सत्यमेव जयते

Report on Resource Adequacy Plan (Generation) for DVC (2025-26 to 2035-36) (Version 2.0)

January, 2026

Government of India
Ministry of Power
Central Electricity Authority

Contents

Disclaimer i

Executive Summary ii

1.0 Introduction 1

2.0 Highlights of the Previous RA Study (Up to FY 2034–35) 2

3.0 RA Study for DVC (from 2025-26 to 2035-36) 4

3.1 Present Power Scenario in DVC 4

3.2 Demand analysis of the year 2024-25 5

4.0 Principles of Generation Planning 7

4.1 Generation Expansion Planning Tool - ORDENA 7

5.0 Reliability Analysis 8

5.1 Variation in Electricity Demand 8

5.2 Variation in RE 9

5.3 Forced Outage of Thermal Generators 9

6.0 Inputs/Assumptions for the Study 10

7.0 Outcome of the model 13

7.1 Unserved Energy Projections 13

7.2 Investment options to meet the unserved energy 14

7.3 Surplus Coal Capacity 18

8.0 Conclusions 19

Disclaimer

This Resource Adequacy Study for DVC has been conducted based on data and inputs provided by DVC Power Department. The findings, analysis and conclusions presented in this report are contingent upon the accuracy, completeness and timeliness of the information furnished by DVC. Any discrepancies or limitations in the data may affect the outcomes of the study accordingly.

In accordance with the Resource Adequacy Guidelines dated 28th June 2023, each Distribution Licensee is mandated to prepare a Resource Adequacy Plan (RAP) for a 10-year horizon, referred to as the Long-Term Distribution Licensee Resource Adequacy Plan (LT-DRAP), which shall be vetted and validated by the Central Electricity Authority (CEA). CEA has facilitated this study and prepared the report solely to assist DVC 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 the utility.

Executive Summary

Ministry of Power had notified the Electricity (Amendment) Rules in December, 2022. As per Rule 16 of the Electricity (Amendment) Rules, Ministry of Power has notified Resource Adequacy (RA) Guidelines. According to these Guidelines, Central Electricity Authority (CEA) is entrusted with the responsibility of preparing the Long-Term National Resource Adequacy Plan (LT-NRAP). Further, each Distribution Utility is required to carry out a Long-Term Distribution Licensee Resource Adequacy Plan (LT-DRAP) to reliably meet its peak electricity demand and electrical energy requirement.

As per the Resource Adequacy Guidelines dated 28th June 2023, each Distribution Licensee shall prepare 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 optimization for the Distribution Licensees. The LT-DRAP shall be prepared by the Distribution Licensees on an annual rolling basis, factoring in the already contracted capacity and optimizing the requirement for additional capacity.

Government of India has notified the Renewable Purchase Obligation (RPO) trajectory up to 2029-30 vide gazette notification dated 20th October 2023, which mandates that a specified portion of energy consumption must be met from renewable energy sources.

To support DVC in fulfilling this requirement, CEA, initially carried a Resource Adequacy (RA) study with a planning horizon up to 2034-35, based on the data available with CEA and in compliance with the RPO trajectory specified in the Ministry of Power's Office Memorandum dated 20th October 2023. This study has now been updated and extended to cover the period up to 2035-36, incorporating the latest data furnished by the Utility and planning assumptions.

The electrical energy requirement and peak electricity demand for DVC, as furnished by the utility, are both projected to increase with a CAGR of 5% each from 2025-26 to 2035-36. However, as per mid-term review of 20th EPS projections, the electrical energy requirement and peak electricity demand for DVC is projected to increase with a CAGR of 4.61% and 4.29% respectively from 2025-26 to 2035-36. The study has been done considering the demand projections furnished by the utility. For satisfying resource adequacy i.e. meeting the electricity demand reliably and at affordable cost, the utility needs to methodically plan its capacity expansion either by investing in new generation or by procuring power. In view of the reduction in cost of solar panels and technology options like Battery Energy Storage Systems, planning for long term optimal generation capacity mix gains tremendous importance so that the future generation capacity mix is cost effective as well as environment friendly.

The study for DVC, based on existing contracted capacity and planned capacity additions, indicates that the available capacity may be insufficient to meet the projected electricity demand. In

particular, the total unserved energy in the year 2035–36 is estimated to be approximately 8156 MU, accounting for around 18% of the projected electrical energy requirement for that year.

To find out the least cost option for generation capacity expansion for the period 2025-26 to 2035-36, generation expansion planning study has been carried out with an objective to minimize 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 plan of DVC along with RPO constraints. The Renewable capacities have been assessed in view of adherence to RPO notified by Ministry of Power considering the fungibility among different sources.

The Resource adequacy studies have projected likely optimal capacity mix for future years till 2035-36 which shall be able to meet anticipated demand reliably at every instance. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 21,663 MW which consists of 4,496 MW from coal; 578 MW from hydro; 10,345 MW from solar; 1,622 MW from Distributed Renewable Energy (DRE) source and 4,622 MW from Storage (BESS/PSP). This capacity will meet the projected electricity demand with prescribed reliability criteria.

1.0 Introduction

Ministry of Power has notified Electricity (Amendment) Rules 2022, in December 2022. Rule 16 (I) of the said rules stipulates that "*A guideline for assessment of resource adequacy during the generation planning stage (one year or beyond) as well as during the operational planning stage (up to one year) shall be issued by the Central Government in consultation with the Authority*". Accordingly, the Resource Adequacy Guidelines have been notified in June, 2023, by Ministry of Power in consultation with Central Electricity Authority.

Resource Adequacy is generally defined as a mechanism to ensure that there is an adequate supply of generation resources to serve expected demand reliably at least cost. A key aspect of resource adequacy planning is to ensure that adequate generation capacities are available round-the-clock to reliably serve demand, under various scenarios. This naturally translates into the need for ensuring adequate reserve margin which could cater to varying levels of demand and supply conditions in the grid. In the wake of high RE generation, it is important to understand demand-supply situation in the grid precisely due to high seasonality and intermittency in RE generation. Resource Adequacy exercise may also help in assessment of capacity requirement to be tied up or contracted on long term, medium term, and short-term basis.

Further, Ministry of Power vide notification dated RPO, had notified the RPO trajectory for the states/Discoms. Based on the trajectory specified, hydro, wind and other (solar, biomass etc.) RPO quantum in million units (MUs) has been calculated to find additional quantum of renewable capacity that the states/Discoms have to contract in addition to the existing/planned capacity to meet their RPO targets.

To support DVC in fulfilling the Resource Adequacy Guidelines and complying with the Renewable Purchase Obligation (RPO) notification, CEA has carried out the RA study for DVC 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 optimize long-term power procurement while ensuring resource adequacy to meet demand on a 24×7 basis, considering variations in demand, RE generation, and forced outage of thermal capacities. The study also assesses the Planning Reserve Margin (PRM) required by DVC 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 DVC up to 2034-35, based on data available with CEA and in accordance with the then RPO trajectory specified in the then Ministry of Power's Office Memorandum dated 20th October 2023.

2.0 Highlights of the Previous RA Study (Up to FY 2034–35)

1. In the earlier Resource Adequacy (RA) study, financial year 2023-24 had been considered as the base year, and the study covered the period from 2024-25 to 2034-35. The fuel-wise contracted capacity by DVC as on 31st March, 2024, is given in Fig. 1.

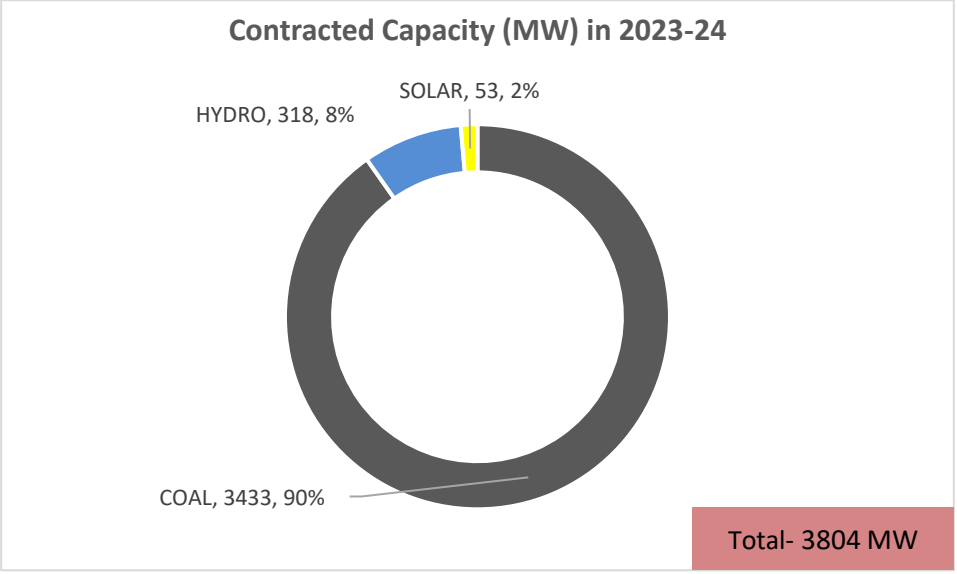


Figure 1: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2024

2. The peak electricity demand and electrical energy projections furnished by the utility, that had been considered in the study is given in Table 1.

