Power Procurement Planning for Uttar Pradesh

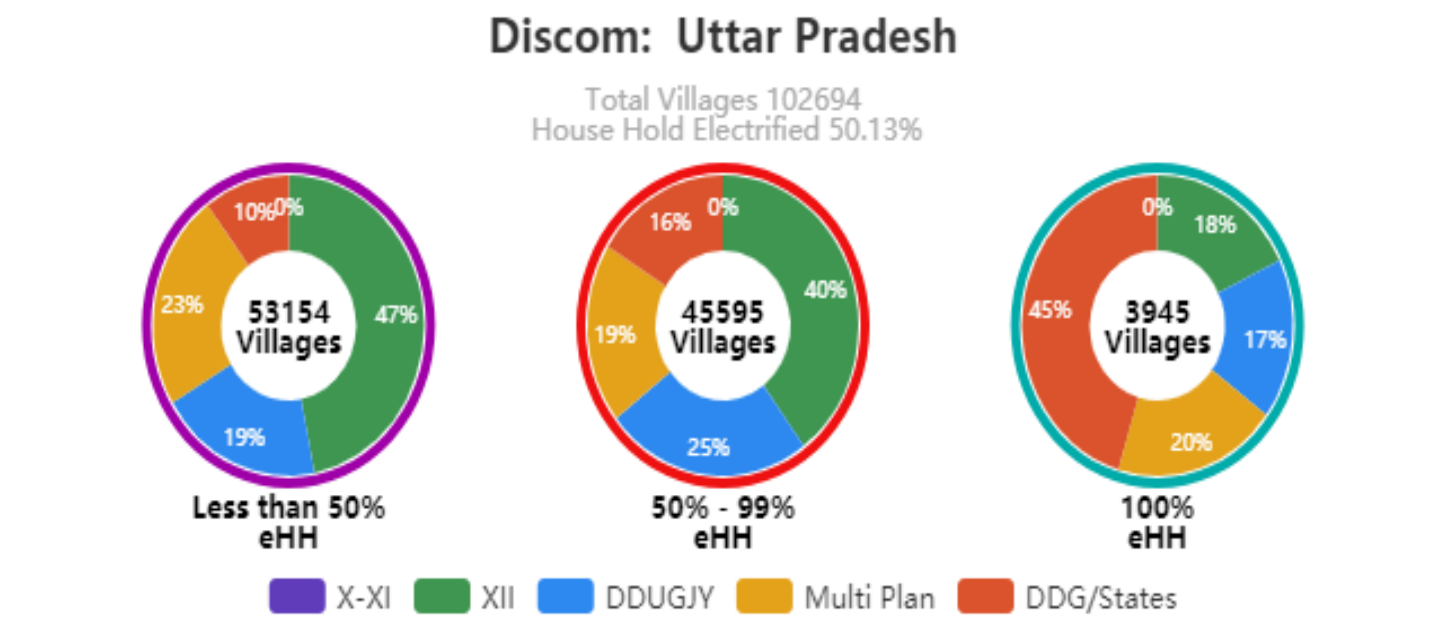
Dr. Anoop Singh
Dept. of IME, IIT Kanpur

Power For All - A joint initiative of Central Government with the State Government

Objective - Provide 24x7 power

through:

- Village Electrification
- Capacity Addition
- Power Purchase Plan
- Strong T & D
- Encourage Renewable Energy
- Customer Centric Initiative
- Reducing AT & C Losses
- Reducing ACS to ARR difference



* Source - MOP –GARV Dashboard

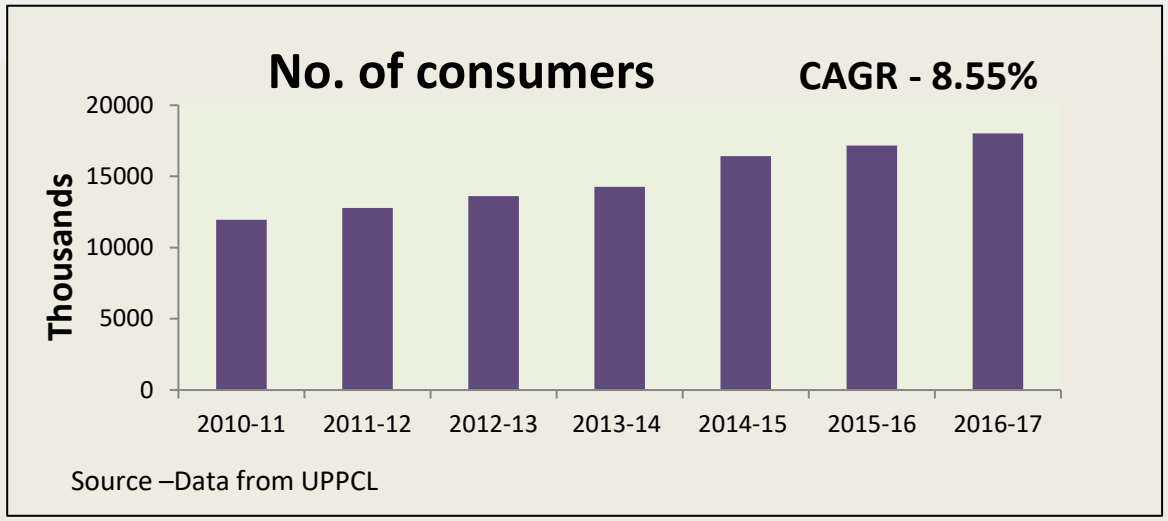
Currently, Average power supply *	
Rural areas	18 hours
Tehsil towns and Bundelkhand	20 hours
District headquarters, cities and industries	24 hours

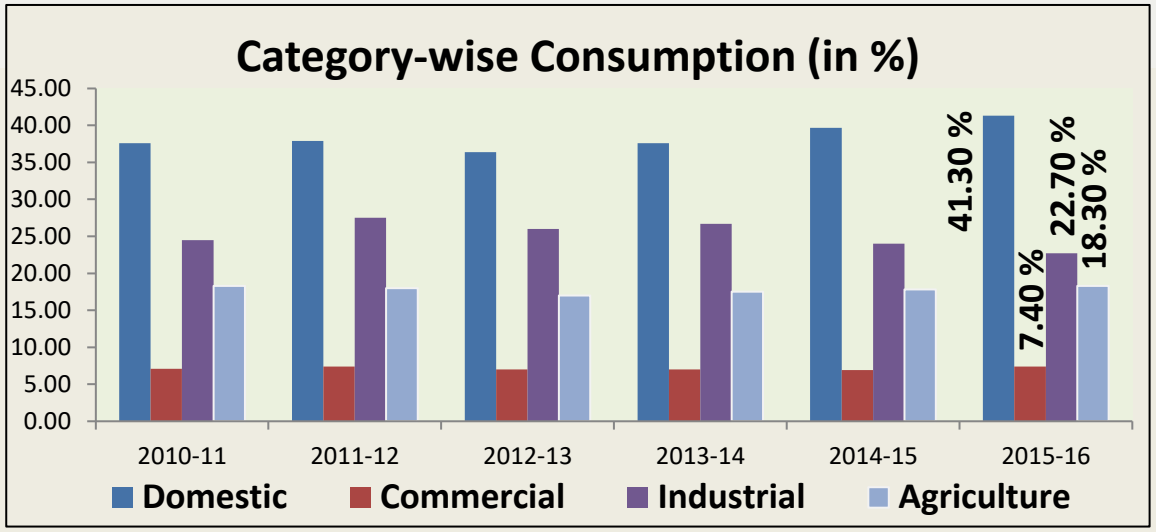
Total Rural Households:	**3,01,22,462**	
EHH Up to 31st Dec16:	**1,48,13,021**	**(49 %)**
EHH from 1st Jan17:	**2,86,587**	**(1%)**
Total EHH :	**1,50,99,608**	**(50%)**

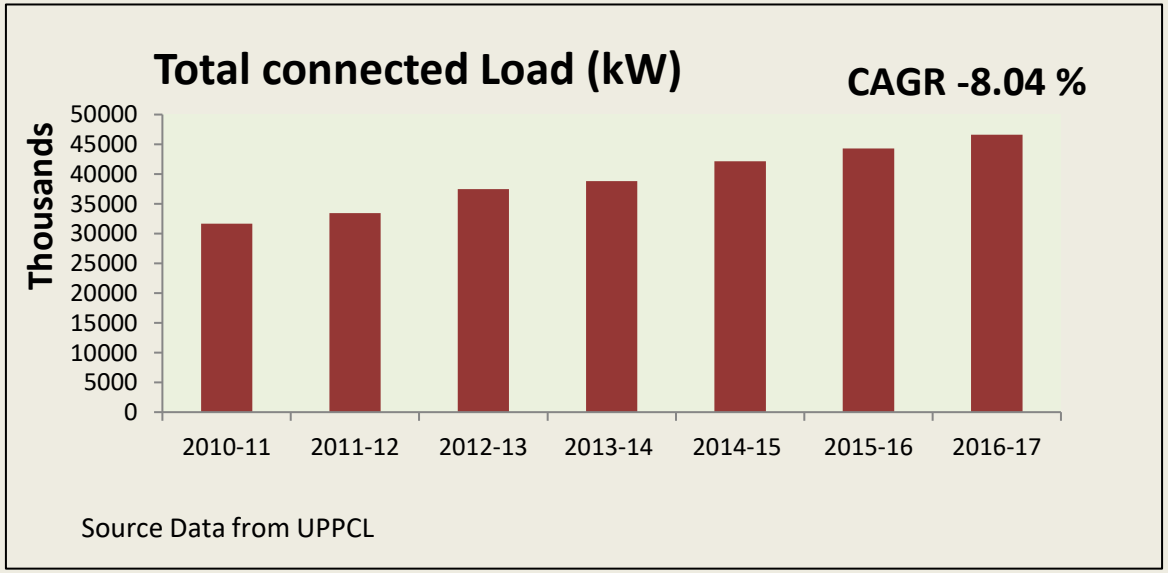
2 * Source -projections as per census, 24x7 Power for All document

