Report On
Resource Adequacy Plan
For the State of
Odisha

(2023-24 to 2033-34)

Government of India
Ministry of Power
Central Electricity Authority

Contents

Executive Summary

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 Distribution Licensee Resource Adequacy Plan) to meet the utility peak and energy requirement reliably.

The electricity demand for the State of Odisha is increasing with a CAGR of 3.92 % from 2023-24 to 2033-34 as forecasted by 20th EPS. The projections of Odisha also indicate that electricity demand may increase with a CAGR of 5.2 % from 2023-24 to 2033-34. 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 starts increasing from the summer months of May and is maximum during the months of August and September months. The electricity demand is significantly less during the winter months (October to March). The peak electricity load is generally observed during solar hours.

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. RPO requirement for Odisha has been assessed in compliance with new RPO trajectory.

To find out the least cost option for generation capacity expansion for the period 2023-24 to 2033-34, long-term study for the State of Odisha 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.

The study was carried out considering existing capacity, planned capacity & capacity required to fulfil the Renewable Purchase Obligations (RPO). It was found that the state's likely contracted capacity along with the trajectory of the banking arrangement is not sufficient to meet projected demand. It was observed that the total unserved energy in the year 2033-34 is expected to be about 5600 MU which is about 8.7 % annual energy during the year 2033-34 and primarily observed in the months from April to September.

Generation capacity expansion pathways have been considered for the long-term study based on the yearly capacity addition plans of the state 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.

No capacity addition in nuclear capacity has been considered in the studies.

The Resource adequacy studies have projected likely optimal capacity mix for future years till 2033-34 which is able to meet anticipated demand reliably at every instance.

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 study has been carried out for Odisha based on the inputs received from Odisha with a view of fulfilling RPO trajectory. The study suggests the optimal resource mix till 2033-34 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 on 24 X 7 basis while considering variation in demand, RE generation and forced outages of thermal capacities. The study has also assessed the requirement of Planning Reserve Margin for Odisha for catering to above highlighted uncertainties so that demand can be met reliably throughout the year.

2.0 Odisha RA Study

2.1 Present Power Scenario in Odisha

As of March 2023, the total contracted capacity for Odisha is 8150 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 47%.

The fuel-wise contracted capacity as on 31st March, 2023 is given in Table and Figure below:

Table 1 Fuel-wise Contracted Capacity as on March 2023

Source	Contracted Capacity (MW)	Percentage
Thermal	4298	53%
Hydro	2466	30%
Wind	350	4%
Solar	1016	12%
Biomass	20	0%
Total	**8150**	**100%**

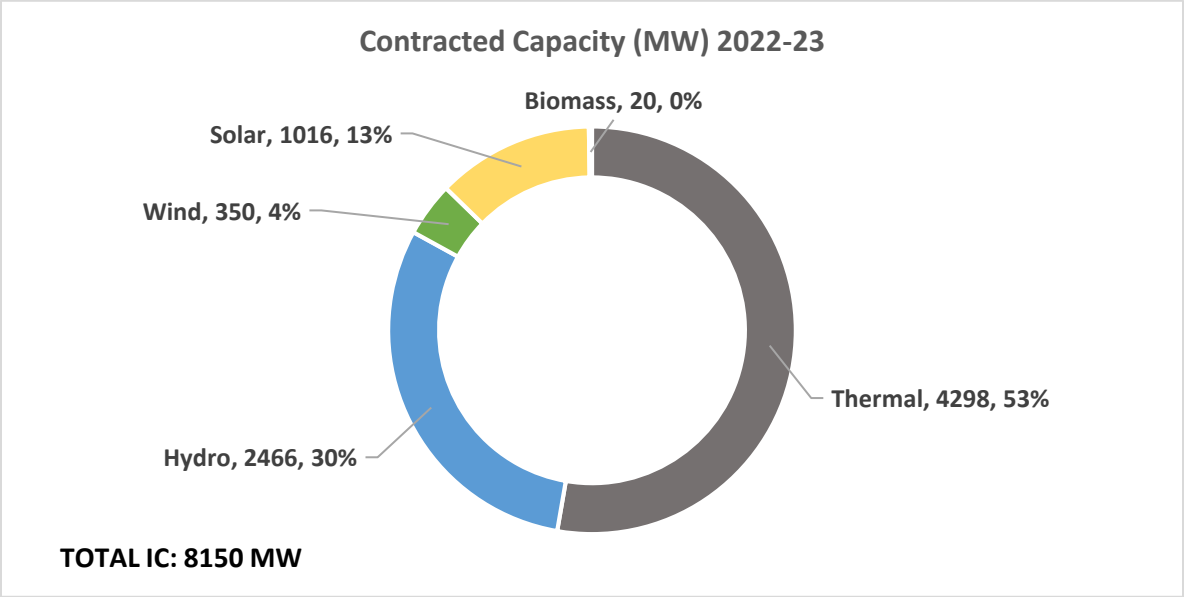


Figure 1 Fuel-wise Contracted Capacity (in MW) as on 31st March, 2023

2.2 Present Demand Analysis (2022-23)

Hourly demand pattern of 2022-23 was analyzed and it was observed that the peak demand season for Odisha is during the months of August and September. Odisha witnesses peak demand

during night hours. Optimal utilization of resources through short-term contracts like banking or STOA can be practiced for managing the seasonal variation in demand and is one of the effective ways for ensuring resource adequacy.

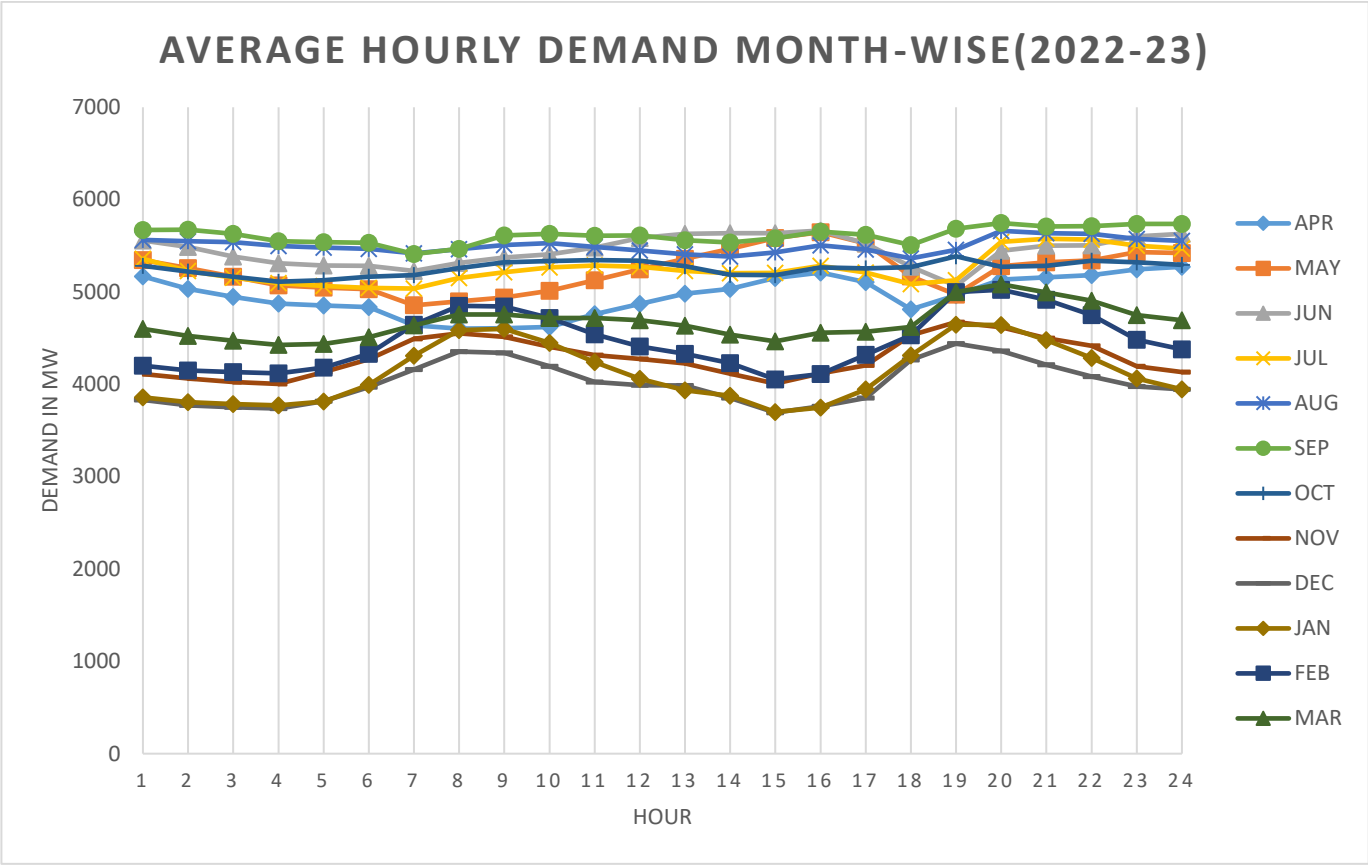


Figure 2 Average Hourly Demand Variation (Month-wise) of Odisha for 2022-23

Odisha sees daily peak during night hours in almost every month of the year and diurnal variation is more during winter months.

