WORLD ENERGY COUNCIL
INDIA

# Alternate Methodology for Electricity Demand Assessment and Forecasting

World Energy Council India

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# Abbreviations

| Abbreviation | Full form |
|---|---|
| BNEF | Bloomberg New Energy Finance |
| CAGR | Compounded Annual Growth Rate |
| CEA | Central Electricity Authority |
| DISCOM | Distribution company/utility |
| DSM | Demand side management |
| EE | Energy Efficiency |
| EV | Electric Vehicle |
| EVSE | Electric Vehicle Supply equipment |
| FAME | Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles |
| GDP | Gross Domestic Product |
| GSDP | Gross State Domestic Product |
| GoI | Government of India |
| GW | Gigawatt |
| HW | Holt-Winters |
| kWh | Kilo Watt hour |
| IESS | India energy security scenarios |
| IRENA | International Renewable Energy Agency |
| MoP | Ministry of Power |
| MNRE | Ministry of New and Renewable Energy |
| MTce | Metric Tons of coal equivalent |
| MU | Million Units |
| MW | Mega Watt |
| NEP | National Energy Policy |
| NITI | National Institution for Transforming India |
| PEUM | Partial end use methodology |
| PFA | Power For All |
| PSU | Public Sector Undertaking |
| RE | Renewable energy |
| RPO | Renewable energy obligation |
| SEC | Specific energy consumption |
| WEC | World Energy Council |

# 1. 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.

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.

> **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 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 18th 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 19th EPS, released in January 2017, has also highlighted the difference and scaled down the energy forecasts for 19th 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.

The following chapters cover in details the scope and each of the objectives.

# 2. Review of forecasting methodologies of major sectors in India

## 2.1. Coal

### 2.1.1. Introduction

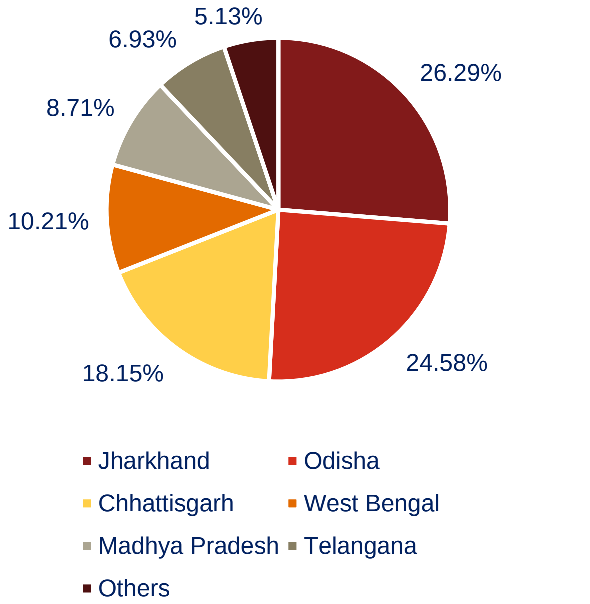
India is the third largest coal producer in the world after China and the USA. The total coal production in India was around 612 million tons (MT) in FY 2015, which increased to 626 MT in FY 2016. Ninety per cent (90%) of the domestic production comes from public sector coal producers with only ten percent (10%) being produced by the private sector. India imported a total of 212 MT of coal in FY 2015 and 193 MT in FY 2016, which is equivalent to ~ 30% of the domestic coal requirement in the country based on tonnage.

The total coal demand in the country was expected to be around 1.2–1.5 billion tons (BT) by 2020 as per various estimates by the government and independent agencies. Considering this, the Ministry of Coal (MoC) had earlier set up a target of more than doubling the coal production in the country to reach a production level of 1.5 BT by FY 2020. The government aimed to increase coal production of Coal India Limited (CIL) to a level of 1 BT by FY 2020, while the balance production was to be met by the private, state and central sector PSUs. However, due to weak demand from thermal power plants and with a net surplus power situation in the country, the Government, in the current FY 2017-18, reduced the production target of CIL from 660 MT to 600 MT. With the policy push for more renewables, the projections in the shorter term are expected to be affected.

Indian coal sector faces a mismatch between the location of coal reserves and mines. While the reserves are concentrated in eastern and central India, the high-demand centers are in the northwest, west and south. Only around 14% of installed capacity is located in the eastern region where coal production is concentrated. The states with high coal availability which account for 95% of coal reserves are

- Jharkhand
- Odisha
- Chhattisgarh
- West Bengal,
- Madhya Pradesh
- Telangana

**Figure 1: Estimate reserves of coal as on March 2017. Total 308.8 BT**




Since the high-demand centers are not in close vicinity of coal reserves, a tons of coal has to travel on average more than 500 km before it is converted to electricity, straining the country's rail network and leading to transit losses. Also, for a number of thermal power stations in India, coal transportation requires last mile connectivity by road, thereby increasing the overall costs.

## 2.1.2. Demand projection of Coal

Coal contributes over half of India's primary commercial energy. Though the share of renewable energy is gradually expected to increase in the coming years, coal is likely to remain as India's most important source of energy mainly due to country's large thermal power capacity and coal's negligible price volatility.

Methodology and demand projection of coal done by various bodies is presented below:

### 2.1.2.1. Draft National Electricity Plan 2016: CEA

The projections provided in the draft National Electricity Plan (NEP), released in December 2016, are based on the draft 19th EPS. The methodology and projections given here are as per the draft NEP 2016. Upon finalization, the methodology and projections might be modified in the future.

#### 2.1.2.1.1. Methodology

CEA carried out the assessment based on the power requirement of States/UTs considering the past growth rates and the increase in electrical energy requirement on account of Power for All, Make in India initiatives, reduction in demand on account of DSM and various efficiency improvement measures being under taken by the Government. The total electricity requirement on All India basis was worked out accordingly.

For the year 2016-17, coal based generation programme of 921 BU was estimated in consultation with the power utilities (estimated growth of 6.9%). The total coal requirement of 600 MT for the power plants has been estimated considering normal monsoon year during the year 2016-17.

With the provisional demand projections and likely Renewable Energy Sources (RES) capacity addition, the coal based generation has been estimated and accordingly provisional coal requirement has been worked out.

The assumptions considered are given as follows:

- The likely capacity addition of RES has been considered in three cases viz.,

**Table 1: Likely capacity addition of RES**

| Case I | Case II | Case III |
|---|---|---|
| 115,326 MW | 90,326 MW | 65,326 MW by the terminal year 2021-22 |

- With the above estimate, the total capacity of RES will be 175 GW in Case-I, 150 GW in Case-II and 125 GW in Case-III respectively by 2021-22
- Coal requirement for the year 2021-22 have been worked out considering 30% reduction in Hydro generation due to failure of monsoon and being supplemented by coal based generation
- During 2026-27, the total capacity of RES has been estimated to be 275 GW capacity, considering 175 GW of total capacity at the end of the year 2021-22 and 100 GW capacity addition of RES during FY2022-27.
- Adequate coal is expected to be available for the coal based power plants during 2021-22 and 2026-27

#### 2.1.2.1.2. Projections

Given the above methodology and assumptions, the coal requirement in the year 2021-22 and 2026-27 have been estimated by CEA as follows:

**Table 2: Estimated Coal requirement in the year 2021-22 and 2026-27[1]**

| Particulars | 2021-2022 | | | 2026-27 |
|---|---|---|---|---|
| **Renewable Scenarios** | **RES: 175 GW** | **RES: 150 GW** | **RES: 125 GW** | **RES: 275 GW** |
| Total coal based generation (BU) | 1074.4 | 1127.4 | 1177.5 | 1331.5 |
| Total coal Requirement (MT) | 727 | 763 | 797 | 901 |
| Imports by plants designed on imported coal (MT) | 50 | 50 | 50 | 50 |
| Domestic Coal Requirement (MT) | 677 | 713 | 747 | 851 |

With CIL production target of one BT by 2019-20, it is expected that there would be no shortage in the availability of coal for the power plants during 2021-22 and 2026-27. In addition, coal production from the captive coal blocks allotted to power utilities would also supplement the availability of domestic coal.

The estimated coal requirement developed by CEA as provided above is more of a top down approach. The aggregation of coal demand by considering individual sectors in which coal is being used is not available for the present projections. Historically, from the period FY06 to FY16, 64-68% of the total raw coal is used by power utilities and 6-10% of the total raw coal by captive power producers. Assuming similar scenario continues for the next decade also, coal will be required to meet the major power requirements of the country.

## 2.1.2.2. NITI Aayog

NITI Aayog's model consists of two projections viz.

- Projections from Demand side: Coal demand based on input demand from Power plants and Industries
- Projections from Supply side: Coal demand to be met by domestic production and imports

### 2.1.2.2.1. Demand side Projections

The assumption considered is that coal demand is based on aggregate of (i) input coal demand from coal power stations and (ii) Industries.

### (i) Methodology for input based demand projections

The general assumptions while deriving various scenarios/levels are as follows:

- The capacities mentioned include utility and captive power plants fired by coal or lignite, though a lower PLF is assumed for as utilization will be less
- Captive power plants do not use efficient technologies as they are mostly small sized while newer technologies (e.g. supercritical technology) need larger capacities
- The energy generation and coal requirement computed for different capacity addition trajectories also depend on efficiencies of coal-fired thermal power plants

NITI Aayog's model has four scenarios:

**Level 1: Least effort scenario**

- Coal based power generation is discouraged due to increasing fuel prices, import dependence, pressure to reduce carbon emissions, reducing prices of renewable energy etc.

[1] Draft National Electricity Plan December 2016

- PLF of power plants remains 73% up to 2032 and improves to 74% in 2047

**Level 2: Determined effort scenario**

- Installed capacity will grow rapidly to 297 GW in 2027, and then grow slowly to 333 GW in 2047 due to increasing coal prices, increasing import dependence and increasing pressures to reduce emissions.
- PLF is assumed to improve to 75% for next two decades and to 76% by 2047

**Level 3: Aggressive effort scenario**

- Level 3 assumes a coal-fired capacity addition slightly lower than 8% GDP growth scenario. The growth rate of capacity addition is assumed to reduce subsequently.
- Current PLF will improve to 77% for next two decades and to 78% in 2047

**Level 4: Heroic effort scenario**

- It assumes a coal-fired capacity addition slightly lower than 9% GDP growth scenario.
- The growth rate of capacity addition is assumed to reduce subsequently.
- Installed capacity will grow to 591 GW in the next 35 years i.e. by 2047 due to improved domestic coal supply, softening of imported coal prices and availability of more carbon space to countries like India.
- Current PLF will improve to 79% for next two decades and to 80% in 2047

### Projections on Coal requirement from Power Stations

As per the methodology adopted and defined scenarios, the demand projection of coal from coal based power station based on different levels is shown in the table below

**Table 3: Coal requirement by Coal Power Stations (MTce)**

| Scenario | 2012 | 2017 | 2022 | 2027 | 2032 | 2037 | 2042 | 2047 |
|---|---|---|---|---|---|---|---|---|
| Level 1 | 464 | 640 | 776 | 849 | 888 | 883 | 855 | 822 |
| Level 2 | 464 | 668 | 863 | 989 | 1032 | 1067 | 1070 | 1059 |
| Level 3 | 464 | 687 | 911 | 1091 | 1239 | 1373 | 1440 | 1446 |
| Level 4 | 464 | 744 | 1039 | 1304 | 1522 | 1699 | 1796 | 1855 |

## (ii) Methodology for assessing aggregated demand projections from Industries

Seven major energy consuming industry sub-sectors have been analyzed to estimate the energy use in each sub-sector to understand the aggregated demand of coal from industry under different trajectories.

| | | | |
|---|---|---|---|
| Aluminum | Cement | Chemicals | Fertilizer |
| Iron and Steel | Pulp and Paper | Textiles | Others |

The general assumption considered is that over the years, the energy intensity of the industry sector has been reducing as several of the units across sectors have moved to processes that are more efficient. The improvement in Energy Efficiency (EE) has been considered as a major driver for reduction in the Specific Energy Consumption (SEC) of industry.

The brief about the four scenarios considered as given in the following

**Level 1: Least effort scenario**

- This trajectory assumes that there will be no new major government policies for EE. The autonomous EE penetration levels are also low
- The efficiency of the units undergoes marginal reduction/revision by end of the terminal year (2047)
- The efficiency of some sub-sector units improves at 5-15% of the efficiency improvement for the units that opt for EE
- The "Others" undergo reduction in energy intensity by a CAGR of ~4%

**Level 2: Determined effort scenario**

- This level includes a gradual enhancement of penetration of EE in Industry
- Industrial units opting for EE would achieve the best efficiency possible in every sub sector
- The units not opting for EE also improve their efficiency, but by a much lesser degree
- The "Others" undergo a reduction in intensity of about 4-5% CAGR

**Level 3: Aggressive effort scenario**

- Building on Level 2, this scenario further increases the EE penetration
- The units not opting for EE increase their efficiency across processes at a rate of 20-30% of the efficiency improvement by units that opt for EE.
- The "Others" undergo an efficiency improvement of about 4-5% CAGR

**Level 4: Heroic effort scenario**

- Indicates the maximum possible improvement that can be achieved in the sector
- This level further increases EE penetration
- In addition, this level assumes that the units not taking up EE undergo an efficiency increase of between 20-50% of the units that opt for EE
- The "Others" improve their intensity by about 5-6% CAGR

## Projections on Coal requirement from Industries

As per the methodology adopted and defined scenarios, the projection for coal in order to meet the demand from industries shown in the table below

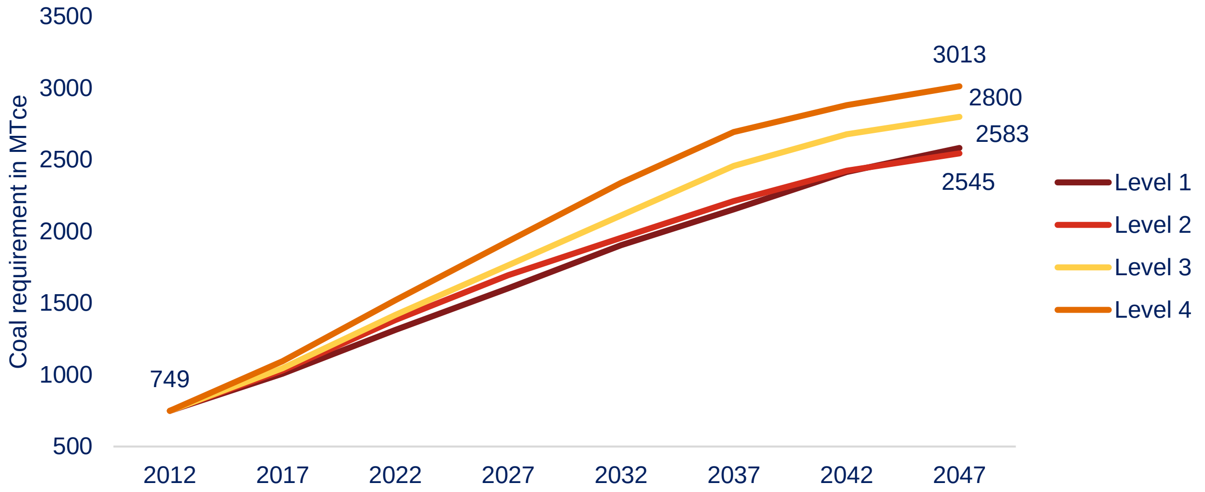
**Table 4: Coal requirement by Industries (MTce)**

| Scenario | 2012 | 2017 | 2022 | 2027 | 2032 | 2037 | 2042 | 2047 |
|---|---|---|---|---|---|---|---|---|
| Level 1 | 285 | 368 | 538 | 754 | 1017 | 1272 | 1561 | 1761 |
| Level 2 | 285 | 363 | 520 | 705 | 925 | 1145 | 1354 | 1486 |
| Level 3 | 285 | 358 | 507 | 674 | 874 | 1084 | 1239 | 1354 |
| Level 4 | 285 | 351 | 481 | 628 | 817 | 996 | 1085 | 1158 |

## Total demand projections of Coal

The total coal demand based on demand from power station and industries is summarized in the graph below. The graph captures the variation in the coal demand based on the four scenario, which were defined.

**Figure 2: Coal requirement based on demand from power stations and industries**




## 2.1.2.2.2. Supply side Projections

NITI Aayog has forecasted coal production till 2047 considering four different scenarios from the supply side. The assumptions are based on domestic supply potential and the balance to be met from imports.

### Methodology

The assumptions while deriving these scenarios/levels are as follows:

- Coal is intended to mean both coal as well as lignite.
- The average life of a mine is 30 years.
- The current mine ability (ratio of India's techno-economically extractable reserves to prove reserves) of Indian mines is 34.6%.
- Maximum coal reserves percentage to be mined by underground coal mining is limited to 12.3% of total proved reserves.
- This is based on assumption that coal reserves up to 300 m will be mined by opencast (OC) method, half of reserves between 300 – 600 m depth would be mined by opencast and underground (UG) method each, and reserves deeper than 600 m will be mined by underground mining.
- Collieries own coal consumption= 0.08% of their coal production.
- Remaining coal production will be considered as net coal production.

The following provides a brief about the assumptions considered under the four scenarios:

**Level 1: Least effort scenario**

- Level 1 assumes that only the currently operating, on-going and planned coal mining projects by CIL (437 million tons per annum (MTPA)) and SCCL (41 MTPA) and currently allocated captive blocks (43 billion ton geological reserves) will come online.
- Production from current (non-captive) mines will reduce by 17% every 5 years (consistent with mine life of 30 years) due to closure of mines.
- Production from captive blocks will start reducing from 2027 onwards as most of the currently producing captive blocks are new. Coal reserves and mine ability of all reserves will remain at present values.

- In this scenario, coal production gradually increases from 582 MTPA in 2011-12 to peak of 866 MTPA in 2037 and then it will start declining and reach 540 MTPA in 2047.
- About 85% of the mineable coal reserves will have been extracted by 2047 in this scenario as no new reserves are added and there is no improvement in mine ability.
- In addition, only OC mining, which is easier and cheaper, will be encouraged whereas the UG mining will be discouraged. So, the UG % will reduce from current of about 9% to 6.4% in 2047

**Level 2: Determined effort scenario**

- Level 2 projections are consistent with realistic (business as usual) projected scenario based the 12th Five Year Plan until 2022.
- Given that the production for 2012-13 fell about 18 million tons short of the target of 575 million tons, it assume that the total shortfall from the target in 2017 would be 50 million tons. This results in an annual production increase of about 5% per annum up to 2017, and about 4% up to 2022.
- Proved coal reserves will grow at a reduced pace of 1% p.a. as most of the prognosticated coal bearing area (75%) has been explored. There would be some improvement in mine ability due to technological improvement.
- In this scenario, coal production will grow to a peak at 1191 MTPA in 2037 and decline marginally by 2047 to 1157 MTPA.
- About 62% of mineable coal reserves would have been extracted by 2047. OC mining will be encouraged but UG mining will not be paid much attention. Therefore, UG mining's percentage will increase just slightly from current 9% to 9.3% in 2047.

**Level 3: Aggressive effort scenario**

- Level 3 is consistent with the optimistic scenario projections until 2022 in the 12th Five Year Plan, tempered by slower-than-expected increase in production. The rate of increase of production reduces slightly going forward.
- Proved coal reserves will grow at about 1.3% p.a. and there would be further improvement in mine ability. With these positive conditions for coal based energy supply, coal production will be 1400 MTPA in 2047.
- About 55% of mineable coal reserves would have been extracted by 2047. UG mining will also be encouraged progressively to tap deeper coal reserves and its share will increase to 10.7% in 2047.

**Level 4: Heroic effort scenario**

- Level 4 is the most optimistic, assuming full encouragement for coal based energy supply.
- Proved coal reserves will grow at 1.5% p.a., production will reach about 1400 MTPA in 2032 as anticipated in the Integrated Energy Policy document, and mine ability will increase better than in other levels. In this scenario, coal production will increase to about 1608 MTPA in 2047, almost consistent with the high-case scenario of global coal production as per Global Coal Production Outlook.
- In this scenario, about 48% of mineable coal reserves would have been extracted by 2047. UG mining will be emphasized significantly along with technological advancements but its share will remain confined to 12.3% in 2047 due to geological constraints.

## Projections

The table below shows the coal production up to the year 2047 as per the four scenarios which were developed

**Table 5: Coal production projections (MT)**

| Scenario | 2012 | 2017 | 2022 | 2027 | 2032 | 2037 | 2042 | 2047 |
|---|---|---|---|---|---|---|---|---|
| Level 1 | 578 | 692 | 766 | 799 | 793 | 779 | 672 | 540 |
| Level 2 | 578 | 719 | 893 | 1034 | 1128 | 1169 | 1175 | 1157 |
| Level 3 | 578 | 766 | 1014 | 1169 | 1283 | 1350 | 1377 | 1400 |
| Level 4 | 578 | 786 | 1048 | 1236 | 1384 | 1498 | 1551 | 1608 |

## Coal Imports

Total import requirements for coal would also depend on how demand from other sectors such as iron and steel and cement changes over time.

75% of domestically produced coal continues to be used for power generation as currently done, coal import requirements from the power sector in 2047 range between 260 MTPA (if coal production and coal-based capacity addition follow a determined path) and 660 MTPA (if coal production and coal-based capacity addition follow a heroic path) even if a heroic effort scenario of technology adoption requiring least coal plays out.

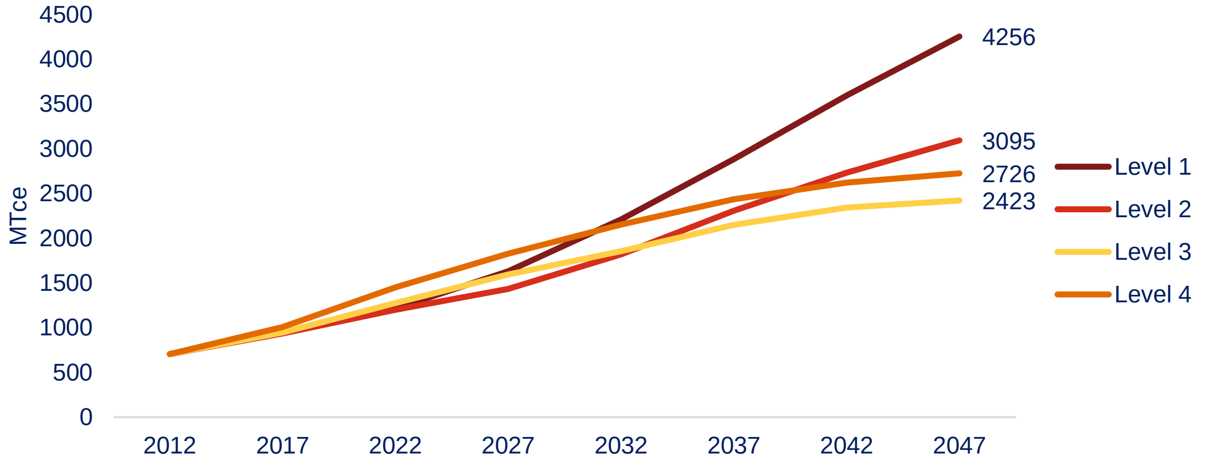
**Table 6: Projections for Coal Imports as per the scenarios (MT)**

| Scenario | 2012 | 2017 | 2022 | 2027 | 2032 | 2037 | 2042 | 2047 |
|---|---|---|---|---|---|---|---|---|
| Level 1 | 124 | 261 | 450 | 828 | 1417 | 2094 | 2943 | 3716 |
| Level 2 | 124 | 204 | 296 | 384 | 666 | 1117 | 1544 | 1938 |
| Level 3 | 124 | 165 | 270 | 411 | 561 | 787 | 943 | 1023 |
| Level 4 | 124 | 207 | 400 | 588 | 752 | 927 | 1058 | 1118 |

## Supply side total projections

Total supply side demand projection based on summation of coal production and import is presented below:

**Figure 3: Total supply side projections**




Coal has always been the primary source of energy for the country and as per estimates the share of coal in India's primary energy supply was between 45-50% and is expected to have significant share in the years to come.

Since the major requirement of coal will be from power plants and currently the thermal plants running at a lower PLF of ~ 57% as on June 2017 at an all India level. With demand for elecrtcity set to increase, the requirements will have to be met from coal only. Even though no new coal based plants may be approved for the next ten years, but post 2027, there is likelihood of capacity addition which is likely to translate into a coal demand of 1.1-1.4 billion tonnes. With the domestic production scenario projected to plateau out for level 2 and level 3 scenarios post 2030, the additions post 2027 will require some amount of import dependence for the country.

## 2.1.3. Summary

- The coal projections given in the section above are based on methodologies developed by CEA and NITI Aayog.
- The projections developed by CEA in the Draft NEP up to FY 2026-27 are predominantly 'Top Down' projections and have been worked out based on an historical growth rate and considering possible scenarios of renewable capacity addition. The aggregation of the demand from individual demand sectors has not been projected.
- The projections developed by NITI Aayog are from the coal demand and supply side up to the year 2047. The projections have been developed considering four scenarios.
    - For the demand side projections, the total aggregated demand has been worked out by considering the demand from Power sector and from eight major Industrial sector wherein coal is required.
    - The supply side projections has been worked out by estimating the coal production from the domestic sector and the balance to be met from imports.
- Historically, between 60%-70% of the raw coal is being consumed by the power sector and the balance is the demand from the Industrial sector. Going ahead, the share is expected to come down Y0Y but will remain as the major power source in the next two decades.

# 2.2. Renewable Energy

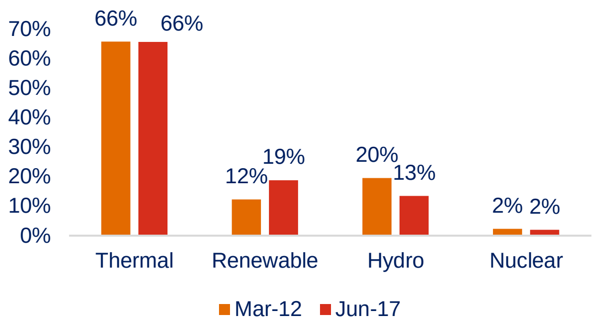
## 2.2.1. Introduction

Demand for renewable sources of energy has witnessed growth in the recent past. Some of the factors, which supported the penetration of the renewables, are policy focus, reducing costs of the sector and environmental considerations.

The following figure highlights the growing share of renewables in the generation capacity in the country.

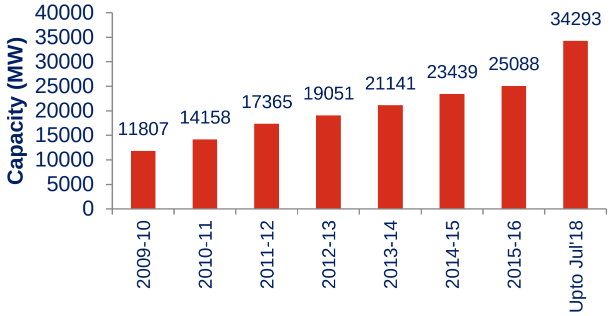
- In a period of five years, the total installed renewable capacity of renewables has more than doubled from 24.5 GW in March 2013 to about 70.6 GW in July 2018.
- While the percentage contribution from thermal has remained constant, the shift has majorly been due to decrease in capacity additions from the Hydro sector.

Figure 4: Share of installed capacity



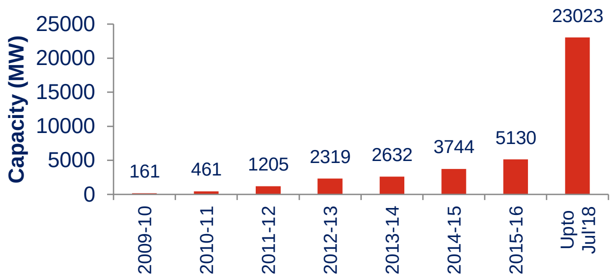

The renewable energy sector is traditionally led by the wind power sector followed by solar. However, over the recent period, the trend has shifted towards solar with solar capacities leaping from ~5 GW to 17 GW in a period of 1-2 years due to policy and reform push from the government and with falling prices of the solar panels. Wind on the other hand has maintained more of a steady growth over the years though the installation has picked up in the period from FY 16 to FY 17.

Figure 5: Installed capacity - Wind




Conducive policy and regulatory framework at the Central as well as State Government level is further aiding in driving demand for renewable energy in the country. Renewable Purchase Obligations (RPO) have been mandated upon the Obligated Entities in line with the aggressive capacity addition targets of the Government of India.

Figure 6: Installed capacity - Solar



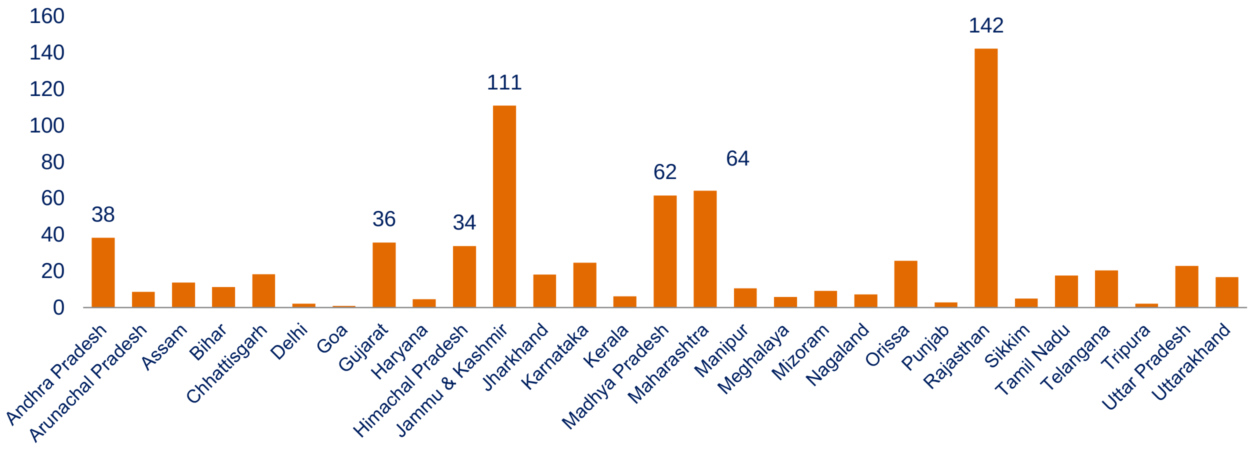

## 2.2.2. Renewable Energy Potential

India has an estimated renewable energy potential of about 900 GW from commercially exploitable sources viz. Wind – 102 GW (at 80 meter mast height); Small Hydro – 20 GW; Bioenergy – 25 GW; and 750 GW solar power, assuming 3% wasteland is made available. The potential of major renewable energy sources is given in the following section

### 2.2.2.1. Solar

As per National Institute of Solar Energy (NISE) total solar energy potential in India is about 748.98 GW with maximum potential in Rajasthan region 142.31GWp.

**Figure 7: State wise estimated solar potential (GW) – NISE Estimate**



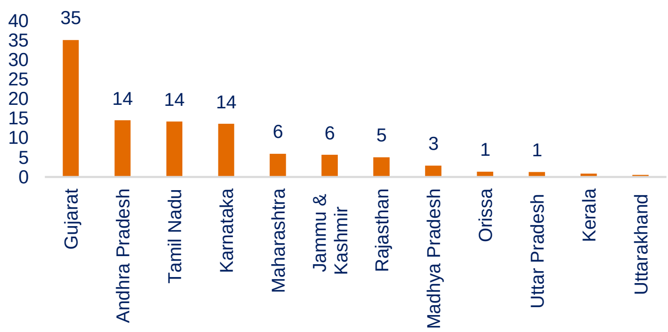

Rajasthan (25%), Gujarat (21%) and Madhya Pradesh (14%) are leading in solar installed capacities contributing to 60% of total installed capacity.

The National Tariff Policy 2016 specifies, "*SERC shall reserve a minimum % for purchase of solar energy …such that it reaches 8% of total consumption of energy by March 2022*". Considering the policy directives, the Government had notified state wise RPO obligations to be fulfilled by the states.

## 2.2.2.2. Wind

Wind power constitutes ~9.8 percentage of total power installed capacity and is ~55.8 percentage of the total Renewable Energy (RE) Capacity generated in the country as on June 2017. The National Institute of Wind Energy (NIWE) has developed the Wind Atlas of India. NIWE also collects data from Solar Radiation Resource Assessment stations to assess and quantify solar radiation availability and develop Solar Atlas of the country. As per NIWE estimate, wind energy potential in India is about ~100 GW at 80m level and ~300 GW at 100m level.

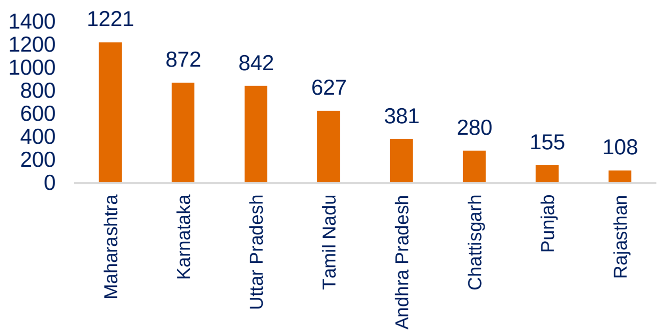
**Figure 8: State wise estimated wind power potential (GW) – NIWE estimate at 80m level**




## 2.2.2.3. Biomass

The current availability of biomass in India is estimated at about 500 million metric tonnes per year. The studies carried out by the Ministry of New and Renewable Energy show a potential of 18000 MW, which includes the biomass availability at about 120-150 million metric tonnes per annum covering agricultural and forestry residues. This apart, about 7000 MW additional power could be generated through bagasse-based cogeneration. A total of approximately 500 biomass power and cogeneration projects aggregating to 4760 MW capacity have been installed in the country for feeding power to the grid. In addition, around 30 biomass power projects aggregating to about 350 MW are under various stages of implementation.

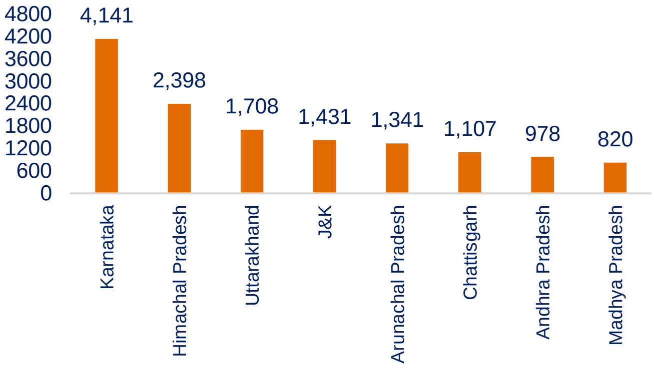
**Figure 9: State wise estimated biomass potential (MW)**



## 2.2.2.4. Small hydro power

In India, hydro projects up to 25 MW station capacities have been categorized as Small Hydro Power (SHP) projects. The estimated potential for power generation in the country from such plants is about 20,000 MW. Ministry of New and Renewable Energy has created a database of potential sites of small hydro and 6,474 potential sites with an aggregate capacity of 19,749.44 MW for projects up to 25 MW capacity have been identified. The installed capacity as on June 2017 is 4379.86 MW.

**Figure 10: State wise estimated SHP potential (MW)**




## 2.2.2.5. Waste to Energy

The total estimated potential of Waste to Energy in the country is about 2556 MW of which 1022 MW is estimated to be industrial wastes. The states with higher potential of waste to energy are Maharashtra (287 MW), Uttar Pradesh (176 MW), Tamil Nadu (151 MW), West Bengal (148 MW), Delhi (131 MW) and Andhra Pradesh (123MW). Rest of the potential is spread out across the states in India.

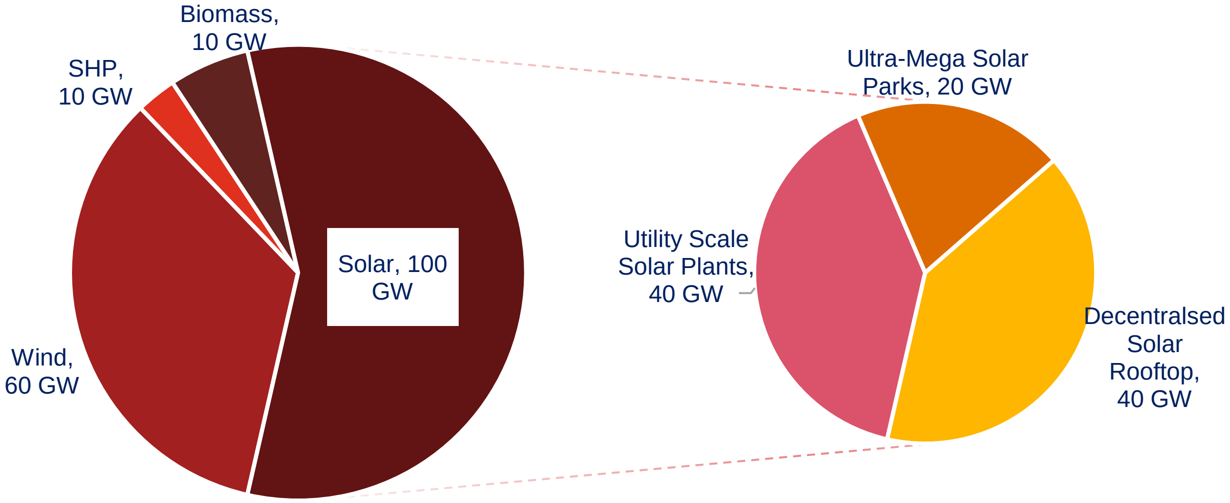
## 2.2.3. Projections for renewables

The Ministry of New and Renewable Energy (MNRE) is the nodal Ministry for all matters relating to new and renewable energy. The Ministry has been facilitating the implementation of broad spectrum programs including harnessing renewable power, renewable energy to rural areas for lighting, cooking and motive power, use of renewable energy in urban, industrial and commercial applications and development of alternate fuels and applications.

The Government of India, in 2015, while reviewing the potential of the renewable sector, realized the importance of the contribution that renewables can make in the country to meet the growing energy needs. Considering the future demand, the government revised the targets for the renewable energy and set an ambitious target of achieving 175 GW of renewable energy capacity in the country by year 2022. Though there is no definite methodology behind the fixation of the target, it was more a target set to utilize the potential, which has to be backed up by policy, and reforms push from the Government.

The source wise breakup of RE targets is indicated in the following figure:

**Figure 11: Renewable Energy targets for 2022 (GW)**



The 175 GW target was further noted as part of India's Intended Nationally Determined Contributions (INDC) submission to the United Nations Framework Convention on Climate Change (UNFCCC), though not as part of the official pledge, but as part of the various mitigation strategies.

As per the provisions laid out in the National Tariff Policy, 2016 and in order to achieve the target of 175 GW renewable capacity by 2022, the MoP in consultation with MNRE has notified the long term growth trajectory of RPOs for Non-Solar as well as Solar as under:

**Table 7: RPO Trajectory defined by the Government**

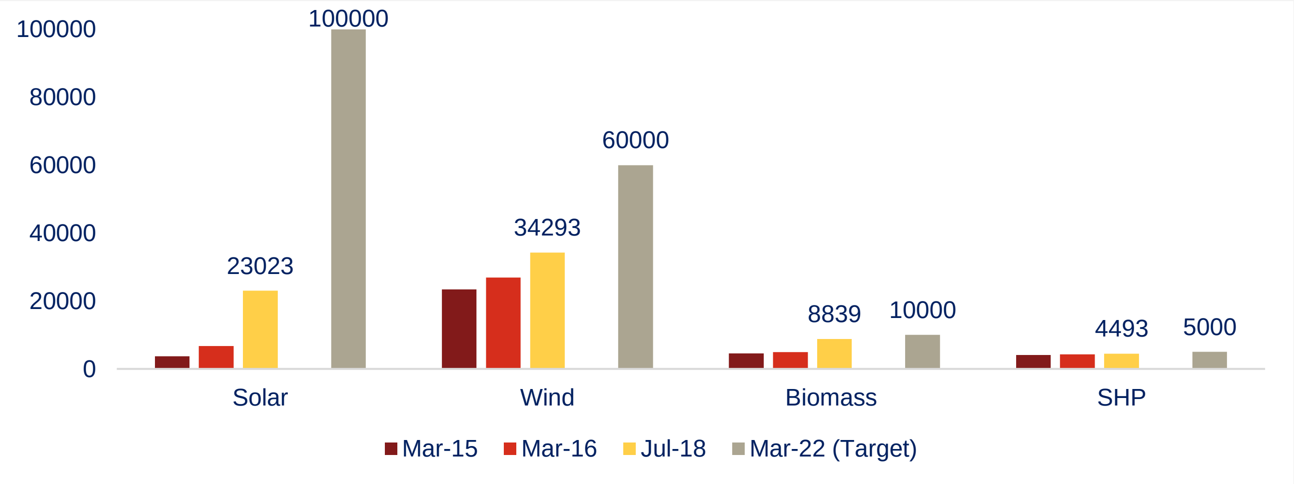
| Trajectory | 2016-17 | 2017-18 | 2018-19 |
|---|---|---|---|
| Non-solar | 8.75% | 9.50% | 10.25% |
| Solar | 2.75% | 4.75% | 6.75% |
| Total | 11.50% | 14.25% | 17.00% |

## 2.2.4. RE Actual Implementation vs. Targets

Of 175 GW, the primary resource is solar and is slated to contribute 100 GW of the total. Most of large MW scale utility projects are expected to come up in solar parks. These parks will have appropriately developed land with all clearances, a transmission system, water access, road connectivity, communication network, etc. The Solar Energy Corporation of India (SECI) is developing these solar parks in collaboration with the respective state governments. The choice of implementation agency is left to the state governments. It could be done by a) the designated state PSU, b) a joint venture between SECI and the state PSU, c) SECI, d) private entrepreneurs. The implementation agency may sell or lease land plots to prospective developers.

Even though the solar sector has picked up in the last three years, there is a long way to go to meet the targets.

**Figure 12: Renewable Energy: Target vs Actual (MW)**

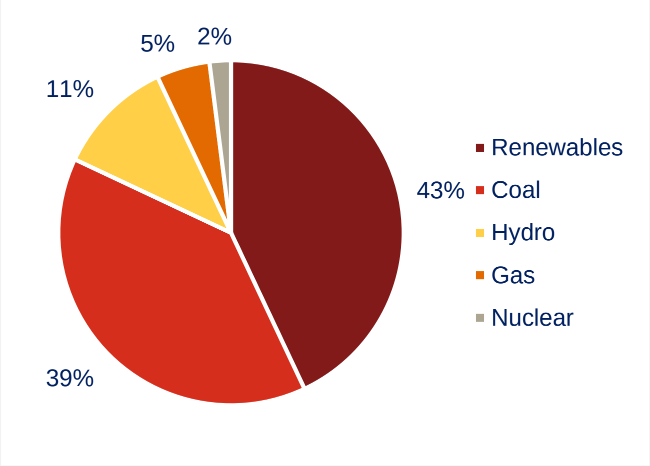



The government has set year on year targets to be achieved, but there was considerable delays. In addition, there are concerns on various fronts that also has led to holding back on many fronts. Lenders and investors find it risky to invest in renewable energy because of the nature of uncertainty in generation. There are concerns regarding regulatory issues related to land acquisition and government clearances for project. Concerns regarding purchase of power by state distribution companies, backing down of renewables by distribution companies, non-payment of dues on time are also few of the concerns which the players are grappling with. The next few years up to 2022 will be crucial for the sector and will eventually decide the future.

## 2.2.5. Targets beyond 2022 for Renewables

The draft National Electricity Plan 2016 provides the projections for Renewable capacity to be added beyond the year 2022. CEA carried out a simulation by considering energy scenarios and projected an addition of 100 GW renewable capacity in the period from 2022 to 2027 taking the total renewable installed capacity to 275 GW.

**Figure 13: Total projected installed capacity by FY 27. Total 640 GW**




CEA estimates that in a period of next ten years, the required installed capacity will double from the current of ~ 330 GW to about ~640 GW by end of 2026-27. The projections were carried out based on the total demand that has been projected up to FY 2026-27. Hydro, Gas and Nuclear based capacity were given the priority due to their inherent advantages to move towards a Low Carbon Growth. Renewable capacity was considered as a must run capacity in the system. The balance requirement has been allotted to coal.

## 2.2.6. Summary

- The projections for renewable energy are more of a top down policy decision and not from a bottom up approach from the individual sectors. The targets have been set considering the potential that the sector has in the country.
- In the period of last five years, the total installed renewable capacity of renewables has more than doubled from 24.5 GW in March 2013 to about 58.3 GW in June 2017, however the growth in the individual sectors have been varied.
- With the evolving policy push and growing interest of the stakeholders, the renewable capacity addition is expected to grow but it is still early to estimate whether the target of 175 GW will be met or not.
- The current projections of other sectors like coal etc. have also been developed considering possible scenarios of renewable capacity additions by the year 2022.
- CEA in the draft NEP has developed a possible scenario beyond the year 2022, wherein it is assumed that by the year 2022, the target of 175 GW will be met and by 2027, the renewable capacity addition will be 275 GW, which will constitute 43% of the projected capacity addition from the current share of ~17%.

## 2.3. Oil & Natural Gas

### 2.3.1. Introduction

India is a net importer of Oil & Gas and imports ~ 80% of its Oil requirements. The sector primarily fuels the important sectors of transport and industries like fertilizers, power etc.

From global shares of oil and gas of 33% and 24% in energy consumption in 2015 respectively, the IEA estimates the respective shares of oil and gas to converge at 25% each by 2035. In India, the shares of oil and gas in energy consumption in 2015-16 were 26% and 6.5%, respectively. [2]

It is expected that in the medium term while the share of oil may not come down, share of gas would rise. India traditionally lagged in the exploration of the oil and gas sector and was more reliant on imports. With increasing population and economic growth, the demand for Oil & Gas has been growing consistently. However, the same has not been backed up with sufficient exploration and production.

As per the Draft Energy Policy 2017 released by NITI Aayog, from 2005-06 to 2015-16, oil production increased by 15% while consumption of petroleum products increased by 62% and, gas production remained static, though there was an upswing in gas consumption between 2009-12 due to gas supplies from KG D6 after which the production has been constantly declining, whereas the consumption of gas increased by 38%.

Adjoining figure[3] highlights the increasing trend of natural gas imports to meet the growing demand. The reliance on imports has exposed India to external price volatility and risks the energy security of the country.

**Figure 14: Consumption of petroleum products**

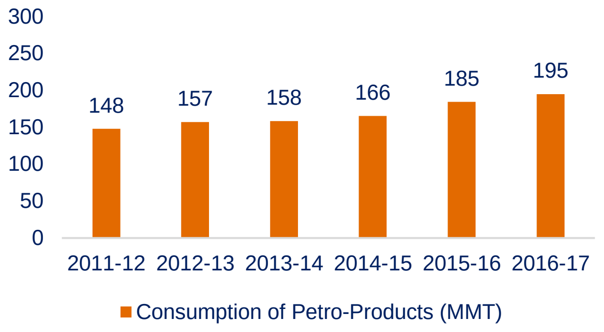



**Figure 15: Domestic production and import of oil**

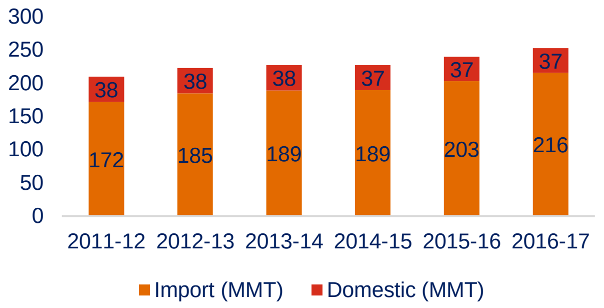
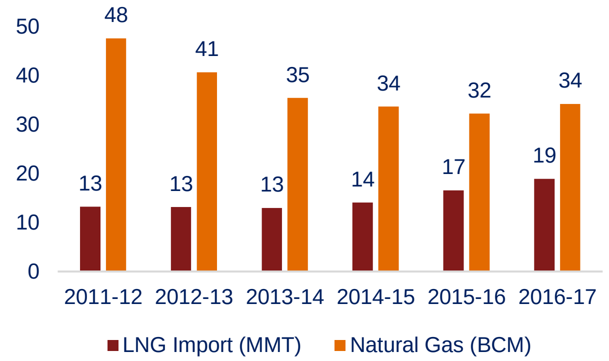



**Figure 16: Gas production and import**




The variation in the global oil prices pose challenges for the Indian economy and its growth. The concern over crude oil prices stems from India's energy import bill of around $150 billion, expected to reach $300 billion by 2030. However, the decline in the oil prices had a positive impact on the economy. India is targeting to reduce its imports by 10% by 2022 and plans to meet three forth of its demand domestically by the year 2040.

[2] Draft Energy Policy 2017
[3] Annual Report 2016-17, MoP&G

## 2.3.2. Oil and Gas Potential

The estimated reserves[4] of crude oil in India as on 31st March 2016 is 621.10 MT against 635.60 MT a year ago. Geographical distribution of Crude oil indicates that the maximum reserves are in the Western Offshore (39.79%) followed by Assam (25.89%), whereas the maximum reserves of Natural Gas are in the Eastern Offshore (36.79%) followed by Western offshore (23.95%). The estimated reserves of Natural Gas in India as on 31st March 2016 stood at 1227.23 Billion Cubic Meters (BCM) as against 1251.90 BCM a year ago.

## 2.3.3. Oil & Gas Projections

### 2.3.3.1. Petroleum Planning and Analysis Cell (PPAC)

Petroleum Planning and Analysis Cell (PPAC) is the official source of data and policy analysis on the hydrocarbon sector in the country. It monitors and analyses trends in prices of crude oil, petroleum products and natural gas and their impact on the oil companies and consumers, and prepare appropriate technical inputs for policymaking. It also collects, compiles and disseminates data on the domestic oil and gas sector in a continuous manner and maintain the data bank, prepares periodic reports on various aspects of oil and gas sector.

#### 2.3.3.1.1. Methodology

The demand for petroleum products has been calculated based on the aggregated Net Demand (Production + Import – Export - Consumption) of individual products in the country based on the past trends. Based on the historical data available from V Plan (1974-79) for each of the petroleum products, PPAC computed the Compounded Annual Growth Rate (CAGR) for each Five-year plan and the Annual CAGR for all the petroleum products up to XII Plan (2012-17). Based on the past growth rate, the demand of petroleum products and natural gas for the 13th Plan was worked out.

#### 2.3.3.1.2. Aggregated Projections[5]

Based on the historical CAGR, demand estimates for the FY 2017-18 to FY 2021-22 is given below. The demand projections have been arrived at considering the growth rate of individual sectors and the demand of each product is then aggregated to arrive at the total demand for petroleum products.

**Table 8: Demand projections from FY17-22 based on CAGR**

| Products | FY 2017-18 | FY 2018-19 | FY 2019-20 | FY 2020-21 | FY 2021-22 |
|---|---|---|---|---|---|
| **1. Petroleum Products ('000 MT)** | | | | | |
| **LPG** | 22597 | 23271 | 23868 | 24342 | 24770 |
| **MS** | 24527 | 26587 | 28774 | 31095 | 33651 |
| **NAPHTHA** | 12516 | 14185 | 14923 | 15388 | 15388 |
| **ATF** | 9263 | 10022 | 10829 | 11673 | 12517 |
| **SKO** | 6549 | 6352 | 6162 | 5977 | 5798 |
| **HSDO** | 86762 | 92050 | 97859 | 104101 | 110785 |
| **LDO** | 400 | 400 | 400 | 400 | 400 |
| **LUBES** | 3120 | 3207 | 3297 | 3389 | 3485 |
| **FO/LSHS** | 7845 | 7845 | 7845 | 7845 | 7845 |
| **BITUMEN** | 6305 | 6544 | 6687 | 6878 | 7165 |
| **PET COKE** | 11419 | 12651 | 14000 | 15476 | 17089 |

[4] Energy Statistics 2017, MoSPI
[5] PPAC, MoP&G

| | | | | | |
|---|---|---|---|---|---|
| **OTHERS** | 6142 | 6071 | 6103 | 6085 | 6067 |
| **Total POL** | **197445** | **209185** | **220747** | **232649** | **244960** |
| **2. Natural Gas (MMSCMD)** | **494** | **523** | **552** | **586** | **606** |

## 2.3.3.2. Petroleum and Natural Gas Regulatory Board (PNGRB)

The Petroleum and Natural Gas Regulatory Board (PNGRB)[6] was constituted under The Petroleum and Natural Gas Regulatory Board Act, 2006 to protect the interests of consumers and entities engaged in specified activities relating to petroleum, petroleum products and natural gas and to promote competitive markets and for matters connected therewith or incidental thereto. The board has also been mandated to regulate the refining, processing, storage, transportation, distribution, marketing and sale of petroleum, petroleum products and natural gas excluding production of crude oil and natural gas so as and to ensure uninterrupted and adequate supply of petroleum, petroleum products and natural gas in all parts of the country.

PNGRB authorized the industry group to conduct a study Vision 2030: Natural Gas Infrastructure in India, which was released on May 2013. The current report provides the projections for the Natural gas for the period from FY 2012-13 to FY 2029-30.

### 2.3.3.2.1. Methodology

Power, fertilizers and other industries consume the bulk of natural gas in India. The basic premise behind the projections carried out in FY 2012-13 was that, for the power sector, there will be shortage of domestic coal and prices of imported coal will increase which will shift the demand towards natural gas. For the fertilizer sector, the assumption was increased food requirement will call for higher fertilizer requirements and natural gas is used in those industries.

The following provide the systematic methodology adopted for carrying out the demand projections:

- The base for the current document are the projections given in the Plan document for the year FY 2012-13 to 2021-22.
- Demand projections were then refined for Power, Fertilizer, CGD and Petrochemical /Refining sectors in order to project the most realistic demand scenario based on inputs from industry players and GoI
- Sectoral demand growth rate beyond 2021-22 assumed (where ever required) based on assumptions used in the 'Plan Document' and industry inputs
- No constraints were applied in terms of natural gas price, supply and infrastructure
- Regional distribution for demand were then projected
- In the final step, the demand projections up to 2030 were consolidated considering all the above factors

### 2.3.3.2.2. Aggregated demand projections

The demand for individual sectors were worked based on past growth trends and then subsequently aggregated to arrive at the total demand.

**Table 9: Segment wise demand projections**

| Demand from Sectors (MMSCMD) | FY 2012-13 | FY 2016-17 | FY 2021-22 | FY 2026-27 | FY 2029-30 |
|---|---|---|---|---|---|
| **Power** | 86.50 | 158.88 | 238.88 | 308.88 | 353.88 |
| **Fertilizer** | 59.86 | 96.85 | 107.85 | 110.05 | 110.05 |

[6] Website of PNGRB

| | | | | | |
|---|---|---|---|---|---|
| **City Gas** | 15.30 | 22.32 | 46.25 | 67.96 | 85.61 |
| **Industrial** | 20.00 | 27.00 | 37.00 | 52.06 | 63.91 |
| **Petrochemical/ Refineries** | 54.00 | 65.01 | 81.99 | 103.41 | 118.85 |
| **Sponge Iron/ Steel** | 7.00 | 8.00 | 10.00 | 12.19 | 13.73 |
| **TOTAL Demand** | 242.66 | 378.06 | 516.97 | 654.55 | 746.03 |

## 2.3.3.3. NITI Aayog

The projections provided in this section are based on the report "A Report on Energy Efficiency and Energy Mix in the Indian Energy System (2030) Using India Energy Security Scenarios, 2047" released by NITI Aayog. The numbers provided are based on possible scenarios, which NITI Aayog, in consultation with other stakeholders, feels will be the most likely case. The scenarios have been developed using the tool India Energy Security Scenarios (IESS), 2047.

### 2.3.3.3.1. Methodology

The IESS, 2047 has been developed with a view that energy scenarios should be carried out together and not in silos as was the practice earlier for each sectors. The IESS considers four possible scenarios or levels, which are given as under

- **Level 1: Least effort scenario -** This assumes that little or no effort is being made in terms of interventions on the demand and the supply side, and represents a pessimistic outlook
- **Level 2: Determined effort -** This describes the level of effort, which is deemed most achievable by the implementation of current policies and programme of the government. It may be seen as the 'current policy' with autonomous improvements
- **Level 3: Aggressive Effort -** This describes the level of effort needing significant change, which is hard but deliverable
- **Level 4: Heroic effort -** This considers extremely aggressive and ambitious changes that push towards the physical and technical limits of what can be achieved

The scenarios developed and provided in the report are considering Level 2 i.e. achievable as per implementation of current policies of the Government.

The IESS, 2047 scenarios are based on certain assumptions relating to likely GDP growth, population, level of economic activity, structure of the economy, urbanization, household occupancy etc. that would impact the demand for energy.

The above analysis was carried out not only by considering the economic behavior in the Demand sectors, but also the technology choices and fuel preference category, leading to significant impact as to how energy or electricity is supplied to meet this demand. The conditions as they obtain in India have been factored in after consulting sector specific players. The effect of energy efficiency has been considered in the demand side factors. From the supply side, domestic resources meet each of the fuel demands first, and the balance is imported. Within electricity, no preference is given to any technology on the supply side and past trends have been used to project deployment of supply side technologies in 2030 and 2047.

### 2.3.3.3.2. Projections

With the above assumptions, the scenario developed for the three years have been provided wherein the primary energy requirement has been projected as provided in the following table

**Table 10: Energy mix as per current policy scenario**

| Primary Energy Supply (TwH) | 2012 | 2022 | 2030 | 2047 |
|---|---|---|---|---|
| **Coal** | 3,284 | 5,792 | 7,773 | 13,401 |
| **Oil** | 1,929 | 3,093 | 4,429 | 7,137 |
| **Gas** | 574 | 1,017 | 1,325 | 2,068 |
| **Nuclear, Hydro and Renewables** | 245 | 629 | 935 | 1,968 |
| **Others** | 985 | 658 | 826 | 1,316 |
| **Total** | 7,017 | 11,189 | 15,286 | 25,890 |

From on the above projections, the share of oil and gas in the Primary Energy Demand has been estimated as below:

**Table 11: Share of Oil and Gas**

| Share of Oil and Gas (TwH) | 2012 | 2022 | 2030 | 2047 |
|---|---|---|---|---|
| **Total supply** | 7,017 | 11,189 | 15,286 | 25,890 |
| **Oil** | 1,929 | 3,093 | 4,429 | 7,137 |
| **Gas** | 574 | 1,017 | 1,325 | 2,068 |
| **Percentage share of Oil** | 27% | 28% | 29% | 28% |
| **Percentage share of Gas** | 8% | 9% | 9% | 8% |

Based on the projections as per the level considered, it is observed that the share of oil and gas in the economy will remain more at a constant level. The share of Oil and Gas is expected to increase proportionately with that of the increase in requirement of primary energy.

## 2.3.4. Summary

- The demand projections for Oil and Gas are based on methodologies developed by PPAC, P&NGRB and NITI Aayog.
- The projections developed by PPAC are bottom up projections developed based on the historical growth rate of individual petroleum products. The total demand up to FY 2020-21 has been arrived at by aggregating the individual projected demand of the products.
- The projections given in the study conducted by PNGRB are based on the demand for Natural Gas assessed for individual sectors namely Power, Fertilizer, City Gas Distribution and Petrochemical /Refining sectors etc. which are dependent on Natural Gas. The individual demand of the industries is then aggregated to arrive at the total demand of Natural Gas for the period up to FY 2029-30.
- The projections developed by NITI Aayog are considering four probable scenarios, which may work out from the current demand. The projections have been developed for primary energy and for three specific years i.e. 2022, 2030 and 2047. The share of Oil and Gas has been worked out from the primary energy in a top down approach. From the derived projections, it is observed that the share of oil and gas is expected to maintain a constant level.

## 2.4. Power

### 2.4.1. Introduction

India is a country with more than 1.3 billion people accounting for almost ~18% of world's population. India faces a formidable challenge in case of providing adequate energy supplies to consumers at a reasonable cost. With anticipated increase in India's nominal GDP, the energy challenge thus is of fundamental importance. In addition, in the last six decades, India's energy use has increased by ~16 times and the installed electricity capacity by around ~85 times. Nevertheless, India as a country has been suffering from energy poverty and pervasive electricity deficits. In recent years, the country's energy consumption has increased at a relatively fast rate due to population growth and economic development and with the economy projected to grow, rapid urbanization and improving standards of living for millions of Indian households, the demand is likely to increase significantly. The supply challenge is also of such magnitude and there are reasonable apprehensions that shortages will be there non-uniformly at various regions of the country even though on an all India level, the situation will be net surplus in the future.

The power sector in India is at a crucial juncture now with several investments being undertaken by the public as well as private sector. There has been an increasing private sector participation in the recent times. It was seen in the 11th plan that 39% of conventional energy capacity addition was from the private sector while 35% from the state utilities and around 26% from central power companies. Private sector also contributed around 59% in the total capacity addition during FY 14-15. The emerging dynamics of Indian power sector market would require industry players to realign their strategies and operating mechanisms to the changing sectoral trends.

Another area to highlight is the increasing share of renewable energy in the demand and supply of power in the country. There has been a shift to renewable power in the recent times as the same constitutes around 19% of the total installed capacity as on January 2018. The higher losses have also been a cause of concern for the power sector and there is a need for efficient management of the infrastructure. The Indian electricity sector has also seen an unprecedented growth in the last decade. The all India installed capacity has nearly doubled in a period of ten years from ~144 GW in 2006 to ~330 GW in 2017[7]. There has also been a steady growth in per capita electricity consumption from 631 kWh in 2006 to 1122 [8]kWh in the year 2015-16.

Within the last half decade, the Indian power sector has witnessed a few success stories and has undergone dynamic changes. However, the road ahead is entailed with innumerable challenges that result from the existing gaps between what is planned and what the sector has been able to deliver. Demand forecasting thus poses a significant role in trying to minimize these gaps.

### 2.4.2. Review of the existing methodologies

There are numerous methods, which are used today for forecasting the electricity demand. The methods have evolved over time from being simplistic and reliant only on past trends to the current form wherein the impact of different factors are modeled to arrive at the demand. The choice of a method is based on the nature of the data available and the desired nature and level of detail of the forecasts required. An approach often used is to employ more than one method and then compare the forecasts. This section provides the commonly used methods used for electricity demand forecasting.

#### 2.4.2.1. Trend method

This method falls under the category of the non-causal models of demand forecasting that do not explain how the values of other variable affected the variable to be predicted. Here, the variable is expressed to be purely a function of time, rather than by relating it to other economic, demographic, policy and technological variables. Trend method is the most widely used forecasting method due to its ease of use and derivation of trend from the

[7] CEA All India Installed Capacity as on 31st May 2017
[8] CEA Final National Electricity Plan, 2018

available data. The inherent assumption in forecasting using trend method is that the future values will continue to growth at the same trend.

The method ignores the impact of any other factor for example, the role of incomes, prices, population growth and urbanization, policy changes etc. Therefore, it does not offer any scope to internalize the changes in factors like effects of government policy, regulatory regimes, demographic trends, aggregate and per capita growth in incomes, technological developments etc. This method is important as it provides a preliminary estimate of the forecasted variable value and is accurate in the short term.

Review of the available literature on trend method highlights that such methods are easy to use indicators that can provide a quick understanding. Though such techniques are relatively less common in academic literature, however practitioners rely on them in many cases. The trend method is used by directly deriving the growth rates from the available data e.g. sales or the growth rates are calculated from derived factors like specific consumption of electricity.

#### 2.4.2.1.1. Use of trend method in electricity demand forecasting

The trend method is the most commonly used method in the power sector. Every utility primarily uses the trend method to forecast its sales and consumer growth. The acceptance of the method in India is quite high and the results derived are also accurate and meets the intended usage of the forecast.

This method is used by CEA in developing forecasts for EPS. The PEUM method used by CEA is a combination of trend and end use method. The 18$^{th}$ and 19$^{th}$ EPS of CEA relies on this method to forecast the consumption of most consumer categories. In the 19$^{th}$ EPS, the energy consumption of each distribution utility was worked out by PEUM method by forecasting for each categories using the past trends. The forecast was refined by incorporating recent trends and policy initiatives.

In the draft NEP 2016, the projections were developed based on historical growth rates. In the case of draft NEP 2016, the past electricity consumption data from the year 1979-80 to 2013-14 was taken and growth rates were derived for three different periods. Based on the review of the growth rates, suitable growth rates were assumed to work out the future projections.

### 2.4.2.2. Time series method

A time series is defined to be an ordered set of data values of a certain variable. Time series models, are essentially, econometric models where the explanatory variables used are lagged values of the variable, which are to be explained and predicted. The intuition underlying time-series processes is that the future behavior of variables is related to its past values, both actual and predicted, with some adaptation/adjustment built-in to take care of how past realizations deviated from those expected. Thus, the essential prerequisite for a time series forecasting technique is data for the last 20 to 30 time periods.

The difference between econometric models based on time series data and time series models itself, lies in the explanatory variables used in the model. In an econometric model, the explanatory variables (such as incomes, prices, population, GDP, temperature etc.) are used as causal factors and a relationship is derived while in the case of time series models only lagged (or previous) values of the same variable are used in the prediction.

#### 2.4.2.2.1. Commonly used time series methods

There are innumerable time series methods available in literature and mostly in academics. However, the following two methods are most commonly used:

- Exponential Smoothing
- Auto Regressive Integrated Moving Averages (ARIMA)

## Exponential Smoothing

Exponential smoothing is a technique that is usually applied to time series data, either to produce smoothed data for presentation, or to make forecasts. Whereas in the simple moving average method the past observations are weighted equally, exponential smoothing assigns exponentially decreasing weights over time. In other words, recent observations are given relatively more weightage in forecasting method than the older observations. Hence, it is preferred for short/ medium term forecasts.

Few of the exponential smoothing techniques used for forecasting are:

- **Simple exponential smoothing**

  The simple exponential smoothing considers only actual and forecasted value of the past to arrive at the forecast for the next period by assigning weights. The model ignores the trend and seasonal components of the time-series data and is represented by the following equations:

  $F_{t+1} = \alpha A_t + (1- \alpha) F_t$

  $F_{t+1}$= forecasted value for period t+1

  $A_t$ = actual value for period t

  $F_t$ = forecasted value for this period

  Where α determines the weight given to the most recent past observation and hence controls the rate of smoothing or averaging.

- **Brown's double exponential smoothing**

  Brown's double exponential smoothing is a forecasting method similar to Simple Exponential Smoothing, except that the smoothing constant in double exponential smoothing is derived by "re-smoothing" the single smoothed constant from simple exponential smoothing model. Brown's Double Exponential Smoothing is meant to be implemented on data that show a linear trend over time and for the short term only.

- **Holt's no seasonal trend smoothing**

  This model uses two smoothing constants, α and β to separately smooth the trend. It further adjusts each smoothed value for the trend of previous period before calculating the new smoothed value. In addition to the advantages of double exponential smoothing this is more flexible in that the level and trend can be smoothed with different weights. This method does not account for the seasonality.

- **Holts-Winter's multiplicative and additive exponential smoothing**

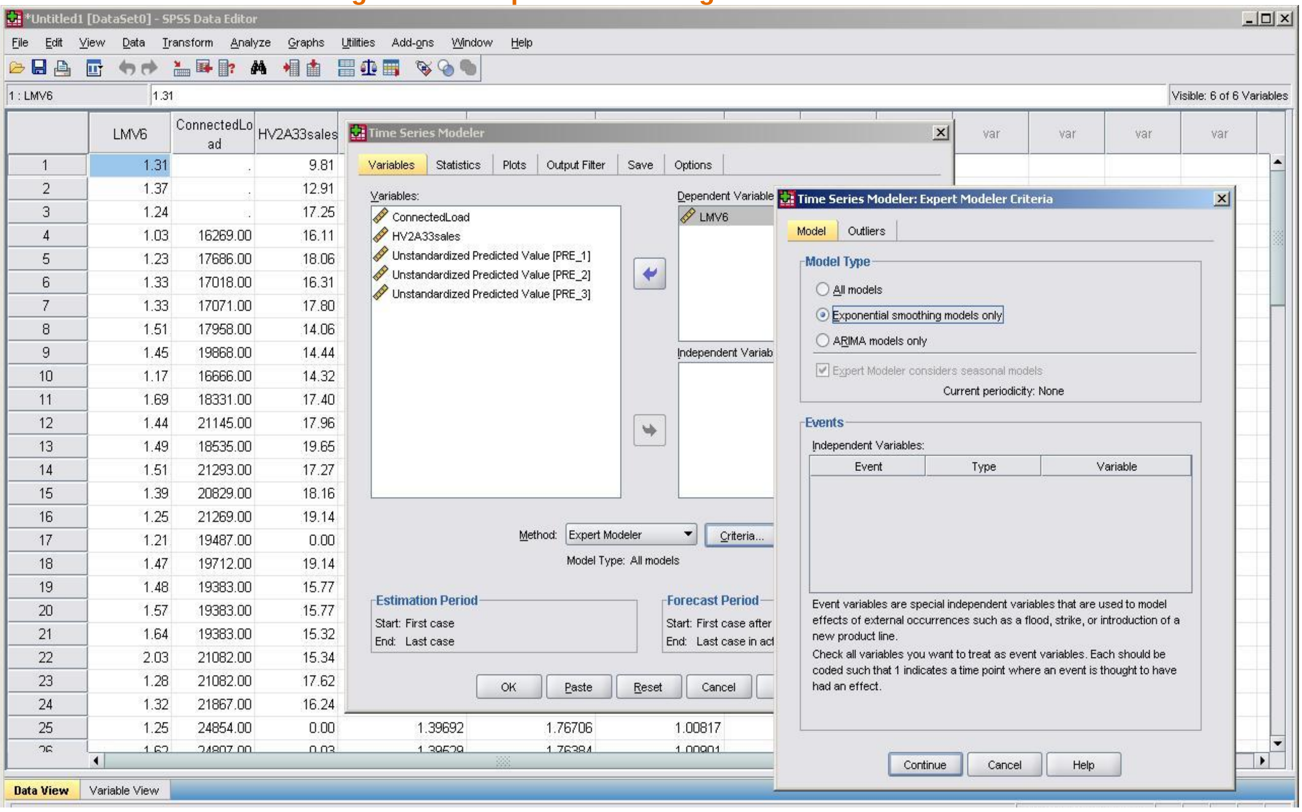
  This model extends Holt's two-parameter model by including a third smoothing operation to adjust for the seasonality. The equation assumes that the trend is additive and that the seasonal influence is multiplicative. This method models trend, seasonality and randomness using as efficient exponential smoothing process. However, the data requirement is greater than other methods

## Auto-Regressive Integrated Moving Averages (ARIMA) Method

An autoregressive integrated moving average (ARIMA) model is a generalization of an autoregressive moving averages (ARMA) model. These models are fitted into a time series to better understand the data or to predict future points in the series. The model is generally referred to as an ARIMA (p, d, and q) model where the p, d and q are integers greater than or equal to zero and refer to the order of the autoregressive, integrated and moving average parts of the model respectively. This technique uses the historic values and the forecast errors to predict the future values of a time-series data. ARIMA modeling can take into account trends, seasonality, cycles, errors and non-stationary aspects of a data set when making forecasts. Since using ARIMA or any form of this method involves complex modeling and calculations, a software is ideally used to generate forecasting results.

