

# LONG TERM ELECTRICITY DEMAND FORECASTING





## **Disclaimer and Notice to Reader**

No one should act on the contents herein or information herein without appropriate professional advice after a thorough examination of the particular situation. Views expressed in the paper are not binding on any person, entity, authority or Court, and hence, no assurance is given that a position contrary to the opinions expressed herein will not be asserted by any person, entity, authority and/or sustained by an appellate authority or a court of law. This report has been prepared under the Technical Assistance titled "Supporting Structural Reforms in the Indian Power Sector" funded by UK aid from the UK government; however the views expressed do not necessarily reflect the UK government's official policies. To the fullest extent permitted by law, KPMG in India does not assume any responsibility and will not accept any liability in respect of this Report to any party other than its Client. KPMG thus disclaims all responsibility or liability for any costs, damages, losses, liabilities, expenses incurred by such third party arising out of or in connection with the report or any part thereof. By reading this Report, the reader of the Report shall be deemed to have accepted the terms mentioned hereinabove.

प्रकाश मस्के  
अध्यक्ष तथा पदेन सचिव भारत सरकार  
**Prakash Mhaske**  
Chairperson & Ex-officio Secretary  
to the Government of India



केन्द्रीय विद्युत प्राधिकरण  
विद्युत मंत्रालय  
सेवा भवन, आर. के. पुरम  
नई दिल्ली-110066  
**Central Electricity Authority**  
Ministry of Power  
Sewa Bhawan, R. K. Puram  
New Delhi-110066

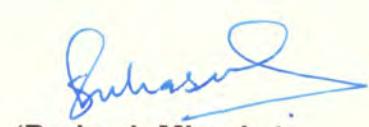
## FOREWORD

Electricity is one of the most important drivers for the growth and development of a country. For steering the economy on the desired growth trajectory, sufficient electrical energy generation, transmission and distribution infrastructure are to be planned well in advance, which in turn requires correct estimation of electricity demand in future. Central Electricity Authority (CEA) conducts periodic Electric Power Survey (EPS) of the country to assess the state and union territory (UT)-wise / region-wise and all-India electricity demand on medium term and long term basis. So far, 19 Electric Power Surveys have been conducted.

The electricity demand projection in 19<sup>th</sup> Electric Power Survey (EPS) was carried out by CEA by using Partial End User Method (PEUM). An exercise has now been undertaken by CEA in collaboration with KPMG for demand projection of the country by using Econometric Method. This report contains electricity demand projection in term of Energy Requirement and Peak Demand for each state/UT as well as the country. The CAGR of Energy Requirement from 2016-17 to 2036-37 with the preferred scenarios of econometric method and PEUM, are in the range of 5%, which indicates that the demand arrived at by the two different method works out to be in the similar range.

I express my sincere appreciation to all the officers of CEA and KPMG who were involved in this study for their valuable support and suggestions during the deliberations and preparation of the report. I am sure that this volume of EPS would be helpful to all the stakeholders of the power sector in the proper planning of electrical infrastructure and power procurement.

New Delhi  
August, 2019



(Prakash Mhaske)



**SANDESH KUMAR SHARMA**  
**Member (Planning)**

दूरभाष (कां) 011-26106988  
TELEPHONE (O) 011-26172926  
TELEFAX (O)

सदस्य

तथा पदेन अपर सचिव भारत सरकार  
केन्द्रीय विद्युत प्राधिकरण  
सेवा भवन, रामाकृष्ण पुरम्

**MEMBER**

& EX-OFFICIO ADDL. SECRETARY TO THE GOVERNMENT OF INDIA  
CENTRAL ELECTRICITY AUTHORITY  
SEWA BHAWAN, R.K. PURAM

नई दिल्ली - 110066

NEW DELHI-110066

## PREFACE

The economic development of our country is dependent upon the reliable power at affordable prices to various sectors and section of the country. Demand projection is an important exercise for power procurement planning and development of the whole power sector. Central Electricity Authority (CEA) carries out Electric Power Surveys for estimating the electricity demand of all the states/UTs, Regions and for the country.

CEA has started taking a more cautious approach to minimize the skepticism involved in any forecasting exercise. CEA is carrying out electricity demand forecasting through two entirely different approaches to minimize the degree of uncertainty in this capital-intensive power sector. The electrical forecasting with two Econometric models namely Partial Adjustment Model (PAM) and Seemingly Unrelated Regression (SUR) are covered in this report considering three GDP scenario of Pessimistic (6.5%), Business as usual (7.3%) and Optimistic (8%) for each model. Apart from enlightening about other possible scenarios that would be quite useful for the investors and planner, electricity demand forecast through Econometric method is also an attempt to review the results of 19<sup>th</sup> EPS (Electric Power Survey) – Volume-I that were arrived upon through conventional Partial End User Method (PEUM).

This report has been prepared by CEA in association with KPMG under the Technical Assistance titles "Supporting Structural Reform in the Indian Power Sector" funded by Department of International Development, UK Government. I would especially like to place on record the valuable contribution of Shri Pankaj Batra, the then Chairperson (I/C), CEA under whose guidance this work was taken up. I would also like to acknowledge the hard work and contribution of Officers of Power Survey & Load Forecasting (PS&LF) Division and KPMG in carrying out this study.

New Delhi  
August, 2019

Sandesh Kumar Sharma



B.K. Arya  
Chief Engineer (PS&LF)  
Central Electricity Authority

#### **ACKNOWLEDGEMENT**

The report of Long Term Demand Forecasting with econometric method has been brought out by CEA in association with KPMG in compliance with the decision of the 19<sup>th</sup> EPS committee. Traditionally, CEA does state/UT-wise, region-wise and all-India electricity demand projection through Partial End User Method (PEUM) which is a bottom-up approach focused on end-uses of different categories of the consumers. It is basically a combination of time series analysis and End-Use Method.

In contrast, the econometric model used in this study is based on parameters such as GDP, real electricity price, weather parameters, and past electricity consumption. The input data set used in this analysis comprises of data on these key drivers of electricity demand for all the Indian states and UTs from 2002-03 to 2015-16. The monthly data of states and UTs spanning over 168 periods (14 years of monthly data) has been considered for model development.

The electric demand forecast has been worked out through two econometric models i.e. Partial Adjustment Model (PAM) and Seemingly Unrelated Regression (SUR) model and for each model, three different electricity demand scenarios corresponding to three GDP growth rate of 6.5%, 7.3% and 8% were considered. The in-sample data forecasting and comparison of the demand projection with actual electrical energy requirement during past two years suggest that PAM model under 7.3% GDP scenario is fitting better and therefore, the results obtained through that is recommended as the most preferred scenario. The report covers state-wise and all- India electricity demand projections up to the year 2036-37.

For preparing this report, I would like to acknowledge Sh. Pankaj Batra, the erstwhile Chairperson (I/C), Sh. Sanjiva Mandilwar, the then Chief Engineer (PSLF) who have provided guidance and valuable support at each and every step of the econometric analysis of electric demand projection. I would also like to appreciate the hard work and contribution of Sh. Deepak Kumar, Director(PSLF), Sh. Ishan Saran, earlier Director(PSLF), Sh. Naresh Kumar, Deputy Director PSLF, Ms Komal Dupare, earlier Assistant Director(PSLF) in shaping up this report. Last but not the least, I wish to acknowledge the excellent efforts of KPMG team working on this report, particularly Dr. Puneet Chitkara, Dr Eshita Gupta, Mr. Parteek Garodia & Ms Deeksha Pandey for their valuable contribution.

  
(B.K. Arya)



# Contents

■ Executive summary	7
■ 1. Introduction	17
■ 2. Methodology for econometric forecasting	26
■ 3. Historical trends of variables	34
■ 4. Choice of model for forecasting electricity demand and estimation of results	50
■ 5. Electricity demand forecasts from FY 2016-17 to FY 2036-37	62
■ Annexure 1: Long panel estimation	76
■ Annexure 2: Details of the data used	78
■ Annexure 3: Coefficient Results	85
■ Annexure 4: State Shares of electricity consumption	94
■ Annexure 5: Electricity Demand Forecasts and Growth rates	98

# Executive summary

---





# Executive summary

## Background

Projection of electricity demand is a prerequisite for power sector planning. A periodic Electric Power Survey (EPS) of the country is conducted by the Central Electricity Authority (CEA) to assess the state-wise/union territory (UT)-wise/region-wise and all-India electricity demand on medium- and long-term basis. So far, 19 Electric Power Surveys have been conducted. The 19<sup>th</sup> Electric Power Survey (EPS) Committee, constituted by the CEA in June 2015, decided that the 19<sup>th</sup> EPS would be brought out in four volumes, as detailed below:

**Volume I:** Discom-wise, state/UT-wise, region-wise and all-India electricity demand projection by partial end use method (PEUM).

**Volume II:** Electric Power Survey of National Capital Region (NCR).

**Volume III:** Electric Power Survey of Mega Cities.

**Volume IV:** Electricity demand projection by econometric method.

The Volume I of the 19<sup>th</sup> EPS Report, covering electricity demand projection of Discoms, states, UTs, regions and the all-India electricity demand using Partial End Use Method (PEUM) of electricity demand forecasting, was brought out in January 2017. Now, in line with 19<sup>th</sup> EPS Committee recommendations, the CEA and KPMG India, has carried out electricity demand forecasting by the **econometric method**.

## Data used

The data set for the econometric analysis comprises data on key drivers of electricity demand for all the Indian states and UTs from 2002-03 to 2015-16. Such a cross-sectional (for all states and UTs) data over multiple time periods is called a panel data set.

**Panel data analysis** help by blending the inter-state differences and intra-state dynamics and this has several advantages over cross-sectional or time-series data. It improves the efficiency of econometric estimates by considering more degrees of freedom and by capturing the impact of variables those might be unobservable. Also, in a time-series model, any factor would typically be strongly correlated with its lagged value that leads to a restricted forecast. This problem may be overcome with the panel data.

The panel data set considered in this analysis has both the **dependent variable** i.e. electricity demand/requirement, and a set of **independent variables** such as state-level gross domestic product (GDP) and weather data for all the states and UTs, except Himachal Pradesh, Arunachal Pradesh, Dadar and Nagar Haveli, Sikkim, Daman and Diu, Andaman and Nicobar Islands and Lakshadweep. For these states/UTs, as weather data



(temperature, rainfall, etc.) was not consistently available, it has been assumed that the growth rate of electricity demand will converge to the national growth rate in future. The monthly data of 25 states and three UTs spanning over 168 periods (14 years of monthly data) has been used for the model development.

## Models for electricity demand forecasting

Electricity demand across states is likely to be dependent on time, i.e. it is natural to expect electricity demand in any given year to be dependent on its previous value, especially as the overall electrical equipment determining electricity demand can be considered as fixed in the short-run. Electricity demand is a derived demand that arises from demand of energy services such as space conditioning, cooking and lighting, for which we require investment in electric equipment. However, adjustment takes time as investment in electric equipment is not immediate. The dynamics arise as a result of the demand stickiness prevalent in electricity consumption because of its capital-intensive nature.

This inertia in demand is captured by including lagged dependent variables in the model which helps in computing dynamic impacts of key drivers on electricity demand and hence improve upon static models where such impacts are not captured. Such an economic model which distinguishes between short-run and long-run electricity responses to its key drivers is known as **Partial Adjustment Model (PAM)**. This model is dynamic as it does not assume an instantaneous adjustment to new equilibrium values when any independent variable (such as price or income) changes. It is assumed that the household can change the rate of utilisation of the existing stock of appliances, but not the existing capital stock with variations in prices or income, so that the short-run and long-run elasticities are not same. These adjustments, however, can vary by regions in India and partial adjustment framework at the regional level provides useful insight into how demand would grow in various regions. The partial adjustment framework has been widely applied in the past for estimating short-run and long-run electricity demand elasticities as well as for obtaining future forecasts of electricity demand.

The PAM model estimates electricity demand (in MU and MW) within regional panel framework which assumes that all the states within a region will have same response for key socio-economic variables included in the model. Thus to estimate differential response of each state with respect to change in key drivers, the state-specific model is also estimated using regional **seemingly unrelated regression (SUR) model**. This model estimates state-specific regression model but takes advantage of the panel data structure to improve overall efficiency of state-level parameter estimates. It pools panel data observations within a region and accounts for correlation in the errors across states within a region.



## Selection of the preferred model

The best model for energy requirement/demand at all-India is selected as the one which **minimizes out-sample mean absolute percentage error<sup>1</sup>** (MAPE) for the year 2015-2016 and has the **least average deviation** from the actual observed demand for the two recent years 2016-17 & 2017-2018. For selecting the best model, first estimation is done using data till 2014-15 and then out sample MAPE is calculated for the year 2015-16 as the complete set of independent variables were available for this year in the sample data frame. The regional partial adjustment model (PAM) performs best in terms of forecasting performance by both these measures. The forecasted electricity requirement/demand from the PAM model matches very closely with the actual electricity requirement for the year 2015-16 with minimum out-sample mean absolute percentage deviation in errors amongst the all estimated models. At the same time, it has the least average deviation from the actual observed demand for the two recent years 2016-17 & 2017-2018 as compared to all other estimated models.

Although, it is found that the partial adjustment model (PAM) has a better forecasting accuracy at all-India level with a relatively lower mean absolute percentage error (MAPE) in out-of-sample data and lower average deviation in two recent years as compared to the seemingly unrelated regression (SUR) model, but for few states, electricity requirement forecasts in the long-run seemed better from the SUR model as compared to the PAM model and thus electricity demand forecasts are obtained from both these models for comparison and better understanding of the future scenario under state-specific demand transitions.

## Partial Adjustment Model – The Model & Its Significant findings

The panel partial adjustment model has been estimated using data for 25 states and three UTs in all the five regions — north, west, south, east and north-east. The monthly data used for the model development in the current study is long panel with 25 states and three UTs spanning over 168 periods (14 years of monthly data) in all the five regions. The dependent variable is the logarithm of monthly state electricity requirement between 2002-03 and 2015-16.

The independent variables include logarithm of state electricity requirement lagged by one and 12 months respectively, logarithm of GDP lagged by 12 months, logarithm of real electricity prices, cooling degree days (CDD), heating degree days (HDD), rainfall, state by month fixed effect (accounting for factors particular to a state that are distinct in every month) and dummies for incorporating structural break between time periods.

The partial **adjustment model** describes change in electricity requirement from one month to the next as some proportion of the difference between the current level of monthly demand and desired/equilibrium long-run monthly demand. The key assumption of the model is that consumers try to bring their actual level of monthly consumption in line with the equilibrium level but they are only partially successful in every period to close this gap. The estimated **speed of adjustment** of short-run deviation from the long-run equilibrium path is about 31% per annum at the all-India level. This implies that the short-run will converge to the long-run equilibrium in 3.2

---

<sup>1</sup> Error is defined as a difference between actual and forecasted electricity requirement/demand.

years. The speed of adjustment turns out to be the highest for the northern region at 42% per annum or 2.4 years and lowest for the eastern region at 22% per annum or 4.5 years.

The PAM model distinguishes between short-run and long-run, and thus estimates both short-run and long-run **income elasticity (as measured by GDP elasticity)**. The long-run income elasticity of Electrical Energy Requirement at the all-India level is 0.74, which is more than three times the short-run elasticity. As expected, the elasticity turns out to be lowest for developed region of western India (0.48), which comprises two developed and big states of India - Gujarat and Maharashtra. The elasticity is the highest in the relatively less-developed eastern region (0.91). The relatively slower growth in electricity demand has been observed in developed states and relatively faster growth in electricity demand has been observed in developing states, indicating convergence in demand and living standards over time.

As in the case of income, the model estimates both short-run and long-run **price elasticity** of electricity demand. A 1% increase in real electricity price results in a small 0.02% decrease on an average in the state Electrical Energy Requirement in the short-run at the all-India level. The long-run price elasticity of -0.06 at the all-India level is three times the short-run elasticity. This reinforces that electricity price increase will have much greater impact on electricity demand in the long-run. This is expected as people are likely to adjust more to electricity price increases over time by switching to alternate sources of energy, primarily renewables. An examination of the coefficients of region-specific partial adjustment model shows that the price elasticity is relatively higher than the all-India average in the southern region (-0.12 in the short-run and -0.38 in the long-run) and western region (-0.07 in the short-run and -0.26 in the long-run). This can possibly be explained by relatively higher average real price in western region and the greater captive generation in the industrial sector in western and southern regions, making utility electricity requirement to be more sensitive to price changes.

The estimated long-run impact of CDDs at the all-India level is about 0.19% increase in Electrical Energy Requirement per one-degree Celsius increase in the CDD. The short-run impact of the CDD is about 0.06% increase in Electrical Energy Requirement per one-degree Celsius increase in the CDD. The long-run impact is estimated to be higher in relatively hot and developed regions in India — west (0.26%) and south (0.22%).

In the short-run, a one unit (100 mm) increase in **rainfall** results in 6% reduction in Electrical Energy Requirement when rainfall is between 0-50 mm, 4% reduction when rainfall is between 50-100 mm, 3% reduction when rainfall is between 100-150 mm and 2% reduction when rainfall is above 200 mm. In India, higher rainfall generally occurs during summer when temperature and humidity are high. While higher rainfall in summers brings down temperature and electricity demand but the associated increase in humidity dampens the impact of rainfall on electricity demand to some extent. As the humidity effect is absent in winters, an increase in rainfall during summer may reduce demand (in percentage terms) lesser as compared to winter. Also in winter, the agricultural demand is very high in many states. Higher rainfall in winter can significantly reduce the agricultural load due to pumps. The estimated impact of rainfall turns out to be the highest in the northern region due to high agricultural load. The estimated average long-run impact at the all-India level in all four rainfall categories is 12% reduction in electricity demand with one unit (100 mm) increase in rainfall.

## Forecasts based on the regional PAM model

All-India electricity requirement forecasts as based on the regional PAM model under three different GDP scenarios-baseline or business-as-usual (BAU) scenario, optimistic scenario and pessimistic scenario are discussed below:

The BAU case assumes that GDP at the all-India level will continue to grow at the average compound annual growth rate (CAGR) of about 7.3% obtained during 2000-01 to 2017-18 and there will be no significant deviations from these past trends. In the optimistic growth scenario, the all-India GDP is assumed to grow at 8% for all future years during 2018-19 to 2036-37. In the pessimistic growth scenario, the all-India GDP is assumed to grow at 6.5% for all future years during FY 2018-19 to FY 2036-37.

An overview of Electrical Energy Requirement (BU) and CAGR (%) for various scenarios is shown in Table 1 and Table 2 respectively:

**Table 1: Electrical Energy Requirement (in BU) from PAM**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17	1152.4	1152.4	1152.4	1160.4
2021-22	1471.5	1477.5	1443.5	1566.0
2026-27	1886.9	1905.4	1776.9	2047.4
2031-32	2378.7	2458.9	2186.7	2530.5
2036-37	2976.3	3175.4	2691.07	3049.4

\*All forecasts are reported for average weather conditions. See details of each scenario.

**Table 2: Electrical Energy Requirement CAGR (%) from PAM**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17 to 2021-22	5.01	5.10	4.61	6.18
2021-22 to 2026-27	5.10	5.22	4.24	5.51
2016-17 to 2026-27	5.05	5.16	4.43	5.84
2026-27 to 2036-37	4.66	5.24	4.24	4.06
2016-17 to 2036-37	4.86	5.20	4.33	4.95

In the BAU scenario of 7.3% GDP growth, Electrical Energy Requirement is projected to increase at a CAGR of 4.86% for the period FY 2016-17 to FY 2036-37. Energy Requirement is projected to increase from 1152.4 BU in

2016-17 to 1886.9 BU in 2026-27, 2378.7 BU in 2031-32 and 2976.3 BU in 2036-37. Under the baseline scenario, Electrical Energy Requirement is likely to increase 2.58 times between FY 2016-17 and FY 2036-37.

In the optimistic scenario of 8% GDP growth, Electrical Energy Requirement is projected to increase at a CAGR of 5.2% for the period FY 2016-17 to FY 2036-37. Energy Requirement is projected to increase from 1152.4 BU in 2016-17 to 1905.5 BU in 2026-27, 2458.9 BU in 2031-32 and 3175.4 BU in 2036-37. Under the optimistic scenario, Electrical Energy Requirement is likely to increase 2.75 times between 2016-17 and 2036-37.

In the low growth scenario of 6.5% growth, Electrical Energy Requirement is projected to increase at a CAGR of 4.33% for the period FY 2016-17 to FY 2036-37. Energy Requirement is projected to increase from 1152.4 BU in 2016-17 to 1776.9 BU in 2026-27, 2186.7 BU in 2031-32 and 2691.07 BU in 2036-37. Under the low growth scenario, Electrical Energy Requirement is likely to increase 2.33 times between 2016-17 and 2036-37.

An overview of Peak Electricity Demand (MW) for various future periods is shown in Table 3:

**Table 3: Peak Electricity Demand (in MW) from PAM**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17	158,994	158,994	158,994	161,834
2021-22	201,481	202,330	195,133	225,751
2026-27	255,911	259,628	239,299	298,774
2031-32	319,794	333,152	293,462	370,462
2036-37	398,172	427,497	359,882	447,702

\*All forecasts are reported for average weather conditions. See details of each scenario.

## Forecasts based on the SUR model

All-India electricity requirement forecasts as based on the regional SUR model under three different GDP scenarios- baseline or business-as-usual (BAU) scenario, optimistic scenario and pessimistic scenario are discussed below:

An overview of Electrical Energy Requirement (BU) and CAGR (%) for various scenarios is shown in Table 4 and Table 5:

**Table 4: Electrical Energy Requirement (in BU) from SUR**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17	1188.2	1188.2	1188.2	1160.4
2021-22	1550.0	1558.3	1488.2	1566.0
2026-27	2056.4	2095.7	1884.5	2047.4
2031-32	2685.1	2836.8	2395.4	2530.5
2036-37	3517.4	3878.2	3066.8	3049.4

\*All forecasts are reported for average weather conditions. See details of each scenario.

**Table 5: Electrical Energy Requirement CAGR (%) from SUR**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17 to 2021-22	5.46	5.57	4.61	6.18
2021-22 to 2026-27	5.82	6.1	4.83	5.51
2016-17 to 2026-27	5.64	5.84	4.72	5.84
2026-27 to 2036-37	5.51	6.35	4.99	4.06
2016-17 to 2036-37	5.58	6.09	4.86	4.95

In the BAU scenario of 7.3% GDP growth, Electrical Energy Requirement is projected to increase at a CAGR of 5.58% for the period FY 2016-17 to FY 2036-37. Energy Requirement is projected to increase from 1188.2 BU in 2016-17 to 2056.4 BU in 2026-27, 2685.1 BU in 2031-32 and 3517.4 BU in 2036-37. Under the baseline scenario, Electrical Energy Requirement is likely to increase 2.96 times between FY 2016-17 and FY 2036-37.

In the optimistic scenario of 8% GDP growth, Electrical Energy Requirement is projected to increase at a CAGR of 6.09% for the period FY 2016-17 to FY 2036-37. Energy Requirement is projected to increase from 1188.2 BU in 2016-17 to reach 2095.7 BU in 2026-27, 2836.8 BU in 2031-32 and 3878.2 BU in 2036-37. Under the optimistic scenario, Electrical Energy Requirement is likely to increase 3.26 times between 2016-17 and 2036-37.

In the low growth scenario of 6.5% growth, Electrical Energy Requirement is projected to increase at a CAGR of 4.86% for the period FY 2016-17 to FY 2036-37. Energy Requirement is projected to increase from 1188.2 BU in 2016-17 to reach 1884.5 BU in 2026-27, 2395.4 BU in 2031-32 and 3066.8 BU in 2036-37. Under the low growth scenario, Electrical Energy Requirement is likely to increase 2.58 times between 2016-17 and 2036-37.

An overview of Peak Electricity Demand (MW) for various future periods is shown in Table 6:

**Table 6: Peak Electricity Demand (in MW) from SUR**

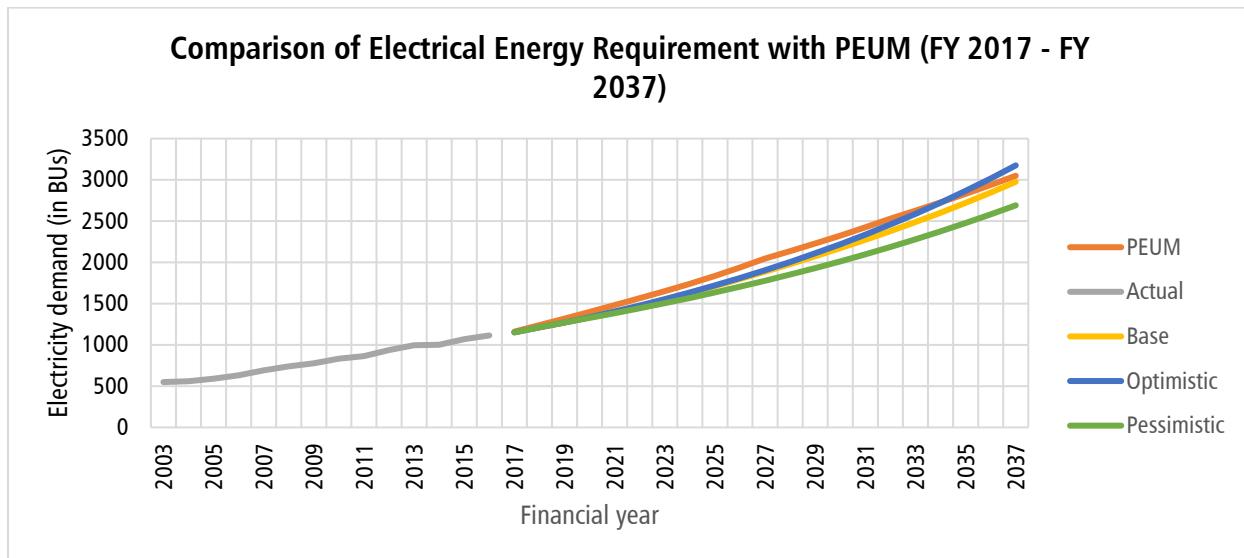
Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17	163,148	163,148	163,148	161,834
2021-22	212,828	213,972	204,340	225,751
2026-27	282,361	287,751	258,747	298,774
2031-32	368,683	389,512	328,904	370,462
2036-37	482,950	532,495	421,081	447,702

\*All forecasts are reported for average weather conditions. See details of each scenario.

## Comparison between 19th EPS forecast by PEUM and econometric method forecast

The difference in the forecast of Electrical Energy Requirement between 19<sup>th</sup> EPS forecast by PEUM and econometric method forecast from PAM for 2016-17 to 2036-37 is shown in Figure 1.

**Figure 1 Comparison of Electrical Energy Requirement under PAM with PEUM (FY 2017 – FY 2037)**



An analysis of the differences between the econometric forecasts under PAM and the 19<sup>th</sup> EPS forecasts by PEUM yields that the 19<sup>th</sup> EPS forecasts by PEUM are higher than both the BAU and the higher GDP growth scenario till the year 2031-32. The implied GDP growth rate in BAU is 7.3% whereas in the optimistic scenario it is around 8%. For the years beyond 2031-32, the econometric method forecasts under the BAU and the higher growth scenario compare favourably to the 19<sup>th</sup> EPS forecast by PEUM.

The actual Electrical Energy Requirement in India in the year 2016-17 and 2017-18 was 1142.9 BU and 1213.3 BU respectively. It is observed that the econometric method forecasts are closer to the actual Electrical Energy Requirement observed during both these years. The econometric method forecasts from PAM are higher than the actual Electrical Energy Requirement in 2016-17 (by 0.8%) and almost equal to the actual Electrical Energy Requirement in FY 2017-18 (with deviation of 0.03%)

The econometric method forecasts from SUR are higher than the actual Electrical Energy Requirement in FY 2016-17 (by 3.96%) and in FY 2017-18 (by 2.43%).



# Introduction

---

1

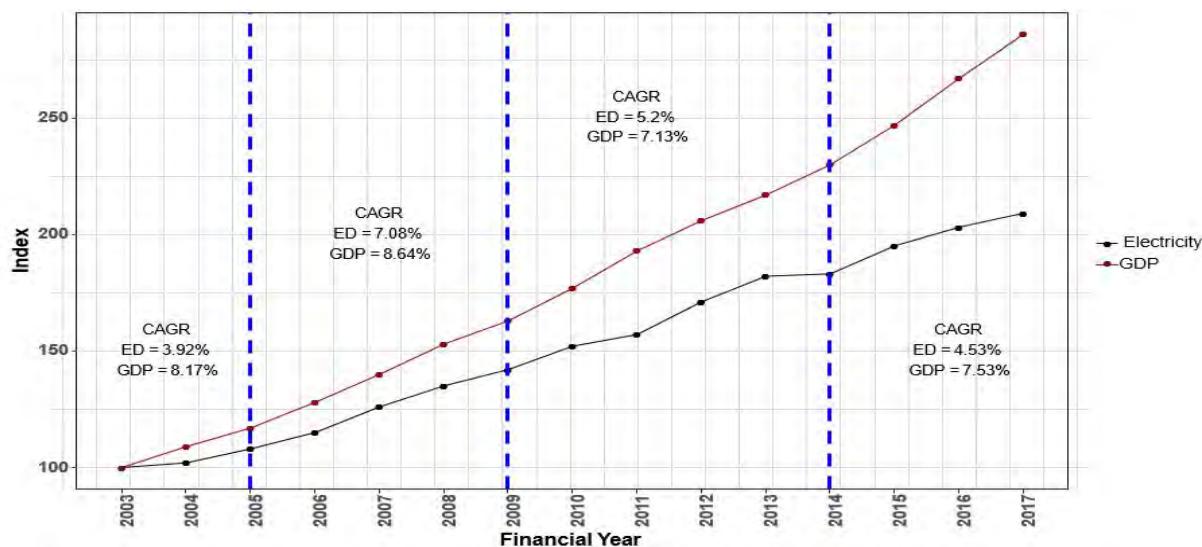


# 1. Introduction

India has witnessed profound social, economic, cultural and demographic changes, most of which have accelerated in the last decade. In the past decade, Electrical Energy Requirement in India increased steadily at a CAGR of 5.42% from 546 BUs in 2002-03 to 1,143 BUs in 2016-17. During the same period, the Indian economy experienced rapid modernisation and economic development with GDP increasing with a CAGR of 7.78% and population increasing with a CAGR of 1.45%. Figure 1.1 shows that India's GDP Index increased 2.8 times from the year 2002-03 to 2016-17 with a corresponding increase in Electrical Energy Requirement of approximately 2.1 times. Apparently, there is a strong positive relationship between income and Electrical Energy Requirement. However, the historical trends depicted in Figure 1.1 imply that the income elasticity of electricity requirement is falling over time. Between the years 2013-14 and 2016-17, the CAGR for GDP was almost double the CAGR for Electrical Energy Requirement. According to the annual report of the Planning Commission on the working of State Power Utilities & Electrical Departments (2014), the elasticity of electricity consumption vis-à-vis GDP has declined from 5.04 in the period 1960-61 to 1965-66 to 1.04 in the period 2006-07 to 2011-12.<sup>2</sup>

The varying relationship between income and Electrical Energy Requirement further highlights the need to understand the causes of these trends in the past, which, forms the basis of the future trajectory of Electrical Energy Requirement.

**Figure 1.1 Trends in all-India GDP and Electrical Energy Requirement (utility)**



In addition to rapid growth and development, many other macroeconomic factors, climatic factors, technological

<sup>2</sup> Report: [http://planningcommission.nic.in/reports/genrep/rep\\_arpower0306.pdf](http://planningcommission.nic.in/reports/genrep/rep_arpower0306.pdf)

As accessed on 1<sup>st</sup> April 2019



changes, consumer preferences, alternative energy sources, state-specific factors and energy policies are expected to impact Electrical Energy Requirement both in the short-run and long-run. For instance, on the one hand, policies and schemes such as Make in India, Dedicated Freight Corridor, Power for All are likely to increase electricity consumption dramatically; on the other hand, roof-top solar programme, Perform, Achieve and Trade (PAT), Bachat Lamp Yojana (BLY) and Star and Labelling programme are likely to reduce electricity demand on the grid. Furthermore, other advanced technologies such as electric vehicles could alter demand. Also with increasing global concerns due to climate change, there has been increasing focus on gradually reducing dependence on fossil fuels and increasing the share of renewable energy sources in the energy mix. The share of off-grid renewables such as solar pumps is expected to decrease demand for grid electricity in the future, as a result of numerous policies and programmes being recently implemented by the Ministry of New and Renewable Energy. Specifically, relatively slower growth in Electrical Energy Requirement during 2013-14 to 2016-17 can be attributed to increasing energy efficiency, rising captive generation and increasing share of off-grid renewables.

Central Electricity Authority (CEA) has been carrying out periodic electricity demand forecast for India by conducting National Electric Power Surveys. The basic objective of electricity demand forecasting has been to provide reliable inputs for carrying out long-term generation expansion planning along with commensurate transmission and distribution facilities. Many government and private organisations have been using the electricity demand forecast for various purposes.

Several methods of forecasting are available which vary from simple extrapolation of the past demand to sophisticated econometric models involving a number of variables and parameters. The earliest indicators used for energy forecasting were simple measures such as growth rates, elasticities, and energy intensity (ratio of Energy requirement to GDP). Over time, sophisticated techniques have been developed to determine electricity demand ranging from econometric models, time series co-integration models, end-use models, hybrid models (that combine features of economic and engineering models), systemic dynamic models, semi-parametric models, scenario approaches, decomposition models, process models, input-output models and artificial neural networks.

Table 1.1 summarises different models that have been used in past studies for forecasting long-term electricity demand.

**Table 1.1 Models for electricity demand forecasting**

Model	Explanation of the approach
<b>Time series</b>	A forecasting model is developed based on the previously observed values of demand. Models for time series data represent different stochastic processes — autoregressive models, integrated models and moving average models.
<b>Multivariate regression</b>	Electricity demand is modelled as a function of a number of independent variables such as income, price and weather-related factors. The most common method used is least squares regression.

Model	Explanation of the approach
<b>Non-parametric/Semi-parametric analysis</b>	<p>Model structure is not fixed as in case of parametric models but determined from data. Extensively used in the past to study the non-linear relationship between electricity demand and its key explanatory variables such as temperature, income and price. A common method used is generalised additive model.</p>
<b>Panel data analysis</b>	<p>A panel data set is one where there are repeated observations on the same unit such as states, households and countries. Fixed effect model allows for unit-specific unobserved factors that are constant over time.</p> <p>A dynamic panel, through inclusion of lagged electricity demand terms, can allow for a dynamic adjustment process of electricity demand when there is a change in the determinants of electricity demand. The adjustment process arises as there is inertia which slows adjustment process in response to changes in economic variables such as GDP. A dynamic panel can also enable us to distinguish between short- and long-term elasticities of electricity demand.</p>
<b>Co-integration analysis</b>	<p>These models are used due to non-stationary nature of electricity consumption, real energy prices and income variables. If the variables are found to be co-integrated, the electricity demand is modelled using the vector error-correction (VECM) framework to estimate short-run and long-run income, price and temperature elasticities.</p>
<b>End-use approach</b>	<p>The end-use approach focusses on end uses or final needs at a disaggregated level. The method aggregates the electricity demand in the economy by consumer categories — residential, industrial, commercial and agriculture. The electricity demand for each category is calculated on the basis of the use of various electric appliances.</p> <p>This method allows incorporation of the energy efficiency improvements in the economy, changes in the energy-mix and other efficiency measures.</p>
<b>Hybrid approach</b>	<p>These models attempt to reduce the methodological divergence between the econometric and engineering models by combining the features of the two traditions.</p>
<b>Input-output models</b>	<p>These models provide a framework that is able to capture the direct as well as indirect energy demands through inter-industry transactions. This approach is highly data-intensive.</p>



Model	Explanation of the approach
<b>Machine learning</b>	Artificial intelligence-based techniques include neural networks, support vector machine, wavelet networks and fuzzy logic.
<b>Scenario approach</b>	This approach involves the development of plausible scenarios that could capture structural changes, emergence of new economic activities or disappearance of activities.

CEA uses the PEUM to forecast the electricity demand. PEUM is a 'bottom-up' approach focusing on end uses or final electrical energy needs of different categories of consumers such as domestic, commercial, irrigation, industries and railway traction. In addition to this method of demand forecasting, CEA has been using simple/multiple regression techniques to validate the forecast of various electric power surveys from time to time.

CEA, in its 18<sup>th</sup> EPS report in collaboration with Indian Statistical Institute (ISI), had published the forecast of electricity demand using econometric method in April, 2014. The forecast was made using multiple regression techniques on panel data through selection of independent econometric variables with state fixed effect technique using past data. The projection of the future had been made by selecting appropriate growth rates for various independent variables and through a set of scenarios. In literature, there exist numerous studies that applied different variants of panel data models to estimate long-term electricity demand at the national/international level.

Electricity demand forecasting models have typically been developed using its key drivers. While electricity demand can be explained by past trends alone (univariate analysis), it is also typically influenced by a combination of drivers that may be broadly categorised as economic, demographic, behavioural and meteorological factors. Some factors have a greater impact on annual electricity demand, while others on monthly electricity demand. GDP, population, and urbanisation are some socio-economic factors that impact electricity demand at an annual level. At a monthly level, the effect of changes in temperature on electricity demand can be significant. Other climate variables such as rainfall, wind and cloud cover also play a role in determining electricity consumption, especially in states where majority of the load is used for domestic and agricultural purposes. These latter variables are typically used in short-term demand forecast (typically day ahead or intra-day forecasts). Some of these drivers are listed in Table 1.2 from past studies.

**Table 1.2 Summary of panel data studies on electricity demand**

S.No.	Paper/Report name	Authors and year of the study	Period under study	Temporal granularity	Spatial granularity	Dependent variables	Independent variables under consideration
1	Causal relationship between energy consumption and GDP growth revisited: a dynamic panel data approach (2008)	Bwo-Nung Huang, M.J. Hwangc, C.W. Yang	1972-2002	Annual energy consumption	82 countries	Log of energy consumption	<ul style="list-style-type: none"> <li>• Log of energy consumption</li> <li>• Log of per capita real GDP</li> <li>• Log of the share of capital formation to GDP to represent capital stock</li> <li>• Log of population to represent labour force</li> </ul> Log of GDP deflator
2	The effect of development on the climate sensitivity of electricity demand in India (2016)	Gupta, Eshita	2005-2009	Daily electricity demand	28 Indian states	Log of daily electricity demand	<ul style="list-style-type: none"> <li>• Gross domestic product per capita</li> <li>• Population</li> <li>• HDD and CDD</li> <li>• Sector-wise electricity price</li> <li>• Pump sets</li> <li>• Rainfall</li> </ul>
3	Residential electricity demand in Spain: new empirical evidence using aggregate data (2013)	Leticia Blázquez, Nina Boogenb and Massimo Filippini	2000-2008	Annual electricity demand of residential sector	47 Spanish provinces	Log of residential electricity demand	<ul style="list-style-type: none"> <li>• Price</li> <li>• Income, i.e. net disposable income (real)</li> <li>• Weather conditions</li> <li>• Population (province-wise)</li> <li>• Household size</li> <li>• Natural gas penetration/proxy for gas price: measured as the number of gas consumers divided by number of houses</li> </ul> CDD/HDD
4	18 <sup>th</sup> Electric Power Survey	Central Electricity Authority and Indian Statistical Institute	1980-2010	Annual electricity demand	All Indian states	Log of electricity demand	<ul style="list-style-type: none"> <li>• Real State Domestic Product per capita</li> <li>• State population rate of urbanisation</li> <li>• Percentage of population electrified</li> </ul>



S.No.	Paper/Report name	Authors and year of the study	Period under study	Temporal granularity	Spatial granularity	Dependent variables	Independent variables under consideration
							<ul style="list-style-type: none"> <li>• Poverty head count ratio</li> <li>• Wholesale Price Index of electricity (all India)</li> </ul> <p>Structure of state (measured by share of agriculture, industry and service in state's domestic product)</p>
5	Seasonal temperature variations and energy demand: a panel cointegration analysis for climate change impact assessment (2013)	Enrica De Cian, Elisa Lanzi, Roberto Roson	1978-2000	Annual energy demand	31 OECD and non-OECD countries	Log of residential electricity demand	<ul style="list-style-type: none"> <li>• Average seasonal temperature</li> <li>• Lagged dependent variable</li> <li>• Alternative energy prices</li> </ul> <p>Real per capita GDP</p>
6	Modelling Ontario's regional electricity system demand using a mixed fixed and random coefficients approach*(1989)	Cheng HSIAO, Dean C. MOUNTAIN and M.W. Luke CHAN, Kai Y. TSUI	1967-1982	Monthly municipal peak and kilowatt-hour demand	Ontario — 9 municipalities	Monthly peak demand	<ul style="list-style-type: none"> <li>• Income</li> <li>• Price of the relevant electricity commodity</li> <li>• Since an income variable was not directly available by municipality, it was approximated by the product of average weekly earnings of the industrial composite and a composite index number of employment for urban areas</li> <li>• Region-specific factors</li> <li>• 12 regional monthly dummies to represent the regional- and seasonal-specific factors</li> </ul> <p>CDDs and HDDs</p>
7	A PES of the US electricity	Anthony Paul, Erica	1990-2006	Monthly demand	USA, state-level (48)	Electricity	<ul style="list-style-type: none"> <li>• Annual disposable income per capita</li> </ul>

S.No.	Paper/Report name	Authors and year of the study	Period under study	Temporal granularity	Spatial granularity	Dependent variables	Independent variables under consideration
	demand by region, season, and sector (2009)	Myers, and Karen Palmer		estimated for each of the three customer classes and nine US census divisions	states and district of Columbia)	consumption per capita per consumer for residential and commercial classes	<p>for the residential class and gross annual state product for the commercial and industrial classes</p> <ul style="list-style-type: none"> <li>• Average retail electricity price; it varies by customer class</li> <li>• HDD and CDD</li> <li>• Number of minutes of daylight in the capital of each state on the 15th day of each month, which varies across months but not across years</li> <li>• The retail price for delivered natural gas that is included only for the residential class</li> </ul> <p>FE that are state-level fixed effects</p>
8	The non-linear link between electricity consumption and temperature in Europe: a threshold panel approach (2008)	Marie Bessec, Julien Fouquaut	1985-2000	Monthly electricity consumption	15 European countries	Electricity consumption	<ul style="list-style-type: none"> <li>• Temperature</li> <li>• Summer holiday dummy</li> <li>• Cubic trend</li> <li>• Population</li> <li>• Production in total manufacturing</li> <li>• Monthly dummy variables</li> </ul>

In the current study, the long-term electricity demand has been forecast both at the state and all-India level. The model has been estimated based on the monthly electricity demand data of 25 states and three UTs during the period 2002-03 to 2015-16, within panel framework for each of the five regions — north, south, east, west and north-east. The states included in different regions for estimating regional panel data models are listed in Table 1.3. The key advantage of using regional panel data analysis is that it allows to control for heterogeneity across differentiated Indian states within a given region and enables to account for state-specific unobserved factors



that are constant over time. For states and UTs(other than Lakshadweep<sup>3</sup>) not included in the panel model, the future Electricity Requirement and Peak Demand forecast has been obtained based on all-India CAGR of 5%. These states/UTs contributed just 1.65% of the total India's Electrical Energy Requirement in FY 2016. Himachal Pradesh has not been included in the analysis due to non-availability of weather data. Weather data for Shimla was available only post FY 2014-15, that was insufficient for the purpose of our analysis

Electricity demand forecast of Telangana is included in the forecast of Andhra Pradesh as its substantial data was not available separately for the past years.

**Table 1.3 States selected in different regions for regional panel data analysis**

Region	States
<b>North</b>	Delhi, Haryana, Rajasthan, Uttar Pradesh, Uttarakhand, Jammu and Kashmir, Punjab, Chandigarh
<b>South</b>	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Puducherry
<b>East</b>	Bihar, Jharkhand, Odisha, West Bengal
<b>West</b>	Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, Goa
<b>North East</b>	Assam, Manipur, Tripura, Meghalaya, Mizoram, Nagaland
<b>Others (forecast on the basis of all-India average rate of growth of 5% per annum)</b>	Himachal Pradesh, Arunachal Pradesh, Dadar and Nagar Haveli, Sikkim, Daman and Diu, Andaman and Nicobar Islands, Lakshadweep

---

<sup>3</sup> In case of Lakshadweep, while Electricity Requirement has been obtained at 5% growth as done for other states but Peak Demand has been considered constant during our forecasting period because almost constant Peak Demand was observed during period FY2011-FY2016.



# Methodology for econometric forecasting

---

2



## 2. Methodology for econometric forecasting

This chapter discusses the modelling techniques used for electricity demand forecasting by econometric method using panel data.

### 2.1 Methodology

#### 2.1.1 Panel data

Panel data typically refers to data containing time-series observations of a number of states. Therefore, observations in panel data involve at least two dimensions; a state-level or cross-sectional dimension and time dimension. Panel data blends the inter-state differences and intra-state dynamics. This leads to several advantages over only cross-sectional or time-series data. Important benefits of panel data estimation are:

- 2.1.1.1 It is a more accurate inference of model parameters. Panel data usually contains more degrees of freedom and more sample variability than cross-sectional data which may be viewed as a panel of only one-time period, or time-series data for only one state, hence improving the efficiency of econometric estimates.
- 2.1.1.2 Panel data controls for omitted variables. A panel model can control for the state-specific, time-invariant factors through the use of state-specific intercepts or "fixed effect". These fixed effects, in essence, capture the impact of variables that are time-invariant and unobservable to the econometrician (such as, the innate preferences of the consumers regarding restricted use of electricity demand. These intrinsic tendencies of consumers would not be expected to change during the time span of roughly 15 years over which the analysis is conducted.)
- 2.1.1.3 The fixed-effect estimation method is carried out by demeaning each of the variables i.e. the variable is transformed by subtracting the mean value of the variable over time (the temporal dimension). Demeaning the variables along the temporal dimension would eliminate the heterogeneous fixed effects (idiosyncrasies that are assumed to be stable). Demeaning variables 'within-subject' implies that the mean value for each variable (over time) is subtracted from each observed value of the variable. Hence, within each subject, all the demeaned variables have a mean of zero. For time-invariant variables, the demeaned variables will have a value of zero for every case, and since they are constants, they will drop out of any further analysis. This removes all the between-subject variability (which may be diluted by the presence of omitted variable bias) and leaves only the within-subject variability to analyse.
- 2.1.1.4 In a time-series model, any factor would typically be strongly correlated with its lagged value. With panel data, we can rely on the inter-state differences to reduce the collinearity between current and lag variables to estimate unrestricted time-adjustment patterns.



2.1.1.5 Panel data arrives at more accurate predictions for individual state outcomes by pooling the data rather than generating predictions of individual state outcomes using the data on the individual state in question. If the electricity demand of each state is similarly dependent on certain variables, panel data provides the possibility of learning an individual state's behaviour by observing the behaviour of others. Thus, it is possible to obtain a more accurate description of an individual state's behaviour by supplementing observations of the individual state in question with data on other states.

Two variants of fixed effect model, the long panel model (adopted in 18<sup>th</sup> EPS) and partial adjustment model (PAM), are estimated. In addition to the two fixed effect models, one state-specific model is estimated using seemingly unrelated regression estimation (SURE) approach. All three models are discussed below in detail.

## 2.1.2 Long panel model

Electricity demand across states is likely to be dependent on time, i.e. it is natural to expect electricity demand in any given year to be dependent on its previous value, especially as the overall capital stock governing electricity supply can be considered as fixed in the short-run. The monthly data used for the model development in the current study is long panel, with each state spanning over 168 periods (monthly data spanning over 14 years).

The most commonly used method of panel data is ordinary least squares (OLS) estimation. OLS is a statistical technique for estimating changes in a dependent variable (such as electricity demand) which is in linear relationship with independent variables (such as GDP, real electricity price etc.). It is named so because, in its computation, the sum of the squared deviations of the predicted values from the observed (past) values of the variables is minimised.

The long time-series-cross-section data may have correlation in electricity demand across states in the same period (known as contemporaneous correlation) as these cross-sectional units are subject to spill overs from economy wide shocks. In addition, there is a correlation of electricity demand with its lagged values within states (known as serial correlation) and non-constant variance of the electricity demand (known as heteroscedasticity) across the ranges of values of the independent variables (that predict it). However, OLS regression requires that there is no contemporaneous correlation in electricity demand across states and no serial correlation within states, and that electricity demand should have constant variance across different ranges of independent variables.

The long-panel fixed effect model transforms the error term associated with the data using the Prais-Winsten<sup>4</sup> regression, so that the assumption requiring no serial correlation in electricity demand or errors is not violated. In this method, coefficient of correlation between the error terms (called rho), is estimated from the data by regressing the OLS residuals on the lagged residuals. This estimated rho is then used to transform both electricity demand and all the independent variables such that the correlation in electricity demand and its one period lagged value is accounted in the estimation.

It also estimates panel-corrected standard errors (PCSE) to account for correlation across units (year-specific shocks) and non-constant variance of the electricity demand. The fixed effect panel data model is estimated in

---

<sup>4</sup> This methodology is explained in the appendix in detail.<sup>5</sup> The theory of partial adjustment model is explained in detail in the appendix.

the current dataset observations on cross-section units which are repeated over long time periods. This model was also estimated in the 18<sup>th</sup> EPS to forecast future electricity demand at the all-India level. The long panel model has been estimated using data for 25 states and three UTs in all the five regions — north, west, south, east and north-east. The estimated model is:

$$\log Y_{State,t} = \beta_1 \log(GDP)_{t-12} + \beta_2 \log(REP) + \beta_3 CDD + \beta_4 HDD + \sum \beta_5 Rainfall \\ + \sum \beta_{s,TP} Dummy + \sum \beta_{s,m} Dummy + \varepsilon_{s,t}$$

The dependent variable is the monthly state Electrical Energy Requirement between 2002-03 and 2015-16. The independent variables used include GDP lagged by 12 months, real electricity prices, CDDs, HDDs, rainfall, state by month fixed effect (accounting for factors particular to a state that are distinct in every month) and dummies for incorporating structural break between time periods.

### 2.1.3 Partial adjustment model (PAM)

Electricity demand is a derived demand that arises from demand of energy services such as space conditioning, cooking and lighting, for which we require investment in electric equipment. However, adjustment takes time as investment in electric equipment is not immediate. The dynamics arise as a result of the demand stickiness prevalent in electricity consumption because of its capital-intensive nature.

Specifically, the partial adjustment model has been used in a fixed effects framework to incorporate the dynamics of electricity demand behaviour and hence improve upon simple “long panel” static models where such impacts are not captured. This inertia in demand is captured by including lagged dependent variables in the model<sup>5</sup>. Thus, this model is dynamic as it does not assume an instantaneous adjustment to new equilibrium values (as in the long panel model) when any independent variable (such as price or income) changes. It is assumed that the household can change the rate of utilisation of the existing stock of appliances, but not the existing capital stock with variations in prices or income, so that the short-run and long-run elasticities are not same. While the long panel model only estimates long-run elasticities, the partial adjustment model estimates both short-run and long-run elasticities. These adjustments vary by regions in India and this provides a useful insight into how demand would grow in various regions. As in the case of the long panel model, the fixed effect PAM has been estimated using data for 25 states and three UTs in all the five regions — north, south, east, west and north-east. The estimated model is:

$$\log Y_{State,t} = \beta_1 \log(ED)_{t-1} + \beta_2 \log(ED)_{t-12} + \beta_3 \log(GDP)_{t-12} + \beta_4 \log(REP) + \beta_5 CDD + \beta_6 HDD \\ + \sum \beta_7 Rainfall + \sum \beta_{s,TP} Dummy + \sum \beta_{s,m} Dummy + \varepsilon_{s,t}$$

The dependent variable is the monthly state Electrical Energy Requirement or Peak Electricity Demand between the years 2002-03 and 2015-16. The independent variables used include electricity demand lagged by one and 12 months, respectively, GDP lagged by 12 months, real electricity prices, CDDs, HDDs, rainfall, state-specific time dummies in order to account for structural breaks over time and state-specific month dummies to account for state-specific seasonality.

---

<sup>5</sup> The theory of partial adjustment model is explained in detail in the appendix.

The above two models (long panel and PAM) estimate electricity demand (in MU and MW) within regional panel framework which implicitly assumes regional convergence in electricity demand over time. The assumption of regional convergence may turn out to be wrong if an individual state takes on its individual path. Thus, for comparison purposes, the state-specific model is estimated using regional seemingly unrelated regression (SUR) model.

#### 2.1.4 Seemingly unrelated regression estimation (SURE)

The SUR model estimates a state-specific model for electricity demand. But instead of estimating each state equation separately, as in the case of OLS, it exploits the additional information from the error structure of other states that are linked by the fact that their disturbances or the error terms are correlated in the same period. The correlation among the equation disturbances can come from many sources like correlated shocks to the macro economy.

