WORLD ENERGY COUNCIL
INDIA

Alternate Methodology for Electricity Demand Assessment and Forecasting

Executive Summary

World Energy Council India

Executive summary

Over the last half a decade, the Indian power sector has witnessed success stories and has undergone dynamic changes. However, the road ahead is entailed with innumerable challenges that result from the gaps between what is planned and what the sector has been able to deliver. Demand forecasting of power, thus, has an important role to play in effective planning and in minimizing the gaps.

Need of electricity demand forecasting

The draft amendments to Tariff Policy released in May 2018 mandates that the Commission should direct Distribution licensees to undertake demand forecasting every year and submit short, medium and long-term power procurement plans.

The forecasts will help drive better decisions on investment, construction and conservation. It will also play a role in the process of regulation, tariff setting and lead to optimized use of resources.

The subject of forecasting has been in existence for decades. It involves prediction of future power demand over different planning horizon. It is an essential tool for planning of generation capacities and commensurate transmission and distribution systems, which will be required to meet the future electricity requirement. Reliable planning of capacity addition for future is largely dependent on accurate assessment of future electricity demand. Electricity demand forecasting is an essential exercise for every utility as it forms the basis for the development and optimization of power portfolio across various term time horizons.

The methods adopted for electricity demand forecasting have also evolved over time. Previously, extrapolation of past trends used to be the primary method. However, with the growing impact of macro and micro economic factors, emergence of alternative technologies (in supply and end-use), demographic and lifestyle changes etc., it has become imperative to use modeling techniques which capture the effect of factors such as price, income, population, technology and other economic, demographic, policy and technological variables. The future will demand the use of more hybridized and probabilistic approaches to forecast the electricity requirement more accurately.

In India, the Electric Power Survey (EPS) carried out by Central Electricity Authority (CEA) is the primary forecasting study based on which all-planning activities in the power sector are carried out. CEA undertakes the study periodically based on historical data using established methodologies. The forecast results are developed for distribution utilities, state, region and at a national level for short, medium and long-term horizons. One of the observed gap in the results of 18^{th} EPS, released in December 2011, has been the YoY variation between forecast and actual electricity requirement. For the period from FY 2011-12 to FY 2015-16, the actual energy demand was lower by up to 11.39% and the peak demand was lower by upto 16.60%. On average, the demand has been lower by 5% on YoY basis. This has left the country with supply overhang with a large newly added capacity distressed with no PPAs.

CEA in 19^{th} EPS, released in January 2017, has also highlighted the difference and scaled down the energy forecasts for 19^{th} EPS by around 14.35% in FY 2016-17, 17.79% for FY 2020-21 and by 24.45% for the year FY 2026-27. The variation between what is projected and actuals may be dependent on various factors like methodology adopted, forecasting technique used, data reliability, usage of growth and other input factors etc.

Besides use of appropriate methodology and tool, accuracy of demand forecast will also depend on choosing the correct baseline data, which takes into account the unserved demand and the latent demand. Therefore, it is important to look at alternate methodologies that can minimize such variations.

During the draft stage of the National Electricity Plan (NEP), the World Energy Council India (WEC India) had provided several suggestions. One of the major suggestions was to undertake baseline correction of historical data before undertaking a forecast. In addition to that, a need was also felt to review the existing demand assessment methodologies in order to identify gaps and to develop an alternate methodology. The present study aims to propose an alternate methodology for electricity demand assessment and forecasting.

1.1. Objective and scope of the study

Objective of the study:

1. Review and identify gaps in the existing electricity demand forecasting methodologies;
2. Develop an alternate bottom up methodology for undertaking electricity demand forecast;
3. Undertake baseline correction of historical data and forecast for a selected state;
4. Validation of forecast results by comparing with results from existing methodologies;
5. Suggest strategies and implementation plan on supply side to meet the forecasted demand.

1.2. Review of forecasting methodologies of major sectors in India

The methodologies employed to undertake forecasts in coal, oil and gas, renewable and power sector have been reviewed in this section. The objective is to understand the forecasting methods currently employed in these sectors and to leverage the same in the design of the alternate methodology for the electricity sector. The review is limited to the sectors in India and are based on the forecasts released by Government sources. The findings are summarized below:

Sector	Duration	Projection by	Method	Other details
Coal	Upto FY 27	CEA	Top down	▪ Coal demand derived based on historical growth rates
	Upto 2047	NITI Aayog	Top down	▪ Demand and supply side forecast ▪ Four scenarios developed ▪ Different growth rates for scenarios considered
Renewable Energy	Upto 2022	MNRE	Top down	▪ Policy decision to install renewable capacity of 175 GW by 2022
	Upto 2027	CEA	Top down	▪ 275 GW of renewable capacity by 2027 in final NEP'18
Oil & Gas	Released yearly	PPAC/ MoP&G	Bottom up	▪ Demand of individual petroleum products derived using historical growth rates
	2022, 2030 and 2047	NITI Aayog	Top down	▪ Share of O&G in primary energy derived for three specific years ▪ Four scenarios were also developed
Electricity	Upto FY2027, FY 2032 and FY 2037	19th EPS by CEA	Bottom up	▪ Forecasts developed at Utility, State & National level across consumer categories ▪ Partial end use and econometric method

	Upto FY 2027	NEP by CEA	Top down	▪ National level supply side planning ▪ Forecasts of 19th EPS is used to undertake planning

The review of the sectors was focused on identifying the specific methodologies used. It was observed that a mix of top down and bottom up methodologies are being used and most of the methodologies relied on using historical growth rates, assumptions and scenarios.

In addition, in electricity sector, the study also involved analysis of certain issues in the existing forecasting methodologies used in 19th EPS and in draft NEP 2016, which were also given as feedback to the draft NEP. The aim is to discuss probable gaps and suggest possible measures. The summary of some of the issues in the existing methodologies are tabulated below:

Particular	Existing methodologies	Possible measures
Granularity of forecast	▪ Forecasts majorly carried out at the State/ utility level	▪ Forecasting at district level or below (like Circle/ Division/Sub division)
Data issues	▪ Non availability and accessibility ▪ No process in place for data collection ▪ Not available in any standard formats, thereby has limited usage ▪ Available data not reliable, validation checks required	▪ Designated authority for managing data is required ▪ Standardisation of formats required ▪ Process may be developed for data acquisition by third parties for undertaking studies
Assessment and assumption of parameters	▪ Assumptions based on roadmap targets rather than actuals	▪ Assumption may be based on analysis of actual data and trends
Base line correction of data	▪ Data from utilities is restricted demand (served demand) ▪ No methodology to undertake baseline correction of historical data to factor in unserved demand	▪ Need to develop methodologies for baseline correction ▪ Data at feeder level should be used to identify supply hours, interruptions during peak and non-peak hours etc.
Lack of sensitivity in forecast models	▪ Lack of sensitivity towards changes in weather parameters, economic parameters e.g. GDP, per capita income	▪ Impact of external independent parameters should be considered
Scenario models	▪ Scenarios not built into the forecast	▪ Scenarios should be developed and analysed
Periodicity of forecasts	▪ Forecasting is carried out after a period of 5 to 10 years ▪ Over time the assumptions and basis of the forecast changes	▪ Exercise needs to be undertaken at shorter time period e.g. yearly to incorporate recent factors ▪ Short term review is required
Seasonality of forecasts	▪ Seasonal factors not considered ▪ Yearly average forecasts are mostly developed which doesn't provide peaks and troughs as per seasons	▪ Forecasting methods which capture seasonal behaviour should be used. It will help the Discoms better plan their supply.