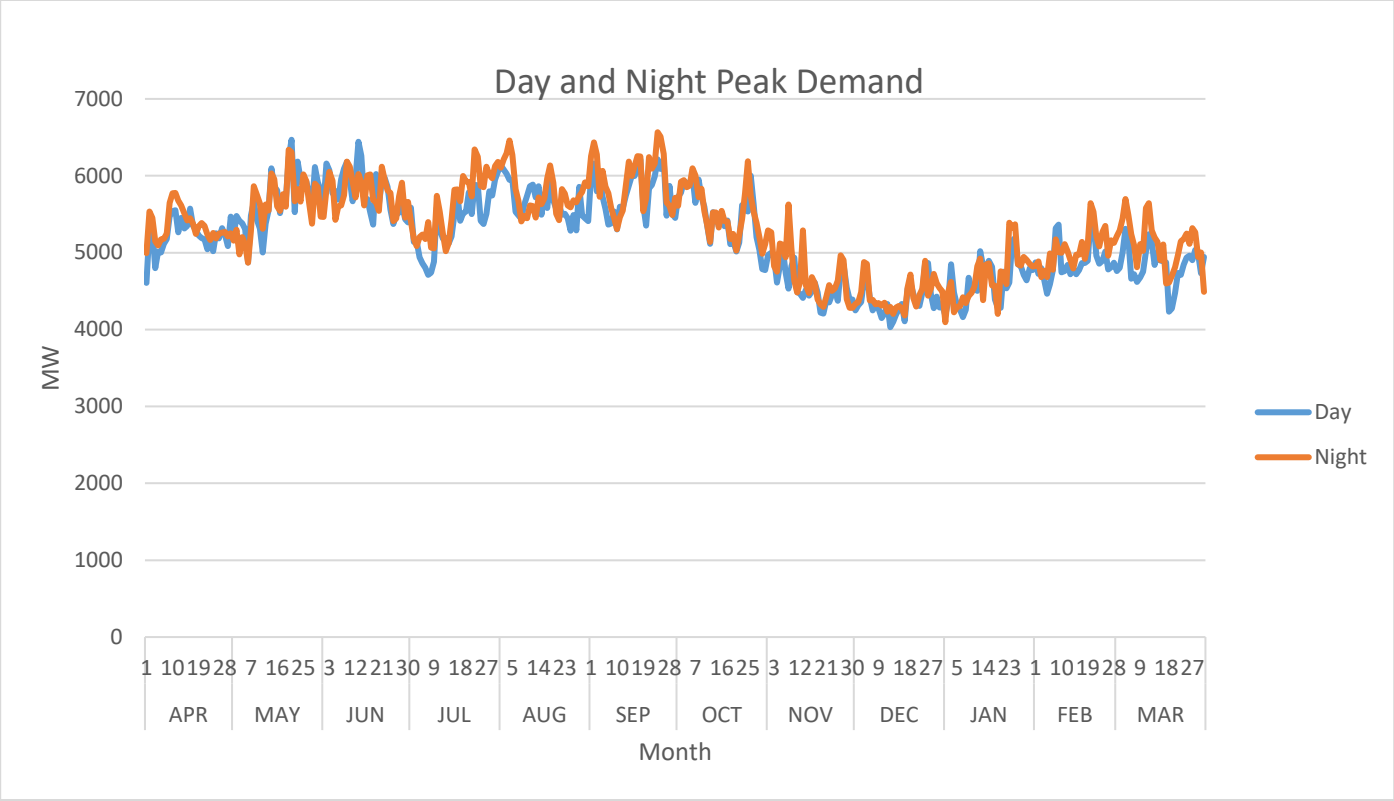


Figure 3 Day and Night Peak in MW of Odisha (2022-23)

The hourly demand pattern of 2022-23 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.

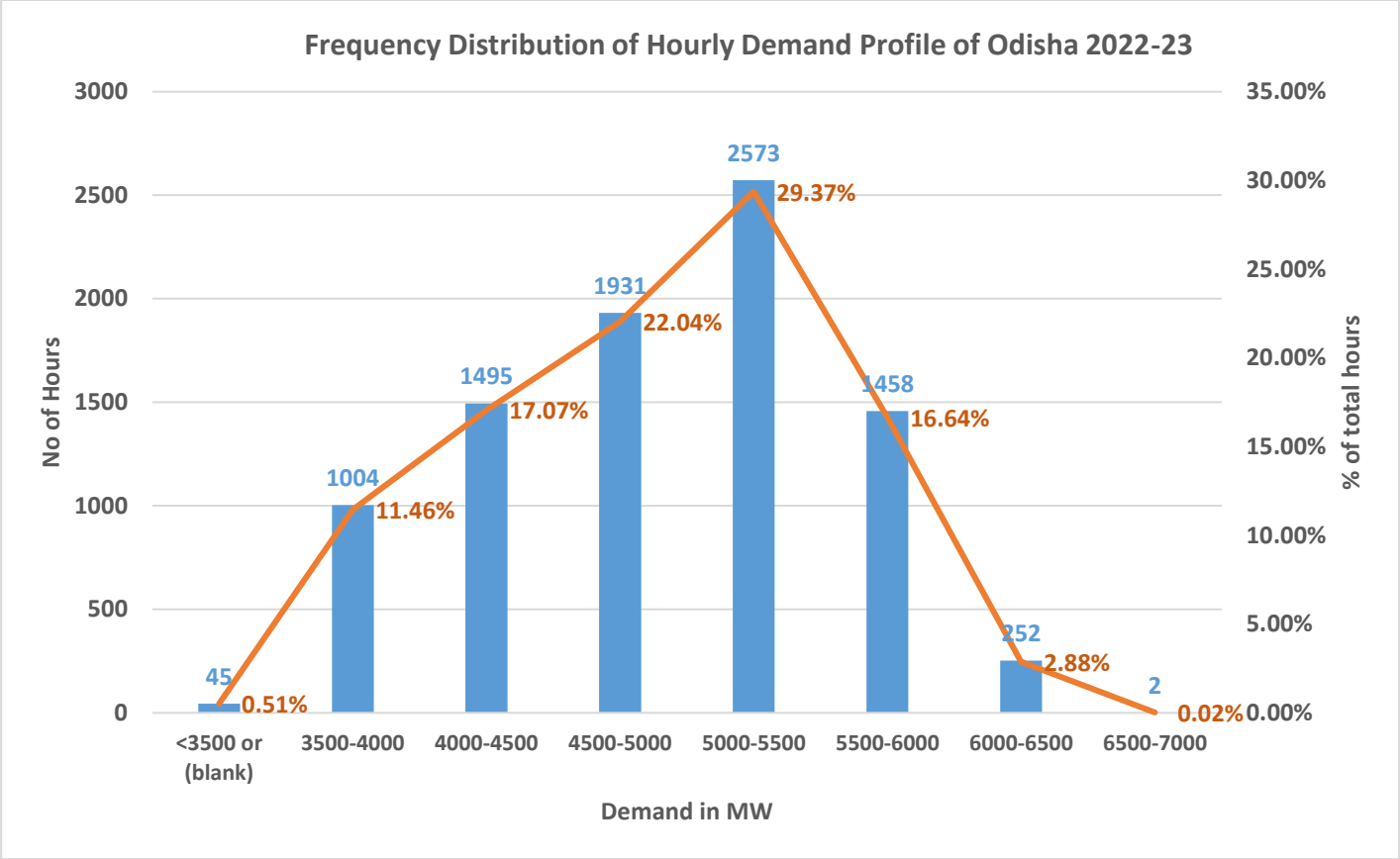


Figure 4 Frequency Distribution of Hourly Demand Profile of Odisha 2022-23

3.0 Inputs/Assumptions for the Study

i) Peak and Energy Demand for the State of Odisha has been taken as per 20th EPS (Electric Power Survey) report. The Demand estimation by Odisha was lower than projected by 20th EPS. 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	2030-31	2031-32	2032-33	2033-34
Energy Projections (MU)	43582	44985	46689	48627	50810	53180	56316	57891	59286	61611	64027
Year on Year Growth		3.22%	3.79%	4.15%	4.49%	4.66%	5.90%	2.80%	2.41%	3.92%	3.92%
Peak Demand Projections (MW)	6635	6918	7252	7630	8053	8514	9107	9456	9782	10166	10564

