

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

(Version 3.0)

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Government of India
Ministry of Power
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Disclaimer

This Resource Adequacy study for Karnataka has been conducted based on the data and inputs provided by Karnataka SLDC/ PCKL. The findings, analysis and conclusions presented in this report are contingent upon the accuracy, completeness and timeliness of the information furnished by Karnataka. 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 Central Electricity Authority (CEA). CEA has facilitated this study and prepared the report solely to assist Karnataka in fulfilling this requirement.

It is expressly stated that the responsibility for the implementation of the study's recommendations, ensuring the adequacy of electricity resources, and undertaking any related actions, including financial implications, if any, rests entirely with Karnataka.

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 the Resource Adequacy (RA) Guidelines. According to these Guidelines, Central Electricity Authority (CEA) is entrusted with the responsibility of preparing the Long-Term National Resource Adequacy Plan (LT-NRAP). Further, each Distribution Utility is required to carry out a Long-Term Distribution Licensee Resource Adequacy Plan (LT-DRAP) to reliably meet its peak electricity demand and electrical energy requirements.

As per the Resource Adequacy Guidelines dated 28th June 2023, each Distribution Licensee shall undertake a Resource Adequacy Plan (RAP) with a 10-year planning horizon, LT-DRAP, to meet its own peak electricity demand and electrical energy requirements. This plan shall be vetted/validated by CEA to leverage the benefits of national-level optimisation 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 optimising the requirement for additional capacity.

Government of India has gazette-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 electrical energy consumption must be met from renewable energy sources.

To support the utility in fulfilling this requirement, CEA, in collaboration with the utility, conducted a Resource Adequacy (RA) study with a planning horizon up to FY 2034-35, based on the data received from the utility and in compliance with the RPO trajectory specified vide gazette notification 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 utility and planning assumptions.

The electrical energy requirement and peak electricity demand for Karnataka are increasing with a CAGR of 7.4% and 7.7% respectively, from 2025-26 to 2035-36 as forecasted by Karnataka. For satisfying resource adequacy, i.e., meeting the electricity demand reliably and at an affordable cost, the utility needs to methodically plan its capacity expansion either by investing in generation capacity or by procuring power. In view of the reduction in cost of solar, wind and technology options like Energy Storage Systems, planning for a long-term optimal generation capacity mix gains tremendous importance so that the future generation capacity mix is cost-effective as well as environmentally friendly.

A study has been carried out for Karnataka, considering the existing contracted capacity and planned capacity addition. It was found that Karnataka's likely contracted capacity may not be

sufficient to meet the projected electricity demand. Further, the total unserved electrical energy in the year 2035-36 is expected to be about 8913 MUs, which is about 4.4% of the projected annual electrical energy requirement during the year 2035-36.

To find out the least cost option for generation capacity expansion for the period 2025-26 to 2035-36, a long-term study has been carried out with the objective to minimise 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 plans of the utility, along with RPO constraints. The renewable capacities have been assessed in view of adherence to the RPO trajectory gazette notified by the Ministry of Power, considering the fungibility among different sources.

The Resource adequacy studies have projected a likely optimal capacity mix for future years till 2035-36, which is able to meet the projected electrical demand reliably. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 1,04,571 MW which consists of 13874 MW from Coal, 370 MW from Gas, 1924 MW from Nuclear, 5258 MW from Hydro, 16101 MW from Wind, 28763 MW from Solar, 392 MW from Biomass & Cogen, 12137 MW from Distributed Renewable Energy (DRE) sources, 15752 MW/74004.5 MWh of Energy storage and 10000 MW of MTOA/STOA arrangement will be required. This capacity shall be able to meet the projected electricity demand with the prescribed reliability criteria.

1.0 Introduction

Ministry of Power has notified the 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 were notified in June 2023 by the Ministry of Power in consultation with the 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 the demand-supply situation in the grid precisely due to high seasonality and intermittency in RE generation. Resource Adequacy exercise may also help in the assessment of capacity requirements to be tied up or contracted on a long-term, medium-term, and short-term basis.

Further, the 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 their 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 Karnataka based on inputs furnished by the Utility. 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 optimise long-term power procurement while ensuring resource adequacy to meet the electricity demand on a 24x7 basis, considering variations in electricity demand, variations in RE generation, and forced outages of thermal units. The study assesses the Planning Reserve Margin (PRM) required by the utility 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 Utility up to FY 2034-35, based on inputs from Karnataka SLDC/ PCKL and in accordance with the RPO trajectory specified in the Ministry of Power's gazette notification dated 20th October, 2023.

2.0 Highlights of the Previous RA Study (up to FY 2034-35)

1. In the earlier Resource Adequacy (RA) study, financial year 2023-24 had been considered as the base year and the study covered the period from 2025-26 to 2034-35. The fuel-wise contracted capacity as on 31st March, 2024 is given in Figure 1 below:

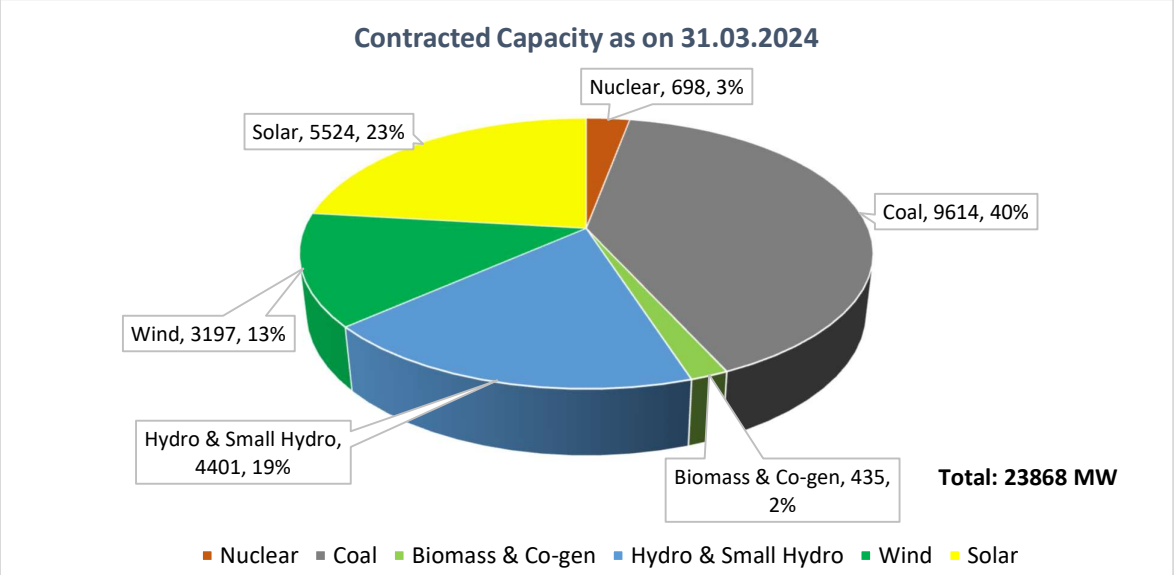


Figure 1: Fuel-wise Contract Capacity (in MW) as on March 2024

2. The hourly demand pattern for 2023-24 had been analysed and considered for the study.
3. The peak electricity demand and electrical energy projections as furnished by Karnataka had been considered for carrying out the resource adequacy study for the state. The demand data in terms of peak electricity demand and electrical energy projections is given in Table 1.

Table 1: Electrical Energy requirement (MU) and Peak electricity demand (MW) projections

Year	**2024-25**	**2025-26**	**2026-27**	**2027-28**	**2028-29**	**2029-30**	**2030-31**	**2031-32**	**2032-33**	**2033-34**	**2034-35**
Electrical Energy Requirement Projections (MU)	92648	100066	107998	118181	125868	134910	144142	153230	164064	176022	189667
Year-on-Year Growth		8.0%	7.9%	9.4%	6.5%	7.2%	6.8%	6.3%	7.1%	7.3%	7.8%
Peak electricity demand Projections (MW)	16579	18075	19690	21745	23372	25051	26765	28453	30464	32685	35218
Year-on-Year Growth		9.0%	8.9%	10.4%	7.5%	7.2%	6.8%	6.3%	7.1%	7.3%	7.7%

4. The actual peak electricity demand and electrical energy requirement of the utility observed during 2024-25 is given in Table 2 below:

Table 2: Actual Electrical Energy Requirement and Peak Electricity Demand in 2024-25

Year	Actual electrical energy requirement (in MU)	Actual peak electricity demand (in MW)
2024-25	92,550	18,395

5. To meet the projected peak electricity demand and electrical energy requirement (as given in Table 1) reliably, the source-wise projected generation capacity (in MW) as outlined in the previous report is given in Table 3.

