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Regulatory Framework for Long-Term Demand Forecasting and Power Procurement Planning

Anoop Singh, Manvendra Pratap, Abhishek Das, Piyush A. Sharma, Kamal K. Gupta

2019

Centre for Energy Regulation
Department of Industrial and Management Engineering
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CENTRAL ELECTRICITY REGULATORY COMMISSION

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CERC

P. K. Pujari
Chairperson

9th January, 2019

Foreword

Regulation in the Indian power sector has evolved significantly since promulgation of the Electricity Act, 2003. As regulation of any infrastructure sector needs the support of credible and independent research that facilitates harnessing the expertise across various verticals, it is laudable if top academic institutions pitch in with their academic and research capabilities for the larger benefit of the infrastructure sector.

In this context, the Centre for Energy Regulation (CER), IIT Kanpur is a novel initiative, which can foster research in the area of regulatory and policy framework in the power sector, while engaging with stakeholders of the sector.

One of the critical challenges facing the distribution and retail supply utilities is to accurately forecast the shape of the load curve, so as to enable them to plan for optimal power procurement for the identified horizon.

I am pleased to note that CER is publishing this monograph on "Regulatory Framework for Long-term Demand Forecasting and Power Procurement Planning", which will provide valuable insights for strengthening the regulatory framework for long-term demand forecasting and power procurement planning. I am sure this will serve as a useful handbook for the State Electricity Regulators for framing relevant regulations for optimizing power procurement cost in the respective states, thus benefitting the final consumers.

I congratulate the authors of this monograph, the participants of the regulatory research camp, and the entire team of CER, IIT Kanpur for this effort. I look forward to seeing many such publications from CER.

(P.K. Pujari)

तीसरी मंजिल, चन्द्रलोक बिल्डिंग, 36, जनपथ, नई दिल्ली-110 001
3rd Floor, Chanderlok Building, 36, Janpath, New Delhi-110 001
Phone : 91-11-2375 3911, Fax : 91-11-2375 3923 E-mail : chairman@cercind.gov.in

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Authors

CER's First Regulatory Research Camp (RRC)

Participants

Mr. Anil Panda
Joint Director (Tariff & Engineering)
Orissa Electricity Regulatory Commission

Mr. Kanti J. Bhuva
Deputy Director (Technical)
Gujarat Electricity Regulatory Commission

Mr. M. S. Vidyasagar
Deputy Director (Planning & Power Procurement)
Andhra Pradesh Electricity Regulatory Commission

Mr. Himanshu Chawla
Deputy Director (Tariff & Engineering)
Delhi Electricity Regulatory Commission

Mr. Rajeev Keskar
Chief General Manager
Madhya Pradesh Power Management Company Limited

Mr. Vivek Dikshit
Superintending Engineer
Uttar Pradesh State Load Despatch Centre

Mr. Sukhjot Singh Sidhu
Additional Superintending Engineer
Punjab State Power Corporation Limited

Mr. Kamal Kumar Gupta
Project Engineer
Indian Institute of Technology Kanpur

RRC Coordinator

Dr. Anoop Singh
Coordinator, Centre for Energy Regulation
Associate Professor
Department of Industrial and Management Engineering
Indian Institute of Technology Kanpur

Table of Contents

Foreword	**iii**
Acknowledgement	**v**
CER's First Regulatory Research Camp (RRC)	**vi**
List of Abbreviations	**5**
Units and Conversion Factors	**8**
Executive Summary	**9**
1. Introduction	**11**
1.1 Historical Power Supply Position in India	13
1.2 Importance of Long-term Demand Forecasting	15
1.3 Importance of Power Procurement Planning	15
2. Regulatory Framework for Long-term Demand Forecasting and Power Procurement Planning	**17**
2.1 International Experience in Long-term Demand Forecasting and Power Procurement Planning Responsibility	17
2.1.1 Australia	18
2.1.2 Japan	20
2.1.3 Thailand	20
2.1.4 Singapore	21
2.1.5 CEER member states, Europe	22
2.1.6 California, United States	22
2.1.7 West Virginia, United States	22
2.2 Existing Legislative and Policy Provisions in India	25
2.2.1 Electricity Act, 2003	25
2.2.2 National Electricity Policy, 2005	25
2.2.3 Tariff Policy, 2006	25
2.2.4 Tariff Policy, 2016	25
3. Long-term Electricity Demand Forecast by CEA	**27**
3.1 Demand Forecasting Methodology used by CEA	27
3.2 Annual Peak Demand and Energy Requirement Projections as per 18th and 19th EPS of India	27

4. Long-term Demand Forecasting and Power Procurement Planning – Existing Practices across States **31**
4.1 Andhra Pradesh 31
4.2 Assam 33
4.3 Madhya Pradesh 34
4.4 Maharashtra 36
4.5 Delhi 38
4.6 Gujarat 39
4.7 Odisha 41
4.8 Punjab 43
4.9 Uttar Pradesh 44

5. Model Long-term Load Forecast and Power Procurement Planning Regulation – Key Ingredients 49
5.1 Recommendations on Regulatory Framework for Long-Term Demand Forecasting 52
5.2 Recommendations on Regulatory Framework for Power Procurement Planning 55

6. Conclusion **57**

7. References **59**

List of Figures

Figure 1: Share of power purchase expense in total ARR, and average cost of power procurement 12

Figure 2: All India historical power supply position, energy-wise 14

Figure 3: All India historical power supply position, peak-demand-wise 14

Figure 4: General workflow of Maximum Demand analysis for NEFR 19

Figure 5: Historical projections of annual peak electricity demand (all India) 28

Figure 6: Historical projection of annual electrical energy requirement (all India) 29

Figure 7: Actual electrical energy requirement vs. projections for Andhra Pradesh 32

Figure 8: Actual peak demand vs. projections for Andhra Pradesh 33

Figure 9: Actual electrical energy requirement vs. projections for Assam 34

Figure 10: Actual peak demand vs. projections for Assam 34

Figure 11: Actual electrical energy requirement vs. projections for Madhya Pradesh 35

Figure 12: Actual peak demand vs. projections for Madhya Pradesh 36

Figure 13: Actual electrical energy requirement vs. projections for Maharashtra 37

Figure 14: Actual peak demand vs. projections for Maharashtra 37

Figure 15: Actual electrical energy requirement vs. projections for NCT Delhi 38

Figure 16: Actual peak demand vs. projections in for NCT Delhi 39

Figure 17: Actual electrical energy requirement vs. projections for Gujarat 40

Figure 18: Actual peak demand vs. projections for Gujarat 40

Figure 19: Actual electrical energy requirement vs. projections for Odisha 42

Figure 20: Actual peak demand vs. projections for Odisha 42

Figure 21: Actual electrical energy requirement vs. projections for Punjab 43

Figure 22: Actual peak demand vs. projections for Punjab 43

Figure 23: Actual electrical energy requirement vs. projections for Uttar Pradesh 45

Figure 24: Actual peak demand vs. projections for Uttar Pradesh 45

Figure 25: Approach for formulating UPPCL's power procurement strategy 46

Figure 26: Realistic Growth – Policy Target (with short-term power procurement) 47

Figure 27: Realistic Growth – Policy Target (without short-term power procurement) 47

List of Tables

Table 1: International regulations on long-term demand forecasting and power procurement planning 24

Table 2: Comparison of electricity demand projections in 18th and 19th eps reports 28

Table 3: Comparison of electrical energy consumption projections in 18th and 19th eps reports 29

Table 4: Prevailing practices of long-term demand forecasting in the select Indian states 50

Table 5: Prevailing practices of power procurement planning in the select Indian states 52

List of Abbreviations

AEMC	:	Australian Energy Market Commission
AEMO	:	Australian Energy Market Operator
AER	:	Australian Energy Regulator
AERC	:	Assam Electricity Regulatory Commission
ANZSIC	:	Australian and New Zealand Standard Industrial Classification
AP	:	Andhra Pradesh
APERC	:	Andhra Pradesh Electricity Regulatory Commission
APPC	:	Average Power Purchase Cost
APTRANSCO	:	Transmission Corporation of Andhra Pradesh Limited
ARR	:	Aggregate Revenue Requirement
BJY	:	Biju Gram Jyoti Yojana
CAG	:	Comptroller and Auditor General
CAGR	:	Compounded Average Growth Rate
CEA	:	Central Electricity Authority
CEER	:	Council of European Energy Regulators
CER	:	Centre for Energy Regulation
CERC	:	Central Electricity Regulatory Commission
CGS	:	Central Generating Station
CoD	:	Commercial Operation Date
CoS	:	Cost of Service
CVC	:	Central Vigilance Commission
DERC	:	Delhi Electricity Regulatory Commission
DF	:	Diversity Factor
DFID	:	Department for International Development
DG	:	Diesel Generator
DISCOMs	:	Distribution Licensees
DNSPs	:	Distribution Network Service Providers
DSM	:	Demand Side Management
EGAT	:	Electricity Generating Authority of Thailand
EMA	:	Electricity Market Authority
EMS	:	Energy Management System
ENTSO-E	:	European Network of Transmission System Operators for Electricity
EPS	:	Electric Power Survey
EPSC	:	Electric Power Survey Committee
ERC	:	Energy Regulatory Commission

ESOO	:	Electricity Statement of Opportunities
EV	:	Electric Vehicle
FY	:	Fiscal Year
GDP	:	Gross Domestic Product
GERC	:	Gujarat Electricity Regulatory Commission
GoI	:	Government of India
GRIDCO	:	Grid Corporation of Odisha Limited
HoldCo	:	Holding Company
HPERC	:	Himachal Pradesh Electricity Regulatory Commission
HPSEB	:	Himachal Pradesh State Electricity Board
IEPR	:	Integrated Energy Policy Report
IRP	:	Integrated Resource Planning
IRPs	:	Integrated Resource Plans
JERC	:	Joint Electricity Regulatory Commission
JSERC	:	Jharkhand State Electricity Regulatory Commission
LBNL	:	Lawrence Berkeley National Laboratory
LF	:	Load Factor
LGBR	:	Load Generation Balance Report
LSE	:	Load Serving Entities
MEA	:	Metropolitan Electricity Authority
MERC	:	Maharashtra Electricity Regulatory Commission
METI	:	Ministry of Economy, Trade and Industry
MMA	:	McLennan Magasanik Associates
MOD	:	Merit Order Despatch
MoP	:	Ministry of Power
MoSPI	:	Ministry of Statistics and Programme Implementation
MoU	:	Memorandum of Understanding
MPERC	:	Madhya Pradesh Electricity Regulatory Commission
MU	:	Million Units
MW	:	megawatt
MYT	:	Multi-Year Tariff
NCT	:	National Capital Territory
NEFR	:	National Electricity Forecasting Report
NEM	:	National Electricity Market
NEP	:	National Electricity Policy
NEPC	:	National Energy Policy Council
NER	:	National Electricity Rules

NTEN	:	Northern Territory Electricity Network
NTNDP	:	National Transmission Network Development Plan
NTP	:	National Transmission Planer
NWIS	:	North West Interconnected System
O&M	:	Operation and Maintenance
OCC	:	Operation and Coordination Committee
OE	:	Office of Electricity
OERC	:	Orissa Electricity Regulatory Commission
OGC	:	Odisha Grid Code
PDP	:	Power Development Plan
PEA	:	Provincial Electricity Authority
PLF	:	Plant Load Factor
PoE	:	Probability of Exceedance
PPA	:	Power Purchase Agreement
PSERC	:	Punjab State Electricity Regulatory Commission
RES	:	Renewable Energy Sources
RGGVY	:	Rajiv Gandhi Grameen Vidyutikaran Yojana
RPO	:	Renewable Purchase Obligation
RRC	:	Regulatory Research Camp
RTC	:	Round the Clock
SEB	:	State Electricity Board
SEMO	:	Singapore Electricity Market Outlook
SEP	:	State Electricity Plan
SERC	:	State Electricity Regulatory Commission
SLDC	:	State Load Despatch Centre
SoP	:	Standards of Performance
STPP	:	Short-term Power Procurement
STU	:	State Transmission Utility
SWIS	:	South West Interconnected System
T&D	:	Transmission and Distribution
TNSP	:	Transmission Network Service Provider
TP	:	Tariff Policy
TS	:	State of Telangana
UPERC	:	Uttar Pradesh Electricity Regulatory Commission
UPPCL	:	Uttar Pradesh Power Corporation Limited
UT	:	Union Territory

Units and Conversion Factors

billion (Bn)	=	10^9
crore (cr)	=	10^7
million (M)	=	10^6
lakh	=	10^5
kilo (k)	=	10^3

Electrical Load or Demand

1 kilowatt (kW)	=	10^3 W
1 megawatt (MW)	=	10^6 W
1 gigawatt (GW)	=	10^9 W
1 terawatt (TW)	=	10^{12} W

Electrical Energy

1 million unit (MU)	=	10^6 kWh or 10^3 MWh or 1 GWh
1 billion unit (BU)	=	10^3 MUs or 10^6 MWh or 10^3 GWh

Executive Summary

Electricity supply chain is a capital intense activity requiring a long gestation period for setting up generation, transmission and distribution assets. A robust and stable regulatory and policy framework provides adequate incentive for investment in such capacities. Further, availability of adequate generation and transmission capacities in future needs to be ensured for reliable operation of the power system. A reliable electricity demand projection can not only help the distribution utilities to plan power procurement in advance, but also assist in creation of transmission infrastructure to ensure reliable electricity supply to consumers. Cost of power procurement is the most important element of the Aggregate Revenue Requirement (ARR) of distribution utilities and accounts for about three-fourth of the final consumer tariff. Power procurement plans and contracts typically have a long-term horizon and, therefore, need to be worked out well in advance, based on a reliable and dependable forecast.

A national-level exercise for long-term electricity demand estimation is carried out by Central Electricity Authority (CEA), which projects state-wise long-term peak demand for electricity. The Electric Power Survey (EPS), published every five years by CEA, projects electricity demand using partial end use method, which is now supplemented with econometric estimates. Our analysis reveals that there is a deviation of up to 25 percent between the electricity demand projections in the EPS Reports and the actual demand of electricity. This mismatch can be attributed to quality of data as well as methodological shortcomings. Application of a standardised approach across states which vary in terms of economic development, consumption profile, agroclimatic conditions, etc. may also explain the range of deviations in demand projections across states.

At the state level, the respective distribution (DISCOMs) and transmission licensees (TRANSCOs) also undertake such an exercise. The objectives, forecast horizon and methodology adopted for such forecasts vary widely. The objectives of some forecasts include transmission capacity planning, power procurement planning and/or regulatory compliance for tariff filings. While licensees in a few states revise their estimates annually, others undertake this activity every five years or more. CEA's projections are adopted for transmission as well as generation planning in some states. A holistic sectoral approach combining long-term electricity demand forecast with power procurement would not only help utilities economise their overall cost of power procurement but also alleviate supply risks, especially with the growing share of renewable energy sources.

We analysed historical demand projections and relevant regulations of selected states – Andhra Pradesh, Assam, Delhi, Gujarat, Madhya Pradesh, Maharashtra, Odisha, Punjab and Uttar Pradesh. Whereas some of the State Electricity Regulatory Commissions (SERCs) have issued specific regulations for demand forecasting and power procurement planning, others have covered only short-term aspects through tariff regulations. The prevailing regulatory framework of the sector across many states does not address the matter of long-term demand forecasting and power procurement planning in an integrated manner. Based on our analysis of different states and some international practices, we identified key aspects that should be considered in formulation of regulations for long-term demand forecasting and power procurement planning. SERCs can consider these key aspects, with appropriate modifications if necessary, while framing model regulations for long-term demand forecasting and power procurement planning.

1. Introduction

Access to affordable and reliable electricity is one of the primary indicators of economic growth and human development. Power has a major role to play in the sustenance and growth of primary (agriculture, mining, etc.), secondary (manufacturing, construction, textile, metallurgy, etc.) as well as tertiary (railways, IT, healthcare, hospitality, etc.) sectors of the economy. In order to fuel the rapid growth of a developing economy like India, electricity sector experiences the challenge to grow at the same pace as the other sectors. This, coupled with the need for reliable and affordable electricity supply to consumers, requires coordinated efforts by generation, transmission, and distribution and retail supply segments of the electricity value chain.

Capital intensive decisions in the power sector have a direct impact on the welfare of the society, and also have long-term implications for the sector. In a restructured power sector, an independent regulator needs to play an important role to see that system adequacy is ensured to meet the projected demand of electricity. That being said, one of the major roles played by a regulator is regulating the price of electricity such that it is affordable to the consumers and, at the same time, viable for the suppliers. To achieve this, due consideration should be given to the availability and cost of procured power.

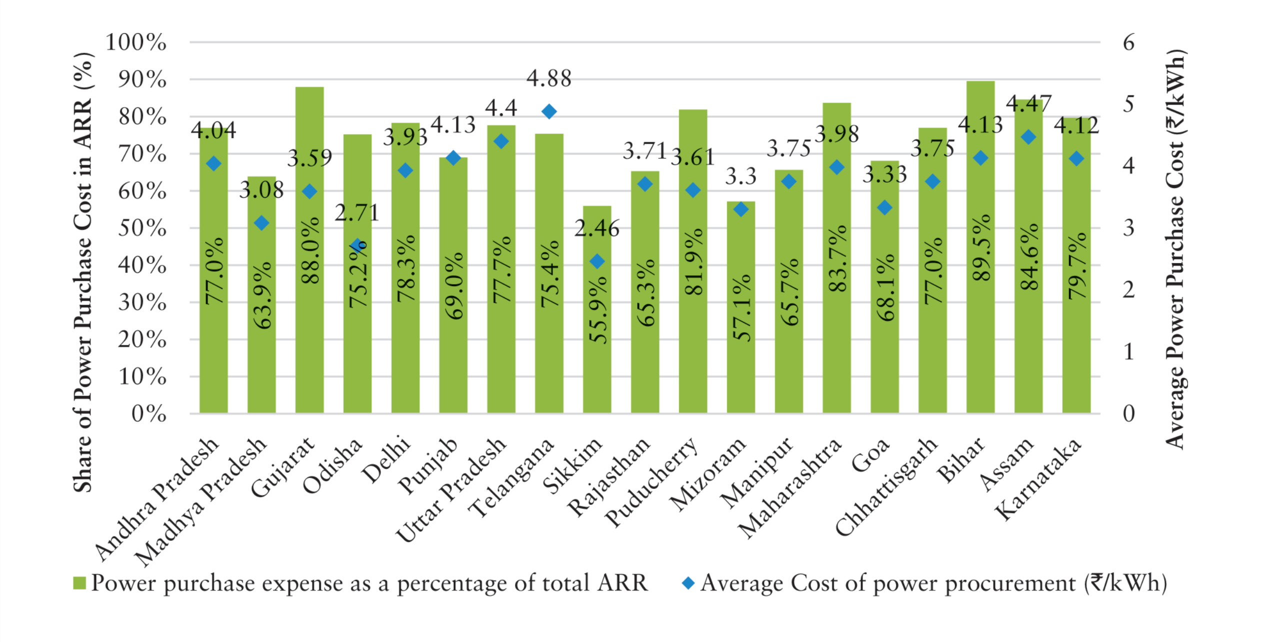

Figure 1: Share of power purchase expense in total ARR, and average cost of power procurement

(Source: Compiled from distribution tariff orders issued by the respective Electricity Regulatory Commissions (ERCs) for 2018-19)

Power procurement accounts for 70-80 percent (*Figure 1*) of the total cost of electricity served to end consumers and is, therefore, the most critical expenditure head in the ARR of a DISCOM.

Evidently, any effort towards reduction of power purchase cost would have a significant impact on retail supply tariff of electricity. The cost of power procurement is highly dependent on the power procurement portfolio, which means that its optimisation would in turn lead to reduction in power purchase cost and, hence, retail tariff.

In order to design an optimal power procurement portfolio, there must be clear visibility of the demand profile for a long-time horizon. In other words, demand forecasting is a key input to power procurement planning. The accuracy of demand forecast determines the optimality of power procurement plans.