Year on Year Growth		4.27%	4.83%	5.21%	5.54%	5.72%	6.96%	3.83%	3.45%	3.93%	3.92%

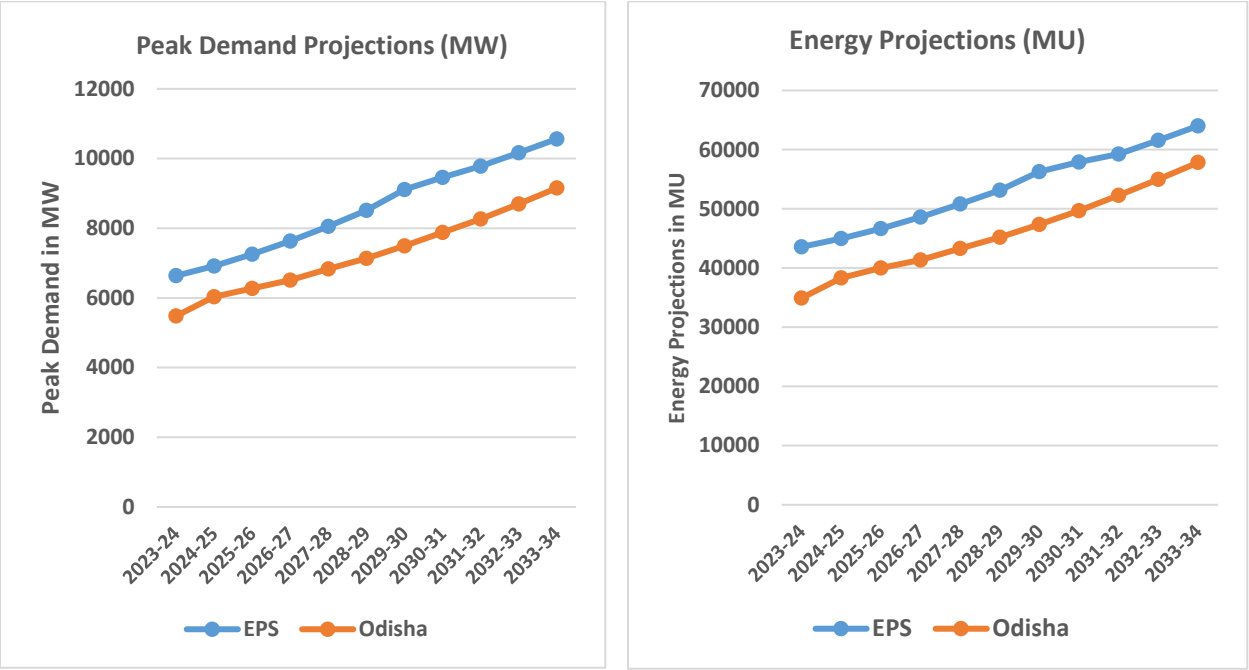


Figure 5 Comparison of Energy Requirement and peak Demand Projections of 20th EPS vs Odisha

ii) Future demand profile for the year 2033-34 has been projected using the demand profile for the year 2022-23 as the base profile.

iii) The actual solar and wind generation profiles and CUFs have been referred from National Electricity Plan.

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

v) Existing & Planned Capacity: As per the information received from Odisha. (List of Planned Thermal and Hydro is attached in **Annexure-I**)

vi) According to the data provided by Odisha, an additional 2142 MW of Coal ,456 MW of Hydro, 1420 MW of PSP, 2271 MW of solar and 1000 MW of wind is planned till 2032.

vii) Ministry of Power, via 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. 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 increase beyond 2029-30. Therefore,

the RPO trajectory is assumed to rise steadily beyond 2029-30 and hence, RPO targets till 2033-34 are given below:

*Table 3 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)	(6)	(5)	(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%	33.10%	3.9%	41.36%
6.	2029-30	3.48%	1.33%	34.02%	4.5%	43.33%
7.	2030-31	40.50%			5.0%	45.50%
8.	2031-32	41.50%			5.5%	47.00%
9.	2032-33	42.30%			6.0%	48.30%
10.	2033-34	43.00%			6.5%	49.50%

*Trajectory for RPO till 2029-30 as per MoP RPO order notified in October,2023. After 2029-30, RPO targets assumed based on anticipated RE capacity requirement on national level given in National Electricity Plan (Vol-I Generation)

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 tabulated below:

*Table 4 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)	(6)	(5)	(7)
1	**2024-25**	301	171	12303	675	13451
2	**2025-26**	677	570	13185	980	15412
3	**2026-27**	958	652	14559	1313	17481
4	**2027-28**	1245	722	16076	1677	19719
5	**2028-29**	1569	755	17603	2074	22001
6	**2029-30**	1960	749	19159	2534	24402
7	**2030-31**	23446			2895	26340
8	**2031-32**	24604			3261	27864
9	**2032-33**	26061			3697	29758
10	**2033-34**	27532			4162	31693

*Considering the fungibility aspect of RPO targets among Wind, Hydro and other RE generation

Accordingly, the source wise MW requirement –planned by the state and additional, considering the fungibility aspects in the RPO, has been estimated and is tabulated below:

Table 5 Projected RE capacity addition required (MW) as per RPO trajectory.

FY	HYDRO		WIND		SOLAR		DRE	TOTAL	
	Planned	Additional	Planned	Additional	Planned	Additional	Additional	Planned	Additional
2024/25	16.5	0	400	400	939	800	550	**1355.5**	**1750**
2025/26	100	0	600	400	0	800	249	**700**	**1449**
2026/27	128.5	100	0	226	0	64	271	**128.5**	**661**
2027/28	104	0	0	0	0	0	297	**104**	**297**
2028/29	0	45	0	0	0	0	324	**0**	**369**
2029/30	107	100	0	0	563	0	375	**670**	**475**
2030/31	0	100	0	0	300	341	294	**300**	**735**
2031/32	0	100	0	0	469	703	299	**469**	**1102**
2032/33	0	100	0	0	0	659	355	**0**	**1114**
2033/34	0	100	0	0	0	800	379	**0**	**1279**
TOTAL	**456**	**645**	**1000**	**1026**	**2271**	**4167**	**3393**	**3727**	**9231**

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.

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 % of peak load forecast of the system.

4.1 Demand variation:

The variation in demand pattern of Odisha for last 5 years has been analyzed. The hourly demand variation for consecutive years (i.e., 2021-22 and 2022-23) has been analyzed. The Demand pattern variation of 2021-22 and 2022-23 is shown below.