Table 1: Peak electricity demand and electrical energy projections as per the 20th EPS Report

	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35
Electrical Energy Projections (MU)	30871	32415	34036	35737	37524	39401	41371	43439	45611	47892	50286
Year on Year Growth		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Peak Electricity Demand Projections (MW)	3674	3858	4051	4253	4466	4689	4924	5170	5428	5700	5985
Year on Year Growth		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%

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

Table 2: Source-wise projected capacity (in MW)

Year	Coal	Hydro	Wind	Solar	Storage	DRE	SToA/MToA*	Hydro Import	Total
2024-25	3433	197	0	152	0	365	1093	121	**5361**
2025-26	3433	197	0	542	0	536	1282	121	**6111**
2026-27	3433	197	0	5463	1969	723	793	121	**12699**
2027-28	4092	197	0	5763	2673	928	296	121	**14070**
2028-29	4700	197	0	6063	2816	1152	0	121	**15049**
2029-30	4700	197	0	6263	3011	1396	172	121	**15860**
2030-31	4700	197	0	8434	3984	1547	68	121	**19051**
2031-32	4700	197	0	9094	4667	1710	39	121	**20528**
2032-33	4700	197	0	9751	5241	1885	66	121	**21961**
2033-34	4700	197	0	10426	5609	2074	189	121	**23316**
2034-35	4760	197	0	11221	5998	2276	260	121	**24833**

**The SToA/MToA value represents the peak power requirement in MW and it was recommended that this requirement may be met through power procurement from the market or through bilateral agreements.*

4. The year-wise planned and additional capacity contract addition (in MW) for the above tabulated cumulative capacity is given in Table 3.

Table 3: Year-wise planned and additional capacity contract addition (in MW)

	Thermal		Solar		Storage		SToA/MToA*	DRE	Total	
Year	**Planned**	**Add.**	**Planned**	**Add.**	**Planned**	**Add.**	**Add.**	**Add.**	**Planned**	**Add.**
2024-25	0	0	46	0	0	0	1093	365	46	1458
2025-26	0	0	390	0	0	0	1282	171	390	1453
2026-27	0	0	780	4141	250	1719	793	187	1030	6840
2027-28	453	206	300	0	0	704	296	205	753	1411
2028-29	608	0	300	0	0	143	0	224	908	367
2029-30	0	0	200	0	0	195	172	244	200	611
2030-31	0	0	200	1971	0	973	68	151	200	3163
2031-32	0	0	200	460	0	683	39	163	200	1345
2032-33	0	0	0	657	0	574	66	175	0	1472
2033-34	0	0	0	675	0	368	189	189	0	1421
2034-35	0	59	0	795	0	389	260	202	0	1705
Total	**1061**	**265**	**2416**	**8699**	**250**	**5748**	**4258**	**2276**	**3727**	**21246**

**Requirement is for a particular year*

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

3.1 Present Power Scenario in DVC

The power supply position for DVC from 2021-22 to 2024-25 is given in Table 4.

Table 4: Power Supply Position of DVC

Power Supply Position						
Year	**Electrical Energy required (MU)**	**Electrical Energy supplied (MU)**	**Gap (MU)**	**Peak Electricity Demand (MW)**	**Peak Met (MW)**	**Peak Electricity Demand not met (MW)**
2021-22	23741	23736	5	3355	3338	17
2022-23	26339	26330	9	3402	3396	6
2023-24	26560	26552	8	3451	3451	0
2024-25	25891	25888	3	3708	3704	4

The data in Table 4 indicates that over the past five years, DVC's electrical energy requirement and peak electricity demand have increased at a Compound Annual Growth Rate (CAGR) of 2.93% and 3.34% respectively.

As per the data provided by the utility, as of March 2025, the total contracted capacity for DVC is 3,966 MW. Out of the total contracted capacity (CC), the share of non-fossil fuel-based CC is 13 %. The fuel-wise contracted capacity as on 31st March, 2025, is given in Table 5 and Fig. 2.

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

Source	**Contracted Capacity (MW)**	**Percentage**
Coal	3435	87%
Hydro	478	12%
Solar	53	1%
Total	**3966**	**100%**

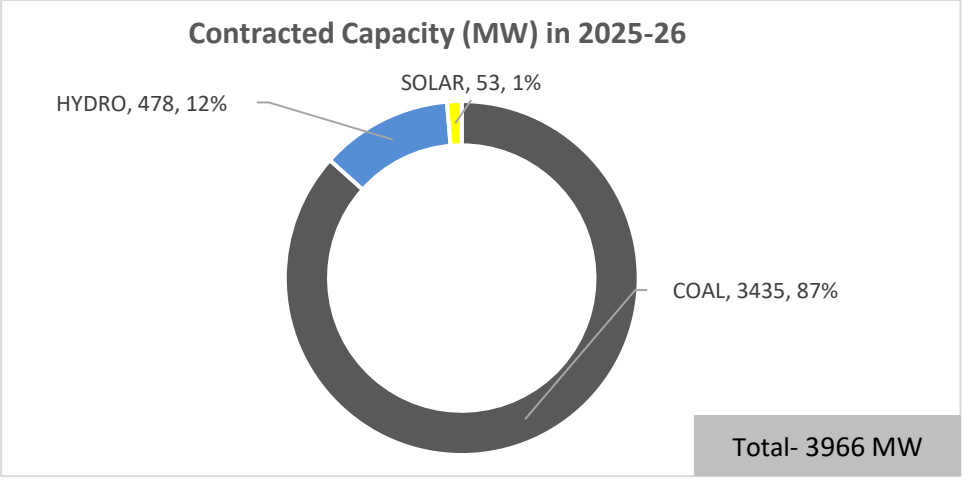


Figure 2: Fuel-wise Contracted Capacity (in MW) as on 31st March, 2025

3.2 Demand analysis of the year 2024-25

Hourly demand pattern of 2024-25 has been analyzed and it was observed that the peak demand season for DVC is typically during the months from May to July. DVC witnesses peak demand during non-solar hours. The month wise average hourly demand observed for the year 2024-25 is shown in Fig. 3.

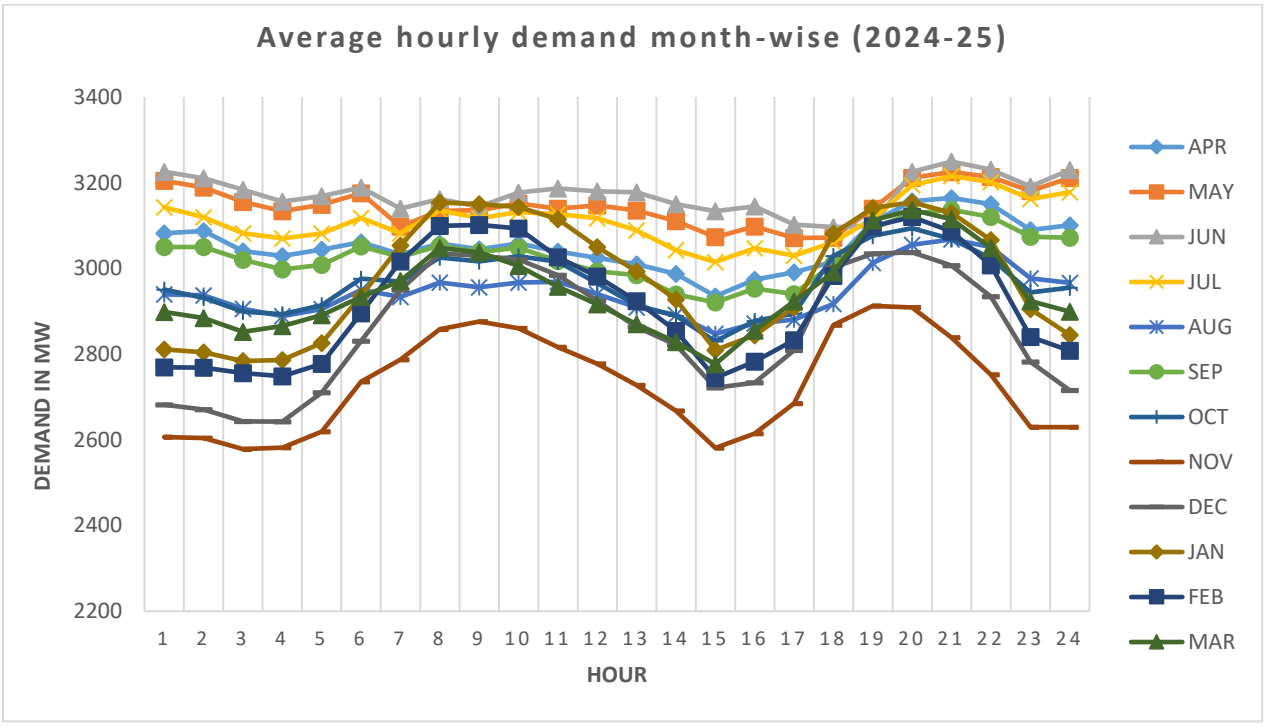


Figure 3: Average Hourly Demand Variation (Month-wise) for 2024-25

From the hourly demand data of 2024-25, the daily peak demand during solar hours and non-solar hours are plotted in Fig. 4. Peak demand generally occurs during non-solar hours.