Based on the time horizon under consideration, demand forecasting and power procurement planning can be categorised as under:

i. long-term: more than 5 years

ii. medium-term: 1 to 5 years

iii. short-term: less than 1 year

Electric utilities often enter into long-term power purchase agreements to meet the long-term projected demand. Such agreements entail a payment of fixed charges and variable charges. On one hand, overestimation of demand results in undue burden of fixed charges in power procurement cost, ultimately leading to higher consumer tariffs. On the other hand, underestimation of demand leads to power shortages which result in either load shedding or costly power purchase. In the short run, it may also result in system imbalances and penalties thereof.

The following nine states – Andhra Pradesh, Assam, Madhya Pradesh, Maharashtra, Delhi, Gujarat, Odisha, Punjab and Uttar Pradesh – were selected for the study, based on a variety of factors which influence demand pattern and power procurement strategy as listed below:

- **Geography:** It has been ensured that at least one representative state was chosen from every electrical region – Northern, Southern, Eastern, Western and North-Eastern. These states cover a range of agroclimatic regions of the country. For example, Assam belongs to the Eastern Himalayan Region; Andhra Pradesh and Odisha belong to the East coast plains and hill region; Odisha, Maharashtra and Madhya Pradesh belong to the Eastern plateau and hills region; Delhi and Punjab belong to Trans Gangetic plain region; and Uttar Pradesh belongs to the Upper and Middle Gangetic plains region.
- **Power Procurement Portfolio:** The states have been chosen based on variety in their sources of power procurement. For example, State Generating Plants have a higher share in Uttar Pradesh's power procurement portfolio, Andhra Pradesh has a higher share of Renewables and Gujarat has a significant shares of IPPs and Renewables.
- **Consumer Mix:** The states chosen reflect a wide diversity in socio-economic conditions which influence the consumer mix. For instance, Delhi is largely urban, whereas Uttar Pradesh and Punjab have significant share of agricultural consumers. Maharashtra and Gujarat have a large industrial base as well as a conducive environment for open access (OA).
- **DISCOM Ownership:** The states chosen differ in terms of the ownership structure of distribution utilities. Whereas Delhi has three private distribution licensees, Maharashtra and Gujarat have a mix of both private and state-owned utilities, with Maharashtra having the peculiarity of multiple distribution licensees in the same area. Uttar Pradesh, Andhra Pradesh, Punjab and Odisha have state-owned utilities. Punjab has a bundled utility for generation and distribution. Among the states having state-owned distribution utilities, there are wide variations in operational and financial performance.

Analysis of the regulatory documents of these states revealed different practices followed for long-term demand forecasting and power procurement planning and that there is a need for making these practices more coherent to further strengthen the existing regulatory framework.

Section 2 of this monograph provides an overview of the existing regulatory frameworks for long-term demand forecasting and power procurement planning in Australia, Japan, Thailand, Singapore, parts of the United States of America, and CEER member states of Europe, and discusses the provisions in various legal and policy documents of India. Whereas Section 3 analyses the approach and methodology adopted by CEA in making long-term demand forecasts presented in various EPS Reports, Section 4 provides insights on long-term demand forecasting and power procurement planning practices followed in the selected nine states. Based on the above, recommendations on the key aspects to be considered in order to frame an integrated set of regulations on long-term demand forecasting and power procurement planning are provided in Section 5.

1.1 Historical Power Supply Position in India

Availability of power supply in India has improved significantly with a decline in peak shortage and energy shortage from over 12 percent and 7 percent respectively in FY 2001 to 2 percent and below 1 percent respectively in FY 2018 [1]. *Figures 2 and 3* respectively present historical power supply position in terms of energy, and historical trend of electricity in terms of peak demand vs. demand met on an all India basis.

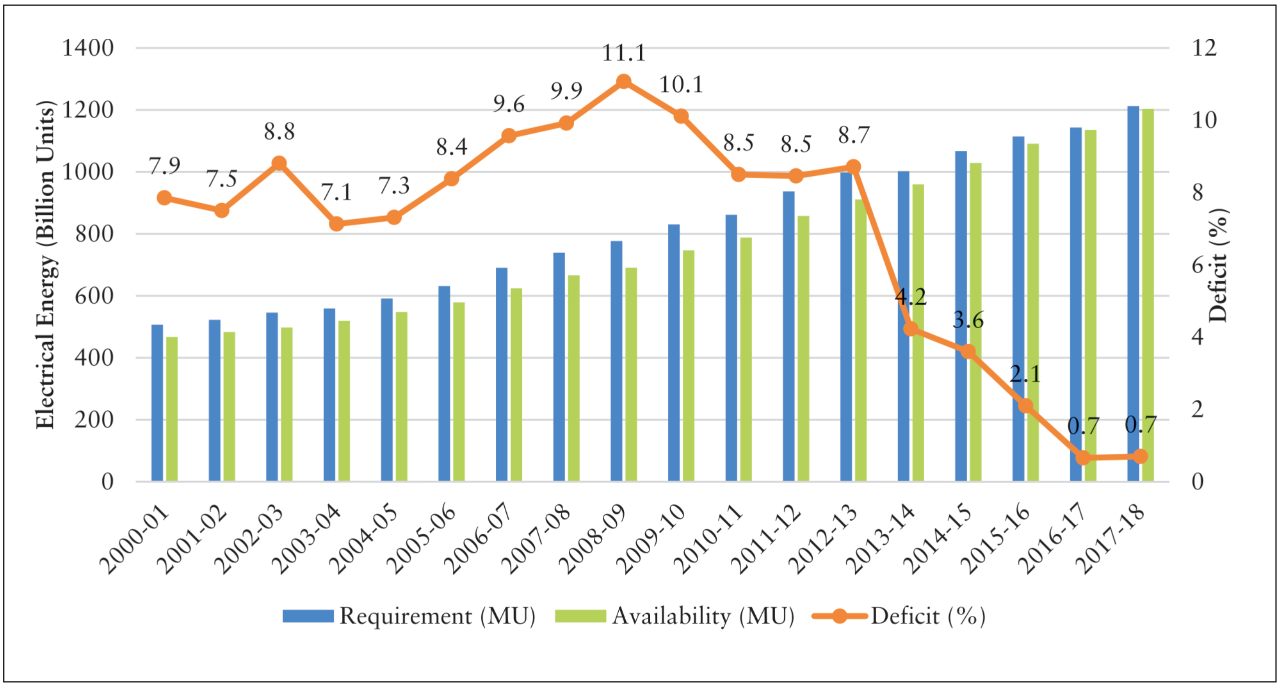

Figure 2: All India historical power supply position, energy-wise

(Source: Growth of Electricity Sector in India from 1947-2017, CEA, 2018 [2]; Load Generation Balance Reports (LGBR), CEA [6-15])

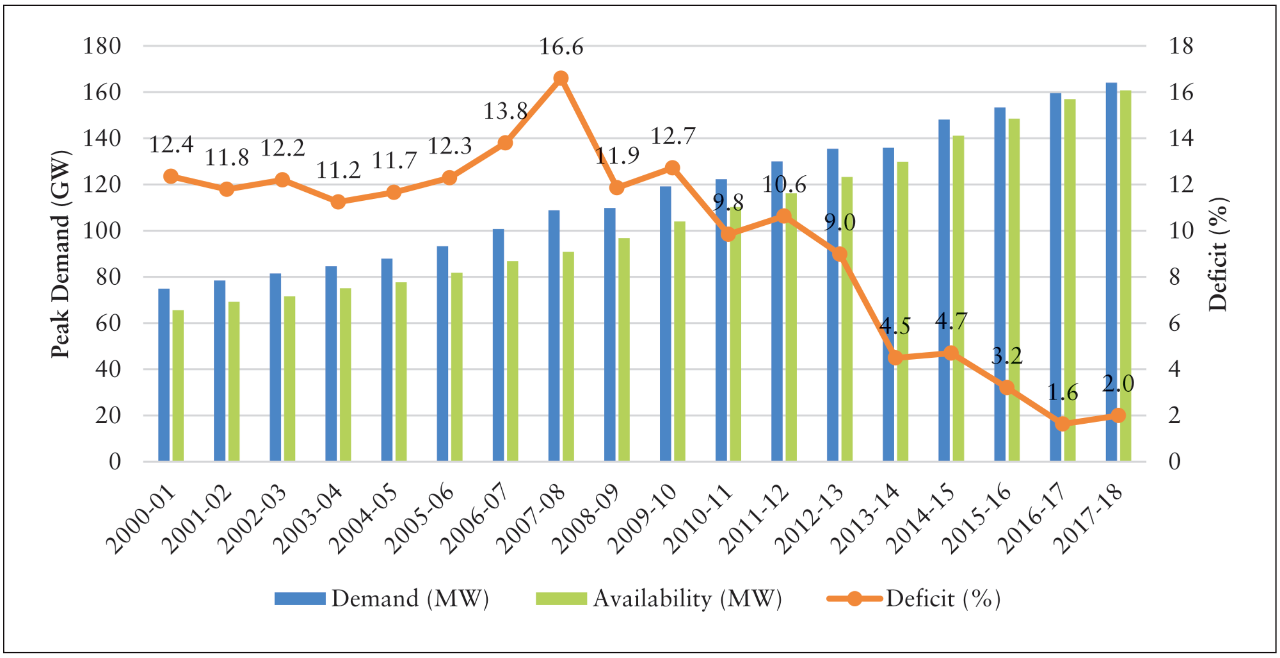

Figure 3: All India historical power supply position, peak-demand-wise

(Source: Growth of Electricity Sector in India from 1947-2017, CEA, 2018 [2]; Load Generation Balance Reports (LGBR), CEA [6-15])

Over the last two decades, India's electrical energy demand has increased over two-fold – from about 500 billion units in FY 2001 to over 1200 billion units in FY 2018. This, in turn, has resulted in a massive increase in the amount of power purchased by DISCOMs to serve their consumers. The total cost of power procurement across the country adds to about ₹5.25 lakh crore (₹5,250 billion). Even a small saving in power procurement cost per unit would translate into a significantly large amount. Hence, it deserves due attention.

1.2 Importance of Long-term Demand Forecasting

As discussed in Section 1.1, forecasting electricity demand is the first step towards ensuring energy availability and optimising expenses. The importance of accuracy in demand forecasting can also be highlighted from the fact that since electricity cannot be stored economically, its supply must match the demand at all times. Furthermore, generation capacity addition and transmission network augmentation depend on demand forecasts by the DISCOMs, which implies that decisions for large investments depend on this activity. Forecasts can never be absolutely accurate, but higher the accuracy, better it is for the energy sector as a whole. Deviation in long-term forecasts, as reflected in short-term variations, can be addressed to some extent by short-term power procurement and ancillary services.

An over-forecast of demand would result in the DISCOM entering into Power Purchase Agreements (PPAs) over and above the required capacity thereby incurring fixed charges for such additional capacity without drawing electricity for the same. This in turn would result in higher consumer tariffs. Since the PPAs are mostly long-term in nature, an over-forecast of demand would imply an inflated retail supply tariff for multiple years. In contrast, an under-forecast would mean unavailability of sufficient power with the DISCOM to meet its obligation of satisfying the end-consumer demand, resulting in frequent load shedding. This might also attract penalties where strict Standards of Performance (SoP) norms are in place. Moreover, consumers who require reliable supply would have to opt for Diesel Generator (DG) sets which are neither economical nor environment-friendly. Inaccurate demand forecast may also cause disproportionate capacity additions resulting in stranded assets, thereby placing the investors' capital at risk. Such situations also lead to inappropriate policy formulations.

The above scenario evidently leads to the conclusion that a robust mechanism must be put in place to ensure proper long-term demand forecasting and power procurement planning for efficient operation of the sector.

1.3 Importance of Power Procurement Planning

Power procurement plans involve commercial decisions by DISCOMs to procure power for meeting long-term demand as per their forecast. Based on demand forecasts, DISCOMs plan for power procurement from available generation sources to satisfy base as well as peak loads. In case of expected shortfall in supply, DISCOMs need to evaluate the alternatives available. Judiciousness of this exercise is very crucial for optimising the overall power procurement cost.

Over-planning for power procurement would result in signing of PPAs in excess of that required. This situation would lead to stranded generation capacity and/or fixed cost payments without drawing power as the power requisitioned by DISCOMs would tend to be less than that agreed for in the PPAs. However, as there is a technical limit to the extent of backing down possible for various generating plants, this would result in the DISCOMs having surplus power. Disposal of this surplus power can only be done at market prices. If the prevailing market rates are lower than Average Power Purchase Cost (APPC) of the licensee during such sale, it might attract objections from various stakeholders and enforcement bodies like Comptroller and Auditor General (CAG) or Central Vigilance Commission

(CVC). Alternatively, this may need complete backing down of power plant(s) which cannot be operated at technical minimum, or lead to a compromise of Merit Order Despatch (MOD) due to technical minimum constraints.

Under-planning, on the other hand, would result in dissatisfied consumers who might ultimately opt out of supply from the DISCOM and end up either setting up captive generating plants of their own or going for open access. This would result in revenue losses to the DISCOM. As a matter of fact, fearing this situation, existing DISCOMs refrain from granting open access to the consumers seeking it. Besides, the applicable SoP may also lead to imposition of penalties thereof.

It is the need of the hour for DISCOMs to be innovative in designing power procurement contracts to cope with future challenges [16]. High aggregate technical and commercial (AT&C) losses, feeble financial health, mandate to provide electricity access to all households in their area of supply and Renewable Purchase Obligation (RPO) compliance pose newer challenges for the existing typical distribution business model. Migration of large consumers to open access and captive routes due to increasing average cost of supply is resulting in a significant loss in cross subsidising the revenue of DISCOMs. Open access transactions are mostly short-term, which makes power procurement planning more challenging. This emerging scenario leads to uncertain future electricity demand which has serious implications on the future planning for power purchase by DISCOMs. So, to meet the future challenges of emerging scenarios, DISCOMs need to be more accurate in forecasting demand and innovative in designing power procurement contracts. Owing to changing load curves because of migration of large consumers and increasing penetration of renewable energy into the grid, both demand and supply are becoming increasingly variable in nature. Therefore, DISCOMs need to structure flexible and innovative power procurement contracts to meet the variations in demand and formulate a mix of power procurement strategies to minimise the overall cost of power procurement.

Furthermore, effective power procurement plan would ensure an optimum mix of long-term and short-term sources which would mitigate the risks associated with short-term power markets. The importance of power purchase planning increases further with growing integration of Renewable Energy Sources (RES) with the grid. RES are dependent on the bounty of nature and are hence inherently variable and uncertain. Power procurement needs to account for the proposed RES roll-out and impact of disruptive technologies like storage, Electric Vehicles (EVs), etc., hence highlighting the importance of this exercise.

Exhibit 1

The Electricity Markets and Policy Group at Energy Analysis and Environmental Impacts Division, Lawrence Berkeley National Laboratory (LBNL) analysed the relationship between planning and actual procurement of 12 load serving entities in the Western United States of America from 2003 to 2014, based on data available from their Integrated Resource Plans (IRPs), public/private databases and regulatory documents [17]. They found that aggregate procurement quantum remained more or less the same as planned for the same time duration, but the procurement mix was significantly different from that planned, with reasons very specific to each utility concerned. It happened because uncertainties associated with both controllable and uncontrollable parameters could not be addressed during the planning stage. Owing to signing of additional PPAs, compliance with new efficiency improvement and renewable portfolio standard targets, capacity augmentation, availability of more economic alternatives, delay in commissioning of projects, etc., the utilities had to amend their original resource plans several times to adapt themselves to the relevant financial, regulatory and technical changes from time to time.

2. Regulatory Framework for Long-term Demand Forecasting and Power Procurement Planning

The main objective of this monograph is to help evolve a regulatory framework for long-term demand forecasting and power procurement planning, while highlighting the need for the same. A regulatory framework covers various outputs including the following:

- Responsibility
- Methodological approach
- Frequency
- Scope
- Monitoring framework
- Compliance monitoring

At this stage, we do not discuss various methodological approaches for long-term demand forecasting and power procurement planning which would entail a detailed discussion separately in future.

2.1 International Experience in Long-term Demand Forecasting and Power Procurement Planning Responsibility

The time span of long-term power procurement plans and demand forecasts, the responsible entity/entities and the role of regulators in such regard inter alia vary across nations as summarised in *Table 1*. The following subsections discuss some of such variations in brief, with reference to a few regulatory regimes.

2.1.1 Australia

The Australian electricity industry comprises two major electricity markets – National Electricity Market (NEM) and South West Interconnected System (SWIS). Other smaller networks include North West Interconnected System (NWIS) and Northern Territory Electricity Network (NTEN). Each of the above networks is operated and maintained as per its regulatory framework. NEM is governed by Australian National Electricity Rules (NER) [18] established by Australian Energy Market Commission (AEMC), a statutory body [19] responsible for market development, rule-making, policy advisory and other such functions. The rules are enforced by Australian Energy Regulator (AER), an independent statutory body responsible for economic regulation of energy markets in Australia. Australian Energy Market Operator (AEMO) is responsible for system and market operations in NEM. AEMO is also entrusted with the task of publishing regional price and load and generation forecasts over different time intervals for various purposes like ensuring secure market operation, ancillary service requirement, spot market operation, loss factor determination, adequacy assessment, etc.

Chapter 3 of NER specifies that maximum level of transparency should be maintained in the market by providing accurate, reliable and timely forecast information to the market participants. Registered participants have to comply with the obligation to provide information as specified in the methodology developed and published by AEMO in such regard. It also lists provisions for short-term load forecasting. Clause 3.13.3(q) specifies that AEMO needs to prepare and publish a *Statement of Opportunities under Transmission Annual Planning Reports* by 31st August of each year, containing projections of aggregate demand and energy requirements for each region.

Chapter 5 of NER specifies principles and processes governing network connection, access, planning and expansion besides the obligations of registered participants, customers, Network Service Providers (NSPs), etc. Section 5.11 binds all participants to provide the required forecast information (as specified in Schedule 5.7) to the concerned NSP(s). Such information is to be utilised for network planning purposes. The transmission and distribution NSPs are required to publish an annual planning Report each year, detailing the forecasts (different growth scenarios), methodology used, input sources, and all assumptions applied in such regard. Section 5.20.1 requires AEMO to publish the proposed inputs (including demand forecasts) to be used for National Transmission Network Development Plan (NTNDP) and invite stakeholders' comments before publishing the NTNDP each year while maintaining a NTNDP database. The NTNDP serves as an efficient development plan for the national transmission grid over a time span of at least 20 years.

Consequently, following the above provisions of NER, AEMO prepares and publishes the NEM Electricity Statement of Opportunities (ESOO), National Electricity Forecasting Reports (NEFR), Independent Planning Reviews, Energy Adequacy Assessment Projection (EAAP) Reports, Power System Frequency Risk Review Reports, etc. *Figure 4* shows the sequence of activities for maximum demand analysis for NEFR.

As per Schedule 5.7, Distribution Network Service Providers (DNSPs) need to make a *Distribution Annual Planning Report* and provide load forecast for the next 10 years at the transmission-distribution connection points. As per Schedule 5.12.2(a), Transmission Network Service Providers (TNSP) need to publish a *Transmission Annual Planning Report* by 30th June every year, setting out the load forecasts submitted by the DNSP.

