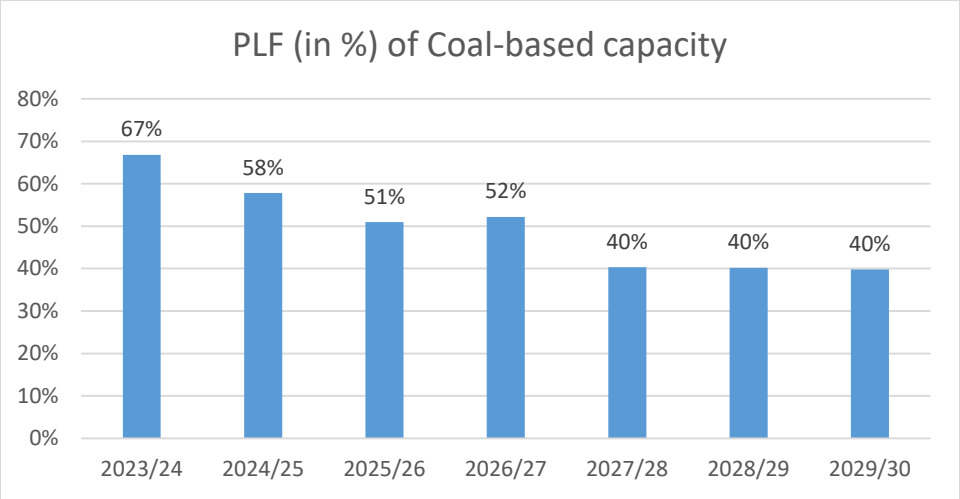


Figure 12 Year-wise coal capacity PLF for Assam (in %)

6.0 Capacity contract requirement for future

It has been found out in the studies that Assam needs to contract following capacities (planned and additional) per year-wise till 2030 to meet its demand reliably along with fulfilment of its RPO as notified by MoP.

Table 9 Year wise Capacity Addition for Assam (in MW)

FY	COAL	HYDRO	WIND	SOLAR	STOA	Total	
	Additional	Planned	Additional	Additional	Additional	Planned	Additional
2023-24	0	80	39	597	962	**80**	**1598**
2024-25	0	412	0	0	790	**412**	**790**
2025-26	0	294	0	0	733	**294**	**733**
2026-27	0	0	0	417	950	**0**	**1367**
2027-28	341	0	0	455	862	**0**	**1658**
2028-29	118	0	0	472	998	**0**	**1588**
2029-30	171	0	102	347	1105	**0**	**1725**

7.0 Alternate Resilient Scenario Analysis

In view of the recent surge in Power demand during the year 2023-24 and capacity addition being delayed vis-a –vis the envisaged timelines, it was realized that stress scenario may be assessed to comprehend such situations arising in the future and prepare the utilities for navigating such challenging situations optimally so as to fulfil their consumer end demand reliably.

The following cases were considered to occur simultaneously in the stress scenario:

- Peak Demand and Energy- 5% increase compared to the APDCL demand projections.
- Capacity Addition being delayed from their anticipated year as follows:

