Resource Adequacy Laws/Guidelines

Ammi Ruhama Toppo

Chief Engineer

Integrated Resource Planning

Central Electricity Authority

Policy Framework

✓ MoP has notified Electricity (Amendment) Rules, 2022 on 29.12.2022

Rule 16:

- ***Resource Adequacy Guidelines*** *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, within six months from the date of commencement of these rules.* **- Final Guidelines issued on 28th June 2023.**

- *State Commission shall* ***frame regulations*** *on resource adequacy, in accordance with the* ***guidelines*** *issued by the Central Government, the* ***distribution licensees*** *shall formulate the* ***resource adequacy plan*** *in accordance with these Regulations and* ***seek approval of the Commission***

- *The* ***National Load Dispatch Centre and the Regional Load Dispatch Centers*** *shall carry out assessments of resource adequacy, for* ***operational planning, at the national and regional levels****, respectively, on an annual basis*

Policy Framework

- *The **State Commission** may determine **non-compliance charges** for failure to comply with the resource adequacy target approved by the Commission.*

- *The **State Load Dispatch Centre** shall carry out assessments of resource adequacy, for **operational planning, at the state level,** in consultation with all the concerned stakeholders on an annual basis ,in accordance with the guidelines issued by the Central Government and the directions of the State Commission.*

- *The State Load Dispatch Centre **shall review** the **operational resource adequacy** on a daily, monthly and quarterly basis*

Roles and Responsibilities in Resource Adequacy Framework

Role of CEA

- Publish Long Term National Resource Adequacy Plan (LT-NRAP) for 10 years containing the following:
  - National Level PRM and reliability indices
  - Share of State in National Peak Demand
  - Capacity credit of all generation technologies
  - Optimal Generation Mix at national level
- LT-NRAP shall be revised annually
- Vetting of state specific LT-DRAP for all states

Role of NLDC

- To Publish Short Term National Resource Adequacy Plan (ST-NRAP) for one year considering the following :-
  - Reserves (Primary, Secondary and Tertiary) in the Grid for grid security
  - Planned maintenance schedules of existing stations
  - Station-wise historic forced outage rates
  - Resource Availability based on new projects
  - Decommissioning plans, if any.

Role of Distribution Utility

- Long-term Discom Resource Adequacy Plan (LT-DRAP) (on annual rolling basis) for 10 year for:
  - Meet the ***peak demand and energy requirement*** of the Discoms along with the RPO Obligations
  - Meeting ***contribution towards national peak*** with PRM
  - Adhering Reliability norms
- LT-DRAP shall be vetted by CEA and submitted to State Commission for approval
- Demonstrate 100% tie-up for the first year and min 90% tie-up for the second year to meet their contribution towards national peak.
- To submit the details of contracted capacities to the respective STU/SLDC after the approval of State Commission.

Role of STU/SLDC

- To provide the following inputs for formulation of LT-NRAP:-
  - Hourly demand (15 minute time block wise)
  - Hourly demand forecasts for the next 10 years
  - Availability from the existing/contracted generation resources
  - Any other inputs required for national RA plan
- Aggregate the total contracted capacities at the state level and submit the information to the respective RLDC.
- RLDCs shall aggregate the capacities at Regional Level and submit to NLDC
- SLDC shall carry out assessments of resource adequacy, for operational planning, at the state level
- Review the ST-DRAP on a daily, monthly and quarterly basis based on actual availability of generation resources.

Judicious mix of Long, Medium and Short-Term Contracts

Type of Contract	Meeting Distribution Licensee Contribution in national Peak	Distribution licensee own peak and electricity requirement
Long-Term	75-80%	>75%
Medium-Term	10-20%	10-20%
Short-Term	0-15*%	0-15%

* Power procurement through the power exchanges, such as the Day-Ahead Market segment, shall not be considered

Timely Procurement of Resources

- The distribution licensee must ensure that procurement process for the projected demand is undertaken and completed sufficiently in advance to ensure its availability for meeting the demand.

Resource	Long Term	Medium Term
Coal/Lignite Based Capacity	7	2
Hydro	9	2
Solar	2	1
Wind	3	1
PSP	5	3
Other Storage	2	1
Nuclear	9	3

Calculation of Resource Adequacy Requirement

- RAR (supply side)= ∑ (Installed Capacity * Capacity Credit)

*Capacity credit- Percentage of installed capacity that a generator can reliably provide to meet peak demand

- RAR (demand side)

  = Contribution to forecasted National peak demand * (1 +PRM)

Integrated Resource Planning (IRP) for RA

- IRP- To determine the target generation capacities for meeting the forecast peak and energy demand over a specified future period.
- Inputs for IRP-
  - Reliability indices
  - Demand pattern (Hourly/sub-hourly demand pattern)
  - Estimated Load Growth
  - VRE generation profiles
  - Technical & Financial parameters of Existing, Planned and Candidate Generating Plants
  - RPO & ESO targets
  - Spinning reserve requirements

DEMAND FORECASTING

Forecast of What?

- Restricted or Unrestricted ?
- Utility only or Overall Power Demand ?
- At User End or at Generator End ?