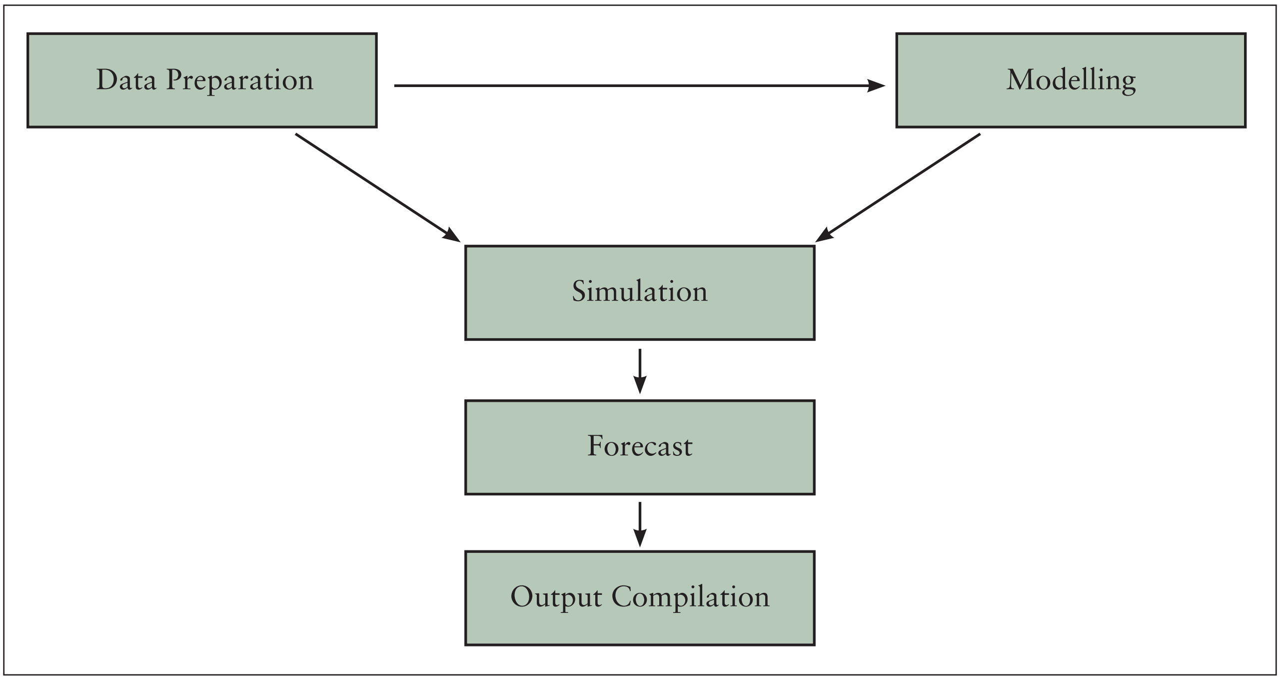

Figure 4: General workflow of Maximum Demand analysis for NEFR

Consequently, following the above provisions of NER, AEMO prepares and publishes annually the NEM *Electricity Statement of Opportunities (ESOO)* for the Eastern and the Southern states and *Wholesale Electricity Market Electricity Statement of Opportunities (WEM ESOO)* for SWIS in Western Australia, hence providing forecasts and analysis of peak demand and energy use for the next 10 years.

The forecast models primarily comprise three main components – energy sales, sent out energy and peak demand.

Energy sales (defined as despatched energy less transmission and distribution line losses) is forecasted using an econometric model that links sales by industry to economic growth by industry, electricity prices and weather conditions. Sales by tariff class are first linked with the appropriate Australian and New Zealand Standard Industrial Classification (ANZSIC) code to develop sales by industry. Residential electricity sales are forecasted based on average sales per connection point and are driven by real income growth, weather and real electricity prices.

Peak demand is computed as the sum of temperature insensitive load, temperature sensitive load and block loads, less embedded generation. Temperature insensitive load includes the proportion of residential and commercial consumption that is not dependent on temperature (electricity use for office buildings, industrial use, cooking, lighting, entertainment equipment and standby use). Temperature sensitive load comprises space heating and cooling, which is highly dependent on climatic and atmospheric temperature. Block loads comprise the largest customers in South West Integrated System (SWIS). Eq. 1 represents the computational components for peak demand.

Peak Demand = Temperature insensitive loads + Temperature sensitive loads + Block loads – Embedded generation (Eq. 1)

External expert agencies are engaged in the preparation of as many as 12 different forecasts of economic activity, electricity consumption (despatched energy and energy sales) and peak demand. Three different cases (low, expected and high) refer to the three economic activity scenarios that feed into the energy and demand forecasts. The probability of exceedance (PoE: 90 percent, 50 percent and

10 percent) relates to weather scenarios. For example, the 10 percent PoE is a forecast that is expected to be exceeded once in every ten years as a result of extreme weather events. The forecast methodology relies on historical demand data at the SWIS level. As IMO does not receive regional consumption or peak demand data, no transmission constraints are specifically considered when preparing these forecasts.

2.1.2 Japan

The energy industry in Japan, which covers electric power, gas and other energy resources, is regulated by Ministry of Economy, Trade and Industry (METI) and other agencies/sub-agencies. METI is the licensing authority for general electricity transmission and distribution business, and it also designates the Chief Electricity Engineer. The Electricity and Gas Market Surveillance Commission established by METI is responsible for monitoring the electricity market and implementing strict regulations in this regard. The Organization for Cross-regional Coordination of Transmission Operators (OCCTO) is responsible for promoting wide-area operations for conducting electricity business, monitoring the status of electricity supply and demand, and giving appropriate instructions during worsened situations of electricity supply and/or demand of electricity.

Section 7 (4) (Article 29) of the Electricity Business Act [20] directs electric utilities to prepare a plan of supply of electricity, and installation and operation of electric facilities (supply plan) every financial year as specified by an order of METI. The utilities must also notify these plans to METI through OCCTO which must scrutinise and summarise the plan before sending the summary to METI. METI may require the electric utility to revise the supply plan in the interest of securing stable electricity supply and realising comprehensive and reasonable development of the electricity business.

Article 12 (1) of the Basic Act on Energy Policy [21] directs the Government to formulate a basic energy plan on energy supply and demand, prescribing basic policy on long-term energy supply and demand, concerned technologies requiring research and development, and related matters. Article 13 (1) of the above Act directs METI to formulate a draft basic energy plan and seek cabinet approval before publicising the plan. Article 14 of the same Act also directs the State to make endeavours to actively disclose information on energy in public domain and make necessary arrangements to raise public awareness. The new approved plan emphasises the importance of reduced dependence on nuclear energy and fossil fuels and increased use of renewable energy resources to achieve the expected energy mix in 2030.

2.1.3 Thailand

Ministry of Energy is the governing body for energy sector in Thailand, whereas National Energy Policy Council (NEPC) determines the policy framework. The Energy Industry Act, 2007 [22] established the Energy Regulatory Commission (EnRC) and empowered it to frame regulations and regulate operations, tariffs and issue of licences, etc. of the energy industry. EnRC regulates the energy industry operations in accordance with the policy framework of the Government. The Office of the Energy Regulatory Commission (OEnRC), a state entity having juristic status, was also established under the Energy Industry Act, 2007 to handle the administrative work of EnRC. As per clause 4 of Section 31, it is the duty of OEnRC to study, compile, analyse and disseminate information related to energy industry operation, competitive conditions of energy industry operation, load forecast and other relevant matters.

The Electricity Generating Authority of Thailand (EGAT), a state-owned utility, is the operator of power transmission system in Thailand, and the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) are the operators of power distribution systems. MEA and PEA distribute power to retail, commercial and industrial consumers and own the electricity distribution networks in their respective regions of operation. EGAT owns and operates most of the country's power generation capacity and all of its transmission network. It essentially sells all the power it generates, or purchases from private power producers and neighbouring countries, to MEA and PEA.

Ministry of Energy, in conjunction with EGAT, prepared a Power Development Plan [23] in harmony with other development plans, that is, Transmission System Development Plan, Energy Efficiency Development Plan, Alternative Energy Development Plan, etc. A long-term load forecast was also prepared in line with the above plans and it was approved by the Thailand Load Forecast and Power Development Subcommittee. The Plan contains details regarding demand forecasts, generation requirements and associated assumptions.

Forecast Methodology:

a. Energy Requirement

MEA & PEA: Econometric Model with Error Correction Econometric Model, taking into account the achievement of DSM implementation and assuming that energy elasticity will continuously decrease; deduction of expected outcome of new DSM projects

EGAT Direct Customers: Direct survey and data collection from all customers

Whole Country: Energy derived from MEA and PEA and direct customers, station use and pump storage + loss

b. Peak Demand

MEA & PEA: Former load profile applied

EGAT Direct Customers: Direct survey and data collection from all customers

EGAT: Former load curve applied

Whole Country: EGAT peak + MEA peak purchased from very small power plants (VSPPs) + PEA peak purchased from VSPPs and others

2.1.4 Singapore

Electricity Market Authority (EMA), a statutory board under Ministry of Trade and Industry of Singapore, established under The Energy Market Authority of Singapore Act, 2001 [24], is responsible for regulating electricity, gas and district cooling systems and services in Singapore and issuing licences for the same. EMA issues codes of practice and standards of performance for the regulation of activities and conduct in the electricity industry as per The Electricity Act, 2002 [25] besides operating the power system of the country. SP Power Assets is the sole transmission (and distribution) licensee in the country. The Transmission Code [26] requires the transmission licensees to formulate a ten-year transmission development plan and submit it to EMA every year for approval. For preparing the plan, the Authority has to provide ten-year electricity demand forecasts to the transmission licensee every year.

The National Electricity Market of Singapore is a competitive wholesale and retail market for electricity. Energy Market Company (EMC) is the licensee that operates the wholesale market. The Singapore Electricity Market Rules (Chapter 6 – Market Operation) [27] issued by EMA require EMC to prepare and update nodal load forecasts (normal, low and high loading scenarios) on the basis of data received from the system operator and the corresponding market outlook scenarios and pre-despatch schedule scenarios. Chapter 6 of the Regulated Supply Service Code [28] issued by EMA requires the market support service licensees to procure from wholesale market the electricity required for fulfilling their obligation of supplying and selling electricity to regulated supply service customers. Of late, the retail electricity market of Singapore is being gradually opened zone-wise for all consumers (Open Electricity Market).

EMA collects information regarding Singapore's energy outlook and disseminates it through publications like Singapore Electricity Market Outlook (SEMO), Singapore Energy Statistics, annual reports, etc. Such publications contain statistical details regarding supplied, forecasted and actual demand, market prices, energy balance, consumer category-wise consumption, peak demand, etc.

2.1.5 CEER Member States, Europe

Directives 2003/54/EC and 2005/89/EC (Electricity Security of Supply Directive) [29] mandate the member states to publish every two years a system adequacy report with the time horizon ranging from 5 to 15 years. The Council of European Energy Regulators (CEER) examines the current practices used for the assessment of generation adequacy by the member states to identify the best practices across Europe and recommend a common framework. It also seeks to identify the entities responsible for generation adequacy and load forecast (along with its parameters like methodology, horizon, assumptions, scenarios – deterministic/stochastic and single/multiple – system stress, availability of capacity at interconnection, Demand Side Management), and consistency of member states' load forecast with ENTSO-E's System Outlook & Adequacy Forecast (SO&AF), etc.

2.1.6 California, United States

As per the Public Resources Code [30], the Energy Commission is directed to regularly assess all aspects of energy demand and supply. Public Resources Code Sections 25216 and 25216.5 empower the Energy Commission to collect data and information on all forms of energy supply, demand, conservation, public safety, research and related matters.

The Energy Commission collects information regarding historical load forecasts and resource assessment from all load-serving entities to prepare the Integrated Energy Policy Report (IEPR). The Commission acquires sector-wise (residential, commercial, industrial, agricultural, water pumping, transportation, communication and street lighting) historical data and forecasts from utilities/Load-serving Entities (LSEs) in a defined electronic format within a given time frame. This information is utilised for power procurement and transmission planning. The LSEs need to submit historical data of retail sales, net electricity load and peak demand (sector-/consumer-wise), peak demand vs. weather scenarios, hourly system load, etc. The Commission also provides forecasted input parameters, assumptions, methods used to develop economic and demographic projections, projected electricity prices for sectors or consumer categories, cost and impact assessment of demand-side management programmes, etc.

2.1.7 West Virginia, United States

The Sixty-Fourth Legislature (1979) directs Public Service Commission of West Virginia to present an annual report to the Legislature on the status of supply and demand balance of electric utilities in the state for the next 10 years. This is an instance where regulatory bodies abide by energy planning directives of the government.

The West Virginia Commission develops a report containing electricity requirement and customer growth over a period of ten years, based on inputs received from all utilities responsible for electricity supply to residential and commercial consumers in West Virginia. Each distribution utility provides its ten-year energy and peak power requirements along with information regarding generation capacity additions and retiring plants. The Commission's staff reviews the projections to determine whether the projected peak load supply is equal to the State's peak demand plus an additional 16 percent as reserve capacity for reliable operation.

In general, utilities in western US take into consideration load forecasts, demand-side management plans, planned generation capacity addition and retirements, uncertainties and risks associated with fuel prices, weather, regulations, legislations, etc. while preparing their resource plans based on different available techniques with a varying degree of importance to each variable [31]. But neither are the plans updated frequently nor is a due consideration given to network capacity expansion activities. Thus, the planning activities lack coordination and consistency as far as the choice of variables is concerned. A need for standardised data collection-related regulation supplemented with the need to host such data in public domain for the benefit of a large number of stakeholders was realised. This would not only create awareness among all concerned stakeholders, but also promulgate research in this area and aid policy makers and regulators.

Table 1: International regulations on long-term demand forecasting and power procurement planning

	Australia	Japan	Thailand	Singapore	European Countries	California	West Virginia
Objective	Network planning	3E+S (Safety, Energy security, Economic efficiency and Environment)	Energy security, Economy and Ecology	Attracting investment in generation asset	Assessment of electricity generation adequacy	Preparing Integrated Energy Policy Report	Energy security
Responsible organisation	National Transmission Planer (NTP)	Ministry of Economy, Trade and Industry (METI)	Ministry of Energy, along with the Electricity Generating Authority of Thailand (EGAT)	Energy Market Authority (EMA)	European Network of Transmission System Operators for Electricity	California Energy Commission	Public Service Commission of West Virginia
Forecast range	20 years	15 years	20 years	10 years	Seasonal, mid-term, 10 years	12 years	10 years
Frequency of forecast	Annual	Updated at least once in every 3 years	Revised in every 3 years	Annual	Updated annually	Updated annually for the next 10 years	Updated annually
Factors considered for forecast	Economic growth, weather conditions, electricity prices	Economic growth, Energy efficiency and conservation measures, population growth	Social (Population) and economic (long-term GDP) growth, Energy efficiency target, RE development target	Economic and Consumer growth	Economic growth, temperature, policy, demographics	Economics, demographics, weather, electric vehicle, etc.	Consumer growth, Annual growth rate
Peak Load or Energy	Both	Energy	Both	Both	Peak load	Both	Peak load
Forecast scenario	Multiple	Multiple	Multiple	Multiple	Multiple	Multiple	Single
Corrective action(s) for forecast	Not defined	Reviewed at least once in every 3 years	Reviewed once in every 3 years	Annual forecast	Annual update	Annual update	Not defined

2.2 Existing Legislative and Policy Provisions in India

Electricity finds place in List-III (Concurrent List) of Seventh Schedule of the Constitution of India. Thus, the subject of electricity is under the joint jurisdiction of Governments in all States and Union Territories (UTs) and the Central Government. In other words, both State and Central Governments have the power to formulate legislations on the subject of electricity. Presently, the main overarching umbrella guiding all activities in the Indian power sector is the Electricity Act, 2003 (hereinafter referred to as the Act). In fulfilment of its obligations under The Act, the Central Government came up with National Electricity Policy (NEP) (2005) and National Tariff Policy (NTP) (2006, later amended in 2016). Each of these policy instruments emphasises improvement of financial efficiency of the sector by optimising the overall cost of its functioning in general, and power procurement by DISCOMs in particular.

2.2.1 Electricity Act, 2003

The Act does not explicitly refer to long-term demand forecasting but empowers the ERCs to regulate power procurement [32]. However, the Preamble of the Act clearly specifies promotion of competition in the sector, tariff rationalisation, efficiency in operation, protection of interests of consumers and other stakeholders, supply of electricity to all areas, etc. Accurate demand forecasting and efficient power procurement planning would considerably help achieve these objectives.

Clause 61 (c) of the Act states that the State/Central/Joint Electricity Regulatory Commissions (SERCs/CERC/JERCs), as and when required, must consider encouraging competition, efficiency, economical use of resources, better performance and optimum investments while determining the tariff, whereas clause 61 (d) emphasises protection of consumers' interests and cost-recovery in a reasonable manner. The Act also empowers ERCs to determine the tariff for licensees (clause (1) of Section 62) and regulate the power purchase process as well as tariff for the utilities (clause (1) (b) of Section 86). Section 73(i) entrusts Central Electricity Authority (CEA) to carry out studies pertaining to cost, efficiency, competitiveness and associated matters which implicitly refers to load forecasting and power procurement planning.

2.2.2 National Electricity Policy, 2005

NEP [33] aims at laying down guidelines to accelerate the development of power sector in the country, provide supply of electricity to all areas, and protect the interests of consumers and other stakeholders of the sector, while keeping in view the availability of energy resources, technology available to exploit these resources, economics of generation using different resources, and energy security. NEP also aims at supplying reliable and quality power (of specified standards) in an efficient manner at reasonable rates. Clause 3.2 of NEP also directs CEA to make short-term and long-term demand projections.

2.2.3 Tariff Policy, 2006

The Tariff Policy (TP), 2006 envisioned electricity access to all consumers in an economic, efficient and reliable manner with transparent, consistent and predictable regulatory practices minimising the perceived regulatory risks [34]. However, it is silent on demand forecasting or power procurement planning.

2.2.4 Tariff Policy, 2016

The revised Tariff Policy [35], in addition to meeting its earlier objectives, also directs the ERCs to mandate the DISCOMs to forecast their load and plan their power procurement annually on a rolling basis. Clause 8 of the Policy states that *"The appropriate Commissions must mandate DISCOMs to undertake the exercise of load forecasting and power procurement planning every year"*.

Although NEP directs CEA to make short-term and long-term demand forecasts, it does not refer to the role of demand forecast in power procurement planning by the distribution utilities. In practice, many distribution utilities (or the holding companies, on their behalf) undertake the task of long-term demand forecasting and power procurement planning. The SERCs either rely on CEA's forecasts or adopt a view whereby the distribution licensees or the holding companies are required to undertake long-term demand forecasting and presenting the results before the Commission.

Tariff Policy, 2016 addresses the lacunae in TP, 2006 by including a provision mandating the DISCOMs to undertake demand forecasting and power procurement planning annually. Under the existing framework, several SERCs have directed the utilities regulated by them to prepare power procurement plans based on long-term demand forecasts. These ERCs adopted an altogether different approach by largely following the spirit of TP, 2016.

3. Long-term Electricity Demand Forecast by CEA

CEA periodically carries out countrywide assessment of electricity demand through the EPS Committee which consists of representatives from both state and central sector power utilities, industrial organisations, central ministries, etc. The first EPS Committee was set up in December, 1962, the first EPS Report was finalised in July, 1963 and the latest (19th EPS Report) was released in January, 2017.

3.1 Demand Forecasting Methodology used by CEA

CEA uses Partial End Use Method - a combination of time series analysis and end use method, to forecast the electricity demand and electrical energy consumption. This bottom-up approach focuses on end-uses or final energy needs of consumers belonging to various categories – domestic, commercial, agricultural, industrial, railways, etc. – according to which projections regarding electricity consumption for all the consumer categories are prepared. After obtaining an estimate of the quantum of energy required at the consumer end, T&D losses are estimated on the basis of past trends and future improvement plans. Aggregate electrical energy requirement at busbar is obtained by grossing up the estimated total energy consumption at the consumer end with T&D losses. After analysing the consumer mix in every state and consumer electricity demand patterns, the annual Load Factor (LF) is estimated and state-wise system peak load is determined. The regional peak is arrived at by considering the Diversity Factor (DF) among states/UTs in the respective regions. Finally, the all India peak is calculated by considering the inter-regional DF.

