
# Report On
# Resource Adequacy Plan for the Union Territory of J&K and Ladakh
## (Period: 2024-25 to 2034-35)

**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.

As per the Resource Adequacy Guidelines, each Distribution licensee shall undertake a Resource Adequacy Plan (RAP) for a 10-year horizon (Long-term Distribution Licensee Resource Adequacy Plan (LT-DRAP)) to meet their own peak and electrical energy requirement. The plan shall be vetted/validated by Central Electricity Authority for leveraging the benefit of national level optimization for the Distribution licensees. The LT-DRAP shall be carried out by the distribution licensees on an annual rolling basis considering the contracted capacity as a part of the system and shall optimize for additional capacity required.

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 J&K has been assessed in compliance with new RPO trajectory.

The electrical energy demand for the UT of J&K and Ladakh is increasing with a CAGR of 4.2 % from 2024-25 to 2034-35 as forecasted by 20$^{th}$ EPS. The projections of J&K also indicate that electrical energy demand may increase with a CAGR of 4.07 % from 2024-25 to 2034-35. For satisfying resource adequacy i.e., meeting the electricity demand reliably and at affordable cost, the UT needs 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.

A study was carried out considering existing capacity, planned capacity & capacity required to fulfil the Renewable Purchase Obligations (RPO) for the UT. It was observed that the total unserved energy in the year 2034-35 is expected to be about 9928 MU which is about 29% of annual energy during the year 2034-35.

To find out the least cost option for generation capacity expansion for the period 2024-25 to 2034-35 to meet the demand reliably, long-term study for the UT of J&K and Ladakh 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. Additionally, Reliability study has been carried out to determine the probability of Unmet demand and hours by implementing the variation in demand, RE (Solar, Wind) and forced outage of thermal generators (Coal, gas) etc. Thus, the Resource adequacy

studies have projected likely optimal capacity mix for future years till 2034-35 which would able to meet anticipated demand reliably at every instance while meeting Renewable Purchase Obligations (RPO).

# 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 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 20$^{th}$ October, 2023 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 J&K & Ladahk based on the inputs received from J&K SLDC with a view of fulfilling RPO trajectory. The study suggests the optimal resource mix till 2034-35 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 catering to above highlighted uncertainties so that demand can be met reliably throughout the year.

# 2.0 J&K RA Study

## 2.1 Present Power Scenario in J&K and Ladakh

The current Power Supply Position for the UT is shown in the Table 1 below:

*Table 1 Power Supply Position*

| Power Supply Position | | | | | | |
|---|---|---|---|---|---|---|
| **Year** | **Energy required (MU)** | **Energy Supplied (MU)** | **Gap (MU)** | **Peak Demand (MW)** | **Peak Met (MW)** | **Demand Not Met (MW)** |
| **2021-22** | 19957 | 18434 | **1524** | 3076 | 2826 | **250** |
| **2022-23** | 19639 | 19322 | **317** | 3137 | 2967 | **170** |
| **2023-24** | 20040 | 19763 | **277** | 3181 | 3133 | **48** |

As of March 2024, the total contracted capacity (winter share) for J&K and Ladakh is 3245 MW. (The summer share for the UT as on 31st March, 2024 is 2625 MW.) For the purpose of RA study, the winter share of the contracted capacity has been considered. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 69.22%.

The fuel-wise contracted capacity as on 31st March, 2024 is given in Table and Figure below:

*Table 2 Fuel-wise Contracted Capacity as on March 2024*

| **Source** | **Contracted Capacity (MW)*** | **Percentage** |
|---|---|---|
| Coal | 870 | 26.81% |
| Gas | 129 | 3.97% |
| Nuclear | 68 | 2.10% |
| Solar | 20 | 0.62% |
| Hydro | 2158 | 66.50% |
| **Total** | **3245** | **100%** |

*Winter share of contracted capacity

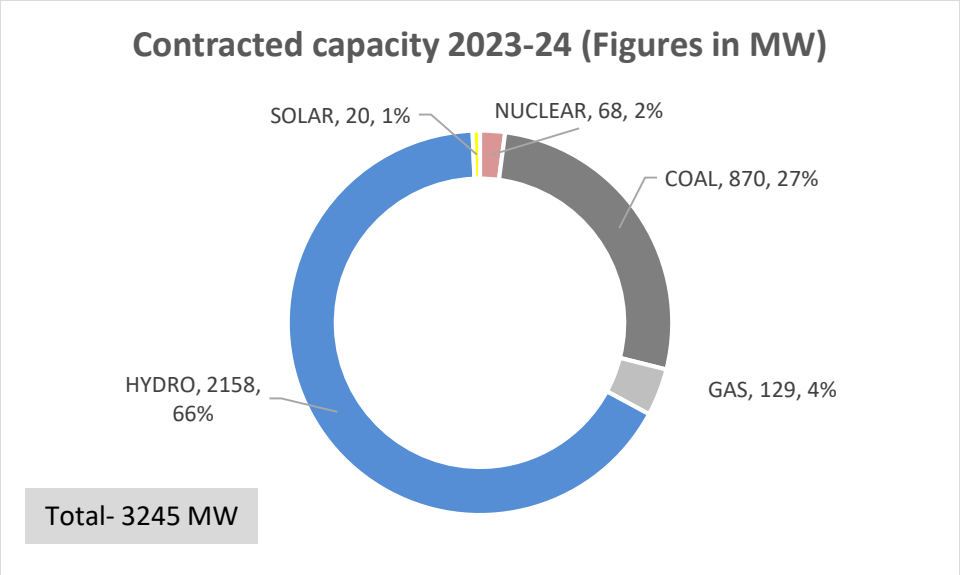



*Figure 1 Fuel-wise Contracted Capacity (in MW) as on 31st March, 2024*

## 2.2 Present Demand Analysis

Hourly demand pattern of 2022-23 and 2023-24 (till Dec) was analyzed and it was observed that the peak demand season for J&K is during the months of December, January and February. J&K witnesses peak demand during both day and 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.