As it is reasonable to expect contemporaneous correlation in electricity demand of different states within a region, pooling temporal cross-sectional observations in the form of Zellner's SUR model help to improve the efficiency of the estimates of state-specific parameters. As a first step, presence of contemporaneous correlation is checked using the Breusch-Pagan test. There was evidence of strong correlation between the error terms of states at the regional level (i.e. between states in each of the five regions considered). Thus, the region-specific model allows to obtain state-specific coefficients adjusted for inter-dependencies in electricity demand, in the same time-period among states in each region. The model is estimated as a system of equations for all states ( $s$ ) within each region with stacking of observations over's':

$$\log Y_s = X_s \beta_s + \varepsilon_s$$

For  $s = 1, \dots, M$ .  $M$  is the number of states in each region.  $Y_s$  and  $\varepsilon_s$  are  $N$ -vectors and  $X_s$  is  $N \times K_s$  matrix, where  $K_s = \dim(\beta_s)$ . The dependent variable is the monthly state Electrical Energy Requirement between 2002-03 and 2015-16.  $X$  represents the set of independent variables used for explaining electricity demand such as GDP, price, rainfall, population etc. The chosen specific independent variables vary across states according to what variables best explain as electricity demand in each state (for example: HDD has been considered for states that experience winters such as northern states while dropped for states that do not experience winters such as southern states).

The model assumes that, within each state, the error terms can be dependent on each other over time (electricity demand in a state at any given period will be closely related to previous period values because of the inertia in electricity demand). The error terms across states can be related only in the same year and not over time. Therefore, the errors can be serially correlated within each cross-sectional unit but allows only contemporaneous correlation across cross-sectional units. Furthermore, the magnitude of this contemporaneous correlation across states does not change over time<sup>6</sup>.

---

<sup>6</sup> There is no time heterogeneity, i.e.  $E(E_{it}E_{jt}) = \sigma_{ij}$



## 2.2 Data used

The dependent variable in all the models is monthly Electrical Energy Requirement or Peak Electricity Demand in a state/India depending on the model under consideration. The monthly Electrical Energy Requirement is measured in Million Units (MU) and monthly Peak Electricity Demand is measured in Megawatts (MW). Key explanatory variables in the proposed forecasting models are categorised into two groups — weather variables i.e. temperature and rainfall, and socio-economic variables i.e. GDP (in billion rupees), population (in numbers), per capita income (in rupees) and sector's share of GDP (in %). All the weather-related variables are available at the monthly or daily level. These monthly driver variables are captured either at a monthly frequency or constructed by taking monthly totals or averages over daily level data. Annual variables, on the other hand, are those variables captured at the end of every financial year.

A key summary of the variables used in the analysis is given in Table 2.1:

**Table 2.1 Variables used in analysis**

Variables used	Description	Period
Agriculture	Share of agriculture in GDP of the state	FY 2002-03 to FY 2015-16
Mining	Share of mining in GDP of the state	FY 2002-03 to FY 2015-16
Electricity	Share of electricity in GDP of the state	FY 2002-03 to FY 2015-16
Industry	Share of industry in GDP of the state	FY 2002-03 to FY 2015-16
Construction	Share of construction in GDP of the state	FY 2002-03 to FY 2015-16
Trade	Share of trade in GDP of the state	FY 2002-03 to FY 2015-16
Banking	Share of banking in GDP of the state	FY 2002-03 to FY 2015-16
Public services	Share of public services in GDP of the state	FY 2002-03 to FY 2015-16
Transport	Share of transport in GDP of the state	FY 2002-03 to FY 2015-16
Manufacturing	Share of manufacturing in GDP of the state	FY 2002-03 to FY 2015-16
Services	Share of services in GDP of the state	FY 2002-03 to FY 2015-16
Gross irrigated area	Gross area units of irrigated area in the state	FY 2002-03 to FY 2015-16
Gross unirrigated area	Gross area units of unirrigated area in the state	FY 2002-03 to FY 2015-16
Annual rainfall	Annual rainfall received	FY 2002-03 to FY 2015-16
CDDs	Cooling degree days	FY 2002-03 to FY 2015-16
HDDs	Heating degree days	FY 2002-03 to FY 2015-16



Monthly rainfall	Monthly rainfall received	FY 2002-03 to FY 2015-16
Structural change	Political party at the centre	FY 2002-03 to FY 2015-16
Per capita	Per capita income of the state	FY 2002-03 to FY 2015-16
GDP	GDP of the state	FY 2002-03 to FY 2015-16
GDP per capita	GDP per capita of the state	FY 2002-03 to FY 2015-16
Lagged electricity demand	Electricity demand lagged by 12 months	FY 2002-03 to FY 2015-16
Electricity prices	State-wise annual real electricity prices	FY 2002-03 to FY 2015-16
Urbanisation	State-wise annual urbanisation rate	FY 2002-03 to FY 2015-16
Villages electrified	State-wise annual percentage of villages electrified	FY 2002-03 to FY 2015-16
Total pump sets	State-wise annual number of pump sets	FY 2002-03 to FY 2015-16
Index of industrial production	Annual all-India index of industrial production	FY 2002-03 to FY 2015-16

All the variables listed in Table 2.1 were tested in the model. However, only those variables that were statistically significant and that improved the fit of the model were included in the final model. To reiterate, the variables that were statistically insignificant or not improving the explanatory power of the model were dropped. Some of the primary reasons for dropping these variables were:

**Collinearity of variables with GDP:** Some variables such as population, rate of urbanisation and rate of poverty were highly correlated with GDP. This is because higher level of economic growth measured by higher GPD values is positively related with the rate of urbanisation and rate of poverty. In a way, one predictor variable can be used to predict the other and this introduced redundant information in the model. Because of the inter-relationships of these variables with GDP, the inclusion of these variables in the model, along with GDP, would affect how GDP singularly affects the electricity demand (by altering the coefficient of the GDP term by making it insignificant or negative). Therefore, to avoid the problem of collinearity, all collinear variables have been removed from the model, except GDP.

**Issues of changes in data methodologies:** Complete data was available for variables such as village electrification and total pump sets used in agriculture. The data methodology adopted for calculation of village electrification was changed multiple times during the period of analysis. Due to change in computation methodologies, the data could not be relied upon as there appeared to be arbitrary fluctuations in the estimates.

**Insignificance of variables:** As discussed above, variables that did not improve fit of the model were excluded to keep the model parsimonious, i.e. to maximise explanatory power of the model using the minimum amount of data. Variables such as the index of industrial production (IIP), structure of the economy, gross irrigated area and gross unirrigated area were statistically insignificant when introduced in the model and were, thus, excluded from our analysis.

Specifically, the variables that have been incorporated in the final version of the models, after multiple iterations, are as given in Table 2.2:

**Table 2.2 Variables used in the final model**

Independent variables	Description	Rationale
GDP	State-wise GDP estimates	To capture structural features of the state
Lagged electricity demand (1 month lag)	State-wise electricity demand estimates	1. To capture structural features of the state 2. To capture short-term dynamics of electricity demand
Lagged electricity demand (12 month lag)	State-wise electricity demand estimates	1. To capture structural features of the state 2. To capture long-term dynamics of electricity demand
HDDs	Heating degree days	To capture weather dynamics of the state
CDDs	Cooling degree days	To capture weather dynamics of the state
Rainfall	Monthly estimates for state-wise rainfall	To capture weather dynamics of the state
Period breaks	Dummy variable reflecting variation in demand due to change in government	To capture structural time break
State fixed effects	Fixed effect for each state	Capture state-specific time invariant factors that impact electricity demand in the state but are unobservable to the econometrician
Month fixed effects	Fixed effect for each month	Capture seasonal factors that impact electricity demand in the state but are unobservable to the econometrician



# Historical trends of variables

---

3

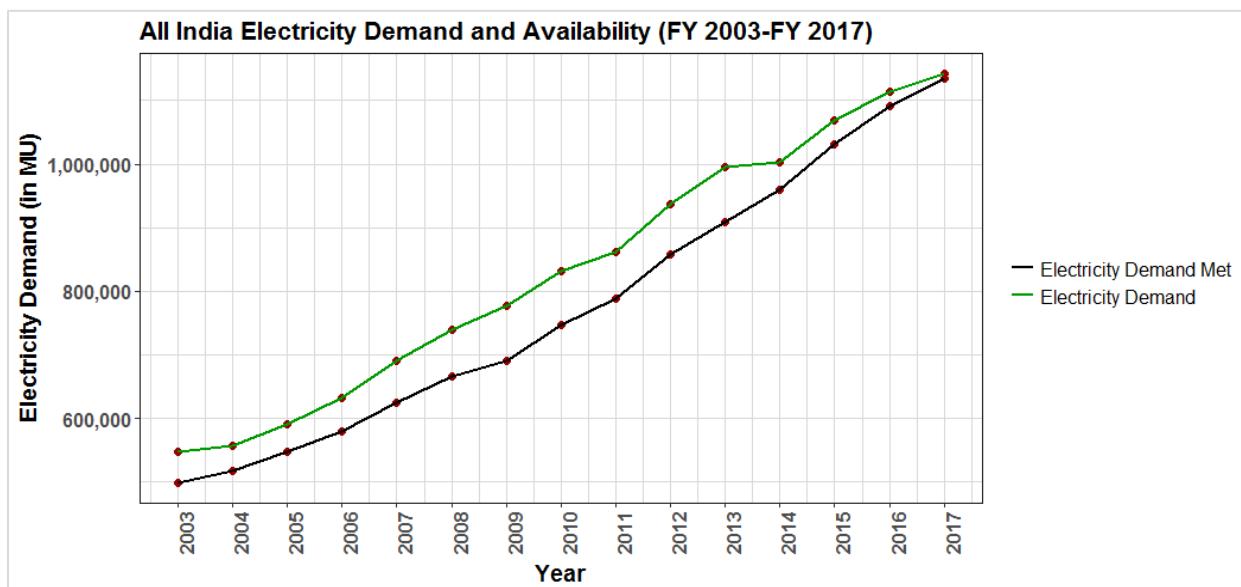


### 3. Historical trends of variables

#### 3.1 Trends in electricity demand

Overall, India has seen a rise in Electrical Energy Requirement and electrical energy met over the years. Figure 3.1 maps the change in the country's Electrical Energy Requirement and electrical energy met during the years 2002-03 to 2016-17. The electrical energy not met as measured by the gap between these two electricity measures has been decreasing over the years.

Figure 3.1 Trends in electrical energy requirement and electrical energy met

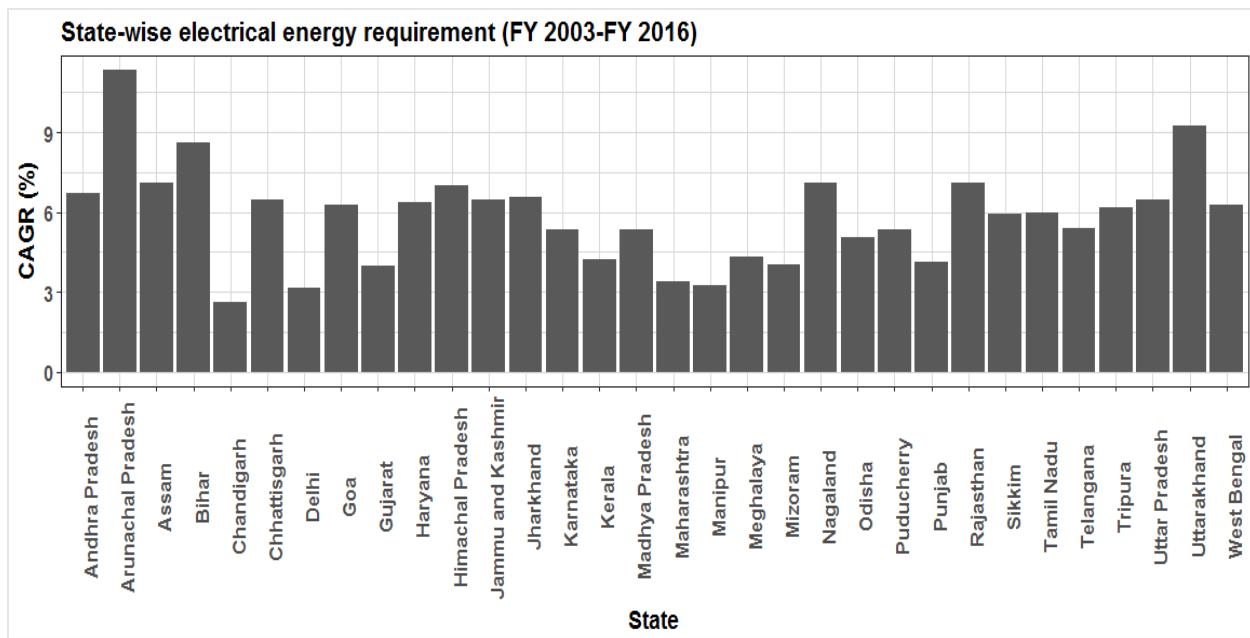


The CAGR of electricity energy requirement over this period has been 5.4%. Growth over the period may be attributed to factors such as economic development, growing population, rise in standard of living coupled with greater electrical appliance penetration, poverty alleviation, urbanisation etc.

Figure 3.2 presents state-wise CAGR of total Electrical Energy Requirement between 2002-03 and 2015-16. Some less developed states with low base Electrical Energy Requirement in the year 2002-03, such as Bihar, Arunachal Pradesh and Chhattisgarh, have witnessed a significant rate of growth during the period 2002-03 to 2015-16.



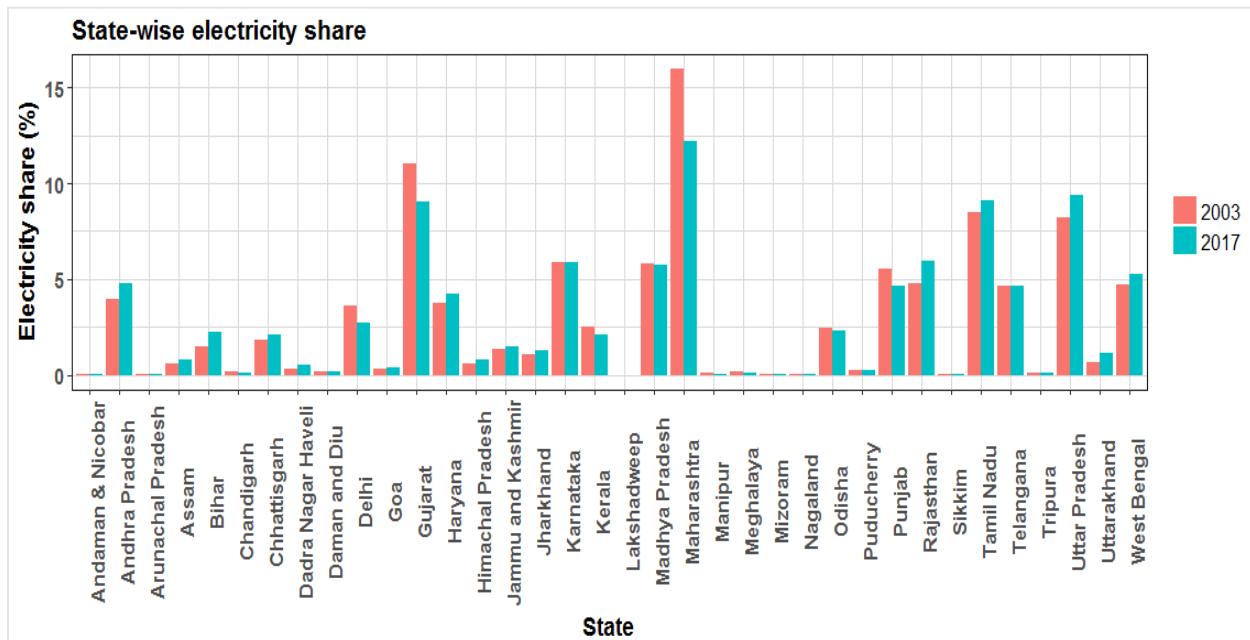
**Figure 3.2 State-wise CAGR of Electrical Energy Requirement**



*Figure 3. 1 State wise*

Figure 3.3 plots each state's share in total Electrical Energy Requirement of India. It is observed that 17 states — Maharashtra, Tamil Nadu, Uttar Pradesh, Gujarat, Punjab, Karnataka, Rajasthan, Madhya Pradesh, Andhra Pradesh & Telangana (bifurcated on a 49:51 basis), West Bengal, Haryana, Delhi, Odisha, Chhattisgarh, Bihar and Kerala account for 92.4% of Electrical Energy Requirement in FY 2015-16.

**Figure 3.3 State-wise electricity shares**

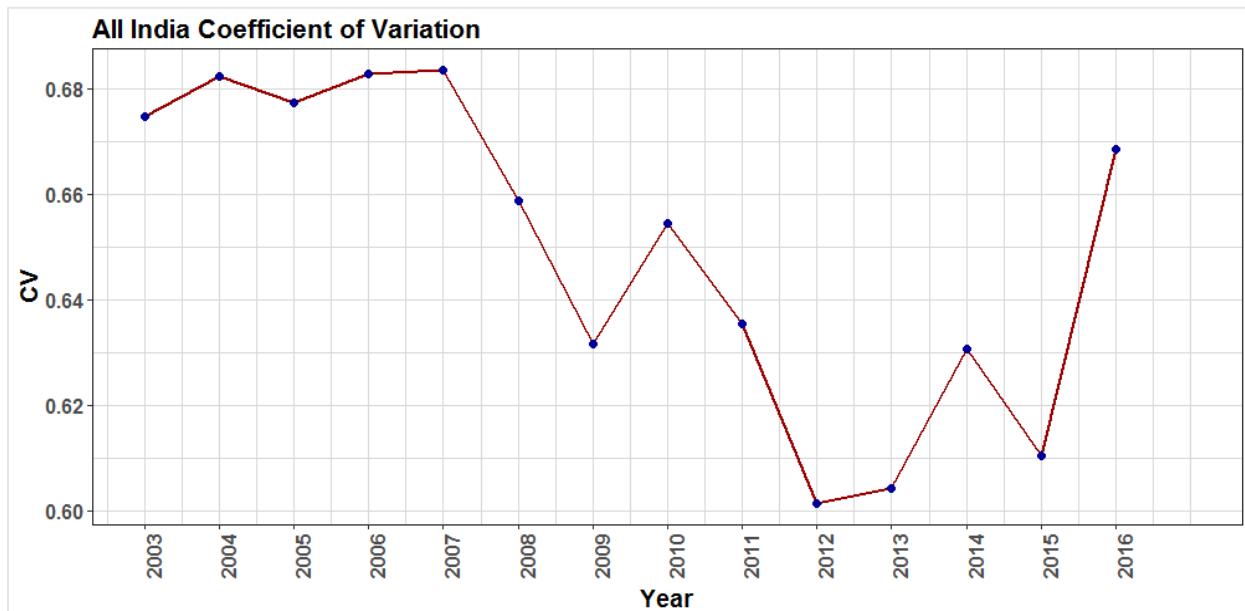


Between FY 2002-03 and FY 2011-12, there seems to be a trend of sigma convergence<sup>7</sup> in the per-capita electricity consumption between states, with a decline in the dispersion in per-capita electricity consumption between states. However, this trend of convergence seems to have reversed post 2011-12 and there appears to be a recent spike in disparity in inter-state per capita electricity consumption in the year 2015-16, as can be seen in Figure 3.4. The dispersion is measured by computing a coefficient of variation (CV) for each financial year, where:

$$CV = (\text{Standard deviation of per capita electricity consumption across states})$$

$$(\text{Mean per capita electricity consumption across states})$$

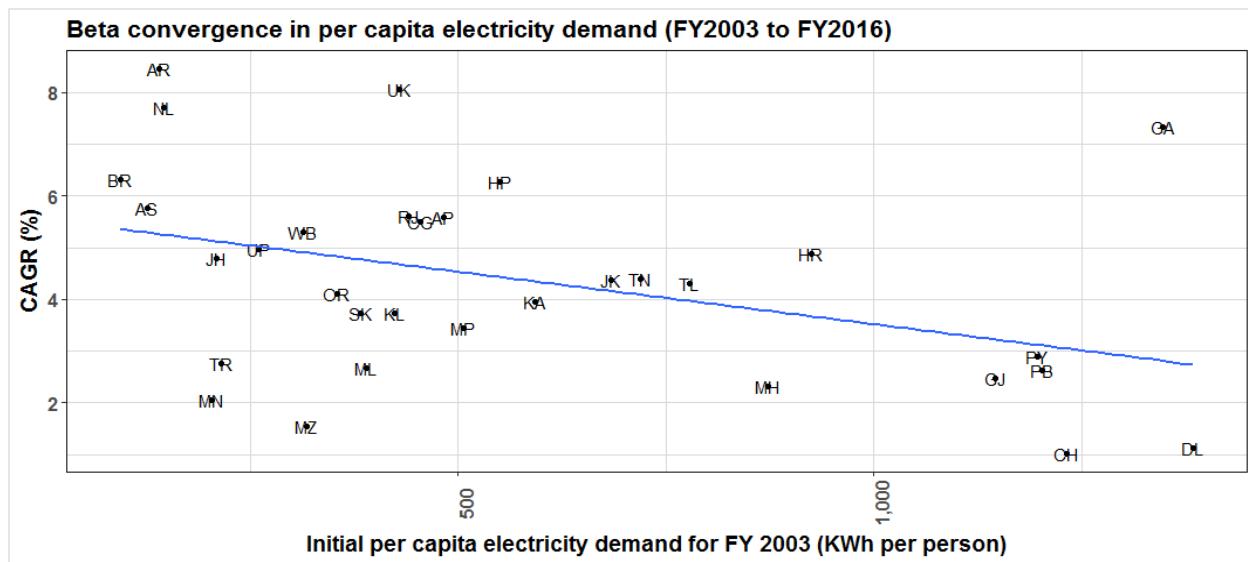
**Figure 3.4 Coefficient of variation**



However, states with lower initial per capita electricity demand in the year 2002-03 seem to be growing faster when compared to states with higher initial per capita electricity demand in the year 2002-03. Figure 3.5 indicates that all states are converging towards the same equilibrium in terms of electricity demand per capita and growth rate, which is known as beta convergence.

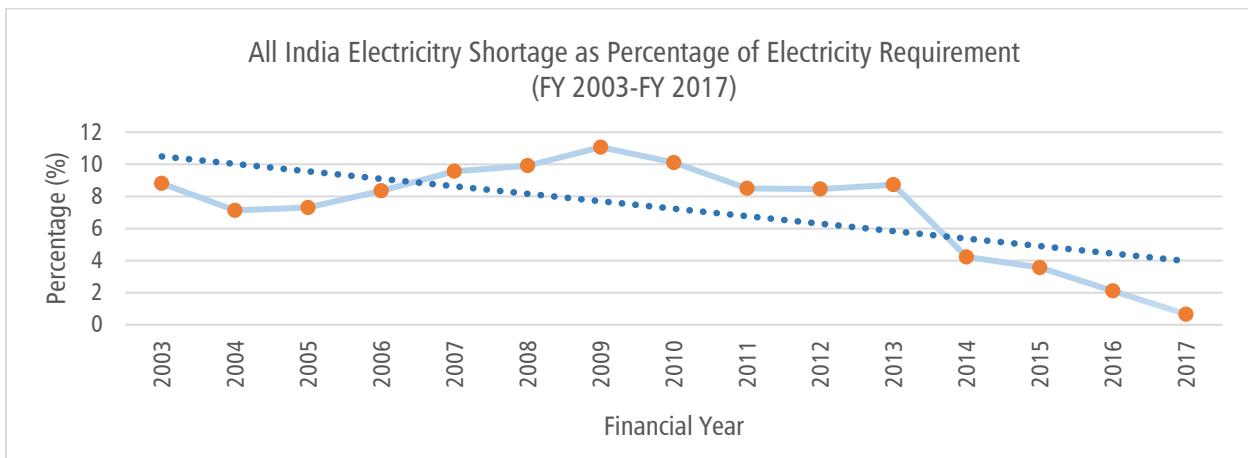
<sup>7</sup> Sigma convergence refers to a decline in relative difference or 'dispersion' over time of per capita values of any variable (such as income or electricity demand) across economies.

**Figure 3.5 Beta convergence**



Furthermore, electrical energy not met or electricity shortage is mapped at an all-India level and at a state level (Figure 3.6 and Figure 3.7). The country's prevailing trend over the years is declining shortage over the years 2008-09 to 2016-17. Relatively less developed states such as Jammu and Kashmir, Uttar Pradesh and Bihar seem to record greater shortage during the year 2016-17. This may be on account of development seen in these states during the same period; higher pace of development is likely to put additional pressure on requirement for electrical energy.

**Figure 3.6 All-India electrical energy not met**



**Figure 3.7 State-wise electrical energy not met in FY 2017**

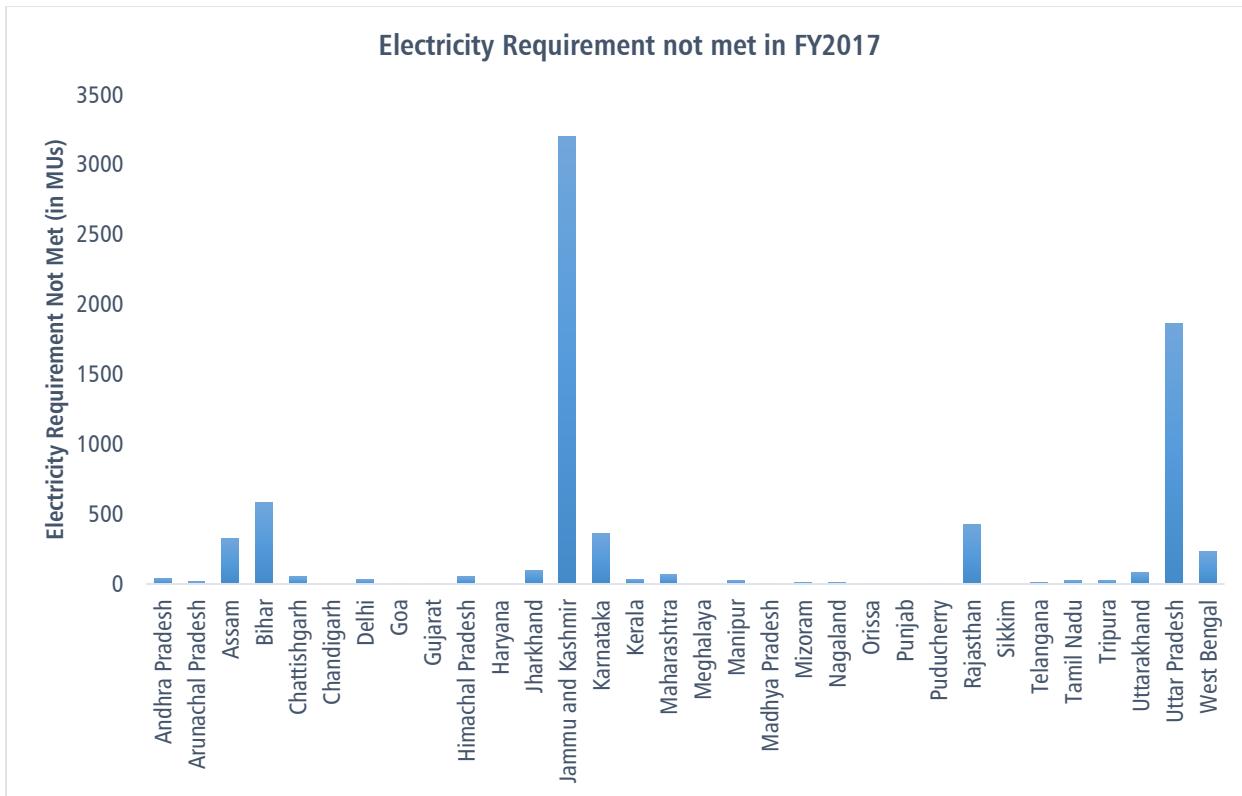
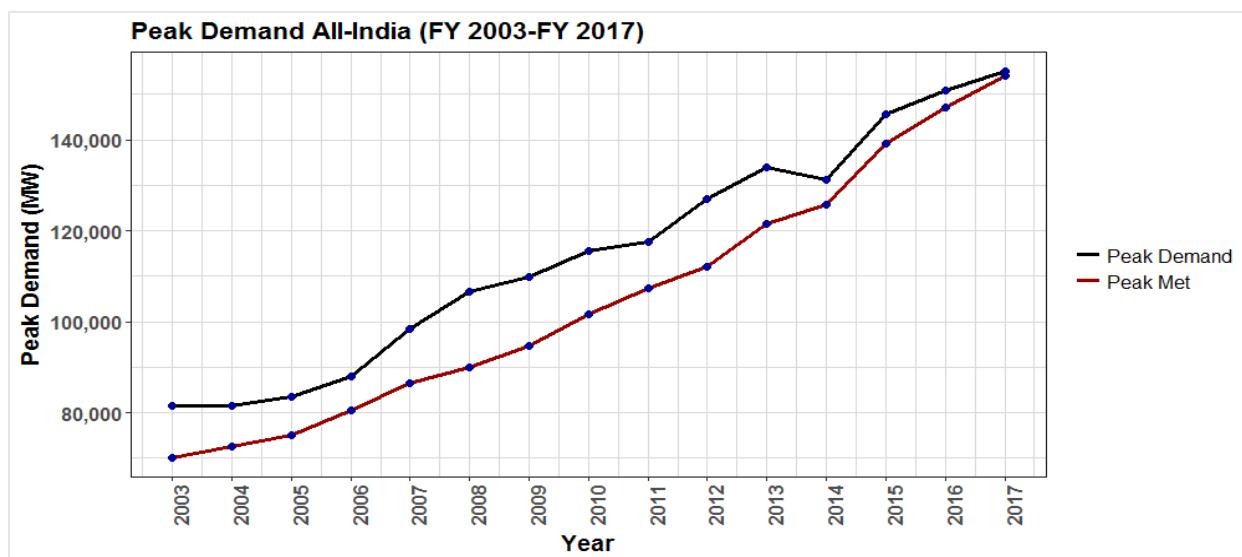
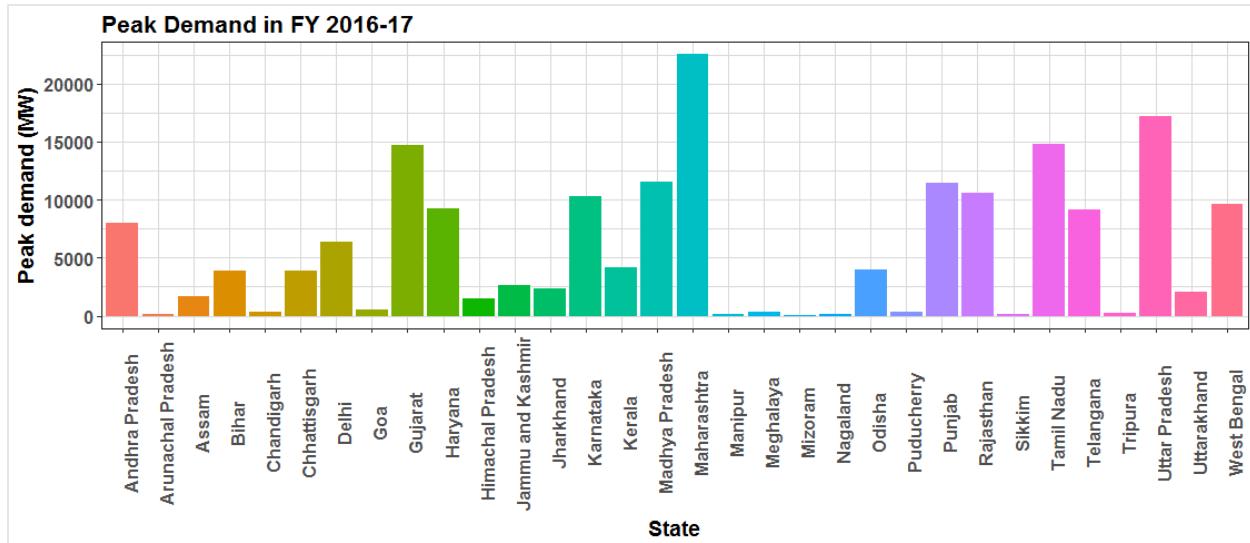


Figure 3.8 presents the data on annual Peak Electricity Demand at the all-India level. Annual Peak Electricity Demand in India has seen a consistent rise over the period 2002-03 to 2016-17. At the same time, Peak Electricity Demand not met has shown a downward trend. Figure 3.9 shows that states like Maharashtra, Uttar Pradesh, Gujarat, Tamil Nadu and Madhya Pradesh have the highest Peak Electricity Demand in the year 2016-17.

**Figure 3.8 All India Peak Electricity Demand**



**Figure 3.9 Peak Electricity Demand in FY 2016-17**

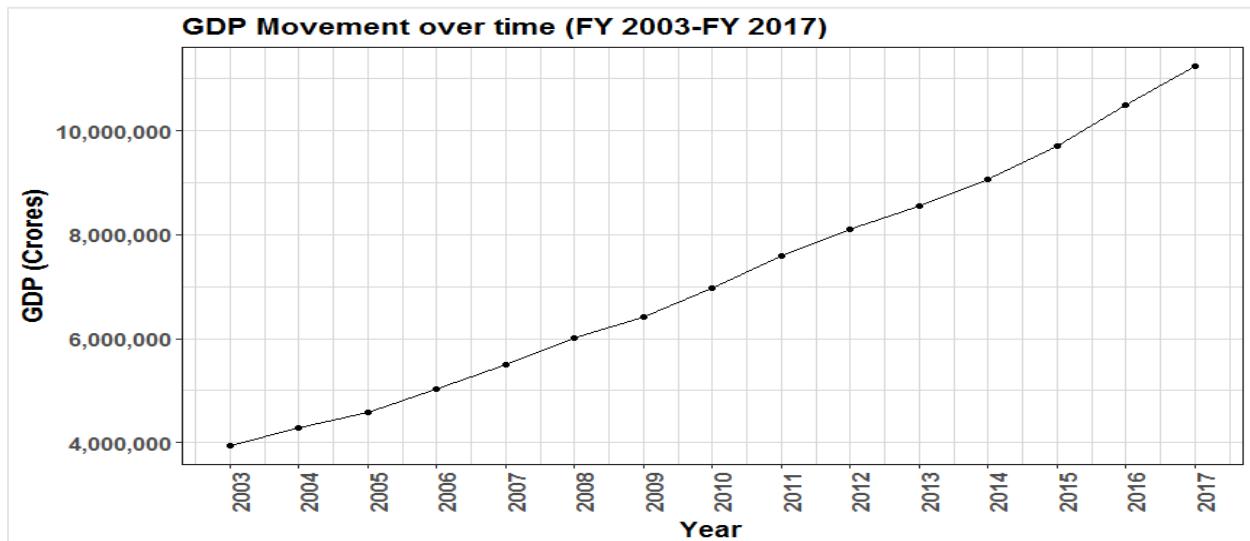


## 3.2 Drivers of electricity demand

### 3.2.1 GDP

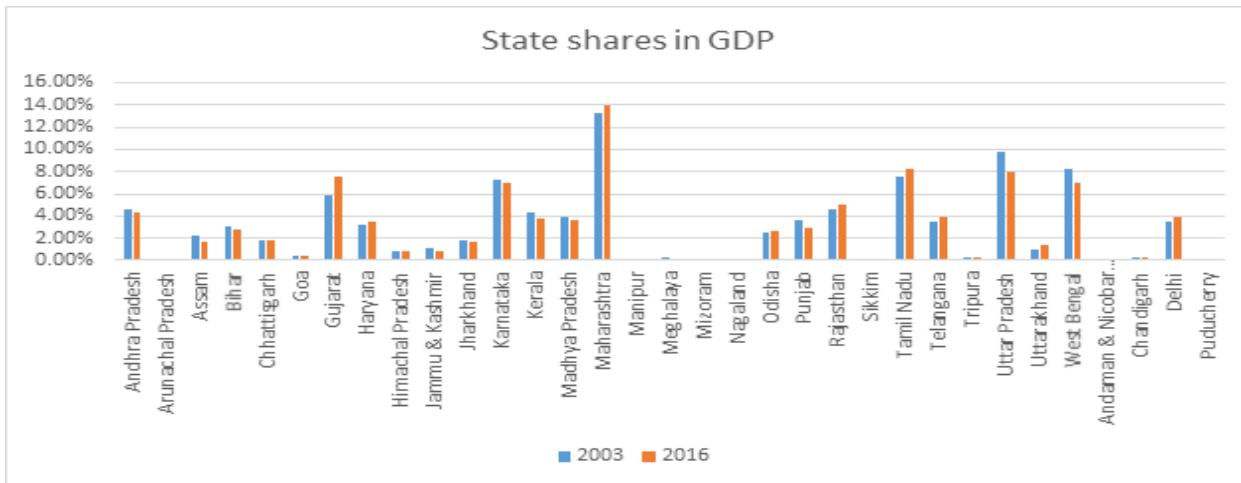
As seen in Figure 3.10, India's GDP has more than doubled during FY 2002-03 to FY 2016-17. Figure 3.11 presents data at the state level.

**Figure 3.10 GDP movement over time**



At the state-level, it is observed that the states such as Maharashtra, Uttar Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh, West Bengal, Gujarat, Kerala, Andhra Pradesh, Telangana and Rajasthan account for the major portion of the country's GDP.

**Figure 3.11 State shares in GDP**

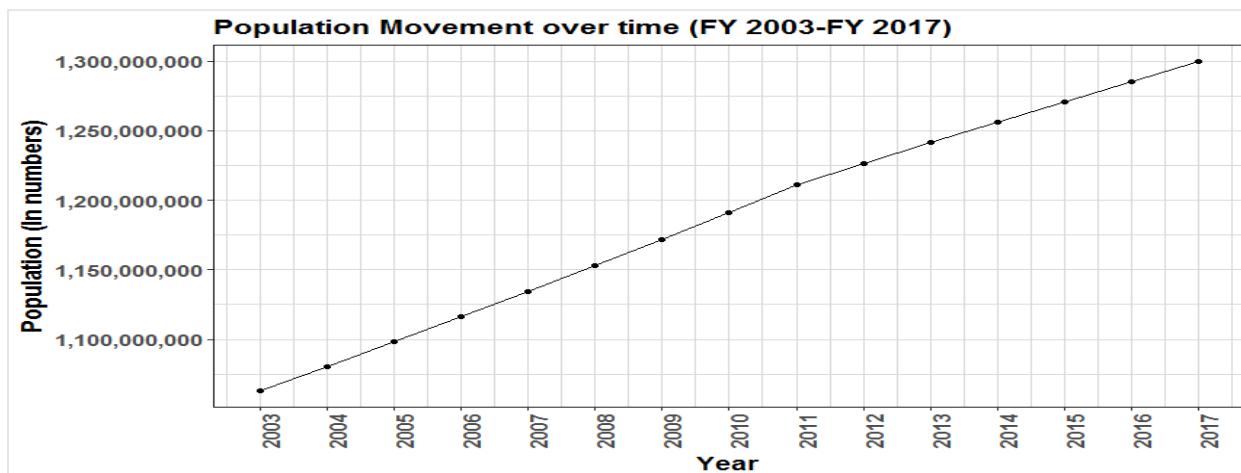


A likely shift in the position of states when compared on the basis of electricity demand growth rate and GDP shares is anticipated to take place. The GDP share of relatively less developed states is expected to increase in future with relatively faster growth as compared to the more developed states. This shift can be attributed to development, rising standards of living and latent demand that are likely to exist in many states on account of insufficient T&D infrastructure, technology penetration, among other factors.

### 3.2.2 Population

As seen in Figure 3.12, India's population has increased by a CAGR of 1.45% during the period 2002-03 to 2016-17. Some states with relatively lower population are seen to have greater electricity demand as compared to states with larger populations. Delhi, Haryana and Punjab have higher electricity demand as compared to states such as Jharkhand, Kerala and Odisha. This difference in state demands can be attributed to the consumer-segment break-up, industrialisation and per capita income. States such as Haryana and Punjab have a greater segment of their demand arising from the industrial and agricultural consumers, while Kerala and Odisha have a consumption pattern skewed towards domestic consumption.

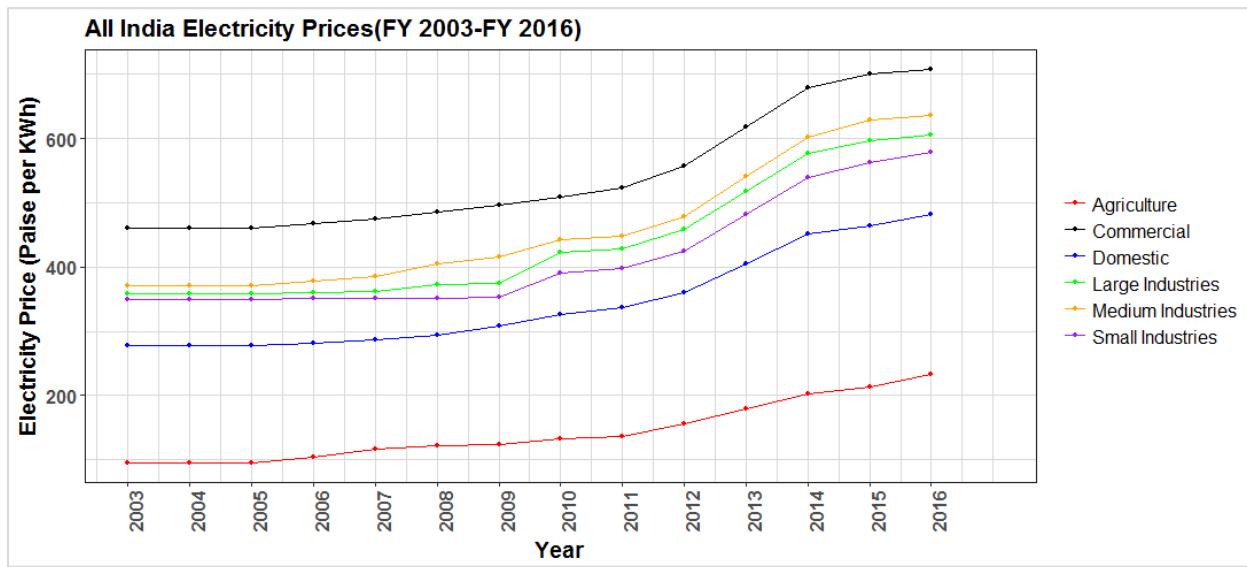
**Figure 3.12 Population increase over time**



### 3.2.3 Electricity price

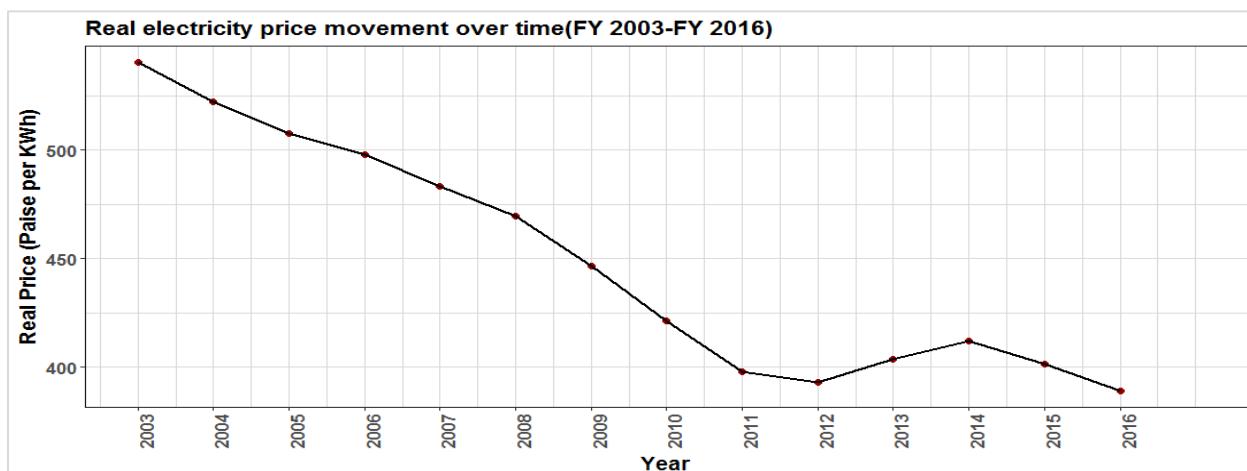
In theory, the electricity price is expected to impact electricity demand negatively. Unlike other goods, consumers of electricity do not face a single price, but rather a price schedule that specifies block pricing across different segments of usage- Agriculture, Commercial, Domestic, Industrial (Large, Medium and Small industries.)

**Figure 3.13 Trends in electricity prices**



While the nominal electricity prices across all usage segments have consistently increased over time (Figure 3.13), there is a declining trend for the average real price movement (Figure 3.14). This indicates that the effective price that the consumer pays for electricity, after the adjustment for inflation, has decreased between FY 2002-03 to FY 2015-16. But during FY 2011-12 to 2013-14, it is observed that there was a sharp increase in nominal prices for all the categories. The real price during this period increases as the percentage increase in the nominal price is greater than the percentage increase in the price index during this period.

**Figure 3.14 Real electricity price movement**



Note: Base year for real price calculation is FY 2012

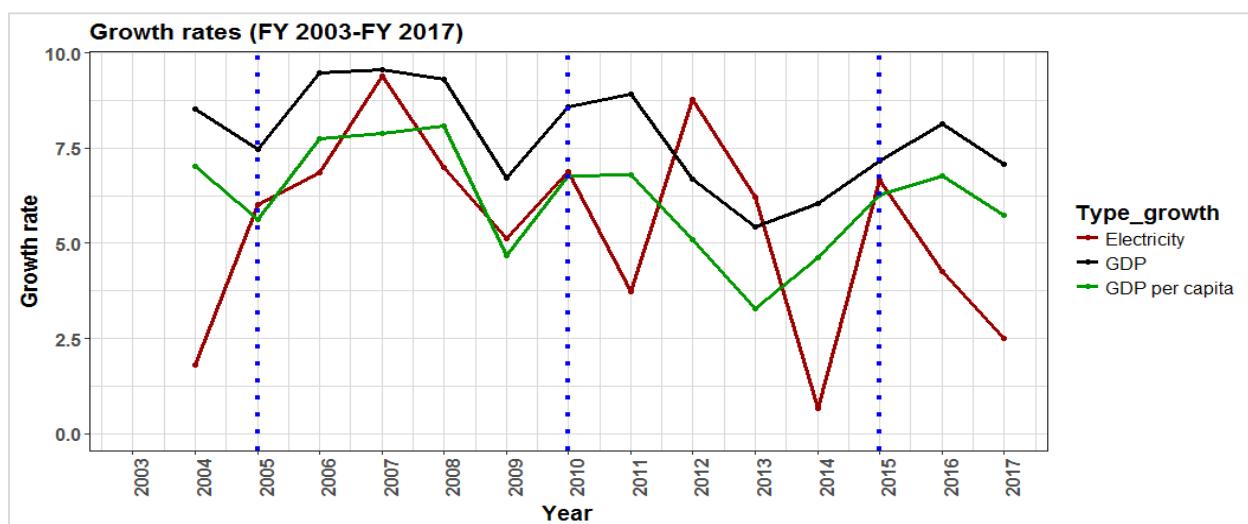
### 3.2.4 Time periods of structural change

For our analysis, we have divided the time period between FY 2002-03 to FY 2015-16 into four distinct time periods, according to the political scenario. It was observed from the data that a distinct pattern of growth seemed to emerge in the year 2015-16. There was a general increasing electricity demand trend for all states prior to the year 2014-15. However, the change of government at the centre in the year 2014-15 coincided with a change in pattern of electricity demand — there was very high growth for states such as Bihar, Goa and the north-eastern states compared to stagnant growth for states such as Delhi or Haryana.

It seems that a change of government at the centre brings about a change in policy regime and can be perceived as a structural time break. Therefore, the time periods of structural change have been defined on the basis of election years as: FY 2002-03 to FY 2003-04, FY 2004-05 to FY 2008-09, FY 2009-10 to FY 2013-14 and FY 2014-15 to FY 2016-17.

The year-on-year growth rates for Electrical Energy Requirement, GDP and population during these periods are shown in the graph below:

**Figure 3.15 Growth rates of Electrical Energy Requirement, GDP and population**



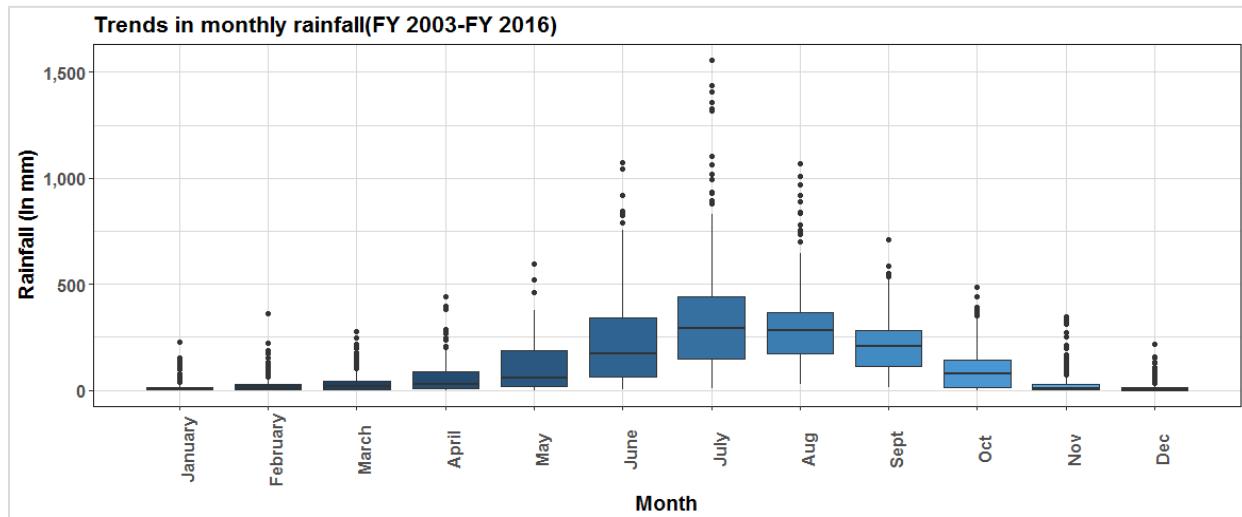
It is important to note that our model used for analysis in this report is at the level of the state and electricity is a state subject. While changes at the centre do influence electricity demand, equally critical would be the changes at the state level. Thus, the econometric model estimated in this study allows for a different response of electricity demand for different time periods for each state. This has been incorporated in the model by including state-specific time period dummies.

### 3.2.5 Monthly rainfall

As regards rainfall, electricity demand is expected to have a negative relationship with rainfall, i.e. as rainfall increases, demand is likely to fall. This is because we would expect rainfall to create more favourable weather conditions in most states, thereby reducing demand of electricity for cooling. In agricultural states, rainfall would reduce the use of irrigation pumps.

Thus, the dominant consumer segment in each state plays an important role in this relationship. Climate variables have a greater impact on demand in states where a significant portion of electricity consumption is attributed to domestic, commercial and agricultural consumers.

**Figure 3.16 Trends in monthly rainfall**

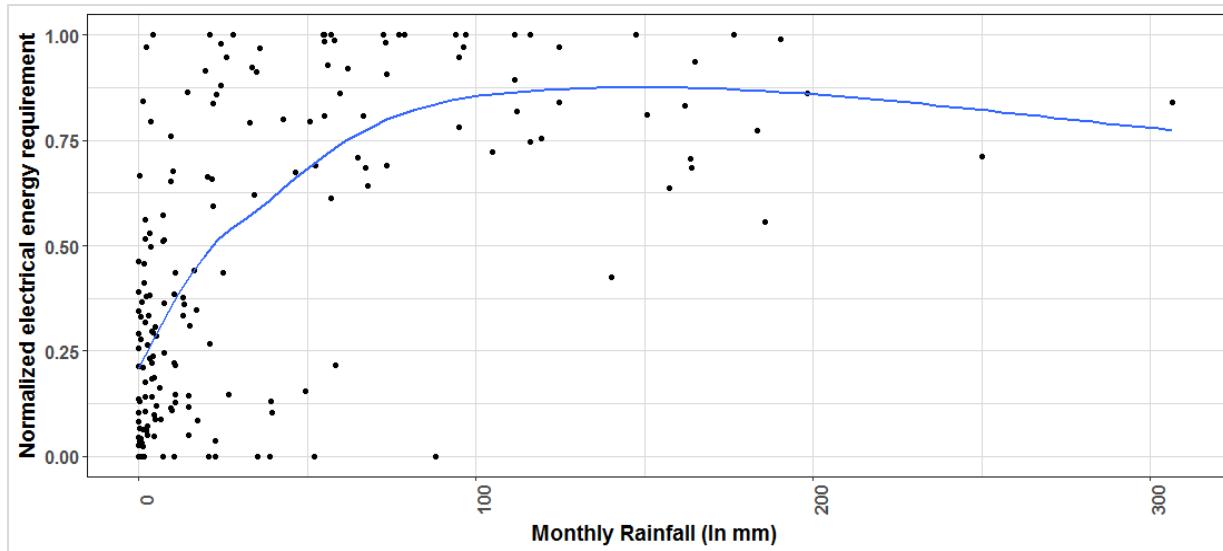


As can be observed in Figure 3.16, the monsoon months of June–Sept consistently receive the highest levels of rainfall, with the maximum rainfall being received particularly in July in terms of an all-India average.