3.2 Annual Peak Demand and Energy Requirement Projections as per 18th and 19th EPS Reports

Forecasts of electricity requirement and peak demand as presented in various EPS Reports have limited reliability. Going by recent estimates of EPS, one tends to conclude that some of the EPS had overestimated the demand for electricity. As shown in *Figures 5 and 6* and *Tables 2 and 3*, the 18th EPS had significantly overestimated the electricity demand; actual demand growth was much lower than expected. Therefore, demand projections in the 19th EPS were accordingly reduced by over 25 percent based on a lower estimated demand growth. The forecasted values of demand in the 18th EPS were closer to the actual values during the initial years, but there were significant deviations in the subsequent years. Compound Average Growth Rate (CAGR) of the projected electrical energy requirement during 2010-11 to 2015-16 was 7.62 percent, whereas the actual CAGR for the same period was 5.28 percent. Moreover, the CAGR of peak demand for 2010-11 to 2015-16 was actually 4.63 percent against the predicted value of 8.50 percent.

Table 2: Comparison of electricity demand projections in 18th and 19th EPS Reports

Year	Peak Electricity Demand					
	Actual Demand (MW)	18th EPS Projections (MW)	Overestimated Demand in 18th EPS (MW)	19th EPS Projections (MW)	Overestimated Demand in 19th EPS (MW)	Difference between 18th and 19th EPS (MW)
(1)	(2)	(3)	(4) = (2) – (3)	(5)	(6) = (2) – (5)	(7) = (3) – (5)
2010-11	1,22,287	1,22,287	0			
2011-12	1,30,006	1,32,685	2,679			
2012-13	1,35,453	1,43,967	8,514			
2013-14	1,35,918	1,56,208	20,290			
2014-15	1,48,166	1,69,491	21,325			
2015-16	1,53,366	1,83,902	30,536			
2016-17	1,59,542	1,99,540	39,998	1,61,834	2,292	37,706
2017-18	1,64,066	2,14,093	50,027	1,76,897	12,831	37,196
2021-22		2,83,470		2,25,751		57,719
2026-27		4,00,705		2,98,774		1,01,931

Source: 18th and 19th Electric Power Survey of India, CEA [4-5]

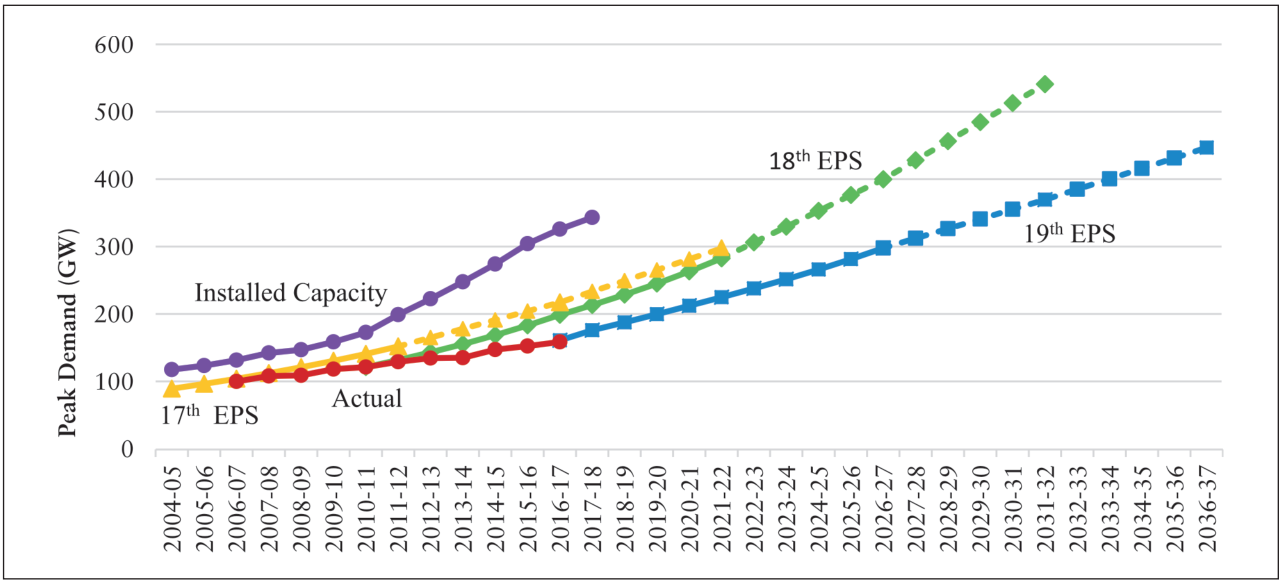

Figure 5: Historical projections of annual peak electricity demand (all India)

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15])

Table 3: Comparison of electrical energy consumption projections in 18th and 19th EPS Reports

Year	Electrical Energy Requirement					
	Actual Consumption (MU)	18th EPS Projections (MU)	Overestimated Consumption in 18th EPS (MU)	19th EPS Projections (MU)	Overestimated Consumption in 19th EPS (MU)	Difference between 18th and 19th EPS (MU)
(1)	(2)	(3)	(4) = (3) – (2)	(5)	(6) = (5) – (2)	(7) = (3) – (5)
2010-11	8,61,591	8,70,831	9,240			
2011-12	9,37,199	9,36,589	-610			
2012-13	9,95,557	1,007,694	12,137			
2013-14	1,002,257	1,084,610	82,353			
2014-15	1068,943	1,167,731	98,788			
2015-16	1,114,408	1,257,589	1,43,181			
2016-17	1,142,928	1,354,874	2,11,946	1,160,429	17,50	1,94,445
2017-18	1,212,134	1,450,982	2,38,848	1,240,760	28,626	2,10,222
2021-22		1,904,861		1,566,023		3,38,838
2026-27		2,710,058		2,047,434		6,62,624

Source: 18th and 19th Electric Power Survey of India, CEA [4-5]

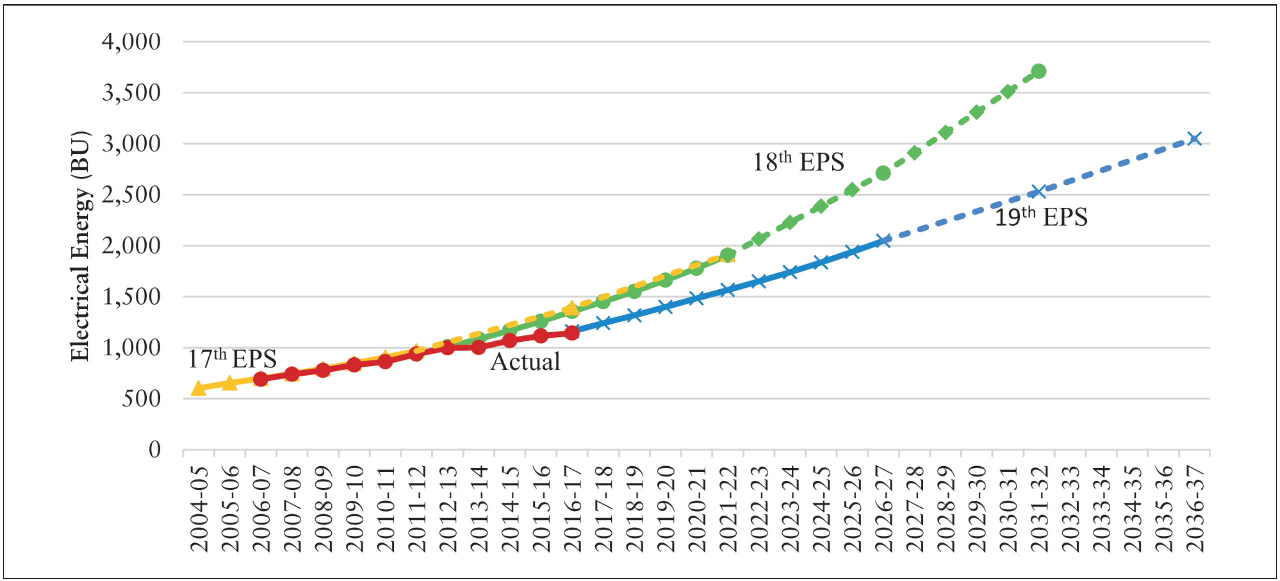

Figure 6: Historical projection of annual electrical energy requirement (all India)

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15])

It is important to mention here that the demand forecasts presented in the EPS reports have traditionally been based on data furnished by the central and state level agencies involved in power procurement planning. Over-forecasts in the past seem to have led the generation companies to plan higher investments and the distribution utilities ending up signing power procurement contracts much above their actual requirements.

4. Long-term Demand Forecasting and Power Procurement Planning – Existing Practices across States

In the pre-reform era, CEA played the main role in long-term electricity demand forecasting across states. This practice was continued to be relied upon even after reforms were introduced at state level.

Prior to the reform process, long-term power procurement planning decisions were taken by the respective SEBs[1], with due techno-economic clearances from CEA. Post sectoral reforms, the responsibility of power procurement was bestowed upon the transmission and bulk supply companies which would procure power on behalf of all the public distribution utilities. However, the transmission and bulk supply licensees also continued to follow the same practices as was used by the erstwhile SEBs, with limited regulatory oversight.

Post the Act, ERCs ought to regulate power purchase in accordance with the principles of economy, efficiency and competition. However, it was not followed in such spirit across all the states. Some SERCs issued specific regulations governing long-term load forecasting and power procurement planning, while, in other states, the historical practices continued with some regulatory oversight. We review such practices across some of the states in the following sections.

4.1 Andhra Pradesh[2]

As shown in *Figures 7 and 8*, the electrical energy and demand estimates made in the EPS Reports for Andhra Pradesh were significantly different from the actuals realised thereafter. However, the state projections were highly realistic.

[1] State Electricity Board (SEB), transmission and bulk supply company or DISCOM as the case may be.

[2] For the consolidated state of Andhra Pradesh till 2014, and the newly formed states of Andhra Pradesh (AP) and Telangana (TS) thereafter.

Andhra Pradesh Electricity Regulatory Commission (APERC) issued *Guidelines for Load Forecasts, Resource Plans and Power Procurement* in December, 2006 [36]. According to these guidelines, transmission and distribution licensees are required to submit their load forecasts over a ten-year period to the Commission, pursuant to Regulation 17.12 of the *Transmission and Bulk Supply Licence Regulations* [37] and Regulation 19.2 of the *Distribution and Retail Supply Licence Regulations* [38]. However, the guidelines do not specify the methodology to be followed for forecasting. Transmission Corporation of Andhra Pradesh Limited (APTRANSCO) is required to collect and consolidate the forecasts of the distribution licensees and submit them with suitable adjustments, if any, to APERC.

The licensees are required to submit their load forecasts in three categories:

a) A detailed forecast for the first five-year control period

b) A simple forecast for the subsequent five-year control period

c) Historical information and data relevant to the load forecast

Part II of the APERC Regulation No. 4 of 2005 and APERC Regulation No. 5 of 2005, which deal with the *Terms and Conditions for Determination of Tariff for Wheeling and Retail Sale of Electricity*, specify that the transmission licensees are required to file before APERC a resource plan comprising the load forecasts, on 1st April of the year preceding the first year of commencement of the control period [39]. Regulation 35 of the APERC Distribution Licence Regulations (Regulation No. 10 of 2013) [40] specifies that the distribution licensees shall prepare and submit to APERC a year-wise demand forecast for its area of supply for two consecutive control periods. It is also stated that the distribution licensees shall purchase electrical capacity or energy in an economical and efficient manner under a transparent power procurement process.

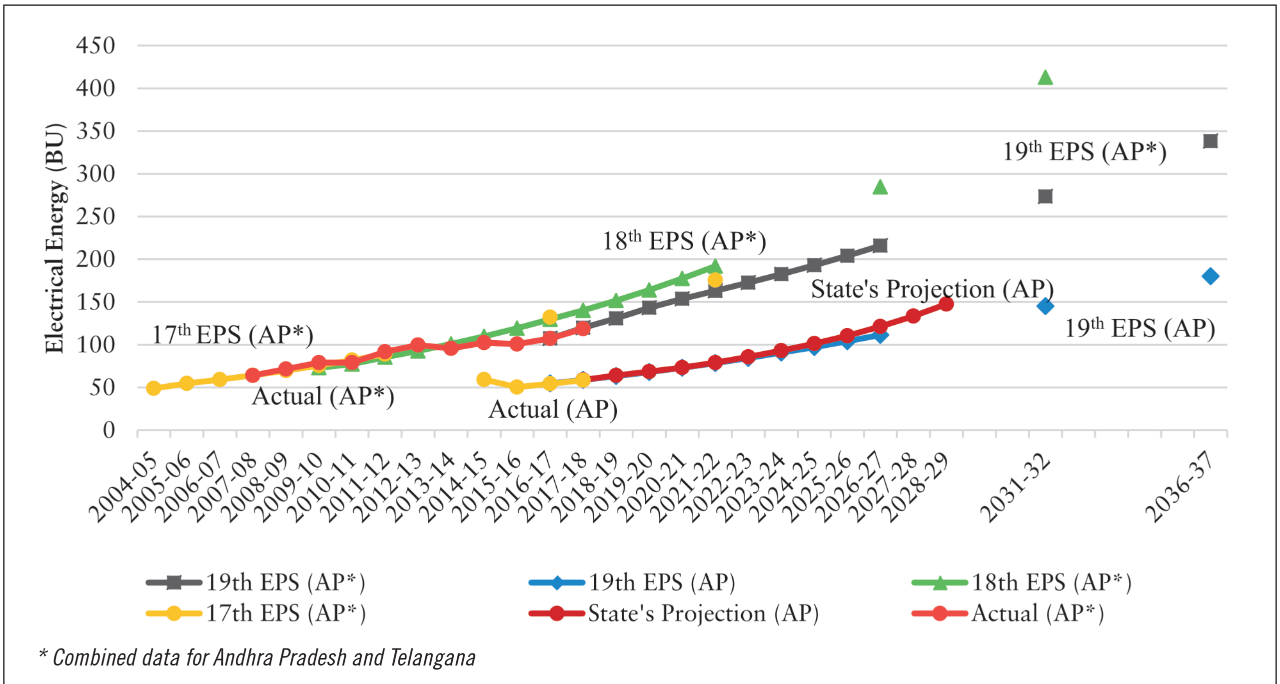

Figure 7: Actual electrical energy requirement vs. projections (Andhra Pradesh)

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15]
The State Electricity Plan (SEP), APTRANSCO;
Resource Plan (FY 2020-2029), APTRANSCO)

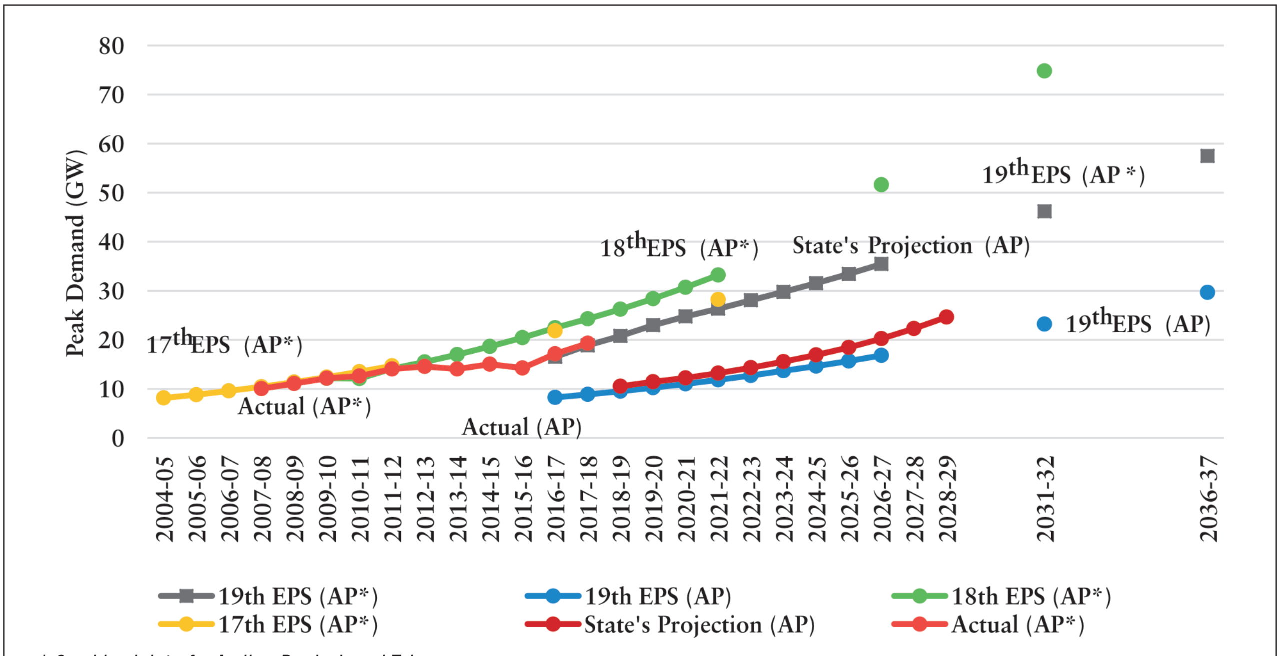

Figure 8: Actual peak demand vs. projections for Andhra Pradesh

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15]
Energy Statistics, Ministry of Statistics and Programme Implementation (MOSPI);
The State Electricity Plan (SEP), APTRANSCO;
Resource Plan (FY 2020-2029), APTRANSCO)

4.2 Assam

Assam Electricity Regulatory Commission (AERC) *MYT Regulations* 2015 [41] lay down regulations concerning demand forecasts and power procurement planning for the control period of Multi Year Tariff (MYT) regime. Regulation 26.2 of the said regulations specifies the components of power procurement plan which the utilities need to furnish before AERC by 1st April of the respective control period. The power procurement plan, considering the demand for peak and off-peak periods, needs to be prepared for each year of the control period, with monthly forecasts and cost-effectiveness analysis based on the information available. This necessitates a category-wise quantitative demand forecast. Regulation 26.3 of the same regulations specifies that the quantitative forecasts must be based on 'factors such as overall economic growth, consumption growth of electricity-intensive sectors, advent of competition in the electricity industry, trends in captive power, impact of loss reduction initiatives, improvement in generating station plant load factors and other relevant factors and past data, with reasonable assumptions for the future'. However, the methodology adopted for demand forecasting or power procurement planning by AERC or the utilities is not specified. The electrical energy consumption and peak demand in Assam are to a large extent, in agreement with the projections reported in the various EPS Reports, as shown in *Figures 9 and 10*.