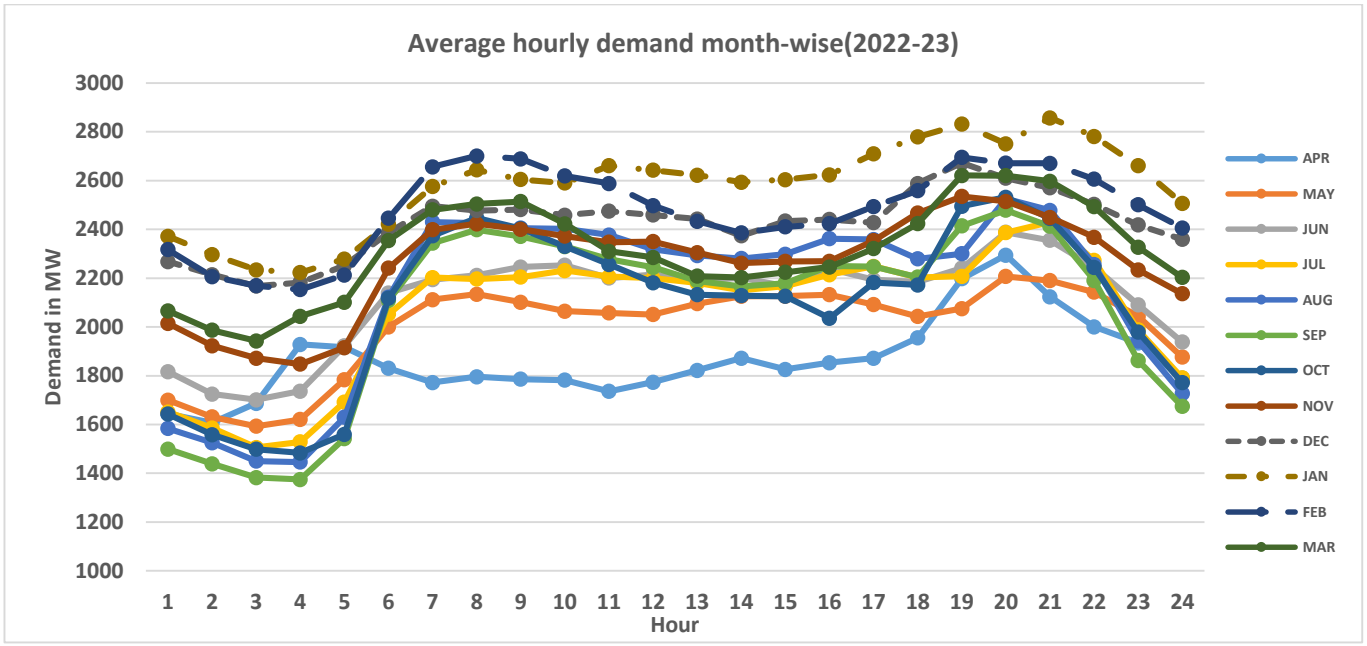



*Figure 2 Average Hourly Demand Variation (Month-wise) of J&K for 2022-23*

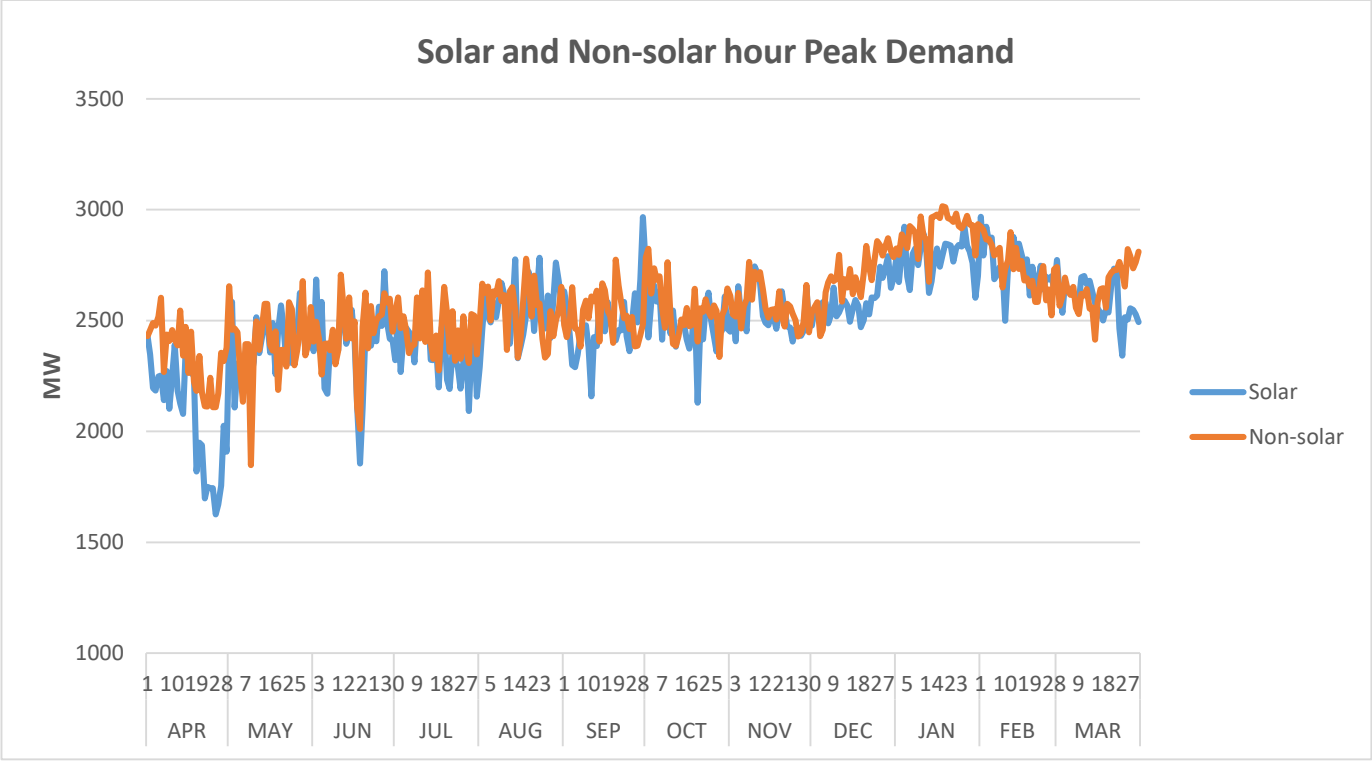



*Figure 3 Solar and Non-solar Peak in MW of J&K (2022-23)*

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.

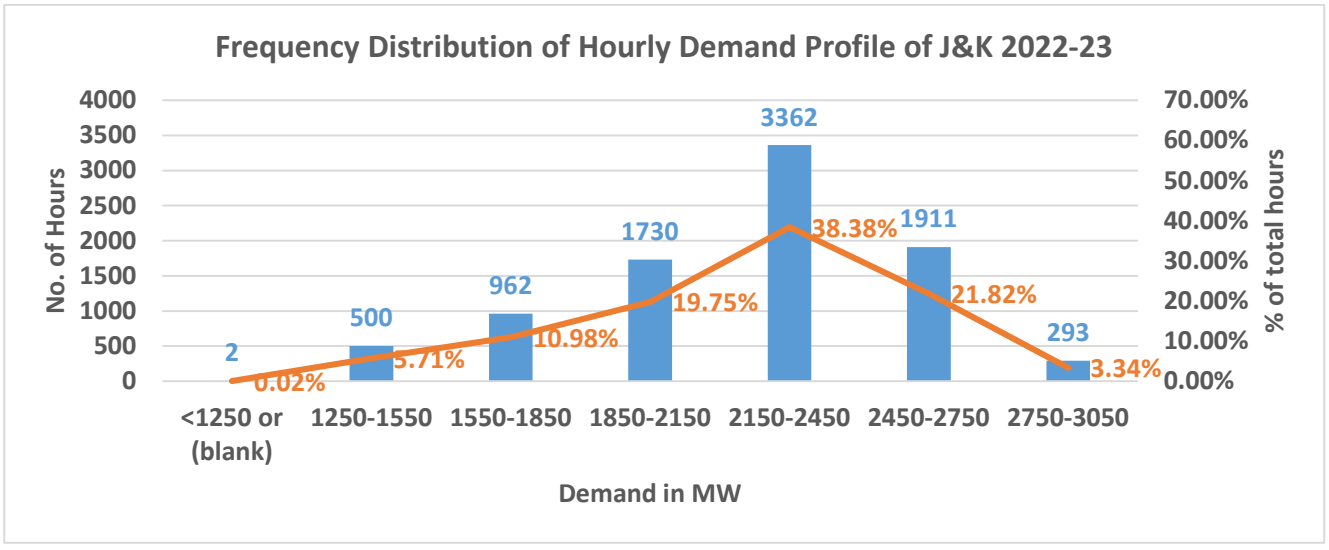



*Figure 4 Frequency Distribution of Hourly Demand Profile of J&K 2022-23*

## 3.0 Inputs/Assumptions for the Study

i) Peak and Energy Demand for the UT of J&K and Ladakh has been taken as per the projections provided by UT department. The Demand estimation by J&K was higher than projected by 20th EPS. Therefore, the studies have been carried out using projections given by J&K UT department.