Table 3: Year-wise capacity projections (in MW)

Year	Nuclear	Coal	Gas	Biomass & Cogen	Hydro	Wind	Solar	PSP	BESS	DRE	STOA
2024-25	698	9614		435	4401	3197	5524				
2025-26	782	9614	370	435	4401	3197	8587	0	1000	1713	3571
2026-27	1003	10614	370	435	4401	4197	10087	0	1000	2378	4025
2027-28	1224	11614	370	435	4401	5947	11087	0	1000	3180	4943
2028-29	1224	11914	370	435	4401	6897	11287	0	1000	4003	6302
2029-30	1924	12026	370	435	4401	8647	14287	3000	1000	4950	3907
2030-31	1924	12026	370	435	4401	10397	16717	4500	1000	5877	3709
2031-32	1924	13506	370	435	4401	11147	16717	4500	1000	6872	4196
2032-33	1924	13875	370	435	4401	11897	17739	4500	1000	8027	5825
2033-34	1924	14884	370	435	4401	12647	18665	4500	1000	9329	7175
2034-35	1924	15735	370	435	4401	13397	20353	4500	1000	10826	8883

*****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.

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

Table 4: Year wise capacity additions for Karnataka (in MW)

FY	Coal		Wind		Solar	
	Planned	Additional	Planned	Additional	Planned	Additional
2024/25	0	0	0	0	753	0
2025/26	0	0	0	0	2310	0
2026/27	1000	0	1000	0	1500	0
2027/28	1000	0	1000	750	1000	0
2028/29	300	0	200	750	200	0
2029/30	0	112	1000	750	1000	2000
2030/31	0	0	1000	750	1000	1430
2031-32	1480	0	0	750	0	0
2032/33	0	369	0	750	0	1021
2033/34	0	1009	0	750	0	926
2034/35	0	851	0	750	0	1688
FY	Nuclear	Gas	PSP	Battery	DRE	Yearly STOA
	Planned	Planned	Planned	Planned	Additional	Additional
2024/25	0	370	0	0	1133	3374
2025/26	84	0	0	1000	580	3571
2026/27	221	0	0	0	664	4025
2027/28	221	0	0	0	802	4943
2028/29	0	0	0	0	823	6302
2029/30	700	0	3000	0	948	3907
2030/31	0	0	1500	0	926	3709
2031-32	0	0	0	0	995	4196
2032/33	0	0	0	0	1155	5825
2033/34	0	0	0	0	1303	7175
2034/35	0	0	0	0	1496	8883

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

3.1 Present Power Scenario in Karnataka

As of March 2025, the total contracted capacity of Karnataka is 23,869 MW, including 37 MW DRE. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 58.7%. Fuel-wise contracted capacity as on 31st March, 2025, is given in Table 5 and Figure 2:

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

Source	Contracted Capacity (MW)	Percentage (%)
Coal	9494	40%
Gas	370	2%
Nuclear	698	3%
Solar	5526	23%
Wind	3001	13%
Hydro	4352	18%
DRE	37	0.2%
Biomass & Cogen	392	2%
Total	**23869**	**100%**

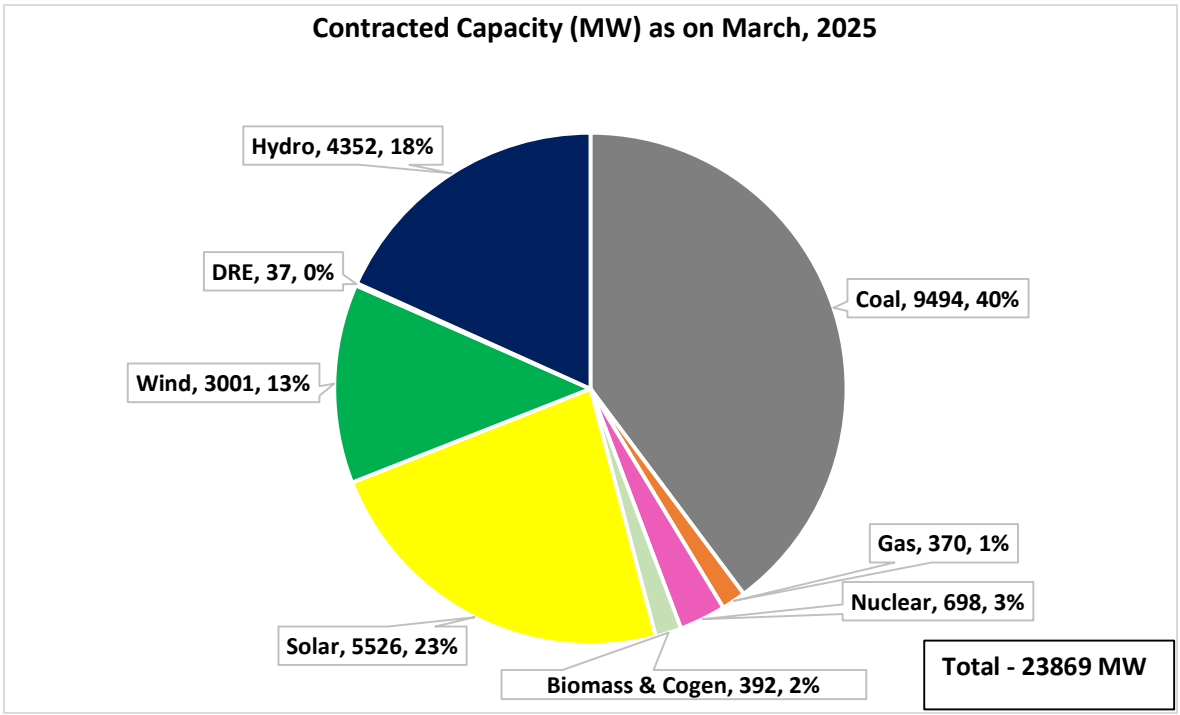


Figure 2: Fuel-wise Contracted Capacity (in MW) as on March, 2025

3.2 Demand Analysis of the FY 2024-25

The hourly demand pattern of 2024-25 was analysed, and it was observed that peak electricity demand occurs during daytime at around 10:00 Hours. Further, it can be observed that the demand is comparatively higher during the months from January to April than the rest of the year. The month-wise variation in average hourly demand observed for the year 2024-25 is depicted in Figure 3.

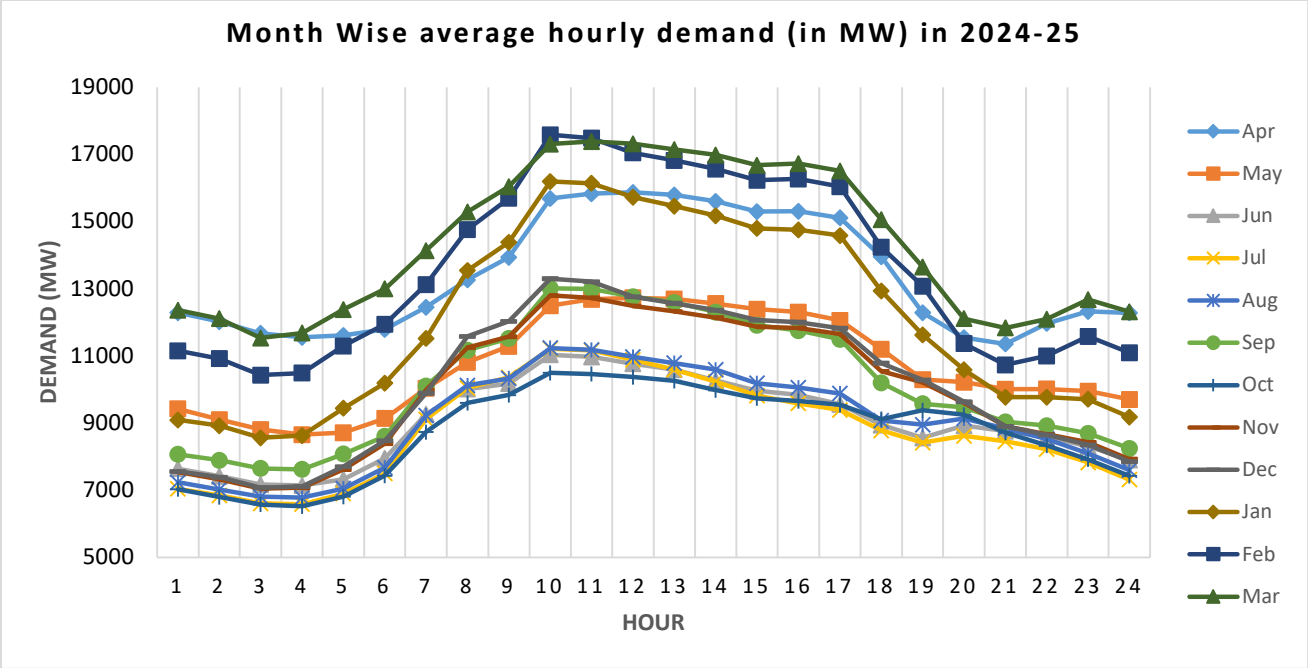


Figure 3: Average Hourly Demand Variation (Month-wise) for 2024-25

From the hourly demand data of 2024-25, the daily peak electricity demand during solar hours and non-solar hours are plotted in the Figure 4.