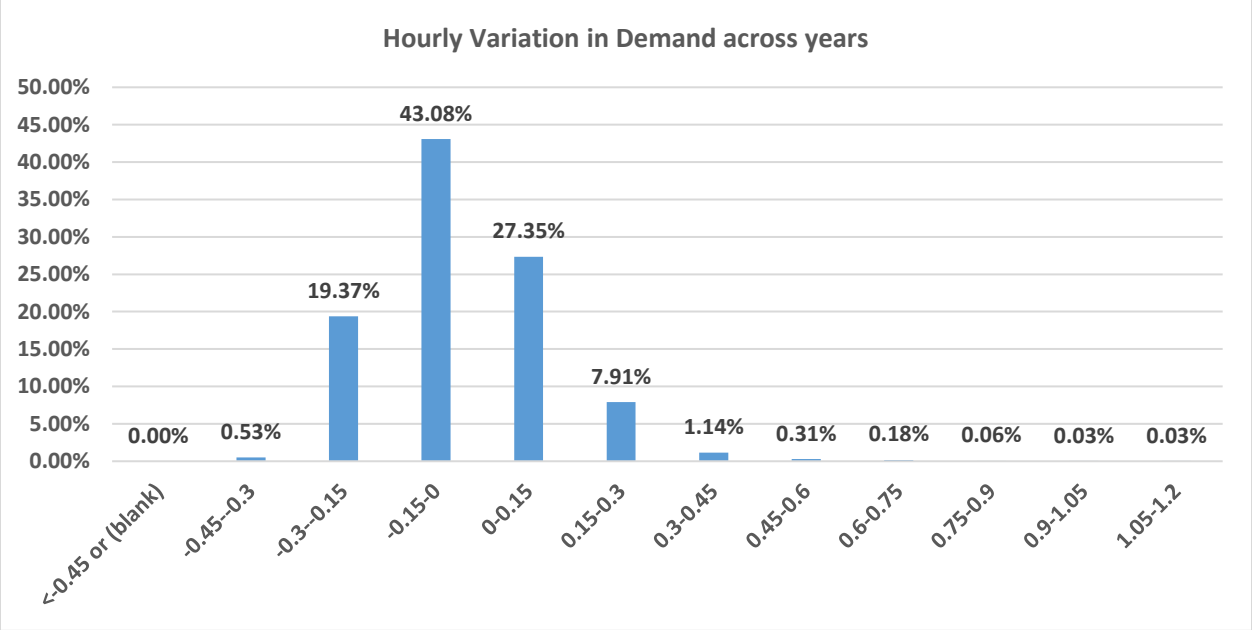


Figure 6 Hourly Variation in Demand across years

It can be observed that the hourly demand typically varies ±15% for 70% 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 ±15% by introducing a random variable (with normal distribution) for demand as per 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 10 % and 50% respectively 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 average forced outage rate of thermal generators 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. It was observed that the total unserved energy in the year 2033-34 is about 5600 MU. The yearly likely unserved energy with the planned capacities is given below.

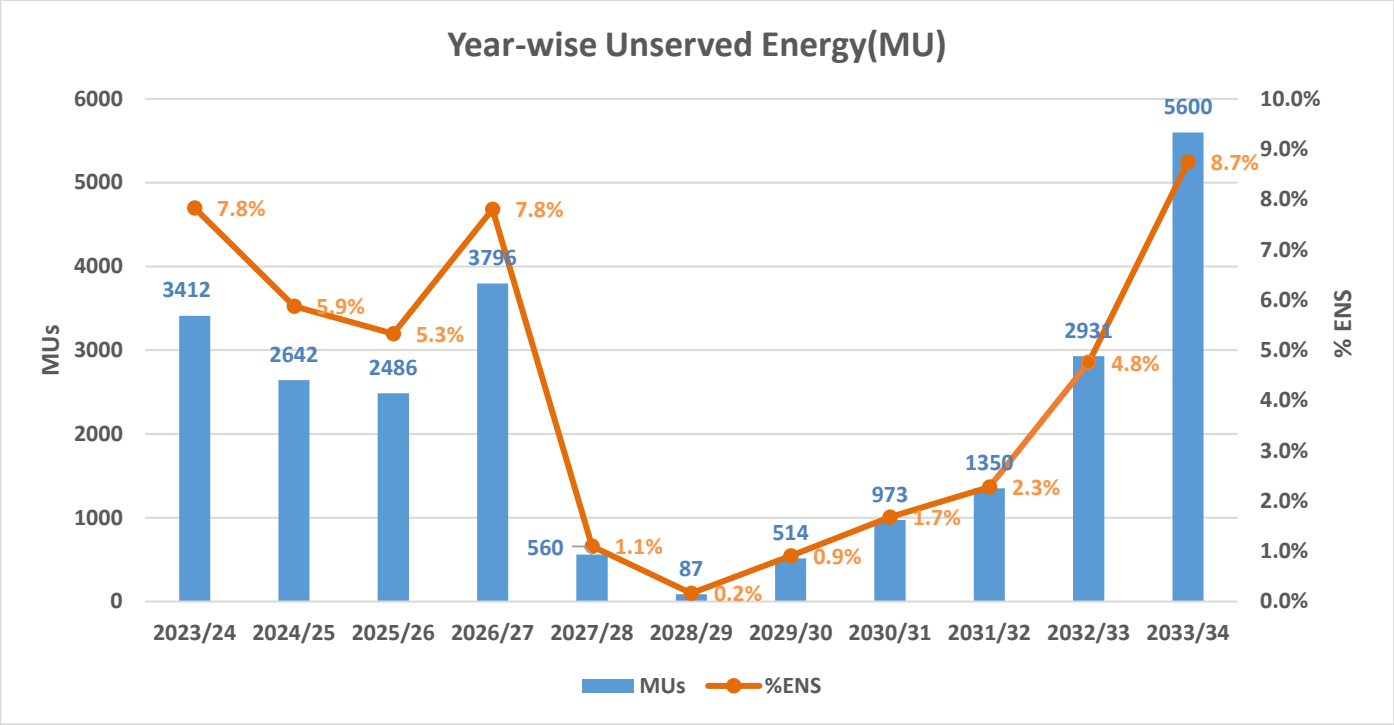


Figure 7 Yearly likely unserved energy with the planned capacities for Odisha (in MU)

The study has also analyzed the Daily and monthly pattern of unserved energy in the year 2033-34, it can be seen that the unserved energy coincides with peak demand months when the contracted capacity (present, planned and additional RE for RPO) is unable to meet the demand.

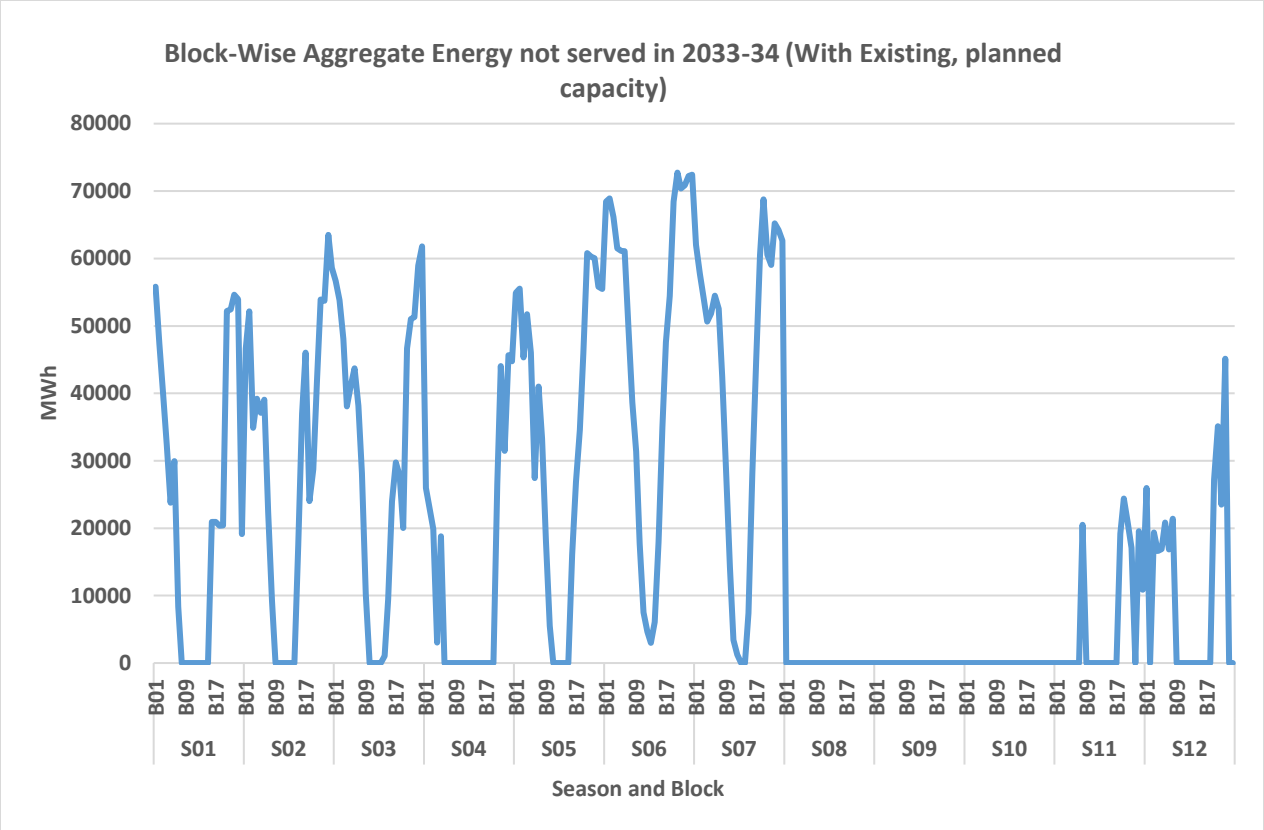


Figure 8 Block-wise Unserved Energy Pattern MWh (2033-34)

5.2 Capacity Mix Projection

The study was carried out considering existing capacity, planned capacity and capacity required to fulfil the RPO obligations. It was observed unserved energy in the year 2033-34.