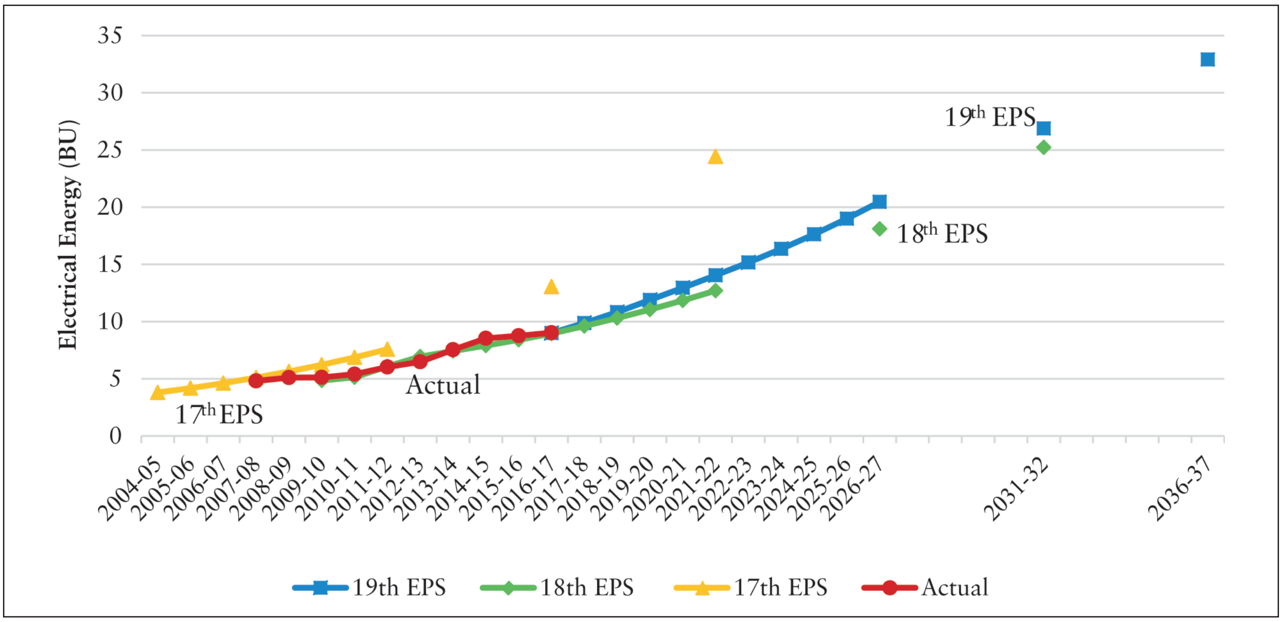

Figure 9: Actual electrical energy requirement vs. projections for Assam

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15])

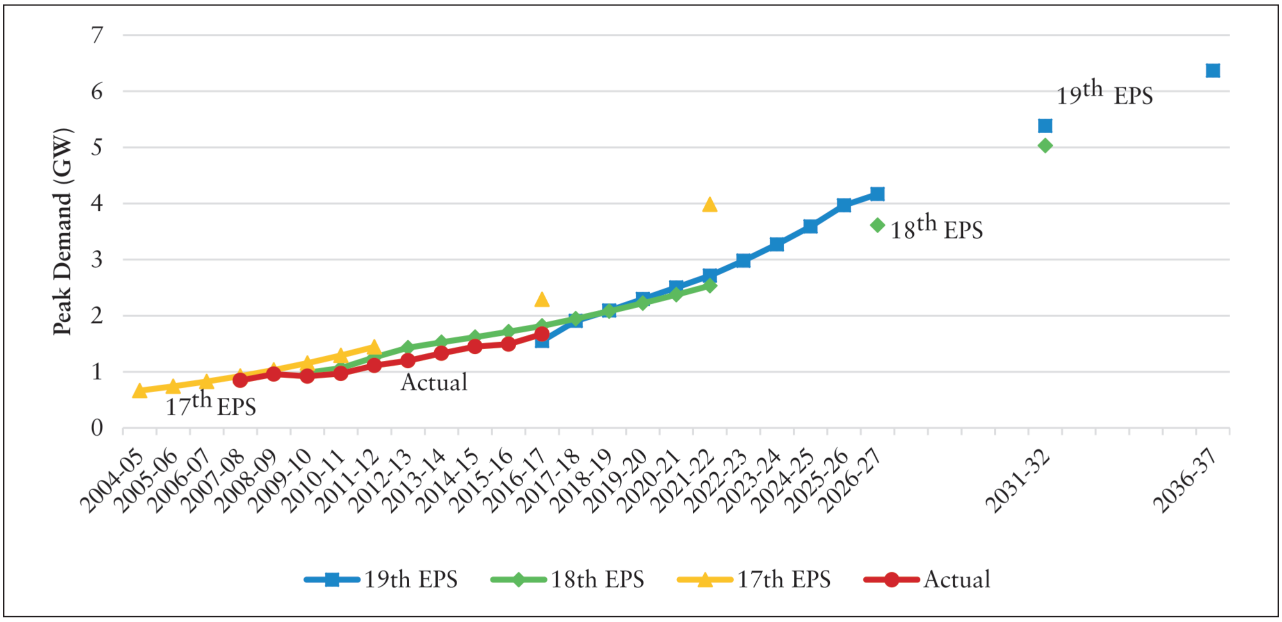

Figure 10: Actual peak demand vs. projections for Assam

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15] Energy Statistics, MOSPI)

4.3 Madhya Pradesh

Section 4.5.1 of the *Madhya Pradesh Electricity Grid Code 2004* [43] states that the distribution licensees shall determine peak load and energy forecasts for their area of supply, for each category of load, over the next 5 years, and submit the same to the State Transmission Utility (STU) annually, by 31st March. Moreover, the Grid Code also mandates them to update the existing forecasts annually or whenever major changes take place. Section 7.3.1 of the Grid Code specifies that long-term (more than 1 year) demand estimation or load forecasting shall be done by the STU, and demand estimation for periods of up to 1 year shall be done by the State Load Despatch Centre (SLDC).

Part II of the Madhya Pradesh Electricity Regulatory Commission (MPERC) *Power Purchase and Procurement Process Regulations, 2004* [44] deals with long-term power procurement, specifying that the licensees need to furnish rolling five-year long-term power procurement plans to MPERC every year. As per Regulation 9 of Part IV of these regulations, licensees need to assess the electricity demand for next 5 years, whereas as per Regulation 14 of Part IV, the demand forecasts should be based on econometric, trend and statistical analyses. Also, Regulations 19 and 22 of Part IV specify that a licensee shall prepare a long-term power procurement plan for the next 5 years, based on load forecasts and assessment of availability, and shall submit the same to MPERC by 31st October every year.

As shown in *Figures 11 and 12,* the electrical energy consumption and peak demand estimates reported in the EPS Reports have been largely accurate.

During 2017-18, the monthly maximum and minimum requirements fluctuated between 4500 and 7000 MU, whereas the availability fluctuated between 5800 and 7600 MU. Even wind power has not been beneficial in mitigating the fluctuations. During November, 2017, the availability was 6147 MU while the requirement was 7086 MU. This shortage was attributed to coal shortage, less hydel power availability due to scant rains, and high irrigational demand in Rabi season. To meet the demand and to provide for the bare minimum reserve for contingency, arrangements were made through banking (983 MU) and short-term purchase (117 MU). In contrast to this, the month of June, 2017 exhibited an availability of 7342 MU, but the requirement was merely 4734 MU. This resulted in an un-requisitioned surplus of 2194 MU. Banking could only be done for 2.4 MU, and 59 MU were despatched through short-term power sale. Remaining surplus capacity was backed down primarily because of high wind velocities yielding more electrical power from wind farms, and low irrigational demand in the rainy season.

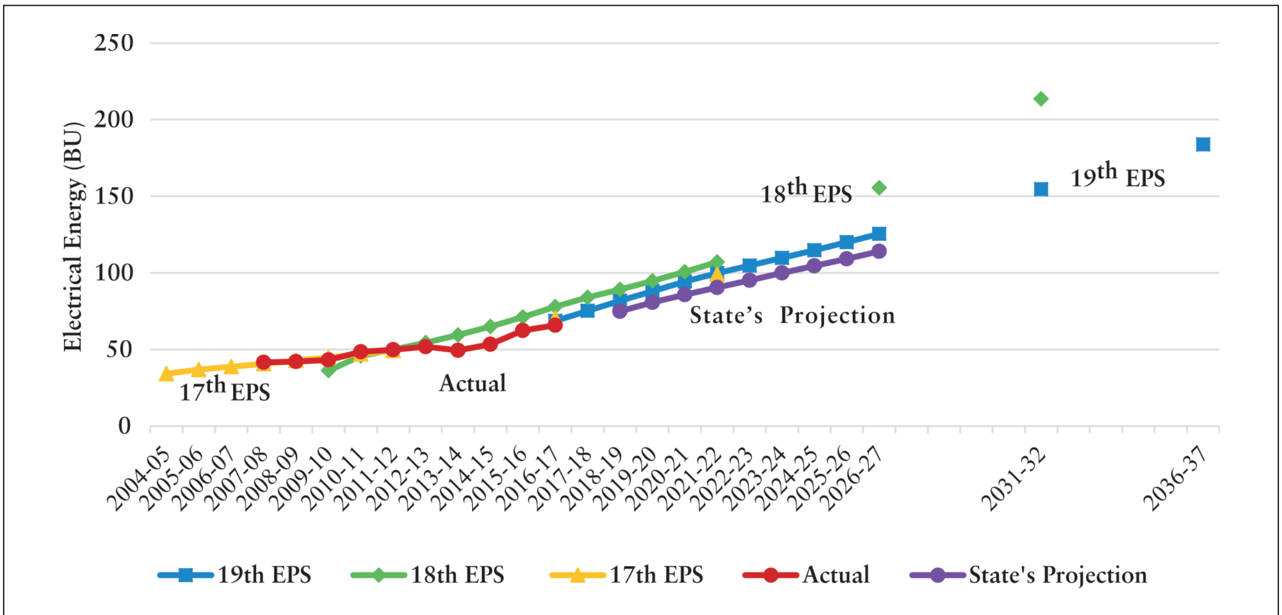

Figure 11: Actual electrical energy requirement vs. projections for Madhya Pradesh

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15])

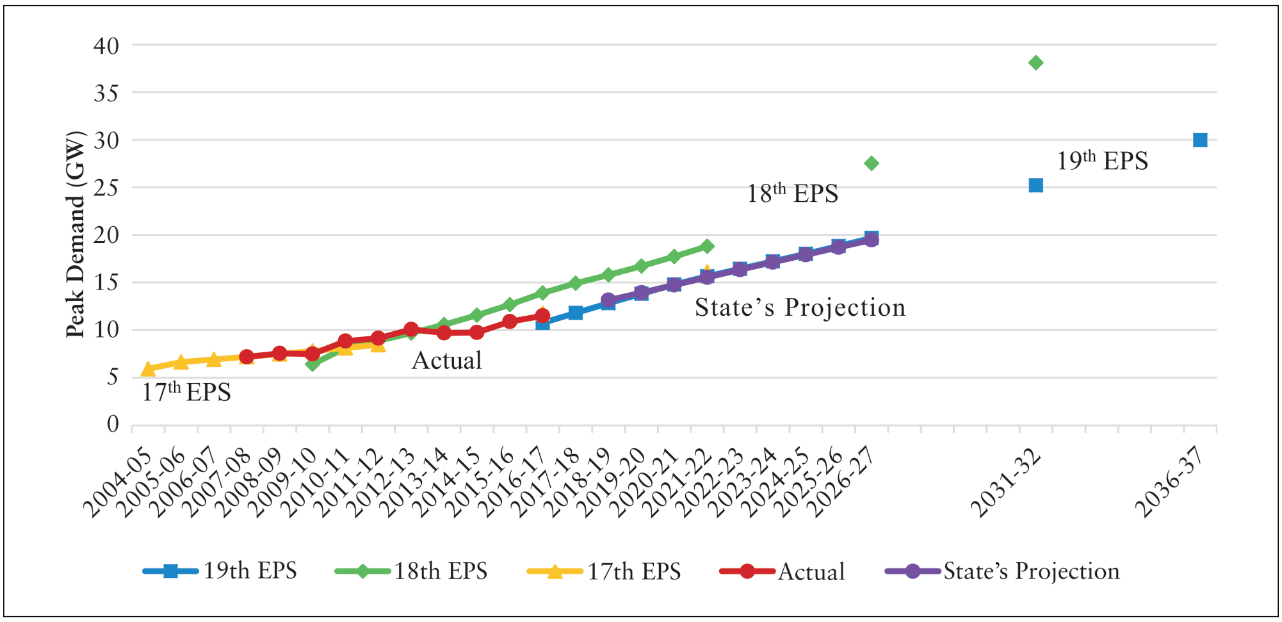

Figure 12: Actual peak demand vs. projections for Madhya Pradesh

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15]
Energy Statistics, MOSPI)

Issues of variability and uncertainty are predominant in circumstances where availability of a large proportion of power is dependent on nature, as in the case of solar, hydel and wind power plants. At the same time, fluctuating demand worsens the situation, thereby leading to either excess or insufficient power generation.

4.4 Maharashtra

Part C of the Maharashtra Electricity Regulatory Commission (MERC) *MYT Regulations 2015* [42] deals with guidelines for power procurement planning. Regulation 18 of the said regulations lays down guidelines for power procurement, which directs the distribution licensees to make an agreement to procure power for long-term durations (exceeding 7 years but not exceeding 25 years), whereas Regulation 19.2 specifies the components of power procurement plan for a ten-year period, which the utilities need to furnish before MERC. The long-term procurement plan should separately state the forecasts for peak and off-peak periods, in terms of quantity of power to be procured (MUs) and maximum demand (MW), in addition to month-wise estimation of demand and supply in MW and MU.

Regulation 19.3 of the same regulations specifies that forecasting techniques should be based on past data and reasonable assumptions for the future, with due consideration to factors such as overall economic growth, consumption growth of electricity-intensive sectors, advent of competition in the electricity industry, trends in captive power, impact of loss reduction initiatives, improvement in generating station plant load factors, and other relevant factors.

As shown in *Figures 13 and 14,* the electrical energy consumption and peak demand estimates reported in the EPS Reports for Maharashtra have been largely accurate.

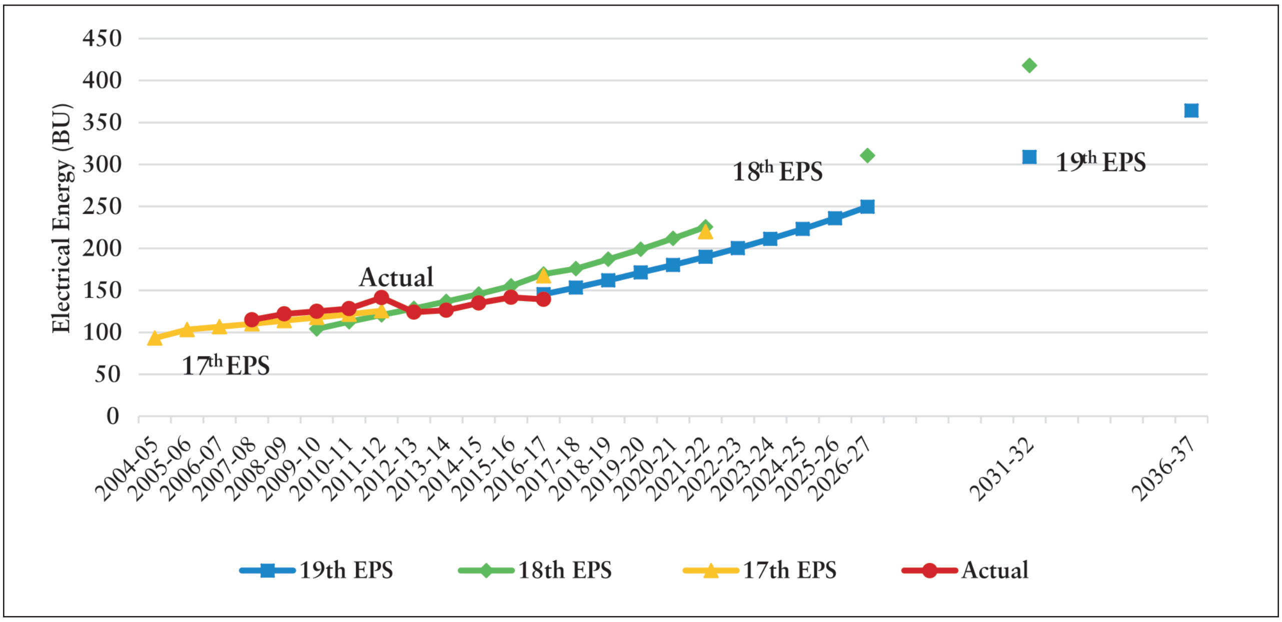

Figure 13: Actual electrical energy requirement vs. projections for Maharashtra

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15])

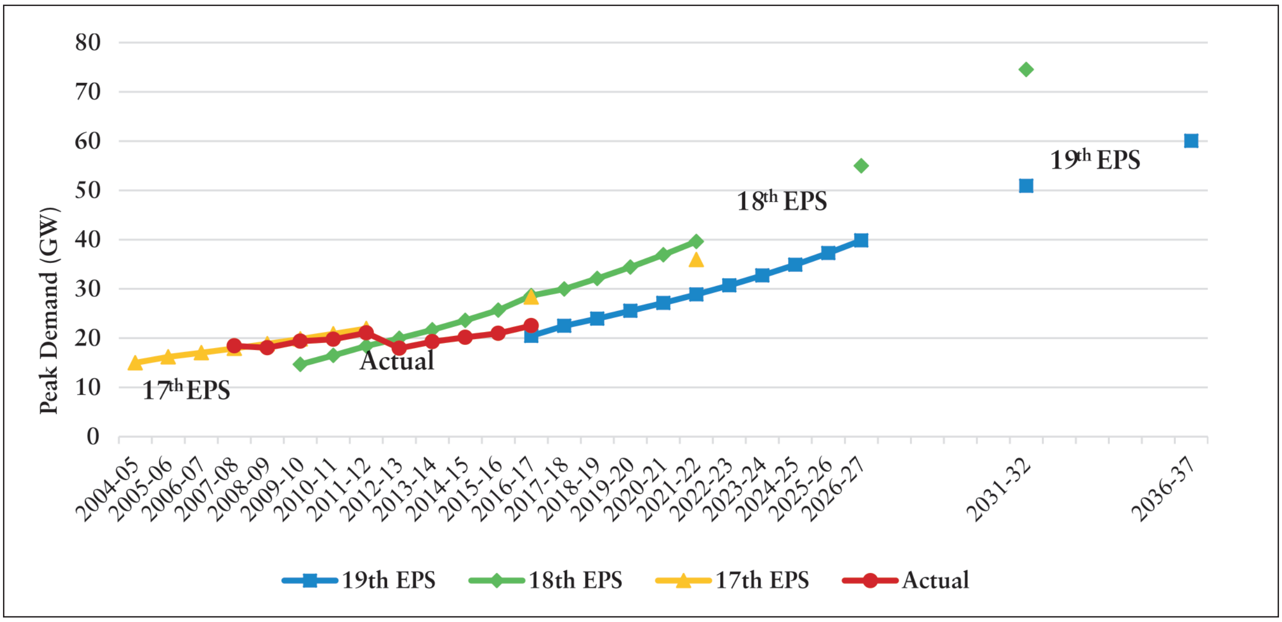

Figure 14: Actual peak demand vs. projections for Maharashtra

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15]
Energy Statistics, MOSPI)

4.5 Delhi

Regulation 5 of Delhi Electricity Regulatory Commission (DERC) *Terms and Conditions for Determination of Tariff Regulations, 2017* [45] specifies that the distribution licensees need to prepare and submit a business plan comprising the yearly projection of sales forecasts for each consumer category over the next 5 years, latest by 31st July of the base year. Regulation 13 of these regulations mandates that distribution licensees should prepare a power procurement plan based on sales forecasts and the distribution loss trajectory, in order to serve the electricity demand in its area of supply, clearly indicating the estimated quantum of power to be procured from long-term resources. Moreover, as per Regulation 14, these licensees are also required to submit the validity of their existing long-term PPAs and the expected Commercial Operation Date (CoD) of additional resources in future. Furthermore, Regulation 121 specifies that DERC shall consider the following factors to determine the quantum of power while approving the cost of power purchase:

(i) Availability of generating stations which may be based on Load Generation Balance Report (LGBR) published by CEA for the corresponding financial year

(ii) Principles of merit order schedule and despatch based on the ranking of all approved sources of supply, in the order of their variable cost of power purchase, on a monthly basis

(iii) Normative cost of banking transactions at the APPC of the distribution licensee

(iv) The gap between APPC of the power portfolio allocated and the average revenue due to different consumer mix of all distribution licensees, provided that DERC may adjust the gap in power purchase cost by redistributing the allocation of power amongst the distribution licensees out of the overall power portfolio allocated to the National Capital Territory (NCT) of Delhi by the Ministry of Power (MoP), Government of India (GoI)

As shown in *Figures 15 and 16,* the electrical energy consumption and peak demand estimates reported in the EPS Reports, for Delhi, have been largely accurate.