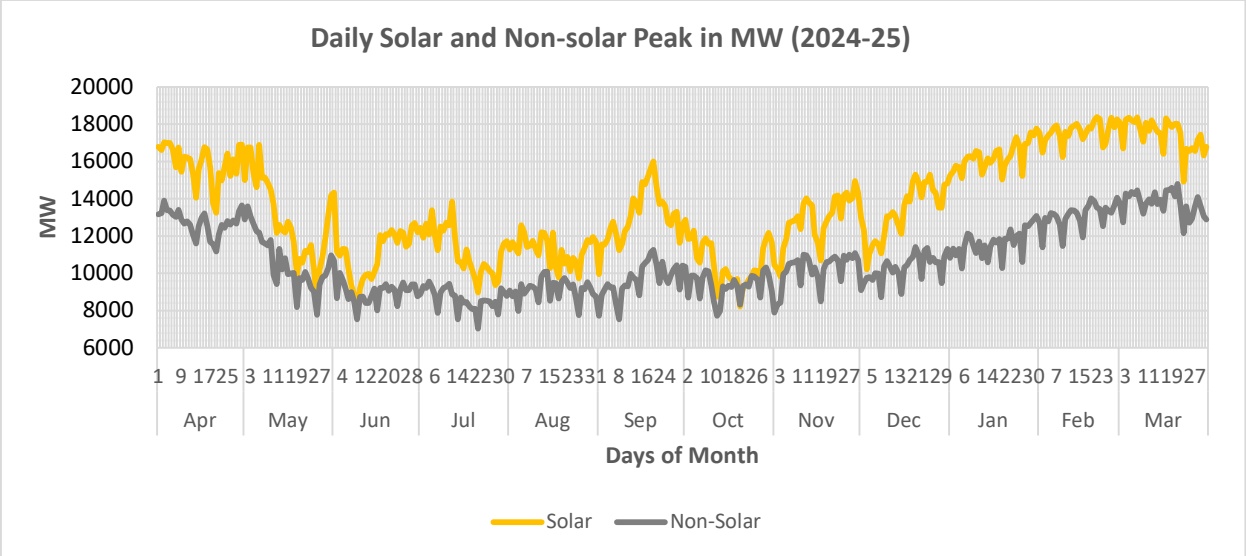


Figure 4: Solar and Non-Solar Peak Electricity Demand in MW for the year 2024-25

As seen from Figure 4 above, the daily peak electricity demand is observed predominantly in solar hours.

The hourly demand pattern for 2024-25 was analysed, as depicted in Figure 5, which shows the number of occurrences of peak and near-peak electricity demand. Such instances are critical for study purpose, as it is necessary to ensure resource adequacy during such instances with an optimal mix of long-term, medium-term and short-term contracts.

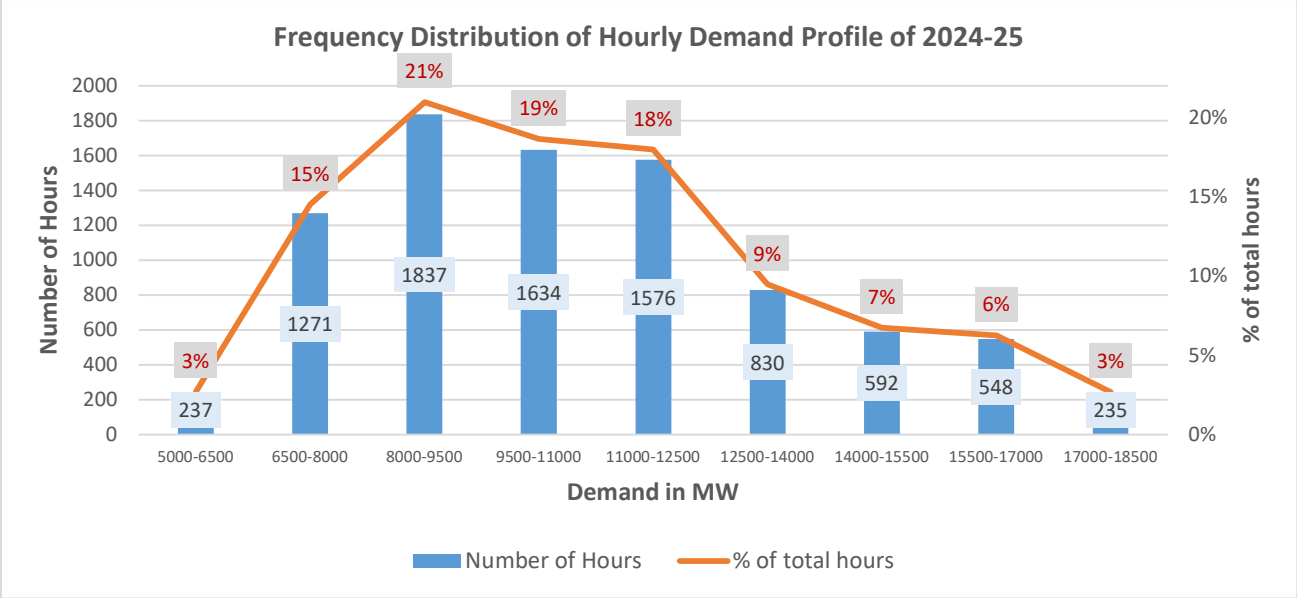


Figure 5: Frequency Distribution of Hourly Demand Profile of 2024-25

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 the objectives of all policies of the Government of India, such as the RPO trajectory, RE capacity addition plan, etc.
iii) To achieve sustainable development.
iv) To fulfil desired operational characteristics of the system, such as reliability and flexibility.
v) Most efficient use of resources.
vi) Fuel availability

4.1 Generation Expansion Planning Tool -STELLAR

Central Electricity Authority (CEA) has successfully developed an indigenously built generation expansion planning tool that integrates long-term capacity planning, economic dispatch, and reliability analysis into a unified framework. Named “STELLAR” (Strategic Expansion for Long-

Term Load Adequacy and Resilience), the tool represents a significant advancement in power system modelling and planning. STELLAR is a state-of-the-art optimisation model framework specifically designed to support long-term decision-making in the electricity sector, with a focus on ensuring resource adequacy, operational resilience, and cost-effective system evolution in line with India's energy transition goals.