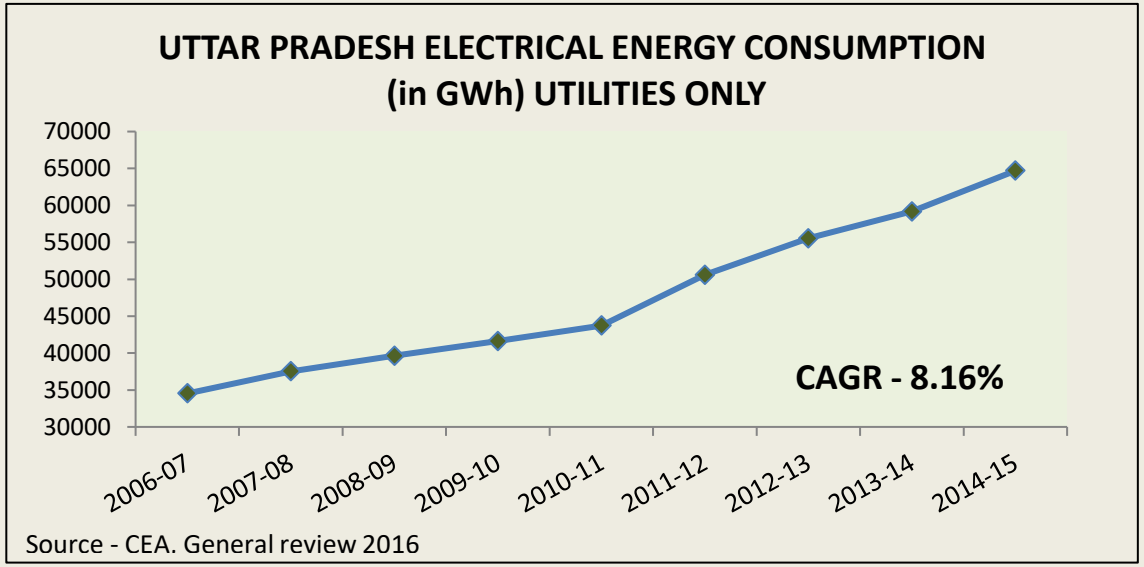
Power supply position in U.P.

Max Unrestricted Demand (MW)	**18,827 MW** (05-06-2017, 22.00
Max Demand Met (MW)	**17,552 MW** (05-06-2017, 22.00)
Max. Energy Requirement	**391.9 MU** (05-06-2017)
Maximum Energy Demand Met	**388.29 M**U (05-06-2017)

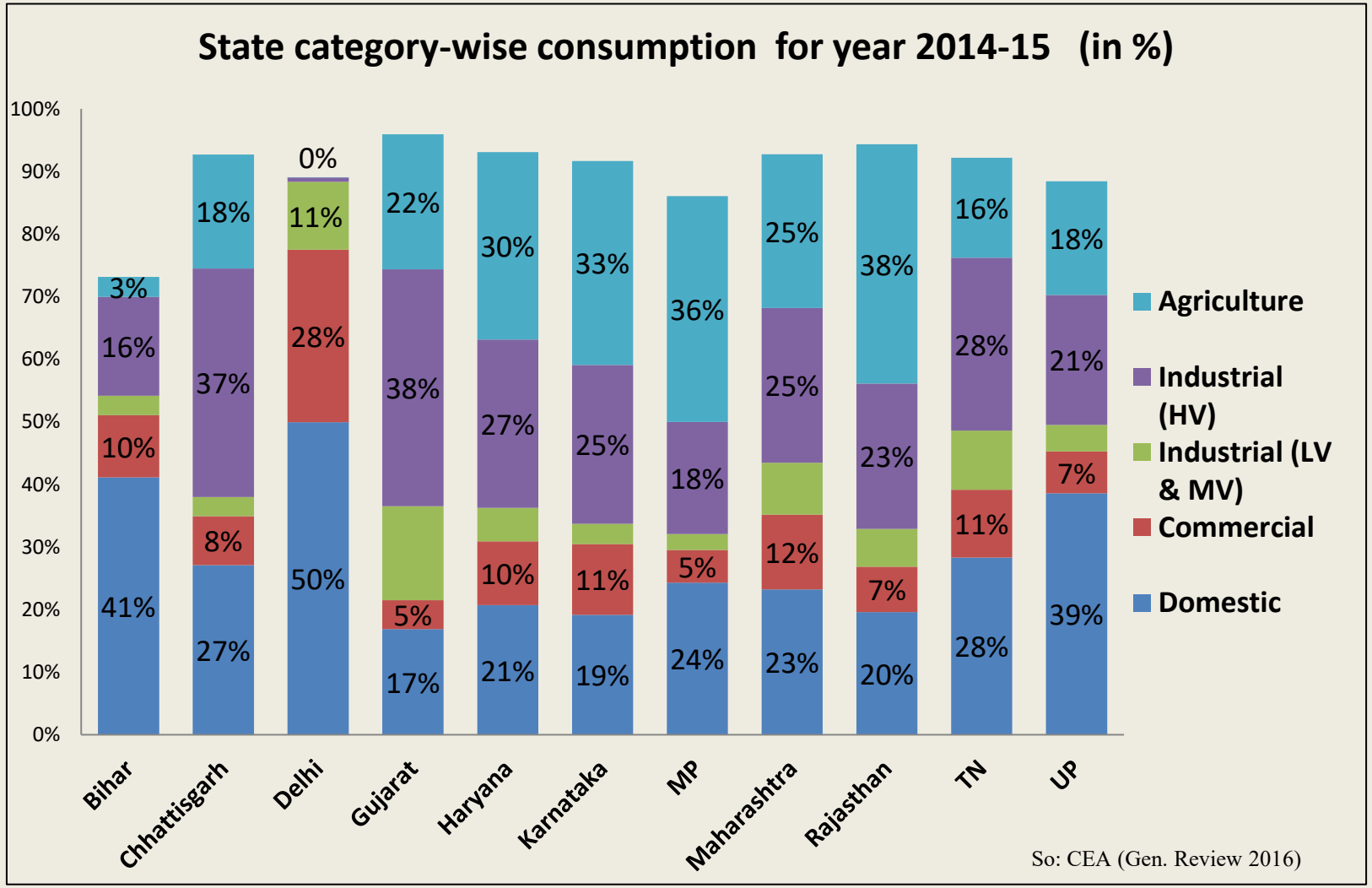








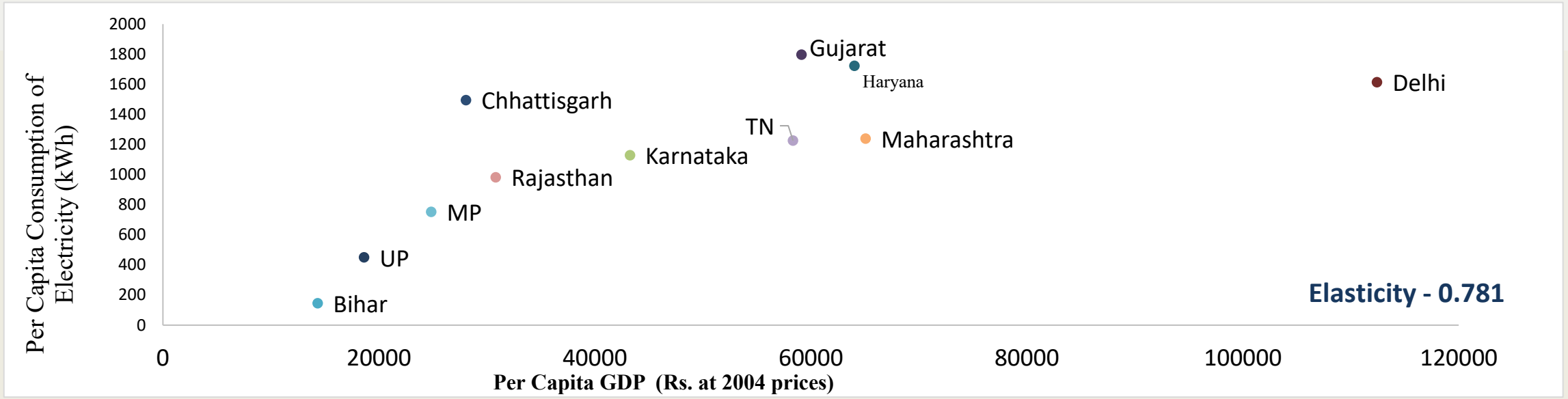
Data Source : UPPCL, http://www.uppcl.org/pdf/staticks-at-a-glance-2015-16.pdf

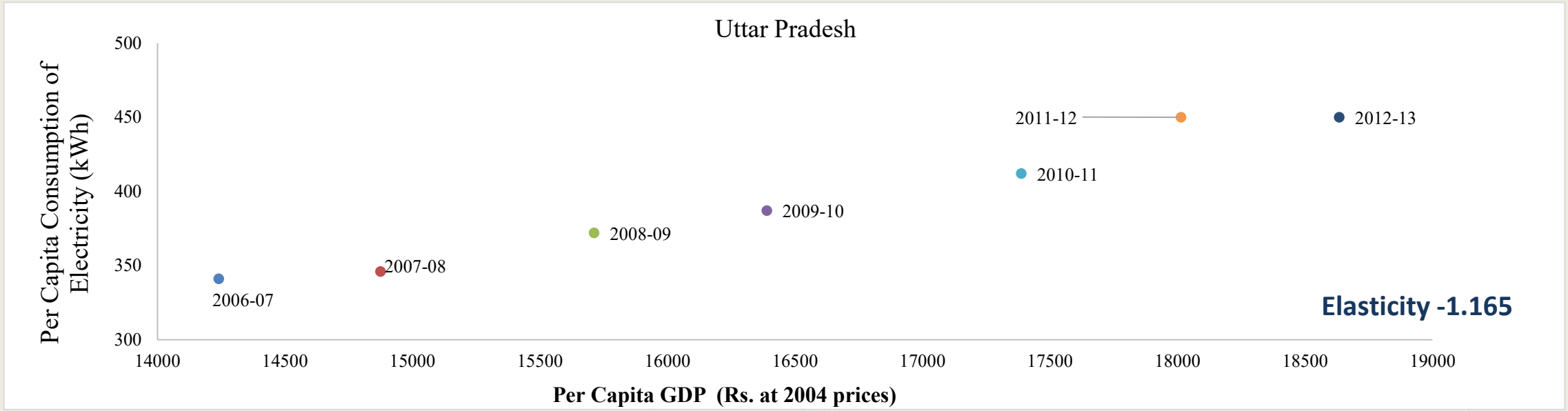


So: CEA (Gen. Review 2016)