*Table 2 Future Demand Projection as provided by J&K*

| | 2024-25 | 2025-26 | 2026-27 | 2027-28 | 2028-29 | 2029-30 | 2030-31 | 2031-32 | 2032-33 | 2033-34 | 2034-35 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Energy Projections (MU)** | 23196 | 24297 | 25268 | 26279 | 27136 | 28423 | 29560 | 30743 | 31745 | 33251 | 34582 |
| **Year on Year Growth** | | 5% | 4% | 4% | 3% | 5% | 4% | 4% | 3% | 5% | 4% |
| **Peak Demand Projections (MW)** | 3555 | 3769 | 3995 | 4235 | 4489 | 4758 | 5044 | 5346 | 5667 | 6007 | 6367 |
| **Year on Year Growth** | | 6% | 6% | 6% | 6% | 6% | 6% | 6% | 6% | 6% | 6% |

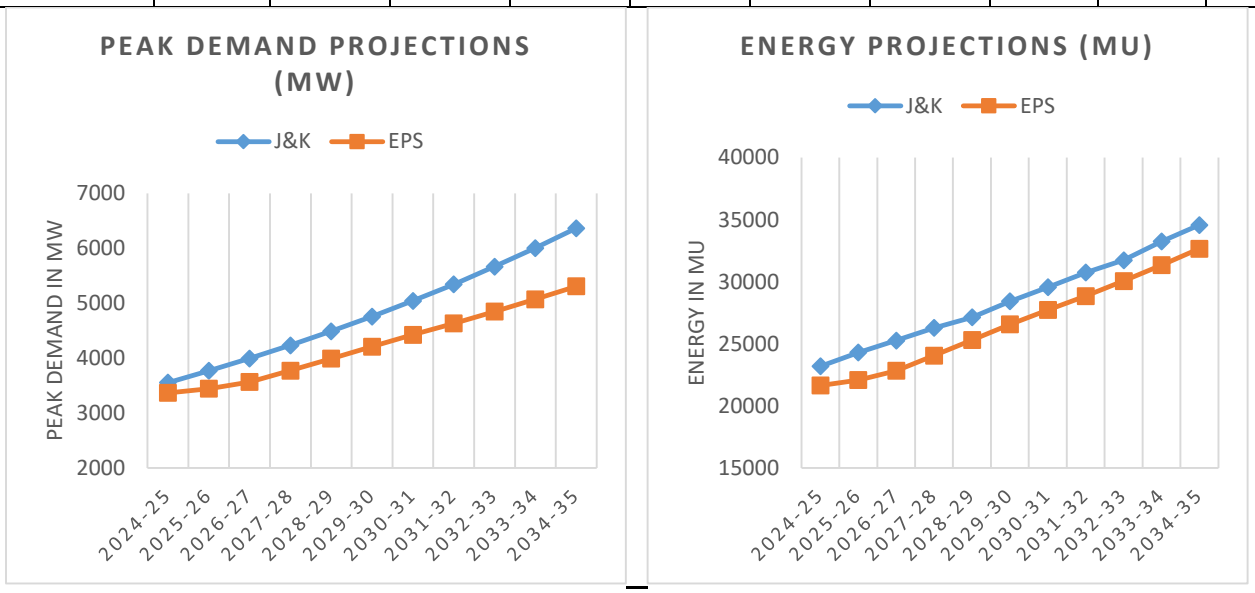



*Figure 5 Comparison of Energy Requirement and peak Demand Projections of 20th EPS vs J&K & Ladakh*

ii) Future demand profile for the year 2034-35 has been projected using the demand profile of J&K for the year 2022-23 as the base profile.

iii) The actual solar generation profiles and CUFs have been taken as provided by J&K.

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

v) Existing & Planned Capacity: As per the information received from J&K SLDC. (List of Planned Capacities is attached in **Annexure-I**). The existing contracted capacity has been taken as per the winter share of capacities

vi) According to the data provided by J&K, an additional 392 MW of Coal (Shakti Scheme), 620 MW of solar and 1206 MW of hydro is planned till 2030.

vii) 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. 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 trajectory till 2034-35 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% | 28.10% | 0.75% | 29.91% |
| 2. | 2025-26 | 1.45% | 1.22% | 29.29% | 1.05% | 33.01% |
| 3. | 2026-27 | 1.97% | 1.34% | 31.29% | 1.35% | 35.95% |
| 4. | 2027-28 | 2.45% | 1.42% | 33.29% | 1.65% | 38.81% |
| 5. | 2028-29 | 2.95% | 1.42% | 35.05% | 1.95% | 41.36% |
| 6. | 2029-30 | 3.48% | 1.33% | 36.27% | 2.25% | 43.33% |
| 7. | 2030-31 | 43.00% | | | 2.50% | 45.50% |
| 8. | 2031-32 | 44.25% | | | 2.75% | 47.00% |
| 9. | 2032-33 | 45.30% | | | 3.00% | 48.30% |
| 10. | 2033-34 | 46.25% | | | 3.25% | 49.50% |
| 11. | 2034-35 | 47.50% | | | 3.50% | 51.00% |

*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)

J&K being a hilly state, the share of DRE in the RPO trajectory has been taken as half of the share as stipulated in RPO order dated 20th October, 2023. The other half of the DRE component has been considered to be met from RE generation from other sources. 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 RE Generation 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** | 156 | 89 | 6518 | 175 | **6938** |
| **2** | **2025-26** | 352 | 296 | 7117 | 255 | **8020** |
| **3** | **2026-27** | 498 | 339 | 7907 | 341 | **9084** |
| **4** | **2027-28** | 644 | 373 | 8748 | 434 | **10199** |
| **5** | **2028-29** | 801 | 385 | 9511 | 529 | **11226** |
| **6** | **2029-30** | 989 | 378 | 10309 | 640 | **12316** |
| **7** | **2030-31** | 12711 | | | 739 | **13450** |
| **8** | **2031-32** | 13604 | | | 845 | **14449** |
| **9** | **2032-33** | 14381 | | | 952 | **15333** |
| **10** | **2033-34** | 15379 | | | 1081 | **16460** |
| **11** | **2034-35** | 16427 | | | 1210 | **17637** |

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

*Table 5 Renewable Energy Deficit/Surplus*

| FY | RE Generation required to meet RPO | RE Generation required to meet RPO | RE Generation available/met (From existing/planned Contracts) | RPO met (%) | RPO Surplus(+)/ Deficit (-) |
|---|---|---|---|---|---|
| | (MU) | (%) | (MU) | (%) | (%) |
| 2024/25 | 6938 | 29.91% | 9477 | 40.86% | 10.95% |
| 2025/26 | 8020 | 33.01% | 10833 | 44.59% | 11.58% |
| 2026/27 | 9084 | 35.95% | 13946 | 55.19% | 19.24% |
| 2027/28 | 10199 | 38.81% | 14350 | 54.61% | 15.80% |
| 2028/29 | 11226 | 41.36% | 14350 | 52.88% | 11.52% |
| 2029/30 | 12316 | 43.33% | 14350 | 50.49% | 7.16% |
| 2030/31 | 13450 | 45.50% | 14350 | 48.54% | 3.04% |
| 2031/32 | 14449 | 47.00% | 14350 | 46.68% | -0.32% |
| 2032/33 | 15333 | 48.30% | 14350 | 45.20% | -3.10% |
| 2033/34 | 16460 | 49.50% | 14350 | 43.16% | -6.34% |
| 2034/35 | 17637 | 51.00% | 14350 | 41.50% | -9.50% |

As per RPO trajectory, J&K needs to add/contract following additional capacity (MW) in the DRE category as DRE generation is not fungible.