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

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

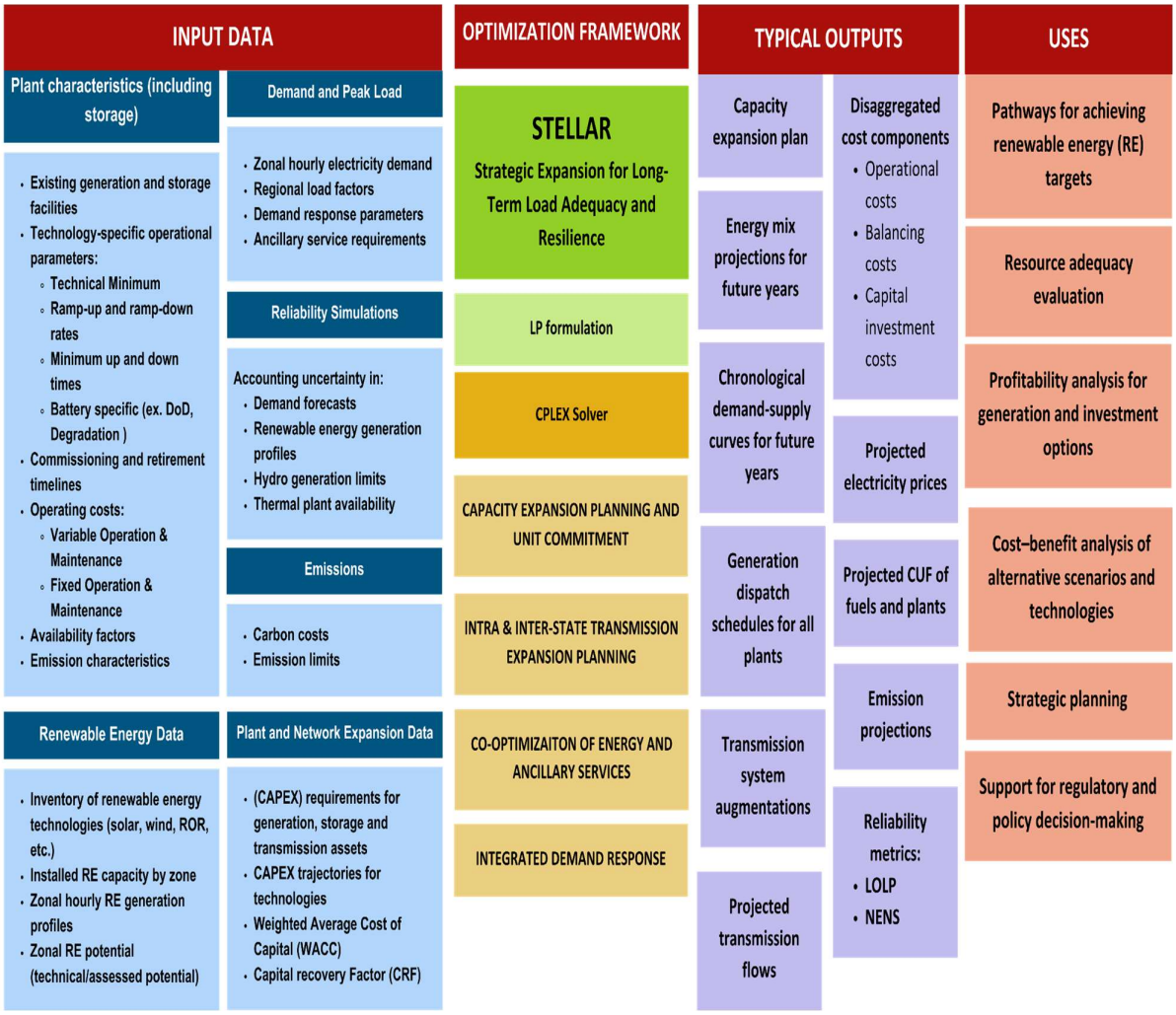


Figure 6: Schematic Diagram

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 in 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 not served, calculated in megawatt-hours (MWh). The metric can be normalised (i.e., divided by the projected electrical energy requirement) to create a Normalised 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 that 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 the economic dispatch model. Monte Carlo simulation helps in analysing the randomness associated with RE energy resource, demand pattern changes and forced outages of the plant. A large number 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 the above variation of system parameters.

Planning Reserve Margin (PRM): To meet the prescribed standard of LOLP / NENS conditions, a sufficient reserve margin needs to be maintained in the system to adequately address 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 percentage of the projected peak electricity demand of the system.

5.1 Demand variation

The hourly demand variation for consecutive years (i.e. 2023-24 and 2024-25, considering 2023-24 as the base) has been analysed. The demand pattern variation of 2023-24 and 2024-25 is given in Figure 6 below:

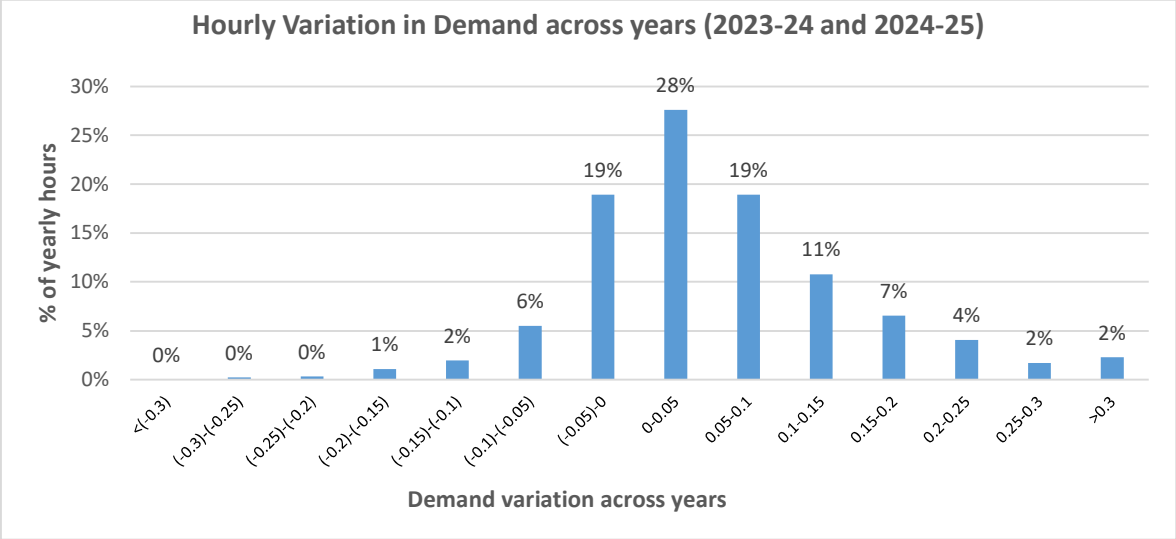


Figure 6: Hourly Variation in Demand across years

It can be observed that the hourly demand typically varies ±10% for around 72% of instances. This variation is primarily due to temperature, weather parameters or any random outages of transmission lines and generation units, etc. This variation has been captured in the reliability study by varying the projected hourly demand for the future years by ±10% by introducing a random variable (with normal distribution) for demand as per observed behaviour over the years.

5.2 Variation in RE Generation

In the Long-term capacity expansion planning studies, a particular profile for solar and wind generation is considered based on the observed solar and wind generation data to determine the optimal capacity mix. However, due to the 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 has been varied by ± 10 % and wind generation has been varied by ± 50% to incorporate the variation in these generation sources and plan for the requisite measures to mitigate such behaviour. Hydro generation has also been varied by ± 10 %.

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 the robustness of the system.

6.0 Inputs/Assumptions for the Study

i) The peak electricity demand and electrical energy requirement for the state of Karnataka has been taken as per the projection by Karnataka SLDC/ PCKL. The peak electricity demand as per projections by the Karnataka SLDC/ PCKL was higher than

the 20th EPS projections. Therefore, the studies have been carried out considering demand projections by Karnataka SLDC/ PCKL as shown in Table 6 and Figure 7 below.

Table 6: Electricity Demand Projection as provided by Karnataka SLDC/ PCKL

Electrical Energy Requirement (MU) and Electrical Peak Demand (MW) Projections				
	Electrical Energy Requirement (MU)	Year-on-Year Growth	Peak Electricity Demand (MW)	Year-on-Year Growth
2025-26	100066		18075	
2026-27	107998	7.93%	19690	8.93%
2027-28	118181	9.43%	21745	10.44%
2028-29	125868	6.50%	23372	7.48%
2029-30	134910	7.18%	25051	7.18%
2030-31	144142	6.84%	26765	6.84%
2031-32	153230	6.30%	28453	6.31%
2032-33	164064	7.07%	30464	7.07%
2033-34	176022	7.29%	32685	7.29%
2034-35	189667	7.75%	35218	7.75%
2035-36	204370	7.75%	37948	7.75%

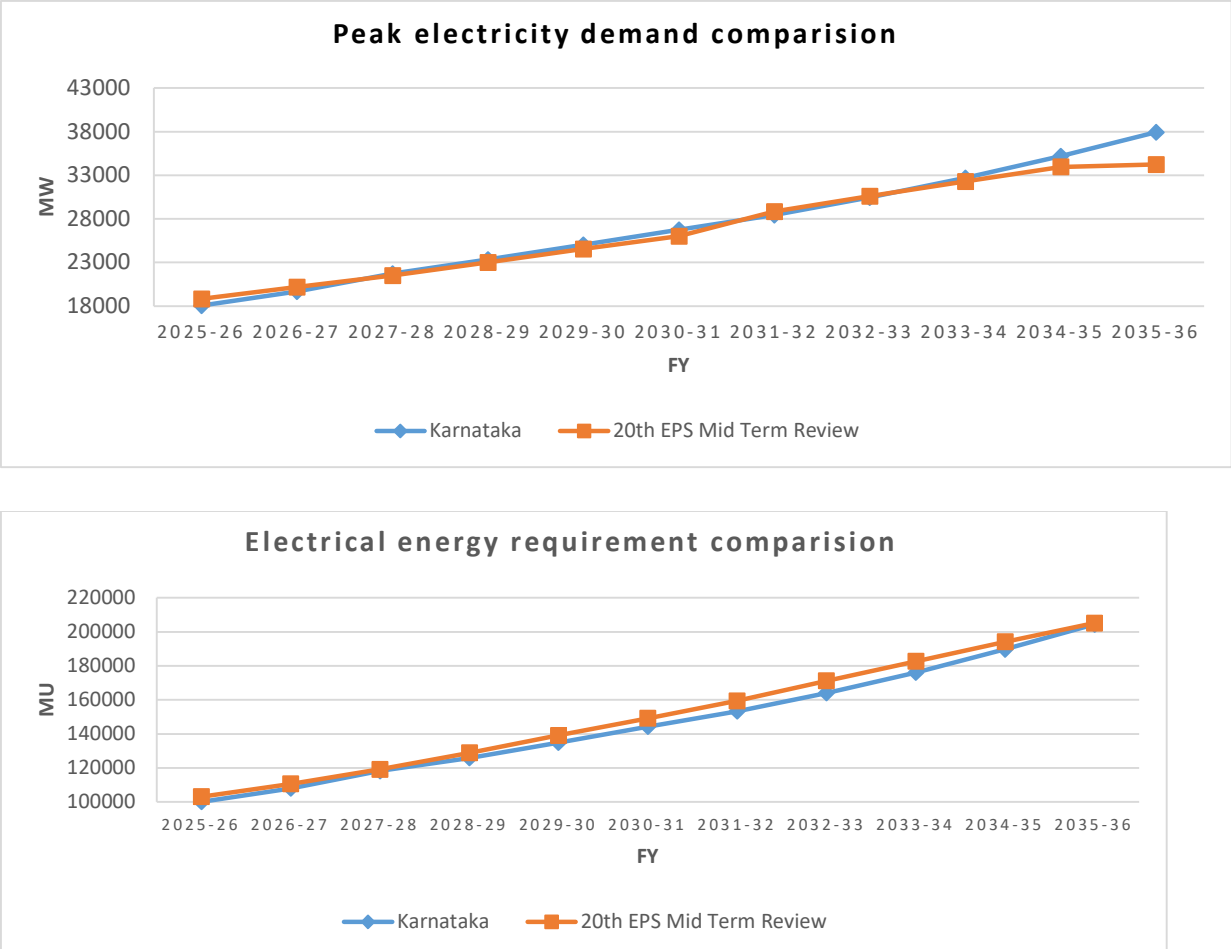


Figure 7: Comparison of Electrical Energy Requirement and peak Demand Projections of 20th EPS Mid Term Review vs Karnataka SLDC/ PCKL