Table 13 Time Delay in commissioning of contracted capacity

Contracted Capacity Type	Years Delayed
Hydro/PSP	2
Renewable Energy Capacity	1

7.1 Capacity Mix Projections

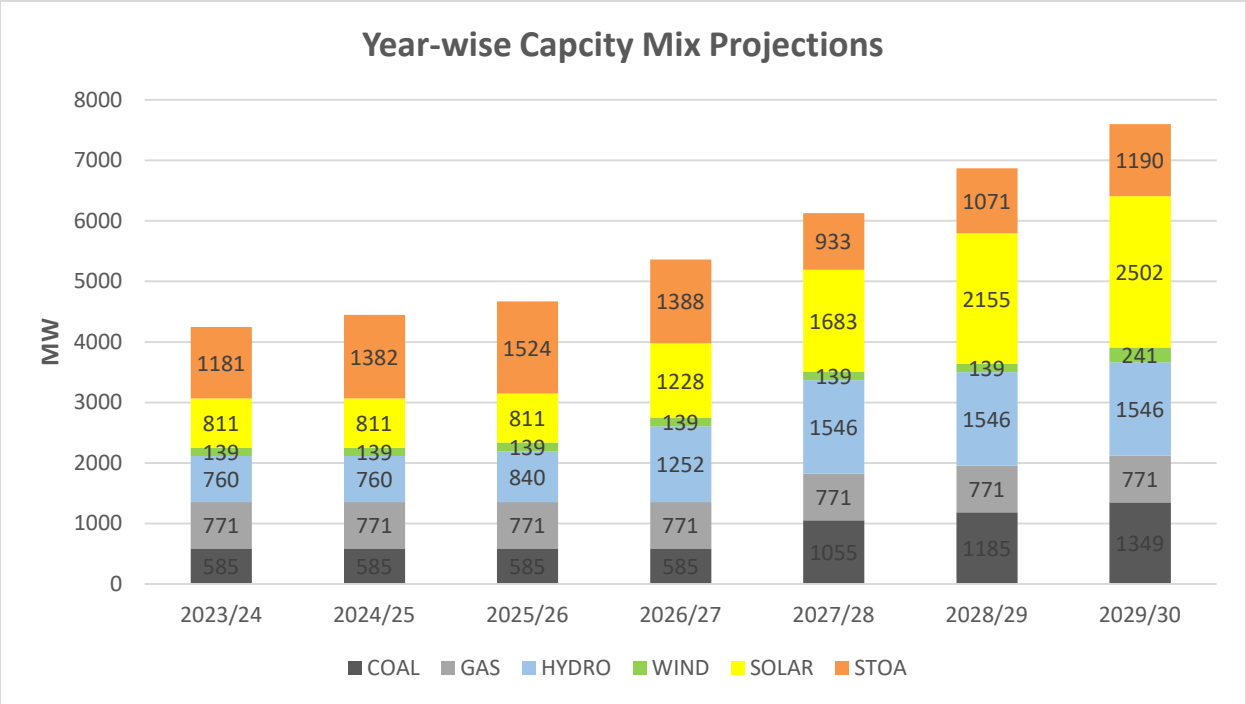


Figure 13: Year-wise capacity projections (in MW) for Most Resilient Scenario

In this scenario, the coal requirement in the year 2029-30 increases by around 143 MW in case of stress case scenario compared to the base case.

Also, the requirement of Short term market based contracts for meeting the peak demand in stress case scenario increases by around 85 MW.

8.0 Conclusion

The study has considered demand projections of 20th EPS for assessing the resource adequacy of Assam. The demand projections by APDCL are lower compared to the demand projections by 20th Electric Power Survey (EPS).

The current capacity mix in Assam has 56% of contracted capacity from fossil fuel sources. The peak demand season is typically from August to September with peak demand occurring during night time.

The study has been done based on the hourly load pattern of the year 2019-20.

Assam is likely to witness energy deficit ranging from 280 MUs to 1580 MUs in different years from 2023-24 to 2029-30 with the existing and planned capacity addition. Assam is deficit in fulfilment of its Renewable Purchase Obligations (RPO) and further needs to contract Solar and Wind capacities to fulfill its Renewable Purchase Obligations. The projected capacity and generation mix fulfils the RPO obligations by 2030 as specified by Ministry of Power.

Assam 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. Assam requires additional coal-based capacities to be procured other than the capacity already planned. The quantum of coal-based capacities required to be contracted is about 341 MW in the year 2027-28 which increases to around 630 MW in the year 2029-30.

The energy requirement to be met from STOA in the year 2029-30 is about 2% of the total energy requirement but is critical in months of peak demand to fulfil the end consumer demand. STOA value reflects the peak value (MW) requirement in the capacity mix.

The coal capacity PLF is expected to remain in the range of 40%- 67% for the years till 2030 ensuring higher absorption of higher renewable energy.

The Alternate Resilient Scenario carried out for Assam for possibility of higher demand than projected by 20th EPS has revealed that the coal requirement increases by around 143 MW in 2029-30 compared to the base case scenario. The dependency on STOA also increases compared to the base case scenario.

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Assumption for Resource Adequacy Studies for the state of Assam

1. Electricity Demand & peak requirement: As per 20th EPS projections
2. Demand Profile: Based on hourly demand profile of 2019-20.
3. Existing & Planned Capacity: As per the information received from APDCL
4. Future Capacity addition: based on RPO trajectory
5. Cost parameters: based on information received from APDCL and NEP

RE CUF considered

Hydro Existing/ Planned PLF	Bioenergy PLF	Solar Existing/ Planned CUF	Wind Planned/ Existing CUF	PSP/ Small Hydro CUF
37%/45 %	18%	16% / 18%	33% / 22%	25% /15%

RPO Trajectory

	RPO Target Trajectory (%)							
	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30
Wind RPO	0.81	1.60	2.46	3.36	4.29	5.23	6.16	6.94
Hydro RPO	0.35	0.66	1.08	1.48	1.80	2.15	2.51	2.82
Other RPO	23.44	24.81	26.37	28.17	29.86	31.43	32.69	33.57

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	20	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	-	-	-	-

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
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 for the candidate capacities:

Resource	Capex* (in ₹/MW)	O&M Fixed Cost (in ₹/MW)	Construction Time (in years)	Amortization /Life time (in years)
Coal	8.34 Cr	19.54 Lakh	4	25
Solar	4.1	1 % of Capex	0.5	25
Pumped Storage	6 Cr	4 % of Capex	7	40
Battery Energy Storage (4-Hour)	5.62 Cr to 4.72 Cr	1 % of Capex	0.5	14
Battery Energy Storage (5-Hour)	6.62 Cr to 5.51 Cr	1 % of Capex	0.5	14
Battery Energy Storage (6-Hour)	7.61 Cr to 6.30 Cr	1 % of Capex	0.5	14

* All the Capex figures are on actual basis at the cost level of 2021-22 i.e., inflation is not considered while calculating capex.

~ The Capex values of PSS candidates are considered as per the project cost details furnished by the respective developers for state and private sector plants and as per RCEs done periodically by CEA for central sector plants.