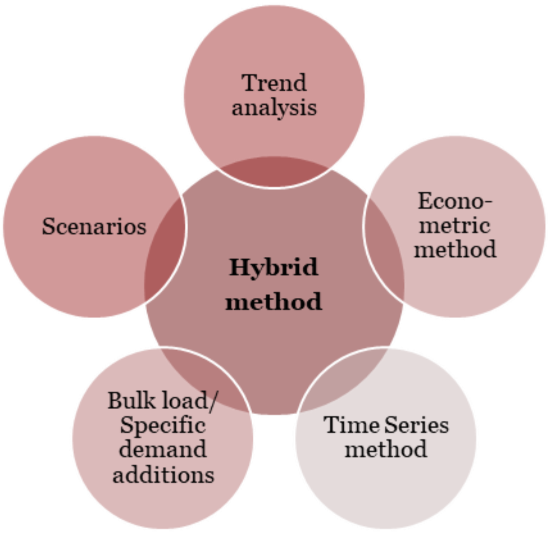
Non-assessment of latent demand	▪ Current methodologies doesn't address latent demand	▪ Methodology for latent demand should be explored, developed and tested
Energy Efficiency	▪ More reliance on potential savings and trajectories which are arrived using assumptions rather than usage	▪ Data for efficiency gains at consumer category level to be collected periodically so as to measure gains
Load factor	▪ Overall system load factor at state level considered with suitable assumptions to arrive at co-incident peak demand	▪ Non-availability of data hinders the determination of actual load factor ▪ Alternate approaches to determine peak demand should be explored
Non-linear relationships	▪ Commonly used techniques don't incorporate non-linear relationships that may exist between the dependent and independent variables	▪ Use of Multivariate Regression to model impact of multiple independent parameters ▪ Use of Exponential smoothing techniques
Combination of methods	▪ Single methods mostly used. May not give accurate forecast	▪ Hybrid approach is required ▪ Multiple forecasting techniques to be used and results to be compared

The review highlighted that there is scope for improvement in existing methodologies that needs to be addressed while developing the alternate methodology. The possible measures were thoroughly analyzed and incorporated in various stages of the alternate methodology.

In the subsequent section, the proposed approach and alternate methodology are addressed.

1.3. Alternate approach and methodology

The proposed methodology is based on a **hybrid approach** involving use of multiple forecasting methods. The hybrid method ***involves baseline correction of historical data***, bulk load additions, specific demand, latent demand, impact of energy efficiency and subsequent use of trend, time series and econometric method. To achieve a higher granularity of forecast, a bottom up methodology has been proposed for the study that involves forecasting at individual consumers categories. The forecast for the state has been derived by aggregating the results at Circle level of the Distribution utility of the State.

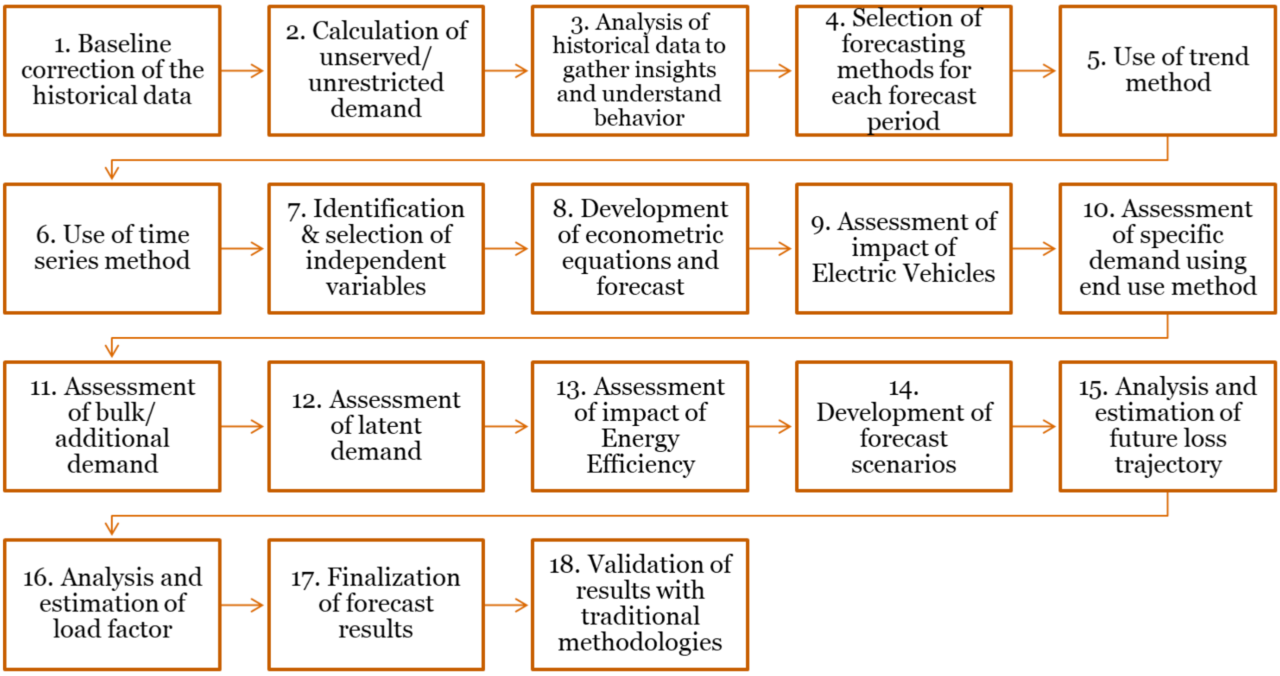


This alternate demand forecast methodology has been detailed here in 18-steps in a schematic representation. The details of each step are given in the main report.

A series of consultation meetings were held with various stakeholders, wherein the methodology was also presented. The inputs obtained were incorporated to fine-tune it before undertaking the forecasting exercise.

The 18-step methodology is given below:

Figure 1: 18-step proposed methodology



In order to undertake forecast, historical data in the form of restricted electricity consumption was collected from the distribution utilities of the selected state for the period from FY 2006-07 to FY 2015-16. The data was collected for each consumer categories at Circle level for the state. As a first step, the collected historical data was used to undertake baseline correction as explained in the next section.

1.4. Baseline correction of historical data

The baseline correction of historical data is required for the following reasons:

- Historical data of demand used for forecasts is energy units recorded at the consumer end and is a 'restricted' data as it doesn't include the unserved demand of consumers due to several reasons, including failure of T&D infrastructure, planned load shedding and unplanned outages.
- Previously, there was deficit of power in India as the overall supply was less than the total demand. Over time, the situation has improved and in future, it is expected that reserve capacity will be built into the system to ensure reliability and quality of power supply, in line with Government's 24 x 7 Power for All (PFA) scheme to supply uninterrupted and reliable power to consumers. Since the historical data to be used for forecasting is for a restricted condition and the forecast period needs to have adequate reserve, it is important that the baseline of historical data is corrected to have a better estimate of future demand.
- The draft amendments to Tariff Policy released on 30th May 2018 also mandates that the appropriate Commission should direct the Distribution licensee to undertake load forecasting every year and to publish and submit to the Commission their short, medium and long-term power procurement plans to meet the load. For appropriate regulatory Commission to assess if the exercise undertaken by the Discoms is fair, having a better understanding of baseline data is essential.