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 wind generation profiles and CUFs have been referred from the previous year's generation data provided by Karnataka SLDC/ PCKL, while the hydro generation profiles and PLFs have been taken as per the data available in CEA.

iv) The capital costs of candidate plants for coal, wind, solar, and BESS 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 furnished by Karnataka SLDC/ PCKL. Source-wise planned capacity is given in Table 7:

Table 7: Source-wise planned capacity addition (in MW)

FY	Coal	Nuclear	Hydro	Solar	Wind	BESS 1hr	BESS 2hr	BESS 2.25hr	BESS 4.4hr	PSP 6 hr	PSP 8 hr	DRE
2025-26				324				2				4000
2026-27	1000	305	142	502		100	500		250			500
2027-28	1000	221	39	4243	2379		1400				1000	1000
2028-29	300			2100	3721		500					
2029-30		700		1268	1000					2000		
2030-31	600		300	1000	1000							
2031-32	1480		225	4300	1000		2000					
2032-33			200	3350	2000		1000			1500		
2033-34				5450	2000							
2034-35				700						1500		
2035-36												
Total	**4380**	**1226**	**906**	**23237**	**13100**	**100**	**5400**	**2**	**250**	**5000**	**1000**	**5500**

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 shown in Table 8.

Table 8: Renewable Purchase Obligation (RPO) trajectory as per the 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 has been assumed to rise steadily beyond 2029-30. Hence, the suggested trajectory of Renewable Purchase Requirement up to FY 2035-36 is given in Table 9.

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

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
1.	2024-25	0.67%	0.38%	27.35%	1.5%	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%
7.	2030-31	40.50%			5.0%	45.5%
8.	2031-32	41.50%			5.5%	47.0%
9.	2032-33	42.30%			6.0%	48.3%
10.	2033-34	43.00%			6.5%	49.5%
11.	2034-35	43.50%			7.0%	50.5%
12.	2035-36	44.00%			7.5%	51.5%

Based on the trajectory specified, RPO quantum in million units (MUs) from hydro, wind, other (Solar, biomass, etc.) and Distributed Renewable Energy (DRE) has been calculated and is tabulated in Table 10 below.

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.	2025-26	1451	1221	28259	2101	33032
2.	2026-27	2128	1447	32335	2916	38825
3.	2027-28	2895	1678	37392	3900	45866
4.	2028-29	3713	1787	41662	4909	52059
5.	2029-30	4695	1794	45896	6071	58457
6.	2030-31	58378			7207	65585
7.	2031-32	63590			8428	72018
8.	2032-33	69399			9844	79243
9.	2033-34	75689			11441	87131
10.	2034-35	82505			13277	95782
11.	2035-36	89923			15328	105251

The year-wise total renewable energy, excluding DRE, met from the existing and planned capacity along with the deficit is shown in Table 11.

Table 11 Renewable Energy Deficit/Surplus

FY	RE Generation required to meet RPO (excluding DRE)		RE Generation (excluding DRE) available or to be met from existing and planned contracts		RE Generation Surplus (+)/ Deficit (-) (excluding DRE)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	30930	30.91%	29372	29.35%	-1.56%
2026-27	35909	33.25%	30855	28.57%	-4.68%
2027-28	41966	35.51%	45683	38.66%	3.15%
2028-29	47150	37.47%	59173	47.01%	9.54%
2029-30	52386	38.83%	64406	47.74%	8.91%
2030-31	58378	40.50%	69356	48.12%	7.62%
2031-32	63590	41.50%	80988	52.85%	11.35%
2032-33	69399	42.30%	93094	56.74%	14.44%
2033-34	75689	43.00%	105283	59.81%	16.81%
2034-35	82505	43.50%	110159	58.08%	14.58%
2035-36	89923	44.00%	110982	54.30%	10.30%

Similarly, the year-wise total renewable energy for Distributed Renewable Energy (DRE) met from the existing and planned capacity along with the deficit is shown in table below:

Table 12 Distributed Renewable Energy (DRE) Deficit/Surplus

FY	DRE Generation required to meet RPO		DRE generation available or met from existing and planned contracts		DRE Generation Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	2101	2.10%	5164	5.16%	3.06%
2026-27	2916	2.70%	5896	5.46%	2.76%
2027-28	3900	3.30%	7195	6.09%	2.79%
2028-29	4909	3.90%	7195	5.72%	1.82%
2029-30	6071	4.50%	7195	5.33%	0.83%
2030-31	7207	5.00%	7195	4.99%	-0.01%
2031-32	8428	5.50%	7195	4.70%	-0.80%
2032-33	9844	6.00%	7195	4.39%	-1.61%
2033-34	11441	6.50%	7195	4.09%	-2.41%
2034-35	13277	7.00%	7195	3.79%	-3.21%
2035-36	15328	7.50%	7195	3.52%	-3.98%

As indicated in the tables above, the utility will not be able to meet its RPO requirements in certain years, based on the existing and planned contracts. The utility will also not be able to meet its DRE requirements from 2030-31 onwards, based on the existing and planned contracts.

7.0 Outcome of the Study

7.1 Unserved Electrical Energy Projections

Initially, the study has been carried out considering only the existing and planned capacity contracts by Karnataka and does not include any banking arrangements or short-term contracts. The total unserved electrical energy for the year 2035-36 would be 8913 MU. Year-

wise likely unserved electrical energy with the existing and planned capacities is given in Figure 8.

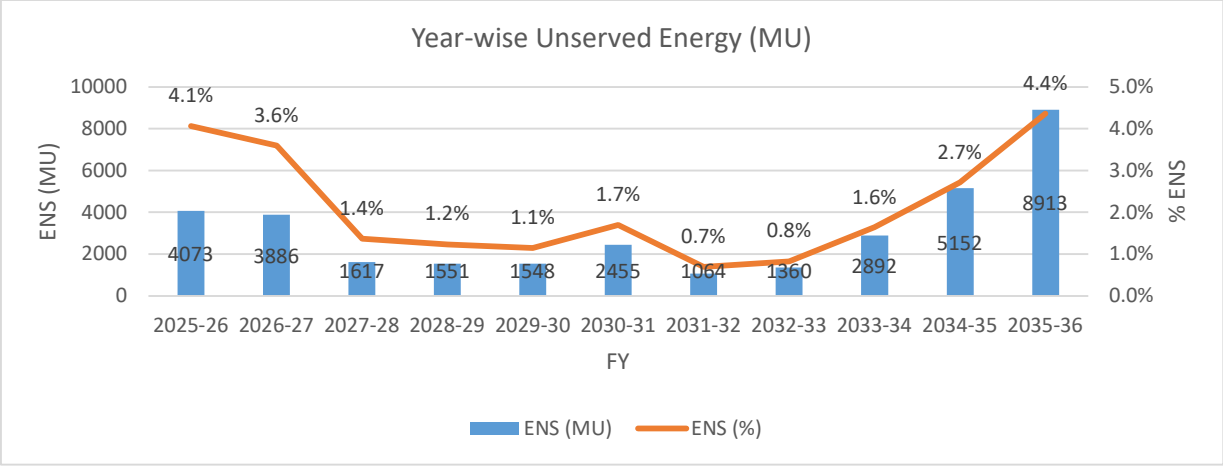


Figure 8: Yearly likely unserved electrical energy (in MU) with the existing and planned capacities

The study has also analysed the daily and monthly pattern of unserved electrical energy for Karnataka in the years 2035-36 and it can be seen from Figure 9 that the unserved energy coincides with peak demand months when the contracted capacity (existing and planned) is unable to meet the demand.