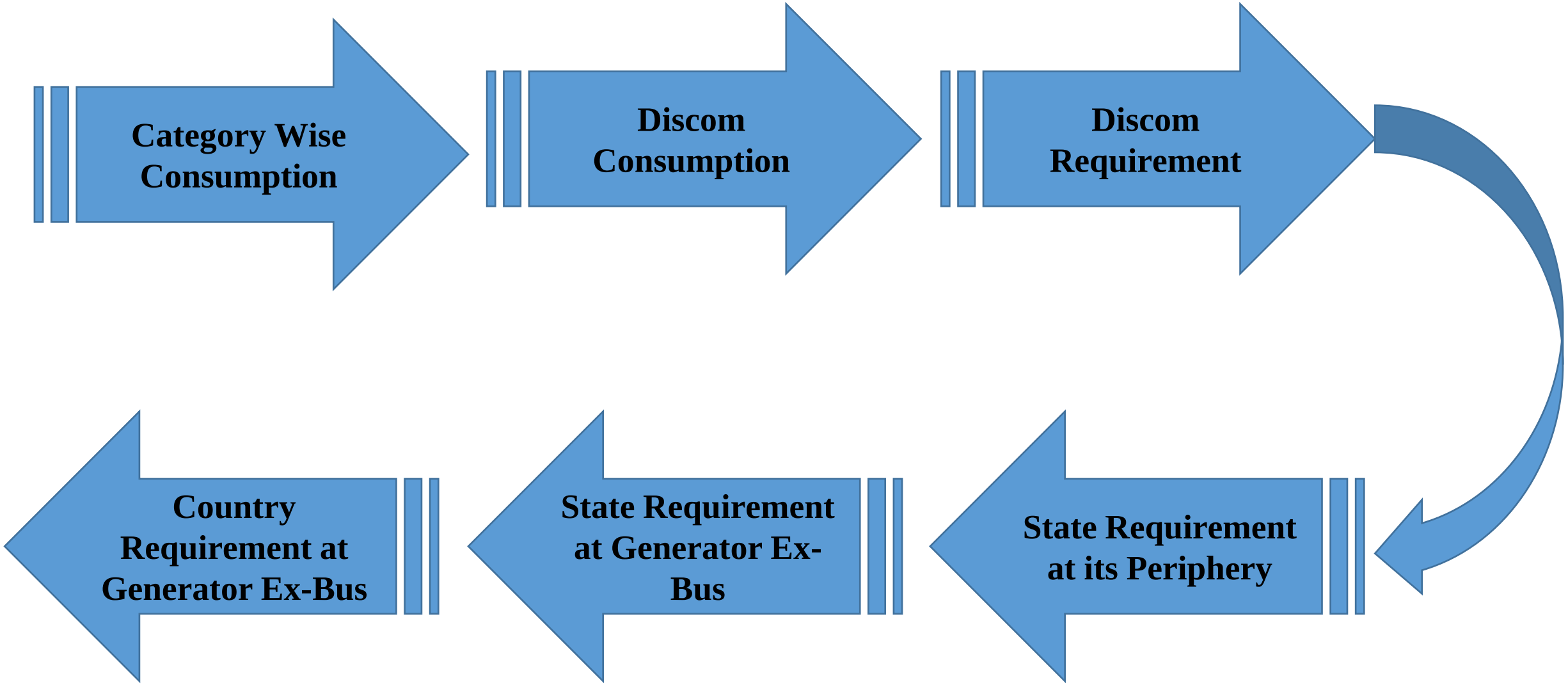
Include or Exclude ?

- Energy Efficiency.
- Weather Conditions.
- Open Access Consumption.
- Latent Demand.

General - Terms, Range & Periodicity

- Term - Medium Term (> 1 & < 5 years) & Long Term (> 5 years)
- Input data – At least for last 10 years
- Periodicity – Annual
- Time Granularity – Yearly/Monthly
- Spatial Granularity – At least at the DISCOM/State (If granular data is available then Zonal level, Circle level, District level, Sub-Station Level, Feeder/Transformer level)
- Scenario – Business As Usual, Optimistic & Pessimistic

Forecasting Approach – Bottom Up



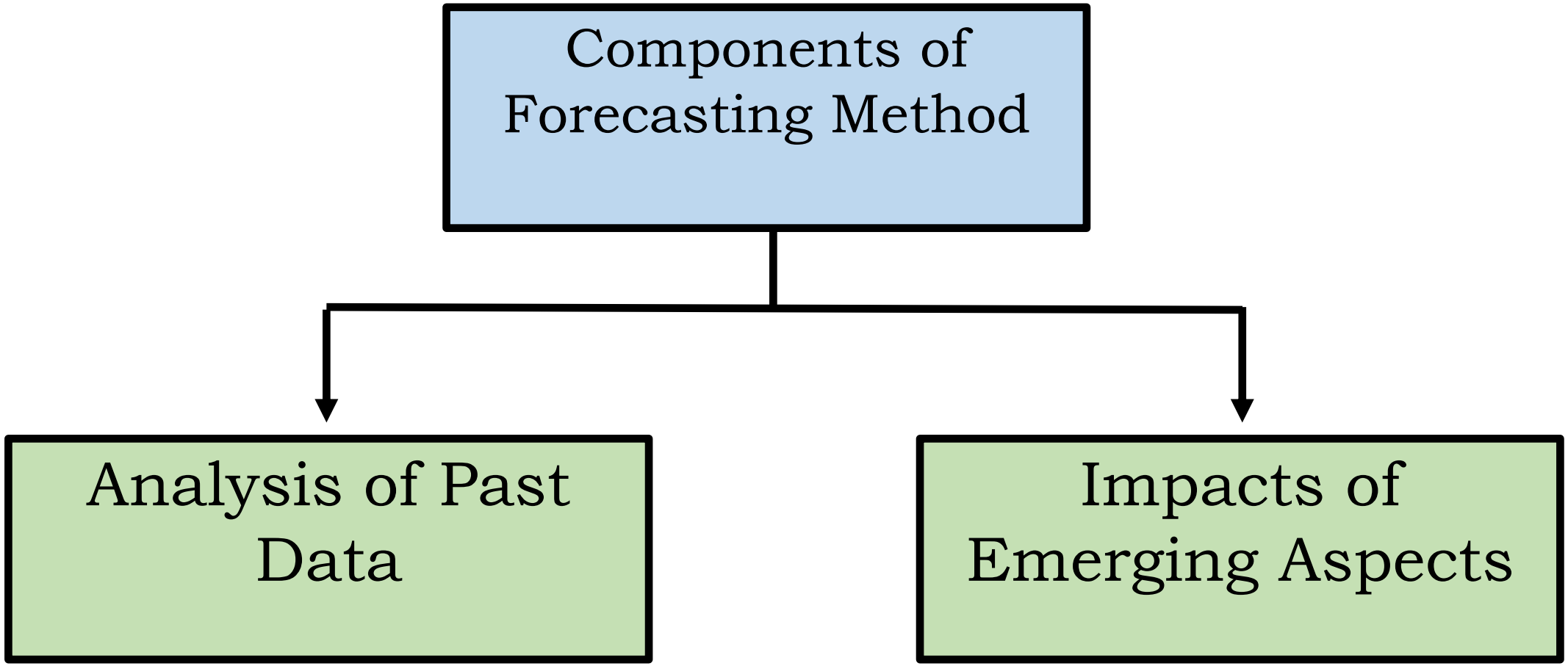
Base Year

- Base Year : (T-3).
- Rationale : Out of Sample Validation.
- If the data for T-3 year is showing some abnormal trends, then the last normal year till which some definite trends were observable may be considered as the base year.