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) The STOA/MTOA requirement can be fulfilled through power procurement from markets or bilateral agreements.
ii) The STOA/MTOA value reflects the peak value requirement in terms of MW.

The capacity projections for Odisha are given below:

Table 6 Year-wise contracted capacity projections (in MW)

Year	COAL	Biomass	Hydro	WIND	Solar	PSP	DRE	STOA	Total

2023/24	4570	20	2466	350	1016	0	0	2203	**10625**
2024/25	4578	20	2482	1150	2755	0	550	2226	**13762**
2025/26	4578	0	2582	2150	3555	0	799	2185	**15850**
2026/27	4578	0	2811	2376	3619	0	1071	2529	**16984**
2027/28	5503	0	2915	2376	3619	0	1367	1912	**17693**
2028/29	6170	0	2960	2376	3619	0	1691	1757	**18574**
2029/30	6170	0	3167	2376	4182	600	2066	1556	**20118**
2030/31	6170	0	3267	2376	4824	920	2360	1462	**21379**
2031/32	6170	0	3367	2376	5996	1420	2659	976	**22964**
2032/33	6170	0	3467	2376	6655	1420	3014	1424	**24527**
2033/34	6225	0	3567	2376	7455	1420	3393	1800	**26237**

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

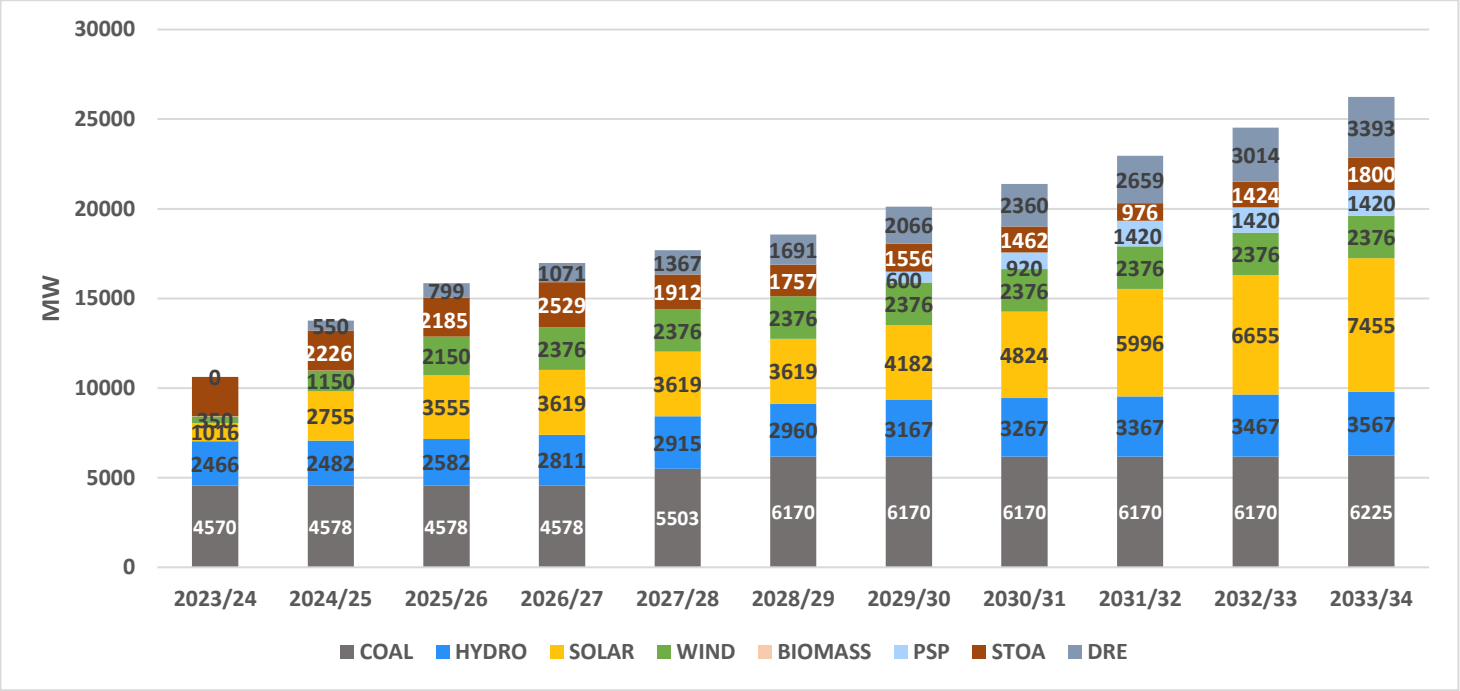


Figure 9 Projected Contracted Capacity Mix Year-wise (MW) for Odisha

As per the Resource Adequacy studies, the total projected contracted Capacity for the year 2033-34 is 26,237 MW which consists of 6225 MW from Coal, 3567 MW from Hydro, 2376 MW from Wind, 7455 MW from Solar, 1420 MW of PSP, 1800 MW from STOA,3393 MW from DRE. 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 Odisha has been assessed as 10%. In addition, the projected/contracted capacity fulfils the stipulated Renewable Purchase Obligation.