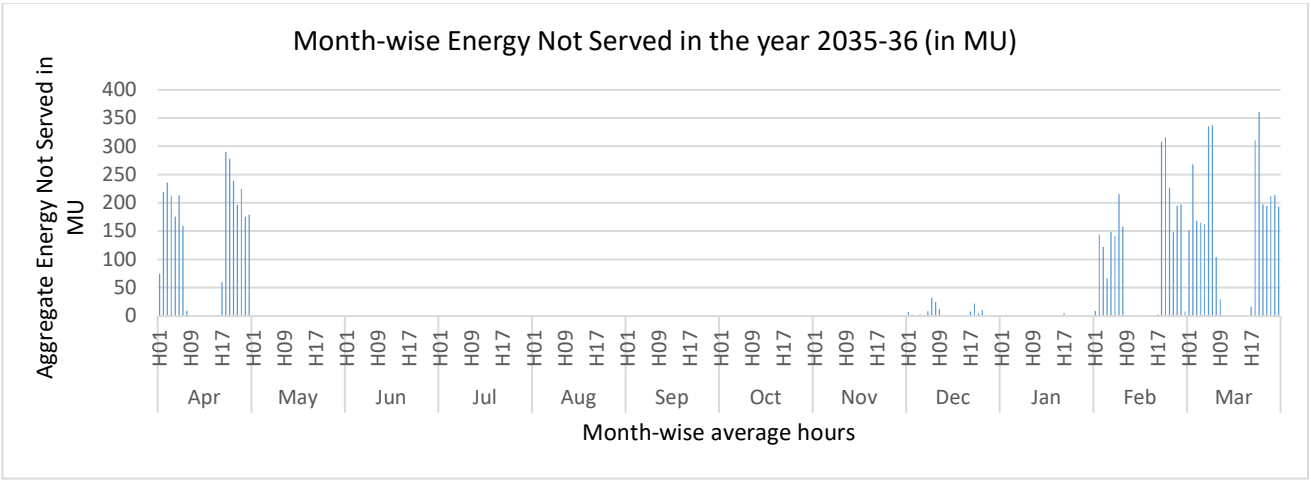


Figure 9: Block-wise Unserved Electrical Energy Pattern MU (2035-36)

From Figure 9, it can be noted that the unmet demand occurs mainly during non-solar hours in the months from February to April. To meet unserved energy, the utility needs to tie up additional capacity.

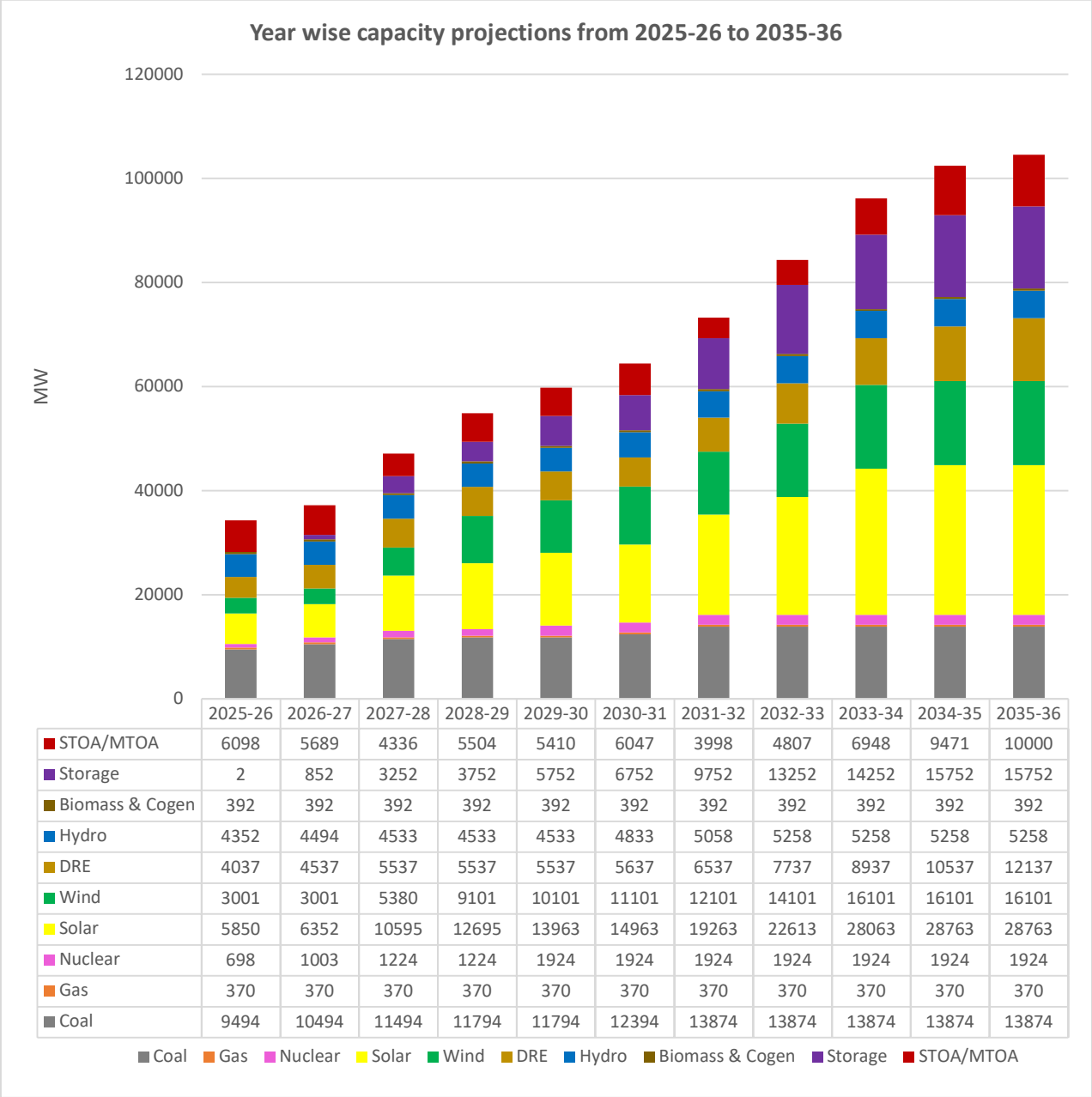
7.2 Options to meet the unserved electrical energy

To meet unserved electrical energy, candidate capacities have been given to the model to find the least cost optimal capacity mix required to meet the demand in compliance with the Renewable Purchase Obligation.

The candidate capacities incorporate the recent market price discoveries and tariff offers received by the utility as communicated by Karnataka SLDC/ PCKL. The capacity projections for Karnataka are given below in Table 12 and Figure 10.

Table 12: Likely requirement of contracted capacity (existing + planned + additional) (in MW)

	Coal	Gas	Nuclear	Solar	Wind	DRE	Hydro	Biomass & Cogen	Storage	STOA/ MTOA
2025-26	9494	370	698	5850	3001	4037	4352	392	2/4.5	6098
2026-27	10494	370	1003	6352	3001	4537	4494	392	852/2204.5	5689
2027-28	11494	370	1224	10595	5380	5537	4533	392	3252/13004.5	4336
2028-29	11794	370	1224	12695	9101	5537	4533	392	3752/14004.5	5504
2029-30	11794	370	1924	13963	10101	5537	4533	392	5752/26004.5	5410
2030-31	12394	370	1924	14963	11101	5637	4833	392	6752/32004.5	6047
2031-32	13874	370	1924	19263	12101	6537	5058	392	9752/42004.5	3998
2032-33	13874	370	1924	22613	14101	7737	5258	392	13252/59004.5	4807
2033-34	13874	370	1924	28063	16101	8937	5258	392	14252/65004.5	6948
2034-35	13874	370	1924	28763	16101	10537	5258	392	15752/74004.5	9471
2035-36	13874	370	1924	28763	16101	12137	5258	392	15752/74004.5	10000



	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
STOA/MTOA	6098	5689	4336	5504	5410	6047	3998	4807	6948	9471	10000
Storage	2	852	3252	3752	5752	6752	9752	13252	14252	15752	15752
Biomass & Cogen	392	392	392	392	392	392	392	392	392	392	392
Hydro	4352	4494	4533	4533	4533	4833	5058	5258	5258	5258	5258
DRE	4037	4537	5537	5537	5537	5637	6537	7737	8937	10537	12137
Wind	3001	3001	5380	9101	10101	11101	12101	14101	16101	16101	16101
Solar	5850	6352	10595	12695	13963	14963	19263	22613	28063	28763	28763
Nuclear	698	1003	1224	1224	1924	1924	1924	1924	1924	1924	1924
Gas	370	370	370	370	370	370	370	370	370	370	370
Coal	9494	10494	11494	11794	11794	12394	13874	13874	13874	13874	13874

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

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.