Consumption Categories

- Domestic
- Commercial
- Public Lighting
- Public Water Works
- Irrigation
- LT Industries
- HT Industries
- Railways
- Bulk Supply
- Open Access
- Others

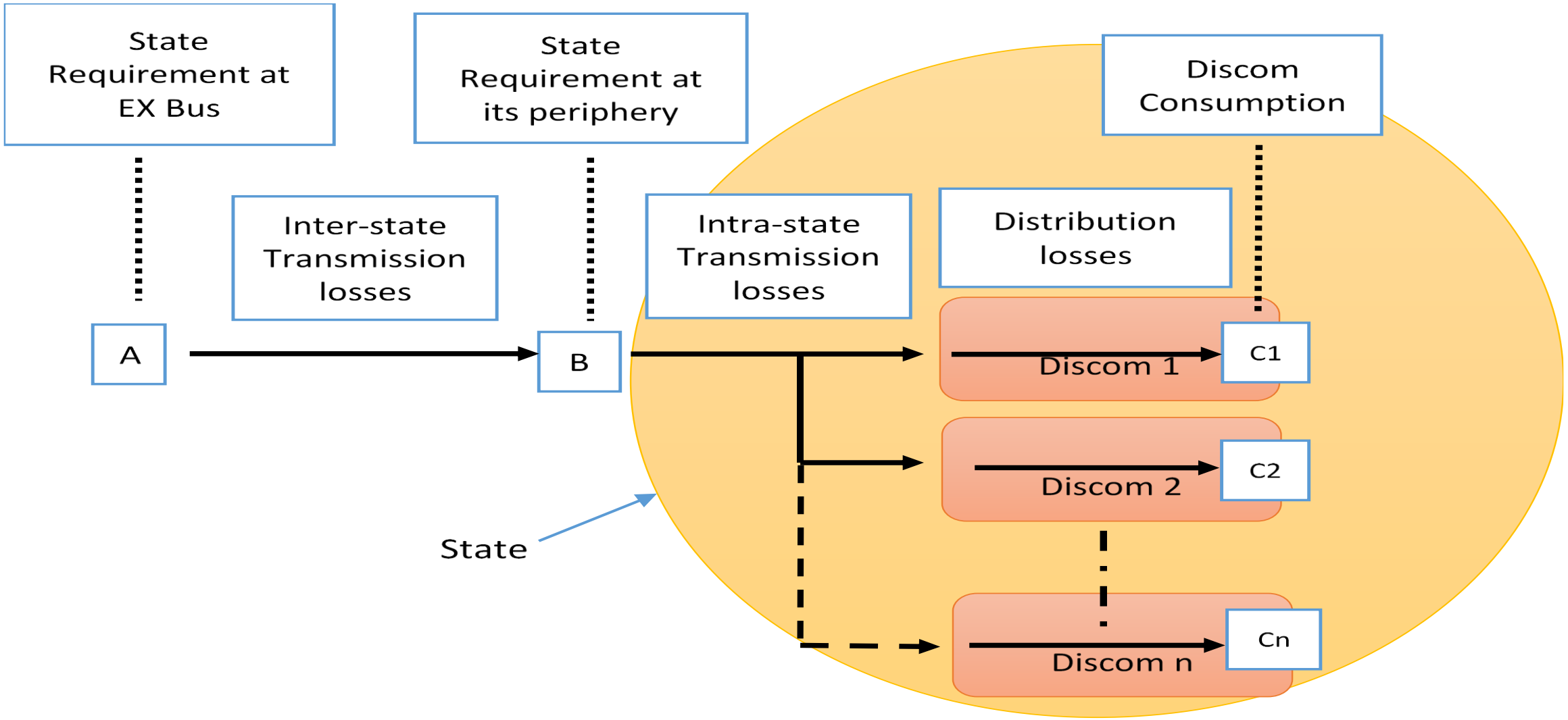
Components of Forecasting Methodology



Analysis of Past Data

- Analysis of past growth rate for each energy consumption category.
- Two of the simplest and appropriate statistical methods - “Least Square Method” and “Weighted Average Method”.
- Other advanced statistical tools may also be used to analyse growth rates.

Factoring in T&D losses in Energy Requirement



Analysis of Past Data – T&D Losses

- Analysis of past growth trends of T&D losses.
- The three components of T&D losses should be analysed separately -
  - ✓ Distribution losses
  - ✓ Intra-state transmission losses
  - ✓ Inter-State transmission losses
- Reduction in losses should not been considered in complete isolation.

Impact of Emerging Aspects

- Should be factored in additionally if upcoming.
- Should not be factored in additionally if they are already in vogue for quite some time in the past and expected to follow similar trajectories in future.

Impact of Emerging Aspects

- Impact should be quantified in sync with the targets set by the government.
- In case of non-availability of any target, suitable assumptions should be taken.
- If the targets are not segregated at annual level or no definite trends are anticipated - Exponential trend with more impact in the later years should be considered.
- As far as possible, the impact of the emerging effects should be apportioned to the corresponding pre-defined consumption categories only.
- In absence of suitable category, a new category could be created if the impact is substantial. Otherwise, it could be clubbed in “Others” category.

Approach for Medium Term & Long Term Forecasting

- Medium Term Forecast - in addition to past growth trends, it should be based on the assessment of impact of specific government policies, developmental plans and other emerging aspects in the definite quantum of electrical energy.
- Long Term Forecast - Based on further extrapolation of the growth trends estimated under medium-term horizon.

Peak Demand

- Should be derived from the energy requirement by applying appropriate load factor.
- Load factors for future should be estimated on its past trend.
- If the pattern of specific consumer mix is expected to differ from the past, the expected load factor should be derived by examining load factors of other Discoms with similar consumer mix.
- Peak electricity demand of the state should be estimated by applying suitable diversity factor, as per the past trends, to the sum of peak electricity demand of its all Discoms.