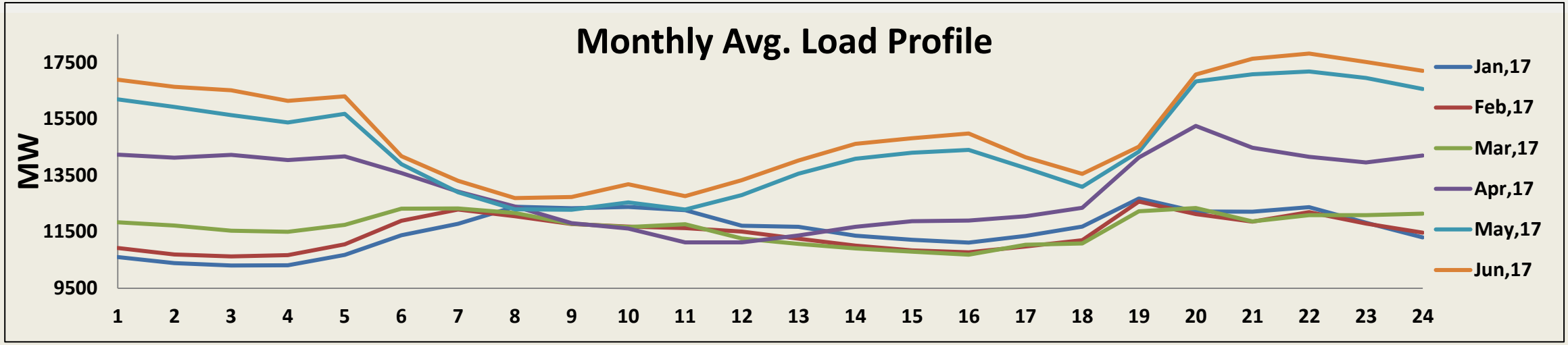
U.P. Category- wise connected load per consumer 2016-17 (kW)	
Domestic	1.69
Commercial	2.67
Industrial(Small & Medium)	10.28
Industrial(Large & Heavy)	381.33
Total (Overall)	2.59

Electricity Consumption in UP (cross-section and time series)