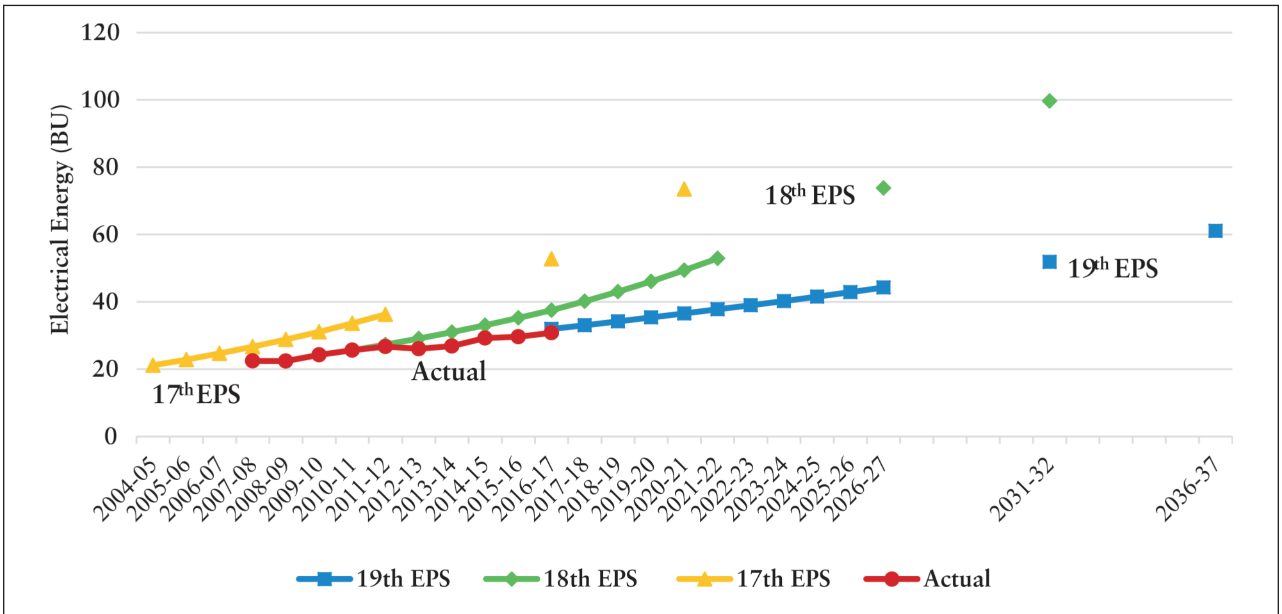

Figure 15: Actual electrical energy requirement vs. projections for NCT Delhi

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15])

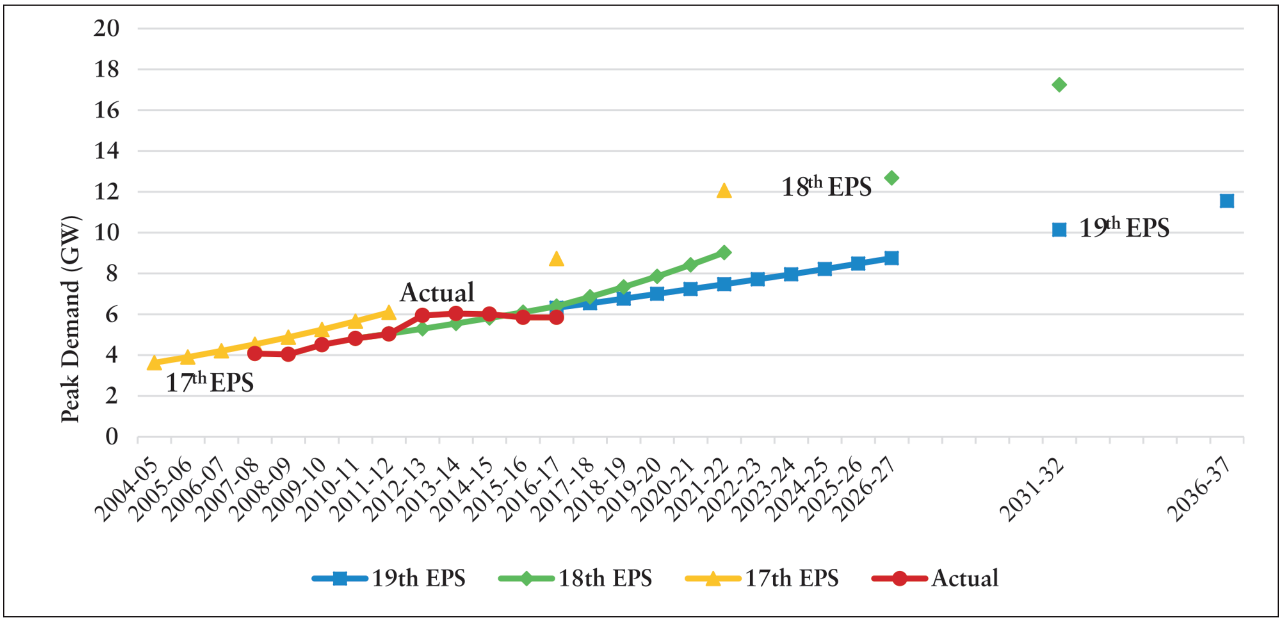

Figure 16: Actual peak demand vs. projections in for NCT Delhi

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15]
Energy Statistics, MOSPI)

4.6 Gujarat

Clause 4.1 of Chapter 4 of the Gujarat Electricity Regulatory Commission (GERC) *Gujarat Electricity Grid Code Regulations, 2013* [46] states that the distribution licensees need to assess load forecasts in their area of supply for each of the next 10 years, submit the same to the STU by 31st January every year and update the data annually. Distribution licensees are also required to justify the materialisation of demand for power by each consumer, if exceeding 5 MW. As per clause 4.2 of the Grid Code, the STU is required to review the methodology used and assumptions made by the distribution licensees for load forecasts, in consultation with them. Clause 4.3 of the Grid Code mandates the STU to forecast the demand for power within the area of supply of each licensee for each of the next 10 years and to comply with the national vision for power generation and transmission plan prepared by CEA. Moreover, clause 4.4 holds the STU responsible for integrating the load forecasts submitted by each of the distribution licensees and determining five-year load forecasts for the state on a long-term basis.

GERC's *Notification No. 2 of 2013* lays down guidelines for procurement of power by distribution licensees. Clause 3 of the notification specifies that distribution licensees need to submit their power procurement plans for the next 5 years, by 31st January every year. These plans would include peak load and energy forecasts in their respective areas of supply for each of the next 10 years; forecast of anticipated power supply position for each of the next five years; projections for additional requirement of power procurement, if any; and hourly load duration projection for each of the next 5 years. As per clause 4 of the said notification, the distribution licensees are required to have long-/medium-term tie-ups with power generators to meet the load requirement of at least 75 percent of the duration of the fifth year and, in the absence of adequate tie-ups, the distribution licensee shall initiate the process of long-term procurement of power. Besides, clause 5 mandates the distribution licensees to have long-/medium-term tie-ups with power generators to meet the load requirement of at least 85 percent of the duration of the third year and in the absence of adequate tie-ups, the distribution licensee shall initiate the process of medium-term procurement of power. Also, as per clause 6, distribution licensees should normally endeavour to procure power through competitive bidding. In case of any proposal for procurement of power through the Memorandum of Understanding (MoU) route, the distribution licensee is required to obtain prior approval of GERC. Furthermore, according to clause 7, in case of procurement of power through competitive bidding, the distribution licensees shall initiate the process for long-/medium-term power procurement in accordance with MoP's *Guidelines for Determination of Tariff by Bidding Process for Procurement of Power by Distribution Licensees.*

Regulation 94.5 of GERC MYT Regulations, 2016 [47] deals with the cost of power generation and power purchase. As per clause 94.5.1 of these regulations, distribution licensees are allowed to recover the cost of power generated by generation businesses or purchased from approved sources for supply to consumers based on the power procurement plan of the distribution licensee, as approved by GERC.

As shown in *Figures 17 and 18,* the electrical energy consumption and peak demand estimates reported in the EPS Reports, for Gujarat, have been largely accurate.

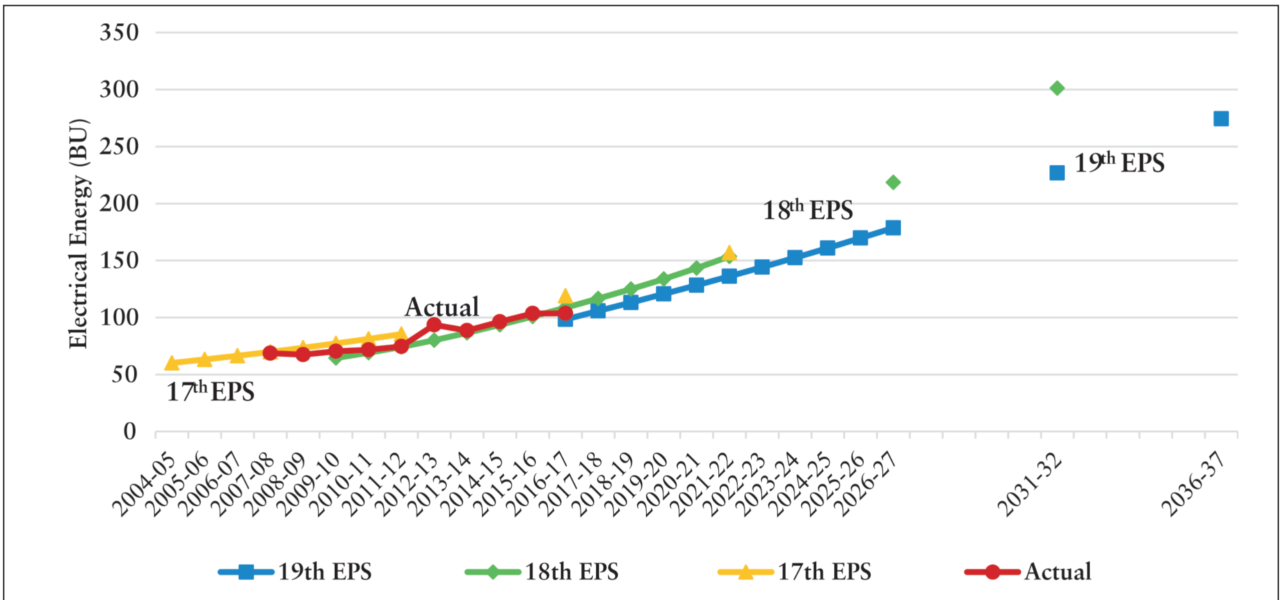

Figure 17: Actual electrical energy requirement vs. projections for Gujarat

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15])

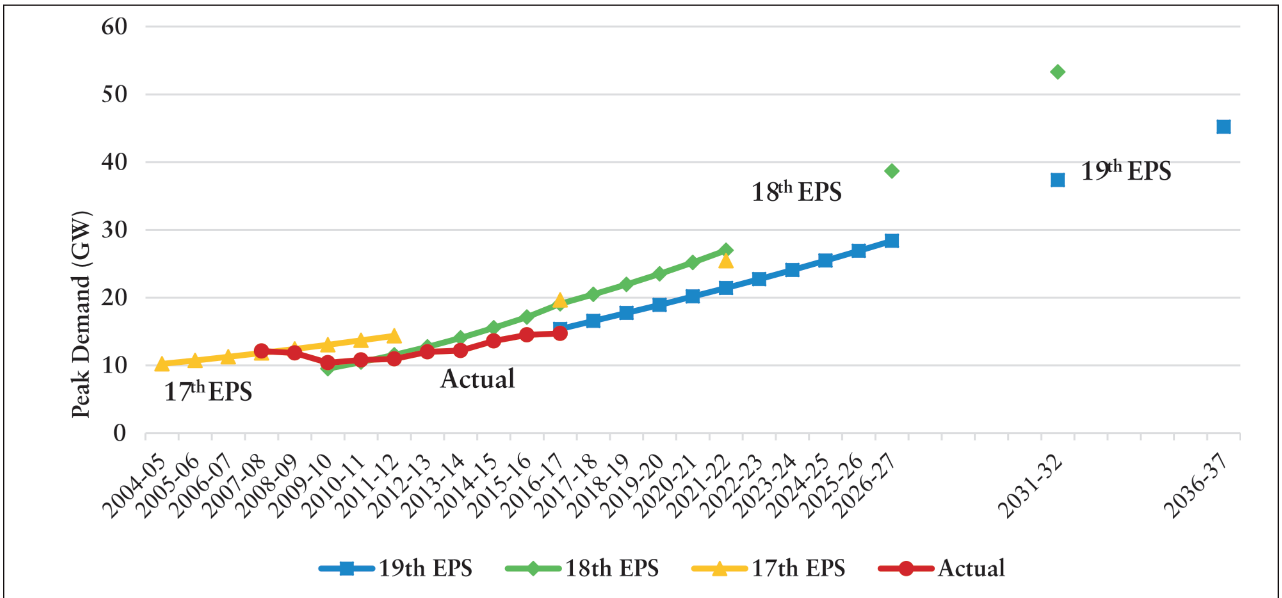

Figure 18: Actual peak demand vs. projections for Gujarat

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15] Energy Statistics, MOSPI)

4.7 Odisha

Section 3.8 of the *Odisha Grid Code (OGC) Regulations, 2015* [48] states that the STU shall prepare and submit a long-term (10 years) plan to Orissa Electricity Regulatory Commission (OERC) for transmission system expansion to meet future electricity demand. In order to fulfil this requirement, STU is required to forecast the demand in the state of Odisha for each of the next 5 years and provide OERC with details of the demand forecast data, the methodology adopted and the assumptions on which the forecasts are made. According to Regulations 3.10 (1) and (2), distribution licensees are responsible for the primary task of load forecasting in their areas of supply. They are required to determine peak load and energy forecasts of their respective areas of supply, for every consumer category, for each of the succeeding 5 years, and submit the same annually, by 31st December, to the STU, along with details of demand forecast data, methodology adopted and assumptions on which the forecasts are made. The demand forecasts are to be updated annually and whenever major changes (5 MW and above) are made in the existing forecasts. The STU is responsible for integrating the load forecasts submitted by each of the distribution licensees and determining long-term load forecasts for the state within 90 days from the date on which the distribution licensees furnish all the required information. If the distribution licensees fail to do so, the STU shall approach OERC for directives.

Regulations 7.3 to 7.9 of the OERC *Terms and Conditions for Determination of Wheeling Tariff and Retail Supply Tariff Regulations, 2014* deal with the procedures pertaining to power purchase. As per Regulation 7.4 of these regulations, the distribution licensees are required to prepare a long-term power procurement plan and submit the same to Grid Corporation of Odisha Limited (GRIDCO) every year. Estimation of the quantum of power purchased for the ensuing fiscal year is based on actual purchase(s) done during the previous year(s) and, to the extent available, for the current year, including any projection for the balance period of current year, with appropriate adjustments for any abnormal variations. Such an estimate should also consider the targets set for Renewable Purchase Obligation (RPO), energy efficiency, Demand Side Management (DSM) schemes and addition of consumers envisaged under different Central and State Government schemes like Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), Biju Gram Jyoti (BJY), etc. GRIDCO shall evaluate the power procurement plan of all distribution licensees, based on guidelines set by OERC in the above regulations, and submit the same before OERC for approval. OERC shall review the prudence of the power procurement plan and approve the quantum of power purchase on the principle of merit order despatch.

In case of direct procurement of power by distribution licensees from generators or other sources to optimise the cost, the same should be based on merit order despatch principles of all generating stations considered for power purchase. While approving such direct purchases, OERC may consider the load profiles during various seasons, technical constraints and avoidable costs after giving due consideration to valid contractual obligations.

As shown in *Figures 19 and 20,* there is significant deviation in the projections of electrical energy and demand presented in the 17th, 18th and 19th EPS Reports for Odisha. However, the state projections and the projections in the 19th EPS are in close conformity with the actuals.

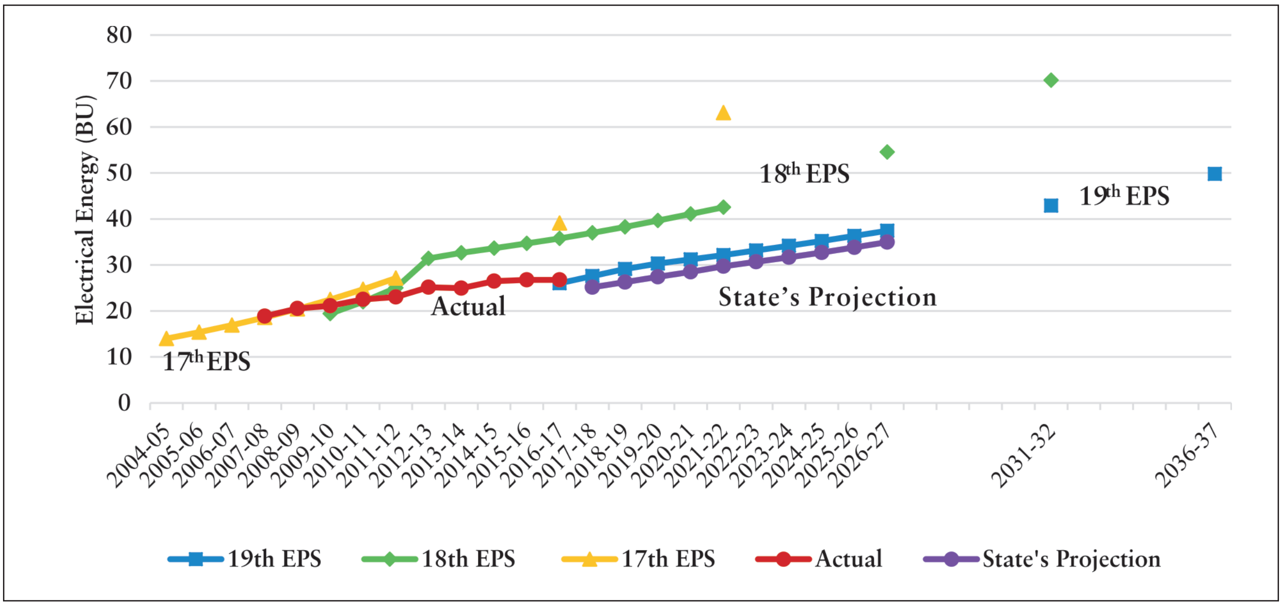

Figure 19: Actual electrical energy requirement vs. projections for Odisha

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15];
Odisha Power Transmission Corporation Limited)

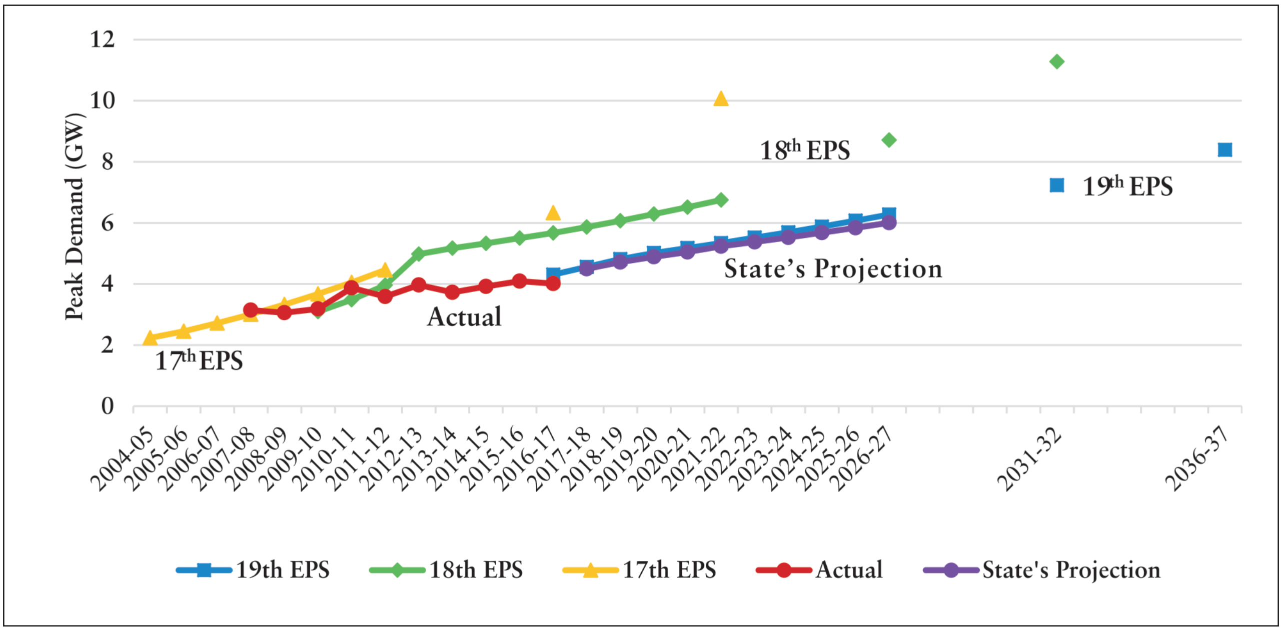

Figure 20: Actual peak demand vs. projections for Odisha

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15];
Energy Statistics, MOSPI;
Odisha Power Transmission Corporation Limited)

4.8 Punjab

Section 3.5 of the Punjab State Electricity Regulatory Commission (PSERC) *Punjab State Grid Code Regulations, 2013* [49] states that distribution licensees shall determine month-wise peak load and energy forecasts for each of the next 10 years as per PSERC *Power Purchase and Procurement process of Licensee Regulations, 2012,* and submit the same to the STU by 30th April, annually. The demand forecasts have to be updated annually or whenever major changes are made in the existing forecasts or planning. As per Section 3.3.4 of the GRID Code, the STU must maintain a historical database based on operational data supplied by the SLDC, using state-of-the-art tools such as Energy Management System (EMS), for demand forecasting. As shown in *Figures 21 and 22* below, there is a narrow range of deviation in the electricity demand and energy requirements presented in 17th, 18th and 19th EPS Reports for Punjab.