General Checks & Balance

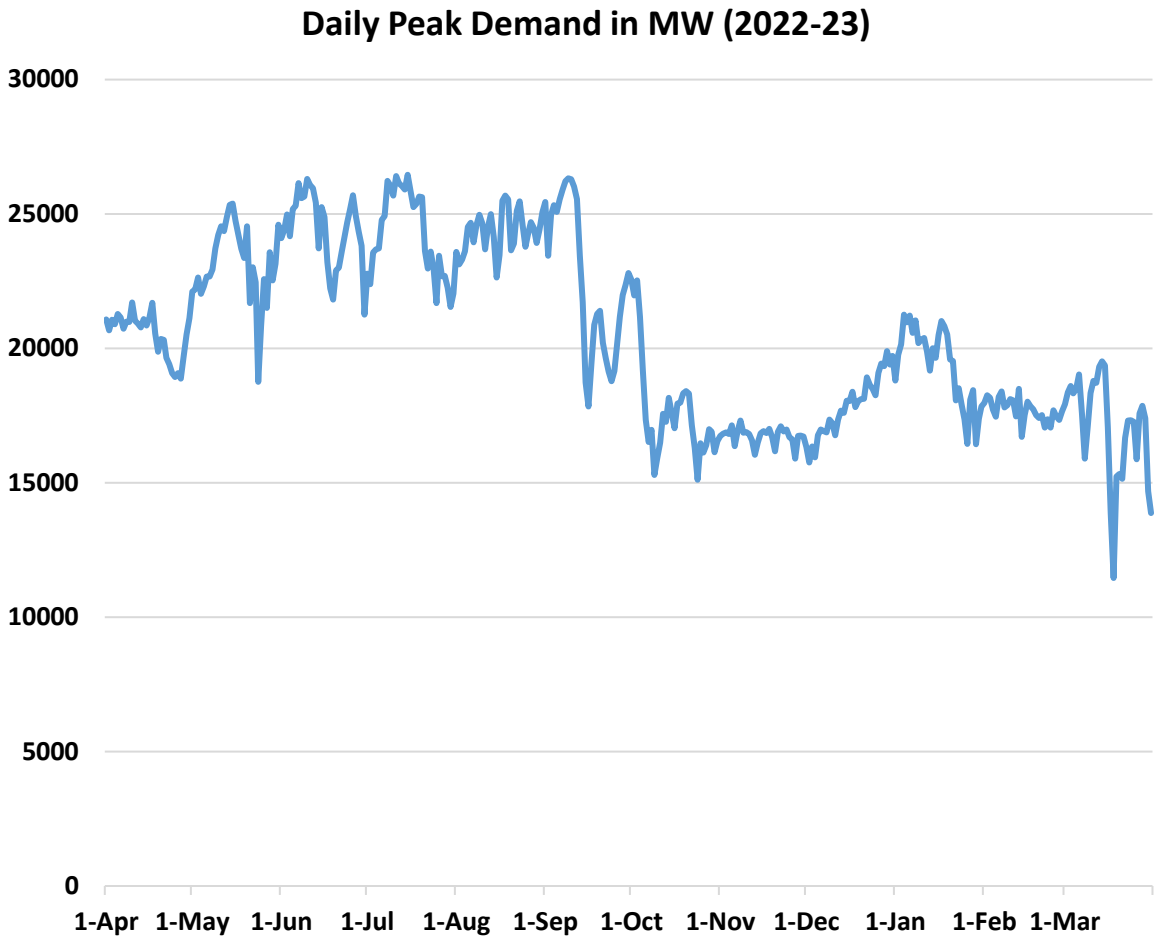
- Load Factor < 1.
- Diversity factor > 1. (Normal Range - 1 to 1.1)
- Every consumption should be accounted for.
- No double accounting of any energy.
- Energy requirement met at state periphery = Total net generation + net import.

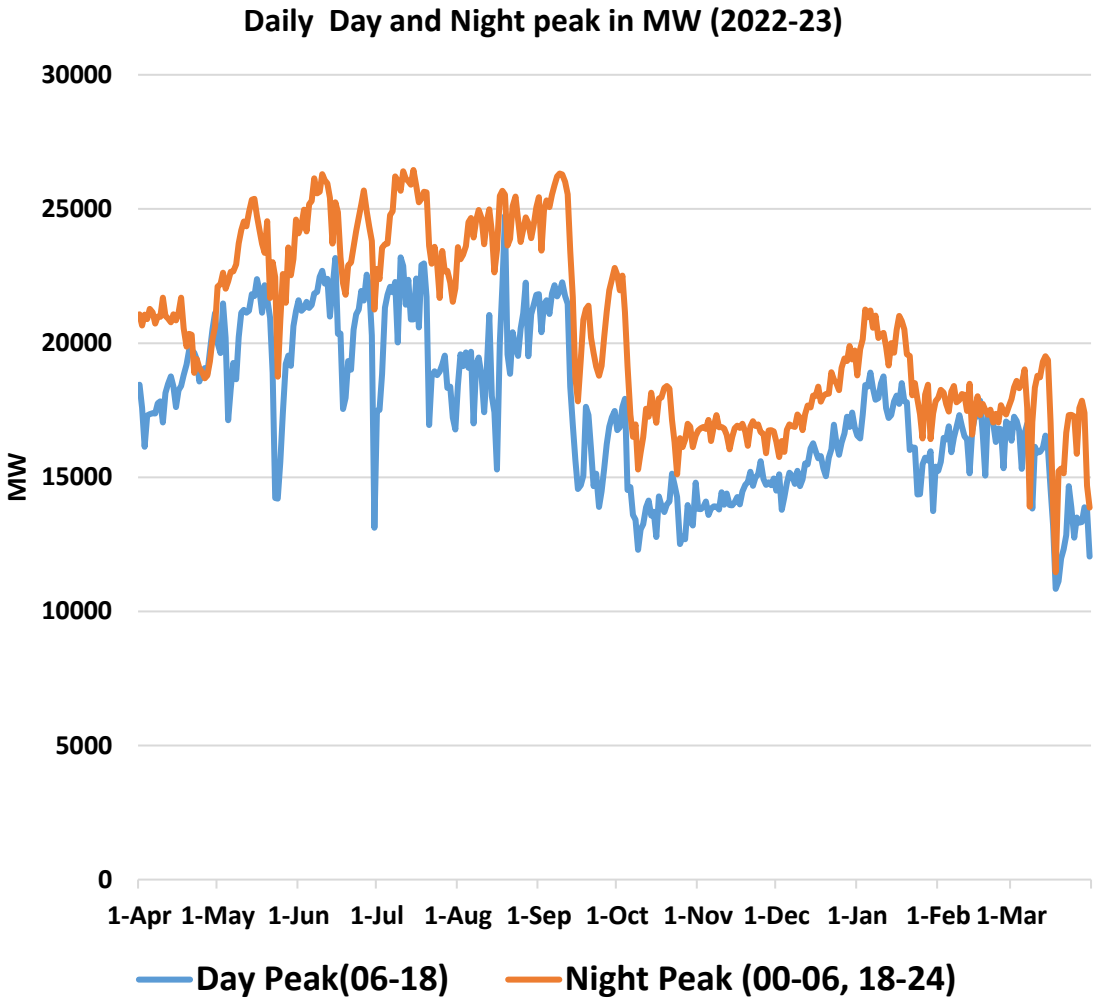
Different Scenario Building

- The forecast under BAU scenario should be derived first.
- Based on BAU Scenario, forecasting under Optimistic and Pessimistic scenarios should be arrived at.