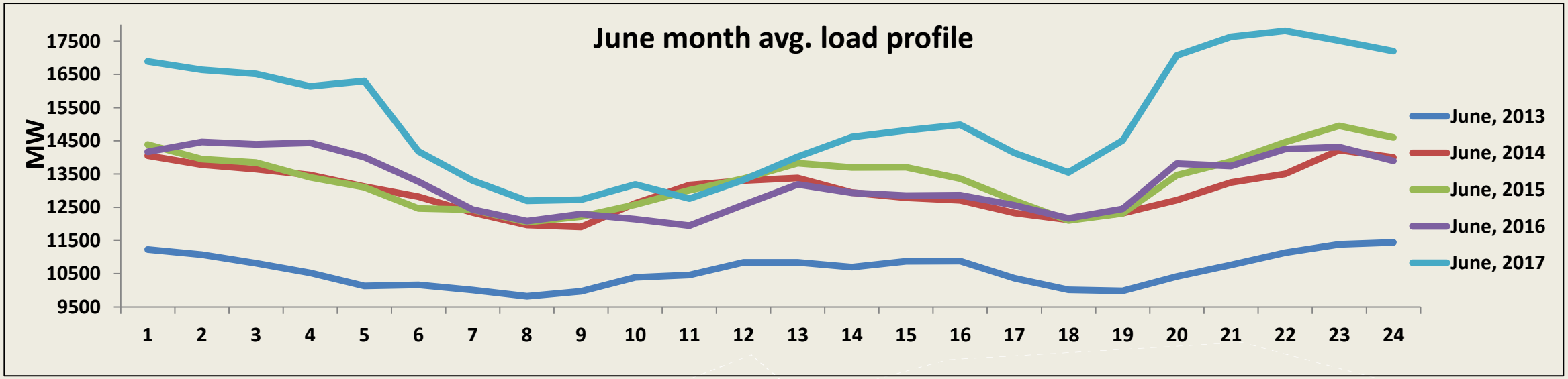




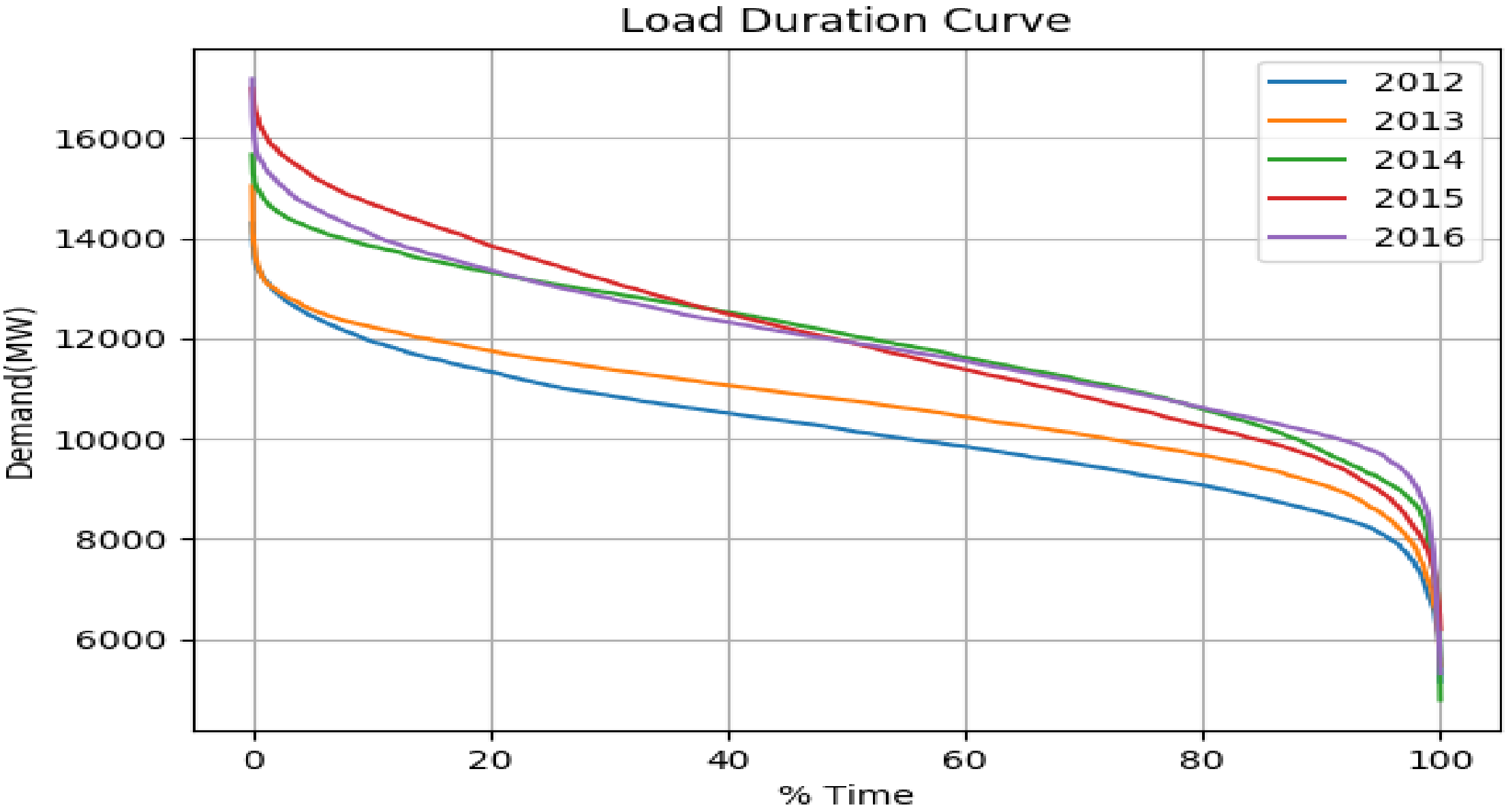
Uttar Pradesh - Power supply position



Source - Night Report ,UPPCL



 Source - Night Report ,UPPCL

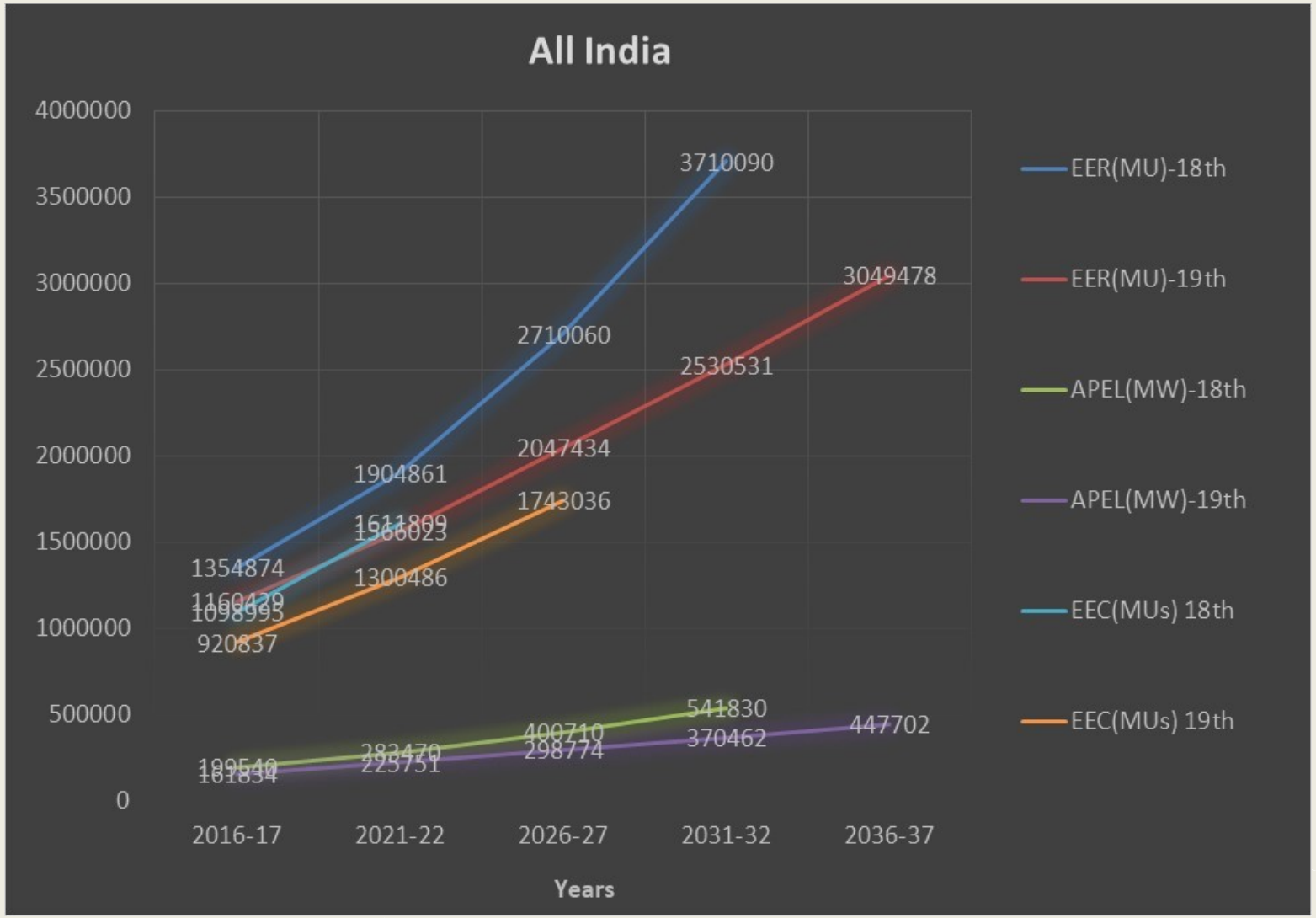


Source - Night Report ,UPPCL

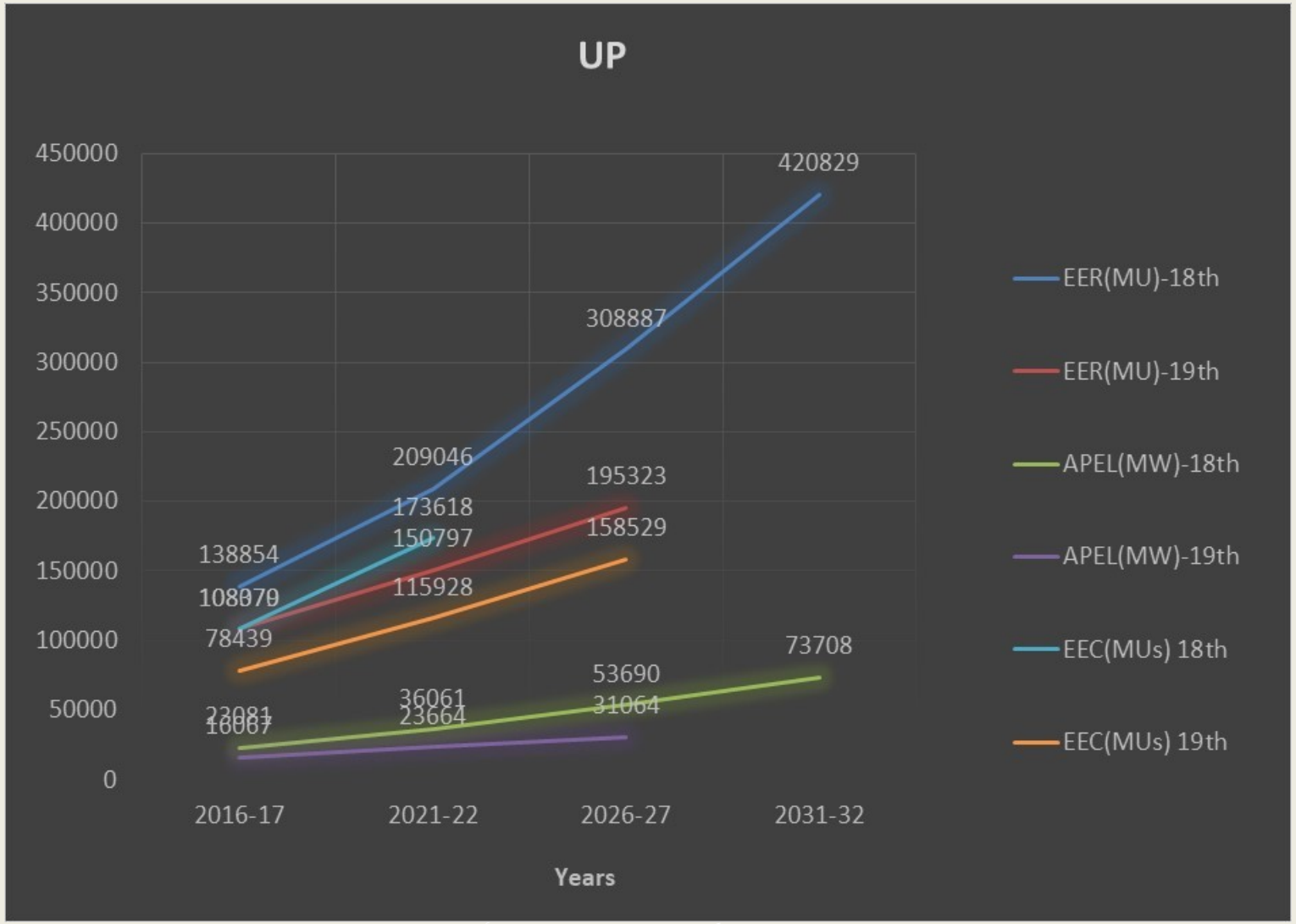
All India

APEL(MW) 2015-16
153366

2015-16 EER 1114408



UP


UP
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
2016-17
2021-22
2026-27
2031-32
Years
420829
308887
209046
195323
173618
158529
150797
138854
115928
108070
78439
73708
53690
36061
31064
23664
23081
16067
EER(MU)-18th
EER(MU)-19th
APEL(MW)-18th
APEL(MW)-19th
EEC(MUs) 18th
EEC(MUs) 19th

Long-Term Power Procurement Planning

Objectives

- Demand projection for the power requirement in Uttar Pradesh
- Assess the available, proposed and expected power procurement from conventional and renewable energy sources
- Optimize the power procurement to meet future peak load & energy requirement
- Develop a power procurement scenario with a mix of long-term, medium-term PPA and short-term power procurement

Methodology

1. Projection of peak load & energy requirement

2. Load profile and load duration curve analysis

3. Expected demand for electricity (load curve) considering Solar gen. profile

4. GAMS Based optimisation model

1. Projection of peak load & energy requirement

Trend Analysis	• Study the past growth pattern
End Use method	• Study category-wise connected load, electricity consumption and growth pattern
Econometric Models	• Forecast considering economic change

2. Load profile and load duration curve analysis

- Inference from historical load profile and load duration curve
- Account for demand profile influenced by supply
- Projecting energy/peak load for future using statistical techniques

Methodology (continued)