Methodology:

The actual supply hours data was accessed from sample feeders to derive the quantum of electricity which remained unserved due to several factors like load curtailment, distribution infrastructure issues etc. The basic premise for this method lies in estimating electricity units that could have been supplied in non-supply hours using actual data available for supplied units in supply hours using a straight-line extrapolation method.

The curtailed energy for a certain category of consumer has been estimated using the following:

- Average actual hours of supply = [Y1]
- Average actual restricted supply units = [X1]
- Average un-restricted supply units [X2] = [(Target supply hours - Y1) * (X1 / Y1)] + X1

Accordingly, the unrestricted supply units for a circle and for each of the three-consumer categories was determined. Since clear tagging of feeders is not available, for the analysis, based on actual hours of supply, different categories of consumers was assumed as follows. For analysis the target supply/ loading hours are also indicated:

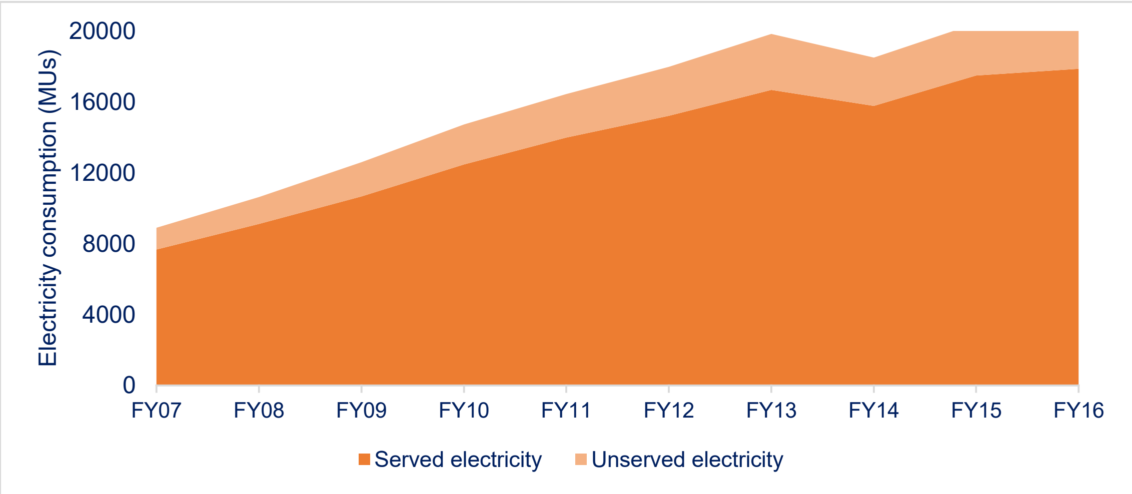
- Domestic 24 hour supply
- Non-domestic 12 hour supply
- Agriculture 8 hour supply

The average gap in electricity supply for the above categories was determined using the target and actual supply data. The gap in hours was converted to units unserved using the straight-line method. The historical served (restricted) demand data from utilities (collected data) was added to the derived unserved units to arrive at the baseline corrected unrestricted demand.

The methodology for baseline correction of historical data has been designed based on the type of data accessed at feeder level. As per the data accessed from sample feeders and based on the methodology, the unserved electricity is in the range of 13-16% of the total unrestricted demand. The challenge in undertaking such a correction is accessing feeder level data and analyzing it to understand the reliability of supply across categories.

The following figure highlights the overall demand data after baseline correction:

Figure 2: Historical data post baseline correction (Illustration)



The unrestricted demand (baseline corrected demand) arrived as above is the summation of the following

- **Served electricity (Restricted)** – which is the electricity served by the utilities in the state to the consumers, accessed from the electricity sales data of utilities
- **Unserved electricity** – the portion of electricity demand which existed in the system but was not served due to various reasons like load curtailment, infrastructure issues etc., derived from gap in supply hours. On an average, the variation of unserved electricity is in range of 13-16% of the total demand.

The unrestricted demand determined above is the baseline corrected demand data, which was then used to forecast the energy demand for each category.

1.5. Implementation of alternate methodology in the selected state

The proposed alternate methodology was implemented in the state of Rajasthan. FY 2015-16 was considered as the Base year and the forecasts were developed for the short term (FY 2016-17 to FY 2020-21), medium term (FY 2021-22 to FY 2025-26) and long term (FY 2025-26 to FY 2031-32) horizons.

Alternate methodology was used to develop forecast at the circle level for 26 circles in the state for the following consumer categories. The categories considered are as defined by distribution utilities in the state.

- Domestic
- Non-domestic
- Public Street light
- Agriculture (metered)
- Agriculture (flat)
- Industry (small + medium)
- Industry (large)
- Public water works
- Mixed load

The steps involved in implementation of the methodology is summarized below:

- Historical data was analyzed, category wise, for each circle to gather insights and to understand the trends at a more granular level i.e. at the Circle level of the distribution utility.
- The forecast was worked out using three methods namely trend method, time series method and econometric method.
    1. The trend method relied on historical growth rates. The forecast model developed has options wherein individual growth rates of consumer categories can be selected at a circle level. In addition, the model has been made flexible enough to select multiple growth rate for short, medium and long term. In summary, the method has housed 702 different growth rates (26 circles, 9 consumer categories and 3 forecast horizons) to arrive at the various forecasts.
    2. The Time series or ("HoltWinter's multiplicative and additive exponential smoothing") models the trend, seasonality and randomness of historical data using an exponential smoothing process. In this method, monthly historical data was used and forecasts were developed for all circles.
    3. Econometric method involved identification and selection of independent variables such as various demographic and economic parameters of the state. The econometric equations with independent variables were then developed for every consumer category across the 26 Circles and unique relations were developed to forecast for each categories for individual circles.

- Since a bottom up approach has been used, the forecasts for each circle and discom were arrived at by aggregating the electricity forecast of individual categories. The demand estimated using the three methods formed the base forecast.
- In addition, demand from open access, electric vehicles, consumer addition due to policy decisions, housing schemes, anticipated bulk demand from master plan, metro, industrial corridor etc. has also been assessed using end use method.
- Based on the methodology developed, a forecast has been developed for capturing the latent demand in the system. Latent demand is the desire to consume a product or service but due to various barriers, the desire is not met and the consumption is curtailed.

  Latent demand is the inherent demand, which is not reflecting due to the following reasons:

  Unmet – the demand from the unconnected consumers, which is present but is not realized currently due to network, infrastructure issues, lack of policy focus etc.

  Unserved – consumers are connected but complete demand is not met due to network restrictions, load curtailments, unreliable supply and deficit in electricity availability etc.

  Behavioral – Even with the given supply, the consumers are not realizing the full potential due to behavioral usage issues.

  Each of the aspects has been analyzed and suitably assessed to arrive at an estimate of latent demand in the state.
- Impact of energy efficiency has also been estimated in order to further refine the forecast of electricity consumption at the state level. Data of savings potential across consumer categories was used. With these benchmarks, a realistic approach was considered and the share of demand to be impacted by energy efficiency was worked out. A YoY increase in % share has been considered with assumption that the impact of energy efficiency will increase as we progress over the years.

The forecast results obtained as above have been segregated into two scenarios.

Scenario 1: Forecast using baseline corrected data – unrestricted forecast (Served + Unserved)

Since the baseline of the historical (served or restricted) data had been corrected by adding the unserved demand (derived from feeder data), the forecasts arrived at for this Scenario is unrestricted forecast i.e. the forecast of the future years contains demand from both served and unserved units. The scenario is reflective of the case when all the unserved demand currently not served by the utilities is fulfilled by way of no interruption of supply, no curtailments etc. This scenario is also useful in case uninterrupted supply is provided to consumers e.g. 24 hours for domestic, 8 hours for agriculture etc.