Case Study
Resource Adequacy Study For the UP

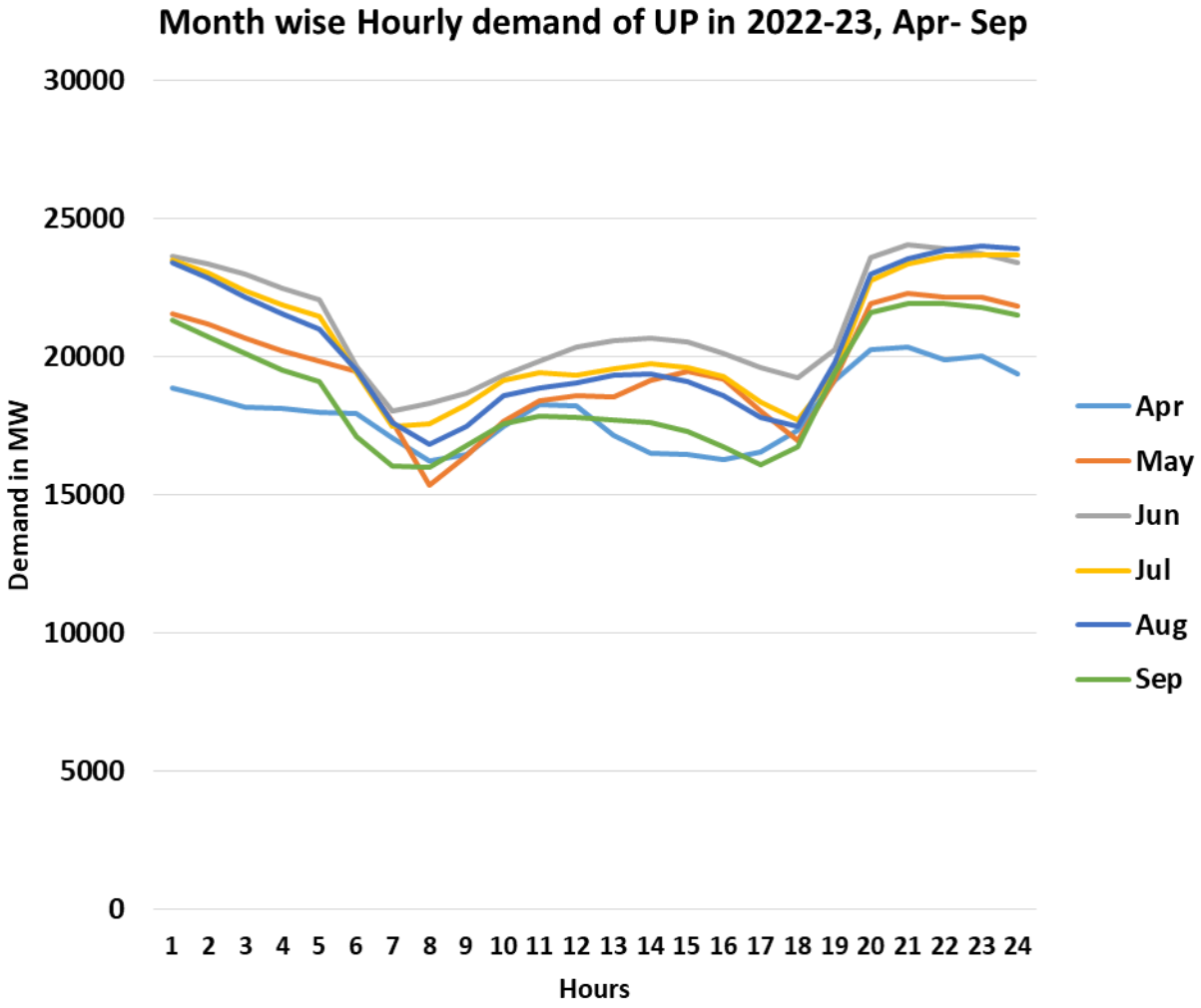
Demand Analysis of Uttar Pradesh

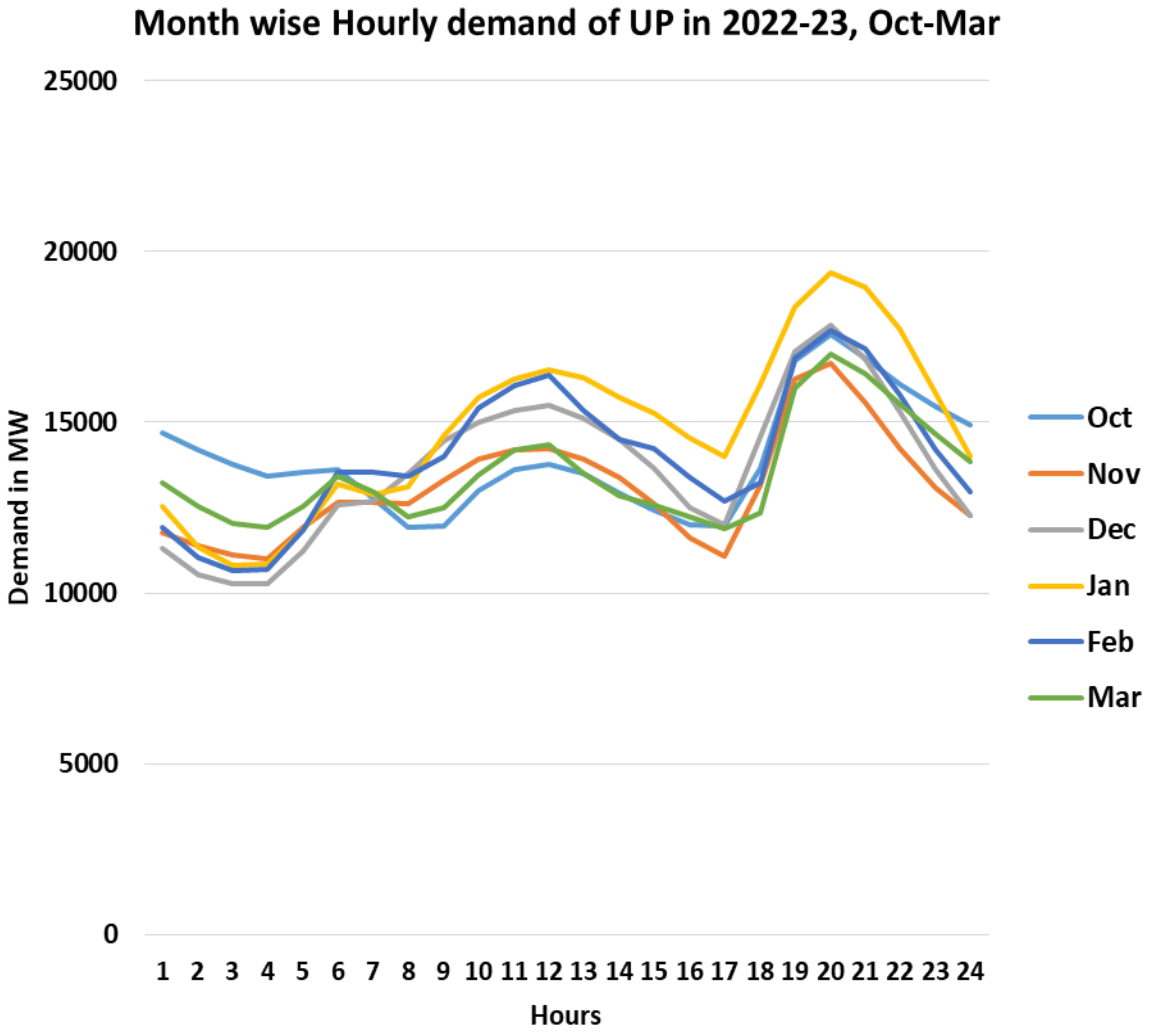




Annual peak of UP occurs during July at night hours.

Demand Analysis of Uttar Pradesh





- **Demand during Summer months i.e. June, July remains substantially high compared to other months.**
- **The diurnal variation of peak and off peak demand is significantly high through out the year.**

Demand Projections

Energy Requirement (MU) and Peak demand projections (MW) considered for RA study*

Year	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31*	2031-32*	2032-33*	2033-34*
Energy Requirement Projections (MU)	162297	173262	185390	198367	212738	227111	243009	260020	278222	296306	315566
Year on Year Growth *(Energy)*		6.8%	7.0%	7.0%	7.2%	6.8%	7.0%	7.0%	7.0%	6.5%	6.5%
Peak Demand Projections (MW)	28737	30605	32595	34713	36970	39373	41932	44657	47560	50651	53943
Year on Year Growth (Peak)		6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%

*Peak demand projections for the years after 2029-30 have been assumed considering similar growth rates as furnished by UPPCL.

Year Wise Contracted Capacity Addition Plan of UPPCL

Resource	Y-o-Y Planned Capacity Addition(MW) till 2029-30							TOTAL
	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2023-30