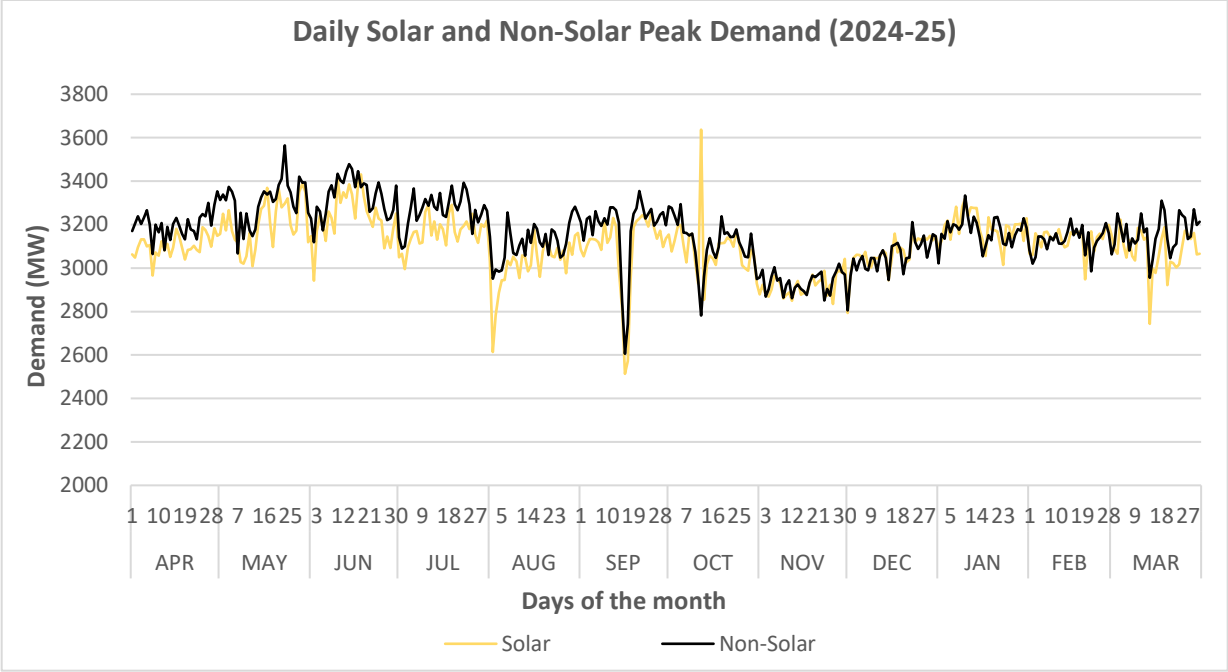


Figure 4: Solar and non-solar peak in MW for the year 2024-25

The hourly demand pattern of 2024-25 was analysed for finding out the number of occurrences of the peak and near peak demand. Such instances are critical for study purpose as it is necessary to ensure resource adequacy during such instances with an optimal mix of long-term, medium-term and short-term contracts. Frequency Distribution of hourly demand profile for 2024-25 is shown in Fig. 5.

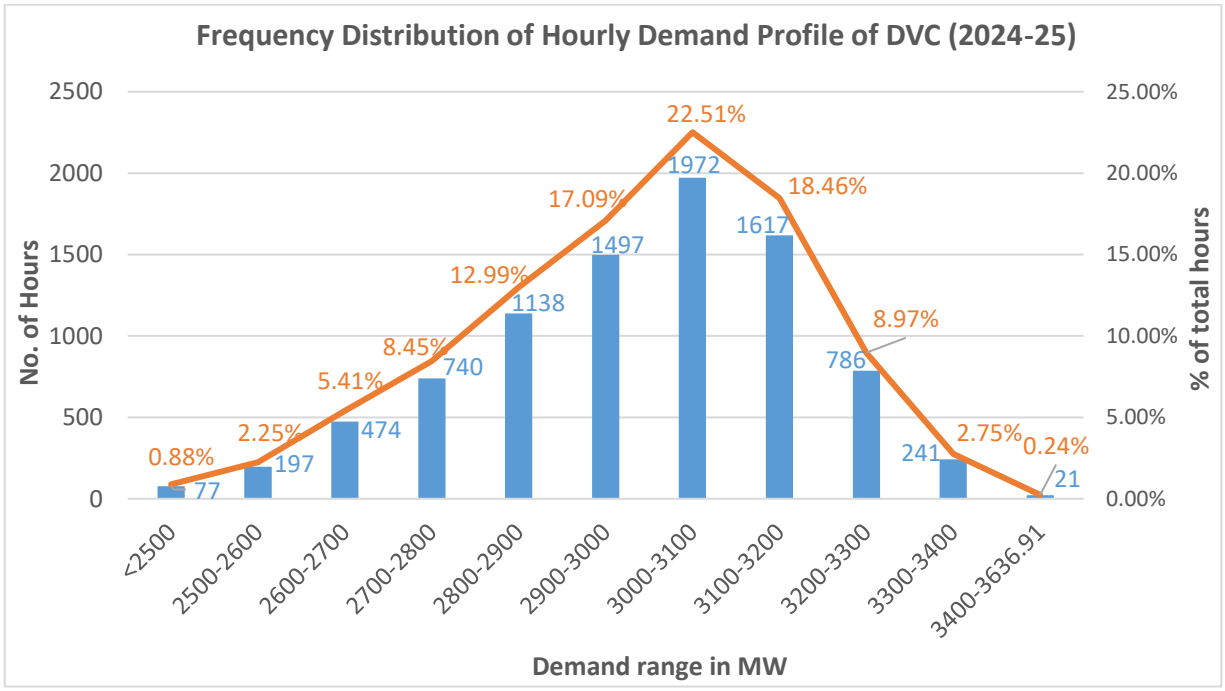


Figure 5: Frequency Distribution of Hourly Demand Profile of 2024-25

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 objectives of all policies of the Government of India such as RPO trajectory, RE capacity addition 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 - ORDENA

The studies have been carried out using generation expansion planning model namely ORDENA. ORDENA is a mixed integer linear optimization program that minimizes the Net Present Value (NPV) of investment and operating costs subject to several constraints. The major constraints include balancing electricity supply and demand, resource supply limits, planning and operating reserve limits, and policy targets. These constraints are met considering a broad portfolio of conventional generation, renewable generation, and storage.

ORDENA has a reliability module to determine the trustworthiness of the system using Monte Carlo simulations. The software is also capable of carrying out hourly/sub-hourly economic generation dispatch considering all the technical constraints associated with various generation technologies.

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

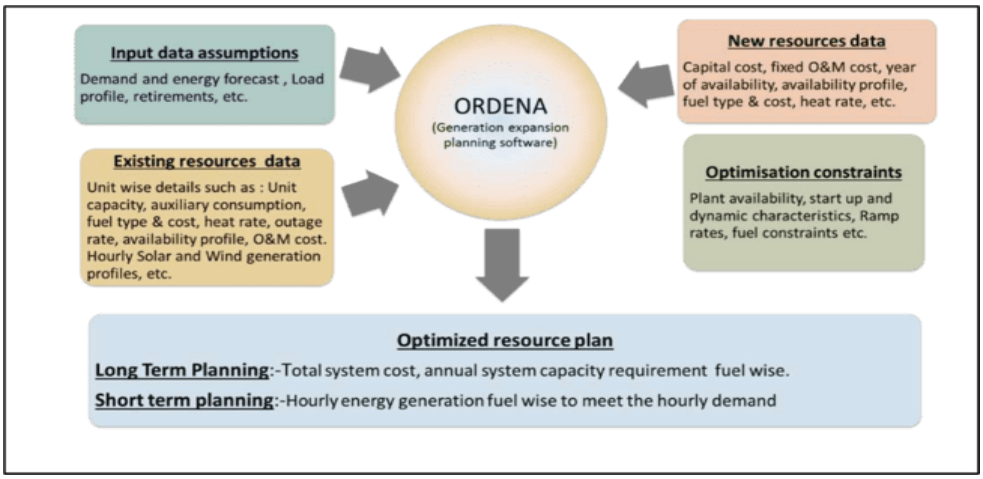


Figure 6: Schematic Diagram

5.0 Reliability Analysis

One of the main criteria of resource adequacy studies is to determine the reliability of the system to meet the demand adequately at every instance of time. This reliability is measured via two indices i.e. LOLP (Loss of Load Probability) and EENS (Expected Energy Not Served). These indices have been defined in resource adequacy guidelines as below:

- **Loss of Load Probability (LOLP)**: Measure of the probability that a system's load may exceed the generation and firm power contracts available to meet that load in a year. E.g., 0.0274 % probability of load being lost.
- **Expected Energy Not Served (EENS):** Expected amount of energy (MWh) that may not be served for each year within the planning period under study. It is a summation of the expected number of megawatt hours of demand that may not be served for the year. This is an energy-centric metric that considers the magnitude and duration of energy being not served, calculated in Mega Watt hours (MWh). The metric can be normalized (i.e., divided by total system energy requirement) 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 is 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 generally expressed as a certain percent of the projected peak electricity demand.