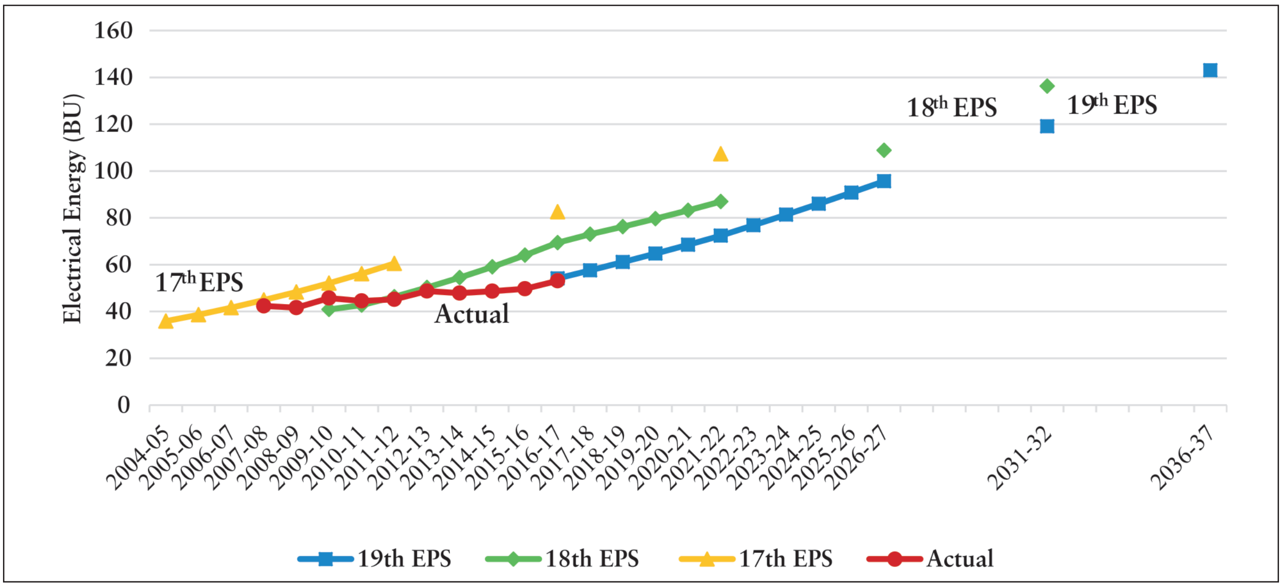

Figure 21: Actual electrical energy requirement vs. projections for Punjab

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15])

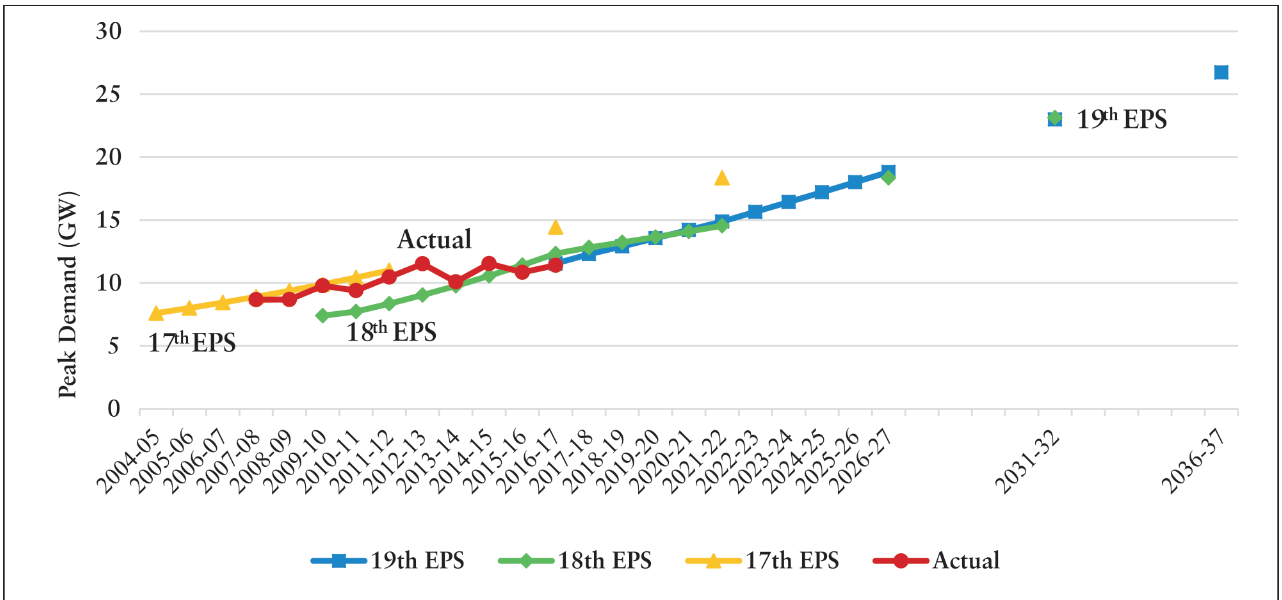

Figure 22: Actual peak demand vs. projections for Punjab

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5]; Load Generation Balance Reports (LGBR), CEA [6-15]; Energy Statistics, Ministry of Statistics and Programme Implementation)

4.9 Uttar Pradesh

Regulation 19 of the Uttar Pradesh Electricity Regulatory Commission (UPERC) *Multi-year Distribution Tariff Regulations, 2014* [50] deals with power purchase quantum and cost. Regulation 19.1 of these regulations directs the distribution licensees to submit a power procurement plan as a part of their MYT petitions to UPERC. The distribution licensees are required to prepare a short-term (less than 1 year) and a medium-term (5 years) plan, separately for peak and off-peak periods, for the unrestricted demand of electricity and for each consumer category in its area of supply, as per Regulations 16 and 17 of these regulations.

End use method and econometric approach are broadly used for long-term electricity demand forecasts in Uttar Pradesh. The multiple log-linear econometric regression formula given in Eq. 2 is used for long-term electricity demand forecast:

$$Log\ E_t = a_0 + a_1 \log (GDP_t) - a_2 \log(T_t) + a_3 \log(P_t) \qquad (Eq.\ 2)$$

where

E_t	:	electricity demand for time period 't'
a_0	:	constant term
a_1	:	percentage change in electricity demand for unit percentage change in GDP
a_2	:	percentage change in electricity demand for unit percentage change in price of electricity
a_3	:	percentage change in electricity demand for unit percentage change in population
GDP_t	:	Gross Domestic Product for time period 't'
T_t	:	average electricity tariff for time period 't'
P_t	:	population during time period 't'

Similarly, multiple log-linear regression analysis needs to be carried out separately for each major category of consumers – domestic, agricultural, commercial and industrial. The demand projected as per the above formula needs to be augmented with the distribution losses (as determined by Regulation 18 of the MYT Regulations) and transmission losses to arrive at power purchase requirement of the distribution licensees.

If there is a long-term requirement of power beyond the procurement plan, the distribution licensees are required to invite bids (through Case 1 or Case 2 bidding mechanism) for power procurement in pursuance of *Guidelines for Determination of Tariff by Bidding Process for Procurement of Power by Distribution Licensees* as notified by GoI from time to time.

As shown in *Figures 23 and 24* below, the electrical energy and demand projections presented for Uttar Pradesh in the 17^{th}, 18^{th} and 19^{th} EPS Reports have a narrow range of deviation. The state projections depict a growth rate higher than that envisaged in the EPS Reports. IIT Kanpur also made projections of electricity demand and energy requirement for the state, which has been presented in *Exhibit 2*.

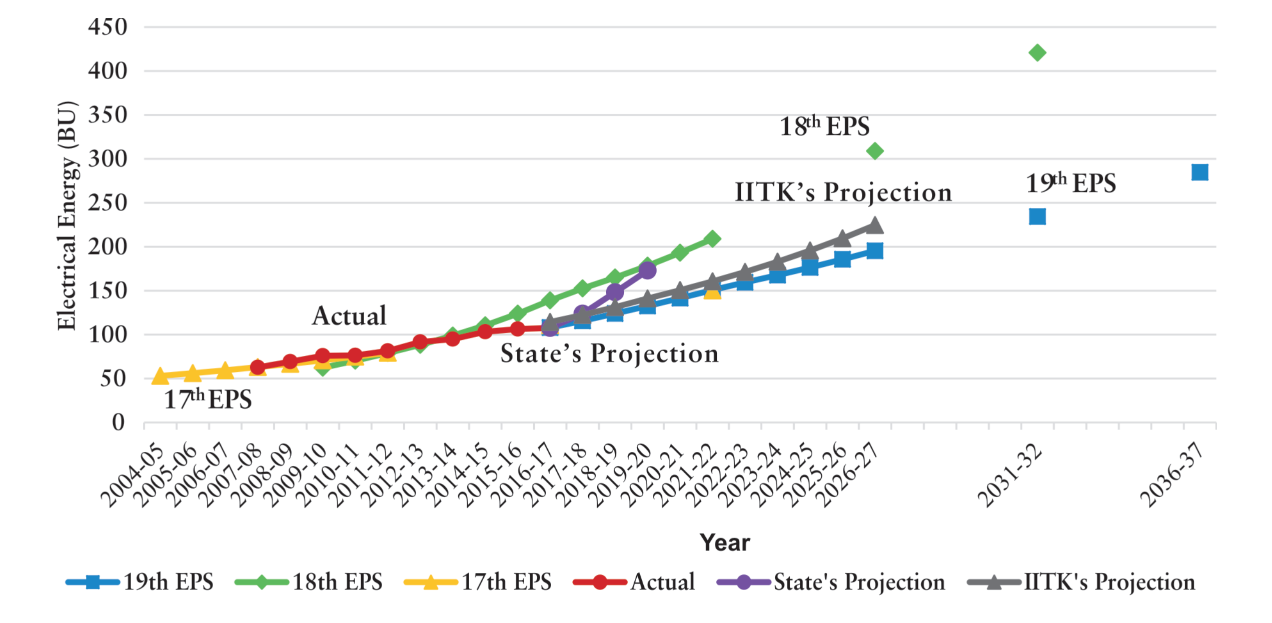

Figure 23: Actual electrical energy requirement vs. projections for Uttar Pradesh

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15];
Tariff Order of respective DISCOMs of Uttar Pradesh)

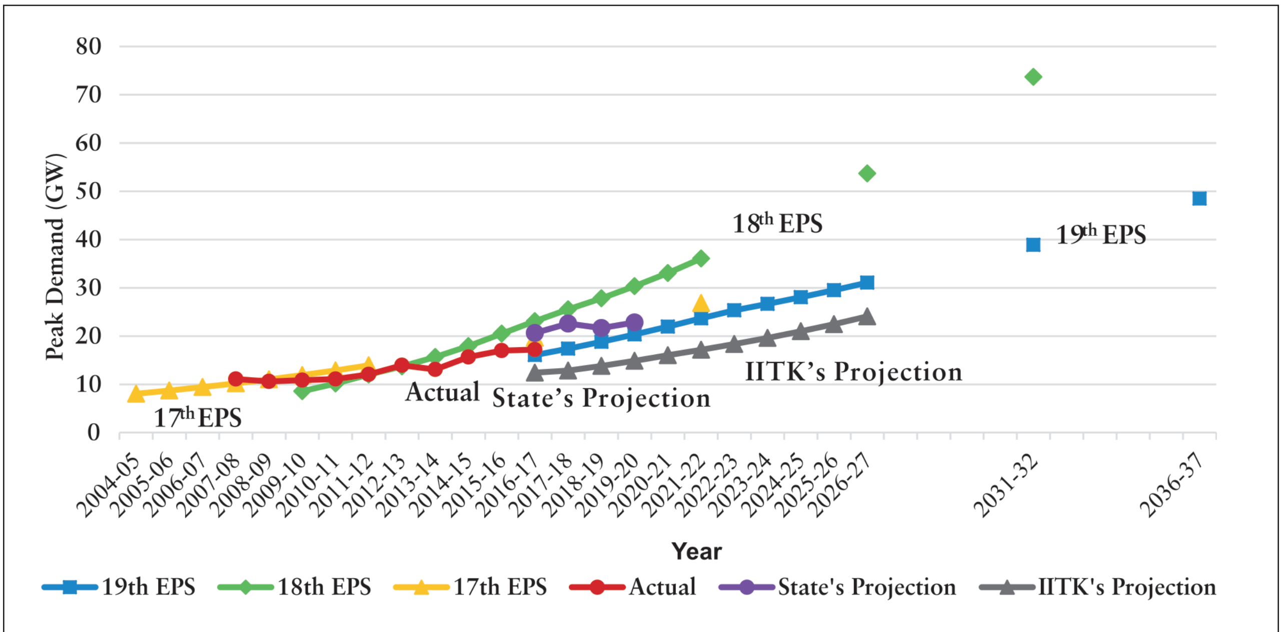

Figure 24: Actual peak demand vs. projections for Uttar Pradesh

(Source: 17th, 18th and 19th Electric Power Survey of India, CEA [3-5];
Load Generation Balance Reports (LGBR), CEA [6-15];
Energy Statistics, MOSPI;
Tariff Order of respective DISCOMs of Uttar Pradesh)

Exhibit 2: Power Procurement Strategy for Uttar Pradesh Power Corporation Limited (UPPCL) – A Study by IIT Kanpur

To improve access to electricity and provide 24×7 quality power at competitive rates to all consumers, electric utilities in Uttar Pradesh, in 2017, entrusted IIT Kanpur, through Energy Analytics Lab (EAL), the task of conducting a study to forecast long-term electricity demand and develop a power procurement strategy.

A long-term power procurement strategy needs to be based on a reliable forecast of electricity demand and realistic projections of expected load profile. Besides, a decision to enter into a long-term power purchase agreement and/or to undertake investment to expand generation capacity must be based on the economics of alternate strategies.

Evidently load forecasts are a crucial input into the decision-making process of a utility. In order to optimise power procurement portfolio, an exercise was performed for UPPCL with the objective to develop annual electricity demand projection for the state of Uttar Pradesh till the period ending in 2026-27. The aim of this exercise was to frame an optimal power procurement strategy, including a mix of long-term as well as short-term power procurement scenarios. This exercise assessed the existing and pipeline PPAs and expected power procurement from conventional and renewable energy sources, including plant retirements.

Methodology

The study involved a four-stage approach as outlined in *Figure 25*. The first step involved making realistic projections of electrical energy requirement and load profile of the state using econometric models, taking into consideration various drivers of demand like socio-economic parameters, historical trends, RE integration, DSM measures, etc. Thereafter, a unit commitment model was developed using GAMS models with the objective of minimising private and social costs. Based on the outcomes of the model, optimum power procurement strategies, with or without short-term measures, were suggested.

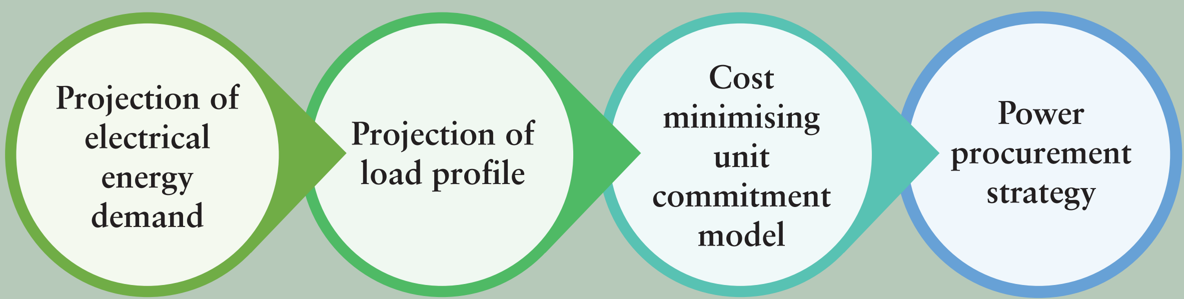

Figure 25: Approach for formulating UPPCL's power procurement strategy

Scenarios

Four alternate scenarios were considered for the development of forecasts and power procurement strategy: (i) high growth scenario, (ii) realistic growth scenario, (iii) medium growth scenario, and (iv) low growth scenario.

Recommendations

Based on the projected electricity demand, power procurement portfolio till 2026-27 was recommended for the realistic scenarios, considering policy targets for RE and DSM, under two scenarios – with and without short-term power procurement – as represented in *Figures 26 and 27* respectively.