Thermal	2902.96	2738.72	0	0	0	800	0	**6441.68**
Solar	214	225	610	0	0	0	0	**1049**
Wind	464	622	1400	0	0	0	0	**2486**
Hydro	0	340	100	368	0	0	0	**808**
Biomass	14	0	0	0	0	0	0	**14**
Nuclear	0	0	0	0	0	0	161.96*	**161.96**
DRE	0	1450	1600	1600	1600	1600	0	**7850**
Total	**3594.96**	**5375.72**	**3710**	**1968**	**1600**	**2400**	**161.96**	**18810.64**

Source: UPPCL

*Allocation of 161.96 MW from Rawatbhata APP unit 7 & 8 (2x700 MW) vide M/o Power allocation Order No. 8/23/2002-S.Th. Dated 17th June, 2011.

RPO trajectory (as per Ministry of Power gazette notification dated 20th October, 2023)

Sl. No.	Year	Wind renewable energy	Hydro renewable energy	Other renewable energy	Distributed renewable energy	Total renewable energy
1	2024-25	0.67%	0.38%	27.35%	1.50%	29.91%
2	2025-26	1.45%	1.22%	28.24%	2.10%	33.01%
3	2026-27	1.97%	1.34%	29.94%	2.70%	35.95%
4	2027-28	2.45%	1.42%	31.64%	3.30%	38.81%
5	2028-29	2.95%	1.42%	33.10%	3.90%	41.36%
6	2029-30	3.48%	1.33%	34.02%	4.50%	43.33%
7	2030-31	40.50%			5.00%	45.50%
8	2031-32	41.50%			5.50%	47.00%
9	2032-33	42.30%			6.00%	48.30%
10	2033-34	43.00%			6.50%	49.50%

Note:- RPO trajectory for the years till 2029-30 is considered based on MoP RPO Notification dated 20th October,2023. RPO targets beyond 2029-30 is considered based on RE generation in National Electricity Plan (Vol-I Generation) (2022-32).