The graphic below shows the time series option in SPSS software.

**Figure 17: Snapshot a working tab in SPSS software**




In the current study, the time series method will be used for short and medium terms forecasts using SPSS software to generate forecast results. The time series methods in general is not ideal for long term forecasts as the results are mostly under projected as lesser weightages are given in the longer period.

### 2.4.2.2.2. Use of time series in electricity demand forecasting

Worldwide, the method is being used for forecasting electricity demand in the short-term period. Due to the complexity involved, the method is mostly limited to academia and most of the literature available is from academic field. Some of the research papers have been quoted in this section to highlight the application of the technique in electricity demand forecasting.

In a research paper titled *'Very short-term electricity demand forecasting using adaptive exponential smoothing methods', the authors Abderrezak Laouafi, Mourad Mordjaoui, Djalel Dib [IEEE Explore, 2014]*, presented the development of three new electricity demand-forecasting models, based on the use of the adaptive Holt's exponential smoothing technique.

In a paper titled *'Forecasting monthly peak demand of electricity in India—A critique' by authors Srinivasa Rao Rallapalli and Sajal Ghosh [ELSEVIER, 2012],* the authors evaluated the monthly peak demand forecasting performance predicted by CEA using trend method and compared it with those predicted by Multiplicative Seasonal Autoregressive Integrated Moving Average (MSARIMA) model. They found that the MSARIMA model outperforms CEA forecasts in all five regional grids in India. For better load management and grid discipline, this study suggested employing sophisticated techniques like MSARIMA for peak load forecasting in India.

CEA in 19$^{th}$ EPS has the mentioned use of time series analysis along with end use methods. The time series method has been used to derive growth indicators giving higher weightage to the recent trends to consider the benefits of energy conservation initiatives and technological changes. However, in cases where no definite trend emerged, weighted average (chronological or maximum AGR-maximum weightage) have been used for forecasting electricity demand.

## 2.4.2.3. Econometric methods

This is a standard quantitative approach for economic analysis that establishes a relationship between the dependent variable and certain chosen independent variables by statistical analysis of historical data. The relationship so determined can then be used for forecasting simply by considering changes in the independent variables and determining their effect on the dependent variable. In the case of electricity demand forecasting, the dependent variable is electricity consumption and independent variables can be population, consumer indices, tariffs, weather variables, time etc.

The set of potentially important independent variables to be tested in the model can be selected based out of experience and the influence of these factors is evaluated statistically. Normally the statistically relevant factors are considered and included in the estimated demand function.

### 2.4.2.3.1. Commonly used econometric methods

Econometric methods can be classified based on the number of independent variables used in the equation. The selection and choice of a variable is based on statistical analysis and the degree of relationship that is obtained. Accordingly, there are two broad type:

- Univariate econometric method
- Multivariate econometric method

### Univariate technique

In the univariate method, the dependent variable is expressed as a function of a single independent variable e.g. population, time etc. and the relationship is developed.

Thus, in case of univariate relationship, one would have:

Y = f (POP)

Where,

Y = electricity demand

POP = population

A sample of univariate econometric model is shown in the table below wherein; only time variable (t) has been used to develop an econometric relationship.

**Table 12: Sample equations for univariate econometric model**

| Sl. | Equation |
|---|---|
| 1. | Electrical Energy Demand = 29.01978 $t^3$ - 966.933 $t^2$ + 22171.28 t + 40252.89 |
| 2. | Electrical Energy Demand = 0.71 t4 - 28.85 t3 + 486.18 t2 + 8221.48 t + 56971.26 |

In many cases, the univariate relationship is directly established by using only one variable and the equation so developed is not further tested with additional variables as the single dependent variable alone provides a strong relationship. In other cases, the dependent variable is tested with multiple variables initially, however only one dependent variables shows a strong relationship and hence is used to develop the regression equation.

### Multivariate technique

This technique is classified under multivariate techniques because it considers the causal-relationships that might exist between multiple variables, demographic, economic, weather-related etc. and the variable that needs to be projected. Taking time-series or cross-sectional/pooled data, causal relationships could be established between electricity demand and other economic variables. The dependent variable, demand for electricity, can be expressed as a function of various economic factors. For illustration, these variables could be population, income per capita and weather related data etc.

Thus, one would have:

Y = f (X, W, POP)

Where,

Y = electricity demand

X = per capita income

W= Weather related parameter

POP = population

Several functional forms and combinations of these and other variables may have to be tried until the basic assumptions of the model are met and the relationship is found statistically significant.

Inserting forecasts of the independent variables into the equation would yield the projections of electricity demand. The sign and the coefficients of each variable, thus estimated, would indicate the direction and strength of each of the right-hand-side variable in explaining the demand in a sector.

More specifically, a single equation regression model for each variable that needs to be forecasted can represent these. The set of independent variable (i.e. variables that might affect the variable whose value is to be projected) for each such model could vary. For example, while electricity consumption by the domestic category could be a function (or affected by) of temperature of the region and GDP, consumption by Non-Domestic category could be a function of per capita income and the number of consumers in that category.

The following table provides a set of sample equations for multivariate econometric method:

**Table 13: Sample equations for multivariate econometric model**

| Sl. | Equation |
|---|---|
| **1.** | Electrical Energy Demand = - 7093.167+ 5.6084^E-4 * (Population) – 0.00254 * (GSDP Tertiary) |
| **2.** | Electrical Energy Demand = - 1257.306 + 1.1082^E-4 * (Population) – 0.741 * (Electricity WPI) + 0.001785 * (GSDP Secondary) |

Since the method considers the various external factors that may influence the dependent variable, it can be used for short/ medium and long term.

## Test for Goodness of Fit

The goodness of fit of a statistical model describes how well it fits a set of observations. Measures of goodness of fit typically summarize the discrepancy between observed values and the values expected under the model in question. This is often measured by a Pearson's chi-square test.

Pearson's chi-squared test uses a measure of goodness of fit which is the sum of differences between observed and expected outcome frequencies (that is, counts of observations), each squared and divided by the expectation. The test statistic being:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Where:

$O_i$ = an observed frequency (i.e. count) for bin i

$E_i$ = an expected (theoretical) frequency for bin i, asserted by the null hypothesis.

The expected frequency is calculated by:

$$E_i = \left(F(Y_u) - F(Y_l)\right) N$$

Where:

F = the cumulative Distribution function for the distribution being tested.

$Y_u$ = the upper limit for class i,

$Y_l$ = the lower limit for class i, and

N = the sample size

The resulting value can be compared to the chi-squared distribution to determine the goodness of fit. The test for Goodness of Fit shall be run for the approaches and finally, the model that yields the best fit shall be adopted.

### 2.4.2.3.2. Use of econometric technique in electricity demand forecasting

The econometric approach has seen significant developments over the past three-four decades. In the 1970s, the main aim was to understand the relationship between energy and other economic variables.

In a paper titled 'The structure of world energy demand' published by the MIT Press, Cambridge, Massachusetts in the year 1979, the author R. S. Pindyck succinctly captures the following:

> *"We have had a rather poor understanding of the response of energy demand in the long run to changes in prices and income, and this has made it difficult to design energy and economic policies. By working with models of energy demand rather different from those that have been used before and by estimating these models using international data, we can better understand the long-run structure of energy demand and its relationship to economic growth".*

The method is widely used across the world for forecasting the electricity demand for any licensee area, regional or at a national level etc. There are numerous literature available wherein econometric technique have been used to derive electricity demand.

M Ishiguro and T Akiyama in their paper titled *'Energy demand in five major Asian developing countries: Structures and Prospects'* published in 1995 have analyzed energy demand in five Asian countries, namely China, India, South Korea, Thailand and Indonesia both at the aggregate level and the sector level using a simple econometric model. They had used the model for forecasting energy demand in these countries up to 2005.

In a study titled *'Regression Based Forecast of Electricity Demand of New Delhi [IJSCP, 2014] carried out by Aayush and Agam Goel, IIT Delhi*, the forecast of electricity of New Delhi area was worked out using three models namely Multivariate Regression, Trend seasonality model and by ARIMA modeling. The paper discusses the significance of climatic and seasonal factors on electricity demand as well as provides a comparison of the relative accuracy of the models employed to derive the forecast.

In Draft NEP 2016, CEA has used univariate econometric forecasting technique to forecast the energy consumption at an all India level. A 3rd and 4th degree regression equation was developed with energy consumption as the dependent variable and time variables as independent variables. In the present case only time variable (t) has been used to develop the relationship.

In the 19th EPS, electricity demand forecast by econometric method has been planned by CEA. The forecast will be developed using multiple regression analysis and the electricity demand (in MU as well as MW) will be estimated for all-India, Regions and state/UT for the period from FY 2016-17 to FY 2036-37.

## 2.4.2.4. End-Usage method

The end-usage approach attempts to capture the impact of energy usage patterns of various zones identified in the state area. The end-usage model for electricity demand focuses the derivation of demand from the end use of a product or area. For e.g. electricity demand from usage of new land in terms of Residential, Commercial, Institutional and Industrial categories. The method takes in to account various approaches to derive the end use demand e.g. by studying the land usage norms, load per area norms and the level/stage of urbanization/development of these zones.

For example, the load in a zone (identified by the dominant consumer category) can be determined by considering factors like the total area of that zone, Percentage occupancy (stage of settlement), the space coverage norm, and the Floor to Space Index (FSI) to arrive at the effective usable area for that zone. Then this usable area is multiplied to the approximate load per area to arrive at the load for that zone. It is further multiplied with the utilization factor to estimate the effective load on the zone.

The following relation defines a tentative methodology for the land usage:

$L_z = A \times O \times S \times F \times LA \times UF$

$L_z$ = Utilized Load of a zone (MW)

A = Area of the zone (sq. km)

O = % of the area occupied based on the level of urbanization/development.

S = Space Coverage Norms/By-laws specified for each consumer category (% of the occupied area that can be covered by any construction)

F = Floor to Space Index specified for each consumer category

LA= Load per area (MW per sq. km)

UF= Utilization factor for each consumer category

Similar estimations can be arrived at depending on data availability to determine the expected load that may come into a system. When summed over different area in the state, aggregate energy demand for the system as a whole can be ascertained. The method is used to refine the forecasts which are obtained by other methods, by adding the expected loads.

The method is typically used in combination with other methods like time series, trends or econometric forecasts to capture demands which might not be captured by past trends or be reflected by independent variables. The additional demand arrived at by end sue method can be then suitable added to the base demand arrived at by the primary methods.

The end-use approach is effective when new technologies and fuels have to be introduced and when there is lack of adequate time-series data on trends in consumption and other variables. The approach demands a high level of detail on each of the end-uses.

### 2.4.2.4.1. Use of end use method in electricity demand forecasting

The technique is used to estimate specific demand from particular categories or to estimate behavioral change in a region over time. For example, the method is ideal to ascertain new demand from industrial activity in a region or to ascertain penetration of energy efficiency. The results obtained greatly help in fine tuning the forecasts developed from primary methods. The method has found application in estimating demand in specific industries and sectors

In a report titled 'India Energy Outlook: End Use Demand in India to 2020' published by Ernest Orlando Lawrence Berkeley National Laboratory in January 2009, the end use method has been used to estimate energy use in agriculture, service and industry sector in India.

CEA in the 19th EPS has also used the end use methodology to estimate the demand from HT Industries above 1 MW. The electricity consumption for LT Industries and HT industries with demand less than 1 MW has been projected on the basis of past trends and programme for development in future, as indicated by state authorities. In the case of H.T. Industries with demand of 1 MW and above, projection is based on the information furnished by end users/state utilities.

## 2.4.2.5. Benefits and challenges of using the forecasting methods

| Method | Benefits | Challenges |
|---|---|---|
| **Trend method** | ▪ Simplicity and ease of use in deriving the forecasts<br>▪ The results obtained in the short and medium terms are fairly estimated<br>▪ Skill and data requirement is very low<br>▪ The models are more tractable and changes are easily reflected<br>▪ No additional data required other that the historical data of the variable to be projected | ▪ The method ignores possible interaction of the variable under study with other economic factors<br>▪ The method cannot be relied upon for long term projections<br>▪ The method cannot incorporate or capture directly the role of certain policy measures/ economic shocks/ new technology that might result in a change |
| **Time series method** | ▪ The method gives good estimates for the short term period e.g. monthly forecasts for a shorter period<br>▪ The data requirement is lesser in sense that only historical data of the single variable to be predicted is required<br>▪ Skill requirement is moderate and can be used in excel also | ▪ The method do not describe cause and effect relationship between variables<br>▪ Estimates for long term period are not reliable<br>▪ The method cannot incorporate or capture the role of certain policy measures/ economic shocks/ new technology that might result in a change in the behavior |
| **Econometric method** | ▪ The method considers the casual relationship between variables<br>▪ It provides good estimates of forecasts across forecast horizon<br>▪ The method is suitable for short, medium and long term forecasts<br>▪ The econometric method is flexible and can be carried for differently for short/medium and long term forecast by selecting different independent variables | ▪ In some cases, no causal relationship might be found upon which other techniques have to be used<br>▪ A drawback of the method is its dependence on the forecast of the independent variables<br>▪ Skill requirement is high as knowledge of statistics is required<br>▪ The method requires more data in comparison to other methods as additional data of independent variables is required. |
| **End Use Method** | ▪ The method is used to estimate demand from specific industries or to ascertain new loads | ▪ The method may lead to a mechanical forecasting of demands. Hence sector knowledge and application of judgement is important |

- It can be used to ascertain impact of new technology when no historical data is available or to understand behavioral change
- End use doesn't require high skill in gathering data and is not data intensive

- The method faces challenges due to non-cooperation from the target end user
- It also does not factor in the variations in the consumption patterns due to demographic, socio-economic, or cultural factors

There are various other advanced methods and techniques that can be used for demand forecasting and which are currently employed across the world. These include- Artificial Neural Networks, Fuzzy systems, simulated annealing, Hybrids etc. As of now, only few firms and educational institutes like IITs have the requisite expertise in using these techniques in India.

## 2.4.3. Demand forecasting

Central Electricity Authority (CEA) is the nodal agency that undertakes demand forecasting of power for the country in all India level, regional level, state level as well as the distribution utility level. It conducts the Electric Power Survey (EPS) periodically. CEA has been using PEUM for making the projections in power demand. In the 18$^{th}$ EPS published in December 2011, Econometric techniques were also being used to validate the forecasts. PEUM method that has been in use by the CEA is basically a bottom-up approach. The 19$^{th}$ EPS also uses the PEUM to undertake the demand forecasting. The forecasting categories that are adopted include- Domestic, Commercial, Public lighting, irrigation, industrial, railways etc.

### 2.4.3.1. Electric Power Survey (EPS) by CEA

The 19th Electric Power Survey Committee was constituted by CEA in June, 2015 and the Committee decided to undertake the electricity demand forecast of Distribution Companies, Mega Cities and National Capital Region and also the electricity demand forecast by Econometric Method. The Volume-1 of the 19th Electric Power Survey Report, currently published, covers the electricity demand forecast of Distribution utility s/States/UTs/Regions and for the country.

The basic objective of the 19$^{th}$ EPS is given as under:

- To forecast the year wise electricity demand for each Distribution utility, State, Union Territory, Region and all- India in detail up to the end of 13th Plan i.e. for the years 2016 -17 to 2021 -22. The category wise forecast at the distribution utility level has also been provided.

- To project the perspective year wise electricity demand for 14$^{th}$ plan i.e. from 2021-22 to 2026-27 and the terminal years of 15th & 16th five year plans i.e. year 2031-32 & 2036-37.

#### 2.4.3.1.1. Methodology adopted by CEA

#### Partial End Use Method (PEUM)

The following broad methodology has been adopted by CEA for the electricity demand forecast in the 19$^{th}$ EPS:

- CEA has continued with the usage of PEUM as the base method for demand forecasting. The PEUM is a combination of time series and end-use methods with higher weights given to short term so as to consider recent trends.
- Energy consumption of each Distribution utility was worked out by PEUM method by forecasting for each categories using the past trends. The forecast was refined by incorporating recent trends and policy initiatives.
- The energy requirement of each Distribution utility was worked out by adding the corresponding Transmission losses (intra-state) and Distribution losses considering the projected reduction in the losses

- The total energy consumption of the state was worked out by aggregating the energy consumption forecasted for each Distribution utility present in the state
- The total energy required of the state was worked out by aggregating the energy required by the Distribution utility s in the state
- The Peak demand of the Distribution utility was worked out by assuming a suitable load factor which was arrived based on trend analysis
- The Peak demand of the State was obtained by applying suitable diversity factor to the peak demand of the Distribution utility
- The total energy projected for the state was then grossed up with inter-state/ regional transmission losses to arrive at the ex-bus energy requirement for the state

## Impact of Policy initiatives considered in the EPS

The power sector saw numerous policy initiatives being brought out by the Government in order to improve the power situation in the country. The EPS has considered the policy measures in the final forecast by way of suitable assumptions. The methodology adopted for major policy and programs are given as under in brief

- **Reduction in AT&C losses**
  The targeted trajectory to reduce losses is to about 13% by the year 2021-22 on an all India basis. However the on ground AT&C loss of the Distribution utilities are on the higher side. Hence in the EPS, the trajectory submitted by the Distribution utilities has been considered to arrive at the energy required.

- **DSM, Energy Conservation and Efficiency improvement programs**
  The impact of various efficiency programs like Standards and Labelling, Perform Achieve Trade (PAT) scheme in Industries, LED distribution program etc. would lead to overall reduction in the energy requirement and peak demand. The impact of such initiatives has been factored in the EPS.

- **Power for All (PFA) initiative**
  The Government of India PFA initiative aims to connect all un-electrified consumers by the year 2019 and to provide quality and uninterrupted power to all. Since the initiative would result in growth in the demand for power for the shorter term, the same has been considered in the EPS.

- **Dedicated Freight Corridor**
  Based on the freight corridor and railway electrification plan, the impact of increased demand for power has been considered.

- **Make in India**
  Since the initiative is to encourage manufacturing of products in the country, there will be increased demand in the commercial and industrial sector. The same has been incorporated by the Distribution utility s in their forecast that has been submitted to CEA.

- **Roof Top Solar programme**
  The policy for Renewables has set a target of 40 GW to be installed in the solar rooftop program by the year 2022. This will be a substantial addition and would lead to some of the local demands being met from the energy that will be generated locally leading to lesser demand on the grid.

- **Electric Vehicles (EV)**
  The growing push for EV (e-rickshaws, 2-3-4 wheelers etc.) and the green mobility programs should lead to an increase in power demand requirement. However, as per the estimates of CEA, the net addition would be under manageable limits even if the targets of the Government for EVs are met.

- **Captive Power pants**
  From the historical trend, it has been observed that the CAGR of energy consumed from captive power plants from the period 2010-11 to 2014-15 is about 8.7%. It has been assumed that in the future, there will be improvement in the supply from the grid due to which the demand for captive plants will decrease. About 15% up to 2021-22 and 25% by 2026-27 could be replaced by electricity from the grid gradually.

## Methodology adopted by CEA for individual categories

The projection for the period up to 2026-27 has been carried out based on various consumer categories. The methodology adopted in each is briefly given in the following:

- **Domestic**
  The forecast for the domestic category has been arrived at by considering the number of consumers during the mid-year for each year and the specific consumption (average power consumption per consumer). Considering the PFA programme, all the households have been considered by the year 2018-19. The specific consumption has been worked out using historical trends and with suitable assumptions for increased supply hours, improvement in economic conditions, efficiency programs etc. A marginally increasing trend has been considered.

- **Commercial**
  The consumption for the category has been estimated by considering the number of consumers during the mid-year for each year and the specific consumption (average power consumption per consumer).

- **Public Lighting and Public Water Works**
  The consumption in the category has been projected based on the connected load and the average consumption of connected load or supply hours. The estimations are totally assumptions based as the inputs like connected load and supply hours have been worked out as per assumptions.

- **Irrigation**
  The power demand for irrigation has been worked out by projecting the number of pumps in mid-year, the average capacity of each pump and the average consumption per load or hours of operation with assumptions. The demand for lift irrigation has been considered based on the end use worked out based on the programme of development of lift irrigation schemes indicated by Distribution utility s/ State Authorities.

- **Industry**
  For projecting the demand from the industrial sector, CEA relied on the historical trends and the end use data. For LT Industries and HT Industries with less than 1 MW load, the projection were based on historical trends. For HT industry with more than 1 MW, the end use data submitted by States/ Distribution utilities etc. were used to arrive at the projections.

- **Railway Traction**
  The estimates for Railway have been carried out based on the existing requirement and the track electrification programme envisaged by Ministry of Railways/Railway Board.

- **Bulk Non-Industrial HT Supply**
  The bulk demand for major institutions, Government and Private establishments, defense etc. has been considered as per end use demand forecasted by the Distribution utility s. Bulk supply also includes supply to Distribution Licensees, which have been considered as point load by the main Distribution Licensee, open access consumers and SEZ's.

## Methodology adopted for other major parameters

Once the projections for individual categories were developed, to arrive at the peak demand and to determine the overall energy requirement, major parameters like Load Factor, Diversity Factor, T&D Loss etc. were suitably projected and considered. The section below provides a brief about the methodologies adopted:

- **Transmission and Distribution loss**
  The T&D loss has been considered as per the trajectory submitted by the Distribution utilities. However, the Distribution utilities were not able to segregate the transmission and distribution losses at their end, hence the intra state Transmission losses were also considered with the loss of the Distribution utilities. The total Intra State T&D loss for the state will be the sum of the Intra State T&D loss considered for each Distribution utility. The interstate T&D loss has been added to the energy requirement of the state to arrive at the energy requirement for the state at the ex-bus of generating end.

- **Load factor**
  As given in the EPS, the load factor depends on the consumers mix and the pattern of utilization of the load. Before estimating the future load factors for individual states, CEA carried out a detailed analysis to ascertain the influence of load mix on the load factor. However the details of the analysis and the results are not mentioned in the EPS.

- **Diversity factor**
  The energy requirement for the country has been worked out by aggregating the energy requirements of all the states. Peak demand on all India basis has been calculated by taking diversity factor among the regions. CEA has provided the region specific diversity factor arrived as per trend analysis.

## 2.4.3.1.2. Demand Projections as given in EPS

The 19th EPS provided projections for All-India, Region wise, State and up to the Distribution utility level for the period FY 2016-17 to FY 2026-27. The projections included energy consumption, energy requirement, peak demand, T&D losses etc. The projections for the period also includes category wise consumption at the Distribution utility level.

For the period beyond 2026-27, CEA has provided perspective demand projections for the terminal years 2031-32 and 2036-37 up to the state level.

## Electricity demand projection from 2016-17 to 2026-27

The electricity demand in terms of energy consumption has been forecasted category wise for each Distribution utility for each state and then aggregated to arrive at the regional and all India level forecast.

**Table 14: Projections at All-India level for the period FY 2016-17 to FY 2020-21**

| | FY 2016-17 | FY 2017-18 | FY 2018-19 | FY 2019-20 | FY 2020-21 | FY 2021-22 |
|---|---|---|---|---|---|---|
| **Electrical Energy Consumption (MU)** | 920,837 | 994,382 | 1066,989 | 1144,579 | 1222,286 | 1300,486 |
| **Electrical Energy Requirement (MU)** | 160,429 | 1240,760 | 1317,962 | 1399,913 | 1483,257 | 1566,023 |
| **Peak Electricity Demand (MW)** | 161,834 | 176,897 | 188,360 | 200,696 | 213,244 | 225,751 |
| **T&D losses** | 20.65 | 19.86 | 19.04 | 18.24 | 17.59 | 16.96 |
| **Derived load factor (%)** | 81.85 | 80.06 | 79.87 | 79.62 | 79.40 | 79.18 |

**Table 15: Projections at All-India level for the period FY 2022-23 to FY 2026-27**

| | FY 2022-23 | FY 2023-24 | FY 2024-25 | FY 2025-26 | FY 2026-27 |
|---|---|---|---|---|---|
| **Electrical Energy Consumption (MU)** | 1380,197 | 1463,505 | 1551,066 | 1644,635 | 1743,036 |
| **Electrical Energy Requirement (MU)** | 1650,594 | 1739,618 | 1836,001 | 1939,111 | 2047,434 |
| **Peak Electricity Demand (MW)** | 238,899 | 252,288 | 266,844 | 282,418 | 298,774 |
| **T&D losses** | 16.38 | 15.87 | 15.52 | 15.19 | 14.87 |
| **Derived load factor (%)** | 78.87 | 78.71 | 78.54 | 78.38 | 78.23 |

**Table 16: CAGR of the projections**

| CAGR (%) | FY 2010-11 to FY 2015-16 (Actual) | FY 2015-16 to FY 2016-17 | FY 2016-17 to FY2021-22 | FY 2021-22 to FY2026-27 |
|---|---|---|---|---|
| **Electrical Energy Consumption (MU)** | - | 8.00 | 7.15 | 6.03 |
| **Electrical Energy Requirement (MU)** | 5.28 | 6.42 | 6.18 | 5.51 |
| **Peak Electricity Demand (MW)** | 4.63 | 9.32 | 6.88 | 5.77 |

## Perspective Electricity demand projection for FY 2031-32 and FY2036-37

The perspective electricity demand in terms of energy consumption for the terminal years of FY 2031-32 and FY 2036-37 has been forecasted for each state and then aggregated to arrive at the regional and all India level forecast.

**Table 17: Perspective electricity demand for FY 2031-32 and 2036-37**

| | Electrical Energy Requirement | | | CAGR (%) | |
|---|---|---|---|---|---|
| | FY 2026-27 | FY 2031-32 | FY 2036-37 | FY 2026-27 to FY 2031-32 | FY 2031-32 to FY 2036-37 |
| **Electrical Energy Consumption (MU)** | 1743,036 | 2192,305 | 2672,302 | 4.69% | 4.04% |
| **T&D Losses (%)** | 14.87% | 13.37% | 12.37% | - | - |
| **Electrical Energy Requirement (MU)** | 2047,434 | 2530,531 | 3049,478 | 4.33% | 3.80% |
| **Peak Electricity Demand (MW)** | 298,774 | 370,462 | 447,702 | 4.40% | 3.86% |
| **Derived Load Factor (%)** | 78.23% | 77.98% | 77.76% | - | - |

## Comparison between 18$^{th}$ EPS and 19$^{th}$ EPS projections

The 18th EPS was published in December 2011 and projections were developed based on the prevailing situations at that time and with a view that demand will increase at a sustained rate over the years. However, the actual growth of electrical energy requirement and peak electricity demand was less as compared to the projections. The variations in the years in the shorter term was ~ 1% between the forecast and the actual. However, over the period, the difference increased and there was greater variation towards the terminal years.

The table below provides a comparison between the 18th EPS projections, the actual demand and the 19th EPS projections:

**Table 18: Comparison of Energy Requirement between 18th and 19th EPS**

| Year | 18th EPS projections (MU) | Actual Energy requirement (MU) | Difference (%) | 18th EPS CAGR (%) | Actual CAGR (%) | 19th EPS Projections | Difference 18th EPS vs 19th EPS (%) |
|---|---|---|---|---|---|---|---|
| **2010-11** | 870,831 | 861,591 | (1.06%) | - | - | - | - |
| **2011-12** | 936,589 | 937,199 | 0.07% | 7.55% | 8.78% | - | - |
| **2012-13** | 1007,694 | 995,557 | (1.20%) | 7.59% | 6.23% | - | - |
| **2013-14** | 1084,610 | 1002,257 | (7.59%) | 7.63% | 0.67% | - | - |
| **2014-15** | 1167,731 | 1068,943 | (8.46%) | 7.66% | 6.65% | - | - |
| **2015-16** | 1257,589 | 1114,408 | (11.39%) | 7.70% | 4.25% | - | - |
| **2016-17** | 1354,874 | | | 7.74% | | 1160,429 | (14.35%) |
| **2021-22** | 1904,861 | - | - | - | - | 1566,023 | (17.79%) |
| **2026-27** | 2710,058 | - | - | - | - | 2047,434 | (24.45%) |

**Table 19: Comparison of Peak demand between 18th EPS and 19th EPS**

| Year | 18th EPS projections (MW) | Actual Energy requirement (MW) | Difference (%) | 18th EPS CAGR (%) | Actual CAGR (%) | 19th EPS Projections | Difference 18th EPS vs 19th EPS (%) |
|---|---|---|---|---|---|---|---|
| **2010-11** | 122,287 | 122,287 | 0.00% | - | - | - | - |
| **2011-12** | 132,685 | 130,006 | (2.02%) | 8.50% | 6.31% | - | - |
| **2012-13** | 143,967 | 135,453 | (5.91%) | 8.50% | 4.19% | - | - |
| **2013-14** | 156,208 | 135,918 | (12.99%) | 8.50% | 0.34% | - | - |
| **2014-15** | 169,691 | 148,166 | (12.58%) | 8.63% | 9.01% | - | - |
| **2015-16** | 183,902 | 153,366 | (16.60%) | 8.37% | 3.51% | - | - |
| **2016-17** | 199,540 | | | 8.50% | | 161,834 | (18.90%) |
| **2021-22** | 283,470 | - | - | - | - | 225,751 | (20.36%) |
| **2016-27** | 400,705 | - | - | - | - | 298,774 | (25.44%) |

The comparison of projections for 18th and 19th EPS highlight that there has been a reduction in the forecast in 19th EPS as compared to that of 18th EPS. The current base year projections have been reduced by about ~ 15% and for peak demand, the projections have come down by ~ 19%. The reason for such a reduction is considering the actual situation in the country which didn't pick up as projected in the 18th EPS. The projections in the 19th EPS are also considering all the initiatives that the government as rolled out in the recent past.

## 2.4.3.2. Draft National Electricity Plan 2016

During the release of the Draft NEP 2016, the 19th EPS was under draft stage. Hence for undertaking generation and transmission expansion planning studies, demand projections were developed.

### 2.4.3.2.1. Methodology 1 – using historical growth rates and aggregating of demand of individual State/UT

The forecast of electricity consumption of all the States/UTs has been done by adopting suitable growth rate, from which the electrical energy requirement of each States/UT was obtained by adding T&D loss of the State/UT. Electrical energy requirement at all-India level was obtained by aggregating the electrical energy requirement of all the States/UTs.

Past electricity consumption data from the year 1979-80 to 2013-14 was taken from General Review Report of CEA. The effect in electricity consumption on account of Power for All, DSM, Energy Efficiency etc. were suitably incorporated. However, no detailed methodology was provided regarding the same.

The growth rates were calculated for three periods

| Groups | Data period | Reason |
|---|---|---|
| I | Electricity consumption from 1979-80 to 2013-14 | To observe overall effect of pre and post Electricity Act |
| II | Electricity consumption from 2000-01 to 2013-14 | Covers the period immediately preceding the enactment of Electricity Act, 2003 and period of reforms |
| III | Electricity consumption from 2009-10 to 2013-14 | Covers the period of latest trends of growth |

Based on the review of the growth rates, suitable growth rates were assumed to work out the future projections. The forecasts for each state/UT was worked out and then added to arrive at the all India energy consumption. The actual T&D loss considered for the year 2013-14 was taken and a reducing trend was assumed. The State/UT wise electrical consumption was grossed up with the T&D loss to arrive at the electricity requirement. The load factor was also assumed and a decreasing trend was considered for future years. The peak demand on all India basis was worked out using the load factor considered.

### 2.4.3.2.2. Projection using historical growth rates

The projections were developed as per the methodology mentioned to arrive at the electrical energy required and peak demand on an all India basis.

**Table 20: Energy requirement and peak demand an all-India basis without DSM, EE measures**

| Year | Electrical Energy requirement (MU) | CAGR (%) | Peak Demand (MW) | CAGR (%) |
|---|---|---|---|---|
| 2016-17 | 1230264 | - | 170950 | - |
| 2021-22 | 1748251 | 7.28 | 244753 | 7.44 |
| 2026-27 | 2335987 | 6.00 | 329998 | 6.15 |

The draft NEP 2016 also calculates the decrease in energy requirement and peak demand due to measures such as DSM, Energy Efficiency and conservation factors. Since the detailed calculation has not been provided regarding the assumptions taken, hence it is difficult to ascertain the how the values have been arrived at.

**Table 21: Energy requirement and peak demand an all-India basis with DSM, EE measures**

| Year | Electrical Energy requirement (MU) | CAGR (%) | Peak Demand (MW) | CAGR (%) |
|---|---|---|---|---|
| 2016-17 | 1204264 | - | 163673 | - |
| 2021-22 | 1611251 | NA | 235317 | NA |
| 2026-27 | 2131987 | NA | 317674 | NA |

### 2.4.3.2.3. Methodology 2 – using Regression method

In the second method, econometric technique was used to forecast the energy consumption at an all India level. Since it's a top down approach, the forecast arrived at is not after aggregation of demand from states but is at the all India level. 3rd and 4th degree Regression equation was developed with energy consumption as the dependent variable and time variables as independent variables.

**Table 22: Regression equations developed**

| Sl. | Equation | Coefficient of determination |
|---|---|---|
| 1. | Electrical Energy Consumption $= 29.01978\,t^3 - 966.933\,t^2 + 22171.28\,t + 40252.89$ | $R^2 = 0.98646$ |
| 2. | Electrical Energy Consumption $= 0.71\,t^4 - 28.85\,t^3 + 486.18\,t^2 + 8221.48\,t + 56971.26$ | $R^2 = 0.98745$ |

### 2.4.3.2.4. Projections using Regression method

The using the equations derived, the electrical consumption for every year at an all India level was calculated up to the year 2026-27. The electrical energy requirement was calculated by grossing up with the derived T&D loss. For comparison, the table also provides the projections arrived earlier using the historical growth rates.

**Table 23: Forecasts developed using both the methodologies**

| Year | Based on Growth Rate | | $4^{th}$ degree Regression equation | | $3^{rd}$ degree Regression equation | |
|---|---|---|---|---|---|---|
| | Electrical Energy Consumption (MU) | Electrical Energy Requirement (MU) | Electrical Energy Consumption (MU) | Electrical Energy Requirement (MU) | Electrical Energy Consumption (MU) | Electrical Energy Requirement (MU) |
| 2016-17 | 973237 | 1230264 | 966852 | 1222198 | 939221 | 1187270 |
| 2017-18 | 1059641 | 1328124 | 1046093 | 1311144 | 1006798 | 1261893 |
| 2018-19 | 1151273 | 1430242 | 1132498 | 1406917 | 1078884 | 1340312 |
| 2019-20 | 1246443 | 1534152 | 1226566 | 1509686 | 1155652 | 1422404 |
| 2020-21 | 1345034 | 1639854 | 1328813 | 1620078 | 1237277 | 1508478 |
| 2021-22 | 1448067 | 1748251 | 1439773 | 1738238 | 1323933 | 1598384 |
| 2022-23 | 1556000 | 1859917 | 1559996 | 1864693 | 1415794 | 1692326 |
| 2023-24 | 1668763 | 1974589 | 1690048 | 1999775 | 1513035 | 1790321 |
| 2024-25 | 1786027 | 2091826 | 1830514 | 2143930 | 1615828 | 1892386 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2025-26 | 1908486 | 2212333 | 1981996 | 2297546 | 1724349 | 1998880 |
| 2026-27 | 2036057 | 2335987 | 2145110 | 2461105 | 1838771 | 2109639 |

## 2.5. Summary

The findings in the chapter 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<br>▪ Four scenarios developed<br>▪ 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<br>▪ 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<br>▪ Partial end use and econometric method |
| | Upto FY 2027 | NEP by CEA | Top down | ▪ National level supply side planning<br>▪ 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.

# 3. Linkage between primary energy and power demand

## 3.1. India: Current energy scenario

The growth in India's economy has led to an ever increasing demand for energy in the country. As per the India Energy Outlook report 2015 of International Energy Agency (IEA), the primary energy demand of India has doubled since the year 2000. Even though India has consistently improved upon the energy intensity, it is still below the global average and in comparison with developed nations. The tables below highlight the energy intensity for India and that of other nations.

**Table 24: Energy Intensity[9]**

| Country | Energy Intensity (Kgoe/US$) |
|---|---|
| United Kingdom | 0.102 |
| Germany | 0.121 |
| Japan | 0.125 |
| Brazil | 0.134 |
| USA | 0.173 |
| China | 0.283 |
| India | 0.191 |

Energy is linked to the standard of living of citizens of any country. With nearly 304 million Indians without access to electricity and energy access still a distant dream of many millions in the country, it may be acknowledged that the country has a long way to go on securing its energy security objective. For India with an ever growing population and with an aim to be a developed country, it is of utmost importance to have focused efforts towards the energy sector. The recently published Draft National Energy Policy (NEP) aims to chart the way forward to meet the Government's recent announcements in the energy domain. The Government plans to electrify all the census villages, and achieve universal electrification with 24x7 electricity by the year 2022. The share of manufacturing in our GDP is to go up to 25% from the present level of 16%, while the Ministry of Petroleum is targeting reduction of oil imports by 10% from 2014-15 levels, both by 2022. As of July 2017, around 18% of the villages are still to be electrified. Other notable targets are to achieve reduction of emissions intensity by 33%-35% by 2030 over 2005, achieving a 175 GW renewable energy capacity by 2022, and to have a share of non-fossil fuel based capacity in the electricity mix at above 40% by 2030.

India at the current situation is at the cusp of a change with multiple factors and policy reforms affecting demand and supply scenario. The pace has picked up and needs to be sustained over time. The country at present offers tremendous opportunities and scenarios. The road ahead will depend on which scenario will be followed.

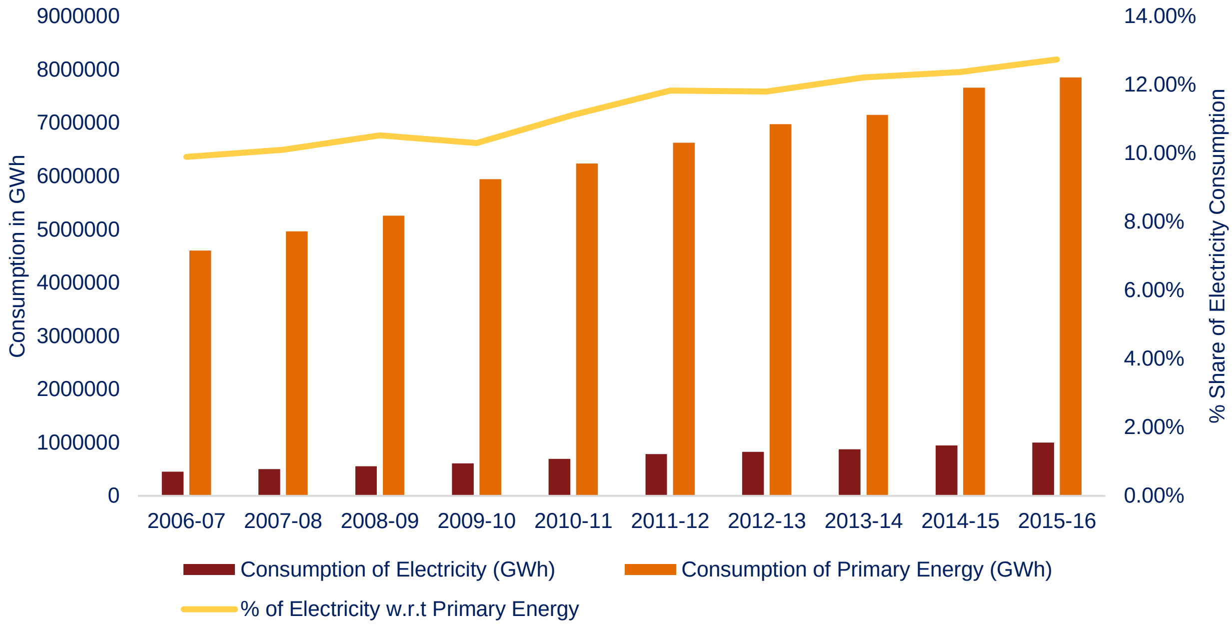
## 3.2. Historical linkage between Primary Energy and Power demand

Primary energy consists of the energy derived from primary sources like coal, oil, natural gas etc. whereas electricity is a secondary energy formed after conversion from primary energy sources. Primary energy can be conventional and renewable. The use of primary energy as a measure ignores conversion efficiency. Thus forms of energy with poor conversion efficiency, particularly the thermal sources, coal, gas and nuclear are overstated, whereas energy sources such as hydro which are converted efficiently, while a small fraction of primary energy are significantly more important than their total raw energy supply may seem to imply.

Historical data highlights a linkage between primary energy and electricity demand and over the period, the share of electricity has been growing at a steady rate. The figure below highlights the trends in consumption of Primary Energy and specific to electricity as such.

[9] World Energy Outlook 2011

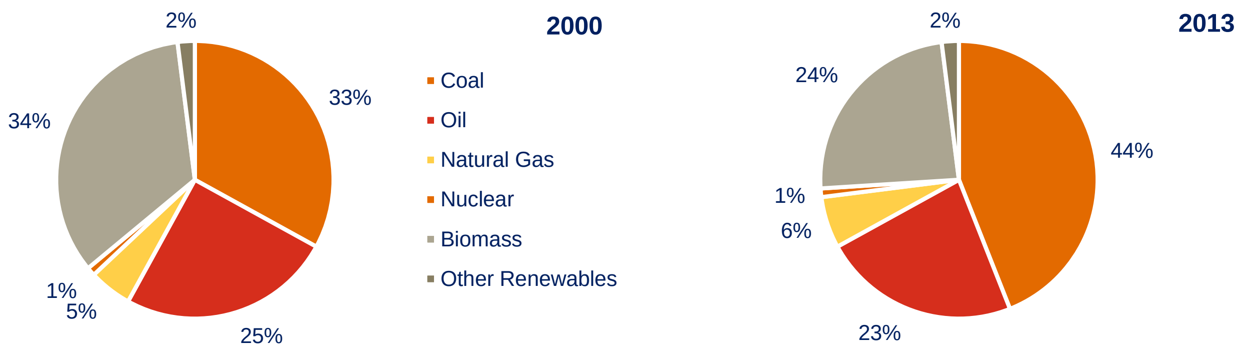
**Figure 18: Consumption of Energy and Share of Electricity in Primary energy consumption[10]**




From the figure above, it is observed that there has been a steady rise in the share of electricity consumption in the past ten years from around 9.90% in the year 2006-07 to about 12.75% in the year 2015-16. Considering the trend it can be safely extrapolated that the trend will continue in the future also. With the recent push from the Government in the energy sector and with the targets of the Government for providing access and quality power, the share is bound to increase.

From the supply side, around three quarters of India's primary energy needs is met by fossil fuels, amongst which coal is the primary source followed by petroleum. With the increase in demand, the dependence on coal has also increased with coal contributing to 44% of the energy mix in 2013 from about 33% in the year 2000 as shown in the figure[11] below. Over the same period, oil and natural gas has maintained a constant share of ~ 30% of the energy mix.

**Figure 19: Primary demand by fuel**




On the demand side, since nearly 70% of the electricity generation capacities are still linked with coal as a primary source, the increased requirement of coal can be attributed to the electricity demand which has also consistently grown over the years. The demand for electricity is bound to increase over the years and most of it will be met with the coal only. With current all India PLF of plants at around 57.43%[12] as on June'17, it is important to note that the increasing demand will be met first by utilizing the available capacity before new plants are being planned.

[10] Energy Statistics 2017, MoSPI
[11] India Energy Outlook, IEA
[12] CEA Power Sector, June'17

Also with increasing share of renewables in the generation capacity and Government commitment in the COP21 regarding cutting of emissions, the share of fuel in the primary energy pie may undergo some changes.

## 3.3. Effect of New influencers on the Power sector

There are several factors which impact the overall electricity demand in any region. Traditionally, these factors have been impacting the demand growth of electricity over the years. A growth in population directly impacts demand for electricity or any variation in weather related parameters impact the demand in any region. Therefore these factors are looked into in detail and analyzed while developing the forecasts for any region or utility. In the present study also, the impact will be studied while undertaking the forecast.

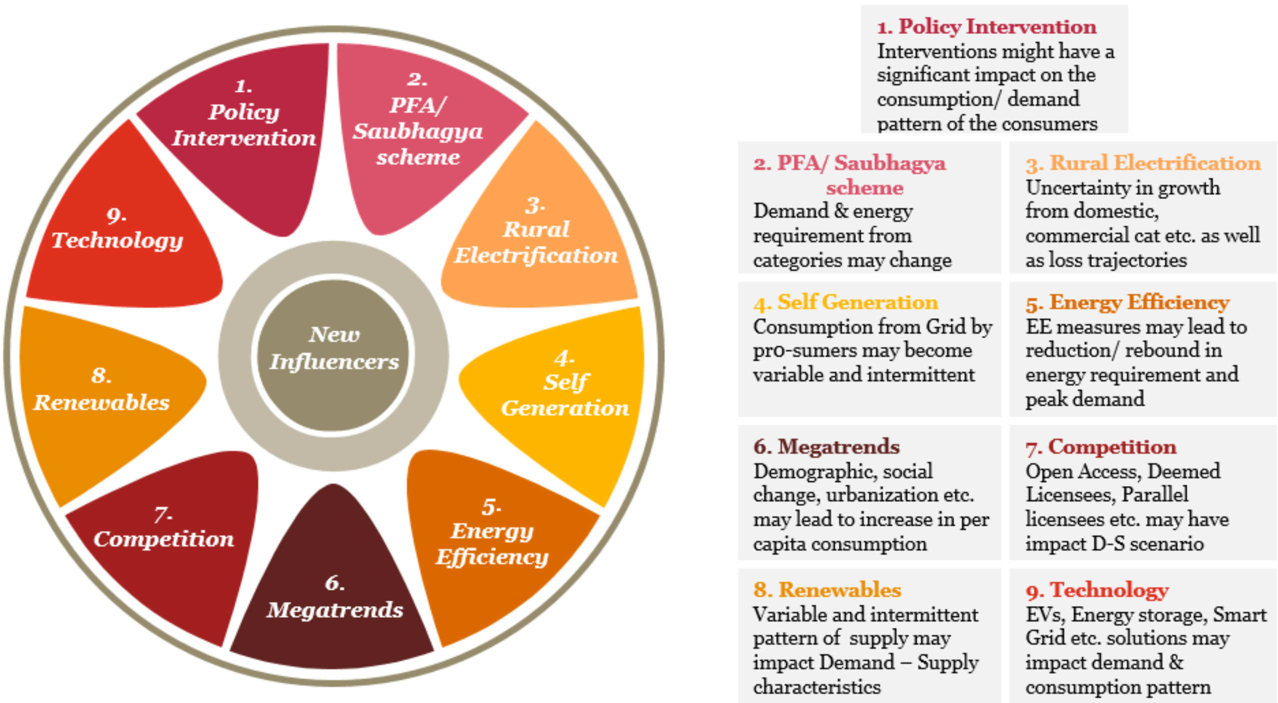
**Traditional factors which impact demand**

- Economic development
- Population growth
- Infrastructure development
- Industrial growth
- Weather related factors
- Network parameters

Other than the traditional factors, various additional factors have also been identified and it is anticipated that these new influencers would affect the demand-supply scenario of power in the country in future. Hence it is important that such factors are looked in in the present study.

The influencers have been categorized into nine broad categories and is highlighted in the figure below:

**Figure 20: New influencers expected to impact electricity demand- supply**




These identified new influencers would affect the future demand supply scenario in the country and also in the end impact the primary energy requirement in the country. The effect of the new influencers are provided below:

- **Policy interventions**
  Interventions as related to the policy guidelines of the government can have a significant impact in the demand-supply scenario of power in the country. The interventions have a direct impact on the sectors. In the past few years, the focus has been on promoting renewable energy especially solar followed by wind. Accordingly the impact is visible in terms of capacity additions and stakeholder interest that are being developed.

- **Power for All and Saubhagya scheme**
  The PFA scheme is expected to improve the entire value chain of the power sector and ensure reliable and uninterrupted electricity supply to all households, industries and commercial establishments. The target is to provide reliable and continuous power supply for all by the year FY2018-19. Power supply to irrigation and unconnected households are also supposed to increase within that time frame. The Saubhagya scheme is targeted more towards ensuring last mile connectivity in urban and rural areas and to release electricity connections to electrified households in the country. With such changes happening, the overall demand and category wise consumption patterns may increase. In order to capture the revised consumption pattern, projection of category wise consumption will be required at a circle/ sub-divisional level. The demand forecasting techniques need to incorporate specific trends at the consumer level.

- **Rural electrification**
  The scheme under DDUGJY focuses on reforms in the rural power sector through separation of feeder lines (rural households and agriculture) and strengthening of distribution as well as transmission infrastructure. As per the data available from MoP, as on August 2017, 3276 villages are to be electrified out of the targeted 18,452 villages i.e. ~ 18% of the villages are to be electrified as on date. These electrification is expected to impact the demand of electricity in the rural areas. Strengthening and augmentation of infrastructure can also impact the consumption patterns and the latent demand from the rural areas will be realized. Since these loads were not considered historically, in future it will impact the demand. With more infrastructure, the actual losses may also vary from the targets and will have an impact on the overall supply that will be required in future.

- **Self-generation**
  Earlier self-generation measures were encouraged owning to high tariffs, unreliability of power supply and some enabling regulatory provisions. Presently, there is a reform push for self-generation and also as a means for areas wherein grid has not reached. Such measures (e.g. solar rooftop) may make the consumption patterns of the households quite variable and intermittent. Increasing tariffs may make consumers shift to a more cost-saving self-generation measures. The consumer of the past may become a pro-sumer. With evolving and enabling regulatory provisions of net metering and upcoming focus on storage solutions, a major demand from the DISCOMs is expected to be reduced in future.

- **Energy efficiency**
  Energy efficiency is expected to reduce the electricity demand and peak load. However, research has suggested that the behavior of households are different then what is expected while designing the policies. The effect is known as the rebound effect in energy efficiency. Similar situation may also happen in India though it is early to arrive at any conclusions. Also, though energy efficient appliances are purchased but are not used instantly and most of it are kept as spare. So the impact is no directly related to the purchase of an appliance but pertaining to its usage. Hence, an overall assessment will have to be made to ascertain the impact of energy efficiency.

- **Megatrends**
  Various evolving megatrends can be seen in the economy today. Some of these trends can have an influence in altering the demand-supply scenario. Some of these megatrends include population growth and other demographic changes (e.g. increase in share of young people changing the population structure), social changes, economic growth and development, rapid urbanization (e.g. penetration of international lifestyles among middle classes), shift of population from rural to urban areas and increase in the living standards of the people.

- **Competition**
  With the changing dynamics of the power sector, competition is set to rise. Few features of competition include open access, parallel licensees, deemed licensees (Railways, SEZs) and local decentralized

energy systems. With consumers shifting to open access, the power demand of the distribution licensees would change. Also, with increase in competitive environment owing to better pricing and procurement policies, the distribution licensees would be required to plan their procurements in an effective way.

- **Renewable energy**
  The total installed capacity of renewable power is 58.3 GW as on June 2017 and it is projected to achieve an installed capacity of 175 GW by the year 2022. The increase in capacity of renewables will affect the demand supply scenario in the country and also affect grid operations. Due to the inherent seasonal/daily variation in generation from the renewable sources, consumption patterns of consumers may be impacted. For example, the generation of wind power is highest during the summers and solar power is directly available only during the daytime. With new technologies like solar roof-top and expected increased penetration of Electric Vehicles (EV), the consumption behaviors may undergo changes.

- **Technology – EV, Storage solution, Smart Grid, RE Hybrids etc.**
  Technology is evolving and continue to make its mark in the power sector. In the near future, technologies such as smart grids, advanced metering, energy storage solutions, RE hybrids and electric vehicles are expected to play a greater role in the power sector in the country. The increase in efficiencies due to technological interventions and subsequent fall in prices of energy storage solutions may change the demand patterns of consumers by increasing the scope for self-generation. The storage solutions is also expected to play a critical role in grid stability with increased penetration of renewables in the Grid. Further, the complimenting nature of generation from solar and wind sources on an intraday as well as on annual basis presents RE hybrids as a potential solution to the large scale grid integration of renewables. The Government's evolving policies aim at EVs playing a greater role in mobility as well as storage solutions and for developing the EV charging infrastructure. The advent of the technologies highlighted is expected to impact the power demand in the future. However the exact impact on power and primary energy can only be gauged based on the strategic directions which are considered now.

The new influencers identified in this chapter is expected to change the existing demand supply scenario and hence it is essential that the impact is captured in the forecast. The subsequent chapter deals in detail about overall alternate methodology proposed for the study.

## 3.4. Effect of New Influencers on the Primary Energy

Since there is a direct linkage between the power demand and primary energy, any impact in the power demand will affect the primary energy in terms of change in the primary energy mix of the future or in the overall requirement. With increasing demand over time, there will be an overall and continuous increase in the primary energy requirement. But the new influencers identified will affect the mix of the primary energy and how the increased energy requirement will be met in the future. The change in the share of energy sources will mean an interplay between the sectors.

Considering the case of increased EV penetration expected in the future, there will be demand for power to meet the charging needs. During day time, more power will be required to meet the increased day time commute. This demand for power may be met by increased generation from renewable sources e.g. solar which peaks during day time. In case, the renewable fueled charging stations draw the requisite mount of power from non-conventional sources during the substantial period of the day, the demand for power from conventional sources would be less in future thereby lesser coal will be required. This highlights the effect of one sector on another wherein an expected increased demand is being met by an increase in share of renewables thereby reducing the dependence on the existing dominant sources. This interplay between the sectors has a direct impact on the primary energy mix and the requirement of energy in the future.

## 3.5. Expected linkage between Primary energy and power demand

In June 2017, NITI Aayog has released the draft Energy Policy, 2017 wherein the future of India in terms of Energy were outlined. As per draft policy ***"the energy demand of India is likely to go up by 2.7-3.2 times between 2012 and 2040 with the electricity component itself rising 4.5 fold".***

NITI Aayog has developed the India Energy Security Scenarios 2047 wherein projections have been done both from a supply and demand perspective considering possible scenarios like as business as usual and ambitious scenarios. The as usual scenario is considering the current conditions and the ambitious scenario considers future efficiency improvements and is cleaner and sustainable.

Some of the assumptions considered in developing the scenarios are

- GDP of the economy is assumed to grow at a CAGR of 8% between 2012 and 2040
- The Population will grow from 1.2 billion to 1.6 billion
- Attainment of development ambitions like Power for All by 2022, Housing for All by 2022, 100 Smart Cities, 175 GW Renewable capacity by 2022
- In developing the two scenarios, different efficiency levels and technological measures were considered which will lead to variation in the final projections

The supply side projections are for primary energy sources like Coal, Oil, Gas, Renewable and others etc. whereas the demand side projections are considering various broad sectors like Industry, Buildings, Transportation, Telecom, Cooking, Pumps and Tractors etc.

Based on the projections, the share of electricity in energy demand has been arrived as given in the following

**Table 25: Share of electricity in primary demand**

| | 2022 | | 2040 | |
|---|---|---|---|---|
| Scenario | As usual | Ambitious | As usual | Ambitious |
| Share of electricity in primary energy demand | 19.6% | 20.4% | 23.2% | 26.1% |

The supply scenario has also been developed considering that the energy demand works on the principles of a reduction in import dependence, and a transition towards cleaner and sustainable supply options. The future scenarios have also considered increased penetration of renewables, lower dependence on oil and coal, possibilities of storage facilities, improvement in gas situation etc.

The following table provide the primary energy supply for three years namely 2012, 2022 and 2040.

**Table 26: Share of primary energy under two scenarios in 2022 and 2040**

| Sources | 2012 | 2022 | | | | 2040 | | | |
|---|---|---|---|---|---|---|---|---|---|
| **(TWh)** | | As usual | % Share | Ambitious | % Share | As usual | % Share | Ambitious | % Share |
| Coal | 3281 | 6021 | 50% | 5529 | 49% | 11320 | 50% | 8433 | 44% |
| Oil | 1936 | 3024 | 25% | 2762 | 24% | 6036 | 27% | 4883 | 25% |
| Gas | 570 | 1018 | 9% | 1016 | 9% | 1762 | 8% | 1788 | 9% |
| Renewable & Clean energy | 266 | 797 | 7% | 823 | 7% | 2010 | 9% | 2602 | 13% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Others | 1060 | 1108 | 9% | 1152 | 10% | 1351 | 6% | 1626 | 8% |
| **Total** | **7113** | **11968** | | **11282** | | **22479** | | **19332** | |

The scenarios developed highlights the possible change in energy mix which may happen under current conditions and with more efforts i.e. the ambitious condition. In the shorter period upto 2022, the will be increase in share of coal from the current situation even if ambitious scenario were to take place. This is majorly to meet the increased electricity demand in the country. Post year 2022, if the share of renewables increase in the primary energy, then there is a possibility of coal share going down. The other energy sources namely Oil and Gas will hold their share in the fuel mix even with both the scenarios.

The projections and expected linkages highlighted in the sections above for various sectors are based on assumptions and scenarios. The scenarios being developed have been aggregated based on current demand supply situation, considering the various initiatives that the government has planned to implement and with some foresight into how the sector might evolve into the future. The reports available in the public domain published by Government and other agencies over time have projected the energy requirements of the country. However, with time, the assumptions change and scenarios have developed while maintaining with the stance that from the demand side there will be growth in the primary energy and electricity consumption in the country.

On the supply side, there is expected to be variation in the energy mix and share of energy from the primary fuel. World over, there has been a trend towards reduction of dependence on fossil fuels and move towards a regime where renewables have a greater share. However, India traditionally being dependent on fossil fuels will have tougher task at hand in reducing the share of fossil fuels. While recent efforts of initiatives towards renewable energy, energy efficiency and government commitments to the international forum for climate change has gained momentum, a lot is to be done in order to change the status quo.

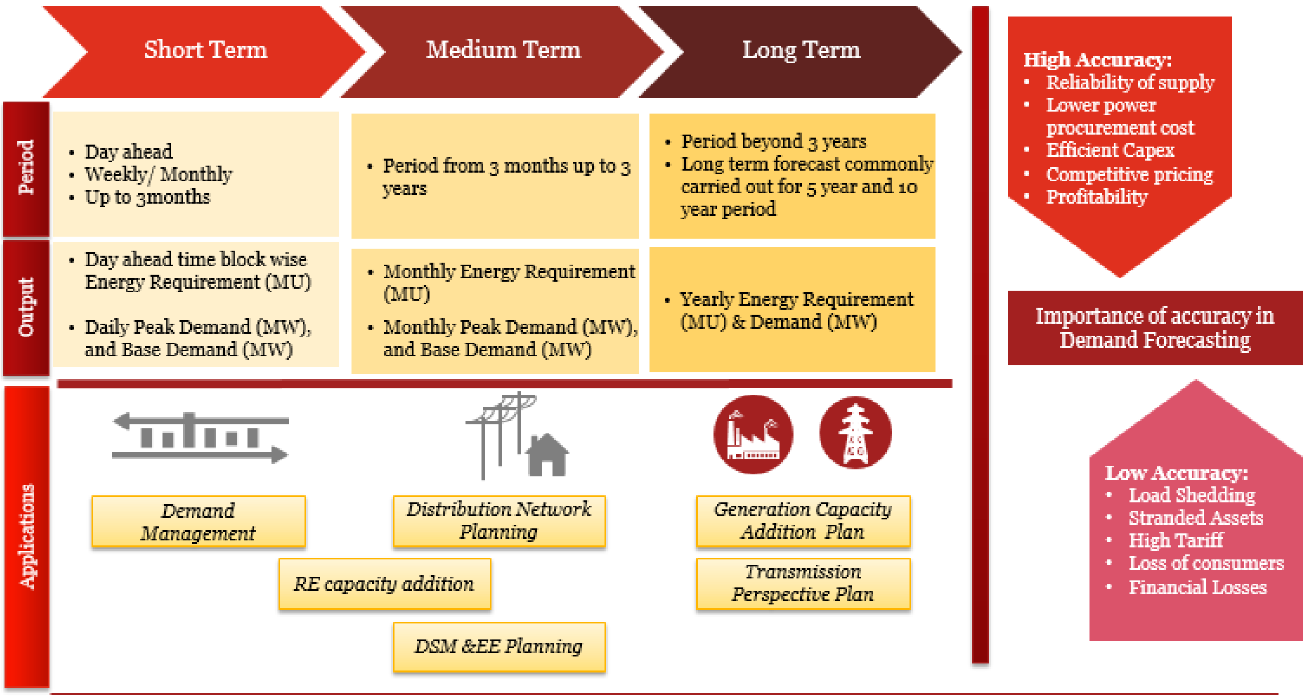
# 4. Gaps in existing demand assessment and forecasting methodologies

Over the last half decade, the Indian power sector has witnessed a few success stories and has undergone dynamic changes. However, the road ahead is entailed with innumerable challenges that result from the existing gaps between what is planned and what the sector has been able to deliver. Demand forecasting of power, thus, has a significant role in trying to minimize these gaps.

The subject of forecasting has been in existence for decades. It involves accurate prediction of future power demand (magnitude as well as geographical location specific) over different planning horizon. Demand assessment is an essential prerequisite for planning of generation capacity addition and commensurate transmission and distribution system required to meet the future electricity requirement of various sectors of the economy. The type and location of power plants is largely dependent on the magnitude, spatial distribution as well as the variation of electricity demand during the day, seasons and on a yearly basis. 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 is forms the basis for the development and optimization of power portfolio across various term time horizons and for planning the network infrastructure to cater to the growth in demand as well as other requirements such as loss reduction and technology upgradation. While definitions of time horizons vary according to application and agency undertaking the forecast, broadly forecasting is undertaken in three time horizons viz. short term, medium term and long term. The following diagram provides a brief overview of the periodicity and application of electricity demand forecasting:

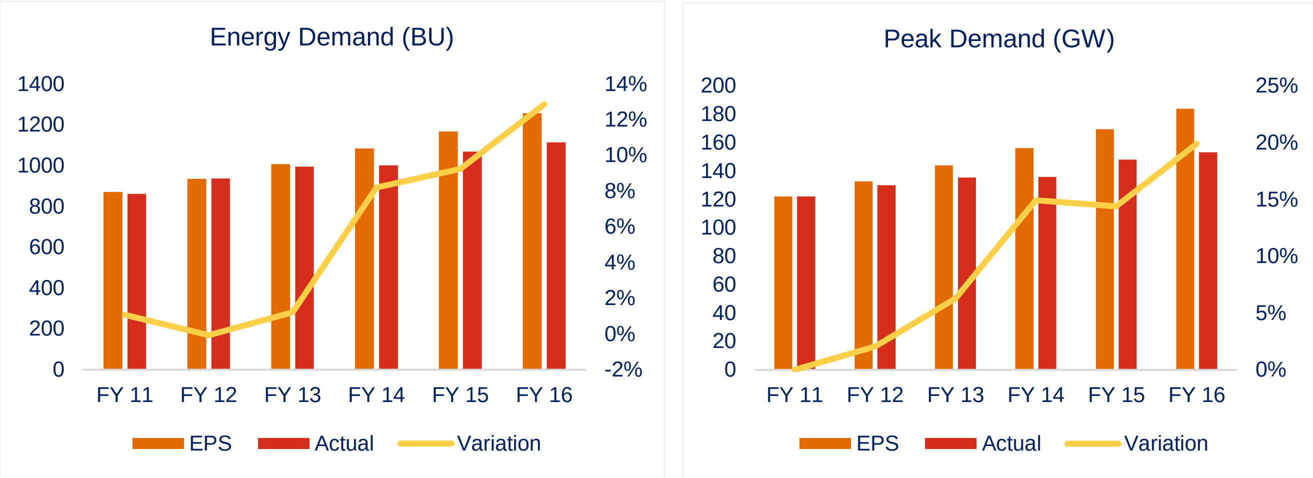
**Figure 21: Periodicity and application of demand forecasting**




Errors in forecasting can lead to bad planning which may be costly. Too high forecasts lead to more power plants and transmission resources than is required – high burden of cost of capital. While on the other hand, low forecasts prevent optimum economic growth and may lead to the installation of many costly and expensive-to-run generators (having short gestation period). These costs are ultimately borne by the consumers.

A glance at the projections made by the CEA in the 18th EPS for the 12th five-year plan viz. FY 2011-12 to FY 2016-17 indicate the year-on-year widening gap between forecast and actual. As indicated in the following figures, the variation between the projected demand and the actual demand has shown an increasing trend.

**Figure 22: Variation between the projected demand in 18th EPS and actual demand**




Source: 18th EPS; LGBR

As can be seen from above graphs, the variation between projected demand, as per EPS projections and the actual demand has been more than 20% overall.

The variation between what is projected and the actuals may be dependent on various factors like economic conditions, methodology adopted, forecasting technique used, data reliability, usage of growth and other input factors etc. Hence, going forward, there is a need to review and identify the same.

The details of the gaps identified are structured into three sections. First, the gaps are identified for the methodologies that are commonly used to forecast power demand in India. Second, gaps due to economic conditions have been shown and finally specific gaps pertaining to methodologies employed in draft NEP 2016, 19th EPS and draft Energy Policy 2017 are given.

## 4.1. General gaps identified based on review of commonly employed methodologies in India

Among the various methods that exist in the context of demand forecasting, three methods are most widely used in case of electricity demand forecasting in India. These are – trend or time series, econometric and partial end use method. The prevailing time horizons for demand forecasting are short term (upto 1 year), medium term (1 to 5 years) and long term (beyond 5 years) as per the requirements of the forecaster. The decision of selecting a forecasting technique and methodology to be adopted depends on a lot of factors, few being the extent of data availability, the applications of the forecasts, the accuracies intended and the level of effort one is willing to put.

Based on the review of the common methodologies and forecasting techniques used currently in India, the following section provides a list of gaps which have been identified:

- **Granularity**
  The 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/ circle level) for better understanding of the behavior and trends and for higher accuracy of the results.

- **Non-availability of accurate data**
  The reliability of any methodology depends on the availability and accuracy of data on parameters. Availability of data is the biggest hindering factor for carrying out the forecasts. Few of the issues with data are:
    - Data is not at all available
    - There is no process in place for data collection
    - Data is not accessible
    - Data is available but not in any standard formats thereby has limited usage
    - Available data is unreliable
    - Collected data requires extensive validation checks

  With unavailability of required data, the methodologies developed are based on assumptions.

- **Improper assessment of parameters**
  The projections rely to a great extent on the estimations and assumptions of certain parameters. Sometime the assumptions are not based on proper assessment of data but on unrealistic targets. The use of such assumed parameters greatly affect the demand that is forecasted. The assumptions considered for losses like T&D play a major role in estimating the energy required and should be considered based on realistic basis rather than considering the targets.

- **Specific trends**
  The traditional forecasting methods such as time series and trend analysis may not take into account the trends that are emerging or specific trends that may affect a particular category as such.
  E.g. Addition of a single consumer in the Industrial category will have larger impact on the demand trends when compared to a similar change in domestic category. The same may not be captured by a historical growth trend. Hence bulk loads may have to be added. The effect of the changes in demand due to schemes like PFA, improvement in power supply, energy efficiency and self-generation etc. may not be captured by conventional techniques alone.

- **Lack of sensitivity**
  There is a lack of sensitivity of the commonly used load forecasting techniques towards changes in weather parameters, customer mix, characteristics of an area, GDP growth etc. The techniques used mostly provide straight line and point results.

- **Assumptions about factors**
  Forecasting is undertaken for a long term based on assumptions and assumptions change within the forecasted period. The results of econometrical models rely on the assumptions and forecast of independent variables. The higher the assumptions in a forecast, the higher the chances of variation with the actual result.

- **Scenario models**
  The forecasting methods should be able to take care of the assumptions made about different inputs. Different scenario models should be developed and analyzed to see how the forecast varies under different scenarios.

- **Periodicity of forecasts**
  Currently demand forecasting is carried out after a period of 5 to 10 years. Over the period the assumptions undergo changes. The exercise needs to be undertaken at shorter time period e.g. yearly,

to take into account changes in the factors affecting demand. There should also be a periodic review of the forecasted demand and forecast should be updated periodically to maintain accuracy.

- **Non-reliability of inputs**
  Reliability of the inputs is paramount before using in any forecasting exercise for accurate modelling of the behavior of electricity demand. Most of the time, the data and input variables provided are not reliable which impacts the end result. Hence it is important that the data should be considered from reliable sources and validated.

- **Seasonality and periodicity for forecast**
  The seasonality factors are not taken into account through the methodologies that are commonly used. It is known that demand for electricity varies according to seasons. For example, the demand from the domestic sector generally peaks when its summer and subsides during monsoon. During monsoon, the power demand from the agricultural and domestic sector is lower while during summer and winter power demand is higher as it is used for cooling and heating purposes.

- **Non-assessment of unmet/ Latent Demand**
  It is pertinent to note that if the demand supply gap is only on account of shortage of power, then increased availability of power to that extent should eliminate the gap or shortage. However, it has also been noted that there are scheduled and un-scheduled power cuts imposed by the Utilities on their consumers not necessarily due to non-availability of adequate power but due to transmission & distribution constraints, and poor financial health of utilities/DISCOMs making it difficult for them to purchase power from available resources. The energy and peak deficit does not include unconnected consumers. In the bid to supply reliable and quality power for each household, it is imperative to take into consideration the latent demand assuming every person has to be provided at least fair minimum amount of electricity. During forecast of demand, with improvement in economic conditions, the specific consumption in future may not be captured by the historical growth rates. Hence, emphasis should be laid on assessment of the same. The Standing Committee on Energy (2014-15) of the 16$^{th}$ Lok Sabha had also recommended the Ministry of Power to issue necessary directions to the Central Electricity Authority (CEA), for assessing latent demands of electricity in the country.

- **Non-linear relationships**
  Most of the commonly used techniques don't incorporate non-linear relationships that may exist between the dependent and independent variables. As many factors influence a demand and the impact of a factor may vary over time, it is important that non-liner relationships are modelled. Such modelling will require use of advanced methodologies and techniques. For example, temperature levels may affect energy demand in a non-linear way. This non-linearity may also be due to geographical differences or seasonal variations.