The impact of rainfall on electricity demand varies by season, temperature, humidity and the level of rainfall. Figure 3.17 plots normalised electricity demand and monthly rainfall in Delhi as an illustrative case. The Electrical Energy Requirement is normalised by subtracting the yearly minimum observed value of demand in the respective year and dividing it by the observed yearly range (maximum demand minus minimum demand) of the Electrical Energy Requirement.

For rainfall levels less than 50 mm, the relationship seems relatively weak with high rainfall associated with both high and low electricity demand. At higher levels of rainfall, the relationship seems to be negative. In India, generally, higher rainfall is experienced during summer and thus associated with higher temperature and humidity. To estimate the non-linear impact of rainfall on electricity demand, rainfall variable is categorised into four different groups: rainfall between 0-50 mm, 50-100 mm, 100-200 mm and above 200 mm. The estimated electricity demand model discussed in the next chapter estimates different electricity demand responses for these categories.

Figure 3.17: Normalised Electrical Energy Requirement and monthly rainfall for Delhi (FY 2016)



### 3.2.6 Temperature variables: HDDs and CDDs

To capture the non-linear impact of temperature on electricity demand, degree day approach has been adopted. Monthly HDDs/CDDs represent the number of days in a month on which the temperature is respectively below/above the threshold cooling/heating point and by how many degrees. The threshold is a point over or under which the heating or cooling appliances will be switched on. HDD, CDD and threshold points are all measured in degree Celsius. It is important to note that electricity equipment penetration is an important factor for the impact of high HDD/CDD to translate into higher electricity demand. If there is minimal penetration such that heating or cooling equipment are not available to the people during low and high temperature, respectively, then electricity demand will not be very sensitive to these weather variables.

Daily HDD and CDD may be defined as follows:

$$HDD_d = \max(0, T^* - T_t)$$

$$CDD_d = \max(0, T_t - T^*)$$

Where, d is a specific day in a particular month,  $T^*$  is the threshold temperature of cold or heat, and  $T_t$  the observed temperature on day t. This provides the sum of daily HDD and CDD in a given month. Monthly HDD and CDD, which represents the number of days in each month where the temperature is below or above the threshold, are computed as follows:

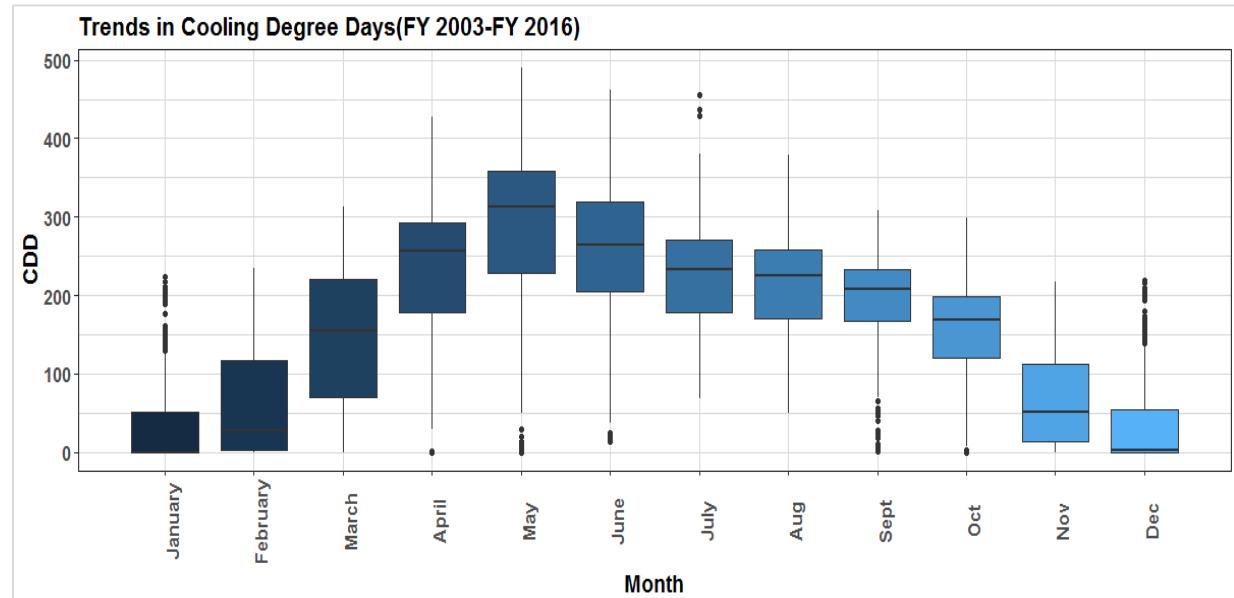
$$MHDD = \sum H D D_{dm}$$

$$MCDD = \sum C D D_{dm}$$

All references to CDD and HDD here forth will imply monthly HDD and CDD (MHDD and MCDD).

With reference to the analysis conducted in the research study by Gupta (2016)<sup>8</sup>, the threshold temperature for India has been assumed to be 21°C for the construction of monthly CDD and HDD for all states. Figure 3.18 and Figure 3.19 give trends in CDD and HDD for all state-level temperature observations for the period FY 2002-03 to FY 2015-16.

**Figure 3.18 Trends in CDD**



**Figure 3.19 Trends in HDD**

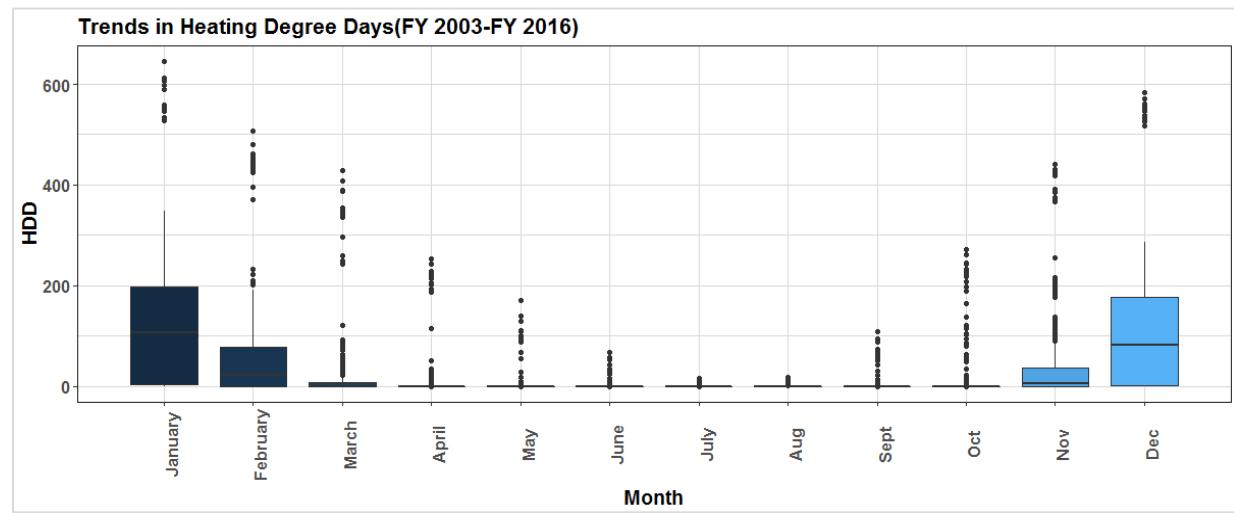


Table 3.1 shows that there is a significant difference in mean CDD across states. While Andhra Pradesh, Rajasthan, Tamil Nadu, Kerala and Telangana have mean monthly CDD above 200, other states such as

<sup>8</sup> Gupta, E., 2016. The effect of development on the climate sensitivity of electricity demand in India. *Climate Change Economics*, 7(02), p.1650003.

Uttarakhand, Manipur, and Jammu and Kashmir clock mean monthly CDDs under 100. For majority of the states, however, CDD ranges between 150 and 200. Furthermore, variance in CDD differs even more drastically in some states over the others. This effectively means that a change in meteorological variables in these states will likely impact electricity demand more than other states which record lower variance. States with high standard deviation ( $>122.5$ ) include Delhi, Haryana, Punjab, Rajasthan, Bihar and Uttar Pradesh.

HDD, on the other hand, also varies across states; however, the mean and variance, in this case, are as anticipated lower than CDDs. Jammu and Kashmir has the highest mean HDD in India. Variance, in this case, was also noted as significant. Uttarakhand, Punjab and Haryana also record HDD above 50 on average.

**Table 3.1 State-wise trends in HDD, CDD and rainfall (FY 2003 - FY 2016)**

State	HDD (degree Celsius)		Rainfall (mm)		CDD (degree Celsius)	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
<b>Andhra Pradesh</b>	0.00	0.00	74.95	72.31	228.31	76.08
<b>Arunachal Pradesh</b>			201.43	175.33		
<b>Assam</b>	22.51	41.96	188.81	177.09	122.10	95.19
<b>Bihar</b>	27.61	55.51	93.71	117.52	179.47	128.15
<b>Chhattisgarh</b>	9.87	20.36	104.01	137.00	150.65	109.92
<b>Chandigarh</b>	69.96	105.01	39.97	54.99	144.33	133.33
<b>Delhi</b>	45.30	76.92	39.97	54.99	181.64	148.29
<b>Goa</b>	0.00	0.00	265.24	395.10	195.99	41.87
<b>Gujarat</b>	3.01	8.59	69.48	118.07	196.92	98.58
<b>Himachal Pradesh</b>			84.96	82.05		
<b>Haryana</b>	53.95	89.42	39.97	54.99	186.99	157.56
<b>Jharkhand</b>	21.09	39.51	98.01	117.48	147.39	108.43
<b>Jammu and Kashmir</b>	244.95	205.14	94.05	68.99	20.02	34.37
<b>Karnataka</b>	0.02	0.14	147.91	168.69	126.38	55.65
<b>Kerala</b>	0.00	0.00	241.89	236.78	209.15	30.51
<b>Maharashtra</b>	0.37	1.32	122.53	170.59	176.13	83.75
<b>Meghalaya</b>	22.51	41.96	188.81	177.09	122.10	95.19
<b>Manipur</b>	56.49	78.52	145.74	132.89	68.09	61.30
<b>Madhya Pradesh</b>	24.30	46.57	85.19	126.84	165.73	132.17
<b>Mizoram</b>	18.56	38.89	145.74	132.89	145.91	91.54
<b>Nagaland</b>	56.43	78.55	145.74	132.89	68.04	61.31
<b>Orissa</b>	4.54	11.03	125.03	147.21	185.29	106.70
<b>Punjab</b>	69.96	105.01	43.32	53.66	144.33	133.33
<b>Puducherry</b>	0.00	0.00	80.45	76.22	217.31	61.09
<b>Rajasthan</b>	28.15	53.77	39.49	63.06	207.92	153.34

State	HDD (degree Celsius)		Rainfall (mm)		CDD (degree Celsius)	
Sikkim			208.16	212.11		
Telangana	0.76	2.71	74.95	72.31	201.77	108.65
Tamil Nadu	0.00	0.00	80.45	76.22	217.31	61.09
Tripura	18.56	38.89	145.74	132.89	145.91	91.54
Uttarakhand	71.29	99.70	127.51	162.48	93.73	89.99
Uttar Pradesh	40.76	74.82	93.51	122.09	172.64	137.03
West Bengal	10.80	24.34	166.64	168.66	182.95	104.43

For the entire period FY 2003 to FY 2016, the national CDD average stands around 160 while the HDD average is about six.

The above degree-day approach estimates the non-linear relationship between electricity demand and temperature by a piece-wise linear function using two segments: one for the summer where the temperature is above the predetermined threshold temperature, and another one for winter where the temperature is below the same threshold temperature. This non-linear relationship between weather variables (CDD, HDD) and electricity demand is illustrated using the data for Delhi in Figures 3.20 and 3.21. The Electrical Energy Requirement is normalised by subtracting the yearly minimum observed value of demand in the respective year and dividing it by the observed yearly range (maximum demand minus minimum demand) of the Electrical Energy Requirement.

**Figure 3.20 Normalized Electrical Energy Requirement and CDD (degree Celsius) for Delhi**

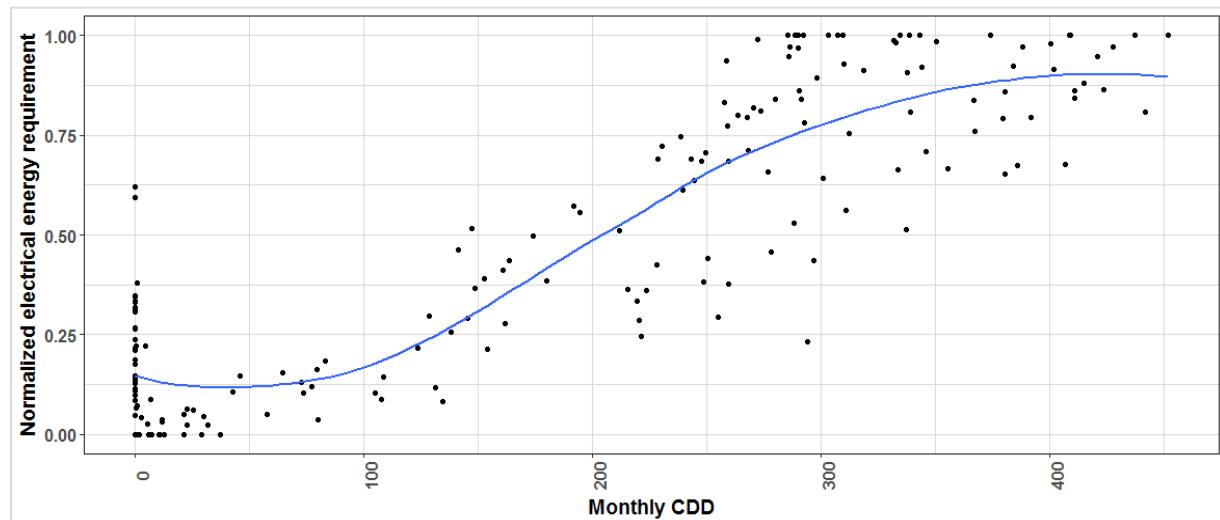
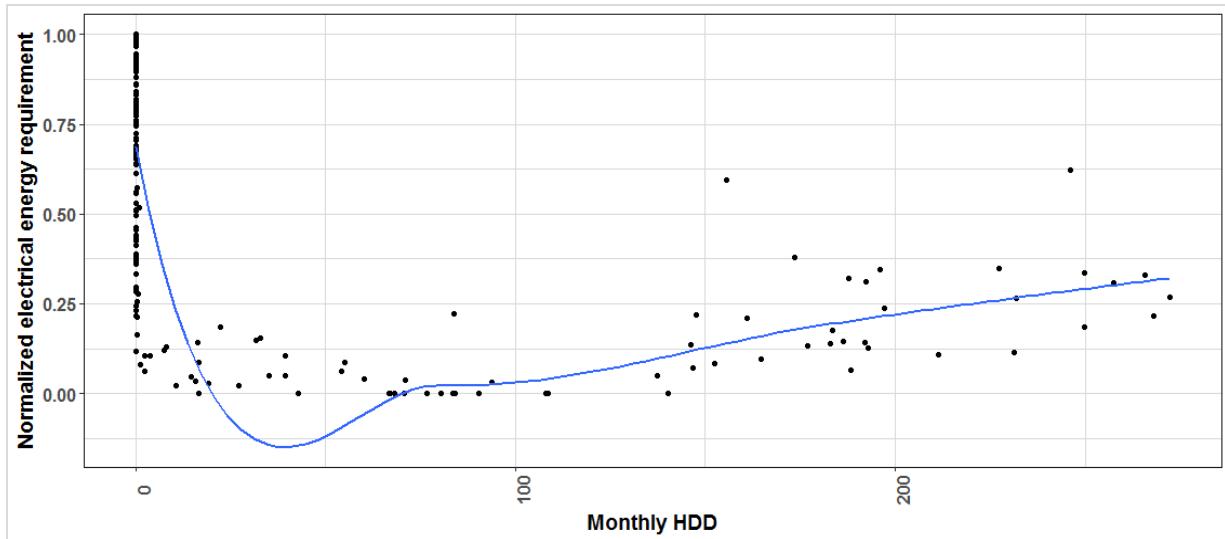


Figure 3.21 Normalized Electrical Energy Requirement and HDD (degree days) for Delhi



# **Choice of model for forecasting electricity demand and estimation of results**

---

**4**



## 4.

# Choice of model for forecasting electricity demand and estimation of results

The details of estimation results of the various models estimated in Chapter 2 are discussed in this chapter. The most appropriate model is selected based on the criterion of out-sample prediction.

## 4.1 Estimation results

The estimated coefficients and associated standard errors for different electrical energy forecasting models (long panel, PAM and SUR) are shown in Tables (A3.1) – (A3.5) of Annexure 3. For long panel and PAM, six equations are estimated, one for each region and one for the all-India level. For the SUR model, 28 equations are estimated, one for each state.

R-square or coefficient of determination represents the proportion of the variance for a dependent variable explained by all the independent variables. It is a commonly used measure of goodness of fit of a linear model. The R-square of all the estimated models is high indicating that selected independent variables well explain electricity demand. All independent variables have expected signs (i.e., the impact of any variable to increase/decrease of the overall Electrical Energy Requirement or Peak Electricity Demand is as expected) and turn out to be statistically significant in all models except HDD. A change in one unit of the log of a variable<sup>9</sup> is approximately equal to a 1% change in its value. It is observed that the impact of different variables varies over time, regions and states. The impact of different variables on electricity demand from all models is discussed below.

### 4.1.1 Lagged electricity demand

Both electricity demand lagged by period one and electricity demand lagged by period 12 have positive and significant impact in PAM models. According to PAM for the total electricity requirement (Table A3.1), at the all-India level, the coefficient of electricity requirement lagged by period one is 0.61 and the coefficient of requirement lagged by period 12 is 0.08. This means that a 1% increase in the previous period Electrical Energy Requirement increases Electrical Energy Requirement in the current period by 0.61% while a 1% increase in Electrical Energy Requirement lagged by 12 periods increases Electrical Energy Requirement by 0.08%. The speed of adjustment for the model is obtained using the two coefficients corresponding to Electrical Energy Requirement lagged by 1 and 12 months. The short-run and long-run elasticities are related according to the following equation:

$$E_{LR} = \frac{E_{SR}}{1 - \beta_1 - \beta_{12}} = \frac{E_{SR}}{\Lambda}$$

<sup>9</sup> The logarithmic form of the variables have been used as the dependent variable and explanatory variables to run the model



The term  $\frac{1}{\Lambda}$  indicates the fraction of the gap between the current electricity consumption and the equilibrium level of consumption that is closed every year. Therefore, the number of years required to bridge this gap towards the equilibrium value is indicated by  $\Lambda$ .

The estimated speed of adjustment of short-run deviation from the long-run equilibrium path is about 31% per annum at the all-India level. This implies that the short-run demand values will converge to the long-run equilibrium in 3.2 years. The speed of adjustment turns out to be the highest for the northern region at 42% per annum or 2.4 years and the lowest for the eastern region at 22% per annum or 4.5 years.

According to PAM for all-India Peak Electricity Demand (Table A3.5), at the all-India level, the coefficient of Peak Electricity Demand lagged by period one is 0.62. This means that a 1% increase in the previous period Peak Electricity Demand increases Peak Electricity Demand in the current period by 0.62%.

This result is very close to the result obtained for the total Electrical Energy Requirement. The estimated speed of adjustment of short-run deviation from the long-run equilibrium path is about 38% per annum at the all-India level. This implies that the short-run demand values will converge to the long-run equilibrium in 2.6 years.

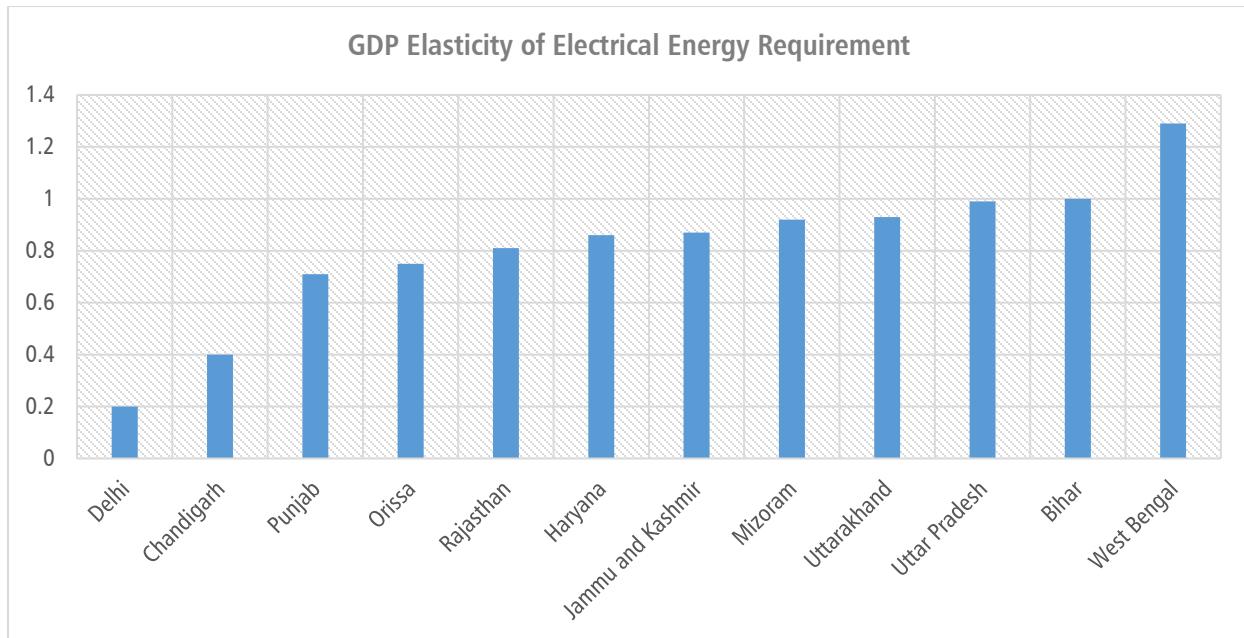
#### 4.1.2 Gross domestic product

Income has a positive sign in all models and has a statistically significant impact on the dependent variable (at 1% level of significance in all models). According to PAM model estimated for all-India panel for Electrical Energy Requirement, a 1% increase in the previous year's gross state domestic product results in about 0.23% increase in state's Electrical Energy Requirement in the current period on an average. Since the short-run GDP elasticity is well below unity, GDP growth, just by itself, with everything else held constant, results in a much less than proportional increase in electricity demand. As expected, the elasticity turns out to be the lowest for western India, which comprises two rich and big states of India — Gujarat and Maharashtra. The elasticity in all other regions vary between 0.2 and 0.3.

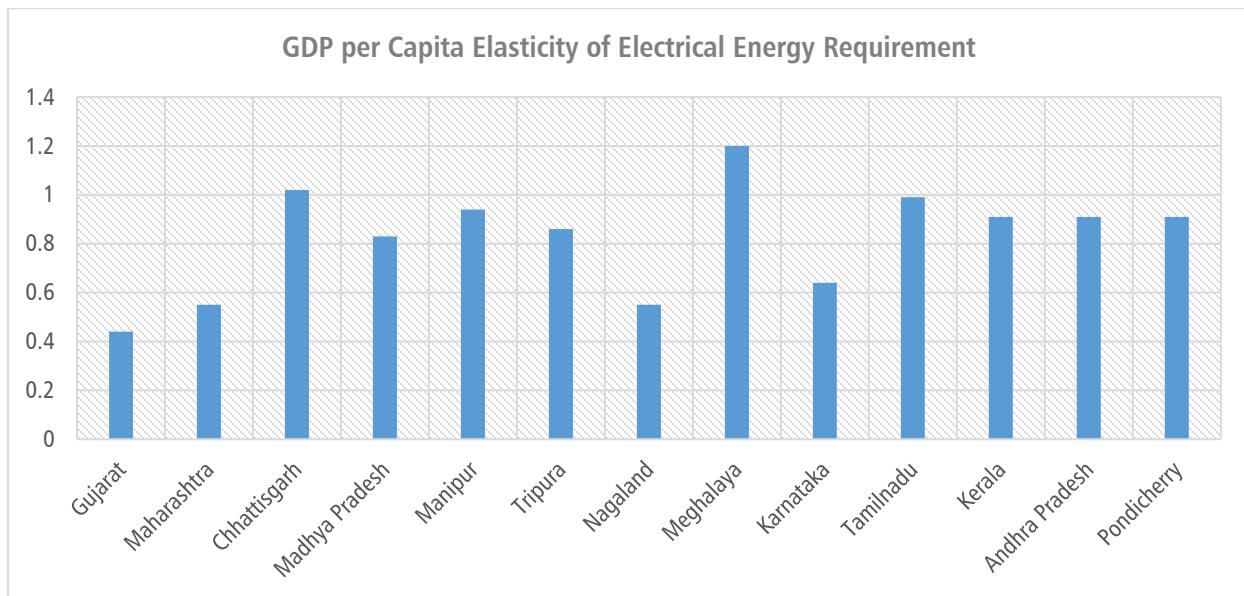
The long-run elasticity level at all-India turns out to be same from both panel data models — PAM and long panel. The long-run elasticity of GDP at the all-India level is 0.74, which is more than three times the short-run elasticity of GDP. The elasticity is the lowest in the western region (0.48–0.49) and the highest in the eastern region (0.91–0.92).

Figure 4.1 and Figure 4.2 show that the state-level income (as measured by GDP or GDP per capita in SUR model) elasticities as estimated from the SUR model are in line with the above estimates from the two panel data models. High income elasticity of over 1 has been found in states such as Bihar, West Bengal and Chhattisgarh. As discussed in Chapter 3, relatively slower growth in electricity demand per capita has been observed in developed states and relatively faster growth in electricity demand per capita has been observed in developing states, indicating convergence in living standards over time. Figures A4.1–A4.4 in the appendix plot sectoral shares of electricity consumption for all states over time. For all the states with high income elasticity of demand, the share of the domestic consumption has increased significantly over time due to electrification of new households. Thus, the higher growth in electricity demand (due to expansion of rural electrification in the past) relative to growth in income during the same period resulted in high income elasticity for these states. In most of these states, commercial sectors such as, real estate and hotels have further contributed significantly to the increased demand over the period of analysis.

**Figure 4.1 Income (GDP) Elasticity of Electrical Energy Requirement**



**Figure 4.2 Income (GDP per Capita) Elasticity of Electrical Energy Requirement**



According to PAM for all-India Peak Electricity Demand (Table A3.5), the coefficient of GDP is 0.25. This means that a 1% increase in GDP increases Peak Electricity Demand by 0.25% in the short-run. The estimated long-run Peak Electricity Demand elasticity at 0.66 is 2.6 times the short-run elasticity. As per state-level regional PAM (Table A3.4), the short-run GDP elasticity of Peak Electricity Demand at 0.09 turns out to be the lowest for the western region. For all other regions, it is between 0.17 and 0.21.

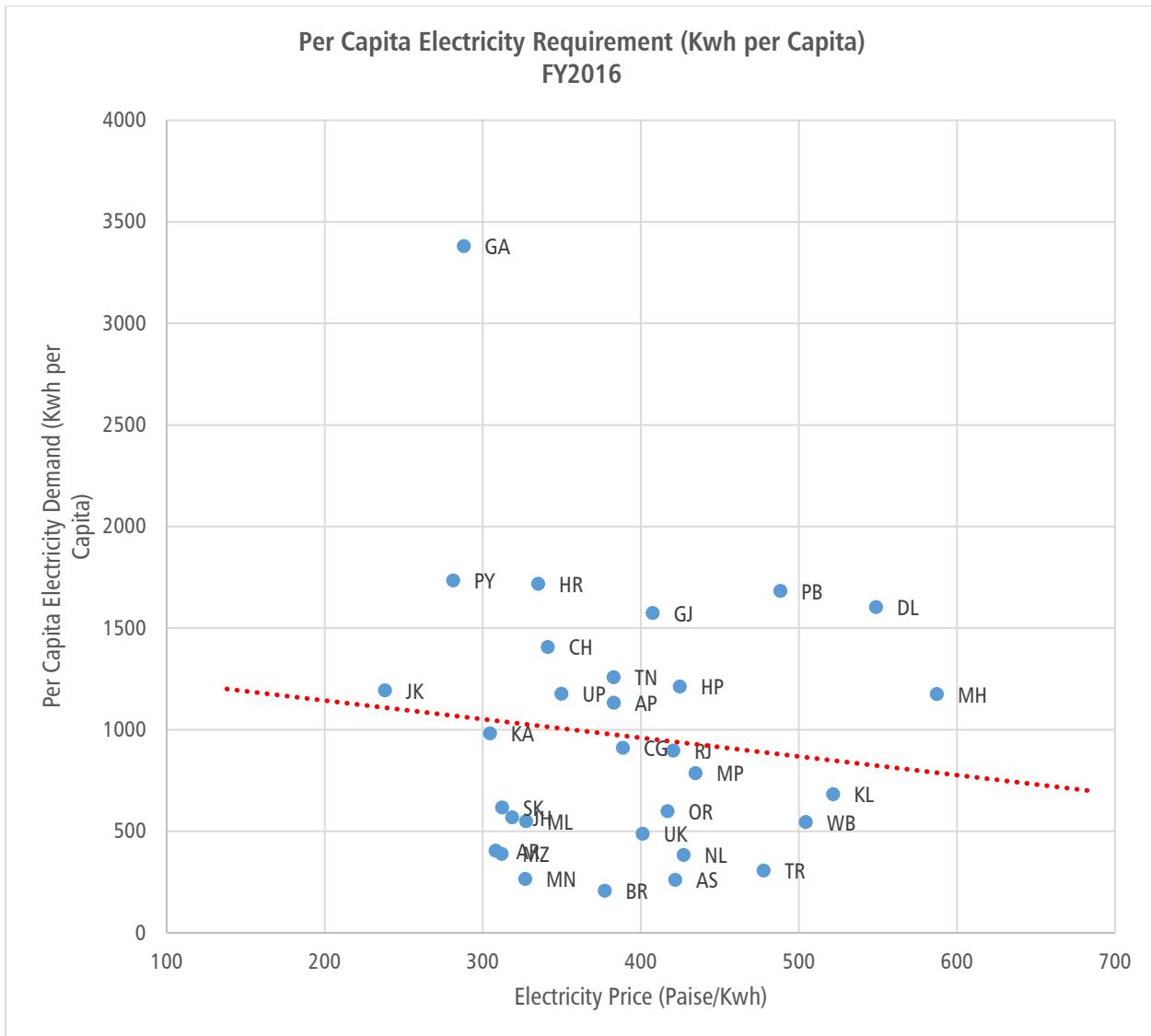
### 4.1.3 Real electricity price

As expected, real electricity price has a negative impact on electricity demand in all models. A 1% increase in real electricity price results in a small 0.02% decrease in the Electrical Energy Requirement at 15% level of significance in the short-run at the all-India level as estimated from PAM (Table A3.1). The long-run price elasticity at the all-India level at 0.06% is more than three times the short-run elasticity. A 1% increase in real electricity price results in about 0.06% decrease in Electrical Energy Requirement in the long-run vis-à-vis 0.02% in the short-run. This reinforces that electricity price increases will have much greater impact on lowering electricity demand in the long-run. This is expected as people are likely to adjust more to electricity price increases over time by switching to more energy efficient alternatives, alternative sources of energy (primarily renewables) and captive generation. Electricity demand is typically price inelastic for residential, small and medium industrial and commercial consumers; however, agriculture consumers and large industrial consumers would shift to solar-based pumps and captive generation, respectively.

Investments in solar pumps/captive generation are long-run decisions and impact grid electricity demand in the long-run — hence long-run elasticities are higher than short-run elasticities (the consumers are not able to respond very systematically to changes in retail electricity prices in the short-run).

Relatively small estimated impact of electricity price can be further inferred from the fact that electricity retail prices are 'regulated' and not discovered through a market mechanism, hence, the typical strong negative relation between price and demand may not be observed — the marginal utility from consumption of electricity by most consumers may be greater than the regulated prices (this is expected because electricity has typically served social objectives of the various governments). The negative and 'low' value of elasticity seems to be driven not so much by the 'response' to real electricity price by each state individually, but the model seems to be inferring it from the relationship across states. This is illustrated in Figure 4.3:

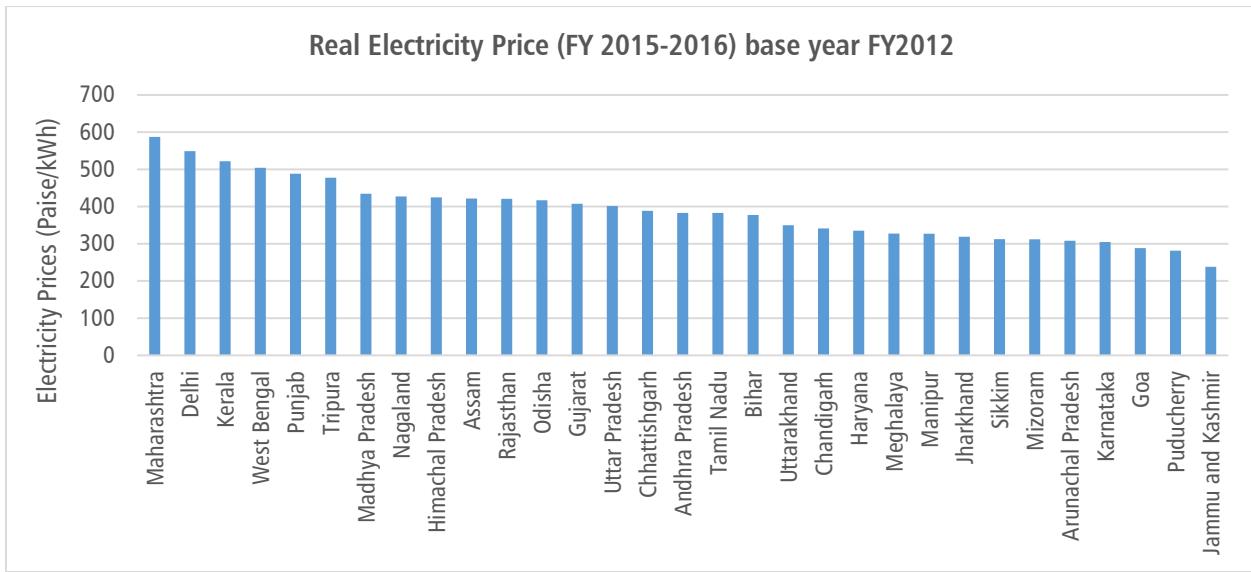
**Figure 4.3 Per Capita Electrical Energy Requirement and Electricity Price (FY2016)**



*Note: Base year for real price calculation is FY 2012*

An examination of the coefficients of region-specific models show that the price elasticity in short run is relatively higher than the all-India average in the southern (0.12) region and western region (0.07). This can possibly be explained by the relatively higher average real price in the western region (Figure 4.4). In addition, the greater captive generation in the industrial sector in the western and southern regions makes utility electricity demand more sensitive to price changes.

**Figure 4.4 State Average Electricity Price**

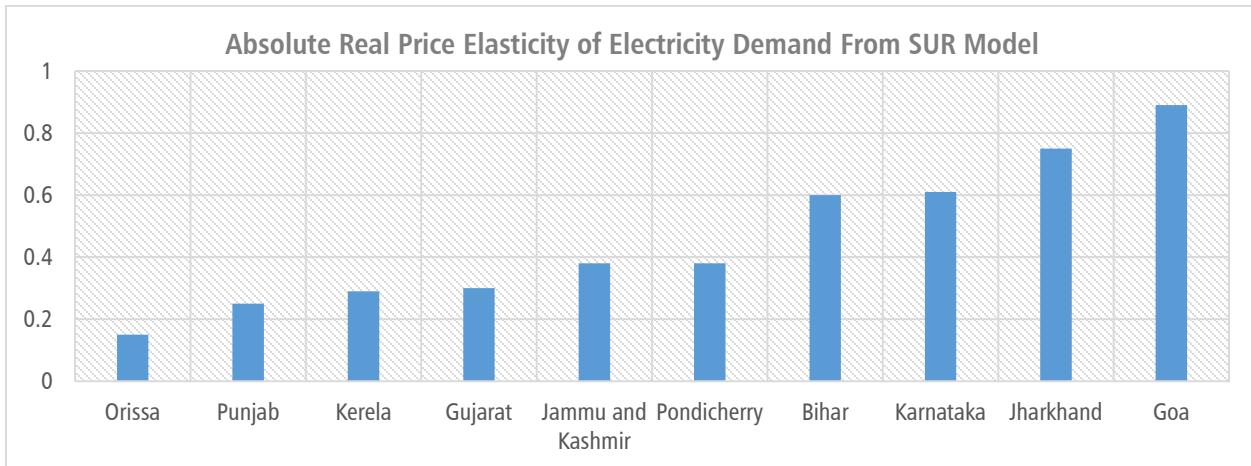


*Note: Base year for real price calculation is FY 2012*

As in the case of short-run price elasticities, the long-run elasticities also vary across regions (0.02–0.38) and states.

The state-level long-run price elasticities as estimated from the SUR model are plotted in Figure 4.5. High price elasticity has been found in states such as Bihar (-0.6), Jharkhand (-0.75), Karnataka (-0.61), Goa (-0.89).

**Figure 4.5 Price Elasticity of Electrical Energy Requirement**

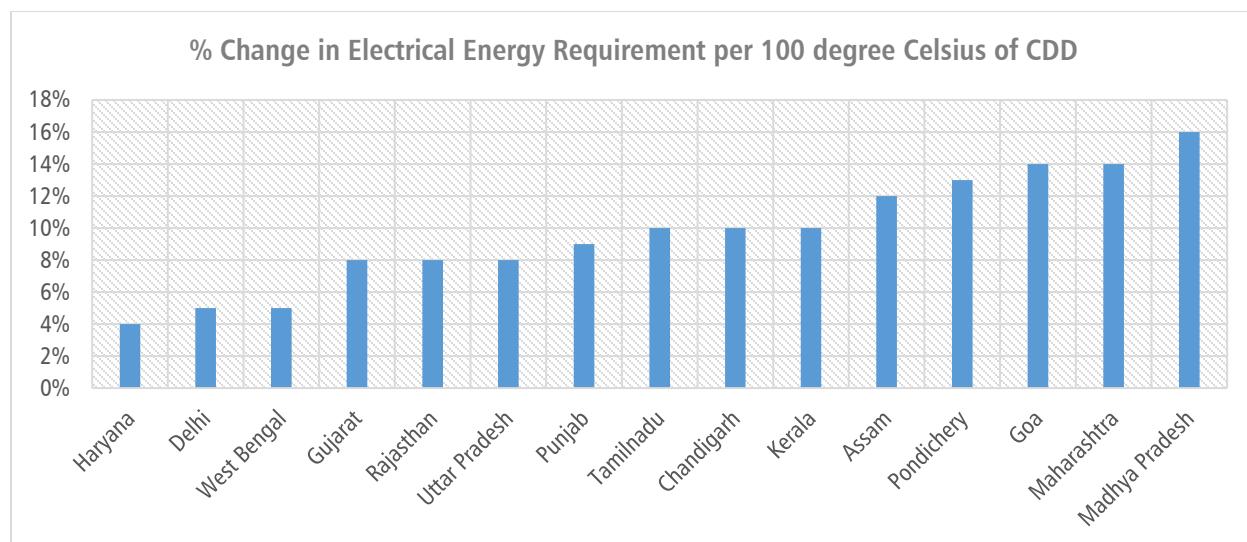


#### 4.1.4 Cooling degree days (CDD)

The impact of CDD is positive and significant in most models. The estimated coefficient is 0.06 in short run. This implies that Electrical Energy Requirement increases by 6% per 100-degree Celsius increase in CDD in the short-run at the all-India level as per PAM (Table A3.1). The impact estimated is higher in relatively hot and rich regions in India — North (7%), West (7%) and South (7%).

The estimated long-run impact at the all-India level is higher from PAM (19.3% per 100 degree Celsius) than the long panel model (7% per 100 degree Celsius). Both models account for state-specific month dummies, which are correlated with temperature. This indicates that the month dummies absorb some impact of CDD in these models and make CDD coefficient relatively small. Dropping the month dummies is not advisable since they also capture many other omitted variables. From the SUR model, CDD has relatively higher impact in hot and rich states/UTs such as Maharashtra (14% per 100 degree Celsius), Gujarat (8% per 100 degree Celsius), Tamil Nadu (10% per 100 degree Celsius), Chandigarh (10% per 100 degree Celsius) and Punjab (9% per 100 degree Celsius) (Figure 4.6). In case of Assam higher percentage increase of demand per 100 degree Celsius can be attributed to higher share of domestic demand while in the case of Madhya Pradesh it can be attributed to higher share of agricultural sector and hot and humid temperature.

**Figure 4.6 Impact of CDD on electricity demand**



According to PAM for all-India Peak Electricity Demand (Table A3.5), the coefficient of CDD is 0.04 in short run. This means that Peak Electricity Demand increases by 4% in the short-run and 10% in the long-run every 100-degree Celsius increase in CDD. As per regional PAM (Table A3.4), the CDD impact on Peak Electricity Demand vary between 4% and 5% in the short-run for every 100-degree Celsius increase in CDD across different regions.

#### 4.1.5 Heating degree days (HDD)

The impact of HDD is positive but insignificant in most models.

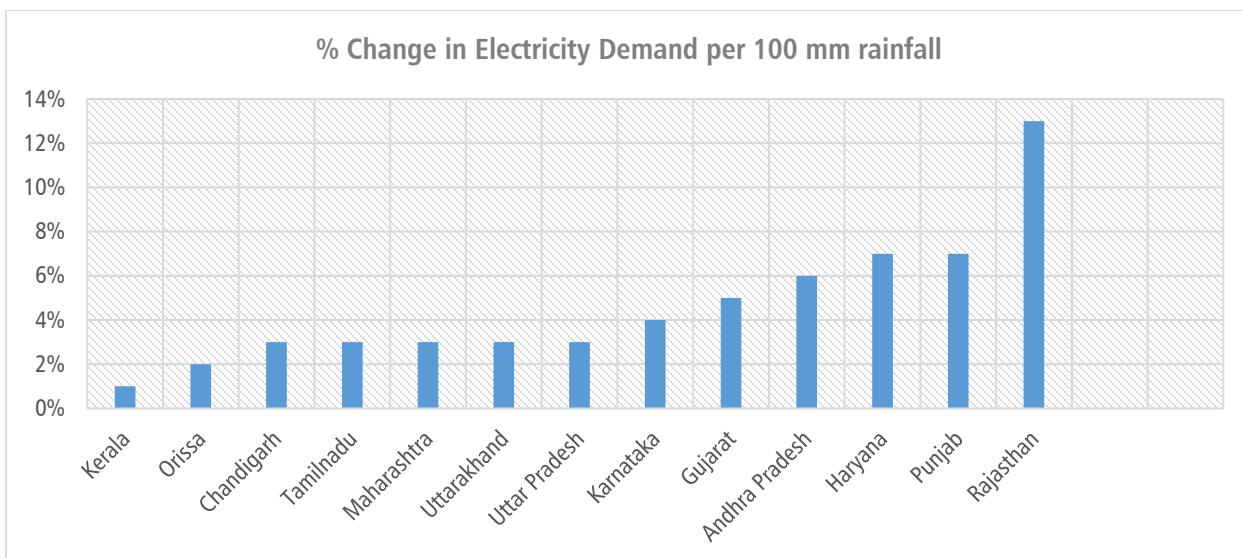
#### 4.1.6 Rainfall

The impact of rainfall is negative and significant in most models. At the all-India level, the estimated impact of rainfall varies across different rainfall categories (as discussed in Chapter 2). It is observed that the reduction in electricity demand is higher when the level of rainfall is lower. A one unit (100 mm) increase in rainfall results in 6% reduction in demand when rainfall is in the range of 0–50 mm, 4% reduction when rainfall is in the range of 50–100 mm, 3% reduction when rainfall is in the range of 100–150 mm and 2% reduction when rainfall is above

200 mm (Table A3.1). In India, higher rainfall generally occurs during summer when temperature and humidity are high. Thus, an increase in rainfall during summer may reduce load lesser than in winter. In addition, the agricultural load is very high in many states during winter. Higher rainfall during winter can significantly reduce the agricultural load due to pumps. The estimated impact of rainfall turns out to be the highest in the northern region due to the high agricultural load.

The estimated average long-run impact at the all-India level in all four categories is 12% reduction in electricity demand with one unit (100 mm) increase in rainfall. The impact of rainfall varies across states (Figure 4.7). The results from the SUR model confirms the above findings as the highest impact of rainfall is observed in the northern agricultural states such as Rajasthan (13% per 100mm), Punjab (7% per 100mm) and Haryana (7% per 100mm).

**Figure 4.7 Impact of Rainfall on Electrical Energy Requirement**



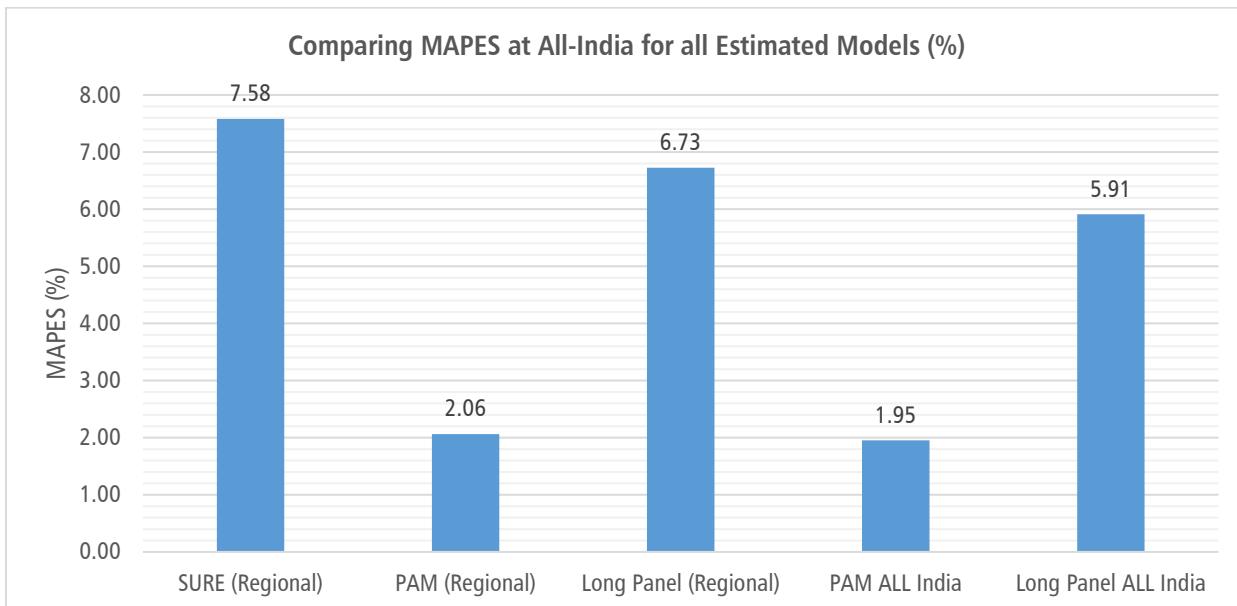
According to PAM for all-India Peak Electricity Demand (Table A3.5), a one unit (100 mm) increase in rainfall results in 5% reduction when rainfall is in the range of 50–100 mm, 5% reduction when rainfall is in the range of 100–150 mm and 4% reduction when rainfall is above 200 mm.

## 4.2. Out-sample prediction and choice of the model

In the section above, the relationships between different variables are reported. However, a forecasting exercise is not just about explaining relationships but models also need to be tested on whether they are good in terms of using historical relationships to project into the future. One method to do this is to assume that one has data till, for example, FY 2014-15 and estimate the models using data from FY 2002-2003 to FY 2014-2015. Thereafter, forecasts for the period FY 2015-16 are made based on the estimated model and the one that fits the actual data for the period best, is the best model used for forecasting beyond FY 2015-16. It is found that PAM gives the lowest mean absolute percentage error at the all-India level and thus forecasts obtained from this model are the most recommended scenario (see Figure 4.8). Two versions of PAM were estimated — all-India panel model and

regional level panel model. As the average Mean Absolute Percentage Error (MAPE) for PAM-all India is very close to PAM at the regional level, PAM at the regional level is selected as it performs better when we compare deviations of forecast demand (keeping weather and other explanatory variables same in both models) from actual demand at the all-India level during 2017 and 2018 (See Figure 4.8 and Figure 4.9). Figure 4.10, which plots the predicted Electrical Energy Requirement from PAM (regional) with actual Electrical Energy Requirement during FY 2002-03 to FY 2015-16, shows that the model fits the actual Electrical Energy Requirement quite closely.

**Figure 4.8 Comparing MAPEs at All-India for all Estimated Models (%)**



**Figure 4.9 Comparison of All-India forecasts (PAM All India, PAM Region) with Actual**

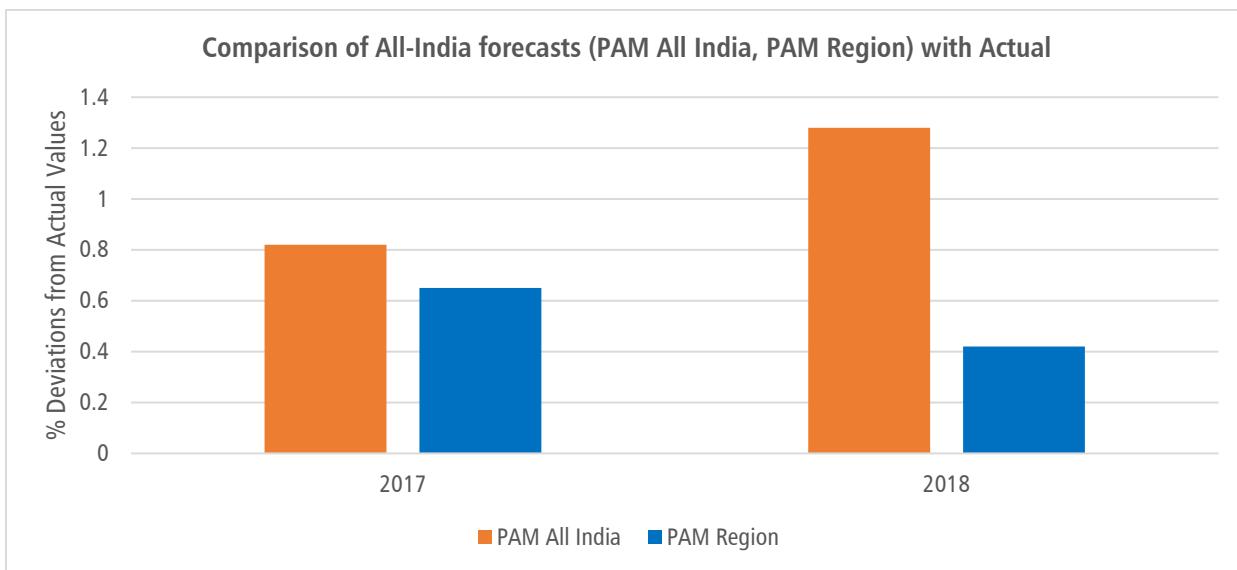
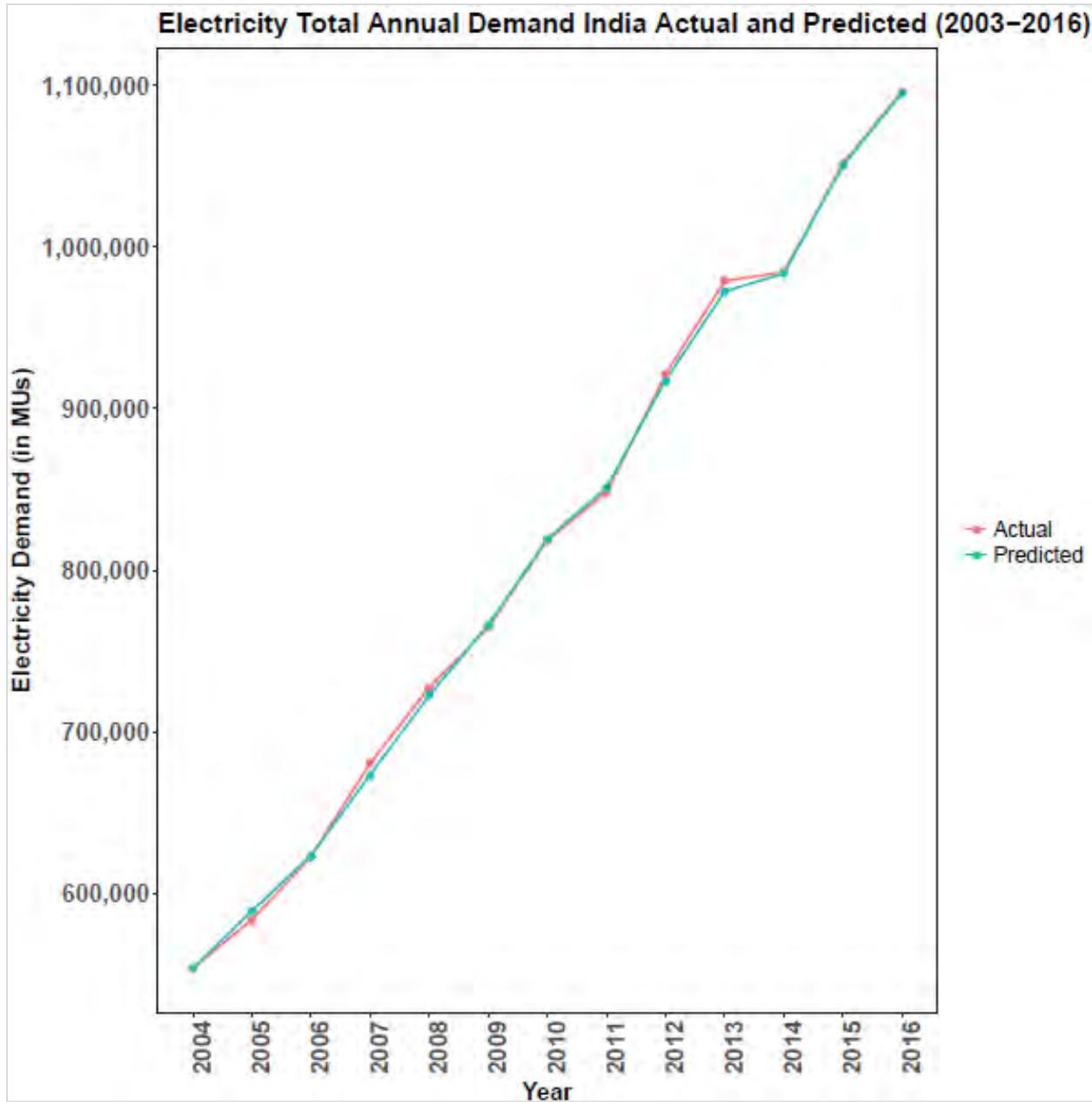


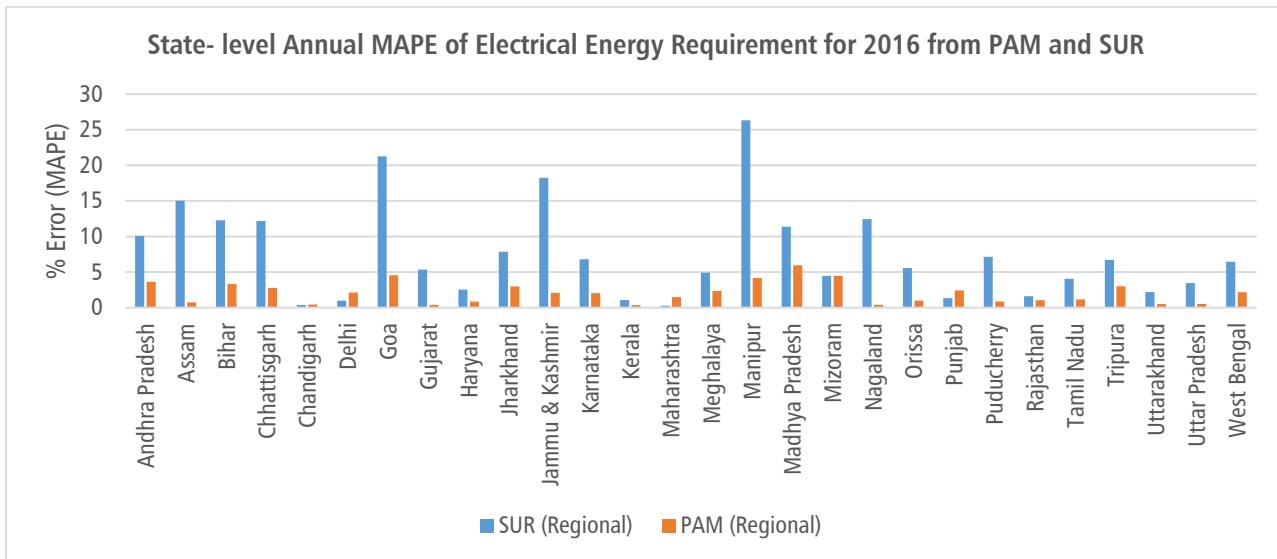
Figure 4.10 Electricity Total Annual Demand India Actual and Predicted from PAM (2003-2016)



For each state, two forecasts are obtained — one from regional PAM and another from the SUR model. While PAM estimates the future demand assuming regional convergence in the standard of living over time, the SUR model estimates state demand based on state-specific path observed in the previous period under study. Figure 4.11 shows that for many states PAM at the regional level outperforms the SUR model in terms of out sample MAPE for 2016. However, for some states/UTs such as Chandigarh, Delhi, Punjab and Maharashtra, the SUR model has lower MAPE as compared to PAM.