*Table 6 YoY capacity addition (MW) required for RPO*

| FY | HYDRO | SOLAR | DRE | TOTAL |
|---|---|---|---|---|
| 2024/25 | 0 | 0 | 142 | 142 |
| 2025/26 | 0 | 0 | 66 | 66 |
| 2026/27 | 0 | 0 | 70 | 70 |
| 2027/28 | 0 | 0 | 76 | 76 |

| | | | | |
|---|---|---|---|---|
| 2028/29 | 0 | 0 | 77 | 77 |
| 2029/30 | 0 | 0 | 90 | 90 |
| 2030/31 | 0 | 0 | 82 | 82 |
| 2031/32 | 0 | 0 | 86 | 86 |
| 2032/33 | 0 | 14 | 88 | 102 |
| 2033/34 | 0 | 456 | 104 | 560 |
| 2034/35 | 0 | 478 | 106 | 584 |
| **TOTAL** | **0** | **948** | **987** | **1935** |

## 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 J&K 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 in the demands of 2021-22 and 2022-23 is shown below.

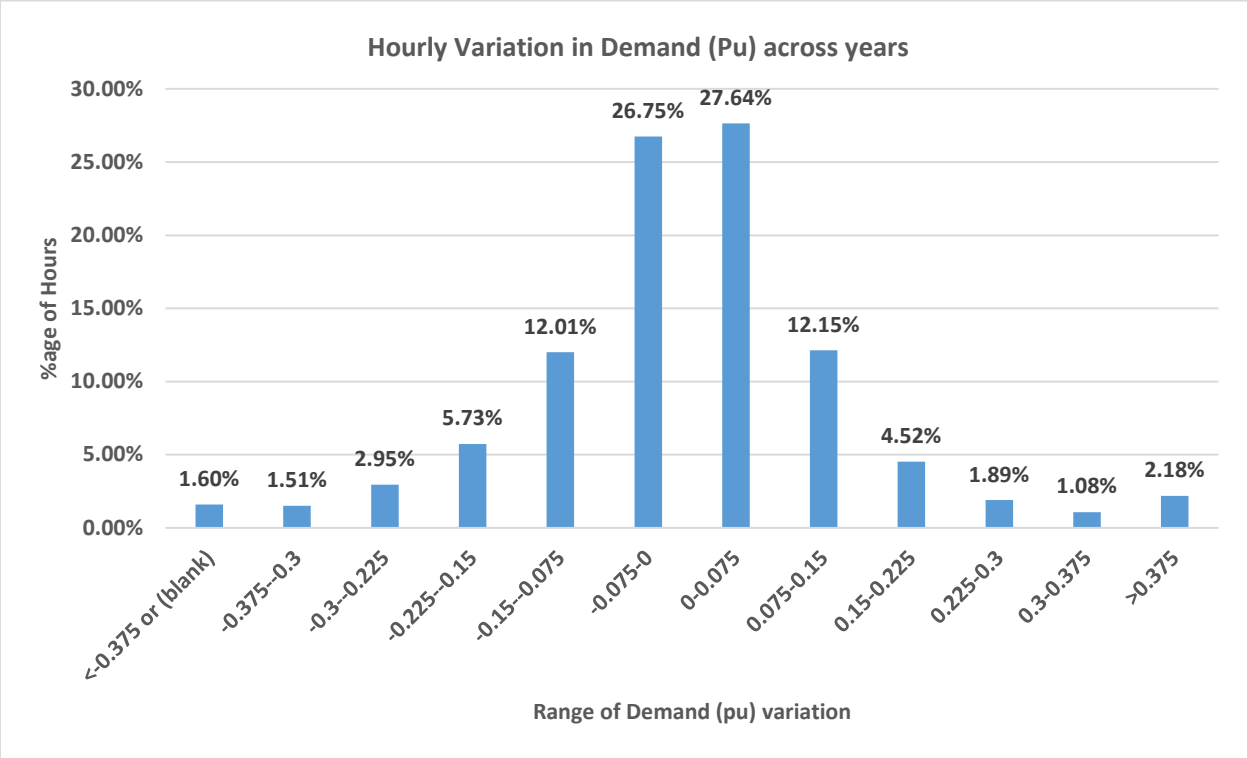



*Figure 6 Hourly Variation in Demand across years*

It can be observed that the hourly demand typically varies ±7.5% for 54% of instances. This variation is primarily due to temperature, weather parameter or any random outages of transmission line and generation units etc. This variation has been captured in the reliability study by varying the projected hourly demand for the future years by varying ±7.5% by introducing a random variable (with normal distribution) for demand as per observed behavior over the years.

## 4.2 RE variation

In the Long-term capacity expansion planning studies, a particular profile for Solar Plants is considered based on the observed solar 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 has been varied by 10 % 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 and planned capacity. It was observed that the total unserved energy in the year 2034-35 is about 8730 MU. The yearly likely unserved energy with the planned capacities is given below.

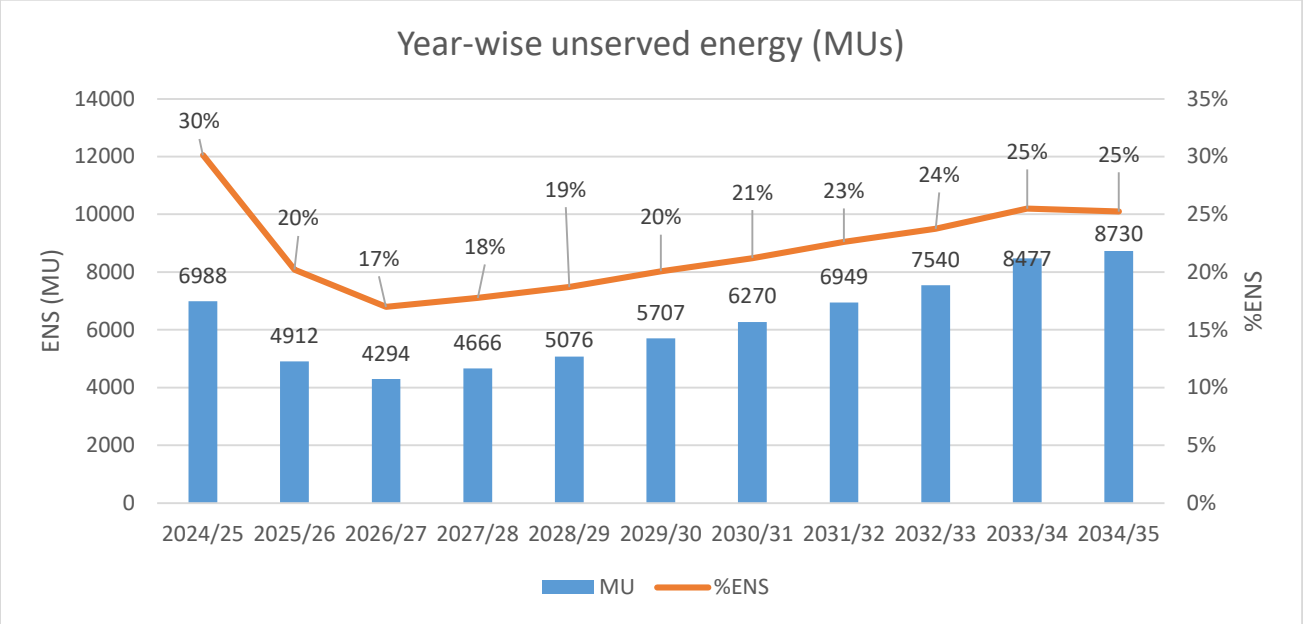



*Figure 7 Yearly likely unserved energy with the planned capacities for J&K and Ladakh (in MU)*

The study has also analyzed the Daily and monthly pattern of unserved energy in the year 2034-35, it can be seen that contracted capacity (present and planned) is unable to meet the demand. It can be seen from the graph below that during the high demand winter months, the proportion of unserved energy is high.