- **Inability to forecasting impact of new technologies**
  The forecasting of the future impact of new technologies is a challenge and hence assumptions and scenarios are built. The inability is also due to unavailability of specific data. Hence, assumptions are built into the models to take into account which increases the uncertainty of the forecast.

- **Combination of methods**
  No single method will provide an accurate forecast. Hence methodologies should be developed by combining forecasting techniques with other inputs derived based on assumptions and experience. E.g. CEA uses time series along with end use method to forecast power demand. Various techniques can be applied and compared in order to minimize errors and to get reliable forecasts.

- **Use of advanced methodologies**

  The methodologies used commonly are not advanced and cannot incorporate behavior of several factors. Also with large datasets, considerable time is required to prepare the data sets for using in conventional methods. However, as the complexity increases a shift towards advanced techniques and hybrid models will be required to arrive at more reliable forecasts. Few of the techniques which are used currently are:

  - Artificial neural networks are computational methods that are non-parametric, non-linear, multivariate and self-adaptive. These methods are gaining popularity due to their reliable predictions. These methods can be applied when there are huge data sets and relations between the variables are difficult to predict.

  - Majority of the load forecasting techniques are based on point forecasting where a single expected output variable is predicted. But with the changes expected in the demand-supply scenario, electricity demand is more active and less predictable. As such, probabilistic load forecasting can be quite useful. Such models can provide additional information on the variability and uncertainty of future load estimates by providing a range of forecasts. Also due to the drawbacks existing in the conventional methods (like lack of inclusion of seasonality elements) reliable forecasts are not easily available in load forecasting practice. Use of probabilistic models provides a range of forecasts with varying probabilities to get an idea of the possible future load demands

  - In hybrid models, two or more advanced techniques can also be combined for forecasting. Such hybridization could turn out to be very effective in case of load forecasting as different methods possess different advantages in solving non-linear problems. A hybridization of these two techniques can be used to incorporate the advantages of the two techniques and balance the deficiencies of each technique and the combined approach delivers better reliable forecast.

## 4.2. Gaps in forecast due to impact of economic factors

Economic factors impact the demand of electricity in a country. Hence during demand forecasting, the economic factors are reviewed and analyzed to ascertain its impact not only on the current demand but also on the forecasted demand. The development of a forecast is dependent on the type of economic condition which has been expected from now, to that period.

The gap in forecast occurs when there is a variation between the forecasted and actual economic condition. Considering the example of 18th EPS which was published in December 2011, the projections were developed based on the prevailing economic conditions at that time and with a view that demand will increase at a sustained rate over the years. However, the actual growth of electrical energy requirement and peak electricity demand was less as compared to the projections. The variation in the years in the shorter term was ~ 1% between the forecast and the actual. However, over the period, the difference increased and there was greater variation towards the terminal years.

The table below provides a comparison between the 18th EPS projections and the actual demand:

**Table 27: Comparison of Energy Requirement between 18th EPS Projections and actuals**

| Year | 18th EPS projections (MU) | Actual Energy requirement (MU) | Difference (%) | 18th EPS CAGR (%) | Actual CAGR (%) |
|---|---|---|---|---|---|
| **2010-11** | 870,831 | 861,591 | (1.06%) | - | - |
| **2011-12** | 936,589 | 937,199 | 0.07% | 7.55% | 8.78% |
| **2012-13** | 1007,694 | 995,557 | (1.20%) | 7.59% | 6.23% |
| **2013-14** | 1084,610 | 1002,257 | (7.59%) | 7.63% | 0.67% |

| | | | | | |
|---|---|---|---|---|---|
| **2014-15** | 1167,731 | 1068,943 | (8.46%) | 7.66% | 6.65% |
| **2015-16** | 1257,589 | 1114,408 | (11.39%) | 7.70% | 4.25% |
| **2016-17** | 1354,874 | | | 7.74% | |
| **2021-22** | 1904,861 | - | - | - | - |
| **2026-27** | 2710,058 | - | - | - | - |

It is worthwhile to analyze the probable causes which may have led to a difference between the forecasted and the actual values.

## 4.2.1. Overall economic scenario during the period when 18th EPS was prepared

CEA had initiated the study for 18th EPS in August 2010 and the final report was published in December 2011. The year FY 2009-10 was considered as the base year of the forecast. All the forecasts for 18th EPS were developed based on the economic scenario that was prevalent during that period and with the assumption that same shall continue in the forecast period.

CEA had finalized the forecasts for the 18th EPS with the following major assumption:

- National GDP was assumed to grow at an average rate of 8 -10% till the end of 12th plan period (FY 2016-17) and around 7 - 9% beyond that period
- All the other assumptions for the forecast were developed as per the prevailing economic conditions of the year FY 2009-10 and FY 2010-11.

The assumption considered at that point in time may have been valid on the economic front. At the beginning of the year FY 2009-10, the GDP growth was forecasted at 7.4%. Subsequently the same was revised to 8% on account of improved performance from manufacturing and services sector. According to the ‘Quick estimates of national income, consumption expenditure, saving and capital formation for 2009-10' released in the year 2011 by the Central Statistical Organization (CSO), the higher GDP growth rate during 2009-10 was achieved due to high growth in manufacturing (8.8 %), financing, insurance, real estate as well as business services (9.2 %), transport, storage and communication (15%), community, social and personal services (11.8%).

The economy continued its growth in the FY 2010-11 and the GDP registered a growth of 8.4%. The major growth happened in the transport, storage and communication sector (14.7%) followed by financing, insurance, real estate & business services (10.4%), trade, hotels & restaurants (9.0%) and construction (8.0%). The growth of secondary sector was 7.2% and that of service sector at 9.3% during 2010-11.

In these two years, the major difference was the growth in the primary sector i.e. agriculture, forestry & fishing that showed a high growth of 7.0% during FY 2010-11 as against 1.0% during the year FY 2009-10.

In view of the actual high growth achieved in the economy, the assumptions considered were also influenced by it. The assumptions held true for the forecasts that were developed for the year FY 2011-12 and FY 2012-13 as the difference between the forecast and the actual values for energy requirement for the two years are only 0.07% and 1.20% respectively. However, for the year FY 2013-14, there was a wide variation between the forecasted CAGR of 7.63% against the actual of 0.67%. The slump in the growth rate in FY 2013-14 lead to increased deviation from the forecasted values.

In the subsequent section, the reasons for slowdown in the growth rate in the FY 2013-14 has been provided.

### 4.2.2. Reasons for slow demand growth in FY 2013-14

The year FY 2013-14 was marked by an overall slowdown of the economy due to domestic reasons like policy paralysis, high inflation rate, stagnation of projects and lower manufacturing outputs etc. A host of other global issues like high crude oil prices during that period also impacted in the overall slowdown of the economy in the year FY 2013-14.

The reasons for slow demand growth in FY 2013-14 are listed below:

- **Downturn in the economic cycle:** The slowdown in the year FY 2013-14 was primarily affected by the downturn in business cycles. After achieving very high growth rates of ~ 8% in the previous 2-3 years, there was an overall slowdown in the economy. India's GDP during FY 2013-14 was registered at 4.7%.
- **Slowdown in the industrial segment:** The major factor leading to slowdown was due to low growth in the industrial sector. The industrial segment grew with an average of 0.4% per annum and there was deceleration in major sectors like steel, automobile etc.
- **Mixed growth in infrastructure:** The infrastructure sector showed a mixed trend. Sectors like power, fertilizer, railways and civil aviation showed positive growth whereas sectors like coal, steel, cement, refinery, crude oil and natural gas production witnessed lower or negative growth.
- **Decline in share of Agriculture:** The share of agriculture in GDP also decreased from 15.2% in the 11th plan to 13. 9% for the year FY 2013-14 indicating a further slowdown in the agriculture sector and a shift toward non-agriculture activities.
- **Slowdown in the services sector:** India's growth was earlier attributed to the increase in share from services sector. However in the year FY 2013-14, the sector grew at 6.8%, lower than FY 2012-13. The sector recorded slow growth due to dismal performance primarily in trade, transport and storage segment.
- **Decline in gross domestic savings (GDS):** Gross domestic saving consists of savings of household sector, private corporate sector and public sector. It is expressed as a percentage of the GDP. Since FY 12, the trend has been declining and in the FY 2013-14, the GDS was lowest at 32.1% and it again increased in the next year. Since GDS is expressed as a percentage of GDP, with lower GDP growth, the net decrease has been substantial.
- **Decline in consumer durables segment:** The segment decreased by 12.2% during FY2013-14 against a growth of 2% achieved in the previous years. This was primarily due to high inflation and interest rates which were prevalent during that time. Overall the demand for items in consumer segment was low.
- **Continued high inflation affected consumer spending:** In FY2013-14, the average WPI was around 6% but across specific commodity groups which directly affect the consumer spending, the inflation was still higher. Average quarterly inflation rate was 9.43% for food items and 10.14% for fuel and power. The overall CPI was around 9.49% in FY 2013-14. The high inflation rate coupled with higher interest rates affected the liquidity and spending power of the consumers.

The above mentioned economic factors have impacted the demand growth of electrical energy. Since, there is no conclusive evidence to establish the extent of impact of each and how much each economic factor has played a role in, the analysis is conjectural.

The next section deals with the specific gaps which have been identified on the methodologies employed in forecasts by CEA.

## 4.3. Specific gaps on methodologies employed in forecasts by CEA

### 4.3.1. Draft National Electricity Plan, 2016

The draft NEP released in December 2016 provides the power demand projections at an all India level developed using two methodologies

- One using historical growth rates
- Using regression technique

During the release of the Draft NEP 2016, the 19th EPS was under draft stage. Hence for undertaking generation and transmission expansion planning studies, demand projections were developed.

The table below highlights the gaps identified:

| Particular | Methodology adopted | Gap |
|---|---|---|
| State/UT as the base level for forecast | The draft NEP 2016 considered the overall historical consumption of each state/UT and derived the overall growth factor. | ▪ The consumption at a lower level e.g. circle/ district and category wise in a State was not considered. |
| Growth rate | The growth has been considered based on historical data for three periods and the rate with the least standard deviations was considered. The growth rate was fine-tuned after considering the actual growth during FY 2014-15 and FY 2o15-16. Subsequently, based on the growth rate adopted, the forecast for each State/UT were developed. | ▪ In a developing country, the future growth trajectory may not be consistent year on year as it is dependent on the several factors like economic performance, government policies & programs and the extent of successful implementation thereof etc. Hence, consideration of a single growth rate to forecast may not always provide an accurate forecast.<br>▪ Though historically, multiple growth rates were looked into, during the forecast, scenarios of growths have not been developed.<br>▪ The growth rates of shorter terms are ideally given more weightages so that effect in the nearer term are captured in the forecast.<br>▪ Category wise growth rate was not considered even though the demand and growth of each category is different. |
| T&D Loss | Overall T&D loss of the state was considered to arrive at the total energy required for the state. The actual T&D losses for the year FY 2013-14 has been taken as the base and thereafter the T&D losses were assumed to reduce during the period FY2014-15 to 2026-27. | ▪ The draft NEP has not mentioned the percentage reduction considered and the methodology adopted to arrive at the decreasing trend. The actual historical T&D loss values for the state could have provided a trend for a reduction in last five years. The actual data of FY 2014-15 & FY 2015-16 was not considered. |
| Effect of PFA in the demand | The draft NEP mentions that the effect of increase in electricity consumption on | ▪ Detailed methodologies and assumptions not given. |

| | | |
|---|---|---|
| | account of PFA has been suitably incorporated. | ▪ Owing to non-availability of reliable data, method of estimation for future will be assumption based on policy targets. |
| Effect of DSM, EE and Conservation Measures in the forecast | The effect of the various measures were considered in energy and peak demand at all India level but detailed methodology is not provided. | ▪ The effect of moderation, methodology adopted and assumptions undertaken were not highlighted. Data availability is a concern for such estimations. Data for total savings for the state will have to be derived based on assumptions.<br>▪ State specific savings in energy and peak demand were not highlighted in the forecast. This would have enabled better overall planning of network infrastructure. |
| Base year of forecast | FY 2013-14 has been considered as the base year. | ▪ The reason for non-consideration of FY 2015-16 as base year may be due to non-availability of data from the states. |
| Load Factor | All India load factor for FY 2013-14 was considered to arrive at the all India peak. | ▪ State specific load factors not considered to arrive at the peak. |
| Regression analysis to forecast at an all India level | The forecast of electrical energy consumption on all-India level was also worked out using regression technique with dependent variable as energy consumption and independent variables as 3rd and 4th degree time variables. | ▪ Other independent variables like Population, GDP, Per Capita Income, WPI, CPI and other macro/micro economic factors not considered to derive the regression equation.<br>▪ The Regression method was also not carried out at the state level using state specific independent variables.<br>▪ Measures like PFA, DSM, EE etc. are not considered to refine the forecast developed using Regression method. |
| Captive power generation | The methodology assumes that there will be a gradual transfer of energy consumption by industries from captive power to utility grid due to improvement in grid supply, thereby increasing the overall demand in the grid. | ▪ The assumption is not backed by state specific data. The correction in demand was not carried out considering the situation at individual states/UTs. |
| Roof Top solar | Contribution of roof-top solar installation towards reduction in electrical energy requirement and peak demand has not been considered. | ▪ The Govt. has set a target of 40GW for roof top solar program by the year 2022. The installation would affect the energy demand initially due to self-generation and usage and subsequently with storage, the peak demand will also be reduced to some extent. However the effect was not considered. |
| Effect of penetration of Electric Vehicles and storage devices | Not mentioned | ▪ Impact of the expected demand from EV and role of storage not considered in the forecasts. |

| | | |
|---|---|---|
| Base line correction of data | Not mentioned | ▪ The draft NEP doesn't clearly state the nature of historical data considered for the state. The energy consumption data from a state utility is mostly a restricted demand and a correction of the baseline data should be carried out before forecasting.<br>▪ Methodology for correction of baseline data for loss due to supply in unmetered categories, theft etc. are not mentioned.<br>▪ The forecast doesn't highlight how with up-lift of economic conditions, living standards and infrastructure development, the latent demand will be captured. |
| Scenarios considered for Renewable installed capacity | Three scenarios were considered upto 2022 i.e. 125GW, 150 GW and 175 GW. | ▪ The scenarios considered are not based on historical installed capacity or growth but based on top down assumptions. |
| Effect of bulk loads in the forecast of States/UT | Not mentioned | ▪ The effect of bulk loads on the power demand has not been mentioned. The expected bulk load addition based on Master/ Development plans of States are not included. |

## 4.3.2. 19th Electric Power Survey, 2017

The Volume-I of 19th EPS forecasts the energy and peak demand for the period FY 2016-17 to FY 2026-27 for each category of each utility and state and subsequently aggregated to arrive at the regional and for all India level. The report also provides the forecast for terminal years of FY 2030-31 and FY 2036-37. CEA has used the PEUM methodology in Volume - I of the forecast and will release the forecasts using Econometric method subsequently. In comparison to the 18th EPS wherein the base level for data and forecast was the State/UT, in 19th EPS the forecasts have been developed at the Utility level.

The table below highlights the potential gaps in the methodology adopted by CEA for 19th EPS:

| Particular | Methodology adopted | Gap |
|---|---|---|
| Distribution utility as the base level for forecast | The 19th EPS has considered the overall historical consumption of each Utility in the State/UTs and derived the overall growth factor for each category. | ▪ The consumption at a lower level e.g. circle/ district was not considered for the bottom-up approach. |
| Base data considered for forecast | The forecasts is based on the data provided by the DISCOMs for the state. Details of correction of baseline data (if any) is not mentioned. | ▪ The data available from DISCOM is a restricted data. Demand restricted due to outages (planned/unplanned), feeder interruption, losses due to thefts etc. should be considered to arrive at the unrestricted base data. The methodology for baseline correction is not clearly highlighted.<br>▪ The major gap is the non-availability of data at feeder/ circle level for the outages and if available, it is not in the standard data required format for usage.<br>▪ Reliability of data available is a major concern. |
| Periodicity of data | Annual electricity data from various utilities considered to derive forecast. | ▪ Seasonal effects and trends of demand is not considered. The reason may be due to non-availability of month wise data at category levels from all states. |
| T&D Loss | The losses for each DISCOM has been considered as per the trajectory of loss reduction by respective DISCOMs | ▪ The loss trajectory should be based on realistic estimates from actual loss data conducted through studies/ audit and not based on top down targets.<br>▪ Most DISCOM are not able to segregate commercial losses from the T&D losses.<br>▪ Determining the actual loss of a DISCOM is a data intensive and is mostly constrained by availability of reliable data at Sub-Division/ Circle level. |
| AT&C Loss | The AT&C loss reduction as agreed to by the states who have participated in the UDAY scheme of GoI has been considered in the 19th EPS. | ▪ The actual loss figures should be considered rather than agreed targets as historically there has been variations.<br>▪ Reliability of the figures quoted as actual loss might be a concern. |

| | | |
|---|---|---|
| Load and diversity factors | Suitable assumptions considered | ▪ The non-availability of data hinders the determination of actual load factor for categories. Hence assumption based approach is considered. |
| DSM, Energy Conservation, Efficiency improvement programs, Roof Top solar programme | These initiatives have been factored in the electricity demand forecast exercise | ▪ Availability of data to measure efficiency gains and units saved is a concern. Future estimations and trajectories are assumption based and subject to variation. Scenarios for efficiency gains not developed. |
| PFA/ Make in India | Initiatives would lead to growth in demand. However no methodology has been specified. | ▪ The estimations would be assumption based and won't be reliant on historical trends. |
| Electric Vehicles | Suitable growth rate has been taken into account in the demand forecast. Considering optimistic scenario, if all vehicles as per target are used, an energy of 10-12 BU will be required additionally at all India level. The batteries will charge during day time using solar generation and during off peak hours at night. So appreciable demand is not anticipated. | ▪ Estimation is assumption based. The acceptance and penetration of EVs in future will be dependent on policy push and initiatives initially. Scenarios for the impact on demand not developed. |
| End Use Method | End-use demand is affected not only by the cost of energy but also by other factors such as climatic conditions, affordability and income of the consumers, preference for end use service etc. Similarly, demand for end-use appliances depends on the relative prices of the appliances, cost of operation, availability of appliances, etc. Projection of electrical energy requirement for lift irrigation schemes, railway traction and HT industries has been done by end use method. | ▪ End use impact for other categories was not considered.<br>▪ Bulk load addition for domestic, commercial, PWW categories etc. also not considered. Growth rates based on only time as a dependent variable may not capture the effect of other factors like demand due to urbanization, impact of master/ development plans/ Smart cities etc.<br>▪ The data for expected load in future and year of commissioning of bulk loads are also not available publicly or are uncertain. |

## 4.4. IESS 2047 – analysis of the gap between demand and supply projections

NITI Aayog has developed the India Energy Security Scenarios (IESS), 2047 as an energy scenario development tool. The guiding principle behind the development is to model the likely energy pathways that might happen in the future and provide options to the user to customize and check the likely future scenarios.

The tool has been designed to develop scenarios between seven demand sectors and ten supply sources. Four default pathways of likely energy scenarios have been pre-defined in the model. However the user has the option of customizing the supply and demand sectors to develop unique scenarios.

In the IESS 2047, it has been highlighted that it is not a forecasting tool but its usage is for scenario development. The model does take into account the known/ estimated energy resources potential of the country nor does it factor in pessimistic/optimistic outlooks on policy, costs, economic growth and other assumptions. The data highlighted are also indicative and not firm estimates.

Considering the above, the tool at best generates scenarios and provides a framework to balance the energy numbers arising out of various combinations of demand and supply choices.

After incorporation of the demand and supply choices, the results in the form of energy demand and energy supply required for a particular year are shown in the tool. What is observed after freezing such a scenario is that, there is a mismatch between the energy demand and energy supply.

Broadly, the observed gap may be due to the following reasons given below. The reasons given are based on a high level assessment that was carried out on the IESS2047 tool.

- **Varied conversion efficiency of the primary energy source**

  The extent of mismatch between supply and demand may be due to conversion efficiency of the primary energy source selected by the user.

  For e.g. for a particular demand, depending on the type of scenario selected, the share of a particular supply source will be different in aggressive effort scenario than in case of a least effort scenario. In the least effort scenario, the demand will be met more from coal while in case of aggressive scenario, solar might have a greater share in meeting the same demand. Since coal and solar have different energy conversion efficiencies, to meet the same demand, the supply required will also vary depending on the type of fuel chosen which is again controlled by the scenario selected.

  In the energy flow diagram, the same is captured under the head ‘losses’.

- **Energy lost due to T&D losses**

  During energy flow from supply to demand, there will be some amount of losses due to transmission or distribution of energy. These are inherent losses which occur at every step until the energy reaches the demand side.

  In the energy flow diagram, the same is captured under the head ‘T&D losses’. The year wise T&D loss numbers are provided in the excel model, however no details have been provided for the basis of the trajectory assumptions considered.

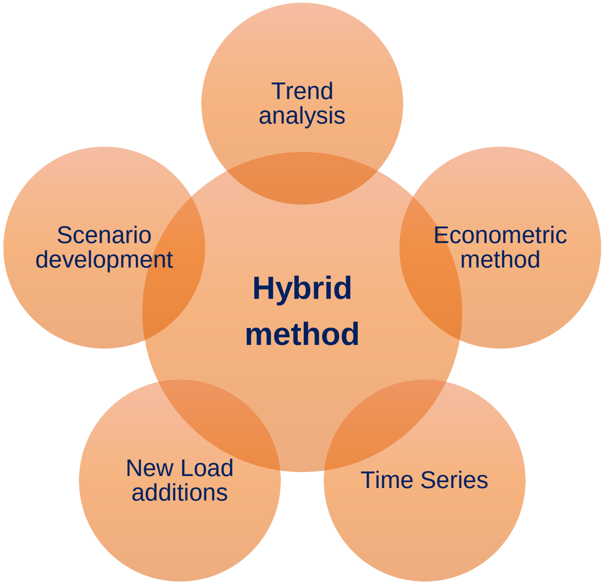
# 5. Proposed alternate approach and methodology

## 5.1. Proposed hybrid method

The review of the existing methodologies highlighted that there are inherent gaps in existing methodologies which needs to be addressed. Broadly, the gaps can be classified under the following:

- Gaps in the approach and methodology
- Gaps due to non-availability and unreliability of data
- Gaps on assessment of input factors considered
- Gaps in forecasting techniques used

In order to address the identified gaps and considering the anticipated impact of new influencers on the demand in future, a hybrid method will be required which will involve use of a number of methods.




Every method has its merits and demerits. Every method is dependent upon a set of input variables. Application of a single method for predicting demand is not possible for every consumer category (data limitations, use of too many assumptions etc.) as nature of every consumer category is different and with new influencers impacting the categories differently, the behavior will also be different. Thus for demand forecasting in the present study, hybrid method will be used wherein the available data is compiled and then on the basis of its availability, decision on use of method will be undertaken.

The hybrid method will also rely on scenario development wherein forecasts using different methods will also be developed considering probable future scenarios. This will ensure mapping of uncertainties and will result in a range of forecast.

In spite of the use of hybrid method, there may still be challenges in addressing some of the gaps e.g. pertaining to non-availability and unreliability of data. Such gaps will have to be addressed in the approach by considering suitable assumptions.

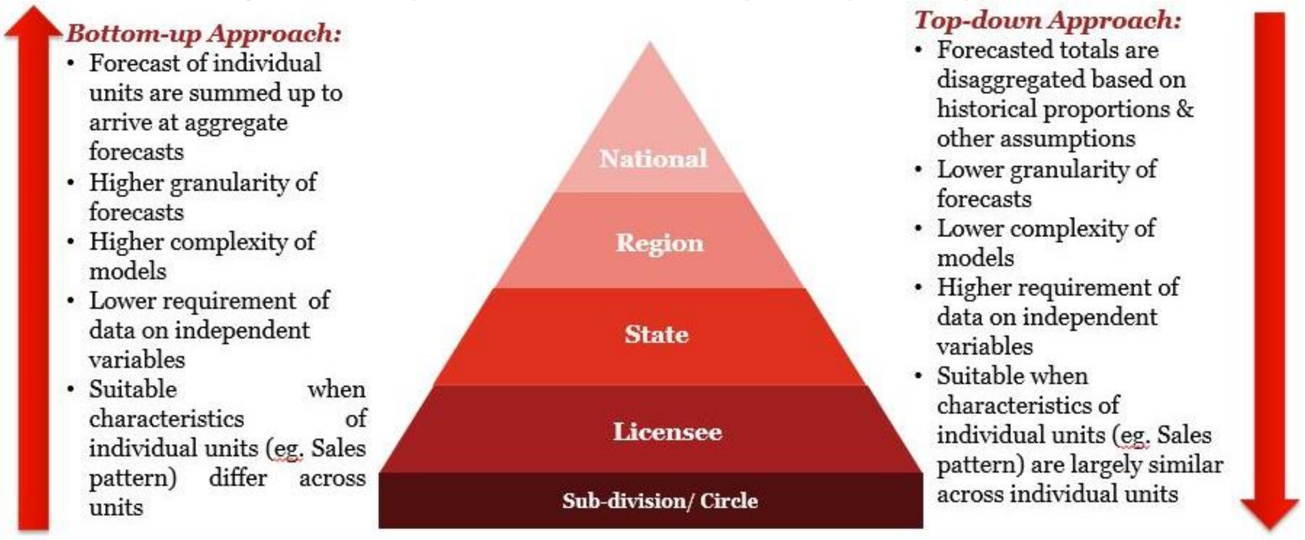
The use of category specific forecasting method will also require that the approach to forecasting is also looked into differently. To meet the objectives of the study and to develop an alternate methodology, a bottom up approach will be more favorable.

## 5.2. Use of bottom up approach

Overall, the approaches to forecasting can be broadly categorized into bottom up and top down. In a bottom up approach, forecast of individual units are summed up to arrive at the aggregate level forecast whereas in a top down, forecast is disaggregated based on proportions and assumptions.

The following graphic highlights a comparison between the bottom up and top down approach to forecasting.

Figure 23: Comparison between bottom up and top down approaches

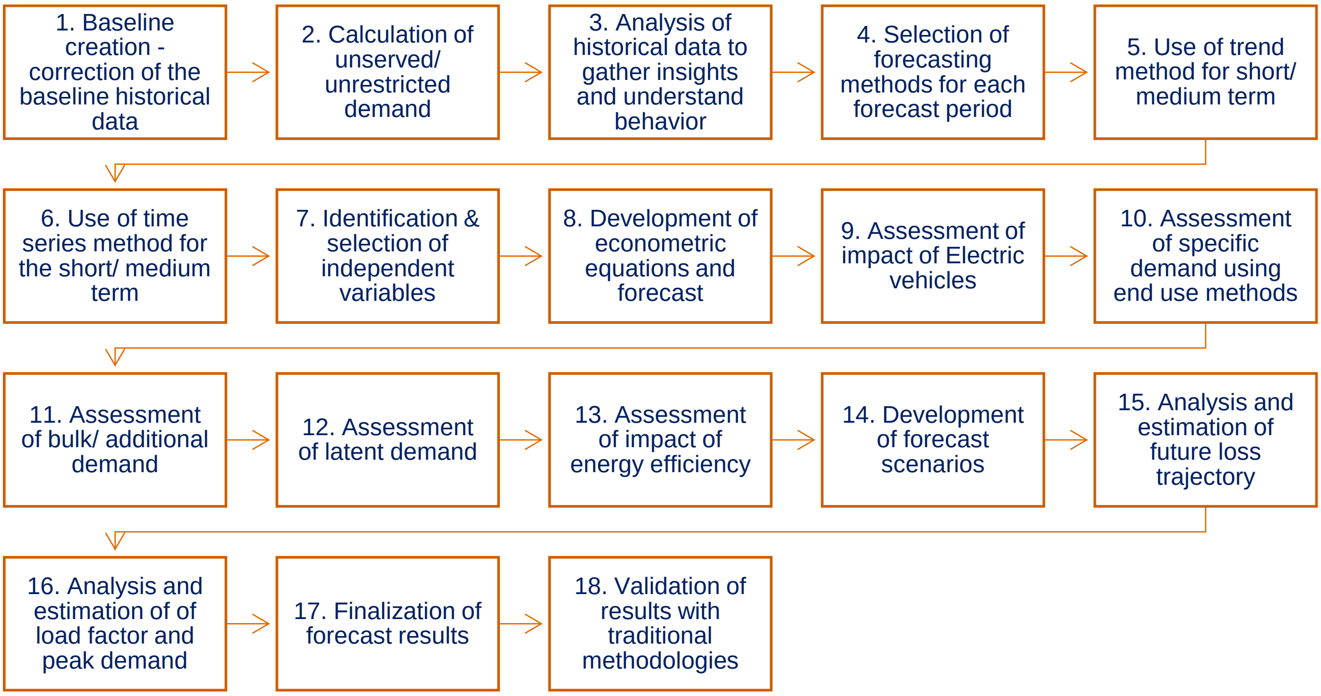



While both the approaches should be tested in order to derive the best results. However, considering the requirements of the study, overall a bottom up approach shall be followed for undertaking the electricity demand forecasting. To achieve higher granularity of forecasts, bottom up approach is the preferred approach in the present context. It is proposed to undertake the forecast at the circle level of utility and then aggregate it up to the higher level. The idea is to analyze the trends at the lower level so that better forecasting accuracy is achieved. However, there is a risk of non-availability of requisite data and available data may not be reliable.

## 5.2.1. Proposed 18-step alternate methodology

The following figure summarizes the 18-step alternate methodology of electricity demand forecasting for the present study.

Figure 24: 18 Step alternate demand forecasting methodology



**Step 1:**

Correction of the baseline historical data

In the past, DISCOMs have been supplying power for restricted demand conditions and managing the extra power requirements though load curtailments etc. But going forward, the aim is to supply uninterrupted power. DISCOMs are expected to serve 24x7 supply (unrestricted supply) to its consumers (except for some category of consumers including agriculture etc.).

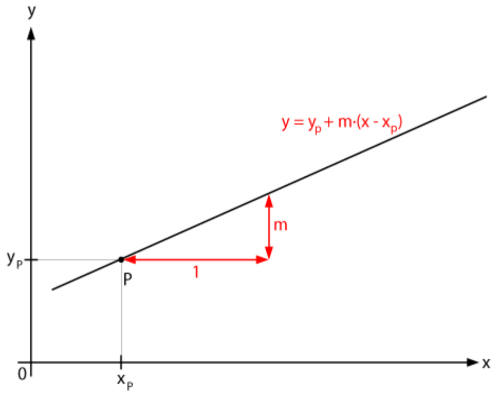
In India, many states have surplus status viz. supply/ availability outweighs the demand, however in many places there are interruptions due to planned load shedding, unplanned outages and due to failure of distribution infrastructure.

Thus, the forecasts should be based on a baseline data which is at the same wavelength as expected future data i.e. using unrestricted baseline data for predicting our future unrestricted demand. The same will also ensure that the historical demand data which is used for projecting the future demand is at the same base i.e. 24 hours supply. The usage of correct base will ensure precision in forecasts.

The proposed methodology takes into account the development of unrestricted demand data for all consumer categories using bottom-up approach.

In the proposed approach, the supply hours will be considered as per the data available from sample feeders to be shared by the DISCOMs. The data will be extracted from feeder meters and then supply hours for normal and block supply will be analyzed to ascertain the current condition of supply. The basic premise for this method lies in estimating the energy units to be supplied in non-supply hours using actual data available for supplied units in supply hours using straight-line method.

**Figure 25: Representation of a straight line method**




The curtailed energy for a certain category of consumer is estimated using:

- Average hours of supply = [$Y_1$]
- Average per day actual restricted supply units = [$X_1$]
- Average daily un-restricted supply units [$X_2$] = [(24 - $Y_1$) * ($X_1$ / $Y_1$)] + $X_1$

Accordingly, the unrestricted supply units for a region and for each category will be determined.

**Step 2:**

Calculation of unserved demand and determination of unrestricted demand from baseline correction

The unserved / unrestricted demand can be assessed using the supply hour data available from sample feeders. Due to various factors like load shedding, transformer failure and 33/11 kV feeder breakdown etc., there is interruption in the power supply and is recorded by feeders. During the time of power interruption, the demand is unserved. The supply hour data from sample feeders will provide an indication of the quantum of unserved demand and can be used to ascertain the unrestricted demand. Individual data for each type of failure is not available and mostly feeder interruption counts are specified. However, additional impact may be captured using suitable adjustment factors. Once unserved units due to various responsible factors is assessed, the same will be added up to the served units to get the unrestricted sales units.

**Step 3:**

Analysis of historical data – category wise to gather insights and understand behavior

The foremost step before using any method is to analyze the historical data. Understanding the dynamics of sales mix and behavior of LT and HT in future is very important. The same impacts the load factor, profile, and also average & peak demand of system. This factor is impacted with the migration/ growth of industries or LT consumers including residential & commercial etc.
The analysis of the data also gives a guidance of the type of forecasting method that can be used.

**Step 4:**

Selection of forecasting methods for each forecast period

There are a number of forecasting methods (Econometric, Time series, Trend analysis etc.) through which electricity demand can be forecasted. For forecasting demand under various time horizons (short, medium and long), combination of methods will be used for different forecast periods. Every method has its merits and demerits. Every method is dependent upon a set of input variables. The selection of the method would depend upon various factors like availability of required data set, practical feasibility of the results obtained from different methods, evaluation of the results obtained through goodness of curve fit, stakeholder consultation etc.

In the present study, we propose to use the following four methods.

**Trend method**

for short/ medium term

**Time series method**

for short/ medium term

**Econometric method**

for short, medium & long term

**End use method**

for short, medium & long term

**Step 5:**

Use of trend method to develop short/ medium term forecast

Post the analysis of the historical data, growth rates (year on year growth and CAGR growth) will be calculated on the baseline corrected data of energy consumption, consumer data etc. and analyzed. The process will be carried out for each consumer category and will be repeated for all the regions. The growth rates will provide a fair estimation of the trends of each category and region. Post review of the rates, trend method will be applied for each category of consumer. The application of trend method for specific categories may vary and different approaches as per requirement will be developed. The model for trend method will also have factors to incorporate effect of energy efficiency, effect of technology advancement, latent demand etc. It is also planned to use different CAGR rates for short, medium and long term.

**Step 6:**

Use of time series method for short/ medium term

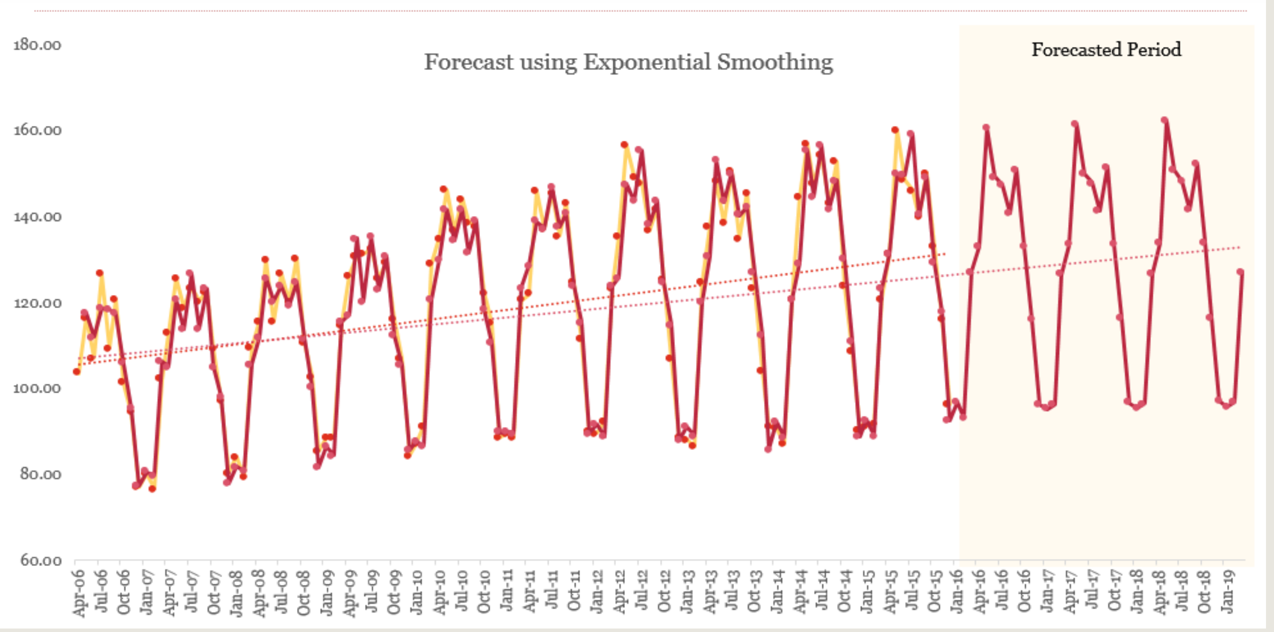
The time series method will also be used to develop forecast for the short and medium term with the baseline corrected energy demand data. For a better accuracy, the method which considers trend and seasonality will be employed. A case study highlights the experience of using the time series method in electricity demand forecasting.

**Figure 26: Case study: Time series method**

**Use of time series forecasting technique to develop short term forecast for a private utility in India**

In one of the recent assignments for a private utility, exponential smoothing technique was used to derive monthly forecasts for the short term horizon. The graphic shows an illustration of the forecast results.

In the assignment, monthly sales data was used for previous ten years and the forecast was developed using exponential smoothing technique. The results obtained for the short term were fairly accurate.




**Step 7:**

Identification & selection of independent variables

For undertaking the forecast using econometric method, identification of independent variables in a crucial step. In the identification stage, a large number of variables are looked into and tested. Following is a tentative list of the independent variables which will be considered.

**Table 28: Tentative list of independent variables**

| Independent Variables – Tentative list (subject to data availability) | |
|---|---|
| Temperature | Population |
| Humidity | GDP or GSDP – Primary |
| Rainfall | GDP or GSDP – Secondary |
| Consumer Price Index (CPI) | GDP or GSDP – Tertiary |
| Wholesale Price Index (WPI) | Per capita income |
| Rate of Inflation | Electricity tariff |
| Number of Consumers | Industry or Manufacturing indices |

From a macroeconomic consideration, all the parameters mentioned above will be assumed to influence electricity demand. For setting up the econometric model, an initial functional form will be formed with electricity demand as the dependent variable and all other parameters mentioned above as independent variables. The correlations will be calculated for all consumer categories. Then regression analysis will be conducted on the software - Statistical Package for Social Sciences (SPSS) to determine the co-efficient of the independent variables and test for significance of these variables. The variables which will have a significance in the 95% confidence level will be chosen and the rest of the insignificant variables will be dropped from the set of variables. Only those variables, wherein, the p - value and t-stat are significant will be considered for developing the equations. For significance, p-value should be less than 0.05. Post the selection of the variables, the regression equations will be developed with the significant variables and initial functional form to derive the final coefficients.

**Step 8:**

Development of econometric equations and forecast

After selection of the independent variables for each category, the final econometric equations will be developed. As the regression equation is a function of various independent variables, the dependent variable can be established only if values of all independent variables are known. Hence to estimate the future value of the dependent variable, the forecast of independent variables are worked out using various approaches. Subsequently, electricity demand forecast is worked out. The values obtained for each category is aggregated to arrive at aggregate level forecasts.

**Figure 27: Case study: use of econometric forecasting technique**

**Use of econometric forecasting technique to determine electricity demand for a state utility in India**

In one of the assignments for a state utility, econometric forecasting was used to derive forecasts for a period of ten years. The graphic shows an illustration of relationships developed for each customer category for a particular region in the state.

| Category | Domestic | Non Domestic | LT Industry | LT PWW | LT STLT | Irrigation Pumps * | Railway Traction | HT Industrial | Coal Mines | Others* |
|---|---|---|---|---|---|---|---|---|---|---|
| Significant Variables | I | G | I | I | G | | G | G | NA | |
| Status | | | | | | | | | | |
| Selected | I | G | I | I | G | Time Trend | G | G | | Time Trend |

The significant variables obtained were carefully analyzed statistically and then final variables are selected. The regression equations were developed post finalization of the significant variables.

| Categories | Equations |
|---|---|
| Domestic | Y = 42758.35*(Income) + (-493495989.34) |
| Non Domestic | Y = 0.0052*(GDP) + (-59264841.73) |
| LT Industry | Y = 5317.50*(Income) + (-44339961.57) |
| LT PWW | Y = 1302.46*(Income) + (-13515978.92) |
| LT STLT | Y = 0.000566*(GDP) + (-5045585.41) |
| Irrigation Pumps | |
| Railway Traction | Y = 0.00279*(GDP) + (-478724.64) |
| HT Industrial | Y = 0.0174108*(GDP) + (-210311994.99) |
| Coal Mines | |

**Step 9:**

Assessment of demand from electric vehicles

The Government has set an ambitious target for an all-electric vehicle economy in the country by 2030. The push for same started initially in the year 2013, when NEMMP 2020 was launched to promote hybrid and electric vehicles in the country. Subsequently FAME scheme was launched w.e.f 1st April, 2015 with the objective to support hybrid/electric vehicles market development and manufacturing eco-system. The scheme has four focus areas i.e. technology development, demand creation, pilot projects and charging infrastructure.

The uptake of EVs will depend in large part on the adequate deployment of electric vehicle supply equipment (EVSE) needed to recharge EVs. The systems are still under planning and estimations have to be developed for the additional power to be required to support these EVSEs. At present, there is no definite data for the number of charging infrastructure available in the selected state nor there a definite outlook of the same. Hence the estimations will be based on scenarios and assumptions.

**Step 10:**

Assessment of specific demand using end use method

The end use method will be used to determine specific demand of certain categories which cannot be captured from historical data or secondary research. The approaches for end use method will vary depending on the target and the end result. E.g. for determination load from agriculture pumps, an end use method shall be used. The power demand for irrigation shall be worked out by projecting the number of pumps in mid-year, the average capacity of each pump and the average consumption per load or hours of operation with assumptions. The demand for lift irrigation shall be based on the end use to be worked out based on the programme of development of lift irrigation schemes indicated by Distribution utilities/ State Authorities.

Open Access is another important factor which will be analyzed as it impacts the demand in all time horizons (short, medium and long). The parameter will be assessed considering the present and forecasted open access consumers, their prevailing contracts and benefit analysis, likelihood of their returning back to DISCOM system, regulated tariffs of DISCOM and expected increase in same, policy changes etc.

Captive power generation is another aspect which will be looked into during the forecasting study. The industries have been using captive power units to meet their power requirements in the past. However with stringent environmental norms, it is estimated that many captive power plants won't be able to meet the requirements and will have to be shut down. The resultant demand is expected to progressively shift to the grid. Since data acquisition will be a challenge in this regard, the estimation will involve assumptions.

**Step 11:**

Assessment of bulk/ additional demand

Impact of additional demand will also be incorporated at this stage post the development of the forecast to refine the results. Any additional load will be added up to the demand arrived by the hybrid approach. The information on such high loads shall be captured by consultations, primary and secondary research, review of infrastructure schemes, housing schemes and master plans etc. Depending on availability of the information on additional load, phasing will be carried out and scenarios will also be developed for various factor which impact the demand.

**Figure 28: Illustration of using additional loads in forecast**

**Illustration of phasing of additional loads and scenario development**

The graph below illustrates the forecasts of a private utility, developed for a ten year period considering different scenarios.

| | | OPTIMISTIC | | REALISTIC | | PESSIMISTIC | |
|---|---|---|---|---|---|---|---|
| Sl. No. | Consumer Name | Year of Comm. | Load (100%) | Year of Comm. | Load (80%) | Year of Comm. | Load (60%) |
| 1 | Hotel | 2017-18 | 5.5 | 2018-19 | 4.4 | 2019-20 | 3.3 |
| 2 | Medical College | 2017-18 | 13.0 | 2018-19 | 10.4 | 2019-20 | 7.8 |
| 3 | Ideal Unique | 2017-18 | 5.0 | 2018-19 | 4.0 | 2019-20 | 3.0 |
| 4 | The 42 Residency | 2018-19 | 5.0 | 2019-20 | 4.0 | 2020-21 | 3.0 |
| 5 | Metro | 2018-19 | 10.0 | 2019-20 | 10.0 | 2020-21 | 10.0 |
| 6 | Railway | 2016-17 | 20.0 | 2017-18 | 20.0 | 2018-19 | 20.0 |
| 7 | ABC Industries | 2016-17 | 3.0 | 2017-18 | 2.4 | 2018-19 | 1.8 |
| 8 | South City Infrastructure | 2016-17 | 2.5 | 2017-18 | 2.0 | 2018-19-20 | 1.5 |
| 9 | Airport | 2019-20 | 1.5 | 2020-21 | 1.5 | 2021-22 | 1.5 |
| 10 | SSKM | 2017-18 (half), 2018-19 | 15.0 | 2018-19 (half), 2019-20 | 12.0 | 2019-20-21 | 12.0 |
| 11 | ESIC Hospital | 2017-18 | 12.0 | 2018-19 | 9.6 | 2019-20 | 9.6 |
| 12 | Riverside Real estate | Phased from FY 20 to FY 23 | 30.0 | Phased from FY 20 to FY 23 | 20.0 | Phased from FY 20 to FY 25 | 15.0 |

**Step 12:**

Assessment of latent demand

Development of reasonable estimates for the latent demand in the system is an essential pre-requisite to undertake an electricity demand forecast study as the trend of historical consumption of electricity may or may not be a reliable indicator of the future trend of electricity consumption. 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. In developing economies there are various factors which may limit electricity consumption. These can range from inadequate infrastructure such as network capacity constraints, negative effect of income, high cost of supply, outdated technology etc. Considering the case of a household with low income, consumption is based on priority of basic needs, thereby impacting demand of other goods e.g. electricity. For an industry, the electricity demand may be suppressed due to factors such as inadequate network infrastructure, insufficient power availability with distribution licensee to cater to the demand, high cost of supply, reliability of supply etc. To assess the latent demand, different approaches will be attempted. One planned approach will be using econometric method whereby the impact of latent demand due to economic conditions can be captured. In an econometric forecast, the factors will be checked for relationship with electricity demand. In case a strong relationship is found, the same shall be considered. Another method can rely on using suitable benchmarking of electricity consumption per consumer in other countries/ regions wherein with that of target region to see the deviation. Such methods will involve consideration of suitable assumptions. A more prudent method will be to conduct primary survey across consumer categories in a target region to understand the quantum of latent demand in the area and in categories. Such a study will also provide a good base for future studies to follow.

**Step 13:**

Assessment of the impact of energy efficiency

As per The World Bank estimate, in India the residential end use appliances, agriculture/irrigation pumps, and municipal infrastructure are the top three areas which will contribute to the energy efficiency potential. The Government has also launched several programme and schemes pertaining to promotion of energy efficiency in this regard. As the population grows and the demand for electricity rises, there will be increased opportunity for energy efficiency to make an impact. Same will be in the case of industries and buildings. Hence going ahead, incorporation of the impact in the forecast is critical. It will also help in ascertaining the behavior change due to efficiency and to estimate any net savings if any. Research has suggested that the behavior of households are very different from what is expected while designing the policies.

In order to capture the behavior and trend, multiple approaches have been proposed. A primary survey has been proposed for the assignment to collect relevant data. The survey will be designed to understand the impact and influence of energy efficiency in households. Depending on the results of the survey, suitable scenarios and assumptions shall be built and incorporated in the forecast. The assessment will also rely on secondary literature in order to consider the impact of energy efficiency.

**Step 14:**

Development of forecast scenarios

The results may be forecasted using the best possible method and with all necessary information like proposed infrastructure plans, weather variables, economic & demographic variables etc., but there is always a probability that the assumptions may not hold true. Hence, scenarios are developed to reduce the uncertainties.

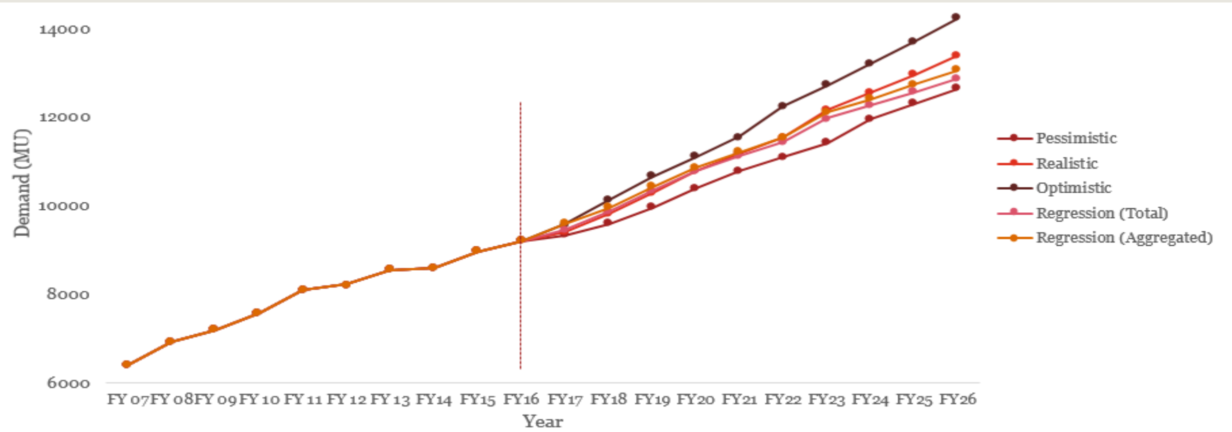
The forecast for the present study shall involve development of two scenarios

- Forecast using baseline corrected data
- Forecast after adjusting for the anticipated unserved demand in future

The scenarios have been proposed considering the aim the study which was to undertake forecasts using baseline correction of historical data. The results of the forecast in each scenarios will enable comparison with the results of the existing methodologies wherein such baseline corrections are not undertaken.

**Figure 29: Illustration of forecast results**

**Illustration of forecasting results post development of scenarios**



**Step 15:**

Analysis and estimation of future loss trajectory

One of the gap identified in estimation of loss trajectory is that the trajectories are developed based on top down targets. Historically, it has been observed that the targets are not met as per the defined timelines and are also periodically revised. Due to which the overall forecasted results vary with that of the actual. Hence it would be more prudent to develop the future loss trajectories based on realistic estimates after analysis of the actual loss data.

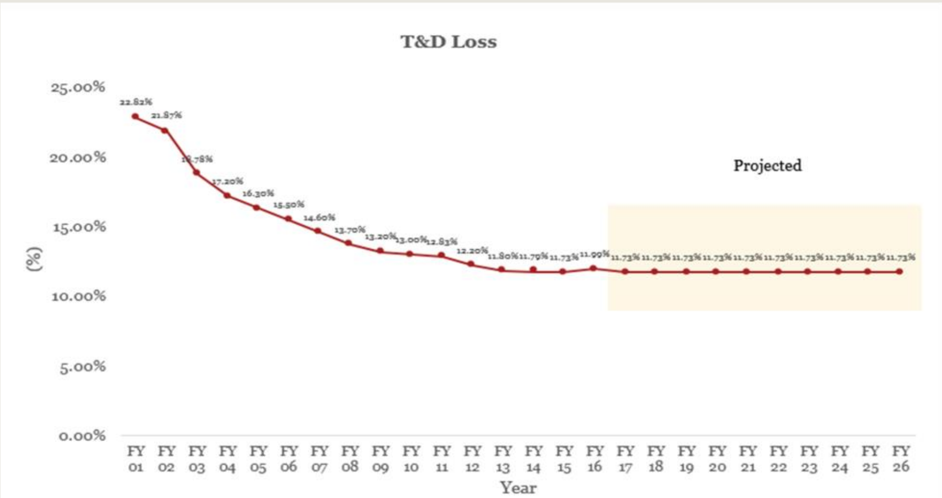
The data pertaining to T&D losses may be available for a limited period and mostly at state level. Also, such data also won't have segregation of losses for specific activities like theft, faulty reading etc. Such information may be available only for select states wherein load flow studies have been carried out by the Utilities in the past. Load flow studies have been previously carried out in states of Orissa, Bihar and by some private utilities for their network. It helps in identifying the losses at various levels and utilities can take their network decisions based on the results of such reports. Before undertaking an exercise of load forecasting, the DISCOMs should also undertake load flow studies in their network on a periodic basis.

In the current assignment, the trajectory shall be developed based on in-depth analysis of available data, trends observed and realistic assumptions will be considered wherever required. Extensive stakeholder consultation shall be involved before finalization of the future loss trajectory.

The following case study highlights the development of a future loss trajectory for a private utility.

**Figure 30: Case study: Illustration of a loss trajectory**

**Illustration of loss trajectory**




The illustrated T&D loss trajectory for the utility was developed based on past behavior, stakeholder consultation and with realistic assumptions.

**Step 16:**

Analysis and estimation of load factor and peak demand

A detailed analysis will be carried out on historic load curves for the state depending on availability of data to observe the loading patterns for peak, average and base demand values. From this analysis, the expected load factors for the forecast years will be computed using the historical data of energy and demand. The load factor, defined as the ratio of the average load to the peak load will provide an estimate of the degree of loading prevalent for each consumer category. From the data, average load factors for each category will be calculated. After forecasting the unrestricted demand, the average load factor shall be used to determine the peak demand in the system.

**Step 17:**

Finalization of forecast results

The results obtained from all the methods will be analyzed and compared. The exercise will be carried out category wise and post the analysis, the results from the best fit model will be identified and selected. In some categories, a particular method may not even produce the required forecast and will have to be dropped. The forecast finalization will also involve consideration of results from bulk load, specific demand, energy efficiency, latent demand etc. The finalization will be for two scenarios as defined in the previous step. Overall based on insights from historical data, after discussion with stakeholders and from experience of forecasting, suitable judgement will have to be applied.

**Step 18:**

Validation of results with traditional methodologies

The final results will then be compared with available forecasts which have been developed using other traditional methodologies for the same period. The comparison will then be analyzed across common parameters and validated.

# 6. Approach adopted for selected state

## 6.1. Rajasthan - Profile

Rajasthan is India's largest state by area (342,239 square kilometers (132,139 sq. mi) or 10.4% of India's total area). Rajasthan is administratively divided into 7 divisions, 33 districts, comprising 295 panchayat samities, 9,894 village panchayats, and 43,264 inhabited villages.[13]

The state is primarily an agrarian state and ~75% of the state population (as per Census 2011) is rural population and rest is urban population. The main industries are mineral based, agriculture based, and textile based.

The GSDP growth rate of the state has been consistent over the last five years. The state is expected to figure amongst the growing states in India by capitalizing on the investor friendly policies launched by the state government, excellent connectivity, and natural resources and with availability of labor in the state.

Figure 31: Rajasthan - GSDP

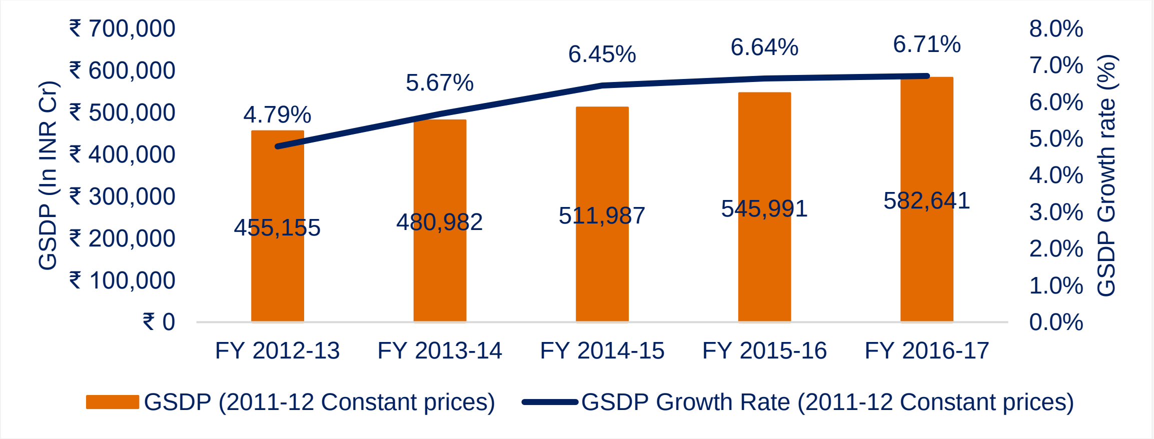
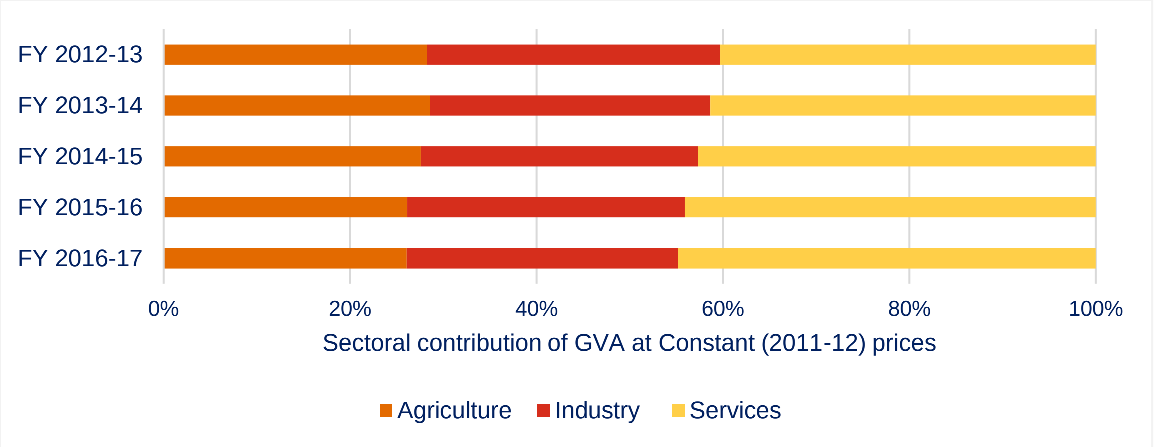



Figure 32: Sectoral contribution to GVA




Though the state has been primarily an agrarian economy and traditionally rich in mineral based industries, the trend of sectoral contribution highlights that the contribution of services sector has been increasing at the expense of industries and agriculture.

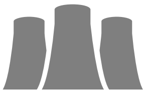
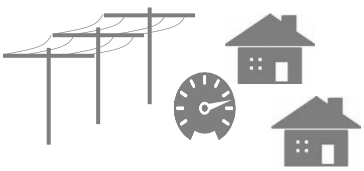
[13] Government of Rajasthan, Economic Review 2016-17 including GSDP data

## 6.2. Power sector in the state

The State of Rajasthan has been amongst the forerunners in initiating various reforms in the power sector which can be gauged from the fact that the Government of Rajasthan brought about a slew of reforms in the late 90's and early 2000's culminating in implementation of Power Sector Reforms Program (2000). The reforms in the power sector aimed to facilitate and attract investments, bring about improvements in the efficiency of delivery system and create an environment for growth for the overall benefit of the people of the state.

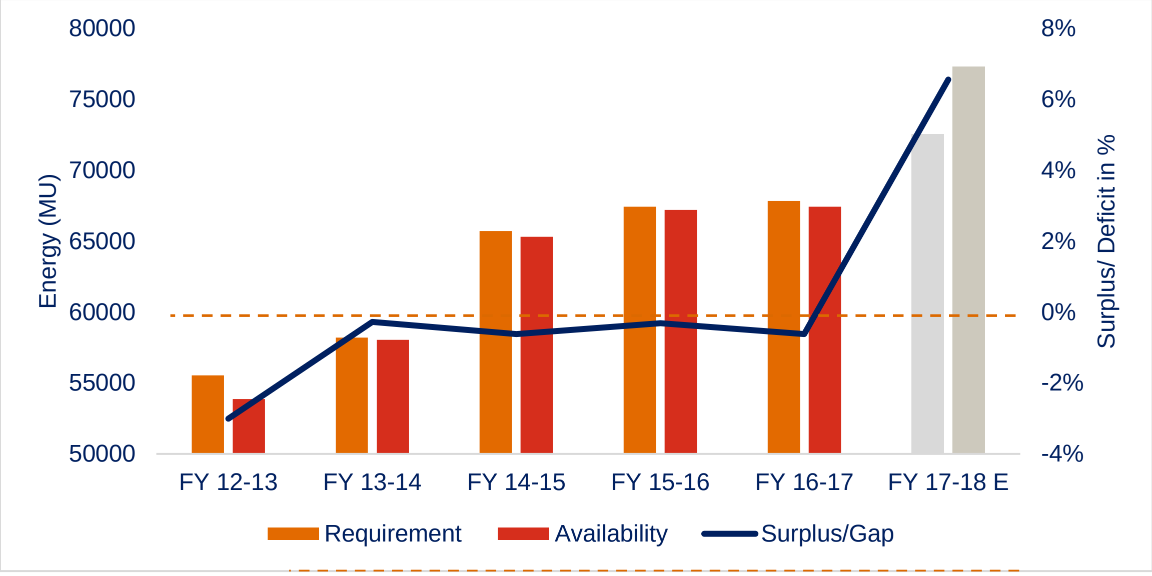
As part of the Power Sector Reforms Program, the State Government decided to restructure the erstwhile Rajasthan State Electricity Board (RSEB) as a pre-cursor to unbundling on the functional lines. On March 21, 2000, Government of Rajasthan approved the provisional Financial Restructuring Plan (FRP) of the state power sector and a provisional transfer scheme drafted. On July 19, 2000, Government of Rajasthan accomplished the first major reform milestone of notifying "Rajasthan Power Sector Reforms Transfer Scheme 2000" and thereby restructuring its vertically integrated Electricity Board (RSEB) to form five (5) successor companies.

**Table 29: Present structure of power sector utilities**

| Function | Company | Objective |
|---|---|---|
| **Generation**  | Rajasthan Rajya Vidyut Utpadan Nigam Limited (RVUN) | Undertake the electricity generation business of erstwhile RSEB |
| **Transmission**  | Rajasthan Rajya Vidyut Prasaran Nigam Limited (RVPN) | Undertake the electricity transmission and bulk supply business of erstwhile RSEB. In addition, RVPN owns Rajasthan's capacity share in the shared power stations of BBMB, Chambal Complex and Satpura. |
| **Distribution**  | Jaipur Vidyut Vitran Nigam Limited (JVVNL) | Manage electricity distribution and retail supply business in Alwar, Bharatpur, Jaipur City, Jaipur District, Dausa, Kota, Jhalawar, and Sawaimadhopur Circles |
| | Ajmer Vidyut Vitran Nigam Limited (AVVNL) | Manage electricity distribution and retail supply business in Banswara, Udaipur, Chittorgarh, Bhilwara, Ajmer, Nagaur, Sikar and Jhunjhunu Circles |
| | Jodhpur Vidyut Vitran Nigam Limited (JdVVNL) | Manage electricity distribution and retail supply business in Sriganganagar, Hanumangarh, Churu, Bikaner, Barmer, Jodhpur City, Jodhpur District, and Pali Circles |

As a result of comprehensive reforms, the power sector in the state of Rajasthan has made significant progress over the last decade in terms of increased generation capacity and strengthening of network infrastructure leading to an improved power supply position. Most consumers are already being provided 21-22 hours of average daily supply[14]. The State is working towards connecting the remaining 20% households and provide 24X7 reliable supply to all consumers in the state.

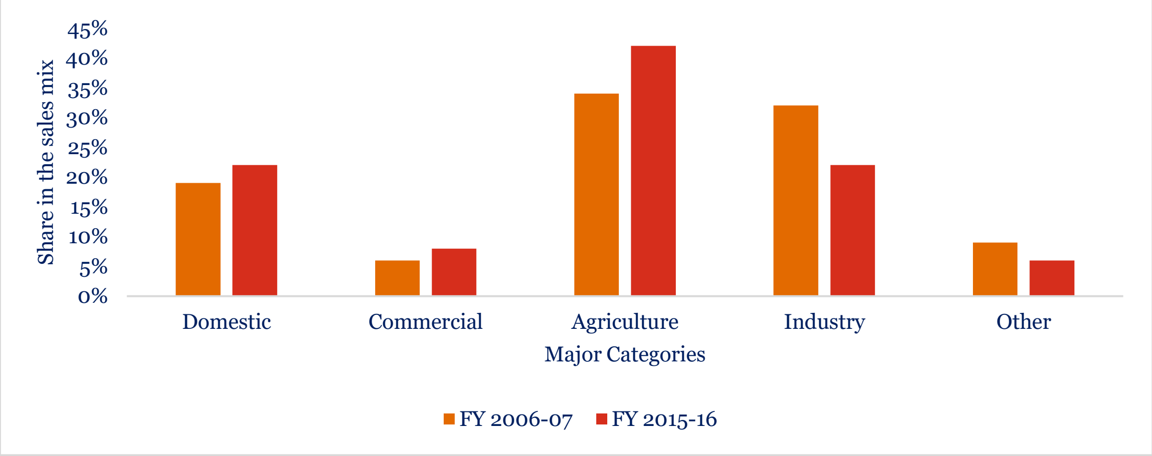
**Figure 33: Electricity requirement and availability scenario in Rajasthan[15]**




The requirement of electricity has been growing consistently over the years, but owing to supply constraints there was deficit. Over the last 3-4 years, the deficit has narrowed down and the state is expected to be power surplus. However, localized supply restrictions due to network and other issues prevail.

In terms of sales mix, agriculture is the dominant category and the share has increased over the last ten years. Domestic and Commercial categories have shown marginal growth whereas demand from industries has decreased substantially in the state.

**Figure 34: Share of electricity demand across categories in the State**




In the next 10-15 years, the demand in the state is expected to continue its growth trajectory due to the various initiatives undertaken by the Central and State Government like providing connection to the unconnected households, plan to provide 24x7 reliable power supply, strengthening of Transmission and Distribution network, metering and loss reduction plans etc. to cater to the expected growth in demand of existing as well as forthcoming consumers.

[14] Rajasthan – Power For All document
[15] LGBR – 2017-18 released by CEA

In the subsequent sections, the details of the implementation of the alternate demand forecasting methodology for the state of Rajasthan has been provided.

# 6.3. Use of a bottom up approach

## 6.3.1. Forecast at Circle level

As outlined in the alternate methodology which has been proposed for the current study, it was mentioned that bottom up methodology will be used. To achieve higher granularity of forecasts, it was proposed to undertake the forecast at the circle level of utility and then aggregate it up to the higher level. The idea is to analyze the trends at the lowest level so that better forecasting accuracy can be achieved.

In view of the above, data pertaining to monthly sales, consumers etc. were collected at the Circle level from the year FY 2006-07.

## 6.3.2. Consolidation of Circle level data

Rajasthan has three distribution utilities and many of the Circles have been carved out of existing bigger circles over the past ten years for better management and operational reasons. During the course of data collection at the Circle level, it was observed that data for many circles were not available since FY 2006-07 as many Circles were formed post that.

Hence it was decided to undertake consolidation of Circles within the same distribution utility. The consolidation of the Circles was carried out for the following reasons:

- To ensure that minimum of 10 years of historical data across consumer categories is available
- Historical data for new Circles was available for only 3-4 years prior to FY 2015-16
- There was sudden drop in sales and consumers in the original circles as new circles were carved out. This drop created inconsistency and would have impacted the forecast

In view of the above, the new Circles created post FY 2006-07 were added back to the original Circles so as to arrive at the original number of Circles as was available in the year FY 2006-07. The details are given in the following table:

**Table 30: Consolidation of Circles for forecast**

| Sl. No. | Circles | Data availability since FY 2006-07 | Circles kept for Forecast |
|---|---|---|---|
| | **JVVNL** | | |
| 1. | Alwar | Yes | Yes |
| 2. | Bharatpur | Yes | Yes |
| 3. | Dausa | Yes | Yes |
| 4. | Jaipur city circle | Yes | Yes |
| 5. | Jaipur district circle | Yes | Yes |
| 6. | Jhalawar | Yes | Yes |
| 7. | Kota | Yes | Yes |
| 8. | Sawai Madhopur | Yes | Yes |
| 9. | Baran | No. | Added to Jhalawar |
| 10. | Bundi | No. | Added to Kota |
| 11. | Dholpur | No. | Added to Bharatpur |
| 12. | Karauli | No. | Added to Dausa |

| | | | |
|---|---|---|---|
| 13. | Tonk | No. | Added to Sawai Madhopur |
| | **AVVNL** | | |
| 1. | Ajmer | Yes | Yes |
| 2. | Bhilwara | Yes | Yes |
| 3. | Nagaur | Yes | Yes |
| 4. | Udaipur | Yes | Yes |
| 5. | Rajsamand | Yes | Yes |
| 6. | Chittorgarh | Yes | Yes |
| 7. | Banswara | Yes | Yes |
| 8. | Jhunjhunu | Yes | Yes |
| 9. | Sikar | Yes | Yes |
| 10. | Pratapgarh | No | Added to Chittorgarh |
| 11. | Dungarpur | No | Added to Banswara |
| | **JdVVNL** | | |
| 1. | Jodhpur city circle | Yes | Yes |
| 2. | Jodhpur district circle | Yes | Yes |
| 3. | Jalore | Yes | Yes |
| 4. | Pali | Yes | Yes |
| 5. | Barmer | Yes | Yes |
| 6. | Bikaner | Yes | Yes |
| 7. | Sri Ganganagar | Yes | Yes |
| 8. | Hanumangarh | Yes | Yes |
| 9. | Churu | Yes | Yes |
| 10. | Sirohi | No | Added to Pali |
| 11. | Jaisalmer | No | Added to Barmer |
| 12. | Bikaner district circle | No | Added to Bikaner |

Post the consolidation, the forecast was planned to be undertaken considering 26 Circles of the State.

The consumer categories considered for the forecast are as per the categories defined by the Distribution utilities in the State of Rajasthan. The historical data accessed for the ten year period is also segregated into the same categories. For ease of forecast and based on category behavior, data for few categories have been consolidated e.g. Industries, Public Water Works etc. after reviewing the historical data and based on the category behavior exhibited in the past.

For the forecast, the category names as defined by the utilities have been retained and the results shall be developed for the following categories

- Domestic
- Non-domestic
- Public Street lights (PSL)

- Agriculture (Metered, Nursery, Poultry)
- Agriculture (Flat – unmetered)
- Industries (Small and Medium) -
- Industries (Large)
- Public Water Works (PWW) – data for Small, Medium and Large added together
- Mixed load

For each circle and utility, the forecast shall be developed for each of the above categories.

The forecast for Railway Traction shall be considered for the whole state as a whole and will be derived separately and added to the demand of the state.