**Figure 4.11 State-level Annual MAPE of Electrical Energy Requirement for 2016 from PAM and SUR**



# **Electricity demand forecasts from FY 2016-17 to FY 2036-37**

---

**5**



## 5.

# Electricity demand forecasts from 2016-17 to 2036-37

In this chapter, India's electricity demand (in terms of Electrical Energy Requirement and Peak Electricity Demand) is projected under three different GDP scenarios (Business As Usual, Optimistic and Pessimistic) and 14 different weather scenarios from Regional PAM (henceforth termed as "PAM" only) & SUR model.

In all future scenarios, it has been assumed that real electricity prices will remain constant at the 2015-16 level. On one hand, future electricity prices are expected to fall with increasing supply from renewables. On the other hand, prices are expected to increase with expected increase in transmission and distribution costs associated with renewables. Overall, the two effects in opposite direction are likely to offset each other and hence constant real prices have been assumed in future.

In all the future scenarios, population at the all-India level are expected to grow as per the medium growth scenario of the United Nations Development program (UNDP) (see Table A5.1 in the Annexure 5).

In all scenarios, for FY 2016-17 and FY 2017-18, the actual or provisional estimates of GDP are used. For FY 2016-17, the actual GDP (at constant prices) growth rate of 7.1% is obtained from the Ministry of Statistics and Programme Implementation (MOSPI). For FY 2017-18, the provisional estimate of GDP (at constant prices) growth rate of 6.6% is obtained from the MOSPI. For subsequent years, a different rate of growth for GDP has been assumed for different scenarios.

## 5.1 Business-as-Usual (BAU)

The **BAU** case assumes that GDP at the all-India level, used in the above model to forecast the future Electrical Energy Requirement and Peak Electricity Demand till the year 2036-37, will continue to grow at the average CAGR of about 7.3% obtained during FY 2000-01 to FY 2017-18, and there will be no significant deviations from these past trends. This may be considered as the most likely scenario. Under this scenario, for FY 2018-19, the expected growth rate of 7.5% in GDP has been taken from Niti Aayog. It is assumed that GDP rises gradually from 7.5% in FY 2018-19 to 8% till FY 2022-23, declines slowly to 7% in FY 2029-30 and thereafter grows at 7% per annum till FY 2036-37 (See Table A5.1 in the Annexure 5 for year-specific growth rate assumptions).

## 5.2 Scenario for faster growth of GDP

Niti Aayog aims to achieve relatively faster growth of 8% as compared to 7.3% achieved during FY 2000-01–FY 2017-18. Attaining the growth rate of 8% per annum on the sustained basis in the future would require concerted internal reforms to transform the structure of India's economy as well as favourable global environment. Policy reforms such as 'Make in India' can increase the stagnant share of the manufacturing sector and provide employment to a large pool of unskilled labour who are currently unemployed or partially employed.



## 5.3 Scenario for lower growth of GDP

The low growth scenario assumes that GDP rises by 6.5% every year between FY 2018-19 and FY 2036-37. In the recent years, there has been deceleration in the growth rate of GDP below 7%. The low growth scenario assumes this lower growth rate 6.5% to continue in future.

## 5.4 Forecast of Energy Requirement through PAM Model

In the BAU scenario for PAM, Electrical Energy Requirement is projected to increase at a CAGR of 4.86% for the period FY 2016-17 to FY 2036-37. Energy Requirement is projected to increase from 1152.4 BU in 2016-17 to 1886.9 BU in 2026-27, 2378.7 BU in 2031-32 and 2976.3 BU in 2036-37. Figure 5.1 and Table A5.2 present the total electricity requirement forecast for India from FY 2016-17 to FY 2036-37. Under the baseline scenario, Electrical Energy Requirement is likely to increase 2.58 times between FY 2016-17 and FY 2036-37.

In the optimistic scenario of 8% GDP growth, Electrical Energy Requirement is projected to increase at a CAGR of 5.2% for the period FY 2016-17 to FY 2036-37. Energy Requirement is projected to increase from 1152.4 BU in 2016-17 to 1905.5 BU in 2026-27, 2458.9 BU in 2031-32 and 3175.4 BU in 2036-37. Under the optimistic scenario, Electrical Energy Requirement is likely to increase 2.75 times between 2016-17 and 2036-37.

In the pessimistic scenario of 6.5 % GDP growth, Electrical Energy Requirement is projected to increase at a CAGR of 4.33% for the period FY 2016-17 to FY 2036-37. Energy Requirement is projected to increase from 1152.4 BU in 2016-17 to 1776.9 BU in 2026-27, 2186.7 BU in 2031-32 and 2691.07 BU in 2036-37. Figure 5.1 and Table A5.4 present the total electricity demand forecast for India during FY 2016-17–FY 2036-37. Under the low growth scenario, Electrical Energy Requirement is likely to increase 2.33 times between FY 2016-17 and FY 2036-37.

An overview of Electrical Energy Requirement (MU) and its CAGR for various scenarios are summarized in Table 5.1a and 5.1b below:

**Table 5.1a Electrical Energy Requirement (in BU)**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17	1152.4	1152.4	1152.4	1160.4
2021-22	1471.5	1477.5	1443.5	1566.0
2026-27	1886.9	1905.4	1776.9	2047.4
2031-32	2378.7	2458.9	2186.7	2530.5
2036-37	2976.3	3175.4	2691.07	3049.4

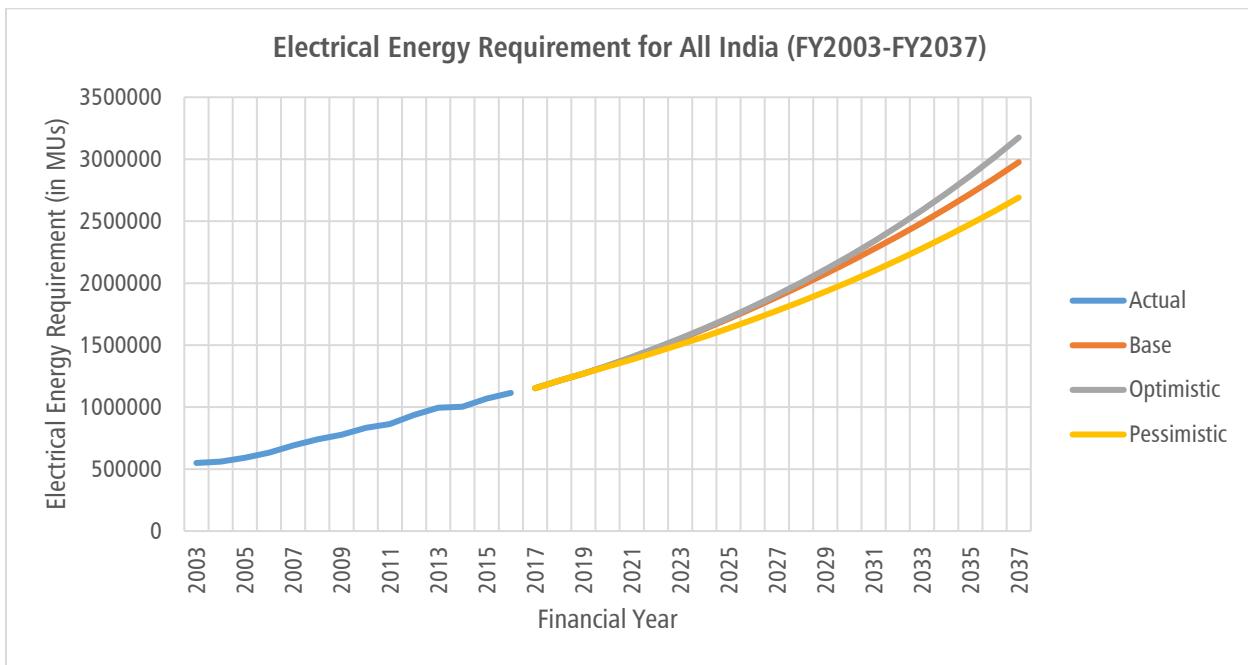
\*All forecasts are reported for average weather conditions. See details of each scenario



**Table 5.1b: Electrical Energy Requirement CAGR (%) from PAM**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17 to 2021-22	5.01	5.10	4.61	6.18
2021-22 to 2026-27	5.10	5.22	4.24	5.51
2016-17 to 2026-27	5.05	5.16	4.43	5.84
2026-27 to 2036-37	4.66	5.24	4.24	4.06
2016-17 to 2036-37	4.86	5.20	4.33	4.95

**Figure 5.1 Electrical Energy Requirement under all scenarios**

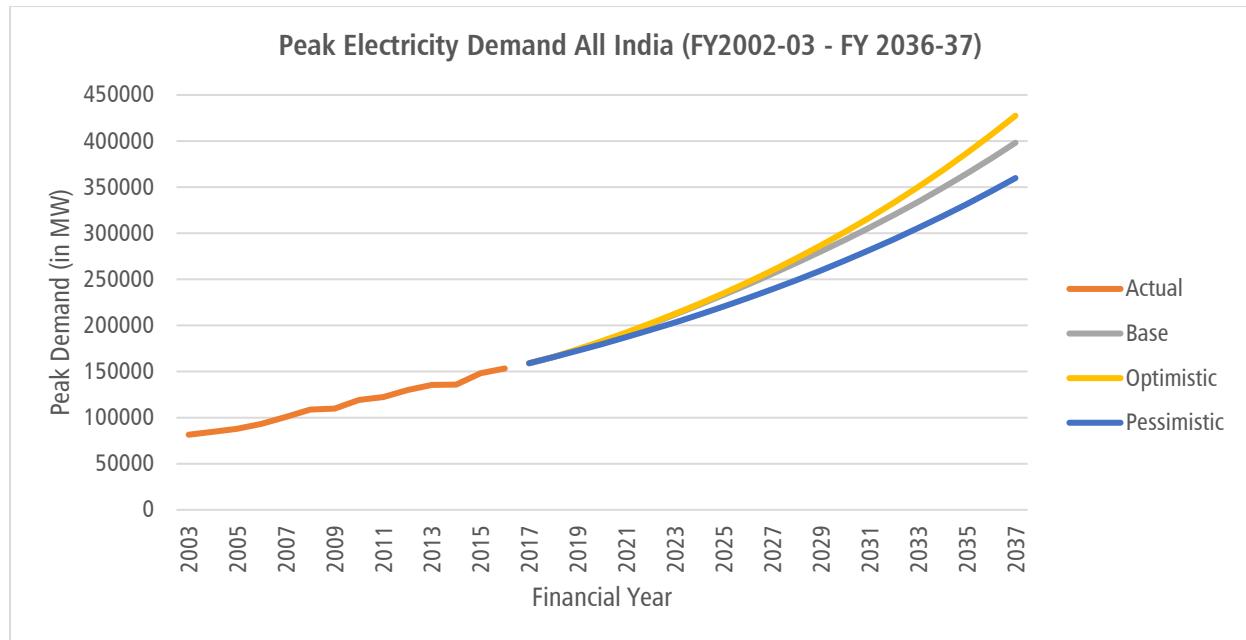


## 5.5 Forecast of Peak Electricity Demand through PAM Model

In the BAU scenario, all-India Peak Electricity Demand is projected to increase at an average annual rate of 4.7% from 158.9 GW in 2016-17 to reach 255.9 GW in 2026-27, 319.7 GW in 2031-32 and 398.1 GW in 2036-37. Figure 5.2 and Tables (A5.5–A5.7) present Peak Electricity Demand forecast for India during FY 2016-17–FY 2036-37. Under the baseline scenario, all-India Peak Electricity Demand is likely to increase 2.5 times between FY 2016-17 and FY 2036-37.

An overview of Peak Electricity Demand (MW) for various future periods is shown in Figure 5.2 and Table 5.2 below:

**Figure 5.2 Peak Electricity Demand**



**Table 5.2 Peak Electricity Demand (in MW)**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17	158,994	158,994	158,994	161,834
2021-22	201,481	202,330	195,133	225,751
2026-27	255,911	259,628	239,299	298,774
2031-32	319,794	333,152	293,462	370,462
2036-37	398,172	427,497	359,882	447,702

\*All forecasts are reported for average weather conditions. See details of each scenario

## 5.6 Forecast of Energy Requirement through SUR Model

All-India electricity demand forecasts as based on the regional SUR model under three different GDP scenarios—baseline or business-as-usual (BAU) scenario, optimistic scenario and pessimistic scenario are discussed below:

An overview of Electrical Energy Requirement (Billion Units (BU)) and CAGR (%) for various scenarios is shown in Table 5.3 and Table 5.4 below:

**Table 5.3: Electrical Energy Requirement (in BU) from SUR**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17	1188.2	1188.2	1188.2	1160.4
2021-22	1550.0	1558.3	1488.2	1566.0
2026-27	2056.4	2095.7	1884.5	2047.4
2031-32	2685.1	2836.8	2395.4	2530.5
2036-37	3517.4	3878.2	3066.8	3049.4

\*All forecasts are reported for average weather conditions. See details of each scenario.

**Table 5.4: Electrical Energy Requirement CAGR (%) from SUR**

Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17 to 2021-22	5.46	5.57	4.61	6.18
2021-22 to 2026-27	5.82	6.1	4.83	5.51
2016-17 to 2026-27	5.64	5.84	4.72	5.84
2026-27 to 2036-37	5.51	6.35	4.99	4.06
2016-17 to 2036-37	5.58	6.09	4.86	4.95

In the BAU scenario of 7.3% GDP growth, Electrical Energy Requirement is projected to increase at a CAGR of 5.58% from 1188.2 BU in 2016-17 to reach 2056.4 BU in 2026-27, 2685.1 BU in 2031-32 and 3517.4 BU in 2036-37. Under this baseline, Electrical Energy Requirement is likely to increase 2.96 times between FY 2016-17 and FY 2036-37.

In the optimistic scenario of 8% GDP growth, Electrical Energy Requirement is projected to increase at a CAGR of over 6.09% from 1188.2 BU in 2016-17 to reach 2095.7 BU in 2026-27, 2836.8 BU in 2031-32 and 3878.2 BU in 2036-37. Under this optimistic, Electrical Energy Requirement is likely to increase 3.26 times between 2016-17 and 2036-37.

In the low growth scenario of 6.5% growth, Electrical Energy Requirement is projected to increase at a CAGR of over 4.86% from 1188.2 BU in 2016-17 to reach 1884.5 BU in 2026-27, 2395.4 BU in 2031-32 and 3066.8 BU in 2036-37. Under this low growth scenario, Electrical Energy Requirement is likely to increase 2.58 times between 2016-17 and 2036-37.

## 5.7 Forecast of Peak Electricity Demand through SUR Model

An overview of Peak Electricity Demand (Megawatt (MW) for various future periods is shown in Table 5.5 below:

**Table 5.5: Peak Electricity Demand (in MW) from SUR**

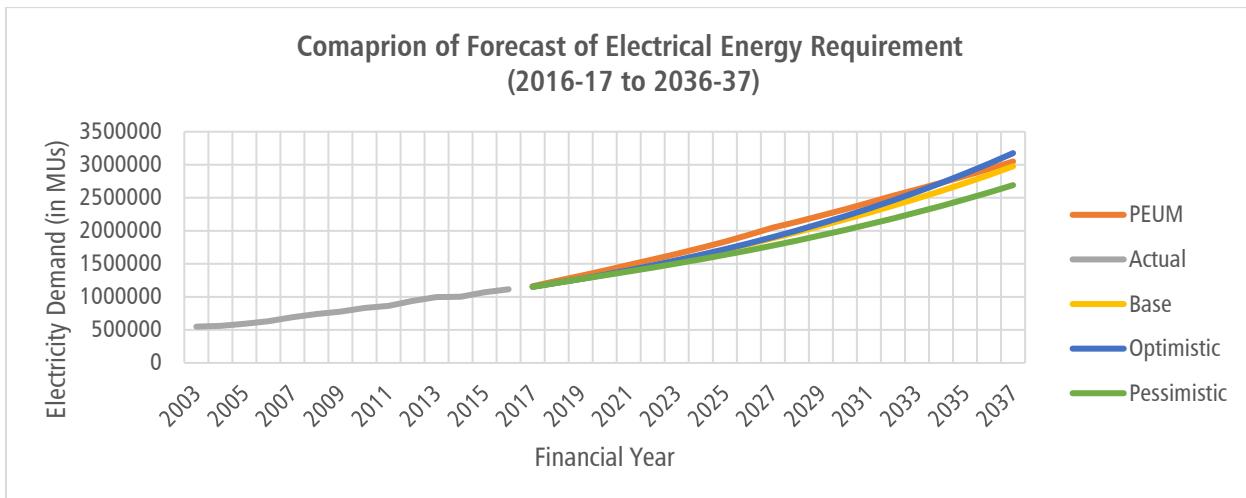
Year	7.3% GDP (BAU scenario)	8% GDP (optimistic scenario)	6.5% GDP (pessimistic scenario)	Projection by PEUM
2016-17	163,148	163,148	163,148	161,834
2021-22	212,828	213,972	204,340	225,751
2026-27	282,361	287,751	258,747	298,774
2031-32	368,683	389,512	328,904	370,462
2036-37	482,950	532,495	421,081	447,702

\*All forecasts are reported for average weather conditions. See details of each scenario.

## 5.8 Comparison of econometric method forecasts with 19th EPS forecasts by PEUM

The difference in the forecast of Electrical Energy Requirement by PEUM and econometric method forecast from PAM for FY 2016-17–FY 2036-37 is shown in Figure 5.3.

**Figure 5.3 Comparison of forecast Electrical Energy Requirement (19th EPS using PEUM vs PAM forecast)**



The table below shows the difference in percentage between 19<sup>th</sup> EPS forecast by PEUM and econometric forecast from PAM.

**Table 5.6 Difference in percentage between 19th EPS forecast by PEUM and PAM forecast (Electrical Energy Requirement)**

Year	7.3% GDP (BAU scenario)	8% GDP (Optimistic Scenario)	6.5% GDP (Pessimistic Scenario)
2016-17	-0.69	-0.69	-0.69
2026-27	-7.8	-6.9	-13.2
2031-32	-6	-2.8	-13.5
2036-37	-2.4	4	-11.75

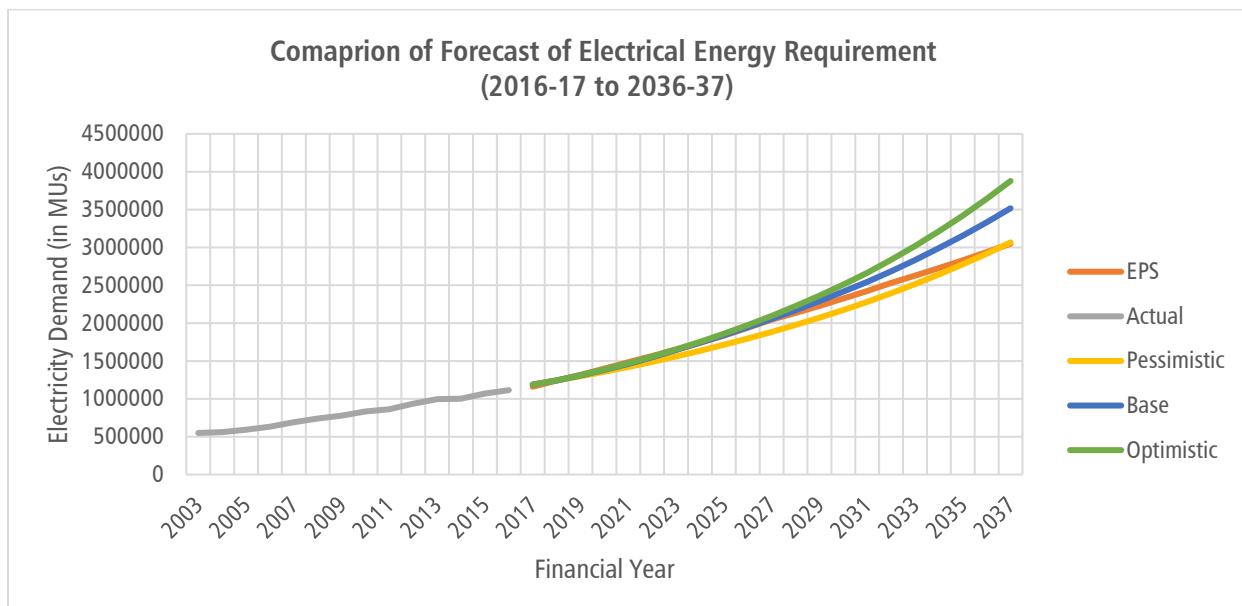
\*All forecasts are reported for average weather conditions. See details of each scenario

An analysis of the differences between the econometric forecasts and the 19<sup>th</sup> EPS forecasts by PEUM vis-à-vis PAM forecasts yields that 19<sup>th</sup> EPS forecasts by PEUM are higher than both the BAU and the higher GDP growth scenario till FY 2031-32. For the years beyond 2031-32, the econometric method forecasts under the BAU scenario and the higher growth scenario compare favourably to the 19<sup>th</sup> EPS forecast by PEUM.

An analysis of the differences between the econometric forecasts under SUR and the 19<sup>th</sup> EPS forecasts by PEUM yields that the 19<sup>th</sup> EPS forecasts by PEUM compare closely to the BAU till FY 2031-32. For the years beyond 2031-32, the econometric method forecasts by SUR under the BAU and the higher growth scenario diverge significantly from the 19<sup>th</sup> EPS forecast by PEUM and forecasts under pessimistic scenario compare favourably with the 19<sup>th</sup> EPS forecast by PEUM.

The difference in the forecast of Electrical Energy Requirement by PEUM and econometric method forecast from SURE for FY 2016-17–FY 2036-37 is shown in Figure 5.4.

**Figure 5.4 Comparison of forecast Electrical Energy Requirement (19th EPS using PEUM vs SURE forecast)**



The table below shows the difference in percentage between 19<sup>th</sup> EPS forecast by PEUM and econometric forecast from SURE.

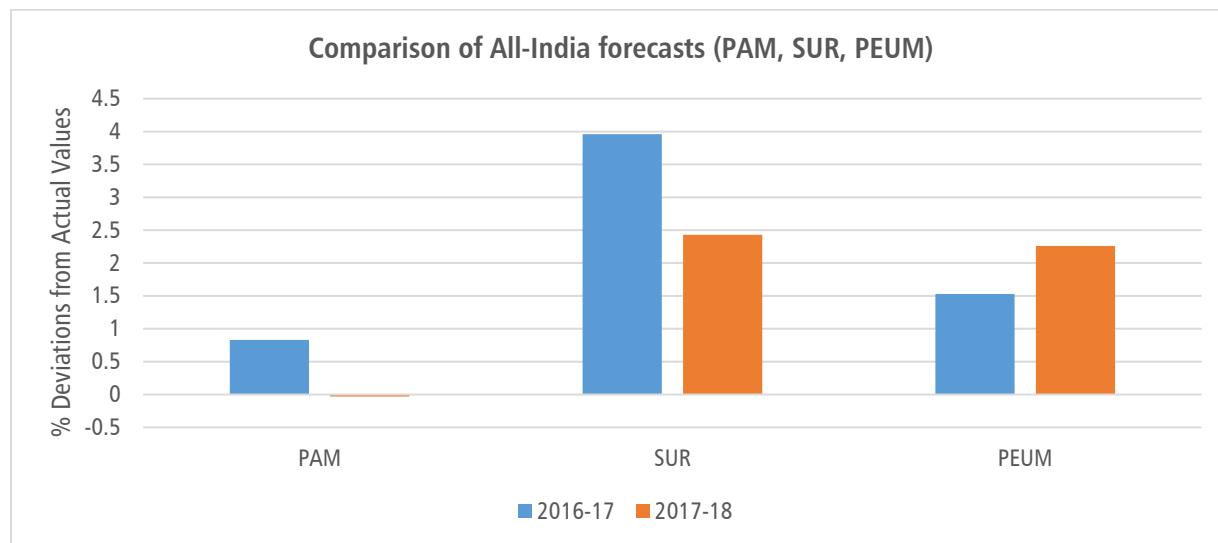
**Table 5.7 Difference in percentage between 19th EPS forecast by PEUM and SURE forecast (Electrical Energy Requirement)**

Year	7.3% GDP (BAU scenario)	8% GDP (Optimistic Scenario)	6.5% GDP (Pessimistic Scenario)
2016-17	-2.39	-2.39	-2.39
2026-27	-0.44	-2.36	7.96
2031-32	-6.11	-12.10	5.33
2036-37	-15.34	-27.18	-0.57

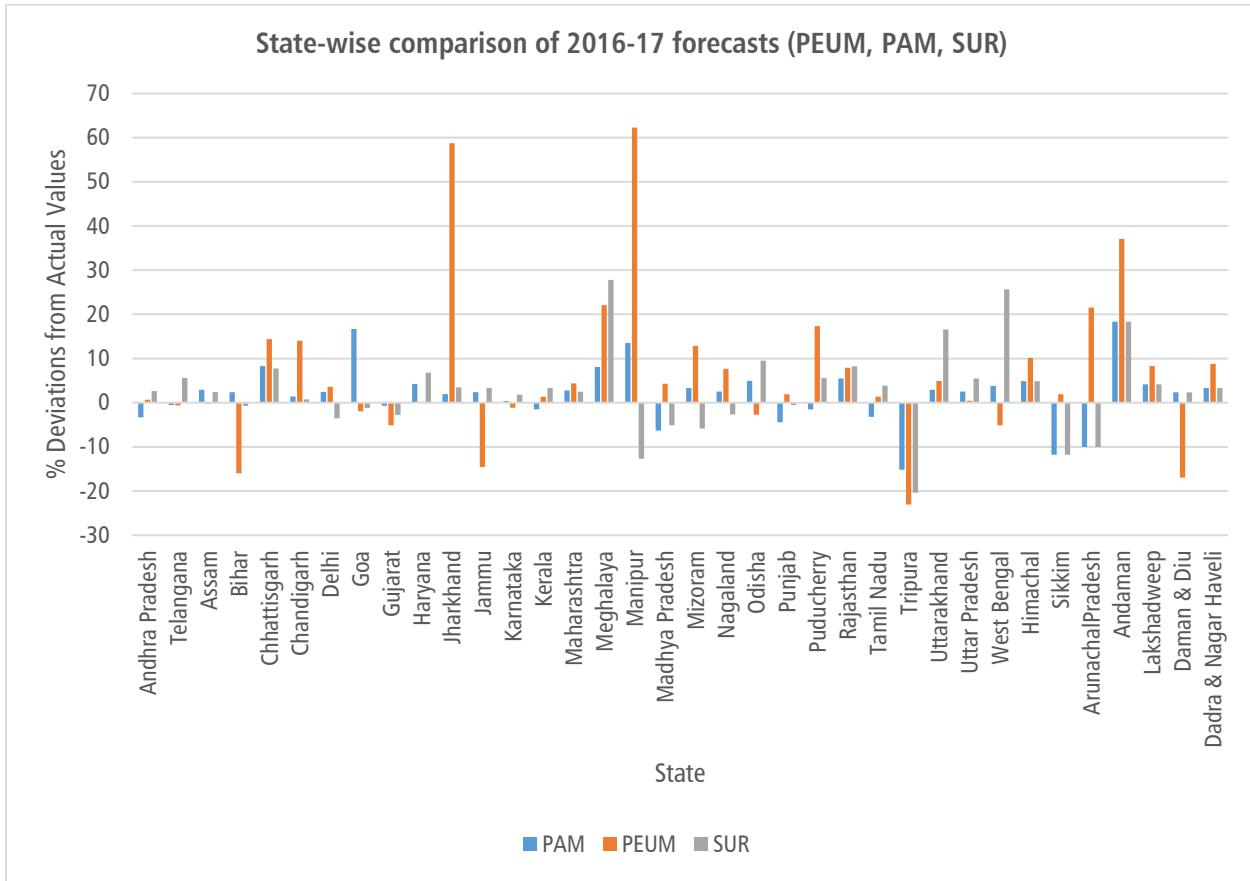
\*All forecasts are reported for average weather conditions. See details of each scenario

Figure 5.5, Figure 5.6 and Figure 5.7 compare econometric forecasts under BAU scenario and the forecasts by PEUM with the actual Electrical Energy Requirement in India in FY 2016-17 and FY 2017-18. It is observed that econometric forecasts are closer to the actual Electrical Energy Requirement observed during both these years. The 19<sup>th</sup> EPS forecasts using PEUM are higher than the actual Electrical Energy Requirement in both these years (1.5% in FY 2016-17 and 2.2% in FY 2017-18). The econometric forecasts from PAM are higher than the actual Electrical Energy Requirement in FY 2016-17 (by 0.7%) and almost equal to the actual Electrical Energy Requirement in 2017-18 (with deviation of -0.06%). At the state level, it is observed that for some states econometric method forecasts are closer to the actual values of Electrical Energy Requirement, while EPS forecasts by PEUM are closer to the actual Electrical Energy Requirement (for example: Tamil Nadu and Haryana). The econometric method forecasts from SUR are higher than the actual Electrical Energy Requirement in FY 2016-17 (by 3.96%) and in FY 2017-18 (by 2.43%).

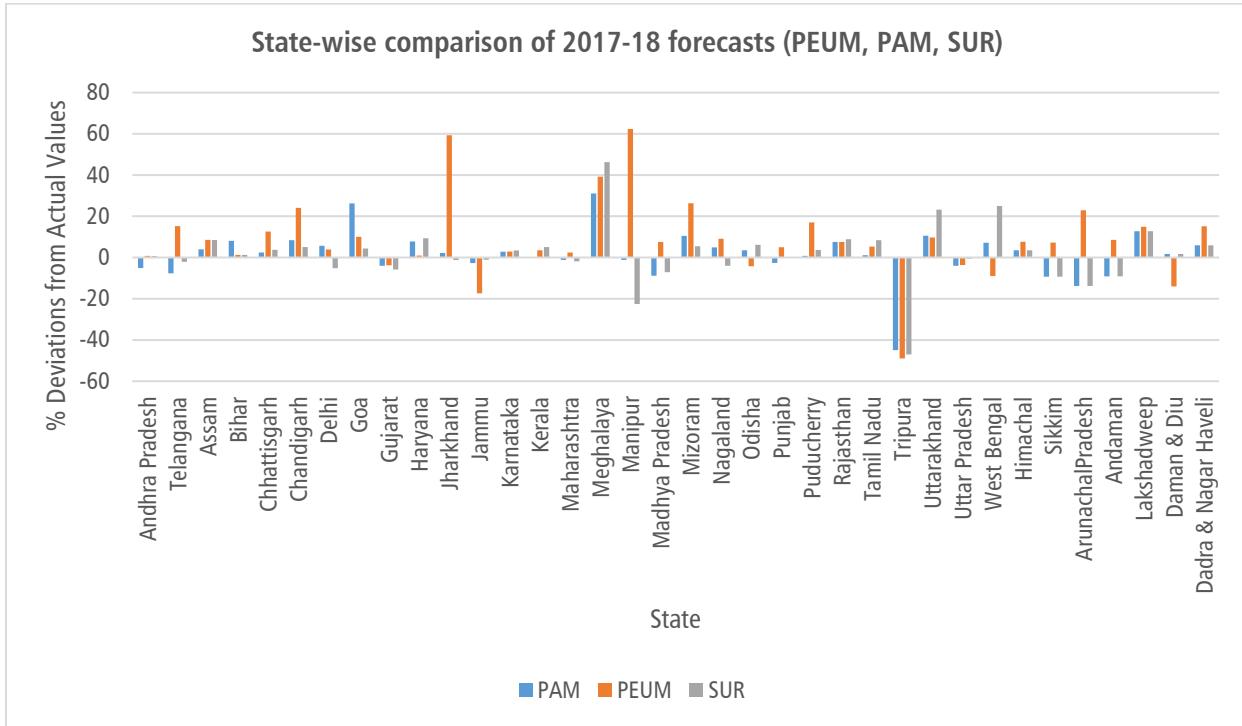
**Figure 5.5 Comparison of forecasted Electrical Energy Requirement (19th EPS using PEUM vs econometric method forecasts)**



**Figure 5.6 Difference in percentage between state-level forecasts and actual Electrical Energy Requirement in 2016-17**

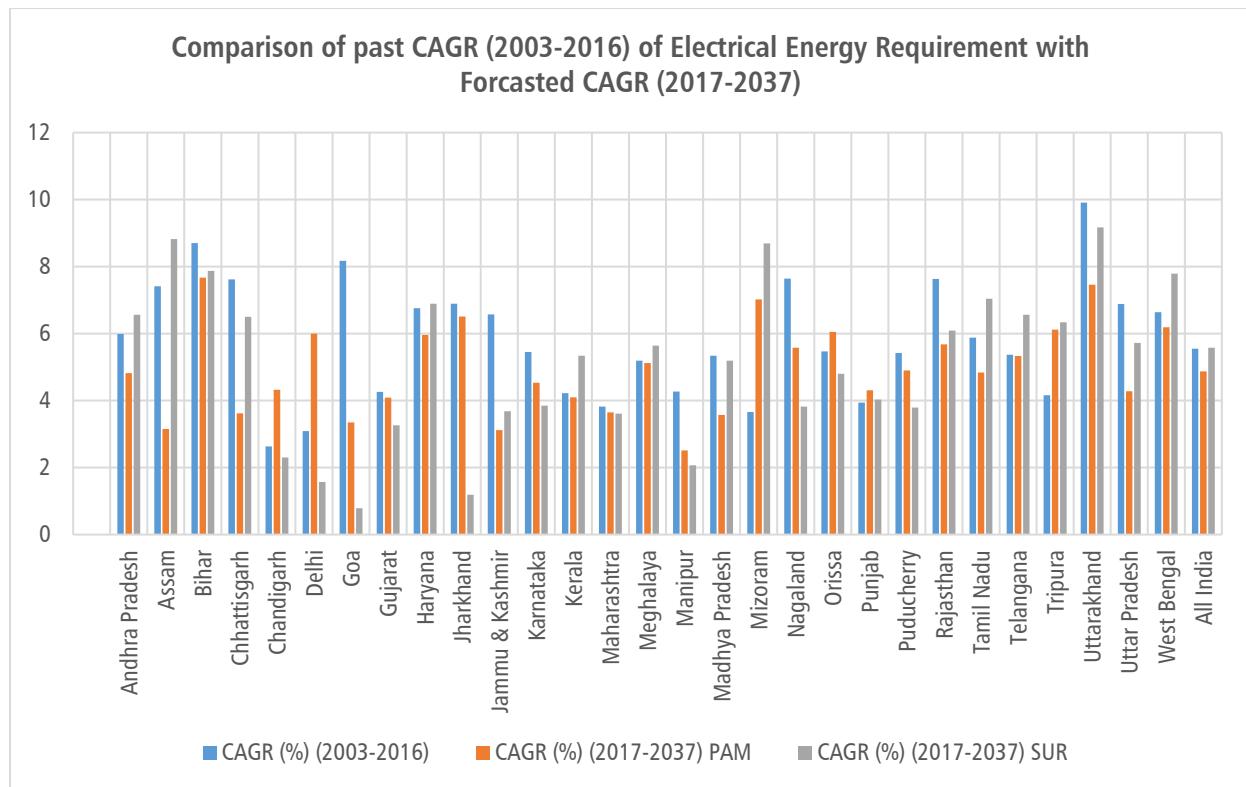


**Figure 5.7 Difference in percentage between state-level forecast and actual Electrical Energy Requirement in 2017-18**



It is observed that the relatively economically less developed states such as Bihar, Jharkhand, Odisha, Rajasthan, Mizoram, Tripura and Nagaland are likely to grow at a rate higher than the all-India compound annual average rate of about 4.86% during FY 2016-17—FY 2036-37. However, for few developing states such as Chhattisgarh and Madhya Pradesh, the CAGR from the PAM (which is the most preferred model at all-India) turns out to be much lower relative to their past observed growth rates. Both these states belong to the western region which also includes two most developed States-Maharashtra and Gujarat. The western region PAM results are dominated by these two states and thus depresses future growth rates of these two developing states. To address this issue, state-specific forecasts are obtained from the SUR model (See Figure 5.8 and Table A5.8). For both Chhattisgarh and Madhya Pradesh, the future rate of growth is higher than the all-India average from the SUR model and it is also aligning with their past growth rates.

**Figure 5.8 Past and Future Growth rate of Electrical Energy Requirement**



## 5.9 Impact of weather on electricity demand under baseline

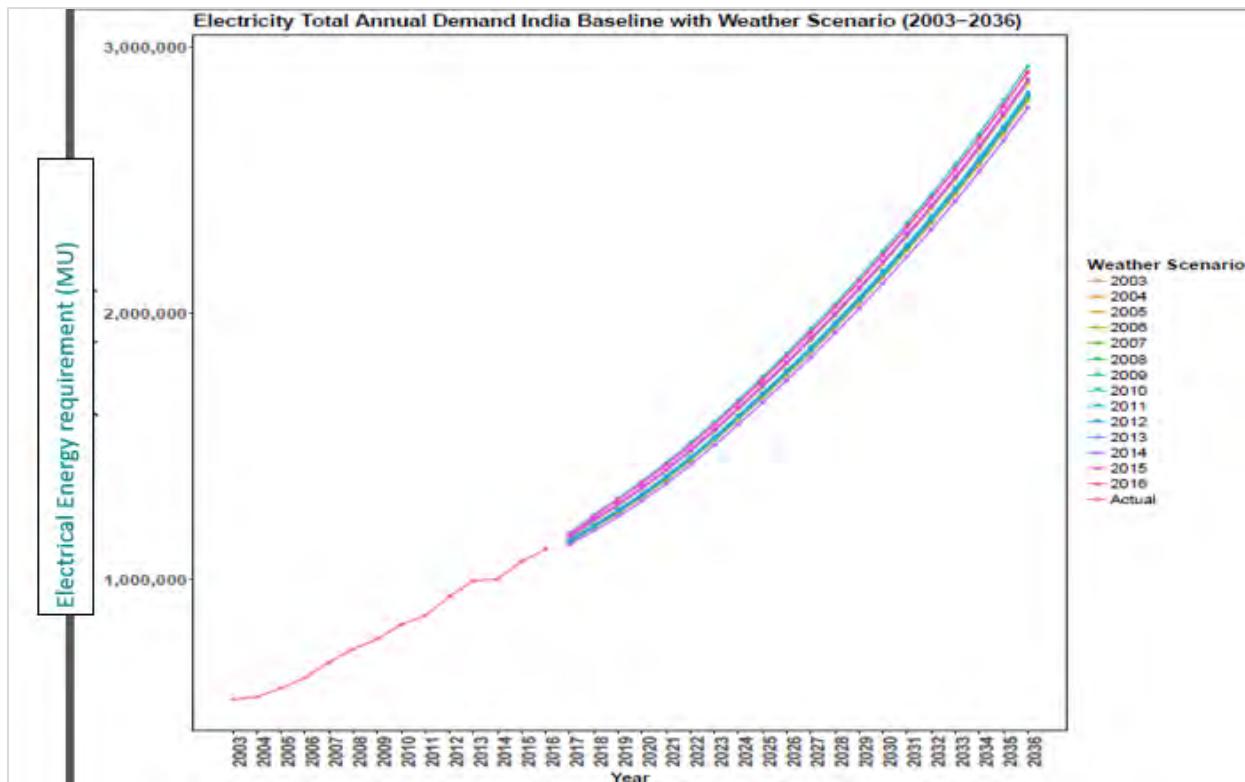
For each future year, electricity demand is forecast under 14 different weather scenarios (CDD, HDD and rainfall). Each weather scenario corresponds to a weather pattern observed during FY 2002-03-FY 2015-16. Figure 5.9 plots forecasts of electricity demand from PAM under all 14 weather scenarios for the baseline GDP growth case. It is observed that the future demand turns out to be the highest for the weather scenario corresponding to the year FY 2009-10 and the lowest for the weather scenario corresponding to the year FY 2013-14. The year FY 2009-10 is the hottest year with the highest monthly average state-level CDD of 167.5 degree days (6.23% higher than average CDD) and the lowest monthly average state-level rainfall of 97.8 mm (14% lower than average rainfall) during FY 2002-03 and FY 2015-16.

On the other hand, the year FY 2013-14 experienced the lowest monthly average state-level CDD of 150 degree days (4.36% lower than average CDD) and average monthly state-level rainfall of 115 mm which is 2.6% higher than the average monthly state-level rainfall during FY 2002-03–FY 2015-16.

In the FY 2009-10 weather scenario, Electrical Energy Requirement is projected to increase at an average annual rate of 4.9% from 1173.5 BU in 2016-17 to reach 3054.87 BU in 2036-37. As compared to the Electrical Energy Requirement obtained under the PAM baseline GDP scenario (which is the average of the forecast demand under all 14 scenarios), Electrical Energy Requirement is about 2.63% higher in this weather scenario in 2036-37 for the 2009-10 weather scenario.

In the FY 2013-14 weather scenario, Electrical Energy Requirement is projected to increase at an average annual rate of 4.83% from 1131.7 BU in 2016-17 to reach 2907.8 BU in 2036-37. As compared to the average Electrical Energy Requirement forecast obtained under the baseline GDP scenario (which is the average of the forecast demand under all 14 scenarios), electricity demand is about 2.3% lower in FY 2036-37 for the 2013-14 weather scenario.

**Figure 5.9 Annual Electrical Energy Requirement under 14 past weather scenarios**



# Annexures

---





## Annexure 1

### Long panel estimation

First, the fixed effect panel model is estimated using ordinary least squares regression. The error terms obtained from this estimation were analysed to identify the relationship exhibited by error terms for a given state in different time periods. The objective was to identify the dependence of an error term in time period 't', if any, on the error terms of previous periods.

Second, the strength of correlation in errors at various lags is studied using the autocorrelation function (ACF) plot. The ACF plot is a visual way to see serial correlation in time-series data. ACF gives a summary of correlation at different periods of time. The plot shows the correlation coefficient for the series lagged by one delay at a time. From the ACF plot, it was observed that the error terms exhibit serial correlation for AR (1). This implies that the error term in time period 't' is dependent on the error term of the previous period. As expected, error terms were also dependent on lags of 12 (error of the same month in the previous year) as electricity demand is bound to have a high degree of seasonality.

The estimation technique called Prais-Winsten regression is used to account for serial correlation in errors within each state. It allows for state-specific AR (1) model for the error over as

$$u_{it} = \rho_i u_{i(t-1)} + \varepsilon_{it},$$

where  $\varepsilon_{it}$  are serially uncorrelated and  $\rho_i$  is coefficient of autocorrelation for state  $i$ . It applies a Cochrane - Orcutt transformation for all observation (except the first observation<sup>10</sup>) in a way to eliminate the serial correlation in the error term  $u_{it}$  so that we can work with serially uncorrelated error  $\varepsilon_{it}$  in the model:

$$U_{it} - \rho_i U_{i(t-1)} = E_{it}$$

Applying this transformation to all variables, we obtain the final equation for the model for each state:

$$\ln E_{it} - \rho_i \ln E_{i(t-1)} = \Theta(X_{it} - \rho_i X_{i(t-1)}) + \alpha_i(1 - \rho_i) + \varepsilon_{it}$$

Where  $E_{it}$  is the electricity demand of state 'i' in time period 't',  $X_{it}$  represents all the independent variables other than the constant term (such as GDP, electricity prices, rainfall etc.),  $\Theta$  is the vector of parameters and  $\alpha$  is a state-specific constant.

$$\sqrt{(1 - \rho_i^2)} \ln E_{it} = \Theta \sqrt{(1 - \rho_i^2)} X_{it} + \alpha_i \sqrt{(1 - \rho_i^2)} + \sqrt{(1 - \rho_i^2)} \varepsilon_{it}$$

Panel data typically displays both contemporaneous correlation across states and state-level heteroskedastic. This

<sup>10</sup> For the first observation, it makes a transformation in the following way:



results in incorrect inferences from standard errors produced by Ordinary Least Squares. Panel Corrected Standard Error (PCSE) are used in the current study to account for these deviations from spherical errors and allowing for better inferences from linear models estimated from panel data.

## Partial adjustment model

The theoretical specification of the model is inspired by the paper 'A partial adjustment model of US electricity demand by region, season and sector' by Anthony Paul, Erica Myers and Karen Palmer.

The equilibrium energy demand of the economy that is expected to prevail in the long-run has been modelled by  $Q^*$ . At any point of time, the actual electricity demand prevailing in the economy is denoted as  $Q_t$ . The actual consumption varies from the desired consumption levels as the capital stock is not at the long-run equilibrium levels. In every time period, consumers try to reduce a part of the gap between their actual consumption and the long-run equilibrium level.

To model the equilibrium-desired level of electricity demand, we have assumed a Cobb Douglas relationship between equilibrium energy demand  $Q^*$  and its drivers (i.e. price, income and other covariates).

$$Q_{i,t}^* = f(P_{i,t}, X_{i,t}) = \alpha P_{i,t}^{\varepsilon_1} X_{i,t}^{\beta}$$

Consumers try to bring their actual level of consumption in line with the equilibrium level. However, they are only partially successful in every period to close this gap.

As capital is not immediately mobile, we use habitual parameters to model energy demand behaviour — that capture the constrained capacity of consumers to immediately adjust to the long-run equilibrium level of consumption in response to a change in price, rainfall, weather or other factors.

This habitual response of consumers is captured through two parameters. The parameter  $\theta_1$  captures the strength of month-to-month behavioural inertia based on the monthly rate of capital turnover for equipment that is operated in all months (e.g. refrigerators). The parameter  $\theta_{12}$  captures the strength of year-on-year behavioural inertia based on the rate of capital turnover that has a seasonal usage pattern (e.g. air conditioners).

$$\left( \frac{Q_{i,t}^2}{Q_{i,t-1} Q_{i,t-12}} \right) = \left( \frac{Q_{i,t}^*}{Q_{i,t-1}} \right)^{\theta_1} \left( \frac{Q_{i,t}^*}{Q_{i,t-12}} \right)^{\theta_{12}}$$

These parameters take a value between 0 and 1, according to which 0 reflects a situation whereby consumers are completely unable to adjust their energy consumption towards the long-run equilibrium level and 1 reflects a situation whereby the capital stock can adjust immediately and no behavioural inertia exists. In reality, we expect a value between 0 and 1 to give a true picture of reality.

Using the above two models, the final specification of the model is specified as:

$$\ln Q_{i,t} = \frac{(1 - \theta_1)}{2} \ln Q_{i,t-1} + \frac{(1 - \theta_{12})}{2} \ln Q_{i,t-12} + \frac{(\theta_1 + \theta_{12})}{2} (\varepsilon_L \ln P_{i,t} + \beta \ln X_{i,t})$$



## Annexure 2

### Details of the data used

#### 1. State GDP

The GDP data is used for every state on an annual level from FY 2002-03 to FY 2015-16. The complete data has been sourced from the Central Statistical Office (CSO), MOSPI. The GDP data between FY 2002-03 and FY 2016 was not at the same base year. The base years corresponding to the data obtained from MOSPI were as follows:

- FY 2002-03 and 2004: Base year was FY 2000
- FY 2005-FY 2011: Base year was FY 2005
- FY 2012-FY2016: Base year was FY 2012

To bring all the data on the same base year, the GDP values for all years were converted to the base year of FY 2012 as on 01.01.2018.

#### GDP (Factor) at base price (FY 2011-12)

FY	GDP (in Crores)	FY	GDP (in Crores)	FY	GDP (in Crores)
2000	3433272	2006	5025695	2012	8106946
2001	3582737	2007	5506611	2013	8546275
2002	3790873	2008	6019940	2014	9063649
2003	3936311	2009	6424768	2015	9712133
2004	4271604	2010	6976910	2016	10503348
2005	4590636	2011	7598676	2017	11247629

#### Assumptions made for obtaining future GDP

For forecasting the GDP data, several assumptions were made both at the all-India and state level.

- a) The all-India growth rate for FY 2016-17 was taken as 7.1% based on actual data from MOSPI. Similarly, the all-India growth rate for FY 2017-18 was taken as 6.6% based on the provisional estimate of GDP from the MOSPI. For subsequent years, different rate of growth for GDP has been assumed for different scenarios.
- b) After FY 2017-18, the growth pattern of all-India GDP is assumed to change according to three possible scenarios — baseline or BAU, pessimistic and optimistic scenario. The BAU case assumes that GDP at the all-India level will continue to increase at about 7.3% CAGR obtained during FY 2000-01 and FY 2017-18, and there will be no significant deviations from these past trends. The growth rate is varied over time but the CAGR of 7.3% is achieved during FY2018-19 and FY 2036-37. The growth rate is assumed to rise for the next five years until FY 2022-23 and then allowed to taper from FY 2023-24 according to the following:



Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	FY 2031 -FY 2037
GDP Baseline growth (%)	7.1	6.6	7.5	7.8	8	8	8	7.8	7.6	7.5	7.4	7.3	7.2	7.1	7

In the pessimistic growth scenario, the all-India GDP is assumed to grow at 6.5% for all future years from FY 2018-19 to FY 2036-37. In the optimistic growth scenario, the all-India GDP is assumed to grow at 8% for all future years from FY 2018-19 to FY 2036-37.