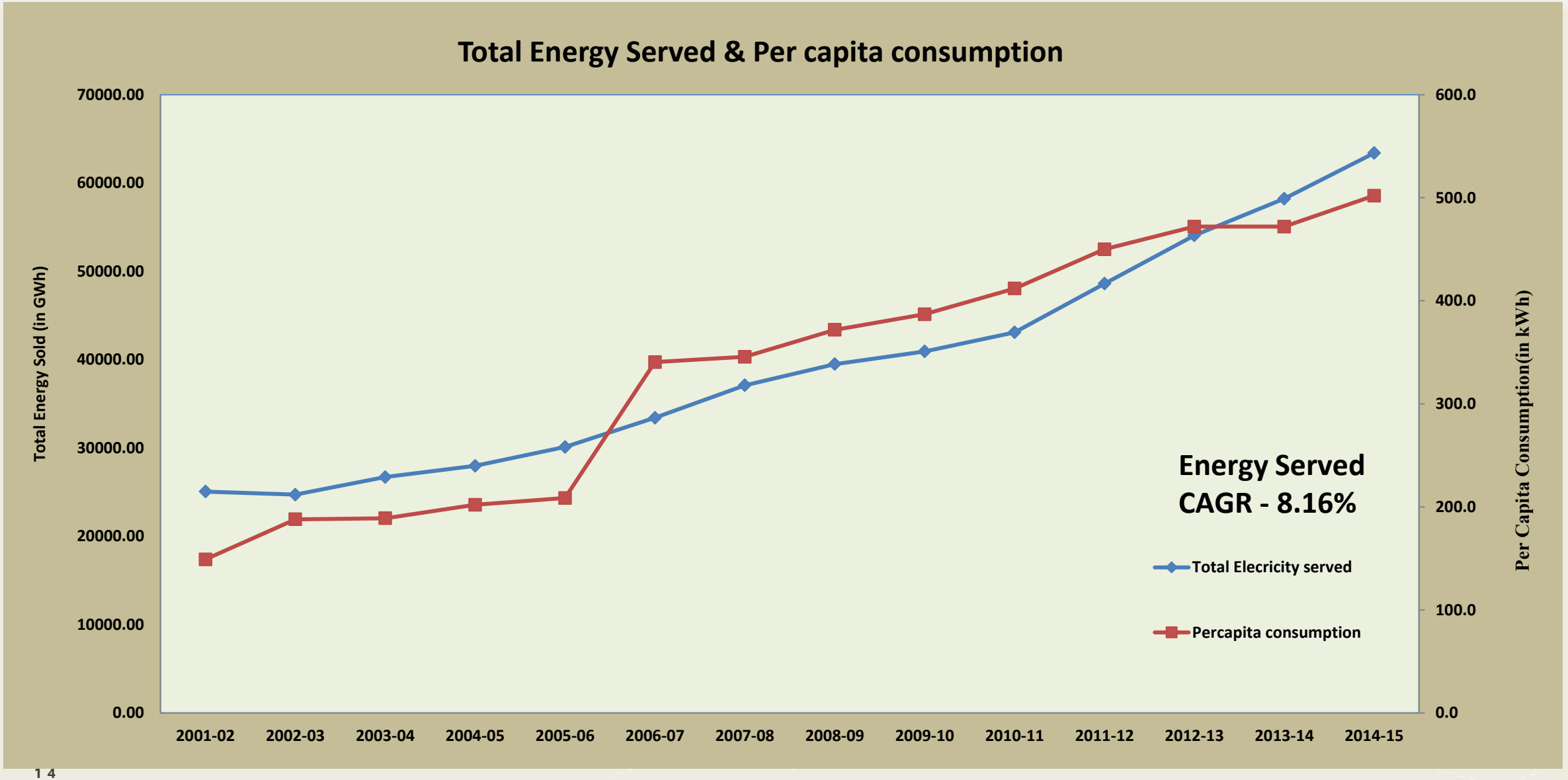
3. Expected demand and load profile

- Solar capacity and projected addition
- Solar generation curve and it’s effect on load profile
- Impact of ToD

4. GAMS Based optimisation model

- Projected Load profile
- Existing and candidate power procurement sources
- Cost of power procurement variables (base charge, Escalation factor, fixed &variable cost)
- Solar addition effect on load profile.

U.P. Electricity Consumption Behaviour



Econometric Method

Energy Require Estimation (at bus bar)

Factors used for Per capita consumption of electricity estimation

- Per capita SGDP,
- Urbanisation ,
- % Share of Agri. & Allied , Industries and Trade & Services in GDP
- Price of electricity

Assumption

a) Economic growth rate (High, Medium, Low and Realistic)
b) Urbanisation projected
c) % Share of different sector in GDP
d) Price of Electricity

15

Econometric Model

Total Energy Required at Bus Bar

Per Capita Electricity Consumption $= f$ *(SGDP, Price of Electricity, Urbanisation , Share of Agri. & Allied Services in State GDP, Share of Industries in State GDP)*

Total energy required = Per Capita Consumption x population (projected)

Regression Models

	Response Variable	Independent Variable					
Model 1	Log(Per capita consumption)	Intercept	log(Per capita SGDP)	% urban population	% primary share	% secondary share	Time
		-4.20 ***	0.861437 ***	0.013862***	2.631797***	2.711178***	-0.020524
Model 2	Log(Per capita consumption)	Intercept	log(Per capita SGDP)	% urban population	% primary share	% secondary share	
		-3.50 ***	0.77216***	0.01 ***	2.42 ***	2.797428***	
Model 3	Log(Per capita consumption)	Intercept	Per capita SGDP	% urban population	% primary share	% secondary share	
		3.83 ***	8.61E-06 ***	0.02 ***	2.81 ***	3.64 ***	
Model 4	Per capita consumption	Intercept	Per capita SGDP	% urban population	% primary share	% secondary share	
		-910 ***	7.36E-03 ***	10.97 ***	1853.00 ***	1788 ***	
Model 5	Per capita consumption	Intercept	Per capita SGDP	% urban population	% primary share	% secondary share	Price
		-870 ***	1.10E-02 ***	8.02 ***	1682.00 ***	2098.00 ***	-41.69 *
Model 6	Log(Per capita consumption)	Intercept	Per capita SGDP	% urban population	% primary share	% secondary share	Price
		3.87 ***	1.40E-05 ***	0.02 ***	2.70 ***	4.11 ***	-0.07 **
Model 7	Log(Per capita consumption)	Intercept	log(Per capita SGDP)	% urban population	% primary share	% secondary share	Price
		-5.10 ***	0.94 ***	0.01 ***	2.18 **	3.24 ***	-0.06 **
Model 8	Log(Per capita consumption)	Intercept	log(Per capita SGDP)	% urban population	% primary share	% secondary share	log(Price)
		-4.90 ***	0.91 ***	0.01 ***	2.14 ***	3.29 ***	-0.12 *

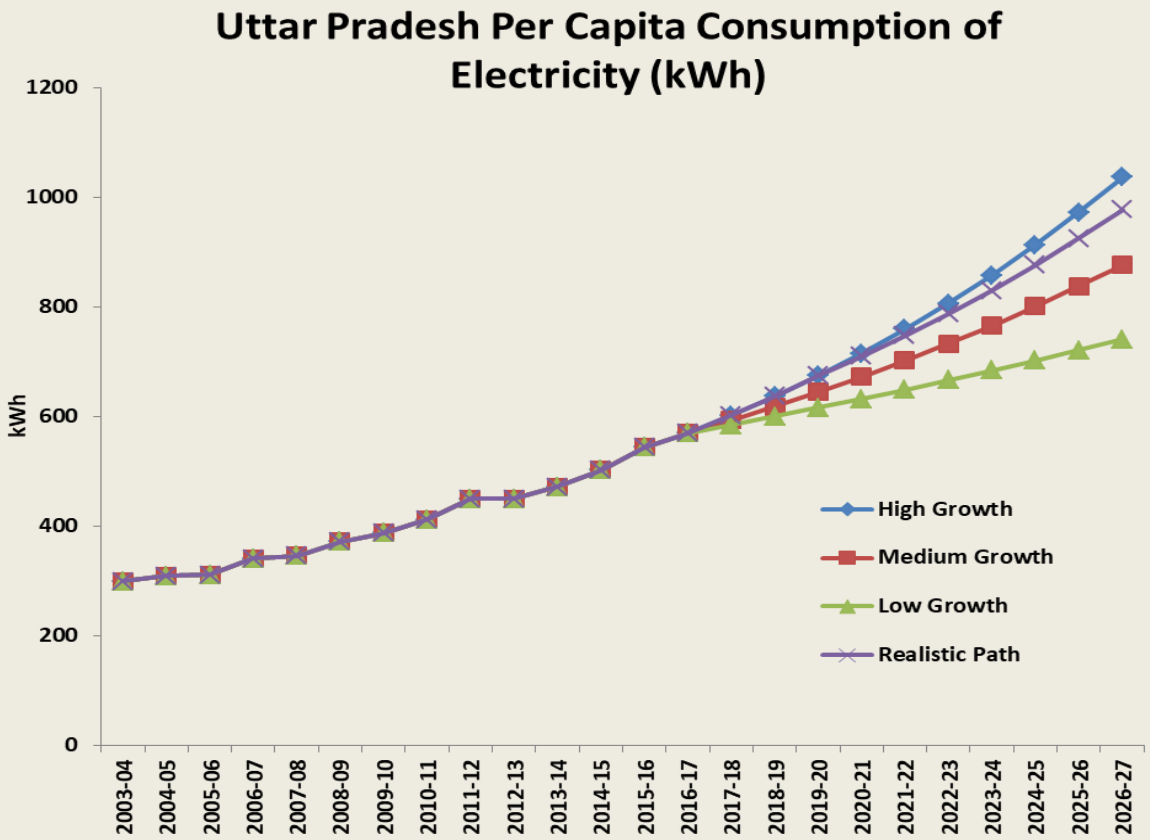
Forecasting Results

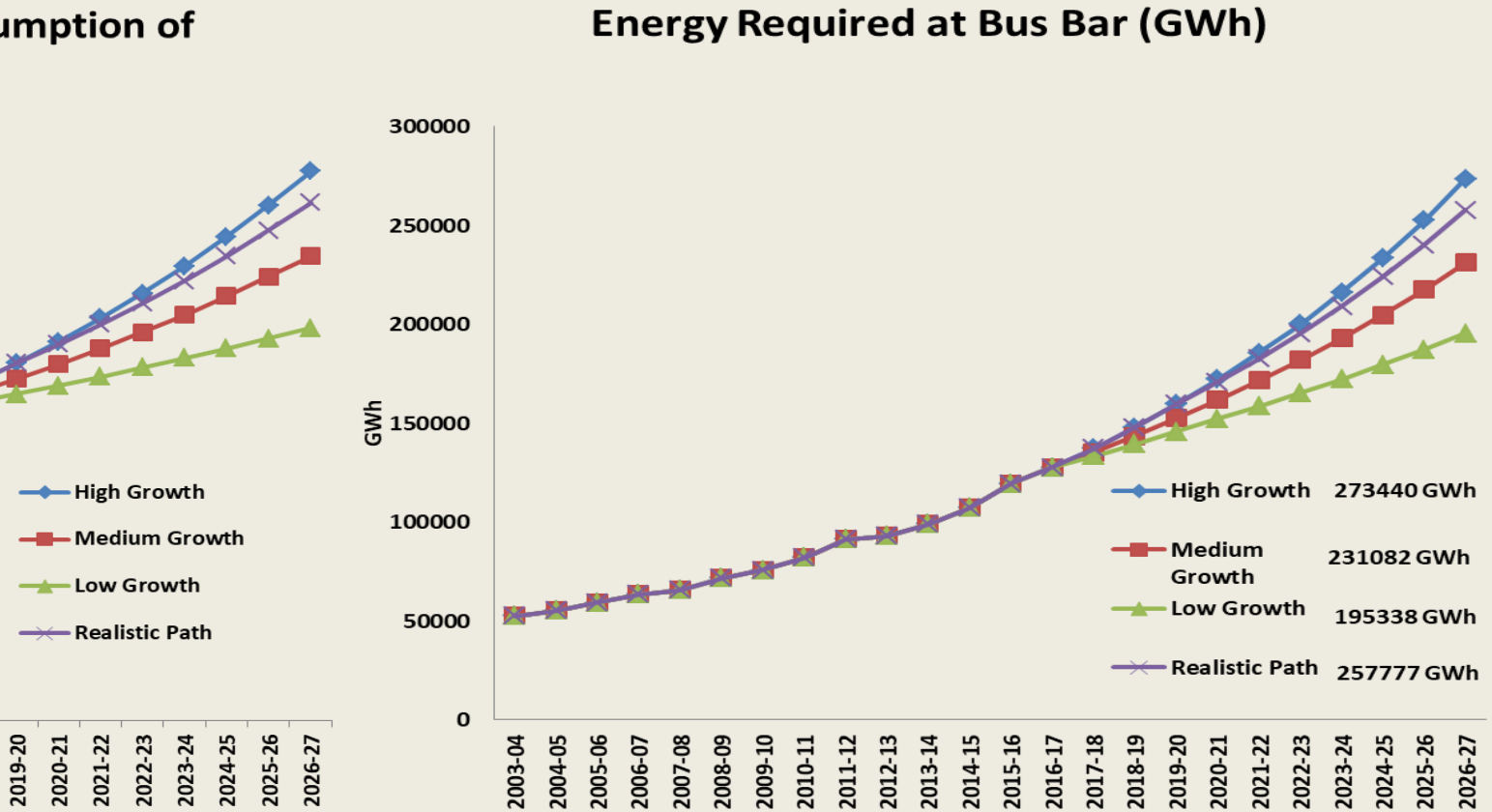
Per capita Consumption of electricity kWh (Model 5)				
Year	High	Medium	Low	Realistic
2015-16	543.47	543.47	543.47	543.47
2016-17	569.74	569.74	569.74	569.74
2017-18	602.13	593.40	584.67	602.13
2018-19	637.05	618.37	600.03	637.05
2019-20	674.72	644.73	615.86	674.72
2020-21	715.37	672.59	632.15	709.87
2021-22	759.25	702.02	648.94	747.42
2022-23	806.62	733.13	666.25	787.55
2023-24	857.78	766.02	684.08	830.45
2024-25	913.04	800.81	702.47	876.32
2025-26	972.74	837.62	721.43	925.37
2026-27	1037.26	876.58	740.99	977.85