# 7. Baseline correction of historical data

The proposed methodology takes into account estimation of unserved electricity requirement and development of a baseline corrected data for consumer categories using a bottom-up approach. The basic premise for this method lies in estimating energy units to be supplied in non-supply hours using actual data available for supplied units in supply hours using a straight-line extrapolation method.

**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' supply; Doesn't reflect the entire consumer demand for the historic period
- Due to failure of T&D infrastructure, planned load shedding and unplanned outages, demand of consumers is not served even when the entire demand is existing in the system thereby leading to an 'unserved demand'
- Previously, the power sector in the country was in a deficit position viz. demand exceeding supply, while in future it is anticipated that the availability of power will be surplus
- Also, it has been envisaged to supply uninterrupted and reliable power to consumers in future. Distribution utilities will be expected to serve 24 x 7 supply (unrestricted supply) to its consumers (except for some category of consumers including agriculture etc.)

The forecasts should be based on a baseline data which is at the same wavelength as the expected future electricity requirement i.e. using unrestricted baseline data for predicting future unrestricted electricity requirement. The correction of the baseline will also ensure that the historical data which is used for projecting is at the same base i.e. 24 hours supply. Usage of correct base will also ensure precision in forecasts.

In the proposed approach, the supply hours was considered as per the data available from sample feeders accessed from the distribution utilities. The supply hours for normal and block supply was analyzed to ascertain the current condition of supply across major categories.

Data collection was carried with support of the utility in the selected state. Discussions were held with utility to understand the following:

- Type of data available
- Period for which required data is available
- Format in which data is available
- Process to be followed to access data

Feeder data for certain months was available as the same had been used by the DISCOMs for internal reporting. The format in which the data was available was, however, not uniform across the DISCOMs. It was also mentioned that data pertaining to interruption counts of feeders are mostly recorded for undertaking O&M activities. However, that data cannot be directly converted into interruption in minutes as the duration of each interruption varies.

Following figure highlights a format in which data was made available by the utility.

**Figure 35: Circle wise feeder data accessed from utility**

| FEEDER | 01-Apr-17 | 02-Apr-17 | 03-Apr-17 | 04-Apr-17 | 05-Apr-17 | 06-Apr-17 | 07-Apr-17 | 08-Apr-17 | 09-Apr-17 | 10-Apr-17 | 11-Apr-17 | 12-Apr-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FEEDER | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 |
| FEEDER | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| FEEDER | 23.5 | 23.5 | 23.5 | 23.5 | 22 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 |
| FEEDER | 23.5 | 23.5 | 23 | 23 | 23.5 | 23.5 | 23.5 | 23.5 | 23 | 23.5 | 23.5 | 23.5 |
| FEEDER | 23.5 | 23.5 | 23 | 23 | 23.5 | 23 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 |
| FEEDER | 23.5 | 23.5 | 23.5 | 23.5 | 23 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 23.5 | 22.5 |
| FEEDER | 24 | 24 | 24 | 22 | 18.5 | 23 | 24 | 24 | 24 | 23.5 | 24 | 24 |
| FEEDER | 24 | 23.5 | 24 | 23 | 23.5 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| FEEDER | 24 | 24 | 24 | 24 | 24 | 23.5 | 24 | 24 | 24 | 24 | 23.5 | 23.5 |
| FEEDER | 24 | 24 | 24 | 24 | 24 | 23 | 24 | 24 | 24 | 23 | 24 | 24 |
| FEEDER | 24 | 23 | 24 | 24 | 24 | 23.5 | 24 | 24 | 24 | 23.5 | 24 | 24 |
| FEEDER | 3 | 3.5 | 2.5 | 2 | 0.5 | 2.5 | 2 | 1 | 0.5 | 4 | 2.5 | 2.5 |
| FEEDER | 6 | 9.5 | 9 | 5.5 | 5.5 | 5 | 8 | 7.5 | 6.5 | 5 | 5.5 | 6.5 |
| FEEDER | | | 4.5 | 7 | 6 | 5 | 5.5 | 6 | 6 | 7 | 7 | 6 |
| FEEDER | 7.5 | 5.5 | 7 | 5 | 5 | 5 | 6 | 5.5 | 6 | 5 | 6.5 | 5.5 |
| FEEDER | 5.5 | 6 | 5 | 5 | 5 | 5 | 5.5 | 5 | 6 | 4.5 | 4.5 | 5.5 |
| FEEDER | | | 6 | 5 | 4.5 | 4.5 | 5 | 4 | 6.5 | 5 | 4 | 6 |
| FEEDER | 5.5 | 4 | 7.5 | 7 | 6.5 | 7 | 6 | 7 | 9.5 | 7 | 6 | 6 |
| FEEDER | 6.5 | 7.5 | 7.5 | 6.5 | 6.5 | 7 | 8 | 5.5 | 5.5 | 6 | 6.5 | 5 |
| FEEDER | | | 3.5 | 5 | 6.5 | 4 | 8 | 6.5 | 7 | 7.5 | 8 | 8 |
| FEEDER | | | 22.5 | 19.5 | 14.5 | 19 | 23.5 | 22 | 23.5 | 23 | 23 | 23 |

Data as available in the above format has been used to assess the unserved demand. Data, as received, is checked for any inconsistency or for any missing variable. Exercise was repeated for daily and monthly data as per the formats shown.

Post validation, it was observed that the supply hours were majorly categorized in three groups:

- 16-24 hours range
- 8 – 16 hours
- Less than 8 hours

From the above observation in data, the gap in supply was determined for three consumer categories. The assumptions considered for the three categories in terms of maximum supply hours be considered is as given below:

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

Since, clear tagging of feeders as Urban/ Rural is not available in the data, further categorization of Domestic, Non Domestic (Commercial) and Agriculture for Urban/ Rural has not been carried out. Ideally, the raw data should highlight the nature of the feeder (Urban/Rural) and to the category to which the feeder is being used to supply.

For the other major categories namely Industries, Public Water Works, Public Street light etc., it has been assumed that the required supply has been provided as per demand.

The assumption has been considered due to following data constraints

- In the accessed feeder data, segregation of industrial feeders at Circle level is not available

- SLDC data records details of planned/ unplanned/ forced outages due to system constraints at state/ region level. In case of a particular system outage at state/ region level, it is difficult to estimate how much of it has led to unserved energy for industry category in a circle.

From the daily and monthly supply hour data, average supply hours for each month and for each circle has been determined.

**Figure 36: Calculation of average monthly supply hours**

| FEEDER | Average (Hours) | Time Block | Gap in Supply (Minutes) | 24 hours | 12 hours | 8 hours |
|---|---|---|---|---|---|---|
| FEEDER | 7.43 | 8 | 34.00 | NA | NA | 34 |
| FEEDER | 7.70 | 8 | 18.00 | NA | NA | 18 |
| FEEDER | 21.57 | 24 | 146.00 | 146 | NA | NA |
| FEEDER | 8.07 | 12 | 236.00 | NA | 236 | NA |
| FEEDER | 7.27 | 8 | 44.00 | NA | NA | 44 |
| FEEDER | 6.42 | 8 | 95.00 | NA | NA | 95 |
| FEEDER | 8.57 | 12 | 206.00 | NA | 206 | NA |
| FEEDER | 22.00 | 24 | 120.00 | 120 | NA | NA |
| FEEDER | 21.07 | 24 | 176.00 | 176 | NA | NA |
| FEEDER | 8.88 | 12 | 187.00 | NA | 187 | NA |

Based on the monthly average supply hour determined for each feeder, the feeders were then categorized into one of the three consumer categories. For e.g. as shown in figure above, the average monthly supply duration for the first feeder is 7.43 hours. Hence, it has been categorized as an agriculture feeder and the gap in supply has been considered w.r.t 8 hours of block supply.

Similarly, all the feeders in a circle were categorized into one of the three categories. Post the categorization, the monthly average gap in supply for each time block for each circle was determined. The table below illustrates the same.

**Table 31: Monthly average supply gap of a sample circle**

| Category | Time block | Monthly avg. gap in supply |
|---|---|---|
| Domestic | 24 hour | 2.4 hours |
| Non domestic | 12 hour | 2.6 hours |
| Agriculture | 8 hour | 1.7 hours |

The monthly average gap in supply hours was determined for all the months for which data is available. In the present scenario, for the selected state the monthly feeder data was available for limited months for the year 2016-17.

**Figure 37: Illustrative - circle wise average supply gap**

| Supply gap (Mins) | Time Block | Month 1 | Month 2 | Month 3 | Month 4 | Average (Mins) | Average (Hours) |
|---|---|---|---|---|---|---|---|
| Circle 1 | *24 hours* | 155 | 124 | 160 | 178 | 168 | 2.8 |
| | *12 hours* | 174 | 176 | 178 | 147 | 169 | 2.8 |
| | *8 hours* | 173 | 168 | 170 | 209 | 142 | 2.4 |
| Circle 2 | *24 hours* | 170 | 167 | 245 | 230 | 201 | 3.4 |
| | *12 hours* | 173 | 140 | 137 | 54 | 148 | 2.5 |
| | *8 hours* | 127 | 155 | 157 | 163 | 126 | 2.1 |
| Circle 3 | *24 hours* | 157 | 128 | 125 | 146 | 142 | 2.4 |
| | *12 hours* | 168 | 143 | 142 | 127 | 155 | 2.6 |
| | *8 hours* | 98 | 118 | 114 | 105 | 99 | 1.7 |

The results as derived in the previous step for the particular period was considered for the same year i.e. FY 2016-17. This has been considered as the base year and the same has been extrapolated circle wise to arrive at the supply gap for the previous ten year i.e. up to FY 2006-07.

The following provides an indicative supply disruption for the state, arrived by averaging the disruption in supply hours for all sample circles.

- Domestic 169 min average disruption; 21.2 hours average supply per day
- Non-domestic 156 min average disruption; 9.4 hours average supply per day
- Agriculture 143 min average disruption; 5.6 hours average supply per day

The supply interruption data given in the national power portal is for the total number of interruptions and total duration of interruptions in a year. The same is not as per category wise and in several feeders the data is not available. Hence direct comparison cannot be carried out unless category wise details are available.

The assumptions considered for the extrapolation are:

- The gap in supply hours have been considered same for a particular year after averaging the monthly data. Month wise variation have not been considered.
- For the year previous to the current year, the gap in supply hours have been increased by 1%. The same has been carried out for each circle and for the three categories which have been defined earlier.
- The assumption of 1% increase in YoY supply gap over the previous years has been considered with the view that in the previous 10 years from FY 2006-07, the gap in supply hours has reduced
- Since there is no definite data available for supply hours to validate, the assumption has been considered based on realistic conditions that over the period of ten years, the improvement in gap in supply hours has been very minimal. Hence consideration of a higher % (say 5%) would not have been a realistic assumption in this case.
- The assumption considered above could have been validated in case feeder level historical data would have been available.

The following figure illustrates the assumptions stated above:

**Table 32: Illustrative: Extrapolation of gap in supply hours highlighted for a sample circle**

| Category | FY 13-14 | FY 14-15 | FY 15-16 | FY 16-17 |
|---|---|---|---|---|
| Domestic | 2.47 | 2.45 | 2.42 | 2.40 |
| Non domestic | 2.68 | 2.65 | 2.63 | 2.60 |
| Agriculture | 1.75 | 1.73 | 1.72 | 1.70 |

The exercise was carried out for the historical data of all the circles. Post the extrapolation of the gap in supply hours for each category is carried out for every circle, the next step is to determine the supply hours for each category. The same is illustrated in the table below.

**Table 33: Illustrative: Calculation of supply hours for historical data highlighted for a sample circle**

| Category | Unit in Hours | | FY 14-15 | FY 15-16 | FY 16-17 |
|---|---|---|---|---|---|
| Domestic | Target supply | | 24.00 | 24.00 | 24.00 |
| | Gap in supply | $Y_2$ | 2.45 | 2.42 | 2.40 |

| | | | | | |
|---|---|---|---|---|---|
| | Actual supply | $Y_1$ | 21.55 | 21.58 | 21.60 |
| Non domestic | Target supply | | 12.00 | 12.00 | 12.00 |
| | Gap in supply | $Y_2$ | 2.65 | 2.63 | 2.60 |
| | Actual supply | $Y_1$ | 9.35 | 9.37 | 9.40 |
| Agriculture | Target supply | | 8.00 | 8.00 | 8.00 |
| | Gap in supply | $Y_2$ | 1.73 | 1.72 | 1.70 |
| | Actual supply | $Y_1$ | 6.27 | 6.28 | 6.30 |

* $Y_2$ and $Y_1$ - as defined in figure 1 of Section 3.1 of the report on Baseline correction

The above exercise was carried out for historical data for all the years.

The next step is to determine the unserved demand which could not be realized due to curtailment of supply. As per the proposed methodology, the unserved demand was determined by a straight line approach using the gap in supply hours calculated above and the restricted demand data available from the state utility.

The following section highlights the calculation for a sample circle done for the domestic category for the year FY 2014-15

- Monthly average hours of supply per month estimated using the methodology described above = [$Y_1$] = 21.55 hours
- Monthly average actual restricted supply units – Domestic category = [$X_1$] = 148 MU (sample value)
- Monthly average hours of supply curtailed for Domestic supply = [$Y_2$] = 2.45 hours
- Monthly average un-served demand based on curtailed supply hours =[$X_2$] = [(24* - $Y_1$) * ($X_1$ / $Y_1$)] = 16.82 MU
- Average unrestricted demand after baseline correction

  = [$X_1$] + [$X_2$]

  = (148 + 16.82) MU = 164.82 MU

  Based on the above calculation

  Served restricted unit = 148 MU

  Unserved units = 16.82 MU

Similarly, the unserved units was derived for each month of the previous ten years across categories and for each circles.

The monthly unserved demand for each categories are then summed up to arrived at the yearly demand. The following figure illustrates the calculation

Figure 38: Category wise monthly served and unserved demand

| | | Apr-06 | May-06 | Jun-06 | Jul-06 | Aug-06 | Sep-06 |
|---|---|---|---|---|---|---|---|
| Domestic | *Served* | 8.17 | 10.23 | 12.44 | 15.17 | 15.63 | 16.38 |
| | *Unserved* | 1.48 | 1.85 | 2.25 | 2.75 | 2.83 | 2.97 |
| | *Total* | 9.65 | 12.08 | 14.70 | 17.92 | 18.47 | 19.35 |
| Non-Domestic | *Served* | 2.56 | 3.01 | 3.66 | 3.80 | 3.97 | 4.01 |
| | *Unserved* | 0.69 | 0.81 | 0.98 | 1.02 | 1.06 | 1.07 |
| | *Total* | 3.25 | 3.82 | 4.64 | 4.82 | 5.03 | 5.08 |

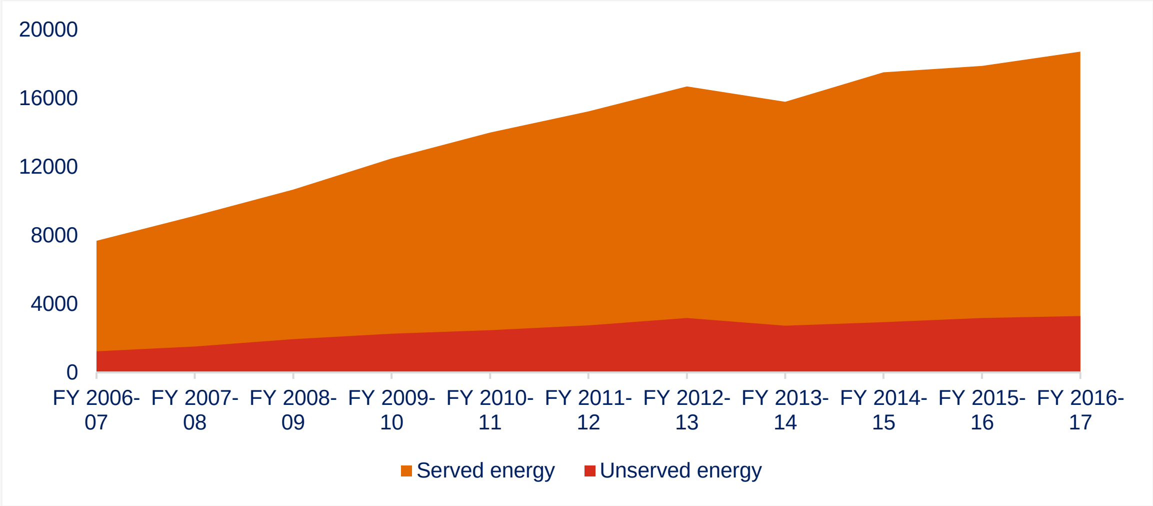
Figure 39: Category wise yearly served and unserved data

| **Unit - Million Unit (MU)** | | FY 2006-07 | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 |
|---|---|---|---|---|---|---|
| Domestic | *Served* | 148.07 | 178.92 | 221.22 | 255.97 | 297.30 |
| | *Unserved* | 26.83 | 32.05 | 39.16 | 44.79 | 51.41 |
| Non-Domestic | *Served* | 40.86 | 49.26 | 57.61 | 67.04 | 74.07 |
| | *Unserved* | 10.95 | 13.04 | 15.06 | 17.31 | 18.88 |

The year wise historical unserved demand determined for each category is added to the restricted demand to arrive at the unrestricted demand. The exercise has been carried out category wise and for each circle.

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

Figure 40: Historical data post baseline correction (Illustration)




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

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

In the subsequent tables, the unrestricted electricity demand post baseline correction is provided. The baseline correction has been carried out for each circles and then aggregated to arrive at the Distribution utility level.

In the subsequent sections, the steps of the methodology have been illustrated using a sample Circle. The Circle of JPDC has been considered for the same. The results of the JPDC circle shall be used to show the three methods that were used.

**Table 34: JVVNL: Baseline corrected historical data**

| JVVNL | MUs | FY 2006-07 | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 | FY 2011-12 | FY 2012-13 | FY 2013-14 | FY 2014-15 | FY 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | Served | 1620 | 1911 | 2180 | 2658 | 3032 | 3142 | 3491 | 3761 | 4068 | 4418 |
| | Unserved | 150 | 182 | 216 | 263 | 304 | 312 | 352 | 359 | 399 | 430 |
| | Total | 1770 | 2093 | 2396 | 2921 | 3336 | 3454 | 3843 | 4121 | 4466 | 4848 |
| Non-Domestic | Served | 647 | 780 | 835 | 898 | 996 | 1188 | 1550 | 1573 | 1805 | 1966 |
| | Unserved | 172 | 205 | 219 | 233 | 258 | 304 | 391 | 398 | 445 | 480 |
| | Total | 819 | 985 | 1054 | 1131 | 1254 | 1492 | 1941 | 1971 | 2249 | 2445 |
| Public Street Light | | 55 | 61 | 75 | 79 | 92 | 110 | 129 | 143 | 168 | 175 |
| Agriculture (M + N + P)) | Served | 884 | 1351 | 2062 | 2777 | 3288 | 4148 | 5135 | 4258 | 4741 | 5261 |
| | Unserved | 389 | 585 | 876 | 1160 | 1349 | 1706 | 2047 | 1670 | 1828 | 1999 |
| | Total | 1273 | 1936 | 2938 | 3936 | 4637 | 5854 | 7182 | 5928 | 6569 | 7259 |
| Agriculture (F) | Served | 1017 | 1047 | 1137 | 1153 | 1051 | 783 | 724 | 581 | 530 | 517 |
| | Unserved | 477 | 484 | 524 | 529 | 477 | 349 | 318 | 255 | 230 | 221 |
| | Total | 1493 | 1532 | 1661 | 1682 | 1527 | 1132 | 1043 | 836 | 760 | 739 |
| Industry (Small + Med) | | 645 | 723 | 760 | 796 | 898 | 904 | 941 | 996 | 1104 | 1036 |
| Industry (L) | | 2071 | 2460 | 2747 | 3095 | 3520 | 3835 | 3721 | 3482 | 4294 | 3775 |
| PWW (S + M + L) | | 288 | 310 | 328 | 346 | 355 | 387 | 416 | 426 | 474 | 529 |
| Mixed Load | | 165 | 186 | 250 | 333 | 430 | 366 | 171 | 161 | 168 | 172 |
| | Restricted | 7391 | 8829 | 10374 | 12136 | 13661 | 14863 | 16278 | 15381 | 17351 | 17850 |
| | Unserved | 1188 | 1456 | 1835 | 2185 | 2388 | 2671 | 3108 | 2683 | 2901 | 3130 |
| | Total | 8579 | 10286 | 12209 | 14321 | 16050 | 17535 | 19386 | 18063 | 20252 | 20980 |

## Table 35: AVVNL: Baseline corrected historical data

| AVVNL | MUs | FY 2006-07 | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 | FY 2011-12 | FY 2012-13 | FY 2013-14 | FY 2014-15 | FY 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | Served | 1069 | 1231 | 1421 | 1609 | 1893 | 2114 | 2410 | 2706 | 2925 | 3133 |
| | Unserved | 153 | 175 | 199 | 223 | 259 | 286 | 320 | 355 | 380 | 402 |
| | Total | 1223 | 1405 | 1620 | 1832 | 2152 | 2400 | 2730 | 3061 | 3305 | 3535 |
| Non-Domestic | Served | 297 | 356 | 388 | 404 | 442 | 514 | 717 | 816 | 901 | 1004 |
| | Unserved | 93 | 110 | 118 | 121 | 131 | 150 | 204 | 230 | 250 | 275 |
| | Total | 390 | 466 | 505 | 525 | 572 | 663 | 921 | 1045 | 1151 | 1280 |
| Public Street Light | | 38 | 40 | 41 | 42 | 47 | 53 | 56 | 61 | 73 | 82 |
| Agriculture (M + N + P)) | Served | 1079 | 1377 | 1623 | 1986 | 2217 | 2705 | 3464 | 3592 | 3545 | 3827 |
| | Unserved | 471 | 592 | 688 | 830 | 914 | 1098 | 1372 | 1403 | 1365 | 1454 |
| | Total | 1550 | 1969 | 2312 | 2816 | 3131 | 3803 | 4836 | 4994 | 4911 | 5281 |
| Agriculture (F) | Served | 1237 | 1268 | 1268 | 1260 | 1278 | 1317 | 1324 | 1282 | 1218 | 1112 |
| | Unserved | 539 | 545 | 537 | 526 | 527 | 535 | 524 | 500 | 469 | 422 |
| | Total | 1776 | 1813 | 1806 | 1786 | 1805 | 1851 | 1848 | 1782 | 1686 | 1534 |
| Industry (Small + Med) | | 570 | 639 | 680 | 756 | 798 | 860 | 908 | 954 | 1066 | 1089 |
| Industry (L) | | 1626 | 1970 | 2011 | 1937 | 2465 | 2446 | 2487 | 2567 | 2630 | 2319 |
| PWW (S + M + L) | | 261 | 294 | 327 | 338 | 354 | 383 | 387 | 426 | 435 | 478 |
| Mixed Load | | 108 | 137 | 154 | 227 | 283 | 256 | 109 | 96 | 106 | 109 |
| | Restricted | 6287 | 7311 | 7914 | 8558 | 9777 | 10646 | 11863 | 12500 | 12899 | 13154 |
| | Unserved | 1256 | 1421 | 1543 | 1701 | 1831 | 2069 | 2420 | 2488 | 2464 | 2554 |
| | Total | 7542 | 8732 | 9457 | 10259 | 11608 | 12714 | 14283 | 14987 | 15364 | 15707 |

**Table 36: JdVVNL: Baseline corrected historical data**

| JdVVNL | MUs | FY 2006-07 | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 | FY 2011-12 | FY 2012-13 | FY 2013-14 | FY 2014-15 | FY 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | Served | 1071 | 1329 | 1414 | 1561 | 1811 | 2007 | 2255 | 2542 | 2793 | 3002 |
| | Unserved | 154 | 188 | 198 | 216 | 248 | 272 | 299 | 334 | 363 | 385 |
| | Total | 1225 | 1517 | 1612 | 1777 | 2059 | 2278 | 2555 | 2876 | 3156 | 3387 |
| Non-Domestic | Served | 313 | 396 | 409 | 417 | 456 | 527 | 780 | 838 | 904 | 986 |
| | Unserved | 98 | 122 | 124 | 125 | 135 | 154 | 222 | 236 | 251 | 270 |
| | Total | 411 | 518 | 533 | 542 | 591 | 681 | 1002 | 1073 | 1156 | 1256 |
| Public Street Light | | 39 | 52 | 80 | 107 | 117 | 118 | 123 | 185 | 142 | 137 |
| Agriculture (M + N + P)) | Served | 1280 | 1849 | 2437 | 3456 | 4069 | 4810 | 6288 | 6443 | 7473 | 7964 |
| | Unserved | 558 | 795 | 1033 | 1445 | 1678 | 1953 | 2490 | 2516 | 2878 | 3026 |
| | Total | 1839 | 2645 | 3470 | 4901 | 5747 | 6763 | 8778 | 8959 | 10351 | 10990 |
| Agriculture (F) | Served | 1162 | 1233 | 1264 | 1441 | 1357 | 1589 | 1388 | 1685 | 1335 | 1310 |
| | Unserved | 507 | 530 | 536 | 602 | 560 | 645 | 550 | 658 | 514 | 498 |
| | Total | 1668 | 1763 | 1799 | 2043 | 1917 | 2234 | 1938 | 2343 | 1849 | 1808 |
| Industry (Small + Med) | | 466 | 535 | 550 | 576 | 638 | 694 | 781 | 803 | 850 | 846 |
| Industry (L) | | 961 | 951 | 956 | 915 | 1077 | 1124 | 990 | 1077 | 1258 | 1183 |
| PWW (S + M + L) | | 499 | 557 | 584 | 656 | 662 | 667 | 675 | 689 | 740 | 796 |
| Mixed Load | | 286 | 320 | 359 | 457 | 533 | 488 | 335 | 324 | 350 | 351 |
| | Restricted | 6078 | 7222 | 8052 | 9586 | 10721 | 12024 | 13615 | 14587 | 15845 | 16574 |
| | Unserved | 1317 | 1636 | 1892 | 2389 | 2620 | 3024 | 3561 | 3744 | 4006 | 4179 |
| | Total | 7394 | 8858 | 9943 | 11975 | 13341 | 15048 | 17176 | 18330 | 19851 | 20753 |

### Table 37: JPDC (Sample Circle): Baseline corrected historical data

| JPDC | MUs | FY 2006-07 | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 | FY 2011-12 | FY 2012-13 | FY 2013-14 | FY 2014-15 | FY 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | Served | 100 | 146 | 174 | 210 | 234 | 279 | 352 | 359 | 381 | 432 |
| | Unserved | 14 | 20 | 24 | 28 | 31 | 37 | 45 | 46 | 48 | 53 |
| | Total | 114 | 166 | 198 | 238 | 265 | 316 | 397 | 405 | 428 | 485 |
| Non-Domestic | Served | 38 | 49 | 55 | 71 | 74 | 108 | 153 | 168 | 195 | 207 |
| | Unserved | 13 | 17 | 19 | 24 | 25 | 36 | 50 | 54 | 62 | 65 |
| | Total | 51 | 66 | 74 | 95 | 100 | 145 | 203 | 222 | 256 | 272 |
| Public Street Light | | 3 | 3 | 3 | 3 | 4 | 5 | 5 | 6 | 7 | 8 |
| Agriculture (M + N + P)) | Served | 197 | 316 | 464 | 641 | 652 | 930 | 1081 | 827 | 896 | 998 |
| | Unserved | 100 | 158 | 229 | 312 | 312 | 438 | 495 | 374 | 399 | 438 |
| | Total | 298 | 475 | 693 | 953 | 964 | 1368 | 1576 | 1201 | 1295 | 1435 |
| Agriculture (F) | Served | 548 | 557 | 650 | 717 | 671 | 489 | 496 | 451 | 419 | 412 |
| | Unserved | 279 | 279 | 321 | 349 | 321 | 230 | 227 | 204 | 187 | 181 |
| | Total | 827 | 836 | 971 | 1066 | 992 | 719 | 723 | 654 | 606 | 593 |
| Industry (Small + Med) | | 67 | 83 | 84 | 90 | 99 | 110 | 116 | 128 | 139 | 136 |
| Industry (L) | | 187 | 239 | 328 | 398 | 506 | 634 | 597 | 559 | 704 | 584 |
| PWW (S + M + L) | | 23 | 24 | 23 | 26 | 31 | 35 | 43 | 40 | 47 | 53 |
| Mixed Load | | 10 | 12 | 17 | 24 | 33 | 34 | 10 | 8 | 7 | 9 |
| | Restricted | 1173 | 1429 | 1799 | 2180 | 2305 | 2624 | 2852 | 2545 | 2794 | 2838 |
| | Unserved | 406 | 475 | 593 | 713 | 690 | 742 | 818 | 677 | 695 | 737 |
| | Total | 1579 | 1904 | 2391 | 2893 | 2995 | 3366 | 3670 | 3223 | 3489 | 3576 |

# 8. Implementation of alternate methodology

## 8.1. Analysis of historical data – category wise to gather insights and understand behavior

The category wise historical data of sales and consumers was analyzed for all the Circles on the following aspects:

- Category wise composition in a circle
- Behavior of the category in the overall mix over the years
- Growth rate over previous year
- CAGR growth rates for the 9 periods

The analysis helped in understanding how the categories have contributed to the demand in a Circle and the demand of the Utility. For e.g. in certain cases, domestic category in one circle had much less growth while in another, the trend was different. The illustrations for the sample circle is highlighted below:

**Figure 41: JPDC – Consumers: Category wise composition**

| Categories | FY 2006-07 | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 | FY 2011-12 | FY 2012-13 | FY 2013-14 | FY 2014-15 | FY 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 61% | 62% | 64% | 66% | 68% | 69% | 70% | 71% | 72% | 73% |
| Non-Domestic | 8% | 8% | 8% | 7% | 7% | 7% | 7% | 7% | 7% | 7% |
| Public Street Light | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Agriculture (M + N + P)) | 13% | 14% | 15% | 16% | 15% | 15% | 14% | 14% | 13% | 13% |
| Agriculture (F) | 16% | 13% | 10% | 9% | 8% | 7% | 6% | 5% | 5% | 4% |
| Industry (Small + Med) | 2% | 2% | 2% | 1% | 2% | 1% | 2% | 2% | 2% | 2% |
| Industry (L) | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| PWW (S + M + L) | 0% | 0% | 0% | 0% | 0% | 1% | 1% | 1% | 1% | 1% |
| Mixed Load | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

**Figure 42: JPDC - Consumers: Growth over previous year**

| Categories | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 | FY 2011-12 | FY 2012-13 | FY 2013-14 | FY 2014-15 | FY 2015-16 | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 7% | 18% | 14% | 10% | 11% | 8% | 11% | 9% | 8% | *11%* |
| Non-Domestic | 7% | 7% | 5% | 3% | 8% | 8% | 9% | 10% | 8% | *7%* |
| Public Street Light | 17% | 8% | 3% | 10% | 3% | 15% | 12% | 20% | 32% | *13%* |
| Agriculture (M + N + P)) | 16% | 24% | 15% | 6% | 4% | 3% | 6% | 5% | 3% | *9%* |
| Agriculture (F) | -13% | -11% | -7% | -5% | -3% | -3% | -5% | -5% | -6% | *-6%* |
| Industry (Small + Med) | 9% | 9% | 1% | 11% | 5% | 12% | 16% | 9% | 2% | *8%* |
| Industry (L) | 18% | 27% | 17% | 21% | 12% | 13% | 10% | 10% | 12% | *16%* |
| PWW (S + M + L) | 4% | 16% | 8% | 11% | 30% | 51% | 14% | 29% | 13% | *20%* |
| Mixed Load | 10% | 59% | 37% | 15% | -31% | -7% | 6% | 7% | 5% | *11%* |

**Figure 43: JPDC Consumers: CAGR growth for 9 periods**

| *CAGR* | 9 year | 8 year | 7 year | 6 year | 5 year | 4 year | 3 year | 2 year | 1 year |
|---|---|---|---|---|---|---|---|---|---|
| Categories | FY 2006-07 | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 | FY 2011-12 | FY 2012-13 | FY 2013-14 | FY 2014-15 |
| Domestic | 7% | 7% | 7% | 8% | 9% | 9% | 9% | 9% | 8% |
| Non-Domestic | 13% | 13% | 13% | 15% | 16% | 20% | 21% | 26% | 32% |
| Public Street Light | 9% | 8% | 6% | 4% | 4% | 4% | 5% | 4% | 3% |
| Agriculture (M + N + P)) | -6% | -6% | -5% | -5% | -4% | -5% | -5% | -6% | -6% |
| Agriculture (F) | 8% | 8% | 8% | 9% | 9% | 10% | 9% | 5% | 2% |
| Industry (Small + Med) | 15% | 15% | 14% | 13% | 11% | 11% | 11% | 11% | 12% |
| Industry (L) | 19% | 21% | 22% | 24% | 27% | 26% | 19% | 21% | 13% |
| PWW (S + M + L) | 9% | 8% | 3% | -2% | -5% | 3% | 6% | 6% | 5% |
| Mixed Load | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Figure 44: JPDC – Historical sales: Category wise composition

| Categories | FY 2006-07 | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 | FY 2011-12 | FY 2012-13 | FY 2013-14 | FY 2014-15 | FY 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 9% | 10% | 10% | 10% | 10% | 11% | 12% | 14% | 14% | 15% |
| Non-Domestic | 3% | 3% | 3% | 3% | 3% | 4% | 5% | 7% | 7% | 7% |
| Public Street Light | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Agriculture (M + N + P)) | 17% | 22% | 26% | 29% | 28% | 35% | 38% | 32% | 32% | 35% |
| Agriculture (F) | 47% | 39% | 36% | 33% | 29% | 19% | 17% | 18% | 15% | 15% |
| Industry (Small + Med) | 6% | 6% | 5% | 4% | 4% | 4% | 4% | 5% | 5% | 5% |
| Industry (L) | 16% | 17% | 18% | 18% | 22% | 24% | 21% | 22% | 25% | 21% |
| PWW (S + M + L) | 2% | 2% | 1% | 1% | 1% | 1% | 2% | 2% | 2% | 2% |
| Mixed Load | 1% | 1% | 1% | 1% | 1% | 1% | 0% | 0% | 0% | 0% |

## Figure 45: JPDC - Historical sales: Growth over previous year

| Categories | FY 2007-08 | FY 2008-09 | FY 2009-10 | FY 2010-11 | FY 2011-12 | FY 2012-13 | FY 2013-14 | FY 2014-15 | FY 2015-16 | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 45% | 20% | 21% | 11% | 19% | 26% | 2% | 6% | 13% | *18%* |
| Non-Domestic | 30% | 13% | 28% | 5% | 46% | 41% | 10% | 16% | 6% | *22%* |
| Public Street Light | 21% | 0% | 4% | 23% | 14% | 10% | 11% | 12% | 16% | *12%* |
| Agriculture (M + N + P)) | 60% | 47% | 38% | 2% | 43% | 16% | -23% | 8% | 11% | *22%* |
| Agriculture (F) | 2% | 17% | 10% | -6% | -27% | 1% | -9% | -7% | -2% | *-2%* |
| Industry (Small + Med) | 25% | 1% | 7% | 11% | 11% | 5% | 10% | 8% | -2% | *8%* |
| Industry (L) | 28% | 37% | 21% | 27% | 25% | -6% | -6% | 26% | -17% | *15%* |
| PWW (S + M + L) | 2% | -3% | 13% | 20% | 14% | 22% | -7% | 18% | 14% | *10%* |
| Mixed Load | 19% | 45% | 42% | 39% | 1% | -70% | -26% | -2% | 19% | *7%* |

## Figure 46: JPDC - Historical sales: CAGR growth rates

| *CAGR* | 9 year | 8 year | 7 year | 6 year | 5 year | 4 year | 3 year | 2 year | 1 year |
|---|---|---|---|---|---|---|---|---|---|
| **Categories** | **FY 2006-07** | **FY 2007-08** | **FY 2008-09** | **FY 2009-10** | **FY 2010-11** | **FY 2011-12** | **FY 2012-13** | **FY 2013-14** | **FY 2014-15** |
| Domestic | 18% | 15% | 14% | 13% | 13% | 12% | 7% | 10% | 13% |
| Non-Domestic | 21% | 20% | 21% | 20% | 23% | 18% | 11% | 11% | 6% |
| Public Street Light | 12% | 11% | 13% | 14% | 13% | 12% | 13% | 14% | 16% |
| Agriculture (M + N + P)) | 20% | 15% | 12% | 8% | 9% | 2% | -3% | 10% | 11% |
| Agriculture (F) | -3% | -4% | -6% | -9% | -9% | -4% | -6% | -4% | -2% |
| Industry (Small + Med) | 8% | 6% | 7% | 7% | 6% | 5% | 5% | 3% | -2% |
| Industry (L) | 13% | 12% | 9% | 7% | 3% | -2% | -1% | 2% | -17% |
| PWW (S + M + L) | 10% | 11% | 13% | 13% | 11% | 11% | 7% | 16% | 14% |
| Mixed Load | -1% | -3% | -9% | -15% | -23% | -29% | -5% | 8% | 19% |

From the figures above, observations as drawn are given below:

- Share of domestic consumers has increased in the circle with corresponding increase in electricity requirement
- There has been a shift of consumers and demand from Agri (F) to Agri (M)
- In the Industrial category, there has been growth in new consumers over the years, however demand in the last 3-4 years has not picked up specifically in Industries (L) category

Similarly, specific trends were observed for each of the 26 circles across categories and this helped in understanding the individual behavior. The trends as observed were used in undertaking the forecasts.

## 8.2. Selection of forecasting methods for each forecast period

There are a number of forecasting methods (Econometric, Time series, Trend analysis etc.) through which electricity demand could be forecasted. For forecasting demand under various time horizons (short, medium and long), combination of methods has been used for different forecast periods. Every method has its merits and demerits. Every method is dependent upon a set of input variables.

After analysis of the historical data, the four methods which were used for the forecast period are given as below:

**Table 38: Selection of forecasting methods**

| Sl. No. | Method | Periodicity | Forecast level | Data level |
|---|---|---|---|---|
| 1. | Trend method | Short/ Medium/ Long | Category wise in each circle | Yearly data |
| 2. | Time series method – Holt Winters method | Short/ Medium/ Long | Category wise in each circle | Monthly data |
| 3. | Econometric method | Short/ Medium/ Long | Category wise in each circle | Yearly data |
| 4. | End use method | Medium/Long | Specific categories | Yearly data |

As per the scope of work of this assignment, the short, medium and long terms requirements have been defined as under:

| | | |
|---|---|---|
| Short term | 5 years | FY 2016-17 to FY 2020-21 |
| Medium term | 5 years | FY 2021-22 to FY 2025-26 |
| Long term | 6 years | FY 2026-27 to FY 2031-32 |

To start with the forecast, periodicity restrictions on the methods have not been imposed.

## 8.3. Use of trend method

Post the analysis of the historical data and after determination of the growth rates (year on year growth and CAGR growth) for energy consumption, consumer data, the forecast model using trend method was developed. The process was carried out for each consumer category and repeated for all the circles.

The application of trend method for specific categories is varied and different approaches and factors have been used to develop the forecast.

**Table 39: Details of category wise approach to forecasting**

| Sl. No | Categories | Method used | Additional factors |
|---|---|---|---|
| 1. | Domestic | Number of consumers x Consumption per consumer | Growth rate of consumers<br>Growth of consumption per consumer<br>Manual option to enter above rates<br>Latent/ Lifestyle<br>Energy Efficiency |
| 2. | Non- domestic | Number of consumers x Consumption per consumer | Growth rate of consumers<br>Growth of consumption per consumer<br>Manual option to enter above rates |

| | | | |
|---|---|---|---|
| | | | Energy Efficiency |
| 3. | Public Street light | Number of consumers x Consumption per consumer | Growth rate of consumers<br>Growth of consumption per consumer<br>Manual option to enter above rates<br>Energy Efficiency |
| 4. | Agriculture (MNP) | Number of consumers x Consumption per consumer | Growth rate of consumers<br>Growth of consumption per consumer<br>Manual option to enter above rates<br>Energy Efficiency |
| 5. | Agriculture (F) | Number of consumers x Consumption per consumer | Growth rate of consumers<br>Growth of consumption per consumer<br>Manual option to enter above rates<br>Energy Efficiency |
| 6. | Industries<br>(Small + Medium) | Sales x Historical growth rate | Manual option to enter growth rate<br>Energy Efficiency |
| 7. | Industries (Large) | Sales x Historical growth rate | Manual option to enter growth rate<br>Energy Efficiency |
| 8. | Public Water Works (PWW) | Sales x Historical growth rate | Manual option to enter growth rate<br>Energy Efficiency |
| 9. | Mixed load | Sales x Historical growth rate | Manual option to enter growth rate<br>Energy Efficiency |
| 10. | Railways | Forecast carried out independent of Distribution utilities | |

The approach as defined above was used separately for the three forecast terms i.e. separate trends were used each of the short, medium and term terms to arrive at the forecast.

In summary, the method was used in:

- 3 Distribution utilities
- 26 Circles
- 9 consumer categories
- 3 forecast horizons – separate trends for Short, Medium and Long Terms

Therefore 702 combinations of individual forecast were developed using the trend method at the lowest forecast level and then aggregated to arrive at the Circle, Distribution utility and State level forecast at unrestricted level. The following table highlights the base forecasts arrived for the sample Circle – JPDC.

**Table 40: Base forecast (Unrestricted) developed for JPDC circle using Trend method**

| JPDC (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 522 | 562 | 604 | 648 | 695 | 748 | 804 | 863 | 925 | 990 | 1068 | 1151 | 1237 | 1328 | 1423 | 1521 |
| Non-Domestic | 293 | 316 | 340 | 366 | 393 | 423 | 454 | 488 | 523 | 561 | 601 | 643 | 688 | 735 | 784 | 836 |
| Public Street Light | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 |
| Agriculture (M + N + P)) | 1523 | 1615 | 1712 | 1813 | 1920 | 2005 | 2094 | 2185 | 2278 | 2373 | 2470 | 2569 | 2670 | 2772 | 2876 | 2980 |
| Agriculture (F) | 508 | 443 | 386 | 337 | 293 | 232 | 183 | 144 | 114 | 90 | 62 | 42 | 29 | 20 | 14 | 9 |
| Industry (Small + Med) | 142 | 148 | 154 | 161 | 167 | 170 | 173 | 176 | 178 | 181 | 183 | 186 | 188 | 190 | 192 | 193 |
| Industry (L) | 617 | 651 | 686 | 723 | 762 | 774 | 786 | 798 | 809 | 819 | 830 | 839 | 848 | 857 | 864 | 871 |
| PWW (S + M + L) | 57 | 60 | 64 | 68 | 72 | 77 | 81 | 86 | 91 | 97 | 102 | 108 | 114 | 120 | 126 | 133 |
| Mixed Load | 9 | 10 | 11 | 11 | 12 | 13 | 14 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 23 |
| | 3680 | 3814 | 3967 | 4138 | 4325 | 4453 | 4600 | 4764 | 4944 | 5137 | 5344 | 5567 | 5804 | 6053 | 6311 | 6577 |

The base forecast for the Circle is excluding the following

- Demand from Railways
- Additional demand due to planned agriculture and domestic connections
- Additional demand due to other factors like new infrastructure projects
- Open access and captive
- Electric vehicles

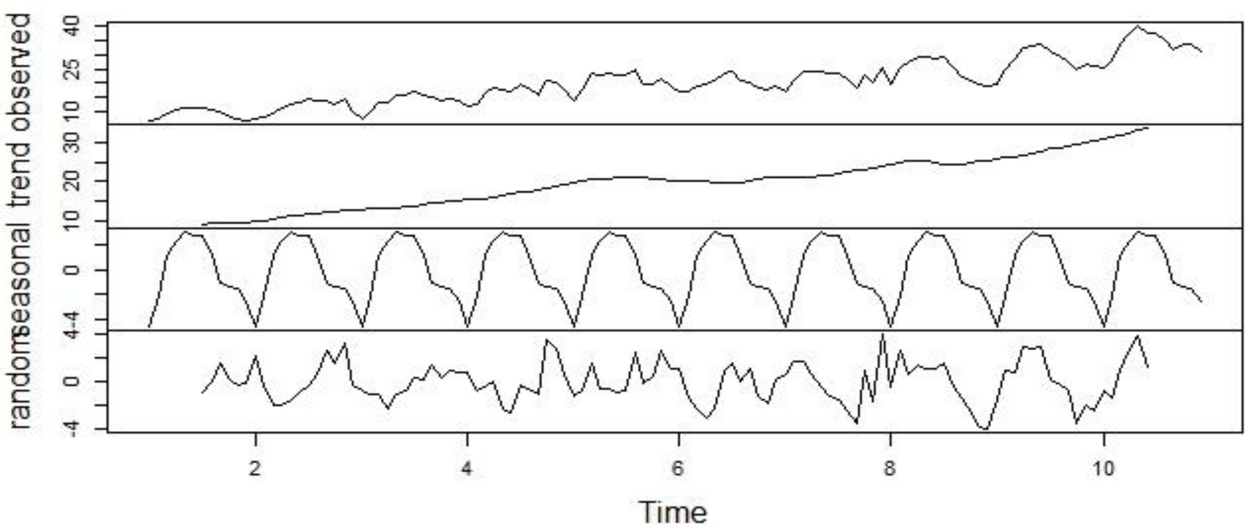
Similarly, the forecasts were worked out for all the other circles.

## 8.4. Use of Holts-Winter's multiplicative and additive exponential smoothing

Exponential smoothing is a technique that is usually applied to time series data, either to produce smoothed data for presentation, or to make forecasts. Whereas in the simple moving average method the past observations are weighted equally, exponential smoothing assigns exponentially decreasing weights over time. In other words, recent observations are given relatively more weightage in forecasting method than the older observations.

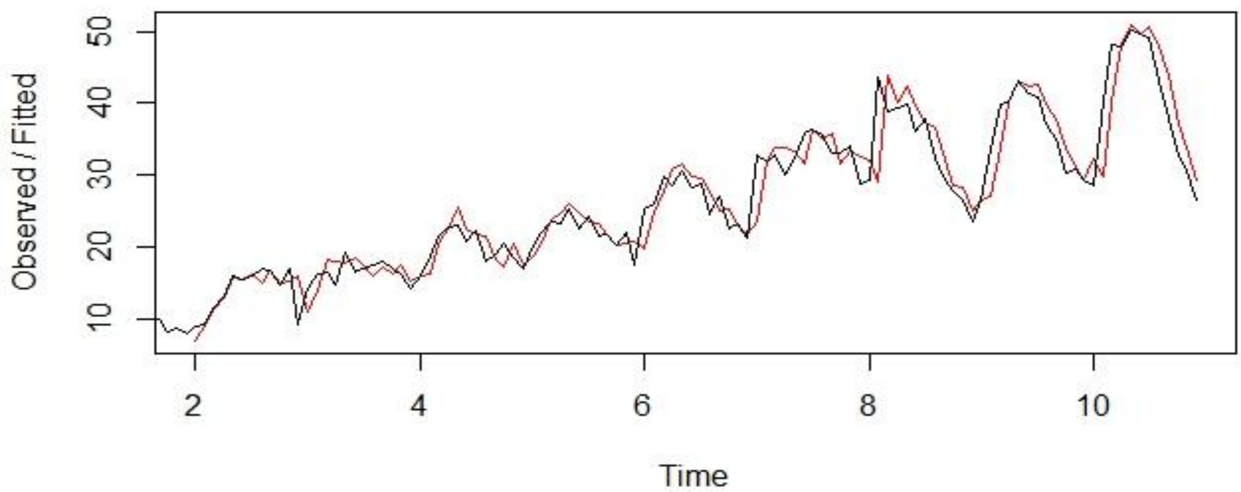
Holts-Winter's multiplicative and additive exponential smoothing is one of the commonly used techniques used for forecasting. This model extends Holt's two parameter model by including a third smoothing operation to adjust for the seasonality. The equation assumes that the trend is additive and that the seasonal influence is multiplicative. This method models trend, seasonality and randomness using as efficient exponential smoothing process. The figure below highlights how the method decomposes a historical data into the different components. The forecast using his method has been developed using R software.

**Figure 47: Decomposition of historical data by Holt-Winter's method**




After the decomposition, the method models the historical data as shown below:

**Figure 48: Modeling of historical data using Holt-Winter's method**




Post the modelling, the monthly forecasts of electricity are developed for each category. The following table highlights the base forecasts arrived for the sample Circle – JPDC.

**Table 41: Base forecast (Unrestricted) developed for JPDC circle using Holt-Winter's method**

| JPDC (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 461 | 511 | 561 | 610 | 660 | 710 | 760 | 809 | 859 | 909 | 958 | 1008 | 1058 | 1108 | 1157 | 1207 |
| Non-Domestic | 275 | 295 | 314 | 334 | 353 | 373 | 392 | 412 | 431 | 450 | 470 | 489 | 509 | 528 | 548 | 567 |
| Public Street Light | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 | 13 | 13 | 14 | 14 | 15 | 15 | 16 | 16 |
| Agriculture (M + N + P)) | 1781 | 1975 | 2169 | 2363 | 2557 | 2751 | 2945 | 3139 | 3333 | 3527 | 3721 | 3915 | 4109 | 4303 | 4497 | 4691 |
| Agriculture (F) | 252 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 165 | 178 | 194 | 211 | 229 | 249 | 269 | 290 | 312 | 335 | 359 | 383 | 408 | 434 | 460 | 487 |
| Industry (L) | 614 | 664 | 714 | 764 | 814 | 864 | 914 | 964 | 1014 | 1064 | 1114 | 1164 | 1214 | 1264 | 1314 | 1364 |
| PWW (S + M + L) | 58 | 63 | 67 | 72 | 76 | 81 | 85 | 89 | 94 | 98 | 103 | 107 | 112 | 116 | 121 | 125 |
| Mixed Load | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 |
| | 3626 | 3747 | 4044 | 4381 | 4720 | 5059 | 5400 | 5741 | 6083 | 6426 | 6770 | 7115 | 7460 | 7806 | 8153 | 8500 |

The base forecast for the Circle is excluding the following

- Railway demand
- Additional demand due to planned agriculture and domestic connections
- Additional demand due to other factors like new infrastructure projects
- Open access and captive
- Electric vehicles

Similarly, the forecasts were worked out for all the other circles.

## 8.5. Identification of Independent variables

For undertaking the forecast using econometric method, identification of independent variables is a crucial step. In this stage, a large number of variables are looked into and tested. Since econometric method has been planned to be used for all the categories, hence a broad range of major independent variables were shortlisted so that impact on electricity can be found out.

Availability of historical data of independent variables is a critical aspect in selection. Also it has to be ensured that the value of the variables are kept at the same base years for uniformity. For e.g. GSDP data is available in base of 2004-05 and also for 2011-12. Since 10 years of historical data is being used from FY 2006-07, the data for the relevant base years have been selected. The historical data of independent variables have been taken from sources available in public domain. Following is the list of the independent variables which are considered.

**Table 42: List of independent variables considered for econometric method**

| Sl. No | Independent variables | Data level |
|---|---|---|
| 1. | Population | State level |
| 2. | Gross GDP | State level, Constant prices at 2004-05 |
| 3. | Per Capita | State level, Constant prices at 2004-05 |
| 4. | Wholesale price index | State level (Base Year 1999-2000=100) |
| 5. | Consumer price index | State level (Base Year 2001=100) |
| 6. | IIP General | State level at Base year 2004-05 |
| 7. | IIP Electricity | State level at Base year 2004-05 |
| 8. | IIP Manufacturing | State level at Base year 2004-05 |
| 9. | Index of Agriculture production | State level |
| 10. | Area under crops | State level |
| 11. | Area under irrigation | State level |
| 12. | Category wise tariff | State level, 9 categories |
| 13. | Number of consumers | Category wise |

Data sources: Economic review published by Govt. of Rajasthan;
Population – Census data

## 8.6. Development of econometric equations and forecast

The Econometric analysis was carried out across 26 circles over 9 consumer categories with the shortlisted independent variables via regression methodology in SPSS software.

From a macroeconomic consideration, all the independent variables mentioned have been assumed to influence electricity demand. Certain category specific exclusions have been also undertaken. For e.g. the independent variables for Agriculture were not included while developing the equations of other categories. For setting up the econometric model, an initial functional form has been formed with electricity demand of that particular category as the dependent variable and the selected intendent variables as independent variables. Then regression analysis was conducted on the SPSS software to determine the co-efficient of the independent variables and to test for significance of these variables. The equations were checked initially using the R sq. and adjusted R sq. values. Those equations wherein the values are above 95% have been shortlisted. Also it has been checked that even with high coefficient of determination, independent variables which were not having impact are dropped.

The equation and the variables used in the equation were selected after analyzing the p – value and t-statistic in the regression results. Post selection of variables, regression equations were developed with significant variables and functional form of equations were derived with the coefficients.

In many of the cases, equations which were not meeting test criteria were dropped. For few categories, no relations could be formed. In categories wherein no equations were formed, the forecast developed using other methods have been used in place.

After selection of the independent variables for each category, the final econometric equations were developed. As the regression equation is a function of various independent variables, the dependent variable can be established only if values of all independent variables are known. Hence to estimate the future value of the dependent variable, the forecast of independent variables are worked out using trend method. Subsequently, electricity demand forecast was worked out for each category and circle. The values obtained for each category was then aggregated to arrive at aggregate level forecasts.

In the following table, the shortlisted independent variables and the equation developed for the sample circle is shown

**Table 43: Econometric equations developed for the Sample circle JPDC**

| Sl. No. | Category | Independent variables | Equation |
|---|---|---|---|
| 1. | Domestic | WPI, Domestic tariff | -186.599 + 1.503 WPI +41.389 DomTariff |
| 2. | Non-Domestic | Population, WPI, Number of consumers | 669.889 – 1.803E^-5 Population + 1.671 WPI + 0.012 Consumers |
| 3. | Public Street Light | GSDP, Consumers | - 1.514 + 2.032E^-5 GSDP + 0.06 Consumers |
| 4. | Agriculture (M + N + P)) | GSDP, Tariff, IAP index, Area under Crops | - 691.657 + 0.016 GSDP – 279.251 Tariff – 2.613 IAP – 3.043 E^-5 AreaCrops |
| 5. | Agriculture (F) | No relation | - |
| 6. | Industry (Small + Med) | Population | -310.072 + 5.989E^-6 Population |
| 7. | Industry (L) | No relation | - |
| 8. | PWW (S + M + L) | GSDP, WPI, CPI, Consumers, IIP General | 15.363 + 0.001 GSDP + 0.175 WPI – 0.486 CPI + 0.005 Consumers – 0.336 IIP Gen |
| 9. | Mixed Load | No relation | - |

Similar equations were developed for the categories in other circles also and forecasts were developed for the circles. The forecast developed for JPDC circle is given in the following table:

**Table 44: Base forecast (Unrestricted) developed for JPDC circle using Econometric method**

| JPDC (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 534 | 590 | 652 | 719 | 793 | 873 | 962 | 1059 | 1165 | 1282 | 1411 | 1553 | 1709 | 1882 | 2072 | 2282 |
| Non-Domestic | 321 | 359 | 400 | 445 | 495 | 548 | 607 | 671 | 740 | 815 | 897 | 985 | 1080 | 1184 | 1295 | 1416 |
| Public Street Light | 9 | 9 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 20 | 22 | 24 | 26 | 28 | 31 |
| Agriculture (M + N + P)) | 1461 | 1592 | 1724 | 1854 | 1981 | 2103 | 2219 | 2326 | 2421 | 2503 | 2566 | 2607 | 2621 | 2603 | 2546 | 2444 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 151 | 160 | 169 | 178 | 188 | 198 | 208 | 218 | 228 | 238 | 249 | 260 | 271 | 283 | 294 | 306 |
| Industry (L) | 614 | 664 | 714 | 764 | 814 | 864 | 914 | 964 | 1014 | 1064 | 1114 | 1164 | 1214 | 1264 | 1314 | 1364 |
| PWW (S + M + L) | 58 | 63 | 67 | 72 | 76 | 81 | 85 | 89 | 94 | 98 | 103 | 107 | 112 | 116 | 121 | 125 |
| Mixed Load | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 |
| | 3159 | 3451 | 3752 | 4061 | 4378 | 4702 | 5032 | 5368 | 5707 | 6049 | 6391 | 6731 | 7067 | 7394 | 7710 | 8009 |

The base forecast for the Circle is excluding

- Railway demand
- Additional demand due to planned agriculture and domestic connections
- Additional demand due to other factors like new infrastructure projects
- Open access and captive
- Electric vehicles

Similarly, the forecasts were worked out for all the other circles.

## 8.7. Impact of Electric Vehicles

The Government of India has set an ambitious target for an all-electric vehicle economy in the country by 2030. The first push for the same started in the year 2013, when NEMMP 2020 was launched to promote hybrid and electric vehicles in the country. Subsequently FAME scheme was launched w.e.f 1st April, 2015 with the objective to support hybrid/electric vehicles market development and manufacturing eco-system. The scheme has four focus areas i.e. technology development, demand creation, pilot projects and charging infrastructure.

The uptake of EVs will depend majorly on the adequate deployment of electric vehicle supply equipment (EVSE) needed to recharge EVs. The systems are still under planning stage and estimations have to be developed for the additional power which will be required to support these EVSEs. At present, there is no definite data for the number of charging infrastructure available in the selected state nor there a definite outlook of the same. Hence the estimation of additional power demand have been worked out based on assumptions and by taking reference to available EV vehicle data.

The methodology used to forecast electricity requirement for EVs for the State of Rajasthan is as given below:

- Historical data of all types of vehicles registered in Rajasthan was considered upto FY 2016-17
- From FY 2017-18, for each vehicle types, conversion factors were used to estimate the number of EVs that might be sold in the state. The premise is that EVs initial sales will start from consumers who will shift from conventional fuel to EVs
- The growth phase of EVs was divided into three phases and different overall sales growth rates were assumed.

| Phases | Period | Nature | YoY growth rate |
|---|---|---|---|
| Phase I | FY 2019-23 | Initiation phase | 10% |
| Phase II | FY 2024-28 | Growth phase | 15% |
| Phase II | FY 2029-32 | Mature phase | 20% |

- To compare the various vehicles types and to determine the motor capacities to be used in the vehicles, data from currently available EVs were considered. Details are as given below:

| Vehicle class | Reference vehicle | Motor Capacity |
|---|---|---|
| Motorized Rickshaws | Mahindra eAlpha Mini | 10kWh |
| Two Wheelers | Hero Electric bike | 1kWh |
| Auto Rickshaws | Mahindra eAlpha Mini | 10kWh |
| Tempo carrying goods | - | 2 x 10kWh |
| Tempo carrying passengers | - | 2 x 10kWh |
| Car | Mahindra eVerito | 30kWh |
| Taxi | Mahindra eVerito | 30kWh |
| Buses and Mini Buses | Ashok Leyland Circuit | 100kWh |
| * Trucks, Trailers, Jeeps, Tractors were not considered | | |

- For each of the vehicle types, average hours of charging were considered based on normal operation.
- The methodology also considered the following assumptions
  - Vehicle life considered for 15 years
  - No EVs will retire during the forecast period
  - The motor capacities have been assumed as constant during the period
  - The phases of growth has been defined considering the maturity levels of EVs over the years
  - It has been assumed that there won't be any infrastructure lag from the supply side and the demand will maintain the growth rates

Based on the above, the additional demand from EVs for the complete state has been worked out as given below:

**Table 45: Additional electricity requirement (MUs) due to EVs in Rajasthan**

| FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 44 | 92 | 145 | 204 | 268 | 338 | 420 | 513 | 620 | 744 | 886 | 1057 | 1261 | 1507 | 1801 |

## 8.8. Assessment of specific demand using end use method

The end use method have been used to determine specific additional demand of certain categories which could not be captured in the base forecast developed using historical demand. The approaches for end use method are varied depending on the target and the end result. In the following sub-sections, the demand assessed for different categories are given.

### 8.8.1. Railways

The Electricity Act, 2003 has provided deemed distribution licensee status to Railways. In November' 15, CERC, in its order against a petition filed by the Railways had clarified that the Railways are authorized entity under the Railway Act to undertake transmission and distribution, in connection with its working and Railway is a deemed Licensee under Electricity Act.

For the state of Rajasthan, the demand from Railway traction was historically included as a separate category in the sales of distribution utilities until the year FY 2015-16. Due to deemed licensee status, the demand is no longer considered under the utilities. In the present forecast, the same has been incorporated separately as an additional demand within the overall demand of the state. To forecast the traction demand in the state, the monthly historical data for traction was analyzed and forecasted using time series methods to arrive at the forecast of the upcoming years.

The following table provides the yearly demand assessed for Railway.

**Table 46: Additional electricity requirement (MUs) from Railway traction**

| FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 433 | 451 | 470 | 488 | 507 | 526 | 544 | 563 | 581 | 600 | 618 | 637 | 656 | 674 | 693 | 711 |

### 8.8.2. Domestic: Power For All (PFA) and Saubhagya scheme

The PFA scheme is expected to improve the entire value chain of the power sector and ensure reliable and uninterrupted electricity supply to all households, industries and commercial establishments. The target was to provide access to electricity to all un-connected consumers by FY 2018-19 and then provide reliable and continuous power supply by the year FY2021-22. Power supply to agriculture and unconnected households is also supposed to increase within this projected time frame.

In continuation of the above, Government launched the Saubhagya scheme which is targeted more towards ensuring last mile connectivity in urban and rural areas and to release electricity connections to un-electrified households in the country. With such changes happening, the overall demand and category wise consumption is expected to increase.

As per available information, ~78% of the ~ 91.57 lakh domestic households in the state are connected and are being provided electricity and the balance ~ 19.80 lakh households are to be connected as per the scheme. The DISCOMs target is to connect 6 lakh household every year.

In the projections developed for the base forecast for the domestic category, because of the growth rate considered, currently around 6 lakh consumers are being added in the year FY 18, FY 19 and FY 20 and hence the demand has already be taken care of. No additional requirement has been added at this point.

### 8.8.3. Agriculture category

The Government of Rajasthan had launched a scheme in the year 2015 to provide 40,000 new agriculture connections every year. In the base forecast, the yearly additions is already considering adding more than 40,000 new connections every year. Hence, no additional requirement is being added in the forecast.

### 8.8.4. Open Access and Captive

Open Access (OA) transactions in Rajasthan are largely categorized by majorly short term open access consumers/ transactions and minimal medium/long term open access consumers and transactions. Short term open access energy demand of the consumer is based on market trends i.e. the consumers will purchase energy from exchange if the price prevailing at the exchanges is favorable to them as compared to the energy charges recovered by the DISCOM from the industrial consumer. The switching by consumers between open access power and DISCOM power is very dynamic and difficult to predict.

Over the past years the DISCOM observed stagnant or negative growth in consumption from Industrial categories (Small/Medium/Large) largely due to increasing trend of short term Open Access transactions. With the consumption going down from a major category, the stranded capacity of the DISCOMs increased leading to further worsening of the already precarious financial position of the DISCOMs.

In 2016 the Rajasthan Electricity Regulatory Commission (RERC) notified the “Rajasthan Electricity Regulatory Commission (Terms and Conditions for Open Access) Regulations, 2016” with the following main provisions:

- Mandatory requirement to give a schedule for 24 hours
- Requirement of uniform schedule for at least 8 hours
- Not more than 25% variation in schedule during the entire day
- Restricting deemed DISCOM drawl based on schedule provided by OA consumer on day ahead basis

These provisions resulted in reducing of the frequency of switching by the short term OA consumers. Moreover, the regulations also ensured that consumers who used to declare fictitious demand of 1 MVA and above and opt for Open Access are not able to do so anymore. Further the regulations have mandated that the open access consumers maintain a contract demand equivalent to the quantum of power being procured from various sources (including open access and DISCOM power).

RERC also came out with an Order on determination of Additional surcharge and Cross subsidy surcharge in 2016. The following were the rates determined by the RERC:

- Additional surcharge of Rs 0.80 per unit
- Voltage wise Cross subsidy surcharge for industrial consumer:
    - 11 KV: Rs. 0.83 per unit

- 33 KV: Rs. 1.39 per unit
- 132 KV: Rs 1.63 per unit

With additional surcharge and cross subsidy surcharge determination by RERC, the DISCOMs observed a reversal in the trend of Open access transactions in the State and this resulted in further reduction in the quantum of power procured from open access. Upon analyzing the recent trends in DISCOM sales from industrial category, it is observed that the sales in the first 6 months of FY 2017-18 increased by 15-20% as compared to the last 6 months of FY 2016-17. Similarly in case of open access transactions, it was observed that the power purchased from open access and captive decreased by ~70% in Rajasthan in the month of November 2017 as compared to November 2016.

Due to the above highlighted factors, it is observed that short term open access forecasting would be very dynamic and is therefore is a challenge to forecast. Thus the quantum of Open Access power has been assessed based on the following approach:

- Combined data for open access and captive power purchased from April 2016 to November 2017 was received from the DISCOMs. However, the data could not be segregated to ascertain specific trends
- The data was extrapolated for the remaining months of FY 2017-18 based on past trend observed from FY 2016-17. Such data for FY 2017-18 has been considered as our base of forecasting power purchased from open access for the future years
- Based on consultation with stakeholders in the state, it has been concluded that the decrease in power purchased from open access may have bottomed out and the growth will thus remain stagnant till any further orders on surcharges are passed by RERC
- For captive power plants, with stringent environmental norms in place, it is anticipated that many captive power plants who won't be able to meet the norms will have to be shut down. And with improved infrastructure, the resultant demand is expected to progressively shift to the grid.
- Considering all the factors and assumptions, a nominal growth rate of 5% from FY 19 has been considered for projection of power purchased from Open access and Captive consumption

**Table 47: Electricity requirement (MUs) from OA and Captive**

| FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4568 | 2845 | 2987 | 3136 | 3293 | 3458 | 3630 | 3812 | 4003 | 4203 | 4413 | 4633 | 4865 | 5108 | 5364 | 5632 |

## 8.9. Assessment of additional demand

The impact of additional demand has been considered in this section post the development of the forecast to further refine the results. The anticipated additional load has been added to the demand arrived by the hybrid approach. The information on such loads has been captured by consultations, primary and secondary research, review of infrastructure schemes, housing schemes and master plans etc. Depending on information on additional load as available in the public domain and with certain approximations, the additional loads have been derived.

### 8.9.1. Housing: Chief Minister's Jan Awas Yojana / Rajasthan housing board

Rajasthan Housing Board (RHB) was established on 24th February 1970 as an autonomous body to provide for measures to be taken to deal with and satisfy the need of housing accommodation in the State. RHB primarily focuses on affordable housing activities for society at large with special emphasis on economically weaker sections. By December, 2016 RHB has taken up construction of 2,50,309 dwelling units, out of which 2,47,425 dwelling units have been completed, 2,44,892 dwelling units have been allotted and 2,31,311 dwelling units have been handed over to applicants.

As per consultation with Housing Board officials, the electrical loads of houses which have been handed over are already included in the demand data taken from the DISCOMs. Hence it was suggested that the additional demand of houses which are under construction should only be considered. As per the data available upto October 2017, 2884 houses are under construction and hand over will start from FY19. As per officials, the houses are occupied on average post 2-3 years of hand over i.e. by FY 21.

**Table 48: Data for State housing scheme as on Oct'17**

| | EWS | LIG | MIG I | MIG II | HIG | Total |
|---|---|---|---|---|---|---|
| Taken Up | 81212 | 69531 | 41759 | 35666 | 22141 | 250309 |
| Completed | 80874 | 68108 | 41501 | 35241 | 21701 | 247425 |
| Allotted | 79617 | 67785 | 40806 | 35053 | 21631 | 244892 |
| Handover | 72771 | 60870 | 37687 | 33534 | 26449 | 231311 |
| Under construction | 338 | 1423 | 258 | 425 | 440 | 2884 |

The expected demand has been worked out as per the load estimation formula shared by RHB.

### 8.9.2. Review of Master Plans

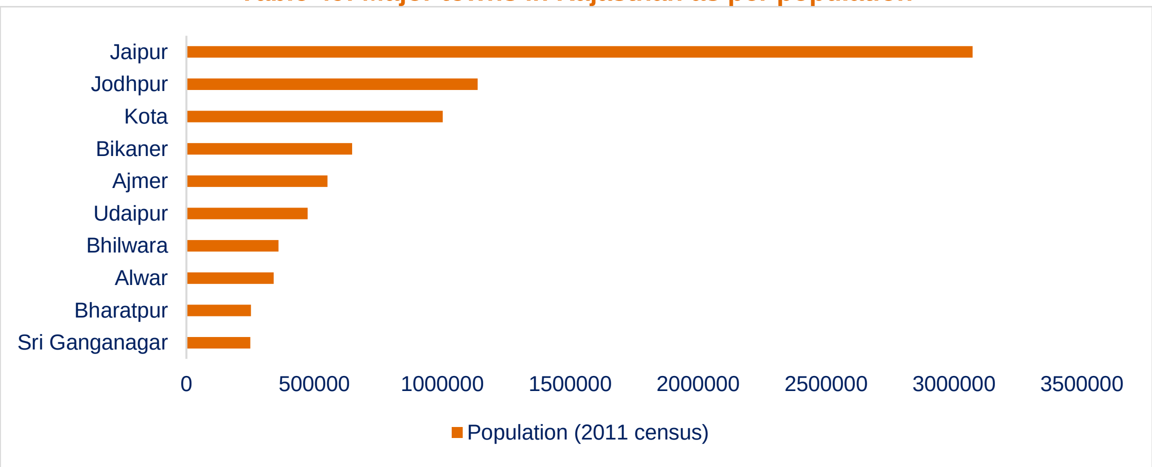
A master plan comprises sector plans and each sector plan comprises several smaller schemes and projects. Out of 190 municipal towns, master plans for 184 municipal towns have been prepared by Town Planning Department, Depart of Urban Development and Housing, Government of Rajasthan and was approved by the Government. Out of all the Master, for the major cities in Rajasthan, the end year of planning period is varied and Master plans have been prepared for the period ending in the year 2025 to upto 2033 in other towns.

In order to estimate the additional load which may arrive due to implementation of planned initiatives, upon consultation, it was understood that the focus of implementation will be centric around Jaipur and few of the major towns.

The following figure provides the list of major towns in Rajasthan in terms of population. It can be observed that out of the top 10 cities in Rajasthan, the combined population of other 9 cities is approximately twice than that of Jaipur.

The premise for development of Master plans of city/ towns is by extrapolating the population of a city/ town upto a target year and then assessing the amenities which will be required additionally to attain a level of standard of living.