- c) After obtaining all-India GDP, it is allocated at the state level. First, the future GDP share of all states was forecast till FY 2025-26. This was done using a regression framework. The dependent variable used was the existing state GDP shares from FY 2002-03 to FY 2015-16. The only independent variable used was time. The state-wise GDP forecasts were obtained by multiplying the state shares obtained from the above regression with the values of all-India GDP. State-wise GDP obtained is normalised, so that it totals to All-India GDP.
- d) After FY 2025-26, states are assumed to grow at the rate of FY 2025-2026 till FY 2036-37. Under this approach, all-India GDP (sum of state-wise forecasts) and state-wise shares in all-India GDP are obtained for all future years. These state-wise shares are then used to allocate all-India GDP forecasts obtained under different scenarios to different states. This ensures that the sum of state-wise GDP forecasts sum to the all-India GDP forecasts obtained under different scenarios in every future year.

## 2. Population

The population statistics for every state for FY 2000-01 and FY 2010-11 are obtained from the census data. For every state, we have used the population data for FY 2000-01 and FY 2010-11 to construct the population statistics from FY 2002-03 to FY 2015-16. This is done using a two-step procedure — in the first step, the state-wise population CAGR was calculated from 2000-01 to 2010-11; in the second step, the calculated CAGR was used to fit a population trend for all states till FY 2015-16.

### Assumptions for forecasting

For forecasting the population data, several assumptions were made for the all-India and state levels as follows:

- a. The all-India population data for FY 2020-21, FY 2030-31 and FY 2040-41 was obtained from the UNDP website.
- b. This data was used to calculate the all-India population CAGR between 2010-11 and 2020-21. This CAGR was applied to compute the all-India population figures for FY 2016-17, FY 2017-18, FY 2018-19 and FY 2019-20.
- c. The following steps were performed to estimate the state-wise population figures for FY 2020-21:

- The state-wise population growth rate and all-India population growth rate were calculated between FY 2000-01 and FY 2010-11. The relationship between the two growth rates (state-level and all-India) was established by taking the ratio of the state growth rate to all-India growth rate. For example, the population growth at the all-India level was 17.64% between FY 2000-01 and FY 2010-11. During the same period, population growth for Maharashtra was 15.99%. Thus, the ratio of the two growth rates (15.99/17.64) measures the degree to which the state-wise population growth rate is higher than (if the ratio is greater than one), lower than (if the ratio is less than one) or equal to (if ratio is equal to one) the all-India population growth rate.
  - Using the all-India population figures between FY 2011 (census) and FY 2021 (UNDP), the all-India population growth rate was computed as 15.47% between FY 2011 and FY 2021. The all-India population for FY 2021 is then allocated to different states assuming that the same population growth rate relationship between a given state and national estimates for FY 2000-01-FY 2010-11 (as observed in Step1) will continue in the future between FY 2010-11 and FY 2020-21. For example, in case of Maharashtra the growth rate of population of 14.02% during FY 2011 and FY 2021 was obtained by multiplying 15.47% all-India growth rate by the past ratio of population growth rate of Maharashtra to all-India growth rate (15.47\*15.99/17.64). This process is repeated for all other states and state-level population estimates are obtained for FY 2021. Under this approach, the all-India population (sum of individual state-wise forecasts) will be close to the UNDP forecasts but not exactly same. Thus, state-wise shares in the all-India population (as obtained by the sum of individual state-wise forecasts) are obtained for FY 2021. These state-wise shares are then used to allocate all-India population forecasts obtained from the UNDP to different states for FY 2021. This ensures that the sum of state-wise population forecasts sum to the all-India population forecasts obtained from the UNDP.
- d. Given the state population values of 2010-11(census) and 2020-21(computed), the state-wise population CAGR is computed for FY 2010-11–FY2020-21. This CAGR is applied to estimate the state-wise population values for FY 2011-12–FY 2019-20. The same process has been repeated for population figures for FY 2021–FY 2031 and FY 2031-FY 2041.

### 3. Price

Price data is obtained at the annual level for every state for the period FY 2002-03–FY 2015-16. The complete data on prices is obtained from the report on 'Electricity Tariff & Duty and Average rates of electricity supply in India' published by the Central Electricity Authority, Government of India. Furthermore, the consumer price index for industrial workers (CPI-IW) is used to adjust the nominal prices for inflation. The complete CPI data is obtained from the Labour Bureau, Ministry of Labour and Employment.

The CPI-IW (CPI for industrial workers) figures were used as these figures are available state-wise for the period of analysis. The entire CPI-IW data was available on two base years — the base year for CPI-IW data after January 2006 is FY 2001 and the base year for CPI-IW data from January 2003 to December 2005 is FY 1983. The data was used after transforming the data on a common base year. For the purpose of our analysis,

the CPI-IW data for 2003 and 2004 on the base year FY 1983 was converted to the base year FY 2001. In order to do this conversion, the conversion rates specified by the Labour Bureau ([http://labourbureaunew.gov.in/LBO\\_LinkFactors.htm](http://labourbureaunew.gov.in/LBO_LinkFactors.htm)) were used.

The electricity price tariff for every state is available for five categories — domestic, agriculture, commercial, small industries, medium industries and large industries. Within each category, electricity tariffs are further divided according to multiple sub-categories. A price variable was constructed to obtain an average annual price for every state across different consumer categories. The construction of this price variable was implemented using a two-step averaging process:

- a) Under each category of Domestic, Agriculture, Commercial, Small Industries, Medium Industries and Large Industries, electricity tariffs are further divided according to multiple sub-categories according to the amount of consumption. A simple average was taken across all subcategories to obtain a representative figure of that category.
- b) A weighted average value was taken to combine the six categories of Agriculture, Commercial, Small Industries, Medium Industries and Large Industries to obtain a single electricity price value for every state. The weights were used according to the respective shares of Agriculture, Commercial, Industry (Small, Medium and Large) in the overall state electricity consumption.
- c) The obtained value for nominal price was converted to real price (adjustment for inflation) through division by the state-wise CPI-IW.

## Assumptions for forecasting

For forecasting the price values, the state-wise real price value for FY 2016 was assumed to continue for all years from FY 2016-17 to FY 2036.

## 4. Rainfall

Rainfall data is obtained state-wise for every month from FY 2002-03 to FY 2015-16. The source of the complete data is <https://en.tutiempo.net/climate/india.html>.

Two primary assumptions have been made to account for the missing values of rainfall in the data set obtained. When less than 15 days in the month are missing, the rainfall value of the previous day available was used. For missing values in a month of more than 15 days, the rainfall values for the same month in the previous year were used. This is because rainfall is assumed to follow a similar trend for a given month over time.



## Assumptions for forecasting

For forecasting the value of rainfall, the 14 available weather scenarios for the past years were used (FY 2002-03–FY 2015-16).

## 5. Cooling degree days (CDD) and heating degree days (HDD)

Temperature data is obtained state-wise for every month from FY 2002-03 to FY 2015-16. Data was taken for 75 Indian Meteorological Department (IMD) stations nationally for which temperature data was available for the period FY 2002-03– FY 2015-16. The complete list of stations used for the weather data has been specified state-wise in the table below. The source of the complete data is <https://en.tutiempo.net/climate/india.html>.

The variables used for HDD and CDD were computed based on the deviation of threshold value of 21 degree Celsius. Details of computation are explained in Chapter 3 on ‘Historical Trends of Data’.

State	Station
Andaman and Nicobar	Port Blair
Andhra Pradesh	Cwc Vishakhapatnam
Andhra Pradesh	Kurnool
Andhra Pradesh	Machilipatnam
Andhra Pradesh	Nellore
Andhra Pradesh	Pbo Anantapur
Assam	Dibrugarh / Mohanbari
Assam	Guwahati
Assam	Tezpur
Bihar	Bhagalpur
Bihar	Gaya
Bihar	Patna
Chhattishgarh	Jagdalpur
Chhattisgarh	Pbo Raipur
Chhattisgarh	Pendra Road
Delhi	New Delhi / Palam
Delhi	New Delhi / Safdarjung
Goa	Goa/Panjim
Gujarat	Ahmadabad
Gujarat	Bhuj-Rudramata
Gujarat	Rajkot
Gujarat	Surat
Gujarat	Veraval
Haryana	Hissar
Jammu and Kashmir	Srinagar

<b>State</b>	<b>Station</b>
Jharkhand	Jamshedpur
Jharkhand	M. O. Ranchi
Karnataka	Bangalore
Karnataka	Belgaum / Sambra
Karnataka	Chitradurga
Karnataka	Gadag
Karnataka	Mangalore / Bajpe
Kerala	Cochin / Willingdon
Kerala	Kozhikode
Kerala	Thiruvananthapuram
Kerala	Thiruvananthapuram
Lakshadweep	Minicoy
Madhya Pradesh	Bhopal / Bairagarh
Madhya Pradesh	Guna
Madhya Pradesh	Gwalior
Madhya Pradesh	Indore
Madhya Pradesh	Jabalpur
Madhya Pradesh	Satna
Maharashtra	Aurangabad Chikalthan Aerodrome
Maharashtra	Bombay / Santacruz
Maharashtra	Nagpur Sonegaon
Maharashtra	Poona
Maharashtra	Ratnagiri
Maharashtra	Sholapur
Manipur	Imphal Tulihal
Odisha	Balasore
Odisha	Bhubaneswar
Odisha	Jharsuguda
Punjab	Amritsar
Punjab	Patiala
Rajasthan	Barmer
Rajasthan	Bikaner
Rajasthan	Ganganagar
Rajasthan	Jaipur / Sanganer
Rajasthan	Jaisalmer
Rajasthan	Jodhpur
Rajasthan	Kota Aerodrome
Tamil Nadu	Coimbatore / Peelamedu
Tamil Nadu	Cuddalore



State	Station
Tamil Nadu	Madras / Minambakkam
Tamil Nadu	Tiruchchirapalli
Telangana	Hyderabad Airport
Telangana	Ramgundam
Tripura	Agartala
Uttar Pradesh	Agra
Uttar Pradesh	Bareilly
Uttar Pradesh	Gorakhpur
Uttar Pradesh	Lucknow / Amausi
Uttarakhand	Dehradun
West Bengal	Calcutta / Dum Dum

## Assumptions for forecasting

For forecasting the temperature variables, the 14 available weather scenarios for the past years were used (FY 2002-03–FY 2015-16).

## 6. Structural breaks

Dummy variables were constructed to allow for structural breaks between defined periods: FY 2003–FY 2005; FY 2006–FY2009; FY 2010 to FY 2014 and FY 2015–FY2017.

In the model, an interaction of the structural break dummy variable was introduced with the state. Therefore, for every state, the dummy allows for a level difference in the electricity demand (through a different intercept) across each of the specified structural time periods. This is done by capturing state-specific factors that influence electricity demand but are unobservable to the modeller.

## Assumptions for forecasting

For forecasting this variable, it was assumed that the future structural change will follow the structural change value for FY 2015-16.



## Annexure 3: (Coefficient Results)

**Table A3.1: PAM Electricity Demand Models [2003-2016]**

	All India	North	East	West	Northeast	South
log(Elec_Demand_lag_1)	0.61 *** (0.01)	0.42 *** (0.02)	0.62 *** (0.03)	0.68 *** (0.03)	0.64 *** (0.03)	0.61 *** (0.03)
log(Elec_Demand_lag_12)	0.08 *** (0.01)	0.16 *** (0.02)	0.16 *** (0.03)	0.05 (0.03)	0.05 (0.03)	0.07 *** (0.02)
log(GDP_lag_12)	0.23 *** (0.01)	0.31 *** (0.03)	0.20 *** (0.04)	0.13 *** (0.03)	0.24 *** (0.04)	0.21 *** (0.03)
log(EP_Adjust_CPI)	-0.02 (0.01)	-0.01 (0.02)	-0.02 (0.03)	-0.07 (0.04)	0.02 (0.03)	-0.12 *** (0.03)
CDD_Avg_Temp	0.06 *** (0.01)	0.07 *** (0.01)	0.03 ** (0.01)	0.07 *** (0.01)	0.02 (0.02)	0.07 *** (0.01)
HDD_Avg_Temp	0.01 (0.01)	0.02 (0.01)	0.02 (0.02)		0.01 (0.02)	
Rain_1 (0-50mm): Rainfall	-0.06 *** (0.01)	-0.13 *** (0.02)	-0.02 (0.02)	-0.08 * (0.03)	0.00 (0.04)	-0.04 * (0.02)
Rain_2 (50-100mm): Rainfall	-0.04 *** (0.01)	-0.07 *** (0.01)	-0.01 (0.01)	-0.07 *** (0.02)	0.01 (0.02)	-0.04 *** (0.01)
Rain_3 (100-200mm): Rainfall	-0.03 *** (0.00)	-0.05 *** (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.02 (0.01)	-0.03 *** (0.00)
Rain_4 (>200mm): Rainfall	-0.02 *** (0.00)	-0.04 *** (0.00)	-0.01 (0.00)	-0.02 *** (0.00)	-0.01 (0.01)	-0.03 *** (0.00)
R^2	0.95	0.96	0.98	0.93	0.91	0.98
Adj. R^2	0.94	0.96	0.97	0.92	0.90	0.97
Num. obs.	4368	1248	624	780	936	780

\*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05



**Table A3.2: Long Panel Electricity Demand Models [2003-2016] (for Energy Requirement)**

	All India	North	East	West	Northeast	South
(Intercept)	-1.10 *	-1.91 ***	-4.11 ***	2.02 *	-3.46 ***	1.01
	(0.44)	(0.48)	(0.89)	(1.01)	(0.75)	(0.70)
log(GDP_lag_12)	0.74 ***	0.79 ***	0.92 ***	0.49 ***	0.71 ***	0.66 ***
	(0.03)	(0.04)	(0.05)	(0.06)	(0.06)	(0.03)
log(EP_Adjust_CPI)	0.00	-0.15 **	-0.04	-0.10	0.17 ***	-0.18 **
	(0.03)	(0.05)	(0.07)	(0.07)	(0.04)	(0.06)
Rainfall	-0.09 ***	-0.11 ***	-0.02	-0.14 ***	-0.03	-0.08 ***
	(0.01)	(0.02)	(0.02)	(0.03)	(0.04)	(0.02)
CDD_Avg_Temp	0.07 ***	0.09 ***	0.04 ***	0.08 ***	0.01	0.09 ***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
HDD_Avg_Temp	0.01	0.01	0.01		-0.01	
	(0.01)	(0.01)	(0.02)		(0.02)	
Rain_2 (50-100mm): Rainfall	0.03	0.04	-0.04	0.16 **	0.01	0.02
	(0.02)	(0.03)	(0.05)	(0.06)	(0.11)	(0.03)
Rain_3 (100-200mm): Rainfall	0.08 ***	0.09 ***	0.02	0.16 ***	0.08	0.04 *
	(0.02)	(0.02)	(0.03)	(0.04)	(0.05)	(0.02)
Rain_4 (> 200mm): Rainfall	0.08 ***	0.09 ***	0.01	0.14 ***	0.02	0.07 ***
	(0.01)	(0.02)	(0.02)	(0.03)	(0.04)	(0.02)
R^2	.99	.99	.99	.99	0.99	.99
Wald	667904.10	221958.96	25684.15	33486.29	19535.28	152987.79
Pchisq	0.00	0.00	0.00	0.00	0.00	0.00
Num obs.	4368	1248	624	780	936	780

\*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05

**Table A3.3: SUR Electricity Demand Models [2003-2016] (for Energy Requirement)**

	North	East	West	North-East	South
eqDL: (Intercept)	5.00 *** (0.49)				
eqDL: log(GDP_DL)		0.20 *** (0.04)			
eqDL: Rainfall_DL		-0.02 (0.01)			
eqDL: CDD_Avg_Temp_DL		0.05 ** (0.02)			
eqDL: HDD_Avg_Temp_DL		-0.00 (0.02)			
eqDL: Time_Zone_2		0.02 (0.02)			
eqDL: Time_Zone_3		0.09 ** (0.03)			
eqDL: Time_Zone_4		0.16 *** (0.04)			
eqHR: (Intercept)		-2.77 *** (0.55)			
eqHR: log(GDP_HR)		0.86 *** (0.05)			
eqHR: Rainfall_HR		-0.07 *** (0.01)			
eqHR: CDD_Avg_Temp_HR		0.04 ** (0.01)			
eqHR: HDD_Avg_Temp_HR		-0.00 (0.02)			
eqPB: (Intercept)		0.83 (0.75)			
eqPB: log(GDP_PB)		0.71 *** (0.06)			
eqPB: log(EP_Adjust_CPI_PB)		-0.25 *** (0.05)			
eqPB: Rainfall_PB		-0.07 *** (0.02)			
eqPB: CDD_Avg_Temp_PB		0.09 *** (0.02)			
eqPB: HDD_Avg_Temp_PB		-0.02 (0.03)			
eqRJ: (Intercept)		-2.09 *** (0.59)			
eqRJ: log(GDP_RJ)		0.81 *** (0.05)			
eqRJ: Rainfall_RJ		-0.13 *** (0.02)			
eqRJ: CDD_Avg_Temp_RJ		0.08 *** (0.02)			
eqRJ: HDD_Avg_Temp_RJ		0.03 (0.03)			
eqUK: (Intercept)		-3.97 *** (0.27)			
eqUK: log(GDP_UK)		0.93 *** (0.02)			
eqUK: Rainfall_UK		-0.03 *** (0.01)			
eqUK: CDD_Avg_Temp_UK		-0.00 (0.02)			
eqUK: HDD_Avg_Temp_UK		0.01 (0.02)			
eqUP: (Intercept)		-4.46 *** (0.66)			
eqUP: log(GDP_UP)		0.99 *** (0.05)			
eqUP: Rainfall_UP		-0.03 *** (0.01)			
eqUP: CDD_Avg_Temp_UP		0.08 ***			



	(0.02)
eqJK: (Intercept)	-0.59
	(1.50)
eqJK: log(GDP_JK)	0.87 ***
	(0.11)
eqJK: log(EP_Adjust_CPI_JK)	-0.38 ***
	(0.10)
eqJK: Rainfall_JK	-0.01
	(0.01)
eqJK: CDD_Avg_Temp_JK	0.14 *
	(0.06)
eqJK: HDD_Avg_Temp_JK	0.02
	(0.02)
eqCH: (Intercept)	0.62
	(1.71)
eqCH: log(GDP_CH)	0.40 ***
	(0.08)
eqCH: log(EP_Adjust_CPI_CH)	0.00
	(0.16)
eqCH: Rainfall_CH	-0.03 *
	(0.01)
eqCH: CDD_Avg_Temp_CH	0.10 ***
	(0.02)
eqCH: HDD_Avg_Temp_CH	0.05 *
	(0.02)
eqBR: (Intercept)	-1.74
	(1.20)
eqBR: log(GDP_BR)	1.00 ***
	(0.06)
eqBR: log(EP_Adjust_CPI_BR)	-0.60 ***
	(0.16)
eqBR: Rainfall_BR	0.01
	(0.01)
eqBR: CDD_Avg_Temp_BR	0.05
	(0.03)
eqBR: HDD_Avg_Temp_BR	0.03
	(0.04)
eqWB: (Intercept)	-8.74 ***
	(0.55)
eqWB: log(GDP_WB)	1.29 ***
	(0.04)
eqWB: Rainfall_WB	0.00
	(0.01)
eqWB: CDD_Avg_Temp_WB	0.05 ***
	(0.01)
eqWB: HDD_Avg_Temp_WB	0.01
	(0.03)
eqOR: (Intercept)	-0.73
	(0.75)
eqOR: log(GDP_OR)	0.75 ***
	(0.05)
eqOR: log(EP_Adjust_CPI_OR)	-0.15 **
	(0.05)
eqOR: Rainfall_OR	-0.02 **
	(0.01)
eqOR: CDD_Avg_Temp_OR	-0.02
	(0.02)
eqOR: HDD_Avg_Temp_OR	0.00
	(0.07)
eqJH: (Intercept)	9.41 ***
	(1.82)
eqJH: log(GDP_JH)	0.18
	(0.11)
eqJH: log(EP_Adjust_CPI_JH)	-0.75 ***
	(0.10)
eqJH: Rainfall_JH	-0.01
	(0.01)
eqJH: CDD_Avg_Temp_JH	-0.02
	(0.03)
eqJH: HDD_Avg_Temp_JH	-0.03
	(0.05)



eqGJ: (Intercept)	5.76 ***
eqGJ: log(Per_Capita_GJ)	(1.45) 0.44 *** (0.09)
eqGJ: log(EP_Adjust_CPI_GJ)	-0.30 *** (0.09)
eqGJ: Rainfall_GJ	-0.05 *** (0.01)
eqGJ: CDD_Avg_Temp_GJ	0.08 * (0.04)
eqMH: (Intercept)	3.67 *** (0.69)
eqMH: log(Per_Capita_MH)	0.55 *** (0.06)
eqMH: log(EP_Adjust_CPI_MH)	-0.12 (0.07)
eqMH: Rainfall_MH	-0.03 ** (0.01)
eqMH: CDD_Avg_Temp_MH	0.14 *** (0.03)
eqCG: (Intercept)	-3.99 *** (1.11)
eqCG: log(Per_Capita(CG))	1.02 *** (0.11)
eqCG: Rainfall(CG)	-0.01 (0.02)
eqCG: CDD_Avg_Temp(CG)	0.05 (0.04)
eqMP: (Intercept)	-0.34 (0.98)
eqMP: log(Per_Capita_MP)	0.83 *** (0.10)
eqMP: Rainfall_MP	-0.00 (0.01)
eqMP: CDD_Avg_Temp_MP	0.16 *** (0.03)
eqGA: (Intercept)	9.49 *** (1.69)
eqGA: log(GDP_GA)	0.12 (0.10)
eqGA: log(EP_Adjust_CPI_GA)	-0.89 *** (0.12)
eqGA: Rainfall_GA	0.00 (0.01)
eqGA: CDD_Avg_Temp_GA	0.14 * (0.07)
eqAS: (Intercept)	-21.46 *** (1.33)
eqAS: log(Per_Capita_AS)	2.61 *** (0.13)
eqAS: Rainfall_AS	0.00 (0.01)
eqAS: CDD_Avg_Temp_AS	0.12 *** (0.03)
eqAS: HDD_Avg_Temp_AS	0.08 (0.04)
eqMN: (Intercept)	-5.98 *** (0.97)
eqMN: log(Per_Capita_MN)	0.94 *** (0.09)
eqMN: Rainfall_MN	0.03 (0.02)
eqMN: CDD_Avg_Temp_MN	-0.05 (0.08)
eqMN: HDD_Avg_Temp_MN	-0.03 (0.06)
eqTR: (Intercept)	-5.00 *** (0.78)
eqTR: log(Per_Capita_TR)	0.86 *** (0.08)
eqTR: Rainfall_TR	-0.02



eqTR: CDD_Avg_Temp_TR	(0.01)
	0.06
	(0.04)
eqTR: HDD_Avg_Temp_TR	0.17 ***
	(0.05)
eqNL: (Intercept)	-2.40
	(1.23)
eqNL: log(Per_Capita_NL)	0.55 ***
	(0.12)
eqNL: Rainfall_NL	-0.03
	(0.02)
eqNL: CDD_Avg_Temp_NL	0.09
	(0.07)
eqNL: HDD_Avg_Temp_NL	-0.04
	(0.06)
eqML: (Intercept)	-8.03 ***
	(1.53)
eqML: log(Per_Capita_ML)	1.20 ***
	(0.14)
eqML: Rainfall_ML	-0.01
	(0.01)
eqML: CDD_Avg_Temp_ML	-0.02
	(0.06)
eqML: HDD_Avg_Temp_ML	-0.10
	(0.08)
eqMZ: (Intercept)	-4.35 ***
	(0.47)
eqMZ: log(GDP_MZ)	0.92 ***
	(0.06)
eqMZ: Rainfall_MZ	-0.01
	(0.01)
eqKA: (Intercept)	4.91 ***
	(0.94)
eqKA: log(Per_Capita_KA)	0.64 ***
	(0.06)
eqKA: Rainfall_KA	-0.04 ***
	(0.01)
eqKA: CDD_Avg_Temp_KA	0.04
	(0.03)
eqKA: log(EP_Adjust_CPI_KA)	-0.61 ***
	(0.06)
eqTN: (Intercept)	-2.09 *
	(1.03)
eqTN: log(Per_Capita_TN)	0.99 ***
	(0.05)
eqTN: log(EP_Adjust_CPI_TN)	-0.07
	(0.10)
eqTN: Rainfall_TN	-0.03 **
	(0.01)
eqTN: CDD_Avg_Temp_TN	0.10 **
	(0.03)
eqKL: (Intercept)	-1.17
	(0.87)
eqKL: log(Per_Capita_KL)	0.91 ***
	(0.05)
eqKL: Rainfall_KL	-0.01 ***
	(0.00)
eqKL: CDD_Avg_Temp_KL	0.10 ***
	(0.02)
eqKL: log(EP_Adjust_CPI_KL)	-0.29 ***
	(0.07)
eqAP: (Intercept)	-2.25 ***
	(0.52)
eqAP: log(Per_Capita_AP)	0.99 ***
	(0.05)
eqAP: Rainfall_AP	-0.06 ***
	(0.01)
eqAP: CDD_Avg_Temp_AP	0.04
	(0.02)
eqPY: (Intercept)	-0.86
	(1.40)



eqPY: log(Per_Capita_PY)		0.68 ***			
eqPY: CDD_Avg_Temp_PY		(0.10)			
eqPY: Rainfall_PY		0.13 *			
eqPY: log(EP_Adjust_CPI_PY)		(0.05)			
		-0.01			
		(0.02)			
		-0.38 ***			
		(0.09)			
<hr/>					
eqDL: Adj. R^2	0.94				
eqHR: Adj. R^2	0.96				
eqPB: Adj. R^2	0.95				
eqRJ: Adj. R^2	0.96				
eqUK: Adj. R^2	0.99				
eqUP: Adj. R^2	0.97				
eqJK: Adj. R^2	0.91				
eqCH: Adj. R^2	0.94				
eqBR: Adj. R^2	0.96				
eqWB: Adj. R^2	0.98				
eqOR: Adj. R^2	0.95				
eqJH: Adj. R^2	0.94				
eqGJ: Adj. R^2	0.86				
eqMH: Adj. R^2	0.87				
eqCG: Adj. R^2	0.83				
eqMP: Adj. R^2	0.90				
eqGA: Adj. R^2	0.83				
eqAS: Adj. R^2	0.96				
eqMN: Adj. R^2	0.56				
eqTR: Adj. R^2	0.88				
eqNL: Adj. R^2	0.81				
eqML: Adj. R^2	0.79				
eqMZ: Adj. R^2	0.92				
eqKA: Adj. R^2	0.95				
eqTN: Adj. R^2	0.97				
eqKL: Adj. R^2	0.97				
eqAP: Adj. R^2	0.96				
eqPY: Adj. R^2	0.85				
Num. obs. (total)	1344	672	840	1008	840
<hr/>					

\*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05



**Table A3.4: PAM Peak Electricity Demand Models [2003-2016]**

	North	East	West	Northeast	South
log(Elec_Demand_lag_1)	0.51 *** (0.03)	0.60 *** (0.03)	0.61 *** (0.03)	0.62 *** (0.03)	0.55 *** (0.03)
log(Elec_Demand_lag_12)	0.19 *** (0.03)	0.21 *** (0.03)	0.09 ** (0.03)	0.05 (0.03)	0.09 ** (0.03)
log(GDP_lag_12)	0.20 *** (0.03)	0.17 *** (0.04)	0.09 ** (0.03)	0.20 *** (0.04)	0.21 *** (0.03)
log(EP_Adjust_CPI)	-0.04 (0.02)	-0.01 (0.04)	-0.08 * (0.03)	0.01 (0.03)	-0.12 *** (0.03)
CDD_Avg_Temp	0.04 *** (0.01)	0.00 (0.01)	0.05 *** (0.01)	0.04 * (0.02)	0.05 *** (0.01)
HDD_Avg_Temp	0.00 (0.01)	-0.02 (0.02)		0.05 * (0.02)	
Time_Zone_Rain_1:Rainfall	-0.04 (0.02)	0.04 (0.03)	-0.07 * (0.03)	0.01 (0.04)	-0.03 (0.02)
Time_Zone_Rain_2:Rainfall	-0.02 * (0.01)	0.00 (0.02)	-0.04 * (0.02)	-0.00 (0.02)	-0.01 (0.01)
Time_Zone_Rain_3:Rainfall	-0.01 * (0.01)	0.02 (0.01)	-0.01 (0.01)	-0.00 (0.01)	-0.02 ** (0.01)
Time_Zone_Rain_4:Rainfall	-0.02 *** (0.00)	0.00 (0.00)	-0.01 *** (0.00)	0.01 * (0.01)	-0.01 *** (0.00)
R^2	0.96	0.97	0.92	0.84	0.96
Adj. R^2	0.95	0.96	0.92	0.82	0.96
Num. obs.	1248	624	780	936	780

\*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05



**Table A3.5: PAM All-India Peak Electricity Demand Model [2003-2016]**

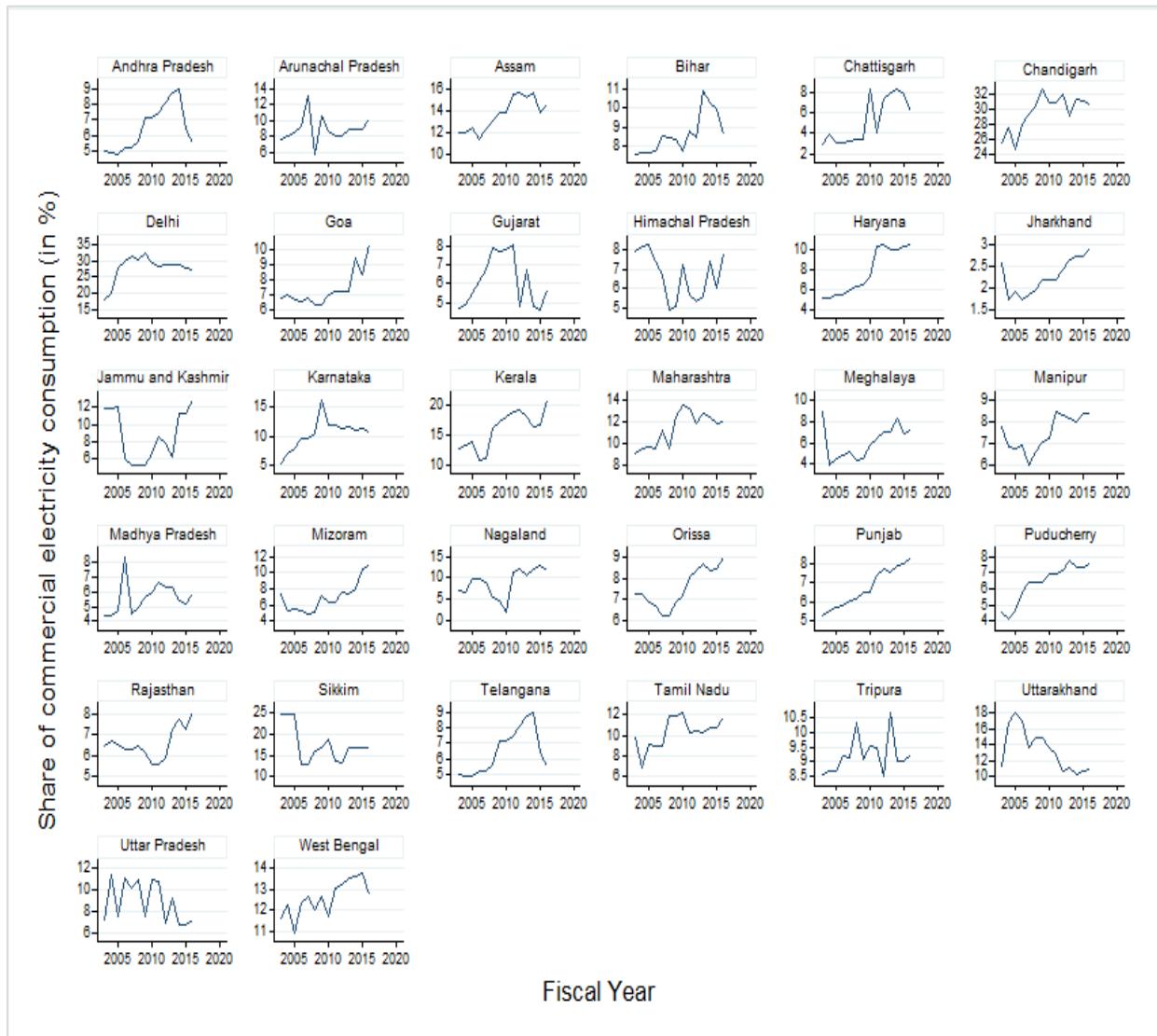
All India	
(Intercept)	0.48 *** (0.11)
log(Peak_Demand_lag_1)	0.62 *** (0.06)
log(GDP)	0.25 *** (0.04)
HDD_Avg_Temp	0.04 (0.02)
CDD_Avg_Temp	0.04 ** (0.01)
Rain_1:Rainfall	-0.04 (0.02)
Rain_2:Rainfall	-0.05 ** (0.01)
Rain_3:Rainfall	-0.05 *** (0.01)
Rain_4:Rainfall	-0.04 *** (0.01)
R^2	0.99
Adj. R^2	0.99
Num. obs.	167
RMSE	0.02



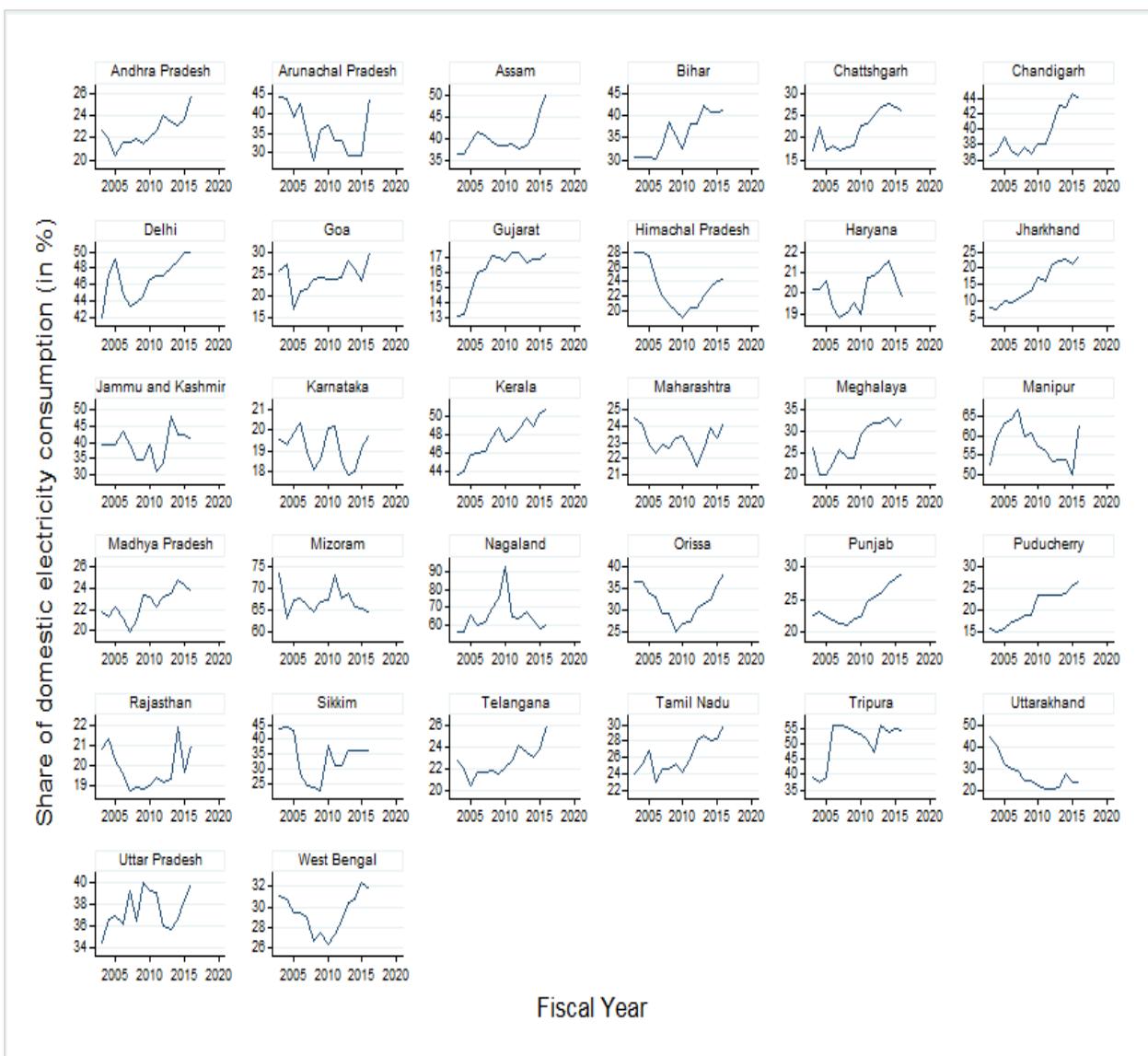


## Annexure 4 (State Shares of electricity consumption)

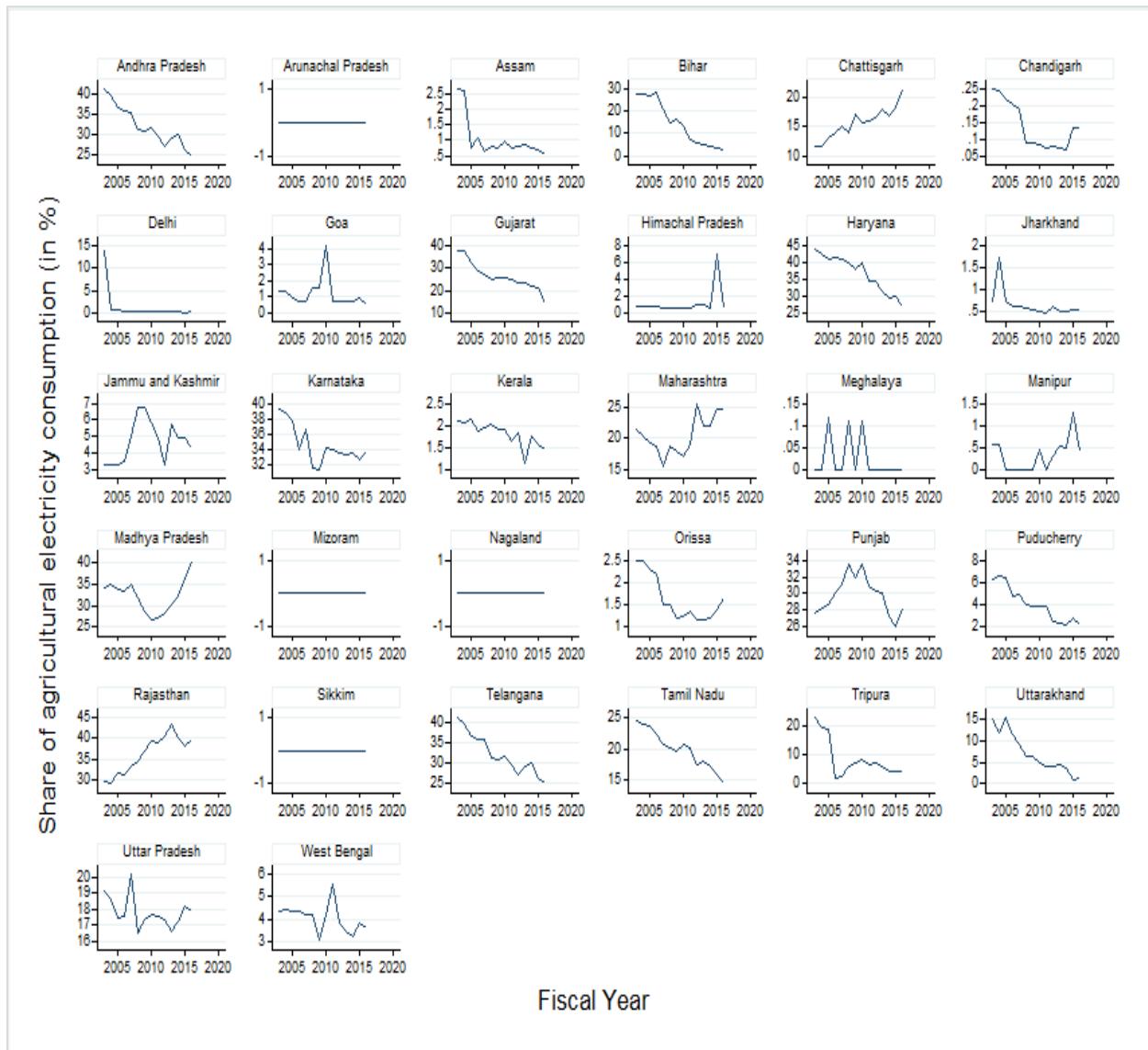
Figure A4.1: Share of Commercial Electricity Consumption



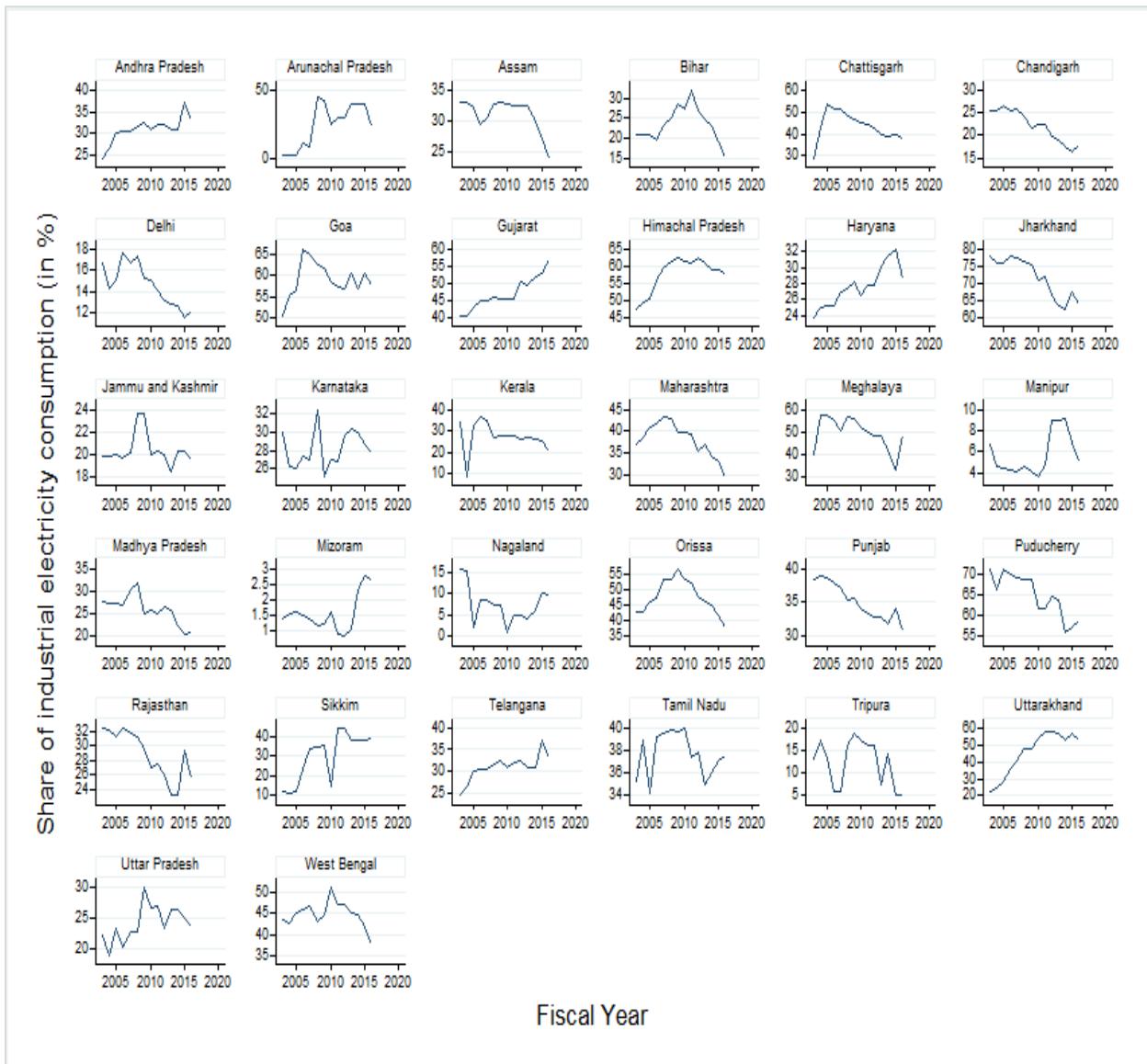
**Figure A4.2: Share of Domestic Electricity Consumption**



**Figure A4.3: Share of Agricultural Electricity Consumption**



**Figure A4.4: Share of Industrial Electricity Consumption**





## Annexure 5 (Electricity Demand Forecasts and Growth rates)

Table A5.1: Growth Rates of GDP and Population

Year	GDP Base (%)	GDP Pessimistic (%)	GDP Optimistic (%)	Population (%)
2017	7.1	7.1	7.1	1.44
2018	6.6	6.6	6.6	1.45
2019	7.5	6.5	8	1.45
2020	7.8	6.5	8	1.45
2021	8	6.5	8	1.45
2022	8	6.5	8	0.87
2023	8	6.5	8	0.87
2024	7.8	6.5	8	0.87
2025	7.6	6.5	8	0.87
2026	7.5	6.5	8	0.87
2027	7.4	6.5	8	0.87
2028	7.3	6.5	8	0.87
2029	7.2	6.5	8	0.87
2030	7.1	6.5	8	0.87
2031	7	6.5	8	0.87
2032	7	6.5	8	0.56
2033	7	6.5	8	0.56
2034	7	6.5	8	0.56
2035	7	6.5	8	0.56
2036	7	6.5	8	0.56
2037	7	6.5	8	0.56



**Table A5.2: Forecasted Electrical Energy Requirement (PAM Baseline Scenario) in MUs**

State/Region	2017	2018	2019	2020	2021	2022	2023
<b>Delhi</b>	31,588	33,625	35,584	37,730	40,080	42,640	45,382
<b>Haryana</b>	50,958	54,723	58,028	61,512	65,286	69,380	73,760
<b>Himachal Pradesh</b>	9,262	9,725	10,211	10,722	11,258	11,821	12,412
<b>Jammu &amp; Kashmir</b>	17,810	18,297	18,819	19,444	20,140	20,890	21,671
<b>Punjab</b>	50,740	53,378	55,694	58,147	60,789	63,629	66,621
<b>Rajasthan</b>	71,560	76,544	80,883	85,475	90,456	95,859	101,629
<b>Uttar Pradesh</b>	110,295	115,211	119,878	125,056	130,728	136,859	143,331
<b>Uttarakhand</b>	13,452	14,883	16,094	17,338	18,673	20,122	21,682
<b>Chandigarh</b>	1,668	1,745	1,817	1,897	1,984	2,078	2,177
<b>Northern Region</b>	<b>357,333</b>	<b>378,131</b>	<b>397,008</b>	<b>417,321</b>	<b>439,394</b>	<b>463,278</b>	<b>488,665</b>
<b>Goa</b>	5,040	5,197	5,352	5,528	5,722	5,931	6,149
<b>Gujarat</b>	102,981	105,580	109,367	113,876	118,850	124,191	129,809
<b>Chhattisgarh</b>	25,714	26,533	27,400	28,381	29,457	30,612	31,823
<b>Madhya Pradesh</b>	61,601	63,736	65,867	68,204	70,741	73,454	76,296
<b>Maharashtra</b>	143,165	148,033	153,106	158,671	164,713	171,179	177,957
<b>D. &amp; N. Haveli</b>	6,221	6,532	6,859	7,202	7,562	7,940	8,337
<b>Daman &amp; Diu</b>	2,454	2,577	2,706	2,841	2,983	3,132	3,289
<b>Western Region</b>	<b>347,176</b>	<b>358,188</b>	<b>370,657</b>	<b>384,703</b>	<b>400,028</b>	<b>416,439</b>	<b>433,660</b>
<b>Andhra Pradesh</b>	52,501	55,418	57,999	60,781	63,816	67,099	70,579
<b>Telangana</b>	52,756	55,688	58,281	61,077	64,127	67,426	70,923
<b>Karnataka</b>	67,154	69,770	72,601	75,873	79,496	83,424	87,584
<b>Kerala</b>	23,929	25,008	25,991	27,061	28,226	29,481	30,802
<b>Tamil Nadu</b>	101,157	107,197	112,772	118,782	125,321	132,399	139,927
<b>Puducherry</b>	2,509	2,689	2,828	2,966	3,113	3,271	3,438
<b>Southern Region</b>	<b>300,006</b>	<b>315,770</b>	<b>330,472</b>	<b>346,540</b>	<b>364,099</b>	<b>383,100</b>	<b>403,253</b>
<b>Bihar</b>	26,326	29,193	31,758	34,334	37,051	39,984	43,151
<b>Jharkhand</b>	14,675	15,564	16,503	17,552	18,720	20,011	21,416
<b>Odisha</b>	28,086	29,804	31,522	33,412	35,495	37,778	40,245
<b>West Bengal</b>	62,728	69,635	75,274	80,519	85,762	91,222	96,962
<b>Sikkim</b>	419	440	462	485	509	534	561
<b>Eastern Region</b>	<b>132,234</b>	<b>144,636</b>	<b>155,519</b>	<b>166,302</b>	<b>177,537</b>	<b>189,529</b>	<b>202,335</b>
<b>Assam</b>	9,282	9,453	9,706	10,040	10,419	10,827	11,249
<b>Manipur</b>	867	864	881	907	938	970	1,003
<b>Meghalaya</b>	1,854	2,041	2,157	2,266	2,382	2,506	2,638
<b>Nagaland</b>	776	833	879	928	981	1,039	1,101
<b>Tripura</b>	1,394	1,434	1,508	1,601	1,707	1,824	1,949
<b>Arunachal Pradesh</b>	656	689	723	759	797	837	879
<b>Mizoram</b>	531	549	582	623	671	724	781
<b>North Eastern Region</b>	<b>15,360</b>	<b>15,863</b>	<b>16,436</b>	<b>17,124</b>	<b>17,895</b>	<b>18,727</b>	<b>19,600</b>
<b>Andaman &amp; Nicobar Islands</b>	284	298	313	329	345	362	380
<b>Lakshadweep</b>	50	53	56	59	62	65	68
<b>All-India</b>	<b>1,152,443</b>	<b>1,212,939</b>	<b>1,270,461</b>	<b>1,332,378</b>	<b>1,399,360</b>	<b>1,471,500</b>	<b>1,547,961</b>

State/Region	2024	2025	2026	2027	2028	2029	2030
<b>Delhi</b>	48,306	51,371	54,561	57,898	61,390	65,043	68,860
<b>Haryana</b>	78,425	83,308	88,385	93,688	99,230	105,020	111,061
<b>Himachal Pradesh</b>	13,033	13,685	14,369	15,087	15,841	16,633	17,465
<b>Jammu &amp; Kashmir</b>	22,472	23,269	24,050	24,821	25,591	26,362	27,135
<b>Punjab</b>	69,752	72,953	76,197	79,504	82,883	86,337	89,865
<b>Rajasthan</b>	107,761	114,161	120,792	127,699	134,894	142,385	150,175
<b>Uttar Pradesh</b>	150,110	157,049	164,084	171,260	178,600	186,107	193,779
<b>Uttarakhand</b>	23,354	25,122	26,980	28,940	31,014	33,210	35,533
<b>Chandigarh</b>	2,282	2,388	2,496	2,607	2,720	2,836	2,955
<b>Northern Region</b>	<b>515,495</b>	<b>543,306</b>	<b>571,914</b>	<b>601,504</b>	<b>632,163</b>	<b>663,933</b>	<b>696,828</b>
<b>Goa</b>	6,375	6,606	6,840	7,077	7,319	7,566	7,816
<b>Gujarat</b>	135,682	141,720	147,891	154,229	160,751	167,461	174,361
<b>Chhattisgarh</b>	33,085	34,375	35,686	37,025	38,394	39,794	41,223
<b>Madhya Pradesh</b>	79,254	82,275	85,338	88,464	91,655	94,913	98,235
<b>Maharashtra</b>	185,017	192,239	199,573	207,066	214,725	222,551	230,544
<b>D. &amp; N. Haveli</b>	8,754	9,192	9,652	10,135	10,642	11,174	11,733
<b>Daman &amp; Diu</b>	3,453	3,626	3,807	3,997	4,197	4,407	4,627
<b>Western Region</b>	<b>451,620</b>	<b>470,033</b>	<b>488,787</b>	<b>507,993</b>	<b>527,683</b>	<b>547,866</b>	<b>568,539</b>
<b>Andhra Pradesh</b>	74,248	78,040	81,931	85,950	90,104	94,394	98,818
<b>Telangana</b>	74,609	78,419	82,330	86,369	90,543	94,853	99,300
<b>Karnataka</b>	91,960	96,471	101,087	105,841	110,738	115,780	120,967
<b>Kerala</b>	32,183	33,594	35,024	36,483	37,976	39,502	41,062
<b>Tamil Nadu</b>	147,893	156,176	164,729	173,613	182,840	192,423	202,366
<b>Puducherry</b>	3,615	3,797	3,983	4,176	4,375	4,580	4,791
<b>Southern Region</b>	<b>424,508</b>	<b>446,497</b>	<b>469,084</b>	<b>492,432</b>	<b>516,576</b>	<b>541,532</b>	<b>567,304</b>
<b>Bihar</b>	46,571	50,219	54,082	58,178	62,519	67,115	71,979
<b>Jharkhand</b>	22,932	24,542	26,234	28,013	29,884	31,848	33,908
<b>Odisha</b>	42,891	45,679	48,589	51,627	54,798	58,106	61,553
<b>West Bengal</b>	103,025	109,346	115,883	122,656	129,679	136,961	144,506
<b>Sikkim</b>	589	618	649	681	715	751	789
<b>Eastern Region</b>	<b>216,008</b>	<b>230,404</b>	<b>245,437</b>	<b>261,155</b>	<b>277,595</b>	<b>294,781</b>	<b>312,735</b>
<b>Assam</b>	11,683	12,112	12,532	12,945	13,359	13,774	14,191
<b>Manipur</b>	1,037	1,070	1,101	1,130	1,159	1,188	1,217
<b>Meghalaya</b>	2,777	2,919	3,065	3,214	3,368	3,527	3,690
<b>Nagaland</b>	1,166	1,234	1,304	1,377	1,453	1,532	1,613
<b>Tripura</b>	2,082	2,223	2,369	2,523	2,685	2,854	3,032
<b>Arunachal Pradesh</b>	923	969	1,017	1,068	1,121	1,177	1,236
<b>Mizoram</b>	842	907	975	1,047	1,123	1,204	1,289