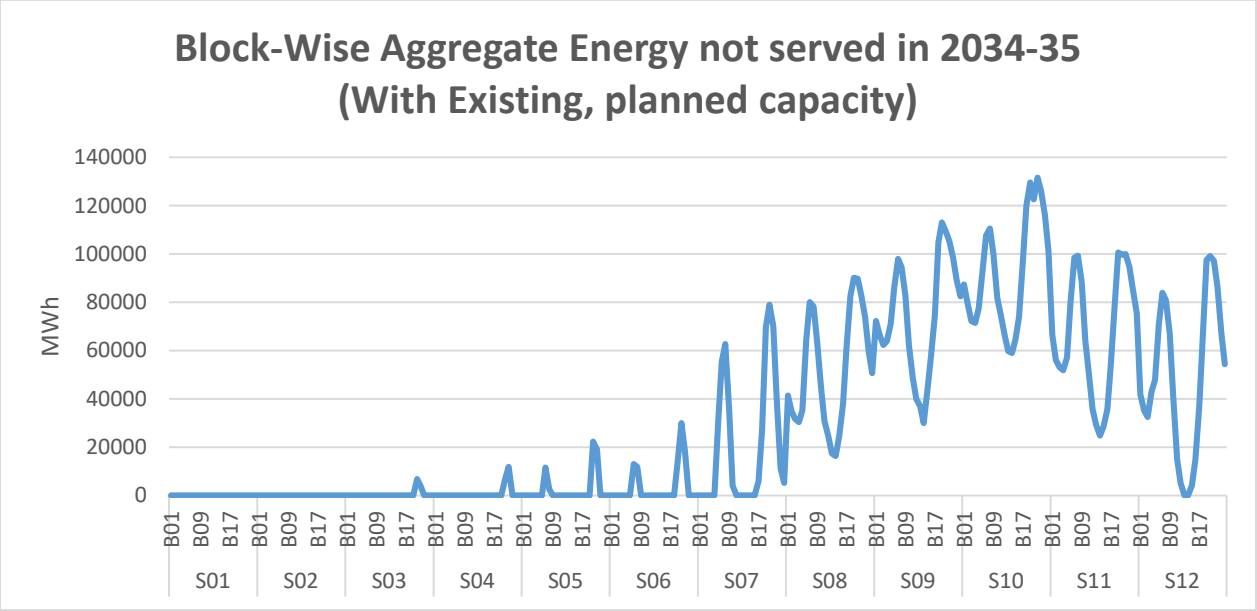



*Figure 8 Block-wise Unserved Energy Pattern MWh (2034-35)*

## 5.2 Capacity Mix Projection

To meet the unserved energy as mention in the section 5.1, 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/banking arrangements.

ii) The STOA/MTOA value reflects the peak value requirement in terms of MW.

The capacity projections for J&K and Ladakh are given below:

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

| Year | Coal | Hydro | Gas | Nuclear | Solar | DRE | MTOA/ STOA | Total |
|---|---|---|---|---|---|---|---|---|
| **2024/25** | 870 | 2359 | 129 | 68 | 20 | 142 | 1350 | **4938** |
| **2025/26** | 1262 | 2359 | 129 | 68 | 640 | 208 | 1134 | **5800** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2026/27** | 1262 | 3270 | 129 | 68 | 640 | 278 | 1116 | **6763** |
| **2027/28** | 1262 | 3364 | 129 | 68 | 640 | 354 | 1195 | **7012** |
| **2028/29** | 2829 | 3364 | 129 | 68 | 640 | 431 | 382 | **7843** |
| **2029/30** | 3008 | 3364 | 129 | 68 | 640 | 521 | 295 | **8025** |
| **2030/31** | 3166 | 3364 | 129 | 68 | 640 | 603 | 305 | **8275** |
| **2031/32** | 3166 | 3364 | 129 | 68 | 940 | 689 | 368 | **8724** |
| **2032/33** | 3166 | 3364 | 129 | 68 | 1240 | 777 | 428 | **9172** |
| **2033/34** | 3500 | 3364 | 129 | 68 | 1540 | 881 | 684 | **10166** |
| **2034/35** | 3700 | 3364 | 129 | 68 | 1840 | 987 | 700 | **10788** |

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

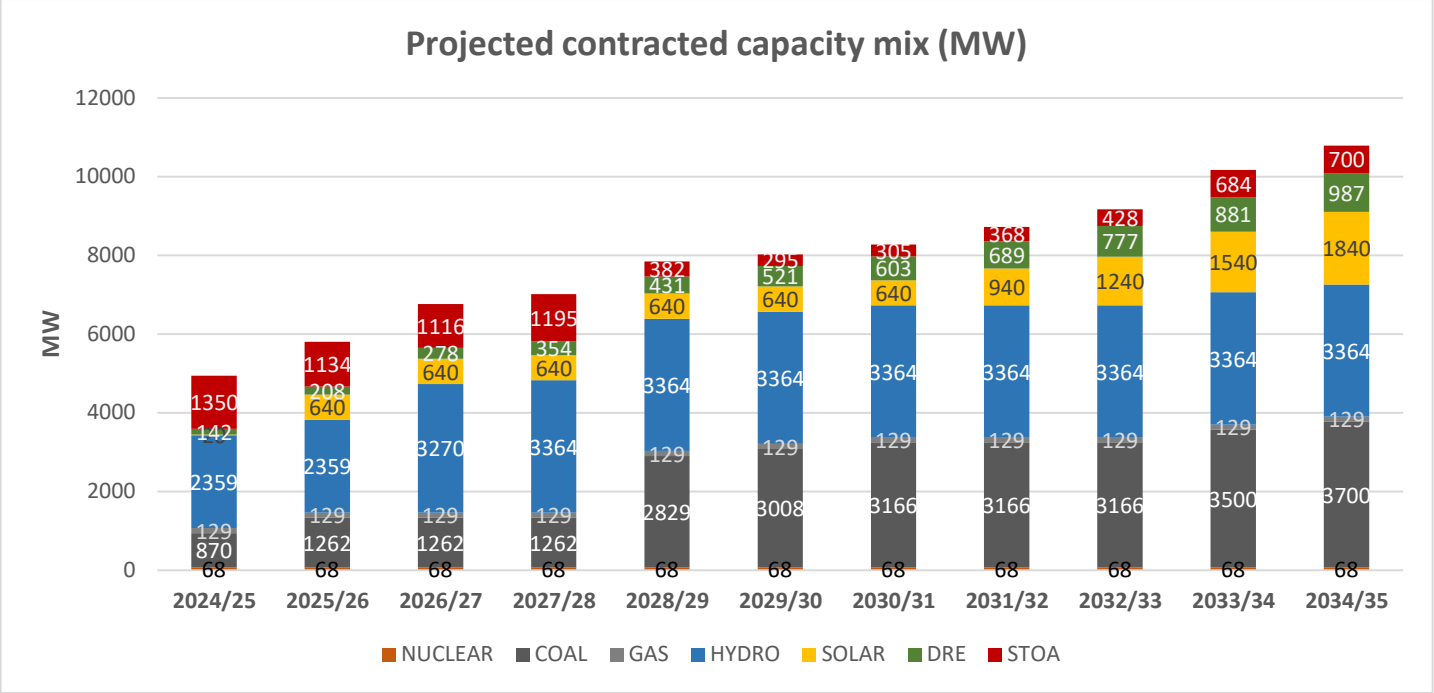



*Figure 9 Projected Contracted Capacity Mix Year-wise (MW) for J&K and Ladakh*

As per the Resource Adequacy studies, the total projected contracted Capacity for the year 2034-35 excluding STOA is 10088 MW which consists of 3700 MW from Coal, 129 MW from Gas, 3364 MW from Hydro, 68 MW from Nuclear, 1840 MW from Solar and 987 MW from DRE. This IC along-with additional 700 MW of STOA 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 J&K and Ladakh has been assessed as 5.10%. In addition, the projected/contracted capacity fulfils the stipulated Renewable Purchase Obligation.