Scenario 2: Forecast after adjusting for anticipated unserved demand in the future

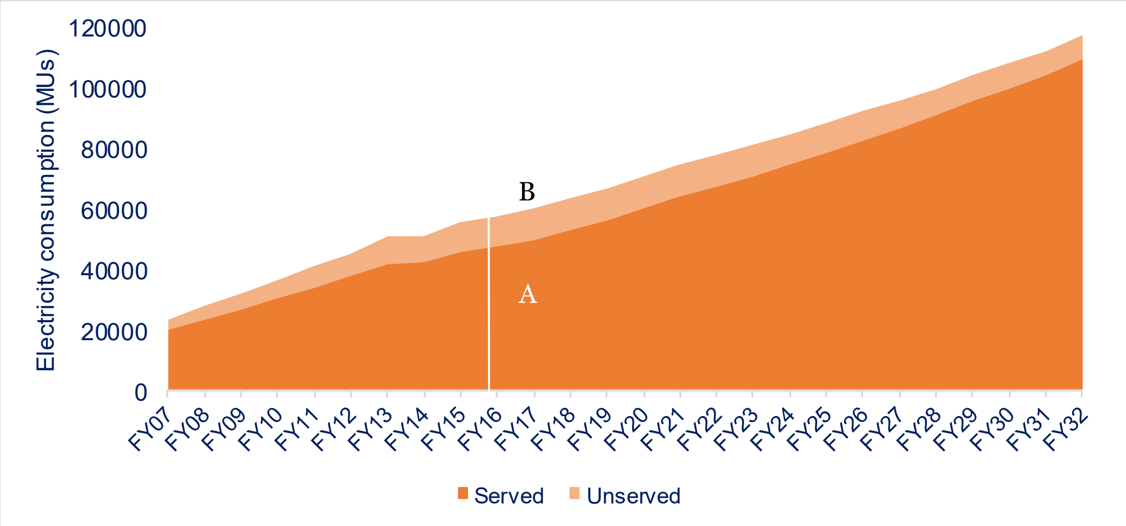
Scenario 2 = Scenario 1 – Future unserved demand

In this scenario, it has been assumed that although with improvement in the supply situation and infrastructure, the share of unserved demand will decrease progressively. However, the reduction will be more gradual and hence across the states/ circles, there will be some amount of unserved demand that will remain, even though overall, there will be a net decrease. The unserved demand for the forecast period has been derived by considering an improving trend of supply hours. It has been assumed that the supply hours will improve by 1% w.r.t previous year. The unserved demand derived for the forecast period has been subtracted from the unrestricted forecast results to arrive at future restricted results.

The figure below highlights an illustration of the same

- A = Served or Restricted demand
- B = Unserved demand
- Scenario 1 = A + B
- Scenario 2 = A = Scenario 1 – B

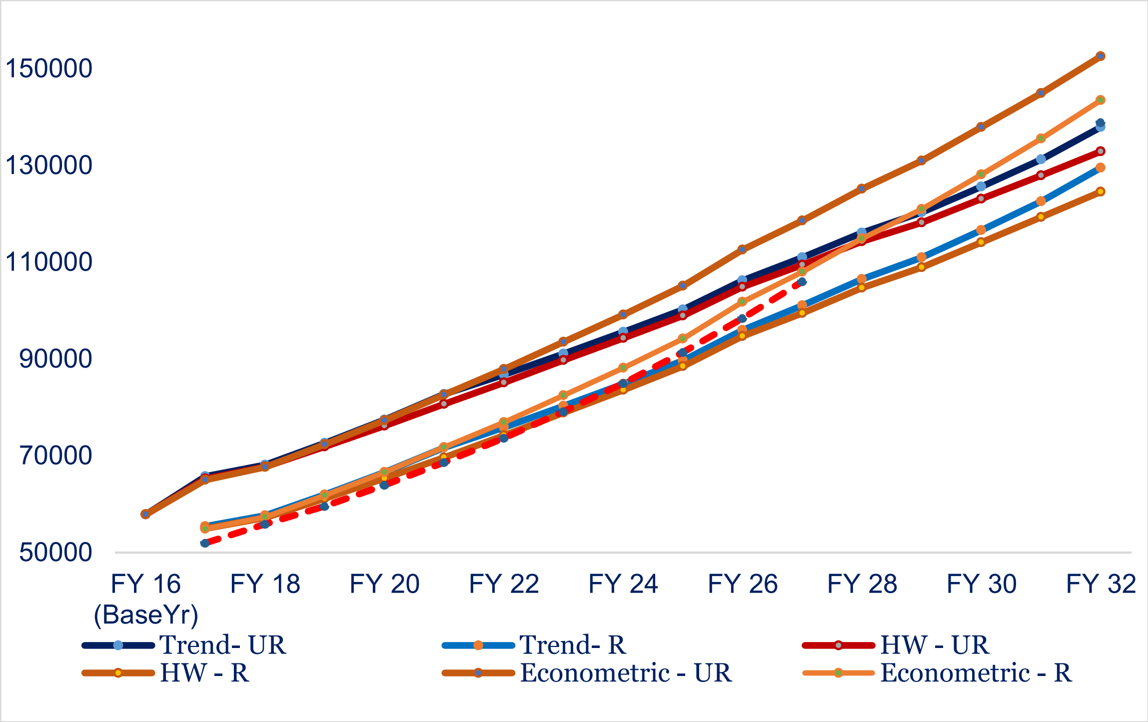
Figure 3: Illustration of the forecast scenarios



The forecast developed using multiple methods have been finalized as per the following steps:

- Unrestricted forecast was developed for the utilities in Rajasthan using the three methods (Scenario 1). Such forecasts have been developed at a Circle level and aggregated to arrive at the utility level forecast
- From the unrestricted forecast, quantum of unserved demand (as explained in Scenario 2) have been subtracted for each circles across the consumer categories to arrive at the restricted forecast. The restricted forecast for each Circles were then summed up to arrive at the forecast at the distribution utility level and subsequently at the state level.
- The results obtained for Scenario 1 and Scenario 2 were based on a bottom up approach. Since additional demand like electricity consumption from infrastructure, open access and captive, electric vehicles, latent demand, demand from railways etc. have been calculated separately, such demands were then added to the aggregated utility demand to arrive at the total electricity consumption forecast for the state.
- Forecasted electricity consumption for the state = Demand from three Utilities + Additional demand

Figure 4: Comparison of the forecast results



In order to estimate the electricity required at the state boundary, the T&D loss trajectory for the future years was forecasted based on historical trends and with suitable assumptions.

Table 1: Projected loss trajectory for the state

Category	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Distribution %	23.3%	20.0%	19.0%	18.0%	17.0%	16.0%	15.0%	15.0%
Transmission %	4.0%	5.2%	5.0%	4.8%	4.6%	4.4%	4.2%	4.1%
T&D %	26.3%	23.5%	24.0%	22.8%	21.6%	20.4%	19.2%	19.1%
	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY 32
Distribution %	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Transmission %	3.9%	3.8%	3.6%	3.5%	3.3%	3.2%	3.1%	3.0%
T&D %	18.9%	18.8%	18.6%	18.5%	18.3%	18.2%	18.1%	18.0%

Based on the T&D losses worked out for each year, energy requirement for the state has been calculated using the following:

Energy requirement = Forecasted Energy consumption / (1- T&D Loss %)

The next step involved calculation of the peak demand. A detailed analysis of the trend of load factor (which is the ratio between average energy consumption rate (average load) and peak energy consumption rate (peak load) over a specified period of time) was carried out and then extrapolated using trends to arrive at the anticipated load factor trajectory. Using the derived load factors and the electricity forecasted, the peak demand for the state arrived at provided the expected coincident peak demand on the system.