5.1 Variation in Electricity Demand

The variation in demand pattern for last two years viz. 2023-24 and 2024-25 (considering 2023-24 as the base year) has been analyzed. The demand pattern variation across 2023-24 and 2024-25 is shown in Fig. 7.

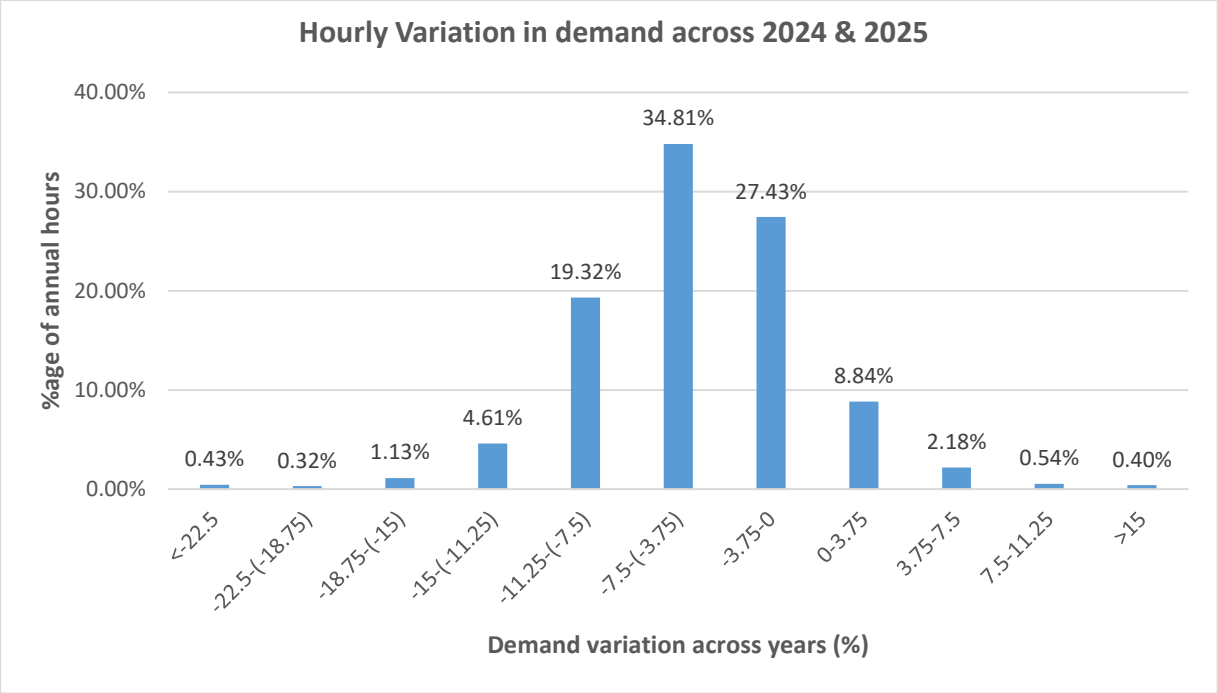


Figure 7: Hourly Variation in Demand across years

It can be observed that the hourly demand typically varies within ±7.5% for ~73% of instances. This variation is primarily due to temperature, weather parameter or any random outages of transmission line and generating units etc. This variation has been captured in the reliability study by incorporating a variation of ±10% in the projected hourly demand for the future years by introducing a random variable (with normal distribution) for demand as per observed behavior over the years.

5.2 Variation in RE

In the Long-term capacity expansion planning studies, a particular profile for Solar is considered based on the observed generation data to determine the optimal capacity mix. However, due to intermittent nature of these sources, generation from these non-dispatchable sources may vary across years. As per the analysis carried out based on historical generation data, solar and hydro based generation has been varied by ±10% and ±5% respectively to incorporate the variation in these generation sources and plan for requisite measures to mitigate such behavior.

5.3 Forced Outage of Thermal Generators

The average forced outage rate of thermal generators is typically 10% with ±5% variation. The same has been incorporated in the model.

Based on these variations, reliability studies have been carried out to ascertain robustness of the system.

6.0 Inputs/Assumptions for the Study

i) The peak electricity demand and electrical energy requirement of DVC, as furnished by the utility and from mid-term review of 20th EPS Report, is given in Table 6. Projections furnished by the utility have been considered in the study.

Table 6: Electricity demand projections

Year	Projections by DVC				Projections as per Mid-term review of 20th EPS			
	Peak Electricity Demand		Electrical Energy Requirement		Peak Electricity Demand		Electrical Energy Requirement	
	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth	Projections (in MW)	Y-o-Y Growth	Projections (in MU)	Y-o-Y Growth
2025-26	3544		27146		3881		29733	
2026-27	3721	5.00%	28503	5.00%	4097	5.57%	31391	5.58%
2027-28	3907	5.00%	29928	5.00%	4281	4.49%	33079	5.38%
2028-29	4103	5.00%	31424	5.00%	4465	4.30%	34791	5.18%
2029-30	4308	5.00%	32996	5.00%	4648	4.10%	36522	4.98%
2030-31	4523	5.00%	34645	5.00%	4829	3.89%	38267	4.78%
2031-32	4749	5.00%	36378	5.00%	5061	4.80%	40018	4.58%
2032-33	4987	5.00%	38197	5.00%	5283	4.39%	41769	4.38%
2033-34	5236	5.00%	40106	5.00%	5503	4.16%	43513	4.18%
2034-35	5498	5.00%	42112	5.00%	5722	3.98%	45243	3.98%
2035-36	5773	5.00%	44217	5.00%	5904	3.18%	46680	3.18%

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 hydro generation profiles and CUFs have been considered as per data available in CEA.

iv) The capital costs of candidate plants for coal, solar, and battery/PSP technologies is detailed in the Annexure and are aligned with current market trends and recent price discovery.

v) The planned capacity has been considered based on the tie-up information as furnished by DVC. The same is summarised in Table 7 and details are furnished in Annexure.

Table 7: Source wise planned capacity addition (MW)

FY	Coal	Hydro	Solar	Storage
2025-26	0	0	342	0
2026-27	0	20	453	0
2027-28	453	0	524	250
2028-29	608	12	228	100
2029-30	0	0	350	0
2030-31	0	68	100	0
2031-32	0	0	100	0
2032-33	0	0	0	0
2033-34	0	0	0	0
2034-35	0	0	0	0
2035-36	0	0	0	0

Total	**1061**	**100**	**2097**	**350**

vi) **Renewable Purchase Obligation (RPO) trajectory**: Ministry of Power vide gazette notification dated 23th October, 2023, had notified the source wise minimum share of consumption of non-fossil sources (renewable energy) by designated consumers, till the year 2029-30 as given in Table 8.

Table 8: Renewable Purchase Obligation (RPO) trajectory (%) as per MoP order

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	**2024-25**	0.67	0.38	27.35	1.5	29.91
2.	**2025-26**	1.45	1.22	28.24	2.1	33.01
3.	**2026-27**	1.97	1.34	29.94	2.7	35.95
4.	**2027-28**	2.45	1.42	31.64	3.3	38.81
5.	**2028-29**	2.95	1.42	33.10	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. However, the DRE percentage has been assumed to be constant from 2029-30 onwards. Therefore, the RPO trajectory is assumed to rise steadily beyond 2029-30. Further, the DRE percentage has been assumed to be 4.5% beyond 2029-30. Hence, the suggested trajectory of Renewable Purchase Requirement up to FY 2035-36 is given in Table 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)	(2)	(3)	(4)	(5)	(6)	(7)
1.	**2025-26**	1.45	1.22	28.24	2.10	33.01
2.	**2026-27**	1.97	1.34	29.94	2.70	35.95
3.	**2027-28**	2.45	1.42	31.64	3.30	38.81
4.	**2028-29**	2.95	1.42	33.10	3.90	41.36
5.	**2029-30**	3.48	1.33	34.02	4.50	43.33
6.	**2030-31**	41.00			4.50	45.50
7.	**2031-32**	42.50			4.50	47.00
8.	**2032-33**	43.80			4.50	48.30
9.	**2033-34**	45.00			4.50	49.50
10.	**2034-35**	46.50			4.50	51.00
11.	**2035-36**	47.50			4.50	52.00

Based on the trajectory specified, RPO quantum in million units (MUs) from hydro, wind, other (Solar, biomass etc.) and distributed renewable energy (DRE) is calculated and given in Table 10.