State/Region	2024	2025	2026	2027	2028	2029	2030
North Eastern Region	20,510	21,434	22,363	23,304	24,268	25,256	26,268
Andaman & Nicobar Islands	399	419	440	462	485	509	534
Lakshadweep	71	75	79	83	87	91	96
All-India	1,628,611	1,712,168	1,798,104	1,886,933	1,978,857	2,073,968	2,172,304

State/Region	2031	2032	2033	2034	2035	2036	2037
Delhi	72,845	77,001	81,369	85,972	90,825	95,944	101,352
Haryana	117,359	123,919	130,806	138,055	145,691	153,734	162,221
Himachal Pradesh	18,338	19,255	20,218	21,229	22,290	23,405	24,576
Jammu & Kashmir	27,910	28,684	29,471	30,275	31,097	31,939	32,804
Punjab	93,464	97,133	100,915	104,829	108,883	113,083	117,445
Rajasthan	158,270	166,673	175,469	184,701	194,399	204,587	215,309
Uttar Pradesh	201,611	209,598	217,836	226,362	235,198	244,356	253,871
Uttarakhand	37,989	40,584	43,343	46,282	49,415	52,756	56,323
Chandigarh	3,076	3,200	3,327	3,459	3,596	3,738	3,886
Northern Region	730,862	766,047	802,754	841,164	881,394	923,542	967,787
Goa	8,071	8,330	8,595	8,868	9,149	9,438	9,736
Gujarat	181,452	188,734	196,269	204,087	212,203	220,629	229,390
Chhattisgarh	42,682	44,169	45,699	47,278	48,909	50,592	52,333
Madhya Pradesh	101,621	105,070	108,615	112,270	116,041	119,931	123,951
Maharashtra	238,701	247,019	255,577	264,407	273,525	282,941	292,681
D. & N. Haveli	12,320	12,936	13,583	14,262	14,975	15,724	16,510
Daman & Diu	4,858	5,101	5,356	5,624	5,905	6,200	6,510
Western Region	589,705	611,359	633,694	656,796	680,707	705,455	731,111
Andhra Pradesh	103,379	108,074	112,954	118,040	123,344	128,877	134,658
Telangana	103,882	108,600	113,504	118,615	123,945	129,504	135,313
Karnataka	126,298	131,772	137,449	143,353	149,498	155,894	162,564
Kerala	42,653	44,275	45,946	47,676	49,466	51,319	53,241
Tamil Nadu	212,674	223,352	234,507	246,188	258,429	271,258	284,724
Puducherry	5,009	5,233	5,466	5,708	5,960	6,223	6,498
Southern Region	593,895	621,306	649,826	679,580	710,642	743,075	776,998
Bihar	77,119	82,545	88,304	94,435	100,970	107,940	115,391



State/Region	2031	2032	2033	2034	2035	2036	2037
Jharkhand	36,065	38,323	40,700	43,210	45,865	48,676	51,659
Odisha	65,140	68,869	72,772	76,870	81,183	85,723	90,517
West Bengal	152,315	160,389	168,797	177,588	186,796	196,450	206,603
Sikkim	828	869	912	958	1,006	1,056	1,108
Eastern Region	331,467	350,995	371,485	393,061	415,820	439,845	465,278
Assam	14,608	15,026	15,451	15,886	16,332	16,788	17,257
Manipur	1,245	1,273	1,301	1,329	1,358	1,388	1,419
Meghalaya	3,857	4,028	4,206	4,392	4,585	4,786	4,996
Nagaland	1,698	1,785	1,877	1,973	2,074	2,179	2,289
Tripura	3,218	3,413	3,619	3,837	4,067	4,311	4,570
Arunachal Pradesh	1,298	1,363	1,431	1,503	1,578	1,657	1,740
Mizoram	1,380	1,476	1,577	1,686	1,802	1,926	2,059
North Eastern Region	27,304	28,364	29,462	30,606	31,796	33,035	34,330
Andaman & Nicobar Islands	561	589	618	649	681	715	751
Lakshadweep	101	106	111	117	123	129	135
All-India	2,273,895	2,378,766	2,487,950	2,601,973	2,721,163	2,845,796	2,976,390

Table A5.2: CAGR of Forecasted Electrical Energy Requirement (PAM Baseline Scenario)

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Delhi	6.18	6.31	6.25	5.76	6
Haryana	6.37	6.19	6.28	5.64	5.96
Himachal Pradesh	5	5	5	5	5
Jammu & Kashmir	3.24	3.51	3.38	2.83	3.1
Punjab	4.63	4.56	4.59	3.98	4.29
Rajasthan	6.02	5.9	5.96	5.36	5.66
Uttar Pradesh	4.41	4.59	4.5	4.01	4.26
Uttarakhand	8.39	7.54	7.96	6.89	7.42
Chandigarh	4.49	4.64	4.57	4.07	4.32
Northern Region	5.33	5.36	5.35	4.87	5.11
Goa	3.31	3.6	3.45	3.24	3.35
Gujarat	3.82	4.43	4.12	4.05	4.09
Chhattisgarh	3.55	3.88	3.71	3.52	3.62
Madhya Pradesh	3.58	3.79	3.69	3.43	3.56
Maharashtra	3.64	3.88	3.76	3.52	3.64

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
D. & N. Haveli	5	5	5	5	5
Daman & Diu	5	5	5	5	5
Western Region	3.71	4.05	3.88	3.71	3.79
Andhra Pradesh	5.03	5.08	5.05	4.59	4.82
Telangana	5.03	5.08	5.05	4.59	4.82
Karnataka	4.43	4.88	4.65	4.38	4.52
Kerala	4.26	4.35	4.31	3.85	4.08
Tamil Nadu	5.53	5.57	5.55	5.07	5.31
Puducherry	5.45	5.01	5.23	4.52	4.87
Southern Region	5.01	5.15	5.08	4.67	4.87
Bihar	8.72	7.79	8.25	7.09	7.67
Jharkhand	6.4	6.96	6.68	6.31	6.49
Odisha	6.11	6.45	6.28	5.78	6.03
West Bengal	7.78	6.1	6.94	5.35	6.14
Sikkim	4.97	4.98	4.98	4.99	4.98
Eastern Region	7.46	6.62	7.04	5.95	6.49
Assam	3.13	3.64	3.38	2.92	3.15
Manipur	2.27	3.1	2.68	2.3	2.49
Meghalaya	6.21	5.1	5.66	4.51	5.08
Nagaland	6.01	5.79	5.9	5.21	5.56
Tripura	5.52	6.7	6.11	6.12	6.12
Arunachal Pradesh	4.99	5	4.99	5	5
Mizoram	6.4	7.66	7.02	7	7.01
North Eastern Region	4.04	4.47	4.26	3.95	4.1
Andaman & Nicobar Islands	4.97	5	4.99	4.98	4.98
Lakshadweep	5.39	5.01	5.2	4.98	5.09
All-India	5.01	5.1	5.05	4.66	4.86

**Table A5.3: Forecasted Electrical Energy Requirement (PAM Optimistic Scenario) in MUs**

State/Region	2017	2018	2019	2020	2021	2022	2023
Delhi	31,588	33,625	35,584	37,818	40,241	42,833	45,596
Haryana	50,958	54,723	58,028	61,656	65,548	69,696	74,108
Himachal Pradesh	9,262	9,725	10,211	10,722	11,258	11,821	12,412
Jammu & Kashmir	17,810	18,297	18,819	19,489	20,221	20,985	21,773
Punjab	50,740	53,378	55,694	58,283	61,033	63,918	66,935

State/Region	2017	2018	2019	2020	2021	2022	2023
Rajasthan	71,560	76,544	80,883	85,675	90,820	96,296	102,109
Uttar Pradesh	110,295	115,211	119,878	125,348	131,253	137,482	144,007
Uttarakhand	13,452	14,883	16,094	17,378	18,748	20,214	21,784
Chandigarh	1,668	1,745	1,817	1,902	1,992	2,088	2,188
Northern Region	357,333	378,131	397,008	418,271	441,114	465,333	490,912
Goa	5,040	5,197	5,352	5,537	5,738	5,949	6,168
Gujarat	102,981	105,580	109,367	114,057	119,178	124,577	130,222
Chhattisgarh	25,714	26,533	27,400	28,426	29,539	30,707	31,925
Madhya Pradesh	61,601	63,736	65,867	68,314	70,937	73,683	76,539
Maharashtra	143,165	148,033	153,106	158,923	165,167	171,710	178,523
D. & N. Haveli	6,221	6,532	6,859	7,202	7,562	7,940	8,337
Daman & Diu	2,454	2,577	2,706	2,841	2,983	3,132	3,289
Western Region	347,176	358,188	370,657	385,300	401,104	417,698	435,003
Andhra Pradesh	52,501	55,418	57,999	60,915	64,056	67,380	70,883
Telangana	52,756	55,688	58,281	61,212	64,368	67,709	71,228
Karnataka	67,154	69,770	72,601	76,041	79,795	83,774	87,961
Kerala	23,929	25,008	25,991	27,120	28,332	29,605	30,934
Tamil Nadu	101,157	107,197	112,772	119,043	125,791	132,953	140,528
Puducherry	2,509	2,689	2,828	2,972	3,124	3,285	3,453
Southern Region	300,006	315,770	330,472	347,303	365,466	384,706	404,987
Bihar	26,326	29,193	31,758	34,407	37,204	40,189	43,393
Jharkhand	14,675	15,564	16,503	17,590	18,797	20,113	21,536
Odisha	28,086	29,804	31,522	33,483	35,640	37,971	40,471
West Bengal	62,728	69,635	75,274	80,690	86,112	91,687	97,505
Sikkim	419	440	462	485	509	534	561
Eastern Region	132,234	144,636	155,519	166,655	178,262	190,494	203,466
Assam	9,282	9,453	9,706	10,067	10,465	10,880	11,306
Manipur	867	864	881	910	942	975	1,008
Meghalaya	1,854	2,041	2,157	2,272	2,392	2,519	2,651
Nagaland	776	833	879	931	986	1,044	1,106
Tripura	1,394	1,434	1,508	1,606	1,715	1,833	1,958
Arunachal Pradesh	656	689	723	759	797	837	879
Mizoram	531	549	582	625	674	727	785
North Eastern Region	15,360	15,863	16,436	17,170	17,971	18,815	19,693
Andaman & Nicobar Islands	284	298	313	329	345	362	380
Lakshadweep	50	53	56	59	62	65	68
All-India	1,152,443	1,212,939	1,270,461	1,335,087	1,404,324	1,477,473	1,554,509



<b>State/Region</b>	<b>2024</b>	<b>2025</b>	<b>2026</b>	<b>2027</b>	<b>2028</b>	<b>2029</b>	<b>2030</b>
<b>Delhi</b>	48,536	51,664	54,992	58,531	62,294	66,293	70,544
<b>Haryana</b>	78,799	83,785	89,084	94,715	100,695	107,045	113,785
<b>Himachal Pradesh</b>	13,033	13,685	14,369	15,087	15,841	16,633	17,465
<b>Jammu &amp; Kashmir</b>	22,579	23,402	24,240	25,093	25,968	26,869	27,799
<b>Punjab</b>	70,084	73,371	76,800	80,375	84,110	88,011	92,085
<b>Rajasthan</b>	108,275	114,814	121,747	129,099	136,887	145,134	153,865
<b>Uttar Pradesh</b>	150,826	157,947	165,380	173,136	181,234	189,693	198,529
<b>Uttarakhand</b>	23,465	25,265	27,193	29,257	31,472	33,850	36,405
<b>Chandigarh</b>	2,292	2,402	2,516	2,636	2,760	2,891	3,027
<b>Northern Region</b>	<b>517,889</b>	<b>546,335</b>	<b>576,321</b>	<b>607,929</b>	<b>641,261</b>	<b>676,419</b>	<b>713,504</b>
<b>Goa</b>	6,396	6,632	6,876	7,130	7,392	7,664	7,946
<b>Gujarat</b>	136,116	142,265	148,680	155,372	162,358	169,649	177,258
<b>Chhattisgarh</b>	33,191	34,507	35,876	37,299	38,777	40,312	41,905
<b>Madhya Pradesh</b>	79,508	82,591	85,795	89,123	92,575	96,155	99,869
<b>Maharashtra</b>	185,609	192,977	200,636	208,600	216,868	225,451	234,361
<b>D. &amp; N. Haveli</b>	8,754	9,192	9,652	10,135	10,642	11,174	11,733
<b>Daman &amp; Diu</b>	3,453	3,626	3,807	3,997	4,197	4,407	4,627
<b>Western Region</b>	<b>453,027</b>	<b>471,790</b>	<b>491,322</b>	<b>511,656</b>	<b>532,809</b>	<b>554,812</b>	<b>577,699</b>
<b>Andhra Pradesh</b>	74,568	78,447	82,526	86,817	91,329	96,069	101,048
<b>Telangana</b>	74,932	78,828	82,927	87,240	91,774	96,537	101,539
<b>Karnataka</b>	92,358	96,974	101,821	106,909	112,244	117,837	123,699
<b>Kerala</b>	32,322	33,769	35,278	36,851	38,491	40,201	41,984
<b>Tamil Nadu</b>	148,533	156,990	165,924	175,362	185,328	195,848	206,949
<b>Puducherry</b>	3,630	3,816	4,012	4,218	4,434	4,661	4,899
<b>Southern Region</b>	<b>426,343</b>	<b>448,824</b>	<b>472,488</b>	<b>497,397</b>	<b>523,600</b>	<b>551,153</b>	<b>580,118</b>
<b>Bihar</b>	46,843	50,562	54,572	58,897	63,560	68,585	74,000
<b>Jharkhand</b>	23,066	24,709	26,471	28,360	30,382	32,546	34,862
<b>Odisha</b>	43,142	45,991	49,028	52,264	55,708	59,374	63,274
<b>West Bengal</b>	103,627	110,091	116,929	124,167	131,830	139,948	148,547
<b>Sikkim</b>	589	618	649	681	715	751	789
<b>Eastern Region</b>	<b>217,267</b>	<b>231,971</b>	<b>247,649</b>	<b>264,369</b>	<b>282,195</b>	<b>301,204</b>	<b>321,472</b>
<b>Assam</b>	11,742	12,186	12,639	13,100	13,573	14,063	14,568
<b>Manipur</b>	1,042	1,076	1,110	1,144	1,178	1,213	1,249
<b>Meghalaya</b>	2,791	2,937	3,091	3,253	3,423	3,601	3,789
<b>Nagaland</b>	1,172	1,242	1,315	1,394	1,476	1,564	1,656
<b>Tripura</b>	2,093	2,236	2,390	2,553	2,728	2,914	3,113



State/Region	2024	2025	2026	2027	2028	2029	2030
Arunachal Pradesh	923	969	1,017	1,068	1,121	1,177	1,236
Mizoram	846	912	983	1,059	1,141	1,229	1,324
North Eastern Region	20,609	21,558	22,545	23,571	24,640	25,761	26,935
Andaman & Nicobar Islands	399	419	440	462	485	509	534
Lakshadweep	71	75	79	83	87	91	96
All-India	1,635,605	1,720,972	1,810,844	1,905,467	2,005,077	2,109,949	2,220,358

State/Region	2031	2032	2033	2034	2035	2036	2037
Delhi	75,061	79,861	84,961	90,378	96,133	102,245	108746
Haryana	120,940	128,534	136,593	145,145	154,220	163,848	174077
Himachal Pradesh	18,338	19,255	20,218	21,229	22,290	23,405	24576
Jammu & Kashmir	28,759	29,750	30,772	31,826	32,913	34,035	35195
Punjab	96,340	100,783	105,421	110,264	115,320	120,597	126115
Rajasthan	163,108	172,891	183,246	194,205	205,801	218,072	231075
Uttar Pradesh	207,760	217,401	227,470	237,986	248,966	260,431	272424
Uttarakhand	39,149	42,097	45,263	48,662	52,313	56,232	60445
Chandigarh	3,170	3,318	3,474	3,637	3,807	3,984	4169
Northern Region	752,625	793,890	837,418	883,332	931,763	982,849	1036822
Goa	8,237	8,539	8,851	9,174	9,508	9,854	10213
Gujarat	185,198	193,482	202,126	211,144	220,551	230,365	240616
Chhattisgarh	43,558	45,275	47,056	48,905	50,823	52,813	54881
Madhya Pradesh	103,720	107,713	111,854	116,148	120,599	125,214	130006
Maharashtra	243,609	253,207	263,170	273,508	284,237	295,369	306937
D. & N. Haveli	12,320	12,936	13,583	14,262	14,975	15,724	16510
Daman & Diu	4,858	5,101	5,356	5,624	5,905	6,200	6510
Western Region	601,500	626,253	651,996	678,765	706,598	735,539	765673
Andhra Pradesh	106,276	111,767	117,532	123,586	129,941	136,612	143626
Telangana	106,794	112,311	118,105	124,187	130,573	137,277	144325
Karnataka	129,843	136,281	143,028	150,098	157,505	165,264	173405
Kerala	43,843	45,781	47,800	49,905	52,099	54,384	56769
Tamil Nadu	218,662	231,022	244,061	257,816	272,326	287,630	303794
Puducherry	5,149	5,412	5,687	5,976	6,279	6,597	6931



State/Region	2031	2032	2033	2034	2035	2036	2037
Southern Region	610,567	642,574	676,213	711,568	748,723	787,764	828850
Bihar	79,833	86,118	92,888	100,179	108,030	116,485	125602
Jharkhand	37,339	39,987	42,819	45,847	49,084	52,543	56246
Odisha	67,424	71,838	76,533	81,527	86,836	92,482	98495
West Bengal	157,657	167,307	177,529	188,355	199,819	211,959	224837
Sikkim	828	869	912	958	1,006	1,056	1108
Eastern Region	343,081	366,119	390,681	416,866	444,775	474,525	506288
Assam	5,090	15,630	16,187	16,763	17,357	17,971	18607
Manipur	1,287	1,325	1,364	1,404	1,445	1,487	1530
Meghalaya	3,985	4,192	4,409	4,637	4,876	5,127	5391
Nagaland	1,754	1,857	1,967	2,082	2,205	2,334	2471
Tripura	3,326	3,552	3,793	4,051	4,325	4,618	4931
Arunachal Pradesh	1,298	1,363	1,431	1,503	1,578	1,657	1740
Mizoram	1,426	1,535	1,653	1,780	1,916	2,063	2221
North Eastern Region	28,166	29,454	30,804	32,220	33,702	35,257	36891
Andaman & Nicobar Islands	561	589	618	649	681	715	751
Lakshadweep	101	106	111	117	123	129	135
All-India	2,336,601	2,458,985	2,587,841	2,723,517	2,866,365	3,016,778	3175410

Table A5.3: CAGR of Forecasted Electrical Energy Requirement (PAM Optimistic Scenario)

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Delhi	6.28	6.44	6.36	6.39	6.38
Haryana	6.46	6.33	6.39	6.28	6.34
Himachal Pradesh	5	5	5	5	5
Jammu & Kashmir	3.34	3.64	3.49	3.44	3.46
Punjab	4.73	4.69	4.71	4.61	4.66
Rajasthan	6.12	6.04	6.08	5.99	6.04
Uttar Pradesh	4.51	4.72	4.61	4.64	4.62
Uttarakhand	8.49	7.68	8.08	7.53	7.8
Chandigarh	4.59	4.77	4.68	4.69	4.69
Northern Region	5.42	5.49	5.46	5.48	5.47
Goa	3.37	3.69	3.53	3.66	3.59
Gujarat	3.88	4.52	4.2	4.47	4.33
Chhattisgarh	3.61	3.97	3.79	3.94	3.86

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Madhya Pradesh	3.65	3.88	3.76	3.85	3.81
Maharashtra	3.7	3.97	3.84	3.94	3.89
D. & N. Haveli	5	5	5	5	5
Daman & Diu	5	5	5	5	5
Western Region	3.77	4.14	3.95	4.11	4.03
Andhra Pradesh	5.12	5.2	5.16	5.16	5.16
Telangana	5.12	5.2	5.16	5.16	5.16
Karnataka	4.52	5	4.76	4.96	4.86
Kerala	4.35	4.48	4.41	4.42	4.41
Tamil Nadu	5.62	5.69	5.66	5.65	5.65
Puducherry	5.54	5.13	5.33	5.09	5.21
Southern Region	5.1	5.27	5.19	5.24	5.21
Bihar	8.83	7.94	8.39	7.87	8.13
Jharkhand	6.51	7.11	6.81	7.09	6.95
Odisha	6.22	6.6	6.41	6.54	6.47
West Bengal	7.89	6.25	7.07	6.12	6.59
Sikkim	4.97	4.98	4.98	4.99	4.98
Eastern Region	7.57	6.77	7.17	6.71	6.94
Assam	3.23	3.78	3.51	3.57	3.54
Manipur	2.38	3.25	2.81	2.95	2.88
Meghalaya	6.32	5.25	5.78	5.18	5.48
Nagaland	6.11	5.95	6.03	5.89	5.96
Tripura	5.63	6.85	6.24	6.8	6.52
Arunachal Pradesh	4.99	5	4.99	5	5
Mizoram	6.48	7.81	7.15	7.69	7.42
North Eastern Region	4.14	4.61	4.38	4.58	4.48
Andaman & Nicobar Islands	4.97	5	4.99	4.98	4.98
Lakshadweep	5.39	5.01	5.2	4.98	5.09
All-India	5.09	5.22	5.16	5.24	5.2

Table A5.4: Forecasted Electrical Energy Requirement (PAM Pessimistic Scenario) in MUs

State/Region	2017	2018	2019	2020	2021	2022	2023
Delhi	31,588	33,625	35,584	37,554	39,592	41,725	43,966
Haryana	50,958	54,723	58,028	61,223	64,486	67,886	71,452
Himachal Pradesh	9,262	9,725	10,211	10,722	11,258	11,821	12,412

State/Region	2017	2018	2019	2020	2021	2022	2023
Jammu & Kashmir	17,810	18,297	18,819	19,353	19,894	20,441	20,993
Punjab	50,740	53,378	55,694	57,874	60,046	62,260	64,537
Rajasthan	71,560	76,544	80,883	85,073	89,348	93,794	98,447
Uttar Pradesh	110,295	115,211	119,878	124,471	129,132	133,917	138,850
Uttarakhand	13,452	14,883	16,094	17,256	18,445	19,690	21,003
Chandigarh	1,668	1,745	1,817	1,888	1,960	2,034	2,109
Northern Region	357,333	378,131	397,008	415,414	434,161	453,568	473,769
Goa	5,040	5,197	5,352	5,510	5,674	5,843	6,017
Gujarat	102,981	105,580	109,367	113,512	117,852	122,358	127,028
Chhattisgarh	25,714	26,533	27,400	28,291	29,211	30,161	31,143
Madhya Pradesh	61,601	63,736	65,867	67,981	70,140	72,362	74,653
Maharashtra	143,165	148,033	153,106	158,164	163,331	168,653	174,145
D. & N. Haveli	6,221	6,532	6,859	7,202	7,562	7,940	8,337
Daman & Diu	2,454	2,577	2,706	2,841	2,983	3,132	3,289
Western Region	347,176	358,188	370,657	383,501	396,753	410,449	424,612
Andhra Pradesh	52,501	55,418	57,999	60,511	63,083	65,752	68,532
Telangana	52,756	55,688	58,281	60,806	63,390	66,072	68,865
Karnataka	67,154	69,770	72,601	75,536	78,583	81,749	85,042
Kerala	23,929	25,008	25,991	26,941	27,902	28,890	29,909
Tamil Nadu	101,157	107,197	112,772	118,257	123,885	129,746	135,872
Puducherry	2,509	2,689	2,828	2,953	3,077	3,206	3,339
Southern Region	300,006	315,770	330,472	345,004	359,920	375,415	391,559
Bihar	26,326	29,193	31,758	34,186	36,604	39,090	41,693
Jharkhand	14,675	15,564	16,503	17,476	18,494	19,564	20,692
Odisha	28,086	29,804	31,522	33,269	35,068	36,936	38,888
West Bengal	62,728	69,635	75,274	80,176	84,735	89,195	93,700
Sikkim	419	440	462	485	509	534	561
Eastern Region	132,234	144,636	155,519	165,592	175,410	185,319	195,534
Assam	9,282	9,453	9,706	9,986	10,275	10,568	10,864
Manipur	867	864	881	902	925	947	969
Meghalaya	1,854	2,041	2,157	2,254	2,349	2,446	2,547
Nagaland	776	833	879	923	968	1,014	1,063
Tripura	1,394	1,434	1,508	1,593	1,684	1,780	1,882
Arunachal Pradesh	656	689	723	759	797	837	879
Mizoram	531	549	582	620	662	706	754
North Eastern Region	15,360	15,863	16,436	17,037	17,660	18,298	18,958



State/Region	2017	2018	2019		2020		2021	2022	2023
<b>Andaman &amp; Nicobar Islands</b>	284	298	313	329	345	362			380
<b>Lakshadweep</b>	50	53	56	59	62	65			68
<b>All-India</b>	<b>1,152,443</b>	<b>1,212,939</b>	<b>1,270,461</b>	<b>1,326,936</b>	<b>1,384,311</b>	<b>1,443,476</b>			<b>1,504,880</b>

State/Region	2024	2025	2026	2027	2028	2029	2030
<b>Delhi</b>	46,323	48,804	51,415	54,163	57,054	60,095	63,293
<b>Haryana</b>	75,198	79,138	83,281	87,638	92,215	97,024	102,074
<b>Himachal Pradesh</b>	13,033	13,685	14,369	15,087	15,841	16,633	17,465
<b>Jammu &amp; Kashmir</b>	21,548	22,104	22,662	23,219	23,782	24,356	24,942
<b>Punjab</b>	66,883	69,303	71,799	74,372	77,028	79,772	82,607
<b>Rajasthan</b>	103,326	108,444	113,815	119,452	125,360	131,551	138,037
<b>Uttar Pradesh</b>	143,940	149,193	154,614	160,207	165,985	171,958	178,131
<b>Uttarakhand</b>	22,393	23,865	25,423	27,072	28,823	30,683	32,661
<b>Chandigarh</b>	2,188	2,269	2,352	2,439	2,528	2,620	2,716
<b>Northern Region</b>	<b>494,832</b>	<b>516,805</b>	<b>539,730</b>	<b>563,649</b>	<b>588,616</b>	<b>614,692</b>	<b>641,926</b>
<b>Goa</b>	6,196	6,381	6,571	6,766	6,967	7,174	7,386
<b>Gujarat</b>	131,866	136,877	142,068	147,444	153,013	158,784	164,763
<b>Chhattisgarh</b>	32,156	33,202	34,282	35,397	36,547	37,733	38,955
<b>Madhya Pradesh</b>	77,016	79,454	81,970	84,565	87,236	89,987	92,820
<b>Maharashtra</b>	179,816	185,671	191,715	197,957	204,389	211,020	217,853
<b>D. &amp; N. Haveli</b>	8,754	9,192	9,652	10,135	10,642	11,174	11,733
<b>Daman &amp; Diu</b>	3,453	3,626	3,807	3,997	4,197	4,407	4,627
<b>Western Region</b>	<b>439,257</b>	<b>454,403</b>	<b>470,065</b>	<b>486,261</b>	<b>502,991</b>	<b>520,279</b>	<b>538,137</b>
<b>Andhra Pradesh</b>	71,428	74,446	77,592	80,871	84,283	87,834	91,528
<b>Telangana</b>	71,775	74,809	77,970	81,265	84,694	88,262	91,973
<b>Karnataka</b>	88,467	92,029	95,733	99,586	103,587	107,741	112,054
<b>Kerala</b>	30,961	32,047	33,169	34,327	35,523	36,757	38,032
<b>Tamil Nadu</b>	142,282	148,990	156,011	163,358	171,038	179,068	187,460
<b>Puducherry</b>	3,478	3,622	3,773	3,929	4,092	4,262	4,438
<b>Southern Region</b>	<b>408,391</b>	<b>425,943</b>	<b>444,248</b>	<b>463,336</b>	<b>483,217</b>	<b>503,924</b>	<b>525,485</b>
<b>Bihar</b>	44,441	47,356	50,454	53,750	57,256	60,984	64,949
<b>Jharkhand</b>	21,884	23,143	24,474	25,881	27,367	28,936	30,592
<b>Odisha</b>	40,933	43,079	45,332	47,700	50,187	52,799	55,540
<b>West Bengal</b>	98,329	103,129	108,125	113,335	118,773	124,452	130,387
<b>Sikkim</b>	589	618	649	681	715	751	789
<b>Eastern Region</b>	<b>206,176</b>	<b>217,325</b>	<b>229,034</b>	<b>241,347</b>	<b>254,298</b>	<b>267,922</b>	<b>282,257</b>

State/Region	2024	2025	2026	2027	2028	2029	2030
<b>Assam</b>	11,160	11,458	11,755	12,052	12,352	12,659	12,973
<b>Manipur</b>	991	1,012	1,032	1,052	1,072	1,092	1,112
<b>Meghalaya</b>	2,652	2,761	2,875	2,992	3,114	3,241	3,373
<b>Nagaland</b>	1,114	1,167	1,223	1,282	1,343	1,408	1,475
<b>Tripura</b>	1,989	2,103	2,223	2,349	2,482	2,623	2,772
<b>Arunachal Pradesh</b>	923	969	1,017	1,068	1,121	1,177	1,236
<b>Mizoram</b>	804	858	914	974	1,038	1,106	1,179
<b>North Eastern Region</b>	<b>19,633</b>	<b>20,328</b>	<b>21,039</b>	<b>21,769</b>	<b>22,522</b>	<b>23,306</b>	<b>24,120</b>
<b>Andaman &amp; Nicobar Islands</b>	399	419	440	462	485	509	534
<b>Lakshadweep</b>	71	75	79	83	87	91	96
<b>All-India</b>	<b>1,568,759</b>	<b>1,635,298</b>	<b>1,704,635</b>	<b>1,776,907</b>	<b>1,852,216</b>	<b>1,930,723</b>	<b>2,012,555</b>

State/Region	2031	2032	2033	2034	2035	2036	2037
<b>Delhi</b>	66,655	70,190	73,906	77,812	81,917	86,230	90770
<b>Haryana</b>	107,378	112,949	118,797	124,938	131,385	138,152	145268
<b>Himachal Pradesh</b>	18,338	19,255	20,218	21,229	22,290	23,405	24576
<b>Jammu &amp; Kashmir</b>	25,539	26,148	26,769	27,403	28,049	28,708	29382
<b>Punjab</b>	85,534	88,559	91,682	94,906	98,236	101,674	105232
<b>Rajasthan</b>	144,831	151,947	159,398	167,199	175,368	183,919	192887
<b>Uttar Pradesh</b>	184,509	191,100	197,908	204,942	212,206	219,709	227477
<b>Uttarakhand</b>	34,764	36,998	39,373	41,896	44,578	47,426	50456
<b>Chandigarh</b>	2,814	2,916	3,022	3,131	3,243	3,359	3479
<b>Northern Region</b>	<b>670,362</b>	<b>700,062</b>	<b>731,073</b>	<b>763,456</b>	<b>797,272</b>	<b>832,582</b>	<b>869527</b>
<b>Goa</b>	7,605	7,829	8,060	8,296	8,540	8,789	9045
<b>Gujarat</b>	170,958	177,375	184,023	190,909	198,041	205,427	213088
<b>Chhattisgarh</b>	40,214	41,511	42,848	44,226	45,645	47,106	48614
<b>Madhya Pradesh</b>	95,736	98,738	101,828	105,010	108,284	111,653	115127
<b>Maharashtra</b>	224,895	232,152	239,628	247,331	255,267	263,441	271877
<b>D. &amp; N. Haveli</b>	12,320	12,936	13,583	14,262	14,975	15,724	16510
<b>Daman &amp; Diu</b>	4,858	5,101	5,356	5,624	5,905	6,200	6510
<b>Western Region</b>	<b>556,586</b>	<b>575,642</b>	<b>595,326</b>	<b>615,658</b>	<b>636,657</b>	<b>658,340</b>	<b>680771</b>
<b>Andhra Pradesh</b>	95,369	99,365	103,519	107,838	112,329	116,998	121860
<b>Telangana</b>	95,834	99,848	104,022	108,363	112,876	117,567	122454
<b>Karnataka</b>	116,531	121,177	125,999	131,002	136,192	141,578	147177
<b>Kerala</b>	39,348	40,706	42,108	43,554	45,047	46,587	48180

State/Region	2031	2032	2033	2034	2035	2036	2037
Tamil Nadu	196,231	205,396	214,973	224,978	235,430	246,348	257772
Puducherry	4,621	4,811	5,009	5,214	5,428	5,650	5881
Southern Region	547,934	571,303	595,630	620,949	647,302	674,728	703324
Bihar	69,165	73,646	78,408	83,470	88,849	94,563	100644
Jharkhand	32,339	34,182	36,127	38,177	40,340	42,621	45031
Odisha	58,419	61,439	64,609	67,935	71,425	75,085	78933
West Bengal	136,589	143,070	149,841	156,916	164,306	172,025	180107
Sikkim	828	869	912	958	1,006	1,056	1108
Eastern Region	297,340	313,206	329,897	347,456	365,926	385,350	405823
Assam	13,293	13,619	13,952	14,292	14,639	14,993	15356
Manipur	1,133	1,154	1,175	1,196	1,218	1,240	1262
Meghalaya	3,509	3,651	3,798	3,951	4,109	4,274	4446
Nagaland	1,545	1,619	1,695	1,776	1,860	1,947	2038
Tripura	2,928	3,094	3,268	3,452	3,645	3,850	4067
Arunachal Pradesh	1,298	1,363	1,431	1,503	1,578	1,657	1740
Mizoram	1,256	1,337	1,424	1,517	1,615	1,720	1832
North Eastern Region	24,962	25,837	26,743	27,687	28,664	29,681	30741
Andaman & Nicobar Islands	561	589	618	649	681	715	751
Lakshadweep	101	106	111	117	123	129	135
All-India	2,097,846	2,186,745	2,279,398	2,375,972	2,476,625	2,581,525	2691072

Table A5.4: CAGR of Forecasted Electrical Energy Requirement (PAM Pessimistic Scenario)

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Delhi	5.72	5.36	5.54	5.3	5.42
Haryana	5.9	5.24	5.57	5.18	5.38
Himachal Pradesh	5	5	5	5	5
Jammu & Kashmir	2.79	2.58	2.69	2.38	2.53
Punjab	4.18	3.62	3.9	3.53	3.71
Rajasthan	5.56	4.96	5.26	4.91	5.08
Uttar Pradesh	3.96	3.65	3.8	3.57	3.69
Uttarakhand	7.92	6.57	7.24	6.42	6.83
Chandigarh	4.05	3.7	3.87	3.62	3.74
Northern Region	4.89	4.44	4.66	4.43	4.55
Goa	3	2.98	2.99	2.95	2.97
Gujarat	3.51	3.8	3.65	3.75	3.7
Chhattisgarh	3.24	3.25	3.25	3.22	3.24
Madhya Pradesh	3.27	3.17	3.22	3.13	3.18
Maharashtra	3.33	3.26	3.29	3.22	3.26



State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
D. & N. Haveli	5	5	5	5	5
Daman & Diu	5	5	5	5	5
Western Region	3.41	3.45	3.43	3.42	3.42
Andhra Pradesh	4.6	4.23	4.41	4.19	4.3
Telangana	4.6	4.23	4.41	4.19	4.3
Karnataka	4.01	4.03	4.02	3.98	4
Kerala	3.84	3.51	3.67	3.45	3.56
Tamil Nadu	5.1	4.72	4.91	4.67	4.79
Puducherry	5.02	4.15	4.59	4.12	4.35
Southern Region	4.59	4.3	4.44	4.26	4.35
Bihar	8.23	6.58	7.4	6.47	6.94
Jharkhand	5.92	5.76	5.84	5.69	5.77
Odisha	5.63	5.25	5.44	5.17	5.3
West Bengal	7.29	4.91	6.09	4.74	5.42
Sikkim	4.97	4.98	4.98	4.99	4.98
Eastern Region	6.98	5.43	6.2	5.33	5.77
Assam	2.63	2.66	2.65	2.45	2.55
Manipur	1.78	2.13	1.95	1.84	1.89
Meghalaya	5.7	4.11	4.9	4.04	4.47
Nagaland	5.5	4.8	5.15	4.74	4.95
Tripura	5.01	5.7	5.36	5.64	5.5
Arunachal Pradesh	4.99	5	4.99	5	5
Mizoram	5.86	6.65	6.25	6.52	6.39
North Eastern Region	3.56	3.53	3.55	3.51	3.53
Andaman & Nicobar Islands	4.97	5	4.99	4.98	4.98
Lakshadweep	5.39	5.01	5.2	4.98	5.09
All-India	4.61	4.24	4.43	4.24	4.33

Table A5.5: Forecasted Peak Electricity Demand (PAM Baseline Scenario) in MW

State	2017	2018	2019	2020	2021	2022	2023
Delhi	5,819	6,033	6,326	6,670	7,048	7,457	7,892
Haryana	9,107	9,688	10,248	10,833	11,451	12,108	12,805
Himachal Pradesh	1,586	1,665	1,748	1,835	1,927	2,023	2,124
Jammu & Kashmir	2,653	2,715	2,780	2,859	2,949	3,047	3,150
Punjab	10,754	11,080	11,507	11,989	12,499	13,035	13,594
Rajasthan	11,478	12,186	12,786	13,424	14,124	14,886	15,701
Uttar Pradesh	16,188	16,892	17,609	18,331	19,087	19,891	20,740
Uttarakhand	2,095	2,261	2,416	2,579	2,757	2,951	3,159
Chandigarh	335	345	357	372	387	404	422
Goa	476	483	486	491	499	509	520
Gujarat	13,647	13,824	14,057	14,363	14,718	15,104	15,506
Chhattisgarh	3,957	4,030	4,092	4,164	4,252	4,349	4,450



State	2017	2018	2019	2020	2021	2022	2023
Madhya Pradesh	10,141	10,106	10,229	10,425	10,651	10,892	11,141
Maharashtra	20,182	20,601	20,940	21,328	21,782	22,279	22,798
D. & N. Haveli	790	830	872	916	962	1,010	1,061
Daman & Diu	320	336	353	371	390	410	431
Andhra Pradesh	7,236	7,597	7,888	8,210	8,560	8,936	9,331
Telangana	8,312	8,728	9,061	9,431	9,834	10,266	10,720
Karnataka	10,736	11,108	11,489	11,933	12,422	12,946	13,497
Kerala	3,899	4,059	4,191	4,337	4,497	4,668	4,846
Tamil Nadu	14,497	15,293	15,955	16,678	17,462	18,303	19,190
Puducherry	364	388	404	421	439	458	478
Bihar	4,422	5,220	5,839	6,386	6,921	7,472	8,051
Jharkhand	2,479	2,808	3,041	3,249	3,464	3,696	3,944
Odisha	5,345	6,289	6,897	7,402	7,894	8,406	8,944
West Bengal	13,104	16,248	18,275	19,828	21,244	22,651	24,086
Sikkim	119	125	131	138	145	152	160
Assam	1,571	1,597	1,633	1,677	1,725	1,776	1,828
Manipur	164	167	170	174	179	183	188
Meghalaya	354	382	397	412	428	445	463
Nagaland	139	149	155	162	169	176	184
Tripura	282	290	302	316	332	349	367
Arunachal Pradesh	148	155	163	171	180	189	198
Mizoram	106	108	113	119	126	134	142
Andaman & Nicobar Islands	40	42	44	46	48	50	53
Lakshadweep	8	8	8	8	8	8	8
All India	158,994	165,745	173,694	182,355	191,679	201,481	211,783

State	2024	2025	2026	2027	2028	2029	2030
Delhi	8,355	8,839	9,343	9,868	10,414	10,983	11,575
Haryana	13,543	14,314	15,114	15,947	16,813	17,713	18,648
Himachal Pradesh	2,230	2,342	2,459	2,582	2,711	2,847	2,989
Jammu & Kashmir	3,256	3,362	3,466	3,569	3,670	3,772	3,874
Punjab	14,177	14,774	15,378	15,993	16,620	17,257	17,906
Rajasthan	16,564	17,463	18,391	19,355	20,353	21,389	22,460
Uttar Pradesh	21,631	22,547	23,479	24,427	25,394	26,379	27,382
Uttarakhand	3,381	3,615	3,859	4,116	4,387	4,671	4,970
Chandigarh	440	459	478	497	517	538	558
Goa	531	543	554	566	577	589	601
Gujarat	15,920	16,340	16,762	17,188	17,619	18,055	18,497
Chhattisgarh	4,554	4,660	4,765	4,872	4,979	5,086	5,195
Madhya Pradesh	11,396	11,653	11,909	12,167	12,427	12,688	12,951
Maharashtra	23,332	23,872	24,413	24,956	25,504	26,056	26,612
D. & N. Haveli	1,114	1,170	1,229	1,290	1,355	1,423	1,494
Daman & Diu	453	476	500	525	551	579	608

State	2024	2025	2026	2027	2028	2029	2030
Andhra Pradesh	9,743	10,166	10,596	11,037	11,490	11,955	12,430
Telangana	11,194	11,679	12,173	12,680	13,201	13,734	14,281
Karnataka	14,071	14,656	15,251	15,860	16,483	17,121	17,772
Kerala	5,031	5,218	5,406	5,598	5,792	5,990	6,191
Tamil Nadu	20,119	21,075	22,054	23,063	24,104	25,176	26,281
Puducherry	499	520	542	564	587	610	634
Bihar	8,666	9,314	9,996	10,715	11,473	12,272	13,114
Jharkhand	4,209	4,489	4,783	5,090	5,412	5,749	6,101
Odisha	9,511	10,103	10,716	11,353	12,015	12,703	13,417
West Bengal	25,567	27,087	28,643	30,243	31,894	33,597	35,354
Sikkim	168	176	185	194	204	214	225
Assam	1,882	1,934	1,984	2,034	2,083	2,132	2,181
Manipur	193	197	202	206	210	214	217
Meghalaya	481	500	519	538	557	577	597
Nagaland	193	201	210	218	228	237	246
Tripura	386	406	426	447	469	491	514
Arunachal Pradesh	208	218	229	240	252	265	278
Mizoram	150	159	168	177	187	197	207
Andaman & Nicobar Islands	56	59	62	65	68	71	75
Lakshadweep	8	8	8	8	8	8	8
All India	222,346	233,155	244,342	255,911	267,866	280,211	292,947

State	2031	2032	2033	2034	2035	2036	2037
Delhi	12,189	12,828	13,495	14,193	14,926	15,695	16,504
Haryana	19,618	20,624	21,675	22,774	23,925	25,132	26,400
Himachal Pradesh	3,138	3,295	3,460	3,633	3,815	4,006	4,207
Jammu & Kashmir	3,976	4,077	4,180	4,284	4,391	4,500	4,612
Punjab	18,567	19,238	19,926	20,634	21,364	22,118	22,899
Rajasthan	23,569	24,715	25,909	27,155	28,458	29,821	31,249
Uttar Pradesh	28,403	29,441	30,505	31,600	32,729	33,896	35,105
Uttarakhand	5,284	5,615	5,964	6,333	6,725	7,140	7,581
Chandigarh	579	601	623	646	669	693	718
Goa	612	624	636	648	660	672	684
Gujarat	18,943	19,395	19,853	20,322	20,800	21,289	21,789
Chhattisgarh	5,304	5,414	5,525	5,638	5,754	5,871	5,990
Madhya Pradesh	13,215	13,480	13,749	14,023	14,302	14,586	14,876
Maharashtra	27,171	27,734	28,304	28,883	29,473	30,074	30,687
D. & N. Haveli	1,569	1,647	1,729	1,815	1,906	2,001	2,101
Daman & Diu	638	670	704	739	776	815	856
Andhra Pradesh	12,918	13,416	13,931	14,465	15,018	15,591	16,186
Telangana	14,840	15,413	16,005	16,618	17,254	17,912	18,595



State	2031	2032	2033	2034	2035	2036	2037
Karnataka	18,437	19,116	19,816	20,541	21,290	22,065	22,868
Kerala	6,394	6,601	6,813	7,031	7,256	7,487	7,725
Tamil Nadu	27,418	28,587	29,800	31,063	32,377	33,744	35,169
Puducherry	659	684	710	736	764	793	823
Bihar	14,001	14,934	15,920	16,964	18,073	19,250	20,504
Jharkhand	6,468	6,852	7,254	7,677	8,122	8,592	9,089
Odisha	14,158	14,927	15,728	16,566	17,444	18,365	19,335
West Bengal	37,168	39,037	40,976	42,996	45,104	47,305	49,613
Sikkim	236	248	260	273	287	301	316
Assam	2,229	2,278	2,326	2,376	2,426	2,478	2,531
Manipur	221	225	229	233	236	240	244
Meghalaya	617	638	660	681	704	728	753
Nagaland	256	266	276	287	298	310	322
Tripura	538	562	588	615	642	671	701
Arunachal Pradesh	292	307	322	338	355	373	392
Mizoram	218	230	242	254	268	281	295
Andaman & Nicobar Islands	79	83	87	91	96	101	106
Lakshadweep	8	8	8	8	8	8	8
All India	306,077	319,794	334,126	349,101	364,747	381,093	398,172

Table A5.5: CAGR of forecasted Peak Electricity Demand (PAM Baseline Scenario)

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Delhi	5.09	5.76	5.42	5.28	5.35
Haryana	5.86	5.66	5.76	5.17	5.47
Himachal Pradesh	4.99	5.00	4.99	5	5
Jammu & Kashmir	2.81	3.21	3.01	2.6	2.8
Punjab	3.92	4.18	4.05	3.65	3.85
Rajasthan	5.34	5.39	5.36	4.91	5.14
Uttar Pradesh	4.21	4.19	4.2	3.69	3.95
Uttarakhand	7.09	6.88	6.99	6.3	6.64
Chandigarh	3.82	4.23	4.02	3.75	3.89
Goa	1.35	2.15	1.75	1.91	1.83
Gujarat	2.05	2.62	2.33	2.4	2.37
Chhattisgarh	1.91	2.30	2.1	2.09	2.09
Madhya Pradesh	1.44	2.24	1.84	2.03	1.93
Maharashtra	2.00	2.30	2.15	2.09	2.12
D. & N. Haveli	5.04	5.02	5.03	5	5.01
Daman & Diu	5.08	5.07	5.08	5.01	5.04
Andhra Pradesh	4.31	4.31	4.31	3.9	4.11
Telangana	4.31	4.31	4.31	3.9	4.11
Karnataka	3.81	4.14	3.98	3.73	3.85

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Kerala	3.67	3.70	3.68	3.27	3.48
Tamil Nadu	4.77	4.73	4.75	4.31	4.53
Puducherry	4.70	4.25	4.48	3.85	4.16
Bihar	11.06	7.48	9.25	6.7	7.97
Jharkhand	8.32	6.61	7.46	5.97	6.71
Odisha	9.48	6.20	7.82	5.47	6.64
West Bengal	11.57	5.95	8.72	5.07	6.88
Sikkim	5.02	5.00	5.01	5	5
Assam	2.48	2.75	2.62	2.21	2.41
Manipur	2.22	2.40	2.31	1.71	2.01
Meghalaya	4.68	3.87	4.27	3.42	3.85
Nagaland	4.83	4.37	4.6	3.98	4.29
Tripura	4.36	5.07	4.71	4.6	4.66
Arunachal Pradesh	5.01	4.89	4.95	5.03	4.99
Mizoram	4.80	5.72	5.26	5.24	5.25
Andaman & Nicobar Islands	4.56	5.39	4.97	5.01	4.99
Lakshadweep	0.00	0.00	0	0	0
All-India	4.85	4.90	4.87	4.52	4.7

**Table A5.6: Forecasted Peak Electricity Demand (PAM Optimistic Scenario) in MW**

State	2017	2018	2019	2020	2021	2022	2023
Delhi	5819	6033	6326	6682	7070	7485	7925
Haryana	9107	9688	10248	10852	11487	12155	12858
Himachal Pradesh	1586	1665	1748	1835	1927	2023	2124
Jammu & Kashmir	2653	2715	2780	2864	2959	3059	3163
Punjab	10754	11080	11507	12010	12539	13085	13650
Rajasthan	11478	12186	12786	13450	14172	14946	15767
Uttar Pradesh	16188	16892	17609	18360	19144	19965	20825
Uttarakhand	2095	2261	2416	2584	2767	2962	3172
Chandigarh	335	345	357	372	389	406	423
Goa	476	483	486	491	500	510	521
Gujarat	13647	13824	14057	14373	14740	15131	15535
Chhattisgarh	3957	4030	4092	4167	4259	4357	4459
Madhya Pradesh	10141	10106	10229	10436	10669	10912	11162
Maharashtra	20182	20601	20940	21343	21815	22319	22841
D. & N. Haveli	790	830	872	916	962	1010	1061
Daman & Diu	320	336	353	371	390	410	431
Andhra Pradesh	7236	7597	7888	8227	8589	8969	9366
Telangana	8312	8728	9061	9451	9867	10303	10758
Karnataka	10736	11108	11489	11959	12464	12994	13546
Kerala	3899	4059	4191	4346	4512	4685	4864

State	2017	2018	2019	2020	2021	2022	2023
Tamil Nadu	14497	15293	15955	16713	17521	18370	19260
Puducherry	364	388	404	422	440	459	479
Bihar	4422	5220	5839	6398	6945	7505	8091
Jharkhand	2479	2808	3041	3255	3477	3712	3963
Odisha	5345	6289	6897	7416	7922	8443	8988
West Bengal	13104	16248	18275	19865	21319	22751	24206
Sikkim	119	125	131	138	145	152	160
Assam	1571	1597	1633	1680	1731	1782	1835
Manipur	164	167	170	174	179	184	189
Meghalaya	354	382	397	413	430	447	465
Nagaland	139	149	155	162	169	177	185
Tripura	282	290	302	317	333	351	369
Arunachal Pradesh	148	155	163	171	180	189	198
Mizoram	106	108	113	120	127	134	142
Andaman & Nicobar Islands	40	42	44	46	48	50	53
Lakshadweep	8	8	8	8	8	8	8
All India	158,994	165,745	174,215	183,124	192,487	202,330	212,676

State	2024	2025	2026	2027	2028	2029	2030
Delhi	8391	8884	9406	9958	10543	11161	11814
Haryana	13601	14386	15217	16095	17023	18003	19038
Himachal Pradesh	2230	2342	2459	2582	2711	2847	2989
Jammu & Kashmir	3270	3379	3490	3603	3718	3836	3957
Punjab	14238	14848	15482	16141	16827	17541	18283
Rajasthan	16635	17552	18519	19540	20616	21750	22945
Uttar Pradesh	21723	22659	23633	24646	25701	26797	27939
Uttarakhand	3395	3633	3886	4155	4443	4749	5076
Chandigarh	442	461	481	502	524	546	570
Goa	532	544	556	568	580	593	606
Gujarat	15950	16376	16812	17260	17718	18189	18671
Chhattisgarh	4563	4670	4780	4892	5006	5124	5243
Madhya Pradesh	11418	11680	11948	12222	12502	12788	13080
Maharashtra	23377	23925	24487	25062	25650	26250	26864
D. & N. Haveli	1114	1170	1229	1290	1355	1423	1494
Daman & Diu	453	476	500	525	551	579	608
Andhra Pradesh	9780	10213	10665	11136	11629	12142	12678
Telangana	11235	11732	12250	12793	13358	13948	14563
Karnataka	14123	14723	15349	16002	16681	17388	18124
Kerala	5049	5242	5441	5648	5862	6083	6313
Tamil Nadu	20193	21171	22196	23270	24394	25572	26804
Puducherry	500	522	545	569	594	619	646
Bihar	8711	9372	10077	10833	11643	12511	13442