1.6. Forecast of Electricity consumption for the state of Rajasthan

Table 2: Summary of the electricity forecast at state level

Scenario	*FY 16 (Base Yr)*	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
UR - Tr	*57855*	65737	68146	72609	77453	82745	86783	91088	95563	100188	106261	111004	116090	120342	125662	131240	137916
Derived			*3.7%*	*6.5%*	*6.7%*	*6.8%*	*4.9%*	*5.0%*	*4.9%*	*4.8%*	*6.1%*	*4.5%*	*4.6%*	*3.7%*	*4.4%*	*4.4%*	*5.1%*
R - Tr		55383	57634	61931	66609	71720	75845	80265	84891	89706	96011	101052	106476	111024	116655	122604	129568
Derived			4.1%	7.5%	7.6%	7.7%	5.8%	5.8%	5.8%	5.7%	7.0%	5.3%	5.4%	4.3%	5.1%	5.1%	5.7%
UR - Eco	*57855*	65015	67673	72353	77301	82636	87935	93513	99186	105129	112577	118613	125202	131020	137930	144980	152578
Derived			*4.1%*	*6.9%*	*6.8%*	*6.9%*	*6.4%*	*6.3%*	*6.1%*	*6.0%*	*7.1%*	*5.4%*	*5.6%*	*4.6%*	*5.3%*	*5.1%*	*5.2%*
R - Eco		54906	57361	61849	66615	71763	76947	82472	88169	94188	101782	108036	114931	120997	128165	135542	143496
Derived			*4.5%*	*7.8%*	*7.7%*	*7.7%*	*7.2%*	*7.2%*	*6.9%*	*6.8%*	*8.1%*	*6.1%*	*6.4%*	*5.3%*	*5.9%*	*5.8%*	*5.9%*
HW		54942	57186	61197	65328	69667	74203	78936	83629	88473	94694	99521	104722	108939	114101	119318	124553
Derived			*4.1%*	*7.0%*	*6.8%*	*6.6%*	*6.5%*	*6.4%*	*5.9%*	*5.8%*	*7.0%*	*5.1%*	*5.2%*	*4.0%*	*4.7%*	*4.6%*	*4.4%*
CEA	*48017*	51971	55872	59573	63962	68648	73709	79184	85025	91399	98449	106051	-	-	-	-	138933
Derived			*7.5%*	*6.6%*	*7.4%*	*7.3%*	*7.4%*	*7.4%*	*7.4%*	*7.5%*	*7.7%*	*7.7%*					

Note:

- **Scenarios: UR** – Unrestricted electricity consumption in MUs, **R** – Restricted electricity consumption in MUs,
- **Methods: Tr** – Trend method, **Eco** – Econometric method, **HW** – HoltWinter's Method

- The % shown are YoY growth rates derived from the forecast results for comparison purpose only
- The base year demand for FY16 is higher than FY17 in some scenarios as data for FY16 is unrestricted demand that has been used to derived unrestricted forecast

Interpretation of forecast results

- The results developed using the forecast methodologies are inclusive of additional demand i.e. Open Access & Captive, Railways, Electric vehicles, expected infrastructure plans, Master Plan of cities, Latent demand, Housing schemes, Metro etc. While CEA in their study has also considered some of the additional demand, however state specific additions could not be determined separately from the results of 19th EPS.
- Higher demand in FY17 compared to CEA is due to baseline correction, actual demand from Open access, latent demand etc. that is not included in 19th EPS
- In the case of an unrestricted scenario forecast, the forecasted demand provides an estimate of the total consumer demand which may be incident on the system in case there is no unserved or unmet demand. In such a scenario, all consumers will be using electricity as per the potential and there is no demand, which is unserved due to any factors.
- In case of a restricted forecast, the forecasted demand provides an estimate of the consumer demand which will be incident on the system in case some consumers are still not electrified or required number of supply hours is not met for electrified consumers.
- Considering an example for econometric method, in the year FY17, the unrestricted forecast is 65015 MUs and restricted forecast is 54906 MUs. It implies that a demand of 10109 MUs (65015 – 54906) or 15.55% of unrestricted demand is not being served or met by the distribution utilities even though the demand existed. In FY 32, for the same method, a demand of 9082 MUs (152578 – 143496) or 6% of unrestricted demand will not be met. This also implies that an improvement in supply situation is envisaged thereby leading to improved meeting of consumer demand.
- Baseline correction has enabled forecasting of the unrestricted forecast, as otherwise only a restricted forecast would have been possible with the restricted historical data. The restricted forecast would only show that demand would increase from 54906 MUs in FY17 to 143496 MUs. With a restricted result, the total consumer demand cannot be inferred.
- Currently the planning for additional capacities is based on the demand forecasting results of EPS. Since the demand forecasting methodology adopted in EPS does not consider the baseline correction of historical data, the total consumer demand for future may not be captured fully since unmet, latent demand etc. are not considered currently. There may be variations between what is projected and the actuals which might occur. In a future scenario, electricity demand forecasting without baseline correction may lead to shortfall in reserve capacities. The shortfall will impact the reliability of supply to consumers in future. Therefore, adoption of alternate methodologies that can minimize such variations will lead to a better estimate and can then be used to plan for adequate reserves in the system. Planning of adequate reserves proactively would ensure that reliable and quality power may be supplied in future in line with Government's 24 x 7 Power for All (PFA) scheme.

Table 3: Summary of the electricity requirement at state level

Scenario MUs	*FY 16 (Base Yr)*	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
UR - Tr	84382	89223	89125	95528	100318	105543	109047	112788	118082	123548	130785	136371	142366	147331	153595	160163	168190
R - Tr		75169	75376	81479	86272	91480	95302	99387	104895	110622	118169	124144	130577	135924	142586	149624	158009
UR - Eco	84382	88242	88506	95191	100120	105404	110494	115792	122559	129641	138559	145718	153541	160404	168590	176932	186071
R - Eco		74522	75019	81372	86280	91535	96687	102120	108946	116148	125271	132724	140946	148134	156654	165414	174996
HW		74571	74791	80514	84614	88861	93240	97741	103335	109101	116548	122264	128426	133371	139464	145614	151893
CEA	69614	73222	76569	79485	83168	87051	91216	95782	101200	108808	117219	126290					161606

Table 4: Annual peak demand for the state

Scenario MW	*FY 16 (Base Yr)*	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Load Factor	0.70	0.702	0.704	0.706	0.708	0.711	0.713	0.715	0.717	0.719	0.721	0.723	0.726	0.728	0.73	0.732	0.734
UR - Tr	11415	14509	14452	15446	16175	16946	17459	18007	18800	19616	20707	21532	22385	23102	24019	24977	26158
R - Tr	11415	12224	12222	13175	13910	14688	15258	15868	16701	17563	18710	19601	20532	21314	22297	23334	24574
UR - Eco	11415	14349	14352	15392	16143	16923	17691	18487	19513	20583	21938	23008	24143	25152	26364	27592	28939
R - Eco	11415	12118	12165	13157	13911	14696	15480	16304	17346	18441	19834	20956	22162	23228	24497	25796	27216
HW	11415	12126	12128	13019	13643	14267	14928	15605	16452	17322	18453	19304	20194	20913	21809	22708	23623
CEA	10961	11535	12070	12540	13133	13761	14435	15176	16048	17282	18651	20131					26575