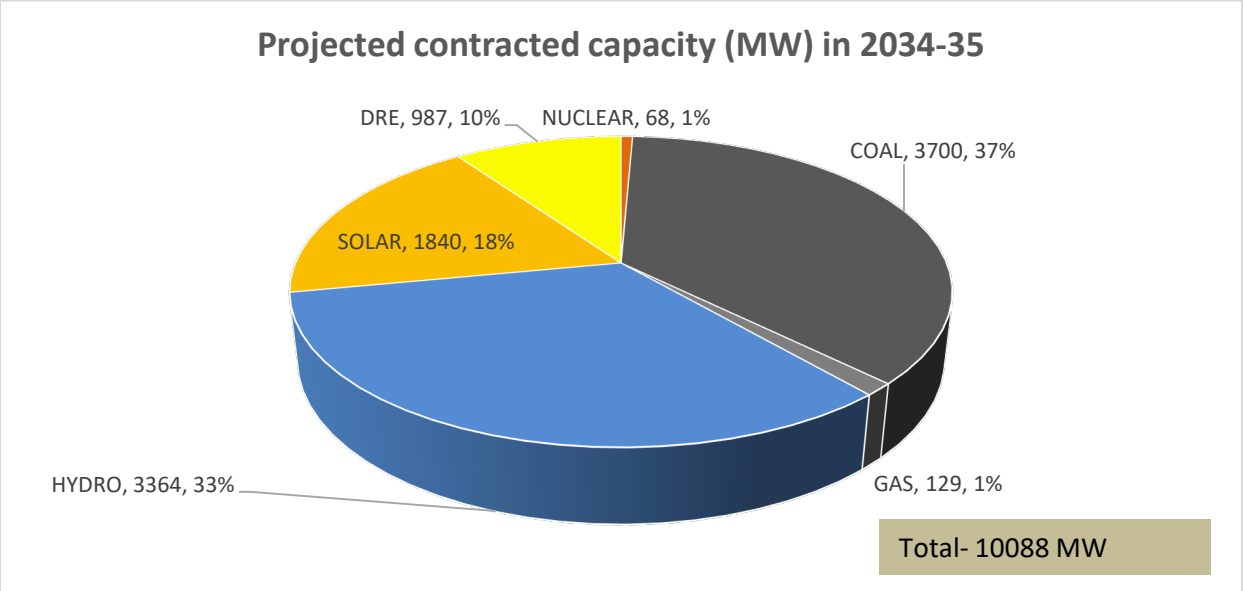
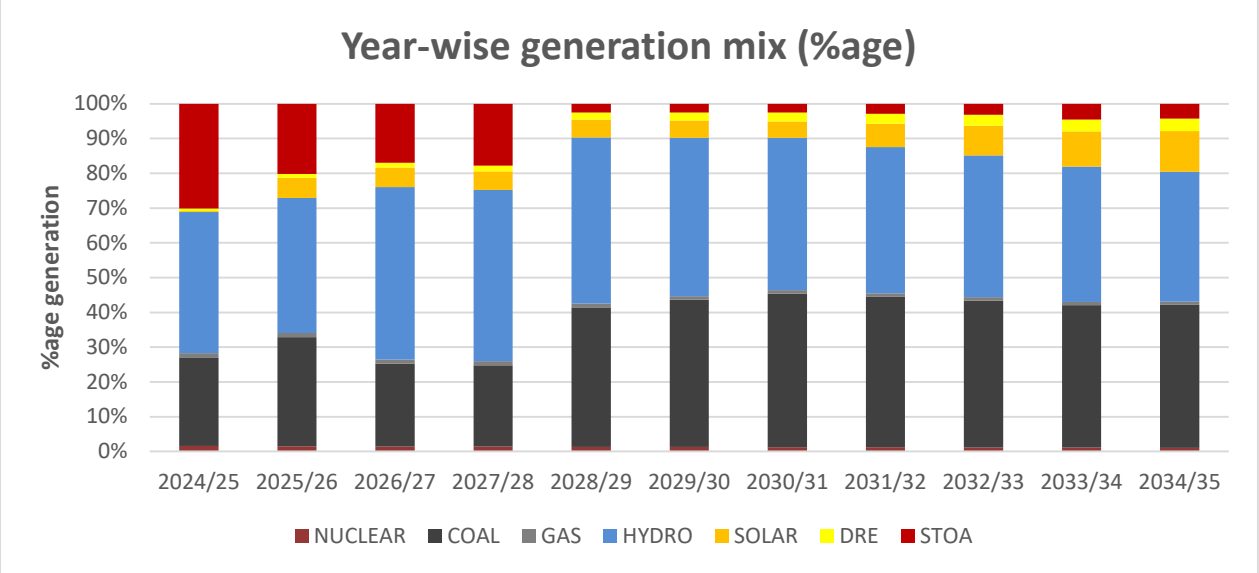



*Figure 10 Contracted Capacity Mix in 2034-35 with 5.10% PRM*

The share of non-fossil fuel-based capacity in the generation mix is projected to be around 62% by 2034-35 with higher contribution from non-fossil fuel-based capacities in alignment with RPO trajectory.