**Table 49: Major towns in Rajasthan as per population**



As per the projections provided in the Jaipur Master Plan 2025, there will be 15, 12,320 households by the year 2025 in the Jaipur master plan area covering city and other limits. The number of domestic households considered for forecast in Jaipur City Circle and Jaipur District Circle combined for the year FY 2024-25 is 18, 10,350. Hence no additional demand as per the master plan for households has been considered.

In terms of additional social amenities proposed in the Jaipur Master Plan 2025 as per population projections, 3480 Ha of area is proposed to be utilized to develop the following: (insert references):

- School- Primary, Secondary
- Colleges
- Technical education institutes
- General hospitals
- Polyclinics
- Police station

To arrive at the estimated additional energy requirement due to Master plan, following assumptions have been considered.

- In the period from 2025-2032, the implementation of the master plan schemes will be in the 10 major cities of Rajasthan
- The impact of the new amenities has been considered from the year FY 2025-26 and subsequent demand is assumed to grow at 10% Y0Y in line with the growth of Commercial categories
- Since base forecast has been developed considering historical growth, major portion of the new anticipated demand will considered in the forecast. Additionally, of the total requirement, 20% has been assumed to be as additional demand over and above the base forecast
- Since combined population of 9 major cities is ~ twice of the population of Jaipur, it has been assumed that the trend will continue.
- To account for development of Jaipur and 9 other major cities in the period from 2025, as per population estimates given above, (3480 x 3) Ha has been assumed will be developed
- The electricity demand has been worked out considering suitable loads for the amenities considered and electricity requirement in terms of MUs has been derived and added to the base forecast.

### 8.9.3. Jaipur Metro Rail project

The work of Jaipur Metro Rail Project Phase I-A has completed and is in operation since 03 June, 2015. As per data accessed from Jaipur Metro, the current load is 4.5 MVA. The Phase I-B of the Metro project is expected to commence operation in FY19 and the load upto 6 MVA. The electrical infrastructure and connectivity with the DISCOM is already in place and is accounted for.

The next phase is expected to commence post phase IB and as per planning, the total expected load of 20MVA is expected by the year 2030.

The additional 14 MVA load has been added from the year 2030 with the assumption that the next phase of operations will commence in the year 2030.

### 8.9.4. Smart City

Smart City Mission Launched in June 2015 with a target of 100 Cities to be developed as Smart Cities in India. Four cities of Rajasthan namely - Jaipur, Udaipur, Kota & Ajmer has been shortlisted for development.

The Smart Cities will be implemented through a dedicated SPV through 2 strategic ways of development

- Area Based Development(ABD)
- Pan City Development

Area Based Development further is sub divided into 3 components

- Retrofitting: Planning & Development in existing built up area
- Redevelopment: Replacing of Existing Built environment
- Greenfield: Development of a Vacant Area

Pan City Development: application of selected Smart Solutions to the existing city-wide infrastructure.

Major initiatives identified for implementation in the four cities.

- Area Based Development (retrofitting & retrofitting model) - Sustainable Mobility Corridors, Heritage and tourism, smart civic infrastructure, conservation of buildings, water body conservation, Environment &eco-friendly recreational projects etc.
- Pan City Development: development envisages application of selected Smart Solutions to the existing city-wide infrastructure. Application of Smart Solutions will involve the use of technology, information and data to make infrastructure and services better. E.g. Integrated Traffic Management, Security & Surveillance system, Intelligent Street lights, City E-governance, Solid Waste Management, Citywide smart utilities system etc.

The idea of smart city development in the four cities considered is majorly for retrofitting and re-development and implementation of smart solutions. The extent of the implementation including additional load if any could not be ascertained directly as there is lack of information in public domain. Considering the current pace of the projects, no additional demand has been considered.

### 8.9.5. Delhi Mumbai Industrial Corridor

Delhi - Mumbai Industrial Corridor (DMIC) is India's most ambitious infrastructure programme aiming to develop new industrial cities. The objective is to expand India's Manufacturing & Services base and develop DMIC as a "Global Manufacturing and Trading Hub". The programme will provide a major impetus to planned urbanization in India with manufacturing as the key driver. In addition to new Industrial Cities, the programme envisages development of infrastructure linkages like power plants, assured water supply, high capacity transportation and logistics facilities as well as softer interventions like skill development programme for employment of the local populace. In the first phase eight new industrial cities are being developed. The programme has been conceptualized in partnership and collaboration with Government of Japan.

The longest stretch of the 1483 km DMIC route (about 39%) passes through Rajasthan. As per the plan, two industrial areas along with associated integrated facilities are to be developed

- Khushkhera- Bhiwadi- Neemrana Investment Region
- Jodhpur Pali Marwar Investment Region

As per the master plans of the two proposed regions, the development has been scheduled under three phases

- Phase 1 – Initiation, pilot phase infrastructure and early development - Years 2016-2022;
- Phase 2 - Core development - Years 2023-2032
- Phase 3 – Mature development and completion - Years 2033-2042

The master plan of the two investment regions provides the estimated power requirement as given below

**Table 50: Demand projected in the DMIC investment regions in Rajasthan**

| Yearly Demand (in MW) | Phase 1 (2016-2022) | Phase 2 (2023- 2032) | Phase 3 (2033-2042) |
|---|---|---|---|
| Khushkhera- Bhiwadi- Neemrana[16] | 955 | 1837 | 3877 |
| Jodhpur Pali Marwar[17] | 11571 | 64183 | 269000 |

[16] Final development plan – Khushkhera - Bhiwadi- Neemrana Investment Region, August 2014
[17] Master Plan-2042, For Jodhpur-Pali-Marwar Industrial Area, Rajasthan Sub Region of DMIC

The projects in Rajasthan have faced considerable delay in land acquisition which started in 2012. Even after five years, the process has not been completed. Due to the delay in execution, the load as envisaged in Phase 1 of the project is expected to impact post the year FY 2026-27 with the assumption that the complete demand as planned will be required. Nominal growth rate has been considered for projection upto the year FY 2032. Due to the delay, the core development is expected to happen post 2032.

### 8.9.6. Rajasthan State Industrial Development and Industrial Corporation (RIICO)

RIICO is an apex organization engaged in fostering the growth of industrialization in the State. The mission of RIICO is to catalyze planned and rapid industrialization of Rajasthan. RIICO develops industrial areas and infrastructure facilities for the industrial units. During the Financial Year 2016-17, RIICO has acquired 1,513.58 acres of land and has developed 248.98 acres of land upto December, 2016.

Few of the recent developments by RIICO are:

- **Japanese park:** RIICO has signed a MOU with JETRO, a Japanese Organization wherein Japanese companies will set up their industrial units at Neemrana Industrial Area, Alwar, Rajasthan. Several multinational companies such as Nissin, Mitsui, Daikin, Mitsubishi and Dainichi have already got land allotted in this industrial area for establishing their units. RIICO has so far allotted 433 acre land to 47 Japanese companies in this area. Out of it, 43 companies have started commercial production as of FY 17.

- **Korean Investment Zone:** RIICO has signed a MoU with Korea Trade Investment Promotion Agency (KOTRA). In pursuance of this MoU, a Korean Investment Zone in Ghiloth Industrial Area, District Alwar has been set up covering an area of 2000 acres.

- **ShahajanpurNeemrana-Behror (SNB)** knowledge city cum urban complex of around 1500 acre

- **Mahindra group** has established an SEZ in partnership with RIICO in Jaipur with an expected investment of `10,000 crore. In this SEZ, various zones shall be established for industrial units of different sectors.

The officials of RICCO were consulted to understand the industrial activities in the State. Some of the observations are

- Industrial activity in the state is growing at historical natural growth rates and is not expected to pick up suddenly
- Most of the SEZ, Areas under RICCO have electrical infrastructure developed. However, actual demand has not been there as new industries have not developed as had been expected
- In the year FY 2016-17, for a target of 2542 acre, only about 10% of the area i.e. 248.98 has been developed due to subdued industrial activity

Considering the above, no additional electricity demand has been added. The growth rates considered in developing the base forecast reflects the views expressed by RICCO.

The anticipated additional electricity demand as anticipated from FY 21 to be added are as given below:

**Table 51: Anticipated energy requirement due to additional demand from new projects at State level (MUs)**

| Head | FY 21 | FY 22 | FY 23 | FY 24 | FY 25 | FY 26 | FY 27 | FY 28 | FY 29 | FY 30 | FY 31 | FY 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Housing | 38 | 77 | 115 | 154 | 192 | 230 | 269 | 307 | 346 | 384 | 422 | 461 |
| Master Plan | - | - | - | - | | 1079 | 1187 | 1305 | 1436 | 1579 | 1737 | 1911 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jaipur Metro | - | - | - | - | - | - | - | - | - | 29 | 29 | 29 |
| Smart City | - | - | - | - | - | - | - | - | - | - | - | - |
| DMIC | - | - | - | - | - | 120 | 127 | 135 | 143 | 152 | 161 | 171 |
| RIICO | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | **38** | **77** | **115** | **154** | **192** | **1429** | **1583** | **1748** | **1925** | **2144** | **2349** | **2571** |

## 8.10. Assessment of latent demand

Development of reasonable estimate for the latent demand in the system has been attempted. The trend of historical consumption of electricity may or may not be a reliable indicator of the future trend of electricity consumption. 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. In developing economies there are various factors which may limit electricity consumption. These can range from inadequate infrastructure such as network capacity constraints, negative effect of income, high cost of supply, outdated technology etc.

Considering the case of a household with low income, consumption is based on priority of basic needs, thereby impacting demand of other goods e.g. electricity. For an industry, the electricity demand may be suppressed due to factors such as inadequate network infrastructure, insufficient power availability with distribution licensee to cater to the demand, high cost of supply, reliability of supply etc.

Latent demand is an inherent demand but 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.

In the following subsections, the assessment of demand has been carried out for each of the heads as mentioned above:

**1. Unmet demand**

The demand from unconnected consumers constitutes a substantial portion of unrealized electricity requirement in the system and remains latent unless connected. Availability of affordable and clean energy has been included as one of the 17 Sustainable Development Goals (SDGs) of the United Nations, adopted at the UN Sustainable Development Summit, September 2015. One of the targets under this goal is to ensure by 2030, universal access to affordable, reliable and modern energy services. In this direction, the Government has also undertaken steps to ensure that electricity access is provided.

In this respect, the demand from additional connections to be released has been already been considered in the base forecast which has been developed.

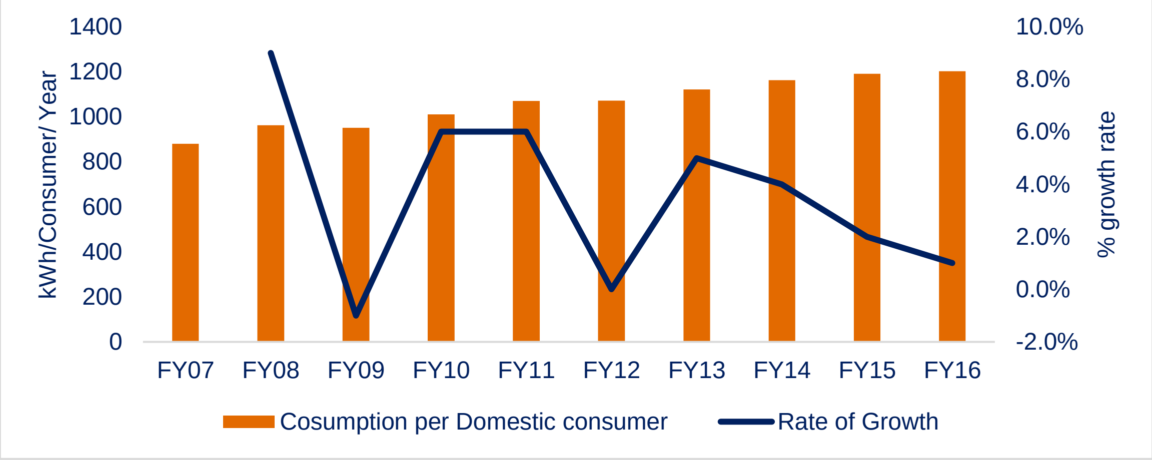
**2. Unserved demand**

The assessment of unserved demand to consumers has been carried in the section of baseline correction of historical data wherein feeder interruption data has been used to estimate the demand curtailment. In case that curtailment had not happened, the unserved latent quantum would have reflected in the system. The methodology undertaken and the assumptions considered has already been explained in the section on baseline correction.

### 3. Behavioral aspect

The figure below shows the average historical consumption of electricity per domestic consumer in the state. While the overall consumption has been increasing, however the rate of growth has been dismal and not in line with the growth prevalent in developing countries.

**Figure 49: Average consumption per domestic consumers in Rajasthan (in kWh/Consumer/Year)**



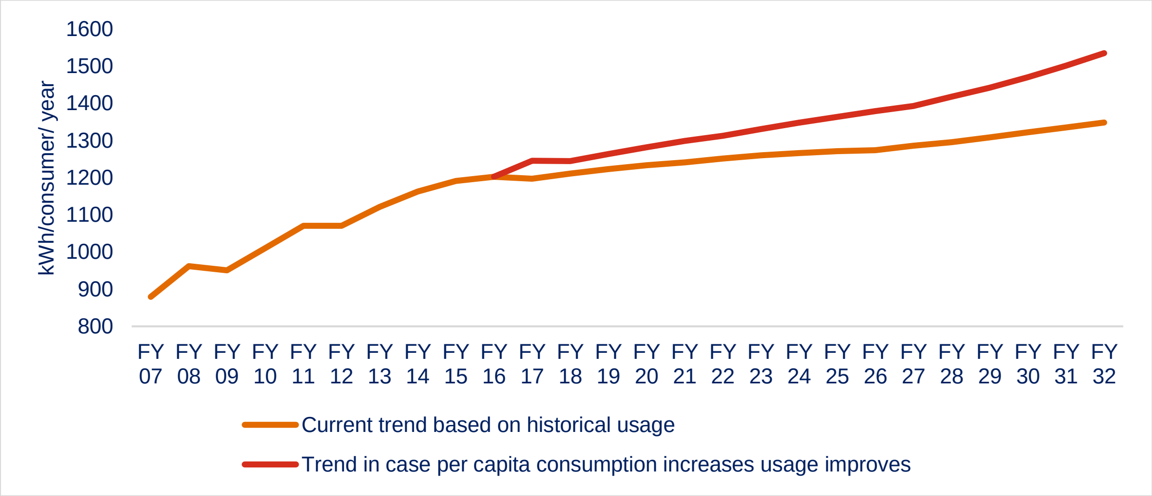

This may be due to unreliable power supply or high tariffs etc. to some extent, but the major aspect is pertaining to usage behavior of the connected consumers. The trend has been similar for the country as a whole wherein the average consumption per consumer has been reported as 1010 kWh/consumer/ year in FY 2014-15 and 1075 kWh/consumer/ year for FY 2015-16[18].

A comparison with other developing countries (e.g. BRICS considered for comparison) shows that overall India's per capita consumption is very low and is even below the World average of 2674 kWh/consumer/year.

Hence the usage behavior is not reflecting the demand which should have been in comparison to a global average or with respect to comparable economies. That difference is a latent aspect of demand due to behavioral usage and can only be realized with change in behavior or by incentives.

For assessing the latent demand, an analysis of the average consumption per consumer per year as forecasted in the base forecast using trend method has been analyzed.

**Figure 50: Comparison of trends of consumption in Rajasthan up to FY 32**




[18] CEA Monthly report December 2017

Historically, over the 10 year period, average CAGR in consumption per consumer for the state has been about 3.6%. In the base forecast, the same has already been considered and projected.

However, for the latent consumer demand to start realizing, that the current rate of growth has to increase as the economy progresses. But changes related to behavior doesn't happen all of a suddenly in a period of 1-3 years and such effects are noticeably observed over long term horizons.

Hence for the present scenario, to arrive at an assessment of the latent demand, the following assumptions have been considered

- The current CAGR growth rate of 3.6% has been assumed to increase by 10% YoY from FY 18. Since there is no definite literature available pertaining to latent demand, the assumption has been considered based on a realistic scenario
- The assumption is also reflective of the fact that in case the CAGR growth improves, it will be gradual over short term
- Based on the above assumption, the YoY growth rate has been arrived at for all the years.
- The difference in consumption per consumer has been worked out for the base case (historical) and case wherein increased CAGR growth rate is considered.
- The difference upon multiplication with the number of domestic consumers gives the additional latent demand which would be incident on the system.

**Table 52: Estimated latent demand due to behavioral aspect for Rajasthan (in MUs)**

| FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | 273 | 389 | 533 | 728 | 850 | 1089 | 1368 | 1690 | 2052 | 2354 | 2800 | 2324 | 2764 | 3285 | 3906 |

## 8.11. Impact of Energy Efficiency

The assessment of the impact of energy efficiency has been carried out using efficiency factors for different categories while developing the forecast. To decide on the factors, various literature were reviewed to understand the actual impact of efficiency across various consumer categories. However, most of the study reports highlight potential of energy efficiency across major categories which are worked out based on estimates and assumptions. There was also a wise variation in the savings potential reported due to the inherent assumptions and methodologies adopted. The potential is also dependent on the quantum of investment and replacements which are required to achieve the same.

The energy savings potential across different consumers categories are as given:

**Table 53: Electricity Savings potential across categories[19]**

| Sl. No. | Consumer category | Electricity savings potential |
|---|---|---|
| 1. | Domestic urban | 15-20% |
| 2. | Domestic rural | 40-50% |
| 3. | Commercial buildings | 20% |
| 4. | Public lightings | 50% |
| 5. | Agriculture | 30% |
| 5. | PWW | 20-25% |
| 6. | Industry | 7-10% |

[19] BEE, NPC study 2009 and EESL study

With these benchmarks in place, 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 will increase as we progress over the years. The awareness towards efficiency will increase and there will be more penetration and acceptance of energy efficiency products. The following table provides the YoY % of energy efficiency considered across categories.

**Table 54: % savings estimated due to energy efficiency**

| Category | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 |
|---|---|---|---|---|---|---|---|---|
| Domestic | 2.0% | 2.3% | 2.6% | 3.0% | 3.5% | 4.0% | 4.6% | 5.3% |
| Non-Domestic | 1.0% | 1.1% | 1.1% | 1.2% | 1.2% | 1.3% | 1.3% | 1.4% |
| PSL | 1.0% | 1.2% | 1.4% | 1.7% | 2.1% | 2.5% | 3.0% | 3.6% |
| Agri | 1.0% | 1.1% | 1.1% | 1.2% | 1.2% | 1.3% | 1.3% | 1.4% |
| Industry | 0.5% | 0.5% | 0.5% | 0.5% | 0.6% | 0.6% | 0.6% | 0.6% |
| PWW | 1.0% | 1.1% | 1.2% | 1.3% | 1.5% | 1.6% | 1.8% | 1.9% |
| Mixed load | 1.0% | 1.1% | 1.1% | 1.2% | 1.2% | 1.3% | 1.3% | 1.4% |

| Category | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|
| Domestic | 6.1% | 7.0% | 8.1% | 9.3% | 10.7% | 12.3% | 14.2% | 16.3% |
| Non-Domestic | 1.5% | 1.6% | 1.6% | 1.7% | 1.8% | 1.9% | 2.0% | 2.1% |
| PSL | 4.3% | 5.2% | 6.2% | 7.4% | 8.9% | 10.7% | 12.8% | 15.4% |
| Agri | 1.5% | 1.6% | 1.6% | 1.7% | 1.8% | 1.9% | 2.0% | 2.1% |
| Industry | 0.6% | 0.7% | 0.7% | 0.7% | 0.7% | 0.7% | 0.8% | 0.8% |
| PWW | 2.1% | 2.4% | 2.6% | 2.9% | 3.1% | 3.5% | 3.8% | 4.2% |
| Mixed load | 1.5% | 1.6% | 1.6% | 1.7% | 1.8% | 1.9% | 2.0% | 2.1% |

## 8.12. Development of forecast scenarios

The forecasts have been developed with 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

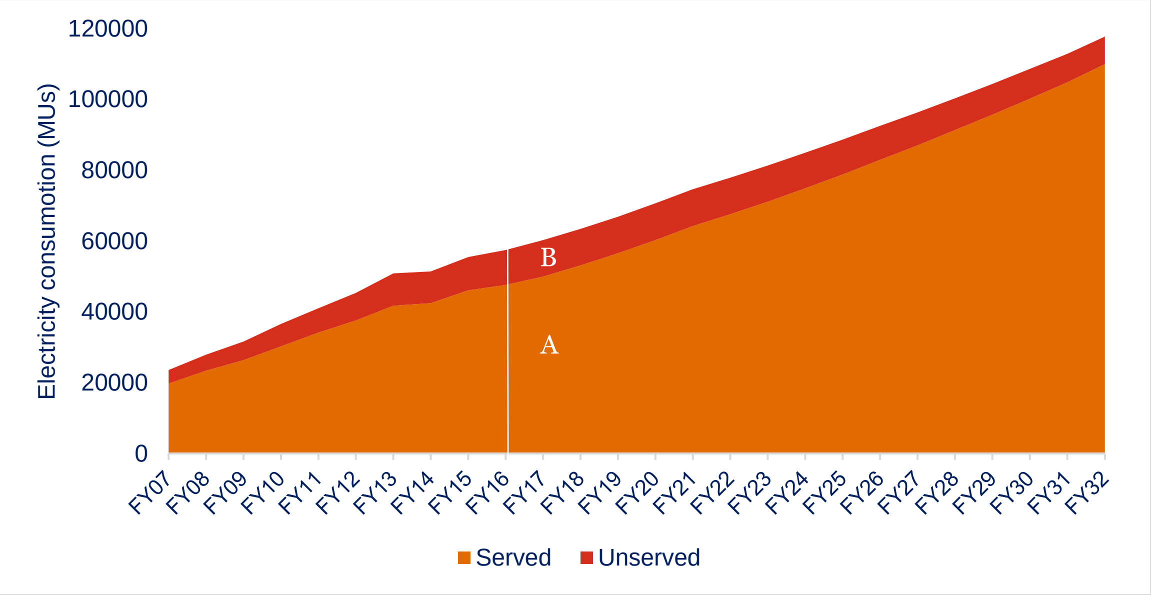
In this scenario, it has been assumed that although with improvement in the supply situation and infrastructure, the share of unserved demand will decrease progressively. However, the reduction will be more gradual and hence across the states/ circles, there will be some amount of unserved demand that 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 Scenario 2 has been derived by continuing with the same assumption that the gap in supply hours will decrease by 1% YoY from FY 2016-17. It was observed that while in some urban circles like JPDC etc. the unserved demand will be nil for domestic categories, in other circles certain % will remain. The resultant net unserved demand for each Circle have been calculated and subtracted from the unrestricted forecast 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 51: Illustration of served - unserved demand for the state**



## 8.13. Estimation of the future loss trajectory

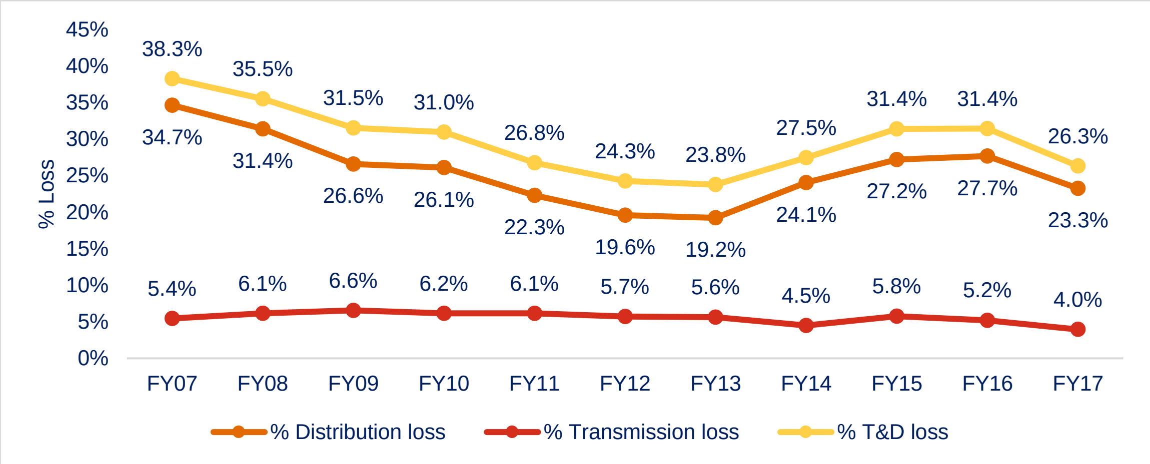
One of the gap identified in estimation of loss trajectory is that the trajectories are developed based on top down targets. Historically, it has been observed that the targets are not met as per the defined timelines and are also periodically revised. Due to which the overall forecasted results vary with that of the actual. Hence in the present section, the future loss trajectories have been estimated based on realistic estimates after analysis of the actual loss data.

The data accessed from the utilities have yearly wise % of distribution loss, transmission loss and transmission and distribution loss figures. The data doesn't have any segregation of losses for specific activities like theft, faulty reading etc.

In the current assignment, the trajectory has been developed based on analysis of available data, trends observed and realistic assumptions after consultation.

For the state, the historical losses are given in the following table

Figure 52: % Actual T&D loss for the state[20]




The estimation of loss trajectory has been carried out after considering the following points:

- The state has a target to achieve distribution loss target of 15% upto FY19 whereas at the end of FY17, the actual distribution loss achieved is 23.3%. As per estimates, the state is expected to reach the distribution loss level of 19.3% by end of FY18.
- It has been highlighted that the reduction of loss from 25% to 20% is possible at a faster rate because same can be achieved by monitoring thefts, leakages and by ensuring metering. However, the reduction below 20% to 15% will be more gradual and require investment in improving the network infrastructure. Reduction below 15% distribution loss at a state level is not envisaged as of now.
- The transmission loss has ranged between 5-6% in the past 10 years and any further reduction will be very gradual and may reach a limit of 3% for the state.

Keeping in mind the above, the projected trajectory for the state is given as below:

Table 55: 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% |

[20] Data accessed from distribution utilities

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| T&D % | 26.3% | 23.5% | 24.0% | 22.8% | 21.6% | 20.4% | 19.2% | 19.1% |

| Category | 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 above T&D losses worked out for each year, energy requirement for the state has been calculated using the following given below.

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

In the table below, energy requirement for the state has been calculated considering the results derived using Trend – restricted method. Similarly, results from other methods can also be calculated.

**Table 56: Calculation of energy requirement for the state**

| Category | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 |
|---|---|---|---|---|---|---|---|---|
| Electricity consumption | 55,383 | 57,634 | 61,931 | 66,609 | 71,720 | 75,845 | 80,265 | 84,891 |
| T&D Loss % | 26.3% | 23.5% | 24.0% | 22.8% | 21.6% | 20.4% | 19.2% | 19.1% |
| Electricity requirement | 75,169 | 75,376 | 81,479 | 86,272 | 91,480 | 95,302 | 99,387 | 104,895 |

| Category | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 |
|---|---|---|---|---|---|---|---|---|
| Electricity consumption | 89,706 | 96,011 | 101,052 | 106,476 | 111,024 | 116,655 | 122,604 | 129,568 |
| T&D Loss % | 18.9% | 18.8% | 18.6% | 18.5% | 18.3% | 18.2% | 18.1% | 18.0% |
| Electricity requirement | 110,622 | 118,169 | 124,144 | 130,577 | 135,924 | 142,586 | 149,624 | 158,009 |

## 8.14. Estimation of load factor and peak demand

Load Factor is the ratio between average energy consumption rate (average load) and peak energy consumption rate (peak load) over a specified period of time and can apply to daily, monthly, seasonal or annual periods.

In the present case, the bottom up approach entailed undertaking forecasts at circle levels and then aggregating upto the utility and state level. To estimate the peak demand that may be incident on the system for the forecast years, commonly used forecasting methodologies assume average load factor and then peak demand is derived which is a co-incident peak demand.

In this section two approaches have been used:

- **Traditional approach:** in this approach, the load factor on an average yearly basis is worked out based on historical average load factor data and then peak demand is derived using the energy requirement (forecasted) and load factor using the following

  Peak Demand (MW) = Electricity required (MUs) / (Load Factor x Time in hours)

  Depending on the period (daily, monthly, annual etc.) for which the calculation is made, the peak demand can be derived.

- **Forecasting approach:** to determine peak demand by forecasting methods using historical peak demand data

## 1. Traditional approach

In this approach, the year wise load factor data was accessed and analyzed to understand the trend. For the state of Rajasthan, the following table provides the yearly data

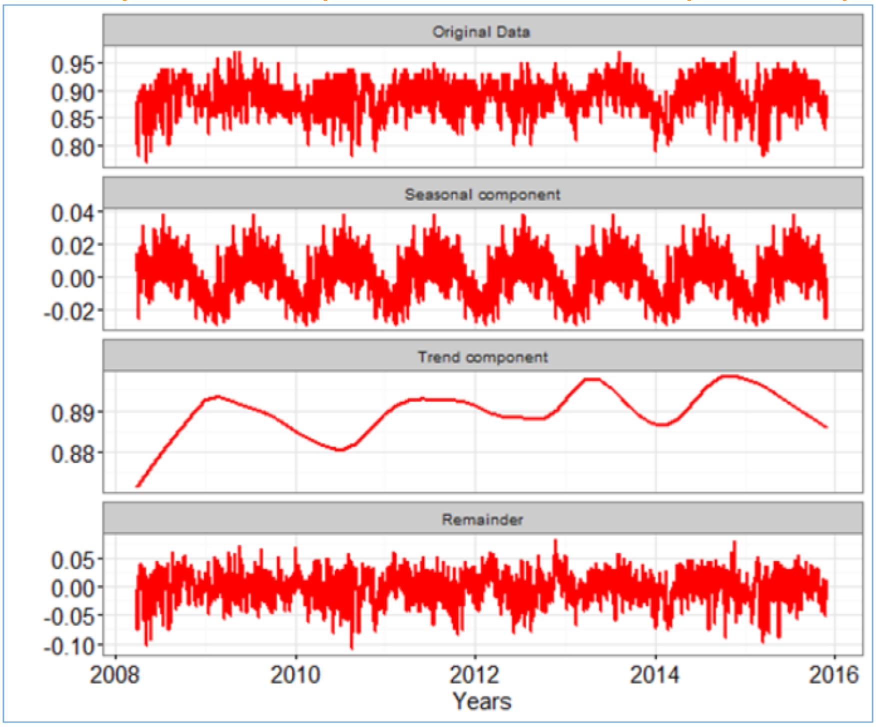
**Table 57: Rajasthan: Load factor data[21]**

| State | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 | FY16 | Monthly LF, avg. of 2008-15 | Daily LF, avg. of 2008-15 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rajasthan | 0.69 | 0.68 | 0.70 | 0.73 | 0.71 | 0.69 | 0.71 | 0.70 | 0.80 | 0.89 |

As per the results of the study conducted by POSOCO, the load factor in the state in increase. The same is already evidenced from the decomposition of the monthly data provided in the same report.

The figure below shows the increase in trend of load factor for the state.

**Figure 53: Rajasthan: Decomposition of load factor trend (POSOCO report)[22]**




[21] Electricity load factor in Indian Power System, POSOCO, January 2016
[22] Electricity load factor in Indian Power System, POSOCO, January 2016, available in public domain

In view of the trend observed, a nominal increasing trend has been considered, derived from past historical load factor data and projected to arrive at the average load factor for the state

**Figure 54: Estimated load factor for the state**

| FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |

Using the load factors derived as above, the co-incident peak demand of the state was determined using the formula provided. The table below provides the annual coincident peak demand calculated using the trend – restricted approach using the electricity forecast and load factor as determined above.

**Table 58: Annual Peak demand for state: Using forecasting results using Trend method**

| FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | Fy27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12224 | 12222 | 13175 | 13910 | 14688 | 15258 | 15868 | 16701 | 17563 | 18710 | 19601 | 20532 | 21314 | 22297 | 23334 | 24574 |

Similarly, peak demand derived for all the scenarios is given in the section on summary electricity forecast results.

The next step is to use a diversity factor to further normalize the demand as it will be unlikely that all the demand will be coincident on the system at the same time. As per the report by POSOCO, diversity factor recognizes that the whole load does not equal the sum of its parts due to time interdependence. The concept of being able to de-rate a potential maximum load to an actual maximum demand is known as the diversity factor.

Diversity factor can be represented as follows

Diversity factor = (sum of individual maximum demand)/ (simultaneous max. demand)

The POSOCO report provides yearly historical data for diversity factor for the Western region of the country as a whole. The diversity factor for the western region is in the range of 1.02 to 1.06 for the period FY 2009-14. The report doesn't provide any trend of diversity factor for the region/ state nor monthly data for could be accessed to analyze and consider a trend. Due to the lack of data and trend available, diversity factor has not be considered to arrive at the diversity adjusted peak demand for the state.

## 2. Direct forecasting approach

In this approach, monthly historical peak demand data for the state from the year FY 2009-10 to FY 2016-17 has been considered and using statistical forecasting methods, the forecast of expected peak demand for the state has been derived. The present method is not reliant on energy requirement or load factor values and is based on past seasonality and trends. The table below provides the historical peak demand of Rajasthan

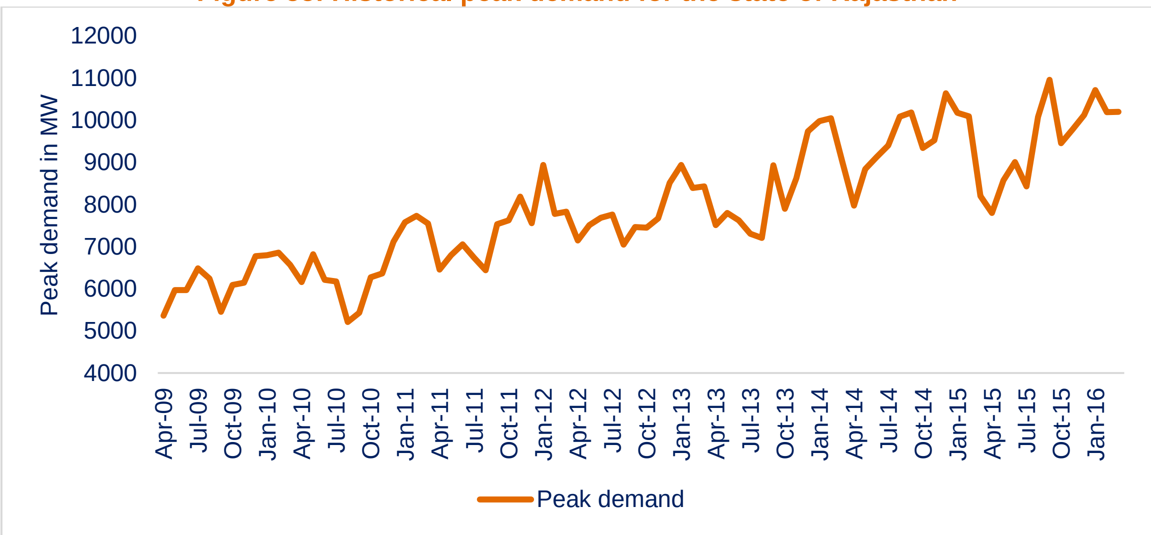
**Table 59: Unrestricted peak demand of Rajasthan[23]**

| | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY10 | 5364 | 5971 | 5968 | 6487 | 6240 | 5453 | 6087 | 6143 | 6771 | 6798 | 6859 | 6567 |
| FY11 | 6159 | 6821 | 6215 | 6171 | 5211 | 5426 | 6275 | 6361 | 7116 | 7582 | 7729 | 7549 |
| FY12 | 6452 | 6800 | 7054 | 6736 | 6443 | 7536 | 7627 | 8188 | 7556 | 8940 | 7779 | 7827 |
| FY13 | 7143 | 7511 | 7686 | 7765 | 7044 | 7464 | 7454 | 7671 | 8511 | 8940 | 8396 | 8433 |
| FY14 | 7512 | 7799 | 7626 | 7306 | 7206 | 8929 | 7899 | 8627 | 9735 | 9977 | 10047 | 9000 |
| FY15 | 7977 | 8844 | 9131 | 9403 | 10087 | 10188 | 9339 | 9525 | 10642 | 10179 | 10095 | 8199 |

23 Source: NRPC, available in public domain

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY16 | 7798 | 8577 | 9010 | 8431 | 10080 | 10961 | 9453 | 9780 | 10123 | 10720 | 10190 | 10200 |
| FY17 | 9027 | 9690 | 9906 | 9288 | 7807 | 9816 | 10000 | 10300 | 10700 | 11300 | 11100 | 10600 |

**Figure 55: Historical peak demand for the state of Rajasthan**




The data highlights that there is a trend and a seasonal component in the peak demand and it is important that such trends are captured using forecasting methods. Also, there is a wide variation in the peak demand across months. In FY 17, the peak demand was maximum during January and minimum in August. To ensure that such trends and seasonality are reflected in the forecast, the Holt-Winter's method was used to forecast the monthly peak demand in the state for the forecast period. The monthly forecast results are provided in the table below:

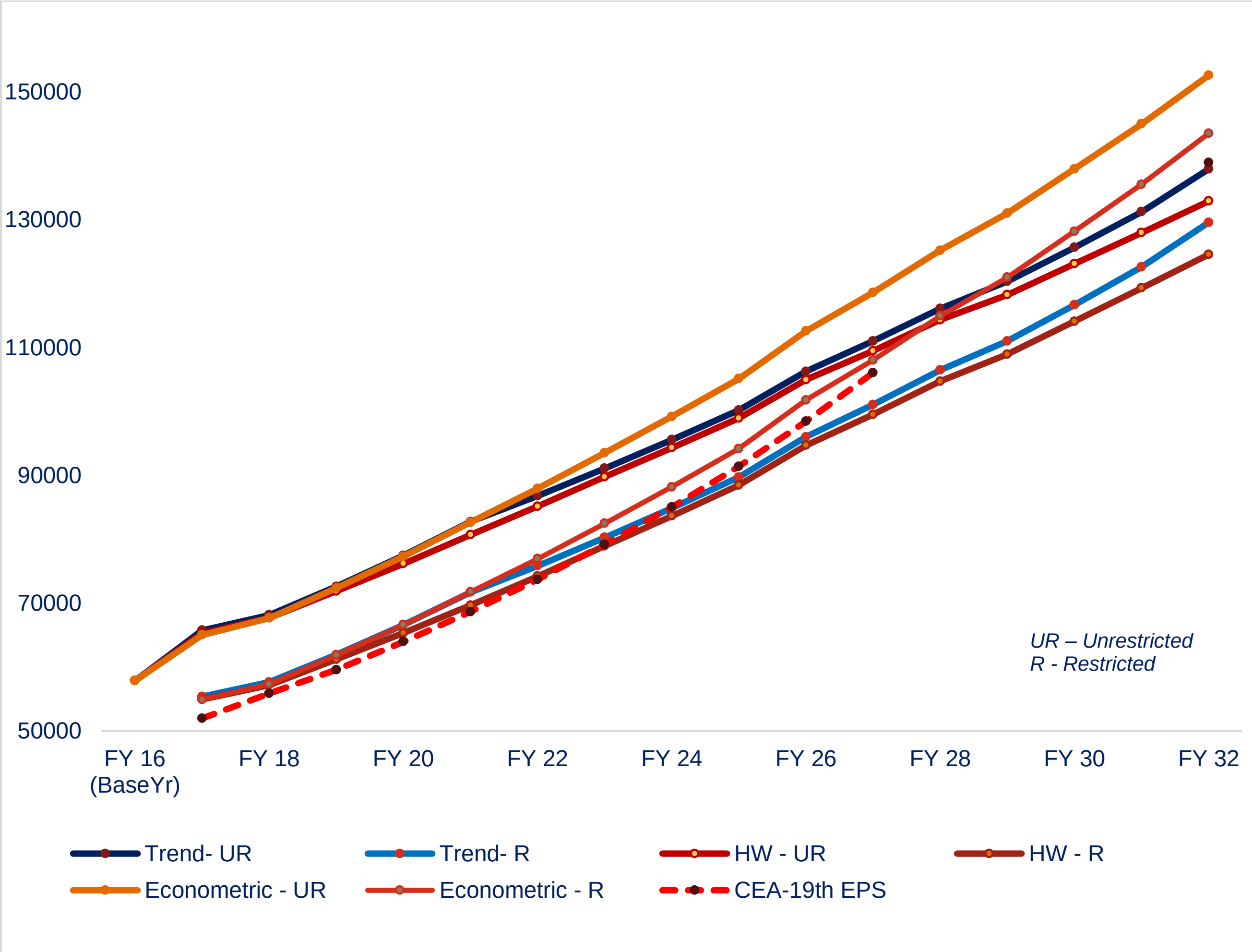
**Table 60: Monthly peak demand for the state determined using forecasting methods**

| MW | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY18 | 10001 | 10386 | 10601 | 9327 | 8716 | 11275 | 11569 | 11032 | 11443 | 12267 | 11934 | 12533 |
| FY19 | 11966 | 12488 | 12794 | 12000 | 11785 | 14137 | 14080 | 13782 | 14244 | 14927 | 14576 | 14593 |
| FY20 | 13317 | 13826 | 14118 | 13314 | 13088 | 15431 | 15365 | 15059 | 15513 | 16189 | 15832 | 15841 |
| FY21 | 14506 | 15013 | 15303 | 14496 | 14267 | 16608 | 16540 | 16232 | 16684 | 17358 | 16999 | 17008 |
| FY22 | 15643 | 16149 | 16439 | 15631 | 15403 | 17743 | 17675 | 17366 | 17818 | 18492 | 18133 | 18142 |
| FY23 | 16759 | 17266 | 17556 | 16749 | 16521 | 18861 | 18794 | 18486 | 18939 | 19613 | 19255 | 19264 |
| FY24 | 17869 | 18377 | 18668 | 17862 | 17634 | 19976 | 19909 | 19603 | 20056 | 20731 | 20374 | 20384 |
| FY25 | 18981 | 19489 | 19781 | 18977 | 18750 | 21093 | 21028 | 20722 | 21177 | 21853 | 21497 | 21508 |
| FY26 | 20098 | 20608 | 20901 | 20098 | 19873 | 22217 | 22153 | 21848 | 22304 | 22982 | 22627 | 22639 |
| FY27 | 21224 | 21735 | 22030 | 21228 | 21004 | 23349 | 23286 | 22983 | 23440 | 24119 | 23766 | 23779 |
| FY28 | 22361 | 22873 | 23169 | 22368 | 22146 | 24492 | 24431 | 24129 | 24587 | 25268 | 24915 | 24930 |
| FY29 | 23508 | 24022 | 24319 | 23520 | 23299 | 25647 | 25587 | 25286 | 25746 | 26428 | 26077 | 26093 |
| FY30 | 24668 | 25183 | 25482 | 24684 | 24464 | 26814 | 26755 | 26456 | 26917 | 27600 | 27250 | 27268 |
| FY31 | 25841 | 26357 | 26657 | 25861 | 25642 | 27993 | 27936 | 27638 | 28100 | 28785 | 28436 | 28455 |
| FY32 | 27026 | 27544 | 27846 | 27050 | 26833 | 29185 | 29129 | 28833 | 29297 | 29982 | 29635 | 29655 |

## 8.15. Finalization of forecast results

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

- Unrestricted forecast were developed for the three utilities 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 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
- The above approach was used to arrive at the state demand for all the options and scenarios.




- The derived results were then compared with that of actual data. The following table provides a comparison of the forecast values at restricted (R) level with that of actual data (from Utilities) for the base year FY 17.

**Table 61: FY 17: Actual vs Forecast for 3 methods**

| FY 17 | JVVNL | | | AVVNL | | | JdVVNL | | | State* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method | Actual (MUs) | For. (MUs) | Varia-tion | Actual (MUs) | For. (MUs) | Varia-tion | Actual (MUs) | For. (MUs) | Varia-tion | Actual (MUs) | For. (MUs) | Varia-tion |
| Trend -R | 18496 | 18897 | 2.2% | 13786 | 13785 | 0.0% | 17732 | 17700 | -0.2% | 50015 | 50382 | 0.7% |
| HW-R | 18496 | 19045 | 3.0% | 13786 | 14110 | 2.4% | 17732 | 17260 | -2.7% | 50015 | 50415 | 0.8% |
| Econometric - R | 18496 | 18844 | 1.9% | 13786 | 14054 | 1.9% | 17732 | 17570 | -0.9% | 50015 | 50468 | 0.9% |

* State demand cumulative of 3 DISCOMs, excluding additional demand

- The variation for the restricted demand condition (Scenario 2) is in the range of 0-3%. Since the forecast for Scenario 1 is higher than that of Scenario 1, the variation will be more in case of Scenario 1.
- The restricted energy consumption forecasted at state level was then grossed up by T&D losses to arrive at the energy required at the state boundary.

## 8.16. Validation of results with traditional methodologies

For validation of the forecast results, the forecast developed by CEA in the 19th EPS has been used. CEA in the 19th EPS has provided year wise forecast for the period FY 2015-16 to FY 2026-27 and also perspective electricity demand projections for the years FY 2031-32 and FY 2036-37.

In the following table, the comparison of forecast results with results of CEA is shown for comparison.

**Table 62: Comparison of forecast results with 19th EPS results for the State (MUs)**

| Year | FY16 (Base Year) | FY 17 | FY 18 | FY 19 | FY 20 | FY 21 | FY 22 | FY 23 | FY 24 | FY 25 | FY 26 | FY 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UR-Tr | 57855 | 65737 | 68146 | 72609 | 77453 | 82745 | 86783 | 91088 | 95563 | 100188 | 106261 | 111004 |
| | | | 3.7% | 6.5% | 6.7% | 6.8% | 4.9% | 5.0% | 4.9% | 4.8% | 6.1% | 4.5% |
| R-Tr | | 55383 | 57634 | 61931 | 66609 | 71720 | 75845 | 80265 | 84891 | 89706 | 96011 | 101052 |
| | | | 4.1% | 7.5% | 7.6% | 7.7% | 5.8% | 5.8% | 5.8% | 5.7% | 7.0% | 5.3% |
| UR-Eco | 57855 | 65015 | 67673 | 72353 | 77301 | 82636 | 87935 | 93513 | 99186 | 105129 | 112577 | 118613 |
| | | | 4.1% | 6.9% | 6.8% | 6.9% | 6.4% | 6.3% | 6.1% | 6.0% | 7.1% | 5.4% |
| R-Eco | | 54906 | 57361 | 61849 | 66615 | 71763 | 76947 | 82472 | 88169 | 94188 | 101782 | 108036 |
| | | | 4.5% | 7.8% | 7.7% | 7.7% | 7.2% | 7.2% | 6.9% | 6.8% | 8.1% | 6.1% |
| HW | | 54942 | 57186 | 61197 | 65328 | 69667 | 74203 | 78936 | 83629 | 88473 | 94694 | 99521 |
| | | | 4.1% | 7.0% | 6.8% | 6.6% | 6.5% | 6.4% | 5.9% | 5.8% | 7.0% | 5.1% |
| CEA | 48017 | 51971 | 55872 | 59573 | 63962 | 68648 | 73709 | 79184 | 85025 | 91399 | 98449 | 106051 |
| | | | 7.5% | 6.6% | 7.4% | 7.3% | 7.4% | 7.4% | 7.4% | 7.5% | 7.7% | 7.7% |

- The results developed using the forecast methodologies are inclusive of additional demand i.e. Open Access & Captive, Railways, Electric vehicles, Delhi Mumbai Industry Corridors, Master Plan of cities, Latent demand, Housing schemes, Metro rail 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.
- The higher demand in FY17 in comparison to CEA results is also due to higher actual demand from Open access consumers in the state and due to addition of latent demand, which is not included in 19th EPS.
- From the results it can be concluded that the forecast using traditional approach is comparable to the electricity consumption requirement developed under the restricted condition (Scenario 2).
- The forecast results arrived at for unrestricted condition (Scenario 1) is higher is comparison to the results presented in the 19th EPS. It can be concluded from the results that forecast using baseline corrected historical data (unrestricted condition) will lead to higher forecast results and may not represent a realistic case.
- Scenario 2 (as explained in earlier sections) is arrived at after subtracting the net unserved demand from the unrestricted forecast. The scenario is more reflective of the current situation.
- While the growth rates (YoY) in 19th EPS is more uniform. However, in alternate methodologies, this is not the case as the approach and methodology is different and also some of the methods used do not use YoY growth rates while arriving at the forecast results.

- Since the methodologies adopted are different, there will be difference in the results which are arrived at. Hence a direct validation of results using YoY growth rates or derived forecast values is not recommended.
- Following table provides a comparison for the year FY 32. The range of results obtained for the terminal year FY32 is also very broad and any of the results can be a possibility going forward.

**Table 63: Comparison of forecasts for year FY32 (MUs)**

| | Trend - UR | Trend - R | HW-R | Econometric-R | Econometric-UR | 19th EPS |
|---|---|---|---|---|---|---|
| FY 32 | 137916 | 129568 | 124553 | 143496 | 152578 | 138933 |

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:

| | 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% |

# 9. Summary of demand forecast results

The following results have been covered in this section:

- Forecasted electricity consumption for Scenario 1 (unrestricted) and Scenario 2 (restricted) condition for Rajasthan
- Derived YoY rates have been highlighted
- The results of 19th EPS has also been highlighted for the State and Utility level for comparison
- Forecasted electricity consumption Scenario 1 (unrestricted) and Scenario 2 (restricted) condition for three utilities – JVVNL, AVVNL, JdVVNL
- Forecasted electricity consumption (restricted condition) for each of the 26 circles
- The results developed from each of the three methods for each case as mentioned above

# 9.1. Rajasthan – Forecast summary

## 9.1.1. Forecast of Electricity consumption

| (MUs) | Scenario | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | UR-Tr | 12574 | 13488 | 14430 | 15389 | 16356 | 17263 | 18136 | 18953 | 19695 | 20340 | 21001 | 21543 | 21970 | 22315 | 22655 | 23159 |
| | R-Tr | 11278 | 12227 | 13219 | 14245 | 15275 | 16265 | 17239 | 18174 | 19050 | 19844 | 20655 | 21356 | 21860 | 22254 | 22655 | 23159 |
| | UR-Eco | 12473 | 13371 | 14298 | 15240 | 16196 | 17176 | 18167 | 19168 | 20177 | 21190 | 22176 | 23157 | 24118 | 25046 | 25900 | 26713 |
| | R-Eco | 11163 | 12097 | 13075 | 14085 | 15106 | 16164 | 17252 | 18369 | 19512 | 20680 | 21835 | 23016 | 24056 | 25010 | 25890 | 26713 |
| | UR-HW | 12222 | 13187 | 14037 | 14862 | 15665 | 16460 | 17231 | 17975 | 18688 | 19368 | 19990 | 20572 | 21086 | 21527 | 21864 | 22115 |
| | CEA | 11534 | 12548 | 13526 | 14563 | 15568 | 16603 | 17774 | 18982 | 20228 | 21626 | 23068 | - | - | - | - | - |
| Non-Domestic | UR-Tr | 5368 | 5785 | 6233 | 6715 | 7233 | 7692 | 8179 | 8693 | 9235 | 9807 | 10436 | 11101 | 11804 | 12546 | 13329 | 14161 |
| | R-Tr | 4270 | 4658 | 5080 | 5539 | 6037 | 6496 | 6987 | 7511 | 8070 | 8666 | 9323 | 10025 | 10776 | 11575 | 12427 | 13341 |
| | UR-Eco | 5272 | 5771 | 6300 | 6850 | 7432 | 7979 | 8558 | 9156 | 9781 | 10434 | 11077 | 11737 | 12425 | 13142 | 13889 | 14816 |
| | R-Eco | 4181 | 4633 | 5119 | 5632 | 6184 | 6717 | 7290 | 7888 | 8523 | 9195 | 9872 | 10576 | 11319 | 12102 | 12928 | 13937 |
| | UR-HW | 5128 | 5469 | 5819 | 6159 | 6503 | 6839 | 7181 | 7515 | 7847 | 8178 | 8517 | 8846 | 9175 | 9502 | 9829 | 10154 |
| | CEA | 4398 | 4883 | 5420 | 6075 | 6808 | 7628 | 8594 | 9685 | 10921 | 12370 | 14008 | - | - | - | - | - |
| PSL | Tr | 420 | 437 | 453 | 470 | 486 | 501 | 517 | 533 | 548 | 562 | 566 | 564 | 556 | 539 | 513 | 475 |
| | Eco | 447 | 460 | 498 | 538 | 579 | 620 | 663 | 707 | 753 | 800 | 847 | 896 | 944 | 991 | 1037 | 1082 |
| | HW | 458 | 500 | 541 | 581 | 620 | 659 | 696 | 733 | 768 | 800 | 832 | 860 | 884 | 905 | 920 | 929 |
| | CEA | 345 | 265 | 290 | 318 | 349 | 384 | 421 | 463 | 509 | 560 | 615 | - | - | - | - | - |
| Agri (M+N+P) | UR-Tr | 25496 | 27628 | 29937 | 32439 | 35150 | 37055 | 39048 | 41131 | 43304 | 45570 | 47735 | 49981 | 52306 | 54709 | 57189 | 60433 |
| | R-Tr | 18512 | 20334 | 22331 | 24520 | 26918 | 28751 | 30691 | 32743 | 34909 | 37195 | 39444 | 41804 | 44277 | 46863 | 49565 | 52985 |
| | UR-Eco | 25241 | 27422 | 29683 | 32003 | 34428 | 36819 | 39262 | 41732 | 44248 | 46820 | 49475 | 52127 | 54806 | 57503 | 60206 | 63037 |
| | R-Eco | 18274 | 20120 | 22075 | 24113 | 26285 | 28472 | 30755 | 33101 | 35534 | 38064 | 40722 | 43425 | 46204 | 49055 | 51968 | 55050 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | UR-HW | 25754 | 28003 | 30120 | 32204 | 34319 | 36397 | 38509 | 40581 | 42648 | 44711 | 46876 | 48932 | 50984 | 53031 | 55075 | 57114 |
| | CEA | 21717 | 23308 | 24514 | 26154 | 27958 | 29946 | 31977 | 34109 | 36481 | 39038 | 41786 | - | - | - | - | - |
| Agri (F) | UR-Tr | 3508 | 3099 | 2746 | 2440 | 2174 | 1935 | 1733 | 1560 | 1411 | 1282 | 1158 | 1054 | 965 | 887 | 818 | 650 |
| | R-Tr | 2532 | 2268 | 2037 | 1835 | 1657 | 1495 | 1357 | 1237 | 1134 | 1043 | 955 | 880 | 815 | 758 | 707 | 569 |
| | UR-Eco | 2674 | 2234 | 1912 | 1718 | 1653 | 1620 | 1616 | 1540 | 1546 | 1557 | 1569 | 1590 | 1613 | 1640 | 1668 | 1699 |
| | R-Eco | 1932 | 1637 | 1421 | 1294 | 1262 | 1252 | 1266 | 1221 | 1241 | 1266 | 1292 | 1325 | 1360 | 1399 | 1440 | 1483 |
| | R-HW | 2916 | 2266 | 1907 | 1713 | 1649 | 1615 | 1612 | 1535 | 1541 | 1552 | 1565 | 1585 | 1609 | 1635 | 1664 | 1694 |
| | CEA | In EPS, Agri (F) is not given separately | | | | | | | | | | | | | | | |
| Industry (S + M) | Tr | 3098 | 3231 | 3371 | 3518 | 3673 | 3818 | 3969 | 4126 | 4289 | 4460 | 4631 | 4809 | 4994 | 5187 | 5387 | 5617 |
| | Eco | 3252 | 3395 | 3544 | 3700 | 3859 | 4028 | 4205 | 4388 | 4578 | 4768 | 4969 | 5175 | 5387 | 5603 | 5818 | 6043 |
| | HW | 3276 | 3422 | 3575 | 3734 | 3896 | 4069 | 4247 | 4430 | 4618 | 4805 | 5001 | 5201 | 5404 | 5610 | 5813 | 6025 |
| | CEA | 3160 | 3362 | 3575 | 3803 | 4045 | 4303 | 4577 | 4869 | 5179 | 5509 | 5860 | - | - | - | - | - |
| Industry (L) | Tr | 7721 | 8197 | 8707 | 9256 | 9847 | 10214 | 10594 | 10989 | 11398 | 11822 | 12317 | 12833 | 13372 | 13935 | 14522 | 15155 |
| | Eco | 8029 | 8584 | 9171 | 9747 | 10319 | 10912 | 11524 | 12158 | 12818 | 13493 | 14033 | 14784 | 15577 | 16415 | 17288 | 18234 |
| | HW | 7935 | 8457 | 8999 | 9516 | 10013 | 10515 | 11015 | 11515 | 12017 | 12507 | 12832 | 13333 | 13837 | 14345 | 14840 | 15354 |
| | CEA | 7771 | 8300 | 8867 | 9474 | 10123 | 10819 | 11564 | 12362 | 13216 | 14132 | 15113 | - | - | - | - | - |
| PWW | Tr | 1901 | 2004 | 2111 | 2224 | 2341 | 2400 | 2458 | 2515 | 2571 | 2624 | 2668 | 2709 | 2746 | 2778 | 2806 | 2810 |
| | Eco | 1942 | 2075 | 2212 | 2353 | 2499 | 2655 | 2817 | 2992 | 3175 | 3368 | 3577 | 3800 | 4044 | 4300 | 4582 | 4885 |
| | HW | 1924 | 2034 | 2143 | 2252 | 2357 | 2463 | 2567 | 2672 | 2775 | 2873 | 2974 | 3071 | 3170 | 3263 | 3357 | 3448 |
| | CEA | 1916 | 2037 | 2173 | 2328 | 2506 | 2694 | 2902 | 3134 | 3396 | 3690 | 4018 | - | - | - | - | - |
| Mixed Load | Tr | 649 | 665 | 682 | 699 | 716 | 726 | 737 | 748 | 759 | 770 | 781 | 791 | 802 | 813 | 824 | 835 |
| | Eco | 683 | 746 | 796 | 850 | 901 | 947 | 983 | 1029 | 1076 | 1124 | 1175 | 1231 | 1281 | 1338 | 1394 | 1446 |
| | HW | 683 | 746 | 796 | 850 | 901 | 947 | 983 | 1029 | 1076 | 1124 | 1175 | 1231 | 1281 | 1338 | 1394 | 1446 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CEA | 676 | 698 | 717 | 737 | 759 | 780 | 802 | 825 | 848 | 872 | 896 | - | - | - | - | - |
| Total for Utilities | UR-Tr | 60736 | 64533 | 68671 | 73151 | 77975 | 81605 | 85371 | 89247 | 93210 | 97236 | 101292 | 105385 | 109515 | 113710 | 118042 | 123294 |
| | | | 6.3% | 6.4% | 6.5% | 6.6% | 4.7% | 4.6% | 4.5% | 4.4% | 4.3% | 4.2% | 4.0% | 3.9% | 3.8% | 3.8% | 4.4% |
| | R-Tr | 50382 | 54021 | 57993 | 62306 | 66950 | 70666 | 74548 | 78575 | 82727 | 86986 | 91340 | 95772 | 100198 | 104703 | 109406 | 114946 |
| | | | 7.2% | 7.4% | 7.4% | 7.5% | 5.6% | 5.5% | 5.4% | 5.3% | 5.1% | 5.0% | 4.9% | 4.6% | 4.5% | 4.5% | 5.1% |
| | UR-Eco | 60576 | 64736 | 69189 | 73929 | 78970 | 84072 | 89326 | 94696 | 100331 | 106172 | 111974 | 118162 | 124548 | 131153 | 137969 | 145308 |
| | | | 6.9% | 6.9% | 6.9% | 6.8% | 6.5% | 6.2% | 6.0% | 6.0% | 5.8% | 5.5% | 5.5% | 5.4% | 5.3% | 5.2% | 5.3% |
| | R-Eco | 50467 | 54423 | 58685 | 63243 | 68097 | 73084 | 78285 | 83679 | 89390 | 95376 | 101396 | 107891 | 114526 | 121388 | 128531 | 136226 |
| | | | 7.8% | 7.8% | 7.8% | 7.7% | 7.3% | 7.1% | 6.9% | 6.8% | 6.7% | 6.3% | 6.4% | 6.1% | 6.0% | 5.9% | 6.0% |
| | HW | 49941 | 53573 | 57259 | 61026 | 64897 | 69025 | 73219 | 77313 | 81494 | 85669 | 89810 | 94018 | 98113 | 102149 | 106120 | 109931 |
| | | | 7.3% | 6.9% | 6.6% | 6.3% | 6.4% | 6.1% | 5.6% | 5.4% | 5.1% | 4.8% | 4.7% | 4.4% | 4.1% | 3.9% | 3.6% |
| | CEA | 51971 | 55872 | 59573 | 63962 | 68648 | 73709 | 79184 | 85025 | 91399 | 98449 | 106051 | - | - | - | - | 138933 |
| | | | 7.5% | 6.6% | 7.4% | 7.3% | 7.4% | 7.4% | 7.4% | 7.5% | 7.7% | 7.7% | | | | | |
| Addl. Consumption to be added to above | | 5001 | 3613 | 3938 | 4303 | 4770 | 5178 | 5717 | 6316 | 6979 | 9025 | 9712 | 10704 | 10826 | 11952 | 13198 | 14622 |
| Total for State | UR-Tr | 65737 | 68146 | 72609 | 77453 | 82745 | 86783 | 91088 | 95563 | 100188 | 106261 | 111004 | 116090 | 120342 | 125662 | 131240 | 137916 |
| | | | 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 |
| | | | 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 | 65015 | 67673 | 72353 | 77301 | 82636 | 87935 | 93513 | 99186 | 105129 | 112577 | 118613 | 125202 | 131020 | 137930 | 144980 | 152578 |
| | | | 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 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 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 |
| | | 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 | 51971 | 55872 | 59573 | 63962 | 68648 | 73709 | 79184 | 85025 | 91399 | 98449 | 106051 | - | - | - | - | 138933 |
| | | 7.5% | 6.6% | 7.4% | 7.3% | 7.4% | 7.4% | 7.4% | 7.5% | 7.7% | 7.7% | | | | | |

**Note:**

- UR – Unrestricted electricity consumption in MUs
- R – Restricted electricity consumption in MUs
- Tr – Trend method
- Eco – Econometric method
- HW – HoltWinters Method
- Additional consumption – Open Access & Captive, Railways, EV, DMIC, Master Plans, Latent demand, Metro etc.
- The % shown are YoY growth rates derived from the forecast results.