Total energy Required at bus bar kWh (Model 5)				
Year	High	Medium	Low	Realistic
2015-16	119413	119413	119413	119413
2016-17	127564	127564	127564	127564
2017-18	137274	135283	133293	137274
2018-19	147884	143546	139290	147884
2019-20	159484	152396	145570	159484
2020-21	172176	161878	152147	170852
2021-22	185529	171544	158576	182640
2022-23	200118	181885	165293	195388
2023-24	216064	192951	172312	209181
2024-25	233500	204799	179649	224109
2025-26	252571	217488	187319	240272
2026-27	273440	231083	195339	257778

Uttar Pradesh Projected Values at bus bar

(Econometric Model)





Data & Data Source

- CEA -General Review (2003-04 to 2014-15)
  1. Category-wise Connected Load, No. of Consumers and Consumption all states
  2. Per Capita Electricity Consumption
  3. No. of Pump set Energized, Mid Year Population
- CSO, MOSPI
  1. State Gross Domestic Product at Constant Price (base year 2011)
- PFC Reports
  1. Weighted Average Price of Electricity Sales (Price at base year 2011)
- Tariff Orders
  1. Power Procurement Cost over past years
- UPPCL & UPSLDC
  1. Night Reports, U.P. No. of consumers, Connected load and Consumption Category-wise
  2. PPA Information and Rate of electricity from power plants
  3. CS3 & CS4 Reports

Assumptions

Per Capita GDP Growth Rate				
Year	High	Medium	Low	Realistic Path
2015-16	7%	7%	7%	7%
2016-17	7%	7%	7%	7%
2017-18	8%	6%	4%	8%
2018-19	8%	6%	4%	8%
2019-20	8%	6%	4%	8%
2020-21	8%	6%	4%	7%
2021-22	8%	6%	4%	7%
2022-23	8%	6%	4%	7%
2023-24	8%	6%	4%	7%
2024-25	8%	6%	4%	7%
2025-26	8%	6%	4%	7%
2026-27	8%	6%	4%	7%

Year	Projected Population (in Million)
2015-16	219.72
2016-17	223.90
2017-18	227.98
2018-19	232.14
2019-20	236.37
2020-21	240.68
2021-22	244.36
2022-23	248.10
2023-24	251.89
2024-25	255.74
2025-26	259.65
2026-27	263.62

% Urban Population	
Year	%
2015-16	23.28
2016-17	23.52
2017-18	23.75
2018-19	23.99
2019-20	24.23
2020-21	24.47
2021-22	24.72
2022-23	24.96
2023-24	25.21
2024-25	25.47
2025-26	25.72
2026-27	25.98

As per Population foundation of India, Scenario B	
UP Population Growth (CAGR)	
2011-2021	1.82%
2021-2031	1.53%
2031-2041	1.22%

21

Assumptions (Contd.)

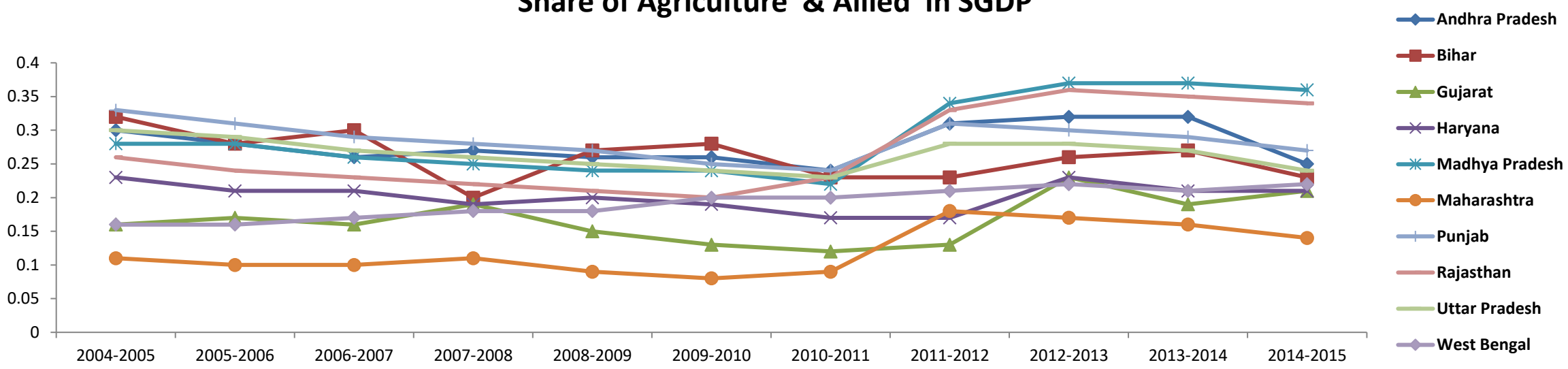
Price of electricity	
2014-15	3.85
2015-16	4.00
2016-17	4.16
2017-18	4.33
2018-19	4.50
2019-20	4.68
2020-21	4.87
2021-22	5.06
2022-23	5.26
2023-24	5.47
2024-25	5.69
2025-26	5.92
2026-27	6.16

% Share of Agri. & Allied Services in SGDP	
Year	Expected
2015-16	24.2%
2016-17	24.1%
2017-18	24.0%
2018-19	23.9%
2019-20	23.8%
2020-21	23.7%
2021-22	23.6%
2022-23	23.5%
2023-24	23.4%
2024-25	23.3%
2025-26	23.2%
2026-27	23.1%

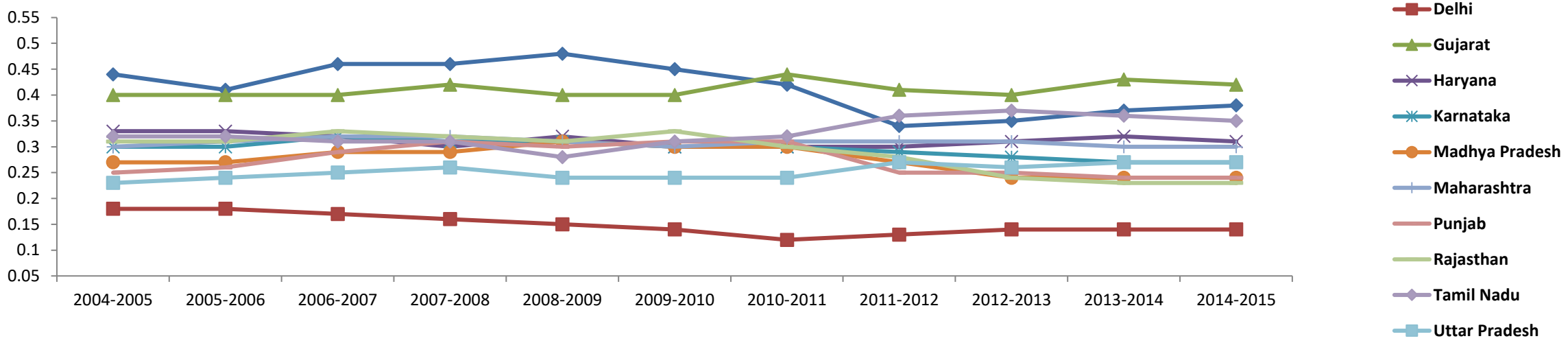
% Share of Industries in SGDP	
Year	Expected
2015-16	27.5%
2016-17	27.7%
2017-18	27.9%
2018-19	28.1%
2019-20	28.3%
2020-21	28.5%
2021-22	28.7%
2022-23	28.9%
2023-24	29.1%
2024-25	29.3%
2025-26	29.5%
2026-27	29.7%

Year	Per capita consumption (kWh)	Total Energy (GWh)
2015-16	543.47	119412.99
2016-17	569.74	127563.85
2017-18	602.13	137273.62
2018-19	637.05	147883.61
2019-20	674.72	159484.41
2020-21	709.87	170852.32
2021-22	747.42	182640.31
2022-23	787.55	195388.45
2023-24	830.45	209180.73
2024-25	876.32	224108.6
2025-26	925.37	240271.55
2026-27	977.85	257777.89