State	2024	2025	2026	2027	2028	2029	2030
Jharkhand	4232	4517	4822	5146	5492	5861	6254
Odisha	9561	10165	10803	11478	12193	12950	13752
West Bengal	25702	27256	28878	30579	32367	34252	36239
Sikkim	168	176	185	194	204	214	225
Assam	1889	1943	1997	2052	2109	2166	2225
Manipur	194	198	203	208	212	217	222
Meghalaya	483	502	522	543	564	586	609
Nagaland	193	202	211	220	230	241	251
Tripura	388	408	429	451	474	499	525
Arunachal Pradesh	208	218	229	240	252	265	278
Mizoram	151	160	169	179	189	200	212
Andaman & Nicobar Islands	56	59	62	65	68	71	75
Lakshadweep	8	8	8	8	8	8	8
All India	223,551	234,982	246,998	259,628	272,904	286,858	301,527

State	2031	2032	2033	2034	2035	2036	2037
Delhi	12505	13235	14007	14823	15685	16595	17558
Haryana	20131	21285	22504	23791	25149	26583	28099
Himachal Pradesh	3138	3295	3460	3633	3815	4006	4207
Jammu & Kashmir	4082	4211	4343	4479	4619	4763	4911
Punjab	19055	19858	20693	21562	22466	23405	24383
Rajasthan	24203	25529	26925	28395	29943	31573	33292
Uttar Pradesh	29126	30362	31647	32985	34376	35823	37331
Uttarakhand	5426	5798	6196	6621	7074	7558	8075
Chandigarh	594	620	647	674	703	733	764
Goa	619	632	646	660	674	689	704
Gujarat	19165	19672	20191	20724	21269	21829	22404
Chhattisgarh	5366	5491	5619	5749	5883	6019	6158
Madhya Pradesh	13379	13683	13994	14312	14637	14968	15306
Maharashtra	27491	28132	28787	29456	30140	30838	31552
D. & N. Haveli	1569	1647	1729	1815	1906	2001	2101
Daman & Diu	638	670	704	739	776	815	856
Andhra Pradesh	13236	13817	14424	15056	15714	16401	17117
Telangana	15204	15872	16568	17294	18051	18839	19662
Karnataka	18890	19687	20516	21379	22277	23210	24182
Kerala	6551	6797	7052	7317	7590	7874	8169
Tamil Nadu	28094	29445	30858	32337	33884	35503	37199
Puducherry	674	704	734	766	799	833	868
Bihar	14441	15512	16661	17893	19214	20630	22150
Jharkhand	6672	7118	7593	8099	8638	9212	9824
Odisha	14603	15504	16459	17471	18543	19679	20885



State	2031	2032	2033	2034	2035	2036	2037
West Bengal	38336	40549	42885	45350	47952	50698	53601
Sikkim	236	248	260	273	287	301	316
Assam	2286	2347	2411	2476	2542	2610	2680
Manipur	227	232	237	243	248	253	258
Meghalaya	633	658	684	711	738	767	797
Nagaland	263	274	287	299	312	326	341
Tripura	552	580	610	641	674	708	744
Arunachal Pradesh	292	307	322	338	355	373	392
Mizoram	224	237	251	265	281	297	314
Andaman & Nicobar Islands	79	83	87	91	96	101	106
Lakshadweep	8	8	8	8	8	8	8
All India	316,945	333,152	350,187	368,093	386,915	406,700	427,497

Table A5.6: CAGR of Forecasted Peak Electricity Demand (PAM Optimistic Scenario)

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Delhi	5.16	5.88	5.52	5.84	5.68
Haryana	5.94	5.78	5.86	5.73	5.8
Himachal Pradesh	4.99	5	4.99	5	5
Jammu & Kashmir	2.89	3.33	3.11	3.15	3.13
Punjab	4	4.29	4.14	4.21	4.18
Rajasthan	5.42	5.51	5.46	5.47	5.47
Uttar Pradesh	4.28	4.3	4.29	4.24	4.27
Uttarakhand	7.17	7	7.09	6.87	6.98
Chandigarh	3.92	4.34	4.13	4.29	4.21
Goa	1.39	2.18	1.78	2.17	1.98
Gujarat	2.09	2.67	2.38	2.64	2.51
Chhattisgarh	1.94	2.34	2.14	2.33	2.24
Madhya Pradesh	1.48	2.29	1.88	2.28	2.08
Maharashtra	2.03	2.35	2.19	2.33	2.26
D. & N. Haveli	5.04	5.02	5.03	5	5.01
Daman & Diu	5.08	5.07	5.08	5.01	5.04
Andhra Pradesh	4.39	4.42	4.41	4.39	4.4
Telangana	4.39	4.42	4.41	4.39	4.4
Karnataka	3.89	4.25	4.07	4.22	4.14
Kerala	3.74	3.81	3.78	3.76	3.77
Tamil Nadu	4.85	4.84	4.85	4.8	4.82
Puducherry	4.75	4.39	4.57	4.31	4.44
Bihar	11.16	7.62	9.37	7.41	8.39
Jharkhand	8.41	6.75	7.58	6.68	7.13
Odisha	9.57	6.33	7.94	6.17	7.05
West Bengal	11.67	6.09	8.84	5.77	7.3

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Sikkim	5.02	5	5.01	5	5
Assam	2.55	2.86	2.71	2.71	2.71
Manipur	2.33	2.48	2.41	2.18	2.29
Meghalaya	4.78	3.97	4.37	3.91	4.14
Nagaland	4.95	4.45	4.7	4.48	4.59
Tripura	4.47	5.14	4.81	5.13	4.97
Arunachal Pradesh	5.01	4.89	4.95	5.03	4.99
Mizoram	4.8	5.96	5.38	5.78	5.58
Andaman & Nicobar Islands	4.56	5.39	4.97	5.01	4.99
Lakshadweep	0	0	0	0	0
All-India	4.94	5.11	5.03	5.11	5.07

Table A5.7: Forecasted Peak Electricity Demand (PAM Pessimistic Scenario) in MW

State	2017	2018	2019	2020	2021	2022	2023
Delhi	5819	6033	6326	6648	6982	7330	7691
Haryana	9107	9688	10248	10795	11341	11898	12474
Himachal Pradesh	1586	1665	1748	1835	1927	2023	2124
Jammu & Kashmir	2653	2715	2780	2848	2919	2991	3065
Punjab	10754	11080	11507	11947	12380	12810	13244
Rajasthan	11478	12186	12786	13374	13980	14614	15276
Uttar Pradesh	16188	16892	17609	18274	18919	19566	20227
Uttarakhand	2095	2261	2416	2570	2730	2898	3074
Chandigarh	335	345	357	371	384	397	411
Goa	476	483	486	490	497	506	515
Gujarat	13647	13824	14057	14343	14657	14985	15322
Chhattisgarh	3957	4030	4092	4159	4235	4315	4398
Madhya Pradesh	10141	10106	10229	10403	10594	10792	10994
Maharashtra	20182	20601	20940	21298	21688	22101	22525
D. & N. Haveli	790	830	872	916	962	1010	1061
Daman & Diu	320	336	353	371	390	410	431
Andhra Pradesh	7236	7597	7888	8175	8469	8774	9090
Telangana	8312	8728	9061	9390	9729	10079	10441
Karnataka	10736	11108	11489	11882	12290	12711	13147
Kerala	3899	4059	4191	4319	4449	4583	4720
Tamil Nadu	14497	15293	15955	16606	17276	17971	18692
Puducherry	364	388	404	419	434	450	466
Bihar	4422	5220	5839	6363	6850	7329	7815
Jharkhand	2479	2808	3041	3237	3428	3624	3828
Odisha	5345	6289	6897	7375	7812	8244	8680
West Bengal	13104	16248	18275	19755	21023	22213	23376
Sikkim	119	125	131	138	145	152	160



State	2017	2018	2019	2020	2021	2022	2023
<b>Assam</b>	1571	1597	1633	1669	1706	1743	1780
<b>Manipur</b>	164	167	170	173	177	180	183
<b>Meghalaya</b>	354	382	397	410	423	437	450
<b>Nagaland</b>	139	149	155	161	167	173	179
<b>Tripura</b>	282	290	302	315	328	343	357
<b>Arunachal Pradesh</b>	148	155	163	171	180	189	198
<b>Mizoram</b>	106	108	113	119	125	131	138
<b>Andaman &amp; Nicobar Islands</b>	40	42	44	46	48	50	53
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>158,994</b>	<b>165,745</b>	<b>172,649</b>	<b>179,840</b>	<b>187,330</b>	<b>195,133</b>	<b>203,260</b>

State	2024	2025	2026	2027	2028	2029	2030
<b>Delhi</b>	8068	8463	8877	9310	9764	10240	10737
<b>Haryana</b>	13073	13700	14355	15041	15759	16509	17295
<b>Himachal Pradesh</b>	2230	2342	2459	2582	2711	2847	2989
<b>Jammu &amp; Kashmir</b>	3139	3214	3288	3362	3437	3513	3590
<b>Punjab</b>	13687	14141	14608	15087	15580	16088	16611
<b>Rajasthan</b>	15968	16691	17446	18235	19059	19919	20816
<b>Uttar Pradesh</b>	20905	21603	22322	23061	23822	24607	25415
<b>Uttarakhand</b>	3260	3456	3662	3879	4109	4351	4607
<b>Chandigarh</b>	425	439	454	469	485	501	518
<b>Goa</b>	524	533	542	552	561	571	581
<b>Gujarat</b>	15668	16020	16380	16747	17121	17504	17894
<b>Chhattisgarh</b>	4483	4569	4657	4747	4838	4931	5026
<b>Madhya Pradesh</b>	11201	11411	11625	11843	12064	12290	12519
<b>Maharashtra</b>	22959	23402	23853	24313	24781	25258	25742
<b>D. &amp; N. Haveli</b>	1114	1170	1229	1290	1355	1423	1494
<b>Daman &amp; Diu</b>	453	476	500	525	551	579	608
<b>Andhra Pradesh</b>	9417	9756	10107	10470	10846	11235	11637
<b>Telangana</b>	10817	11206	11609	12027	12459	12906	13368
<b>Karnataka</b>	13598	14064	14546	15044	15559	16090	16638
<b>Kerala</b>	4862	5007	5156	5310	5467	5629	5795
<b>Tamil Nadu</b>	19443	20223	21034	21877	22752	23661	24605
<b>Puducherry</b>	482	499	517	535	554	574	594
<b>Bihar</b>	8318	8843	9395	9977	10593	11245	11934
<b>Jharkhand</b>	4040	4262	4494	4739	4996	5266	5550
<b>Odisha</b>	9128	9590	10070	10570	11092	11638	12208
<b>West Bengal</b>	24538	25714	26918	28159	29444	30779	32167
<b>Sikkim</b>	168	176	185	194	204	214	225
<b>Assam</b>	1816	1853	1890	1926	1962	1999	2037
<b>Manipur</b>	186	189	192	195	197	200	203
<b>Meghalaya</b>	464	479	494	509	525	541	557

State	2024	2025	2026	2027	2028	2029	2030
<b>Nagaland</b>	186	193	200	207	214	222	230
<b>Tripura</b>	373	389	406	423	441	460	480
<b>Arunachal Pradesh</b>	208	218	229	240	252	265	278
<b>Mizoram</b>	145	152	160	168	176	185	194
<b>Andaman &amp; Nicobar Islands</b>	56	59	62	65	68	71	75
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>211,726</b>	<b>220,544</b>	<b>229,730</b>	<b>239,299</b>	<b>249,266</b>	<b>259,648</b>	<b>270,462</b>

State	2031	2032	2033	2034	2035	2036	2037
<b>Delhi</b>	11258	11804	12375	12972	13598	14252	14937
<b>Haryana</b>	18116	18974	19872	20811	21792	22817	23890
<b>Himachal Pradesh</b>	3138	3295	3460	3633	3815	4006	4207
<b>Jammu &amp; Kashmir</b>	3669	3749	3831	3914	3998	4084	4172
<b>Punjab</b>	17149	17704	18275	18863	19468	20091	20734
<b>Rajasthan</b>	21752	22728	23746	24808	25915	27070	28276
<b>Uttar Pradesh</b>	26247	27105	27988	28898	29836	30801	31797
<b>Uttarakhand</b>	4878	5164	5467	5786	6124	6482	6861
<b>Chandigarh</b>	535	553	571	590	609	629	650
<b>Goa</b>	592	602	612	623	634	645	656
<b>Gujarat</b>	18292	18698	19113	19537	19969	20410	20861
<b>Chhattisgarh</b>	5122	5220	5320	5421	5524	5629	5736
<b>Madhya Pradesh</b>	12752	12989	13229	13474	13723	13976	14234
<b>Maharashtra</b>	26235	26737	27247	27766	28294	28831	29378
<b>D. &amp; N. Haveli</b>	1569	1647	1729	1815	1906	2001	2101
<b>Daman &amp; Diu</b>	638	670	704	739	776	815	856
<b>Andhra Pradesh</b>	12053	12483	12927	13386	13860	14351	14859
<b>Telangana</b>	13845	14339	14849	15377	15922	16485	17068
<b>Karnataka</b>	17204	17788	18391	19012	19654	20315	20998
<b>Kerala</b>	5966	6141	6321	6506	6696	6891	7092
<b>Tamil Nadu</b>	25584	26601	27656	28752	29888	31068	32295
<b>Puducherry</b>	615	636	659	682	705	730	756
<b>Bihar</b>	12665	13438	14258	15125	16044	17016	18047
<b>Jharkhand</b>	5849	6164	6494	6842	7207	7591	7995
<b>Odisha</b>	12805	13430	14083	14767	15482	16230	17014
<b>West Bengal</b>	33612	35117	36686	38319	40022	41795	43647
<b>Sikkim</b>	236	248	260	273	287	301	316
<b>Assam</b>	2075	2113	2152	2192	2233	2274	2316
<b>Manipur</b>	206	209	212	215	218	220	222
<b>Meghalaya</b>	574	592	610	629	648	667	687
<b>Nagaland</b>	238	247	256	265	274	284	294
<b>Tripura</b>	500	522	544	567	591	616	642

State	2031	2032	2033	2034	2035	2036	2037
Arunachal Pradesh	292	307	322	338	355	373	392
Mizoram	203	213	224	235	246	258	271
Andaman & Nicobar Islands	79	83	87	91	96	101	106
Lakshadweep	8	8	8	8	8	8	8
All India	281,727	293,462	305,684	318,416	331,679	345,493	359,882

Table A5.7: CAGR of Forecasted Peak Electricity Demand (PAM Pessimistic Scenario)

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Delhi	4.73	4.9	4.81	4.84	4.83
Haryana	5.49	4.8	5.15	4.74	4.94
Himachal Pradesh	4.99	5	4.99	5	5
Jammu & Kashmir	2.43	2.37	2.4	2.18	2.29
Punjab	3.56	3.33	3.44	3.23	3.34
Rajasthan	4.95	4.53	4.74	4.48	4.61
Uttar Pradesh	3.86	3.34	3.6	3.26	3.43
Uttarakhand	6.7	6	6.35	5.87	6.11
Chandigarh	3.45	3.39	3.42	3.32	3.37
Goa	1.23	1.76	1.49	1.74	1.62
Gujarat	1.89	2.25	2.07	2.22	2.14
Chhattisgarh	1.75	1.93	1.84	1.91	1.87
Madhya Pradesh	1.25	1.88	1.56	1.86	1.71
Maharashtra	1.83	1.93	1.88	1.91	1.9
D. & N. Haveli	5.04	5.02	5.03	5	5.01
Daman & Diu	5.08	5.07	5.08	5.01	5.04
Andhra Pradesh	3.93	3.6	3.76	3.56	3.66
Telangana	3.93	3.6	3.76	3.56	3.66
Karnataka	3.43	3.43	3.43	3.39	3.41
Kerala	3.29	2.99	3.14	2.94	3.04
Tamil Nadu	4.39	4.01	4.2	3.97	4.09
Puducherry	4.33	3.52	3.93	3.52	3.72
Bihar	10.63	6.36	8.48	6.11	7.29
Jharkhand	7.89	5.51	6.69	5.37	6.03
Odisha	9.05	5.1	7.06	4.88	5.96
West Bengal	11.13	4.86	7.95	4.48	6.2
Sikkim	5.02	5	5.01	5	5
Assam	2.1	2.02	2.06	1.86	1.96
Manipur	1.88	1.61	1.75	1.31	1.53
Meghalaya	4.3	3.1	3.7	3.04	3.37
Nagaland	4.47	3.65	4.06	3.57	3.82
Tripura	3.99	4.28	4.14	4.26	4.2
Arunachal Pradesh	5.01	4.89	4.95	5.03	4.99

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
<b>Mizoram</b>	4.33	5.1	4.71	4.9	4.81
<b>Andaman &amp; Nicobar Islands</b>	4.56	5.39	4.97	5.01	4.99
<b>Lakshadweep</b>	0	0	0	0	0
<b>All-India</b>	4.18	4.17	4.17	4.17	4.17

**Table A5.8: Forecasted Total Electrical Energy Requirement (SUR Model Baseline) in MUs**

State/Region	2017	2018	2019	2020	2021	2022	2023
<b>Delhi</b>	29,737	30,166	30,651	31,161	31,691	32,230	32,777
<b>Haryana</b>	52,214	55,498	59,417	63,764	68,536	73,663	79,170
<b>Himachal Pradesh</b>	9,262	9,725	10,211	10,722	11,258	11,821	12,412
<b>Jammu &amp; Kashmir</b>	17,979	18,604	19,382	20,229	21,135	22,068	23,027
<b>Punjab</b>	52,795	54,712	57,030	59,555	62,265	65,088	68,030
<b>Rajasthan</b>	73,428	77,481	82,313	87,643	93,456	99,655	106,264
<b>Uttar Pradesh</b>	113,462	119,293	126,448	134,378	143,041	152,234	161,985
<b>Uttarakhand</b>	15,233	16,583	18,184	19,978	21,974	24,156	26,541
<b>Chandigarh</b>	1,657	1,691	1,732	1,775	1,821	1,868	1,916
<b>Northern Region</b>	<b>365,767</b>	<b>383,753</b>	<b>405,368</b>	<b>429,205</b>	<b>455,177</b>	<b>482,783</b>	<b>512,122</b>
<b>Goa</b>	4,268	4,298	4,333	4,369	4,407	4,444	4,483
<b>Gujarat</b>	100,834	103,604	106,830	110,282	113,929	118,002	122,212
<b>Chhattisgarh</b>	25,587	26,881	28,484	30,269	32,227	34,560	37,062
<b>Madhya Pradesh</b>	62,412	64,958	68,083	71,524	75,254	79,604	84,206
<b>Maharashtra</b>	142,771	146,988	152,029	157,482	163,296	169,807	176,577
<b>D. &amp; N. Haveli</b>	6,221	6,532	6,859	7,202	7,562	7,940	8,337
<b>Daman &amp; Diu</b>	2,454	2,577	2,706	2,841	2,983	3,132	3,289
<b>Western Region</b>	<b>344,547</b>	<b>355,838</b>	<b>369,324</b>	<b>383,969</b>	<b>399,658</b>	<b>417,489</b>	<b>436,166</b>
<b>Andhra Pradesh</b>	55,734	58,797	62,546	66,717	71,297	76,468	82,014
<b>Telangana</b>	56,005	59,083	62,851	67,042	71,645	76,841	82,414
<b>Karnataka</b>	68,091	70,200	72,763	75,554	78,544	81,917	85,435
<b>Kerala</b>	25,106	26,262	27,681	29,247	30,951	32,802	34,759
<b>Tamil Nadu</b>	108,565	114,928	122,671	131,290	140,766	151,677	163,427
<b>Puducherry</b>	2,691	2,765	2,858	2,959	3,068	3,199	3,336
<b>Southern Region</b>	<b>316,192</b>	<b>332,035</b>	<b>351,370</b>	<b>372,809</b>	<b>396,271</b>	<b>422,904</b>	<b>451,385</b>
<b>Bihar</b>	25,522	27,349	29,554	32,026	34,767	37,743	40,972
<b>Jharkhand</b>	14,890	15,050	15,234	15,427	15,628	15,832	16,038
<b>Odisha</b>	29,307	30,568	32,084	33,744	35,538	37,426	39,411
<b>West Bengal</b>	75,955	81,255	87,856	95,317	103,641	112,670	122,462
<b>Sikkim</b>	419	440	462	485	509	534	561
<b>Eastern Region</b>	<b>146,093</b>	<b>154,662</b>	<b>165,190</b>	<b>176,999</b>	<b>190,083</b>	<b>204,205</b>	<b>219,444</b>
<b>Assam</b>	9,237	9,864	10,749	11,778	12,944	14,403	15,993
<b>Manipur</b>	667	677	691	707	724	746	767
<b>Meghalaya</b>	2,192	2,277	2,389	2,515	2,653	2,827	3,011

State/Region	2017	2018	2019	2020	2021	2022	2023
<b>Nagaland</b>	737	762	792	825	859	895	933
<b>Tripura</b>	1,309	1,379	1,464	1,557	1,658	1,774	1,897
<b>Arunachal Pradesh</b>	656	689	723	759	797	837	879
<b>Mizoram</b>	484	524	572	625	684	748	818
<b>North Eastern Region</b>	<b>15,282</b>	<b>16,172</b>	<b>17,380</b>	<b>18,766</b>	<b>20,319</b>	<b>22,230</b>	<b>24,298</b>
<b>Andaman &amp; Nicobar Islands</b>	284	298	313	329	345	362	380
<b>Lakshadweep</b>	50	53	56	59	62	65	68
<b>All-India</b>	<b>1,188,215</b>	<b>1,242,811</b>	<b>1,309,001</b>	<b>1,382,136</b>	<b>1,461,915</b>	<b>1,550,038</b>	<b>1,643,863</b>

State/Region	2024	2025	2026	2027	2028	2029	2030
<b>Delhi</b>	33,321	33,861	34,403	34,947	35,492	36,038	36,585
<b>Haryana</b>	84,950	91,002	97,404	104,165	111,294	118,804	126,706
<b>Himachal Pradesh</b>	13,033	13,685	14,369	15,087	15,841	16,633	17,465
<b>Jammu &amp; Kashmir</b>	23,973	24,898	25,819	26,750	27,690	28,636	29,588
<b>Punjab</b>	71,000	73,992	77,045	80,165	83,349	86,595	89,901
<b>Rajasthan</b>	113,142	120,284	127,780	135,632	143,844	152,426	161,383
<b>Uttar Pradesh</b>	172,011	182,285	192,953	204,036	215,533	227,442	239,761
<b>Uttarakhand</b>	29,095	31,824	34,763	37,936	41,359	45,046	49,013
<b>Chandigarh</b>	1,964	2,011	2,059	2,106	2,154	2,202	2,250
<b>Northern Region</b>	<b>542,489</b>	<b>573,842</b>	<b>606,595</b>	<b>640,824</b>	<b>676,556</b>	<b>713,822</b>	<b>752,652</b>
<b>Goa</b>	4,520	4,557	4,594	4,630	4,666	4,702	4,738
<b>Gujarat</b>	126,461	130,742	135,105	139,551	144,077	148,683	153,366
<b>Chhattisgarh</b>	39,669	42,379	45,231	48,225	51,361	54,643	58,073
<b>Madhya Pradesh</b>	88,936	93,787	98,826	104,043	109,440	115,018	120,773
<b>Maharashtra</b>	183,429	190,354	197,438	204,667	212,038	219,550	227,197
<b>D. &amp; N. Haveli</b>	8,754	9,192	9,652	10,135	10,642	11,174	11,733
<b>Daman &amp; Diu</b>	3,453	3,626	3,807	3,997	4,197	4,407	4,627
<b>Western Region</b>	<b>455,222</b>	<b>474,637</b>	<b>494,653</b>	<b>515,248</b>	<b>536,421</b>	<b>558,177</b>	<b>580,507</b>
<b>Andhra Pradesh</b>	87,801	93,825	100,169	106,836	113,830	121,156	128,820
<b>Telangana</b>	88,229	94,281	100,657	107,357	114,384	121,746	129,448
<b>Karnataka</b>	88,996	92,596	96,283	100,049	103,892	107,811	111,802
<b>Kerala</b>	36,767	38,820	40,948	43,154	45,435	47,792	50,222
<b>Tamil Nadu</b>	175,760	188,670	202,335	216,760	231,973	247,999	264,859
<b>Puducherry</b>	3,474	3,614	3,756	3,902	4,050	4,202	4,355
<b>Southern Region</b>	<b>481,027</b>	<b>511,806</b>	<b>544,148</b>	<b>578,058</b>	<b>613,564</b>	<b>650,706</b>	<b>689,506</b>
<b>Bihar</b>	44,394	48,011	51,873	55,986	60,363	65,013	69,948
<b>Jharkhand</b>	16,242	16,443	16,644	16,844	17,043	17,242	17,440
<b>Odisha</b>	41,443	43,515	45,658	47,869	50,147	52,493	54,905
<b>West Bengal</b>	132,763	143,557	155,010	167,153	180,005	193,585	207,907
<b>Sikkim</b>	589	618	649	681	715	751	789
<b>Eastern Region</b>	<b>235,431</b>	<b>252,144</b>	<b>269,834</b>	<b>288,533</b>	<b>308,273</b>	<b>329,084</b>	<b>350,989</b>
<b>Assam</b>	17,634	19,306	21,032	22,854	24,766	26,765	28,847

State/Region	2024	2025	2026	2027	2028	2029	2030
<b>Manipur</b>	787	805	821	837	853	868	882
<b>Meghalaya</b>	3,200	3,393	3,593	3,800	4,014	4,234	4,461
<b>Nagaland</b>	971	1,009	1,049	1,089	1,130	1,173	1,216
<b>Tripura</b>	2,025	2,159	2,300	2,447	2,601	2,763	2,932
<b>Arunachal Pradesh</b>	923	969	1,017	1,068	1,121	1,177	1,236
<b>Mizoram</b>	893	973	1,058	1,150	1,248	1,354	1,467
<b>North Eastern Region</b>	<b>26,433</b>	<b>28,614</b>	<b>30,870</b>	<b>33,245</b>	<b>35,733</b>	<b>38,334</b>	<b>41,041</b>
<b>Andaman &amp; Nicobar Islands</b>	399	419	440	462	485	509	534
<b>Lakshadweep</b>	71	75	79	83	87	91	96
<b>All-India</b>	<b>1,741,072</b>	<b>1,841,537</b>	<b>1,946,619</b>	<b>2,056,453</b>	<b>2,171,119</b>	<b>2,290,723</b>	<b>2,415,325</b>

State/Region	2031	2032	2033	2034	2035	2036	2037
<b>Delhi</b>	37,133	37,688	38,250	38,820	39,397	39,982	40576
<b>Haryana</b>	135,011	143,846	153,244	163,239	173,870	185,174	197213
<b>Himachal Pradesh</b>	18,338	19,255	20,218	21,229	22,290	23,405	24576
<b>Jammu &amp; Kashmir</b>	30,544	31,528	32,540	33,581	34,652	35,753	36889
<b>Punjab</b>	93,263	96,744	100,346	104,074	107,932	111,924	116064
<b>Rajasthan</b>	170,722	180,585	191,000	201,997	213,607	225,864	238824
<b>Uttar Pradesh</b>	252,485	265,854	279,899	294,653	310,150	326,423	343550
<b>Uttarakhand</b>	53,279	57,909	62,934	68,389	74,308	80,731	87709
<b>Chandigarh</b>	2,298	2,348	2,398	2,449	2,501	2,554	2608
<b>Northern Region</b>	<b>793,073</b>	<b>835,757</b>	<b>880,829</b>	<b>928,431</b>	<b>978,707</b>	<b>1,031,810</b>	<b>1088009</b>
<b>Goa</b>	4,773	4,808	4,844	4,880	4,916	4,952	4988
<b>Gujarat</b>	158,124	163,254	168,543	173,994	179,613	185,404	191382
<b>Chhattisgarh</b>	61,651	65,698	70,001	74,578	79,445	84,620	90132
<b>Madhya Pradesh</b>	126,707	133,301	140,225	147,494	155,126	163,136	171560
<b>Maharashtra</b>	234,975	243,372	252,053	261,027	270,304	279,893	289822
<b>D. &amp; N. Haveli</b>	12,320	12,936	13,583	14,262	14,975	15,724	16510
<b>Daman &amp; Diu</b>	4,858	5,101	5,356	5,624	5,905	6,200	6510
<b>Western Region</b>	<b>603,408</b>	<b>628,470</b>	<b>654,605</b>	<b>681,859</b>	<b>710,284</b>	<b>739,929</b>	<b>770904</b>
<b>Andhra Pradesh</b>	136,827	145,594	154,905	164,793	175,291	186,438	198293
<b>Telangana</b>	137,494	146,303	155,660	165,595	176,145	187,345	199258
<b>Karnataka</b>	115,864	120,272	124,838	129,568	134,467	139,541	144806
<b>Kerala</b>	52,726	55,393	58,190	61,121	64,194	67,413	70793
<b>Tamil Nadu</b>	282,572	302,239	323,237	345,656	369,587	395,130	422438
<b>Puducherry</b>	4,511	4,687	4,870	5,059	5,255	5,458	5669
<b>Southern Region</b>	<b>729,994</b>	<b>774,488</b>	<b>821,700</b>	<b>871,792</b>	<b>924,939</b>	<b>981,325</b>	<b>1041257</b>
<b>Bihar</b>	75,179	80,791	86,813	93,272	100,201	107,632	115614
<b>Jharkhand</b>	17,637	17,835	18,036	18,238	18,443	18,649	18857
<b>Odisha</b>	57,383	59,968	62,663	65,474	68,406	71,462	74655
<b>West Bengal</b>	222,989	239,129	256,399	274,876	294,641	315,779	338433

State/Region	2031	2032	2033	2034	2035	2036	2037
<b>Sikkim</b>	828	869	912	958	1,006	1,056	1108
<b>Eastern Region</b>	<b>374,016</b>	<b>398,592</b>	<b>424,823</b>	<b>452,818</b>	<b>482,697</b>	<b>514,578</b>	<b>548,667</b>
<b>Assam</b>	31,005	33,571	36,338	39,321	42,536	46,001	49,748
<b>Manipur</b>	896	913	931	948	966	985	1004
<b>Meghalaya</b>	4,694	4,966	5,253	5,556	5,876	6,213	6,569
<b>Nagaland</b>	1,260	1,305	1,352	1,401	1,451	1,503	1,557
<b>Tripura</b>	3,109	3,303	3,510	3,728	3,960	4,206	4,467
<b>Arunachal Pradesh</b>	1,298	1,363	1,431	1,503	1,578	1,657	1,740
<b>Mizoram</b>	1,588	1,719	1,861	2,014	2,179	2,357	2,550
<b>North Eastern Region</b>	<b>43,850</b>	<b>47,140</b>	<b>50,676</b>	<b>54,471</b>	<b>58,546</b>	<b>62,922</b>	<b>67,635</b>
<b>Andaman &amp; Nicobar Islands</b>	561	589	618	649	681	715	751
<b>Lakshadweep</b>	101	106	111	117	123	129	135
<b>All-India</b>	<b>2,545,003</b>	<b>2,685,142</b>	<b>2,833,362</b>	<b>2,990,137</b>	<b>3,155,977</b>	<b>3,331,408</b>	<b>3,517,358</b>

**Table A5.8: CAGR of Forecasted Total Electrical Energy Requirement (SUR Model Baseline)**

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
<b>Delhi</b>	1.62	1.63	1.63	1.5	1.57
<b>Haryana</b>	7.13	7.18	7.15	6.59	6.87
<b>Himachal Pradesh</b>	5	5	5	5	5
<b>Jammu &amp; Kashmir</b>	4.18	3.92	4.05	3.27	3.66
<b>Punjab</b>	4.28	4.25	4.27	3.77	4.02
<b>Rajasthan</b>	6.3	6.36	6.33	5.82	6.07
<b>Uttar Pradesh</b>	6.06	6.03	6.04	5.35	5.7
<b>Uttarakhand</b>	9.66	9.45	9.55	8.74	9.15
<b>Chandigarh</b>	2.43	2.43	2.43	2.16	2.29
<b>Northern Region</b>	5.71	5.83	5.77	5.44	5.6
<b>Goa</b>	0.81	0.82	0.82	0.75	0.78
<b>Gujarat</b>	3.19	3.41	3.3	3.21	3.26
<b>Chhattisgarh</b>	6.2	6.89	6.54	6.45	6.5
<b>Madhya Pradesh</b>	4.99	5.5	5.24	5.13	5.19
<b>Maharashtra</b>	3.53	3.81	3.67	3.54	3.6
<b>D. &amp; N. Haveli</b>	5	5	5	5	5
<b>Daman &amp; Diu</b>	5	5	5	5	5
<b>Western Region</b>	3.92	4.3	4.11	4.11	4.11
<b>Andhra Pradesh</b>	6.53	6.92	6.72	6.38	6.55
<b>Telangana</b>	6.53	6.92	6.72	6.38	6.55
<b>Karnataka</b>	3.77	4.08	3.92	3.77	3.84
<b>Kerala</b>	5.49	5.64	5.57	5.07	5.32
<b>Tamil Nadu</b>	6.92	7.4	7.16	6.9	7.03
<b>Puducherry</b>	3.52	4.05	3.79	3.81	3.8
<b>Southern Region</b>	5.99	6.45	6.22	6.06	6.14

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Bihar	8.14	8.21	8.17	7.52	7.85
Jharkhand	1.23	1.25	1.24	1.14	1.19
Odisha	5.01	5.05	5.03	4.54	4.79
West Bengal	8.21	8.21	8.21	7.31	7.76
Sikkim	4.97	4.98	4.98	4.99	4.98
Eastern Region	6.93	7.16	7.04	6.64	6.84
Assam	9.29	9.67	9.48	8.09	8.78
Manipur	2.26	2.33	2.3	1.84	2.07
Meghalaya	5.22	6.09	5.66	5.63	5.64
Nagaland	3.96	4	3.98	3.64	3.81
Tripura	6.27	6.64	6.46	6.2	6.33
Arunachal Pradesh	4.99	5	4.99	5	5
Mizoram	9.1	8.98	9.04	8.29	8.66
North Eastern Region	7.78	8.38	8.08	7.36	7.72
Andaman & Nicobar Islands	4.97	5	4.99	4.98	4.98
Lakshadweep	5.39	5.01	5.2	4.98	5.09
All-India	5.46	5.82	5.64	5.51	5.58

Table A5.9: Forecasted Total Electrical Energy Requirement (SUR Model Optimistic) in MUs

State/Region	2017	2018	2019	2020	2021	2022	2023
Delhi	29,737	30,166	30,680	31,202	31,732	32,272	32,820
Haryana	52,214	55,498	59,656	64,123	68,922	74,078	79,616
Himachal Pradesh	9,262	9,725	10,211	10,722	11,258	11,821	12,412
Jammu & Kashmir	17,979	18,604	19,460	20,343	21,254	22,193	23,157
Punjab	52,795	54,712	57,217	59,829	62,552	65,389	68,344
Rajasthan	73,428	77,481	82,621	88,103	93,947	100,178	106,822
Uttar Pradesh	113,462	119,293	127,030	135,244	143,963	153,214	163,029
Uttarakhand	15,233	16,583	18,263	20,099	22,108	24,303	26,702
Chandigarh	1,657	1,691	1,735	1,780	1,826	1,873	1,921
Northern Region	365,767	383,753	406,873	431,445	457,562	485,321	514,823
Goa	4,268	4,298	4,335	4,372	4,410	4,448	4,486
Gujarat	100,834	103,604	107,046	110,595	114,252	118,336	122,558
Chhattisgarh	25,587	26,881	28,620	30,471	32,442	34,791	37,309
Madhya Pradesh	62,412	64,958	68,346	71,911	75,662	80,036	84,662
Maharashtra	142,771	146,988	152,416	158,043	163,878	170,412	177,206
D. & N. Haveli	6,221	6,532	6,859	7,202	7,562	7,940	8,337
Daman & Diu	2,454	2,577	2,706	2,841	2,983	3,132	3,289
Western Region	344,547	355,838	370,328	385,435	401,189	419,095	437,847
Andhra Pradesh	55,733	58,797	62,833	67,146	71,756	76,960	82,542
Telangana	56,005	59,083	63,139	67,473	72,106	77,335	82,944
Karnataka	68,091	70,200	72,979	75,868	78,871	82,258	85,790



State/Region	2017	2018	2019	2020	2021	2022	2023
Kerala	25,106	26,262	27,798	29,421	31,135	32,997	34,965
Tamil Nadu	108,565	114,928	123,233	132,133	141,670	152,651	164,477
Puducherry	2,691	2,765	2,867	2,972	3,082	3,213	3,351
Southern Region	<b>316,191</b>	<b>332,035</b>	<b>352,849</b>	<b>375,013</b>	<b>398,620</b>	<b>425,414</b>	<b>454,069</b>
Bihar	25,522	27,349	29,692	32,235	34,994	37,989	41,240
Jharkhand	14,890	15,050	15,246	15,445	15,646	15,850	16,057
Odisha	29,307	30,568	32,196	33,909	35,712	37,609	39,604
West Bengal	75,955	81,255	88,382	96,118	104,511	113,616	123,491
Sikkim	419	440	462	485	509	534	561
Eastern Region	<b>146,093</b>	<b>154,662</b>	<b>165,978</b>	<b>178,192</b>	<b>191,372</b>	<b>205,598</b>	<b>220,953</b>
Assam	9,237	9,864	10,880	11,979	13,165	14,649	16,266
Manipur	667	677	694	711	728	750	772
Meghalaya	2,192	2,277	2,403	2,535	2,674	2,849	3,035
Nagaland	737	762	794	828	862	898	936
Tripura	1,309	1,379	1,470	1,566	1,668	1,784	1,908
Arunachal Pradesh	656	689	723	759	797	837	879
Mizoram	484	524	574	629	688	753	823
North Eastern Region	<b>15,282</b>	<b>16,172</b>	<b>17,538</b>	<b>19,007</b>	<b>20,582</b>	<b>22,520</b>	<b>24,619</b>
Andaman & Nicobar Islands	284	298	313	329	345	362	380
Lakshadweep	50	53	56	59	62	65	68
All-India	<b>1,188,214</b>	<b>1,242,811</b>	<b>1,313,935</b>	<b>1,389,480</b>	<b>1,469,732</b>	<b>1,558,375</b>	<b>1,652,759</b>

State/Region	2024	2025	2026	2027	2028	2029	2030
Delhi	33,376	33,942	34,517	35,102	35,695	36,297	36,909
Haryana	85,566	91,956	98,821	106,188	114,093	122,573	131,672
Himachal Pradesh	13,033	13,685	14,369	15,087	15,841	16,633	17,465
Jammu & Kashmir	24,147	25,160	26,196	27,270	28,386	29,545	30,748
Punjab	71,422	74,627	77,963	81,444	85,074	88,859	92,804
Rajasthan	113,906	121,459	129,512	138,087	147,216	156,934	167,279
Uttar Pradesh	173,437	184,471	196,166	208,574	221,741	235,714	250,538
Uttarakhand	29,323	32,185	35,310	38,733	42,485	46,595	51,096
Chandigarh	1,971	2,021	2,072	2,125	2,179	2,234	2,291
Northern Region	<b>546,181</b>	<b>579,506</b>	<b>614,926</b>	<b>652,610</b>	<b>692,710</b>	<b>735,384</b>	<b>780,802</b>
Goa	4,525	4,564	4,603	4,642	4,682	4,722	4,762
Gujarat	126,921	131,430	136,090	140,912	145,896	151,050	156,378
Chhattisgarh	40,010	42,906	46,012	49,337	52,897	56,707	60,784
Madhya Pradesh	89,556	94,733	100,209	105,989	112,092	118,535	125,337
Maharashtra	184,270	191,616	199,253	207,179	215,406	223,945	232,809
D. & N. Haveli	8,754	9,192	9,652	10,135	10,642	11,174	11,733
Daman & Diu	3,453	3,626	3,807	3,997	4,197	4,407	4,627
Western Region	<b>457,489</b>	<b>478,067</b>	<b>499,626</b>	<b>522,191</b>	<b>545,812</b>	<b>570,540</b>	<b>596,430</b>
Andhra Pradesh	88,528	94,948	101,835	109,213	117,112	125,568	134,620



State/Region	2024	2025	2026	2027	2028	2029	2030
Telangana	88,959	95,411	102,331	109,745	117,683	126,180	135,276
Karnataka	89,473	93,312	97,316	101,484	105,822	110,337	115,037
Kerala	37,047	39,249	41,577	44,038	46,639	49,390	52,297
Tamil Nadu	177,212	190,925	205,693	221,583	238,675	257,056	276,821
Puducherry	3,494	3,643	3,799	3,961	4,130	4,306	4,489
Southern Region	484,713	517,488	552,551	590,024	630,061	672,837	718,540
Bihar	44,767	48,595	52,748	57,249	62,126	67,411	73,138
Jharkhand	16,266	16,478	16,693	16,910	17,130	17,352	17,577
Odisha	41,704	43,912	46,235	48,675	51,240	53,935	56,768
West Bengal	134,198	145,804	158,381	172,010	186,784	202,798	220,153
Sikkim	589	618	649	681	715	751	789
Eastern Region	237,524	255,407	274,706	295,525	317,995	342,247	368,425
Assam	18,022	19,922	21,968	24,217	26,688	29,403	32,384
Manipur	793	814	834	855	876	898	920
Meghalaya	3,233	3,443	3,666	3,903	4,155	4,423	4,707
Nagaland	975	1,016	1,058	1,103	1,148	1,196	1,246
Tripura	2,040	2,182	2,333	2,494	2,667	2,851	3,047
Arunachal Pradesh	923	969	1,017	1,068	1,121	1,177	1,236
Mizoram	900	984	1,074	1,174	1,282	1,400	1,529
North Eastern Region	26,886	29,330	31,950	34,814	37,937	41,348	45,069
Andaman & Nicobar Islands	399	419	440	462	485	509	534
Lakshadweep	71	75	79	83	87	91	96
All-India	1,753,263	1,860,292	1,974,278	2,095,709	2,225,087	2,362,956	2,509,896

State/Region	2031	2032	2033	2034	2035	2036	2037
Delhi	37,530	38,161	38,802	39,452	40,113	40,783	41,464
Haryana	141,432	151,900	163,127	175,166	188,074	201,914	216,772
Himachal Pradesh	18,338	19,255	20,218	21,229	22,290	23,405	24,576
Jammu & Kashmir	31,997	33,293	34,638	36,035	37,483	38,986	40,549
Punjab	96,917	101,204	105,671	110,327	115,179	120,234	125,511
Rajasthan	178,289	190,006	202,474	215,741	229,855	244,870	260,866
Uttar Pradesh	266,265	282,947	300,640	319,403	339,298	360,391	382,795
Uttarakhand	56,027	61,427	67,340	73,814	80,902	88,661	97,164
Chandigarh	2,348	2,408	2,468	2,530	2,593	2,658	2,725
Northern Region	829,143	880,601	935,378	993,697	1,055,787	1,121,902	1,192,422
Goa	4,803	4,844	4,885	4,927	4,968	5,010	5,052
Gujarat	161,885	167,818	173,960	180,317	186,897	193,707	200,765
Chhattisgarh	65,147	70,087	75,393	81,091	87,209	93,777	100,840
Madhya Pradesh	132,516	140,496	148,942	157,880	167,338	177,347	187,955
Maharashtra	242,008	251,936	262,254	272,978	284,122	295,702	307,754
D. & N. Haveli	12,320	12,936	13,583	14,262	14,975	15,724	16,510

State/Region	2031	2032	2033	2034	2035	2036	2037
Daman & Diu	4,858	5,101	5,356	5,624	5,905	6,200	6,510
Western Region	623,537	653,218	684,373	717,079	751,414	787,467	825,386
Andhra Pradesh	144,308	154,972	166,405	178,660	191,797	205,876	220,988
Telangana	145,011	155,727	167,216	179,531	192,732	206,879	222,065
Karnataka	119,929	125,234	130,765	136,530	142,538	148,800	155,337
Kerala	55,369	58,664	62,148	65,832	69,727	73,845	78,206
Tamil Nadu	298,073	321,774	347,320	374,851	404,519	436,485	470,977
Puducherry	4,679	4,892	5,114	5,346	5,589	5,841	6,104
Southern Region	767,369	821,263	878,968	940,750	1,006,902	1,077,726	1,153,677
Bihar	79,342	86,062	93,340	101,223	109,758	118,999	129,018
Jharkhand	17,804	18,034	18,266	18,502	18,739	18,980	19,224
Odisha	59,744	62,870	66,154	69,604	73,228	77,033	81,036
West Bengal	238,957	259,329	281,396	305,296	331,176	359,196	389,587
Sikkim	828	869	912	958	1,006	1,056	1,108
Eastern Region	396,675	427,164	460,068	495,583	533,907	575,264	619,973
Assam	35,657	39,549	43,854	48,612	53,871	59,680	66,115
Manipur	943	969	997	1,025	1,053	1,083	1,114
Meghalaya	5,009	5,359	5,733	6,132	6,558	7,012	7,497
Nagaland	1,298	1,351	1,407	1,465	1,525	1,588	1,654
Tripura	3,257	3,489	3,736	4,001	4,284	4,587	4,911
Arunachal Pradesh	1,298	1,363	1,431	1,503	1,578	1,657	1,740
Mizoram	1,669	1,822	1,989	2,171	2,370	2,586	2,822
North Eastern Region	49,131	53,902	59,147	64,909	71,239	78,193	85,853
Andaman & Nicobar Islands	561	589	618	649	681	715	751
Lakshadweep	101	106	111	117	123	129	135
All-India	2,666,517	2,836,843	3,018,663	3,212,784	3,420,053	3,641,396	3,878,197

Table A5.9: CAGR of Forecasted Total Electrical Energy Requirement (SUR Model Optimistic)

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
Delhi	1.65	1.7	1.67	1.68	1.68
Haryana	7.25	7.47	7.36	7.4	7.38
Himachal Pradesh	5	5	5	5	5
Jammu & Kashmir	4.3	4.21	4.25	4.05	4.15
Punjab	4.37	4.49	4.43	4.42	4.42
Rajasthan	6.41	6.63	6.52	6.57	6.54
Uttar Pradesh	6.19	6.36	6.28	6.26	6.27
Uttarakhand	9.79	9.77	9.78	9.63	9.71
Chandigarh	2.48	2.56	2.52	2.52	2.52
Northern Region	5.82	6.1	5.96	6.21	6.09
Goa	0.83	0.86	0.84	0.85	0.85
Gujarat	3.25	3.55	3.4	3.6	3.5

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
<b>Chhattisgarh</b>	6.34	7.24	6.79	7.41	7.1
<b>Madhya Pradesh</b>	5.1	5.78	5.44	5.9	5.67
<b>Maharashtra</b>	3.6	3.98	3.79	4.04	3.91
<b>D. &amp; N. Haveli</b>	5	5	5	5	5
<b>Daman &amp; Diu</b>	5	5	5	5	5
<b>Western Region</b>	4	4.5	4.25	4.68	4.46
<b>Andhra Pradesh</b>	6.67	7.25	6.96	7.3	7.13
<b>Telangana</b>	6.67	7.25	6.96	7.3	7.13
<b>Karnataka</b>	3.85	4.29	4.07	4.35	4.21
<b>Kerala</b>	5.62	5.94	5.78	5.91	5.85
<b>Tamil Nadu</b>	7.05	7.74	7.4	7.83	7.61
<b>Puducherry</b>	3.61	4.27	3.94	4.42	4.18
<b>Southern Region</b>	6.11	6.76	6.44	6.94	6.69
<b>Bihar</b>	8.28	8.55	8.41	8.46	8.44
<b>Jharkhand</b>	1.26	1.3	1.28	1.29	1.29
<b>Odisha</b>	5.11	5.29	5.2	5.23	5.22
<b>West Bengal</b>	8.39	8.65	8.52	8.52	8.52
<b>Sikkim</b>	4.97	4.98	4.98	4.99	4.98
<b>Eastern Region</b>	7.07	7.53	7.3	7.69	7.49
<b>Assam</b>	9.66	10.58	10.12	10.57	10.34
<b>Manipur</b>	2.37	2.66	2.51	2.68	2.6
<b>Meghalaya</b>	5.38	6.5	5.94	6.75	6.34
<b>Nagaland</b>	4.03	4.2	4.11	4.13	4.12
<b>Tripura</b>	6.39	6.93	6.66	7.01	6.83
<b>Arunachal Pradesh</b>	4.99	5	4.99	5	5
<b>Mizoram</b>	9.24	9.29	9.27	9.17	9.22
<b>North Eastern Region</b>	<b>8.06</b>	<b>9.1</b>	<b>8.58</b>	<b>9.45</b>	<b>9.01</b>
<b>Andaman &amp; Nicobar Islands</b>	4.97	5	4.99	4.98	4.98
<b>Lakshadweep</b>	5.39	5.01	5.2	4.98	5.09
<b>All-India</b>	5.57	6.1	5.84	6.35	6.09

**Table A5.10: Forecasted Total Electrical Energy Requirement (SUR Model Pessimistic) in MUs**

State/Region	2017	2018	2019	2020	2021	2022	2023
<b>Delhi</b>	29,737	30,166	30,595	31,029	31,469	31,915	32,367
<b>Haryana</b>	52,214	55,498	58,939	62,590	66,466	70,579	74,944
<b>Himachal Pradesh</b>	9,262	9,725	10,211	10,722	11,258	11,821	12,412
<b>Jammu &amp; Kashmir</b>	17,979	18,604	19,225	19,856	20,495	21,142	21,795
<b>Punjab</b>	52,795	54,712	56,653	58,655	60,719	62,847	65,040
<b>Rajasthan</b>	73,428	77,481	81,695	86,138	90,823	95,761	100,967
<b>Uttar Pradesh</b>	113,462	119,293	125,285	131,554	138,112	144,969	152,136
<b>Uttarakhand</b>	15,233	16,583	18,025	19,581	21,258	23,065	25,013

State/Region	2017	2018	2019	2020	2021	2022	2023
<b>Chandigarh</b>	1,657	1,691	1,725	1,760	1,796	1,832	1,868
Northern Region	<b>365,767</b>	<b>383,753</b>	<b>402,353</b>	<b>421,885</b>	<b>442,396</b>	<b>463,931</b>	<b>486,542</b>
<b>Goa</b>	4,268	4,298	4,328	4,358	4,388	4,419	4,450
<b>Gujarat</b>	100,834	103,604	106,397	109,257	112,185	115,491	118,885
<b>Chhattisgarh</b>	25,587	26,881	28,212	29,610	31,076	32,852	34,729
<b>Madhya Pradesh</b>	62,412	64,958	67,555	70,256	73,065	76,395	79,875
<b>Maharashtra</b>	142,771	146,988	151,252	155,639	160,153	165,267	170,544
<b>D. &amp; N. Haveli</b>	6,221	6,532	6,859	7,202	7,562	7,940	8,337
<b>Daman &amp; Diu</b>	2,454	2,577	2,706	2,841	2,983	3,132	3,289
Western Region	<b>344,547</b>	<b>355,838</b>	<b>367,309</b>	<b>379,163</b>	<b>391,412</b>	<b>405,496</b>	<b>420,109</b>
<b>Andhra Pradesh</b>	55,733	58,797	61,971	65,316	68,843	72,822	77,032
<b>Telangana</b>	56,005	59,083	62,273	65,634	69,178	73,177	77,407
<b>Karnataka</b>	68,091	70,200	72,330	74,524	76,784	79,369	82,040
<b>Kerala</b>	25,106	26,262	27,446	28,680	29,967	31,356	32,806
<b>Tamil Nadu</b>	108,565	114,928	121,546	128,540	135,931	144,462	153,523
<b>Puducherry</b>	2,691	2,765	2,840	2,917	2,995	3,094	3,196
Southern Region	<b>316,191</b>	<b>332,035</b>	<b>348,406</b>	<b>365,611</b>	<b>383,698</b>	<b>404,280</b>	<b>426,004</b>
<b>Bihar</b>	25,522	27,349	29,279	31,343	33,553	35,917	38,447
<b>Jharkhand</b>	14,890	15,050	15,209	15,369	15,532	15,696	15,861
<b>Odisha</b>	29,307	30,568	31,859	33,203	34,603	36,059	37,575
<b>West Bengal</b>	75,955	81,255	86,804	92,716	99,013	105,717	112,854
<b>Sikkim</b>	419	440	462	485	509	534	561
Eastern Region	<b>146,093</b>	<b>154,662</b>	<b>163,613</b>	<b>173,116</b>	<b>183,210</b>	<b>193,923</b>	<b>205,298</b>
<b>Assam</b>	9,237	9,864	10,490	11,137	11,802	12,662	13,556
<b>Manipur</b>	667	677	685	693	700	712	723
<b>Meghalaya</b>	2,192	2,277	2,363	2,451	2,543	2,664	2,791
<b>Nagaland</b>	737	762	788	815	843	871	901
<b>Tripura</b>	1,309	1,379	1,452	1,528	1,609	1,700	1,796
<b>Arunachal Pradesh</b>	656	689	723	759	797	837	879
<b>Mizoram</b>	484	524	567	613	662	715	772
North Eastern Region	<b>15,282</b>	<b>16,172</b>	<b>17,068</b>	<b>17,996</b>	<b>18,956</b>	<b>20,161</b>	<b>21,418</b>
<b>Andaman &amp; Nicobar Islands</b>	284	298	313	329	345	362	380
<b>Lakshadweep</b>	50	53	56	59	62	65	68
All-India	<b>1,188,214</b>	<b>1,242,811</b>	<b>1,299,118</b>	<b>1,358,159</b>	<b>1,420,079</b>	<b>1,488,218</b>	<b>1,559,819</b>