## 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 19$^{th}$ 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 19$^{th}$ 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 64: Summary of the electricity requirement at state level**

| Scenario<br><br>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 65: Summary of peak demand at state level**

| Scenario<br><br>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 |

## 9.2. Forecast at DISCOM level

### 9.2.1. JVVNL – Forecast of electricity consumption

| (MUs) | Scenario | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | UR-Tr | 5,225 | 5,622 | 6,038 | 6,471 | 6,921 | 7,350 | 7,785 | 8,223 | 8,665 | 9,112 | 9,581 | 10,081 | 10,642 | 11,321 | 12,208 | 13,452 |
| | R-Tr | 4,761 | 5,172 | 5,609 | 6,069 | 6,531 | 6,979 | 7,438 | 7,907 | 8,385 | 8,876 | 9,386 | 9,930 | 10,532 | 11,259 | 12,208 | 13,452 |
| | UR-Eco | 5245 | 5630 | 6028 | 6440 | 6867 | 7309 | 7767 | 8243 | 8738 | 9253 | 9785 | 10339 | 10918 | 11523 | 12157 | 12830 |
| | R-Eco | 4783 | 5188 | 5613 | 6059 | 6505 | 6969 | 7456 | 7966 | 8502 | 9064 | 9640 | 10255 | 10856 | 11487 | 12148 | 12830 |
| | UR-HW | 5051 | 5402 | 5753 | 6105 | 6456 | 6808 | 7159 | 7510 | 7862 | 8213 | 8564 | 8916 | 9267 | 9619 | 9970 | 10321 |
| | CEA | 4838 | 5271 | 5717 | 6148 | 6568 | 7000 | 7466 | 7946 | 8441 | 8973 | 9522 | - | - | - | - | - |
| Non-Domestic | UR-Tr | 2,597 | 2,757 | 2,925 | 3,103 | 3,289 | 3,479 | 3,679 | 3,889 | 4,109 | 4,339 | 4,573 | 4,817 | 5,072 | 5,337 | 5,612 | 5,897 |
| | R-Tr | 2,092 | 2,248 | 2,415 | 2,592 | 2,780 | 2,975 | 3,181 | 3,400 | 3,631 | 3,876 | 4,130 | 4,397 | 4,678 | 4,973 | 5,283 | 5,608 |
| | UR-Eco | 2602 | 2826 | 3060 | 3304 | 3559 | 3818 | 4090 | 4373 | 4669 | 4979 | 5290 | 5615 | 5955 | 6309 | 6679 | 7093 |
| | R-Eco | 2095 | 2303 | 2523 | 2756 | 3003 | 3259 | 3530 | 3816 | 4120 | 4441 | 4770 | 5117 | 5484 | 5871 | 6280 | 6737 |
| | UR-HW | 2550 | 2721 | 2883 | 3042 | 3199 | 3354 | 3508 | 3661 | 3813 | 3964 | 4115 | 4266 | 4416 | 4565 | 4715 | 4864 |
| | CEA | 2117 | 2275 | 2441 | 2642 | 2856 | 3084 | 3351 | 3636 | 3942 | 4296 | 4675 | - | - | - | - | - |
| PSL | Tr | 184 | 189 | 195 | 199 | 204 | 200 | 196 | 191 | 185 | 178 | 169 | 159 | 147 | 133 | 118 | 102 |
| | Eco | 207 | 226 | 246 | 267 | 289 | 313 | 338 | 364 | 393 | 423 | 456 | 492 | 530 | 572 | 617 | 667 |
| | HW | 213 | 232 | 250 | 269 | 287 | 305 | 324 | 342 | 361 | 379 | 397 | 416 | 434 | 453 | 472 | 490 |
| | CEA | 155 | 122 | 131 | 141 | 152 | 163 | 176 | 189 | 204 | 220 | 236 | - | - | - | - | - |
| Agri (M+N+P) | UR-Tr | 7,700 | 8,164 | 8,652 | 9,166 | 9,705 | 10,254 | 10,832 | 11,439 | 12,075 | 12,741 | 13,423 | 14,134 | 14,877 | 15,651 | 16,456 | 17,291 |
| | R-Tr | 5,600 | 6,018 | 6,463 | 6,937 | 7,440 | 7,967 | 8,527 | 9,122 | 9,754 | 10,423 | 11,118 | 11,853 | 12,629 | 13,447 | 14,308 | 15,213 |
| | UR-Eco | 7890 | 8548 | 9216 | 9892 | 10573 | 11231 | 11884 | 12528 | 13157 | 13765 | 14345 | 14888 | 15383 | 15819 | 16182 | 16497 |
| | R-Eco | 5750 | 6312 | 6896 | 7498 | 8119 | 8734 | 9358 | 9989 | 10621 | 11249 | 11867 | 12465 | 13036 | 13566 | 14044 | 14490 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | UR-HW | 8405 | 9063 | 9720 | 10378 | 11035 | 11692 | 12350 | 13007 | 13664 | 14321 | 14978 | 15635 | 16292 | 16949 | 17606 | 18263 |
| | CEA | 6101 | 6366 | 6473 | 6861 | 7240 | 7580 | 7916 | 8268 | 8683 | 9102 | 9528 | - | - | - | - | - |
| Agri (F) | UR-Tr | 632 | 546 | 472 | 409 | 354 | 279 | 220 | 173 | 136 | 107 | 74 | 51 | 35 | 24 | 16 | 11 |
| | R-Tr | 444 | 390 | 342 | 299 | 263 | 210 | 168 | 134 | 107 | 85 | 59 | 41 | 29 | 20 | 14 | 10 |
| | UR-Eco | 105 | 87 | 68 | 57 | 55 | 55 | 54 | 53 | 53 | 52 | 47 | 49 | 50 | 51 | 53 | 54 |
| | R-Eco | 77 | 64 | 52 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 40 | 42 | 44 | 45 | 47 | 49 |
| | UR-HW | 357 | 126 | 68 | 57 | 55 | 55 | 54 | 53 | 53 | 52 | 47 | 49 | 50 | 51 | 53 | 54 |
| | CEA | In EPS, Agri (F) is not given separately | | | | | | | | | | | | | | | |
| Industry (S + M) | Tr | 1,068 | 1,101 | 1,136 | 1,171 | 1,207 | 1,248 | 1,290 | 1,333 | 1,378 | 1,424 | 1,471 | 1,520 | 1,571 | 1,622 | 1,676 | 1,731 |
| | Eco | 1209 | 1242 | 1277 | 1316 | 1358 | 1404 | 1453 | 1505 | 1559 | 1614 | 1671 | 1728 | 1785 | 1843 | 1900 | 1955 |
| | HW | 1219 | 1268 | 1322 | 1381 | 1445 | 1516 | 1591 | 1670 | 1754 | 1842 | 1933 | 2027 | 2124 | 2224 | 2326 | 2431 |
| | CEA | 1107 | 1182 | 1261 | 1347 | 1438 | 1535 | 1639 | 1750 | 1869 | 1995 | 2130 | - | - | - | - | - |
| Industry (L) | Tr | 4,010 | 4,259 | 4,523 | 4,805 | 5,103 | 5,255 | 5,411 | 5,572 | 5,736 | 5,904 | 6,077 | 6,253 | 6,434 | 6,619 | 6,809 | 7,003 |
| | Eco | 3946 | 4216 | 4494 | 4780 | 5073 | 5374 | 5683 | 5998 | 6320 | 6648 | 6982 | 7321 | 7667 | 8018 | 8374 | 8735 |
| | HW | 3954 | 4238 | 4530 | 4829 | 5136 | 5450 | 5771 | 6099 | 6433 | 6773 | 7119 | 7471 | 7828 | 8190 | 8558 | 8930 |
| | CEA | 4030 | 4303 | 4594 | 4905 | 5237 | 5591 | 5969 | 6373 | 6804 | 7264 | 7755 | - | - | - | - | - |
| PWW | Tr | 560 | 594 | 630 | 668 | 710 | 735 | 760 | 786 | 813 | 840 | 867 | 895 | 923 | 951 | 980 | 1,008 |
| | Eco | 571 | 618 | 668 | 724 | 784 | 851 | 925 | 1006 | 1095 | 1195 | 1306 | 1428 | 1565 | 1718 | 1889 | 2079 |
| | HW | 561 | 597 | 631 | 664 | 696 | 728 | 759 | 791 | 822 | 853 | 884 | 915 | 945 | 976 | 1006 | 1037 |
| | CEA | 585 | 642 | 703 | 782 | 875 | 980 | 1097 | 1233 | 1393 | 1580 | 1795 | - | - | - | - | - |
| Mixed Load | Tr | 177 | 182 | 188 | 193 | 198 | 204 | 209 | 214 | 220 | 226 | 231 | 236 | 242 | 248 | 253 | 259 |
| | Eco | 206 | 233 | 256 | 277 | 298 | 318 | 338 | 358 | 379 | 401 | 423 | 447 | 471 | 498 | 525 | 552 |
| | HW | 206 | 233 | 256 | 277 | 298 | 318 | 338 | 358 | 379 | 401 | 423 | 447 | 471 | 498 | 525 | 552 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CEA | 203 | 209 | 215 | 221 | 227 | 233 | 239 | 245 | 251 | 257 | 263 | - | - | - | - | - |
| Total for Utilities | UR-Tr | 22153 | 23415 | 24759 | 26185 | 27691 | 29005 | 30383 | 31820 | 33316 | 34870 | 36465 | 38146 | 39942 | 41906 | 44128 | 46754 |
| | | | 5.7% | 5.7% | 5.8% | 5.8% | 4.7% | 4.8% | 4.7% | 4.7% | 4.7% | 4.6% | 4.6% | 4.7% | 4.9% | 5.3% | 6.0% |
| | R-Tr | 18897 | 20154 | 21499 | 22933 | 24436 | 25772 | 27180 | 28659 | 30208 | 31831 | 33508 | 35284 | 37184 | 39273 | 41649 | 44386 |
| | | | 6.7% | 6.7% | 6.7% | 6.6% | 5.5% | 5.5% | 5.4% | 5.4% | 5.4% | 5.3% | 5.3% | 5.4% | 5.6% | 6.0% | 6.6% |
| | UR-Eco | 21982 | 23625 | 25313 | 27056 | 28857 | 30673 | 32531 | 34428 | 36362 | 38329 | 40304 | 42307 | 44325 | 46351 | 48376 | 50463 |
| | | | 7.5% | 7.1% | 6.9% | 6.7% | 6.3% | 6.1% | 5.8% | 5.6% | 5.4% | 5.2% | 5.0% | 4.8% | 4.6% | 4.4% | 4.3% |
| | R-Eco | 18844 | 20402 | 22024 | 23720 | 25473 | 27265 | 29124 | 31046 | 33032 | 35079 | 37154 | 39295 | 41439 | 43618 | 45823 | 48095 |
| | | | 8.3% | 8.0% | 7.7% | 7.4% | 7.0% | 6.8% | 6.6% | 6.4% | 6.2% | 5.9% | 5.8% | 5.5% | 5.3% | 5.1% | 5.0% |
| | HW | 19259 | 20618 | 22153 | 23749 | 25352 | 26992 | 28651 | 30330 | 32032 | 33759 | 35504 | 37279 | 39070 | 40892 | 42751 | 44574 |
| | | | 7.1% | 7.4% | 7.2% | 6.7% | 6.5% | 6.1% | 5.9% | 5.6% | 5.4% | 5.2% | 5.0% | 4.8% | 4.7% | 4.5% | 4.3% |
| | CEA* | 19135 | 20370 | 21535 | 23045 | 24591 | 26166 | 27854 | 29642 | 31587 | 33687 | 35905 | - | - | - | - | - |
| | | | 6.5% | 5.7% | 7.0% | 6.7% | 6.4% | 6.5% | 6.4% | 6.6% | 6.6% | 6.6% | | | | | |

## 9.2.2. AVVNL – Forecast of electricity consumption

| (MUs) | Scenario | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | UR-Tr | 3,788 | 4,046 | 4,307 | 4,566 | 4,819 | 5,079 | 5,319 | 5,531 | 5,703 | 5,823 | 5,935 | 5,970 | 5,913 | 5,751 | 5,476 | 5,086 |
| | R-Tr | 3,361 | 3,631 | 3,908 | 4,189 | 4,469 | 4,761 | 5,039 | 5,295 | 5,517 | 5,691 | 5,860 | 5,954 | 5,913 | 5,751 | 5,476 | 5,086 |
| | UR-Eco | 3900 | 4192 | 4494 | 4807 | 5131 | 5461 | 5803 | 6157 | 6524 | 6903 | 7297 | 7705 | 8128 | 8568 | 9024 | 9507 |
| | R-Eco | 3457 | 3757 | 4073 | 4405 | 4753 | 5113 | 5491 | 5888 | 6303 | 6739 | 7197 | 7676 | 8128 | 8568 | 9024 | 9507 |
| | UR-HW | 3782 | 4172 | 4458 | 4742 | 5028 | 5319 | 5613 | 5909 | 6209 | 6511 | 6816 | 7124 | 7434 | 7747 | 8062 | 8380 |
| | CEA | 3404 | 3684 | 3975 | 4298 | 4616 | 4945 | 5346 | 5763 | 6194 | 6708 | 7240 | - | - | - | - | - |
| Non-Domestic | UR-Tr | 1,411 | 1,555 | 1,713 | 1,887 | 2,078 | 2,200 | 2,327 | 2,462 | 2,603 | 2,752 | 2,895 | 3,044 | 3,198 | 3,358 | 3,524 | 3,694 |
| | R-Tr | 1,110 | 1,239 | 1,383 | 1,542 | 1,719 | 1,841 | 1,971 | 2,110 | 2,257 | 2,413 | 2,568 | 2,730 | 2,901 | 3,079 | 3,266 | 3,461 |
| | UR-Eco | 1366 | 1510 | 1662 | 1823 | 1992 | 2138 | 2291 | 2451 | 2620 | 2797 | 2960 | 3129 | 3306 | 3490 | 3681 | 3957 |
| | R-Eco | 1072 | 1200 | 1338 | 1485 | 1643 | 1784 | 1935 | 2095 | 2265 | 2446 | 2619 | 2800 | 2991 | 3193 | 3404 | 3699 |
| | UR-HW | 1326 | 1393 | 1471 | 1550 | 1630 | 1710 | 1790 | 1870 | 1951 | 2032 | 2113 | 2194 | 2275 | 2356 | 2438 | 2519 |
| | CEA | 1119 | 1241 | 1370 | 1524 | 1695 | 1878 | 2096 | 2329 | 2582 | 2879 | 3198 | - | - | - | - | - |
| PSL | Tr | 90 | 98 | 107 | 117 | 127 | 132 | 137 | 141 | 144 | 146 | 146 | 143 | 139 | 132 | 122 | 110 |
| | Eco | 92 | 81 | 90 | 99 | 109 | 119 | 130 | 142 | 155 | 170 | 185 | 202 | 220 | 240 | 263 | 290 |
| | HW | 97 | 109 | 121 | 133 | 145 | 156 | 168 | 180 | 191 | 203 | 214 | 226 | 237 | 249 | 261 | 272 |
| | CEA | 71 | 56 | 61 | 67 | 74 | 81 | 89 | 98 | 108 | 119 | 130 | - | - | - | - | - |
| Agri (M+N+P) | UR-Tr | 5,658 | 6,060 | 6,488 | 6,944 | 7,429 | 7,888 | 8,370 | 8,876 | 9,407 | 9,963 | 10,499 | 11,059 | 11,644 | 12,255 | 12,890 | 13,549 |
| | R-Tr | 4,116 | 4,469 | 4,849 | 5,260 | 5,701 | 6,132 | 6,591 | 7,078 | 7,595 | 8,144 | 8,687 | 9,261 | 9,868 | 10,507 | 11,181 | 11,888 |
| | UR-Eco | 5511 | 5921 | 6328 | 6759 | 7214 | 7645 | 8047 | 8455 | 8864 | 9285 | 9710 | 10134 | 10558 | 10977 | 11391 | 11867 |
| | R-Eco | 3994 | 4350 | 4713 | 5101 | 5517 | 5922 | 6314 | 6719 | 7132 | 7564 | 8007 | 8459 | 8918 | 9382 | 9850 | 10380 |
| | UR-HW | 5716 | 6378 | 6882 | 7385 | 7889 | 8392 | 8896 | 9399 | 9903 | 10406 | 10970 | 11473 | 11977 | 12480 | 12984 | 13487 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CEA | 5293 | 5592 | 5768 | 5966 | 6241 | 6539 | 6822 | 7099 | 7400 | 7725 | 8062 | - | - | - | - | - |
| Agri (F) | UR-Tr | 1,260 | 1,107 | 978 | 869 | 776 | 695 | 626 | 565 | 511 | 464 | 422 | 384 | 350 | 320 | 292 | 267 |
| | R-Tr | 917 | 816 | 731 | 658 | 595 | 541 | 493 | 450 | 413 | 379 | 349 | 322 | 297 | 274 | 253 | 234 |
| | UR-Eco | 1333 | 1032 | 795 | 657 | 622 | 608 | 615 | 539 | 538 | 536 | 535 | 533 | 532 | 531 | 530 | 529 |
| | R-Eco | 966 | 758 | 592 | 496 | 476 | 471 | 482 | 428 | 433 | 437 | 441 | 445 | 449 | 454 | 458 | 462 |
| | UR-HW | 1333 | 1032 | 795 | 657 | 622 | 608 | 615 | 539 | 538 | 536 | 535 | 533 | 532 | 531 | 530 | 529 |
| | CEA | In EPS, Agri (F) is not given separately | | | | | | | | | | | | | | | |
| Industry (S + M) | Tr | 1,147 | 1,208 | 1,272 | 1,341 | 1,413 | 1,480 | 1,551 | 1,625 | 1,702 | 1,783 | 1,866 | 1,953 | 2,044 | 2,138 | 2,237 | 2,340 |
| | Eco | 1162 | 1229 | 1297 | 1367 | 1438 | 1510 | 1584 | 1659 | 1736 | 1815 | 1895 | 1976 | 2059 | 2144 | 2230 | 2318 |
| | HW | 1151 | 1209 | 1266 | 1323 | 1381 | 1438 | 1495 | 1552 | 1610 | 1667 | 1724 | 1782 | 1839 | 1896 | 1953 | 2011 |
| | CEA | 1159 | 1233 | 1313 | 1397 | 1486 | 1582 | 1683 | 1791 | 1906 | 2028 | 2158 | - | - | - | - | - |
| Industry (L) | Tr | 2,425 | 2,537 | 2,653 | 2,774 | 2,901 | 3,039 | 3,184 | 3,336 | 3,495 | 3,661 | 3,892 | 4,137 | 4,397 | 4,673 | 4,964 | 5,273 |
| | Eco | 2665 | 2832 | 3039 | 3229 | 3413 | 3596 | 3780 | 3968 | 4161 | 4359 | 4602 | 4817 | 5043 | 5280 | 5532 | 5799 |
| | HW | 2673 | 2844 | 3051 | 3237 | 3413 | 3582 | 3746 | 3906 | 4064 | 4220 | 4410 | 4562 | 4714 | 4865 | 5014 | 5164 |
| | CEA | 2508 | 2713 | 2934 | 3173 | 3432 | 3712 | 4015 | 4342 | 4696 | 5079 | 5494 | - | - | - | - | - |
| PWW | Tr | 506 | 535 | 565 | 596 | 629 | 648 | 666 | 684 | 702 | 718 | 728 | 736 | 742 | 745 | 747 | 745 |
| | Eco | 532 | 574 | 617 | 662 | 709 | 759 | 812 | 869 | 931 | 998 | 1070 | 1149 | 1234 | 1328 | 1431 | 1544 |
| | HW | 521 | 557 | 591 | 625 | 658 | 690 | 722 | 754 | 786 | 817 | 849 | 880 | 911 | 942 | 972 | 1003 |
| | CEA | 507 | 538 | 574 | 611 | 652 | 694 | 739 | 787 | 839 | 894 | 952 | - | - | - | - | - |
| Mixed Load | Tr | 113 | 117 | 121 | 126 | 130 | 131 | 131 | 132 | 133 | 134 | 136 | 137 | 139 | 140 | 142 | 143 |
| | Eco | 114 | 126 | 135 | 144 | 153 | 162 | 171 | 180 | 188 | 197 | 206 | 215 | 224 | 232 | 241 | 250 |
| | HW | 114 | 126 | 135 | 144 | 153 | 162 | 171 | 180 | 188 | 197 | 206 | 215 | 224 | 232 | 241 | 250 |
| | CEA | 116 | 121 | 127 | 133 | 140 | 147 | 154 | 162 | 170 | 179 | 188 | - | - | - | - | - |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total for Utilities | UR-Tr | 16398 | 17263 | 18205 | 19220 | 20301 | 21291 | 22311 | 23352 | 24400 | 25444 | 26519 | 27564 | 28566 | 29512 | 30394 | 31208 |
| | | | 5.3% | 5.5% | 5.6% | 5.6% | 4.9% | 4.8% | 4.7% | 4.5% | 4.3% | 4.2% | 3.9% | 3.6% | 3.3% | 3.0% | 2.7% |
| | R-Tr | 13785 | 14650 | 15590 | 16602 | 17683 | 18704 | 19763 | 20851 | 21957 | 23070 | 24231 | 25374 | 26438 | 27440 | 28388 | 29281 |
| | | | 6.3% | 6.4% | 6.5% | 6.5% | 5.8% | 5.7% | 5.5% | 5.3% | 5.1% | 5.0% | 4.7% | 4.2% | 3.8% | 3.5% | 3.1% |
| | UR-Eco | 16676 | 17498 | 18458 | 19546 | 20781 | 21998 | 23232 | 24421 | 25716 | 27060 | 28458 | 29860 | 31304 | 32791 | 34322 | 36060 |
| | | | 4.9% | 5.5% | 5.9% | 6.3% | 5.9% | 5.6% | 5.1% | 5.3% | 5.2% | 5.2% | 4.9% | 4.8% | 4.8% | 4.7% | 5.1% |
| | R-Eco | 14054 | 14908 | 15893 | 16986 | 18210 | 19437 | 20700 | 21949 | 23305 | 24725 | 26221 | 27738 | 29267 | 30821 | 32432 | 34249 |
| | | | 6.1% | 6.6% | 6.9% | 7.2% | 6.7% | 6.5% | 6.0% | 6.2% | 6.1% | 6.1% | 5.8% | 5.5% | 5.3% | 5.2% | 5.6% |
| | HW | 14100 | 15208 | 16156 | 17179 | 18300 | 19470 | 20666 | 21789 | 22997 | 24215 | 25549 | 26799 | 28015 | 29226 | 30450 | 31688 |
| | | | 7.9% | 6.2% | 6.3% | 6.5% | 6.4% | 6.1% | 5.4% | 5.5% | 5.3% | 5.5% | 4.9% | 4.5% | 4.3% | 4.2% | 4.1% |
| | CEA | 14177 | 15178 | 16122 | 17170 | 18335 | 19578 | 20944 | 22372 | 23895 | 25610 | 27423 | - | - | - | - | - |
| | | | 7.1% | 6.2% | 6.5% | 6.8% | 6.8% | 7.0% | 6.8% | 6.8% | 7.2% | 7.1% | | | | | |

## 9.2.3. JdVVNL – Forecast of electricity consumption

| (MUs) | Scenario | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | UR-Tr | 3,561 | 3,820 | 4,085 | 4,352 | 4,616 | 4,834 | 5,032 | 5,199 | 5,327 | 5,406 | 5,485 | 5,492 | 5,415 | 5,243 | 4,971 | 4,621 |
| | R-Tr | 3,156 | 3,424 | 3,702 | 3,987 | 4,275 | 4,526 | 4,761 | 4,972 | 5,148 | 5,277 | 5,410 | 5,472 | 5,415 | 5,243 | 4,971 | 4,621 |
| | UR-Eco | 3556 | 3834 | 4124 | 4428 | 4746 | 5079 | 5429 | 5796 | 6182 | 6590 | 7019 | 7473 | 7954 | 8463 | 9004 | 9579 |
| | R-Eco | 3151 | 3436 | 3738 | 4057 | 4396 | 4755 | 5137 | 5542 | 5974 | 6433 | 6923 | 7445 | 7954 | 8463 | 9004 | 9579 |
| | UR-HW | 3638 | 3923 | 4201 | 4475 | 4748 | 5020 | 5291 | 5561 | 5831 | 6101 | 6371 | 6641 | 6911 | 7181 | 7451 | 7721 |
| | CEA | 3293 | 3593 | 3834 | 4117 | 4384 | 4659 | 4962 | 5273 | 5593 | 5944 | 6306 | - | - | - | - | - |
| Non-Domestic | UR-Tr | 1,361 | 1,473 | 1,594 | 1,725 | 1,865 | 2,013 | 2,172 | 2,342 | 2,523 | 2,717 | 2,968 | 3,240 | 3,534 | 3,851 | 4,194 | 4,570 |
| | R-Tr | 1,068 | 1,171 | 1,283 | 1,405 | 1,538 | 1,681 | 1,835 | 2,002 | 2,182 | 2,376 | 2,626 | 2,899 | 3,197 | 3,523 | 3,878 | 4,272 |
| | UR-Eco | 1346 | 1487 | 1635 | 1792 | 1957 | 2112 | 2274 | 2444 | 2622 | 2809 | 2988 | 3176 | 3372 | 3578 | 3793 | 4065 |
| | R-Eco | 1056 | 1182 | 1316 | 1460 | 1614 | 1763 | 1921 | 2089 | 2267 | 2457 | 2644 | 2842 | 3051 | 3273 | 3507 | 3800 |
| | UR-HW | 1304 | 1416 | 1529 | 1641 | 1753 | 1866 | 1978 | 2090 | 2203 | 2315 | 2428 | 2540 | 2652 | 2765 | 2877 | 2989 |
| | CEA | 1161 | 1366 | 1609 | 1908 | 2258 | 2665 | 3147 | 3719 | 4397 | 5196 | 6135 | - | - | - | - | - |
| PSL | Tr | 147 | 149 | 152 | 154 | 155 | 169 | 184 | 201 | 219 | 238 | 251 | 262 | 271 | 274 | 272 | 264 |
| | Eco | 153 | 158 | 170 | 181 | 193 | 204 | 216 | 227 | 239 | 251 | 262 | 274 | 286 | 297 | 309 | 321 |
| | HW | 153 | 166 | 178 | 190 | 202 | 214 | 226 | 238 | 250 | 263 | 275 | 287 | 299 | 311 | 323 | 335 |
| | CEA | 118 | 87 | 98 | 110 | 124 | 139 | 156 | 175 | 197 | 221 | 249 | - | - | - | - | - |
| Agri (M+N+P) | UR-Tr | 12,138 | 13,404 | 14,797 | 16,330 | 18,016 | 18,913 | 19,846 | 20,816 | 21,822 | 22,865 | 23,814 | 24,787 | 25,785 | 26,804 | 27,844 | 29,592 |
| | R-Tr | 8,796 | 9,847 | 11,019 | 12,324 | 13,776 | 14,652 | 15,573 | 16,542 | 17,560 | 18,628 | 19,639 | 20690 | 21,780 | 22,909 | 24,076 | 25,884 |
| | UR-Eco | 12020 | 13177 | 14385 | 15644 | 16960 | 18318 | 19737 | 21219 | 22769 | 24388 | 26083 | 27856 | 29712 | 31657 | 33694 | 35854 |
| | R-Eco | 8716 | 9681 | 10712 | 11807 | 12969 | 14191 | 15487 | 16863 | 18322 | 19869 | 21510 | 23251 | 25098 | 27057 | 29135 | 31361 |
| | UR-HW | 11893 | 12873 | 13853 | 14832 | 15812 | 16792 | 17771 | 18751 | 19731 | 20711 | 21690 | 22670 | 23650 | 24629 | 25609 | 26589 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CEA | 10324 | 11350 | 12273 | 13327 | 14478 | 15827 | 17239 | 18742 | 20398 | 22211 | 24196 | - | - | - | - | - |
| Agri (F) | UR-Tr | 1,616 | 1,446 | 1,295 | 1,163 | 1,045 | 961 | 887 | 822 | 763 | 710 | 663 | 619 | 579 | 543 | 509 | 372 |
| | R-Tr | 1,171 | 1,062 | 965 | 877 | 799 | 745 | 696 | 653 | 614 | 579 | 546 | 517 | 489 | 464 | 440 | 325 |
| | UR-Eco | 1255 | 1134 | 1064 | 1020 | 991 | 973 | 964 | 965 | 975 | 990 | 1008 | 1031 | 1056 | 1084 | 1115 | 1148 |
| | R-Eco | 910 | 833 | 793 | 770 | 758 | 754 | 757 | 767 | 784 | 806 | 832 | 860 | 892 | 927 | 964 | 1004 |
| | UR-HW | 1255 | 1134 | 1064 | 1020 | 991 | 973 | 964 | 965 | 975 | 989 | 1008 | 1031 | 1056 | 1084 | 1115 | 1148 |
| | CEA | In EPS, Agri (F) is not given separately | | | | | | | | | | | | | | | |
| Industry (S + M) | Tr | 883 | 922 | 963 | 1,007 | 1,053 | 1,090 | 1,128 | 1,168 | 1,209 | 1,253 | 1,294 | 1,336 | 1,380 | 1,426 | 1,474 | 1,546 |
| | Eco | 897 | 942 | 988 | 1036 | 1086 | 1138 | 1193 | 1250 | 1310 | 1373 | 1439 | 1508 | 1580 | 1656 | 1735 | 1819 |
| | HW | 922 | 963 | 1005 | 1049 | 1094 | 1140 | 1187 | 1234 | 1282 | 1330 | 1380 | 1429 | 1479 | 1530 | 1581 | 1632 |
| | CEA | 895 | 947 | 1001 | 1059 | 1121 | 1186 | 1255 | 1327 | 1404 | 1486 | 1572 | - | - | - | - | - |
| Industry (L) | Tr | 1,286 | 1,401 | 1,531 | 1,678 | 1,843 | 1,919 | 1,999 | 2,081 | 2,167 | 2,257 | 2,348 | 2,442 | 2,540 | 2,643 | 2,749 | 2,879 |
| | Eco | 1459 | 1579 | 1685 | 1788 | 1895 | 2008 | 2131 | 2266 | 2415 | 2581 | 2549 | 2750 | 2977 | 3233 | 3522 | 3848 |
| | HW | 1348 | 1417 | 1463 | 1498 | 1525 | 1547 | 1565 | 1580 | 1592 | 1602 | 1393 | 1394 | 1393 | 1391 | 1388 | 1384 |
| | CEA | 1233 | 1285 | 1339 | 1396 | 1455 | 1516 | 1580 | 1647 | 1716 | 1789 | 1865 | - | - | - | - | - |
| PWW | Tr | 835 | 875 | 917 | 959 | 1,002 | 1,018 | 1,032 | 1,045 | 1,056 | 1,066 | 1,073 | 1,078 | 1,081 | 1,082 | 1,080 | 1,057 |
| | Eco | 858 | 906 | 953 | 999 | 1044 | 1089 | 1132 | 1175 | 1217 | 1258 | 1297 | 1336 | 1373 | 1409 | 1444 | 1476 |
| | HW | 861 | 903 | 947 | 993 | 1039 | 1085 | 1132 | 1179 | 1226 | 1273 | 1321 | 1368 | 1416 | 1463 | 1511 | 1559 |
| | CEA | 824 | 857 | 896 | 936 | 979 | 1021 | 1066 | 1114 | 1164 | 1216 | 1271 | - | - | - | - | - |
| Mixed Load | Tr | 358 | 366 | 373 | 380 | 387 | 392 | 397 | 401 | 406 | 410 | 414 | 418 | 422 | 425 | 429 | 432 |
| | Eco | 370 | 396 | 414 | 439 | 461 | 479 | 487 | 505 | 525 | 544 | 565 | 591 | 609 | 634 | 656 | 675 |
| | HW | 370 | 396 | 414 | 439 | 461 | 479 | 487 | 505 | 525 | 544 | 565 | 591 | 609 | 634 | 656 | 675 |
| | CEA | 357 | 368 | 375 | 383 | 392 | 400 | 409 | 418 | 427 | 436 | 446 | - | - | - | - | - |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total for Utilities | UR-Tr | 22,185 | 23,856 | 25,707 | 27,746 | 29,983 | 31,309 | 32,677 | 34,075 | 35,494 | 36,922 | 38,309 | 39,675 | 41,007 | 42,292 | 43,521 | 45,332 |
| | | | 7.5% | 7.8% | 7.9% | 8.1% | 4.4% | 4.4% | 4.3% | 4.2% | 4.0% | 3.8% | 3.6% | 3.4% | 3.1% | 2.9% | 4.2% |
| | R-Tr | 17,700 | 19,217 | 20904 | 22,771 | 24,831 | 26,191 | 27,605 | 29,065 | 30,562 | 32,084 | 33,600 | 35,114 | 36,576 | 37,990 | 39,369 | 41,279 |
| | | | 8.6% | 8.8% | 8.9% | 9.0% | 5.5% | 5.4% | 5.3% | 5.2% | 5.0% | 4.7% | 4.5% | 4.2% | 3.9% | 3.6% | 4.9% |
| | UR-Eco | 21918 | 23613 | 25418 | 27327 | 29332 | 31401 | 33563 | 35848 | 38253 | 40783 | 43212 | 45995 | 48920 | 52011 | 55271 | 58784 |
| | | | 7.7% | 7.6% | 7.5% | 7.3% | 7.1% | 6.9% | 6.8% | 6.7% | 6.6% | 6.0% | 6.4% | 6.4% | 6.3% | 6.3% | 6.4% |
| | R-Eco | 17570 | 19113 | 20768 | 22537 | 24415 | 26382 | 28461 | 30685 | 33053 | 35572 | 38022 | 40857 | 43820 | 46949 | 50276 | 53882 |
| | | | 8.8% | 8.7% | 8.5% | 8.3% | 8.1% | 7.9% | 7.8% | 7.7% | 7.6% | 6.9% | 7.5% | 7.3% | 7.1% | 7.1% | 7.2% |
| | HW | 17260 | 18552 | 19851 | 21161 | 22472 | 23997 | 25529 | 27094 | 28683 | 30292 | 31723 | 33389 | 35034 | 36686 | 38359 | 39979 |
| | | | 7.5% | 7.0% | 6.6% | 6.2% | 6.8% | 6.4% | 6.1% | 5.9% | 5.6% | 4.7% | 5.3% | 4.9% | 4.7% | 4.6% | 4.2% |
| | CEA | 18204 | 19853 | 21425 | 23236 | 25190 | 27413 | 29813 | 32415 | 35296 | 38499 | 42038 | - | - | - | - | - |
| | | | 9.1% | 7.9% | 8.5% | 8.4% | 8.8% | 8.8% | 8.7% | 8.9% | 9.1% | 9.2% | | | | | |

# 10. Functional strategies for supply side to meet the projected demand

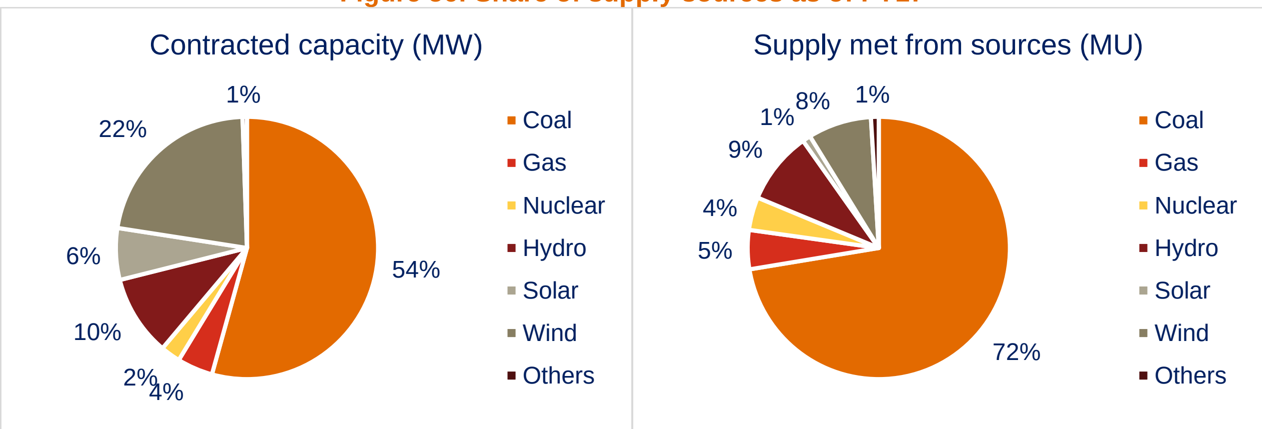
The demand forecasted using alternate approach in the previous section have to be met by ramp up of supply sources or by planned procurement plans. While the Utilities currently have tied up capacities to meet the electricity and peak demand requirement, the same may not be sufficient to meet the future demand.

## 10.1. Existing supply position in Rajasthan

Power sector in Rajasthan has witnessed substantial growth over the past decade due to increase in generation capacity and strengthening of network infrastructure. These initiative have led to an improvement in the overall power supply position of the state. Currently, most connected consumers in the state are being provided with at least 21-22 hours of power supply[24].

In terms of generation capacity, the total power generation installed capacity has grown from 10,160 MW to 18,826 MW during April 2012 to February 2017. The share of the generation in terms of MW and MUs is given in the following:

Figure 56: Share of supply sources as of FY17




The table below provides the breakup of the sources[25] as of February 2017:

Figure 57: Contracted capacity of Rajasthan as of February FY17 (MW)

| Sl. No. | Source | Central sector | State sector | Private | Total |
|---|---|---|---|---|---|
| 1. | Coal | 1015 | 5190 | 3196 | 9401 |
| 2. | Hydro | 742 | 1088 | - | 1829 |
| 3. | Gas | 221 | 604 | - | 825 |
| 4. | Nuclear | 573 | - | - | 573 |
| 5. | Renewable | 775 | 165 | 5258 | 6198 |
| | Total | 3326 | 7047 | 8454 | 18826 |

It can be observed (Figure 1) that nearly 72% of the state demand (in MUs) is met through supply from coal based sources. Even though the state has a high potential for renewables and current installed capacity (FY17)

[24] Rajasthan Power for All document
[25] State Renewable Energy Action Plan

for renewables is about 29% (in MWs), contribution of renewable energy towards meeting electricity requirement of the state is a meagre 9%.

In terms of renewable energy (RE) potential, Rajasthan has solar potential of 142 GW[26] and wind potential of 18.7 GW[27]. The state receives maximum solar radiation intensity in India with very low average rainfall. It also has uncultivated land in abundance and favorable climate, which has led to the state emerging as the leading hub for renewable energy. RE capacity addition in state has grown at yearly rate of 22 %, which is more than national average of 14%[28]. At present, installed RE capacity in the state is around 6.2 GW, of which wind energy capacity is ~70%. However, solar is expected to overtake and lead the renewable energy generation in the state in future.

## 10.2. Options for Supply side evaluation

The following two options of demand side results have been considered for evaluating the supply side option.

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

**Scenario 2:** Demand derived from unrestricted condition – result using econometric method

The following table summarizes the two scenarios which have been considered.

**Table 66: Demand projections for the State (in MUs) considered for supply side evaluation**

| | FY 17 | FY 18 | FY 19 | FY 20 | FY 21 | FY 22 | FY 23 | FY 24 |
|---|---|---|---|---|---|---|---|---|
| Scenario 1 – Restricted (R) | 55383 | 57634 | 61931 | 66609 | 71720 | 75845 | 80265 | 84891 |
| Scenario 2 – Unrestricted (UR) | 65015 | 67673 | 72353 | 77301 | 82636 | 87935 | 93513 | 99186 |

| | FY 25 | FY 26 | FY 27 | FY 28 | FY 29 | FY 30 | FY 31 | FY 32 |
|---|---|---|---|---|---|---|---|---|
| Scenario 1 – Restricted (R) | 89706 | 96011 | 101052 | 106476 | 111024 | 116655 | 122604 | 129568 |
| Scenario 2 – Unrestricted (UR) | 105129 | 112577 | 118613 | 125202 | 131020 | 137930 | 144980 | 152578 |

## 10.3. Assessment of supply capacity required to meet projected demand for the state

Supply side planning is a critical task which leads to meeting of the ever increasing demand of power in any region or state. The planning of capacity to be required in future is crucial as it involves capital investment and also substantial period of time before it can be used for generation. Historically, the capacity has been dependent on coal, but moving ahead, the same may not be the case. Since resources are limited, it is essential that planning is optimized.

Broad assumptions considered for the current evaluation are:

- Assessment of supply side is for the consumer demand at state level to be met by the Distribution utilities.

[26] NISE Estimate
[27] NIWE estimate
[28] State Renewable energy action plan

- All other additional demand from e.g. electric vehicles, latent demand, demand from new housing and infrastructure, metro, industrial corridor etc. has been assumed to be met by state distribution utilities
- Evaluation is based on the assumption that electricity from coal based stations will be least priority i.e. available capacities from other sources will be considered first to meet the demand. The same is in line with the goal of reducing emissions and reducing dependence on coal based sources
- The planning is as per the current policy decision wherein renewable capacity addition has been given impetus by the Government
- Renewable sources – Solar, Wind, Biomass etc. have been considered as must run
- Electricity scheduled from available/ new hydro and gas based stations will be considered before coal based sources
- Generation from rooftop solar plants has been considered and has been given preference in consumption by consumers to meet their own demand first.
- For meeting peak demand, availability from various generation sources have been considered. The peaking availability has been considered as per data given in the final NEP'2018.
- Impact of pricing of power supply has not been considered

## 10.3.1. Electricity requirement of state consumers to be met by sources other than Distribution utilities

### 10.3.1.1. Demand from Open Access, Captive and Railways

Electricity requirement for open access consumers as well as for captive and railways are not met by the distribution utilities. Hence, the projected demand for the three heads have been deducted from the overall state demand. The following table provides the quantum of projected demand to be subtracted from the overall state demand.

**Table 67: Electricity demand from Open Access, Captive and Railways**

| MUs | FY 17 | FY 18 | FY 19 | FY 20 | FY 21 | FY 22 | FY 23 | FY 24 |
|---|---|---|---|---|---|---|---|---|
| OA & captive | 4568 | 2845 | 2987 | 3136 | 3293 | 3458 | 3630 | 3812 |
| Railways | 433 | 451 | 470 | 488 | 507 | 526 | 544 | 563 |

| MUs | FY 25 | FY 26 | FY 27 | FY 28 | FY 29 | FY 30 | FY 31 | FY 32 |
|---|---|---|---|---|---|---|---|---|
| OA & captive | 4003 | 4203 | 4413 | 4633 | 4865 | 5108 | 5364 | 5632 |
| Railways | 581 | 600 | 618 | 637 | 656 | 674 | 693 | 711 |

### 10.3.1.2. Demand to be met from rooftop solar plants

India has set a path to achieve 100 GW installed capacity through grid-connected solar energy, out of which 40 GW is targeted to come through rooftop solar installations by 2022. Till date, efforts have been put in place to develop the rooftop solar photovoltaic sector in India by the government, regulatory commissions and concerned agencies. Basic framework exists in the country and implementation of rooftop solar power plants has been ongoing. However, considering the targets committed with respect to rooftop solar photovoltaic plants, there is still a high gap to be met in terms of installed capacity.

In February 2015, the regulations for net metering for rooftop solar system was issued by the Rajasthan Electricity Regulatory Commission, under which, an individual could use the power generated and the surplus could be fed into the DISCOM's grid. In October'17, Rajasthan Renewable Energy Corporation Ltd (RRECL) came out with tender for 18 MW of grid-connected rooftop solar projects under the RREC's rooftop power generation program for 2017-18. As per India Solar Rooftop map[29], 2017, the total installed rooftop capacity in Rajasthan has been reported at 129 MW. The capacity includes that of industrial, commercial, residential and public sector installations in the state.

The report also highlights that between FY13 to FY17, the all India market for rooftop solar has grown at a CAGR of 66% mainly due to sudden surge in installations and low installed base capacity till FY13-14. However, in terms of installed capacity, ~ 10.8GW is expected at an all India basis by FY21. Target for FY22 for rooftop solar is 40 GW. For Rajasthan, MNRE has given a target of 2300 MW upto FY22.

To project the solar rooftop capacity in the state, the following data/ assumptions have been considered:

- Estimated installed capacity from FY19 to FY22 has been assumed to grow at 66% in line with that of the country. The assumption is also based on the fact that Rajasthan is one of the leading states in solar installation and since the state has been given a target of 2300MW, the period upto FY22 will involve major installations.
- Post FY22, a nominal growth rate of 15% upto FY32 has been considered
- Capacity Utilization Factor of 19% and auxiliary consumption of 0.25%, as per CERC RE Regulations, 2017 and 300 days of solar availability has been considered

The following tables provides the projected installed capacity and electricity to be generated in MUs.

**Table 68: Expected consumer demand to be met by rooftop solar**

| | FY 17 | FY 18 | FY 19 | FY 20 | FY 21 | FY 22 | FY 23 | FY 24 |
|---|---|---|---|---|---|---|---|---|
| MW | 52 | 129 | 214 | 355 | 590 | 980 | 1126 | 1295 |
| MUs | 71 | 176 | 292 | 485 | 805 | 1337 | 1537 | 1768 |

| | FY 25 | FY 26 | FY 27 | FY 28 | FY 29 | FY 30 | FY 31 | FY 32 |
|---|---|---|---|---|---|---|---|---|
| MW | 1490 | 1713 | 1970 | 2266 | 2606 | 2996 | 3446 | 3963 |
| MUs | 2033 | 2338 | 2689 | 3092 | 3556 | 4089 | 4702 | 5408 |

The energy projections (in MU) have been assumed to be used by respective prosumers to meet the self-demand. Hence the same will not be met by Distribution utilities and will be subtracted from the total state demand projections along with Open Access, Captive, and Railways etc. The balance available demand under both the scenarios is the net electricity requirement which will have to be served by the distribution utilities in the state.

### 10.3.2. Electricity requirement to be met by Distribution utilities in the state

The net addressable electricity demand has been arrived as per the following formula:

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)

[29] India Solar Rooptop map, Bridge to India, September 2017

**Table 69: Net addressable electricity demand at consumer end 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 |

| MUs | 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 |

To meet the net addressable demand at the consumer end, the distribution utilities will have to enter into agreements with the available generation sources. The addressable demand required at the state boundary is arrived by grossing up the demand at the consumer end with the overall T&D losses

**Table 70: Net addressable electricity demand at state boundary to be procured by Distribution utilities**

| MUs | FY 17 | FY 18 | FY 19 | FY 20 | FY 21 | FY 22 | FY 23 | FY 24 |
|---|---|---|---|---|---|---|---|---|
| Scenario 1-R | 68286 | 70836 | 76547 | 80950 | 85606 | 88618 | 92314 | 97305 |
| Scenario 2-UR | 81359 | 83965 | 90259 | 94798 | 99530 | 103810 | 108719 | 114968 |

| MUs | FY 25 | FY 26 | FY 27 | FY 28 | FY 29 | FY 30 | FY 31 | FY 32 |
|---|---|---|---|---|---|---|---|---|
| Scenario 1-R | 102462 | 109381 | 114660 | 120322 | 124812 | 130520 | 136494 | 143680 |
| Scenario 2-UR | 121481 | 129770 | 136234 | 143286 | 149292 | 156524 | 163802 | 171741 |

The projection of the balance generation sources is given in the following section.

## 10.3.3. Projection of generation sources to meet projected electricity demand

### 10.3.3.1. Wind power

The installed wind power capacity has grown at a CAGR of 8% during the period FY13 to FY18 as per actual data. As of FY18, the reported wind power installed capacity is 4295 MW. CAGR rate of 8% has been used to project the installed capacity for forecast period.

To arrive at the energy in MUs to be generated, an average CUF of 22% has been considered as per CERC RE Regulations 2017.

### 10.3.3.2. Solar

Installation of solar capacity has witnessed a 5 year CAGR rate of 32% for the period from FY13 to FY18. While the higher rate is because of low base in FY13 and a high growth achieved in the period of FY16-18. The momentum is expected to continue upto FY 22 and hence the same CAGR rate has been considered for projections upto FY22. As per planning estimates[30], the installed capacity is expected to reach 4049 MW by FY22 against a target of 5762 MW.

[30] RRVPNL data accessed

Projected energy which can be met from solar sources has been arrived at by considered a CUF of 19% CERC RE Regulations 2017, 30o days of solar availability and a deration of 0.5%.

### 10.3.3.3. Biomass

Biomass capacity in FY15 in Rajasthan has been reported at 75 MW and as of FY18, the installed capacity is 120MW. In terms of actual electricity procured by the utilities, 279 MU were procured in FY15 and it increased to 293 MU in FY18. Even though there has been an increase in capacity (in MW), the energy procured (in MU) has not increased at the same pace indicating a decrease in net PLF to 32% in FY 18. As per the State Renewable Energy plan, projects of 18.8MW are in pipeline. YoY capacity addition of 20MW has been considered upto FY 22. For period post FY22, a CAGR of 15% (which is the CAGR for period FY15 to FY22) has been assumed to continue for the remaining years. To project the electricity generated, a YoY improvement in PLF of 1% has been taken with assumption that there will be better fuel availability and intake by utilities.

### 10.3.3.4. Hydro

Growth in installed capacity for hydro power stations tied up to Rajasthan has grown at a CAGR of 6% in the period from FY13 to FY17. It has been assumed that the same growth will continue. In addition expected capacity of 230 MW (share of Rajasthan) from Parbati II, Tehri Stage II and Teesta VI hydro power plants have also been added in year FY22[31].

Even though country has hydro power potential, the growth in installed capacity has lagged in comparison to other generation sources. The electricity procured from hydro power stations in the previous five years indicates a net PLF in range of 30-35% and the electricity consumption has increased at a rate of 6.2% upto FY17. For the future projections, the present condition has been extrapolated assuming the same growth rate of 6.2%.

### 10.3.3.5. Nuclear

The capacity linked to Rajasthan as of FY18 is 557 MW and actual electricity procured is 2971 MU. Two new installations (Unit VII and Unit VIII) as part of expansion of existing Rajasthan Atomic Power Project are expected to be commissioned in year FY19 and FY20. The expected electricity to be generated has been derived using the actual average PLF observed for the previous years.

### 10.3.3.6. Gas and Coal

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.

Thermal capacity using coal for Rajasthan was 10226 MW as of FY 17 including share from central stations and for plants managed by Rajasthan Vidyut Utpadan Nigam (RVUN). For the period of FY 13 to FY 17, the CAGR growth in capacity is 14%. For the period from FY19 to FY as per CEA[32] data, the capacity addition for Rajasthan is expected to be 1386 MW in FY19, 66 MW in FY20 and 500MW in FY21. Post the capacity additions, no increase in capacity has been estimated for the period from FY22 to FY27 for the state.

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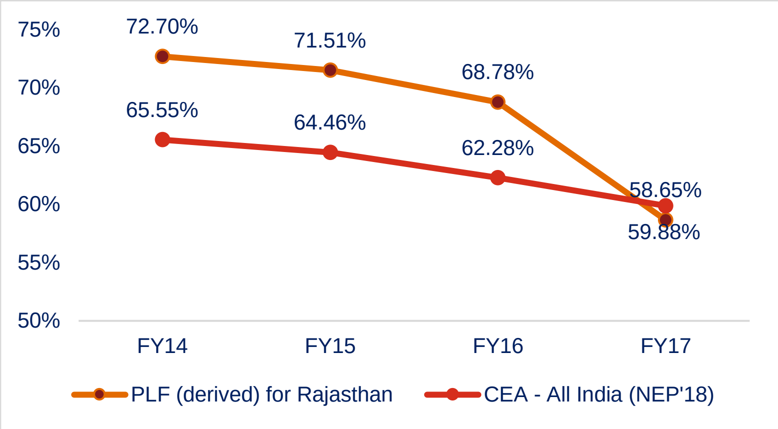
[31] 91st CEA quarterly review, Jan'18

[32] Broad status of thermal power projects in the country, CEA, Dec'17

For the period from FY14 to FY17, based on the actual MW capacity and electricity procured from thermal power stations, a decreasing trend of average PLF has been observed (auxiliary consumption considered as 6.5% as per final NEP'18[33]).

**Figure 58: Trend of PLF for coal based thermal power stations**




The decrease in trend for coal based stations may be attributed to excess capacity and due to subdued demand coupled with higher penetration of renewable energy. As per the final NEP'18, 112% achievement has been achieved against the target set for the period FY 2012-17. Specifically for Rajasthan, where nearly 29% of capacity (in terms of MW) is renewable based, the decrease in PLF in the year from FY16 to FY17 is higher.

For a renewable rich state like Rajasthan, the trend is expected to further decrease in case the momentum of RE addition continues and if the system is able to accommodate the increasing energy generated from RE sources in the state.

Since coal has been given the least priority in planning, the distribution utility in the state has to meet the balance electricity demand of consumer by sourcing electricity generated from the installed coal based capacities. Since the PLF of coal based power plants is already decreasing, the focus in planning will be to utilize the already installed capacity to meet the increasing demand.

Depending on the results of the scenarios used, the requirement of coal based capacity to meet the electricity demand will be different.

### 10.3.3.7. Retirement of old units

The retirement of old units has been considered as per the data provided in the final NEP'2018. At an all India level, it is estimated that by the year 2022, coal capacities of 22,716MW will be retired, 5927 MW of old units and 16789 MW will complete 25 years by 2022 and won't meet the new environmental norms. It has also been estimated that 25,572MW of coal capacities will be retired by the year 2027.

The capacities linked with Rajasthan which will retire by the year 2022 and 2027 were worked out from the data given. The following capacities are expected to be retired for the state of Rajasthan

**Table 71: Expected capacities to be retired by 2022 and 2027**

| Retiring capacities | Upto 2022 | | Upto 2027 | |
|---|---|---|---|---|
| | CEA | Rajasthan | CEA | Rajasthan |
| Retirement due to age | 5927 | 0 | 0 | 0 |
| Due to environmental norms - Coal | 16789 | 850 | 25572 | 1378 |

The expected capacities to be retired by the year 2032 has been projected using the data available for 2022 and 2027 and it is expected that approximately 2234 MW of capacities will be retired for Rajasthan. The projection is based on the assumption that there will not any change in the current norms. The following section provides an estimate of the coal based capacities to be required in order to meet the electricity requirement.

[33] CEA Final NEP'18, Page 142

## Coal capacities required to meet electricity consumption demand

The summary of generation capacities and the electricity to be generated from all the sources is given in the table below:

**Table 72: Summary of projections - generation sources**

| | 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** | | | | | | | | | | | | | | | | |
| MW | 4124 | 4295 | 4650 | 5035 | 5452 | 5592 | 6055 | 6557 | 7100 | 7687 | 8324 | 9013 | 9759 | 10567 | 11442 | 12389 |
| MUs | 7948 | 8360 | 9142 | 9997 | 10934 | 11327 | 12387 | 13548 | 14817 | 16202 | 17720 | 19379 | 21193 | 23177 | 25347 | 27719 |
| **Solar** | | | | | | | | | | | | | | | | |
| MW | 1194 | 1784 | 2358 | 3116 | 3519 | 4049 | 4657 | 5355 | 6159 | 7083 | 8145 | 9367 | 10772 | 12387 | 14246 | 16382 |
| MUs | 1987 | 2999 | 4004 | 5343 | 6095 | 7083 | 8228 | 9556 | 11100 | 12893 | 14975 | 17394 | 20203 | 23464 | 27255 | 31655 |
| **Biomass** | | | | | | | | | | | | | | | | |
| MW | 102 | 120 | 138 | 158 | 178 | 198 | 227 | 261 | 300 | 345 | 396 | 455 | 523 | 600 | 690 | 792 |
| MUs | 250 | 300 | 352 | 411 | 473 | 536 | 627 | 735 | 862 | 1011 | 1184 | 1388 | 1627 | 1904 | 2233 | 2615 |
| **Hydro** | | | | | | | | | | | | | | | | |
| MW | 1931 | 2047 | 2171 | 2302 | 2441 | 2818 | 2988 | 3168 | 3359 | 3561 | 3776 | 4004 | 4245 | 4501 | 4772 | 5060 |
| MUs | 5582 | 5917 | 6276 | 6655 | 7056 | 8146 | 8638 | 9158 | 9710 | 10294 | 10916 | 11575 | 12271 | 13011 | 13795 | 14627 |
| **Nuclear** | | | | | | | | | | | | | | | | |
| MW | 557 | 557 | 1257 | 1957 | 1957 | 1957 | 1957 | 1957 | 1957 | 1957 | 1957 | 1957 | 1957 | 1957 | 1957 | 1957 |
| MUs | 3123 | 3123 | 7047 | 10972 | 10972 | 10972 | 10972 | 10972 | 10972 | 10972 | 10972 | 10972 | 10972 | 10972 | 10972 | 10972 |
| **Gas** | | | | | | | | | | | | | | | | |
| MW | 825 | 825 | 825 | 825 | 825 | 838 | 838 | 838 | 838 | 838 | 838 | 838 | 838 | 838 | 838 | 838 |
| MUs | 1517 | 1517 | 1517 | 1517 | 1517 | 1541 | 1541 | 1541 | 1541 | 1541 | 1541 | 1541 | 1541 | 1541 | 1541 | 1541 |
| **Total** | | | | | | | | | | | | | | | | |
| MW | 8733 | 9628 | 11399 | 13393 | 14372 | 15452 | 16722 | 18136 | 19713 | 21471 | 23436 | 25634 | 28094 | 30850 | 33945 | 37418 |
| MUs | 20407 | 22216 | 28338 | 34895 | 37047 | 39605 | 42393 | 45510 | 49002 | 52913 | 57308 | 62249 | 67807 | 74069 | 81143 | 89129 |

Of the net addressable electricity requirement at state boundary, the MUs to be met by all the generation sources (other than coal) is given as above. The balance electricity requirement is to be met from based thermal power stations.

**Table 73: Balance electricity demand to be met by coal based sources**

| MUs | FY 17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 |
|---|---|---|---|---|---|---|---|---|
| Scenario 1-R | 47879 | 48620 | 48209 | 46055 | 48559 | 49013 | 49921 | 51795 |
| Scenario 2-UR | 60952 | 61749 | 61921 | 59903 | 62483 | 64205 | 66326 | 69458 |

| | FY 25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|
| Scenario 1-R | 53460 | 56468 | 57352 | 58073 | 57005 | 56451 | 55351 | 54551 |
| Scenario 2-UR | 72479 | 76857 | 78926 | 81037 | 81485 | 82455 | 82659 | 82612 |

To derive the coal capacities, a PLF of 70% has been considered for the year FY17 and a YoY progressive increase of 0.75% has been assumed.

**Table 74: Coal capacities required to meet net addressable electricity demand**

| MW | FY 17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 |
|---|---|---|---|---|---|---|---|---|
| Scenario 1-R | 7808 | 7870 | 7745 | 7344 | 7686 | 7700 | 7784 | 8016 |
| Scenario 2-UR | 9940 | 9995 | 9948 | 9552 | 9890 | 10086 | 10342 | 10750 |

| | FY 25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|
| Scenario 1-R | 8212 | 8610 | 8680 | 8723 | 8499 | 8354 | 8130 | 7953 |
| Scenario 2-UR | 11134 | 11719 | 11945 | 12173 | 12149 | 12202 | 12141 | 12044 |

In the results arrived at for both the scenarios, the requirement for meeting peak demand has not been included. The following section looks into the capacity required to meet the peak demand in the state.

### 10.3.4. Projection of generation source to meet projected peak demand

Distribution utilities have to plan for meeting the peak demand which may be incident on the system. The planning for peak demand is critical as otherwise there will be load curtailments or blackouts or the grid system may also fail in extreme circumstances. Hence, the system has to be designed keeping in view the future network requirements and the utilities should plan the generation sources so that peak demand can be met, other than meeting the electricity demand. To arrive at the additional capacity required to meet the peak demand, capacity of only conventional sources have been considered.

## Peaking availability

To arrive at the conventional capacity required, the peaking availabilities of the generating units have been considered as per the data provided in the final NEP'18.

**Table 75: Peaking availability of the generating units**

| Sl. No. | Generation source | Peaking availability |
|---|---|---|
| 1. | Thermal | 85% |
| 2. | Gas | 88% |
| 3. | Hydro | 68% |
| 4. | Nuclear | 87.5% |

## Spinning reserve

In addition, to peaking availability of the generating units, spinning reserve is also considered. As per the final NEP'18, the electricity policy stipulates that in addition to enhancing the overall availability of installed capacity to 85%, a spinning reserve of at least 5% at national level is required to be created to ensure grid security, quality and reliability of power supply. However, in the present scenario, since the planning is being undertaken at the state level, additional 5% for spinning reserve has not been considered.

## PLFs of generation sources considered to meet peak

In order to meet the peak demand, the PLFs for various generation sources have been considered. The PLFs have been considered based on the quantum of peak demand that may be met by the sources. The details of PLF for various generation sources and the quantum of peak demand met by the sources are given in the following table:

### Table 76: PLFs of generation sources considered to meet peak demand

| MW | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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% |
| Gas | 21% | 21% | 21% | 21% | 21% | 21% | 21% | 21% | 21% | 21% | 21% | 21% | 21% | 21% | 21% | 21% |
| Nuclear | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% |

### Table 77: Quantum of peak demand met by various generation sources other than coal

| MW | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| Gas | 173 | 173 | 173 | 173 | 173 | 176 | 176 | 176 | 176 | 176 | 176 | 176 | 176 | 176 | 176 | 176 |
| Nuclear | 446 | 446 | 1006 | 1566 | 1566 | 1566 | 1566 | 1566 | 1566 | 1566 | 1566 | 1566 | 1566 | 1566 | 1566 | 1566 |
| Total | 2669 | 2794 | 3507 | 4231 | 4405 | 4741 | 4953 | 5180 | 5425 | 5689 | 5972 | 6279 | 6610 | 6966 | 7352 | 7768 |

The balance of the net addressable peak demand has to be met by the coal based generation sources.

| MW | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total peak demand for the state** | | | | | | | | | | | | | | | | |
| Scenario 1-R | 12224 | 12222 | 13175 | 13910 | 14688 | 15258 | 15868 | 16701 | 17563 | 18710 | 19601 | 20532 | 21314 | 22297 | 23334 | 24574 |
| Scenario 2-UR | 14349 | 14352 | 15392 | 16143 | 16923 | 17691 | 18487 | 19513 | 20583 | 21938 | 23008 | 24143 | 25152 | 26364 | 27592 | 28939 |
| **Peak demand for Railways, OA, Rooftop etc**. | | | | | | | | | | | | | | | | |
| | 825 | 563 | 606 | 663 | 739 | 852 | 912 | 978 | 1051 | 1131 | 1219 | 1315 | 1423 | 1544 | 1678 | 1828 |
| **Balance net addressable peak demand to be met by the state DISCOMs** | | | | | | | | | | | | | | | | |
| Scenario 1-R | 11399 | 11659 | 12569 | 13247 | 13949 | 14406 | 14956 | 15723 | 16512 | 17579 | 18382 | 19217 | 19891 | 20753 | 21656 | 22746 |
| Scenario 2-UR | 13524 | 13789 | 14786 | 15480 | 16184 | 16839 | 17575 | 18535 | 19532 | 20807 | 21789 | 22828 | 23729 | 24820 | 25914 | 27111 |
| **Balance peak demand to be met by coal based sources (after considering the peak demand met by other generation sources). The coal capacity derived to meet peak demand shall also be used to meet the electricity demand for coal. The derived PLF also given in the following** | | | | | | | | | | | | | | | | |
| 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:** | | | | | | | | | | | | | | | | |
| 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.

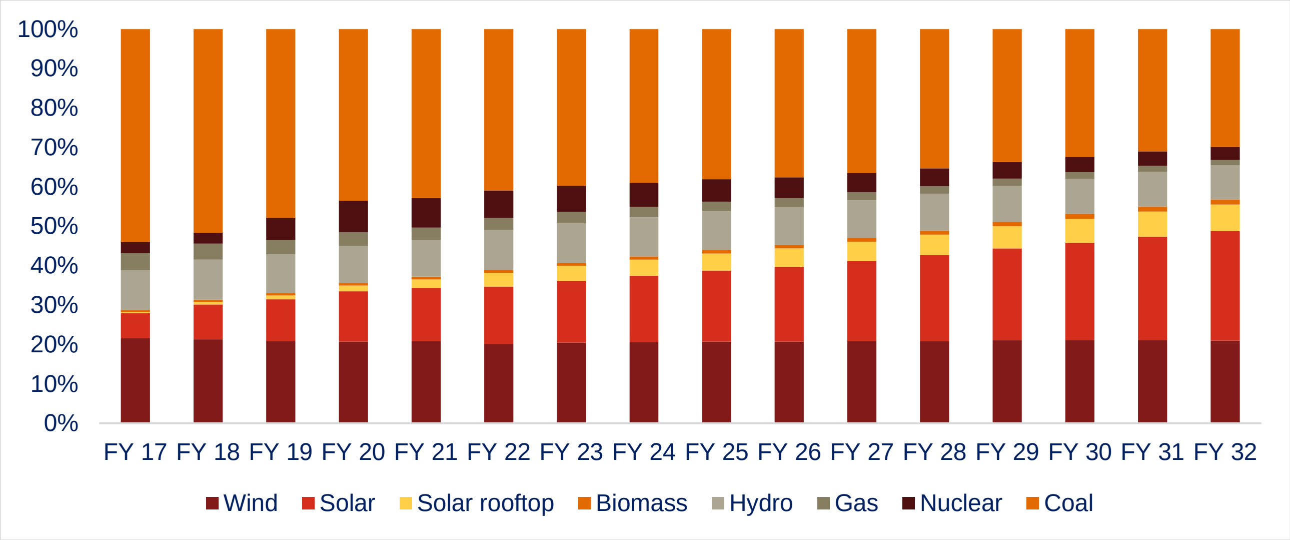
| MW | FY 17 | FY 18 | FY 19 | FY 20 | FY 21 | FY 22 | FY 23 | FY 24 | FY 25 | FY 26 | FY 27 | FY 28 | FY 29 | FY 30 | FY 31 | FY 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tied up capacity | 10226 | 10905 | 12291 | 12357 | 12857 | 12007 | 12007 | 12007 | 12007 | 12007 | 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.

## 10.4. Projected supply position in Rajasthan

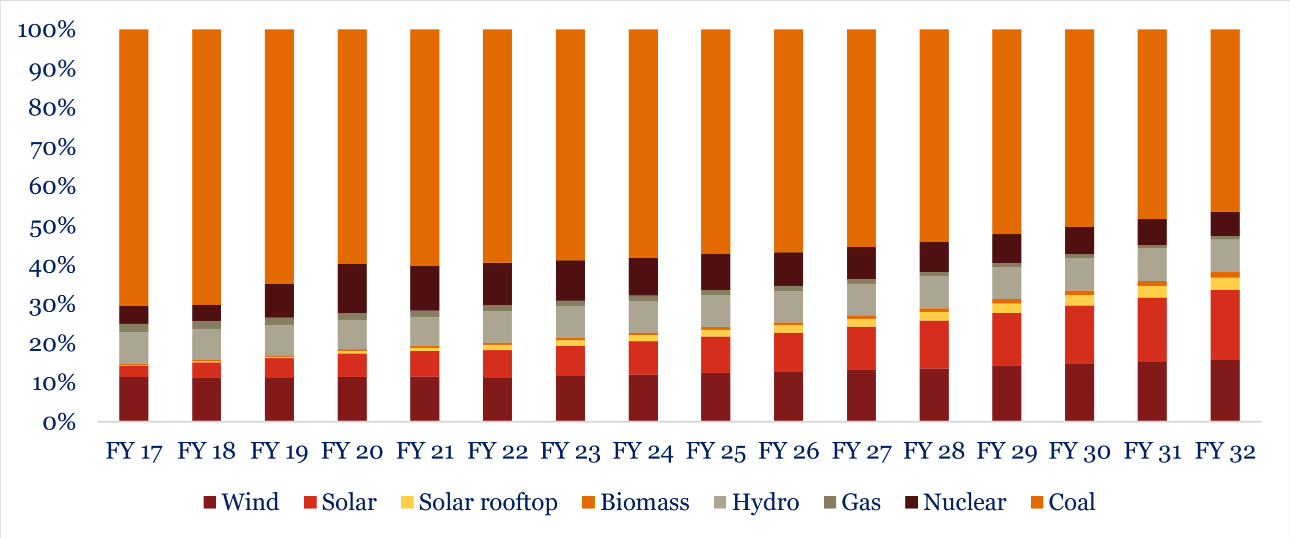
The expected change in installed capacities of generation sources, in case current policies continue, is highlighted in the following figure. From a current scenario wherein installed capacity of coal based power plants constitute 54% and 29% from renewables, by the year FY32 RE may constitute up to 55% and share of coal will be 30% and balance will be met from hydro, gas and nuclear based power stations. Major installed capacity is expected to be from solar in the state.

Figure 59: Scenario 1: Projected supply position (MW) and change in share of generation sources




However, coal will still be the dominant generation source in meeting the electricity demand of consumers. Currently as of FY17, with 54% share of installed capacity, electricity from coal based plants contributes upto 71% of the total requirements and same is expected to decrease up to 46% as of FY32.

Figure 60: Scenario 1: Projected supply position (MUs) and electricity to be supplied by generation sources




For Scenario 2, the share of coal based capacity will decrease to 35% and renewables is expected to constitute 51% by FY32. The higher coal share than scenario 1 is due to higher requirement of coal based stations to meet the peak demand. The share of electricity from generation sources in this scenario will remain the same i.e. 46% from coal and 37% from renewable sources as of FY32.

# 10.5. Functional strategies for managing higher integration of renewables

## 10.5.1. Managing the load curve

The increase in contribution of renewables will also bring with it more variability and uncertainty and the overall systems will require a change in order to effectively integrate the same. Electricity generation from renewables will vary over time in a day and over seasons and it is difficult to predict a specific trend unless short term demand forecasting is undertaken using advanced methods. While generation in solar is expected to mostly follow a fixed pattern in the day time, seasonal variation in it brings uncertainty and variability e.g. in monsoons. Similarly, generation from wind follows seasonal pattern - maximum during monsoon and having day wise variability also. Also generation from solar is maximum during a time when the load requirement is not maximum, hence to use the generated electricity, power from other sources will have to be curtailed which brings in more balancing and ramping requirements. Generation from rooftop also is more localized and may involve bi-directional flow in comparison to conventional sources which requires planning of dispatch and availability of transmission networks.

Hence integration of renewables will bring with it greater challenges which have to be addressed in order to utilize the capacities in an optimized manner. This will require higher management of generation sources at the block levels in a day.

The following section will look into the possible scenarios of how the daily demand can be managed in event of a higher integration of renewables.

The typical demand profile in the state of Rajasthan and the average generation profile of solar and wind is as indicated in the figures below. Hourly generation is average generation profile of wind and solar. To calculate Net Load profile, RE generation is deducted from state's total demand profile.

Figure 61: Typical load curve in a day - Rajasthan

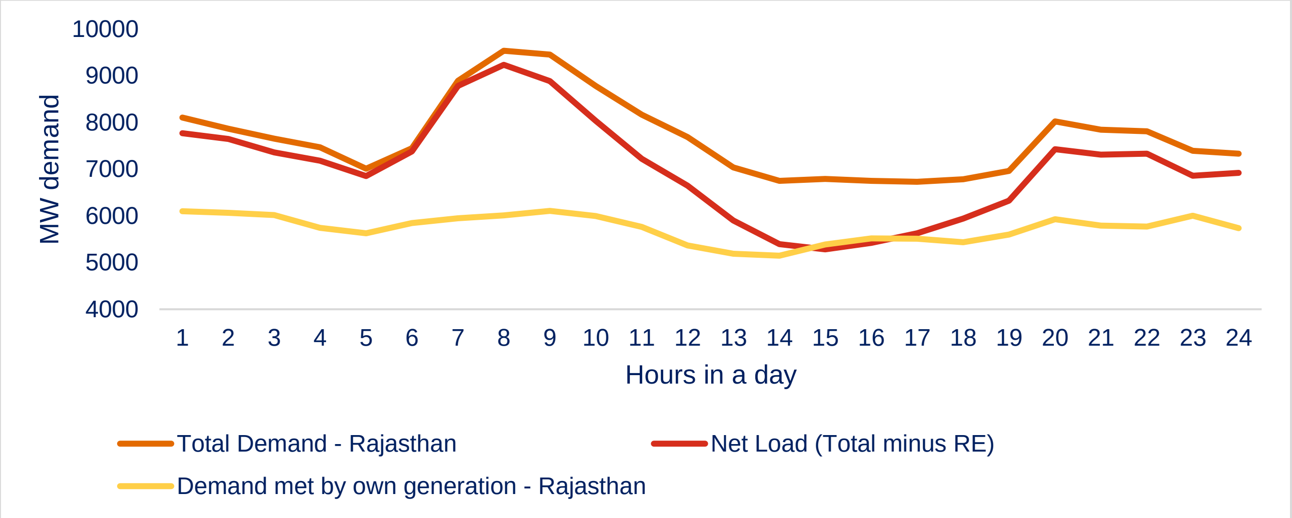
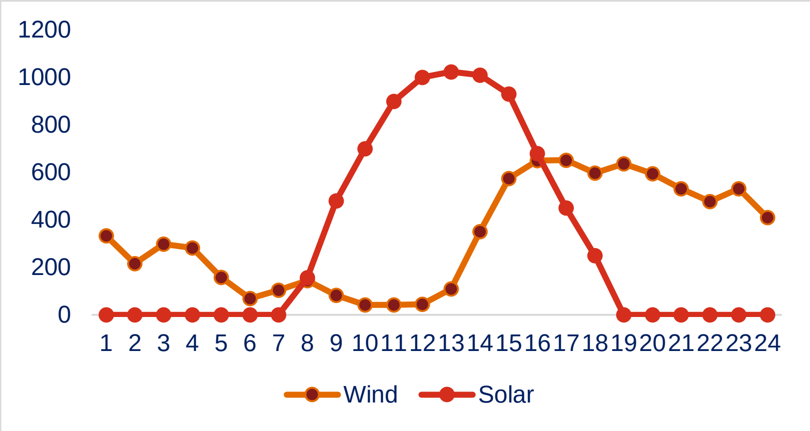


**Figure 62: Average generation profile of wind and solar in a day**

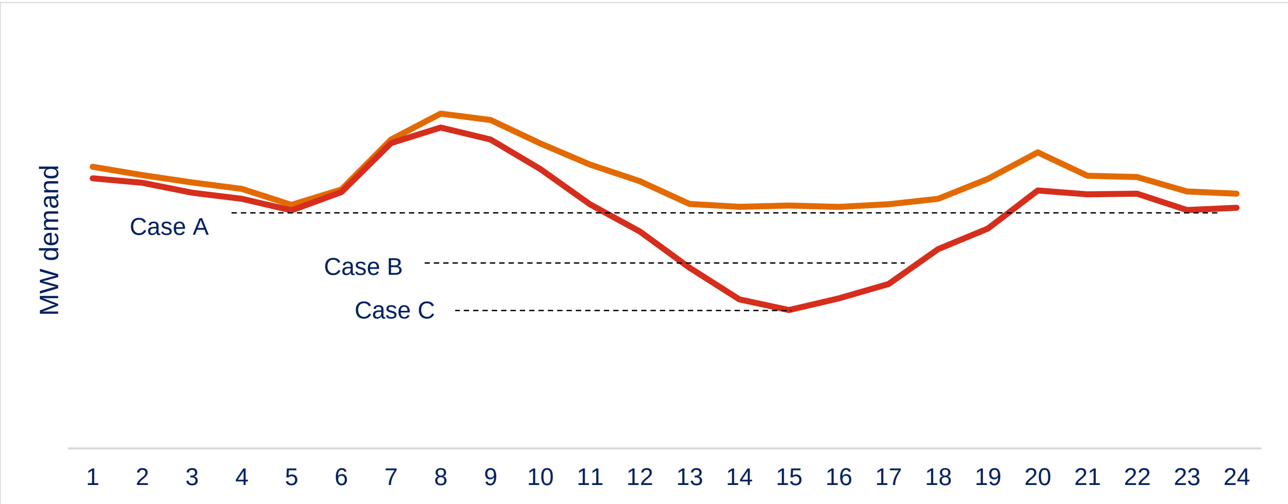



In future years also, the state profile is expected to remain similar. From the profile, it can be seen that there are two peaks in a day which are to be addressed.

The state has implemented a rooster system for supplying to agriculture (more than ~40% of the state demand) and for other services (e.g. public water works). It also follows a loss based supply management in order to better address the peak demand. Hence, the morning peak (8-9 am) is mostly due to demand from domestic consumers, industrial (e.g. start of production) and from commercial segments. The demand decreases and again reaches a peak around 7-9 pm. This variation in the daily load curve requires ramping and balancing requirements. In the present scenario, since share of renewables is lesser (~10% in MU terms), the ramping and balancing requirement is also less. However, with renewable contribution expected to reach ~32% by FY32, the requirements will be much higher.

In order to serve the variation in the load curve, the net demand, post usage of all renewable sources, shall be served by the conventional generation sources.

The following figure provides an illustration of probable curve and net demand curve (higher renewables).




The requirement of ramping and balancing will depend on where the base load (to be met by coal and nuclear sources) is fixed.

## Case A

In the present case, the base load is considered near to the average load of the net demand curve. In this scenario, the complete base load requirements will be met from coal and nuclear sources and other variation will be met from hydro, gas, renewables and other short term market instruments. For a high renewable scenario, most of the renewable generation during the day will have to be either exported or additional storage requirements will have to be developed. In case of storage availability, electricity generated during the day can be stored and utilized to meet the demand of post afternoon and evening.

| Requirements | |
|---|---|
| Ramping | Lower ramping up/ down will be required from coal based stations. Nuclear is more inflexible, hence more suitable for lesser variation. |
| Balancing | Balancing requirement from gas and hydro stations will be less. More in line with lower growth in installations of gas and hydro stations in the country |
| Storage | High storage requirement to utilize electricity from renewables. Otherwise excess renewable generation will have to exported to other states or to be utilized using short term market |

### Case B

Base load is considered as shown in the above illustration and it is planned to utilize higher renewables so as to meet the state demand than case A. This will involve lower quantum of export and facilities required for storage will also be lesser than case A. In case the cost of availing electricity through storage remains high, to meet up for the additional requirement during morning and evening, there will be requirement of flexible generators such as reservoir hydropower plants, gas based generating plants which could respond and adjust to the demand-supply fluctuations in a short time frame.

| Requirements | |
|---|---|
| Ramping | Medium ramping requirement for coal based stations.<br><br>Ramp up – to meet morning peak<br><br>Ramp down – to accommodate renewable generation<br><br>Ramp up – to meet evening peak in case of adequate balancing and storage requirements are not developed. |
| Balancing | Capacity of hydro and availability of gas based stations will have to be improved in this case to meet the increased ramping requirements in shorter time period. |
| Storage | Storage requirement to utilize electricity generated from renewables post evening and to reduce variability. |

### Case C

Base load to accommodate the maximum renewable energy consumption in the state.

| Requirements | |
|---|---|
| Ramping | Higher ramping requirement for coal based stations. This requirement can be developed post analysis of minimum operating conditions of coal based power plants. Investments and retrofitting requirements and costs will have to be factored in. |
| Balancing | Capacity of hydro and availability of gas based stations will have to be improved so that system operators have the flexibility at hand in order to accommodate the renewable generation. |
| Storage | Storage requirement to reduce variability of renewable generation. |

The above cases provides broad level strategies which will have to be undertaken in order to accommodate a high renewable scenario.