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)	(2)	(3)	(4)	(5)	(6)	(7)
1.	**2025-26**	393.61	331.18	7665.93	570.06	8960.78
2.	**2026-27**	561.51	381.94	8533.78	769.58	10246.80
3.	**2027-28**	733.24	424.98	9469.24	987.63	11615.09
4.	**2028-29**	927.02	446.23	10401.50	1225.55	12997.17
5.	**2029-30**	1148.25	438.84	11225.14	1484.81	14297.04
6.	**2030-31**	14204.65			1559.05	15763.70
7.	**2031-32**	15460.55			1637.00	17097.55
8.	**2032-33**	16730.14			1718.85	18448.98
9.	**2033-34**	18047.92			1804.79	19852.71
10.	**2034-35**	19581.99			1895.03	21477.02
11.	**2035-36**	21003.27			1989.78	22993.05

As indicated in Table 11, DVC with its existing and envisaged future capacity additions will not be able to meet its RPO requirements from the year 2025-26 onwards.

Table 11: Renewable Energy Surplus/Deficit other than DRE

FY	RE Generation required to meet RPO		RE Generation available/met (From existing/ planned contracts)		RPO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	8390.72	30.91%	1953.88	7.20%	-23.71%
2026-27	9477.23	33.25%	2926.10	10.27%	-22.98%
2027-28	10627.46	35.51%	3943.02	13.17%	-22.34%
2028-29	11771.61	37.46%	4432.15	14.10%	-23.36%
2029-30	12812.23	38.83%	5111.40	15.49%	-23.34%
2030-31	14204.65	41.00%	5569.81	16.08%	-24.92%
2031-32	15460.55	42.50%	5763.88	15.84%	-26.66%
2032-33	16730.14	43.80%	5763.88	15.09%	-28.71%
2033-34	18047.92	45.00%	5763.88	14.37%	-30.63%
2034-35	19581.99	46.50%	5763.88	13.69%	-32.81%
2035-36	21003.27	47.50%	5763.88	13.04%	-34.46%

Table 12: Renewable Energy from DRE

FY	DRE required to meet RPO		DRE available/met (From existing/ planned contracts)		RPO Surplus (+)/ Deficit (-)
	(MU)	(%)	(MU)	(%)	(%)
2025-26	570.06	2.10%	0.00	0.00%	-2.10%
2026-27	769.58	2.70%	0.00	0.00%	-2.70%
2027-28	987.63	3.30%	0.00	0.00%	-3.30%
2028-29	1225.55	3.90%	0.00	0.00%	-3.90%
2029-30	1484.81	4.50%	0.00	0.00%	-4.50%
2030-31	1559.05	4.50%	0.00	0.00%	-4.50%
2031-32	1637.00	4.50%	0.00	0.00%	-4.50%
2032-33	1718.85	4.50%	0.00	0.00%	-4.50%
2033-34	1804.79	4.50%	0.00	0.00%	-4.50%
2034-35	1895.03	4.50%	0.00	0.00%	-4.50%
2035-36	1989.78	4.50%	0.00	0.00%	-4.50%

7.0 Outcome of the model

7.1 Unserved Energy Projections

Initially, the study has been carried out considering only the existing and planned capacity contracts. The projected total unserved energy (ENS) for the year 2035-36 is about 8156 MUs which is about 18% of the energy demand in 2035-36. The year-wise likely unserved energy with the existing and planned capacities is given in Fig 8.

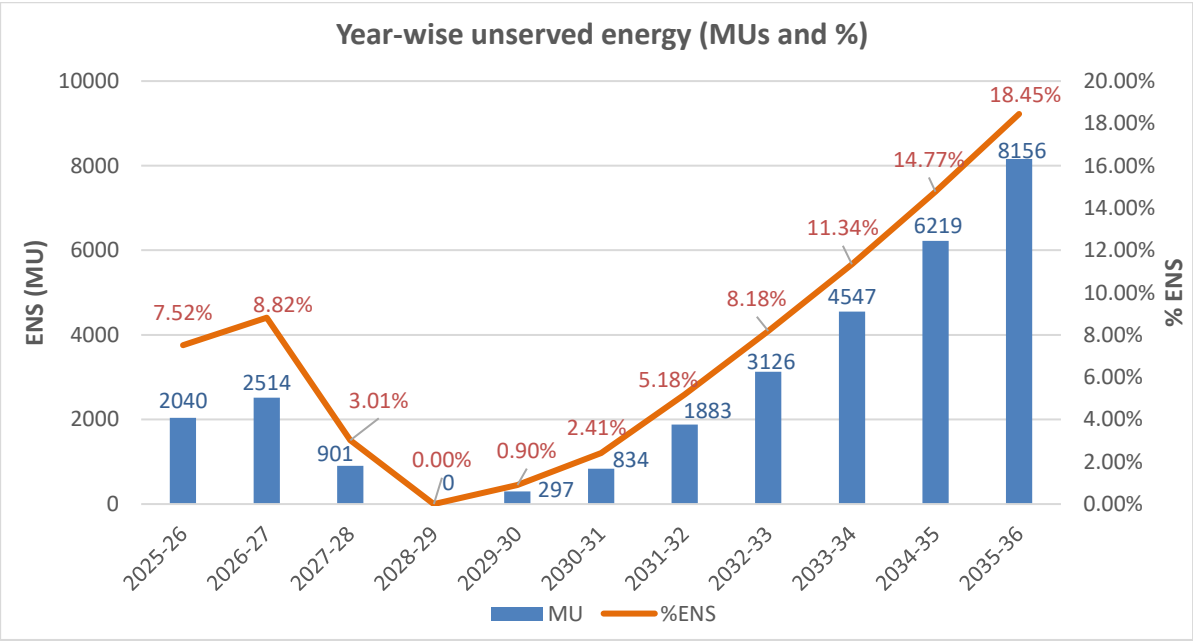


Figure 8: Yearly likely unserved energy (in MU) with the existing and planned capacities

The study has also analyzed the daily and monthly pattern of unserved energy in the year 2035-36. It can be seen that contracted capacity (existing and planned) is unable to meet the projected electricity demand. Details are shown in Fig. 9.

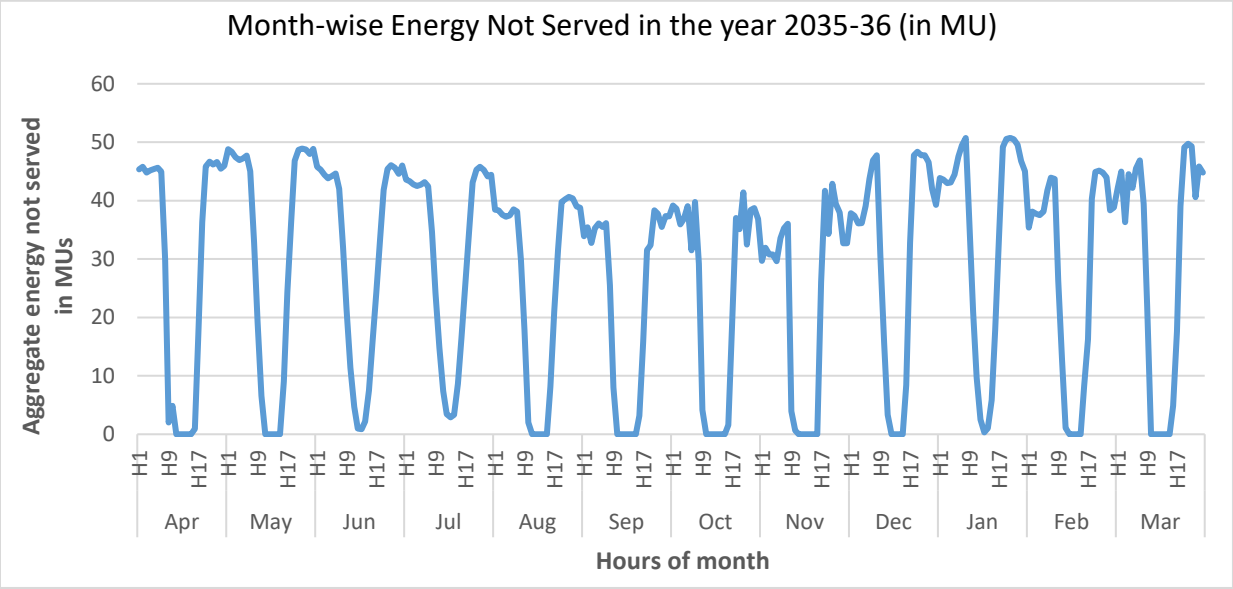


Figure 9: Month-wise Unserved Energy Pattern MU (2035-36)

The unmet demand occurs mainly during non-solar hours throughout the year. Additionally, DVC is expected to face unmet demand even during solar hours in June and July, when electricity demand is higher compared to other months.