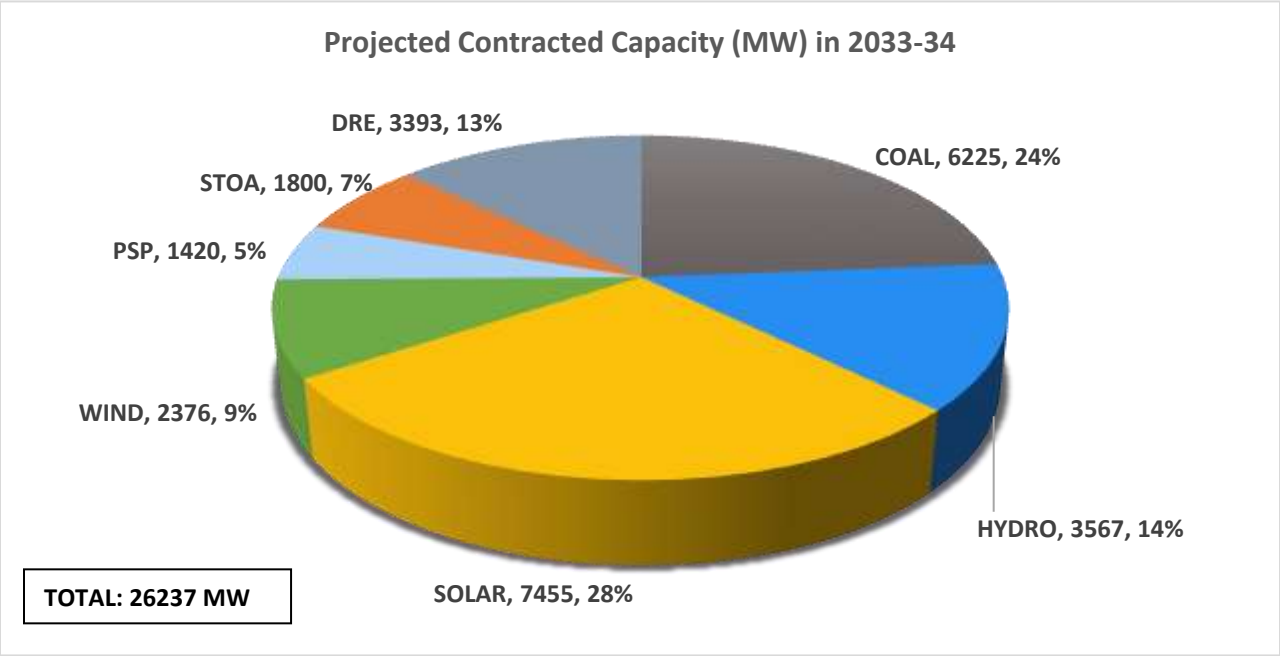
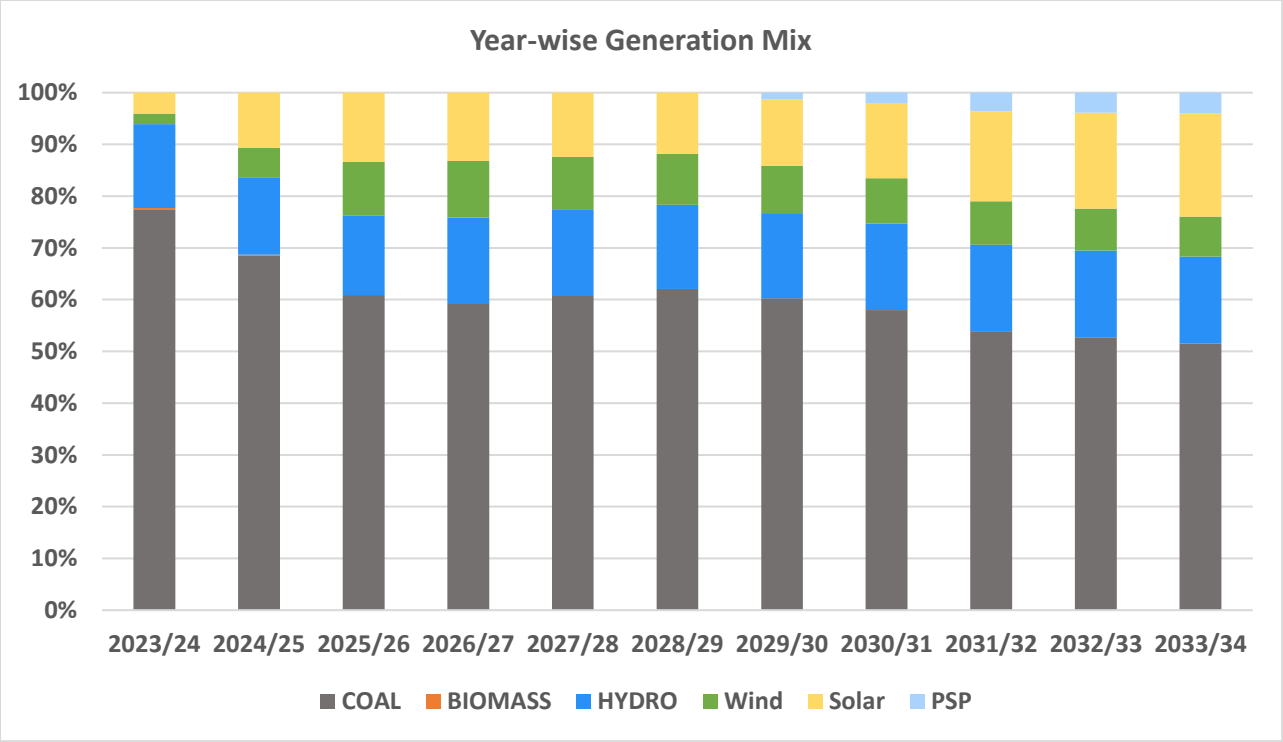
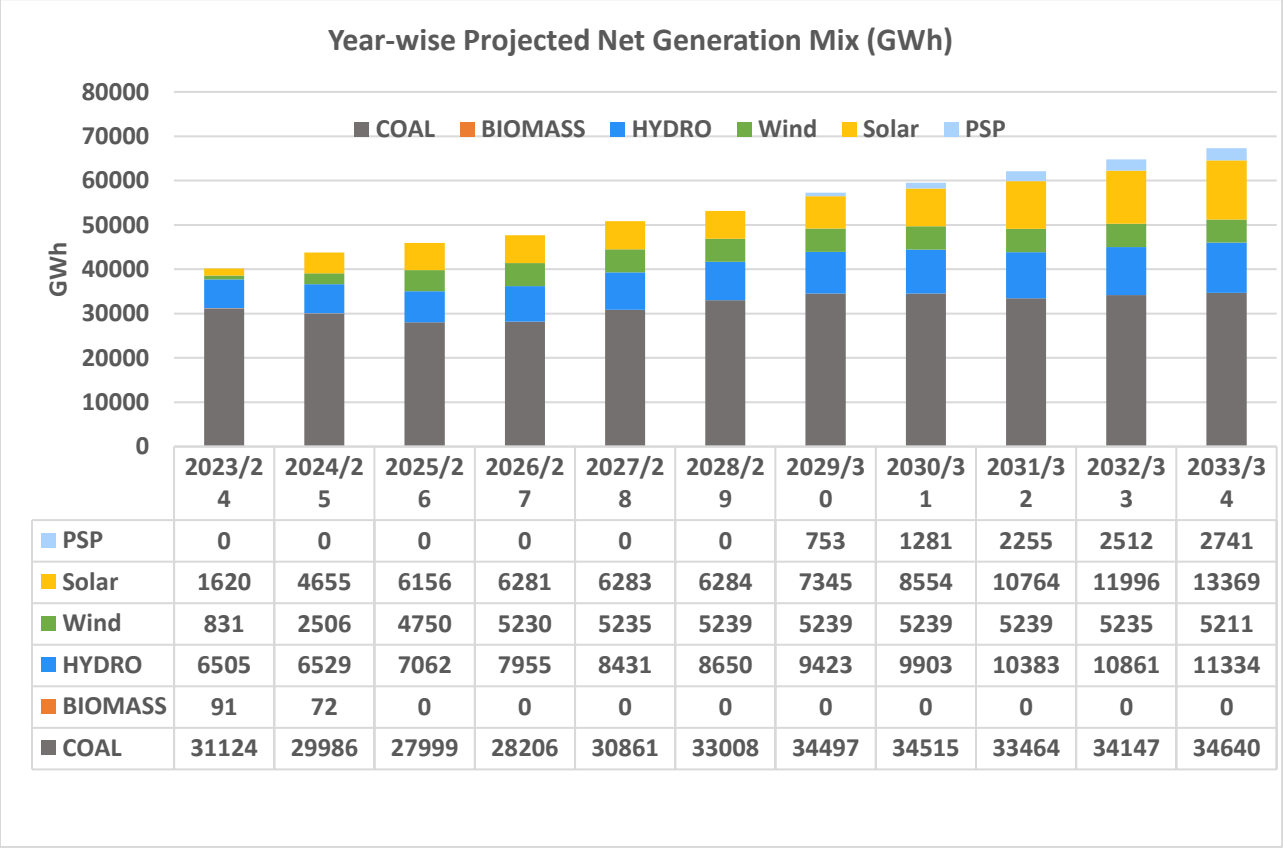


Figure 10 Contracted Capacity Mix in 2033-34 with 10% PRM

The share of non-fossil fuel-based capacity in the generation mix is projected to increase to around 69.4 % by 2033-34 with higher contribution from non-fossil fuel-based capacities in alignment with RPO trajectory.





	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34
PSP	0	0	0	0	0	0	753	1281	2255	2512	2741
Solar	1620	4655	6156	6281	6283	6284	7345	8554	10764	11996	13369
Wind	831	2506	4750	5230	5235	5239	5239	5239	5239	5235	5211
HYDRO	6505	6529	7062	7955	8431	8650	9423	9903	10383	10861	11334
BIOMASS	91	72	0	0	0	0	0	0	0	0	0
COAL	31124	29986	27999	28206	30861	33008	34497	34515	33464	34147	34640

Figure 11 Year-wise projected net generation mix (in GWh)

5.3 Capacity contract requirement for future

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

Table 7 Year wise Capacity Addition for Odisha (in MW)

FY	Thermal		Hydro		SOLAR		Wind		PSP		Yearly STOA	DRE	Total	
	Planned	Additional	Planned	Additional	Planned	Additional	Planned	Additional	Planned	Additional	Additional	Additional	Planned	Additional
2023/24	271	0	0	0	0	0	0	0	0	0	2203	0	**271**	**2203**
2024/25	271	0	16.5	0	939	800	400	400	0	0	2226	550	**1626.5**	**3976**
2025/26	0	0	100	0	0	800	600	400	0	0	2185	249	**700**	**3634**
2026/27	0	0	128.5	100	0	64	0	226	0	0	2529	271	**128.5**	**3190**
2027/28	933	0	104	0	0	0	0	0	0	0	1912	297	**1037**	**2209**
2028/29	667	0	0	45	0	0	0	0	0	0	1757	324	**667**	**2126**
2029/30	0	0	107	100	563	0	0	0	600	0	1556	375	**1270**	**2031**
2030/31	0	0	0	100	300	341	0	0	320	0	1462	294	**620**	**2197**
2031-32	0	0	0	100	469	703	0	0	500	0	976	299	**969**	**2078**
2032/33	0	0	0	100	0	659	0	0	0	0	1424	355	**0**	**2538**
2033/34	0	55	0	100	0	800	0	0	0	0	1800	379	**0**	**3134**
Total	**2142**	**55**	**456**	**645**	**2271**	**4167**	**1000**	**1026**	**1420**	**0**	**20030**	**3393**	**7289**	**29316**

5.4 Coal Capacity Performance

The coal capacity PLF is expected to remain in the range of 64%- 82% for the years till 2034(reducing from 82% in 2023-24 to 2033-34) ensuring higher absorption of higher renewable energy.