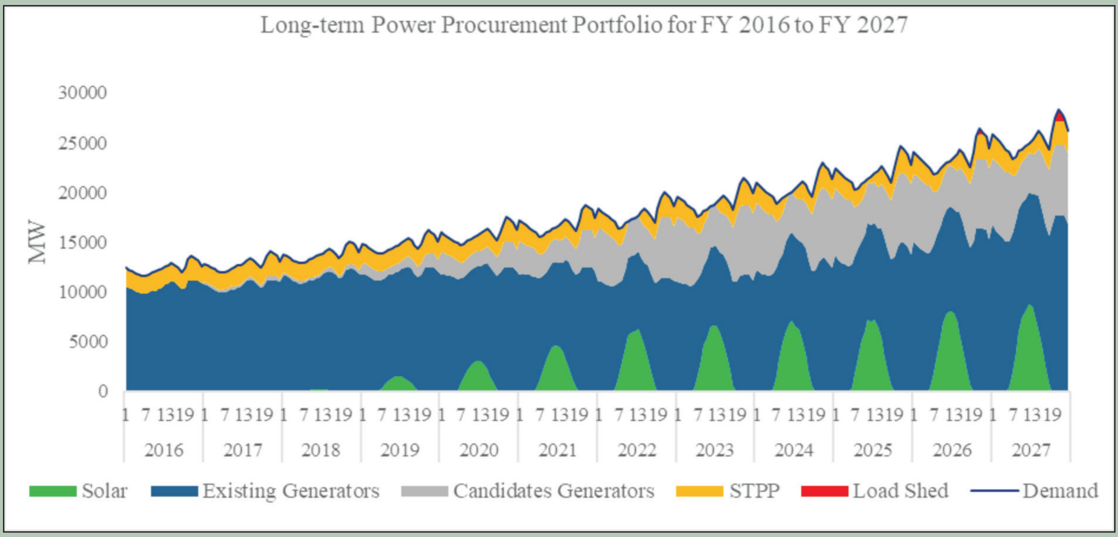

Figure 26: Realistic Growth – Policy Target (with Short-term Power Procurement)

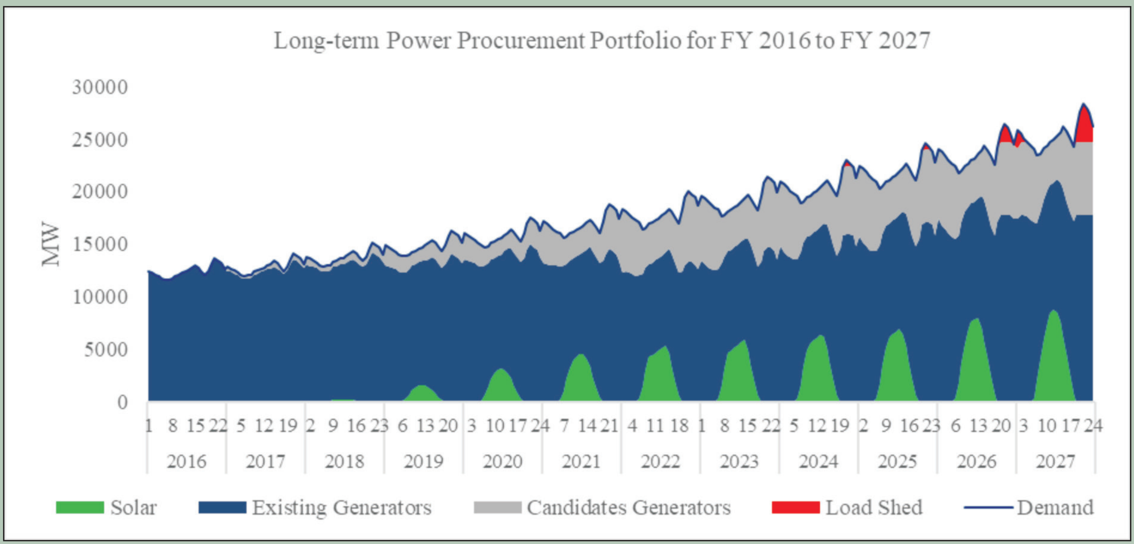

Figure 27: Realistic Growth – Policy Target (without Short-term Power Procurement)

A number of alternate strategies included floating the candidate plants to minimise the overall private and social costs. Based on the findings of the study, estimating significantly higher economic benefits for the full-float optimal procurement strategy, it was suggested that the distribution utilities should undertake such an exercise more frequently.

5. Model Long-term Load Forecast and Power Procurement Planning Regulation – Key Ingredients[3]

Long-term demand forecasting and power procurement planning requires foresighted planning by the utilities which must also be closely monitored and regulated by the respective ERCs. After deregulation, the United Kingdom power sector realised that intervention of the regulator had an important role to play in addition to load forecasting, power procurement planning and other activities undertaken by the utilities [51]. Taking United Kingdom's realisation as a general principle, India needs to put in place a strong regulatory framework.

The review of the existing regulatory framework for long-term demand forecasting and power procurement planning across the selected states presented in Section 4 reveals that there are significant variations in the framework. These variations, summarised in *Tables 4 and 5,* arise because of the differences in approach, methodology, responsibility, time horizon, etc. adopted for long-term demand forecasting and power procurement planning across states. For example, the distribution licensee(s) is/are entrusted with the responsibility of long-term demand forecasting in some states (like Delhi, Gujarat, Madhya Pradesh and Uttar Pradesh), the holding company undertakes the same exercise in some states, and the transmission licensee in others. Such exercises are also undertaken jointly by distribution and transmission licensees in a few states like Andhra Pradesh and Odisha. A number of states have enshrined the framework through specific regulations, tariff regulations, guidelines, etc. There is also a formal regulatory framework in case of some states.

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[3]The recommendations provided in this monograph have been supported by the ideas that emerged during the deliberations at the Regulatory Research Camp.

Table 4: Prevailing practices of long-term demand forecasting in the select Indian states

State	Agency	Objective	Forecasting Horizon	Deadline	Information/ data Sharing Responsibility	Compliance	Forecasting Methodology	Internal Review	Relevant Regulations
AP	DISCOM and STU	Tariff and transmission planning	10 years; first 5 years – detailed, next 5 years – simple	One year before the start of control period	DISCOM to furnish data to STU and ERC		Not specified	Public consultation; the Commission might need to independently assess, verify and validate	Guidelines for load forecast, resource plans and power procurement, Dec 2006; Reg 4 of 2005; Reg 10 of 2013; Reg 5 of 2005; Transmission and bulk supply licence regulations (17.12), Distribution and retail supply licence regulations (19.2)
DL	DISCOM	MYT and transmission planning	5 years	31st July of the base year	DISCOM to furnish data to ERC		Must consider all consumer types, DSM measures, policies, net metering and economic data		Grid Code; Regulations 5.7, 23.1 and 23.2 of MYT Regulation, 2017
GJ	DISCOMs	Transmission and power procurement planning	10 years; hourly peak and energy for first 5 years, annual peak and energy for next 5 years	31st January of every year	DISCOM to furnish data to STU SLDC		Trend analysis and reasonable assumptions for future (after considering consumer types, DSM measures, policies and economic data)		Grid Code, 2013; Guideline for power procurement by Distribution Licensee (2 of 2013); Regulations 19.2, 96.1 and 96.2 of MYT Regulations, 2016

State	Agency	Objective	Forecasting Horizon	Deadline	Information/ data Sharing Responsibility	Compliance	Forecasting Methodology	Internal Review	Relevant Regulations
MP	DISCOM	MYT and transmission planning	5 years, on a rolling basis	31st March (DISCOM to STU)	STU to maintain database		DISCOM to adopt appropriate method (Part IV of Power Purchase & Procurement Process Regulations, 2004,)	Operation and Coordination Committee (OCC)	Grid Code; Power purchase & Procurement Process Regulations, 2004
OR	STU and DISCOMs	Transmission planning	First 5 years by DISCOM, next 5 years by STU	31st Dec (DISCOM to STU), 31st March (STU to ERC)	DISCOM to furnish data to STU for submitting the compiled data to ERC	STU shall approach OERC in case of non-compliance	Must consider past trends and economic data	Operation and Coordination Committee (OCC)	Clauses 3.10 (1) and (2) and 3.8 of Orissa Grid Code, 2015; Regulations 5 and 7.3 of Terms and Conditions for determination of Wheeling & Retail Supply Tariff, 2014
PB	STU	Transmission and power procurement planning	10 years, month-wise	30th April (DISCOM to STU), 30th Nov (STU to ERC)	DISCOM to furnish data to STU for submitting the compiled data to ERC		Month-wise peak/off-peak load considering paddy/non-paddy seasons		Clauses 3.4.3 and 3.5.1 of Grid Code, 2013
UP	DISCOM	MYT	5 years	1st June (along with business plan)	DISCOM to furnish the forecasts to ERC		Must consider economic indicators of the state		MYT Regulations; Grid Code

Notes – AP: Andhra Pradesh; DL: Delhi; GJ: Gujarat; MP: Madhya Pradesh; OR: Odisha; PB: Punjab; UP: Uttar Pradesh

Table 5: Prevailing practices of power procurement planning in the select Indian states

	Who	By When	Horizon	Regulations
AP	DISCOMs	One year before the start of the control period	MYT	Guidelines for Load Forecast, Resource Plans and Power Procurement, 2006; Regulations 4 of 2005; Regulations 10 of 2013; Distribution license;
DL	DISCOMs	31st July	B Plan	Multi-Year Tariff Regulations 2017;
GJ	HoldCo/ DISCOM	31st Jan	Rolling 5 year	Power Procurement Guidelines 2013; Multi-Year Tariff Regulations 2016;
MP	HoldCo/ DISCOM	31st Oct	Rolling 5 year	Power Purchase and Procurement Regulations, 2004;
OR	HoldCo	30th Nov	10 year, revised yearly	Terms and Conditions for determination of Wheeling & Retail Supply Tariff, 2014; Grid Code
PB	DISCOM	30th Nov	Rolling 10 year	Power Purchase and Procurement regulations 2012;
UP	Holdco/ DISCOM	1st June	B Plan	MYT Regulations

Notes – AP: Andhra Pradesh; DL: Delhi; GJ: Gujarat; MP: Madhya Pradesh; OR: Odisha; PB: Punjab; UP: Uttar Pradesh

We emphasise the need for a holistic set of regulations on long-term demand forecasting and power procurement planning. The key recommendations are outlined in *Sections 5.1 and 5.2* below.

5.1 Recommendations on Regulatory Framework for Long-Term Demand Forecasting

Quantum of power procurement and associated cost have traditionally been essential components of ARR, with a section or two devoted to their analysis. Power procurement cost being the most important component of consumer tariff, we believe that this aspect needs special attention by means of a separate regulation for its approval. The exercise of long-term demand forecasting should be undertaken separately and before the approval of ARR and determination of tariff. This would ensure that adequate time and efforts are dedicated for prudence check of the largest cost component of consumer tariff.

Presently, the guidelines on long-term demand forecasting have been laid down in various regulations/ documents like Tariff Regulations, Grid Code(s), etc. The SERCs should bring together relevant portions of the existing regulations, guidelines, etc. and develop a separate regulation outlining the framework for long-term demand forecasting and power procurement planning. This would also ensure that conflicts or gaps in the existing regulatory framework are addressed. The distribution licensee(s) and the holding company in charge of power purchase on behalf of DISCOMs would play a key role here.

Demand forecast should not be seen as a stand-alone activity. It should not only draw clues from increase in consumer base envisaged, but also from the overall economic activities of the nation. The utilities of western United States use a mix of economic variables (sales, tariffs, GDP, income, employment, etc.), environmental variables (degree days, etc.) and demographic variables (population, household and appliance specific data, etc.) for different consumer categories [52]. Forecasted/historical values of above variables are obtained by the concerned utilities from several public/private sources. A mix of time-series regression, cross-sectional regression, engineering end use and statistically adjusted end use method(s) were used to forecast category-wise energy, peak demand and per capita consumption to a varying degree of detail. However, it was not possible for the authors to validate the results owing to lack of sufficient information.

We recommend consideration of the following factors while formulating a regulatory framework for long-term demand forecasting:

i. **Overall Scope:** Whereas formulation of such regulations must focus on long-term demand forecasting and power procurement planning, the regulations should encompass a wider set of related aspects like short-term demand forecasting and short-term power procurement planning, sale of excess power from underutilised PPAs through short-/medium-/long-term contracts, provision for reserves, ancillary services, shortage, etc.

ii. **Responsibility:** The regulations should clearly identify the nodal entity in charge of long-term demand forecasting and power procurement planning. While doing so, the regulations may take into consideration the existing structure of the sector and the institutional framework already in place. The regulations should also be able to accommodate (i) a situation enabling further unbundling or reorganisation of the sector, and (ii) carriage and content separation and changes due to technical disruptions in future.

iii. **Forecast Horizon:** Monthly long-term demand forecasting must be done every year, for at least a ten-year horizon, on a rolling basis. That is, this exercise must be undertaken every year by revisiting the figures forecasted in the previous year and comparing the same with the current figures.

iv. **Scope of Forecast:** The regulations should identify each distribution utility as a unit of forecast while appropriately accounting for franchisees, open access, captive generation, solar rooftop, DSM initiatives and retail supply competition in future.

v. **Nodal Entity:** The regulations should identify, in addition to the entity responsible for forecasting and power procurement planning, a nodal entity to compile and publish the approved forecasts and power procurement plans.

vi. **Regulatory Process:** The responsible nodal entity must submit its forecast(s) to the respective ERCs at least 3 months before filing of the tariff petition. The annual submission for long-term demand forecast and power procurement planning should also include stakeholder consultation along with a public hearing, giving adequate opportunity to the stakeholders to express their views. SERCs may get the methodological approach, long-term demand forecasts and power procurement plans reviewed by a public institution having adequate expertise and experience in this regard.

vii. **Base Year:** The year prior to the year in which long-term demand forecast and power procurement plan is being submitted must be the base year.

viii. **Resource Adequacy:** The distribution utility or the supplier must ensure and demonstrate resource adequacy in terms of long-term or medium-term PPAs and other alternate measures identified above up to the extent of 90-95 percent of the projected peak demand for the fifth year and 75-80 percent of the projected peak demand for the tenth year.

ix. **Methodology:** The regulation should provide only a broad methodological framework and leave the details of the methodology to the entity responsible. This would allow for the evolution of the methodology and its improvement over time with learning. However, the regulations may identify key factors that should be accounted for the development of forecasts and choice of power procurement strategy. Some of the key aspects are identified below.

a. Long-term demand forecast

The key factors that influence long-term demand are:

- Existing and expected consumer mix
- Economic activities across key sectors like industrial, agricultural, commercial and transportation, etc.
- Growth in population across rural and urban areas
- Expected changes in lifestyle due to better availability of electricity and technological development
- Growth in open access, captive generation, solar rooftop, storage, retail competition, franchisee, etc.

b. Power procurement strategy

The key considerations are:

- Minimising the cost of power purchase to meet the desired resource adequacy for the projected long-term demand of electricity as the objective of the utility
- The existing as well as pipeline PPAs including generation capacity addition in the state through CGS, IPPs and RES
- Meeting RPO (solar/non-solar) and its compliance, considering the role of RECs

Furthermore, there should be an extensive stakeholder consultation during the demand forecasting exercise, and an external review mechanism by a public institution should be in place.

x. **Data Sharing and Warehousing:** Being one of the key ingredients of long-term demand forecasting and power procurement planning, the regulations should specify the role of various stakeholders in collecting, verifying and archiving the associated data. These data and all other relevant information should be archived and made publicly accessible in order to promote research for improving upon the prevailing methodology. Role of academic community should be highlighted for the same.

xi. **Compliance Monitoring:** The regulations must also provide for a mechanism to monitor regulatory compliance in the matter and a forum for grievance redressal. The relevance of the regulations can only be ensured by implementing a compliance monitoring framework which would identify responsibilities of the stakeholders and the mechanism to address the shortfall thereof.

Exhibit 3

A study on long-term demand forecasting for Romania compared the two most widely used approaches for demand forecasting – econometric approach and end use accounting approach [53]. The former tries to establish a statistical relationship between energy consumption and macroeconomic variables of the country and then uses historical data to predict the future. This is suitable for forecast at an aggregated level. The latter approach uses data from the end-users/consumers to prepare forecasts at sector levels which can be further aggregated to arrive at state/regional/national level forecasts.

The broad sectors used in the study included residential, services, industry and transportation, which were further divided into a number of subcategories. The study used energy consumption, socio-economic, demographic and technological data obtained from various sources. The following key factors were identified and used as inputs – GDP, population, building floor space, demolition and occupancy rates, appliance ownership, industrial production, mining and quarrying, construction, transport demand and rebound effect. Using these inputs, forecasts were made for various growth rate scenarios for Romania for the time period 2013-2050.

5.2 Recommendations on Regulatory Framework for Power Procurement Planning

Power procurement plan for a distribution utility has to be made on the basis of demand forecasts for the next 10 years, with a load curve for each month. As electricity demand is variable across different hours of the day, planning needs to be done keeping in view the peak and base demands which need to be matched with the generation capacities of base and peaking plants and the PPAs in place. The key factors to be considered in such regulations are enumerated below:

i. **Existing Contractual Agreements:** Every distribution utility may have a set of long-term, medium-term and short-term power PPAs in place. Due consideration must be given to, but not limited to, the following parameters of existing, prospective and pipeline PPAs:
   - Capacity, technical minimum
   - Must-run status
   - Ramp-up and ramp-down rates
   - Start-up time
   - Fixed cost, variable cost and compensation to operate between PLF range of 55-85 percent
   - Expected availability
   - Reserve margin
   - Peak, off-peak, round-the-clock (RTC) and seasonal nature of demand and power procurement plan

ii. **Network Constraints:** Capacity, charges and inter- and intra-state transmission and distribution network losses are key inputs to the power procurement plan and must duly reflect in the regulations, along with the projected transmission capacity additions[4].

[4]*A power procurement strategy may in turn provide the estimated requirement for intra- and inter-state transmission capacity additions in future.*

iii. **Renewable Energy:** The regulations must also provide for the purchase of green energy not only for the mere fulfilment of RPO but also for mitigating the uncertainties associated with rooftop generation (net/gross metering) and the inherent variability of renewable generation.

iv. **Captive Generation and Open Access:** The regulations must provide for captive generation at consumer premises and its interaction with the grid. Improved availability of electricity from the utility and greater open access may have a significant impact on electricity demand and may thus necessitate a dynamic power procurement strategy.

v. **Disruptive Technologies:** New and emerging technologies like economical storage, smart grids, electric vehicles, etc. are likely to play an important role in the making of power procurement portfolio of DISCOMs and must be provided for in the regulations; addition of urban electrified transportation systems like metro rail should also be considered.

vi. **Banking:** A very significant factor in the entire energy management process of utilities is the availability of banking arrangement of long-term nature. Banking enables the utilities to optimise their power procurement cost by purchasing higher quantum of power during periods of low rate, irrespective of the demand during that time. This would significantly influence power procurement planning as a whole and, therefore, the regulations must have appropriate provisions for the same.

vii. **Carriage and Content Separation:** Carriage and content separation is likely to significantly disrupt long-term demand forecasts and power procurement, leading to rebalancing of the power procurement portfolio.

A robust power procurement plan would ensure that demand of electricity in the state is met in the most economical and efficient manner, thereby having satisfied consumers and prosperous utilities.

6. Conclusion

The Electricity Act, 2003 gives ample power to SERCs for effectively regulating power utilities and ensuring their economic and efficient operation. Power procurement cost, which has the highest impact on consumer tariffs, needs due regulatory attention. DISCOMs procure power through a mix of long-term, medium-term and short-term arrangements. Decisions regarding quantity, cost and associated terms of procurement depend on the projected demand profile and the available options for procurement. A reliable forecast would enable the utilities to design their power procurement portfolio in a manner that meets the consumer demand in an economical manner, keeping in view the requirements of system adequacy.

We reviewed the existing regulatory framework for long-term demand forecasting and power procurement planning across selected states of India, along with practices followed in a few other countries. We observed that the demand projections reported by CEA in 17th, 18th and 19th EPS Reports varied by up to 25 percent. Also, there exist differences in the scope, objective, time horizon, entity responsible, etc. for demand forecasting across the states in India as well as across countries. Through the analysis of these parameters, we identified the following key factors to be considered while framing a holistic set of regulations on long-term demand forecasting and power procurement planning:

- Demand projections and power procurement plans should be made considering various sources of power like long-term, short-term, ancillary services, etc.
- The forecasts should be made at the distribution utility level and nodal agencies may be identified and entrusted with the responsibility of making long-term demand projections, and compiling and publishing those projections.
- Demand projections must be made for at least a ten-year horizon, which must be revised every year, based on updated scenarios.

- The regulations should not specify any particular methodology and should leave room for innovation. However, the factors to be considered, like economic indicators, climatic condition, anticipated load growth, etc. may be specified.
- Factors like network constraints, high renewable energy penetration, captive generation, etc. need to be factored in while making power procurement plans.

The review enabled us to identify the key parameters that need to be incorporated while framing a holistic set of regulations for long-term demand forecasting and power procurement planning. The exercise of demand forecasting needs to be more streamlined, with specific timelines for each activity, a standardised forecast horizon and frequency of revision. Electricity demand forecasts would serve as an input to power procurement planning by DISCOMs and capacity augmentation planning by TRANSCOs and GENCOs, at state, regional and national levels. Therefore, inputs from all stakeholders and interest groups may be incorporated in order to enrich and enhance the efficacy of demand projections and power procurement planning.

The drivers for electricity demand vary across states and so do the demand patterns and options for power procurement. The recommendations provided in this monograph may be adopted with suitable modifications as per the context of the respective states. The existing regulatory framework can thereby be strengthened further to the benefit of the sector in general, and consumers in particular.

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Centre for Energy Regulation
Department of Industrial and Management Engineering
Indian Institute of Technology Kanpur
Kanpur–208016, India
Email: cer.iitk.ac.in   Phone: +91-512-259-7453

cer.iitk.ac.in

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