7.2 Investment options to meet the unserved energy

To meet this unserved energy, energy investment options (i.e., candidate capacities) have been given to the model to find the least cost optimal capacity mix required to meet the electricity demand while fulfilling the RPO obligations. The capacity projections (existing, planned, to be tied up) for DVC are given in Table 12.

Table 13: Year-wise contracted capacity projections (existing, planned, to be tied up) (in MW)

Year	Coal	Hydro	Solar	STORAGE	DRE	SToA/MToA
2025-26	3435	478	395	0	465	614
2026-27	3435	498	4408	1397	628	86
2027-28	3888	498	5065	1850	805	0
2028-29	4496	510	5661	2124	999	0
2029-30	4496	510	6204	2457	1211	0
2030-31	4496	578	6789	2741	1271	0
2031-32	4496	578	7462	3069	1335	0
2032-33	4496	578	8132	3420	1402	0
2033-34	4496	578	8821	3773	1472	0
2034-35	4496	578	9623	4222	1545	0
2035-36	4496	578	10345	4622	1622	0

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

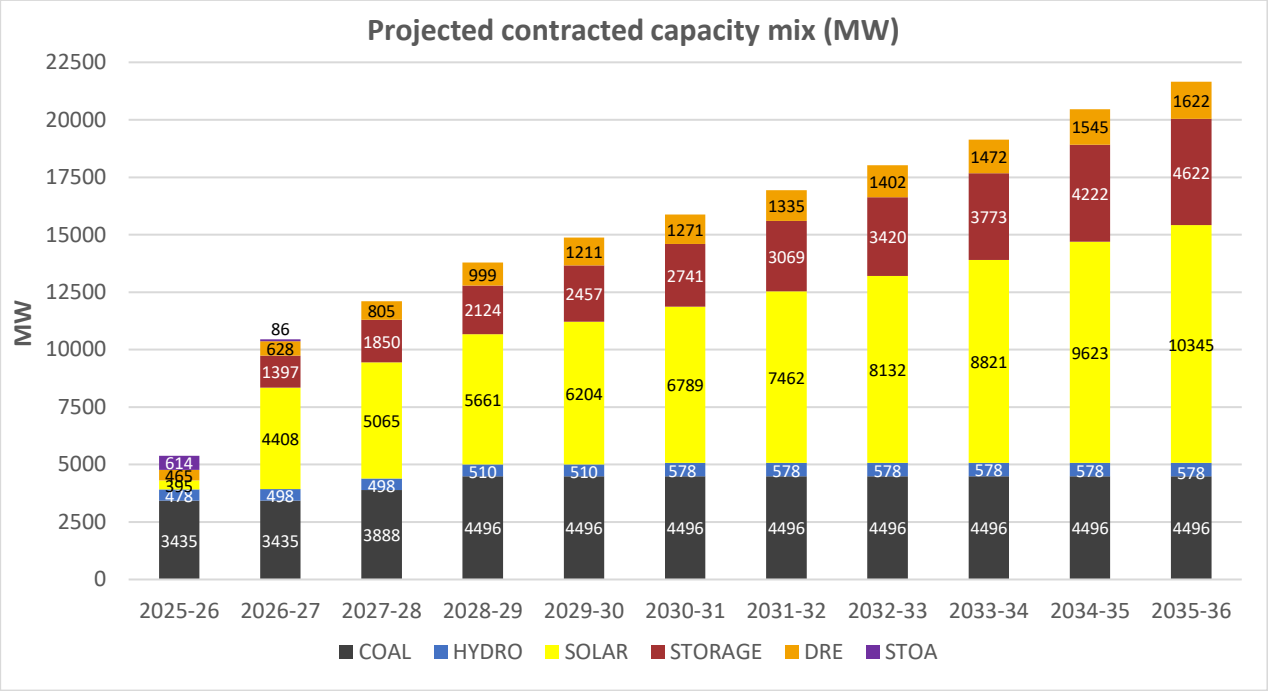


Figure 10: Projected Contracted Capacity Mix Year-wise (MW)

The SToA/MToA requirement can be fulfilled through power procurement from market or bilateral agreements. The SToA/MToA value reflects the peak value requirement and seasonal banking requirements in terms of MW.

Reliability studies have been conducted based on the projected capacity for the year 2035-36. The analysis confirms that the projected capacity meets the reliability criteria specified in the National Electricity Plan (NEP), with the Loss of Load Probability (LoLP) and Not-Served Energy (NENS) remaining within the permissible limits of 0.2% and 0.05%, respectively as specified in the National Electricity Plan (Generation)].

The Resource adequacy studies have projected likely optimal capacity mix for future years till 2035-36 which shall be able to meet anticipated electricity demand reliably. Based on the study, the likely total projected contracted capacity for the year 2035-36 is around 21,663 MW which consists of 4,496 MW from coal; 578 MW from hydro; 10,345 MW from solar; 1,622 MW from Distributed Renewable Energy (DRE) source and 4,622 MW from Storage (BESS/PSP). This capacity shall be able to meet the projected demand with prescribed reliability criteria and to comply with the stipulated Renewable Purchase Obligation (RPO) targets. Based on the capacity addition, the planning reserve margin works out to be about 20%. Capacity mix required by 2035-36 is shown in Figure 11.

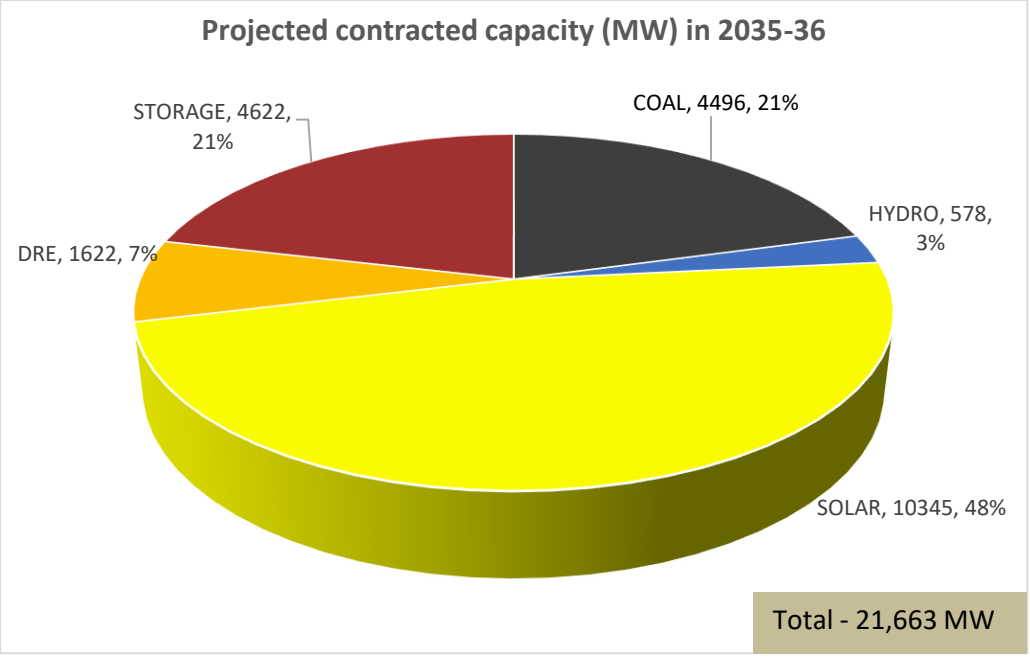


Figure 11: Contracted Capacity Mix in 2035-36

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

As per the study, DVC likely needs to contract the following capacities (planned and additional) every year till 2035-36 to meet its demand reliably as shown in Table 13.