As per the Rajasthan State Renewable Energy Action Plan for Rajasthan, 2017, Rajasthan will require around 1.475 GW balancing reserve to meet net load ramp up/down requirement by FY22 incase renewable target for the state is met. The plan also provides the ramping requirements as of year FY22.

Table 78: Ramp up/ down requirement of Rajasthan as of FY22

| Type | Time | Quantum | Reason |
|---|---|---|---|
| Ramp up | 6 to 8 AM | ~ 1000 MW | To meet morning peak |
| Ramp down | 8 AM to 12 noon | ~ 2200 MW | Mainly to accommodate increasing solar generation. In case base load is lowered further, higher ramp down than specified will be required. |
| Ramp up | 4 to 6 PM | ~ 1000 MW | Due to dip in solar generation |
| Ramp up | 6 to 8 PM | ~ 500 MW | To meet evening peak |

Such ramping requirements will have to be addressed by developing flexible capacities in the state. The state is expected to have 830 MW as flexible generation capacity, for grid balancing by year 2019, hence additional 645 MW flexible energy forces will have to be developed to balance the grid with RE capacity addition.

The ramping requirements post FY22 up to FY32 will be far higher and additional market instruments, enhancement of technical capabilities and installation of more storage facilities etc. will have to be brought in to accommodate higher integration of renewables in the state.

### 10.5.2. Safe limit of RE integration without storage

Ministry of Power and USAID have undertaken a detailed study at National and Regional level (Greening the Grid: Pathways to Integrate 175 Gigawatts of Renewable Energy into India's Electric Grid, Volume I: National Study, Volume II: Regional study, June 2017) to evaluate pathways for RE integration by FY22. The study was focused at operational level and was undertaken considering various RE options but mostly the results pertain to the target of 175 GW installed capacity.

As per the study, by FY22, the integration of RE is possible with minimum of 1.4% curtailment. The results also highlighted that new fast-ramping infrastructure for the RE, such as storage, is not necessary to manage the added variability of wind and solar. With the expected transmission and generation capacities, system has the flexibility to manage added variability and uncertainty. The above conclusion is based on an analysis at national level and not restricted to a state. At a state level, a restricted study might not lead to an efficient result as a national level analysis will enable efficient operation and will provide the operator with greater options in flexibly managing the integration.

The study also highlighted that even though ramping requirement will increase by 27% at a national level, the same can be met using the ramping facilities of all generating stations. The minimum curtailment of 1.4% is based on the criteria that thermal plants won't operate below 55% as specified by CERC. In case further lowering is allowed, the curtailment can be brought down to 0.76%. In case battery storage is used, the curtailment of 1.4% can be reduced to 1.1%. However, batteries also have efficiency losses and energy lost in efficiency is expected to be higher than that lost due to curtailment.

**The state specific results for Rajasthan are as given below**:

- Rajasthan can integrate the equivalent of 49% of total generation in the state by 2022 with 5.6% annual wind and solar curtailment. Currently, as of FY17, ~55% of the total requirement is generated from its own generating stations. Out of which ~ 16-18% is currently contributed from RE in the state. Higher RE contribution will lead to change in the generation mix in the state.

- Currently, around 5.6% of wind and solar is curtailed annually and most of these curtailments happen in majorly the same time. The report suggests that to overcome the same, more transmission planning will be required for better consumption and export of RE in the state.
- With respect to the present situation, by FY 22 the net imports to the state will decrease by 22% but exports will increase by 11%.
- The addition of RE in Rajasthan will change the net load, which is the load that is not met by RE and therefore must be met by conventional generation. Increased daytime solar generation causes a dip in net load, which requires Rajasthan to either increase net exports, back down its thermal generators, or curtail RE.
- The PLF of thermal power plants will decrease and generator starts will increase substantially
- Low hydro availability in the state will limit its usage in supporting the net load in the state
- For the state of Rajasthan, the high level of integration is possible by coordinated planning between all the stakeholders involved in intrastate transmissions. Further, investment in transmission infrastructure needs to look into so that RE can be evacuated and flexible reserves of coal and hydro can be used.
- The present study results highlight that additional storage facilities might not be required for integration up to FY22. However, post FY22, storage is expected to play a greater role.

### 10.5.3. Impact of storage in integration

Energy storage is likely to play a greater role in the power sector of the country in the medium and long term (post FY22). The drivers for grid-level energy storage are rapidly decreasing cost of energy storage, and the multitude of benefits provided by energy storage to the grid in general and to grids with high penetration of renewable energy in particular. Some of the benefits can be to optimize generation by reducing intermittency and variability, support in reliable operation of grid, frequency regulation, asset optimization in the form of supporting current balancing assets, reduction in peak demand, acting as reserve and helping in increasing consumption at a consumer level etc.

As of today, battery storage is considered expensive. However, for several storage technologies, it is expected that costs will fall with economies of scale. The prices of various storage technologies have fallen at different rates. For lithium ion batteries, prices have fallen by 73% between 2010 and 2017, as per Bloomberg New Energy Finance (BNEF), driven mostly by demand from electrical vehicles and improving technology, and are likely to fall by another 72% by 2030. BNEF's lithium-ion battery price index shows a fall from $1,000 per kWh in 2010 to $209 per kWh in 2017. International Renewable Energy Agency (IRENA) estimates that the prices of energy storage technologies are likely to fall between 50-66% ranges from the present prices by the year 2030, depending upon technology under consideration.

Taking India as an example, BNEF[34] in a recent study have highlighted that the benchmark levellised cost of electricity (LCOE) from various sources have been declining. BNEF had reported that LCOE for solar PV at $41 per MWh (INR 2.75 per kWh), onshore wind at $39 MWh (INR 2.61 per kWh), coal at $68 per MWh (INR 4.56 per kWh) and combined cycle gas at $93 per MWh (INR 6.23 per kWh). In comparison, in case battery storage is added to wind and solar, the costs for wind-plus-battery and solar-plus-battery systems in India have wide cost ranges, of $34-208 per MWh (INR 2.28-13.94 per kWh) and $47-308 per MWh (INR 3.15–20.64 per kWh) respectively, depending on project characteristics. Unless, the price stabilizes and becomes affordable, the adoption of storage will take some time. Meantime, storage options other than batteries will have to be utilized to meet the requirements. 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.

[34] Tumbling costs for wind, solar, batteries are squeezing fossil fuels, 28 March, 2018

Of the many storage options, hydro pumped storage has been prevalent in India. But for other storage systems like Lithium ion battery based, compressed storage, lead acid based etc., large scale implementation to support grid level balancing will require some time. The investment in other forms of storage technologies will require cost benefit analysis and careful selection of the technology.

As of 2017, as per IRENA, the following storage capacities have been announced, contracted and are under construction in India.

**Table 79: Announced, Contracted and Under Construction Storage Capacity by Technology Type**

| Country | Electrochemical (unspecified) | Li Ion battery | Total (kW) |
|---|---|---|---|
| India | 111000 | 125 | 110125 |

In January 2018[35], AES India and Mitsubishi corporation started construction of India's first utility scale energy storage system of 10 MW capacity that will serve the grid operated by Tata Power Delhi Distribution Limited. The project has been initiated to demonstrate energy storage and to help create a business case for future deployment.

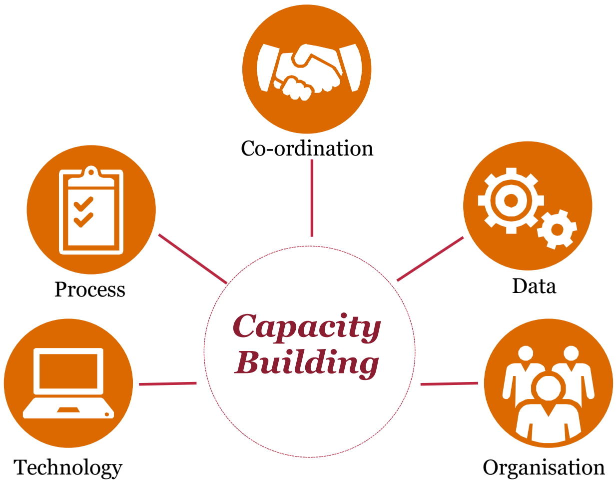
In India, out of the available options, pumped storage has been used actively. At present ~ 4.785 GW capacity is pumped storage capacity, of which ~ 2.45 GW[36] is under operation. For the short term, plans may be developed to restore the available capacity of pumped storage for usage in balancing till other storage technologies are demonstrated and deployed. Even with decreasing costs, the technologies will have to undergo the phases of demonstration and deployment up to certain levels before it achieves maturity. Such installations will also have to be supported by policy and regulatory actions. NITI Aayog in November 2017 released a document highlighting the potential of battery manufacturing in India with possible pathways and possible policy measures and incentives. Though it was more towards supporting the goal of EVs in India by 2030, the development of domestic battery industry would also benefit the usage of batteries in grid balancing. CEA in January 2017 has also brought out a discussion paper highlighting the technologies along with possible operating models and requirements for implementation.

However, until a full-fledged deployment takes place, the balancing requirement till FY22 will have to be met using available sources. Some of the probable solutions which may be looked at:

- Ensuring gas availability will enable substantial installed capacities of gas based plants to support in grid balancing
- Possible retrofitting options to support flexible operation in new power plants may be checked so that by the time the plants are commissioned, it can support higher flexibility
- Strengthening of market instruments – short term, power exchanges, ancillary market etc.
- Capacity building in utilities for undertaking forecasting and planning

[35] India's first grid-scale electricity storage system, January 2018 accessed from The Economic Times
[36] Report on Operational Analysis for Optimization of Hydro Resources & facilitating Renewable Integration in India, June 2017

## 10.5.4. Need for capacity building




The integration of RE will also call for usage of advanced forecasting in order to plan for power procurement and investment. Forecasting will have an increasingly important role in the grid with the increase in proportion of RE. Since solar, wind and hydro energy are dependent on highly variable weather conditions, usage of short term forecasting involving modeling of weather parameters will be crucial going ahead. Hence it is essential that utilities start capturing data and develop capacities.

Currently, most of the utilities do not have the expertise to forecast and plan. Hence, capacity building will have to be undertaken. Broadly, following major heads have been identified across which work has to be done in order:

**Co-ordination**

- Large scale RE integration has to be carried out with co-ordination - intra state and inter state
- States have to develop co-ordination mechanisms and suitable channels to support integration

**Data**

- Data is the key and utilities have to manage data in proper formats so that same can be used continuously by the utilities
- Systems and procedures have to be developed to enable sharing of data

**Process**

- Standard Operating Procedure for undertaking forecasting function has to be developed.
- SoP shall include roles and responsibilities of identified staff, formats for data management, flow of information , methodologies & tools to be deployed, procedure for periodic review and updating of forecasts to maintain relevance

**Technology**

- Technology requirements will have to be developed by utilities and implemented
- Partial / complete grant based funding to be considered by MoP/ State
- Licences and computer systems for advanced analystical software can be made vailable to Utilities

**Organization**

- Dedicated staff for forecasting purpose with number, roles & responsibility as per SoP
- Annual training curriculum for requisite skill building to be developed for conitnuos upgradation
- Capacity building should begin to have readiness to deploy advanced techniques as such integration can be forecasted only useing advanced methods

# 11. Data challenges

The study involved extensive use of data which were accessed from various sources. However, challenges were encountered while accessing and using data. Summary of challenges are highlighted in the following section:

### 1. Historical data from utilities

- The utilities don't have any formal process through which data for the required period could be accessed for conducting the study. There was no designated official responsible for providing data for such a study
- There was resistance 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 common formats. Every utility had its own formats of reporting and data storage. This requires additional time in checking and validation of data and to develop a common format for use in forecasting.

### 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 is not available. Hence suitable assumptions had to be built in for undertaking baseline correction.
- Feeder level data has 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.
- Data not available in any definite format. The formats varied across utilities and across months.
- Since installed feeders are also of varied make and models even in the same utility, the outputs provided were varied. In few feeders, OEM software are 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 were 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.

# 12. Recommendations

The demand forecasting study using the proposed alternate methodology has involved analysis of extensive data pertaining to various parameters and for various consumer categories. The methodology has been proposed considering the gaps which were highlighted in traditional methodologies. Development of the forecast including baseline correction has been based on availability of data which could be accessed. However, challenges still remain and will have to be addressed in case similar studies are undertaken in future.

Based on the present study, following are the recommendations which may be looked into:

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 DISCOMSs 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.

# 13. Annexure

## 13.1. Forecast results – Circle wise

### 13.1.1. Alwar

Table 80: Alwar - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 545 | 629 | 728 | 846 | 987 | 1142 | 1330 | 1558 | 1839 | 2190 | 2632 | 3199 | 3937 | 4916 | 6231 | 7973 |
| Non-Domestic | 190 | 209 | 229 | 251 | 275 | 293 | 312 | 331 | 352 | 373 | 390 | 407 | 424 | 442 | 459 | 477 |
| Public Street Light | 11 | 12 | 13 | 14 | 15 | 15 | 15 | 15 | 14 | 14 | 13 | 13 | 12 | 11 | 9 | 8 |
| Agriculture (M + N + P)) | 1441 | 1540 | 1644 | 1755 | 1871 | 2038 | 2218 | 2412 | 2620 | 2844 | 3085 | 3342 | 3617 | 3911 | 4224 | 4557 |
| Agriculture (F) | 23 | 19 | 16 | 14 | 12 | 9 | 8 | 6 | 5 | 4 | 3 | 2 | 1 | 1 | 1 | 1 |
| Industry (Small + Med) | 193 | 198 | 203 | 208 | 214 | 222 | 231 | 240 | 250 | 259 | 270 | 280 | 291 | 302 | 313 | 325 |
| Industry (L) | 1943 | 2086 | 2239 | 2403 | 2578 | 2660 | 2744 | 2830 | 2919 | 3009 | 3102 | 3197 | 3294 | 3394 | 3495 | 3599 |
| PWW (S + M + L) | 47 | 49 | 52 | 55 | 58 | 60 | 63 | 67 | 70 | 73 | 76 | 80 | 83 | 87 | 91 | 95 |
| Mixed Load | 21 | 22 | 23 | 24 | 25 | 25 | 25 | 25 | 25 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| Total electricity consumption | 4414 | 4764 | 5148 | 5569 | 6034 | 6465 | 6945 | 7484 | 8093 | 8791 | 9595 | 10544 | 11685 | 13087 | 14848 | 17059 |

## Table 81: Alwar - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 591 | 630 | 669 | 708 | 747 | 786 | 825 | 864 | 904 | 943 | 982 | 1021 | 1060 | 1099 | 1138 | 1177 |
| Non-Domestic | 236 | 256 | 276 | 296 | 316 | 336 | 356 | 376 | 396 | 416 | 436 | 456 | 476 | 496 | 516 | 536 |
| Public Street Light | 10 | 10 | 11 | 12 | 12 | 13 | 14 | 15 | 15 | 16 | 17 | 17 | 18 | 19 | 20 | 20 |
| Agriculture (M + N + P)) | 2276 | 2420 | 2565 | 2710 | 2854 | 2999 | 3144 | 3288 | 3433 | 3578 | 3722 | 3867 | 4012 | 4156 | 4301 | 4446 |
| Agriculture (F) | 33 | 35 | 36 | 38 | 39 | 40 | 42 | 43 | 45 | 46 | 47 | 49 | 50 | 51 | 53 | 54 |
| Industry (Small + Med) | 194 | 203 | 212 | 220 | 229 | 238 | 247 | 256 | 265 | 274 | 282 | 291 | 300 | 309 | 318 | 327 |
| Industry (L) | 1829 | 1952 | 2074 | 2197 | 2319 | 2442 | 2564 | 2687 | 2809 | 2932 | 3054 | 3177 | 3299 | 3422 | 3544 | 3666 |
| PWW (S + M + L) | 48 | 51 | 55 | 58 | 62 | 65 | 69 | 72 | 75 | 79 | 82 | 86 | 89 | 93 | 96 | 100 |
| Mixed Load | 38 | 48 | 55 | 61 | 67 | 72 | 76 | 81 | 85 | 89 | 93 | 96 | 100 | 103 | 107 | 110 |
| Total electricity consumption | 5254 | 5604 | 5952 | 6299 | 6645 | 6991 | 7336 | 7681 | 8026 | 8371 | 8715 | 9060 | 9404 | 9748 | 10092 | 10436 |

## Table 82: Alwar - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 506 | 550 | 595 | 641 | 688 | 736 | 785 | 834 | 883 | 932 | 980 | 1027 | 1072 | 1114 | 1152 | 1175 |
| Non-Domestic | 217 | 244 | 273 | 305 | 340 | 376 | 416 | 458 | 504 | 553 | 595 | 640 | 687 | 736 | 789 | 862 |
| Public Street Light | 9 | 10 | 11 | 12 | 12 | 13 | 13 | 14 | 15 | 15 | 16 | 16 | 16 | 17 | 17 | 17 |
| Agriculture (M + N + P)) | 1691 | 1820 | 1954 | 2089 | 2229 | 2369 | 2515 | 2660 | 2808 | 2959 | 3115 | 3271 | 3429 | 3590 | 3753 | 3919 |
| Agriculture (F) | 25 | 26 | 28 | 29 | 30 | 32 | 33 | 35 | 36 | 38 | 40 | 41 | 43 | 44 | 46 | 48 |
| Industry (Small + Med) | 191 | 195 | 198 | 201 | 203 | 204 | 205 | 204 | 202 | 199 | 194 | 187 | 178 | 166 | 151 | 133 |
| Industry (L) | 1820 | 1942 | 2064 | 2186 | 2305 | 2427 | 2549 | 2671 | 2792 | 2911 | 3033 | 3154 | 3276 | 3398 | 3516 | 3637 |
| PWW (S + M + L) | 49 | 54 | 59 | 65 | 72 | 80 | 89 | 100 | 112 | 126 | 142 | 160 | 181 | 205 | 233 | 265 |
| Mixed Load | 37 | 47 | 54 | 60 | 66 | 71 | 75 | 80 | 84 | 87 | 91 | 95 | 98 | 102 | 105 | 108 |
| Total electricity consumption | 4545 | 4888 | 5237 | 5588 | 5945 | 6308 | 6680 | 7055 | 7436 | 7820 | 8205 | 8591 | 8980 | 9373 | 9762 | 10163 |

## 13.1.2. Bharatpur & Dholpur

Table 83: Bharatpur and Dholpur - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 353 | 389 | 428 | 468 | 510 | 541 | 571 | 597 | 619 | 636 | 646 | 647 | 638 | 618 | 587 | 537 |
| Non-Domestic | 81 | 87 | 93 | 100 | 107 | 116 | 126 | 136 | 147 | 159 | 172 | 186 | 200 | 215 | 232 | 249 |
| Public Street Light | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 13 | 13 | 13 | 12 | 11 | 10 | 10 | 8 | 7 |
| Agriculture (M + N + P)) | 399 | 429 | 462 | 497 | 534 | 565 | 597 | 631 | 666 | 702 | 726 | 750 | 774 | 798 | 822 | 845 |
| Agriculture (F) | 18 | 16 | 15 | 13 | 12 | 9 | 8 | 6 | 5 | 4 | 3 | 2 | 1 | 1 | 1 | 0 |
| Industry (Small + Med) | 84 | 87 | 89 | 91 | 93 | 96 | 98 | 101 | 103 | 106 | 108 | 111 | 114 | 116 | 119 | 122 |
| Industry (L) | 168 | 175 | 182 | 189 | 197 | 202 | 207 | 213 | 218 | 223 | 229 | 235 | 240 | 246 | 252 | 258 |
| PWW (S + M + L) | 43 | 46 | 50 | 53 | 57 | 59 | 61 | 63 | 65 | 67 | 69 | 72 | 74 | 76 | 78 | 81 |
| Mixed Load | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 9 |
| Total electricity consumption | 1170 | 1253 | 1342 | 1436 | 1534 | 1612 | 1691 | 1769 | 1846 | 1920 | 1975 | 2022 | 2061 | 2090 | 2108 | 2108 |

## Table 84: Bharatpur and Dholpur - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 414 | 444 | 475 | 505 | 535 | 565 | 596 | 626 | 656 | 686 | 717 | 747 | 777 | 808 | 838 | 868 |
| Non-Domestic | 118 | 127 | 135 | 144 | 152 | 160 | 168 | 176 | 184 | 192 | 200 | 207 | 215 | 222 | 230 | 237 |
| Public Street Light | 17 | 20 | 22 | 24 | 26 | 28 | 30 | 31 | 33 | 34 | 36 | 37 | 38 | 40 | 41 | 42 |
| Agriculture (M + N + P)) | 554 | 593 | 632 | 671 | 711 | 750 | 789 | 829 | 868 | 907 | 947 | 986 | 1025 | 1064 | 1104 | 1143 |
| Agriculture (F) | 25 | 23 | 21 | 19 | 17 | 14 | 12 | 10 | 8 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 92 | 102 | 112 | 122 | 134 | 146 | 159 | 172 | 186 | 201 | 217 | 232 | 249 | 266 | 284 | 302 |
| Industry (L) | 172 | 192 | 212 | 232 | 253 | 273 | 293 | 313 | 333 | 353 | 373 | 393 | 414 | 434 | 454 | 474 |
| PWW (S + M + L) | 48 | 57 | 63 | 68 | 73 | 78 | 82 | 86 | 90 | 93 | 97 | 100 | 103 | 107 | 110 | 113 |
| Mixed Load | 10 | 11 | 12 | 12 | 13 | 14 | 14 | 15 | 16 | 16 | 17 | 17 | 18 | 19 | 19 | 20 |
| Total electricity consumption | 1450 | 1568 | 1684 | 1799 | 1914 | 2028 | 2143 | 2258 | 2374 | 2490 | 2602 | 2721 | 2840 | 2959 | 3079 | 3199 |

**Table 85: Bharatpur and Karauli - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 337 | 367 | 397 | 428 | 460 | 492 | 525 | 558 | 591 | 624 | 656 | 688 | 719 | 747 | 773 | 791 |
| Non-Domestic | 81 | 89 | 97 | 105 | 115 | 124 | 134 | 145 | 156 | 167 | 179 | 192 | 205 | 219 | 233 | 248 |
| Public Street Light | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| Agriculture (M + N + P)) | 396 | 430 | 465 | 498 | 530 | 561 | 590 | 615 | 636 | 652 | 663 | 666 | 660 | 644 | 614 | 570 |
| Agriculture (F) | 18 | 17 | 15 | 14 | 13 | 11 | 10 | 8 | 7 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 87 | 88 | 90 | 90 | 91 | 91 | 91 | 90 | 89 | 87 | 85 | 83 | 80 | 76 | 71 | 66 |
| Industry (L) | 163 | 169 | 176 | 182 | 189 | 196 | 203 | 211 | 218 | 226 | 234 | 242 | 251 | 259 | 268 | 277 |
| PWW (S + M + L) | 43 | 44 | 46 | 48 | 49 | 50 | 50 | 50 | 50 | 49 | 47 | 45 | 41 | 37 | 31 | 24 |
| Mixed Load | 10 | 11 | 12 | 12 | 13 | 13 | 14 | 15 | 15 | 16 | 17 | 17 | 18 | 18 | 19 | 20 |
| Total electricity consumption | 1147 | 1229 | 1311 | 1393 | 1475 | 1556 | 1635 | 1711 | 1782 | 1848 | 1905 | 1957 | 1998 | 2026 | 2037 | 2024 |

## 13.1.3. Dausa and Karauli

Table 86: Dausa and Karuali - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 268 | 301 | 337 | 375 | 415 | 445 | 473 | 500 | 524 | 543 | 556 | 563 | 560 | 548 | 529 | 488 |
| Non-Domestic | 73 | 80 | 88 | 96 | 105 | 117 | 130 | 145 | 161 | 178 | 198 | 219 | 242 | 268 | 296 | 326 |
| Public Street Light | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 6 | 6 | 5 | 4 | 4 |
| Agriculture (M + N + P)) | 695 | 743 | 793 | 846 | 902 | 945 | 988 | 1033 | 1078 | 1125 | 1172 | 1221 | 1270 | 1319 | 1369 | 1420 |
| Agriculture (F) | 35 | 29 | 24 | 20 | 17 | 13 | 10 | 8 | 6 | 5 | 3 | 2 | 2 | 1 | 1 | 1 |
| Industry (Small + Med) | 58 | 62 | 66 | 71 | 76 | 81 | 87 | 93 | 99 | 106 | 113 | 120 | 128 | 137 | 146 | 156 |
| Industry (L) | 57 | 63 | 69 | 75 | 82 | 87 | 93 | 99 | 105 | 112 | 119 | 126 | 134 | 142 | 151 | 160 |
| PWW (S + M + L) | 35 | 36 | 38 | 40 | 42 | 43 | 45 | 46 | 48 | 49 | 51 | 52 | 53 | 55 | 56 | 58 |
| Mixed Load | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Total electricity consumption | 1235 | 1328 | 1429 | 1537 | 1653 | 1745 | 1839 | 1936 | 2033 | 2130 | 2224 | 2315 | 2401 | 2480 | 2558 | 2618 |

### Table 87: Dausa and Karauli - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 282 | 305 | 328 | 351 | 374 | 397 | 419 | 442 | 465 | 488 | 511 | 534 | 557 | 579 | 602 | 625 |
| Non-Domestic | 132 | 167 | 193 | 216 | 237 | 256 | 275 | 292 | 309 | 325 | 341 | 356 | 371 | 386 | 400 | 414 |
| Public Street Light | 12 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 28 | 30 | 33 | 36 | 38 | 41 | 44 | 47 |
| Agriculture (M + N + P)) | 1003 | 1071 | 1139 | 1207 | 1275 | 1343 | 1410 | 1478 | 1546 | 1614 | 1682 | 1750 | 1818 | 1886 | 1954 | 2022 |
| Agriculture (F) | 36 | 21 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 60 | 63 | 66 | 69 | 72 | 75 | 78 | 81 | 84 | 87 | 90 | 93 | 96 | 100 | 103 | 106 |
| Industry (L) | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| PWW (S + M + L) | 41 | 42 | 43 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 54 | 55 | 56 | 57 | 58 |
| Mixed Load | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 23 | 25 | 28 | 31 | 34 | 37 | 41 | 46 | 50 |
| Total electricity consumption | 1628 | 1747 | 1859 | 1975 | 2096 | 2216 | 2334 | 2453 | 2571 | 2688 | 2805 | 2923 | 3040 | 3157 | 3275 | 3393 |

**Table 88: Dausa and Karauli - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 243 | 265 | 289 | 315 | 341 | 369 | 398 | 428 | 460 | 492 | 525 | 558 | 592 | 626 | 658 | 689 |
| Non-Domestic | 67 | 72 | 77 | 82 | 88 | 94 | 100 | 107 | 113 | 120 | 128 | 135 | 143 | 151 | 160 | 168 |
| Public Street Light | 8 | 9 | 11 | 13 | 15 | 17 | 19 | 22 | 25 | 29 | 32 | 36 | 41 | 45 | 50 | 56 |
| Agriculture (M + N + P)) | 802 | 883 | 969 | 1057 | 1149 | 1242 | 1339 | 1435 | 1531 | 1627 | 1724 | 1815 | 1902 | 1983 | 2055 | 2116 |
| Agriculture (F) | 25 | 15 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 62 | 68 | 74 | 81 | 88 | 95 | 104 | 113 | 123 | 133 | 145 | 157 | 171 | 185 | 201 | 218 |
| Industry (L) | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 66 | 67 | 68 | 69 | 70 |
| PWW (S + M + L) | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| Mixed Load | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 25 | 27 | 30 | 33 | 37 | 40 | 45 | 49 |
| Total electricity consumption | 1309 | 1420 | 1536 | 1663 | 1800 | 1941 | 2087 | 2236 | 2388 | 2542 | 2699 | 2853 | 3005 | 3152 | 3292 | 3421 |

## 13.1.4. Jaipur city circle

Table 89: JCC - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 1802 | 1907 | 2010 | 2111 | 2185 | 2246 | 2294 | 2326 | 2338 | 2328 | 2299 | 2240 | 2150 | 2025 | 1868 | 1681 |
| Non-Domestic | 1123 | 1200 | 1281 | 1367 | 1458 | 1542 | 1630 | 1722 | 1817 | 1916 | 2018 | 2124 | 2233 | 2346 | 2461 | 2579 |
| Public Street Light | 87 | 88 | 89 | 90 | 91 | 87 | 82 | 78 | 73 | 67 | 62 | 56 | 50 | 44 | 37 | 31 |
| Agriculture (M + N + P)) | 28 | 29 | 30 | 31 | 31 | 32 | 33 | 34 | 34 | 35 | 36 | 36 | 37 | 37 | 38 | 38 |
| Agriculture (F) | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 276 | 278 | 281 | 284 | 286 | 295 | 303 | 312 | 321 | 330 | 340 | 349 | 359 | 369 | 379 | 390 |
| Industry (L) | 577 | 602 | 629 | 657 | 686 | 697 | 707 | 718 | 729 | 740 | 751 | 762 | 772 | 783 | 794 | 805 |
| PWW (S + M + L) | 124 | 125 | 125 | 126 | 126 | 128 | 129 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 138 |
| Mixed Load | 85 | 87 | 90 | 92 | 94 | 97 | 99 | 102 | 104 | 106 | 109 | 111 | 113 | 115 | 117 | 119 |
| Total electricity consumption | 4103 | 4317 | 4536 | 4758 | 4959 | 5123 | 5278 | 5421 | 5548 | 5656 | 5748 | 5814 | 5850 | 5857 | 5833 | 5781 |

Table 90: JCC - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 1934 | 2040 | 2145 | 2251 | 2357 | 2463 | 2568 | 2674 | 2780 | 2886 | 2991 | 3097 | 3203 | 3309 | 3414 | 3520 |
| Non-Domestic | 1289 | 1342 | 1396 | 1450 | 1504 | 1557 | 1611 | 1665 | 1718 | 1772 | 1826 | 1880 | 1933 | 1987 | 2041 | 2095 |
| Public Street Light | 101 | 106 | 110 | 115 | 119 | 124 | 128 | 132 | 137 | 141 | 146 | 150 | 155 | 159 | 164 | 168 |
| Agriculture (M + N + P)) | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 67 | 68 | 69 | 70 | 70 | 71 | 72 | 72 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 350 | 351 | 355 | 360 | 369 | 380 | 394 | 410 | 427 | 447 | 468 | 490 | 513 | 538 | 563 | 590 |
| Industry (L) | 657 | 721 | 791 | 869 | 955 | 1048 | 1148 | 1255 | 1368 | 1487 | 1612 | 1742 | 1878 | 2019 | 2166 | 2317 |
| PWW (S + M + L) | 126 | 129 | 132 | 134 | 137 | 140 | 143 | 145 | 148 | 151 | 154 | 157 | 159 | 162 | 165 | 168 |
| Mixed Load | 91 | 101 | 112 | 122 | 132 | 142 | 152 | 163 | 173 | 183 | 193 | 204 | 214 | 224 | 234 | 245 |
| Total electricity consumption | 4608 | 4851 | 5102 | 5364 | 5636 | 5918 | 6210 | 6510 | 6819 | 7135 | 7459 | 7789 | 8126 | 8469 | 8819 | 9174 |

### Table 91: JCC - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 1793 | 1917 | 2045 | 2174 | 2284 | 2392 | 2499 | 2605 | 2707 | 2808 | 2901 | 2991 | 3074 | 3147 | 3207 | 3256 |
| Non-Domestic | 1096 | 1187 | 1282 | 1379 | 1481 | 1586 | 1695 | 1807 | 1922 | 2041 | 2166 | 2293 | 2425 | 2560 | 2700 | 2844 |
| Public Street Light | 100 | 104 | 109 | 113 | 117 | 120 | 124 | 128 | 131 | 134 | 137 | 139 | 141 | 142 | 143 | 142 |
| Agriculture (M + N + P)) | 44 | 46 | 47 | 49 | 50 | 51 | 53 | 54 | 55 | 56 | 58 | 59 | 60 | 61 | 62 | 64 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 349 | 350 | 353 | 358 | 366 | 378 | 391 | 407 | 425 | 444 | 464 | 486 | 510 | 534 | 559 | 585 |
| Industry (L) | 654 | 717 | 787 | 865 | 949 | 1041 | 1141 | 1247 | 1359 | 1476 | 1600 | 1730 | 1865 | 2005 | 2148 | 2298 |
| PWW (S + M + L) | 127 | 132 | 138 | 145 | 154 | 164 | 176 | 191 | 207 | 227 | 249 | 275 | 305 | 339 | 378 | 423 |
| Mixed Load | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 | 220 | 230 | 239 |
| Total electricity consumption | 4253 | 4553 | 4871 | 5203 | 5531 | 5873 | 6230 | 6598 | 6978 | 7366 | 7766 | 8174 | 8589 | 9008 | 9426 | 9851 |

## 13.1.5. JPDC

Table 92: JPDC - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 471 | 518 | 567 | 618 | 671 | 724 | 776 | 826 | 871 | 910 | 940 | 957 | 951 | 927 | 885 | 825 |
| Non-Domestic | 224 | 244 | 266 | 290 | 316 | 344 | 374 | 406 | 441 | 479 | 519 | 562 | 607 | 656 | 708 | 764 |
| Public Street Light | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 8 | 8 | 7 | 6 |
| Agriculture (M + N + P)) | 1063 | 1143 | 1229 | 1320 | 1417 | 1500 | 1587 | 1678 | 1772 | 1870 | 1971 | 2076 | 2184 | 2295 | 2410 | 2527 |
| Agriculture (F) | 354 | 314 | 277 | 245 | 216 | 173 | 139 | 111 | 89 | 71 | 49 | 34 | 24 | 17 | 12 | 8 |
| Industry (Small + Med) | 142 | 149 | 157 | 164 | 172 | 176 | 181 | 185 | 189 | 194 | 198 | 203 | 208 | 212 | 217 | 222 |
| Industry (L) | 620 | 658 | 698 | 740 | 784 | 802 | 821 | 840 | 859 | 878 | 898 | 918 | 938 | 958 | 978 | 999 |
| PWW (S + M + L) | 57 | 60 | 64 | 68 | 72 | 77 | 81 | 86 | 91 | 97 | 102 | 108 | 114 | 120 | 126 | 133 |
| Mixed Load | 9 | 10 | 11 | 11 | 12 | 13 | 14 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 23 |
| Total electricity consumption | 2950 | 3105 | 3278 | 3467 | 3671 | 3819 | 3982 | 4156 | 4337 | 4523 | 4703 | 4884 | 5053 | 5214 | 5366 | 5506 |

**Table 93: JPDC - Forecast of electricity consumption using HW method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 461 | 511 | 561 | 610 | 660 | 710 | 760 | 809 | 859 | 909 | 958 | 1008 | 1058 | 1108 | 1157 | 1207 |
| Non-Domestic | 275 | 295 | 314 | 334 | 353 | 373 | 392 | 412 | 431 | 450 | 470 | 489 | 509 | 528 | 548 | 567 |
| Public Street Light | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 | 13 | 13 | 14 | 14 | 15 | 15 | 16 | 16 |
| Agriculture (M + N + P)) | 1781 | 1975 | 2169 | 2363 | 2557 | 2751 | 2945 | 3139 | 3333 | 3527 | 3721 | 3915 | 4109 | 4303 | 4497 | 4691 |
| Agriculture (F) | 252 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 165 | 178 | 194 | 211 | 229 | 249 | 269 | 290 | 312 | 335 | 359 | 383 | 408 | 434 | 460 | 487 |
| Industry (L) | 614 | 664 | 714 | 764 | 814 | 864 | 914 | 964 | 1014 | 1064 | 1114 | 1164 | 1214 | 1264 | 1314 | 1364 |
| PWW (S + M + L) | 58 | 63 | 67 | 72 | 76 | 81 | 85 | 89 | 94 | 98 | 103 | 107 | 112 | 116 | 121 | 125 |
| Mixed Load | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 |
| Total electricity consumption | 3626 | 3747 | 4044 | 4381 | 4720 | 5059 | 5400 | 5741 | 6083 | 6426 | 6770 | 7115 | 7460 | 7806 | 8153 | 8500 |

Table 94: JPDC - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 466 | 519 | 578 | 642 | 712 | 789 | 872 | 963 | 1062 | 1170 | 1285 | 1409 | 1527 | 1650 | 1778 | 1910 |
| Non-Domestic | 243 | 274 | 310 | 349 | 393 | 440 | 493 | 551 | 615 | 685 | 762 | 846 | 937 | 1037 | 1147 | 1266 |
| Public Street Light | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 19 | 20 | 21 | 23 | 24 | 26 |
| Agriculture (M + N + P)) | 1009 | 1115 | 1224 | 1333 | 1444 | 1552 | 1660 | 1761 | 1855 | 1940 | 2014 | 2070 | 2105 | 2114 | 2091 | 2029 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 150 | 159 | 168 | 178 | 187 | 196 | 206 | 216 | 227 | 237 | 247 | 258 | 269 | 281 | 292 | 303 |
| Industry (L) | 611 | 661 | 711 | 761 | 809 | 859 | 909 | 958 | 1008 | 1057 | 1106 | 1156 | 1206 | 1255 | 1304 | 1353 |
| PWW (S + M + L) | 58 | 62 | 66 | 71 | 75 | 79 | 83 | 88 | 92 | 96 | 100 | 104 | 108 | 112 | 116 | 120 |
| Mixed Load | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 |
| Total electricity consumption | 2556 | 2813 | 3083 | 3361 | 3651 | 3951 | 4261 | 4579 | 4903 | 5231 | 5565 | 5896 | 6209 | 6509 | 6790 | 7048 |

## 13.1.6. Jhalawar and Baran

Table 95: Jhalawar and Baran - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 272 | 296 | 320 | 345 | 371 | 409 | 448 | 487 | 526 | 561 | 593 | 617 | 629 | 627 | 612 | 583 |
| Non-Domestic | 73 | 77 | 82 | 87 | 92 | 96 | 100 | 105 | 109 | 114 | 119 | 123 | 128 | 133 | 138 | 143 |
| Public Street Light | 15 | 16 | 16 | 17 | 18 | 17 | 17 | 17 | 16 | 16 | 15 | 14 | 13 | 12 | 10 | 9 |
| Agriculture (M + N + P)) | 856 | 917 | 981 | 1048 | 1120 | 1174 | 1230 | 1288 | 1347 | 1408 | 1470 | 1533 | 1597 | 1662 | 1728 | 1795 |
| Agriculture (F) | 3 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 58 | 60 | 63 | 66 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 |
| Industry (L) | 64 | 68 | 72 | 77 | 82 | 86 | 89 | 93 | 97 | 102 | 106 | 110 | 115 | 120 | 125 | 130 |
| PWW (S + M + L) | 29 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 45 | 47 | 50 | 52 | 55 | 58 | 60 | 63 |
| Mixed Load | 11 | 11 | 12 | 13 | 14 | 16 | 17 | 19 | 21 | 23 | 25 | 27 | 30 | 33 | 36 | 39 |
| Total electricity consumption | 1380 | 1477 | 1580 | 1688 | 1801 | 1906 | 2013 | 2123 | 2234 | 2343 | 2451 | 2553 | 2644 | 2722 | 2789 | 2842 |

Table 96: Jhalawqr and Baran - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 296 | 320 | 344 | 367 | 391 | 415 | 438 | 462 | 486 | 510 | 533 | 557 | 581 | 605 | 628 | 652 |
| Non-Domestic | 72 | 78 | 84 | 90 | 96 | 102 | 108 | 114 | 120 | 126 | 132 | 138 | 144 | 150 | 156 | 162 |
| Public Street Light | 20 | 25 | 30 | 35 | 40 | 45 | 49 | 54 | 59 | 64 | 69 | 74 | 79 | 83 | 88 | 93 |
| Agriculture (M + N + P)) | 1192 | 1279 | 1367 | 1455 | 1543 | 1631 | 1718 | 1806 | 1894 | 1982 | 2070 | 2157 | 2245 | 2333 | 2421 | 2509 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 89 | 89 | 90 | 91 | 93 | 96 | 100 | 104 | 110 | 116 | 123 | 130 | 137 | 145 | 154 | 163 |
| Industry (L) | 75 | 90 | 105 | 120 | 135 | 150 | 165 | 180 | 195 | 210 | 226 | 241 | 256 | 271 | 286 | 301 |
| PWW (S + M + L) | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 39 | 41 | 43 | 45 | 47 | 49 | 51 | 52 | 54 |
| Mixed Load | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 23 | 24 | 25 | 26 | 27 |
| Total electricity consumption | 1781 | 1921 | 2062 | 2204 | 2346 | 2490 | 2634 | 2779 | 2925 | 3071 | 3218 | 3366 | 3514 | 3662 | 3811 | 3960 |

**Table 97: Jhalawar and Baran - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 245 | 262 | 279 | 296 | 311 | 330 | 348 | 366 | 383 | 398 | 408 | 417 | 419 | 418 | 415 | 409 |
| Non-Domestic | 54 | 60 | 65 | 71 | 76 | 82 | 88 | 94 | 100 | 106 | 113 | 119 | 126 | 132 | 139 | 146 |
| Public Street Light | 20 | 25 | 30 | 34 | 39 | 43 | 48 | 52 | 57 | 61 | 65 | 68 | 72 | 75 | 77 | 79 |
| Agriculture (M + N + P)) | 757 | 848 | 944 | 1043 | 1148 | 1255 | 1367 | 1480 | 1595 | 1711 | 1829 | 1944 | 2055 | 2162 | 2261 | 2350 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 88 | 89 | 89 | 91 | 93 | 95 | 99 | 104 | 109 | 115 | 122 | 129 | 136 | 144 | 153 | 162 |
| Industry (L) | 75 | 90 | 105 | 120 | 134 | 149 | 164 | 179 | 194 | 209 | 224 | 239 | 254 | 269 | 283 | 298 |
| PWW (S + M + L) | 26 | 28 | 30 | 32 | 33 | 35 | 37 | 39 | 40 | 42 | 44 | 45 | 47 | 49 | 50 | 52 |
| Mixed Load | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| Total electricity consumption | 1277 | 1413 | 1554 | 1699 | 1849 | 2007 | 2169 | 2333 | 2498 | 2663 | 2825 | 2984 | 3132 | 3273 | 3403 | 3521 |

## 13.1.7. Kota and Bundi

**Table 98: Kota and Bundi - Forecast of electricity consumption using trend method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 699 | 756 | 814 | 874 | 933 | 987 | 1038 | 1083 | 1120 | 1148 | 1153 | 1141 | 1111 | 1063 | 996 | 910 |
| Non-Domestic | 239 | 255 | 273 | 291 | 310 | 339 | 372 | 406 | 444 | 485 | 528 | 576 | 627 | 681 | 740 | 803 |
| Public Street Light | 33 | 34 | 36 | 37 | 38 | 40 | 40 | 41 | 42 | 42 | 41 | 40 | 39 | 37 | 34 | 30 |
| Agriculture (M + N + P)) | 723 | 778 | 837 | 900 | 967 | 1063 | 1167 | 1281 | 1405 | 1539 | 1685 | 1843 | 2013 | 2197 | 2395 | 2608 |
| Agriculture (F) | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 223 | 232 | 241 | 250 | 259 | 269 | 279 | 290 | 300 | 312 | 323 | 335 | 347 | 360 | 372 | 386 |
| Industry (L) | 414 | 429 | 445 | 462 | 480 | 497 | 516 | 535 | 555 | 575 | 596 | 617 | 640 | 662 | 686 | 710 |
| PWW (S + M + L) | 72 | 76 | 81 | 85 | 90 | 92 | 95 | 97 | 99 | 102 | 104 | 106 | 108 | 111 | 113 | 115 |
| Mixed Load | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 30 | 30 | 29 | 29 | 28 | 28 | 27 | 26 |
| Total electricity consumption | 2432 | 2590 | 2756 | 2928 | 3106 | 3317 | 3536 | 3763 | 3995 | 4231 | 4460 | 4687 | 4913 | 5138 | 5363 | 5588 |

Table 99: Kota and Bundi - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 749 | 799 | 849 | 899 | 949 | 999 | 1049 | 1099 | 1149 | 1199 | 1248 | 1298 | 1348 | 1398 | 1448 | 1498 |
| Non-Domestic | 317 | 340 | 362 | 385 | 407 | 430 | 453 | 475 | 498 | 521 | 543 | 566 | 588 | 611 | 634 | 656 |
| Public Street Light | 36 | 38 | 41 | 44 | 47 | 49 | 52 | 55 | 58 | 60 | 63 | 66 | 69 | 71 | 74 | 77 |
| Agriculture (M + N + P)) | 970 | 1050 | 1131 | 1211 | 1292 | 1372 | 1453 | 1534 | 1614 | 1695 | 1775 | 1856 | 1937 | 2017 | 2098 | 2178 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 227 | 239 | 251 | 263 | 275 | 287 | 298 | 310 | 322 | 334 | 346 | 358 | 370 | 381 | 393 | 405 |
| Industry (L) | 397 | 407 | 417 | 427 | 437 | 448 | 458 | 468 | 478 | 488 | 499 | 509 | 519 | 529 | 539 | 550 |
| PWW (S + M + L) | 74 | 81 | 87 | 93 | 99 | 105 | 111 | 118 | 124 | 130 | 136 | 142 | 148 | 155 | 161 | 167 |
| Mixed Load | 26 | 24 | 21 | 19 | 16 | 13 | 11 | 8 | 6 | 5 | 4 | 5 | 6 | 8 | 11 | 13 |
| Total electricity consumption | 2796 | 2978 | 3159 | 3341 | 3522 | 3704 | 3885 | 4066 | 4249 | 4432 | 4615 | 4799 | 4985 | 5171 | 5358 | 5544 |

**Table 100: Kota and Bundi - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 745 | 802 | 863 | 926 | 991 | 1055 | 1121 | 1190 | 1259 | 1331 | 1393 | 1450 | 1506 | 1559 | 1607 | 1658 |
| Non-Domestic | 234 | 262 | 293 | 325 | 359 | 390 | 423 | 458 | 494 | 532 | 573 | 615 | 659 | 706 | 755 | 814 |
| Public Street Light | 37 | 41 | 46 | 51 | 57 | 64 | 71 | 79 | 87 | 97 | 107 | 118 | 130 | 142 | 155 | 168 |
| Agriculture (M + N + P)) | 702 | 770 | 843 | 920 | 1005 | 1073 | 1146 | 1223 | 1303 | 1388 | 1478 | 1573 | 1672 | 1777 | 1887 | 2038 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 234 | 245 | 256 | 268 | 279 | 291 | 303 | 315 | 327 | 340 | 353 | 366 | 379 | 393 | 406 | 421 |
| Industry (L) | 395 | 405 | 415 | 425 | 435 | 445 | 455 | 465 | 475 | 485 | 495 | 505 | 515 | 525 | 535 | 545 |
| PWW (S + M + L) | 74 | 80 | 86 | 92 | 98 | 104 | 109 | 115 | 121 | 127 | 133 | 138 | 144 | 149 | 155 | 160 |
| Mixed Load | 26 | 24 | 21 | 18 | 16 | 13 | 10 | 8 | 6 | 5 | 4 | 5 | 6 | 8 | 10 | 13 |
| Total electricity consumption | 2447 | 2629 | 2822 | 3025 | 3239 | 3434 | 3639 | 3851 | 4073 | 4303 | 4535 | 4769 | 5011 | 5259 | 5510 | 5817 |

## 13.1.8. Sawai Madhopur and Tonk

Table 101: Sawai Madhopur and Tonk - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 350 | 377 | 404 | 432 | 459 | 485 | 509 | 530 | 548 | 561 | 567 | 566 | 556 | 534 | 500 | 456 |
| Non-Domestic | 89 | 96 | 102 | 110 | 117 | 127 | 137 | 148 | 160 | 173 | 186 | 200 | 215 | 232 | 248 | 266 |
| Public Street Light | 8 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 8 | 7 | 7 |
| Agriculture (M + N + P)) | 394 | 438 | 487 | 540 | 598 | 651 | 707 | 767 | 831 | 900 | 974 | 1053 | 1137 | 1227 | 1322 | 1423 |
| Agriculture (F) | 9 | 7 | 6 | 5 | 5 | 4 | 3 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 42 | 43 | 44 | 45 | 47 | 48 | 49 | 51 | 52 |
| Industry (L) | 167 | 178 | 189 | 201 | 214 | 224 | 233 | 244 | 254 | 265 | 277 | 288 | 301 | 313 | 327 | 340 |
| PWW (S + M + L) | 154 | 170 | 188 | 207 | 229 | 237 | 246 | 254 | 263 | 272 | 281 | 290 | 299 | 308 | 317 | 326 |
| Mixed Load | 7 | 8 | 8 | 9 | 9 | 10 | 10 | 10 | 11 | 11 | 11 | 12 | 12 | 12 | 13 | 13 |
| Total electricity consumption | 1213 | 1317 | 1430 | 1551 | 1680 | 1786 | 1895 | 2008 | 2122 | 2237 | 2352 | 2466 | 2578 | 2684 | 2785 | 2883 |

**Table 102: Sawai Madhopur and Tonk - Forecast of electricity consumption using HW method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 323 | 353 | 383 | 413 | 443 | 473 | 503 | 533 | 563 | 593 | 623 | 654 | 684 | 714 | 744 | 774 |
| Non-Domestic | 112 | 117 | 123 | 129 | 134 | 140 | 145 | 151 | 157 | 162 | 168 | 173 | 179 | 185 | 190 | 196 |
| Public Street Light | 9 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 27 |
| Agriculture (M + N + P)) | 572 | 614 | 656 | 698 | 740 | 782 | 824 | 866 | 908 | 950 | 992 | 1034 | 1076 | 1118 | 1160 | 1202 |
| Agriculture (F) | 11 | 8 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 42 | 42 | 43 | 44 | 45 | 45 | 46 | 47 | 47 | 48 | 49 | 50 | 50 | 51 | 52 | 52 |
| Industry (L) | 155 | 157 | 160 | 162 | 164 | 166 | 168 | 171 | 173 | 175 | 177 | 179 | 181 | 184 | 186 | 188 |
| PWW (S + M + L) | 139 | 146 | 154 | 161 | 169 | 177 | 184 | 192 | 199 | 207 | 215 | 222 | 230 | 237 | 245 | 253 |
| Mixed Load | 11 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 37 | 39 | 42 | 45 |
| Total electricity consumption | 1373 | 1462 | 1551 | 1638 | 1728 | 1820 | 1911 | 2002 | 2094 | 2185 | 2277 | 2368 | 2460 | 2552 | 2644 | 2736 |

Table 103: Sawai Madhopur and Tonk - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 352 | 385 | 420 | 455 | 490 | 527 | 564 | 601 | 638 | 675 | 712 | 760 | 787 | 812 | 833 | 851 |
| Non-Domestic | 83 | 90 | 98 | 106 | 115 | 124 | 134 | 144 | 155 | 166 | 178 | 191 | 204 | 218 | 233 | 249 |
| Public Street Light | 9 | 11 | 12 | 14 | 15 | 17 | 19 | 22 | 24 | 27 | 30 | 33 | 37 | 40 | 44 | 48 |
| Agriculture (M + N + P)) | 291 | 331 | 374 | 419 | 466 | 516 | 568 | 622 | 678 | 735 | 795 | 856 | 917 | 979 | 1041 | 1101 |
| Agriculture (F) | 7 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 42 | 42 | 43 | 44 | 44 | 45 | 46 | 46 | 47 | 48 | 48 | 49 | 50 | 51 | 51 | 52 |
| Industry (L) | 154 | 157 | 159 | 161 | 163 | 165 | 167 | 169 | 172 | 174 | 176 | 178 | 180 | 182 | 184 | 187 |
| PWW (S + M + L) | 148 | 169 | 192 | 218 | 247 | 280 | 316 | 356 | 401 | 450 | 506 | 568 | 637 | 713 | 799 | 894 |
| Mixed Load | 11 | 14 | 16 | 18 | 20 | 21 | 23 | 25 | 27 | 29 | 32 | 34 | 36 | 39 | 41 | 44 |
| Total electricity consumption | 1098 | 1205 | 1317 | 1434 | 1561 | 1695 | 1836 | 1985 | 2141 | 2305 | 2477 | 2669 | 2849 | 3035 | 3227 | 3426 |

## 13.1.9. Ajmer

Table 104: Ajmer - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 577 | 621 | 665 | 709 | 753 | 800 | 845 | 885 | 919 | 946 | 971 | 984 | 974 | 944 | 896 | 830 |
| Non-Domestic | 216 | 240 | 267 | 296 | 329 | 345 | 361 | 377 | 394 | 412 | 430 | 448 | 466 | 485 | 504 | 523 |
| Public Street Light | 12 | 13 | 13 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 13 | 12 | 11 | 10 |
| Agriculture (M + N + P)) | 187 | 210 | 236 | 265 | 297 | 328 | 362 | 400 | 441 | 485 | 534 | 587 | 645 | 707 | 775 | 848 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 324 | 339 | 356 | 373 | 392 | 413 | 436 | 459 | 484 | 511 | 538 | 567 | 597 | 629 | 662 | 697 |
| Industry (L) | 531 | 557 | 585 | 614 | 645 | 677 | 710 | 745 | 781 | 819 | 871 | 925 | 983 | 1044 | 1109 | 1177 |
| PWW (S + M + L) | 124 | 132 | 140 | 149 | 158 | 160 | 161 | 163 | 164 | 165 | 165 | 165 | 165 | 164 | 162 | 160 |
| Mixed Load | 37 | 39 | 41 | 43 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 44 | 44 | 44 |
| Total electricity consumption | 2008 | 2151 | 2303 | 2464 | 2632 | 2782 | 2934 | 3089 | 3244 | 3397 | 3568 | 3735 | 3888 | 4030 | 4164 | 4289 |

## Table 105: Ajmer - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 652 | 714 | 762 | 803 | 840 | 874 | 906 | 936 | 965 | 992 | 1018 | 1043 | 1067 | 1091 | 1114 | 1136 |
| Non-Domestic | 267 | 282 | 297 | 312 | 327 | 342 | 356 | 371 | 386 | 401 | 416 | 431 | 446 | 461 | 476 | 491 |
| Public Street Light | 13 | 13 | 14 | 15 | 16 | 17 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 24 | 25 |
| Agriculture (M + N + P)) | 260 | 286 | 311 | 336 | 362 | 387 | 412 | 438 | 463 | 489 | 514 | 539 | 565 | 590 | 615 | 641 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 327 | 344 | 360 | 377 | 394 | 410 | 427 | 443 | 460 | 477 | 493 | 510 | 526 | 543 | 560 | 576 |
| Industry (L) | 551 | 588 | 625 | 662 | 700 | 737 | 774 | 812 | 849 | 886 | 924 | 961 | 998 | 1035 | 1073 | 1110 |
| PWW (S + M + L) | 127 | 136 | 144 | 153 | 162 | 171 | 180 | 189 | 197 | 206 | 215 | 224 | 233 | 242 | 250 | 259 |
| Mixed Load | 34 | 34 | 33 | 32 | 32 | 31 | 31 | 30 | 30 | 29 | 29 | 28 | 28 | 27 | 27 | 26 |
| Total electricity consumption | 2231 | 2396 | 2547 | 2691 | 2832 | 2969 | 3104 | 3238 | 3369 | 3500 | 3629 | 3758 | 3885 | 4012 | 4138 | 4264 |

### Table 106: Ajmer - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 574 | 617 | 662 | 708 | 754 | 801 | 849 | 896 | 944 | 992 | 1038 | 1084 | 1120 | 1149 | 1173 | 1193 |
| Non-Domestic | 187 | 206 | 226 | 248 | 271 | 287 | 303 | 320 | 338 | 356 | 376 | 395 | 416 | 437 | 458 | 492 |
| Public Street Light | 12 | 13 | 14 | 15 | 15 | 16 | 17 | 18 | 18 | 19 | 19 | 20 | 20 | 21 | 21 | 21 |
| Agriculture (M + N + P)) | 199 | 225 | 253 | 283 | 316 | 352 | 391 | 433 | 478 | 526 | 579 | 635 | 695 | 760 | 829 | 903 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 322 | 338 | 354 | 371 | 387 | 404 | 422 | 439 | 458 | 476 | 495 | 514 | 534 | 554 | 573 | 594 |
| Industry (L) | 540 | 571 | 605 | 640 | 676 | 715 | 755 | 798 | 843 | 889 | 938 | 990 | 1045 | 1102 | 1161 | 1225 |
| PWW (S + M + L) | 129 | 141 | 154 | 169 | 185 | 203 | 224 | 247 | 272 | 300 | 332 | 367 | 406 | 450 | 498 | 552 |
| Mixed Load | 34 | 33 | 33 | 32 | 32 | 31 | 31 | 30 | 29 | 29 | 28 | 28 | 27 | 27 | 26 | 26 |
| Total electricity consumption | 1995 | 2144 | 2301 | 2465 | 2636 | 2809 | 2991 | 3181 | 3380 | 3587 | 3805 | 4033 | 4263 | 4498 | 4741 | 5005 |

## 13.1.10. Bhilwara

**Table 107: Bhilwara - Forecast of electricity consumption using trend method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 364 | 391 | 419 | 447 | 474 | 502 | 528 | 551 | 570 | 584 | 597 | 603 | 594 | 574 | 543 | 501 |
| Non-Domestic | 120 | 136 | 154 | 174 | 197 | 206 | 216 | 226 | 237 | 248 | 259 | 270 | 282 | 293 | 305 | 317 |
| Public Street Light | 16 | 18 | 20 | 22 | 25 | 25 | 26 | 26 | 27 | 27 | 26 | 26 | 25 | 23 | 22 | 19 |
| Agriculture (M + N + P)) | 338 | 373 | 410 | 452 | 497 | 536 | 578 | 623 | 670 | 721 | 779 | 841 | 907 | 978 | 1052 | 1132 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 153 | 163 | 175 | 187 | 200 | 210 | 222 | 233 | 246 | 259 | 272 | 287 | 301 | 317 | 333 | 351 |
| Industry (L) | 618 | 641 | 665 | 690 | 715 | 741 | 768 | 796 | 825 | 855 | 908 | 965 | 1025 | 1089 | 1157 | 1228 |
| PWW (S + M + L) | 29 | 29 | 30 | 31 | 31 | 31 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 31 | 30 | 30 |
| Mixed Load | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Total electricity consumption | 1642 | 1756 | 1877 | 2006 | 2143 | 2257 | 2374 | 2492 | 2611 | 2729 | 2878 | 3027 | 3170 | 3310 | 3447 | 3581 |

## Table 108: Bhilwara - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 403 | 426 | 449 | 472 | 496 | 519 | 542 | 565 | 588 | 612 | 635 | 658 | 681 | 704 | 728 | 751 |
| Non-Domestic | 138 | 141 | 145 | 151 | 157 | 163 | 170 | 177 | 185 | 192 | 200 | 208 | 215 | 223 | 231 | 239 |
| Public Street Light | 13 | 14 | 15 | 16 | 18 | 19 | 20 | 21 | 22 | 24 | 25 | 26 | 27 | 28 | 30 | 31 |
| Agriculture (M + N + P)) | 560 | 607 | 653 | 700 | 746 | 792 | 839 | 885 | 932 | 978 | 1025 | 1071 | 1117 | 1164 | 1210 | 1257 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 150 | 157 | 165 | 172 | 179 | 187 | 194 | 201 | 208 | 216 | 223 | 230 | 238 | 245 | 252 | 260 |
| Industry (L) | 627 | 630 | 633 | 636 | 639 | 642 | 645 | 648 | 651 | 655 | 658 | 661 | 664 | 667 | 670 | 673 |
| PWW (S + M + L) | 35 | 36 | 38 | 40 | 41 | 43 | 45 | 47 | 48 | 50 | 52 | 53 | 55 | 57 | 59 | 60 |
| Mixed Load | 6 | 8 | 9 | 9 | 10 | 11 | 12 | 12 | 13 | 14 | 15 | 15 | 16 | 17 | 17 | 18 |
| Total electricity consumption | 1932 | 2019 | 2107 | 2197 | 2286 | 2377 | 2467 | 2558 | 2649 | 2740 | 2831 | 2922 | 3014 | 3105 | 3197 | 3289 |

Table 109: Bhilwara - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 364 | 395 | 426 | 458 | 490 | 524 | 557 | 591 | 625 | 659 | 691 | 724 | 750 | 771 | 789 | 804 |
| Non-Domestic | 97 | 107 | 117 | 128 | 140 | 148 | 157 | 166 | 175 | 185 | 195 | 205 | 216 | 227 | 238 | 255 |
| Public Street Light | 16 | 18 | 21 | 24 | 27 | 31 | 35 | 40 | 46 | 51 | 58 | 65 | 73 | 81 | 90 | 99 |
| Agriculture (M + N + P)) | 326 | 358 | 393 | 431 | 473 | 518 | 567 | 619 | 677 | 739 | 807 | 881 | 962 | 1049 | 1145 | 1250 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 150 | 157 | 165 | 171 | 178 | 183 | 189 | 193 | 197 | 200 | 202 | 204 | 205 | 204 | 203 | 200 |
| Industry (L) | 624 | 627 | 630 | 633 | 635 | 638 | 641 | 644 | 648 | 650 | 653 | 656 | 659 | 662 | 664 | 668 |
| PWW (S + M + L) | 34 | 36 | 38 | 39 | 41 | 42 | 44 | 46 | 47 | 49 | 50 | 52 | 53 | 55 | 56 | 58 |
| Mixed Load | 6 | 8 | 9 | 9 | 10 | 11 | 12 | 12 | 13 | 14 | 14 | 15 | 16 | 16 | 17 | 18 |
| Total electricity consumption | 1617 | 1706 | 1799 | 1895 | 1994 | 2096 | 2202 | 2312 | 2427 | 2546 | 2672 | 2802 | 2933 | 3066 | 3203 | 3352 |

## 13.1.11. Nagaur

Table 110: Nagaur - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 329 | 358 | 388 | 418 | 449 | 480 | 510 | 538 | 562 | 582 | 601 | 613 | 611 | 596 | 570 | 531 |
| Non-Domestic | 101 | 118 | 137 | 159 | 184 | 199 | 214 | 230 | 247 | 265 | 285 | 305 | 327 | 350 | 374 | 399 |
| Public Street Light | 12 | 13 | 15 | 17 | 19 | 20 | 22 | 23 | 23 | 24 | 25 | 25 | 25 | 24 | 23 | 21 |
| Agriculture (M + N + P)) | 966 | 1033 | 1104 | 1178 | 1257 | 1340 | 1427 | 1519 | 1615 | 1715 | 1821 | 1930 | 2045 | 2164 | 2287 | 2414 |
| Agriculture (F) | 236 | 215 | 195 | 177 | 160 | 145 | 131 | 119 | 107 | 97 | 87 | 79 | 71 | 64 | 57 | 51 |
| Industry (Small + Med) | 128 | 134 | 140 | 146 | 153 | 158 | 165 | 171 | 177 | 184 | 191 | 198 | 206 | 213 | 221 | 229 |
| Industry (L) | 125 | 131 | 136 | 143 | 149 | 157 | 165 | 174 | 183 | 193 | 205 | 218 | 232 | 246 | 261 | 277 |
| PWW (S + M + L) | 77 | 82 | 87 | 92 | 97 | 99 | 100 | 101 | 102 | 103 | 103 | 103 | 103 | 103 | 102 | 101 |
| Mixed Load | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Total electricity consumption | 1981 | 2089 | 2207 | 2336 | 2474 | 2604 | 2740 | 2880 | 3024 | 3170 | 3325 | 3479 | 3625 | 3766 | 3901 | 4030 |

## Table 111: Nagaur - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 396 | 463 | 517 | 565 | 611 | 654 | 696 | 736 | 775 | 814 | 851 | 889 | 925 | 961 | 997 | 1032 |
| Non-Domestic | 109 | 117 | 124 | 132 | 139 | 147 | 154 | 162 | 169 | 176 | 184 | 191 | 199 | 206 | 214 | 221 |
| Public Street Light | 16 | 18 | 20 | 21 | 23 | 24 | 25 | 26 | 27 | 29 | 30 | 31 | 32 | 32 | 33 | 34 |
| Agriculture (M + N + P)) | 1406 | 1528 | 1650 | 1772 | 1894 | 2016 | 2138 | 2260 | 2381 | 2503 | 2625 | 2747 | 2869 | 2991 | 3113 | 3235 |
| Agriculture (F) | 251 | 196 | 149 | 111 | 78 | 66 | 74 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 130 | 136 | 142 | 148 | 155 | 161 | 167 | 173 | 179 | 185 | 191 | 197 | 203 | 209 | 215 | 222 |
| Industry (L) | 136 | 153 | 169 | 185 | 202 | 218 | 234 | 251 | 267 | 283 | 299 | 316 | 332 | 348 | 365 | 381 |
| PWW (S + M + L) | 93 | 103 | 111 | 118 | 124 | 130 | 136 | 141 | 146 | 151 | 156 | 160 | 165 | 169 | 173 | 177 |
| Mixed Load | 6 | 7 | 8 | 9 | 10 | 10 | 11 | 12 | 13 | 14 | 15 | 15 | 16 | 17 | 18 | 19 |
| Total electricity consumption | 2544 | 2721 | 2891 | 3062 | 3235 | 3426 | 3634 | 3760 | 3958 | 4155 | 4351 | 4546 | 4741 | 4935 | 5128 | 5321 |

**Table 112: Nagaur - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 426 | 467 | 510 | 557 | 606 | 654 | 704 | 758 | 813 | 871 | 930 | 992 | 1048 | 1099 | 1148 | 1204 |
| Non-Domestic | 102 | 116 | 132 | 148 | 167 | 183 | 200 | 218 | 237 | 257 | 279 | 302 | 326 | 351 | 378 | 413 |
| Public Street Light | 11 | 12 | 13 | 14 | 15 | 17 | 18 | 19 | 20 | 22 | 23 | 24 | 26 | 27 | 28 | 29 |
| Agriculture (M + N + P)) | 951 | 1014 | 1077 | 1138 | 1199 | 1257 | 1313 | 1362 | 1406 | 1442 | 1470 | 1485 | 1486 | 1470 | 1434 | 1373 |
| Agriculture (F) | 180 | 142 | 110 | 83 | 59 | 50 | 57 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 133 | 140 | 147 | 154 | 162 | 169 | 177 | 184 | 192 | 200 | 208 | 217 | 225 | 234 | 243 | 252 |
| Industry (L) | 136 | 153 | 173 | 195 | 220 | 249 | 282 | 320 | 362 | 411 | 467 | 530 | 602 | 685 | 778 | 884 |
| PWW (S + M + L) | 92 | 102 | 110 | 116 | 122 | 128 | 133 | 138 | 143 | 147 | 152 | 156 | 160 | 163 | 167 | 170 |
| Mixed Load | 6 | 7 | 8 | 9 | 9 | 10 | 11 | 12 | 13 | 14 | 14 | 15 | 16 | 17 | 18 | 18 |
| Total electricity consumption | 2038 | 2153 | 2279 | 2415 | 2560 | 2717 | 2895 | 3011 | 3187 | 3364 | 3543 | 3720 | 3888 | 4046 | 4193 | 4344 |

## 13.1.12. Udaipur

Table 113: Udaipur - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 513 | 555 | 597 | 641 | 684 | 727 | 767 | 803 | 835 | 858 | 881 | 893 | 884 | 857 | 813 | 753 |
| Non-Domestic | 251 | 278 | 309 | 342 | 379 | 406 | 434 | 464 | 496 | 529 | 565 | 601 | 640 | 681 | 723 | 767 |
| Public Street Light | 14 | 14 | 15 | 16 | 16 | 16 | 16 | 16 | 15 | 15 | 14 | 13 | 12 | 11 | 10 | 9 |
| Agriculture (M + N + P)) | 205 | 229 | 255 | 283 | 315 | 339 | 365 | 393 | 422 | 453 | 487 | 522 | 558 | 597 | 638 | 681 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 104 | 106 | 107 | 109 | 111 | 113 | 116 | 118 | 121 | 123 | 126 | 129 | 132 | 134 | 137 | 140 |
| Industry (L) | 382 | 399 | 417 | 435 | 454 | 479 | 504 | 531 | 560 | 589 | 627 | 666 | 707 | 751 | 798 | 847 |
| PWW (S + M + L) | 47 | 49 | 51 | 53 | 55 | 57 | 58 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 66 | 66 |
| Mixed Load | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 | 31 | 31 | 32 | 32 |
| Total electricity consumption | 1541 | 1655 | 1777 | 1906 | 2041 | 2164 | 2289 | 2414 | 2539 | 2661 | 2793 | 2918 | 3029 | 3128 | 3217 | 3294 |

## Table 114: Udaipur - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 591 | 639 | 686 | 734 | 782 | 830 | 878 | 926 | 974 | 1022 | 1070 | 1117 | 1165 | 1213 | 1261 | 1309 |
| Non-Domestic | 304 | 322 | 339 | 356 | 373 | 390 | 408 | 425 | 442 | 459 | 477 | 494 | 511 | 528 | 546 | 563 |
| Public Street Light | 18 | 19 | 20 | 21 | 22 | 23 | 25 | 26 | 27 | 28 | 30 | 31 | 32 | 33 | 35 | 36 |
| Agriculture (M + N + P)) | 300 | 316 | 332 | 349 | 365 | 382 | 398 | 414 | 431 | 447 | 524 | 540 | 556 | 573 | 589 | 606 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 106 | 108 | 110 | 112 | 114 | 116 | 119 | 121 | 123 | 125 | 127 | 129 | 132 | 134 | 136 | 138 |
| Industry (L) | 386 | 443 | 501 | 558 | 616 | 673 | 731 | 789 | 846 | 904 | 997 | 1055 | 1112 | 1170 | 1228 | 1285 |
| PWW (S + M + L) | 48 | 51 | 54 | 57 | 61 | 64 | 67 | 70 | 73 | 77 | 80 | 83 | 86 | 90 | 93 | 96 |
| Mixed Load | 26 | 29 | 33 | 36 | 40 | 43 | 47 | 50 | 54 | 57 | 60 | 64 | 67 | 71 | 74 | 78 |
| Total electricity consumption | 1777 | 1926 | 2075 | 2224 | 2373 | 2522 | 2671 | 2820 | 2970 | 3119 | 3364 | 3513 | 3663 | 3812 | 3961 | 4110 |