State/Region	2024	2025	2026	2027	2028	2029	2030
<b>Delhi</b>	32,825	33,290	33,760	34,236	34,718	35,206	35,700
<b>Haryana</b>	79,575	84,491	89,706	95,230	101,086	107,292	113,866
<b>Himachal Pradesh</b>	13,033	13,685	14,369	15,087	15,841	16,633	17,465
<b>Jammu &amp; Kashmir</b>	22,453	23,113	23,775	24,452	25,147	25,858	26,587
<b>Punjab</b>	67,298	69,625	72,020	74,490	77,040	79,670	82,384
<b>Rajasthan</b>	106,456	112,242	118,342	124,763	131,521	138,633	146,115

State/Region	2024	2025	2026	2027	2028	2029	2030
<b>Uttar Pradesh</b>	159,626	167,450	175,619	184,168	193,115	202,474	212,261
<b>Uttarakhand</b>	27,111	29,371	31,804	34,434	37,278	40,354	43,678
<b>Chandigarh</b>	1,906	1,943	1,982	2,021	2,060	2,101	2,142
<b>Northern Region</b>	<b>510,283</b>	<b>535,210</b>	<b>561,377</b>	<b>588,881</b>	<b>617,806</b>	<b>648,221</b>	<b>680,198</b>
<b>Goa</b>	4,481	4,512	4,543	4,575	4,606	4,638	4,670
<b>Gujarat</b>	122,371	125,949	129,624	133,399	137,278	141,262	145,355
<b>Chhattisgarh</b>	36,713	38,810	41,027	43,365	45,832	48,434	51,177
<b>Madhya Pradesh</b>	83,515	87,320	91,299	95,444	99,769	104,281	108,986
<b>Maharashtra</b>	175,988	181,606	187,403	193,367	199,511	205,837	212,349
<b>D. &amp; N. Haveli</b>	8,754	9,192	9,652	10,135	10,642	11,174	11,733
<b>Daman &amp; Diu</b>	3,453	3,626	3,807	3,997	4,197	4,407	4,627
<b>Western Region</b>	<b>435,275</b>	<b>451,015</b>	<b>467,355</b>	<b>484,282</b>	<b>501,835</b>	<b>520,033</b>	<b>538,897</b>
<b>Andhra Pradesh</b>	81,485	86,195	91,178	96,436	101,989	107,849	114,031
<b>Telangana</b>	81,882	86,615	91,622	96,906	102,486	108,374	114,587
<b>Karnataka</b>	84,801	87,653	90,601	93,640	96,775	100,007	103,340
<b>Kerala</b>	34,319	35,898	37,545	39,262	41,055	42,925	44,876
<b>Tamil Nadu</b>	163,145	173,364	184,216	195,721	207,925	220,864	234,582
<b>Puducherry</b>	3,301	3,410	3,522	3,638	3,757	3,880	4,006
<b>Southern Region</b>	<b>448,933</b>	<b>473,135</b>	<b>498,684</b>	<b>525,603</b>	<b>553,987</b>	<b>583,899</b>	<b>615,422</b>
<b>Bihar</b>	41,154	44,051	47,151	50,462	54,001	57,781	61,819
<b>Jharkhand</b>	16,029	16,198	16,369	16,541	16,715	16,890	17,067
<b>Odisha</b>	39,153	40,795	42,503	44,279	46,126	48,046	50,041
<b>West Bengal</b>	120,449	128,529	137,124	146,258	155,981	166,326	177,331
<b>Sikkim</b>	589	618	649	681	715	751	789
<b>Eastern Region</b>	<b>217,374</b>	<b>230,191</b>	<b>243,796</b>	<b>258,221</b>	<b>273,538</b>	<b>289,794</b>	<b>307,047</b>
<b>Assam</b>	14,483	15,436	16,413	17,445	18,538	19,693	20,914
<b>Manipur</b>	733	743	751	760	769	777	786
<b>Meghalaya</b>	2,923	3,061	3,205	3,356	3,512	3,676	3,847
<b>Nagaland</b>	931	963	995	1,029	1,064	1,100	1,137
<b>Tripura</b>	1,898	2,006	2,119	2,239	2,365	2,497	2,638
<b>Arunachal Pradesh</b>	923	969	1,017	1,068	1,121	1,177	1,236
<b>Mizoram</b>	833	899	969	1,045	1,127	1,215	1,309
<b>North Eastern Region</b>	<b>22,724</b>	<b>24,077</b>	<b>25,469</b>	<b>26,942</b>	<b>28,496</b>	<b>30,135</b>	<b>31,867</b>
<b>Andaman &amp; Nicobar Islands</b>	399	419	440	462	485	509	534
<b>Lakshadweep</b>	71	75	79	83	87	91	96
<b>All-India</b>	<b>1,635,059</b>	<b>1,714,122</b>	<b>1,797,200</b>	<b>1,884,474</b>	<b>1,976,234</b>	<b>2,072,682</b>	<b>2,174,061</b>

State/Region	2031	2032	2033	2034	2035	2036	2037
<b>Delhi</b>	36,200	36,707	37,219	37,738	38,263	38,795	39,334
<b>Haryana</b>	120,831	128,210	136,024	144,300	153,064	162,343	172,185
<b>Himachal Pradesh</b>	18,338	19,255	20,218	21,229	22,290	23,405	24,576
<b>Jammu &amp; Kashmir</b>	27,334	28,099	28,883	29,684	30,506	31,347	32,211

State/Region	2031	2032	2033	2034	2035	2036	2037
<b>Punjab</b>	85,183	88,069	91,046	94,115	97,280	100,542	103,913
<b>Rajasthan</b>	153,987	162,267	170,976	180,135	189,766	199,893	210,560
<b>Uttar Pradesh</b>	222,495	233,196	244,383	256,076	268,296	281,067	294,446
<b>Uttarakhand</b>	47,270	51,153	55,348	59,881	64,778	70,067	75,788
<b>Chandigarh</b>	2,184	2,226	2,269	2,313	2,358	2,403	2,449
<b>Northern Region</b>	<b>713,822</b>	<b>749,182</b>	<b>786,366</b>	<b>825,471</b>	<b>866,601</b>	<b>909,862</b>	<b>955,462</b>
<b>Goa</b>	4,702	4,735	4,767	4,800	4,833	4,866	4,899
<b>Gujarat</b>	149,558	154,095	158,762	163,561	168,497	173,572	178,800
<b>Chhattisgarh</b>	54,070	57,341	60,803	64,466	68,342	72,442	76,788
<b>Madhya Pradesh</b>	113,891	119,349	125,055	131,021	137,258	143,777	150,606
<b>Maharashtra</b>	219,054	226,298	233,765	241,464	249,400	257,579	266,026
<b>D. &amp; N. Haveli</b>	12,320	12,936	13,583	14,262	14,975	15,724	16,510
<b>Daman &amp; Diu</b>	4,858	5,101	5,356	5,624	5,905	6,200	6,510
<b>Western Region</b>	<b>558,453</b>	<b>579,855</b>	<b>602,091</b>	<b>625,198</b>	<b>649,210</b>	<b>674,160</b>	<b>700,139</b>
<b>Andhra Pradesh</b>	120,555	127,681	135,212	143,170	151,579	160,463	169,866
<b>Telangana</b>	121,142	128,303	135,871	143,868	152,318	161,245	170,694
<b>Karnataka</b>	106,776	110,508	114,361	118,340	122,448	126,689	131,077
<b>Kerala</b>	46,910	49,071	51,326	53,679	56,133	58,694	61,372
<b>Tamil Nadu</b>	249,122	265,238	282,362	300,557	319,887	340,419	362,269
<b>Puducherry</b>	4,136	4,284	4,436	4,594	4,757	4,925	5,099
<b>Southern Region</b>	<b>648,641</b>	<b>685,085</b>	<b>723,568</b>	<b>764,208</b>	<b>807,122</b>	<b>852,435</b>	<b>900,377</b>
<b>Bihar</b>	66,131	70,735	75,651	80,898	86,500	92,478	98,869
<b>Jharkhand</b>	17,245	17,425	17,606	17,789	17,973	18,159	18,347
<b>Odisha</b>	52,115	54,269	56,508	58,834	61,250	63,759	66,371
<b>West Bengal</b>	189,034	201,480	214,712	228,779	243,729	259,615	276,536
<b>Sikkim</b>	828	869	912	958	1,006	1,056	1,108
<b>Eastern Region</b>	<b>325,353</b>	<b>344,778</b>	<b>365,389</b>	<b>387,258</b>	<b>410,458</b>	<b>435,067</b>	<b>461,231</b>
<b>Assam</b>	22,204	23,747	25,389	27,136	28,994	30,969	33,079
<b>Manipur</b>	795	806	818	830	842	854	866
<b>Meghalaya</b>	4,025	4,234	4,453	4,683	4,925	5,177	5,442
<b>Nagaland</b>	1,175	1,214	1,254	1,296	1,339	1,383	1,428
<b>Tripura</b>	2,785	2,947	3,118	3,299	3,490	3,692	3,906
<b>Arunachal Pradesh</b>	1,298	1,363	1,431	1,503	1,578	1,657	1,740
<b>Mizoram</b>	1,411	1,521	1,639	1,766	1,902	2,049	2,207
<b>North Eastern Region</b>	<b>33,693</b>	<b>35,832</b>	<b>38,102</b>	<b>40,513</b>	<b>43,070</b>	<b>45,781</b>	<b>48,668</b>
<b>Andaman &amp; Nicobar Islands</b>	561	589	618	649	681	715	751
<b>Lakshadweep</b>	101	106	111	117	123	129	135
<b>All-India</b>	<b>2,280,624</b>	<b>2,395,427</b>	<b>2,516,245</b>	<b>2,643,414</b>	<b>2,777,265</b>	<b>2,918,149</b>	<b>3,066,763</b>



**Table A5.10: CAGR of Forecasted Total Electrical Energy Requirement (SUR Model Pessimistic)**

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
<b>Delhi</b>	1.42	1.41	1.42	1.4	1.41
<b>Haryana</b>	6.21	6.17	6.19	6.1	6.15
<b>Himachal Pradesh</b>	5	5	5	5	5
<b>Jammu &amp; Kashmir</b>	3.29	2.95	3.12	2.79	2.96
<b>Punjab</b>	3.55	3.46	3.5	3.38	3.44
<b>Rajasthan</b>	5.45	5.43	5.44	5.37	5.41
<b>Uttar Pradesh</b>	5.02	4.9	4.96	4.8	4.88
<b>Uttarakhand</b>	8.65	8.34	8.5	8.21	8.35
<b>Chandigarh</b>	2.03	1.98	2.01	1.94	1.97
<b>Northern Region</b>	4.87	4.89	4.88	4.96	4.92
<b>Goa</b>	0.7	0.7	0.7	0.69	0.69
<b>Gujarat</b>	2.75	2.93	2.84	2.97	2.91
<b>Chhattisgarh</b>	5.13	5.71	5.42	5.88	5.65
<b>Madhya Pradesh</b>	4.13	4.55	4.34	4.67	4.5
<b>Maharashtra</b>	2.97	3.19	3.08	3.24	3.16
<b>D. &amp; N. Haveli</b>	5	5	5	5	5
<b>Daman &amp; Diu</b>	5	5	5	5	5
<b>Western Region</b>	3.31	3.61	3.46	3.75	3.61
<b>Andhra Pradesh</b>	5.49	5.78	5.64	5.82	5.73
<b>Telangana</b>	5.49	5.78	5.64	5.82	5.73
<b>Karnataka</b>	3.11	3.36	3.24	3.42	3.33
<b>Kerala</b>	4.55	4.6	4.57	4.57	4.57
<b>Tamil Nadu</b>	5.88	6.26	6.07	6.35	6.21
<b>Puducherry</b>	2.83	3.29	3.06	3.43	3.25
<b>Southern Region</b>	5.04	5.39	5.21	5.53	5.37
<b>Bihar</b>	7.07	7.04	7.05	6.96	7.01
<b>Jharkhand</b>	1.06	1.05	1.06	1.04	1.05
<b>Odisha</b>	4.23	4.19	4.21	4.13	4.17
<b>West Bengal</b>	6.84	6.71	6.77	6.58	6.67
<b>Sikkim</b>	4.97	4.98	4.98	4.99	4.98
<b>Eastern Region</b>	5.83	5.89	5.86	5.97	5.92
<b>Assam</b>	6.51	6.62	6.56	6.61	6.59
<b>Manipur</b>	1.31	1.31	1.31	1.31	1.31
<b>Meghalaya</b>	3.98	4.73	4.35	4.95	4.65
<b>Nagaland</b>	3.4	3.39	3.39	3.33	3.36
<b>Tripura</b>	5.37	5.66	5.51	5.72	5.62
<b>Arunachal Pradesh</b>	4.99	5	4.99	5	5
<b>Mizoram</b>	8.12	7.89	8	7.76	7.88
<b>North Eastern Region</b>	5.7	5.97	5.83	6.09	5.96
<b>Andaman &amp; Nicobar Islands</b>	4.97	5	4.99	4.98	4.98
<b>Lakshadweep</b>	5.39	5.01	5.2	4.98	5.09
<b>All-India</b>	4.61	4.83	4.72	4.99	4.86



**Table A5.11: Forecasted Peak Electricity Demand (SUR Model Baseline) in MW**

State	2017	2018	2019	2020	2021	2022	2023
<b>Delhi</b>	5,622	5,745	5,885	6,034	6,190	6,350	6,514
<b>Haryana</b>	9,578	10,191	10,924	11,738	12,633	13,596	14,631
<b>Himachal Pradesh</b>	1,586	1,665	1,748	1,835	1,927	2,023	2,124
<b>Jammu &amp; Kashmir</b>	2,840	2,958	3,106	3,268	3,443	3,624	3,812
<b>Punjab</b>	11,178	11,458	11,793	12,153	12,535	12,927	13,330
<b>Rajasthan</b>	11,791	12,402	13,129	13,927	14,795	15,716	16,695
<b>Uttar Pradesh</b>	16,623	17,525	18,635	19,870	21,223	22,663	24,197
<b>Uttarakhand</b>	2,295	2,456	2,644	2,851	3,077	3,319	3,579
<b>Chandigarh</b>	348	363	381	401	422	444	468
<b>Goa</b>	560	582	607	635	664	695	728
<b>Gujarat</b>	14,549	14,909	15,329	15,776	16,247	16,771	17,312
<b>Chhattisgarh</b>	4,200	4,385	4,612	4,863	5,136	5,459	5,802
<b>Madhya Pradesh</b>	10,956	11,428	12,009	12,650	13,347	14,163	15,028
<b>Maharashtra</b>	21,170	21,600	22,109	22,654	23,229	23,864	24,518
<b>D. &amp; N. Haveli</b>	790	830	872	916	962	1,010	1,061
<b>Daman &amp; Diu</b>	320	336	353	371	390	410	431
<b>Andhra Pradesh</b>	7,489	7,837	8,262	8,727	9,236	9,803	10,405
<b>Telangana</b>	8,604	9,004	9,491	10,027	10,610	11,262	11,953
<b>Karnataka</b>	11,016	11,302	11,647	12,021	12,420	12,866	13,328
<b>Kerala</b>	4,125	4,269	4,444	4,635	4,840	5,059	5,288
<b>Tamil Nadu</b>	15,487	16,199	17,055	17,994	19,012	20,166	21,389
<b>Puducherry</b>	411	425	441	460	480	505	531
<b>Bihar</b>	3,847	4,131	4,474	4,860	5,289	5,755	6,263
<b>Jharkhand</b>	2,200	2,265	2,340	2,421	2,507	2,597	2,689
<b>Odisha</b>	4,373	4,541	4,742	4,961	5,196	5,442	5,699
<b>West Bengal</b>	11,847	12,639	13,623	14,733	15,966	17,299	18,740
<b>Sikkim</b>	119	125	131	138	145	152	160
<b>Assam</b>	1,508	1,598	1,724	1,868	2,031	2,231	2,447
<b>Manipur</b>	135	137	139	142	145	149	153
<b>Meghalaya</b>	427	445	468	495	525	562	602
<b>Nagaland</b>	134	138	142	147	151	156	161
<b>Tripura</b>	259	265	272	280	287	296	305
<b>Arunachal Pradesh</b>	148	155	163	171	180	189	198
<b>Mizoram</b>	92	95	98	101	105	108	112
<b>Andaman &amp; Nicobar Islands</b>	40	42	44	46	48	50	53
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>163,148</b>	<b>170,644</b>	<b>179,732</b>	<b>189,774</b>	<b>200,728</b>	<b>212,828</b>	<b>225,710</b>



State	2024	2025	2026	2027	2028	2029	2030
<b>Delhi</b>	6,678	6,843	7,009	7,178	7,348	7,520	7,693
<b>Haryana</b>	15,719	16,859	18,067	19,344	20,692	22,114	23,612
<b>Himachal Pradesh</b>	2,230	2,342	2,459	2,582	2,711	2,847	2,989
<b>Jammu &amp; Kashmir</b>	3,999	4,183	4,368	4,556	4,746	4,940	5,136
<b>Punjab</b>	13,732	14,131	14,534	14,940	15,350	15,763	16,178
<b>Rajasthan</b>	17,710	18,759	19,857	21,003	22,198	23,442	24,735
<b>Uttar Pradesh</b>	25,779	27,405	29,098	30,864	32,700	34,608	36,587
<b>Uttarakhand</b>	3,852	4,139	4,442	4,763	5,104	5,465	5,847
<b>Chandigarh</b>	492	517	542	568	594	622	650
<b>Goa</b>	760	794	829	864	900	938	976
<b>Gujarat</b>	17,855	18,401	18,955	19,518	20,090	20,670	21,258
<b>Chhattisgarh</b>	6,156	6,521	6,902	7,299	7,711	8,139	8,582
<b>Madhya Pradesh</b>	15,921	16,838	17,795	18,787	19,817	20,885	21,989
<b>Maharashtra</b>	25,171	25,824	26,484	27,150	27,821	28,498	29,180
<b>D. &amp; N. Haveli</b>	1,114	1,170	1,229	1,290	1,355	1,423	1,494
<b>Daman &amp; Diu</b>	453	476	500	525	551	579	608
<b>Andhra Pradesh</b>	11,025	11,666	12,334	13,029	13,751	14,502	15,279
<b>Telangana</b>	12,667	13,403	14,170	14,969	15,799	16,660	17,553
<b>Karnataka</b>	13,793	14,260	14,735	15,218	15,707	16,203	16,705
<b>Kerala</b>	5,520	5,754	5,994	6,239	6,489	6,745	7,005
<b>Tamil Nadu</b>	22,654	23,957	25,317	26,731	28,202	29,729	31,313
<b>Puducherry</b>	557	583	611	639	668	698	728
<b>Bihar</b>	6,803	7,374	7,986	8,639	9,335	10,076	10,865
<b>Jharkhand</b>	2,782	2,876	2,972	3,069	3,168	3,269	3,371
<b>Odisha</b>	5,961	6,227	6,500	6,781	7,069	7,364	7,666
<b>West Bengal</b>	20,251	21,829	23,498	25,263	27,125	29,087	31,150
<b>Sikkim</b>	168	176	185	194	204	214	225
<b>Assam</b>	2,667	2,888	3,115	3,352	3,598	3,852	4,115
<b>Manipur</b>	156	159	162	165	168	171	173
<b>Meghalaya</b>	643	685	729	774	821	870	921
<b>Nagaland</b>	167	172	177	182	188	193	199
<b>Tripura</b>	314	323	332	341	350	360	369
<b>Arunachal Pradesh</b>	208	218	229	240	252	265	278
<b>Mizoram</b>	115	119	122	126	130	134	138
<b>Andaman &amp; Nicobar Islands</b>	56	59	62	65	68	71	75
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>239,058</b>	<b>252,852</b>	<b>267,280</b>	<b>282,361</b>	<b>298,105</b>	<b>314,527</b>	<b>331,636</b>

State	2031	2032	2033	2034	2035	2036	2037
<b>Delhi</b>	7,868	8,047	8,229	8,416	8,606	8,800	8,998
<b>Haryana</b>	25,188	26,867	28,654	30,558	32,584	34,742	37,043
<b>Himachal Pradesh</b>	3,138	3,295	3,460	3,633	3,815	4,006	4,207
<b>Jammu &amp; Kashmir</b>	5,334	5,539	5,751	5,970	6,197	6,432	6,676
<b>Punjab</b>	16,597	17,024	17,462	17,910	18,369	18,838	19,319
<b>Rajasthan</b>	26,080	27,495	28,985	30,552	32,202	33,937	35,765
<b>Uttar Pradesh</b>	38,638	40,798	43,074	45,471	47,997	50,656	53,462
<b>Uttarakhand</b>	6,251	6,683	7,143	7,634	8,159	8,718	9,315
<b>Chandigarh</b>	679	708	740	772	806	841	878
<b>Goa</b>	1,015	1,056	1,098	1,142	1,187	1,235	1,285
<b>Gujarat</b>	21,853	22,493	23,151	23,828	24,522	25,236	25,971
<b>Chhattisgarh</b>	9,041	9,557	10,100	10,673	11,278	11,916	12,590
<b>Madhya Pradesh</b>	23,131	24,403	25,742	27,153	28,638	30,200	31,847
<b>Maharashtra</b>	29,867	30,600	31,350	32,117	32,901	33,703	34,525
<b>D. &amp; N. Haveli</b>	1,569	1,647	1,729	1,815	1,906	2,001	2,101
<b>Daman &amp; Diu</b>	638	670	704	739	776	815	856
<b>Andhra Pradesh</b>	16,083	16,957	17,875	18,841	19,858	20,928	22,056
<b>Telangana</b>	18,477	19,481	20,536	21,647	22,814	24,043	25,339
<b>Karnataka</b>	17,214	17,762	18,326	18,907	19,506	20,122	20,757
<b>Kerala</b>	7,270	7,550	7,839	8,139	8,450	8,772	9,106
<b>Tamil Nadu</b>	32,955	34,753	36,645	38,638	40,734	42,941	45,268
<b>Puducherry</b>	759	794	831	870	910	952	996
<b>Bihar</b>	11,703	12,604	13,572	14,613	15,732	16,935	18,230
<b>Jharkhand</b>	3,475	3,582	3,691	3,804	3,920	4,040	4,164
<b>Odisha</b>	7,974	8,295	8,627	8,972	9,331	9,702	10,088
<b>West Bengal</b>	33,316	35,628	38,095	40,727	43,535	46,530	49,731
<b>Sikkim</b>	236	248	260	273	287	301	316
<b>Assam</b>	4,386	4,704	5,044	5,408	5,796	6,210	6,654
<b>Manipur</b>	175	178	182	185	188	191	194
<b>Meghalaya</b>	973	1,034	1,099	1,168	1,241	1,318	1,400
<b>Nagaland</b>	204	210	216	222	228	235	242
<b>Tripura</b>	379	389	399	410	421	432	443
<b>Arunachal Pradesh</b>	292	307	322	338	355	373	392
<b>Mizoram</b>	142	146	150	154	159	163	167
<b>Andaman &amp; Nicobar Islands</b>	79	83	87	91	96	101	106
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>349,441</b>	<b>368,683</b>	<b>389,034</b>	<b>410,560</b>	<b>433,331</b>	<b>457,418</b>	<b>482,950</b>



**Table A5.11: CAGR of Forecasted Peak Electricity Demand (SUR Model Baseline)**

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
<b>Delhi</b>	2.47	2.48	2.47	2.29	2.38
<b>Haryana</b>	7.26	7.31	7.28	6.71	7
<b>Himachal Pradesh</b>	4.99	5	4.99	5	5
<b>Jammu &amp; Kashmir</b>	5	4.68	4.84	3.89	4.37
<b>Punjab</b>	2.95	2.94	2.94	2.6	2.77
<b>Rajasthan</b>	5.92	5.97	5.94	5.47	5.7
<b>Uttar Pradesh</b>	6.4	6.37	6.38	5.65	6.01
<b>Uttarakhand</b>	7.66	7.49	7.57	6.94	7.26
<b>Chandigarh</b>	4.99	5.05	5.02	4.45	4.74
<b>Goa</b>	4.41	4.45	4.43	4.05	4.24
<b>Gujarat</b>	2.88	3.08	2.98	2.9	2.94
<b>Chhattisgarh</b>	5.38	5.98	5.68	5.6	5.64
<b>Madhya Pradesh</b>	5.27	5.81	5.54	5.42	5.48
<b>Maharashtra</b>	2.42	2.61	2.52	2.43	2.48
<b>D. &amp; N. Haveli</b>	5.04	5.02	5.03	5	5.01
<b>Daman &amp; Diu</b>	5.08	5.07	5.08	5.01	5.04
<b>Andhra Pradesh</b>	5.53	5.85	5.69	5.41	5.55
<b>Telangana</b>	5.53	5.86	5.69	5.4	5.55
<b>Karnataka</b>	3.15	3.41	3.28	3.15	3.22
<b>Kerala</b>	4.17	4.28	4.22	3.85	4.04
<b>Tamil Nadu</b>	5.42	5.8	5.61	5.41	5.51
<b>Puducherry</b>	4.21	4.82	4.51	4.54	4.53
<b>Bihar</b>	8.39	8.46	8.43	7.75	8.09
<b>Jharkhand</b>	3.37	3.4	3.38	3.1	3.24
<b>Odisha</b>	4.47	4.5	4.48	4.05	4.27
<b>West Bengal</b>	7.87	7.87	7.87	7.01	7.44
<b>Sikkim</b>	5.02	5	5.01	5	5
<b>Assam</b>	8.15	8.48	8.32	7.1	7.7
<b>Manipur</b>	1.99	2.06	2.03	1.63	1.83
<b>Meghalaya</b>	5.65	6.61	6.13	6.11	6.12
<b>Nagaland</b>	3.09	3.13	3.11	2.89	3
<b>Tripura</b>	2.71	2.87	2.79	2.65	2.72
<b>Arunachal Pradesh</b>	5.01	4.89	4.95	5.03	4.99
<b>Mizoram</b>	3.26	3.13	3.19	2.86	3.03
<b>Andaman &amp; Nicobar Islands</b>	4.56	5.39	4.97	5.01	4.99
<b>Lakshadweep</b>	0	0	0	0	0
<b>All-India</b>	5.46	5.82	5.64	5.51	5.58



**Table A5.12: Forecasted Peak Electricity Demand (SUR Model Optimistic) in MW**

State	2017	2018	2019	2020	2021	2022	2023
<b>Delhi</b>	5,622	5,745	5,893	6,046	6,202	6,363	6,527
<b>Haryana</b>	9,578	10,191	10,969	11,806	12,706	13,673	14,715
<b>Himachal Pradesh</b>	1,586	1,665	1,748	1,835	1,927	2,023	2,124
<b>Jammu &amp; Kashmir</b>	2,840	2,958	3,121	3,290	3,466	3,648	3,838
<b>Punjab</b>	11,178	11,458	11,820	12,192	12,575	12,968	13,373
<b>Rajasthan</b>	11,791	12,402	13,175	13,996	14,868	15,794	16,777
<b>Uttar Pradesh</b>	16,623	17,525	18,726	20,005	21,367	22,817	24,361
<b>Uttarakhand</b>	2,295	2,456	2,653	2,865	3,092	3,335	3,596
<b>Chandigarh</b>	348	363	382	403	424	447	471
<b>Goa</b>	560	582	609	637	667	698	730
<b>Gujarat</b>	14,549	14,909	15,357	15,816	16,289	16,814	17,356
<b>Chhattisgarh</b>	4,200	4,385	4,631	4,891	5,166	5,491	5,836
<b>Madhya Pradesh</b>	10,956	11,428	12,058	12,722	13,424	14,244	15,114
<b>Maharashtra</b>	21,170	21,600	22,148	22,710	23,286	23,923	24,578
<b>D. &amp; N. Haveli</b>	790	830	872	916	962	1,010	1,061
<b>Daman &amp; Diu</b>	320	336	353	371	390	410	431
<b>Andhra Pradesh</b>	7,489	7,837	8,294	8,776	9,286	9,856	10,461
<b>Telangana</b>	8,604	9,004	9,529	10,082	10,668	11,323	12,018
<b>Karnataka</b>	11,016	11,302	11,676	12,063	12,463	12,911	13,375
<b>Kerala</b>	4,125	4,269	4,459	4,656	4,862	5,082	5,312
<b>Tamil Nadu</b>	15,487	16,199	17,116	18,085	19,108	20,268	21,498
<b>Puducherry</b>	411	425	443	463	483	507	533
<b>Bihar</b>	3,847	4,131	4,495	4,892	5,324	5,794	6,305
<b>Jharkhand</b>	2,200	2,265	2,345	2,429	2,515	2,605	2,697
<b>Odisha</b>	4,373	4,541	4,757	4,982	5,219	5,466	5,724
<b>West Bengal</b>	11,847	12,639	13,702	14,851	16,094	17,438	18,891
<b>Sikkim</b>	119	125	131	138	145	152	160
<b>Assam</b>	1,508	1,598	1,742	1,896	2,061	2,265	2,484
<b>Manipur</b>	135	137	140	143	146	150	154
<b>Meghalaya</b>	427	445	471	499	529	567	607
<b>Nagaland</b>	134	138	142	147	152	157	162
<b>Tripura</b>	259	265	273	280	288	297	306
<b>Arunachal Pradesh</b>	148	155	163	171	180	189	198
<b>Mizoram</b>	92	95	98	101	105	108	112
<b>Andaman &amp; Nicobar Islands</b>	40	42	44	46	48	50	53
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>163,148</b>	<b>170,644</b>	<b>180,410</b>	<b>190,782</b>	<b>201,801</b>	<b>213,972</b>	<b>226,932</b>



State	2024	2025	2026	2027	2028	2029	2030
<b>Delhi</b>	6,695	6,868	7,045	7,226	7,412	7,602	7,797
<b>Haryana</b>	15,834	17,039	18,334	19,726	21,222	22,829	24,554
<b>Himachal Pradesh</b>	2,230	2,342	2,459	2,582	2,711	2,847	2,989
<b>Jammu &amp; Kashmir</b>	4,033	4,235	4,444	4,661	4,889	5,127	5,376
<b>Punjab</b>	13,788	14,215	14,654	15,105	15,570	16,048	16,540
<b>Rajasthan</b>	17,822	18,932	20,110	21,361	22,687	24,093	25,585
<b>Uttar Pradesh</b>	26,004	27,751	29,610	31,588	33,694	35,936	38,324
<b>Uttarakhand</b>	3,876	4,176	4,497	4,843	5,215	5,615	6,046
<b>Chandigarh</b>	496	522	549	578	608	640	674
<b>Goa</b>	764	800	837	876	917	959	1,003
<b>Gujarat</b>	17,914	18,488	19,080	19,690	20,319	20,967	21,635
<b>Chhattisgarh</b>	6,202	6,592	7,006	7,445	7,911	8,406	8,930
<b>Madhya Pradesh</b>	16,038	17,018	18,058	19,158	20,324	21,559	22,867
<b>Maharashtra</b>	25,251	25,942	26,652	27,379	28,126	28,891	29,676
<b>D. &amp; N. Haveli</b>	1,114	1,170	1,229	1,290	1,355	1,423	1,494
<b>Daman &amp; Diu</b>	453	476	500	525	551	579	608
<b>Andhra Pradesh</b>	11,103	11,785	12,508	13,276	14,089	14,950	15,862
<b>Telangana</b>	12,755	13,540	14,371	15,253	16,186	17,176	18,223
<b>Karnataka</b>	13,855	14,353	14,868	15,401	15,952	16,521	17,110
<b>Kerala</b>	5,552	5,803	6,064	6,336	6,620	6,916	7,225
<b>Tamil Nadu</b>	22,801	24,183	25,648	27,200	28,843	30,583	32,425
<b>Puducherry</b>	560	589	619	651	684	718	755
<b>Bihar</b>	6,862	7,466	8,125	8,839	9,616	10,460	11,376
<b>Jharkhand</b>	2,793	2,893	2,995	3,102	3,212	3,326	3,443
<b>Odisha</b>	5,995	6,278	6,574	6,883	7,206	7,544	7,898
<b>West Bengal</b>	20,461	22,157	23,989	25,967	28,105	30,415	32,909
<b>Sikkim</b>	168	176	185	194	204	214	225
<b>Assam</b>	2,718	2,970	3,237	3,527	3,843	4,185	4,557
<b>Manipur</b>	157	161	165	168	172	176	180
<b>Meghalaya</b>	650	696	745	797	853	912	976
<b>Nagaland</b>	167	173	178	184	190	196	203
<b>Tripura</b>	315	324	334	344	354	365	375
<b>Arunachal Pradesh</b>	208	218	229	240	252	265	278
<b>Mizoram</b>	115	119	123	127	131	135	140
<b>Andaman &amp; Nicobar Islands</b>	56	59	62	65	68	71	75
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>240,732</b>	<b>255,427</b>	<b>271,078</b>	<b>287,751</b>	<b>305,515</b>	<b>324,445</b>	<b>344,621</b>

State	2031	2032	2033	2034	2035	2036	2037
<b>Delhi</b>	7,996	8,200	8,410	8,624	8,843	9,068	9,299
<b>Haryana</b>	26,408	28,399	30,536	32,831	35,295	37,941	40,785
<b>Himachal Pradesh</b>	3,138	3,295	3,460	3,633	3,815	4,006	4,207
<b>Jammu &amp; Kashmir</b>	5,637	5,909	6,194	6,492	6,804	7,129	7,470
<b>Punjab</b>	17,046	17,566	18,101	18,651	19,217	19,799	20,399
<b>Rajasthan</b>	27,166	28,843	30,620	32,504	34,501	36,617	38,863
<b>Uttar Pradesh</b>	40,865	43,569	46,446	49,508	52,765	56,229	59,920
<b>Uttarakhand</b>	6,508	7,006	7,540	8,115	8,733	9,397	10,111
<b>Chandigarh</b>	709	746	785	825	868	913	960
<b>Goa</b>	1,050	1,098	1,148	1,201	1,256	1,314	1,375
<b>Gujarat</b>	22,323	23,061	23,823	24,609	25,420	26,256	27,119
<b>Chhattisgarh</b>	9,487	10,111	10,775	11,482	12,233	13,033	13,885
<b>Madhya Pradesh</b>	24,251	25,795	27,434	29,174	31,022	32,983	35,068
<b>Maharashtra</b>	30,482	31,340	32,221	33,125	34,054	35,006	35,985
<b>D. &amp; N. Haveli</b>	1,569	1,647	1,729	1,815	1,906	2,001	2,101
<b>Daman &amp; Diu</b>	638	670	704	739	776	815	856
<b>Andhra Pradesh</b>	16,828	17,881	18,998	20,183	21,438	22,771	24,187
<b>Telangana</b>	19,334	20,544	21,827	23,188	24,630	26,160	27,787
<b>Karnataka</b>	17,719	18,375	19,054	19,757	20,484	21,237	22,018
<b>Kerala</b>	7,547	7,888	8,243	8,614	9,001	9,404	9,825
<b>Tamil Nadu</b>	34,374	36,514	38,784	41,192	43,744	46,451	49,326
<b>Puducherry</b>	793	836	881	929	979	1,032	1,088
<b>Bihar</b>	12,371	13,451	14,624	15,898	17,280	18,780	20,410
<b>Jharkhand</b>	3,565	3,690	3,820	3,954	4,093	4,236	4,384
<b>Odisha</b>	8,267	8,653	9,056	9,477	9,916	10,376	10,857
<b>West Bengal</b>	35,604	38,513	41,654	45,045	48,706	52,656	56,926
<b>Sikkim</b>	236	248	260	273	287	301	316
<b>Assam</b>	4,961	5,435	5,954	6,520	7,137	7,812	8,551
<b>Manipur</b>	184	188	193	198	203	208	213
<b>Meghalaya</b>	1,044	1,123	1,208	1,300	1,398	1,503	1,616
<b>Nagaland</b>	209	216	223	230	237	245	253
<b>Tripura</b>	387	398	411	423	436	449	462
<b>Arunachal Pradesh</b>	292	307	322	338	355	373	392
<b>Mizoram</b>	144	149	154	159	164	169	174
<b>Andaman &amp; Nicobar Islands</b>	79	83	87	91	96	101	106
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>366,126</b>	<b>389,512</b>	<b>414,477</b>	<b>441,131</b>	<b>469,590</b>	<b>499,981</b>	<b>532,495</b>



**Table A5.12: CAGR of Forecasted Peak Electricity Demand (SUR Model Optimistic)**

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
<b>Delhi</b>	2.51	2.58	2.54	2.55	2.55
<b>Haryana</b>	7.38	7.61	7.49	7.53	7.51
<b>Himachal Pradesh</b>	4.99	5	4.99	5	5
<b>Jammu &amp; Kashmir</b>	5.13	5.02	5.08	4.83	4.95
<b>Punjab</b>	3.02	3.1	3.06	3.05	3.05
<b>Rajasthan</b>	6.02	6.22	6.12	6.17	6.14
<b>Uttar Pradesh</b>	6.54	6.72	6.63	6.61	6.62
<b>Uttarakhand</b>	7.76	7.75	7.75	7.64	7.7
<b>Chandigarh</b>	5.13	5.27	5.2	5.2	5.2
<b>Goa</b>	4.5	4.65	4.58	4.61	4.59
<b>Gujarat</b>	2.94	3.21	3.07	3.25	3.16
<b>Chhattisgarh</b>	5.51	6.28	5.89	6.43	6.16
<b>Madhya Pradesh</b>	5.39	6.11	5.75	6.23	5.99
<b>Maharashtra</b>	2.48	2.74	2.61	2.77	2.69
<b>D. &amp; N. Haveli</b>	5.04	5.02	5.03	5	5.01
<b>Daman &amp; Diu</b>	5.08	5.07	5.08	5.01	5.04
<b>Andhra Pradesh</b>	5.65	6.14	5.89	6.18	6.04
<b>Telangana</b>	5.65	6.14	5.89	6.18	6.04
<b>Karnataka</b>	3.23	3.59	3.41	3.64	3.52
<b>Kerala</b>	4.26	4.51	4.39	4.48	4.43
<b>Tamil Nadu</b>	5.53	6.06	5.79	6.13	5.96
<b>Puducherry</b>	4.29	5.13	4.71	5.27	4.99
<b>Bihar</b>	8.54	8.81	8.67	8.73	8.7
<b>Jharkhand</b>	3.44	3.55	3.5	3.52	3.51
<b>Odisha</b>	4.56	4.72	4.64	4.66	4.65
<b>West Bengal</b>	8.04	8.29	8.16	8.17	8.16
<b>Sikkim</b>	5.02	5	5.01	5	5
<b>Assam</b>	8.48	9.26	8.87	9.26	9.06
<b>Manipur</b>	2.13	2.29	2.21	2.4	2.31
<b>Meghalaya</b>	5.84	7.05	6.44	7.32	6.88
<b>Nagaland</b>	3.22	3.22	3.22	3.24	3.23
<b>Tripura</b>	2.78	2.98	2.88	2.99	2.94
<b>Arunachal Pradesh</b>	5.01	4.89	4.95	5.03	4.99
<b>Mizoram</b>	3.26	3.29	3.28	3.2	3.24
<b>Andaman &amp; Nicobar Islands</b>	4.56	5.39	4.97	5.01	4.99
<b>Lakshadweep</b>	0	0	0	0	0
<b>All-India</b>	5.57	6.1	5.84	6.35	6.09



**Table A5.13: Forecasted Peak Electricity Demand (SUR Model Pessimistic) in MW**

State	2017	2018	2019	2020	2021	2022	2023
<b>Delhi</b>	5,622	5,745	5,869	5,995	6,125	6,257	6,391
<b>Haryana</b>	9,578	10,191	10,835	11,519	12,245	13,016	13,836
<b>Himachal Pradesh</b>	1,586	1,665	1,748	1,835	1,927	2,023	2,124
<b>Jammu &amp; Kashmir</b>	2,840	2,958	3,076	3,196	3,319	3,444	3,571
<b>Punjab</b>	11,178	11,458	11,739	12,025	12,318	12,616	12,920
<b>Rajasthan</b>	11,791	12,402	13,036	13,702	14,402	15,138	15,911
<b>Uttar Pradesh</b>	16,623	17,525	18,455	19,430	20,452	21,524	22,648
<b>Uttarakhand</b>	2,295	2,456	2,626	2,806	2,996	3,198	3,413
<b>Chandigarh</b>	348	363	378	394	410	427	444
<b>Goa</b>	560	582	604	626	650	674	700
<b>Gujarat</b>	14,549	14,909	15,272	15,643	16,022	16,448	16,885
<b>Chhattisgarh</b>	4,200	4,385	4,574	4,771	4,976	5,223	5,482
<b>Madhya Pradesh</b>	10,956	11,428	11,911	12,414	12,938	13,561	14,214
<b>Maharashtra</b>	21,170	21,600	22,031	22,471	22,919	23,422	23,936
<b>D. &amp; N. Haveli</b>	790	830	872	916	962	1,010	1,061
<b>Daman &amp; Diu</b>	320	336	353	371	390	410	431
<b>Andhra Pradesh</b>	7,489	7,837	8,196	8,571	8,963	9,404	9,864
<b>Telangana</b>	8,604	9,004	9,417	9,848	10,298	10,803	11,333
<b>Karnataka</b>	11,016	11,302	11,589	11,884	12,185	12,529	12,882
<b>Kerala</b>	4,125	4,269	4,415	4,566	4,722	4,888	5,060
<b>Tamil Nadu</b>	15,487	16,199	16,931	17,696	18,494	19,405	20,359
<b>Puducherry</b>	411	425	438	452	467	485	504
<b>Bihar</b>	3,847	4,131	4,431	4,753	5,099	5,469	5,866
<b>Jharkhand</b>	2,200	2,265	2,330	2,397	2,466	2,537	2,610
<b>Odisha</b>	4,373	4,541	4,712	4,890	5,073	5,264	5,461
<b>West Bengal</b>	11,847	12,639	13,467	14,346	15,281	16,273	17,326
<b>Sikkim</b>	119	125	131	138	145	152	160
<b>Assam</b>	1,508	1,598	1,687	1,778	1,872	1,991	2,115
<b>Manipur</b>	135	137	138	139	141	143	145
<b>Meghalaya</b>	427	445	463	482	501	527	554
<b>Nagaland</b>	134	138	142	145	149	153	157
<b>Tripura</b>	259	265	271	277	284	291	298
<b>Arunachal Pradesh</b>	148	155	163	171	180	189	198
<b>Mizoram</b>	92	95	98	100	103	106	109
<b>Andaman &amp; Nicobar Islands</b>	40	42	44	46	48	50	53
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>163,148</b>	<b>170,644</b>	<b>178,375</b>	<b>186,482</b>	<b>194,984</b>	<b>204,340</b>	<b>214,171</b>



State	2024	2025	2026	2027	2028	2029	2030
<b>Delhi</b>	6,529	6,669	6,812	6,958	7,107	7,258	7,413
<b>Haryana</b>	14,707	15,632	16,615	17,657	18,762	19,935	21,179
<b>Himachal Pradesh</b>	2,230	2,342	2,459	2,582	2,711	2,847	2,989
<b>Jammu &amp; Kashmir</b>	3,699	3,829	3,960	4,094	4,233	4,376	4,523
<b>Punjab</b>	13,230	13,547	13,869	14,197	14,533	14,876	15,226
<b>Rajasthan</b>	16,723	17,577	18,474	19,416	20,404	21,440	22,527
<b>Uttar Pradesh</b>	23,825	25,058	26,349	27,703	29,124	30,614	32,177
<b>Uttarakhand</b>	3,640	3,881	4,136	4,408	4,697	5,005	5,332
<b>Chandigarh</b>	463	482	501	522	543	565	587
<b>Goa</b>	726	753	781	810	841	872	904
<b>Gujarat</b>	17,332	17,790	18,258	18,739	19,231	19,735	20,251
<b>Chhattisgarh</b>	5,754	6,040	6,339	6,653	6,982	7,326	7,687
<b>Madhya Pradesh</b>	14,898	15,615	16,367	17,152	17,974	18,833	19,730
<b>Maharashtra</b>	24,461	24,998	25,546	26,105	26,675	27,257	27,850
<b>D. &amp; N. Haveli</b>	1,114	1,170	1,229	1,290	1,355	1,423	1,494
<b>Daman &amp; Diu</b>	453	476	500	525	551	579	608
<b>Andhra Pradesh</b>	10,347	10,854	11,386	11,942	12,525	13,134	13,773
<b>Telangana</b>	11,887	12,469	13,081	13,720	14,390	15,089	15,823
<b>Karnataka</b>	13,245	13,618	14,002	14,395	14,799	15,212	15,637
<b>Kerala</b>	5,237	5,420	5,609	5,804	6,006	6,214	6,428
<b>Tamil Nadu</b>	21,360	22,409	23,510	24,661	25,867	27,130	28,452
<b>Puducherry</b>	524	544	566	588	611	635	659
<b>Bihar</b>	6,292	6,749	7,238	7,762	8,323	8,924	9,567
<b>Jharkhand</b>	2,685	2,762	2,841	2,923	3,006	3,092	3,180
<b>Odisha</b>	5,666	5,878	6,097	6,325	6,560	6,804	7,056
<b>West Bengal</b>	18,444	19,630	20,889	22,223	23,640	25,143	26,738
<b>Sikkim</b>	168	176	185	194	204	214	225
<b>Assam</b>	2,242	2,372	2,503	2,642	2,787	2,940	3,100
<b>Manipur</b>	147	148	150	151	153	155	156
<b>Meghalaya</b>	583	613	644	677	711	747	785
<b>Nagaland</b>	161	166	170	174	179	184	189
<b>Tripura</b>	305	312	320	328	336	344	352
<b>Arunachal Pradesh</b>	208	218	229	240	252	265	278
<b>Mizoram</b>	112	115	119	122	125	129	132
<b>Andaman &amp; Nicobar Islands</b>	56	59	62	65	68	71	75
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>224,502</b>	<b>235,357</b>	<b>246,764</b>	<b>258,747</b>	<b>271,347</b>	<b>284,589</b>	<b>298,509</b>



State	2031	2032	2033	2034	2035	2036	2037
<b>Delhi</b>	7,571	7,732	7,896	8,063	8,234	8,407	8,584
<b>Haryana</b>	22,498	23,897	25,381	26,953	28,620	30,387	32,263
<b>Himachal Pradesh</b>	3,138	3,295	3,460	3,633	3,815	4,006	4,207
<b>Jammu &amp; Kashmir</b>	4,674	4,830	4,991	5,156	5,326	5,501	5,682
<b>Punjab</b>	15,584	15,949	16,321	16,702	17,090	17,486	17,891
<b>Rajasthan</b>	23,667	24,863	26,116	27,431	28,808	30,253	31,770
<b>Uttar Pradesh</b>	33,815	35,532	37,331	39,217	41,193	43,263	45,437
<b>Uttarakhand</b>	5,680	6,051	6,445	6,864	7,310	7,784	8,289
<b>Chandigarh</b>	611	636	661	687	715	743	772
<b>Goa</b>	938	973	1,009	1,046	1,085	1,124	1,164
<b>Gujarat</b>	20,780	21,349	21,933	22,532	23,146	23,775	24,421
<b>Chhattisgarh</b>	8,064	8,488	8,933	9,400	9,891	10,406	10,948
<b>Madhya Pradesh</b>	20,669	21,715	22,813	23,963	25,168	26,431	27,757
<b>Maharashtra</b>	28,454	29,101	29,761	30,434	31,122	31,823	32,540
<b>D. &amp; N. Haveli</b>	1,569	1,647	1,729	1,815	1,906	2,001	2,101
<b>Daman &amp; Diu</b>	638	670	704	739	776	815	856
<b>Andhra Pradesh</b>	14,441	15,164	15,921	16,716	17,548	18,419	19,333
<b>Telangana</b>	16,590	17,421	18,292	19,205	20,160	21,161	22,212
<b>Karnataka</b>	16,072	16,543	17,026	17,522	18,031	18,554	19,092
<b>Kerala</b>	6,650	6,882	7,123	7,371	7,627	7,891	8,164
<b>Tamil Nadu</b>	29,835	31,349	32,936	34,600	36,345	38,175	40,097
<b>Puducherry</b>	685	714	744	776	808	842	877
<b>Bihar</b>	10,255	10,991	11,778	12,621	13,522	14,485	15,517
<b>Jharkhand</b>	3,271	3,363	3,459	3,557	3,657	3,760	3,866
<b>Odisha</b>	7,316	7,586	7,865	8,154	8,453	8,762	9,082
<b>West Bengal</b>	28,430	30,225	32,128	34,147	36,286	38,554	40,964
<b>Sikkim</b>	236	248	260	273	287	301	316
<b>Assam</b>	3,267	3,467	3,677	3,899	4,134	4,381	4,643
<b>Manipur</b>	158	160	162	164	166	168	170
<b>Meghalaya</b>	824	870	919	971	1,025	1,082	1,142
<b>Nagaland</b>	193	198	204	209	214	220	226
<b>Tripura</b>	361	370	379	389	398	408	418
<b>Arunachal Pradesh</b>	292	307	322	338	355	373	392
<b>Mizoram</b>	136	140	143	147	151	155	159
<b>Andaman &amp; Nicobar Islands</b>	79	83	87	91	96	101	106
<b>Lakshadweep</b>	8	8	8	8	8	8	8
<b>All India</b>	<b>313,141</b>	<b>328,904</b>	<b>345,493</b>	<b>362,954</b>	<b>381,332</b>	<b>400,676</b>	<b>421,081</b>

**Table A5.13: CAGR of Forecasted Peak Electricity Demand (SUR Model Pessimistic)**

State/Region	FY 2016-17 to FY 2021-22	FY 2021-22 to FY 2026-27	FY 2016-17 to FY 2026-27	FY 2026-27 to FY 2036-37	FY 2016-17 to FY 2036-37
<b>Delhi</b>	2.16	2.15	2.15	2.12	2.14
<b>Haryana</b>	6.33	6.29	6.31	6.21	6.26
<b>Himachal Pradesh</b>	4.99	5	4.99	5	5
<b>Jammu &amp; Kashmir</b>	3.93	3.52	3.72	3.33	3.53
<b>Punjab</b>	2.45	2.39	2.42	2.34	2.38
<b>Rajasthan</b>	5.12	5.1	5.11	5.05	5.08
<b>Uttar Pradesh</b>	5.3	5.18	5.24	5.07	5.16
<b>Uttarakhand</b>	6.86	6.63	6.74	6.52	6.63
<b>Chandigarh</b>	4.18	4.1	4.14	3.99	4.06
<b>Goa</b>	3.78	3.74	3.76	3.69	3.73
<b>Gujarat</b>	2.48	2.64	2.56	2.68	2.62
<b>Chhattisgarh</b>	4.46	4.96	4.71	5.11	4.91
<b>Madhya Pradesh</b>	4.36	4.81	4.58	4.93	4.76
<b>Maharashtra</b>	2.04	2.19	2.12	2.23	2.17
<b>D. &amp; N. Haveli</b>	5.04	5.02	5.03	5	5.01
<b>Daman &amp; Diu</b>	5.08	5.07	5.08	5.01	5.04
<b>Andhra Pradesh</b>	4.66	4.89	4.78	4.94	4.86
<b>Telangana</b>	4.66	4.9	4.78	4.94	4.86
<b>Karnataka</b>	2.61	2.82	2.71	2.86	2.79
<b>Kerala</b>	3.45	3.49	3.47	3.47	3.47
<b>Tamil Nadu</b>	4.61	4.91	4.76	4.98	4.87
<b>Puducherry</b>	3.37	3.93	3.65	4.08	3.86
<b>Bihar</b>	7.29	7.25	7.27	7.17	7.22
<b>Jharkhand</b>	2.89	2.87	2.88	2.84	2.86
<b>Odisha</b>	3.78	3.74	3.76	3.68	3.72
<b>West Bengal</b>	6.55	6.43	6.49	6.31	6.4
<b>Sikkim</b>	5.02	5	5.01	5	5
<b>Assam</b>	5.71	5.82	5.77	5.8	5.78
<b>Manipur</b>	1.16	1.09	1.13	1.19	1.16
<b>Meghalaya</b>	4.3	5.14	4.72	5.37	5.04
<b>Nagaland</b>	2.69	2.61	2.65	2.65	2.65
<b>Tripura</b>	2.36	2.42	2.39	2.45	2.42
<b>Arunachal Pradesh</b>	5.01	4.89	4.95	5.03	4.99
<b>Mizoram</b>	2.87	2.85	2.86	2.68	2.77
<b>Andaman &amp; Nicobar Islands</b>	4.56	5.39	4.97	5.01	4.99
<b>Lakshadweep</b>	0	0	0	0	0
<b>All-India</b>	4.61	4.83	4.72	4.99	4.86