Table 14: Year wise Capacity Addition (in MW)

	Coal	**Hydro**	**Solar**		**DRE**
Year	Planned Contracts	Planned Contracts	Planned Contracts	Additional Requirement	Additional Requirement
2025-26	0	0	342	0	465
2026-27	0	20	453	3560	163
2027-28	453	0	524	133	178
2028-29	608	12	228	368	194
2029-30	0	0	350	193	211
2030-31	0	68	100	485	60
2031-32	0	0	100	572	63
2032-33	0	0	0	670	67
2033-34	0	0	0	690	70
2034-35	0	0	0	802	74
2035-36	0	0	0	721	77
Total	**1061**	**100**	**2097**	**8194**	**1622**

	Storage		Total		SToA/MToA*
Year	Planned Contracts	Additional Requirement	Planned Contracts	Additional Requirement	Additional Requirement
2025-26	0	0	342	465	614
2026-27	0	1397	473	5120	86
2027-28	250	202	1227	514	0
2028-29	100	175	948	736	0
2029-30	0	332	350	737	0
2030-31	0	284	168	830	0
2031-32	0	328	100	964	0
2032-33	0	352	0	1089	0
2033-34	0	352	0	1112	0
2034-35	0	449	0	1325	0
2035-36	0	400	0	1198	0
Total	**350**	**4272**	**3608**	**14088**	**-**

**Yearly requirement*

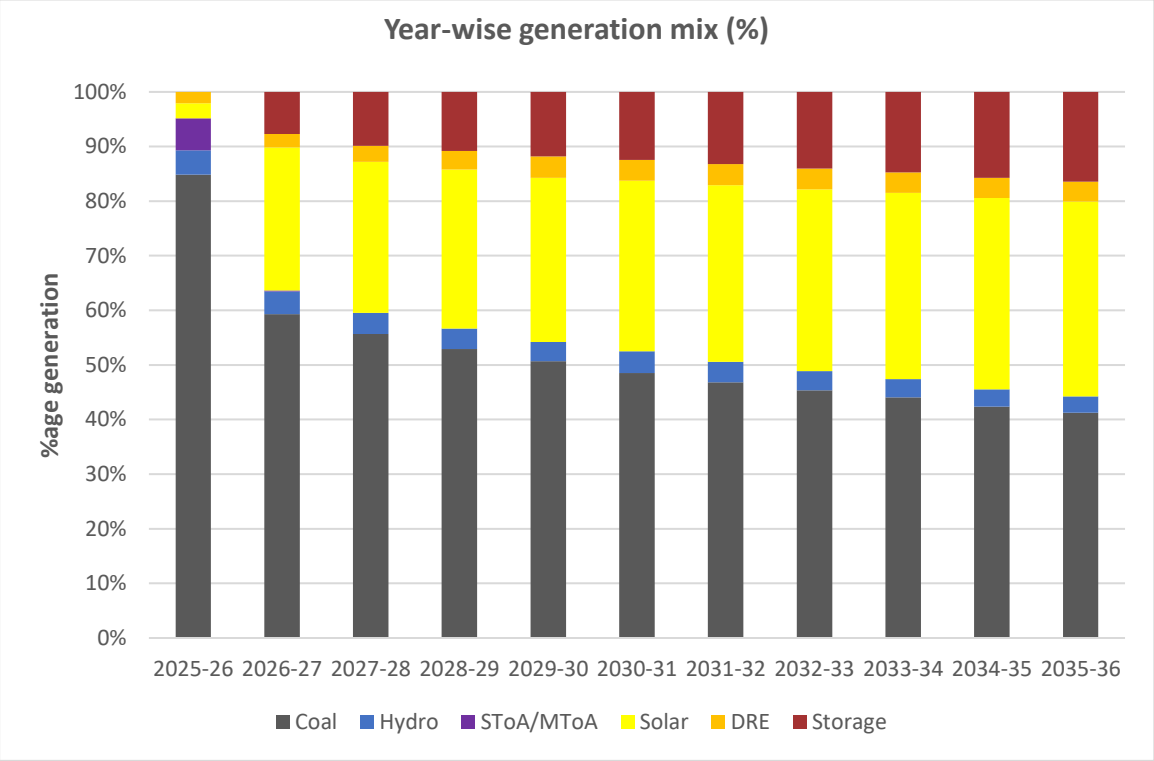
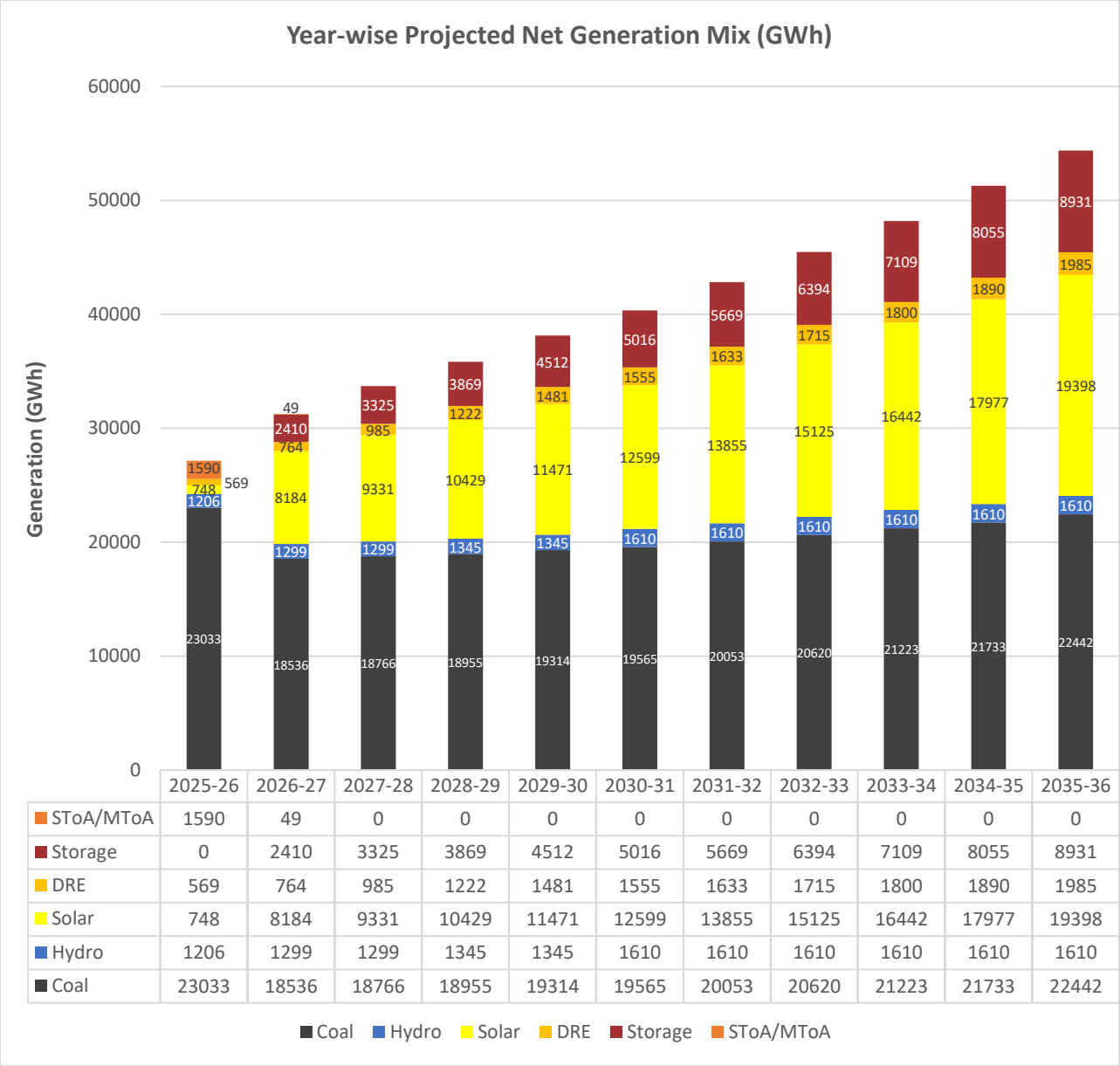


Figure 12: Year-wise projected net generation mix (in %)



	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36
SToA/MToA	1590	49	0	0	0	0	0	0	0	0	0
Storage	0	2410	3325	3869	4512	5016	5669	6394	7109	8055	8931
DRE	569	764	985	1222	1481	1555	1633	1715	1800	1890	1985
Solar	748	8184	9331	10429	11471	12599	13855	15125	16442	17977	19398
Hydro	1206	1299	1299	1345	1345	1610	1610	1610	1610	1610	1610
Coal	23033	18536	18766	18955	19314	19565	20053	20620	21223	21733	22442

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

7.3 Surplus Coal Capacity

Surplus capacity is available with DVC due to RE availability, demand variation etc. The pattern of surplus capacities has been observed as given in Figure 14. This capacity can be shared with other states/ Discoms to reduce the fixed cost burden on the utility, resulting in reduction in the cost for consumer. DVC is expected to have a minimum surplus coal-based capacity ranging between 105 MW and 290 MW during the period from August to November.