The forecast of electricity demand for the state and the derived peak demand was compared with the results of 19th EPS. A comparative table is given below:

Table 5: Comparison of forecast results w.r.t. 19th EPS for the state

	Electricity demand			Peak demand		
	FY22	FY27	FY32	FY22	FY27	FY32
UR - Tr	17.7%	4.7%	-0.7%	20.9%	7.0%	-1.6%
R - Tr	2.9%	-4.7%	-6.7%	5.7%	-2.6%	-7.5%
UR - Eco	19.3%	11.8%	9.8%	22.6%	14.3%	8.9%
R - Eco	4.4%	1.9%	3.3%	7.2%	4.1%	2.4%
HW	0.7%	-6.2%	-10.4%	3.4%	-4.1%	-11.1%

1.7. Functional strategies for supply side to meet the projected demand

The demand forecasted for the state will have to be met by a matching augmentation in supply, which also have to be built in adequate reserve capacity. The current tied up capacities to meet the electricity and peak demand requirement will need to be reviewed. The following summarizes in brief the functional strategies:

- Total generation capacity tied up for the state of Rajasthan has grown from 10,160 MW to 18,826 MW during the period from April 2012 to February 2017. As of FY17, 54% of the contracted capacity is coal based and electricity from coal is used to meet 72% of the requirements. Share of renewable energy is 29% based on installed capacity but meet 9% of the electricity requirement
- For evaluating the supply side, one scenario each from restricted and unrestricted demand were considered for evaluating the supply side options.

  Scenario 1: Demand derived from restricted condition – result using trend method

  Scenario 2: Demand derived from unrestricted condition – result using econometric method
- The expected demand to be met from open access, captive, railways and rooftop solar power plants was evaluated individually and subtracted from the total demand of the state. The evaluation of the supply side is focused on meeting net addressable demand to be met by the distribution utilities in the state.

  Net addressable electricity demand at consumer end to be met by distribution utilities

  = Total projected electricity demand – (electricity demand met by OA, Captive, Railways, rooftop solar)
- The net addressable electricity demand to be met by distribution utilities is given in the table below.

Table 6: Net addressable electricity demand (MUs) to be met by Distribution utilities

MUs	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Scenario 1 – R	50311	54162	58182	62499	67115	70525	74553	78749
Scenario 2 – UR	59943	64201	68604	73191	78031	82615	87801	93044

	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Scenario 1 – R	83089	88871	93332	98114	101948	106784	111845	117817
Scenario 2 – UR	98512	105437	110893	116840	121944	128059	134221	140827

The above addressable electricity consumption has been grossed up with the T&D losses to arrive at the electricity requirement at the state boundary before proceeding for supply side assessment.

- Similarly, the net peak demand to be addressed by the distribution utilities was also calculated and is given below:

Table 7: Net addressable peak demand (MW) to be met by Distribution Utilities

MW	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Scenario 1 – R	11399	11659	12569	13247	13949	14406	14956	15723
Scenario 2 – UR	13524	13789	14786	15480	16184	16839	17575	18535

	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Scenario 1 – R	16512	17579	18382	19217	19891	20753	21656	22746
Scenario 2 – UR	19532	20807	21789	22828	23729	24820	25914	27111

❖ Planning has been done as per the current policy direction wherein renewable capacity addition has been given impetus by the Government. All renewable sources have been considered as must run. Electricity scheduled from available/ new hydro and nuclear based stations have been considered before gas and coal based stations.

❖ For gas and coal, two scenarios have been considered

Planning scenario – Gas based stations has been accorded a higher priority than coal based stations to derive the additional coal capacities which will be required. For gas, the committed capacity additions upto FY22 as per final NEP'18 has been considered. Also, as per the results of the final NEP'18, there would be no capacity additions from FY22 onwards. Starting from FY17, a PLF of 21% has been considered which is expected to remain constant till FY32. In case availability of gas improves, the PLF is expected to go up.

Merit order scenario – In case merit order is considered, gas will be accorded the least priority. Since availability of gas is a concern, the unfilled load due to low PLF of gas based stations may have to met from additional coal based capacities in future.

❖ For meeting peak demand, only conventional generation sources (Coal, Gas, Hydro, Nuclear etc.) have been considered. The peaking availability, retirement of existing units due to age and new environmental norms etc., spinning reserve etc. have been considered as per data given in the final NEP'18. Historically, some capacity of wind also supports peak demand occasionally, but due to its inherent nature, sometimes it has led to additional strain on conventional sources. In Gujarat, sudden unexpected drop in wind generation was experienced in the month of December'17, mostly during the morning hours, a time during which the demand was increasing. Due to such drop in wind generation, the demand was met from coal and from available gas based stations at a higher rate. This led to an additional burden on the conventional stations and available gas stations.

❖ Capacity addition for all generation sources has been worked out based on realistic growth rates derived from actual historical data, existing capacity addition plans and after review of targets given. The electricity to be generated from the expected capacity additions for all the generation sources was used to meet the addressable demand. The balance electricity requirement has been used to derive the capacity of coal based thermal power plants. The net required capacity of coal-based plants has been worked out for meeting the electricity and peak demand across two study scenarios. However, going ahead, in future cost of storage will also be a determining factor. BNEF's lithium-ion battery price index has reported a fall from $1,000 per kWh in 2010 to $209 per kWh in 2017. As per analysis, in case the price falls to $90 per kWh, it is expected to be at par with current costs of coal-based stations operating at a base load condition with 60% PLF. Storage costs at $ 147 per kWh is expected to be at par in case of peak load at 25% PLF.

❖ From a current scenario wherein installed capacity of coal based power plants constitute 54% and 29% from renewables, by FY32 renewable energy capacity may constitute up to 55% and share of coal based capacity will be 31% and balance will be met from hydro, gas and nuclear based power stations.

❖ Coal will still be the dominant generation source in meeting the electricity demand of consumers. As of FY17, electricity from coal based plants contribute up to 72% of the total requirements and it is expected to decrease up to ~50% as of FY32.

- The supply side evaluation also assessed the various strategic scenarios for managing the daily load curve in the event of higher penetration of renewable energy. The scenarios looked into ramping, balancing and storage requirements under various base load condition.

- The study also highlighted the safe limit for integration of renewables in the state without storage up to FY22. The integration of renewables up to FY22 is possible in the state with more coordinated planning and higher export of renewable energy. The impact of storage in integration of renewable energy has been analyzed. While additional storage facilities may not be required for integration up to FY22, but post FY22, storage is expected to play a greater role in the integration.

- The study concludes by highlighting the need for capacity building at distribution utilities across technology, data management and processes.