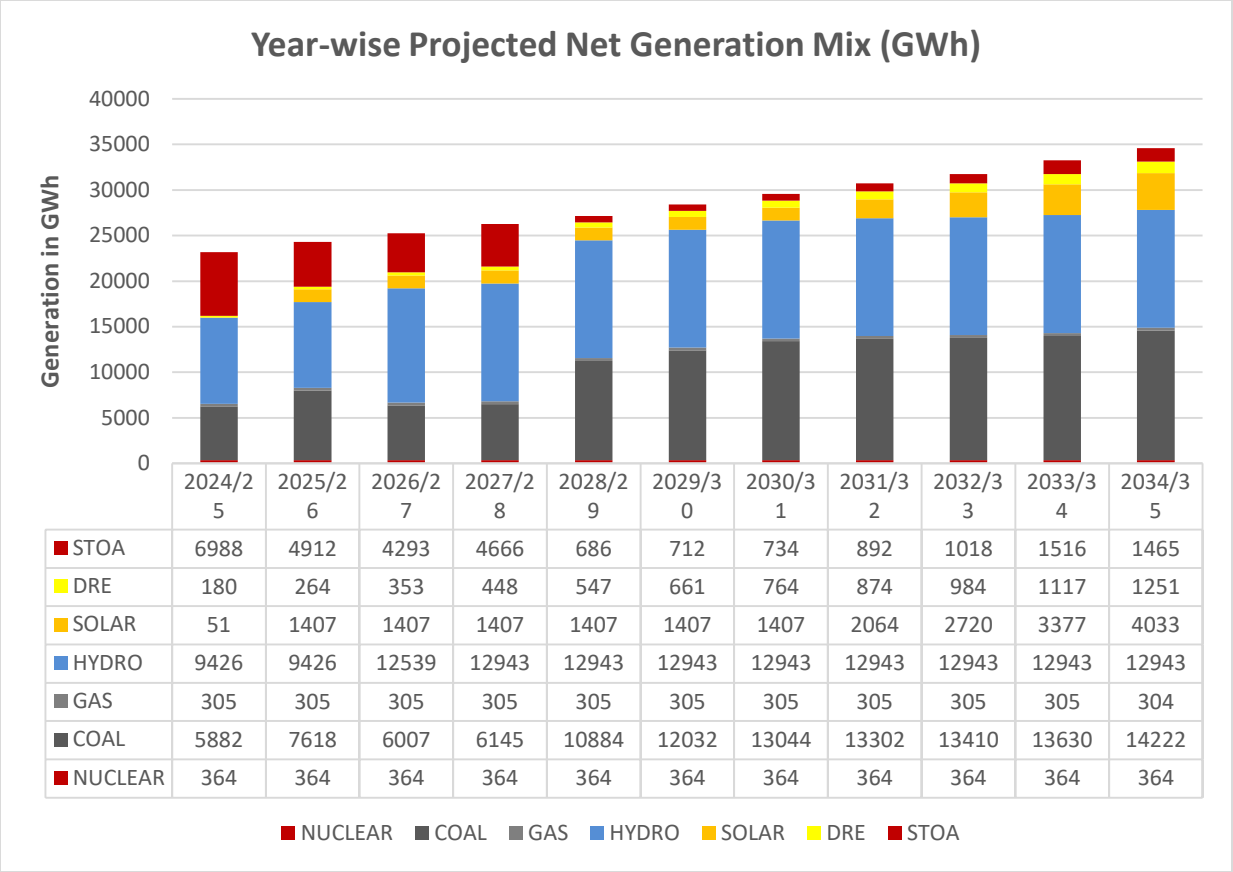



*Figure 11 Year-wise projected net generation mix (in GWh)*

## 5.3 Capacity contract requirement for future

It has been found out in the studies that J&K and Ladakh needs to contract following capacities (planned and additional) every year till 2034-35 to meet its demand reliably along with fulfilment of its RPO as notified by MoP.

*Table 7 Year wise Capacity Addition for J&K and Ladakh (in MW)*

| FY | Thermal | | SOLAR | | Hydro | | DRE | | Total | | Yearly STOA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Planned | Additional | Planned | Additional | Planned | Additional | Planned | Additional | Planned | Additional | Additional |
| **2024/25** | 0 | 0 | 0 | 0 | 201 | 0 | 0 | 142 | **201** | **142** | 1350 |
| **2025/26** | 392 | 0 | 620 | 0 | 0 | 0 | 0 | 66 | **1012** | **66** | 1134 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2026/27** | 0 | 0 | 0 | 0 | 911 | 0 | 0 | 70 | **911** | **70** | 1116 |
| **2027/28** | 0 | 0 | 0 | 0 | 94 | 0 | 0 | 75 | **94** | **75** | 1195 |
| **2028/29** | 0 | 1567 | 0 | 0 | 0 | 0 | 0 | 78 | **0** | **1645** | 382 |
| **2029/30** | 0 | 179 | 0 | 0 | 0 | 0 | 0 | 90 | **0** | **269** | 295 |
| **2030/31** | 0 | 158 | 0 | 0 | 0 | 0 | 0 | 81 | **0** | **239** | 305 |
| **2031-32** | 0 | 0 | 0 | 300 | 0 | 0 | 0 | 87 | **0** | **387** | 368 |
| **2032/33** | 0 | 0 | 0 | 300 | 0 | 0 | 0 | 87 | **0** | **387** | 428 |
| **2033/34** | 0 | 333 | 0 | 300 | 0 | 0 | 0 | 105 | **0** | **738** | 684 |
| **2034/35** | 0 | 201 | 0 | 300 | 0 | 0 | 0 | 106 | **0** | **607** | 700 |
| **Total** | **392** | **2438** | **620** | **1200** | **1206** | **0** | **0** | **987** | **2218** | **4625** | **7957** |

## 5.4 Coal Capacity Performance

The coal capacity PLF is expected to remain in the range of 46%- 81% for the years till 2035 (reducing from 81% in 2024-25 to 46% in 2034-35) ensuring higher absorption of higher renewable energy.

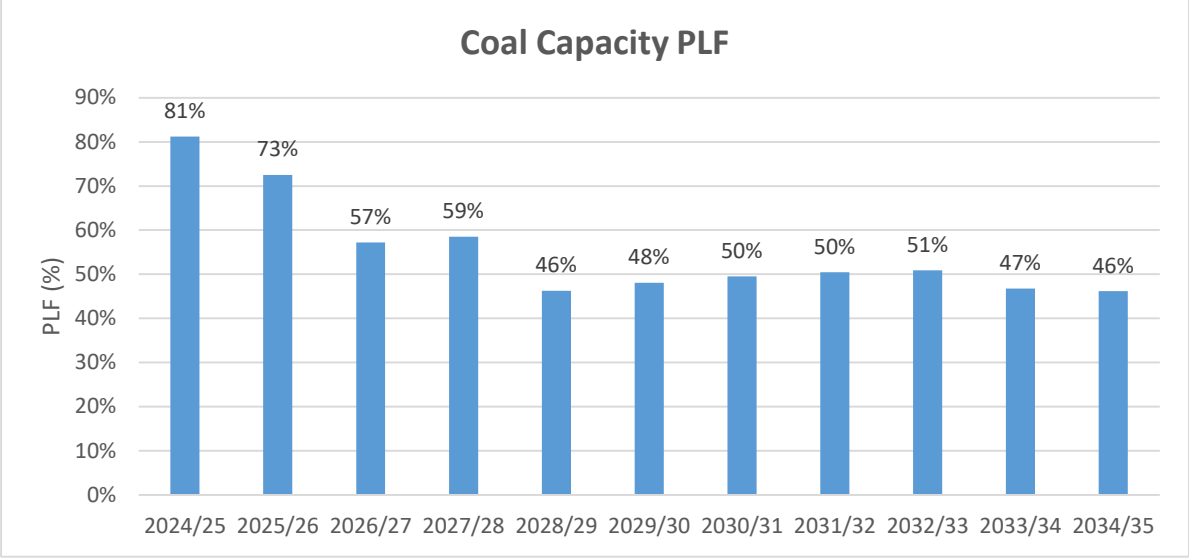



*Figure 12 Year-wise coal capacity PLF for J&K and Ladakh (in %)*

### 5.5 Day-wise Surplus Capacity J&K and Ladakh (MW)

Surplus capacity is available with states due to RE availability, Demand variation etc. The pattern of surplus capacities for J&K and Ladakh has been observed as below. This capacity can be shared with other states which might result in reduced fixed cost burden on the utilities resulting in further reduction in the cost for consumer. J&K and Ladakh has likely surplus capacity available from April to September in the range of 230-740 MW for 2027-28 as shown below which can be shared with other states.