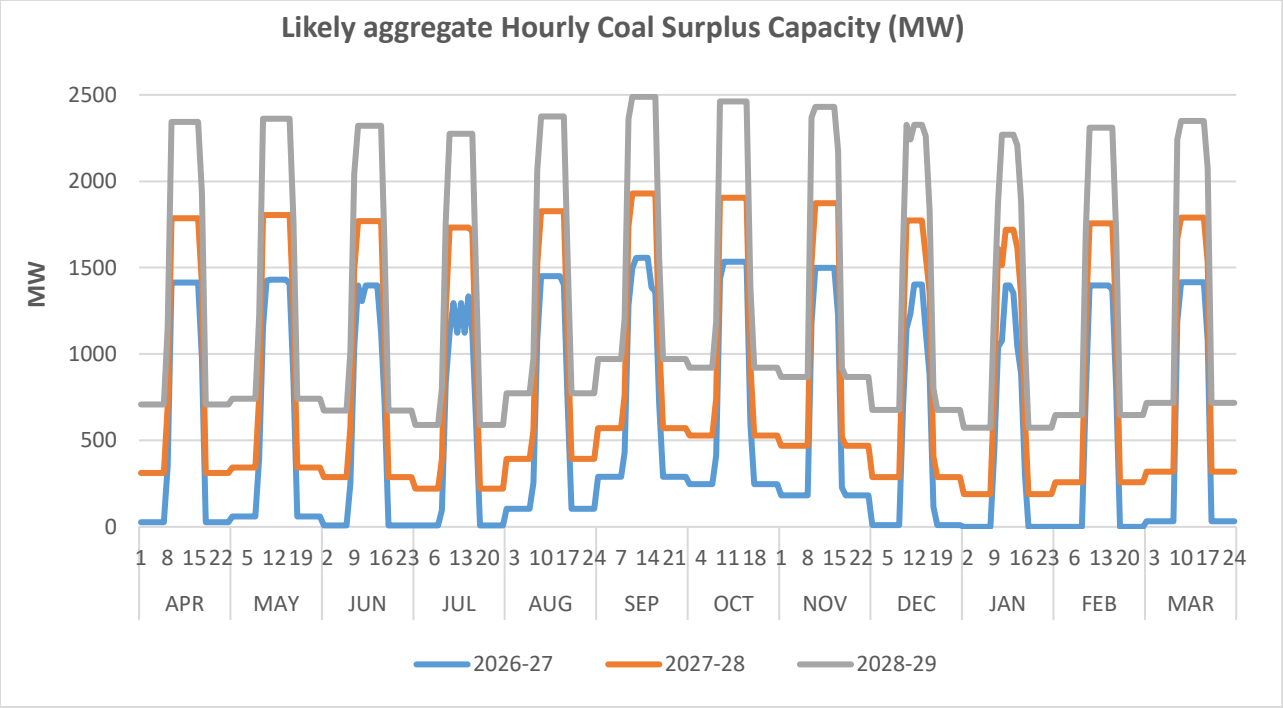


Figure 14: Surplus Coal Capacity Year-wise (MW)

8.0 Conclusions

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

1. The study has been carried out considering electrical energy requirement and peak electricity demand projections as per the projections furnished by DVC, which envisages that annual electrical energy requirement and peak electricity demand are likely to grow at a CAGR of 5% each for the period from 2025-26 to 2035-36. The projected peak electricity demand and electrical energy requirement in 2035-36 is 5,773 MW and 44,217 MU. It has been observed that the peak demand season in DVC is typically from May to July with peak demand occurring during non-solar hours.
2. DVC, with its existing and planned capacity addition only, is likely to witness energy deficit ranging from 297 MUs to 8156 MUs in different years from 2026-27 to 2035-36 (except in 2028-29). The deficit may reduce depending upon the capacity tie up, banking arrangement etc.
3. The likely total projected contracted capacity for the year 2035-36 is around 21,663 MW which consists of 4,496 MW from Coal; 578 MW from Hydro; 10,345 MW from Solar; 1622 MW from Distributed Renewable Energy (DRE) source and 4622 MW from Storage (BESS/PSP). This capacity shall be able to meet the projected demand with prescribed reliability criteria while

complying with the stipulated Renewable Purchase Obligation (RPO) targets. The storage requirement can be met from PSP or a combination of PSP and BESS.

4. In order for DVC to fulfill its Renewable Purchase Obligation, the utility, in addition to the existing and already planned contracts, needs to tie up approximately 8,194 MW of solar-based capacity, and 1,622 MW of Distributed Renewable Energy (DRE)-based capacity by 2035-36 (refer Table 14) in order to fulfill its Renewable Purchase Obligation. The projected capacity and generation mix outlined in the report meet the utility's RPO requirements for the years 2025-26 to 2035-36.
5. As per studies, DVC is expected to have a minimum surplus coal-based capacity ranging between 105 MW and 290 MW during the period from August to November. This surplus capacity may be banked or shared with other states whose demand profile complements that of DVC.
6. The Planning Reserve Margin (PRM) for DVC has been assessed at about 20%. Further, the study indicates year-wise short-term/medium-term/bilateral requirements inclusive of the PRM capacity to meet the demand optimally.
7. Timely commissioning of planned capacities is critical for ensuring that DVC meets its projected peak electricity demand and electrical energy requirements reliably. Any deviation from the planned schedule may lead to resource shortfalls and could significantly increase the cost of reliably meeting DVC's power demand.

****

Annexure

Planned Future Contracts (MW) considered in the study

S. No.	Tied capacity name	Type of generation	Expected COD	DVC share (in MW)
1.	Raghunathpur Thermal Power Station Ph-II Unit-1	Coal	2027-28	139
2.	Raghunathpur Thermal Power Station Ph-II Unit-2	Coal	2028-29	139
3.	Koderma Thermal Power Station Ph-II Unit-1	Coal	2027-28	314
4.	Koderma Thermal Power Station Ph-II Unit-2	Coal	2028-29	314
5.	Durgapur Thermal Power Station	Coal	2028-29	155
6.	Teesta-VI HEP	Hydro	2027-28	12
7.	Dibang MPP Hydro Electric Project	Hydro	2030-31	68
8.	Kiru HEP	Hydro	2026-27	15
9.	Rangeet-IV HEP	Hydro	2026-27	5
10.	DVC Solar	Solar	2025-26	342
11.	DVC Solar	Solar	2026-27	453
12.	DVC Solar	Solar	2027-28	524
13.	DVC Solar	Solar	2028-29	228
14.	DVC Solar	Solar	2029-30	350
15.	DVC Solar	Solar	2030-31	100
16.	DVC Solar	Solar	2031-32	100
17.	Battery (2hrs)	BESS	2027-28	250
18.	Battery (4hrs)	BESS	2028-29	100
	TOTAL			**3608**

Assumption for Resource Adequacy Studies

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

RE CUF considered

Hydro	Solar	DRE
32 %	21%	14%

Technical Parameters

Technology	Type	Availability (%)	Ramping (%/min)	Min. Technical. (%)
Coal/ Lignite	Existing/Planned	85	1	55
	Candidate	88	1	55
Gas	Existing	90	3	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	-
BESS	Candidate	98	NA	-

Technology	Type	Heat Rate (MCal/MWh)		Aux. Consum. (%)	Min. online time (hr)	Min. offline time (hr)
		At max loading	At min loading			
Coal	Existing/ Planned	2300 to 2879	2438 to 3052	7.0	6	4
	Candidate (SC & USC)	2060 to 2125	2183 to 2253	6.5	6	4
Gas	Existing	2000 to 2900	2260 to 3277	2.5	4	3
Nuclear	Existing/ Planned	2777	2777	10	6	4
	Candidate	2777	2777	10	-	-

Technology	Type	Heat Rate (MCal/MWh)		Aux. Consum. (%)	Min. online time (hr)	Min. offline time (hr)
		At max loading	At min loading			
Biomass	Existing/ Planned	4200	4450	8	6	4
	Candidate	4200	4450	8	6	4
Hydro	Existing/ Planned	-	-	0.7	-	-
	Candidate	-	-	0.7	-	-
Pumped Storage Plant	Existing/ Planned	-	-	Pump efficiency 80 %	-	-
	Candidate	-	-		-	-
BESS	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

Following cost parameters have been assumed:

Resource	Capex* (in ₹/MW)	O&M Fixed Cost (in ₹/MW)	Construction Time (in years)	Amortization /Life time (in years)
Coal	12 Cr	30 Lakh	4	25
Solar	4.5 Cr	1 % of Capex	1	25
Battery Energy Storage (4-Hour)	4.98 Cr to 3 Cr	5.9 Lakh	1	15
Battery Energy Storage System (6-Hour)	6.79 Cr to 3.90 Cr	5.9 Lakh	1	15
Pumped Storage Plant	6 Cr	30 Lakh	4	40