I. Coal based capacities required to meet electricity consumption demand

Table 8: Summary of the expected cumulative capacity additions for various generation sources other than Coal

(MW)	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Wind	4124	4295	4650	5035	5452	5592	6055	6557	7100	7687	8324	9013	9759	10567	11442	12389
Solar	1194	1784	2358	3116	3519	4049	4657	5355	6159	7083	8145	9367	10772	12387	14246	16382
Biomass	102	120	138	158	178	198	227	261	300	345	396	455	523	600	690	792
Hydro	1931	2047	2171	2302	2441	2818	2988	3168	3359	3561	3776	4004	4245	4501	4772	5060
Nuclear	557	557	1257	1957	1957	1957	1957	1957	1957	1957	1957	1957	1957	1957	1957	1957
Gas	825	825	825	825	825	838	838	838	838	838	838	838	838	838	838	838

***Assumptions**:*

Wind: CUF of 22% as per the CERC Renewable Energy Sources Regulations 2017

Solar: CUF of 19% as per the CERC Renewable Energy Sources Regulations 2017

Biomass: Actual PLF for FY16 has been derived at 28% and it is expected to progressively increase YoY to 46% by FY32

Hydro: Actual PLF for the period FY13 to FY17 is in range of 30-33%. Similar trend has been considered for the forecast period

Nuclear: PLF has decreased from 75% in FY13 to 64% in FY17. A progressive YoY increase has been considered and is expected to reach a PLF of 75% in FY32

Gas: PLF has decreased from 29% in FY15 to 21% in FY17. A constant PLF of 21% has been considered from FY17 to FY32. Capacity additions for gas considered as per the final NEP'18 i.e. wherein no additional capacity is expected post FY22

Coal: Capacity derived by assuming a 70% PLF in FY17 and a progressive YoY increase of 0.75% considered from FY17 onwards

Table 9: Coal based capacity required to meet balance net addressable energy requirement of Discoms

(MW)	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Scenario 1 –R	7808	7870	7745	7344	7686	7700	7784	8016	8212	8610	8680	8723	8499	8354	8130	7953
Scenario 2 –UR	9940	9995	9948	9552	9890	10086	10342	10750	11134	11719	11945	12173	12149	12202	12141	12044

II. Coal based capacities required to meet peak demand

Table 10: Summary of the expected cumulative capacity additions for various generation sources other than Coal

(MW)	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Wind	4124	4295	4650	5035	5452	5592	6055	6557	7100	7687	8324	9013	9759	10567	11442	12389
Solar	1194	1784	2358	3116	3519	4049	4657	5355	6159	7083	8145	9367	10772	12387	14246	16382
Biomass	102	120	138	158	178	198	227	261	300	345	396	455	523	600	690	792
Hydro	1931	2047	2171	2302	2441	2818	2988	3168	3359	3561	3776	4004	4245	4501	4772	5060
Nuclear	557	557	1257	1957	1957	1957	1957	1957	1957	1957	1957	1957	1957	1957	1957	1957
Gas	825	825	825	825	825	838	838	838	838	838	838	838	838	838	838	838

***Assumption**:* The PLFs of generation sources considered for meeting the peak demand is given in the table below:

Table 11: Availability from sources other than coal for meeting the peak demand

%	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Wind	11%	11%	11%	11%	11%	12%	12%	12%	12%	12%	12%	12%	12%	13%	13%	13%
Solar	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Biomass	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Hydro	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Nuclear	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Gas	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%

The net peak demand to be met by other generation sources is given in the following table:

Table 12: Share of addressable peak demand to be met by other generation sources

MW	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Wind	454	477	522	571	624	646	707	773	846	925	1011	1106	1210	1323	1447	1582
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	51	60	69	79	89	99	114	131	150	173	198	228	262	300	345	396
Hydro	1545	1638	1737	1842	1953	2254	2390	2534	2687	2849	3021	3203	3396	3601	3818	4048
Nuclear	446	446	1006	1566	1566	1566	1566	1566	1566	1566	1566	1566	1566	1566	1566	1566
Gas	173	176	179	181	184	187	190	193	196	199	202	206	209	212	215	219
Total	2669	2794	3507	4231	4405	4741	4953	5180	5425	5689	5972	6279	6610	6966	7352	7768

The balance of the addressable peak demand (of Distribution utilities) is to be met by coal capacities. The projected coal capacities shall meet the balance electricity demand to be met by coal at the derived PLFs, which is also given in the table below:

Table 13: Coal capacity required to meet addressable peak demand (without considering peaking availability)

MW	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Scenario 1 – R	8730	8865	9062	9016	9544	9665	10003	10543	11087	11890	12410	12938	13281	13787	14304	14978
Derived PLF	63%	63%	61%	58%	58%	58%	57%	56%	55%	54%	53%	51%	49%	47%	44%	42%
Scenario 2 –UR	10855	10995	11279	11249	11779	12098	12622	13355	14107	15118	15817	16549	17119	17854	18562	19343
Derived PLF	64%	64%	63%	61%	61%	61%	60%	59%	59%	58%	57%	56%	54%	53%	51%	49%

In case 85% peaking availability (as per Final NEP'18) is also considered in the above, the derived coal capacity is given below:

MW	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Scenario 1 – R	10271	10429	10661	10607	11228	11371	11768	12404	13044	13989	14600	15221	15624	16220	16828	17622
Derived PLF	53%	53%	52%	50%	49%	49%	48%	48%	47%	46%	45%	44%	42%	40%	38%	35%
Scenario 2 –UR	12771	12935	13269	13235	13857	14233	14849	15712	16597	17786	18608	19470	20140	21005	21838	22757
Derived PLF	54%	54%	53%	52%	51%	51%	51%	50%	50%	49%	48%	48%	46%	45%	43%	41%

In such a scenario wherein the PLFs are below 55%, there is a need to explore other peaking power sources than depending on coal based capacities only to meet the peak demand.

Based on the above results, the coal capacity required to meet peak demand, being the higher capacity, has been considered as the final capacity required for the state.

MW	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30	FY 31	FY 32
Tied up capacity	10226	10905	12291	12357	12857	12007	12007	12007	12007	12007	11604	11974	12082	12323	12527	12825
(Deficit)/ Excess of coal capacities																
Scenario 1 – R	-45	476	1630	1750	1629	636	239	-397	-1037	-1982	-2996	-3247	-3542	-3897	-4301	-4797
Scenario 2 –UR	-2545	-2030	-978	-878	-1000	-2226	-2842	-3705	-4590	-5779	-7004	-7496	-8058	-8682	-9311	-9932

The present planning of tied up capacities for the state is based on non-consideration of baseline correction. In view of the same, a gap in supply side requirement is observed. Over the forecast period, the gap is increasing and will impact the planning of reserve capacities in the state. The shortage of tied up capacities will also impact the reliability of power supply in the state in the long term. Going ahead, all demand forecasting exercises should incorporate baseline correction of data in order to address the gap in capacities while planning the supply side generation sources.

1.8. Data challenges

The study involved extensive use of data that were accessed from various sources. However, challenges were encountered while accessing and using data. Summary of challenges are highlighted below:

1. Historical data from utilities

- The utilities do not have any formal process through which data for the required period could be accessed for conducting the study. There is no designated office responsible for providing data for such a study.
- There was apprehension in sharing of data for the study. Concerns regarding usage of the data/ purpose was raised at various levels.
- Required data (sales, consumers etc.) was not available for a longer duration for all the three utilities in the state. Hence, a common period of ten years had to be considered.
- Data is not maintained in standard/common formats. Every utility has its own format(s) of reporting and data storage. This makes use of data analytics difficult.