### Table 115: Udaipur - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 492 | 532 | 573 | 615 | 658 | 701 | 745 | 789 | 833 | 877 | 920 | 962 | 996 | 1023 | 1046 | 1066 |
| Non-Domestic | 239 | 264 | 291 | 319 | 350 | 377 | 405 | 435 | 466 | 499 | 533 | 569 | 606 | 646 | 687 | 737 |
| Public Street Light | 14 | 16 | 17 | 18 | 20 | 21 | 22 | 22 | 23 | 24 | 25 | 26 | 27 | 27 | 28 | 30 |
| Agriculture (M + N + P)) | 204 | 223 | 233 | 252 | 281 | 318 | 329 | 342 | 352 | 371 | 392 | 415 | 438 | 463 | 489 | 517 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 106 | 108 | 111 | 113 | 116 | 119 | 122 | 125 | 129 | 132 | 136 | 140 | 144 | 148 | 152 | 157 |
| Industry (L) | 384 | 441 | 498 | 556 | 612 | 669 | 727 | 784 | 841 | 897 | 990 | 1047 | 1105 | 1162 | 1218 | 1275 |
| PWW (S + M + L) | 47 | 50 | 53 | 57 | 60 | 63 | 66 | 69 | 72 | 75 | 78 | 81 | 84 | 86 | 89 | 92 |
| Mixed Load | 25 | 29 | 32 | 36 | 39 | 42 | 46 | 49 | 53 | 56 | 60 | 63 | 66 | 70 | 73 | 76 |
| Total electricity consumption | 1511 | 1663 | 1809 | 1966 | 2136 | 2310 | 2462 | 2616 | 2769 | 2931 | 3134 | 3302 | 3465 | 3625 | 3782 | 3949 |

## 13.1.13. Rajsamand

Table 116: Rajsamand - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 162 | 173 | 185 | 197 | 209 | 221 | 233 | 243 | 251 | 257 | 263 | 265 | 261 | 252 | 238 | 220 |
| Non-Domestic | 49 | 53 | 57 | 61 | 66 | 71 | 76 | 81 | 86 | 92 | 98 | 104 | 111 | 118 | 125 | 132 |
| Public Street Light | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 15 | 15 | 14 | 14 | 13 | 12 |
| Agriculture (M + N + P)) | 81 | 86 | 92 | 98 | 104 | 111 | 118 | 125 | 133 | 141 | 152 | 164 | 176 | 190 | 204 | 218 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 256 | 276 | 296 | 318 | 342 | 359 | 376 | 395 | 414 | 434 | 455 | 476 | 499 | 523 | 548 | 574 |
| Industry (L) | 267 | 279 | 290 | 302 | 315 | 324 | 333 | 343 | 353 | 363 | 386 | 410 | 436 | 463 | 491 | 522 |
| PWW (S + M + L) | 14 | 15 | 16 | 16 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| Mixed Load | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Total electricity consumption | 837 | 890 | 946 | 1004 | 1065 | 1116 | 1167 | 1220 | 1271 | 1323 | 1390 | 1456 | 1520 | 1581 | 1641 | 1699 |

Table 117: Rajsamand - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 178 | 186 | 194 | 202 | 211 | 219 | 227 | 235 | 244 | 252 | 260 | 268 | 276 | 285 | 293 | 301 |
| Non-Domestic | 62 | 65 | 69 | 72 | 76 | 80 | 83 | 87 | 90 | 94 | 97 | 101 | 105 | 108 | 112 | 115 |
| Public Street Light | 6 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 | 20 | 21 | 23 | 24 |
| Agriculture (M + N + P)) | 117 | 133 | 148 | 164 | 179 | 195 | 210 | 225 | 241 | 256 | 272 | 287 | 302 | 318 | 333 | 349 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 260 | 279 | 298 | 317 | 336 | 355 | 374 | 393 | 412 | 432 | 451 | 470 | 489 | 508 | 527 | 546 |
| Industry (L) | 258 | 258 | 258 | 258 | 258 | 258 | 258 | 258 | 258 | 258 | 258 | 258 | 258 | 258 | 258 | 258 |
| PWW (S + M + L) | 13 | 14 | 14 | 15 | 16 | 16 | 17 | 18 | 18 | 19 | 20 | 20 | 21 | 22 | 22 | 23 |
| Mixed Load | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 9 | 10 |
| Total electricity consumption | 897 | 945 | 994 | 1043 | 1091 | 1140 | 1188 | 1237 | 1286 | 1334 | 1383 | 1431 | 1480 | 1529 | 1577 | 1626 |

**Table 118: Rajsamand - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 158 | 171 | 184 | 198 | 211 | 226 | 240 | 255 | 270 | 286 | 301 | 316 | 329 | 339 | 349 | 357 |
| Non-Domestic | 47 | 52 | 58 | 64 | 71 | 77 | 84 | 91 | 98 | 106 | 114 | 122 | 132 | 141 | 151 | 164 |
| Public Street Light | 7 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 15 | 16 | 17 | 17 | 18 | 18 | 19 | 20 |
| Agriculture (M + N + P)) | 78 | 84 | 91 | 98 | 106 | 117 | 129 | 142 | 155 | 170 | 186 | 203 | 222 | 241 | 263 | 282 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 261 | 284 | 308 | 332 | 357 | 383 | 411 | 439 | 468 | 498 | 529 | 561 | 594 | 629 | 664 | 701 |
| Industry (L) | 257 | 257 | 257 | 257 | 257 | 257 | 257 | 257 | 257 | 256 | 256 | 256 | 256 | 256 | 256 | 256 |
| PWW (S + M + L) | 13 | 14 | 14 | 15 | 15 | 16 | 17 | 17 | 18 | 18 | 19 | 20 | 20 | 21 | 21 | 22 |
| Mixed Load | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 9 | 10 |
| Total electricity consumption | 822 | 872 | 923 | 977 | 1032 | 1092 | 1155 | 1219 | 1287 | 1356 | 1429 | 1504 | 1579 | 1655 | 1733 | 1812 |

## 13.1.14. Chittorgarh and Pratapgarh

Table 119: Chitorgarh and Pratapgarh - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 293 | 316 | 339 | 362 | 385 | 410 | 434 | 456 | 475 | 489 | 504 | 511 | 508 | 493 | 469 | 435 |
| Non-Domestic | 73 | 80 | 88 | 97 | 107 | 114 | 121 | 129 | 137 | 146 | 155 | 164 | 174 | 184 | 194 | 205 |
| Public Street Light | 9 | 10 | 11 | 12 | 13 | 13 | 14 | 15 | 15 | 15 | 16 | 16 | 15 | 15 | 14 | 13 |
| Agriculture (M + N + P)) | 853 | 918 | 988 | 1063 | 1142 | 1226 | 1315 | 1409 | 1509 | 1615 | 1726 | 1843 | 1966 | 2095 | 2231 | 2372 |
| Agriculture (F) | 16 | 10 | 7 | 4 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 45 | 46 | 47 | 48 | 49 | 51 | 53 | 55 | 57 | 58 | 60 | 62 | 64 | 67 | 69 | 71 |
| Industry (L) | 205 | 214 | 223 | 233 | 243 | 256 | 270 | 285 | 300 | 316 | 336 | 357 | 379 | 402 | 427 | 454 |
| PWW (S + M + L) | 34 | 35 | 36 | 37 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 37 | 37 | 36 | 36 |
| Mixed Load | 21 | 21 | 22 | 22 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 22 | 22 |
| Total electricity consumption | 1549 | 1651 | 1761 | 1879 | 2003 | 2134 | 2270 | 2410 | 2554 | 2701 | 2857 | 3014 | 3166 | 3315 | 3462 | 3607 |

Table 120: Chitorgarh and Pratapgarh - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 345 | 384 | 417 | 447 | 476 | 504 | 531 | 558 | 584 | 609 | 635 | 660 | 684 | 709 | 733 | 757 |
| Non-Domestic | 87 | 94 | 101 | 109 | 116 | 123 | 131 | 138 | 145 | 153 | 160 | 167 | 175 | 182 | 189 | 197 |
| Public Street Light | 11 | 12 | 13 | 14 | 15 | 16 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 24 |
| Agriculture (M + N + P)) | 1134 | 1231 | 1329 | 1427 | 1525 | 1622 | 1720 | 1818 | 1916 | 2013 | 2111 | 2209 | 2307 | 2404 | 2502 | 2600 |
| Agriculture (F) | 18 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Industry (L) | 408 | 434 | 450 | 460 | 466 | 471 | 473 | 474 | 474 | 473 | 471 | 469 | 466 | 464 | 461 | 457 |
| PWW (S + M + L) | 35 | 36 | 38 | 39 | 41 | 42 | 44 | 45 | 47 | 48 | 50 | 51 | 53 | 54 | 56 | 57 |
| Mixed Load | 21 | 22 | 23 | 25 | 26 | 27 | 28 | 30 | 31 | 32 | 34 | 35 | 36 | 37 | 39 | 40 |
| Total electricity consumption | 2105 | 2260 | 2417 | 2566 | 2710 | 2851 | 2989 | 3125 | 3259 | 3392 | 3525 | 3656 | 3787 | 3917 | 4047 | 4177 |

## Table 121: Chitorgarh and Pratapgarh - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 290 | 317 | 344 | 372 | 401 | 431 | 461 | 492 | 523 | 555 | 586 | 617 | 643 | 666 | 685 | 703 |
| Non-Domestic | 62 | 69 | 76 | 83 | 91 | 99 | 108 | 117 | 126 | 136 | 146 | 157 | 169 | 181 | 194 | 208 |
| Public Street Light | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agriculture (M + N + P)) | 871 | 966 | 1065 | 1168 | 1275 | 1385 | 1501 | 1620 | 1742 | 1870 | 2004 | 2140 | 2281 | 2427 | 2578 | 2734 |
| Agriculture (F) | 13 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 44 | 46 | 48 | 51 | 53 | 55 | 57 | 59 | 61 | 63 | 65 | 67 | 68 | 70 | 71 | 71 |
| Industry (L) | 406 | 432 | 447 | 458 | 464 | 468 | 470 | 471 | 471 | 469 | 468 | 466 | 463 | 460 | 457 | 454 |
| PWW (S + M + L) | 36 | 39 | 42 | 46 | 50 | 54 | 59 | 65 | 71 | 78 | 86 | 94 | 104 | 114 | 126 | 139 |
| Mixed Load | 21 | 22 | 23 | 24 | 26 | 27 | 28 | 29 | 31 | 32 | 33 | 34 | 35 | 37 | 38 | 39 |
| Total electricity consumption | 1755 | 1891 | 2046 | 2201 | 2359 | 2519 | 2684 | 2852 | 3025 | 3202 | 3387 | 3575 | 3764 | 3955 | 4149 | 4349 |

## 13.1.15. Banswara and Dungarour

Table 122: Banswara and Dungarpur - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 343 | 376 | 411 | 447 | 485 | 524 | 564 | 602 | 637 | 667 | 698 | 720 | 726 | 717 | 694 | 654 |
| Non-Domestic | 62 | 68 | 75 | 83 | 92 | 97 | 103 | 109 | 115 | 122 | 128 | 135 | 143 | 150 | 158 | 166 |
| Public Street Light | 5 | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 5 |
| Agriculture (M + N + P)) | 179 | 196 | 214 | 234 | 256 | 279 | 304 | 331 | 360 | 391 | 420 | 451 | 484 | 519 | 555 | 594 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 33 | 34 | 35 | 36 | 36 | 37 | 38 | 39 | 40 | 41 | 41 | 42 | 43 | 43 | 44 | 45 |
| Industry (L) | 72 | 75 | 78 | 82 | 85 | 90 | 95 | 100 | 105 | 110 | 117 | 125 | 132 | 141 | 149 | 159 |
| PWW (S + M + L) | 14 | 15 | 15 | 16 | 16 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 19 |
| Mixed Load | 5 | 5 | 6 | 6 | 6 | 5 | 4 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 |
| Total electricity consumption | 712 | 774 | 840 | 909 | 982 | 1055 | 1131 | 1207 | 1283 | 1358 | 1432 | 1500 | 1554 | 1596 | 1626 | 1642 |

**Table 123: Banswara and Dungarpur - Forecast of electricity consumption using HW method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 371 | 395 | 418 | 442 | 466 | 490 | 514 | 538 | 562 | 586 | 609 | 633 | 657 | 681 | 705 | 729 |
| Non-Domestic | 79 | 84 | 89 | 94 | 98 | 103 | 108 | 113 | 118 | 123 | 128 | 133 | 138 | 143 | 148 | 153 |
| Public Street Light | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 10 | 11 | 12 | 12 | 13 | 13 | 14 |
| Agriculture (M + N + P)) | 247 | 265 | 283 | 300 | 318 | 336 | 354 | 372 | 390 | 408 | 425 | 443 | 461 | 479 | 497 | 515 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 44 | 45 | 46 | 47 |
| Industry (L) | 95 | 115 | 136 | 156 | 177 | 198 | 218 | 239 | 260 | 280 | 301 | 321 | 342 | 363 | 383 | 404 |
| PWW (S + M + L) | 15 | 16 | 16 | 16 | 17 | 17 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 21 | 21 | 22 |
| Mixed Load | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Total electricity consumption | 850 | 921 | 991 | 1061 | 1131 | 1202 | 1272 | 1342 | 1412 | 1483 | 1553 | 1623 | 1693 | 1764 | 1834 | 1904 |

**Table 124: Banswara and Dungarpur - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 322 | 345 | 369 | 393 | 417 | 440 | 464 | 487 | 510 | 532 | 552 | 572 | 587 | 597 | 605 | 610 |
| Non-Domestic | 63 | 70 | 78 | 86 | 94 | 101 | 109 | 117 | 125 | 133 | 142 | 152 | 162 | 172 | 183 | 197 |
| Public Street Light | 5 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 8 | 9 | 9 | 9 | 10 | 10 | 11 |
| Agriculture (M + N + P)) | 170 | 188 | 207 | 227 | 249 | 272 | 297 | 323 | 351 | 381 | 412 | 446 | 481 | 519 | 559 | 602 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| Industry (L) | 94 | 115 | 135 | 156 | 176 | 197 | 217 | 238 | 258 | 278 | 299 | 319 | 340 | 360 | 380 | 401 |
| PWW (S + M + L) | 15 | 15 | 16 | 16 | 17 | 17 | 17 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 20 | 21 |
| Mixed Load | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Total electricity consumption | 708 | 780 | 854 | 929 | 1006 | 1083 | 1162 | 1242 | 1324 | 1407 | 1492 | 1578 | 1661 | 1742 | 1823 | 1908 |

## 13.1.16. Jhunjhunu

Table 125: Jhunjhunu - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 347 | 376 | 406 | 436 | 467 | 496 | 524 | 550 | 572 | 589 | 605 | 614 | 608 | 590 | 561 | 520 |
| Non-Domestic | 108 | 121 | 135 | 151 | 169 | 188 | 208 | 230 | 255 | 282 | 306 | 332 | 360 | 391 | 423 | 457 |
| Public Street Light | 8 | 9 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 17 | 18 | 18 | 17 | 17 | 16 | 15 |
| Agriculture (M + N + P)) | 468 | 512 | 559 | 610 | 665 | 710 | 758 | 808 | 861 | 916 | 924 | 930 | 937 | 942 | 946 | 949 |
| Agriculture (F) | 391 | 373 | 355 | 338 | 321 | 305 | 290 | 275 | 261 | 247 | 234 | 221 | 209 | 197 | 185 | 174 |
| Industry (Small + Med) | 35 | 38 | 41 | 44 | 48 | 51 | 55 | 60 | 64 | 69 | 73 | 78 | 82 | 87 | 92 | 97 |
| Industry (L) | 61 | 65 | 68 | 72 | 76 | 81 | 87 | 92 | 99 | 105 | 113 | 122 | 131 | 142 | 153 | 165 |
| PWW (S + M + L) | 85 | 92 | 99 | 107 | 115 | 123 | 130 | 138 | 146 | 154 | 156 | 157 | 158 | 159 | 159 | 159 |
| Mixed Load | 8 | 9 | 9 | 10 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Total electricity consumption | 1513 | 1594 | 1684 | 1781 | 1885 | 1980 | 2079 | 2182 | 2287 | 2393 | 2444 | 2488 | 2521 | 2542 | 2554 | 2556 |

Table 126: Jhunjhunu - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 383 | 460 | 471 | 494 | 529 | 574 | 627 | 686 | 752 | 823 | 898 | 978 | 1062 | 1151 | 1243 | 1338 |
| Non-Domestic | 127 | 129 | 138 | 147 | 156 | 165 | 174 | 182 | 191 | 200 | 209 | 218 | 227 | 235 | 244 | 253 |
| Public Street Light | 8 | 9 | 11 | 13 | 14 | 16 | 17 | 19 | 21 | 22 | 24 | 25 | 27 | 29 | 30 | 32 |
| Agriculture (M + N + P)) | 589 | 644 | 669 | 694 | 720 | 745 | 770 | 795 | 820 | 845 | 870 | 895 | 920 | 945 | 970 | 995 |
| Agriculture (F) | 608 | 550 | 548 | 546 | 544 | 542 | 541 | 539 | 538 | 536 | 535 | 533 | 532 | 531 | 530 | 529 |
| Industry (Small + Med) | 32 | 34 | 35 | 37 | 38 | 39 | 41 | 42 | 43 | 45 | 46 | 47 | 49 | 50 | 51 | 53 |
| Industry (L) | 62 | 95 | 109 | 117 | 124 | 129 | 133 | 136 | 138 | 141 | 142 | 144 | 145 | 146 | 146 | 147 |
| PWW (S + M + L) | 80 | 84 | 89 | 93 | 98 | 103 | 108 | 112 | 117 | 122 | 127 | 131 | 136 | 141 | 146 | 150 |
| Mixed Load | 8 | 11 | 13 | 14 | 15 | 16 | 18 | 19 | 20 | 22 | 23 | 24 | 26 | 27 | 28 | 29 |
| Total electricity consumption | 1896 | 2018 | 2083 | 2156 | 2238 | 2329 | 2427 | 2531 | 2640 | 2755 | 2873 | 2996 | 3123 | 3254 | 3388 | 3526 |

Table 127: Jhunjhunu - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 343 | 373 | 406 | 440 | 476 | 515 | 555 | 596 | 640 | 685 | 731 | 778 | 821 | 860 | 896 | 932 |
| Non-Domestic | 118 | 137 | 157 | 180 | 205 | 229 | 255 | 284 | 315 | 349 | 375 | 402 | 432 | 463 | 496 | 551 |
| Public Street Light | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agriculture (M + N + P)) | 387 | 426 | 468 | 513 | 560 | 572 | 583 | 589 | 593 | 593 | 590 | 581 | 566 | 545 | 518 | 549 |
| Agriculture (F) | 436 | 400 | 404 | 407 | 411 | 415 | 419 | 422 | 426 | 430 | 434 | 438 | 441 | 445 | 449 | 453 |
| Industry (Small + Med) | 38 | 40 | 43 | 46 | 49 | 52 | 55 | 59 | 63 | 67 | 71 | 76 | 81 | 86 | 92 | 98 |
| Industry (L) | 61 | 94 | 108 | 117 | 123 | 128 | 132 | 135 | 138 | 140 | 141 | 143 | 144 | 145 | 145 | 145 |
| PWW (S + M + L) | 78 | 83 | 87 | 92 | 96 | 101 | 106 | 111 | 115 | 120 | 125 | 130 | 135 | 140 | 145 | 151 |
| Mixed Load | 8 | 11 | 12 | 14 | 15 | 16 | 18 | 19 | 20 | 21 | 23 | 24 | 25 | 26 | 28 | 29 |
| Total electricity consumption | 1476 | 1565 | 1686 | 1808 | 1935 | 2028 | 2122 | 2216 | 2310 | 2404 | 2490 | 2571 | 2645 | 2711 | 2769 | 2907 |

## 13.1.17. Sikar

**Table 128: Sikar - Forecast of electricity consumption using trend method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 432 | 465 | 497 | 531 | 563 | 600 | 636 | 668 | 696 | 718 | 740 | 752 | 747 | 727 | 692 | 643 |
| Non-Domestic | 131 | 145 | 160 | 177 | 196 | 216 | 239 | 263 | 289 | 318 | 343 | 370 | 398 | 429 | 461 | 495 |
| Public Street Light | 8 | 8 | 9 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 9 | 8 | 7 |
| Agriculture (M + N + P)) | 839 | 913 | 992 | 1077 | 1169 | 1263 | 1363 | 1471 | 1585 | 1707 | 1845 | 1992 | 2149 | 2316 | 2493 | 2681 |
| Agriculture (F) | 273 | 218 | 174 | 139 | 111 | 88 | 70 | 56 | 44 | 35 | 28 | 22 | 18 | 14 | 11 | 9 |
| Industry (Small + Med) | 69 | 72 | 76 | 79 | 83 | 87 | 91 | 95 | 100 | 104 | 109 | 114 | 119 | 125 | 130 | 136 |
| Industry (L) | 165 | 177 | 190 | 204 | 218 | 234 | 251 | 270 | 289 | 310 | 329 | 350 | 372 | 395 | 419 | 445 |
| PWW (S + M + L) | 81 | 86 | 91 | 96 | 101 | 106 | 112 | 117 | 123 | 128 | 134 | 139 | 144 | 149 | 153 | 157 |
| Mixed Load | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 9 | 10 |
| Total electricity consumption | 2002 | 2088 | 2194 | 2318 | 2457 | 2612 | 2779 | 2957 | 3144 | 3338 | 3546 | 3757 | 3965 | 4171 | 4377 | 4582 |

Table 129: Table 92: Sikar - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 465 | 506 | 543 | 580 | 618 | 655 | 692 | 729 | 766 | 803 | 840 | 878 | 915 | 952 | 989 | 1026 |
| Non-Domestic | 153 | 160 | 169 | 178 | 187 | 196 | 206 | 215 | 224 | 233 | 242 | 251 | 260 | 269 | 278 | 287 |
| Public Street Light | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 | 31 | 34 | 38 | 41 | 44 | 47 | 50 | 53 |
| Agriculture (M + N + P)) | 1102 | 1368 | 1506 | 1643 | 1780 | 1918 | 2055 | 2192 | 2330 | 2467 | 2604 | 2742 | 2879 | 3016 | 3154 | 3291 |
| Agriculture (F) | 456 | 285 | 98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 67 | 70 | 74 | 78 | 82 | 86 | 90 | 93 | 97 | 101 | 105 | 109 | 113 | 116 | 120 | 124 |
| Industry (L) | 151 | 128 | 171 | 203 | 231 | 256 | 279 | 300 | 321 | 341 | 360 | 378 | 396 | 414 | 432 | 449 |
| PWW (S + M + L) | 77 | 82 | 87 | 93 | 98 | 104 | 109 | 115 | 120 | 126 | 131 | 137 | 142 | 148 | 153 | 158 |
| Mixed Load | 5 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 9 |
| Total electricity consumption | 2482 | 2616 | 2667 | 2798 | 3022 | 3243 | 3462 | 3679 | 3896 | 4112 | 4327 | 4542 | 4757 | 4970 | 5184 | 5397 |

## Table 130: Sikar - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 418 | 453 | 492 | 531 | 573 | 617 | 663 | 711 | 761 | 813 | 865 | 918 | 966 | 1009 | 1050 | 1088 |
| Non-Domestic | 147 | 166 | 188 | 210 | 235 | 261 | 289 | 319 | 352 | 387 | 417 | 447 | 480 | 515 | 552 | 605 |
| Public Street Light | 8 | 9 | 10 | 11 | 12 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 28 | 31 | 33 | 36 |
| Agriculture (M + N + P)) | 768 | 818 | 873 | 929 | 990 | 1054 | 1123 | 1195 | 1271 | 1352 | 1439 | 1530 | 1627 | 1729 | 1837 | 1952 |
| Agriculture (F) | 327 | 207 | 72 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 70 | 75 | 80 | 85 | 91 | 97 | 103 | 110 | 117 | 124 | 132 | 141 | 149 | 159 | 168 | 178 |
| Industry (L) | 150 | 128 | 170 | 202 | 230 | 254 | 277 | 298 | 319 | 338 | 357 | 376 | 394 | 411 | 428 | 445 |
| PWW (S + M + L) | 82 | 88 | 96 | 104 | 112 | 121 | 131 | 143 | 154 | 167 | 182 | 197 | 214 | 232 | 253 | 275 |
| Mixed Load | 5 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 |
| Total electricity consumption | 1974 | 1951 | 1985 | 2079 | 2249 | 2425 | 2609 | 2800 | 3000 | 3209 | 3422 | 3642 | 3866 | 4094 | 4330 | 4589 |

## 13.1.18. Jodhpur City circle

Table 131: JCC - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 443 | 466 | 488 | 510 | 530 | 555 | 578 | 598 | 612 | 622 | 629 | 629 | 614 | 587 | 550 | 502 |
| Non-Domestic | 250 | 270 | 291 | 313 | 336 | 367 | 400 | 435 | 474 | 515 | 562 | 613 | 668 | 728 | 792 | 860 |
| Public Street Light | 90 | 90 | 91 | 91 | 91 | 105 | 122 | 140 | 160 | 181 | 197 | 212 | 224 | 232 | 235 | 230 |
| Agriculture (M + N + P)) | 13 | 15 | 17 | 19 | 22 | 24 | 26 | 28 | 30 | 33 | 35 | 38 | 40 | 43 | 46 | 49 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 144 | 146 | 148 | 150 | 152 | 158 | 165 | 171 | 178 | 185 | 187 | 189 | 192 | 194 | 197 | 199 |
| Industry (L) | 286 | 296 | 306 | 316 | 326 | 340 | 354 | 368 | 383 | 399 | 412 | 425 | 438 | 452 | 466 | 480 |
| PWW (S + M + L) | 36 | 37 | 38 | 38 | 39 | 39 | 39 | 39 | 39 | 39 | 38 | 37 | 36 | 35 | 34 | 32 |
| Mixed Load | 96 | 98 | 100 | 101 | 103 | 105 | 106 | 108 | 109 | 111 | 112 | 113 | 114 | 115 | 116 | 117 |
| Total electricity consumption | 1359 | 1418 | 1478 | 1538 | 1599 | 1693 | 1789 | 1887 | 1986 | 2083 | 2172 | 2256 | 2327 | 2386 | 2434 | 2470 |

### Table 132: JCC - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 583 | 613 | 643 | 672 | 702 | 732 | 762 | 792 | 821 | 851 | 881 | 911 | 941 | 971 | 1000 | 1030 |
| Non-Domestic | 307 | 327 | 346 | 365 | 384 | 403 | 422 | 441 | 460 | 479 | 498 | 517 | 536 | 556 | 575 | 594 |
| Public Street Light | 78 | 86 | 93 | 101 | 108 | 116 | 123 | 131 | 138 | 146 | 154 | 161 | 169 | 176 | 184 | 191 |
| Agriculture (M + N + P)) | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 157 | 164 | 170 | 177 | 184 | 191 | 198 | 205 | 212 | 219 | 225 | 232 | 239 | 246 | 253 | 260 |
| Industry (L) | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 |
| PWW (S + M + L) | 36 | 37 | 38 | 39 | 40 | 40 | 41 | 42 | 43 | 44 | 45 | 45 | 46 | 47 | 48 | 49 |
| Mixed Load | 98 | 105 | 111 | 117 | 124 | 130 | 136 | 143 | 149 | 156 | 162 | 168 | 175 | 181 | 187 | 194 |
| Total electricity consumption | 1578 | 1649 | 1720 | 1791 | 1861 | 1932 | 2003 | 2074 | 2144 | 2215 | 2286 | 2357 | 2428 | 2498 | 2569 | 2640 |

**Table 133: JCC - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 487 | 518 | 551 | 586 | 622 | 660 | 699 | 740 | 782 | 825 | 869 | 914 | 952 | 986 | 1017 | 1046 |
| Non-Domestic | 259 | 286 | 316 | 346 | 379 | 417 | 458 | 501 | 546 | 594 | 631 | 669 | 709 | 750 | 793 | 849 |
| Public Street Light | 77 | 85 | 92 | 99 | 106 | 113 | 120 | 126 | 132 | 138 | 144 | 149 | 154 | 157 | 160 | 162 |
| Agriculture (M + N + P)) | 12 | 14 | 15 | 16 | 18 | 19 | 21 | 23 | 25 | 27 | 29 | 32 | 34 | 38 | 41 | 46 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 156 | 163 | 170 | 176 | 183 | 190 | 197 | 204 | 210 | 217 | 224 | 231 | 238 | 244 | 251 | 258 |
| Industry (L) | 301 | 301 | 301 | 301 | 301 | 301 | 301 | 301 | 301 | 301 | 301 | 301 | 301 | 301 | 300 | 300 |
| PWW (S + M + L) | 36 | 37 | 37 | 38 | 39 | 40 | 40 | 41 | 42 | 43 | 43 | 44 | 45 | 45 | 46 | 47 |
| Mixed Load | 97 | 104 | 110 | 116 | 122 | 128 | 135 | 141 | 147 | 153 | 159 | 165 | 171 | 178 | 184 | 190 |
| Total electricity consumption | 1426 | 1507 | 1592 | 1680 | 1770 | 1868 | 1970 | 2076 | 2185 | 2298 | 2400 | 2504 | 2603 | 2699 | 2792 | 2896 |

## 13.1.19. Jodhpur district circle

Table 134: Jodhpur DC - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 240 | 269 | 300 | 334 | 370 | 393 | 416 | 437 | 455 | 469 | 482 | 489 | 486 | 472 | 449 | 410 |
| Non-Domestic | 73 | 79 | 86 | 93 | 101 | 110 | 121 | 132 | 145 | 158 | 174 | 191 | 210 | 231 | 253 | 274 |
| Public Street Light | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 3 | 3 |
| Agriculture (M + N + P)) | 2181 | 2426 | 2697 | 2996 | 3325 | 3561 | 3810 | 4072 | 4350 | 4641 | 4841 | 5045 | 5252 | 5462 | 5674 | 6053 |
| Agriculture (F) | 467 | 408 | 357 | 312 | 273 | 250 | 228 | 209 | 191 | 174 | 159 | 145 | 132 | 120 | 109 | 0 |
| Industry (Small + Med) | 94 | 103 | 113 | 124 | 136 | 142 | 149 | 155 | 162 | 170 | 177 | 185 | 193 | 201 | 210 | 213 |
| Industry (L) | 69 | 74 | 79 | 84 | 89 | 92 | 95 | 98 | 102 | 105 | 108 | 112 | 115 | 119 | 122 | 126 |
| PWW (S + M + L) | 253 | 266 | 279 | 292 | 306 | 311 | 316 | 320 | 324 | 327 | 329 | 330 | 331 | 330 | 328 | 315 |
| Mixed Load | 22 | 23 | 24 | 25 | 26 | 26 | 26 | 25 | 25 | 25 | 25 | 25 | 25 | 24 | 24 | 24 |
| Total electricity consumption | 3401 | 3651 | 3938 | 4264 | 4630 | 4890 | 5165 | 5454 | 5757 | 6073 | 6300 | 6526 | 6747 | 6963 | 7173 | 7419 |

Table 135: Jodhpur DC - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 256 | 284 | 312 | 341 | 369 | 397 | 425 | 454 | 482 | 510 | 538 | 566 | 595 | 623 | 651 | 679 |
| Non-Domestic | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 | 219 | 229 | 239 |
| Public Street Light | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 6 | 6 |
| Agriculture (M + N + P)) | 3101 | 3376 | 3650 | 3925 | 4200 | 4475 | 4749 | 5024 | 5299 | 5573 | 5848 | 6123 | 6398 | 6672 | 6947 | 7222 |
| Agriculture (F) | 510 | 420 | 373 | 345 | 329 | 320 | 317 | 320 | 325 | 334 | 346 | 360 | 376 | 394 | 413 | 434 |
| Industry (Small + Med) | 93 | 100 | 107 | 113 | 120 | 127 | 133 | 140 | 147 | 153 | 160 | 167 | 173 | 180 | 187 | 193 |
| Industry (L) | 64 | 64 | 64 | 64 | 64 | 63 | 63 | 63 | 63 | 63 | 62 | 62 | 62 | 62 | 62 | 62 |
| PWW (S + M + L) | 264 | 282 | 301 | 319 | 338 | 357 | 375 | 394 | 412 | 431 | 449 | 468 | 486 | 505 | 523 | 542 |
| Mixed Load | 22 | 27 | 31 | 35 | 40 | 44 | 49 | 53 | 58 | 62 | 66 | 71 | 75 | 80 | 84 | 88 |
| Total electricity consumption | 4404 | 4657 | 4952 | 5266 | 5592 | 5926 | 6266 | 6611 | 6959 | 7310 | 7665 | 8021 | 8379 | 8740 | 9101 | 9465 |

Table 136: Jodhpur DC - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 165 | 185 | 206 | 228 | 252 | 278 | 305 | 334 | 364 | 396 | 430 | 464 | 497 | 528 | 558 | 587 |
| Non-Domestic | 67 | 74 | 81 | 88 | 96 | 105 | 114 | 123 | 134 | 145 | 156 | 169 | 182 | 196 | 211 | 226 |
| Public Street Light | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 |
| Agriculture (M + N + P)) | 2281 | 2527 | 2787 | 3053 | 3334 | 3621 | 3923 | 4233 | 4554 | 4886 | 5235 | 5591 | 5960 | 6341 | 6735 | 7142 |
| Agriculture (F) | 366 | 305 | 275 | 257 | 248 | 245 | 246 | 250 | 258 | 268 | 281 | 295 | 312 | 330 | 350 | 371 |
| Industry (Small + Med) | 98 | 108 | 119 | 131 | 144 | 157 | 172 | 188 | 204 | 222 | 242 | 263 | 285 | 309 | 335 | 363 |
| Industry (L) | 64 | 64 | 64 | 63 | 63 | 63 | 63 | 63 | 62 | 62 | 62 | 62 | 62 | 61 | 61 | 61 |
| PWW (S + M + L) | 261 | 279 | 297 | 315 | 333 | 351 | 368 | 386 | 403 | 420 | 437 | 454 | 471 | 487 | 503 | 519 |
| Mixed Load | 22 | 26 | 31 | 35 | 39 | 44 | 48 | 52 | 57 | 61 | 65 | 70 | 74 | 78 | 82 | 87 |
| Total electricity consumption | 3328 | 3572 | 3863 | 4176 | 4513 | 4867 | 5243 | 5633 | 6041 | 6465 | 6913 | 7372 | 7846 | 8335 | 8840 | 9361 |

## 13.1.20. Jalore

Table 137: Jalore - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 134 | 144 | 154 | 165 | 175 | 187 | 200 | 211 | 221 | 229 | 237 | 243 | 243 | 237 | 227 | 212 |
| Non-Domestic | 55 | 62 | 70 | 79 | 88 | 97 | 106 | 116 | 127 | 139 | 154 | 172 | 191 | 212 | 235 | 260 |
| Public Street Light | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| Agriculture (M + N + P)) | 841 | 925 | 1017 | 1117 | 1226 | 1334 | 1451 | 1576 | 1710 | 1855 | 2009 | 2175 | 2351 | 2540 | 2740 | 2953 |
| Agriculture (F) | 352 | 340 | 328 | 316 | 304 | 301 | 298 | 295 | 291 | 288 | 284 | 280 | 275 | 271 | 266 | 261 |
| Industry (Small + Med) | 179 | 191 | 203 | 216 | 230 | 245 | 260 | 277 | 295 | 313 | 333 | 354 | 376 | 400 | 425 | 451 |
| Industry (L) | 29 | 32 | 35 | 39 | 43 | 45 | 48 | 50 | 53 | 56 | 59 | 62 | 65 | 69 | 72 | 76 |
| PWW (S + M + L) | 55 | 59 | 62 | 66 | 69 | 70 | 70 | 70 | 70 | 69 | 69 | 68 | 67 | 66 | 65 | 64 |
| Mixed Load | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Total electricity consumption | 1651 | 1758 | 1875 | 2002 | 2141 | 2285 | 2438 | 2601 | 2773 | 2955 | 3152 | 3359 | 3575 | 3800 | 4035 | 4282 |

## Table 138: Jalore - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 184 | 214 | 237 | 257 | 275 | 293 | 309 | 325 | 341 | 356 | 371 | 387 | 402 | 417 | 433 | 448 |
| Non-Domestic | 60 | 65 | 70 | 74 | 79 | 84 | 88 | 93 | 98 | 102 | 107 | 112 | 116 | 121 | 126 | 130 |
| Public Street Light | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Agriculture (M + N + P)) | 1196 | 1303 | 1411 | 1519 | 1626 | 1734 | 1841 | 1949 | 2057 | 2164 | 2272 | 2379 | 2487 | 2594 | 2702 | 2810 |
| Agriculture (F) | 329 | 313 | 303 | 299 | 298 | 300 | 303 | 309 | 316 | 324 | 333 | 342 | 353 | 365 | 377 | 389 |
| Industry (Small + Med) | 185 | 200 | 216 | 231 | 246 | 261 | 276 | 291 | 306 | 321 | 337 | 352 | 367 | 382 | 397 | 412 |
| Industry (L) | 37 | 38 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| PWW (S + M + L) | 59 | 64 | 70 | 75 | 81 | 86 | 92 | 97 | 103 | 108 | 114 | 119 | 125 | 130 | 136 | 141 |
| Mixed Load | 3 | 4 | 4 | 5 | 5 | 6 | 7 | 7 | 8 | 8 | 9 | 9 | 10 | 11 | 11 | 12 |
| Total electricity consumption | 2056 | 2204 | 2352 | 2502 | 2654 | 2807 | 2961 | 3117 | 3274 | 3431 | 3590 | 3750 | 3910 | 4071 | 4233 | 4396 |

## Table 139: Jalore - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 130 | 140 | 151 | 163 | 175 | 187 | 200 | 214 | 228 | 242 | 257 | 272 | 286 | 298 | 309 | 319 |
| Non-Domestic | 56 | 64 | 73 | 82 | 93 | 102 | 111 | 121 | 131 | 142 | 154 | 166 | 180 | 194 | 209 | 230 |
| Public Street Light | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Agriculture (M + N + P)) | 811 | 880 | 954 | 1033 | 1117 | 1195 | 1279 | 1367 | 1459 | 1557 | 1662 | 1772 | 1887 | 2010 | 2139 | 2296 |
| Agriculture (F) | 236 | 227 | 224 | 223 | 225 | 229 | 235 | 242 | 250 | 259 | 270 | 281 | 293 | 306 | 319 | 333 |
| Industry (Small + Med) | 176 | 190 | 205 | 221 | 237 | 254 | 272 | 291 | 311 | 331 | 353 | 377 | 401 | 426 | 453 | 481 |
| Industry (L) | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 48 | 49 |
| PWW (S + M + L) | 58 | 63 | 69 | 74 | 79 | 85 | 90 | 95 | 100 | 106 | 111 | 116 | 121 | 126 | 130 | 135 |
| Mixed Load | 3 | 4 | 4 | 5 | 5 | 6 | 7 | 7 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 12 |
| Total electricity consumption | 1510 | 1609 | 1721 | 1842 | 1975 | 2102 | 2238 | 2382 | 2533 | 2693 | 2864 | 3042 | 3227 | 3420 | 3621 | 3858 |

## 13.1.21. Pali and Sirohi

Table 140: Pali and Sirohi - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 462 | 502 | 543 | 586 | 628 | 659 | 688 | 712 | 731 | 743 | 763 | 773 | 767 | 744 | 706 | 660 |
| Non-Domestic | 158 | 174 | 192 | 211 | 232 | 251 | 271 | 292 | 314 | 338 | 371 | 406 | 444 | 486 | 530 | 587 |
| Public Street Light | 13 | 13 | 14 | 14 | 14 | 14 | 13 | 13 | 12 | 11 | 10 | 10 | 9 | 8 | 7 | 6 |
| Agriculture (M + N + P)) | 490 | 538 | 591 | 649 | 711 | 779 | 853 | 933 | 1020 | 1114 | 1215 | 1325 | 1442 | 1569 | 1704 | 1836 |
| Agriculture (F) | 39 | 36 | 34 | 31 | 29 | 27 | 25 | 23 | 21 | 20 | 18 | 17 | 15 | 14 | 13 | 13 |
| Industry (Small + Med) | 139 | 145 | 150 | 155 | 161 | 166 | 172 | 178 | 185 | 191 | 198 | 204 | 211 | 219 | 226 | 240 |
| Industry (L) | 380 | 413 | 448 | 487 | 528 | 541 | 554 | 567 | 581 | 594 | 608 | 622 | 636 | 650 | 664 | 699 |
| PWW (S + M + L) | 50 | 52 | 53 | 55 | 57 | 56 | 56 | 55 | 54 | 53 | 52 | 51 | 49 | 48 | 46 | 45 |
| Mixed Load | 12 | 12 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| Total electricity consumption | 1742 | 1884 | 2036 | 2199 | 2373 | 2506 | 2643 | 2785 | 2929 | 3075 | 3246 | 3418 | 3585 | 3747 | 3907 | 4096 |

Table 141: Pali and Sirohi - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 519 | 557 | 595 | 633 | 671 | 709 | 747 | 785 | 823 | 861 | 899 | 937 | 975 | 1013 | 1051 | 1089 |
| Non-Domestic | 196 | 213 | 230 | 247 | 264 | 281 | 298 | 314 | 331 | 348 | 365 | 382 | 399 | 416 | 433 | 450 |
| Public Street Light | 15 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 23 | 24 | 24 | 25 | 26 | 27 |
| Agriculture (M + N + P)) | 621 | 719 | 816 | 914 | 1012 | 1110 | 1208 | 1306 | 1404 | 1502 | 1599 | 1697 | 1795 | 1893 | 1991 | 2089 |
| Agriculture (F) | 56 | 54 | 52 | 50 | 48 | 46 | 44 | 42 | 40 | 38 | 36 | 34 | 32 | 30 | 28 | 26 |
| Industry (Small + Med) | 140 | 144 | 148 | 151 | 155 | 159 | 163 | 167 | 171 | 175 | 179 | 182 | 186 | 190 | 194 | 198 |
| Industry (L) | 527 | 562 | 576 | 581 | 580 | 575 | 567 | 556 | 543 | 528 | 512 | 495 | 476 | 457 | 436 | 415 |
| PWW (S + M + L) | 50 | 52 | 54 | 56 | 58 | 59 | 61 | 63 | 65 | 67 | 69 | 70 | 72 | 74 | 76 | 78 |
| Mixed Load | 14 | 15 | 17 | 18 | 20 | 22 | 23 | 25 | 26 | 28 | 29 | 31 | 32 | 34 | 35 | 37 |
| Total electricity consumption | 2137 | 2331 | 2504 | 2668 | 2826 | 2980 | 3130 | 3278 | 3424 | 3568 | 3711 | 3852 | 3993 | 4132 | 4271 | 4409 |

**Table 142: Pali and Sirohi - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 455 | 490 | 527 | 564 | 601 | 640 | 678 | 717 | 756 | 795 | 832 | 869 | 899 | 923 | 943 | 959 |
| Non-Domestic | 159 | 182 | 208 | 235 | 265 | 284 | 305 | 326 | 348 | 371 | 395 | 421 | 447 | 475 | 504 | 553 |
| Public Street Light | 13 | 14 | 15 | 16 | 16 | 17 | 18 | 18 | 19 | 20 | 20 | 21 | 21 | 22 | 22 | 22 |
| Agriculture (M + N + P)) | 476 | 513 | 552 | 594 | 639 | 686 | 737 | 791 | 848 | 908 | 974 | 1043 | 1116 | 1193 | 1275 | 1363 |
| Agriculture (F) | 40 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 29 | 28 | 27 | 25 | 24 | 22 |
| Industry (Small + Med) | 139 | 143 | 147 | 151 | 154 | 158 | 162 | 166 | 170 | 173 | 177 | 181 | 185 | 189 | 193 | 196 |
| Industry (L) | 524 | 559 | 573 | 578 | 577 | 572 | 563 | 552 | 540 | 524 | 508 | 491 | 473 | 454 | 433 | 412 |
| PWW (S + M + L) | 50 | 52 | 53 | 55 | 57 | 59 | 60 | 62 | 64 | 65 | 67 | 68 | 70 | 71 | 73 | 74 |
| Mixed Load | 14 | 15 | 17 | 18 | 20 | 21 | 23 | 24 | 26 | 27 | 29 | 30 | 32 | 33 | 35 | 36 |
| Total electricity consumption | 1871 | 2008 | 2131 | 2249 | 2366 | 2472 | 2580 | 2690 | 2801 | 2915 | 3033 | 3152 | 3269 | 3385 | 3501 | 3639 |

## 13.1.22. Barmer and Jaisalmer

Table 143: Barmer and Jaisalmer - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 271 | 305 | 341 | 381 | 422 | 449 | 475 | 499 | 519 | 535 | 551 | 559 | 555 | 539 | 513 | 479 |
| Non-Domestic | 132 | 146 | 161 | 178 | 197 | 216 | 237 | 259 | 284 | 310 | 345 | 384 | 426 | 473 | 524 | 580 |
| Public Street Light | 7 | 7 | 7 | 8 | 8 | 8 | 7 | 7 | 7 | 6 | 6 | 5 | 5 | 4 | 4 | 3 |
| Agriculture (M + N + P)) | 1369 | 1572 | 1804 | 2069 | 2371 | 2518 | 2673 | 2834 | 3003 | 3179 | 3362 | 3552 | 3750 | 3953 | 4164 | 4487 |
| Agriculture (F) | 39 | 34 | 31 | 27 | 24 | 16 | 11 | 7 | 5 | 3 | 2 | 2 | 1 | 1 | 0 | 0 |
| Industry (Small + Med) | 71 | 74 | 77 | 80 | 83 | 84 | 84 | 85 | 85 | 86 | 86 | 87 | 87 | 87 | 88 | 93 |
| Industry (L) | 267 | 319 | 381 | 455 | 543 | 577 | 614 | 653 | 694 | 738 | 784 | 833 | 885 | 940 | 998 | 1050 |
| PWW (S + M + L) | 108 | 113 | 118 | 124 | 129 | 129 | 129 | 128 | 127 | 126 | 124 | 123 | 121 | 118 | 115 | 113 |
| Mixed Load | 80 | 83 | 86 | 90 | 94 | 97 | 101 | 105 | 109 | 113 | 117 | 121 | 125 | 129 | 133 | 134 |
| Total electricity consumption | 2343 | 2653 | 3007 | 3411 | 3871 | 4095 | 4331 | 4578 | 4833 | 5096 | 5378 | 5665 | 5954 | 6245 | 6540 | 6941 |

Table 144: Barmer and Jaisalmer - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 297 | 324 | 350 | 377 | 403 | 430 | 457 | 483 | 510 | 536 | 563 | 590 | 616 | 643 | 670 | 696 |
| Non-Domestic | 168 | 188 | 208 | 228 | 248 | 268 | 288 | 307 | 327 | 347 | 367 | 387 | 407 | 427 | 447 | 467 |
| Public Street Light | 11 | 12 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 23 | 24 |
| Agriculture (M + N + P)) | 1783 | 1943 | 2104 | 2264 | 2424 | 2585 | 2745 | 2905 | 3066 | 3226 | 3386 | 3547 | 3707 | 3867 | 4028 | 4188 |
| Agriculture (F) | 46 | 39 | 32 | 25 | 18 | 11 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 71 | 73 | 75 | 76 | 78 | 80 | 81 | 83 | 85 | 86 | 88 | 90 | 91 | 93 | 95 | 96 |
| Industry (L) | 162 | 170 | 178 | 185 | 193 | 201 | 209 | 216 | 224 | 232 | 240 | 248 | 255 | 263 | 271 | 279 |
| PWW (S + M + L) | 105 | 110 | 116 | 121 | 126 | 132 | 137 | 143 | 148 | 153 | 159 | 164 | 169 | 175 | 180 | 186 |
| Mixed Load | 76 | 79 | 81 | 83 | 85 | 87 | 90 | 92 | 94 | 96 | 98 | 101 | 103 | 105 | 107 | 109 |
| Total electricity consumption | 2720 | 2937 | 3155 | 3373 | 3591 | 3809 | 4026 | 4247 | 4471 | 4696 | 4921 | 5146 | 5370 | 5595 | 5820 | 6044 |

Table 145: Barmer and Jaisalmer - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 272 | 310 | 354 | 403 | 457 | 519 | 587 | 663 | 747 | 841 | 943 | 1056 | 1172 | 1292 | 1418 | 1552 |
| Non-Domestic | 122 | 133 | 145 | 158 | 172 | 187 | 203 | 219 | 237 | 256 | 276 | 297 | 320 | 343 | 369 | 396 |
| Public Street Light | 11 | 11 | 12 | 13 | 14 | 15 | 15 | 16 | 17 | 18 | 18 | 19 | 19 | 20 | 20 | 20 |
| Agriculture (M + N + P)) | 1341 | 1482 | 1629 | 1781 | 1941 | 2105 | 2278 | 2454 | 2637 | 2827 | 3026 | 3230 | 3440 | 3658 | 3883 | 4116 |
| Agriculture (F) | 33 | 28 | 24 | 19 | 14 | 9 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 71 | 73 | 74 | 76 | 78 | 79 | 81 | 82 | 84 | 86 | 87 | 89 | 91 | 92 | 94 | 96 |
| Industry (L) | 273 | 331 | 397 | 471 | 556 | 652 | 761 | 885 | 1026 | 1183 | 1363 | 1565 | 1794 | 2052 | 2341 | 2669 |
| PWW (S + M + L) | 104 | 109 | 114 | 120 | 125 | 130 | 135 | 140 | 145 | 150 | 155 | 159 | 164 | 169 | 173 | 178 |
| Mixed Load | 76 | 78 | 80 | 82 | 84 | 86 | 88 | 91 | 93 | 95 | 97 | 99 | 101 | 103 | 105 | 107 |
| Total electricity consumption | 2302 | 2555 | 2830 | 3123 | 3440 | 3781 | 4152 | 4551 | 4986 | 5454 | 5965 | 6514 | 7101 | 7729 | 8404 | 9133 |

## 13.1.23. Bikaner

**Table 146: Bikaner - Forecast of electricity consumption using trend method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 378 | 415 | 453 | 493 | 534 | 570 | 604 | 636 | 664 | 687 | 709 | 721 | 718 | 700 | 668 | 624 |
| Non-Domestic | 129 | 141 | 155 | 171 | 187 | 204 | 223 | 242 | 264 | 287 | 318 | 352 | 389 | 429 | 474 | 524 |
| Public Street Light | 15 | 14 | 14 | 14 | 14 | 13 | 12 | 12 | 11 | 10 | 9 | 8 | 8 | 7 | 6 | 5 |
| Agriculture (M + N + P)) | 2564 | 2895 | 3266 | 3681 | 4147 | 4386 | 4634 | 4893 | 5162 | 5441 | 5729 | 6026 | 6333 | 6648 | 6972 | 7513 |
| Agriculture (F) | 182 | 165 | 150 | 137 | 124 | 112 | 102 | 92 | 84 | 76 | 68 | 62 | 55 | 50 | 45 | 44 |
| Industry (Small + Med) | 129 | 134 | 139 | 145 | 150 | 150 | 150 | 149 | 149 | 148 | 148 | 147 | 147 | 146 | 146 | 155 |
| Industry (L) | 78 | 83 | 89 | 96 | 103 | 107 | 112 | 117 | 122 | 127 | 133 | 138 | 144 | 150 | 157 | 165 |
| PWW (S + M + L) | 139 | 145 | 151 | 157 | 163 | 167 | 172 | 176 | 180 | 184 | 187 | 190 | 192 | 194 | 195 | 191 |
| Mixed Load | 63 | 64 | 65 | 66 | 66 | 65 | 65 | 64 | 63 | 62 | 61 | 60 | 59 | 58 | 57 | 57 |
| Total electricity consumption | 3676 | 4057 | 4483 | 4958 | 5487 | 5775 | 6074 | 6382 | 6699 | 7022 | 7362 | 7705 | 8046 | 8383 | 8718 | 9278 |

## Table 147: Bikaner - Forecast of electricity consumption using HW method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 422 | 452 | 482 | 511 | 541 | 571 | 600 | 630 | 660 | 690 | 719 | 749 | 779 | 808 | 838 | 868 |
| Non-Domestic | 154 | 167 | 181 | 194 | 207 | 220 | 234 | 247 | 260 | 274 | 287 | 300 | 313 | 327 | 340 | 353 |
| Public Street Light | 24 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 30 | 30 | 31 | 32 | 32 | 33 | 34 | 34 |
| Agriculture (M + N + P)) | 3470 | 3729 | 3988 | 4247 | 4506 | 4765 | 5024 | 5282 | 5541 | 5800 | 6059 | 6318 | 6577 | 6836 | 7095 | 7354 |
| Agriculture (F) | 255 | 259 | 263 | 266 | 270 | 274 | 278 | 282 | 286 | 290 | 294 | 297 | 301 | 305 | 309 | 313 |
| Industry (Small + Med) | 137 | 142 | 147 | 152 | 158 | 163 | 168 | 174 | 179 | 184 | 189 | 195 | 200 | 205 | 210 | 216 |
| Industry (L) | 79 | 83 | 88 | 93 | 98 | 102 | 107 | 112 | 116 | 121 | 126 | 131 | 135 | 140 | 145 | 149 |
| PWW (S + M + L) | 140 | 146 | 153 | 160 | 167 | 173 | 180 | 187 | 193 | 200 | 207 | 214 | 220 | 227 | 234 | 240 |
| Mixed Load | 65 | 67 | 69 | 71 | 73 | 75 | 77 | 79 | 81 | 83 | 85 | 87 | 89 | 91 | 93 | 95 |
| Total electricity consumption | 4745 | 5070 | 5395 | 5721 | 6046 | 6371 | 6696 | 7021 | 7346 | 7671 | 7996 | 8322 | 8647 | 8972 | 9297 | 9622 |

**Table 148: Bikaner - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 361 | 391 | 422 | 453 | 485 | 517 | 550 | 583 | 616 | 649 | 681 | 712 | 738 | 758 | 776 | 790 |
| Non-Domestic | 115 | 125 | 136 | 148 | 160 | 173 | 187 | 201 | 217 | 233 | 251 | 269 | 289 | 310 | 332 | 356 |
| Public Street Light | 24 | 25 | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Agriculture (M + N + P)) | 2332 | 2664 | 3028 | 3419 | 3847 | 4306 | 4808 | 5345 | 5927 | 6555 | 7241 | 7975 | 8767 | 9622 | 10544 | 11538 |
| Agriculture (F) | 183 | 188 | 193 | 199 | 204 | 210 | 215 | 221 | 227 | 232 | 238 | 244 | 250 | 256 | 262 | 268 |
| Industry (Small + Med) | 130 | 137 | 143 | 150 | 157 | 165 | 173 | 181 | 190 | 199 | 209 | 219 | 230 | 241 | 252 | 265 |
| Industry (L) | 77 | 82 | 88 | 95 | 101 | 108 | 115 | 123 | 131 | 139 | 148 | 157 | 167 | 177 | 188 | 199 |
| PWW (S + M + L) | 139 | 146 | 153 | 160 | 167 | 174 | 182 | 190 | 197 | 205 | 213 | 221 | 229 | 237 | 245 | 253 |
| Mixed Load | 64 | 66 | 68 | 70 | 72 | 74 | 76 | 77 | 79 | 81 | 83 | 85 | 87 | 89 | 91 | 93 |
| Total electricity consumption | 3424 | 3823 | 4256 | 4718 | 5219 | 5753 | 6332 | 6949 | 7612 | 8322 | 9093 | 9912 | 10785 | 11719 | 12719 | 13791 |

## 13.1.24. Sri Ganganagar

Table 149: Sri Ganganagar - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 521 | 563 | 605 | 648 | 691 | 727 | 760 | 789 | 811 | 826 | 840 | 843 | 827 | 794 | 746 | 697 |
| Non-Domestic | 124 | 137 | 151 | 166 | 183 | 201 | 219 | 239 | 261 | 284 | 315 | 350 | 387 | 428 | 473 | 524 |
| Public Street Light | 6 | 6 | 7 | 8 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 6 | 6 | 5 | 5 | 4 |
| Agriculture (M + N + P)) | 128 | 144 | 162 | 182 | 204 | 210 | 216 | 222 | 228 | 234 | 239 | 245 | 251 | 256 | 261 | 281 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 51 | 51 | 52 | 53 | 54 | 54 | 55 | 56 | 57 | 58 | 58 | 59 | 60 | 61 | 62 | 65 |
| Industry (L) | 109 | 114 | 119 | 124 | 129 | 133 | 137 | 140 | 144 | 148 | 152 | 156 | 160 | 164 | 168 | 177 |
| PWW (S + M + L) | 23 | 24 | 25 | 27 | 28 | 30 | 32 | 35 | 37 | 40 | 44 | 48 | 52 | 58 | 64 | 71 |
| Mixed Load | 74 | 74 | 75 | 75 | 76 | 76 | 76 | 77 | 77 | 77 | 77 | 77 | 77 | 77 | 77 | 77 |
| Total electricity consumption | 1035 | 1113 | 1196 | 1283 | 1374 | 1439 | 1503 | 1565 | 1622 | 1674 | 1732 | 1783 | 1819 | 1842 | 1856 | 1896 |

**Table 150: Sri Ganganagar - Forecast of electricity consumption using HW method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 590 | 635 | 680 | 724 | 769 | 814 | 858 | 903 | 948 | 992 | 1037 | 1082 | 1126 | 1171 | 1216 | 1261 |
| Non-Domestic | 147 | 161 | 176 | 191 | 206 | 221 | 236 | 251 | 265 | 280 | 295 | 310 | 325 | 340 | 355 | 369 |
| Public Street Light | 6 | 6 | 7 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 | 12 | 13 | 14 | 14 |
| Agriculture (M + N + P)) | 194 | 196 | 197 | 199 | 200 | 201 | 203 | 204 | 206 | 207 | 208 | 210 | 211 | 213 | 214 | 215 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 62 | 62 | 63 | 65 | 69 | 74 | 79 | 85 | 92 | 99 | 107 | 115 | 124 | 133 | 143 | 153 |
| Industry (L) | 114 | 131 | 145 | 157 | 168 | 177 | 186 | 195 | 203 | 210 | 0 | 0 | 0 | 0 | 0 | 0 |
| PWW (S + M + L) | 39 | 41 | 42 | 43 | 44 | 45 | 46 | 46 | 47 | 47 | 48 | 48 | 48 | 48 | 48 | 48 |
| Mixed Load | 78 | 80 | 81 | 83 | 85 | 86 | 88 | 90 | 91 | 93 | 94 | 96 | 98 | 99 | 101 | 103 |
| Total electricity consumption | 1230 | 1312 | 1391 | 1470 | 1549 | 1627 | 1705 | 1783 | 1862 | 1940 | 1801 | 1873 | 1945 | 2017 | 2090 | 2163 |

**Table 151: Sri Ganganagar - Forecast of electricity consumption using econometric method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 515 | 557 | 602 | 647 | 692 | 739 | 786 | 833 | 881 | 928 | 974 | 1020 | 1056 | 1086 | 1111 | 1133 |
| Non-Domestic | 130 | 147 | 166 | 186 | 207 | 225 | 245 | 265 | 287 | 310 | 334 | 360 | 387 | 416 | 446 | 487 |
| Public Street Light | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agriculture (M + N + P)) | 139 | 142 | 145 | 148 | 151 | 154 | 157 | 160 | 163 | 166 | 169 | 172 | 175 | 178 | 181 | 185 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 48 | 48 | 47 | 47 | 46 |
| Industry (L) | 114 | 131 | 144 | 156 | 167 | 176 | 185 | 193 | 201 | 209 | 0 | 0 | 0 | 0 | 0 | 0 |
| PWW (S + M + L) | 38 | 40 | 42 | 43 | 44 | 45 | 45 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 46 |
| Mixed Load | 77 | 79 | 81 | 82 | 84 | 85 | 87 | 88 | 90 | 91 | 93 | 94 | 96 | 97 | 99 | 100 |
| Total electricity consumption | 1069 | 1146 | 1229 | 1311 | 1394 | 1474 | 1554 | 1635 | 1717 | 1799 | 1665 | 1740 | 1809 | 1871 | 1931 | 1996 |

## 13.1.25. Hanumangarh

Table 152: Hanumangarh - Forecast of electricity consumption using trend method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 394 | 424 | 454 | 485 | 515 | 550 | 584 | 615 | 642 | 664 | 685 | 697 | 694 | 677 | 646 | 603 |
| Non-Domestic | 74 | 81 | 88 | 96 | 105 | 116 | 127 | 141 | 155 | 170 | 191 | 214 | 239 | 267 | 299 | 331 |
| Public Street Light | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 3 |
| Agriculture (M + N + P)) | 424 | 476 | 535 | 601 | 674 | 711 | 749 | 788 | 828 | 870 | 913 | 958 | 1003 | 1050 | 1097 | 1183 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 34 | 35 | 36 | 37 | 37 | 38 | 39 | 40 | 40 | 41 | 42 | 43 | 44 | 44 | 45 | 48 |
| Industry (L) | 39 | 39 | 40 | 41 | 42 | 42 | 43 | 44 | 45 | 46 | 46 | 47 | 48 | 49 | 50 | 52 |
| PWW (S + M + L) | 50 | 55 | 60 | 65 | 71 | 73 | 76 | 78 | 80 | 82 | 84 | 85 | 87 | 88 | 89 | 87 |
| Mixed Load | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 |
| Total electricity consumption | 1022 | 1118 | 1221 | 1333 | 1452 | 1539 | 1626 | 1713 | 1799 | 1881 | 1969 | 2052 | 2123 | 2183 | 2232 | 2310 |

**Table 153: Hanumangarh - Forecast of electricity consumption using HW method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 441 | 475 | 510 | 545 | 580 | 614 | 649 | 684 | 719 | 753 | 788 | 823 | 858 | 892 | 927 | 962 |
| Non-Domestic | 93 | 102 | 111 | 120 | 128 | 137 | 146 | 155 | 164 | 172 | 181 | 190 | 199 | 208 | 216 | 225 |
| Public Street Light | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 |
| Agriculture (M + N + P)) | 603 | 624 | 646 | 667 | 689 | 710 | 732 | 753 | 774 | 796 | 817 | 839 | 860 | 882 | 903 | 924 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 33 | 33 | 33 | 33 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 31 | 31 | 31 |
| Industry (L) | 32 | 32 | 32 | 31 | 31 | 31 | 31 | 31 | 31 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| PWW (S + M + L) | 45 | 39 | 37 | 37 | 37 | 38 | 39 | 41 | 42 | 44 | 47 | 49 | 52 | 54 | 57 | 60 |
| Mixed Load | 5 | 12 | 10 | 16 | 18 | 17 | 5 | 4 | 4 | 4 | 5 | 12 | 10 | 16 | 18 | 17 |
| Total electricity consumption | 1256 | 1322 | 1383 | 1453 | 1520 | 1585 | 1640 | 1705 | 1771 | 1838 | 1907 | 1980 | 2047 | 2119 | 2189 | 2256 |

Table 154: Hanumangarh - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 397 | 432 | 468 | 504 | 541 | 580 | 618 | 657 | 696 | 735 | 772 | 810 | 840 | 865 | 886 | 905 |
| Non-Domestic | 77 | 88 | 100 | 113 | 127 | 142 | 158 | 175 | 194 | 214 | 235 | 258 | 283 | 309 | 338 | 368 |
| Public Street Light | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Agriculture (M + N + P)) | 424 | 461 | 500 | 539 | 581 | 624 | 669 | 714 | 762 | 811 | 863 | 915 | 970 | 1026 | 1084 | 1144 |
| Agriculture (F) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industry (Small + Med) | 33 | 33 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 31 | 31 | 31 | 31 |
| Industry (L) | 32 | 32 | 31 | 31 | 31 | 31 | 31 | 31 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 |
| PWW (S + M + L) | 49 | 54 | 58 | 62 | 66 | 69 | 73 | 77 | 80 | 84 | 87 | 90 | 93 | 96 | 99 | 101 |
| Mixed Load | 5 | 11 | 10 | 16 | 18 | 17 | 5 | 4 | 4 | 4 | 5 | 11 | 10 | 16 | 18 | 17 |
| Total electricity consumption | 1021 | 1114 | 1204 | 1302 | 1401 | 1499 | 1591 | 1695 | 1803 | 1914 | 2030 | 2152 | 2263 | 2379 | 2491 | 2600 |

## 13.1.26. Churu

**Table 155: Churu - Forecast of electricity consumption using trend method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 313 | 337 | 362 | 386 | 411 | 434 | 456 | 475 | 491 | 503 | 514 | 518 | 511 | 493 | 465 | 434 |
| Non-Domestic | 74 | 82 | 90 | 99 | 109 | 120 | 132 | 145 | 159 | 174 | 195 | 217 | 242 | 270 | 300 | 332 |
| Public Street Light | 7 | 7 | 8 | 8 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 9 | 9 | 8 | 7 |
| Agriculture (M + N + P)) | 787 | 856 | 930 | 1010 | 1096 | 1129 | 1162 | 1195 | 1228 | 1261 | 1294 | 1326 | 1357 | 1388 | 1418 | 1528 |
| Agriculture (F) | 93 | 78 | 65 | 55 | 46 | 38 | 32 | 27 | 22 | 18 | 15 | 13 | 11 | 9 | 7 | 7 |
| Industry (Small + Med) | 41 | 43 | 45 | 47 | 49 | 52 | 54 | 56 | 59 | 62 | 64 | 67 | 70 | 73 | 77 | 81 |
| Industry (L) | 28 | 31 | 33 | 36 | 40 | 41 | 42 | 43 | 44 | 45 | 47 | 48 | 49 | 50 | 52 | 54 |
| PWW (S + M + L) | 120 | 125 | 130 | 135 | 140 | 142 | 143 | 144 | 145 | 146 | 146 | 146 | 145 | 144 | 143 | 140 |
| Mixed Load | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Total electricity consumption | 1470 | 1565 | 1669 | 1782 | 1904 | 1969 | 2035 | 2100 | 2164 | 2224 | 2289 | 2349 | 2399 | 2441 | 2474 | 2589 |

**Table 156: Churu - Forecast of electricity consumption using HW method**

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 347 | 369 | 392 | 415 | 438 | 460 | 483 | 506 | 528 | 551 | 574 | 597 | 619 | 642 | 665 | 688 |
| Non-Domestic | 88 | 93 | 98 | 103 | 108 | 113 | 117 | 122 | 127 | 132 | 137 | 142 | 147 | 152 | 157 | 162 |
| Public Street Light | 10 | 11 | 13 | 14 | 15 | 16 | 18 | 19 | 20 | 22 | 23 | 24 | 25 | 27 | 28 | 29 |
| Agriculture (M + N + P)) | 909 | 967 | 1024 | 1081 | 1138 | 1195 | 1253 | 1310 | 1367 | 1424 | 1481 | 1539 | 1596 | 1653 | 1710 | 1767 |
| Agriculture (F) | 59 | 49 | 41 | 34 | 27 | 22 | 17 | 12 | 8 | 4 | 0 | -3 | -6 | -9 | -12 | -14 |
| Industry (Small + Med) | 44 | 46 | 48 | 50 | 52 | 53 | 55 | 57 | 59 | 61 | 63 | 65 | 67 | 69 | 71 | 72 |
| Industry (L) | 31 | 35 | 39 | 44 | 48 | 53 | 57 | 62 | 66 | 70 | 75 | 79 | 84 | 88 | 93 | 97 |
| PWW (S + M + L) | 124 | 130 | 136 | 142 | 148 | 155 | 161 | 167 | 173 | 179 | 185 | 191 | 198 | 204 | 210 | 216 |
| Mixed Load | 8 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 20 |
| Total electricity consumption | 1619 | 1708 | 1800 | 1892 | 1985 | 2079 | 2173 | 2268 | 2363 | 2459 | 2555 | 2651 | 2747 | 2844 | 2941 | 3038 |

Table 157: Churu - Forecast of electricity consumption using econometric method

| (MUs) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | 307 | 333 | 360 | 388 | 417 | 446 | 477 | 508 | 540 | 572 | 604 | 636 | 663 | 687 | 708 | 726 |
| Non-Domestic | 60 | 68 | 77 | 86 | 95 | 105 | 116 | 128 | 141 | 154 | 169 | 184 | 200 | 218 | 237 | 257 |
| Public Street Light | 10 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 24 | 25 |
| Agriculture (M + N + P)) | 807 | 892 | 984 | 1081 | 1185 | 1296 | 1414 | 1539 | 1672 | 1814 | 1966 | 2126 | 2297 | 2477 | 2670 | 2874 |
| Agriculture (F) | 42 | 36 | 30 | 25 | 21 | 17 | 13 | 9 | 6 | 3 | 0 | -3 | -5 | -8 | -10 | -12 |
| Industry (Small + Med) | 40 | 41 | 43 | 44 | 45 | 47 | 49 | 50 | 52 | 54 | 56 | 59 | 61 | 64 | 66 | 69 |
| Industry (L) | 30 | 35 | 39 | 44 | 48 | 52 | 57 | 61 | 66 | 70 | 74 | 79 | 83 | 88 | 92 | 96 |
| PWW (S + M + L) | 114 | 117 | 118 | 119 | 120 | 119 | 118 | 116 | 114 | 110 | 105 | 99 | 92 | 83 | 73 | 62 |
| Mixed Load | 8 | 8 | 9 | 10 | 11 | 12 | 13 | 13 | 14 | 15 | 16 | 17 | 17 | 18 | 19 | 20 |
| Total electricity consumption | 1419 | 1542 | 1673 | 1810 | 1957 | 2111 | 2274 | 2445 | 2624 | 2812 | 3012 | 3219 | 3432 | 3651 | 3879 | 4116 |

## 13.2. 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)<br><br>Peak | Supply disruption (in minutes)<br><br>Non Peak | Reason of Failure. Data sheet should have options to select/ capture reasons<br><br>1. DT Failure<br>2. Feeder breakdown<br>3. Scheduled load shedding<br>4. Capacity constraint<br>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 format**

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

## 3. Load factor – capture 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 Open Access consumers | 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 | | | | | | | | | | | | | |