Table 13: Likely planned and additional capacity to be contracted by the utility (in MW)

	Coal		Hydro	Nuclear	Solar	Wind	DRE	
	Planned	**Additional**	**Planned**	**Planned**	**Planned**	**Planned**	**Planned**	**Additional**
2025/26					324		4000	
2026/27	1000		142	305	502		500	
2027/28	1000		39	221	4243	2379	1000	
2028/29	300				2100	3721		
2029/30				700	1268	1000		
2030/31	600		300		1000	1000		100
2031/32	1480		225		4300	1000		900
2032/33			200		3350	2000		1200
2033/34					5450	2000		1200
2034/35					700			1600
2035/36								1600
Total	**4380**	**0**	**906**	**1226**	**23237**	**13100**	**5500**	**6600**
	PSP			**BESS**				**STOA/MTOA**
	Planned PSP 6h	**Planned PSP 8h**	**Additional PSP 6 h**	**Planned Battery 1h**	**Planned Battery 2h**	**Planned Battery 2.25h**	**Planned Battery 4.4h**	**Yearly**
2025/26						2		6098
2026/27				100	500		250	5689
2027/28		1000			1400			4336
2028/29					500			5504
2029/30	2000							5410
2030/31			1000					6047
2031/32			1000		2000			3998
2032/33	1500		1000		1000			4807
2033/34			1000					6948
2034/35	1500							9471
2035/36								10000
Total	**5000**	**1000**	**4000**	**100**	**5400**	**2**	**250**	

The STOA/MTOA value reflects the peak power requirement in MW. The STOA/MTOA requirement can be fulfilled through power procurement from market, bilateral agreements or banking arrangement.

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 Normalised Energy Not Served (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 as shown in Figure 11 is around 1,04,571 MW which consists of 13874 MW from Coal, 370 MW from Gas, 1924 MW from Nuclear, 5258 MW from Hydro, 16101 MW from

Wind, 28763 MW from Solar, 392 MW from Biomass & Cogen, 12137 MW from Distributed Renewable Energy (DRE) sources, 15752 MW/74004.5 MWh of Energy storage and 10000 MW of MTOA/STOA arrangement will be required. This capacity shall be able to meet the projected demand with prescribed reliability criteria.

It is important to note that any deviations in the commissioning schedule of the planned capacity could result in a situation where the utility 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 reliably meeting the utility's power demand.

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 Karnataka has been assessed as 9%. In addition, the projected/contracted capacity fulfils the stipulated Renewable Purchase Obligation.

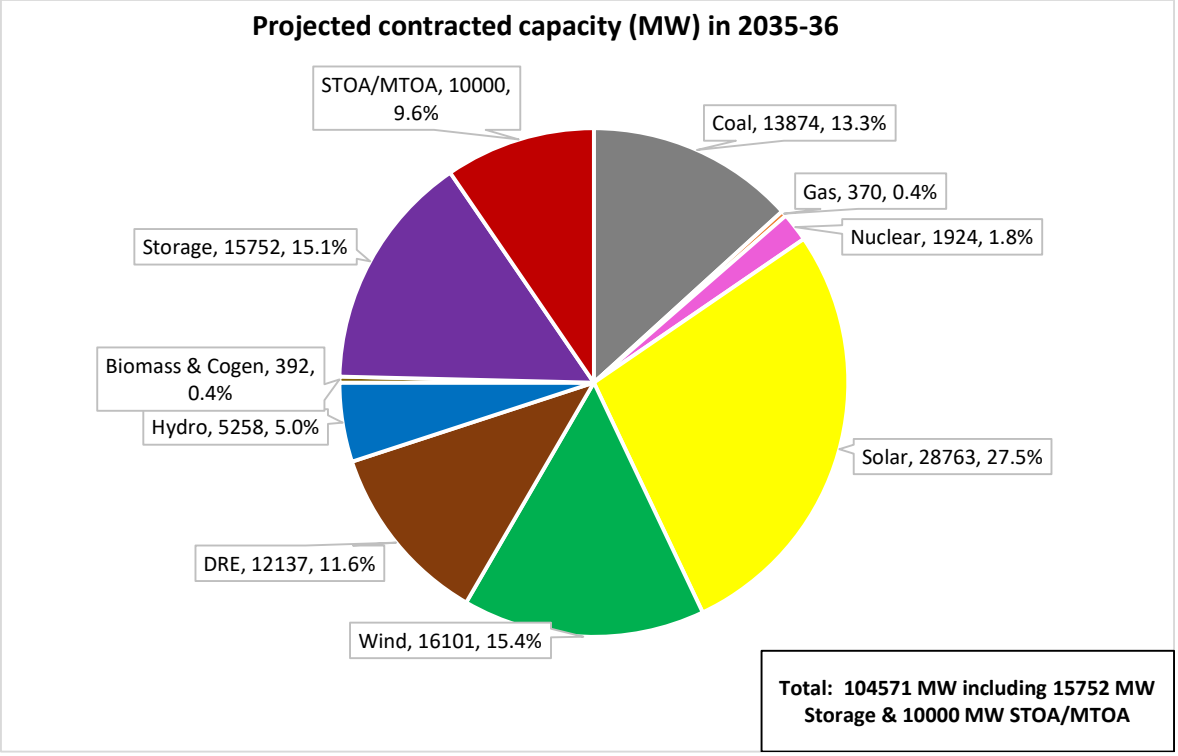


Figure 11: Contracted Capacity Mix in 2035-36

The share of non-fossil fuel-based capacity is projected to increase to around 77% by 2035-36 from 59% in 2024-25. Further, the share of non-fossil fuel-based generation will be around 68% in the year 2035-36. The projected generation mix for the utility is shown in Figure 12.

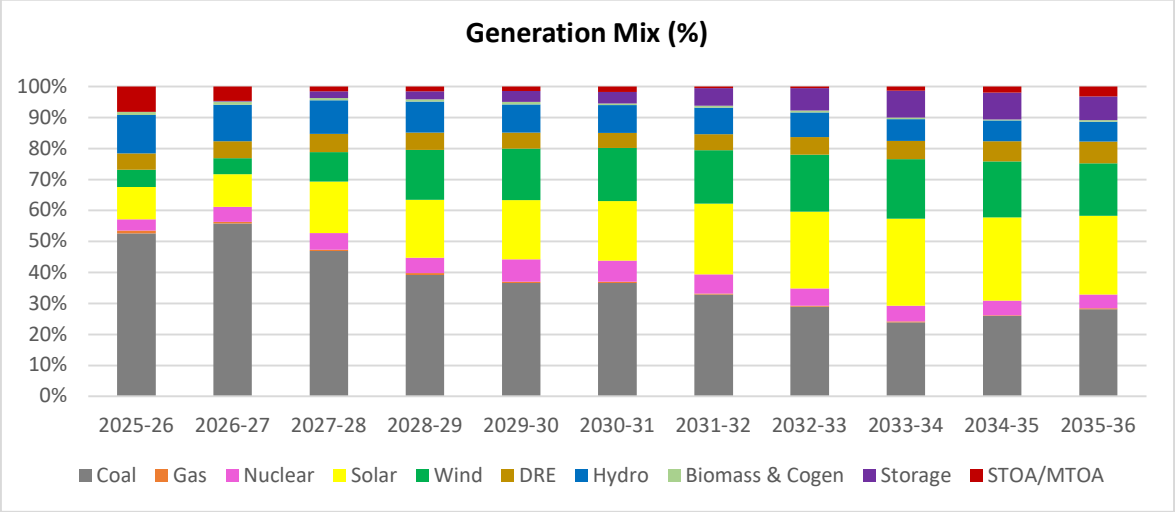
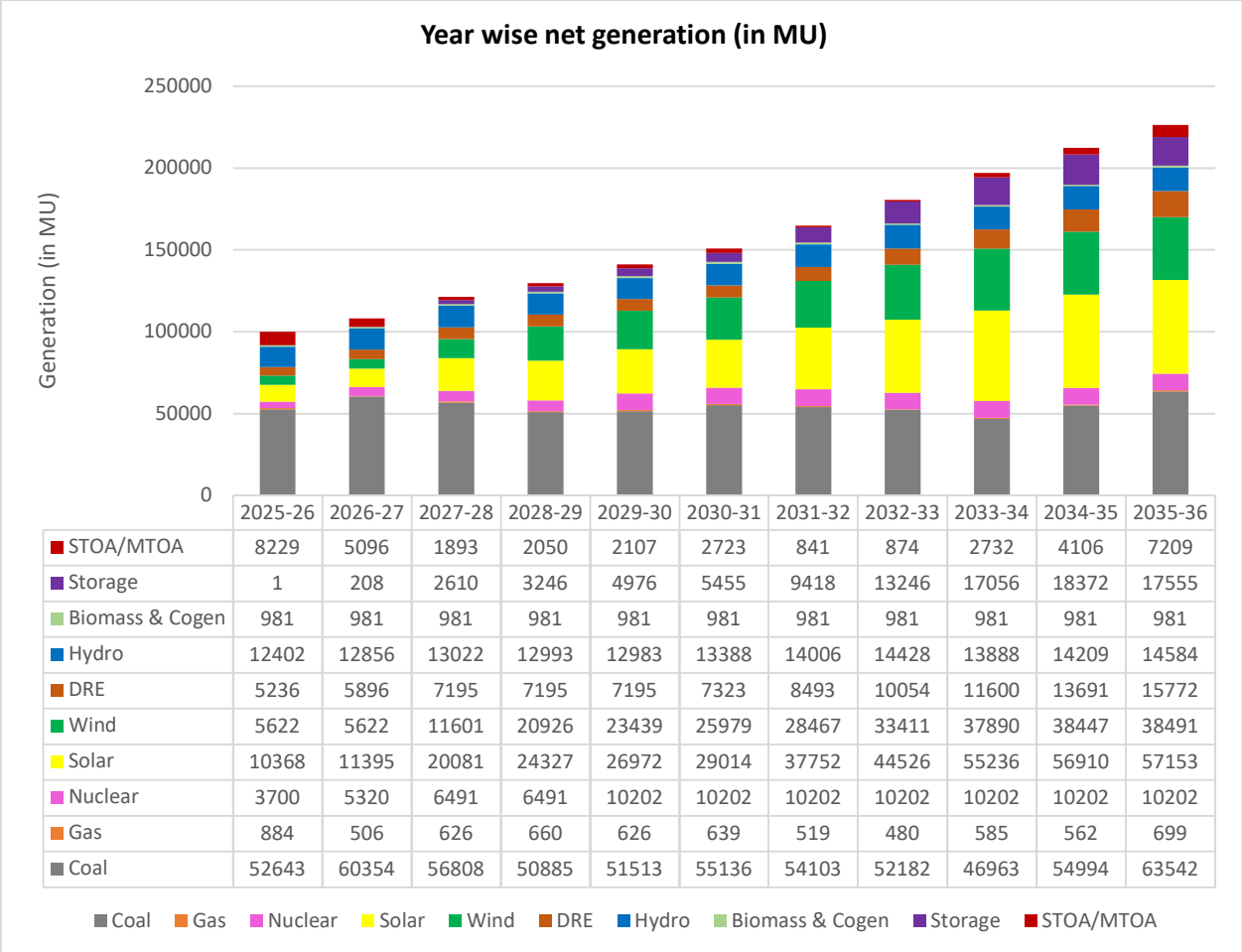