2. Challenges at feeder level data

- Supply hour data at feeder level was available only for few selected feeders and in limited circles
- Historical supply hour data at feeder level was not available. Hence, suitable assumptions had to be built in for undertaking baseline correction for the historical period.
- Feeder level data had interruption counts of supply and doesn't directly provide gap in supply hours for consumer categories
- Category (industry/ agriculture etc.) and area wise (urban/ rural) segregation of feeders was not present. Hence details of supply hour gaps in specific categories could not be worked out.
- Since installed feeders were also of varied make and models even in the same utility, the outputs provided were varied. In few feeders, OEM software was required to access data.

3. Challenges in application of forecasting methodology

- Challenge in accessing data for independent variables at a granular level e.g. District/ circle.
- Data pertaining to disposable income, historical weather parameters at granular level not available.
- No definite source for accessing data for estimating power demand from infrastructure projects or HT Industries. In most of the Government offices, there is no designated authority responsible for storage and upkeep of data pertaining to future projects in the state.
- Challenges were encountered in receiving responses for surveys and during data collection from HT industries and bulk consumers.
- No conclusive study could be found to establish the effect of energy efficiency. Various studies projected different efficiency potentials and scenarios.
- T&D loss data available at a state level. Segregated data pertaining to technical losses due to theft, faulty reading etc. are not maintained.
- Data for load factor and diversity factor is available only at a yearly average level for the state/ region.

1.9. Recommendations

Based on the present study, following are the recommended actions:

1. **Changes at Policy/ regulatory level**

   Insufficient/ lack of authentic data is the weakest link for any forecasting study. There are no standard formats available for capturing of data by the Utilities. The issue may be taken up at policy level viz. CEA/ Electricity Regulators may propose data recording by Utilities in standard formats.

   Suggested data formats have been appended below.

2. **Establishment of designated authority for data management**

   Establishment of designated authority (e.g. MIS cell) for managing data is required at Discom/ STU level. Such authority shall record and maintain data in standard formats and also should be responsible for periodic updating of the data. It should be the single point of contact for third parties to access data. A governance structure should be in place, which will be responsible for according approvals post validation checks. This will enable better accessibility of required data and also remove data concerns which are currently being experienced at various levels.

3. **Increased granularity of forecasts**

   Presently, forecasts are majorly carried out at the Utility or State level. The granularity of the forecasts needs to be increased by conducting demand forecasting at district level or below (like divisional/sub divisional level) for better understanding of the behavior and trends and for higher accuracy and use of the results. Study at a more granular level would be possible only with availability of data at such levels.

4. **Periodicity of forecasts to be increased to shorter duration**

   Currently demand forecasting is carried out after a period of 5 to 10 years. The exercise needs to be undertaken at shorter period e.g. yearly, to take into account changes in the factors affecting demand. There should also be a periodic review and updating of the forecasted demand.

5. **Use of advanced methods**

   It is recommended that use of advanced statistical methods should be encouraged. In a recent meet of the Hon'ble Minister for Power with the Regulators and State Discoms, it was mentioned that the Discoms should be mandated to deploy advanced statistical tools for undertaking demand forecasting and power procurement planning exercises, the funding of which may be availed from the PSDF fund.

6. **Shift towards technological/ Data and Analytics platforms**

   The idea of undertaking demand forecasting is to effectively plan for infrastructure and capex, optimize costs, understand future requirements and plan for power procurement. In a scenario, wherein the future demand will involve interplay for many factors, it is important that forecasting should be undertaken in technology enabled solutions e.g. forecasting software that is more dynamic and responsive to changes. Such a transition will also help in improved dash boarding of results.

7. **Pilot studies for assessing latent demand**

   It is recommended that pilot studies may be conducted to understand the factors affecting latent demand across consumer categories.

8. **Use of the alternate methodology in other states**

   The proposed alternate methodology has been implemented only on the selected state. Enabling capturing of required data in standard templates can prepare replicable model for baseline correction.

9. Use of baseline correction to undertake forecasts for Rajasthan

It is recommended that while conducting supply side planning for tying up generation capacities, a baseline correction based approach should be followed in order to minimize the gaps between the actual demand and required tied up capacities.

Sample data formats

1. **Format for capturing daily disruption in supply hours at circle/sub-division level.**
   Data source: SE (Meters) or department that is responsible for Metering, Testing and Issuance of meters in Utilities

   The data accessed for the present study for supply hours had either disruption counts or average disruption in a feeder per day. There was no mention of categories served to, whether disruption was in peak or-non peak hours and the reason of failure was not specified. Hence, the same have been added to the suggested format, so that complete data can be captured for analysis.

   Existing format

Circle Name	Sub-division name	Feeder name	Date 1	Date 2	Date 3	Date 4	Date 5

   Suggested format – data to be captured for each day

Date	Circle/ Sub-division Name	Feeder name	Feeder level	Urban/ Rural	Consumer category to which it is tagged	Feeder Switch Off time	Feeder load before interruption/ Last recorded hourly value of load	Feeder Switch On time	Feeder load after restoration/ interruption	Supply disruption (in minutes) Peak	Supply disruption (in minutes) Non Peak	Reason of Failure. Data sheet should have options to select/ capture reasons 1. DT Failure 2. Feeder breakdown 3. Scheduled load shedding 4. Capacity constraint 5. Others

2. **Sales/ Connected load/ Number of consumers at Circle level/ Sub-division level to be captured for each month**
   Data source: Respective Circles/ Commercial department
   Data is captured in the given format presently. Existing format can be continued to capture data.

Existing/ Suggested format

Consumer Categories	Urban/ Rural	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar

3. **Load factor – to be captured at granular level wherever possible**
   Data source: State SLDC
   Load factor data pertaining to consumer categories across months are not available. The data accessibility should be provided in case such data was already captured.

Suggested format to capture load factor

Consumer Categories	Urban/ Rural	Average Supply duration (Hr)	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Domestic			0.71	0.75	0.69									
Industry			0.30	0.32	0.33									

4. **Details of Open Access and Captive consumers (Load in MW, Electricity in MUs to be captured)**
Source: Commercial department of Utilities, Energy Department
Data for open access across months are maintained in given format. Data for captive power plants should also be captured on a monthly basis in given format.

Existing format for OA. To be used for Captive consumers also

Details of Captive consumer	Feeder level (33kV/ 11kV)	Load	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar
M/s ABC														
M/s DEF														

5. **Format for new Connections added per month for all categories – Domestic, Commercial, HT/ bulk consumer (Industries, SEZ, Government establishments, Housing complexes etc.)**
Source: HT Billing, Metering department, Energy department
Data in suggested format should be made available across portals. Currently there is no specific format available.

Suggested format

Circle	Sub-division	Connection applied in Month/ Year	Name of Consumer	Contract Demand	Supply Voltage	Expected Month/ Year of load	Connection approved/ released (Yes/ No)

6. **Monthly details of Agriculture connections released/ Solar pumps etc. installed**

Source: Commercial Department, Energy department

The data pertaining to number of connections are captured along with average load of pumps. Detailed list of connections in suggested format should be captured for record of the utilities/ Government.

Suggested format

Circle	Sub-division	Agriculture Connection issued	Name and details	Contract Demand	Supply Voltage	Capacity of pump (solar, non-solar etc.)

7. **Monthly/ Quarterly data for Independent variables – Data at District/ Circle level**

Source: Government Planning Department, Economics and Statistics department

Yearly data of variables are available at a State level. In case it is captured on a monthly/ quarterly basis at a more granular level, it can be utilized for monthly forecasts.

Suggested format

Independent variables	State/ District	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Population													
Per capita income													
Disposable income													
Consumers													
WPI/CPI													
Wages													