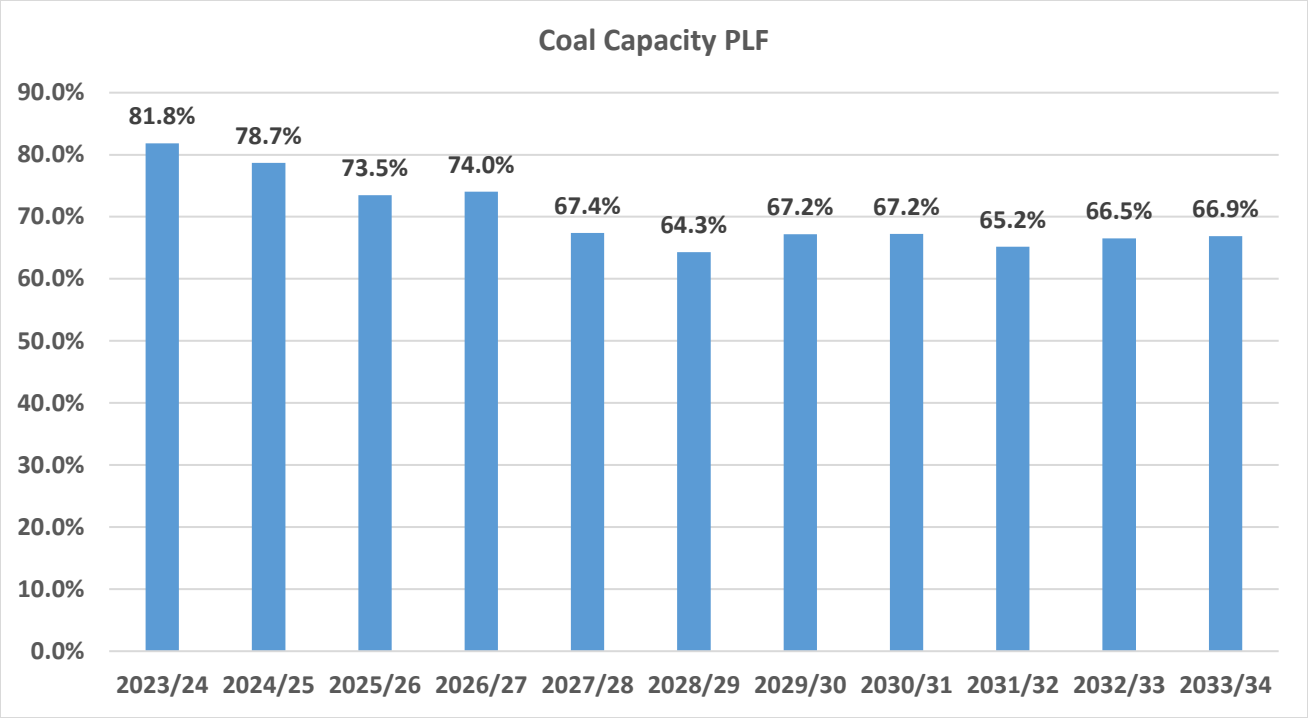


Figure 12 Year-wise coal capacity PLF for Odisha (in %)

5.5 Day-wise Surplus Capacity Odisha (MW)

Surplus capacity is available with states due to RE availability, Demand variation etc. The pattern of surplus capacities for Odisha has been observed as below. This capacity can be shared with other states and reduce the fixed cost burden on the utilities resulting in reduction in the cost for consumer. Odisha has likely surplus capacity available during the day time (during June, July, August and winter months) in the range of 360-1800 MW for 2026-27 as shown below which can be shared with other states.

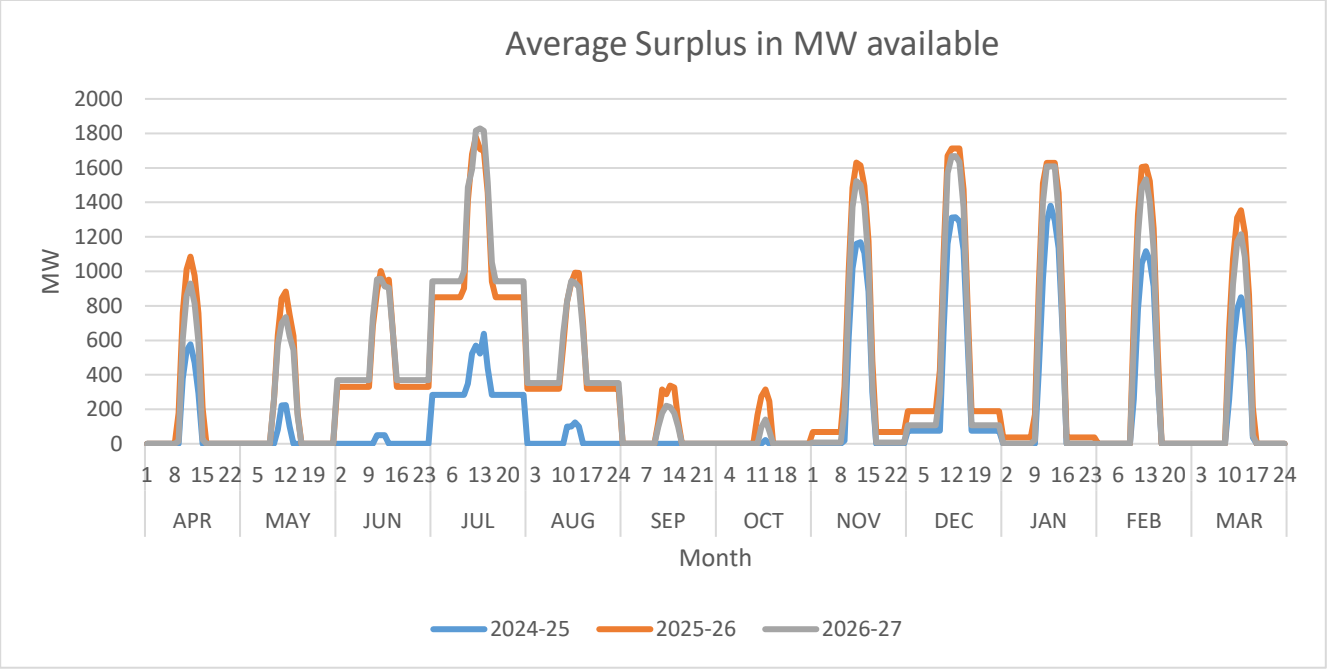


Figure 13 Surplus Coal Capacity Year-wise (MW)

6.0 Alternate Resilient Scenario Analysis

In view of the recent surge in Power demand during the year 2023-24 and capacity addition being delayed compared to the envisaged timelines, it was realized that a 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 Alternate Resilient scenario:

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

Table 8 Time Delay in commissioning of contracted capacity

Contracted Capacity Type	Years Delayed
Hydro	2
Nuclear	2
Renewable Energy Capacity	1
Coal	1