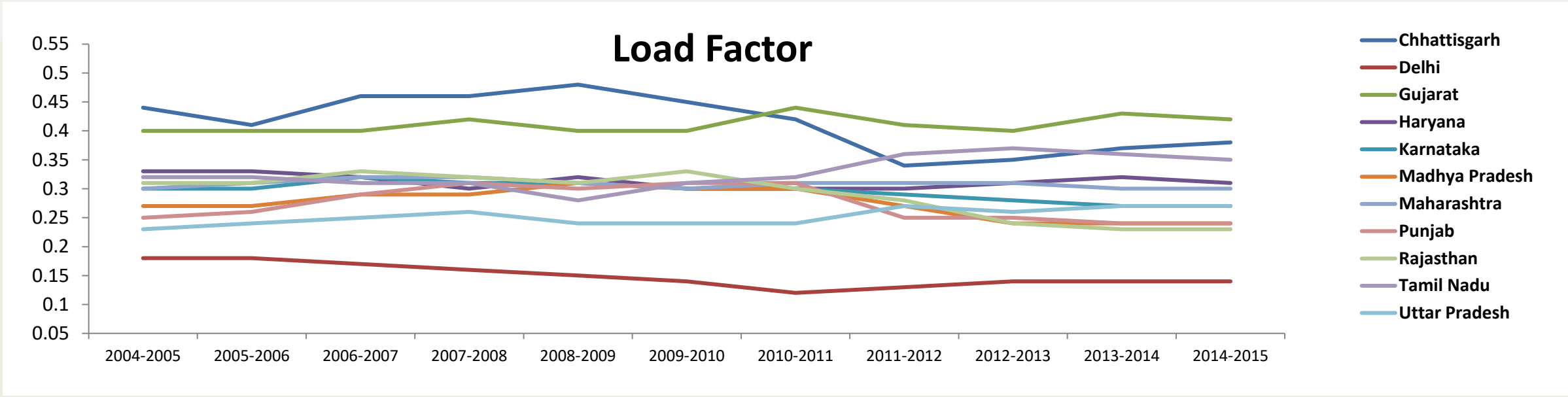
Share of Agriculture & Allied in SGDP

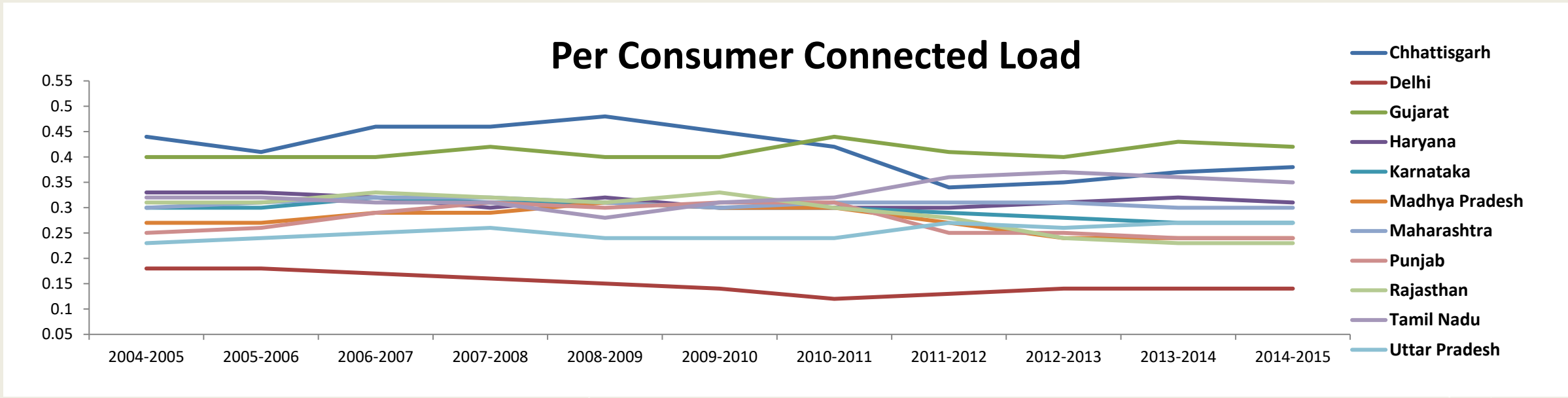


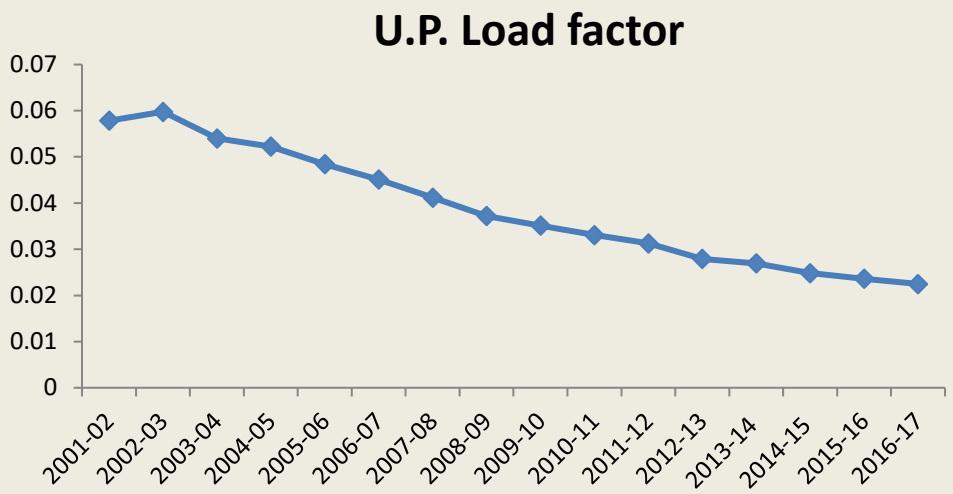
Share of Industries in SGDP

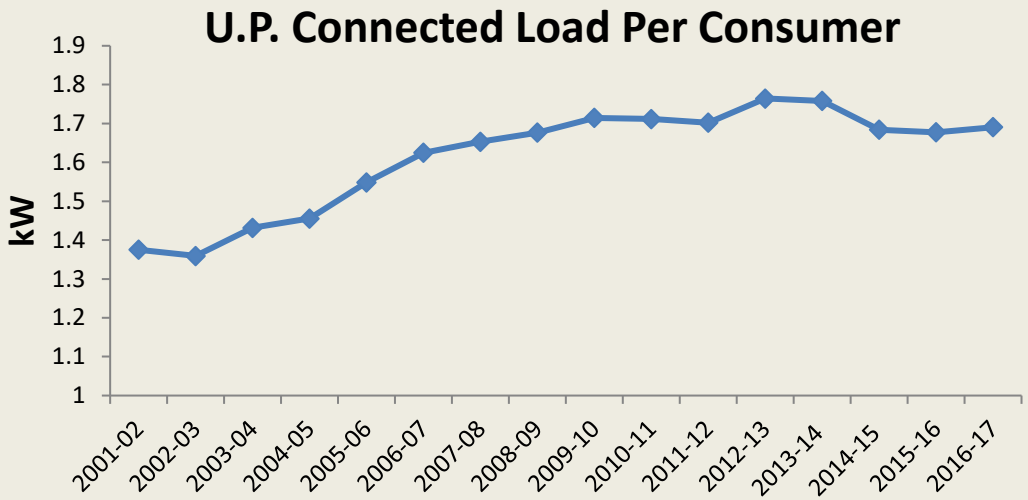


Partial End Use - State Level

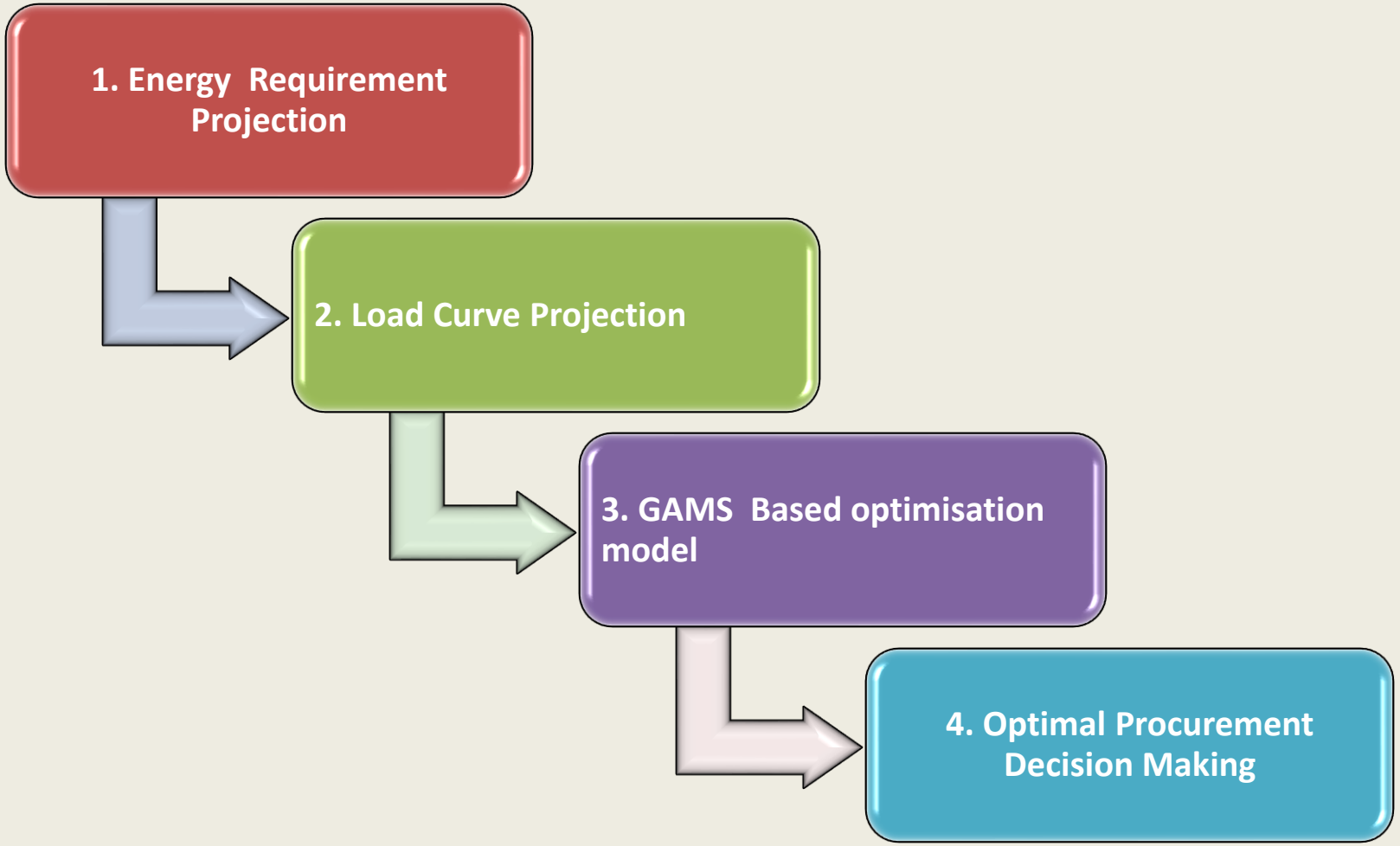




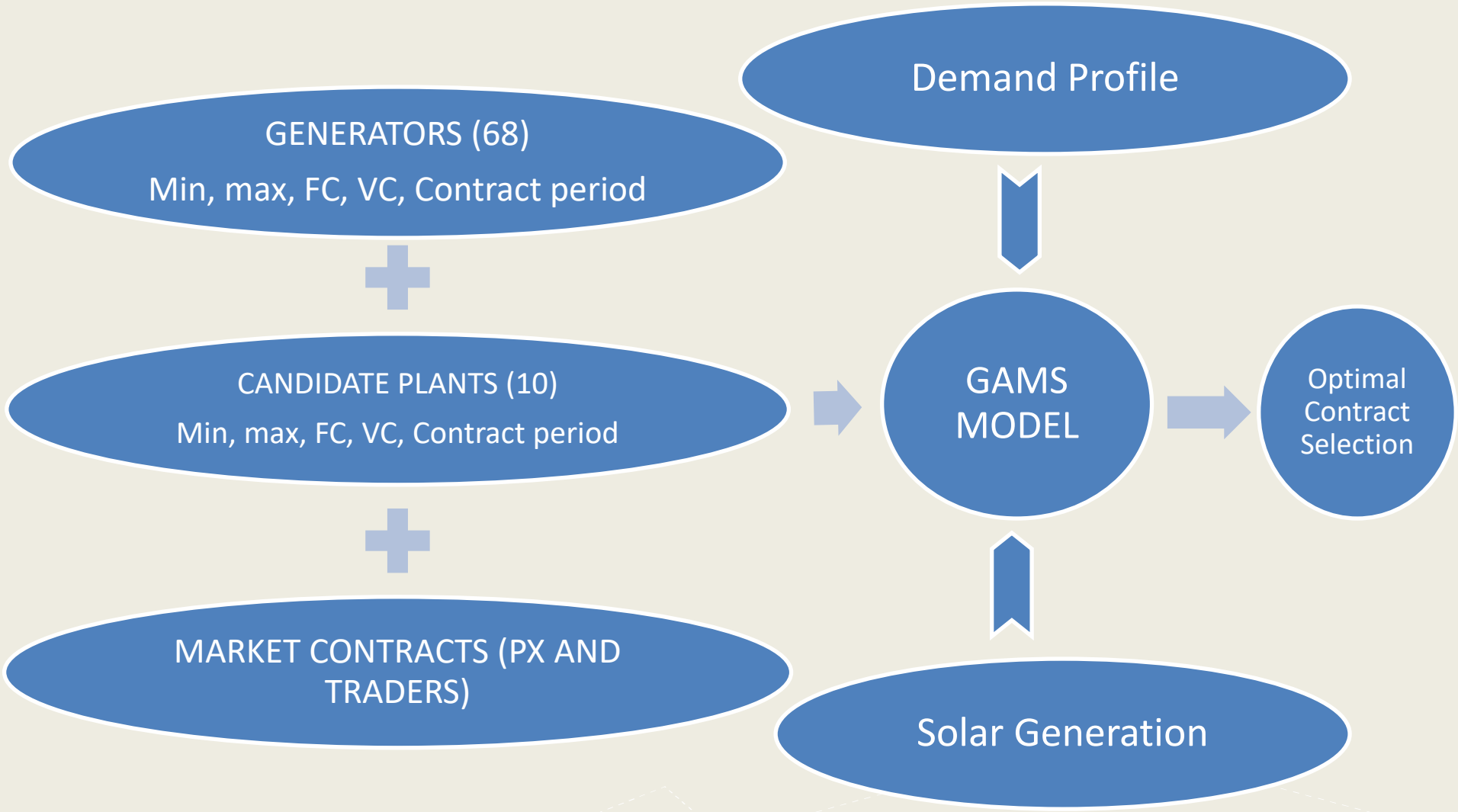

U.P. Load factor
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17


U.P. Connected Load Per Consumer
kW
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17

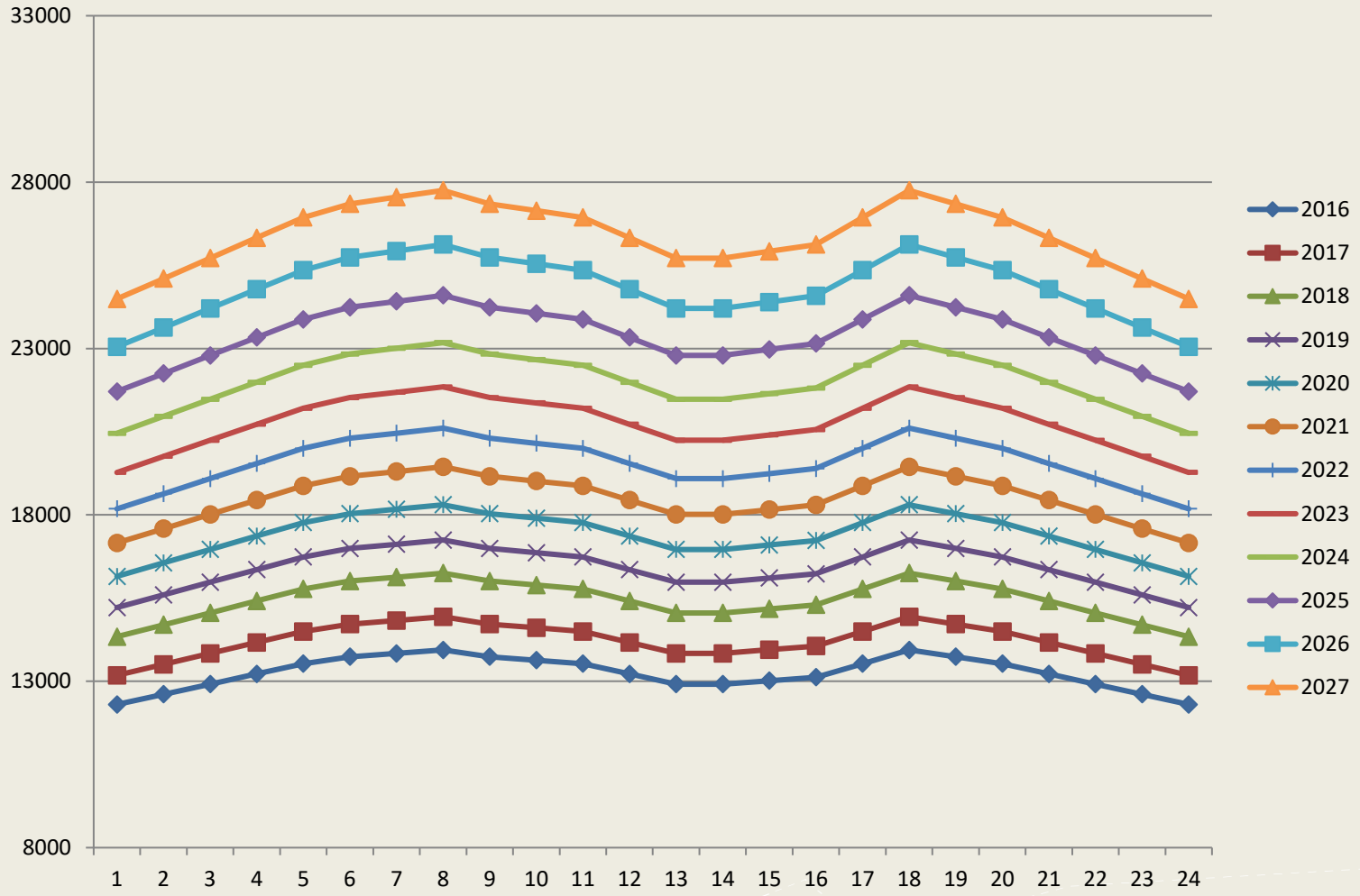
Methodology (IITK)



3. GAMS Based optimisation model



- Demand Profile (tentative) (MW)



Disruptive Changes in future

- ❑Open Access
- ❑Rooftop Solar
- ❑Retail competition
- ❑Metro & Electric Traction
- ❑Electric vehicles
- ❑Smart Grid
- ❑Storage
- ❑Franchisee (with exist clause for power procurement?)

Tasks Ahead

- Discuss and Freeze Assumptions – (Discussion with UPPCL)
- Develop Forecast – (Presentation at UPPCL)
- Develop Power Procurement Plan

References

1. Statistics-at-a-glance-2015-16 (http://www.uppcl.org/pdf/staticks-at-a-glance-2015-16.pdf)
2. 24 x7 Power for All Uttar Pradesh MOP
3. Data – UPPCL Night Report
4. Data – UPPCL Connected load , Nos. of consumer