Figure 12: Year-wise projected generation mix (in %)

The year-wise projected generation in MU is depicted below in Figure 13:



	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
STOA/MTOA	8229	5096	1893	2050	2107	2723	841	874	2732	4106	7209
Storage	1	208	2610	3246	4976	5455	9418	13246	17056	18372	17555
Biomass & Cogen	981	981	981	981	981	981	981	981	981	981	981
Hydro	12402	12856	13022	12993	12983	13388	14006	14428	13888	14209	14584
DRE	5236	5896	7195	7195	7195	7323	8493	10054	11600	13691	15772
Wind	5622	5622	11601	20926	23439	25979	28467	33411	37890	38447	38491
Solar	10368	11395	20081	24327	26972	29014	37752	44526	55236	56910	57153
Nuclear	3700	5320	6491	6491	10202	10202	10202	10202	10202	10202	10202
Gas	884	506	626	660	626	639	519	480	585	562	699
Coal	52643	60354	56808	50885	51513	55136	54103	52182	46963	54994	63542

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

8.0 Conclusions

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

1. The study has been carried out considering electrical energy requirement projections and peak electricity demand projections as per Karnataka SLDC/ PCKL which envisages that the annual electrical energy requirement of the utility is likely to grow at a CAGR of 7.4% while the peak electricity demand for the utility is likely to grow at a CAGR of 7.7% for the period of 2025-26 to 2035-36.
2. High electricity demand in Karnataka is typically in the months from December to April, with peak electricity demand occurring during the daytime. The demand during the months of October and November remains significantly low compared to other months, reflecting the seasonality in demand.
3. Karnataka is likely to witness energy deficit ranging from 4073 MUs to 8913 MUs in different years from 2025-26 to 2035-36 with the existing and planned capacity addition only. The deficit may reduce depending upon the banking or MTOA/STOA arrangement, etc.

4. The likely total projected contracted capacity for the year 2035-36 is around 1,04,571 MW which consists of 13874 MW from Coal, 370 MW from Gas, 1924 MW from Nuclear, 5258 MW from Hydro, 16101 MW from Wind, 28763 MW from Solar, 392 MW from Biomass & Cogen, 12137 MW from Distributed Renewable Energy (DRE) sources, 15752 MW/74004.5 MWh of Energy storage and 10000 MW of MTOA/STOA arrangement will be required. This capacity shall be able to meet the projected demand with prescribed reliability criteria.

5. As per the resource adequacy study, to ensure reliability of supply and adherence to the Renewable Purchase Obligation (RPO) trajectory up to 2035-36, the State needs to tie up additional generation capacity over and above the existing and planned generation capacities. An additional capacity of approximately 4000 MW PSP and 6600 MW of DRE is projected to be required. In addition to this, the utility will likely require MTOA/ STOA arrangements ranging from around 6000 MW to 10000 MW in different years, as outlined in the report. The STOA/MTOA requirement can be fulfilled through power procurement from the market or bilateral/banking agreements.
6. The current capacity mix of the utility has 41% of contracted capacity from fossil fuel sources (Coal + Gas). The share of fossil fuel-based capacity is likely to reduce to 23% in 2035-36. In 2035-36, the RE-based contract capacity (that includes hydro, solar, wind, DRE, Biomass & Cogen) is likely to constitute around 60% of the total contract capacity.
7. 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, utilities are strongly encouraged to adopt scientific tools and robust methodologies for demand forecasting.

8. Timely commissioning of planned capacities is critical to ensure that the utility can meet the projected peak electricity demand and electrical 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 utility's power demand.

Annexure

Planned Future Contracted (MW) considered in the study

S No	Tied capacity name	Type of generation	Expected CoD	Karnataka share (in MW)
1	Coal India Phase-1 under shakti policy	Coal	2026-27	1000
2	Coal India Phase-2 under shakti policy	Coal	2027-28	1000
3	Damodar Valley Corporation_KTPS_II	Coal	2028-29	300
4	Godhna_TPS	Coal	2031-32	1480
5	NTPC- Telangana PH-II	Coal	2030-31	600
6	Kiru NHPC	Hydro	2026-27	48
7	Kwar NHPC	Hydro	2026-27	47
8	Pakaldul NHPC	Hydro	2026-27	47
9	Teesta VI NHPC	Hydro	2027-28	39
10	Shivanasamudram R-O-R	Hydro	2030-31	300
11	Dibang NHPC	Hydro	2031-32	225
12	Mahadayi	Hydro	2032-33	200
13	Bhavini	Nuclear	2026-27	84.4
14	Kudankulam-U3	Nuclear	2026-27	221
15	Kudankulam-U4	Nuclear	2027-28	221
16	Kaiga U5 & U6	Nuclear	2029-30	700
17	PSP Soudatti	PSP	2027-28	700
18	PSP Narihalla	PSP	2027-28	300
19	PSP Sharavathi	PSP	2029-30	2000
20	PSP Varahi	PSP	2032-33	1500
21	PSP Netravati Stage-I	PSP	2034-35	1500

Assumption for Resource Adequacy Studies

1. Electrical energy requirement & peak electricity demand requirement: As per projections of Karnataka.
2. Demand Profile: Based on the 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 the National Electricity Plan, recent market trends, and existing tariff information received from Karnataka SLDC/ PCKL.

RE CUF considered

Hydro	Solar Existing & Planned	Wind Existing & Planned	DRE
30 %	19.73% & 23%	21.47% & 28.8%	14.5%

Technical Parameters

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical (%)
Coal/ Lignite	Existing/Planned	85	1	55
	Candidate	88	1	55
Gas	Existing	70	5	40
Nuclear	Existing/Planned	68	Const. Load	-
Biomass	Existing/Planned	60	2	50
Hydro	Existing/Planned/ Candidate	As per available hourly generation profile	100	-
Solar	Existing/Planned		-	-
	Candidate		-	-
Wind	Existing/Planned		-	-
	Candidate		-	-
Pumped storage	Existing/Planned	95	50	-
	Candidate		50	-
Battery Energy Storage	Candidate	98	NA	-

Technology	Type	Heat Rate (MCal/MWh)		Aux. Consum. (%)
		At max loading	At min loading	
Coal	Existing/ Planned	2300 to 2879	2438 to 3052	7.0
	Candidate (SC & USC)	2300	2438	6.5
Gas	Existing	2000	2260	2.5
Nuclear	Existing/ Planned	2777	2777	10
	Candidate	2777	2777	10
Biomass	Existing/ Planned	4200	4450	8
	Candidate	4200	4450	8
Hydro	Existing/ Planned	-	-	0.7
	Candidate	-	-	0.7
Pumped Storage	Existing/ Planned	-	-	Round trip efficiency 80 %
	Candidate	-	-	
Battery Energy Storage	Candidate	-	-	Round-trip efficiency 88%

Transmission Parameters

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

Financial Parameters

The following cost parameters have been assumed:

Resource	Capex (in ₹/MW)	O&M Fixed Cost (in ₹/MW)	Construction Time (in years)	Amortization /Lifetime (in years)
Coal	12 Cr	30 Lakh	4	25
PSP	6 Cr	30 Lakh	4	40