6.1 Capacity Mix Projections

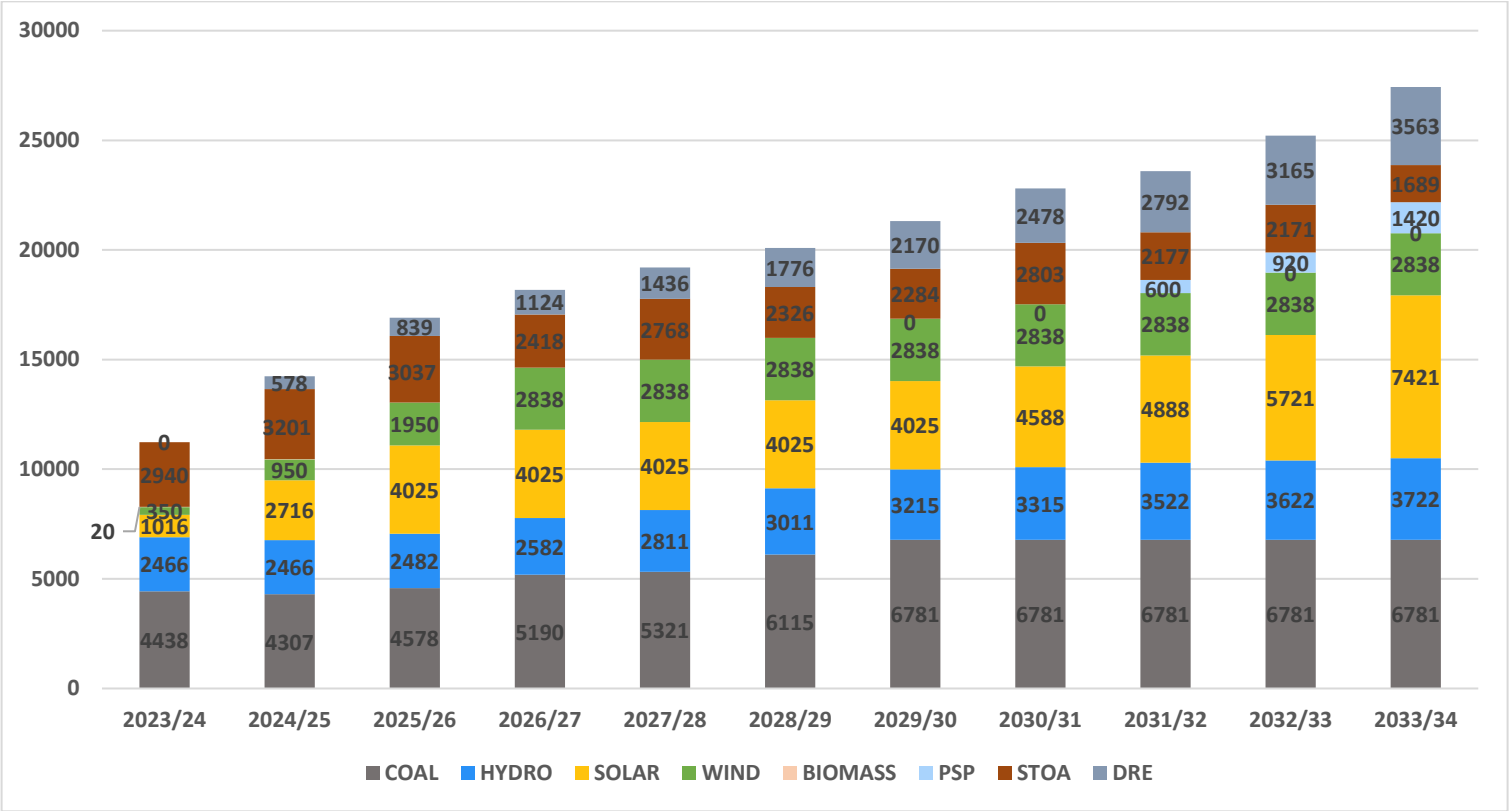


Figure 14: Year-wise capacity projections (in MW) for Alternate Resilient Scenario

In this scenario, coal requirement increases by around 620 MW, Hydro requirement increases by 155 MW, Wind requirement increases by 462 MW compared to the base case. The STOA requirement increases by around 550-1350 MW in case of Alternate Resilient scenario from 2024/25 compared to the base case.

If Additional Capacity required for meeting RPO in Alternate Resilient scenario is only 70% realized due to delay in commissioning of RE projects, then, coal capacity requirement may further increase by 350 MW starting from year 2026-27.

7.0 Conclusion

The study was carried for assessing the resource adequacy of Odisha based on the demand projections by Electric Power Survey. The following conclusions can be drawn based on the studies: -

- The demand projections by Odisha are lower compared to the demand projections by 20th Electric Power Survey (EPS).
- The current capacity mix in Odisha has 47% of IC from fossil fuel sources. The peak demand season is Monsoon months from June to September. The study is based on the hourly load pattern of the year 2022-23.
- Odisha is likely to witness energy deficit ranging from 87 MUs to 5600 MUs in different years from 2023-24 to 2033-34 with the existing and planned capacity addition. Odisha is deficit in fulfilment of its Renewable Purchase Obligations (RPO) and needs to contract renewable capacities for fulfilling them. The projected capacity and generation mix fulfils the RPO by 2030 as per the Ministry of Power notification dated 20th October,2023.
- Odisha is likely to have unserved energy in coming years and may need to contract non-fossil capacities for meeting energy requirements other than the planned capacities. The additional quantum of capacities required (other than already planned) to be contracted is about 55 MW from Coal,4168 MW from solar, 1026 MW from Wind, 645 MW from Hydro, 3393 MW of DRE till 2033-34.
- STOA value reflects the peak value (MW) requirement in the capacity mix. However, in energy terms, the requirement from STOA is quite less.
- The coal capacity PLF is expected to remain in the range of 64%- 82% for the years till 2033-34 ensuring higher absorption of higher renewable energy.
- In Alternate Resilient scenario, coal requirement increases by around 620 MW, Hydro requirement increases by 155 MW, Wind requirement increases by 462 MW, DRE requirement increases by 170 MW compared to the base case. The STOA requirement increases by around 550-1350 MW in case of from 2024/25 compared to the base case.
- It is likely that Odisha may have surplus capacity available during the day time (during June, July, August and winter months) in the range of 360-1800 MW for 2026-27 which can be shared with other states.

Annexure-I

Future Contracted/Approved Capacity (MW) of Central and State Sector (Thermal, Hydro)

SR. NO	POWER PLANT	ODISHA'S SHARE (MW)	TYPE OF GENERATION	EXPECTED COD/ REMARK
1	TTPS Expansion Project	660	THERMAL	FY 2027-28
2	NTPC N. Karanpura	264	THERMAL	U-1: FY 2023-24 U-2: FY 2024-25
3	NTPC Darlipali	400	THERMAL	FY 2028-29
4	NTPC Barh-I	418	THERMAL	U-2: FY 2023-24 U-3: FY 2024-25 U-1: FY 2027-28 (re-allocated)
5	NLCIL Talabira Thermal Power Project, Phase I	400	THERMAL	U-1: FY 2027-28 U-2: FY 2028-29 U-3: FY 2028-29
6	Kharagpur SHEP	16.5	HYDRO	FY 2024-25
7	Teesta-VI HEP	100	HYDRO	FY 2025-26
8	Ratle HE PROJECT	100	HYDRO	FY 2026-27
9	Indravati SHEP	3.5	HYDRO	FY 2026-27
10	Shahid Laxman SHEP	25	HYDRO	FY 2026-27
11	Teesta- IV	104	HYDRO	FY 2027-28
12	Kharag HEP, Kandhmal	63	HYDRO	FY 2029-30
13	Salki HEP, Kandhmal	44	HYDRO	FY 2029-30
14	Upper Indravati HEP	600	PSP	FY 2029-30
15	Upper Kolab HEP	320	PSP	FY 2030-31
16	Balimela PSP	500	PSP	FY 2031-32
	TOTAL	**4018**		

Assumption for Resource Adequacy Studies for the state of Odisha

1. Electricity Demand & peak requirement: As per 20th Electric Power Survey
2. Demand Profile: Based on hourly demand profile of 2022-23
3. Existing & Planned Capacity: As per the information received from ODISHA
4. Future Capacity addition: based on RPO trajectory
5. Cost parameters: based on information in National Electricity Plan

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 in the year 2021-2022:

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
Hydro~	6 Cr to 20 Cr	2.5% of Capex	5 to 8	40
Solar**	4.5 Cr to 4.1 Cr	1 % of Capex	0.5	25
Wind(Onshore)	6 Cr	1% of Capex	1.5	25
Wind(Offshore)	13.7 Cr	1% of Capex	1.5	25
Biomass	9 Cr	2% of Capex	3	20
Pumped Storage	3 Cr to 8 Cr	5 % of Capex	7	40
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

* 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 Hydro and 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.

**Solar Cost is assumed to reduce from Rs 4.5 Cr/MW in 2021-22 to Rs 4.1 Cr/MW in 2029-30.