Source wise year on year RE capacity required to fulfil RPO

FY	HYDRO		WIND		SOLAR		DRE		TOTAL	
	Planned	Additional	Planned	Additional	Planned	Additional	Planned	Additional	Planned	Additional
2024/25	340	0	622	0	225	0	1450	0	2637	0
2025/26	100	0	1400	0	610	0	1600	0	3710	0
2026/27	368	250	0	800	0	8000	1600	0	1968	9050
2027/28	0	250	0	800	0	8000	1600	0	1600	9050
2028/29	0	250	0	800	0	8000	1600	0	1600	9050
2029/30	0	250	0	1800	0	3613	0	710	0	6373
2030/31	0	0	0	800	0	5457	0	1617	0	7874
2031/32	0	0	0	800	0	4891	0	1801	0	7492
2032/33	0	0	0	800	0	4774	0	1938	0	7512
2033/34	0	0	0	800	0	2265	0	2140	0	5205
TOTAL	**808**	**1000**	**2022**	**7400**	**835**	**45000**	**7850**	**8206**	**11515**	**61606**

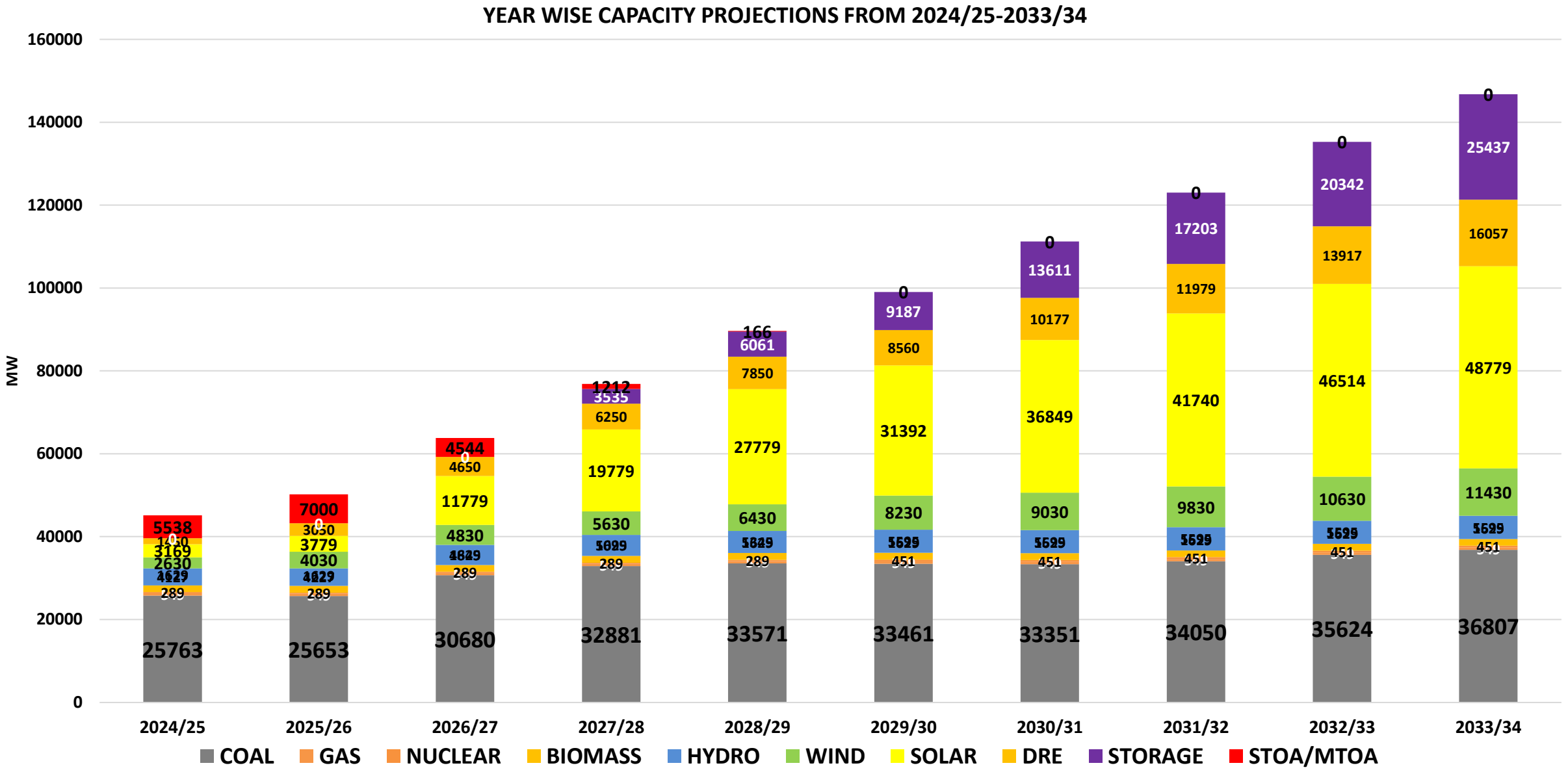
Assumptions for the Resource Adequacy Studies (2/2)

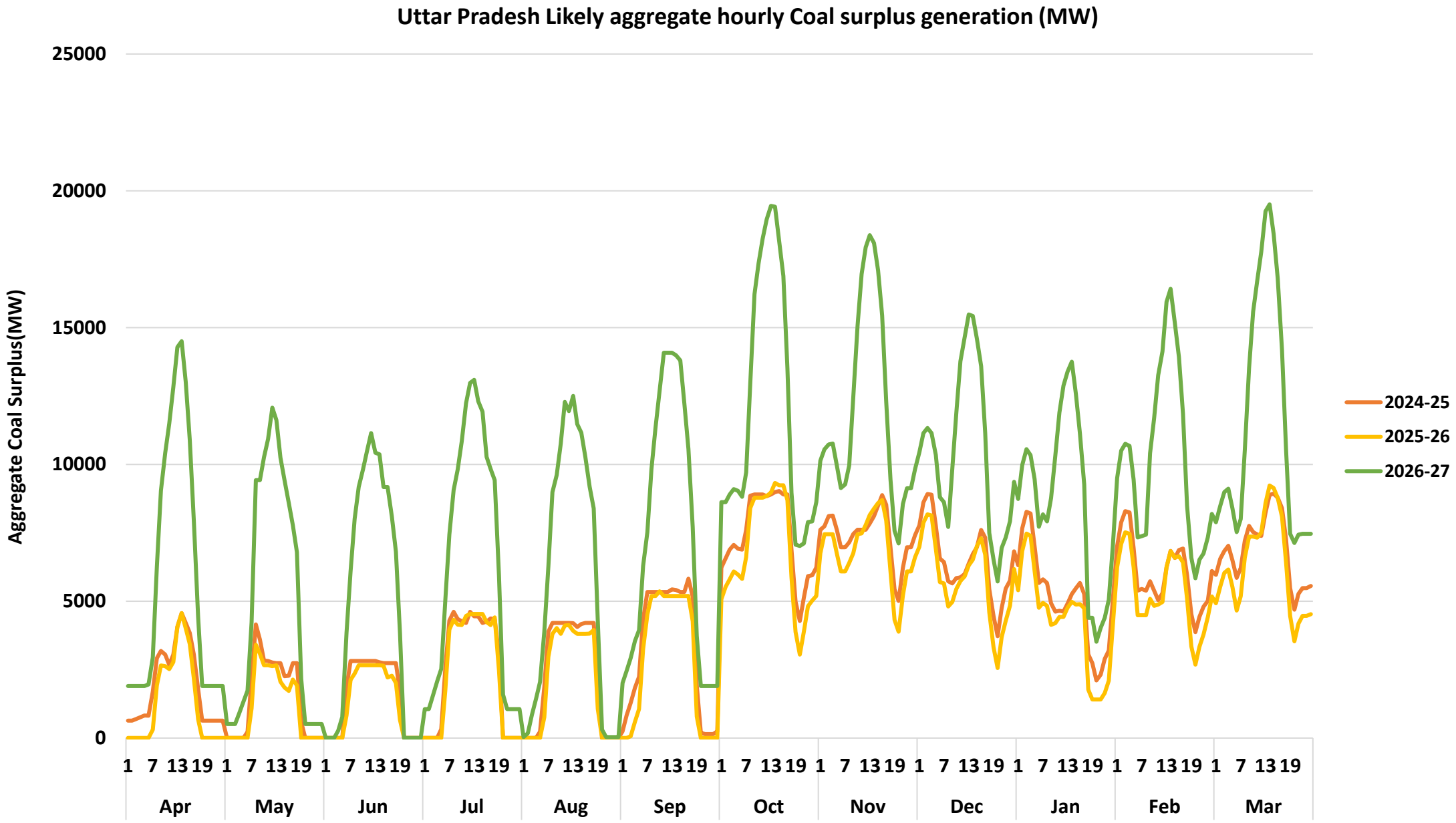
- For doing reliability analysis the range of variation considered for generating the samples of different system parameters is as below:

SI No.	System Parameter	Range of Variation (in %)
1.	Forced outage of conventional generators	10±5
2.	Solar Generation	±5
3.	Wind generation	±50
4	Hydro generation	±5
5.	Demand*	±15

*Based on the hourly variation of demand for the year 2021-22 and 2022-23.

Projected Contracted Capacity of Uttar Pradesh 2024-34 to meet the demand




Uttar Pradesh Likely aggregate hourly Coal surplus generation (MW)
Aggregate Coal Surplus(MW)
25000
20000
15000
10000
5000
0
1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19 1 7 13 19
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
2024-25
2025-26
2026-27

Projected Contracted Capacity (in MW) of Uttar Pradesh 2023-34 to meet the demand

YEAR	COAL	GAS	NUCLEAR	BIOMASS	HYDRO	WIND	SOLAR	STORAGE (MW/MWh)	DRE	STOA
2024/25	25763	549	289	1629	4127	2630	3169	0/0	1450	5538
2025/26	25653	549	289	1629	4227	4030	3779	0/0	3050	7000
2026/27	30680	549	289	1629	4845	4830	11779	0/0	4650	4544
2027/28	32881	549	289	1629	5095	5630	19779	3535/ 14141	6250	1212
2028/29	33571	549	289	1629	5345	6430	27779	6061/ 24244	7850	166
2029/30	33461	549	451	1629	5595	8230	31392	9187/ 36748	8560	0
2030/31	33351	549	451	1629	5595	9030	36849	13610/ 54443	10177	0
2031/32	34050	549	451	1629	5595	9830	41740	17202/ 68811	11979	0
2032/33	35624	549	451	1629	5595	10630	46514	20341/ 81366	13917	0
2033/34	36807	549	451	1629	5595	11430	48779	25437/ 101748	16057	0

Recommended Year-Wise Capacity Addition (in MW)

FY	COAL		HYDRO		WIND		SOLAR		NUCLEAR	DRE		TOTAL		STORAGE MW/ MWh	STOA/ MTOA/ Bilateral
	Planned contract	Additional contract	Planned contract	Additional contract	Planned	Additional contract	Planned	Additional contract	Planned	Planned	Additional contract	Planned contract	Additional contract	Additional contract	Year wise requirement of state
2024/25	2739	0	340	0	622	0	225	0	0	1450	0	5376	0	0/0	5538
2025/26	0	0	100	0	1400	0	610	0	0	1600	0	3710	0	0/0	7000
2026/27	0	5027	368	250	0	800	0	8000	0	1600	0	1968	14077	0/0	4544
2027/28	0	2312	0	250	0	800	0	8000	0	1600	0	1600	11362	3535/14141	1212
2028/29	800	0	0	250	0	800	0	8000	0	1600	0	2400	9050	2525/10102	166
2029/30	0	0	0	250	0	1800	0	3613	162	0	710	162	6373	3125/12503	0
2030/31	0	0	0	0	0	800	0	5457	0	0	1617	0	7874	4423/17695	0
2031/32	0	699	0	0	0	800	0	4891	0	0	1801	0	8191	3591/14367	0
2032/33	0	1574	0	0	0	800	0	4774	0	0	1938	0	9086	3138/12554	0
2033/34	0	1183	0	0	0	800	0	2265	0	0	2140	0	6388	5095/20382	0
TOTAL	**3539**	**10794**	**808**	**1000**	**2022**	**7400**	**835**	**45000**	**162**	**7850**	**8207**	**15216**	**72401**	**15216/ 72401**	

Conclusion

- The Peak demand for the state occurs during summer months viz. July-Aug.
- On daily basis, the peak demand is observed during night hours (Non solar hours).
- Share of Thermal is 68% of present contracted capacities (20.6 GW) decreases to 25 % by 2033-34.
- 5,027 MW of additional Coal based capacity required from 2026-27 onwards (beyond under construction/ planned) which increases to 10,794 by 2033-34.
- Year on year STOA/MTOA/Banking arrangement/Bilateral arrangement to meet the power deficit in peak hours during May to August is:

Year	2024/25	2025/26	2026/27	2027/28	2028/29
STOA/MTOA/ Bilateral arrangement	5538	7000	4544	1212	166

- Given the projected capacity mix, the PRM for the state in 2033-34 is likely to be 16% in order to meet the reliability criteria (EENS 0.05% and LOLP 0.2%).

Thank You