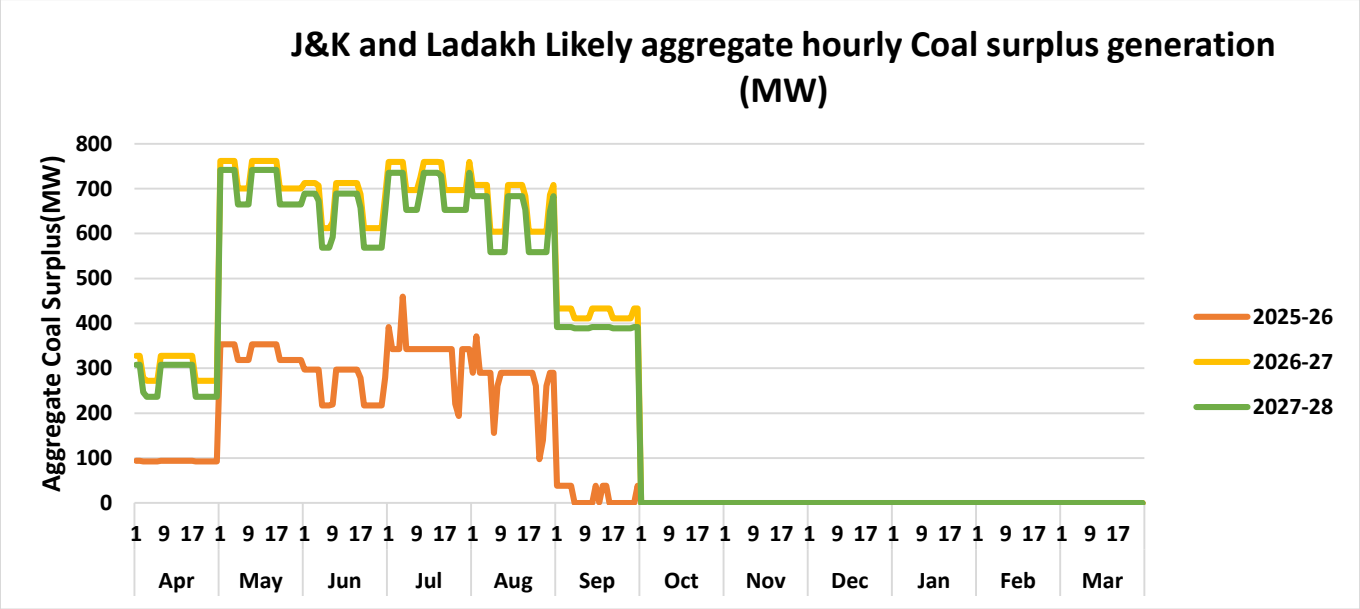



*Figure 13 Surplus Coal Capacity Year-wise (MW)*

## 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 vis-à-vis 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 demand submitted by J&K.
- 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

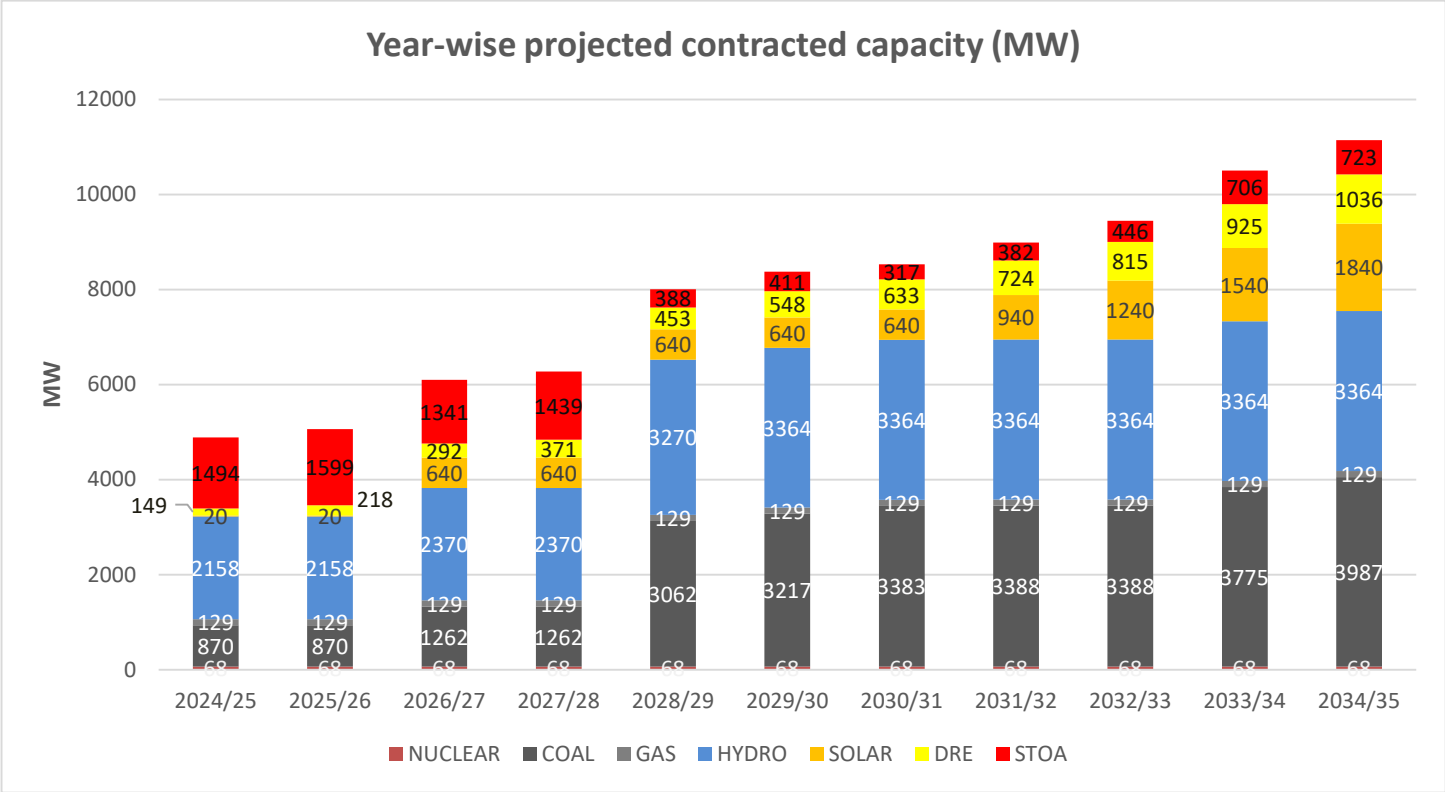



*Figure 14: Year-wise capacity projections (in MW) for Alternate Resilient Scenario*

In this scenario, coal requirement increases by around 287 MW compared to the base case in terminal year 2034-35. The STOA requirement in 2024-25 increases by around 144 MW in case of Alternate Resilient scenario in comparison to the base case.

# 7.0 Conclusion

The study was carried for assessing the resource adequacy of J&K and Ladakh based on the demand projections provided by the UT of J&K and ladakh. The following conclusions can be drawn based on the studies: -

- As seen historically, the electricity demand for the UT is more in winter months and is maximum during the months of December and January. The RA study is based on the hourly load pattern of the year 2022-23.

- The demand projections by J&K and Ladakh are higher compared to the demand projections by 20th Electric Power Survey (EPS) and the same have been considered for carrying out the RA studies.
- The current capacity mix of UT consists of 69.22% share from non-fossil fuel sources.
- J&K is surplus in fulfilment of its Renewable Purchase Obligations (RPO) and need not contract renewable capacities for fulfilling them. The projected capacity and generation mix fulfils the RPO till 2029-30 as per the Ministry of Power notification dated 20th October, 2023.
- J&K and Ladakh is likely to witness energy deficit ranging from 4293 MUs to 9929 MUs in different years from 2024-25 to 2034-35 with the existing and planned capacity addition.
- As J&K is likely to have unserved energy in coming years there is 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 2438 MW from Coal, 1200 MW from solar, 987 MW of DRE till 2034-35.
- The coal capacity PLF is expected to remain in the range of 46%- 81% for the years till 2035 (reducing from 81% in 2024-25 to 46% in 2034-35) ensuring higher absorption of higher renewable energy.
- In the alternate resilient scenario, coal requirement increases by around 287 MW compared to the base case in terminal year 2034-35. The STOA requirement in 2024-25 increases by around 144 MW in case of Alternate Resilient scenario in comparison to the base case.
- J&K and Ladakh is likely to have surplus capacity available from April to September (in the range of 230-740 MW for 2027-28) which can be shared with other states.

Annexure-I

## Future Contracted/Approved Capacity (MW) of Central Sector (Thermal)

| SR. NO | POWER PLANT | (MW) | TYPE OF GENERATION | EXPECTED COD/ REMARK |
|---|---|---|---|---|
| 1 | Shakti B(IV) Scheme | 392 | THERMAL | FY 2025-26 |
| | **TOTAL** | **392** | | |

# Assumption for Resource Adequacy Studies for the UT of J&K and Ladakh

1. Electricity Demand & peak requirement: As per projections given by J&K
2. Demand Profile: Based on hourly demand profile of 2022-23
3. Existing & Planned Capacity: As per the information received from J&K
4. Future Capacity addition: based on RPO trajectory and information provided by J&K
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.